PEDSAFE:

Pedestrian Safety Guide and Countermeasure Selection System

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16. Abstract

This report is the next generation of the *Pedestrian Facilities User Guide – Providing Safety and Mobility*.[1] It includes an update of 47 engineering countermeasures or treatments, along with education and enforcement programs, that may be implemented to improve pedestrian safety and mobility. Included in this version are 71 case studies that illustrate these concepts applied in practice in a number of communities throughout the United States.

The most significant enhancement is the integration of the countermeasures and case studies into an expert system known as PEDSAFE. This system and the content of this guide are included on the enclosed CD and are available on-line at http://safety.fhwa.dot.gov/pedsafe and at www.walkinginfo.org/pedsafe. The system allows the user to refine their selection of treatments on the basis of site characteristics, such as geometric features and operating conditions, and the type of safety problem or desired behavioral change. The purpose of the system is to provide the most applicable information for identifying safety and mobility needs and improving conditions for pedestrians within the public right-of-way. PEDSAFE is intended primarily for engineers, planners, safety professionals, and decisionmakers, but it may also be used by citiznes for identifying problems and recommending solutions for their communities.

[1] *Pedestrian Facilities User Guide – Providing Safety and Mobility* was authored by Charles V. Zegeer, Cara Seiderman, Peter Lagerwey, Mike Cyneki, Michael Ronkin, and Robert Schneider.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
			LENGTH	
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
			AREA	
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
			VOLUME	
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
			MASS	
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
			TEMPERATURE (exact degrees)	
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
			ILLUMINATION	
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
			FORCE and PRESSURE or STRESS	
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
			LENGTH	
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
			AREA	
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
			VOLUME	
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
			MASS	
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
			TEMPERATURE (exact degrees)	
°C	Celsius	1.8C+32	Fahrenheit	°F
			ILLUMINATION	
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
			FORCE and PRESSURE or STRESS	
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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Bicycle and Pedestrian Program

Table of Contents

How To Use This Guide

The recently published *Pedestrian Facilities User Guide—Providing Safety and Mobility* provided descriptions of 47 unique engineering countermeasures or treatments that may be implemented to improve pedestrian safety and mobility.[1] Included for each of the 47 treatments were a general description, purpose or objective, considerations for implementation, and estimated costs. While that level of information alone is useful to engineers, planners, and other safety professionals, the guide also included two matrices that related the 47 treatments (plus two additional countermeasures of education and enforcement) to specific performance objectives and specific types of collisions. These matrices provide the practitioner with the ability to select the most appropriate treatment(s) if they have a well-defined crash problem or are trying to achieve a specific change in behavior.

This report is the next generation of the information just described. It includes an update of the content of the first version along with case studies that illustrate these concepts applied in practice in a number of communities throughout the United States. The most significant enhancement is the integration of the countermeasures and case studies into an expert system known as PEDSAFE. This system and the content of this guide are included on the enclosed CD and are available online at http://safety.fhwa.dot.gov/pedsafe and at www.walkinginfo.org/pedsafe. The system allows the user to refine their selection of treatments on the basis of site characteristics, such as geometric features and operating conditions, and the type of safety problem or desired behavioral change. The purpose of the system is to provide the most applicable information for identifying safety and mobility needs and improving conditions for pedestrians within the public right-of-way. PEDSAFE is intended primarily for engineers, planners, safety professionals, and decisionmakers, but it may also be used by citizens for identifying problems and recommending solutions for their communities.

Chapter 1: The Big Picture gives an overview on how to create a safe, walkable environment. *Chapter 2: Pedestrian Crash Statistics* describes basic pedestrian crash trends and statistics in the U.S. *Chapter 3: Selecting Improvements for Pedestrians* discusses the approaches to select the most appropriate countermeasures. One approach is based on the need to resolve a known safety problem, while the other is based on the desire to change behaviors of motorists and/or pedestrians.

Chapter 4: The Expert System describes the Web/CD application, including a description of the overall content and step-by-step instructions for use. *Chapter 5: The Countermeasures* contains the details of 49 engineering, education, and enforcement treatments for pedestrians. These improvements relate to pedestrian facility design, roadway design, intersection design, traffic calming, traffic management, signals and signs, and other measures. In *Chapter 6: Case Studies* are the 71 examples of implemented treatments in communities throughout the U.S.

Further resources are provided in *Chapter 7: Implementation and Resources*, including sections on community involvement in developing priorities, devising strategies for construction, and raising funds for pedestrian improvements. A list of useful web sites, guides, handbooks, and other references is also provided.

There are also several appendices with supporting materials. *Appendix A* includes an assessment form that can be used in the field to collect the information needed to effectively use the expert system. *Appendix B* provides a detailed matrix showing the specific countermeasures that are associated with each of the 71 case studies. The last two appendices provide recommended guidelines for the installation of sidewalks/ walkways (*Appendix C*) and crosswalks (*Appendix D*).

The Big Picture ∞ Chapter 1

PHOTO BY MICHAEL RONKIN

Walking is such a basic human activity that it has frequently been overlooked in the quest to build sophisticated transportation systems. Now people want to change that. They want to live in places that are welcoming, safe, and enjoyable. They want livable communities where they can walk, bicycle, recreate, and socialize.

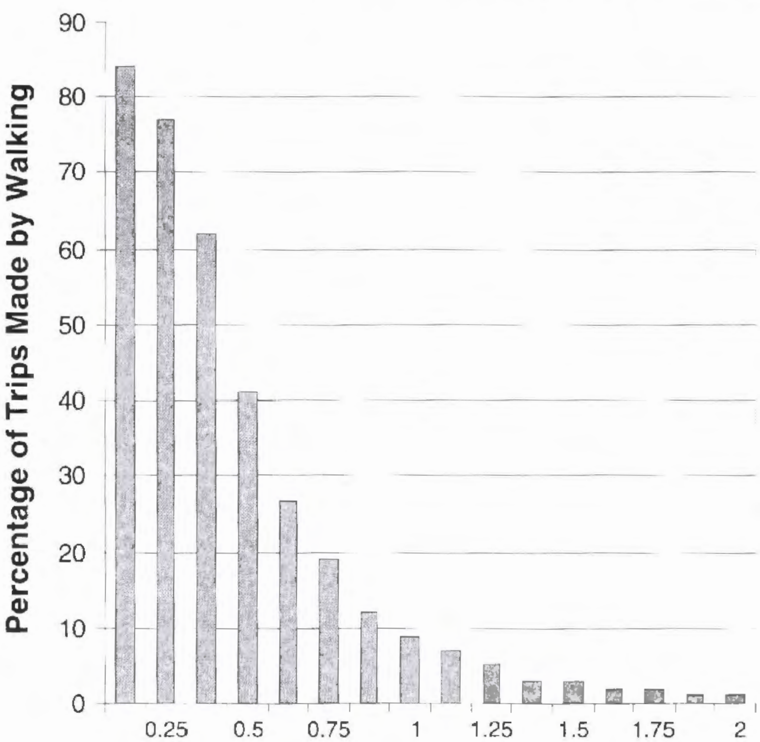
Creating a pedestrian environment involves more than laying down a sidewalk or installing a signal. A truly viable pedestrian system involves both the big picture and the smallest details—from how a city is built to what materials are under our feet. Facilities should be accessible to all pedestrians, especially those with disabilities and children. Accessible design is the foundation for all pedestrian design and facilities need to be planned, designed, operated, and maintained to be usable by all people.

Because most of the work that will be done involves retrofitting existing places, improving the pedestrian environment will probably be done on a street-by-street, neighborhood-by-neighborhood basis.

PHOTO BY CARA SEIDERMAN

Design streets for people to use them. Assume people will walk.

The Relationship Between Distance to Transit Facility and Pedestrian Mode Choice



Distance to Transit Station (miles)
1 mi = 1.61 km

Source: Federal Transit Administration, Transit Cooperative Research Program, Transit and Urban Form, TCRP Report 16, 1996. Chart adapted from Figure 19.

LAND USE

Creating a walkable community starts with the very nature of the built environment: having destinations close to each other; siting schools, parks, and public spaces appropriately; allowing mixed-use developments; having sufficient densities to support transit; creating commercial districts that people can access by foot and wheelchair; and so on. Most walking trips are less than 0.8 km (0.5 mi).[1] While mixed-use developments with sufficient density to support transit and neighborhood commercial businesses can make walking a viable option for residents, single-use, low-density residential land-use patterns discourage walking. When residents are segregated from sites such as parks, offices, and stores, there will be fewer pedestrian trips because destinations are not close enough for walking. The connection between land-use planning and transportation planning is critical, but all too often ignored.

Integrating land-use and transportation planning allows new developments to implement these strategies from the onset. Communities that support balanced transportation make walking and public transit attractive options.


PHOTO BY CARA SEIDERMAN

A busy commercial street in Ann Arbor, Michigan, emphasizes pedestrian use and provides attractive areas for people to sit, stroll, and meet.

In established communities, many of these goals can be met with "in-fill development" to increase density and community viability. Changes in zoning laws and sidewalk warrants to allow mixed-use development and pedestrian connections, such as sidewalks, easy-to-access crosswalks, and shared-use paths, can also increase pedestrian safety and mobility.

ASSUME THAT PEOPLE WILL WALK

Whether building new infrastructure or renovating existing places, it should always be assumed that people will walk and plans should be made to accommodate pedestrians. People will want to walk everywhere they can, and a comfortable, inviting, and safe environment should be provided for them. There are many reasons that people walk: to run errands, to visit neighbors, to go to local stores, to take their children to the local park, for exercise, or even for the sheer enjoyment of being a pedestrian. Children should be able to walk to school or to their friends' houses. All of these activities constitute a significant number of trips. About four-fifths of all trips are non-work-related.

If people aren't walking, it is probably because they are prevented from doing so. Either the infrastructure is insufficient or has serious gaps. Are there continuous walkways? Are there physical barriers such as rivers, drainage ways, walls, or freeways that prevent convenient walking access in a community? Do bridges for automobiles also provide a safe walking area for pedestrians? Does the lack of curb ramps or the existence of steep grades or steps prevent access for the elderly or people using wheelchairs? Are there information barriers preventing people with visual disabilities from crossing the street? Is there a major road that separates the residential neighborhood from the commercial district? Are there places for people to cross roads safely?

Walking rates in different neighborhoods within the same city are directly related to the quality of the system. In other words, in high-quality pedestrian environments, lots of people walk. Where the system fails—missing sidewalks, major barriers, no safe crossings—people walk less, and those who do are at greater risk.

People also want to walk in an environment where they can feel safe, not only safe from motor vehicle traffic, but safe from crime or other concerns that can affect personal security. Areas need to be well lit to encourage walking during evening hours. If the pedestrian system is not accessible, it is often not safe. For example, lack of access may cause wheelchair users to use the street rather than a poorly maintained sidewalk. Some populations may be at a higher risk of pedestrian crashes. Children under age 15 are the most overrepresented group in pedestrian crashes and people over age 65 have the most pedestrian fatalities. Therefore, it is especially important to provide adequate facilities in the vicinity of land uses such as retirement homes and school zones. But it is important to keep in mind that children and people who are elderly or have disabilities are part of every community, so adequate facilities are needed everywhere people are expected to walk.

The walking environment should be open and inviting, but not sterile and vacant. Pedestrians need more than sidewalks and crosswalks. In addition to protecting pedestrians from motor vehicle traffic, it is important to have a secure, pleasant, and interesting walking environment to encourage people to walk.

Traditionally, safety problems have been addressed by analyzing police crash reports and improvements have been made only after they are warranted by crash numbers. However, planners and engineers should consider problem-identification methods such as interactive public workshops, surveying pedestrians and drivers, and talking with police to identify safety problems in an area before crashes occur. This may help proactively identify locations for pedestrian safety improvements and will involve citizens in the process of improving safety and mobility in their own communities.

This roadway may act as a barrier to pedestrians. Those who are walking along the waterfront may find it difficult to cross to the commercial establishments and those on the commercial side may be reluctant to cross to the waterfront.

TRANSIT

Walking and transit are complementary. Good walking conditions for pedestrians are important inducements to using public transportation, since most public transit trips include a pedestrian trip at one or both ends. People should be able to walk to a bus stop or a train station from their homes and to jobs, shopping, and other activities. Conversely, good public transportation, with buses, subways, and paratransit vehicles that run frequently and are reliable, is essential to achieving a walkable city. The trip should be as seamless as possible and transit stops should be friendly, comfortable places. Consideration needs to be given to the location of the stop relative to intersections, how to get transit users safely across the street, and a variety of other issues. For more information, refer to Chapter 14 in *Design and Safety of Pedestrian Facilities.*[2]

When development occurs around a transit stop, more transit can be supported, and people will have more options for how to travel there. Special attention should be paid to how people will get from the transit stop to their destinations. No matter how convenient the trip is otherwise, if pedestrians don't feel safe for even a short distance, they will choose not to go, or to go by another mode (usually driving—and the more people who drive, the less pedestrian-friendly a place becomes).

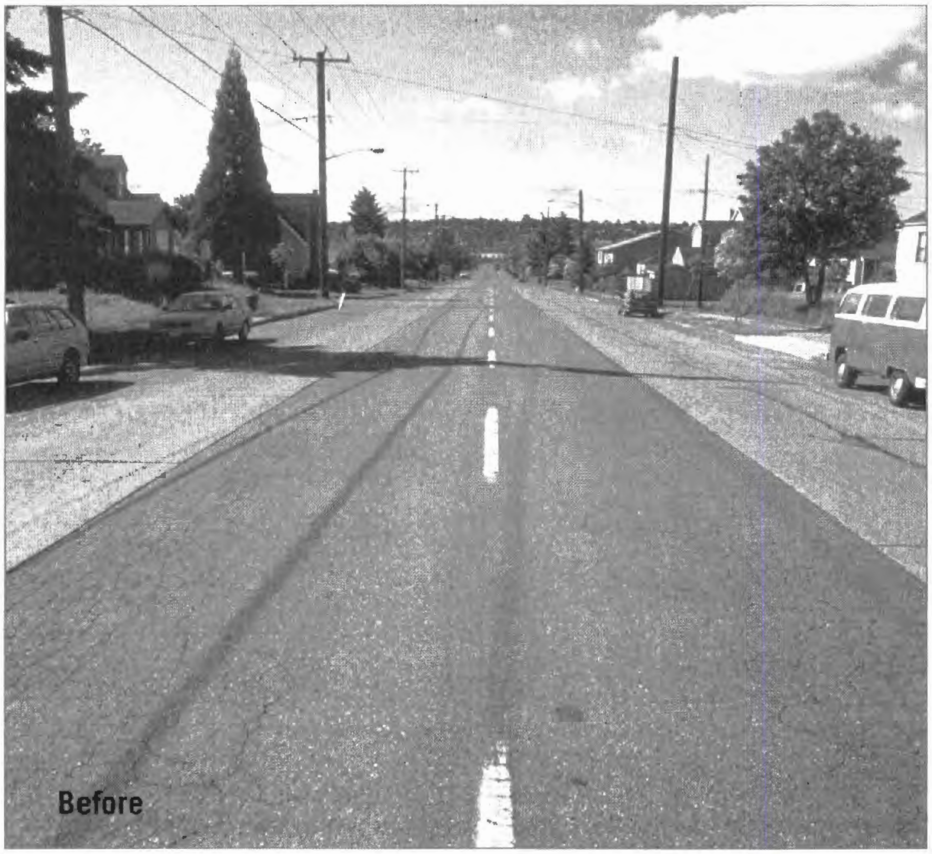
STREETS: THE ARTERIES OF LIFE

Streets serve many functions, including:

- Linkage. They connect parts of cities to each other, one town to another, and activities and places.
- Transportation. They provide the surface and structure for a variety of modes. All modes and users should be provided for: pedestrians, bicyclists, transit, motor vehicles, emergency services, maintenance services, etc.
- Access. They provide public access to destinations.
- Public right-of-way. Space for utilities and other underground infrastructure is usually a hidden function of the street.
- Sense of place. The street is a definable place, a place for people to interact, the heart of a community. A street can serve this role by being a venue for parties, fairs, parades, and community celebrations, or by simply being a place where neighbors stop to chat.

Streets are often designed to emphasize some functions over others. At one extreme is a limited-access highway that serves as a corridor for motor vehicle travel. At the other extreme is a private cul-de-sac, which has no linkage and has limited access. Many streets are designed so that certain desirable functions are not provided. Examples include commercial streets where access to destinations is difficult, and strip development along high-speed roads where no sidewalks or pedestrian crossings exist.

When streets and roads are evaluated for improvements, it is helpful to consider whether the design effectively meets all the desired functions of the roadway. If not, the street should be redesigned to adequately meet those functions.



Pedestrian injuries are less severe on lower speed roadways. The street pictured above is a heavily traveled arterial in one of Seattle, Washington's thriving residential neighborhoods. High speed and concerns about pedestrian safety resulted in the redesign shown in the "after" picture. Bike lanes and a median strip have encouraged slower traffic speeds. Speeds were reduced by about 4.8 km/h (3 mi/h), while average daily traffic remained about the same.

HOW PEDESTRIANS ARE AFFECTED BY TRAFFIC: VOLUME AND SPEED

High volumes of traffic can inhibit a person's feeling of safety and comfort and create a "fence effect" where the street is almost an impenetrable barrier. The effect of traffic volumes on community life has been measured. In his seminal 1980 study, Donald Appleyard looked at how traffic volumes on comparable streets in San Francisco affected community life. People living on a street with light traffic (2,000 vehicles per day) had three times as many friends and twice as many acquaintances on the street as did people living on a street with heavy traffic (16,000 vehicles a day).[3]

Traffic speed is usually the more critical aspect to walkability and safety. Though pedestrians may feel comfortable on streets that carry a significant amount of traffic at low speeds, faster speeds increase the likelihood of pedestrians being hit. At higher speeds, motorists are less likely to see a pedestrian, and even less likely to actually stop in time to avoid a crash. At a mere 49.9 km/h (31 mi/h), a driver will need about 61.0 m (200 ft) to stop, which may exceed available sight distance; that number is halved at 30.6 km/h (19 mi/h).[4]

Unfortunately, most of our streets are designed to encourage higher traffic speeds. Fortunately, we do have tools that can change this, primarily by redesigning streets through traffic calming or by designing new streets with lower design speeds. Speed reductions can increase pedestrian safety considerably. The safety benefits of reduced speeds extend to motorists and cyclists as well, although the


Street designs that accommodate people with disabilities create a better walking environment for all pedestrians.

advantage to pedestrians is the most substantial.

ADA DESIGN GUIDELINES

The Americans with Disabilities Act (ADA) was enacted in 1990 to ensure people with disabilities have equal opportunities and access to public spaces as those who do not have disabilities. People with disabilities may have diminished mobility, limited vision, or reduced cognitive skills. In some instances, individuals may experience a combination of disabilities, which is more common as a person grows older. A person may experience a disability on a permanent or temporary basis. Without accessible pedestrian facilities, people with disabilities will have less opportunities to engage in employment, school, shopping, recreation, and other everyday activities. New or altered facilities must provide access for all pedestrians. This also needs to occur when implementing all the tools and treatments that are presented in this guide.

While improvements for persons with disabilities were mandated by the Federal Government to ensure access and mobility for physically-challenged pedestrians, most of these improvements benefit all pedestrians. Some of the items that will be presented in this guide, such as adequate time to cross streets, well-designed curb ramps, limited driveways, and sidewalks that are wide and clear of obstructions and have minimal cross-slope, are examples of design features that will accommodate pedestrians with disabilities, persons using strollers, and indeed, all pedestrians.[5]

All new construction or retrofit projects must include curb ramps and other accessible features that comply with ADA requirements. Agencies should review their street system to identify other barriers to accessibility and prioritize the needed improvements. This review was a requirement of the Rehabilitation Act (1973) and ADA. States, cities, and other localities were to develop a planning document and a transition plan for removing barriers in their existing facilities. The barriers should have been removed by 1995. Examples of barriers that are often overlooked include poles and signs in the middle of a sidewalk, steeply sloped driveways, and interruptions such as broken or missing sidewalk sections. An adequate level of surveillance and maintenance is also important to providing accessibility, especially in winter months in areas where snow accumulates. While all streets should be upgraded to be accessible, public agencies should set priorities for high-use areas, such as commercial districts, schools, parks, transit facilities, etc., and retrofit as rapidly as possible.

The design criteria for the construction and alteration of facilities covered by law were developed by the U.S. Access Board and are the ADA Accessibility Guidelines (ADAAG). These guidelines serve as the basis for standards that are maintained by the U.S. Department of Justice and the U.S. Department of Transportation and are the minimum criteria for designing public right-of-way space. In addition, the Access Board is currently developing Public Rights-of-Way Guidelines, which will supplement ADAAG. A draft version of these guidelines is available at www.access-board.gov/rowdraft.htm. For the latest ADAAG information and guidance on ADA requirements and issues, visit www.access-board.gov.

Pedestrian Crash Statistics
Chapter 2

PHOTO BY DAN BURDEN

Magnitude of the Problem

Pedestrians Most at Risk

Area Type

Location Type

Times of Occurrence

Speeding

Alcohol Impairment

Chapter 1 provided an overview of the need to provide a more pedestrian-friendly environment along and near streets and highways. This chapter provides an overview of the pedestrian safety problem and related factors that must be understood to select appropriate facilities and programs to improve pedestrian safety and mobility. A brief description of the pedestrian crash problem in the United States is discussed in the following sections and is also reported by Zegeer and Seiderman in the ITE *Traffic Safety Toolbox*.[1] Similar statistics should be produced for States and municipalities to better understand the specific problems at the community level and thus select appropriate countermeasures.

MAGNITUDE OF THE PROBLEM

Pedestrian/motor vehicle crashes are a serious problem throughout the world and the United States has a particular problem with pedestrian deaths and injuries.

Specifically, 4,749 pedestrians were reported to have been killed in motor vehicle crashes in the United States in 2003.[2] These deaths accounted for 11 percent of the 42,643 motor vehicle deaths nationwide that year. An estimated 70,000 pedestrians were injured or killed in motor vehicle collisions, which represents 2 percent of the 2.9 million total persons injured in traffic crashes.[2] A drop in pedestrian fatalities in recent years may reflect the fact that people are walking less, as evidenced by the U.S. Census and the Nationwide Personal Transportation Survey (NPTS). The need to reduce pedestrian deaths and injuries while promoting increased walking continues to be an important goal for the engineering profession.

PHOTO BY DAN BURDEN

Older pedestrians are more likely to be injured or killed when struck by a motor vehicle than younger pedestrians.

Crash involvement rates per 100,000 people are highest for young males.

PEDESTRIANS MOST AT RISK

Crash involvement rates (crashes per 100,000 people) are the highest for 5- to 9-year-old males, who tend to dart out into the street. This problem may be compounded by the fact that speeds are frequently a problem in areas where children are walking and playing.

In general, males are more likely to be involved in a crash than females; in 2003, 69 percent of pedestrian fatalities were male, and the male pedestrian injury rate was 58 percent higher than for females.[2]

Rates for older persons (age 65 and over) are lower than for most age groups, which may reflect greater caution by older pedestrians (e.g., less walking at night, fewer dart-outs) and a reduced amount of walking near traffic. However, older adult pedestrians are much more vulnerable to serious injury or death when struck by a motor vehicle than younger pedestrians. For example, the percentage of pedestrian crashes resulting in death exceeds 20 percent for pedestrians over age 75, compared to less than 8 percent for pedestrians under age 14.[3,4]

AREA TYPE

Pedestrian crashes occur most frequently in urban areas where pedestrian activity and traffic volumes are greater compared to rural areas. The National Safety Council estimates that 85.7 percent of all non-fatal pedestrian crashes in the United States occur in urban areas and 14.3 percent occur in rural areas. Seventy-two percent of all pedestrian fatalities in 2003 occurred in urban areas.[2] The percentage of rural fatalities relative to the total number of rural pedestrian crashes is more than doubled. In many cases, this is due to increased vehicle speeds found on rural roads. In addition, many rural areas

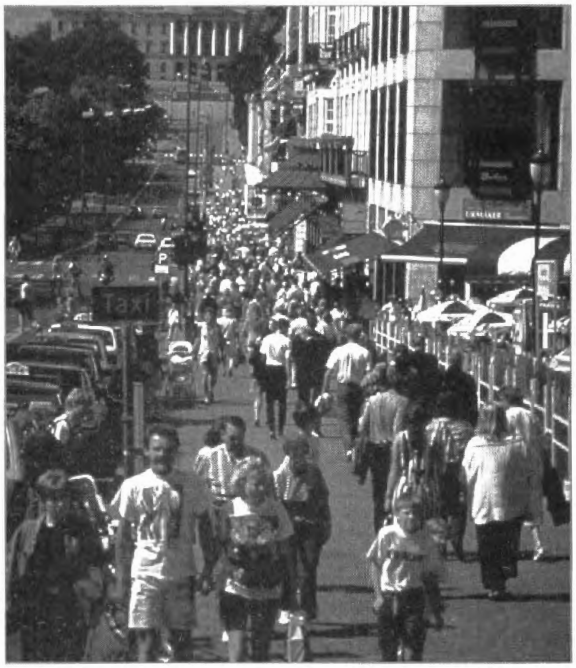


PHOTO BY DAN BURDEN

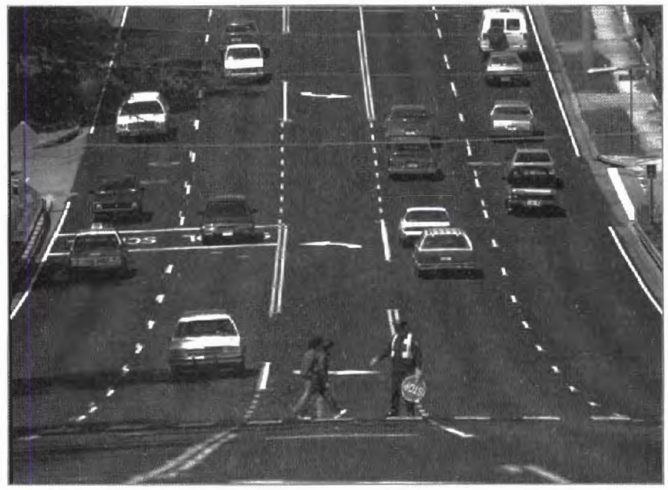
The majority of all pedestrian crashes occur in urban areas where pedestrian activity and traffic volumes are greatest.

Pedestrians sometimes choose the most direct path, which often places them at greater risk.

have no sidewalks, paths, or shoulders to serve as separated pedestrian facilities.

LOCATION TYPE

In terms of crash location, 65 percent of crashes involving pedestrians occur at non-intersections. This is particularly true for pedestrians under age 9, primarily because of dart-outs into the street. For ages 45 to 65, pedestrian crashes are approximately equal for intersections and non-intersections. Pedestrians age 65 and older are more likely to be injured or killed at intersections (59 percent) compared to non-intersections (41 percent), since older pedestrians tend to cross at intersections more often than younger ones.[5] Moreover,



Wide multilane roadways without adequate crossing islands create an unsafe environment for many pedestrians.

some older pedestrians have diminished physical and visual abilities that make street crossings more challenging. In recent years, an emphasis has been placed on improving the design criteria used by engineers to ensure that the needs of all users are being met; the *Highway Design Handbook for Older Drivers and Pedestrians* is one resource.[6]

TIMES OF OCCURRENCE

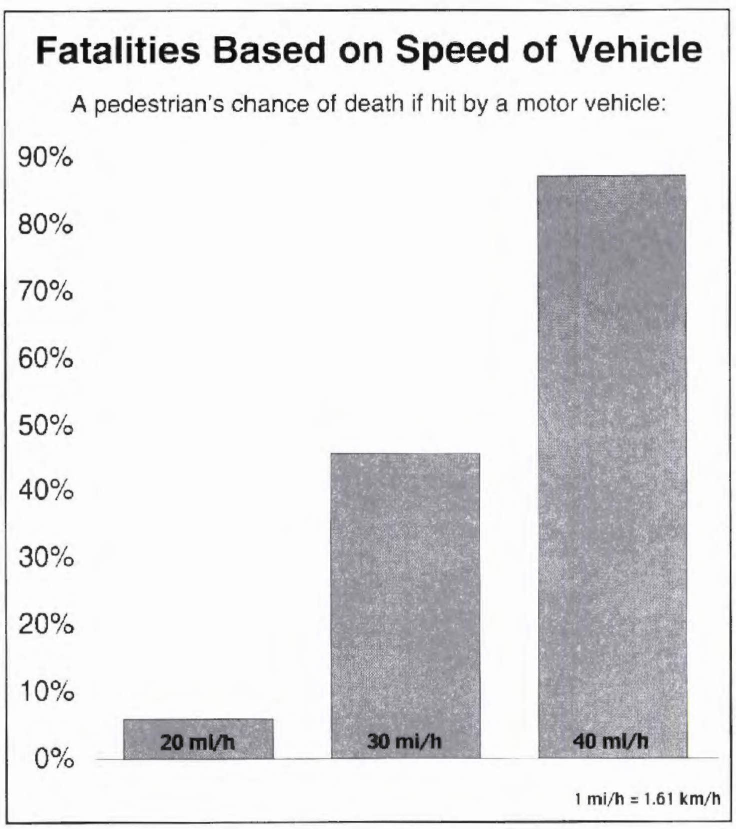
Pedestrian crashes are most prevalent during morning and afternoon peak periods, when the traffic levels are highest. Fatal pedestrian crashes typically peak later in the day, between 5 and 11 p.m., where darkness and alcohol use are factors.[7] In 2003, 54 percent of the pedestrian fatalities occurred between 4 p.m. and midnight. Nearly one-half of all pedestrian fatalities occurred on Friday, Saturday, or Sunday (16 percent, 18 percent, and 13 percent, respectively).[2,8] Crashes where

Fatal pedestrian collisions occur more often during periods of darkness.

older pedestrians are hit are more evenly distributed throughout the days of the week than those for younger pedestrians. Older pedestrians are more likely to be struck during daylight hours, when they are most likely to be exposed to traffic.[3] September through January have the highest number of nationwide pedestrian fatalities, with typically fewer daylight hours and more inclement weather.[4,9] Child pedestrian fatalities are greatest in May, June, and July, perhaps due to an increase in outside activity.[9]

SPEEDING

Speeding is a major contributing factor in crashes of all types. In 2003, speeding was a contributing factor in 31 percent of all fatal crashes.[2] Speeding has serious consequences when a pedestrian is involved. A pedestrian hit at 64.4 km/h (40 mi/h) has an 85 percent chance of being killed; at 48.3 km/h (30 mi/h), the likelihood goes down to 45 percent, while at 32.2 km/h (20 mi/h), the fatality rate is only 5 percent.[10] Faster speeds increase the likelihood of a pedestrian being hit. At higher speeds, motorists are less likely to see a pedestrian, and are even less likely to be able to stop in time to avoid hitting one.



Source: U.K. Department of Transportation, *Killing Speed and Saving Lives*, London, 1987.

ALCOHOL IMPAIRMENT

Driving under the influence of alcohol is a well-publicized issue as related to motorists in this country. In 2003, alcohol was involved in 40 percent of the fatal crashes in the U.S. However, alcohol is also a contributing factor in pedestrian crashes. Of the 4,662 traffic crashes that resulted in a pedestrian fatality in 2003,

Alcohol impairment continues to be a serious problem for pedestrians involved in motor vehicle collisions.

34 percent involved pedestrians with a blood-alcohol concentration (BAC) of 0.08 or greater. More than half of the pedestrian fatalities in the age groups of 21 to 24, 25-34, and 35 to 44 involved intoxicated pedestrians (55 percent, 57 percent, and 55 percent, respectively).[2]

Selecting Improvements for Pedestrians Chapter 3

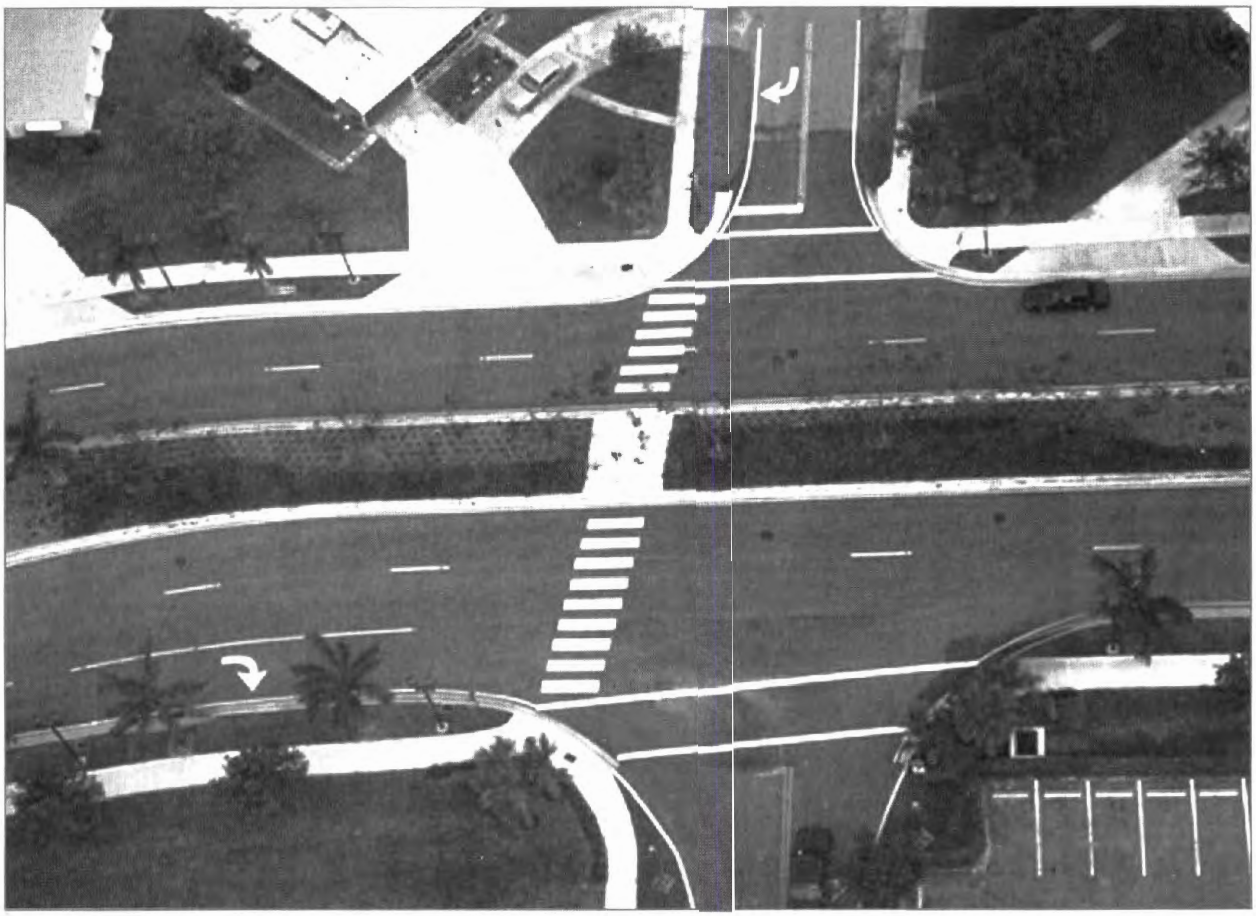


PHOTO BY MICHAEL RONKIN

Identification of High-Crash Locations
Pedestrian Crash Typing
Definitions of Pedestrian Crash Types
Crash-Related Countermeasures
Performance Objectives
Program of Improvements

PHOTO BY ROBERT SCHNEIDER

Pedestrians are quite often in conflict with left-turning vehicles when permissive signal phasing is used.

Deciding on the set of treatments that will provide the greatest benefits in terms of providing safety and mobility requires transportation and land-use planners, engineers, law enforcement officials, and community leaders to engage in problem-solving. In most cases, a two-prong approach is required. The first prong involves an examination of the pedestrian crash problem through a review of historical crash data. Two specific types of crash analyses include the identification of high-crash locations and the detailed examination of pre-crash maneuvers that lead to pedestrian-motor vehicle incidents. Both are described in more detail in this chapter.

However, many of the problems faced by pedestrians either do not involve crashes or the crashes are not reported. Thus, the second prong addresses these types of problems by focusing on performance objectives that will lead to changes in behavior, which in turn, will result in a safer and more accessible environment for pedestrians. The types of objectives most often pursued by local agencies are discussed in this chapter.

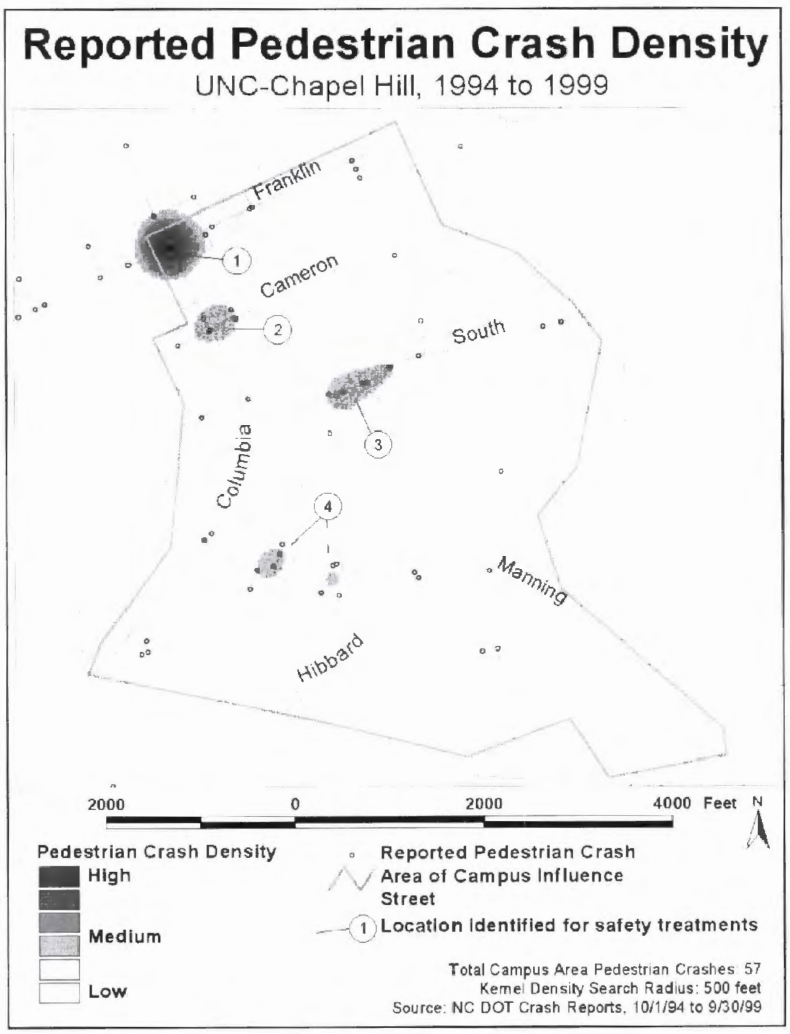
IDENTIFICATION OF HIGH-CRASH LOCATIONS

A first step in the problem-solving process of improving pedestrian safety and mobility is to identify locations or areas where pedestrian crash problems exist and where engineering, education, and enforcement measures will be most beneficial. Mapping the locations of reported pedestrian crashes in a neighborhood, campus, or city is a simple method of identifying sites for improving walking safety. One method of analyzing crash locations includes using computerized Geographic Information Systems (GIS) software, as shown by the density map of reported pedestrian crashes on a college campus pictured below.

This type of map can help transportation engineers and planners focus safety improvements on intersections, street sections, or neighborhoods where pedestrian crashes have occurred.

Several issues should be considered when creating GIS maps of reported crash locations. First, the total number of pedestrians and vehicles that use each location will affect reported crash density.

Second, pedestrian crashes may not be reported frequently enough to establish a pattern of unsafe walking locations. In either case, performing a conflict analysis, noting pedestrian and driver behavior or examining roadway and walkway characteristics at specific sites, or mapping locations known to have a high potential for pedestrian crashes in an area may improve the identification of unsafe locations for walking. Other methods for identifying locations with possible pedestrian problems include using walkability checklists and calculating a pedestrian level of service.



PEDESTRIAN CRASH TYPING

The development of effective roadway design and operation, education, and enforcement measures to accommodate pedestrians and prevent crashes is hindered by insufficient detail in computerized State and local crash files. Analysis of these databases can provide information on where pedestrian crashes occur (city, street, intersection, two-lane road, etc.), when they occur (time of day, day of week, etc.), and characteristics of the victims involved (age, gender, injury severity, etc.). Current crash files cannot provide a sufficient level of detail regarding the sequence of events leading to the crash.

In the 1970s, methods for typing pedestrian and bicycle crashes were developed by the National Highway Traffic Safety Administration (NHTSA) to better define the sequence of events and precipitating actions leading to pedestrian/motor vehicle crashes.[1,2,3,4] These methodologies were applied by Hunter in a 1996 study to more than 8,000 pedestrian and bicycle crashes from 6 States.[1,2,3,4] The results provided a representative summary of the distribution of crash types experienced by pedestrians and bicyclists. Some of the most frequently occurring types, include dart-out first half (i.e., the pedestrian is struck in the first half of the street being crossed) (24 percent), intersection dash (13 percent), dart-out second half (10 percent), midblock dart (8 percent), and turning-vehicle crashes (5 percent).[1,2,3,4]

The crash-typing methodology described above has evolved over time and has been refined as part of a software package known as the Pedestrian and Bicycle Crash Analysis Tool (PBCAT).[5] The development of PBCAT was sponsored by the Federal Highway Administration (FHWA) and NHTSA through the University of North Carolina Highway Safety Research Center. Those interested may register for the PBCAT software and user's manual from the Pedestrian and Bicycle Information Center website at: www.walkinginfo.org/pbcat.

PBCAT is a software product intended to assist State and local pedestrian and bicycle coordinators, planners, and engineers with the problem of lack of data regarding the sequence of events leading to a crash. PBCAT accomplishes this goal through the development and analysis of a database containing details associated with crashes between motor vehicles and pedestrians or bicyclists. One of these details is the crash type, which describes the pre-crash actions of the parties involved. The more than 60 specific pedestrian crash types used in PBCAT can be collapsed into 12 crash typing groups for purposes of selecting treatments.

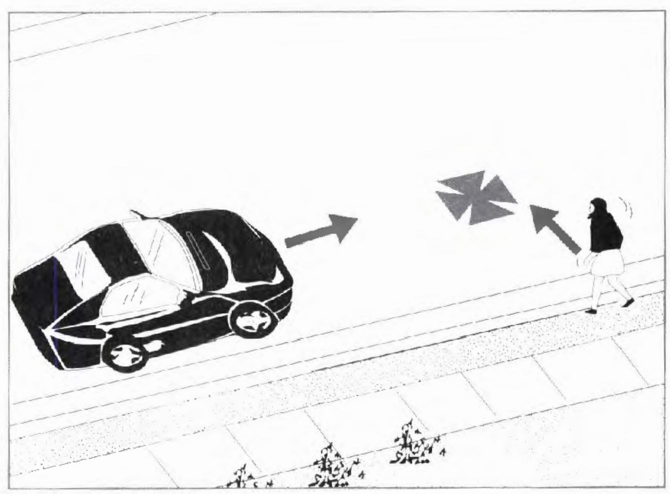
DEFINITIONS OF PEDESTRIAN CRASH TYPES

Provided below are the definitions of the 12 crash types included in the PEDSAFE application. These definitions are from the PBCAT software.[5] For any crash type, there are multiple problems or possible causes that may have led to the crash. The following section also provides examples of a few possible causes/problems for each crash type and some of the countermeasures within PEDSAFE that may be applicable. At the end of each potential solution is the countermeasure number in parentheses, which can be used to quickly locate the countermeasure description in Chapter 5. Neither the list of problems and possible causes nor the suggested countermeasures are to be considered comprehensive. Practitioners will still be required to supplement the analysis and recommendations with their own investigations and knowledge of local policies and practices.

1. DART/DASH

The pedestrian walked or ran into the roadway at an intersection or midblock location and was struck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before the impact.

Possible Cause/Problem #1
Child runs into neighborhood/collector street.



General Countermeasures

a. Provide adequate nighttime lighting (5).
b. Add on-street bike lanes (8).
c. Narrow travel lanes (9).
d. Provide curb extensions (19).
e. Install spot street narrowing at high midblock-crossing locations (20).

f. Implement traffic-calming measures such as chicanes, speed humps, or speed tables (22, 24, 25).

g. Provide a raised pedestrian crossing (27).

h. Design gateway to alert motorists that they are entering neighborhood with high level of pedestrian activity (28).

i. Convert street to driveway link/serpentine, woonerf, or a pedestrian street (31, 32, 36).

j. Install street diverters or full/partial street closures at selected intersection(s) (33, 34, 35).

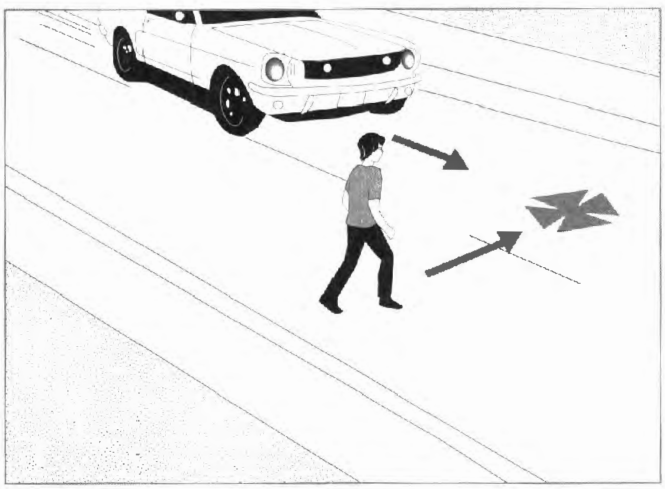
k. Provide adult crossing guard (in school zone) (44).

l. Remove or restrict on-street parking (47).

m. Educate children about safe crossing behavior and adults about speeding (48).

Possible Cause/Problem #2

Pedestrian is struck while crossing a high-speed and/or high-volume arterial street.



General Countermeasures

a. Relocate bus stop (4).

b. Improve/add nighttime lighting (5).

c. Install overpass or underpass (6).

d. Install medians or pedestrian crossing islands (18, 21).

e. Provide curb extensions at intersections or midblock to improve direct line of sight between vehicle and pedestrian (19).

f. Add traffic-calming measures (19-32).

g. Provide staggered crosswalk through the median (forcing pedestrians to walk and look to the right for oncoming traffic in the second half of street) (21).

h. Install midblock traffic signal with pedestrian signals, if warranted (37, 38).

i. Install standard warning sign (see Manual on Uniform Traffic Control Devices (MUTCD)) or yellow or fluorescent yellow/green signs to alert drivers to pedestrian crossing area (40, 43).

j. Bus young children across busy streets (44).

k. Adjust school district boundaries (44).

l. Use speed-monitoring trailer (46).

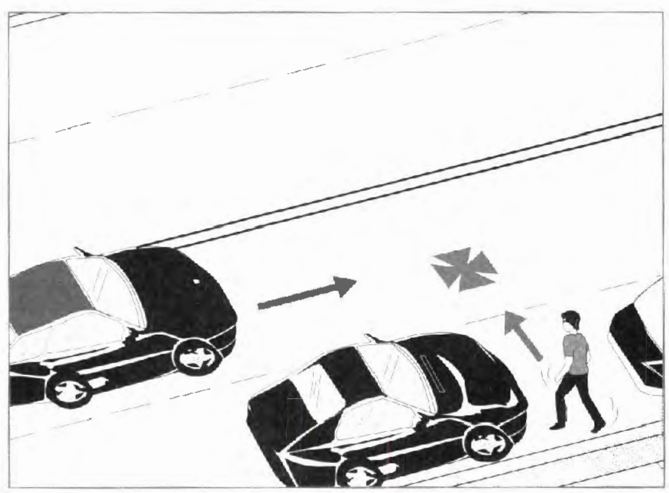
m. Enforce speed limits, pedestrian ordinances (49).

2. MULTIPLE THREAT/TRAPPED

The pedestrian entered the roadway in front of stopped or slowed traffic and was struck by a multiple-threat vehicle in an adjacent lane after becoming trapped in the middle of the roadway.

Possible Cause/Problem #1 (multiple threat)

The pedestrian entered the traffic lane in front of stopped traffic and was struck by a vehicle traveling in the same direction as the stopped vehicle. The stopped vehicle may have blocked the visibility between the pedestrian and the striking vehicle, and/or the motorist may have been speeding.



General Countermeasures

a. Relocate bus stop to far side of crossing area (4).

b. Improve roadway lighting (5).

c. Provide midblock or intersection curb extensions (19).

d. Install traffic-calming devices such as speed tables or raised pedestrian crossings on local or other neighborhood streets (25, 27).

e. Provide raised crosswalks to improve pedestrian visibility (27).

f. Install traffic signals if warranted, including pedestrian signals (37, 38).

g. Install flashers or advance warning signs (37, 43).

h. Recess stop lines 9.1 m (30 ft) in advance of crosswalk (42).

i. Install barriers or signs to prohibit crossings and direct pedestrians to safer crossing locations nearby (43).

j. Enforce crosswalk laws (49).

Possible Cause/Problem #2

Pedestrian is struck while crossing a high-speed and/or high-volume arterial street.

General Countermeasures

a. Reduce roadway width. For example, add sidewalks and bike lanes to a roadway by narrowing four-lane undivided roadways to two through lanes plus a center two-way left-turn lane or wide raised median (1, 8, 9, 10).

b. Improve roadway lighting (5).

c. Construct overpass or underpass (6).

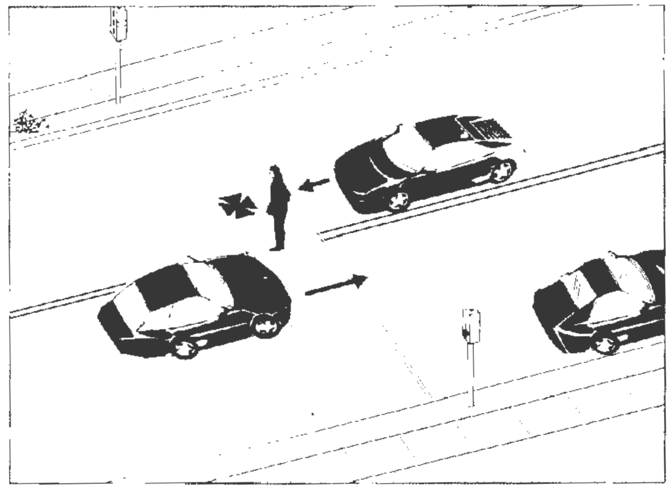
d. Narrow travel lanes (e.g., add bike lanes) to slow vehicle speeds and reduce crossing distance (9).

e. Install raised median or pedestrian crossing island (12, 21).

f. Increase police enforcement of speed limit (49).

Possible Cause/Problem #3 (trapped)

Pedestrian began crossing on green signal and became trapped in the roadway when the signal changed.



General Countermeasures

a. Reduce roadway width (9).

b. Provide midblock or intersection curb extensions (19).

c. Install raised pedestrian crossing island (21).

d. Provide raised crosswalk to improve pedestrian visibility (27).

e. Install pedestrian signals (38).

f. Adjust pedestrian signal timing (39).

g. Enforce crosswalk laws (49).

3. UNIQUE MIDBLOCK (MAILBOX, ICE-CREAM VENDOR, PARKED VEHICLE)

The pedestrian was struck while crossing the road to/from a mailbox, newspaper box, or ice-cream truck, or while getting into or out of a stopped vehicle.

Possible Cause/Problem #1

Pedestrian struck while going to/from a private residence mailbox/newspaper box.

General Countermeasures

a. Improve lighting (5).

b. Add bike lanes and reduce total roadway and lane width (8, 9, 10).

c. Provide raised median on multi-lane arterial street (12).

d. Provide traffic-calming measures (e.g., chicanes or raised devices on residential streets) (22, 26, 27).

e. Construct gateway or provide signs that identify neighborhood as an area with high levels of pedestrian activity (28, 45).

f. Install pedestrian warning signs (see MUTCD) (43).

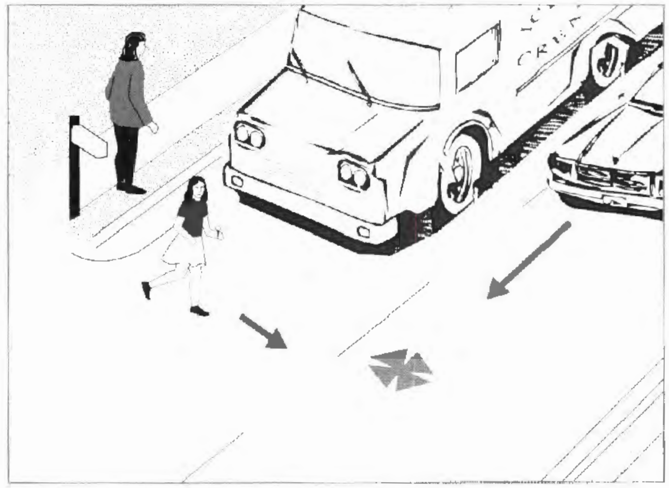
g. Implement driver education program (48).

h. Implement pedestrian education program (48).

i. Relocate mailboxes to safer crossing area or provide safer crossings at existing location.

Possible Cause/Problem #2

Pedestrian struck while going to/from an ice-cream vendor or similar destination.



General Countermeasures

a. Reduce roadway width or remove a lane (9, 10).

b. Provide traffic-calming measures on local streets (19-32).

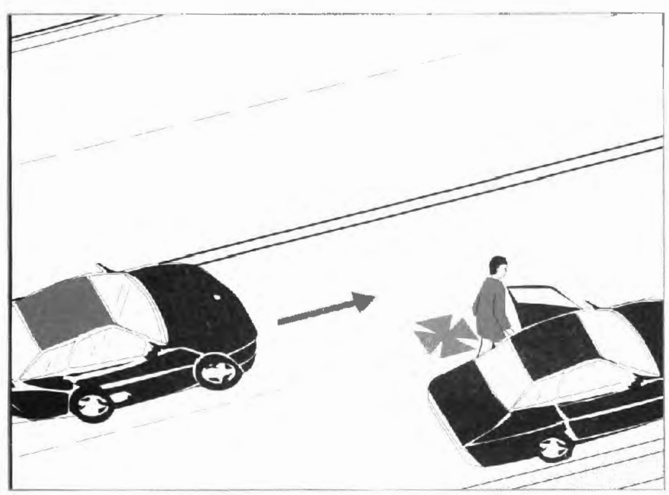
c. Add pedestrian crossing islands to roadway (21).

d. Create Public Service Announcements (PSAs) to educate parents, children, and drivers (48).

e. Adopt an Ice-Cream Truck Ordinance. This ordinance would prohibit motorists from passing a stopped ice-cream truck. Trucks would be equipped with flashing lights and a "stop" arm that would extend when the truck stopped to serve children (49).

Possible Cause/Problem #3

Pedestrian struck while getting into/out of parked vehicle.



General Countermeasures

a. Improve roadway lighting (5).

b. Implement traffic-calming measures on local/collector streets (19-32).

c. Implement speed-reduction measures such as chicanes or speed tables (22, 26).

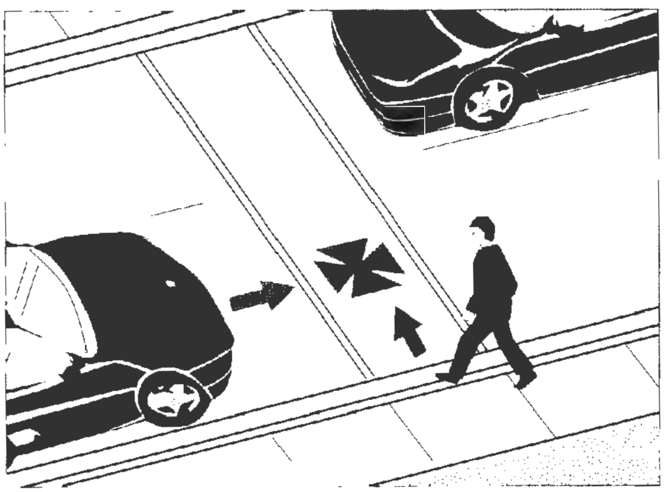
d. Restrict on-street parking (47).

4. THROUGH VEHICLE AT UNSIGNALIZED LOCATION

The pedestrian was struck at an unsignalized intersection or midblock location. Either the motorist or the pedestrian may have failed to yield.

Possible Cause/Problem #1

Motorist fails to yield to pedestrian at two-lane, low-speed road crosswalk (or unmarked crossing).



General Countermeasures

a. Improve crosswalk marking visibility (3).

b. Improve roadway lighting (5).

c. Reduce curb radius to slow vehicle speeds (14).

d. Install curb extensions or choker (19, 20).

e. Use special paving treatments along street to slow traffic, add chicanes, or use serpentine design (20, 22, 31).

f. Construct raised pedestrian crossing island (21).

g. Install speed humps, speed tables, raised intersections, or raised crosswalks (24, 25, 26, 27).

h. Use landscaping that slows vehicle speeds without impeding sightlines (29).

i. Install traffic signal with pedestrian signals, if warranted (37, 38).

j. Install overhead CROSSWALK, school zone, or other warning signs (43).

Possible Cause/Problem #2

Pedestrian has difficulty crossing multilane road (which may also have high travel speeds and/or high traffic volumes).

General Countermeasures

a. Ensure that curb ramps are provided to make crossing easier for all pedestrians (2).

b. Place bus stop at far side of intersection (4).

c. Install nighttime lighting (5).

d. Construct overpass or underpass (6).

e. Install bike lanes and/or narrow or reduce the number of roadway lanes (8, 9, 10).

f. Add bike lanes or modify four-lane, undivided street to two lanes plus a two-way, left-turn lane (TWLTL) or wide median with turning pockets (8, 10).

g. Install raised medians or pedestrian crossing islands (12, 21).

h. Install traffic signal with pedestrian signals, if warranted (37, 38).

i. Use police speed enforcement (49).

Possible Cause/Problem #3

Motorist unwilling to yield due to high motorist speeds or high traffic volumes.

General Countermeasures

a. Install bike lanes and/or narrow or reduce the number of roadway lanes (8, 9, 10).

b. Construct pedestrian crossing island or medians (12, 21).

c. Implement traffic-calming measures (19-32).

d. Provide gateway, create a pedestrian street, or identify neighborhood with signs (28, 36, 45).

e. Install traffic signal with pedestrian signals, if necessary (37, 38).

f. Install signs or sidewalk barriers to guide pedestrians to safer crossing locations (43).

g. Use speed-monitoring trailer (46).

h. Increase police enforcement of speed limit (49).

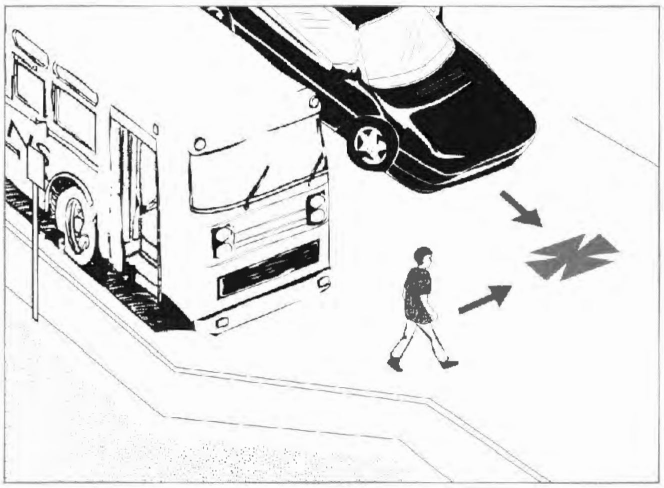
i. Install special overhead pedestrian-actuated flashers with warning signs.

5. BUS-RELATED

The pedestrian was struck by a vehicle while: (1) crossing in front of a commercial bus stopped at a bus stop; (2) going to or from a school bus stop; or (3) going to or from, or waiting near a commercial bus stop.

Possible Cause/Problem #1

Motorist fails to yield to pedestrian or pedestrian crosses during inadequate gap in traffic due to limited sight distance at intersection.



General Countermeasures

a. Install crosswalk markings to encourage pedestrians to cross in the crosswalk behind the bus (3).

b. Move bus stop to far side of intersection or crosswalk (4).

c. Consider an alternative bus stop location (4).

d. Mark bus stop area with pedestrian warning signs (4).

e. Install or improve roadway lighting (5).

f. Install pedestrian crossing medians or raised crosswalk (12, 21, 27).

g. Install curb extension (19).

h. Remove parking in areas that obstruct the vision of motorists and pedestrians (47).

Possible Cause/Problem #2

Pedestrian has difficulty walking along roadway and crossing at midblock location with high vehicle speeds and/or high volumes.

General Countermeasures

a. Provide an accessible sidewalk and curb ramps (1, 2).

b. Install sidewalk and/or sidewalk barriers to direct pedestrians to a nearby crossing location (2).

c. Provide bus pull-off area (4).

d. Consider an alternative bus stop location (4).

e. Install or improve roadway lighting (5).

f. Add bike lanes or painted shoulder (8).

g. Reduce number of roadway lanes (10).

h. Install midblock curb extensions (19).

i. Install traffic and pedestrian signals, if warranted (37, 38).

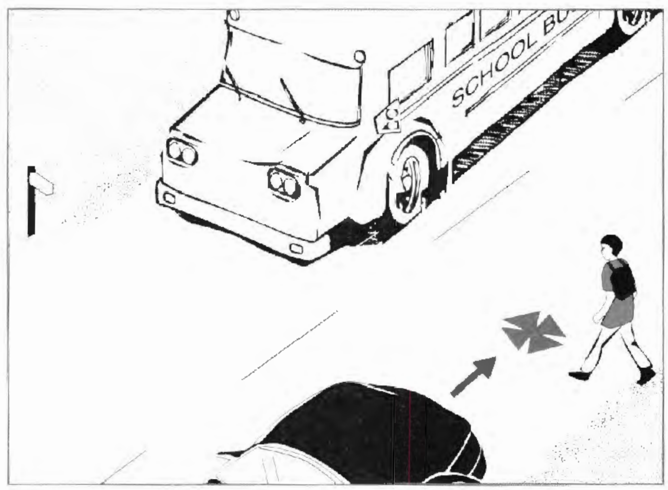
j. Add recessed stop lines (42).

k. Provide pedestrian education/training (48).

l. Increase police speed enforcement (49).

Possible Cause/Problem #3

Pedestrian has difficult time crossing, waiting, or walking in the vicinity of school bus stop.



General Countermeasures

a. Provide sidewalks (1).

b. Install or improve roadway lighting (5).

c. Provide street furniture or other amenities at bus stop (7).

d. Select safer location for school bus stop (44).

e. Implement pedestrian/driver education programs (48).

f. Educate pedestrians to cross behind the bus at far side of bus stops (48).

g. Involve school, neighborhood groups, and PTA in promoting education and enforcement (48, 49).

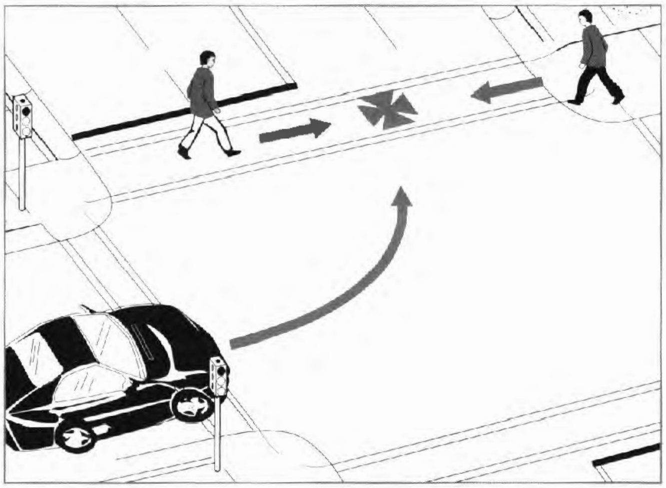
h. Enforce regulations against passing stopped school bus (49).

6. TURNING VEHICLE

The pedestrian was attempting to cross at an intersection, driveway, or alley and was struck by a vehicle that was turning right or left.

Possible Cause/Problem #1

Conflict between pedestrian and left-turning vehicle.



General Countermeasures

a. Add curb ramps or curb extensions (2, 19).

b. Install raised median and pedestrian crossing island (12, 21).

c. Convert to one-way street network (if justified by surrounding areawide pedestrian and traffic volume study) (13).

d. Consider using modified T-intersections, intersection median barriers, diverters, or street closures (17, 18, 33, 34).

e. Use traffic-calming devices, such as a raised intersection or raised pedestrian crossing, to reduce vehicle speeds (26, 27).

f. Provide separate left-turn and WALK/DON'T WALK signals (38).

g. Add special pedestrian signal phasing (e.g., exclusive protected pedestrian signal or leading pedestrian interval) (38).

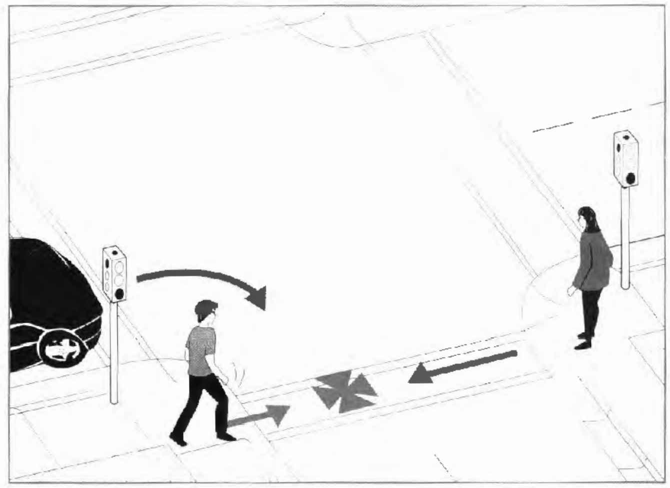
h. Prohibit left turns (43).

i. Install warning signs for pedestrians and/or motorists (see MUTCD) (43).

j. Develop/provide Public Safety Announcement (PSA) safety messages (48).

Possible Cause/Problem #2

Conflict between pedestrian and right-turning vehicle.



General Countermeasures

a. Provide marked crosswalks and advanced stop lines (3, 42).

b. Improve intersection lighting to improve visibility (5).

c. Remove intersection snow/clutter at the corner to improve visibility and give pedestrian space to stand outside of roadway (7).

d. Install raised median and pedestrian crossing island (12, 21).

e. Reduce right-turn radii (14).

f. Add curb extensions (19)

g. Use a traffic-calming device, such as a raised intersection or raised pedestrian crossing, to reduce vehicle speeds (26, 27).

h. Consider street closure (35).

i. Provide leading pedestrian interval (39).

j. Prohibit Right Turn on Red (RTOR) (41).

k. Install warning signs for pedestrians and/or motorists (43).

l. Remove on-street parking from the approaches to crosswalks (47).

Possible Cause/Problem #3

Substantial number of school children crossing and large turning vehicle movement.

General Countermeasures

a. Install crosswalk markings (3).

b. Improve intersection lighting (5).

c. Consider using modified T-intersections, intersection median barriers, diverters, or street closures (17, 18, 33, 34).

d. Install curb extensions (19).

e. Install pedestrian crossing islands for wide two-way streets (21).

f. Add exclusive pedestrian phase or leading pedestrian interval (39).

g. Restrict Right Turn on Red (41).

h. Prohibit left turns (43).

i. Provide adult crossing guards during school crossing periods, or two guards for wide streets (44).

j. Educate motorists (48).

k. Educate children about safe crossing behavior (48).

l. Provide police enforcement at the intersection (49).

Possible Cause/Problem #4

Inadequate sight distance and/or intersection geometrics.

General Countermeasures

a. Add marking treatments that improve visibility of pedestrian crossing areas (3).

b. Improve intersection lighting (5).

c. Reduce turn radii (14).

d. Install pedestrian safety islands (21).

e. Remove sight obstructions and/or roadside obstacles (e.g., trees/shrubs, mailboxes, poles, newsstands, trash cans) (29).

f. Install motorist regulatory signs and/or pedestrian warning signs (see MUTCD) (37, 38).

g. Provide special pedestrian signal phasing (e.g., exclusive protected pedestrian signal interval) (39).

h. Prohibit Right Turn on Red (RTOR) (41).

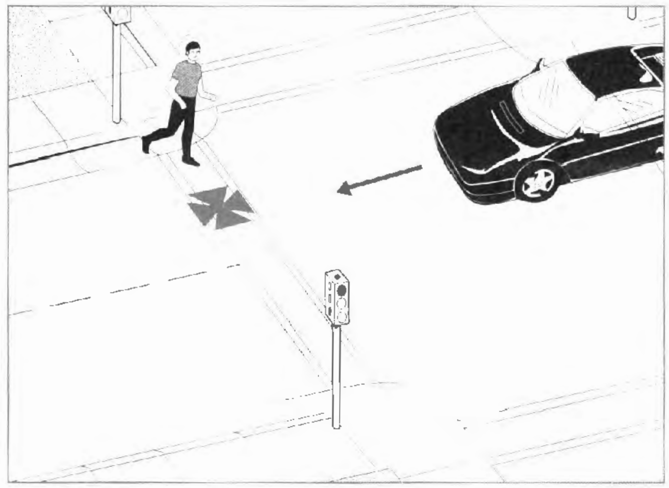
i. Prohibit left turns (43).

7. THROUGH VEHICLE AT SIGNALIZED LOCATION

The pedestrian was struck at a signalized intersection or midblock location by a vehicle that was traveling straight ahead.

Possible Cause/Problem #1

Pedestrian could not see traffic signal.



General Countermeasures

a. Install new or larger pedestrian WALK/DON'T WALK and/or audible pedestrian signals (38).

Possible Cause/Problem #2

Children crossing in school zones.

General Countermeasures

a. Provide pavement markings and school zone signs (3, 44).

b. Convert to one-way street network (if justified by surrounding areawide pedestrian and traffic volume study) (13).

c. Consider using intersection median barriers, diverters, or street closures (18, 33, 34).

d. Provide curb extensions to reduce crossing distance (19).

e. Use traffic-calming devices such as mini-circle or raised intersection to reduce vehicle speeds (23, 26).

f. Provide a raised pedestrian crossing (27).

g. Provide advanced stop lines (42).

h. Install pedestrian signals (43).

i. Provide adult crossing guards, or two guards for wide streets (44).

j. Install school regulatory flashers (e.g., SPEED LIMIT 25 MPH WHEN FLASHING) (44).

k. Provide pedestrian education to students and motorists (48).

l. Increase police enforcement (49).

Possible Cause/Problem #3

Excessive delay to pedestrians prior to getting the WALK interval.

General Countermeasures

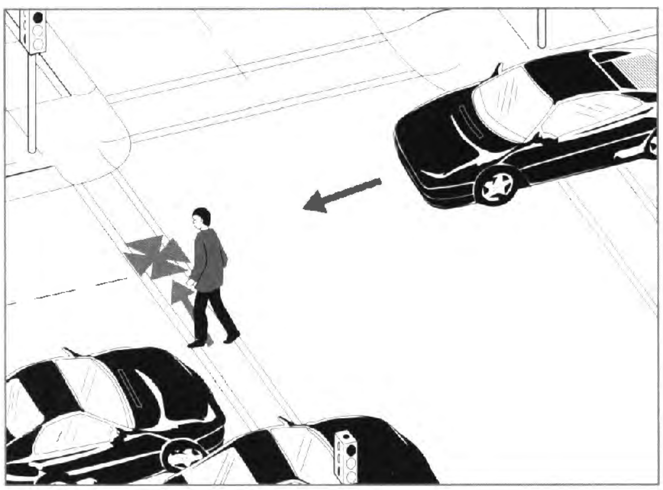
a. Provide pedestrian crossing islands (21).

b. Re-time signal to be more responsive to pedestrian needs (e.g., shorter cycle lengths or convert to fixed-time operation) (39).

c. Provide quick-response pedestrian push-buttons or automatic (e.g., microwave or infrared) detectors (40).

Possible Cause/Problem #4

Lack of pedestrian compliance with WALK phase due to other causes.



General Countermeasures

a. Re-time signal to be more responsive to pedestrian needs (e.g., shorter cycle length) (39).

b. Provide adequate WALK and clearance intervals (39).

c. Provide leading pedestrian interval (39).

d. Provide adult crossing guard at school crossings (44).

e. Provide pedestrian and motorist education (48).

Possible Cause/Problem #5

Motorist did not see pedestrian in time to stop.

General Countermeasures

a. Add marking treatments that improve visibility of pedestrian crossing areas (3, 30).

b. Move bus stop to far side of intersection (4).

c. Improve nighttime lighting (5).

d. Add curb extensions (19).

e. Add pedestrian crossing islands or raised crosswalk (21, 27).

f. Use traffic-calming devices, such as speed tables or a speed-monitoring trailer, on streets approaching the intersection if speed is an issue (25, 46).

g. Construct raised intersection (26).

h. Remove sight obstructions such as mailboxes or parked vehicles (29, 47).

i. Remove on-street parking near intersection (e.g., up to 30.5 m [100 ft]) (47).

Possible Cause/Problem #6

Motorist ran red light at signalized intersection.

General Countermeasures

a. Improve lighting (5).

b. Add short all-red interval at signal (39).

c. Increase police enforcement (49).

d. Install camera enforcement (49).

8. WALKING ALONG ROADWAY

The pedestrian was walking or running along the roadway and was struck from the front or from behind by a vehicle.

Possible Cause/Problem #1

Inadequate walking area.

General Countermeasures

a. Provide a sidewalk on both sides of road (1).

b. Provide an asphalt path or paved shoulder (1).

c. Construct and maintain sidewalks and curb ramps to be usable by people with disabilities (1, 2).

d. Add sidewalk, install bicycle lanes or painted shoulders, reduce number of lanes (e.g., four lanes to three lanes), and add planting strips (1, 8, 10, 29).

Possible Cause/Problem #2

High vehicle speeds and/or volume.

General Countermeasures

a. Add sidewalk or walkway (1).

b. Construct and maintain sidewalks and curb ramps to be usable by people with disabilities (1, 2).

c. Increase lateral separation between pedestrians and motor vehicles (e.g., bike lanes or landscape buffers) (1, 8, 29).

d. Provide lighting (5).

e. Construct gateway or install signs to identify neighborhood as area with high pedestrian activity (28, 45).

f. Install "Walk on Left Facing Traffic" signs (43).

g. Use speed-monitoring trailers (46).

h. Increase police enforcement of speed limit (49).

Possible Cause/Problem #3

Inadequate route to school.

General Countermeasures

a. Provide sidewalks on both sides of road (1).

b. Construct and maintain sidewalks and curb ramps to be usable by people with disabilities (1, 2).

c. Implement traffic-calming methods at selected sites (19-32).

d. Provide adult crossing guards (44).

e. Involve school groups and PTA in evaluating safe routes to school and promoting education and enforcement (48, 49).

Possible Cause/Problem #4

Sidewalks are not accessible to all pedestrians.

General Countermeasures

a. Repair and maintain sidewalks (1).

b. Remove obstacles in sidewalk (1).

c. Build missing sidewalk segments (1).

d. Construct curb ramps (2).

e. Relocate poles and street furniture to provide continuous passage in sidewalk area (7).

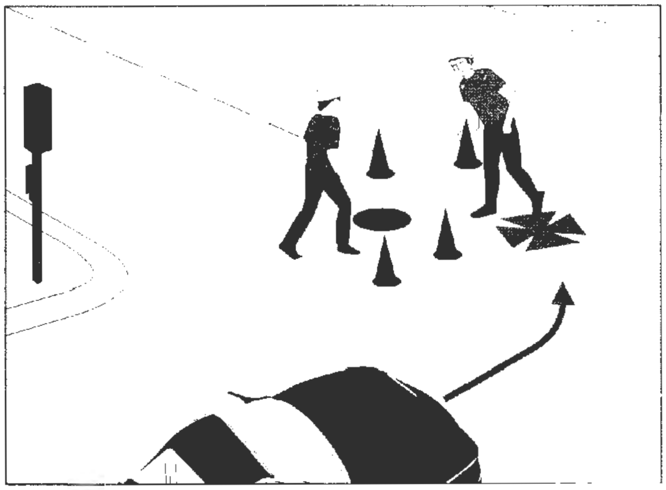
f. Enforce parking laws to prevent cars from blocking sidewalks and curb ramps (49).

9. WORKING/PLAYING IN ROAD

A vehicle struck a pedestrian who was: (1) standing or walking near a disabled vehicle, (2) riding a play vehicle that was not a bicycle (e.g., wagon, sled, tricycle, skates), (3) playing in the road, or (4) working in the road.

Possible Cause/Problem #1

Worker, policeman, etc. struck in roadway (arterial street).



General Countermeasures

a. Improve lighting and retroreflective materials on workers (5).

b. Improve traffic control measures (e.g., signs, markings, cones, barricades, and flashers) warning motorists of workers' presence (43).

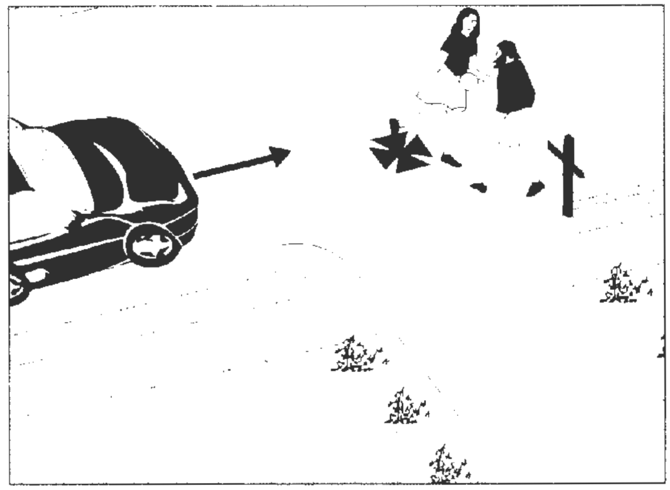
c. Increase worker safety training (48).

d. Increase police enforcement of speed limits in work zones (49).

e. Provide better physical separation/protection from motor vehicles.

Possible Cause/Problem #2

Pedestrian was struck playing on foot or on play vehicle (e.g., skateboard, wagon, sled, in-line skates) on local/collector street.



General Countermeasures

a. Provide accessible sidewalks or walkways on both sides of street (1, 2).

b. Improve lighting (5).

c. Introduce traffic-calming measures (e.g., street narrowing, speed humps) (9, 24).

d. Convert streets to a woonerf or use signs to identify neighborhood as area with high levels of pedestrian activity (32, 45).

e. Consider street closures (full or partial) or using diverters (34, 35).

f. Implement pedestrian and motorist education programs (48).

g. Provide community park/playground.

Possible Cause/Problem #3

Vehicle speeds are excessive on local street.

General Countermeasures

a. Narrow streets and/or travel lanes (9).

b. Convert to driveway link/serpentine street (11, 31).

c. Install traffic-calming devices such as chicanes, mini-circles, speed humps, and/or speed tables (22, 23, 24, 25).

d. Use speed-monitoring trailers in conjunction with police enforcement (46, 49).

Possible Cause/Problem #4

Walking to/from disabled vehicle.

General Countermeasures

a. Provide sidewalks, walkways, or paved shoulders (1).

b. Provide adequate nighttime lighting (5).

c. Educate drivers about what to do if a vehicle becomes disabled (48).

d. Provide motorist assistance program.

Possible Cause/Problem #5

Working on or standing by a disabled vehicle.

General Countermeasures

a. Provide paved shoulders (1).

b. Provide adequate nighttime lighting (5).

c. Educate drivers about what to do if a vehicle becomes disabled (48).

d. Provide a motorist assistance program.

10. NON-ROADWAY (SIDEWALK, DRIVEWAY, PARKING LOT, OR OTHER)

The pedestrian was standing or walking near the roadway edge, on the sidewalk, in a driveway or alley, or in a parking lot, when struck by a vehicle.

Possible Cause/Problem #1

Pedestrian was struck while waiting to cross roadway, standing at or near curb.

General Countermeasures

a. Provide accessible sidewalks/walkways and crosswalks (1, 3).

b. Provide sidewalk buffer (bike lane or landscape strip) (1, 8, 29).

c. Improve nighttime lighting (5).

d. Reduce curb radii to slow turning cars (14).

e. Install sidewalk barriers (29).

f. Use adult crossing guard (44).

g. Implement driver education program (48).

h. Increase speed enforcement (49).

Possible Cause/Problem #2

Pedestrian was struck in parking lot, driveway, private road, gas station, alley, etc.

General Countermeasures

a. Maintain level sidewalk across driveway area (1).

b. Move sidewalk farther back so that driver will have more time to stop for a pedestrian crossing a driveway (1).

c. Improve nighttime lighting (5).

d. Remove landscaping or other visual obstructions near driveways (29).

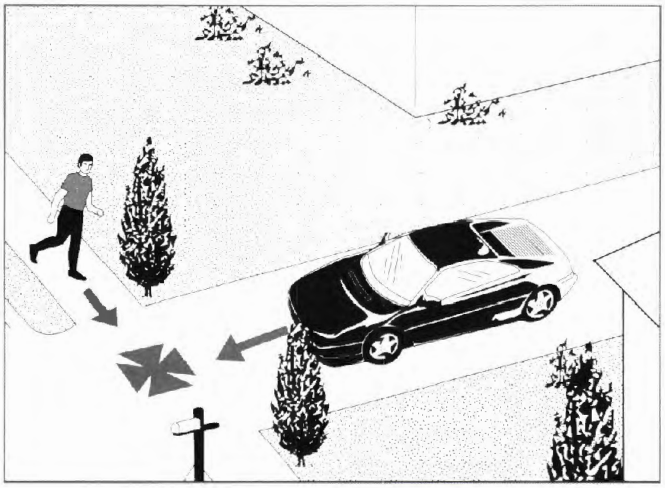
e. Implement pedestrian and motorist education programs (48)

f. Redesign or re-stripe parking lot to provide clear pedestrian path across parking lot.

g. Build/improve local parks for child activities.

Possible Cause/Problem #3

Vehicle entered or exited a driveway or alley and struck pedestrian.



General Countermeasures

a. Provide sidewalk or walkway (1).

b. Maintain level sidewalks across driveways or alleys (11).

c. Provide clear walking path across driveway (11).

d. Remove unneeded driveways and alleys (11).

e. Remove sight obstructions (e.g., trim hedges or lower fencing) (11, 29).

f. Narrow driveways and reduce turning radii (14).

g. Add adequate planting strip or sidewalk separation (29).

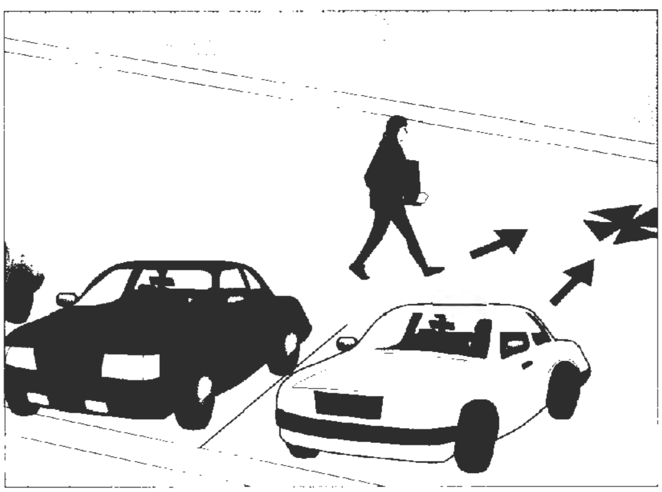
h. Provide advance warning signs for drivers (43).

11. BACKING VEHICLE

The pedestrian was struck by a backing vehicle on a street, in a driveway, on a sidewalk, in a parking lot, or at another location.

Possible Cause/Problem #1

Pedestrian struck by backing vehicle.



General Countermeasures

a. Provide clearly delineated walkways for pedestrians in parking lots (1).

b. Relocate pedestrian walkways (1).

c. Improve nighttime lighting (5).

d. Remove unneeded driveways and alleys (11).

e. Remove landscaping or other sight obstruction near driveways (11, 29).

f. Provide curb extensions or raised pedestrian crossings to improve the visibility of pedestrians to backing motorists (19, 27).

g. Eliminate, modify, or relocate parking if feasible (47).

h. Enhance pedestrian education (48).

i. Enhance motorist education (48).

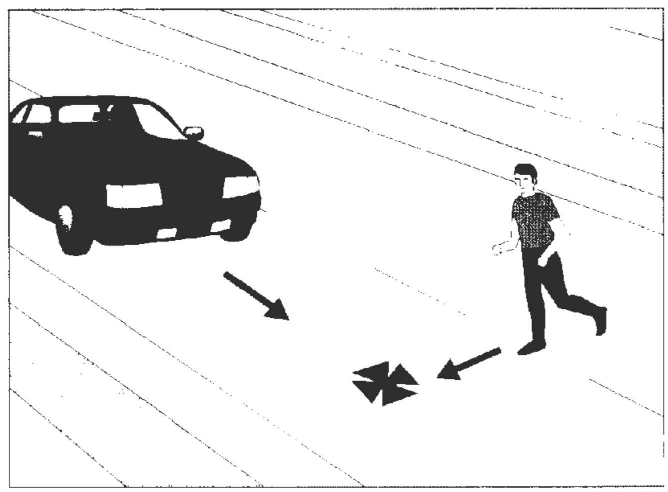
j. Provide auditory backing alert on vehicle.

12. CROSSING EXPRESSWAY

The pedestrian was struck while crossing a limited-access expressway or expressway ramp.

Possible Cause/Problem #1

Disabled vehicle (pedestrian crosses expressway to seek help).



General Countermeasures

a. Install/upgrade roadway lighting (5).

b. Educate drivers on what to do if a vehicle is disabled (48).

c. Increase police surveillance (49).

d. Provide motorist assistance program.

Possible Cause/Problem #2

Pedestrians routinely cross section of expressway.

General Countermeasures

a. Install/upgrade nighttime lighting (5).

b. Provide pedestrian overpass/underpass (6).

c. Install large, visible pedestrian warning signs (43).

d. Increase police surveillance (49).

e. Install pedestrian fencing or barriers along roadway right-of-way.

MISCELLANEOUS

Finally, there are a number of other pedestrian crash types, such as:

- intentional crashes
- driverless vehicle incidents
- pedestrian struck after a vehicle/vehicle collision
- pedestrian struck by falling cargo
- emergency vehicle striking a pedestrian
- pedestrian standing or lying in the road

Possible Cause/Problem #1

Pedestrian lying in road.

General Countermeasures

a. Install or upgrade nighttime lighting (5).

b. Increase police enforcement and surveillance (49).

c. Provide taxi rides home from bars.

Possible Cause/Problem #2

Emergency vehicle-related.

General Countermeasures

a. Install/upgrade lighting (5).

b. Provide public education (48).

c. Increase police surveillance (49).

Possible Cause/Problem #3

Pedestrian falls from vehicle.

General Countermeasures

a. Pass/enforce laws and provide education programs against riding in back of pickup trucks (48, 49).

b. Increase police enforcement of teens "vehicle surfing" (49).

CRASH-RELATED COUNTER-MEASURES

A total of 49 different pedestrian countermeasures are presented in Chapter 5 of this guide. To assist engineers and planners who may want further guidance on which measures are appropriate to address certain types of pedestrian crashes, a matrix is provided on pages 28-31. The applicable treatments within the seven categories of countermeasures are shown for each of the 12 crash type groups.

To illustrate how to use the table, consider the second crash type group in the table ("Multiple Threat/Trapped"). This is a crash involving an unsignalized crossing on a multilane road, where one vehicle stops to let a pedestrian cross the street. The pedestrian steps into the street in front of the stopped vehicle and then continues into the adjacent lane in front of an oncoming vehicle and is struck. The driver of the second vehicle may not see the pedestrian, since the sight distance is typically blocked by the first (stopped) vehicle.

The chart shows that there are 20 potential countermeasures that may reduce the probability of this type of crash, depending on the site conditions. These countermeasures include curb extensions (which improve sight distance between pedestrians and motorists), pedestrian crossing islands (which provide places of refuge in the middle of the street), crosswalk enhancements, and other possible countermeasures.

In Chapter 5, details are provided on each of the countermeasures listed. The quick reference index at the start of Chapter 5 can be used to easily locate the page containing the detailed description. The Web/CD application allows the list of countermeasures to be refined on the basis of site characteristics (see Chapter 4).

These charts are intended to give general information on candidate solutions that should be considered when trying to reduce a pattern of pedestrian crashes at a location or roadway section. Many pedestrian crashes are the direct result of careless or illegal driver behavior and/or unsafe pedestrian behavior. Many of these crashes cannot necessarily be prevented by roadway improvements alone. In such cases, pedestrian and/or motorist education and enforcement activities may be helpful.

PERFORMANCE OBJECTIVES

Pedestrians face a variety of challenges when they walk along and across streets with motor vehicles. Communities are asking for help to "slow traffic down," "make it safer to cross the street," and "make the street more inviting to pedestrians."

The following is a list of requests (objectives) that transportation professionals are likely to face when working to provide pedestrian safety and mobility:

- Reduce speed of motor vehicles.
- Improve sight distance and visibility for motor vehicles and pedestrians.
- Reduce volume of motor vehicles.
- Reduce exposure time for pedestrians.
- Improve access and mobility for all pedestrians, especially those with disabilities.
- Encourage walking by improving aesthetics, safety, and security.
- Improve compliance with traffic laws (motorists and pedestrians).
- Eliminate behaviors that lead to crashes (motorists and pedestrians).

Each of these objectives can be accomplished through a variety of the individual treatments presented in this chapter. Yet, most treatments will work best when used at multiple locations and in combination with other treatments.

In addition, many of the treatments will accomplish two or more objectives. The key is to make sure that the right treatments are chosen to accomplish the desired effect.

The matrix located on pages 32-33 shows which countermeasures are appropriate to consider for the eight performance objectives. In using the chart, it is important to remember that it is simply a guide. In all cases, good engineering judgment should be applied when making decisions about what treatment will be best for a specific location.

PROGRAM OF IMPROVEMENTS

Some pedestrian crashes are associated with deficient roadway designs. Pedestrians and motorists often contribute to pedestrian crashes through a disregard or lack of understanding of laws and safe driving or walking behavior. Because most crashes are a result of human error, crashes will not be completely eliminated as long as pedestrians and vehicles share the same space. Yet, the consequences of these crashes are exacerbated by speeding, failing to yield, or failing to check both directions for traffic, so new education, enforcement, and engineering tools are needed to manage the conflict between pedestrians and drivers.

A complete program of pedestrian safety improvements includes:[27]

- Provision of pedestrian facilities, such as sidewalks and crosswalks.
- Roadway and engineering measures, such as traffic control devices, lighting, and roadway design strategies implemented on streets and highways for both pedestrian and vehicular movements.
- Programs to enforce existing traffic laws and ordinances for motorists (e.g., obeying speed limits, yielding to pedestrians when turning, traffic signal compliance, obeying drunk-driving laws) and pedestrians (e.g., crossing the street at legal crossings, obeying traffic and pedestrian signals).
- Wearing of reflective clothing and materials by pedestrians, and/or using a flashlight when walking at night.
- Education programs provided to motorists and pedestrians.

Roadway improvements can often reduce the likelihood of a pedestrian crash. Physical improvements are most effective when tailored to an individual location and traffic problem. Factors to consider when choosing an improvement include: location characteristics, pedestrian and vehicle volume and types, vehicle speed, design of a given location, city laws and ordinances, and financial constraints. Many of these factors are included for consideration in the PEDSAFE Selection Tool (see Chapter 4).

It is important to remember that overuse or unjustified use of any traffic control measure is not recommended, since this may breed disrespect for such devices. Although facilities for pedestrians can, in many cases, reduce the risk of pedestrian collisions, crash reduction is not the only reason for providing such facilities. Other benefits of pedestrian facilities include improved access to destinations by walking, better air quality due to less dependence on driving, and improved personal health. Traffic and transportation engineers have the responsibility for providing facilities for all modes of travel, including walking.

COUNTERMEASURES ASSOCIATED WITH

CRASH TYPE GROUP	A. Pedestrian Facility Design	B. Roadway Design	C. Intersection Design
1. Dart/Dash	• Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass • Steet Furniture	• Bike Lane/Shoulder • Road/Lane Narrowing • Raised Median	
2. Multiple Threat / Trapped	• Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Bike Lane/Shoulder • Road/Lane Narrowing • Fewer Lanes • Raised Median	• Intersection Median Barrier
3. Unique Midblock (mailbox, ice cream vendor, parked vehicles)	• Roadway Lighting	• Bike Lane/Shoulder • Road/Lane Narrowing • Raised Median	
4. Through Vehicle at Unsignalized Location	• Curb Ramp • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Bike Lane/Shoulder • Road/Lane Narrowing • Fewer Lanes • Raised Median • Smaller Curb Radius	• Intersection Median Barrier
5. Bus-Related	• Sidewalk/Walkway • Curb Ramps • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Street Furniture	• Bike Lane/Shoulder • Fewer Lanes	
6. Turning Vehicle	• Curb Ramp • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Raised Median • One-way Street • Smaller Curb Radius • Right-Turn Slip Lane	• Modern Roundabout • Modified T-Intersection • Intersection Median Barrier

SPECIFIC CRASH TYPE GROUPS

D. Traffic Calming	E. Traffic Management	F. Signals and Signs	G. Other Measures
• Curb Extension • Choker • Pedestrian Crossing Island • Chicane • Speed Humps • Speed Table • Raised Pedestrian Crossing • Gateway • Driveway Link/Serpentine • Woonerf	• Diverter • Full Street Closure • Partial Street Closure • Pedestrian Street	• Traffic Signal • Pedestrian Signal • Signal Enhancement • Sign Improvement	• School Zone Improvement • Identify Neighborhood • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Pedestrian Crossing Island • Speed Table • Raised Pedestrian Crossing		• Traffic Signals • Pedestrian Signal • Advanced Stop Lines • Sign Improvement	• School Zone Improvement • Ped./Driver Education • Police Enforcement
• Chicane • Speed Humps • Speed Table • Gateway		• Sign Improvement	• Identify Neighborhood • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Choker • Pedestrian Crossing Island • Chicane • Speed Humps • Speed Table • Raised Intersection • Raised Pedestrian Crossing • Gateway • Landscape Options • Paving Treatments • Driveway Link/Serpentine	• Pedestrian Street	• Traffic Signals • Pedestrian Signal • Sign Improvement	• School Zone Improvement • Identify Neighborhood • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Pedestrian Crossing Island • Raised Pedestrian Crossing		• Traffic Signal • Pedestrian Signal • Advanced Stop Lines • Sign Improvement	• School Zone Improvement • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Pedestrian Crossing Island • Mini-Circle • Raised Intersection • Raised Pedestrian Crossing • Paving Treatments	• Diverter • Full Street Closure • Partial Street Closure	• Traffic Signals • Pedestrian Signal • Pedestrian Signal Timing • Signal Enhancement • RTOR Restriction • Advanced Stop Lines • Sign Improvement	• School Zone Improvement • Parking Enhancement • Ped./Driver Education • Police Enforcement

COUNTERMEASURES ASSOCIATED WITH

CRASH TYPE GROUP	A. Pedestrian Facility Design	B. Roadway Design	C. Intersection Design
7. Through Vehicle At Signalized Location	• Curb Ramp • Crosswalk Enhancements • Transit Stop Treatments • Roadway Lighting • Overpass/Underpass	• Raised Median • One-way Street	• Modern Roundabout • Intersection Median Barrier
8. Walking Along Roadway	• Sidewalk/Walkway • Curb Ramp • Roadway Lighting • Street Furniture	• Bike Lane/Shoulder • Road/Lane Narrowing • Fewer Lanes	
9. Working/Playing In Road	• Sidewalk/Walkway • Roadway Lighting	• Bike Lane/Shoulder • Road/Lane Narrowing	
10. Non-Roadway (sidewalk, driveway, parking lot, or other)	• Sidewalk/Walkway • Roadway Lighting	• Bike Lane/Shoulder • Driveway Improvement • Smaller Curb Radius	
11. Backing Vehicle	• Sidewalk/Walkway • Roadway Lighting	• Driveway Improvement	
12. Crossing Expressway	• Roadway Lighting • Overpass/Underpass		

SPECIFIC CRASH TYPE GROUPS

D. Traffic Calming	E. Traffic Management	F. Signals and Signs	G. Other Measures
• Curb Extension • Pedestrian Crossing Island • Mini-Circle • Raised Intersection • Raised Pedestrian Crossing • Paving Treatments	• Diverter • Full Street Closure • Partial Street Closure	• Traffic Signal • Pedestrian Signal • Pedestrian Signal Timing • Signal Enhancement • Advanced Stop Lines • Sign Improvement • Police Enforcement	• School Zone Improvement • Speed-Monitoring Trailer • Parking Enhancement • Ped./Driver Education
		• Sign Improvement	• School Zone Improvement • Identify Neighborhood • Speed-Monitoring Trailer • Ped./Driver Education • Police Enforcement
• Chicane • Mini-Circle • Speed Humps • Speed Table • Gateway • Driveway Link/Serpentine • Woonerf	• Diverter • Full Street Closure • Partial Street Closure • Pedestrian Street	• Sign Improvement	• Identify Neighborhood • Speed-Monitoring Trailer • Ped./Driver Education • Police Enforcement
• Curb Extension • Landscape Options		• Sign Improvement	• School Zone Improvement • Parking Enhancement • Ped./Driver Education • Police Enforcement
• Curb Extension • Raised Pedestrian Crossing • Landscape Options			• Parking Enhancement • Ped./Driver Education
		• Sign Improvement	• Ped./Driver Education • Police Enforcement

COUNTERMEASURES ASSOCIATED WITH

OBJECTIVE	A. Pedestrian Facility Design	B.Roadway Design	C.Intersection Design
1. Reduce Speed of Motor Vehicles *To be used in conjunction with other treatments	• Street Furniture*	• Add Bike Lane/Shoulder • Road Narrowing • Reduce Number of Lanes • Driveway Improvements • Curb Radius Reduction • Right-Turn Slip Lane	• Modern Roundabouts
2. Improve Sight Distance and Visibility for Motor Vehicles and Pedestrians	• Crosswalk Enhancements • Roadway Lighting • Move Poles/Newspaper Boxes at Street Corners	• Add Bike Lane/Shoulder	
3. Reduce Volume of Motor Vehicles		• Reduce Number of Lanes	
4. Reduce Exposure for Pedestrians	• Overpasses/Underpasses	• Road Narrowing • Reduce Number of Lanes • Raised Median • Pedestrian Crossing Island	
5. Improve Pedestrian Access and Mobility	• Sidewalk/Walkway • Curb Ramps • Crosswalk Enhancements • Transit Stop Treatments • Overpasses/Underpasses	• Raised Median	
6. Encourage Walking by Improving Aesthetics	• Street Furniture • Roadway Lighting • Landscaping Options	• Raised Median	
7. Improve Compliance With Traffic Laws			• Red-Light Cameras
8. Eliminate Behaviors That Lead to Crashes			• Red-Light Cameras

SPECIFIC PERFORMANCE OBJECTIVES

D. Traffic Calming	E. Traffic Management	F. Signals and Signs	G.Other Measures
• Curb Extension • Choker • Chicane • Mini-Circle • Speed Humps • Speed Table • Raised Pedestrian Crossing • Raised Intersection • Driveway Link/Serpentine • Woonerf • Landscaping Options* • Paving Treatments*		• Signal Enhancement (e.g., Adjust Signal Timing for Motor Vehicles) • Sign Improvement*	• Speed-Monitoring Trailer • School Zone Improvement
• Curb Extension • Speed Table • Raised Pedestrian Crossing • Raised Intersection • Paving Treatments		• Sign Improvement (e.g., Warning Sign) • Advanced Stop Lines	
• Woonerf	• Diverters • Full Street Closure • Partial Street Closure • Pedestrian Street		
• Curb Extension • Choker • Pedestrian Crossing Island		• Pedestrian Signal Timing • Accessible Pedestrian Signal	
• Choker • Pedestrian Crossing Island		• Traffic Signal • Signal Enhancement • Accessible Pedestrian Signal • Pedestrian Signal Timing	
• Gateway • Landscaping • Paving Treatments			• Identify Neighborhood
• Traffic Calming: Choker, Chicane, Mini-Circle, Speed Hump, Speed Table			• Speed-Monitoring Trailer • Pedestrian/Driver Education • Police Enforcement
• Traffic Calming: Choker, Chicane, Mini-Circle, Speed Hump, Speed Table		• Pedestrian Signal Timing	• Pedestrian/Driver Education • Police Enforcement

The Expert System ∞ Chapter 4

PHOTO BY DAN BURDEN

The PEDSAFE expert system is provided on the enclosed CD and is available online at http://safety.fhwa.dot.gov/pedsafe and at www.walkinginfo.org/pedsafe. This chapter provides an overview of the application and specific instructions on how to access and use the tools available. The application is designed to:

- Provide information on the countermeasures available to prevent pedestrian crashes and/or improve motorist and pedestrian behavior.
- Highlight the purpose, considerations and cost estimates associated with each countermeasure.
- Provide a decision process to select the most applicable countermeasures for a specific location.
- Provide links to case studies showing the various treatments and programs implemented in communities around the country.
- Provide easy access to resources such as statistics, implementation guidance, and reference materials.

The expert system combines the resources provided in this document with online tools (see home page below) to enable practitioners to effectively select engineering, education, or enforcement treatments to mitigate a known crash problem or achieve a specific performance objective.

The resource materials included in the web/CD application are related to this document as follows:

Web/CD Application	Print Document*
Background	Chapter 1: The Big Picture
Crash Statistics	Chapter 2: Pedestrian Crash Statistics
Crash Analysis Objectives	Chapter 3: Selecting Improvements for Pedestrians
Implementation Publications	Chapter 7: Implementation and Resources

*Chapters 5 and 6 include the countermeasures and case studies, which are available as *Tools* on the web/CD application.

PEDSAFE

Pedestrian Safety Guide and Countermeasure Selection System

The Pedestrian Safety Guide and Countermeasure Selection System is intended to provide practitioners with the latest information available for improving the safety and mobility of those who walk. The online tools provide the user with a list of possible engineering, education, or enforcement treatments to improve pedestrian safety and/or mobility based on user input about a specific location. [read more]

Resources:

Background – understand what is needed to create a viable pedestrian system.

Crash Statistics – learn about the factors related to the pedestrian crash problem.

Crash Analysis – learn how crash typing can lead to the selection of the most appropriate countermeasures.

Objectives – learn how selected treatments may address many requested improvements to the pedestrian environment.

Implementation – read about the necessary components for implementing pedestrian treatments.

More Info – access additional information through a variety of resources.

Downloads – access print versions of the guide and other relevant materials.

Available Tools:

Selection Tool – find appropriate countermeasures on the basis of desired objectives and specific location information.

Interactive Matrices – view the countermeasures associated with crash types and performance objectives.

Countermeasures – read descriptions of the 49 engineering, education, and enforcement treatments.

Case Studies – review real-world examples of implemented treatments.

Project sponsored by:

U.S. Department of Transportation
Federal Highway Administration

The PEDSAFE web/CD application is organized into resources and tools.

HOW TO USE PEDSAFE

The remainder of this chapter focuses on the tools available on the web/CD application, which include:

- Selection Tool – This interactive tool allows the user to develop a list of possible countermeasures on the basis of site characteristics, such as geometric features and operating conditions, and the type of safety problem or desired behavioral change. The decision logic used to determine when specific treatments are and are not applicable is based on input from an expert panel of practitioners.
- Interactive Matrices – This tool shows the relationship between the countermeasures and the performance objectives or crash types and can be used to display applicable countermeasures.
- Countermeasures - Details of 49 engineering, education and enforcement treatments or programs for improving pedestrian safety and/or mobility are provided in the categories of pedestrian facility design, roadway design, intersection design, traffic calming, traffic management, signals and signs, and other measures.
- Case Studies – More than 70 real-world examples illustrate various treatments and/or programs as implemented in a state or municipality.

PEDSAFE is designed to allow the tools and information to be accessed from multiple points of entry. Links are provided to allow users to easily navigate between the tools and to quickly access the resource materials. Provided below are four examples of how a user may choose to enter the system and access the tools.

1) Selection Tool – The user may have information available about geometrics and operating conditions of a particular location and either has a specific type of crash problem or desires to change motorist/pedestrian behavior at the site. All of the known information may be entered by answering a series of questions. The system will then display the countermeasure options to be considered.

2) Interactive Matrices - The user has a specific type of crash problem or desires to change motorist/pedestrian behavior but does not have specific information about the characteristics of the site. The matrices can be used to view and access the types of countermeasures available for further consideration.

3) Countermeasures – The user is interested in acquiring information about a particular treatment or program. The countermeasures page can be directly accessed and displays the seven categories of treatments included. Detailed descriptions of the 49 countermeasures can be accessed from this point. Links to relevant case studies can then be accessed from the description pages.

4) Case Studies – The user wishes to see specific examples of treatments that have been installed. The case studies page provides the option of selecting a specific implementation example by type of treatment or by location (State and municipality). From there, the user can access the countermeasure description pages that are relevant to a particular example.

Each of these tools is described in more detail in the remainder of the chapter.

SELECTION TOOL

The interactive selection tool allows the user to refine their selection of countermeasures on the basis of specific site characteristics and/or the type of safety problem or desired behavioral change. One begins by choosing *selection tool* from the *Tools* menu. A screen will appear with specific instructions on how to use the tool (*see next page*), which is a simple 3-step process:

Step 1: Enter the Location– A text box is provided for the user to describe the location of interest. In the figure on the next page, a specific intersection location—Main Street and Broadway Avenue—has been entered.

Step 2: Select the Goal of the Treatment— The user must then choose a particular type of crash problem to be mitigated or a performance objective to be achieved. As shown in the figure on page 41, there are 8 performance objectives and 12 crash groups. Only one can be selected. As the user proceeds through the steps, the previous input is shown on the right side of the screen. In this example, the roadway location that was previously entered is provided.

Step 3: Describe the Site—Finally, the user is asked to provide input about the characteristics of the site. As shown in the figure on page 40, there are seven questions that are asked in reference to the general location, geometric features, and operating conditions. The answers to these questions are used to narrow the list of appropriate countermeasures for a specific goal. For example, if the location of interest were roadway segment (midblock location), then the treatments associated with intersection improvements would not be applicable and would not be included in the results as applicable countermeasures.

Home > Selection Tool

Selection Tool

How the Tool Works

The selection tool is designed to receive input on several variables from the user in three steps.

1 Choose the Location

First, enter the location of the site in question. This allows the user to create reports for several different sites and keep the results separated by location. It is used for reporting purposes only and is not stored permanently by the operators of this web site.

2 Select the Goal of the Treatment

Second, one must decide on the goal of the treatment. It may either be to acheive a specific performance objective, such as reduce traffic volumes, or to mitigate a specific type of pedestrian-motor vehicle collision.

3 Describe the Site

Once a specific goal has been selected, the third step is to provide answers to a series of questions related to the geometric and operational characteristics of the site in question. The answers to these questions are used to narrow the list of appropriate countermeasures for a specific goal. For example, if the location of interest were a segment of roadway, or midblock location, then the treatments associated with intersection improvements would not be applicable and thus, would not be included in the results as possible countermeasures.

For any question where the information is not known, an entry of "unknown" will simply retain the countermeasures relevant to the question, and the range of treatments will not be reduced.

Use the Selection Tool

Start Here

The *Selection Tool* includes three simple steps that are described on the opening page for the tool.

Home > Selection Tool > Step One

Data Input

1 Enter the Location

For the roadway location being addressed, please enter a description.

Location

Main Street and Broadway Avenue

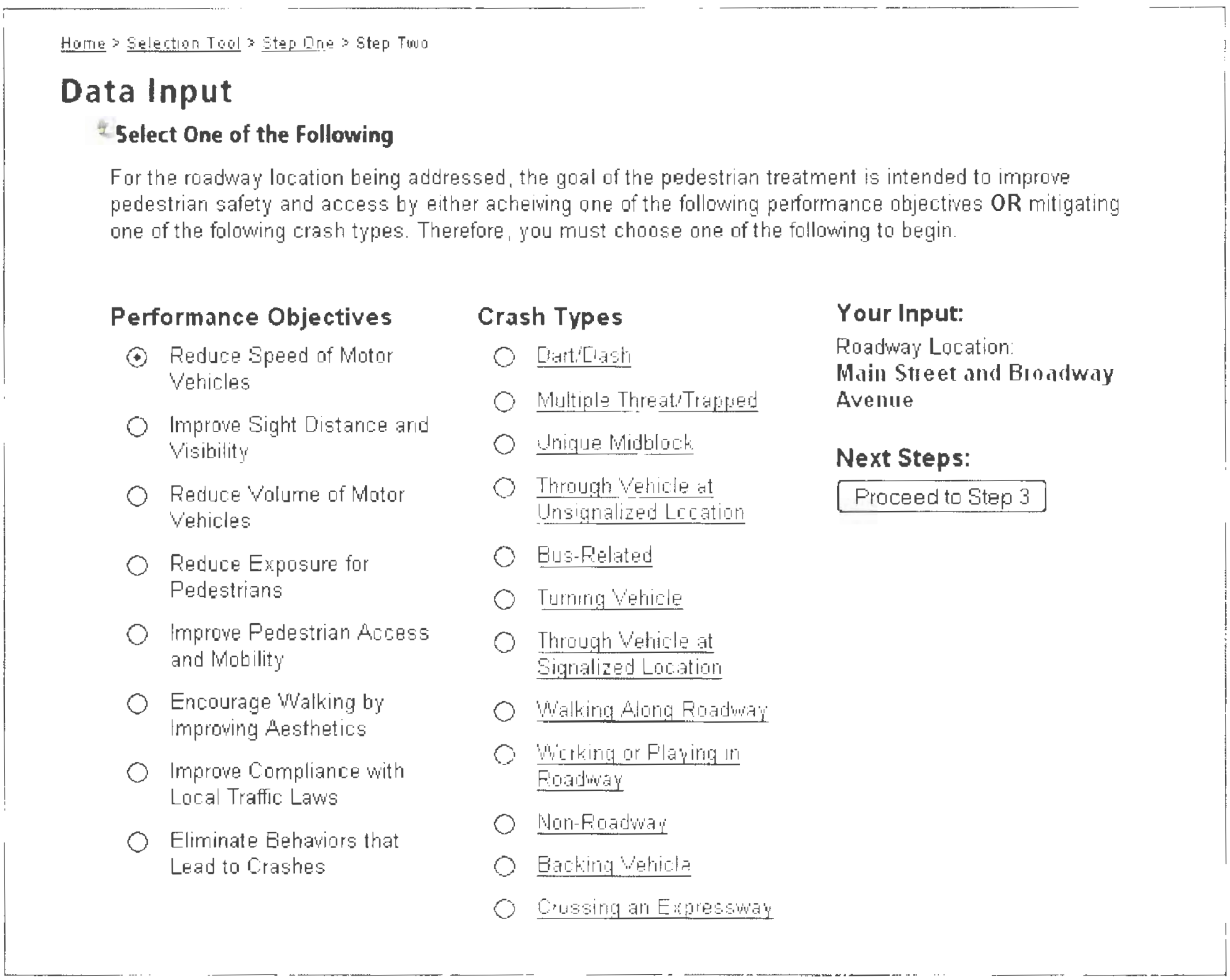
Proceed to Step 2

The user may enter any combination of text and numbers to describe the location of interest.

The field investigation form included in Appendix A can be used for site visits to obtain the information asked for in this last step. For any question where the information is not known, an entry of "unknown/not applicable" will simply retain all countermeasures relevant to the question, and the choice of treatments will not be reduced.

After completing these three steps, the user clicks *Get Results*. The information entered is used to develop a list of applicable countermeasures, which are presented as shown on page 41. The user can then read more about a specific countermeasure by selecting it, which takes the user to the countermeasure description page.

In addition to the applicable countermeasures, the results page also provides the user with a summary of the inputs made in the three steps. Options are provided for changing these inputs for the location of interest, exporting the results to Excel, or starting over with a new location.



A specific performance objective desired or crash type to be mitigated must be selected in step 2.

Home > Selection Tool > Step One > Step Two > Step Three

Data Input

Answer the Following Questions

1. In what type of area is the roadway located?
   - ○ Urban CBD
   - ○ Urban Other
   - ◉ Suburban
   - ○ Rural
   - ○ Not Applicable/Unknown

2. What is the functional class of the roadway?
   - ○ Local
   - ◉ Collector or Minor Arterial
   - ○ Principal Arterial
   - ○ Not Applicable/Unknown

3. Is the problem at an intersection or midblock (roadway segment) location?
   - ◉ Intersection
   - ○ Midblock
   - ○ Not Applicable/Unknown

4. What is the vehicle volume at this location (expressed in terms of average daily traffic (ADT) for the primary roadway)?
   - ○ <10,000
   - ◉ >=10,000 and <= 25000
   - ○ > 25000
   - ○ Not Applicable/Unknown

5. Is vehicle speed low or high?
   - ◉ <= 45 mph
   - ○ > 45 mph
   - ○ Not Applicable/Unknown

6. What is the number of through travel lanes (both directions)?
   - ○ 2 or fewer lanes
   - ◉ 3 or 4 lanes
   - ○ 5 or more lanes
   - ○ Not Applicable/Unknown

7. Is a traffic signal present, being considered, or not an option?
   - ○ Present (Removal not an option)
   - ◉ Present (Removal is an option or being considered)
   - ○ Not present (Installation is not an option)
   - ○ Not present (Installation is an option)
   - ○ Not Applicable/Unknown

Your Input:

Roadway Location:

Your Performance Objective:
Reduce Speed of Motor Vehicles

Next Steps:

Edit:

Change Your Performance Objective

Start Over

[Get Results]

The characteristics of the location are provided in Step 3 by answering seven questions.

Home > Selection Tool > Step One > Step Two > Step Three > Applicable Countermeasures

Applicable Countermeasures

Based upon your input, the following countermeasures were found:

Pedestrian Facility Design
Street Furniture

Roadway Design
Curb Radius Reduction

Intersection Design
Roundabouts

Traffic Calming
Curb Extensions
Chokers
Raised Intersections
Raised Pedestrian Crossings
Landscaping
Specific Paving Treatments

Signals and Signs
Signing

Other Measures
School Zone Improvements

Your Input:

Roadway Location:
Main Street and Broadway Avenue

Your Performance Objective:
Reduce Speed of Motor Vehicles

Your answers to the previous questions:

Type of Area: **Suburban**
Functional Class: **Collector or Minor Arterial**
Intersection or Midblock: **Intersection**
Volume: **Medium (>=10,000 and <= 25000 ADT)**
Speed: **Low (<= 45 mph)**
No. of Lanes: **3 or 4 lanes**
Traffic Signal: **Present (Removal is an option or being considered)**

Next Steps:

Edit:

Change Your Performance Objective
Change Your Answers

Save:

Output Results to Excel

Start Over

The results produced from the Selection Tool provide a list of applicable countermeasures and present the user with options to edit the responses, save the results, or start over.

INTERACTIVE MATRICES

Also included in the web/CD application are two matrices that may be accessed by selecting *interactive matrices* from the *Tools* menu. The objectives matrix (shown below) provides the user with a quick view of the relationship between the 8 performance objectives and the 7 countermeasure groups. The crash analysis matrix (shown on the following page) allows the user to see the relationship between the 12 crash type groups and the 7 countermeasure groups. In either matrix, a filled cell indicates that there is a specific countermeasure within the countermeasure group (shown in the columns) that is applicable to the crash group or performance objective listed in each row. The user can click on the bullet in any filled cell to obtain a drop-down list of the specific applicable countermeasures. From there, the user can choose to select a countermeasure and be linked to the countermeasure description page or select another cell within the matrix.

Home > Objectives > Interactive Matrix

Objectives

Interactive Matrix

Select an Objective and Countermeasure Group from the matrix below, or view the text-only version.

Countermeasures

Objective	Pedestrian Facility Design	Roadway Design	Intersection Design	Traffic Calming	Traffic Management	Signals and Signs	Other Measures
1. Reduce Speed of Motor Vehicles	•	•	•	•		•	•
2. Improve Sight Distance and Visibility for Motor Vehicles and Pedestrians	•	•		•		•	
3. Reduce Volume of Motor Vehicles		•		•	•		
4. Reduce Exposure for Pedestrians	•	•		•		•	
5. Improve Pedestrian Access and Mobility	•	•		•		•	
6. Encourage Walking by Improving Aesthetics	•	•		•			•
7. Improve Compliance With Traffic Laws			•	•			•
8. Eliminate Behaviors That Lead to Crashes			•	•		•	•

Cells with a bullet indicate there are one or more countermeasures within a countermeasure group that are applicable to a specific performance objective.

Home > Crash Analysis > Crash-Related Countermeasures > Interactive Matrix

Crash Analysis

Interactive Matrix

Select a Crash Group and Countermeasure Group from the matrix below, or view the text-only version.

Crash Group	Pedestrian Facility Design	Roadway Design	Intersection Design	Traffic Calming	Traffic Management	Signals and Signs	Other Measures
1. Dart/Dash	•	•		•	•	•	•
2. Multiple Threat/Trapped	•	•	•	•		•	•
3. Unique Midblock	•	•		•		•	•
4. Through Vehicle at Unsignalized Location	•	•	•	•	•	•	•
5. Bus-Related	•	•		•		•	•
6. Turning Vehicle	•	•	•	•	•	•	•
7. Through Vehicle at Signalized Location	•	•	•	•	•	•	•
8. Walking Along Roadway	•	•				•	•
9. Working or Playing in Roadway	•	•		•	•	•	•
10. Non-Roadway	•	•		•		•	•
11. Backing Vehicle	•	•		•			•
12. Crossing an Expressway	•					•	•

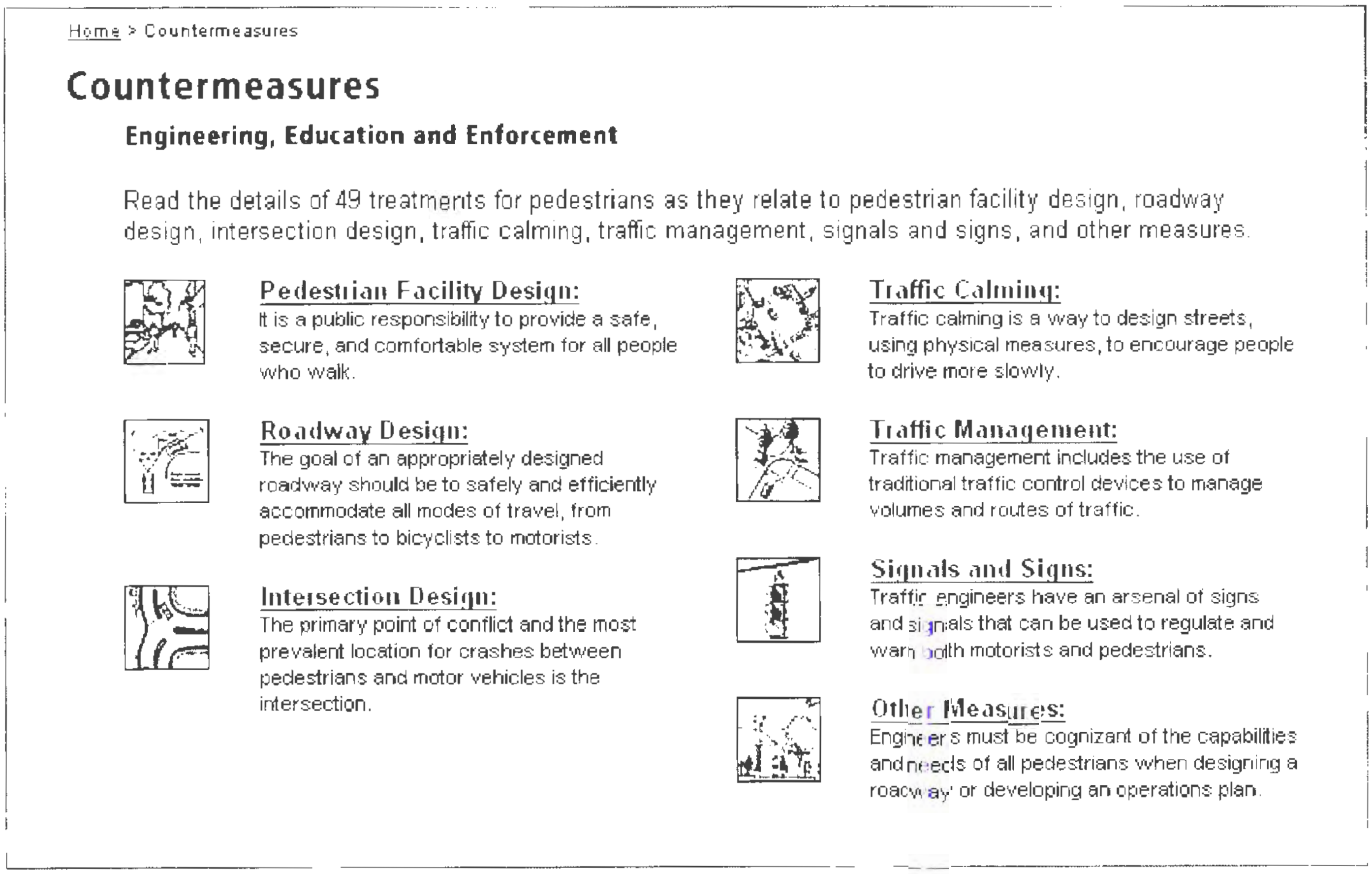
Cells with a bullet indicate there are one or more countermeasures within a countermeasure group that are applicable to a specific crash group.

COUNTERMEASURES

Each of the 49 engineering, education, and enforcement countermeasures described in Chapter 5 are included in the web/CD application. After selecting *countermeasures* within the *Tools* menu, the user may select one of the following seven categories of treatments:

- Pedestrian Facility Design
- Roadway Design
- Intersection Design
- Traffic Calming
- Traffic Management
- Signals and Signs
- Other Measures

A specific countermeasure may then be selected from those listed for each category. Each countermeasure includes a description of the treatment or program, purpose(s), considerations that one should be aware of, and cost estimates. Finally, there is a link to specific case studies where the particular countermeasure has been implemented. An example countermeasure description page is shown on the following page for Curb Ramps.



Home > Countermeasures

Countermeasures

Engineering, Education and Enforcement

Read the details of 49 treatments for pedestrians as they relate to pedestrian facility design, roadway design, intersection design, traffic calming, traffic management, signals and signs, and other measures.

Pedestrian Facility Design:
It is a public responsibility to provide a safe, secure, and comfortable system for all people who walk.

Roadway Design:
The goal of an appropriately designed roadway should be to safely and efficiently accommodate all modes of travel, from pedestrians to bicyclists to motorists.

Intersection Design:
The primary point of conflict and the most prevalent location for crashes between pedestrians and motor vehicles is the intersection.

Traffic Calming:
Traffic calming is a way to design streets, using physical measures, to encourage people to drive more slowly.

Traffic Management:
Traffic management includes the use of traditional traffic control devices to manage volumes and routes of traffic.

Signals and Signs:
Traffic engineers have an arsenal of signs and signals that can be used to regulate and warn both motorists and pedestrians.

Other Measures:
Engineers must be cognizant of the capabilities and needs of all pedestrians when designing a roadway or developing an operations plan.

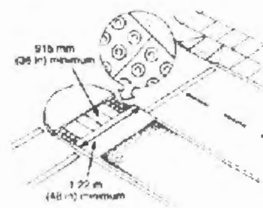
The 49 countermeasures are divided among the 7 categories of improvements shown here.

Home > Countermeasures > Pedestrian Facility Design > Curb Ramps

Curb Ramps:

Curb Ramps

- view purpose
- view considerations
- view estimated cost
- view case studies



? view

Curb ramps provide access between the sidewalk and roadway for people using wheelchairs, strollers, walkers, crutches, handcarts, bicycles, and also for pedestrians with mobility impairments who have trouble stepping up and down high curbs. Curb ramps must be installed at all intersections and midblock locations where pedestrian crossings exist, as mandated by federal legislation (1973 Rehabilitation Act and ADA 1990). Curb ramps must have a slope of no more than 1:12 (must not exceed 25.4 mm/0.3 m (1 in/ft) or a maximum grade of 8.33 percent), and a maximum slope on any side flares of 1:10. More information on the specifications for curb ramps can be found in the *Draft Guidelines for Accessible Public Rights of Way.*[4]

Where feasible, separate curb ramps for each crosswalk at an intersection should be provided rather than having a single ramp at a corner for both crosswalks. This provides improved orientation for visually impaired pedestrians. Similarly, tactile warnings will alert pedestrians to the sidewalk/street edge. All newly constructed and altered roadway projects must include curb ramps. In addition, all agencies should upgrade existing facilities. They can begin by conducting audits of their pedestrian facilities to make sure transit services, schools, public buildings, and parks, etc. are accessible to pedestrians who use wheelchairs.

While curb ramps are needed for use on all types of streets, priority locations are in downtown areas and on streets near transit stops, schools, parks, medical facilities, shopping areas, and near residences with people who use wheelchairs.

For more information about curb ramp design, see *Designing Sidewalks and Trails for Access, Parts I and II*, by the Federal Highway Administration, and *Accessible Rights-of-Way: A Design Guide*, by the U.S. Access Board and the Federal Highway Administration. The Access Board?s right-of-way report can be found at www.access-board.gov.

Purpose

- Provide access to street crossings.

top of page

Considerations

- Follow Americans with Disabilities Act (ADA) design guidelines.
- Texture patterns must be detectable to blind pedestrians.

top of page

Estimated Cost

The cost is approximately $800 to $1,500 per curb ramp (new or retrofitted).

top of page

Case Studies

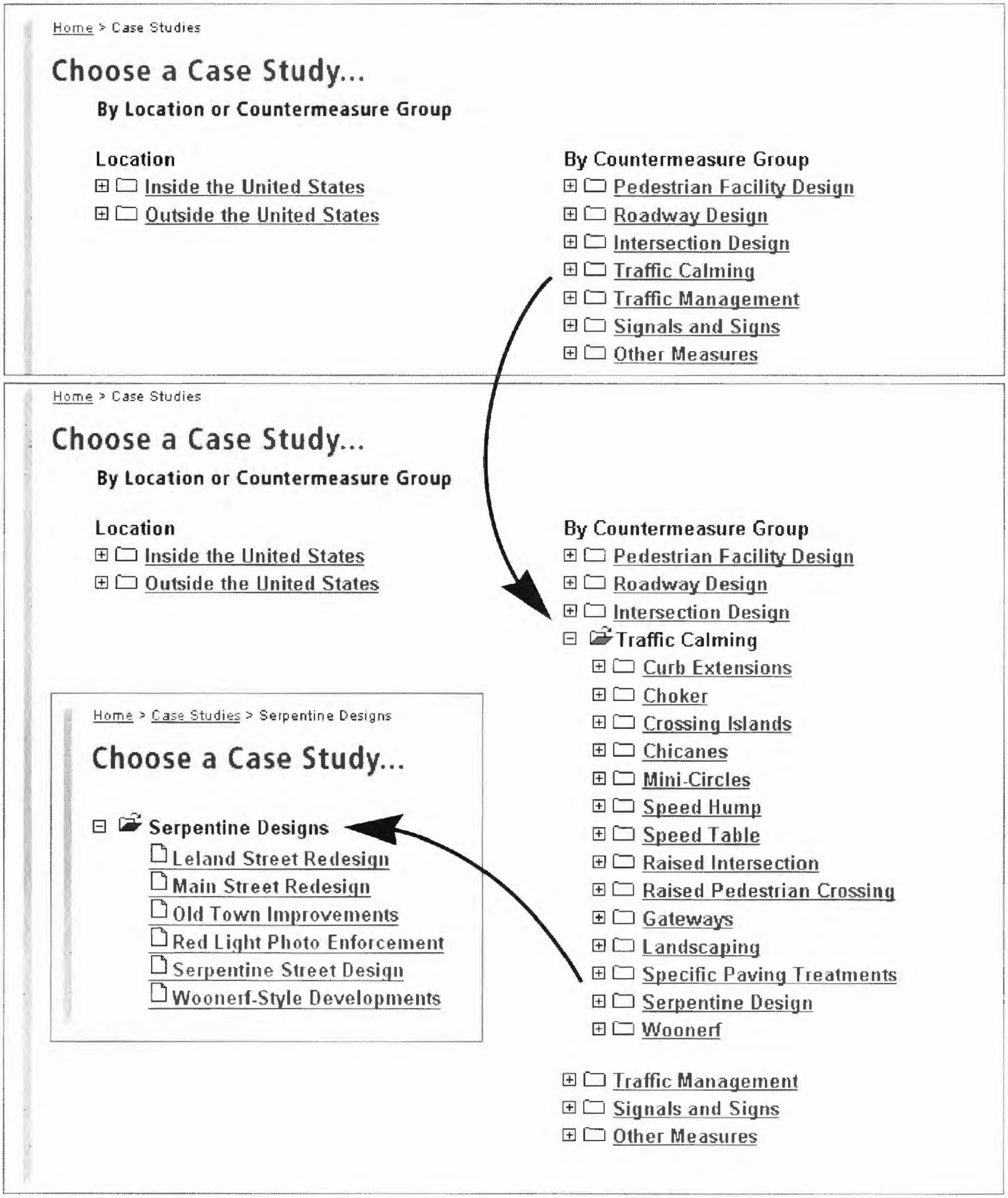
Cambridge, MA
Berkeley, CA
Clemson, SC
Albany, NY
Grand Junction, CO
Fort Plain, NY
Austin, TX
St. Petersburg, FL

top of page

Each countermeasure includes a description, purpose, considerations, estimated cost, and links to case studies where the treatment or program has been implemented.

CASE STUDIES

The 71 case studies described in Chapter 6 are included in the web/CD application. The user can access the implementation examples by selecting *case studies* within the *Tools* menu. As shown on the following page, the user then has the option of selecting a case study on the basis of location or type of countermeasure. The figure on the following page provides an example of selection by countermeasure. The selection of the *Traffic Calming* countermeasure group produces a list of the 14 traffic calming treatments included in the application. The selection of *Serpentine Design* produces a list of six case studies in which serpentine design was a component of the treatments implemented. Accessing each of these case studies provides information about the specific problem that was addressed, the solution implemented, and the results achieved.



The case studies may be selected by location or by countermeasure. Opening a Countermeasure Group folder reveals the list of countermeasures included. Selecting a specific countermeasure reveals the case studies in which that treatment/program was a component.

Countermeasures
Chapter 5

PHOTO BY DAN BURDEN

Pedestrian Facility Design
Roadway Design
Intersection Design
Traffic Calming
Traffic Management
Signals and Signs
Other Measures

A total of 49 engineering, education, and enforcement countermeasures are discussed in this chapter. The treatments and programs selected for inclusion in this document are those that have been in place for an extended period of time and/or have been proven effective at the time the material for this product was being complied. Since that time, new countermeasures continue to be developed, implemented, and evaluated. Thus, practitioners should not necessarily limit their choices to those included here; this material is a starting point. More information on the latest treatments and programs can be found through many of the Web sites and resources included in Chapter 7.

The categories of improvements include:

- Pedestrian Facility Design
- Roadway Design
- Intersection Design
- Traffic Calming
- Traffic Management
- Signals and Signs
- Other Measures

The following index can be used to quickly locate the countermeasure of interest.

PEDESTRIAN FACILITY DESIGN

Walkways are the portion of the public right-of-way that provide a separated area for people traveling on foot. Walkways that are safe, accessible, and aesthetically pleasing attract pedestrians. People walk for many reasons: to go to a neighbor's house, to run errands, for school, or to get to a business meeting. People also walk for recreation and health benefits or for the enjoyment of being outside. Some pedestrians must walk to transit or other destinations if they wish to travel independently. It is a public responsibility to provide a safe, secure, and comfortable system for all people who walk. The countermeasures related to pedestrian facility design include:

- Sidewalks and Walkways
- Curb Ramps
- Marked Crosswalks and Enhancements
- Transit Stop Treatments
- Roadway Lighting Improvements
- Street Furniture/Walking Environment

PHOTO BY DAN BURDEN

1. SIDEWALKS AND WALKWAYS

Sidewalks and walkways are "pedestrian lanes" that provide people with space to travel within the public right-of-way that is separated from roadway vehicles. They also provide places for children to walk, run, skate, ride bikes, and play. Sidewalks are associated with significant reductions in pedestrian collisions with motor vehicles.[1] Such facilities also improve mobility for pedestrians and provide access for all types of pedestrian travel: to and from home, work, parks, schools, shopping areas, transit stops, etc. Walkways should be part of every new and renovated facility and every effort should be made to retrofit streets that currently do not have sidewalks.

PHOTO BY DAN BURDEN

This sidewalk and buffer zone provides a safe place for pedestrians to walk outside of the paths of vehicles in the street.

While sidewalks are typically made of concrete, less expensive walkways may be constructed of asphalt, crushed stone, or other materials if they are properly maintained and accessible (firm, stable, and slip-resistant). In more rural areas, in particular, a "side path" made of one of these materials may be suitable. Both FHWA and the Institute of Transportation Engineers (ITE) recommend a minimum width of 1.5 m (5 ft) for a sidewalk or walkway, which allows two people to pass comfortably or to walk side-by-side. Wider sidewalks should be installed near schools, at transit stops, in downtown areas, or anywhere high concentrations of pedestrians exist. Sidewalks should be continuous along both sides of a street and sidewalks should be fully accessible to all pedestrians, including those in wheelchairs.[2,3]

A buffer zone of 1.2 to 1.8 m (4 to 6 ft) is desirable and should be provided to separate pedestrians from the street. The buffer zone will vary according to the street type. In downtown or commercial districts, a street furniture zone is usually appropriate. Parked cars and/or bicycle lanes can provide an acceptable buffer zone. In more suburban or rural areas, a landscape strip is generally most suitable. Careful planning of sidewalks and walkways is important in a neighborhood or area in order to provide adequate safety and mobility. For example, there should be a flat sidewalk provided in areas where driveways slope to the roadway.

Recommended guidelines and priorities for sidewalks and walkways are given in Appendix C.

Purpose

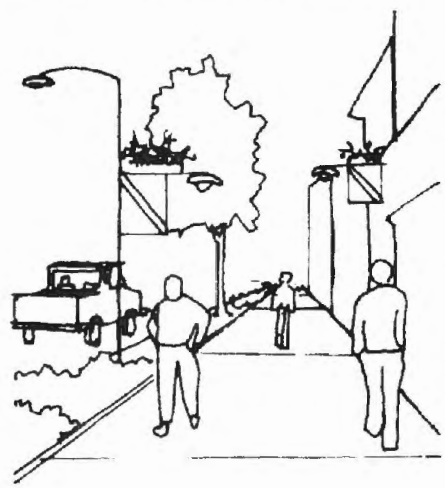
- Create the appropriate facility for the walking area of the public right-of-way.
- Improve pedestrian safety dramatically.

Considerations

- While continuous walkways are the goal, retrofitting areas without them will usually occur in phases. Lack of a seamless system is no excuse not to provide parts of the system.
- In retrofitting streets that do not have a continuous or accessible system, locations near transit stops, schools, parks, public buildings, and other areas with high concentrations of pedestrians should be the highest priority.
- Street furniture placement should not restrict pedestrian flow.

Estimated Cost

The cost for concrete curbs and sidewalks is approximately \$49/linear meter (\$15/linear foot) for curbing and \$118/square meter (\$11/square foot) for walkways. Asphalt curbs and walkways are less costly, but require more maintenance, and are somewhat more difficult to walk and roll on for pedestrians with mobility impairments.



Adapted from *Making Streets That Work*, Seattle, 1996

2. CURB RAMPS

Curb ramps provide access between the sidewalk and roadway for people using wheelchairs, strollers, walkers, crutches, handcarts, bicycles, and also for pedestrians with mobility impairments who have trouble stepping up and down high curbs. Curb ramps must be installed at all intersections and midblock locations where pedestrian crossings exist, as mandated by federal legislation (1973 Rehabilitation Act and ADA 1990). Curb ramps must have a slope of no more than 1:12 (must not exceed 25.4 mm/0.3 m (1 in/ft) or a maximum grade of 8.33 percent), and a maximum slope on any side flares of 1:10. More information on the specifications for curb ramps can be found in the *Draft Guidelines for Accessible Public Rights of Way.*[4]

PHOTO BY MICHAEL RONKIN

A curb ramp should be designed to provide direct access and should have the proper width and slope.

Where feasible, separate curb ramps for each crosswalk at an intersection should be provided rather than having a single ramp at a corner for both crosswalks. This provides improved orientation for visually impaired pedestrians. Similarly, tactile warnings will alert pedestrians to the sidewalk/street edge. All newly constructed and altered roadway projects must include curb ramps. In addition, all agencies should upgrade existing facilities. They can begin by conducting audits of their pedestrian facilities to make sure transit services, schools, public buildings, and parks, etc. are accessible to pedestrians who use wheelchairs.

While curb ramps are needed for use on all types of streets, priority locations are in downtown areas and on streets near transit stops, schools, parks, medical facilities, shopping areas, and near residences with people who use wheelchairs.

For more information about curb ramp design, see *Designing Sidewalks and Trails for Access, Parts I and II*, by the Federal Highway Administration, and *Accessible Rights-of-Way: A Design Guide*, by the U.S. Access Board and the Federal Highway Administration. The Access Board's right-of-way report can be found at www.access-board.gov.

Purpose

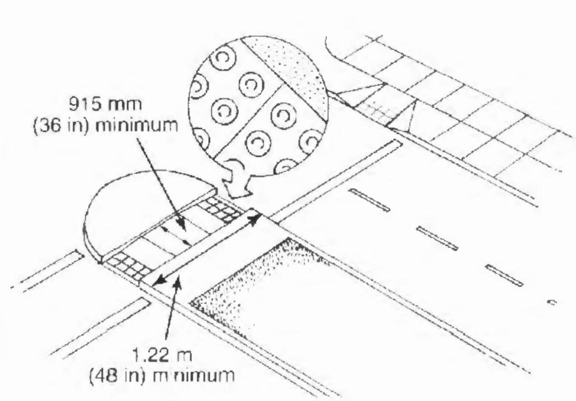
- Provide access to street crossings.

Considerations

- Follow Americans with Disabilities Act (ADA) design guidelines.
- Texture patterns must be detectable to blind pedestrians.

Estimated Cost

The cost is approximately $800 to $1,500 per curb ramp (new or retrofitted).



Adapted from *Designing Sidewalks and Trails for Access, Part II of II*, Washington, DC, 2001

3. MARKED CROSSWALKS AND ENHANCEMENTS

Marked crosswalks indicate optimal or preferred locations for pedestrians to cross and help designate right-of-way for motorists to yield to pedestrians. Crosswalks are often installed at signalized intersections and other selected locations. Various crosswalk marking patterns are given in the MUTCD.[5] Marked crosswalks are desirable at some high pedestrian volume locations (often in conjunction with other measures) to guide pedestrians along a preferred walking path. In some cases, they can be raised and should often be installed in conjunction with other enhancements that physically reinforce crosswalks and reduce vehicle speeds. It is also sometimes useful to supplement crosswalk markings with warning signs for motorists. At some locations, signs can get "lost" in visual clutter, so care must be taken in placement.


PHOTO BY PETER LAGERWEY

The "ladder" pattern shown above is more visible to motorists than parallel lines and requires less maintenance if painted to allow the tires of motor vehicles to track between the painted lines.

Pedestrians are sensitive to out-of-the-way travel, and reasonable accommodation should be made to make crossings both convenient and safe at locations with adequate visibility.

Recommended guidelines and priorities for crosswalk installation at controlled locations are given in Appendix D. These guidelines are based on a major study of 1,000 marked crosswalks and 1,000 unmarked crossings in 30 U.S. cities. Recommendations are also given for providing other pedestrian crossing enhancements at uncontrolled locations with and without a marked crosswalk.[6]

Purpose

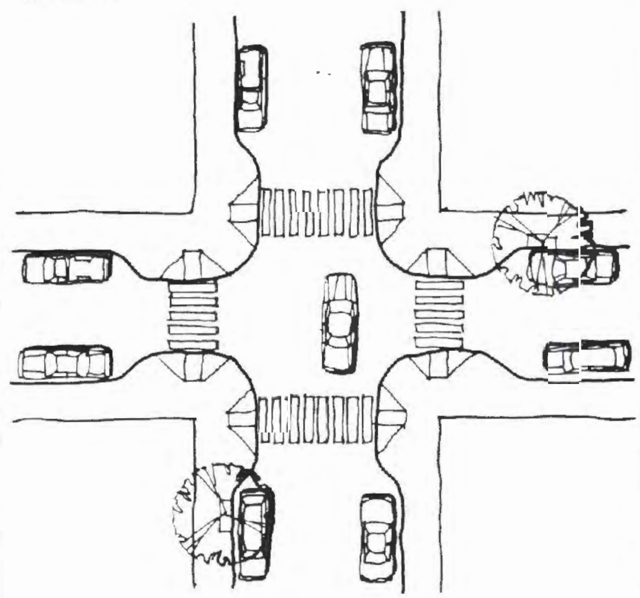
- Warn motorists to expect pedestrian crossings.
- Indicate preferred crossing locations.

Considerations

- Crosswalk locations should be convenient for pedestrian access.
- Crosswalk markings alone are unlikely to benefit pedestrian safety. Ideally, crosswalks should be used in conjunction with other measures, such as curb extensions, to improve the safety of a pedestrian crossing, particularly on multi-lane roads with average daily traffic (ADT) above about 10,000.
- Marked crosswalks are important for pedestrians with vision loss.
- Crosswalk markings must be placed to include the ramp so that a wheelchair does not have to leave the crosswalk to access the ramp.

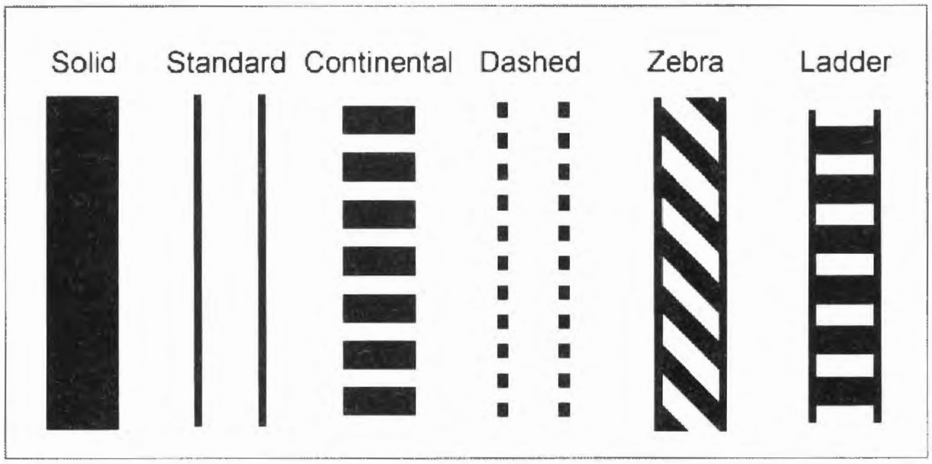
Estimated Cost

Approximate installation costs are $100 for a regular striped crosswalk, $300 for a ladder crosswalk, and $3,000 for a patterned concrete crosswalk. Maintenance of the markings must also be considered and varies by region of the country and materials used.


City of Cambridge, MA

Crosswalk Materials

It is important to ensure that crosswalk markings are visible to motorists, particularly at night. Crosswalks should not be slippery, create tripping hazards, or be difficult to traverse by those with diminished mobility or visual capabilities. Granite and cobblestones are examples of materials that are aesthetically pleasing, but may become slippery when wet or be difficult to cross by pedestrians who are blind or using wheelchairs. One of the best



Examples of different crosswalk marking patterns.

materials for marking crosswalks is inlay tape, which is installed on new or repaved streets. It is highly reflective, long-lasting, and slip-resistant, and does not require a high level of maintenance. Although initially more costly than paint, both inlay tape and thermoplastic are more cost-effective in the long run. Inlay tape is recommended for new and resurfaced pavement, while thermoplastic may be a better option on rougher pavement surfaces. Both inlay tape and thermoplastic are more visible and less slippery than paint when wet.

PHOTO BY DAN BURDEN

Some crosswalks are angled to the right in the median. This is intended to facilitate a pedestrian's view of oncoming traffic before crossing the second half of the street.

4. TRANSIT STOP TREATMENTS

Good public transportation is as important to the quality of a community as good roads. Well-designed transit routes and accessible stops are essential to a usable system.

PHOTO BY BARBARA GRAY

The transit shelter above is in a lively commercial district. The shelter design reflects the surrounding architecture. Pedestrian-scale lighting and landscaping add visual interest and security.

Bus stops should be located at intervals that are convenient for passengers. The stops should be designed to provide safe and convenient access and should be comfortable places for people to wait. Adequate bus stop signing, lighting, a bus shelter with seating, trash receptacles, and bicycle parking are also desirable features. Bus stops should be highly visible locations that pedestrians can reach easily by means of accessible travel routes. Therefore, a complete sidewalk system is essential to support a public transportation system. Convenient crossings are also important.

Proper placement of bus stops is key to user safety. For example, placing the bus stops on the near side of intersections or crosswalks may block the pedestrians' view of approaching traffic, and the approaching drivers' view of pedestrians. Approaching motorists may be unable to stop in time when a pedestrian steps from in front of a stopped bus into the traffic lanes at the intersection.

Far-side bus stops generally encourage pedestrians to cross behind the bus. Relocating the bus stop to the far side of the intersection can improve pedestrian safety since it eliminates the sight-distance restriction caused by the bus. Placing bus stops at the far side of intersections can also improve motor vehicle operation.

The bus stop location should be fully accessible to pedestrians in wheelchairs, should have paved connections to sidewalks where landscape buffers exist, and should not block pedestrian travel on the sidewalk. Adequate room should exist to operate wheelchair lifts. Yet, it is also useful to install curb ramps at bus stops so that a passenger can board from the street if bus-lift deployment is blocked. Additional information on making bus stops accessible can be found in Chapter 3 of *Accessible Rights-of-Way: A Design Guide.*[7]

Purpose

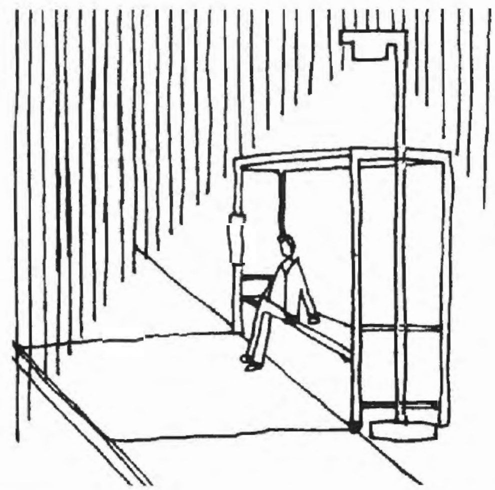
- Provide safe, convenient, and inviting access for transit users.

Considerations

- Ensure that access to and from stops is provided when transit stops are created.
- Ensure adequate room to load wheelchairs.
- Ensure a clear and comfortable path for passing pedestrians when placing transit shelters.
- Locate transit stops on the far side of marked crosswalks.

Estimated Cost

$1,000 to $10,000. Cost varies widely depending on type of improvements.



Adapted from *Making Streets That Work*, Seattle, 1996

5. ROADWAY LIGHTING IMPROVEMENTS

Good quality and placement of lighting can enhance an environment as well as increase comfort and safety. Pedestrians often assume that motorists can see them at night; they are deceived by their own ability to see the oncoming headlights. Without sufficient overhead lighting, motorists may not be able to see pedestrians in time to stop.

PHOTO BY DAN BURDEN

This well-lit commercial district is an attractive place to shop in the evening. The combination of pedestrian-scaled street lighting, holiday lights in the trees, and light from shop windows enhances visibility and creates a secure and festive atmosphere.

In commercial areas with nighttime pedestrian activity, streetlights and building lights can enhance the ambiance of the area and the visibility of pedestrians by motorists. It is best to place streetlights along both sides of arterial streets and to provide a consistent level of lighting along a roadway. Nighttime pedestrian crossing areas may be supplemented with brighter or additional lighting. This includes lighting pedestrian crosswalks and approaches to the crosswalks.

In commercial areas or in downtown areas, specialty pedestrian-level lighting may be placed over the sidewalks to improve pedestrian comfort, security, and safety. Mercury vapor, incandescent, or less expensive high-pressure sodium lighting is often preferred as pedestrian-level lighting. Low-pressure sodium lights are low energy, but have a high level of color distortion.

Purpose

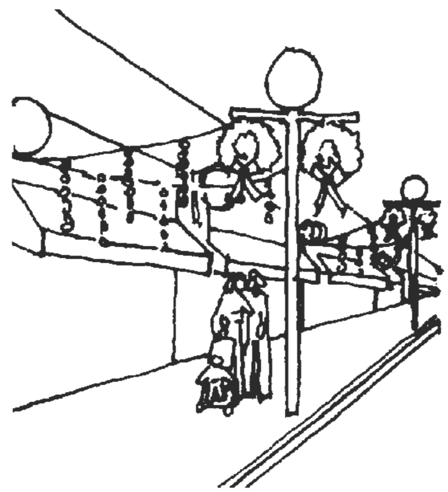
- Enhance safety of all roadway users, particularly pedestrians.
- Enhance commercial districts.
- Improve nighttime security.

Considerations

- Ensure that pedestrian walkways and crosswalks are well lit.
- Install lighting on both sides of wide streets and streets in commercial districts.
- Use uniform lighting levels.

Estimated Cost

Varies depending on fixture type and service agreement with local utility.



Adapted from *Making Streets That Work*, Seattle, 1996

6. PEDESTRIAN OVERPASSES / UNDERPASSES

Pedestrian overpasses and underpasses allow for the uninterrupted flow of pedestrian movement separate from the vehicle traffic. However, they should be a measure of last resort, and it is usually more appropriate to use traffic-calming measures or install a pedestrian-activated signal that is accessible to all pedestrians. This is also an extremely high-cost and visually intrusive measure.

PHOTO BY YAN JIA

This pedestrian overpass takes advantage of existing topography and allows pedestrians to avoid conflicts with traffic at street level.

Such a facility must accommodate all persons, as required by the ADA. More information on the specifications for accessing overpasses and underpasses can be found in the *Draft Guidelines for Accessible Public Rights of Way*.[4] These measures include ramps or elevators. Extensive ramping will accommodate wheelchairs and bicyclists, but results in long crossing distances and steep slopes that discourage use.

Studies have shown that many pedestrians will not use an overpass or underpass if they can cross at street level in about the same amount of time.[8,9] Overpasses work best when the topography allows for a structure without ramps (e.g., overpass over a sunken freeway). Underpasses work best when designed to feel open and accessible. Grade separation is most feasible and appropriate in extreme cases where pedestrians must cross roadways such as freeways and high-speed, high-volume arterials.

Purpose

- Provide complete separation of pedestrians from motor vehicle traffic.
- Provide crossings where no other pedestrian facility is available.
- Connect off-road trails and paths across major barriers.

Considerations

- Use sparingly and as a measure of last resort. Most appropriate over busy, high-speed highways, railroad tracks, or natural barriers.
- Pedestrians will not use if a more direct route is available.
- Lighting, drainage, graffiti removal, and security are also major concerns with underpasses.
- Must be wheelchair accessible, which generally results in long ramps on either end of the overpass.

Estimated Cost

$500,000 to $4 million, depending on site characteristics.

7. STREET FURNITURE / WALKING ENVIRONMENT

Sidewalks should be continuous and should be part of a system that provides access to goods, services, transit, and homes. Well-designed walking environments are enhanced by urban design elements and street furniture, such as benches, bus shelters, trash receptacles, and water fountains.

PHOTO BY MICHAEL RONKIN

This is a good example of a street furniture zone along the sidewalk on Portland, Oregon's light-rail transit line.

Sidewalks and walkways should be kept clear of poles, signposts, newspaper racks, and other obstacles that could block the path, obscure a driver's view or pedestrian visibility, or become a tripping hazard. Benches, water fountains, bicycle parking racks, and other street furniture should be carefully placed to create an unobstructed path for pedestrians. More information on the requirements for street furniture can be found in the *Draft Guidelines for Accessible Public Rights of Way*.[2] Such areas must also be properly maintained and kept clear of debris, overgrown landscaping, tripping hazards, or areas where water accumulates. Snow removal is also important for maintaining pedestrian safety and mobility. In most areas, local ordinances give property owners the responsibility of removing snow within 12 to 48 hours after a storm.

Walking areas should also be interesting for pedestrians and provide a secure environment. Storefronts should exist at street level and walking areas should be well lit and have good sightlines.

Purpose

- Enhance the pedestrian environment.
- Enliven commercial districts by fostering community life.

Considerations

- Good-quality street furniture will show that the community values its public spaces and is more cost-effective in the long run.
- Include plans for landscape irrigation and maintenance at the outset.
- Ensure proper placement of furniture; do not block pedestrian walkway or curb ramps or create sightline problems.
- Ensure adequacy of overhead clearances and detectability of protruding objects for pedestrians who are blind or visually impaired.

Estimated Cost

Varies depending on the type of furniture, the material out of which it is constructed, and the amount of planting material used.

Adapted from *Making Streets That Work*, Seattle, 1996

ROADWAY DESIGN

Design and operational elements of the roadway affect the ability of pedestrians to safely and easily cross streets. A geometric element such as street width affects the time needed to cross the street, whereas an operational parameter like traffic direction (one-way vs. two-way) affects the number of potential conflicts between motorists and crossing pedestrians. The countermeasures related to roadway design include:

- Bicycle Lanes
- Roadway Narrowing
- Lane Reduction
- Driveway Improvements
- Raised Medians
- One-way/Two-way Street Conversions
- Curb Radius Reduction
- Improved Right-Turn Slip Lane Design

PHOTO BY DAN BURDEN

8. BICYCLE LANES

Bike lanes indicate a preferential or exclusive space for bicycle travel along an arterial street. Bike lanes have been found to provide more consistent separation between bicyclists and passing motorists. Marking bicycle lanes can also benefit pedestrians—as turning motorists slow and yield more to bicyclists, they will also be doing so for pedestrians.

PHOTO BY CARA SEIDERMAN

A well-marked bicycle lane and bicycle parking in Cambridge, Massachusetts.

Bike lanes are typically designated by striping and/or signing. Colored pavement (e.g., blue or red surfaces) is also used in some locations, although it is not yet an accepted MUTCD standard. If the addition of bike lanes results in fewer motor vehicle lanes, safety may be enhanced for pedestrians crossing the street. Bicycle lanes also provide a buffer between motor vehicle traffic and pedestrians when sidewalks are immediately adjacent to the curb. On high-speed, high-volume roads, it may be more appropriate to provide a multi-use path to physically separate both bicyclists and pedestrians from motor vehicle traffic. However, the application of this treatment requires that care be taken to minimize the conflicts between bicyclists and pedestrians.

Purpose

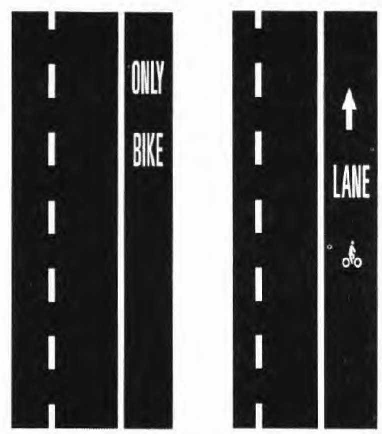
- Create on-street travel facilities for bicyclists.
- Narrow the roadway to encourage lower motor vehicle speeds.
- Provide additional separation between pedestrians and motor vehicles.
- Adding on-street bike lanes reduces the distance pedestrians must travel to cross automobile lanes.

Considerations

- All roads should be evaluated for on-street bicycle facilities.
- Provide adequate space between the bike lane and parked cars so that open doors do not create a hazard for bicyclists.

Estimated Cost

The cost of installing a bike lane is approximately $3,100 to $31,000 per kilometer ($5,000 to $50,000 per mile), depending on the condition of the pavement, the need to remove and repaint the lane lines, the need to adjust signalization, and other factors. It is most cost efficient to create bicycle lanes during street reconstruction, street resurfacing, or at the time of original construction.



ADAPTED FROM MUTCD

Typical optional word and symbol pavement markings for bicycle lanes.

9. ROADWAY NARROWING

Roadway narrowing can be achieved in several different ways:

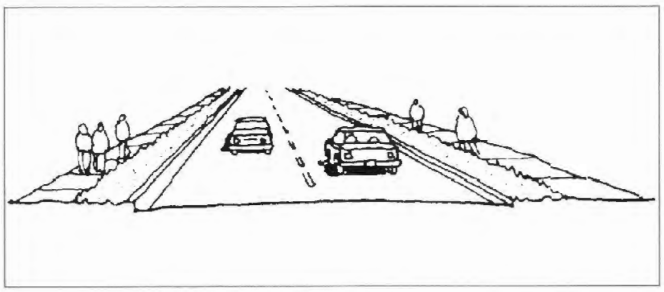
a. Lane widths can be reduced (to 3.0 or 3.4 m [10 or 11 ft]) and excess asphalt striped with a bicycle lane or shoulder.

b. Travel lanes can be removed (see #10).

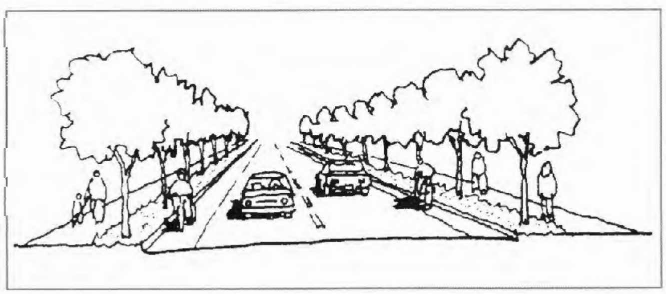
c. On-street parking lanes can be added.

d. Curbs can be moved to narrow the cross section and extend the width of sidewalks and landscape areas.

This can reduce vehicle speeds along a roadway section and enhance movement and safety for pedestrians. Bicycle travel will also be enhanced and bicyclist safety improved when bicycle lanes are added.



Before



After

SKETCHES BY MICHAEL KIMELBERG

Purpose

- Multiple benefits of lower vehicle speeds, increased safety, and redistributing space to other users.

Considerations

- Bicyclists must be safely accommodated. Bike lanes or wide curb lanes are needed if motor vehicle volumes and/or speeds are high.
- Road narrowing must consider school bus and emergency service access, and truck volumes.
- Evaluate whether narrowing may encourage traffic to divert to other local streets in the neighborhood.

Estimated Cost

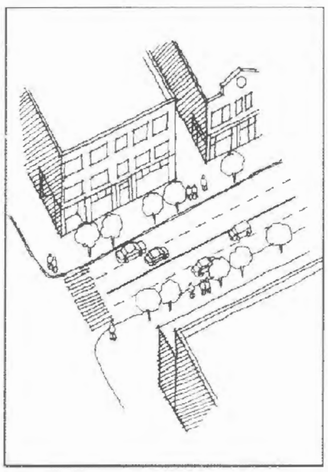
Adding striped shoulders or on-street bike lanes can cost as little as $620 per kilometer ($1,000 per mile) if the old paint does not need to be changed. The cost for restriping a kilometer of street to bike lanes or reducing the number of lanes to add on-street parking is $3,100 to $6,200 ($5,000 to $10,000 per mile), depending on the number of old lane lines to be removed. Constructing a raised median or widening a sidewalk can cost $62,000 or more per kilometer ($100,000 or more per mile).

PHOTO BY DAN BURDEN

Colored asphalt has been used to identify bike lanes on this street in Holland. The bike lanes visually narrow the street and help reduce speeds. Although the curb-to-curb width is more than 9.1 m (30 ft), the motorist only sees 3.4 m (11 ft) of driving space.

10. LANE REDUCTION

Some roads have more travel lanes than necessary and are difficult to cross because of their width. Reducing the number of lanes on a multi-lane roadway can reduce crossing distances for pedestrians and may slow vehicle speeds. A traffic analysis should be done to determine whether the number of lanes on a roadway (many of which were built without such an analysis) is appropriate. Level-of-service analysis for intersections should not dictate the design for the entire length of roadway. For example, a four-lane undivided road can be converted to one through lane in each direction, with a center left-turn lane or with a raised median, and turn pockets and bicycle lanes on both sides of the roadway. Turning pockets may be needed only at specific locations.



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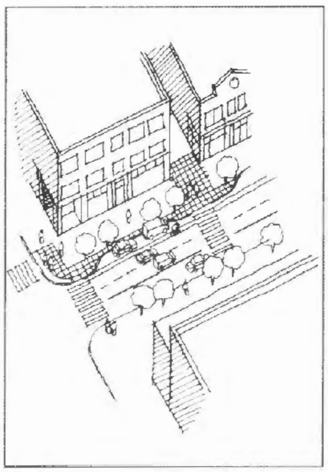


After

PHOTO BY CARA SEIDERMAN

This street in Cambridge, Massachusetts, was reduced from four lanes to three. The conversion introduced wider sidewalks, additional space for landscaping, street furniture and cafes, and bicycle lanes.

Purpose

- Remedy a situation where there is excess capacity.
- Provide space for pedestrians, bicyclists, and parked cars.
- Reduce crossing time, which can help optimize signal timing.
- Improve social interaction and neighborhood feel along the street.

Considerations

- Roadway capacity operation and overall road safety need to be considered before reducing the number of lanes.
- Ensure street connections so major arterials can be crossed at controlled intersections.

Estimated Cost

The cost for restriping a kilometer of four-lane street to one lane in each direction plus a two-way, left-turn lane and bike lanes is about $3,100 to $12,400 ($5,000 to $20,000 per mile), depending on the amount of lane lines that need to be repainted. The estimated cost of extending sidewalks or building a raised median is much higher and can cost $62,000 per kilometer ($100,000 per mile) or more.

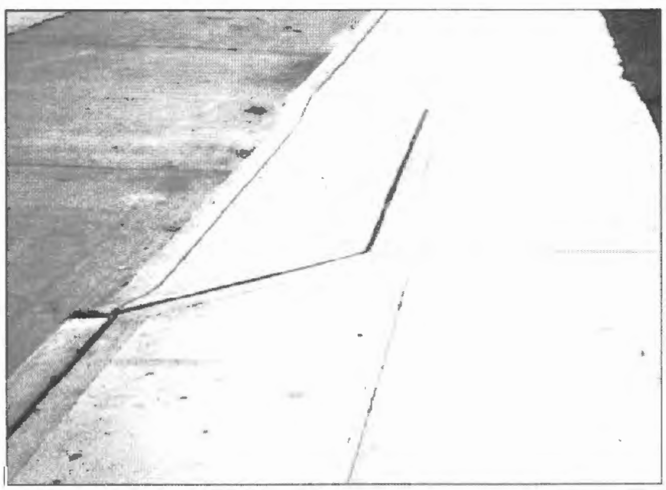
If a reconfiguration is done after repaving or with an overlay, and curbs do not need to be changed, there is little or no cost for the change.

Depending on conditions, it may also be possible to add on-street parking while allowing for bicycle lanes on both sides of the street—instead of a center turn lane. If no sidewalks exist along the roadway, these should be added. If sidewalks exist, and there is adequate room, a landscaped buffer is desirable to separate pedestrians from the travel lane.

A typical three-lane configuration consisting of two travel lanes and a two-way left-turn lane (TWLTL) also has advantages for motorists. Through traffic can maintain a fairly constant speed, while left-turning drivers can exit the traffic stream and wait in the TWLTL. However, TWLTLs can also create problems for opposing left-turn vehicles and may be used as acceleration lanes by some motorists. Designs that incorporate raised medians and left-turn bays may offer a better solution.

11. DRIVEWAY IMPROVEMENTS

Several driveway designs may cause safety and access problems for pedestrians, including excessively wide and/or sloped driveways, driveways with large turning radii, multiple adjacent driveways, driveways that are not well defined, and driveways where motorist attention is focused on finding a gap in congested traffic. In addition, driveways without a level sidewalk landing may not comply with ADA standards. Refer to Chapter 5 in *Designing Sidewalks and Trails for Access, Part II of II: Best Practices Design Guide* for further guidance.



PHOTOS BY PETER LAGERWEY

The top example shows a driveway with a wide apron to accommodate two adjacent driveways and a landscaped planting strip. The driveway in the lower picture demonstrates how to provide driveway access across a sidewalk while maintaining a continuous, level walkway for pedestrians.

Examples of driveway improvements include narrowing or closing driveways, tightening turning radii, converting driveways to right-in only or right-out only movements, and providing median dividers on wide driveways.

When driveways cross sidewalks, it is necessary to maintain a sidewalk level across the driveway of no more than 2 percent sideslope (see sketch). This is more usable for all pedestrians, especially those in wheelchairs, and makes it clear to motorists that they must watch for pedestrians. It is important to minimize large signs and bushes at driveways to improve the visibility between motorists and pedestrians. The sidewalk material (usually concrete) should be maintained across the driveway as well.

Purpose

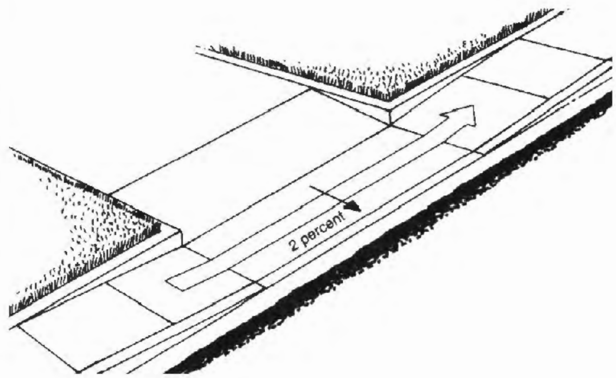
- Reduce pedestrian/motor vehicle conflicts.
- Improve access for people with disabilities.
- Improve visibility between cars and pedestrians at driveways.

Considerations

- It is best to properly design and consolidate driveways at the outset. Local regulations can require appropriate design when driveways are created.

Estimated Cost

No additional cost if part of original construction.



Adapted from *Designing Sidewalks and Trails for Access, Part II of II*, Washington, DC, 2001

12. RAISED MEDIANS

Medians are raised barriers in the center portion of the street or roadway that can serve as a place of refuge for pedestrians who cross a street midblock or at an intersection location. They may provide space for trees and other landscaping that, in turn, can help change the character of a street and reduce speeds. They also have benefits for motorist safety when they replace center turn lanes. Desired turning movements need to be carefully provided so that motorists are not forced to travel on inappropriate routes, such as residential streets, or make unsafe U-turns.

PHOTO BY DAN BURDEN

This attractive median provides curb ramps and median openings for wheelchair users.

Continuous medians may not be the most appropriate treatment in every situation. In some cases, separating opposing traffic flow and eliminating left-turn friction can increase traffic speeds by decreasing the perceived friction of the roadway. They may also take up space that can be better used for wider sidewalks, bicycle lanes, landscaping buffer strips, or on-street parking and may cause problems for emergency vehicles. In some environments, medians can be constructed in sections, creating an intermittent rather than continuous median. Another good alternative device for two-, three- or four-lane roads is the crossing island, which provides a crossing refuge for pedestrians and, in some designs, aids in decreasing vehicle speeds.

Raised medians are most useful on high-volume, high-speed roads, and they should be designed to provide tactile cues for pedestrians with visual impairments to indicate the border between the pedestrian refuge area and the motorized vehicle roadway. Examples of good and bad designs for raised median crossings can be found in Chapter 8 of *Designing Sidewalks and Trails for Access: Part II of II: Best Practices Design Guide.*[1]

Purpose

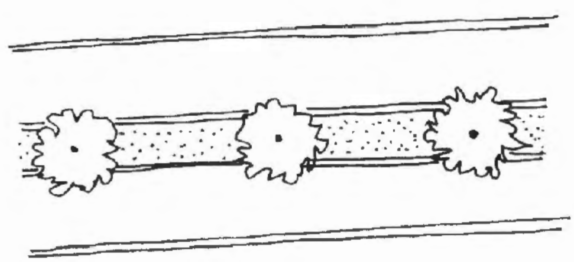
- Manage motor vehicle traffic and provide comfortable left-hand turning pockets with fewer or narrower lanes.
- Provide a refuge for pedestrians crossing the street.
- Provide space for street trees and other landscaping.

Considerations

- Ensure that there is enough room for wider sidewalks, bike lanes, and planting strips before proceeding with construction.
- Landscaping in medians should not obstruct the visibility between pedestrians and approaching motorists.
- Median crossings at midblock and intersection locations must be fully accessible by means of ramps or cut-throughs, with detectable warnings.

Estimated Cost

The cost for adding a raised median is approximately $15,000 to $30,000 per 30 m ($15,000 to $30,000 per 100 ft), depending on the design, site conditions, and whether the median can be added as part of a utility improvement or other street construction project.



Adapted from *Making Streets That Work*, Seattle, 1996

13. ONE-WAY / TWO-WAY STREET CONVERSIONS

One-way streets can simplify crossings for pedestrians, who must look for traffic in only one direction. While studies have shown that conversion of two-way streets to one-way generally reduces pedestrian crashes, one-way streets tend to have higher speeds, which creates new problems. If a street is converted to one-way, it should be evaluated to see if additional changes should be made, especially if the street or lanes are overly wide. Also, traffic circulation in the surrounding area must be carefully considered before conversion to one-way streets.

PHOTO BY CARA SEIDERMAN

Cars are forced to drive slowly on this two-way street with parking.

As a system, one-way streets can increase travel distances of motorists and bicyclists and can create confusion, especially for non-local residents. One-way streets operate best in pairs, separated by no more than 0.4 km (0.25 mi). Conversion costs can be quite high to build crossovers where the one-way streets convert back to two-way streets, and to rebuild traffic signals and revise striping, signing, and parking meters.

One-way streets work best in downtown or very heavily congested areas. One-way streets can offer improved signal timing and accommodate odd-spaced signals; however, signal timing for arterials that cross a one-way street pair is difficult.

Conversions can go the other way as well: some places are returning one-way streets back to two-way to allow better local access to businesses and homes and to slow traffic. Two-way streets tend to be slower due to "friction," especially on residential streets without a marked center line, and they may also eliminate the potential for multiple-threat crashes that exists on multi-lane, one-way streets.

Purpose

- Manage traffic patterns.
- Reduce conflicts.
- A one-way to two-way conversion will generally reduce speeds.

Considerations

- Consider impacts on other streets.
- Be aware that one-way streets may decrease automobile accessibility to businesses.
- Be careful not to create speeding problems where a two-way street is changed to a one-way street. Redesign or traffic-calming measures may be required to address this.
- Will improve signal synchronization on the one-way streets, but will hinder synchronization on cross-streets.
- Generally requires a one-way pair, with two nearby streets being converted to one-way.

Estimated Cost

$12,400 to $124,000 per kilometer ($20,000 to $200,000 per mile), depending on length of treatment and whether the conversion requires modification to signals. If crossovers are needed at the end points of the one-way streets, they may cost millions of dollars.

14. CURB RADIUS REDUCTION

One of the common pedestrian crash types involves a pedestrian who is struck by a right-turning vehicle at an intersection. A wide curb radius typically results in high-speed turning movements by motorists. Reconstructing the turning radius to a tighter turn will reduce turning speeds, shorten the crossing distance for pedestrians, and also improve sight distance between pedestrians and motorists.

PHOTO BY DAN BURDEN

Tight corner radii keep turning vehicle speeds down and minimize crossing distances for pedestrians.

Nearby land uses and types of road users should be considered when designing an intersection so that curb radii are sized appropriately. If a curb radius is made too small, large trucks or buses may ride over the curb, placing pedestrians in danger.

Where there is a parking and/or bicycle lane, curb radii can be even tighter, because the vehicles will have more room to negotiate the turn. Curb radii can, in fact, be tighter than any modern guide would allow: older cities in the Northeast and in Europe frequently have radii of 0.6 to 1.5 m (2 to 5 ft) without suffering any detrimental effects.

More typically, in new construction, the appropriate turning radius is about 4.6 m (15 ft) and about 7.6 m (25 ft) for arterial streets with a substantial volume of turning buses and/or trucks. Tighter turning radii are particularly important where streets intersect at a skew. While the corner characterized by an acute angle may require a slightly larger radius to accommodate the turn moves, the corner with an obtuse angle should be kept very tight, to prevent high-speed turns.

Purpose

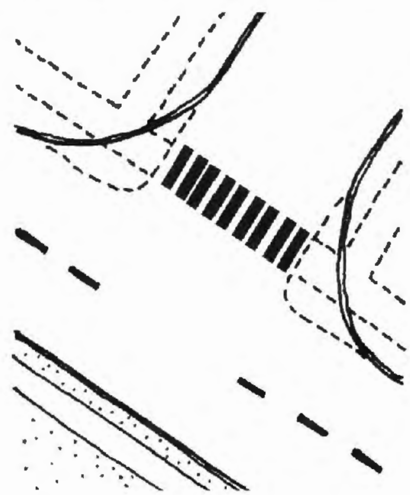
- Safer intersection design.
- Slow right-turning vehicles.
- Reduce crossing distances, improve visibility between drivers and pedestrians, and provide space for accessible curb ramps.
- Shorter crossing distances can lead to improved signal timing.

Considerations

- Consider effective radii by taking into account parking and bicycle lanes.
- Make sure that public maintenance vehicles, school buses, and emergency vehicles are accommodated.
- Large trucks and buses may ride over the curb at intersections with tight radii, creating a danger for pedestrians who are waiting to cross.

Estimated Cost

Construction costs for reconstructing a tighter turning radii are approximately $2,000 to $20,000 per corner, depending on site conditions (e.g., drainage and utilities may need to be relocated).



Adapted from *Making Streets That Work*, Seattle, 1996

15. IMPROVED RIGHT-TURN SLIP-LANE DESIGN

Intersections should be designed to accommodate safe pedestrian crossings using tight curb radii, shorter crossing distances, and other tools as described in this document. While right-turn slip lanes are generally a negative facility from the pedestrian perspective due to the emphasis on easy and fast motor vehicle travel, they can be designed to be less problematic. At many arterial street intersections, pedestrians have difficulty crossing due to right-turn movements and wide crossing distances. Well-designed right-turn slip lanes provide pedestrian crossing islands within the intersection and a right-turn lane that is designed to optimize the right-turning motorist's view of the pedestrian and of vehicles to his or her left. Pedestrians are able to cross the right-turn lane and wait on the refuge island for their walk signal.

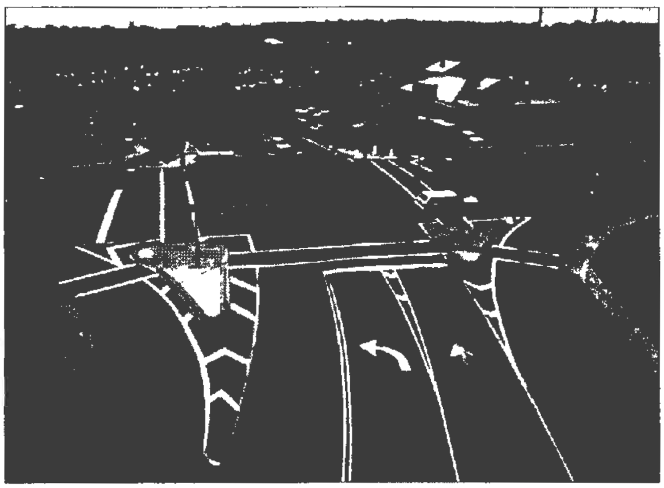


PHOTO BY DAN BURDEN

A slip lane designed at the proper angle, as shown on the right side of intersection, provides the driver with greater visibility of pedestrians. The lane on the left creates a higher speed, lower visibility right turn.

Purpose

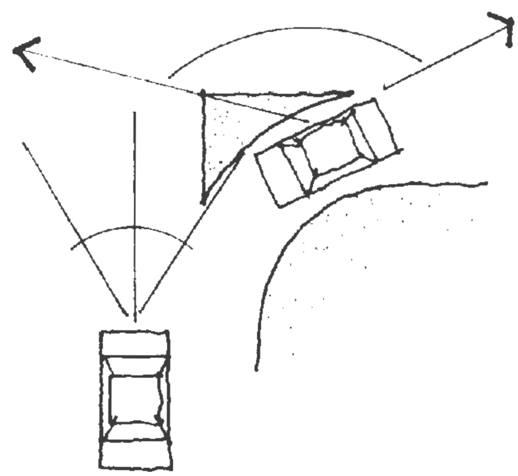
- Separate right-turning traffic.
- Slow turning-vehicle speeds and improve safety.
- Allow drivers to see approaching cross-street traffic more clearly.
- Reduce the crossing distance for pedestrians.

Considerations

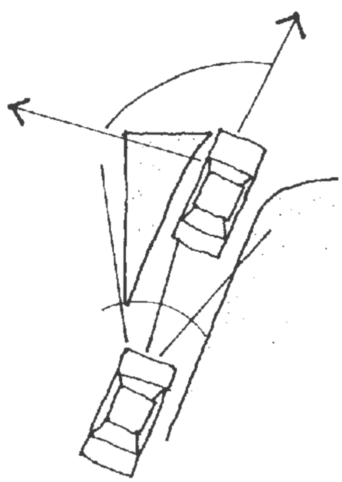
- Evaluate first whether a slip lane is really necessary.

Estimated Cost

Approximately $50,000 to $200,000 to reconfigure roadway, add striping and construct an island, assuming additional right-of-way is not required.



High speed, low visibility, head turner.
Current AASHTO standard.



14 to 18 mi/h, good visibility. Recommended design
1mi/h = 1.61 km/h.

SKETCHES BY MICHAEL KIMELBERG

The problem for pedestrians is that many slip lanes are designed for unimpeded vehicular movement. The design of corner islands, lane width, and curb radii of right-turn slip lanes should discourage high-speed turns, while accommodating large trucks and buses. The triangular "porkchop" corner island that results should have the "tail" pointing to approaching traffic. Since the traffic signal is timed based on a shorter crossing, the pedestrian crossing time has a much smaller influence on the timing of the signal. This design has an additional advantage for the pedestrian; the crosswalk is located in an area where the driver is still looking ahead. Older designs place the crosswalk too far down, where the driver is already looking left for a break in the traffic.

Channelized right turn-lanes remain a challenge for visually-impaired pedestrians. First, there are difficulties associated with knowing where the crosswalk is located or knowing where to cross. Second, it is difficult for a pedestrian who is visually-impaired to know when a vehicle has yielded right-of way. While accessible pedestrian signals can help with these issues, more research is currently underway through the National Cooperative Highway Research Program (NCHRP) to further explore the problem and develop potential solutions. Refer to NCHRP Project 3-78, Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities (at www4.trb.org/trb/crp.nsf/NCHRP+projects) for the latest status report.

INTERSECTION DESIGN


PHOTO BY DAN BURDEN

There are several countermeasures that are specifically aimed at improving intersection safety and mobility, including many of those described in the sections on roadway design and traffic calming. The countermeasures included in this section are as follows:

- Roundabouts
- Modified T-Intersections
- Intersection Median Barriers

16. ROUNDABOUTS

A roundabout is a circular intersection that eliminates some of the conflict traffic, such as left turns, that causes crashes at traditional intersections. Traffic maneuvers around the circle in a counterclockwise direction, and then turns right onto the desired street. All traffic yields to motorists in the roundabout and left-turn movements are eliminated. Unlike a signalized intersection, vehicles generally flow and merge through the roundabout from each approaching street without having to stop.

PHOTO BY DAN BURDEN

This Fort Pierce, Florida, roundabout is being constructed to reduce speeding, improve safety, and enhance the aesthetics of the community.

Roundabouts need to accommodate pedestrians and bicyclists. It is important that automobile traffic yields to pedestrians crossing the roundabout. Splitter islands at the approaches slow vehicles and allow pedestrians to cross one direction of travel at a time. Single-lane approaches can be designed to keep speeds down to safer levels and allow pedestrians to cross. Multilane approaches can create multiple threats for pedestrians and are not recommended.

Wayfinding and gap selection cues need to be adequately addressed in the design of roundabouts so that roundabouts are not a barrier to pedestrians with vision impairments. One possible solution is the use of accessible pedestrian signals placed on sidewalks and splitter islands to indicate both where to cross and when to cross. More research is currently underway through the National Cooperative Highway Research Program (NCHRP) to further explore the problem and develop potential solutions. Refer to NCHRP Project 3-78, Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities (at www4.trb.org/trb/crp.nsf/NCHRP+projects) for the latest status report.

Purpose

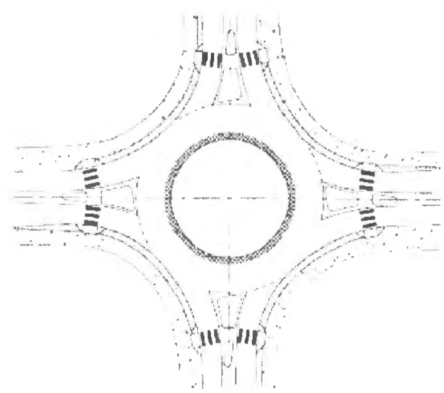
- Improve safety at intersections experiencing a large number of angle collisions.
- Convert signalized intersection to improve traffic flow efficiency.
- Reduce speeds at intersection.
- Create a gateway into an area.

Considerations

- Street widths and/or available right-of-way need to be sufficient to accommodate a properly designed roundabout.
- Roundabouts have a mixed record regarding pedestrian and bicyclist safety—a low design speed is required.
- Roundabouts are generally not appropriate for the intersection of two multilane roads.
- Roundabouts often work best where the traffic flows are balanced on all approaches.
- Deflection on each leg of the intersection must be set to control speeds to 24-29 km/h (15-18 mi/h).

Estimated Cost

The cost for a landscaped roundabout varies widely and can range from $45,000 to $150,000 for neighborhood intersections and up to $250,000 for arterial street intersections, not including additional right-of-way acquisition. Yet, roundabouts have lower ongoing maintenance costs than traffic signals.



SKETCH BY MICHAEL KIMELBERG

Bicyclists also may be disadvantaged by roundabout design. Unless the road is narrow (one lane in each direction), speeds are slow, and traffic very light, bicyclists may not be able to share the road comfortably. Marking bicycle lanes through the roundabout has not been shown to be safer. In larger roundabouts, an off-road bicycle path may be necessary to allow cyclists to use the pedestrian route. This is inconvenient and takes longer but it will improve safety. Refer to the FHWA report *Roundabouts, An Informational Guide* (online at http://www.tfhrc.gov/safety/00068.htm) for more information related to the design of facilities for both pedestrians and bicyclists.

17. MODIFIED T-INTERSECTIONS

This design treatment is intended for certain T-intersections on lower-volume streets in residential areas where there is a need to reduce the speeds of through traffic. It involves a gradual curb extension or bulb at the top of the T, such that vehicles are deflected slightly as they pass straight through the intersection (see diagram). This type of design can help to discourage cut-through traffic in a neighborhood and can reduce speeds at the intersection. If not properly designed, it can create confusion regarding priority of movement. Consider a mini-circle before installing this treatment.

PHOTO BY DAN BURDEN

This modified T-intersection in Portland, Oregon, is intended to reduce speeds of through traffic as well as restrict left-turning vehicles.

Purpose

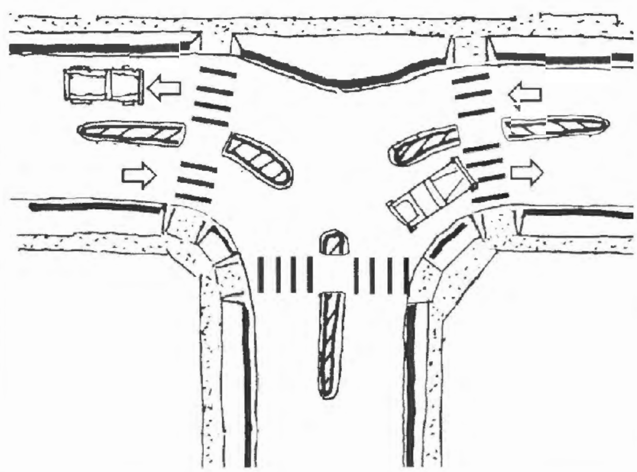
- Reduce vehicle speeds through a T-intersection on a low-volume street.

Considerations

- Used when vehicle volumes are low to moderate.
- A mini-traffic circle may accomplish the same objective and may be less costly and confusing.
- If designed to eliminate some turning movements, the affected neighborhood residents should be consulted for input and an analysis of traffic patterns done to ensure that through traffic would not be diverted inappropriately.
- Pedestrian and bicycle access must be accommodated through the island.

Estimated Cost

$20,000 to $60,000, depending on the design and whether drainage and utilities need to be relocated.



18. INTERSECTION MEDIAN BARRIERS

This shortened version of a raised curb median extends through the intersection to prevent cross-street through movements and left turning movements to cross-streets from the main street.


PHOTO BY DAN BURDEN

Intersection median barriers need to keep walking and bicycling flowing freely through the neighborhood.

This treatment can benefit pedestrians who need to cross any leg of the intersection, but restricts vehicle entry into and out of neighborhoods and can therefore greatly reduce cut-through traffic. However, since this treatment can dramatically influence traffic patterns and have potentially negative consequences caused by shifting traffic, it should be used cautiously. Crossing islands can provide benefits to pedestrians if that is the desire. This is also a traffic management technique.

Cut-throughs must be incorporated into the design for pedestrian and bicyclist use.

Purpose

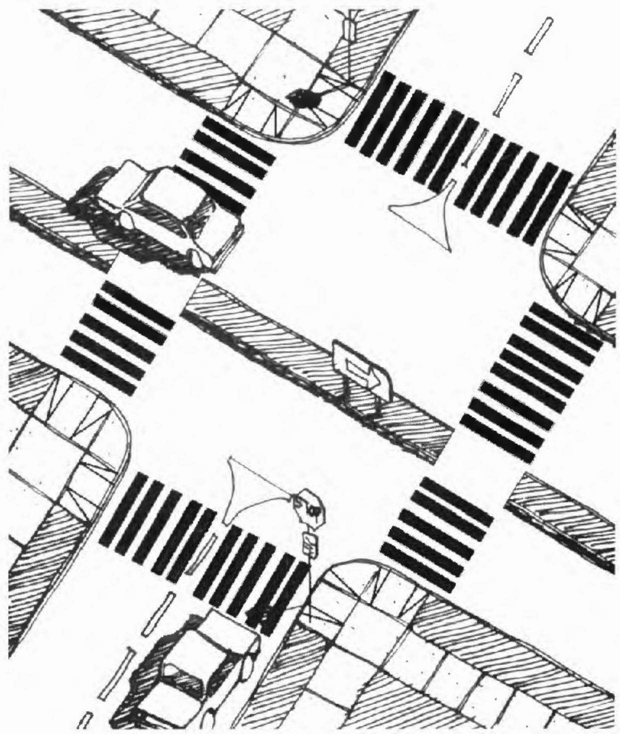
- Reduce cut-through traffic on a neighborhood street.

Considerations

- Local residents need to be provided access so they do not have to drive excessive distances to their homes.
- An analysis of traffic patterns should be done to ensure that cut-through traffic would not be diverted to a nearby street.
- Design should ensure safe and convenient bicycle and pedestrian access.
- Ensure that emergency access is not negatively impacted. Some designs (e.g., high mountable curbs) may allow fire truck access, while inhibiting cars.

Estimated Cost

$10,000 to $20,000.



TRAFFIC CALMING

Traffic calming is a way to design streets, using physical measures, to encourage people to drive more slowly. It creates physical and visual cues that induce drivers to travel at slower speeds. Traffic calming is self-enforcing. The design of the roadway results in the desired effect, without relying on compliance with traffic control devices such as signals, signs, and without enforcement. While elements such as landscaping and lighting do not force a change in driver behavior, they can provide the visual cues that encourage people to drive more slowly.

PHOTO BY DAN BURDEN

The reason traffic calming is such a powerful and compelling tool is that it has proven to be so effective. Some of the effects of traffic calming, such as fewer and less severe crashes, are clearly measurable. Others, such as supporting community livability, are less tangible, but equally important.

Experience throughout Europe, Australia, and North America has shown that traffic calming, if done correctly, reduces traffic speeds, the number and severity of crashes, and noise level. Research on traffic-calming projects in the United States supports their effectiveness at decreasing automobile speeds, reducing the numbers of crashes, and reducing noise levels for specific contexts. Looking at a sample of various speed studies shows that typical speed reductions of 5 to 20 percent at the 85th percentile speed can be realized by the use of traffic-calming measures—including speed tables, mini-circles, speed humps, and other standard traffic-calming devices.[1] Use of several of the traffic-calming measures have also resulted in substantial reductions in motor vehicle crashes. For example, the implementation of traffic mini-circles in Seattle has resulted in a reduction of approximately 80 percent of intersection accidents.[1]

PHOTO BY DAN BURDEN

There are certain overall considerations that are applicable to both traffic management and traffic calming:

- Vehicle speed is more critical than volume in terms of safety and should be addressed first where there are monetary constraints.
- Neighborhood involvement is important to successful implementation. Rationale for traffic-calming and management measures should be explained clearly to community residents and installation of these treatments should incorporate public input. Please see Chapter 7: Implementation and Resources for a discussion of public process.

PHOTO BY CARA SEIDERMAN

- Traffic-calming and management measures should fit into, and preferably enhance, the street environment.
- Traffic-calming designs should be predictable and easy to understand by drivers and other users.
- Devices that meet multiple goals are usually more acceptable. For example, a raised crosswalk may be more understandable to motorists than a speed hump. The former has a clear goal, whereas the latter may be perceived as a nuisance.

PHOTO BY PETER LAGERWEY

This midblock crossing is in Kalamazoo, Michigan. The landscaping and textured crosswalk are visually appealing and provide a clear message about where pedestrians can be expected to cross the street.

- Treatments need to be well designed and based on current available information on their applications and effects. Information on U.S. experiences with various traffic-calming measures can be found in ITE's *Traffic Calming: State of the Practice.*[1]
- Devices should accommodate emergency vehicles.
- Traffic-calming areas or facilities should be adequately signed, marked, and lit to be visible to motorists.
- Treatments need to be spaced appropriately to have the desired effect on speed—too far apart and they will have a limited effect, too close and they will be an unnecessary cost and annoyance. Devices usually need to be spaced about 91 to 152 m (300 to 500 ft) apart. If they are spaced too far apart, motorists may speed up between them. This is particularly the case where the devices are added onto the street (e.g., speed humps). Whole street designs are usually able to create an environment that supports slower speeds for the entire length.
- Facilities should not be underdesigned or they will not work. Keeping the slopes too gradual for a speed table or curves too gentle for a chicane will not solve the problem and will appear as a waste of money and may ruin chances for future projects.
- Traffic-calming measures should accommodate bicyclists and pedestrians with disabilities.
- If a measure is likely to divert traffic onto another local street, the areawide street system should be considered so as not to shift the problem from one place to another.
- Devices should be thought of as elements of a traffic-calming system and be placed to improve pedestrian conditions throughout an area.

Traffic calming treatments may be used in combination and are often most effective this way. The 14 traffic calming countermeasures in this guide include:

- Curb Extensions
- Chokers
- Crossing Islands
- Chicanes
- Mini-Circles
- Speed Humps
- Speed Tables
- Raised Intersections
- Raised Pedestrian Crossings
- Gateways
- Landscaping
- Specific Paving Treatments
- Serpentine Design
- Woonerf

PHOTO BY DAN BURDEN

Traffic-calming improvements need to include input from and coordination with neighborhoods that are impacted.

TRIALS AND TEMPORARY INSTALLATIONS FOR TRAFFIC CALMING

In communities trying traffic calming for the first time, it may be useful to lay out a new design with cones or temporary markings to test it. This provides emergency vehicle drivers, residents, and others with an opportunity to test the design to ensure that they are comfortable with it. Some communities have constructed elaborate temporary devices with concrete or plastic ("jersey") barriers. These can instill a negative reaction in the community due to their unaesthetic appearance and they do not generally have any significant benefits over the simpler test devices. Another option is to install more aesthetic test devices, such as painted flexible curbs that are bolted into the pavement and can easily be adjusted or removed.

19. CURB EXTENSIONS

Curb extensions—also known as bulb-outs or neck-downs—extend the sidewalk or curb line out into the parking lane, which reduces the effective street width. Curb extensions significantly improve pedestrian crossings by reducing the pedestrian crossing distance, visually and physically narrowing the roadway, improving the ability of pedestrians and motorists to see each other, and reducing the time that pedestrians are in the street.

PHOTO BY DAN BURDEN

This curb extension in Venice, Florida, reduced motorist turning speeds by 9.7 to 12.9 km/h (6 to 8 mi/h). Pedestrian crossing distance and time exposed to traffic was also reduced.

Curb extensions placed at an intersection essentially prevent motorists from parking in or too close to a crosswalk or from blocking a curb ramp or crosswalk. Motor vehicles parked too close to corners present a threat to pedestrian safety, since they block sightlines, obscure visibility of pedestrians and other vehicles, and make turning particularly difficult for emergency vehicles and

PHOTO BY PETER LAGERWEY

A curb extension on an arterial street in Seattle, Washington. The crossing distance for pedestrians is substantially reduced by the installation of this device. The extension is limited to 1.8 m (6 ft) to allow bicyclists to pass safely.

Purpose

- Improve safety for pedestrians and motorists at intersections.
- Increase visibility and reduce speed of turning vehicles.
- Encourage pedestrians to cross at designated locations.
- Prevent motor vehicles from parking at corners.
- Shorten crossing distance and reduce pedestrian exposure.

Considerations

- Curb extensions can provide adequate space on narrow sidewalks for curb ramps and landings.
- Curb extensions should only be used where there is a parking lane, and where transit and bicyclists would be traveling outside the curb edge for the length of the street.
- Midblock extensions provide an opportunity to enhance midblock crossings. Care should be taken to ensure that street furniture and landscaping do not block motorists' views of pedestrians.
- Where intersections are used by significant numbers of trucks or buses, the curb extensions need to be designed to accommodate them. However, it is important to take into consideration that those vehicles should not be going at high speeds, and most can make a tight turn at slow speeds.
- It is not necessary for a roadway to be designed so that a vehicle can turn from a curb lane to a curb lane. Vehicles can often encroach into adjacent lanes safely where volumes are low and/or speeds are slow. Speeds should be slower in a pedestrian environment.
- Emergency access is often improved through the use of curb extensions if intersections are kept clear of parked cars. Fire engines and other emergency vehicles can climb a curb where they would not be able to move a parked car. At midblock locations, curb extensions can keep fire hydrants clear of parked cars and make them more accessible.
- Curb extensions can create additional space for curb ramps, landscaping, and street furniture that are sensitive to motorist and pedestrian sightlines; this is especially beneficial where sidewalks are otherwise too narrow.
- Ensure that curb extension design facilitates adequate drainage.

PHOTO BY PETER LAGERWEY

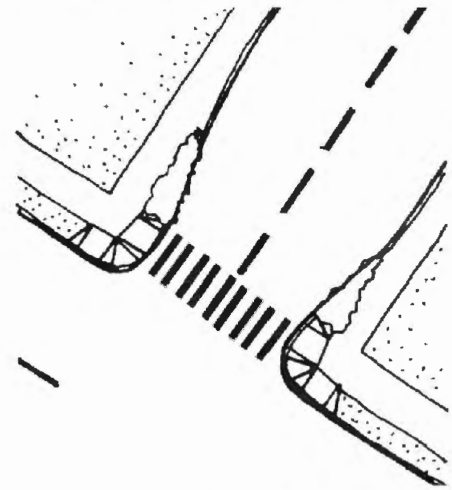
A curb extension on a residential street in Seattle, Washington. In addition to improving pedestrian safety at this intersection, the extension provides additional sidewalk space for a bicycle rack and accessible curb ramp.

trucks. Motorists are encouraged to travel more slowly at intersections or midblock locations with curb extensions, as the restricted street width sends a visual cue to motorists. Turning speeds at intersections can be reduced with curb extensions (curb radii should be as tight as is practicable). Curb extensions also provide additional space for curb ramps and for level sidewalks where existing space is limited.

Curb extensions are only appropriate where there is an on-street parking lane. Curb extensions must not extend into travel lanes, bicycle lanes, or shoulders (curb extensions should not extend more than 1.8 m (6 ft) from the curb). The turning needs of larger vehicles, such as school buses, need to be considered in curb extension design.

Estimated Cost

Curb extensions cost from $2,000 to $20,000 per corner, depending on design and site conditions. Drainage is usually the most significant determinant of cost. If the curb extension area is large and special pavement and street furnishings and planting are included, costs would also be higher. Costs can go up significantly if something major, such as a utility pole or controller box, is moved.



Adapted from *Making Streets That Work*, Seattle, 1996

20. CHOKERS

Chokers are curb extensions that narrow a street by widening the sidewalks or planting strips, effectively creating a pinch point along the street. Chokers can be created by bringing both curbs in, or they can be done by more dramatically widening one side at a midblock location. They can also be used at intersections, creating a gateway effect when entering a street.

PHOTO BY MICHAEL KING

This choker narrows the street from two lanes to one. Traffic is forced to slow down and, in some cases, wait for an approaching vehicle to pass before proceeding.

Chokers can have a dramatic effect by reducing a two-lane street to one lane at the choker point (or two narrow lanes), requiring motorists to yield to each other or slow down. In order for this to function effectively, the width of the travelway cannot be wide enough for two cars to pass: 4.9 m (16 ft) is generally effective (and will allow emergency vehicles to pass unimpeded). This kind of design is usually only appropriate for low-volume, low-speed streets.

Purpose

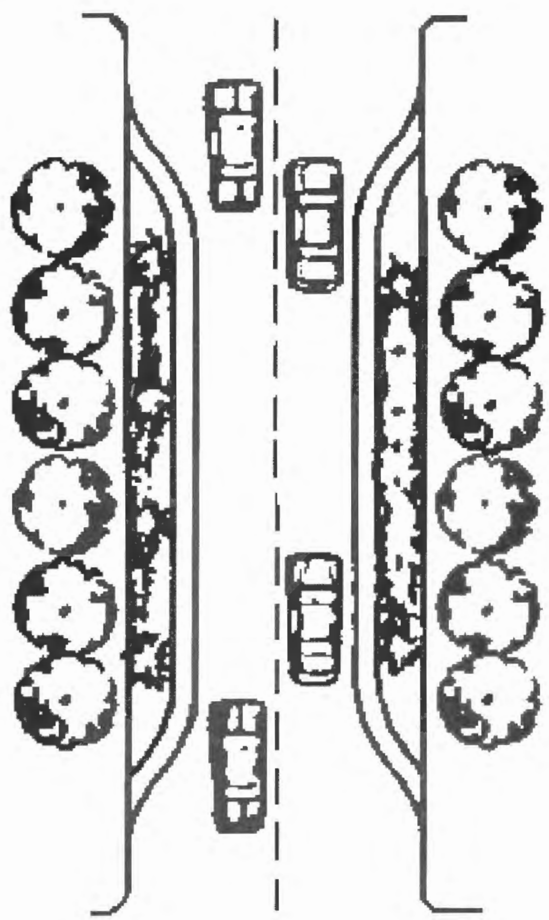
- Slow vehicles at a mid-point along the street.
- Create a clear transition between a commercial and a residential area.
- Narrow overly wide intersections and midblock areas of streets.
- Add room along the sidewalk or planting strip for landscaping or street furniture.

Considerations

- If two travel lanes are maintained on a two-way street and/or the travel-lane widths are unchanged (at the location of the choker), it will have a minimal effect on speed.
- Consult with local fire and sanitation departments before setting minimum width.
- Ensure that bicyclist safety and mobility are not diminished.

Estimated Cost

$5,000 to $20,000, depending on site conditions and landscaping. Drainage may represent a significant cost.



Adapted from *Making Streets That Work*, Seattle, 1996

21. CROSSING ISLANDS

Crossing islands—also known as center islands, refuge islands, pedestrian islands, or median slow points—are raised islands placed in the center of the street at intersections or midblock to help protect crossing pedestrians from motor vehicles. Center crossing islands allow pedestrians to deal with only one direction of traffic at a time, and they enable them to stop partway across the street and wait for an adequate gap in traffic before crossing the second half of the street. Where midblock or intersection crosswalks are installed at uncontrolled locations (i.e., where no traffic signals or stop signs exist), crossing islands should be considered as a supplement to the crosswalk. They are also appropriate at signalized crossings. If there is enough width, center crossing islands and curb extensions can be used together to create a highly improved pedestrian crossing. Detectable warnings are needed at cut-throughs to identify the pedestrian refuge area.

PHOTO BY DAN BURDEN

Crossing islands allow pedestrians to be concerned with one direction of traffic at a time. The roadway markings in the design shown here also help make motorists aware that a pedestrian may be crossing.

This kind of facility has been demonstrated to significantly decrease the percentage of pedestrian crashes.[2] The factors contributing to pedestrian safety include reduced conflicts, reduced vehicle speeds approaching the island (the approach can be designed to force a greater slowing of cars, depending on how dramatic the curvature is), greater attention called to the existence of a pedestrian crossing, opportunities for additional signs in the middle of the road, and reduced exposure time for pedestrians.

Curb extensions may be built in conjunction with center crossing islands where there is on-street parking. Care should be taken to maintain bicycle access. Bicycle lanes (or shoulders, or whatever space is being used for bicycle travel) must not be eliminated or squeezed in order to create the curb extensions or islands.

Purpose

- Enhance pedestrian crossings, particularly at unsignalized crossing points.
- Reduce vehicle speeds approaching pedestrian crossings.
- Highlight pedestrian crossings.

Considerations

- Do not squeeze bicycle access.
- Illuminate or highlight islands with street lights, signs, and/or reflectors to ensure that motorists see them.
- Design islands to accommodate pedestrians in wheelchairs. A cut-through design such as depicted in the photo must include detectable warnings (see figure on p. 53).
- Crossing islands at intersections or near driveways may affect left-turn access.

Estimated Cost

Costs range from $4,000 to $30,000. The cost for an asphalt island or one without landscaping is less than the cost of installing a raised concrete pedestrian island with landscaping.

PHOTO BY DAN BURDEN

22. CHICANES

Chicanes create a horizontal diversion of traffic and can be gentler or more restrictive depending on the design.

Diverting the Path of Travel. Shifting a travel lane has an effect on speeds as long as the taper is not so gradual that motorists can maintain speeds. For traffic calming, the taper lengths may be as much as half of what is suggested in traditional highway engineering.

Shifts in travelways can be created by shifting parking from one side to the other (if there is only space for one side of parking) or by building landscaped islands (islands can also effectively supplement the parking shift).

PHOTO BY PETER LAGERWAY

The chicanes pictured above narrow this residential street to one lane and require traffic to move slowly.

Diversion Plus Restriction (Angled Slow Points). Diverting the path of travel plus restricting the lanes (as described under "Chokers") usually consists of a series of curb extensions, narrowing the street to two narrow lanes or one lane at selected points and forcing motorists to slow down to maneuver between them. Such treatments are intended for use only on residential streets with low traffic volumes.

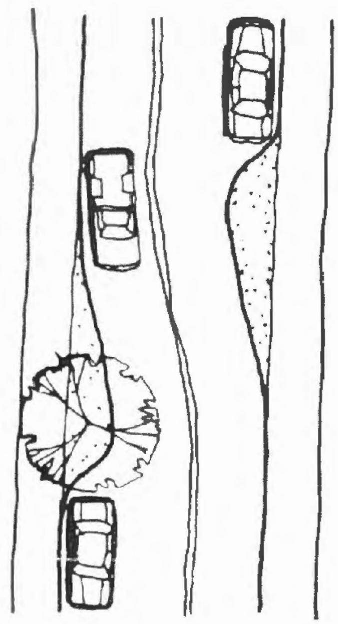
If there is no restriction (i.e., the number of lanes is maintained), chicanes can be created on streets with higher volumes, such as collectors or minor arterials.

Purpose
- Reduce vehicle speeds.
- Add more green (landscaping) to a street.

Considerations
- Chicanes may reduce on-street parking.
- Maintain good visibility by planting only low shrubs or trees with high canopies.
- Ensure that bicyclist safety and mobility are not diminished.

Estimated Cost

Costs for landscaped chicanes are approximately $10,000 (for a set of three chicanes) on an asphalt street and $15,000 to $30,000 on a concrete street. Drainage and utility relocation often represents the most significant cost consideration.



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23. MINI-CIRCLES

Mini-circles are raised circular islands constructed in the center of residential street intersections (generally not intended for use where one or both streets are arterial streets). They reduce vehicle speeds by forcing motorists to maneuver around them. Mini-circles have been found to reduce motor vehicle crashes by an average of 90 percent in Seattle, WA.[3] Drivers making left turns are directed to go on the far side of the circle (see diagram at right) prior to making the turn. Signs should be installed directing motorists to proceed around the right side of the circle before passing through or making a left turn. Mini-circles are commonly landscaped (bushes, flowers, or grass), most often at locations where the neighborhood has agreed to maintain the plants. In locations where landscaping is not feasible, traffic circles can be enhanced through specific pavement materials.

PHOTO BY DAN BURDEN

A traffic mini-circle helps reduce vehicle speeds, but still allows cars and emergency vehicles to pass through the intersection with little difficulty.

Mini-circles are an intersection improvement as well as a traffic-calming device and can take the place of a signal or four-way stop sign. Many unwarranted four-way stop signs are installed because of the demand for action by the community.

Mini-circles must be properly designed to slow vehicles and benefit pedestrians and bicyclists. Right-turning vehicles are not controlled at an intersection with a mini-circle, potentially putting pedestrians and bicyclists at risk.

Therefore, tight curb radii should complement this treatment to discourage high-speed right-turn maneuvers. The occasional larger vehicle going through an intersection with a traffic circle (e.g., a fire truck or moving van) can be accommodated by creating a mountable curb in the outer portion of the circle.

Purpose

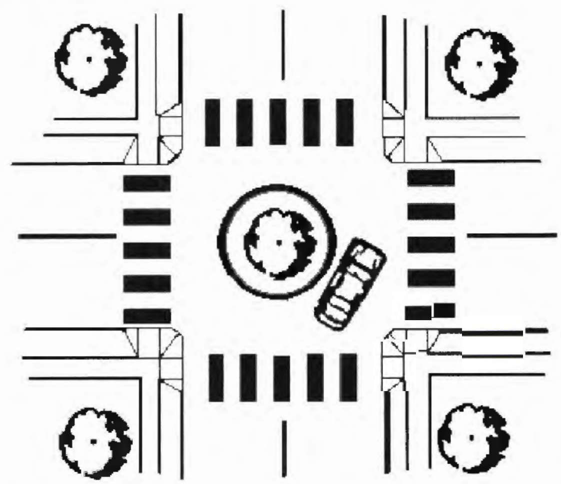
- Manage traffic at intersections where volumes do not warrant a stop sign or a signal.
- Reduce crash problems at the intersection of two local streets.
- Reduce vehicle speeds at the intersection.

Considerations

- Do not make generous allowances for motor vehicles by increasing the turning radii—this compromises pedestrian and bicyclist safety.
- Larger vehicles that need access to streets (e.g., school buses and fire engines) may need to make lefthand turns in front of the circle.
- Use yield, not stop, controls.
- Mini-circle landscaping should not impede the sight distance.
- Treat a series of intersections along a local street as part of a neighborhood traffic improvement program.

Estimated Cost

The cost is approximately $6,000 for a landscaped traffic mini-circle on an asphalt street and about $8,000 to $12,000 for a landscaped mini-circle on a concrete street.



Adapted from *Making Streets That Work*, Seattle, 1996

24. SPEED HUMPS

25. SPEED TABLES

Speed humps are paved (usually asphalt) and approximately 75 to 100 mm (3 to 4 in) high at their center, and extend the full width of the street with height tapering near the drain gutter to allow unimpeded bicycle travel. Speed humps should not be confused with the speed "bump" that is often found in mall parking lots. There are several designs for speed humps. The traditional 3.7-m (12-ft) hump has a design speed of 24 to 32 km/h (15 to 20 mi/h), a 4.3-m (14-ft) hump a few miles per hour higher, and a 6.7-m (22-ft) table has a design speed of 40 to 48 km/h (25 to 30 mi/h). The longer humps are much gentler for larger vehicles.

PHOTO BY SCOTT WAINWRIGHT

Speed humps are frequently used on some residential streets to reduce speeds. However, they can create unwanted noise if they are too severe, or cause motorists to slow down more than is necessary.

A "speed table" is a term used to describe a very long and broad speed hump, or a flat-topped speed hump, where sometimes a pedestrian crossing is provided in the flat portion of the speed table (see countermeasure #27). The speed table can either be parabolic, making it more like a speed hump, or trapezoidal, which is used more frequently in Europe. Speed tables can be used in combination with curb extensions where parking exists.

Purpose

- Reduce vehicle speeds. Raised measures tend to have the most predictable speed reduction impacts.
- Enhance the pedestrian environment at pedestrian crossings.

Considerations

- Do not use if on a sharp curve.
- If the street is a bus route or primary emergency route, the design must be coordinated with operators. Usually, some devices are acceptable if used prudently—one device may be appropriate and may serve the primary need (e.g., if there is a particular location along a street that is most in need of slowing traffic and improving pedestrian conditions).
- The aesthetics of speed humps and speed tables can be improved through the use of color and specialized paving materials.
- Noise may increase, particularly if trucks use the route regularly.
- May create drainage problems on some streets.
- Speed humps and tables should be properly designed and constructed to reduce the chance of back problems or other physical discomfort experienced by vehicle occupants. Tight tolerances are required during construction.

Estimated Cost

The cost for each speed hump is approximately $1,000. Speed tables are $2,000 to $15,000, depending on drainage conditions and materials used.

26. RAISED INTERSECTIONS

27. RAISED PEDESTRIAN CROSSINGS

A raised intersection is essentially a speed table (see photograph below) for the entire intersection. Construction involves providing ramps on each vehicle approach, which elevates the entire intersection to the level of the sidewalk. They can be built with a variety of materials, including asphalt, concrete, stamped concrete, or pavers. The crosswalks on each approach are also elevated as part of the treatment to enable pedestrians to cross the road at the same level as the sidewalk, eliminating the need for curb ramps. Use detectable warnings to mark the boundary between the sidewalk and the street.

PHOTO BY ITE PEDESTRIAN BICYCLE COUNCIL

A raised intersection slows all vehicular movements through the intersection and improves pedestrian crossings in all directions.

PHOTO BY DAN BURDEN

A raised pedestrian crossing provides a continuous route for the pedestrian at the same level as the sidewalk. Pavement markings may be used on the slope to make the crossing visible to motorists.

A raised pedestrian crossing is also essentially a speed table, with a flat portion the width of a crosswalk, usually 3.0 to 4.6 m (10 to 15 ft). Raised intersections and crosswalks encourage motorists to yield. On one street in Cambridge, MA, motorists yielding to pedestrians crossing at the raised devices went from approximately 10 percent before installation of the project to 55 percent after installation.[4]

Purpose

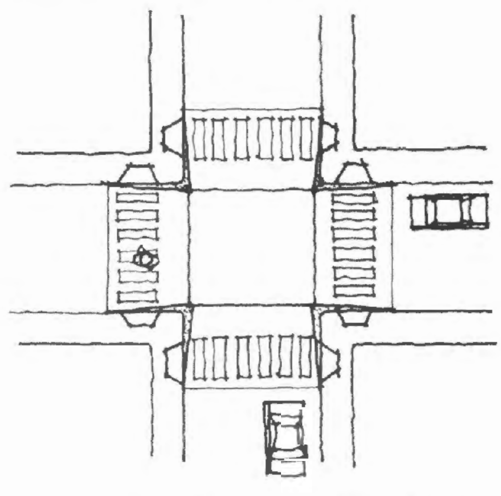
- Reduce vehicle speeds.
- Enhance the pedestrian environment at the crossings.

Considerations:

- Don't use if on a sharp curve or if the street is on a steep grade.
- May not be appropriate if the street is a bus route or emergency route. One device may be necessary and serve the primary need. Several raised devices may be disruptive, so other measures should be considered.
- Speed tables and raised crosswalks and intersections can be an urban design element through the use of special paving materials.
- Detectable warning strips at edges enable pedestrians with vision impairments to detect the crossing.
- Care must be taken to manage drainage.

Estimated Cost

Raised crosswalks are approximately $2,000 to $15,000, depending on drainage conditions and material used. The cost of a raised intersection is highly dependent on the size of the roads. They can cost from $25,000 to $75,000.



Adapted from *Making Streets That Work*, Seattle, 1996

28. GATEWAYS

A gateway is a physical or geometric landmark that indicates a change in environment from a higher speed arterial or collector road to a lower speed residential or commercial district. They often place a higher emphasis on

PHOTO BY DAN BURDEN

The combination of landscaping and a short median create a gateway to this neighborhood.

aesthetics and are frequently used to identify neighborhood and commercial areas within a larger urban setting. Gateways may be a combination of street narrowing, medians, signing, archways, roundabouts, or other identifiable feature. Gateways should send a clear message to motorists that they have reached a specific place and must reduce speeds. This can help achieve the goal of meeting expectations and preparing motorists for a different driving environment. Gateways are only an introduction and slower speeds are not likely to be maintained unless the entire area has been redesigned or other traffic-calming features are used.

Purpose

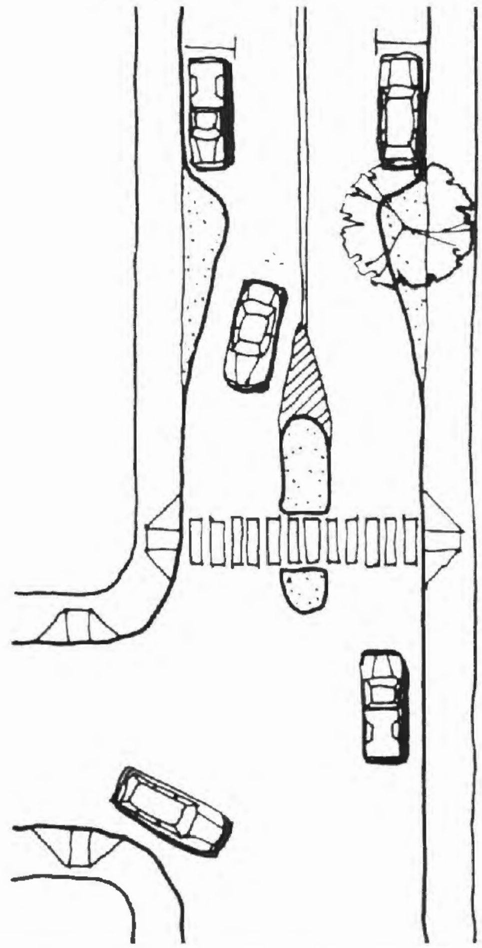
- Create an expectation for motorists to drive more slowly and watch for pedestrians when entering a commercial, business, or residential district from a higher speed roadway.
- Create a unique image for an area.

Considerations

- Traffic-slowing effects will depend upon the device chosen and the overall traffic-calming plan for the area.

Estimated Cost

Varies widely depending on the measures chosen.



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29. LANDSCAPING

The careful use of landscaping along a street can provide separation between motorists and pedestrians, reduce the visual width of the roadway (which can help to reduce vehicle speeds), and provide a more pleasant street environment for all. This can include a variety of trees, bushes, and/or flowerpots, which can be planted in the buffer area between the sidewalk or walkway and the street.


PHOTO BY DAN BURDEN

Landscaping with low shrubs, ground cover, and mature trees that are properly pruned can add shade, color, and visual interest to a street.

The most significant issue with any landscaping scheme is ongoing maintenance. Some communities have managed effectively by creating homeowners associations to pay for landscape maintenance or through the volunteer efforts of neighbors. Others have found them to be unreliable and budget for public maintenance instead. Consider adding irrigation systems in areas with extensive planting.

Choosing appropriate plants, providing adequate space for maturation, and preparing the ground can help ensure that they survive with minimal maintenance, and don't buckle the sidewalks as they mature. The following guidelines should be considered: plants should be adapted to the local climate and fit the character of the surrounding area—they should survive without protection or intensive irrigation; and plant's growth patterns should not obscure signs or pedestrians' and motorists' views of each other.

Purpose

- Enhance the street environment.
- Calm traffic by creating a visual narrowing of the roadway.

Considerations

- Maintenance must be considered and agreed to up-front, whether it is the municipality or the neighborhood residents who will take responsibility for maintenance.
- Shrubs should be low-growing and trees should be trimmed up to at least 2.4 to 3.0 m (8 to 10 ft) to ensure that sight distances and head room are maintained and personal security is not compromised.
- Plants and trees should be chosen with care to match the character of the area; be easily maintained; and not create other problems, such as buckling sidewalks.
- Minimum clear widths and heights, as specified in the *Draft Guidelines for Accessible Public Rights-of-Way*, must be maintained.

Estimated Cost

Opportunities for funding landscaping are often more flexible than for major street changes. For example, the cost of the actual landscaping may be paid for by the corresponding neighborhood or business groups. Often, municipalities will pay for the initial installation and homeowners associations, neighborhood residents, or businesses agree to maintain anything more elaborate than basic tree landscaping.

30. SPECIFIC PAVING TREATMENTS

Paving materials are important to the function and look of a street, both in the road and on the sidewalk. Occasionally, paving materials in and of themselves act as a traffic-calming device (e.g., when the street is paved in brick or cobblestone). However, some of these materials may be noisy and unfriendly to bicyclists, pedestrians, wheelchairs, or snowplow blades. In particular, cobblestones should not be used in the expected pedestrian or bicycle path, although they may be used as aesthetic elements in a streetscape design. Smooth travel surfaces are best for all pedestrians.

PHOTO BY CARA SEIDERMAN

Brick or cobblestone streets help slow traffic and create a feeling that the street is not a highway or fast-moving arterial.

The pedestrian walkway material should be firm, planar, and slip-resistant. Concrete is the preferred walking surface. A different look can be achieved by using stamped concrete or concrete pavers, which are available in a variety of colors and shapes; however, jointed surfaces may induce vibration, which can be painful to some pedestrians. They can also be used on the top of raised devices.

It is important to ensure crosswalk visibility. High visibility markings are often best. Textured crosswalks should be marked with reflective lines since these types of crosswalks are not as visible, especially at night or on rainy days.

Colored paving can often enhance the function of portions of the roadway, such as a colored bicycle lane. This can create the perception of street narrowing, in addition to enhancing the travel facility for bicyclists.

Purpose

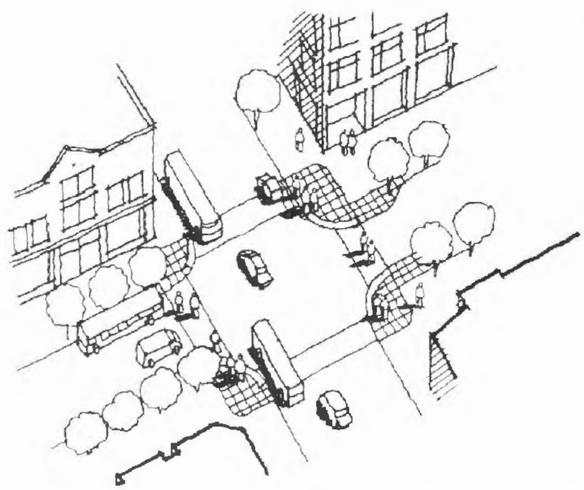
- Send a visual cue about the function of a street.
- Create an aesthetic enhancement of a street.
- Delineate separate space for pedestrians or bicyclists.

Considerations

- Slippery surfaces, such as smooth granite and paint, and uneven surfaces, such as cobblestones and brick, should not be used in the primary pedestrian or bicycle travel paths. Bumpy surfaces may be especially uncomfortable for wheelchair users and a tripping hazard for all pedestrians.
- Coordinate choice and placement of materials with maintenance agencies.
- Design and maintenance must ensure crosswalk visibility over time.
- Using materials such as bricks and cobblestones may increase the cost of construction and maintenance.

Estimated Cost

Variable; materials requiring hand labor (cobblestones or pavers) have a higher cost.



SKETCH BY MICHAEL KIMELBERG

31. SERPENTINE DESIGN

Serpentine design refers to the use of a winding street pattern with built-in visual enhancements through a neighborhood, which allow for through movement while forcing vehicles to slow. The opportunities for significant landscaping can be used to create a park-like atmosphere.

PHOTO BY CARA SEIDERMAN

The serpentine street is a curving roadway that helps slow traffic through the use of curbs and landscaping.

Such designs are usually implemented with construction of a new neighborhood street or during reconstruction of an existing street corridor. This type of design can be more expensive than other traffic-calming options and needs to be coordinated with driveway access.

Purpose

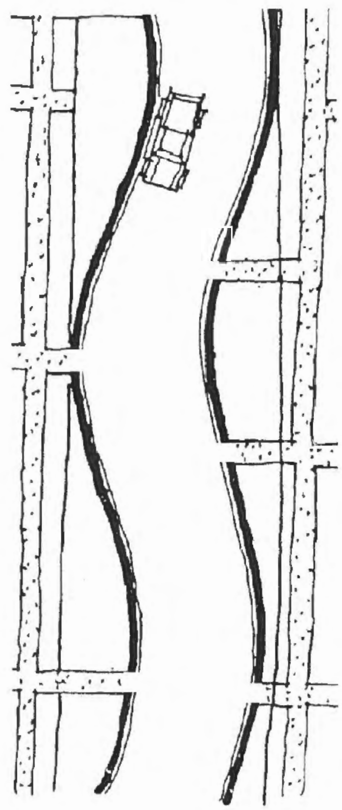
- Change the entire look of a street to send a message to drivers that the road is not for fast driving.

Considerations

- Where costs are a concern, lower cost, equally effective traffic-calming strategies may be preferable.
- Most cost-effective to build as a new street or where a street will soon undergo major reconstruction for utility or other purposes.

Estimated Cost

The cost can be high ($60,000 to $90,000 per block) to retrofit a street, but may be no extra to build a new street with this design if adequate right-of-way is available.



Adapted from *Making Streets That Work*, Seattle, 1996

32. WOONERF

"Woonerf" ("Street for living") is a Dutch term for a common space created to be shared by pedestrians, bicyclists, and low-speed motor vehicles. They are typically narrow streets without curbs and sidewalks, and vehicles are slowed by placing trees, planters, parking areas, and other obstacles in the street. Motorists become the intruders and must travel at very low speeds below 16 km/h (10 mi/h). This makes a street available for public use that is essentially only intended for local residents. A woonerf identification sign is placed at each street entrance.

PHOTO BY DAN BURDEN

Motorists, bicyclists, and pedestrians share the space on this woonerf or "living street" in Asheville, North Carolina.

Consideration must be given to provide access by fire trucks, sanitation vehicles and other service vehicles (school buses and street sweepers), if needed.

Purpose

- Create a very low automobile volume, primarily on local access streets.
- Create a public space for social and possibly commercial activities and play by area children.

Considerations

- A woonerf is generally not appropriate where there is a need to provide nonresident motorists with access to services or through travel.
- The design needs to keep vehicle speeds very low in order to make the streets safe for children.

Estimated Cost

The cost to retrofit a woonerf may be quite high, but there would be no extra cost if designed into the original construction.

TRAFFIC MANAGEMENT

Although they are sometimes lumped together, traffic management and traffic calming are different tools and address different problems. Traffic management includes the use of traditional traffic control devices to manage volumes and routes of traffic. Traffic calming deals with what happens to traffic once it is on a street. For example, limiting access to a street (e.g., diverting traffic from entering a street on one end) may reduce the amount of traffic on that street, but will do nothing to affect the speed of the traffic that travels on that street or others. Traffic management and traffic calming are often complementary, and a plan to retrofit an area often includes a variety of tools.

PHOTO BY MICHAEL CYNECKI

Communities should think about the broader context of traffic. If there is too much traffic on any one street, it may be that there is too much traffic altogether. A more significant plan to reduce overall traffic volumes would be appropriate—encouraging and providing for alternate modes of travel by developing pedestrian and bicycling networks, implementing Transportation Demand Management, enhancing transit systems, improving land-use planning, etc. Comprehensive traffic reduction or mitigation strategies are important; however, these are beyond the scope of this guide. Resources that provide guidance on these issues are included in Chapter 7.

Traffic calming and traffic management should be assessed from an areawide perspective. The problem should not just be shifted from one street to another. Although implementation usually occurs in stages, an overall plan can be developed up-front, involving a larger neighborhood or area of the city.

Traffic calming has also helped reduce motor vehicle traffic volumes and increase walking and bicycling. For example, on one traffic-calmed street in Berkeley, CA,

PHOTO BY DAN BURDEN

This street closure in Charlotte provides needed open space in an urban neighborhood.

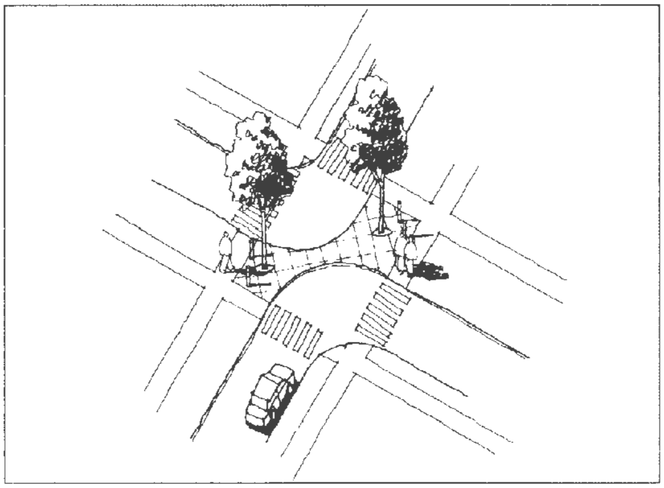
the number of bicyclists and pedestrians more than doubled after the street was reconstructed with traffic-calming tools, and motor vehicle volumes decreased by about 20 percent (see Case Study No. 1; Chapter 6). Traffic volume reduction raises the question: Where does the traffic go? In the Berkeley case, traffic volumes on parallel streets did not account for all of the traffic that disappeared from the traffic-calmed street. Ideally, the reduction in traffic means that some people chose a different mode of travel, such as transit, walking, or bicycling. This is only feasible if a system is in place to support those modes. What is often the case in selective street redesign is that traffic is routed onto other streets. It is desirable to keep traffic on collector and arterial streets and off residential streets. However, in many communities, arterials are already over capacity, and alternate routes may also involve other residential streets.

Traffic management and traffic calming should involve the community. Neighborhood participation and the community involvement process are discussed in Chapter 7. Specific traffic management countermeasures described in this section include:

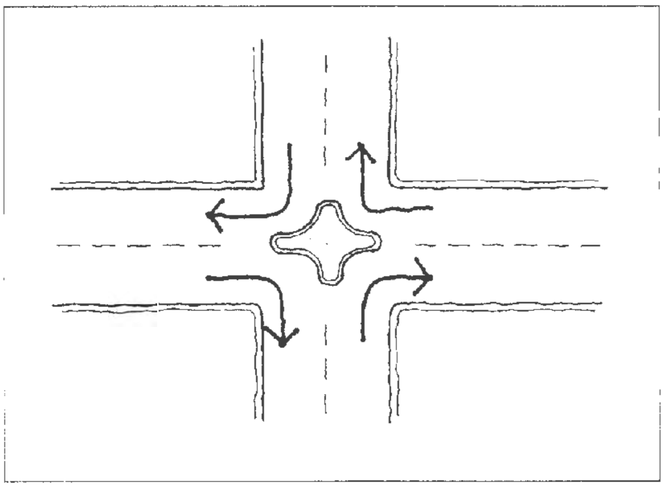
- Diverters
- Full Street Closure
- Partial Street Closure
- Pedestrian Streets/Malls

33. DIVERTERS

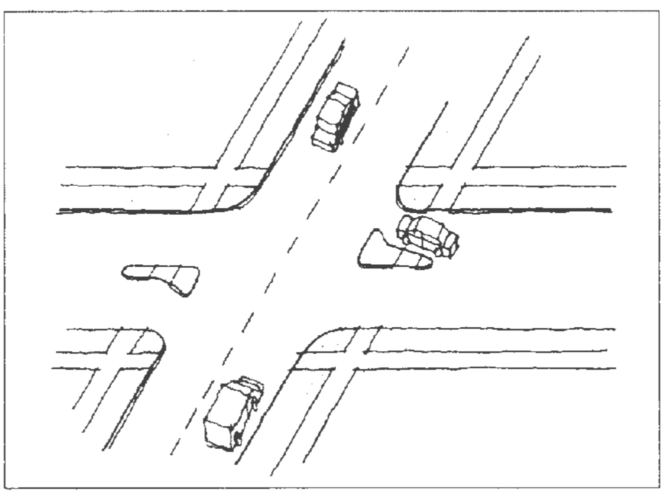
A diverter is an island built at a residential street intersection that prevents certain through and/or turning



Diagonal Diverter



Star Diverter



Forced Turn Diverter

movements. Diverters affect people living in the neighborhood more than anyone else. Therefore, diverters should be considered only when less restrictive measures are not appropriate.

Purpose

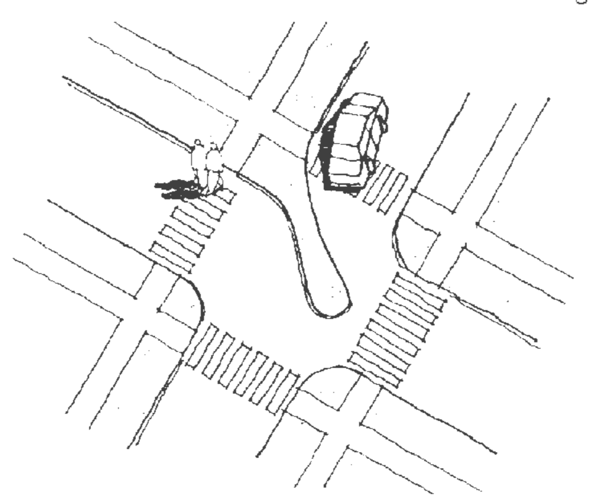
- Discourage or prevent traffic from cutting through a neighborhood.

Considerations

- Impacts residents more than through traffic.
- Consider less restrictive measures first.
- Evaluate traffic patterns to determine whether other streets would be adversely affected.
- Design diverters to allow bicycle, pedestrian, and emergency vehicle access. If this cannot be done and the street is a major bicycle corridor, a diverter should not be used.
- Diverters generally do not effectively address midblock speeding problems.
- Diagonal diverters may be used in conjunction with other traffic management tools and are most effective when applied to the entire neighborhood street network.
- Diverters should have strong neighborhood support.
- The effect of diverters on service vehicles should be considered.

Estimated Cost

$15,000 to $45,000 each, depending on the type of diverter and the need to accommodate drainage.



Truncated Diverter

Four types of diverters are: diagonal, star, forced turn, and truncated. A diagonal diverter breaks up cut-through movements and forces right or left turns in certain directions. A star diverter consists of a star-shaped island placed at the intersection, which forces right turns from each approach. A truncated diagonal diverter is a diverter with one end open to allow additional turning movements. Other types of island diverters can be placed on one or

PHOTO BY DAN BURDEN

Traffic diverters restrict certain traffic movements and should only be considered when less restrictive measures are not appropriate.

more approach legs to prevent through and left-turn movements and force vehicles to turn right.

As with other traffic management tools, diverters must be used in conjunction with other traffic management tools within the neighborhood street network. Any of these diverters can be designed for bicycle and pedestrian access.

34. FULL STREET CLOSURE

A full street closure is accomplished by installing a physical barrier that blocks a street to motor vehicle traffic and provides some means for vehicles to turn around. Full street closures should be used only in the rarest of circumstances. Neighborhoods with cul-de-sac streets require extensive out-of-the-way travel, which is not a mere convenience issue, but has serious implications for impacts on other streets. All traffic is forced to travel on feeder streets, which has negative consequences for the people who live on those streets and forces higher levels of control at critical intersections.

PHOTO BY DAN BURDEN

Access is closed on this residential street.

If a street closure is done, it should always allow for the free through movement of all pedestrians, including wheelchair users, and bicyclists. Emergency vehicles should also be able to access the street; this can be done with a type of barrier or gate that is electronically operated, permitting only large vehicles to traverse it. Examples are mountable curbs or an accessway with a raised element in the center that a low vehicle would hit, though those treatments may not be able to stop pickups or sport utility vehicles. This is usually only appropriate for places with no snow (otherwise the device would be covered with snow and the accessway could not be cleared).

Purpose

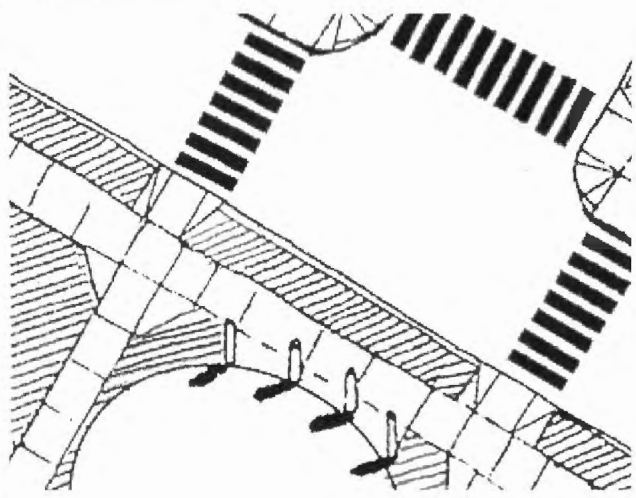
- Ultimate limitation of motor vehicle traffic to certain streets.

Considerations

- Part of an overall traffic management strategy.
- Analyze whether other streets would receive diverted traffic as a result of the street closure, and whether alternative streets exist for through traffic.
- Provide a turnaround area for motor vehicles, including service vehicles, and provide for surface drainage.
- Full street closures may be considered for local streets, but are not appropriate for collector streets.
- Do not use if the street is an emergency or school bus route.
- Do not adversely affect access to destinations in the community by pedestrians and bicyclists.
- Not an appropriate measure for addressing crime or other social problems.

Estimated Cost

The cost for a full, landscaped street closure varies from approximately $30,000 to $100,000, depending on conditions.



SKETCH BY YAN JIA

35. PARTIAL STREET CLOSURE

A partial street closure uses a semi-diverter to physically close or block one direction of motor vehicle travel into or out of an intersection; it could also involve blocking one direction of a two-way street. Partial street closures at the entrance to a neighborhood or area should consider the traffic flow pattern of the surrounding streets as well. The design of this measure should allow for easy access by bicyclists and all pedestrians.

PHOTO BY MIKE CYNECKI

This partial street closure is found in Phoenix, AZ.

A partial closure provides better emergency access than a full closure. Since this design also allows motorists to easily violate the prohibitions, police enforcement may be required. If the partial closure only eliminates an entrance to a street, a turnaround is not needed; closing an exit will generally require a turnaround.

Purpose

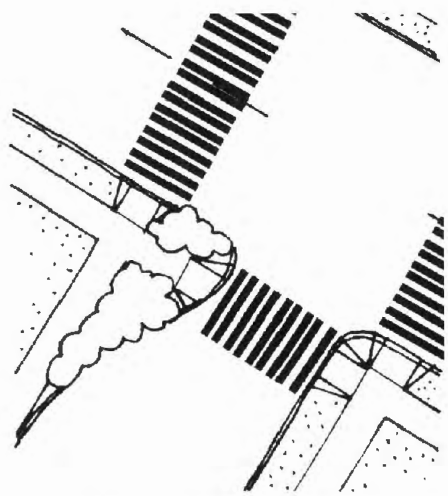
- Prevent turns from an arterial street onto a residential street.
- Reduce cut-through traffic.
- Restrict access to a street without creating one-way streets.

Considerations

- Do not adversely affect access by service vehicles.
- Analyze whether less restrictive measures would work.
- Analyze whether other local streets will be adversely affected and/or access into or out of the neighborhood would not be adequate.
- Will create out-of-the-way travel for residents and put additional traffic on other streets.
- Consider impact on school bus routes, emergency access, and trash pickup.
- Will not solve speeding issues; speeds may increase on the new one-way street.

Estimated Cost

A well-designed, landscaped partial street closure at an intersection typically costs approximately $10,000 to $25,000. They can be installed for less if there are no major drainage issues and landscaping is minimal.



Adapted from *Making Streets That Work*, Seattle, 1996

36. PEDESTRIAN STREETS/MALLS

There are two types of pedestrian streets/malls: (1) those that eliminate motor vehicle traffic (deliveries permitted during off-peak hours) and; (2) those that allow some motor vehicle traffic at very low speeds. The second type can be thought of as a pedestrian street that allows some motor vehicles, as opposed to a motor vehicle street that allows some pedestrians.

PHOTO BY CARA SEIDERMAN

Church Street in Burlington, Vermont, is a successful pedestrian street with market stalls, public art, landscaping, and cafes.

Pedestrian streets have been successful in places that are thriving and have high volumes of pedestrians. Examples of successful pedestrian streets include Church Street in Burlington, VT; Downtown Crossing in Boston, MA; Maiden Lane in San Francisco, CA; Occidental Street in Seattle, WA; Third Street Promenade in Santa Monica, CA; and, Fremont Street in Las Vegas, NV.

Another option is to create a part-time pedestrian street, as is done, for example, in the French Quarter in New Orleans, LA, which uses removable barriers to close the street to motorists at night.

Purpose

- Create a significant public space in a downtown district, a tourist district, or a special events or marketplace area.
- Enhance the experience for people in a commercial district.

Considerations

- Pedestrian streets (those that eliminate motor vehicles) created with the notion of attracting people in areas that are on the decline have usually been unsuccessful.
- The pedestrian environment can often be enhanced through other measures, including street narrowing/sidewalk widening and the addition of landscaping.

Estimated Cost

A pedestrian street can be created simply by blocking either end of an existing street with nothing more than a few signs. Temporary pedestrian streets can be created for weekends or holidays. If the street is going to be a permanent public space, care should be taken in the design. Depending on the extent of the treatment (one block or several blocks) and the quality of the materials used, a true pedestrian street can cost from $100,000 to several million dollars.

SIGNALS AND SIGNS

Traffic control devices are often used by traffic engineers to improve safety and access for pedestrians. In addition to marked crosswalks (see countermeasure number 3), several other devices are available, including:

- Traffic Signals
- Pedestrian Signals
- Pedestrian Signal Timing
- Traffic Signal Enhancements
- Right-Turn-On-Red Restrictions
- Advanced Stop Lines
- Signing

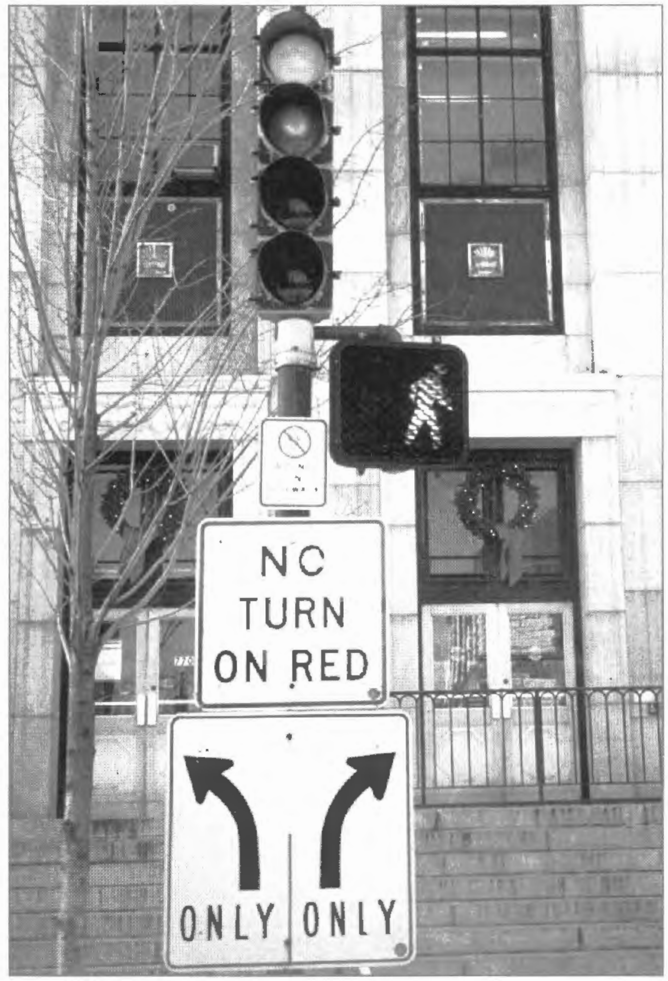


PHOTO BY CARA SEIDERMAN

37. TRAFFIC SIGNALS

Traffic signals create gaps in the traffic flow, allowing pedestrians to cross the street. They should allow adequate crossing time for pedestrians and an adequate clearance interval based upon a maximum walking speed of 1.2 m/s (4.0 ft/s). In areas where there is a heavy concentration of the elderly or children, a lower speed of less than 1.1 m/s (3.5 ft/s) should be used in determining pedestrian clearance time. Signals are particularly important at high-use, mid-block crossings on higher speed roads, multi-lane roads, or at highly congested intersections. National warrants from the Manual on Uniform Traffic Control Devices are based on the number of pedestrians and vehicles crossing the intersection, among other factors.[1] However, judgment must also be used on a case-by-case basis. For example, a requirement for installing a traffic signal is that there are a certain number of pedestrians present. If a new facility is being built—a park or recreational path, for example—there will be a new demand, and the signal could be installed in conjunction with the new facility based on projected crossing demand. There may also be latent demand if a destination is not currently accessible, but could become so with new facilities or redesign.

PHOTO BY BARBARA GRAY

A traffic signal at a busy intersection with high volumes of pedestrians, bicyclists, and cars.

In downtown areas, signals are often closely spaced, sometimes every block. Timed sequencing of signals may reduce the amount of time allotted per cycle for pedestrian crossing to unsafe lengths. Signals are usually spaced farther apart in suburban or outlying areas, but similar considerations for pedestrian phasing should be made. When high pedestrian traffic exists during a majority of the day, fixed-time signals should be used to consistently allow crossing opportunities. Pedestrian actuation should only be used when pedestrian crossings are intermittent and should be made accessible to all pedestrians, including those with disabilities.

Purpose

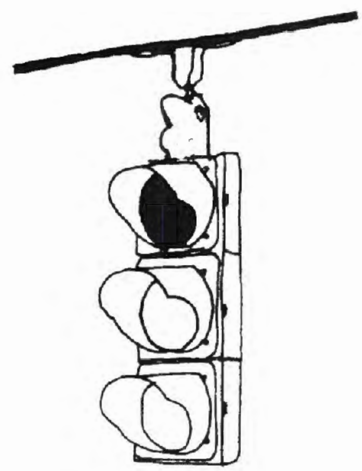
- Provide intervals in a traffic system where pedestrians can cross streets safely.

Considerations

- Where pedestrian traffic is regular and frequent, pedestrian phases should come up automatically. Pedestrian actuation should only be used when pedestrian crossings are intermittent.
- Signal cycles should be kept short (ideally 90 seconds maximum) to reduce pedestrian delay. Pedestrians are very sensitive to delays.
- Marked crosswalks at signals encourage pedestrians to cross at the signal and discourage motorists from encroaching into the crossing area.

Estimated Cost

$30,000 to $140,000.



Adapted from *Making Streets That Work*, Seattle, 1996

38. PEDESTRIAN SIGNALS

Pedestrian signal indications should be used at traffic signals wherever warranted, according to the MUTCD. The use of WALK/DON'T WALK pedestrian signal indications at signal locations are important in many cases, including when vehicle signals are not visible to pedestrians, when signal timing is complex (e.g., there is a dedicated left-turn signal for motorists), at established school zone crossings, when an exclusive pedestrian interval is provided, and for wide streets where pedestrian clearance information is considered helpful.[1]

PHOTO BY ROBERT SCHNEIDER

Pedestrian signals should always be clearly visible to the pedestrian while in the crosswalk and waiting on the far side of the street.

The international pedestrian symbol signal is preferable and is recommended in the MUTCD. Existing WALK and DON'T WALK messages may remain for the rest of their useful life but should not be used for new installations.[1] Pedestrian signals should be clearly visible to the pedestrian at all times when in the crosswalk or waiting on the far side of the street. Larger pedestrian signals can be beneficial in some circumstances (e.g., where the streets are wide). Signals may be supplemented with audible or other messages to make crossing information accessible for all pedestrians, including those with vision impairments. The decision to install audible pedestrian signals should consider the noise impact on the surrounding area. Much more extensive information on the use of accessible pedestrian signals (APS) and the types of APS technologies now available is provided online at www.walkinginfo.org/aps.

Purpose

- Indicate appropriate time for pedestrians to cross.
- Provide pedestrian clearance interval.

Considerations

- Ensure that signals are visible to pedestrians.
- When possible, provide a walk interval for every cycle.
- Pedestrian push buttons must be well positioned and within easy reach for all approaching pedestrians. Section 4E.09 within the MUTCD provides detailed guidance for the placement of push buttons to ensure accessibility.[2]

Estimated Cost

$20,000 to $40,000.

Example of an pedestrian regulatory sign used in conjunction with a pushbutton. The recommended language for such signs can be found in Section 2B.44 of the MUTCD.

39. PEDESTRIAN SIGNAL TIMING

There are several types of signal timing for pedestrian signals, including concurrent, exclusive, "leading pedestrian interval" (LPI), and all-red interval. In general, shorter cycle lengths and longer walk intervals provide better service to pedestrians and encourage better signal compliance. For optimal pedestrian service, fixed-time signal operation usually works best. Pedestrian pushbuttons may be installed at locations where pedestrians are expected intermittently. Quick response to the pushbutton or feedback to the pedestrian should be programmed into the system. When used, pushbuttons should be well-signed and within reach and operable from a flat surface for pedestrians in wheelchairs and with visual disabilities. They should be conveniently placed in the area where pedestrians wait to cross. Section 4E.09 within the MUTCD provides detailed guidance for the placement of push buttons to ensure accessibility.[1]

PHOTO BY BARBARA GRAY

With a leading pedestrian interval, pedestrians get an advance walk signal before motorists get a green. This gives the pedestrians several seconds to establish their presence in the crosswalk before motorists start to turn.

In addition to concurrent pedestrian signal timing (where motorists may turn left or right across pedestrians' paths after yielding to pedestrians), exclusive pedestrian intervals (see Traffic Signal Enhancements) stop traffic in all directions. Exclusive pedestrian timing has been shown to reduce pedestrian crashes by 50 percent in some downtown locations with heavy pedestrian volumes and low vehicle speeds and volumes.[2] With concurrent signals, pedestrians usually have more crossing opportunities and have to wait less. Unless a system is willing to take more time from vehicular phases, pedestrians will often have to wait a long time for an exclusive signal. This is not very pedestrian-friendly, and many pedestrians will simply choose to ignore the signal and cross if and when there is a gap in traffic, negating the potential safety benefits of the exclusive signal.[3] Exclusive pedestrian phases do introduce a problem for pedestrians with visual impairments, as the audible cues associated with surging parallel traffic streams are no longer present,

Purpose

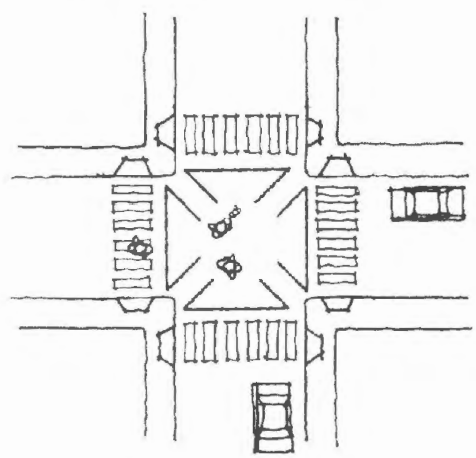
- A "Pedestrian Scramble" provides an exclusive pedestrian crossing phase with no conflicting traffic.
- A short all-red clearance interval provides a better separation between cars and pedestrians.

Considerations

- A "Pedestrian Scramble" usually creates a longer cycle length and a longer wait between crossings.
- The Scramble may eliminate the ability to synchronize timing at adjacent traffic signals.
- Scramble timing is most applicable to downtown areas with high pedestrian volumes (e.g., more than 1,200 pedestrian crossings per day).
- Scramble timing eliminates conflicts with turning vehicles if pedestrians and motorists obey their signals.
- The benefits of this treatment may not extend to vision-impaired pedestrians.
- Wider intersections require longer cycle lengths.
- Longer walk or pedestrian clearance intervals may also lead to longer cycle lengths.
- Use fixed-time operation unless pedestrian arrivals are intermittant.

Estimated Cost

Adjusting signal timing is very low cost and requires a few hours of staff time to accomplish. New signal equipment ranges from $20,000 to $140,000.



SKETCH BY MICHAEL KIMELBERG

Exclusive walk phase or "Pedestrian Scramble."

PHOTO BY HERMAN HUANG

The pedestrian has a dedicated walk phase at this intersection of a busy street and a trail crossing.

which makes it difficult to know when to begin crossing.

A simple, useful change is the LPI. An LPI gives pedestrians an advance walk signal before the motorists get a green light, giving the pedestrian several seconds to start in the crosswalk where there is a concurrent signal. This makes pedestrians more visible to motorists and motorists more likely to yield to them. This advance crossing phase approach has been used successfully in

PHOTO BY HERMAN HUANG

The pedestrian has a dedicated walk phase and is allowed to cross diagonally at this intersection.

several places, such as New York City, for two decades and studies have demonstrated reduced conflicts for pedestrians.[4] The advance pedestrian phase is particularly effective where there is a two-lane turning movement. To be useful to pedestrians with vision impairments, an LPI needs to be accompanied by an audible signal to indicate the WALK interval.

There are some situations where an exclusive pedestrian phase may be preferable to an LPI. Exclusive phases are desirable where there are high-volume turning movements that conflict with the pedestrians crossing.

40. TRAFFIC SIGNAL ENHANCEMENTS

A variety of traffic signal enhancements that can benefit pedestrians and bicyclists are available. These include automatic pedestrian detectors, providing larger traffic signals to ensure visibility, placing signals so that motorists waiting at a red light can't see the other signals and anticipate the green, and installing countdown signals to provide pedestrians with information about the amount of time remaining in a crossing interval.

PHOTO BY JEFF BAGDADE

This countdown signal indicates to pedestrians the amount of time they have remaining to cross (until the flashing DON'T WALK ends).

Countdown signals may be designed to begin counting down at the beginning of the walk phase or at the beginning of the clearance (flashing DON'T WALK) interval.

Since pedestrian pushbutton devices are not activated by about one-half of pedestrians (even fewer activate them where there are sufficient motor vehicle gaps), new "intelligent" microwave or infrared pedestrian detectors are now being installed and tested in some U.S. cities. These automatically activate the red traffic and WALK signals when pedestrians are detected. Detectors can also be used to extend the crossing time for slower moving pedestrians in the crosswalk. Automatic pedestrian detectors have been found to improve pedestrian signal compliance and also reduce pedestrian conflicts with motor vehicles. However, they are still considered experimental and their reliability may vary under different environmental conditions.[5]

More information on some of these technologies is available online at www.walkinginfo.org/pedsmart. This web site was developed in 1999 and includes information on several types of smart technologies, the problems they may address, and the vendors of the devices. Locations where many of the devices were installed at that time are also included as case studies.

Purpose

- Improve pedestrian accommodation at signalized crossings.

Considerations

- Pedestrian signals need to indicate the crossing interval by visual, audible, and/or tactile means if pedestrians with vision impairments are to take advantage of them.
- The effects of pedestrian countdown signals on pedestrian safety are not well known. Further research is needed to better understand their effects.

Estimated Cost

About $5,000 to add new pedestrian signals and mark crosswalks.

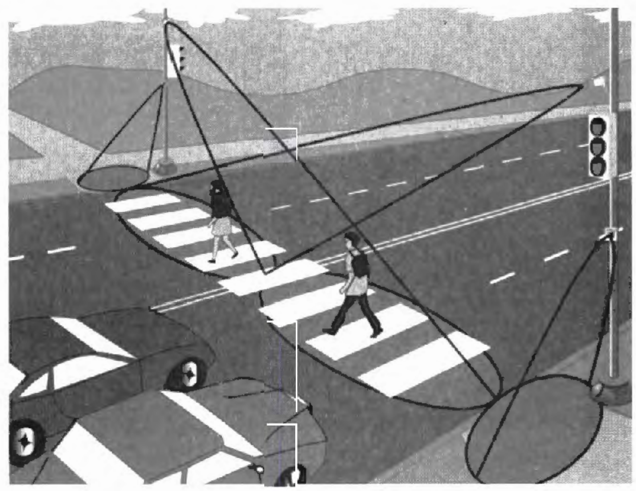


ILLUSTRATION BY CHRISTIAN VALIULIS

An automated pedestrian detection system.

41. RIGHT-TURN-ON-RED RESTRICTIONS

A permissible Right Turn on Red (RTOR) was introduced in the 1970s as a fuel-saving measure and has sometimes had detrimental effects on pedestrians. While the law requires motorists to come to a full stop and yield to cross-street traffic and pedestrians prior to turning right on red, many motorists do not fully comply with the regulations, especially at intersections with wide turning radii. Motorists are so intent on looking for traffic approaching on their left that they may not be alert to pedestrians approaching on their right. In addition, motorists usually pull up into the crosswalk to wait for a gap in traffic, blocking pedestrian crossing movements. In some instances, motorists simply do not come to a full stop.

PHOTO BY CARA SEIDERMAN

Prohibiting right turns can benefit pedestrian safety at some locations.

One concern that comes up when RTOR is prohibited is that this may lead to higher right-turn-on-green conflicts when there are concurrent signals. The use of the leading pedestrian interval (LPI) can usually best address this issue (see Countermeasure No. 39). Where pedestrian volumes are very high, exclusive pedestrian signals should be considered.

Prohibiting RTOR should be considered where and/or when there are high pedestrian volumes. This can be done with a simple sign posting, although there are some options that are more effective than a standard sign. For example, one option is a larger 762-mm by 914-mm (30-in by 36-in) NO TURN ON RED sign, which is more conspicuous. For areas where a right-turn-on-red restriction is needed during certain times, time-of-day restrictions may be appropriate. A variable-message NO TURN ON RED sign is also an option.[6]

Purpose

- Increase pedestrian safety and decrease crashes with right-turning vehicles.

Considerations

- Prohibiting RTOR is a simple, low-cost measure. Together with a leading pedestrian interval, the signal changes can benefit pedestrians with minimal impact on traffic.
- Part-time RTOR prohibitions during the busiest times of the day may be sufficient to address the problem.
- Signs should be clearly visible to right-turning motorists stopped in the curb lane at the crosswalk.

Estimated Cost

$30 to $150 per NO TURN ON RED sign plus installation at $200 per sign. Electronic signs have higher costs.

PHOTO BY SCOTT WAINWRIGHT

Example of an electronic blank-out sign for right-turn prohibition (Burlington, VT).

42. ADVANCED STOP LINES

At signalized intersections and midblock crossings, the vehicle stop line can be moved farther back from the pedestrian crosswalk for an improved factor of safety and for improved visibility of pedestrians. In some places, the stop line has been moved back by 4.6 to 9.1 m (15 to 30 ft) relative to the marked crosswalk with considerable safety benefits for pedestrians. One study found that use of a "Stop Here For Pedestrians" sign alone reduced conflicts between drivers and pedestrians by 67 percent. With the addition of an advanced stop line, this type of conflict was reduced by 90 percent compared to baseline levels.[7]

PHOTO BY CARA SEIDERMAN

Advanced stop lines are used at this signalized crossing to improve sight distances and to give the motorist who initially fails to see the crosswalk more time to stop. The bicyclist can advance ahead, which aids in bicyclist safety, particularly with right-turning motorists.

The advanced stop lines allow pedestrians and drivers to have a clearer view of each other and more time in which to assess each other's intentions. The effectiveness of this tool depends upon whether motorists are likely to obey the stop line, which varies from place to place.

Advanced stop lines are also applicable for non-signalized crosswalks on multi-lane roads to ensure that drivers in all lanes have a clear view of a crossing pedestrian.

Purpose

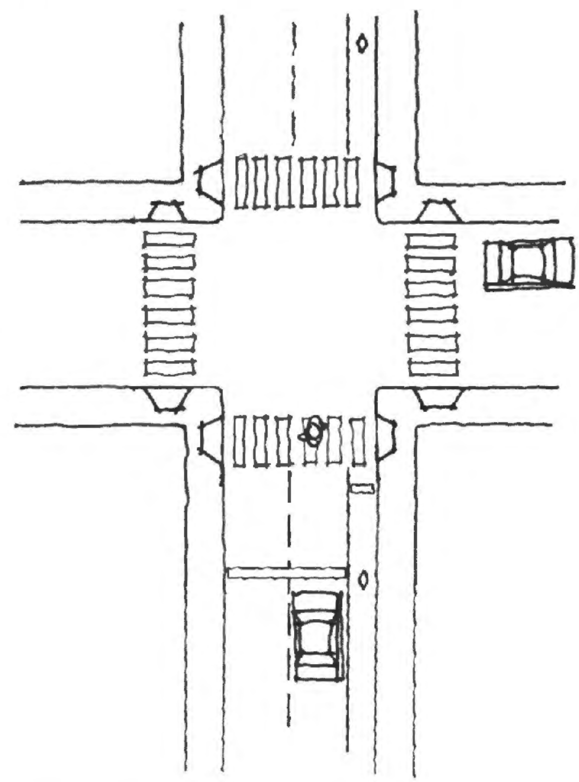
- Improve visibility of pedestrians to motorists.
- Allow pedestrians to advance in a crosswalk before motor vehicles turn.

Considerations

- Effectiveness depends on motorist compliance with the marked stop line.
- If placed too far in advance of the crosswalk, motorists may ignore the line.
- In some locations, a wider crosswalk may be an effective alternative.

Estimated Cost

There is no extra cost when the recessed stop line is installed on new paving or as part of repaving projects. A STOP HERE ON RED (R10-6) sign can be used to supplement the recessed stop line.



SKETCH BY MICHAEL KIMELBERG

43. SIGNING

Signs can provide important information that can improve road safety. By letting people know what to expect, there is a greater chance that they will react and behave appropriately. For example, giving motorists advance warning of an upcoming pedestrian crossing or that they are entering a traffic-calmed area will alert them to modify their speed. Sign use and movement should be done judiciously, as overuse breeds noncompliance and disrespect. Too many signs may also create visual clutter and signs can get lost.

PHOTO BY BARBARA GRAY

This experimental sign instructs drivers to yield to pedestrians when turning at this intersection.

Regulatory signs, such as STOP, YIELD, or turn restrictions require certain driver actions and can be enforced. Warning signs can provide helpful information, especially to motorists and pedestrians unfamiliar with an area. Some examples of signs that affect pedestrians include pedestrian warning signs, motorist warning signs, NO TURN ON RED signs, and guide signs.

Advance pedestrian warning signs should be used where pedestrian crossings may not be expected by motorists, especially if there are many motorists who are unfamiliar with the area. A new fluorescent yellow/green color is approved for pedestrian, bicycle, and school warning signs (Section 2A.11 of the MUTCD). This bright color attracts the attention of drivers because it is unique.

All signs should be periodically checked to make sure that they are in good condition, free from graffiti, reflective at night, and continue to serve a purpose. In unusual cases, signs may be used to prohibit pedestrian crossings at an undesirable location and re-route them to a safer crossing location, or warn pedestrians of unexpected driver maneuvers. It is preferable to create safe crossings where there are clear pedestrian destinations. If unexpected driving maneuvers occur at what is an otherwise legal pedestrian crossing, an evaluation should be done to find ways to remedy or prevent the unsafe motorist maneuvers.

Purpose

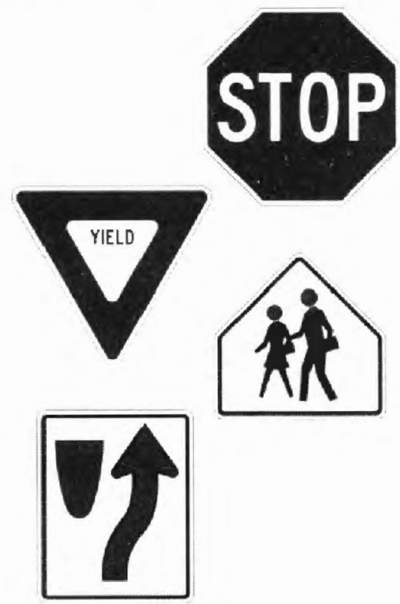
- Provide regulation, warning, or information to road users as to what to expect and how to behave.

Considerations

- Overuse of signs breeds noncompliance and disrespect. Too many signs can lead to visual clutter with the result that a driver is not likely to read or pay attention to any of the signs.
- Traffic signs used on public property must comply with the Manual on Uniform Traffic Control Devices (MUTCD).
- Signs should be checked to assure adequate nighttime reflectivity.

Estimated Cost

$50 to $150 per sign plus installation costs.



Manual on Uniform Traffic Control Devices (MUTCD)

OTHER MEASURES

In addition to the more traditional engineering treatments described in other sections of this chapter, there are several other countermeasures that should be considered under specific circumstances. For example, crossings in the vicinity of a school warrant consideration of the recommendations related to school zone improvements. The countermeasures described in this section include:

- School Zone Improvements
- Neighborhood Identity
- Speed Monitoring Trailer
- On-Street Parking Enhancements
- Pedestrian/Driver Education
- Police Enforcement

PHOTO BY DAN BURDEN

44. SCHOOL ZONE IMPROVEMENTS

A variety of roadway improvements may be used to enhance the safety or mobility of children in school zones. The use of well-trained adult crossing guards has been found to be one of the most effective measures for assisting children in crossing streets safely.[1] Sidewalks or separated walkways and paths are essential for a safe trip from home to school on foot or by bike. Adult crossing guards require training and monitoring and should be equipped with a bright and reflective safety vest and a STOP paddle. Police enforcement in school zones may be needed in situations where drivers are speeding or not yielding to children in crosswalks.

PHOTO BY BARBARA GRAY

Children leaving school in this Honolulu suburb walk their bikes to the intersection where a crossing guard controls movements.

Purpose

- Provide enhanced safety around schools.

Considerations

- Safety must be a combined effort between local traffic officials, police, school officials, parents, and students.

Estimated Cost

Costs would depend on the school zone treatment selected. For example, if signs were chosen, costs might include \$50 to \$150 per sign plus installation costs.

Manual of Uniform Traffic Control Devices (MUTCD)

Other helpful measures include parking prohibitions near intersections and crosswalks near schools; increased child supervision at crossings; and the use of signs and markings, such as the school advance warning sign (which can be fluorescent yellow/green) and SPEED LIMIT 25 MPH WHEN FLASHING. Schools should develop "safe routes to school" plans and work with local agencies to identify and correct problem areas. Marked crosswalks can help guide children to the best routes to school. School administrators and parent-teacher organizations need to educate students and parents about school safety and access to and from school. Education, enforcement, and well-designed roads must all be in place to encourage motorists to drive appropriately.

One of the biggest safety hazards around schools is parents or caretakers dropping off and picking up their children. There are two immediate solutions: (1) there needs to be a clearly marked area where parents are permitted to drop off and pick up their children, and (2) drop-off/pick-up regulations must be provided to parents on the first day of school. Drop-off areas must be located away from where children on foot cross streets or access the school. Parent drop-off zones must also be separated

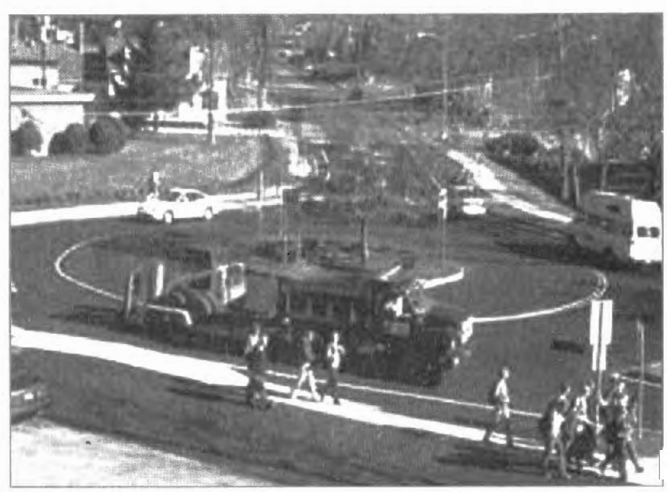


PHOTO BY DAN BURDEN

Vehicles must slow down to enter the tight curve of this modern roundabout in a school zone in Montpelier, Vermont. The roundabout creates a safer interaction between vehicles and pedestrians.

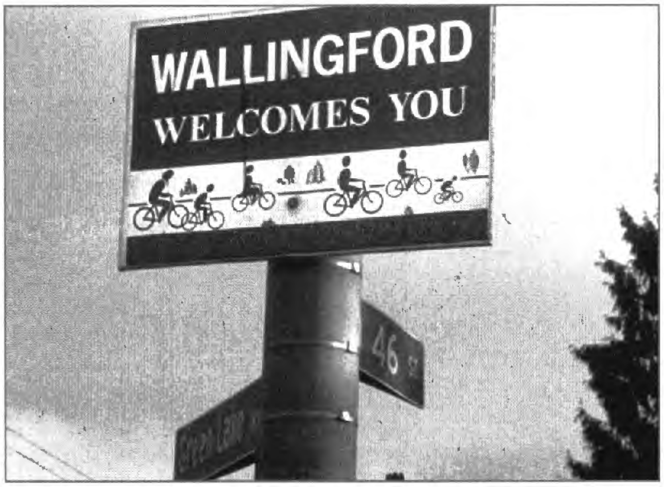
from bus drop-off zones. If parents can be trained to do it right at the start of the school year, they are likely to continue good behavior throughout the year.

For a longer term solution, it is preferable to create an environment where children can walk or bicycle safely to school, provided they live within a suitable distance. One concept that has been successful in some communities is the concept of a "walking bus," where an adult accompanies children to school, starting at one location and picking children up along the way. Soon, a fairly sizeable group of children are walking in a regular formation, two by two, under the supervision of a responsible adult, who is mindful of street crossings. The presence of such groups affects drivers' behavior, as they tend to be more watchful of children walking. Parents take turns accompanying the "walking school bus" in ways that fit their schedules.

45. NEIGHBORHOOD IDENTITY

Many neighborhoods or business districts want to be recognized for their unique character. This can enhance the walking environment and sense of community.

PHOTO BY PETER LAGERWEY



An identity sign in Seattle's Wallingford neighborhood marks an entry to the area.

Examples of treatments include gateways, traffic calming, welcome signs, flower planters, banners, decorative street lighting, unique street name signs, and other details. Neighborhood identity treatments rarely provide any direct traffic improvements, but they help develop interest in enhancing the community.

Purpose

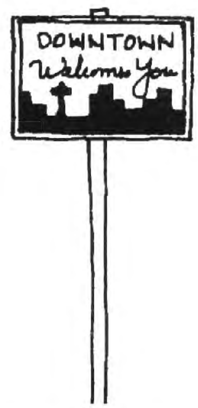
- Increase the visibility of a neighborhood or district and support community efforts to define their neighborhood.

Considerations

- Supports community efforts, but has no direct traffic benefits.

Estimated Cost

$50 to $150 per sign. Some signs may cost more because they are usually custom made.



Adapted from *Making Streets That Work*, Seattle, 1996

46. SPEED-MONITORING TRAILER

Speed-monitoring trailers—sign boards on trailers that display the speed of passing vehicles—are used by police departments and transportation agencies as educational tools that can enhance enforcement efforts directed at speed compliance. Speed radar trailers are best used in residential areas and may be used in conjunction with Neighborhood Speed Watch or other neighborhood safety education programs. They can help raise residents' awareness of how they themselves are often those speeding, not just "outsiders." Speed trailers are not substitutes for permanent actions, such as traffic-calming treatments, to address neighborhood speeding issues.

PHOTO BY DAN BURDEN

Speed-monitoring trailers let motorists know the speed limit and the speed they are traveling.

Speed-monitoring trailers can be used at several locations and should have occasional police monitoring and enforcement to maintain driver respect.

Purpose

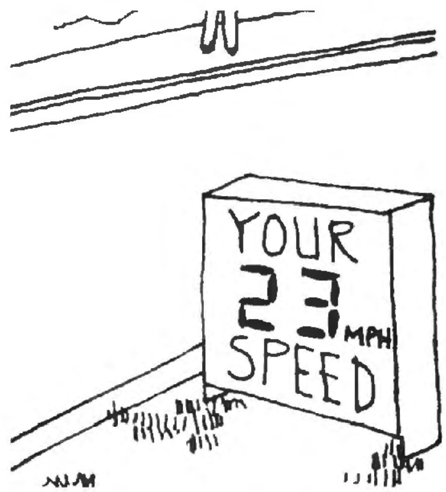
- Enhance enforcement efforts through public education and awareness.

Considerations

- Occasional enforcement is needed to supplement the speed-monitoring trailers.
- Speed-monitoring trailers are not a substitute for engineering measures.
- Should not obstruct pedestrian travelway or sightlines.

Estimated Cost

$10,000 to $15,000 to purchase the speed-monitoring trailer, plus the cost to move the trailer to different locations and to monitor the trailer.



Adapted from *Making Streets That Work*, Seattle, 1996

47. ON-STREET PARKING ENHANCEMENTS

On-street parking can be both a benefit and a detriment to pedestrians. On-street parking does increase positive "friction" along a street and can narrow the effective crossing width, both of which encourage slower speeds; parking can also provide a buffer between moving motor vehicle traffic and pedestrians along a sidewalk. In addition, businesses reliant on on-street parking as opposed to parking lots are more geared toward pedestrian access. This attention can foster a more vibrant pedestrian commercial environment.

PHOTO BY CARA SEIDERMAN

On-street parking in Concord, Massachusetts, shields pedestrians from moving traffic.

On the other hand, parking creates a visual barrier between motor vehicle traffic and crossing pedestrians, especially children and people using wheelchairs. Therefore, where there is parking, curb extensions should be built where pedestrians cross. Parking needs to be removed on the approaches to crosswalks.

At least 6 m (20 ft) of parking should be removed on the approach to a marked or unmarked crosswalk and about 6 m of parking should be removed downstream from the crosswalk. Some agencies require that parking be removed 9 to 15 m (30 to 50 ft) from intersections for pedestrian safety reasons. Well-designed curb extensions can reduce these distances and maximize the number of on-street parking spaces.

Purpose

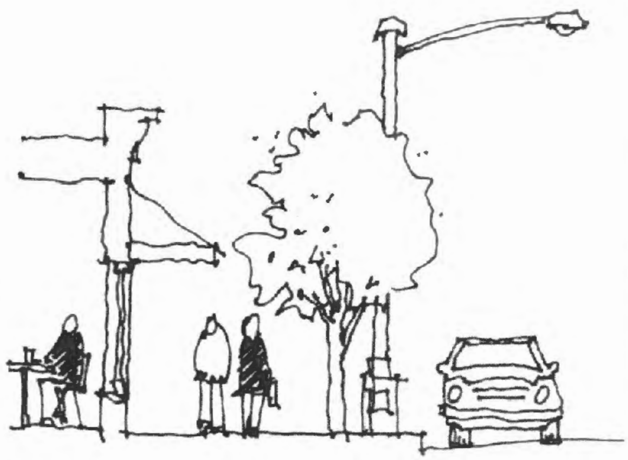
- Provide motorist access to destinations along a street.
- Aid in speed reduction by increasing friction along the street.
- Provide a buffer between sidewalk edge and moving traffic.

Considerations

- Parking may take up space desired for other uses, such as wider sidewalks or bicycle lanes.
- Approaches to crosswalks and intersections should be cleared and curb extensions added at crossing locations for pedestrian safety.
- Parking meters should be used in downtown areas where there is a need for parking turnover. This can generate revenue for the community.

Estimated Cost

$30 to $150 per sign. About $300 per parking meter and installation. Curb paint and stall marks or striping costs are additional (optional).



SKETCH BY MICHAEL KIMELBERG

48. PEDESTRIAN/DRIVER EDUCATION

Providing education, outreach, and training is a key strategy in increasing pedestrian and motorist awareness and behavior. While efforts most certainly provide information, the primary goal of an educational strategy is to motivate people to alter their behavior and reduce reckless actions. To implement the strategy, an integrated, multidisciplinary approach that links hard policies (e.g., changes in infrastructure) and soft policies (e.g., public relations campaigns) and addresses both pedestrians and drivers has the greatest chance of success.

Education oftens starts at an early age with structured programs for elementary school students.

Purpose

- Provide information to roadway users.
- To motivate a change in specific behaviors to reduce the risk of pedestrian injuries.

Considerations

- Educational messages should encourage people to think about their own travel attitudes and behaviors and make more informed choices.
- Pedestrian educational campaigns must be a part of a long-term and ongoing traffic safety program.
- Educational programs and materials should be sensitive of different groups of people.
- Outreach material should be interesting and involve visual as well as written messages.
- Difficulty in gaining political support needed to ensure a comprehensive program.
- Difficulty in introducing safety education within established school system curriculums.

Estimated Cost

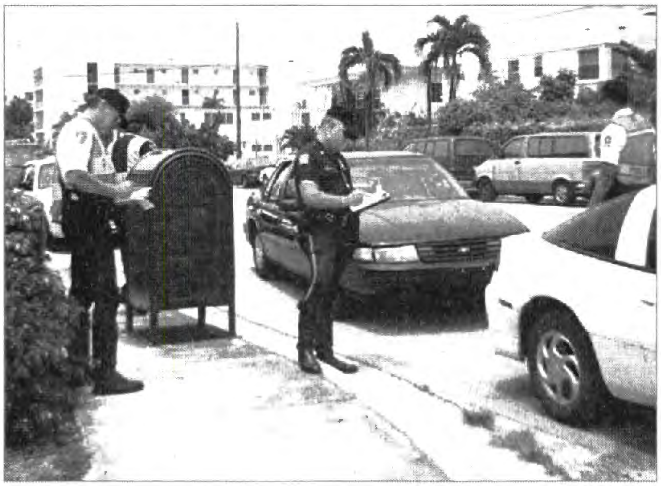
Costs vary widely depending on type of educational programs used.

There are several broad approaches to education that can be conducted with moderate resources. They include 1) highlighting pedestrian features when introducing new infrastructure; 2) conducting internal campaigns within the organization to build staff support for pedestrian safety programs; 3) incorporating pedestrian safety messages into public relations efforts; 4) developing relationships with sister state agencies and statewide consumer groups; and 5) marketing alternative travel modes.

There are three specific types of educational campaigns – public awareness, targeted campaigns, and individual campaigns. Public awareness campaigns are a great example of a vehicle used to garner public support. An effective campaign can "lay the groundwork" for subsequent pedestrian safety initiatives and can increase the likelihood of their success. Campaigns to target groups are usually aimed at changing behavior patterns in specific groups of people (e.g., motorists, elderly, school children). Since changing behavior in these groups can be a long and arduous task, these campaigns tend to be ongoing efforts aimed at long-term results. Individual campaigns differ from campaigns at target groups because the audience is reached through an intermediary. Intervention occurs at an individual level through safety guards, doctors and other authority figures. Using these different approaches in concert reaches a broader audience and increases the likelihood of long-term success in changing attitudes and behaviors.

49. POLICE ENFORCEMENT

Police enforcement is a primary component in preserving pedestrian right-of-way and maintaining a safe environment for all modes of travel. Well-publicized enforcement campaigns are often effective in deterring careless and reckless driving and encouraging drivers to share the roadway with pedestrians and bicyclists when combined with strategically installed traffic control devices and public education programs. Most importantly, by enforcing the traffic code, police forces implant a sense of right and wrong in the general public and lend credibility to traffic safety educational programs and traffic control devices.



Police enforcement of motorist yielding behavior at pedestrian crossings is one ingredient needed for creating a safer walking environment.

Over the years, police departments around the country have consistently enforced traffic laws pertaining to driving under the influence, speeding, and running red lights. They have developed effective and socially accepted methods for measuring this behavior and apprehending offenders. However, enforcement of right of way laws has proven more difficult, as police forces have focused attention on more objective violations and/or not provided appropriate training to police officers. Good enforcement requires enforcing traditional traffic laws as well as ensuring equal protection for drivers as well as pedestrians and bicyclists.

There are a number of actions that municipalities can use to implement enforcement campaigns designed to protect pedestrians. These include increased police presence around school zones, residential neighborhoods, and other areas with high pedestrian activity; "pedestrian stings" involving police officers in civilian clothing; and high profile, hard hitting mass media campaigns to sign-post change and help set the public agenda. Some enforcement campaigns require special legislation to provide a legal basis for stricter crosswalk codes or right of way changes while other campaigns operate under existing ordinances.

Purpose

- Increase driver-awareness of the need to share the roadway
- Reduce pedestrian-related traffic crashes

Considerations

- Campaigns must be sensitive to the needs of different neighborhoods, age/ethnic groups, etc.
- To avoid PR problems, police officers need to be trained properly beforehand
- Enforcement should be conducted with the help of staff support and awareness of the courts
- Enforcement operations should be focused on drivers rather than pedestrians
- Enforcement operations should begin with warnings and flyers before moving on to issuing citations for violations

Estimated Cost

Cost varies depending on amount of training, number of officers involved, public relations work, duration of the program, and other factors

Case Studies ∞ Chapter 6

PHOTO BY DAN BURDEN

The 49 engineering, education, and enforcement countermeasures are described in Chapter 5. Included in this chapter are case studies that illustrate these treatments and/or programs as implemented in a state or municipality. Examples are included from 20 States and the countries of Canada and Switzerland. Provided on the following pages is a list of the 71 case studies by countermeasure group. A more detailed matrix showing the case studies by specific countermeasure is included in Appendix B on pages 302-303.

Each case study includes a description of the problem that was addressed, relevant background information, a description of the implemented solution, and any quantitative results from evaluation studies or qualitative assessments. Also included for each study is a point of contact in the event that further information is desired. Please note that in some cases, the specific individual listed may have left the position or agency. There should still be someone at the municipal or state agency that is familiar with the project and can provide any supplemental information.

Not all traffic control devices (TCDs) in the case studies comply with the MUTCD. FHWA does not endorse the use of non-compliant TCDs except under experimentation, which must be approved by the FHWA Office of Transportation Operations.

Case Study Number	Case Study Title	Pedestrian Facility Design	Roadway Design	Intersection Design	Traffic Calming	Traffic Management	Signals and Signs	Other Measures
1	Serpentine Street Design	■			■		■	
2	55th Street Corridor Improvements	■	■		■			
3	Park Road Restriping	■	■				■	
4	Downtown Revitalization Partnerships	■			■		■	■
5	Accessibility During Construction	■					■	
6	Old Town Improvements	■			■			■
7	Solutions from Citizen Input	■	■		■			
8	Curb Extensions in Rural Village	■			■			
9	Safe Routes to School Program	■						■
10	High-Volume Pedestrian Crossings	■	■		■			
11	Small Town Traffic Calming	■	■		■			■
12	Park Trail Bridges	■						
13	Fifth Street Traffic Calming	■	■		■			■
14	Roundabout for Downtown Revitalization	■		■	■			
15	Redesign for Streetcar Access	■	■					
16	Street Redesign for Revitalization						■	■
17	Bridgeport Way Corridor Improvements	■	■		■			
18	ADA Curb Ramps	■						
19	Large Intersection Solutions	■	■		■		■	
20	Granite Street Traffic Calming	■			■		■	
21	Pedestrian-Friendly Redesign		■		■			■
22	Berkshire Street Traffic Calming	■	■		■			
23	Exclusive Pedestrian Phasing	■					■	
24	Main Street Redesign	■	■		■			■
25	Illuminated Crosswalk	■						
26	Traffic Calming and Emergency Vehicles	■			■			
27	School Zone Improvements	■					■	■
28	Pedestrian Crossing Devices	■					■	
29	Gateway Treatments	■	■		■			
30	Raised Crosswalk at School	■			■		■	■
31	Speed Tables at BWI Airport	■			■		■	
32	Trail Intersection Improvements	■	■		■		■	
33	Safe School Route Mapping	■					■	■
34	Staggered Median				■			
35	Curb Extensions for Transit Access	■	■		■		■	
36	Double-Ladder Crosswalks	■						

Case Study Number	Case Study Title	Pedestrian Facility Design	Roadway Design	Intersection Design	Traffic Calming	Traffic Management	Signals and Signs	Other Measures
37	Zebra Crosswalk Markings	■					■	■
38	School Zone Traffic Calming	■			■	■		■
39	Third Street Promenade	■			■	■		
40	Vermont Street Footbridge	■						
41	Greenway Pedestrian Bridge	■						■
42	Pfluger Pedestrian-Bicycle Bridge	■						
43	Grade-Separated Trail Crossing	■						
44	State Street Pedestrian Mall	■				■		
45	Elm Street Traffic Calming		■		■			
46	Leland Street Redesign		■		■			
47	Seventh Avenue Traffic Calming		■	■	■			
48	Main Street Roundabout			■	■			
49	School Zone Roundabout			■				■
50	Harold Street Traffic Calming				■			
51	Curb Bulbouts with Bicycle Parking				■			
52	Traffic Calming Program				■	■		
53	Chicanes for Traffic Control				■			
54	Mid-Block Speed Table				■		■	■
55	Emergency Vehicles and Traffic Calming				■	■		
56	Neighborhood Traffic Circles				■			
57	Speed Humps for Cut-Through Traffic	■		■				
58	Raised Intersection				■			
59	Woonerf-Style Developments				■	■		
60	Wall Street Revitalization				■	■		
61	Church Street Marketplace					■		
62	Pedestrian Countdown Signals (1 of 2)						■	
63	Pedestrian Countdown Signals (2 of 2)						■	
64	Antimated Eyes Signal						■	
65	Leading Pedestrian Interval (1 of 2)						■	
66	Leading Pedestrian Interval (2 of 2)						■	
67	Red Light Camera Enforcement						■	■
68	Red Light Photo Enforcement	■	■		■		■	
69	Advance Yield Markings						■	
70	Radar Trailers in Neighborhoods							■
71	Neighborhood Speed Watch Programs							■

Serpentine Street Design

PROBLEM

Milvia Street was becoming more difficult for pedestrians and bicyclists to travel because of motorists using it to avoid traffic congestion on the parallel arterial routes between north Berkeley and downtown Berkeley and the University of California.

BACKGROUND

Milvia Street is primarily a residential street with a large number of pedestrian traffic generators in close proximity to each other, including three daycare centers, a preschool, two elementary schools, a junior high school, and a city park. Milvia Street is located between two parallel arterials that provide an effective connection between north Berkeley and the downtown and University areas. As such, it was being used by motorists to avoid the stoplights on those arterials. When combined with a difficult offset intersection at the corner of Delaware, this had created a difficult place where pedestrians, cyclists, parked cars and fast moving cars were mixing in a confined street. Further, a six-story office building was to be built nearby, which would increase traffic and make traveling along and across the street more difficult for pedestrians. After a considerable community effort to influence the office building project, the City received roughly $100,000 from the developers to prevent adverse impacts from the new traffic it would generate on Milvia.

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center.

Information provided by Chuck DeLeuw, City of Berkeley, CA and Mourad Bouaouina, University of Californaia at Berkeley.

SOLUTION

A "slow street" plan from proposed by Urban Ecology, a local non-profit organization. The City retained transportation consultant Kenneth M. Bankston Associates to evaluate the Urban Ecology plan and alternatives. The report was used by City Public Works and Parks and Waterfront Department staff in coordination with local residents and street users to develop a recommended plan for a "slow street." With the mitigation funds from the developers and some additional city funds, the plan was implemented in 1989 to create the "Milvia Slow Street."

The design covers roughly six blocks of residential street in which 30 curb bulb-outs were placed to narrow the street at intersections and mid-block locations. These bulb-outs and planted islands create a serpentine design, which requires vehicles to slow and negotiate a winding path along the street.

Traffic calming improvements within the serpentine design were also intended to increase the aesthetic quality of the street. The bulbouts and islands were landscaped and maintained by the local neighborhood residents. Some stamped concrete paving was installed near the new building to create a rumble strip for the entrance way, a decorative sign was erected notifying drivers that they are entering a calmed, residential neighborhood. Finally, the entire street was re-paved, speed humps were also installed on several blocks, the cracked sidewalks were redone, and ADA-compliant ramps were installed to make the sidewalk accessible to all pedestrians.

RESULTS

As the first street in Berkeley to have speed humps installed, Milvia attracted considerable attention. There has been opposition from the fire department because speed humps may increase the difficulty of emergency response teams. Some bicyclists were concerned about

Mid-block alignment shifting parallel parking from one side to the other.

the design because it did not provide a straight path for riding, it included speed humps, and removed previously-existing designated bicycle lanes. Drivers who used the street to cut-through between arterials also were unhappy with the project because they did not like driving over speed humps. Other residents were con-

Mid-block landscaped bulb-out with parallel parking.

cerned because traveling over speed humps and other raised devices can jar vehicles and cause pain for disabled and elderly passengers.

In 1990, a year after implementation, graduate students at the University of California evaluated traffic speeds and volumes, including pedestrian and bicycle volumes. During the afternoon peak, the number of pedestrians increased from 63 to 93 (48 percent) on one block and from 42 to 95 (126 percent) on a second block of the street. An opinion survey was given to 18 people living within 3 blocks of the street and 14 other street users. Over 80 percent felt that the slow street improved pedestrian safety.

The study also found that daily motor vehicle volumes were lowered by the project from 540 to 441 (18 percent) on the first block and 500 to 399 (20 percent) on the second block. Post-project mean vehicle speeds along the street ranged from 14.6 mi/h to 16.1 mi/h (23.5 km/h–26 km/h) at the speed humps and from 17.0 mi/h to 20.0 mi/h (27 km/h–32 km/h) between the humps.

Though no official speed data have been collected recently along the Milvia "slow street", periodic observation shows that speeds continue to be slower than before the improvement, and motor vehicle traffic volumes are also lower. In addition, the street landscaping increased the attractiveness of the neighborhood.

Since the installation, Milvia Street resident and original supporter of the "slow street" concept, Kate Obenour, feels that the street has become much safer and that the number and severity of accidents has decreased dramatically. The success of Milvia Street has led to the installation of speed humps on over twenty other streets in Berkeley. However, it should be noted that, after installation of over 150 speed humps, the Fire Department and members of the disabled community expressed concerns about adding more. As a result, a moratorium on speed hump construction is in place until adoption of a formal traffic calming policy.

CONTACT

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REFERENCES

Bankston, Kenneth, and Associates. "Final Report—Proposed Slow Street Design Evaluation in Berkeley, California," February 1988.

Bouaouina, Mourad and Robinsion, Bruce. "An Assessment of Neighborhood Traffic Calming: Milvia Slow Street in Berkeley, California," Submitted to Professor E. Deakin, University of California at Berkeley, Fall 1990.

55th Street Corridor Improvements

PROBLEM

High traffic volumes and speeds were creating an unsafe and unpleasant walking and bicycling environment along 55th Street in Boulder, Colorado.

BACKGROUND

Residents near 55th Street were concerned about speeding vehicles and high traffic volume in the corridor where the posted speed limit was 56 km/h (35 mi/h). Residents had difficulty entering 55th Street from numerous side streets, and they had expressed concerns about the difficulty of crossing and the unpleasantness of walking along 55th Street. They believed that prior improvements on nearby Cherryvale Road, made by Boulder County, had diverted excessive traffic onto 55th Street and exacerbated this problem.

New concrete raised crossing with pedestrian refuge median on 55th Street.

Prepared by Bill Cowern and Mike Sweeney, City of Boulder.

SOLUTION

A Capital Improvement Project was implemented to provide improved bicycle and pedestrian facilities in the corridor, and to provide some traffic calming for vehicles. The following improvements were made:

- A continuous sidewalk was constructed on the east-side of 55th Street.
- Bicycle lanes were provided on both sides of 55th Street.
- A bicycle/pedestrian underpass was constructed along the Centennial Trail alignment.
- Two raised crossings and one raised intersection were constructed, with pedestrian refuge islands at both of the raised crossing locations.

The project intended to improve transportation operations for all modes of travel by providing a number of transportation upgrades, including bicycle lanes, pedestrian facilities, speed mitigation devices and left turn access lanes on 55th Street. Intersection improvements at the Arapahoe Road and Baseline Road intersections were also a part of the project. To accomplish these goals, approximately $1.7 million was spent to construct the improvements.

New bicycle/pedestrian underpass beneath 55th Street.

RESULTS

Staff conducted a before and after study by collecting transportation data before and after the project and comparing the results of this data collection with the goals of the project. According to the study, both travel speeds and traffic volumes decreased after the completion of the project. Table 1 shows that approximately 3,000 vehicles appear to have been diverted from 55th Street.

A review of the peak hour traffic volumes at the intersection of Arapahoe and 55th Street showed reduced traffic volumes traveling north-south through the intersection following the project (see Table 2).

A corresponding increase in traffic turning to and from 55th Street north of Arapahoe Road suggested that traffic was diverting east and west along Arapahoe Road instead of traveling north-south on 55th Street between Arapahoe Road and Baseline Road.

Travel speeds in the corridor were significantly reduced, and the 85th percentile speed in the corridor is closer to the speed limit than it was prior to project construction. There was substantial traffic diversion as a result of the project, but it does not appear that this diversion has caused any other issues in the area. The diverted traffic appears to have been dispersed to several different roadways or eliminated.

With the addition of several improved bicycle facilities, the amount of bicycle activity in the corridor is substantially higher than it was prior to construction of the project. However, a safety issue developed at the intersection of 55th Street and Arapahoe Road, where bicycles were being hit by turning traffic.

Second Raised Crossing on 55th Street.

Pedestrian improvements appear to have met with mixed success. The new underpass is well utilized, but there does not appear to be any other increase in pedestrian activity in the corridor. Overall, the decrease in traffic speeds and volumes has increased pedestrian safety along the street.

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Travel Speeds (85th Percentile Speed)			Traffic Volumes		
Before Project	After Project	Difference	Before Project	After Project	Difference
67km/h (42 mi/h)	61 km/h (38 mi/h)	-6km/h (-4 mi/h)	12,400 vpd	9,400 vpd	-3,000 vpd

Table 1. Speed and Volume Data.

Peak Period	Before Project	After Project	Change
AM peak period	1245 vph	924 vph	-321 vph
Noon peak period	660 vph	441 vph	-219 vph
PM peak period	1162 vph	891 vph	-271 vph

Table 2. Arapahoe and 55th north-south through traffic.

Park Road Restriping

PROBLEM

Throughout the 1990's, Lakeshore Drive, a park access road in North Park, experienced increasing volumes of motor vehicle, bicycle, and pedestrian traffic. In the 1980's, the open section, two-way road was striped with a 1.5 m (5 ft) bicycle lane on one side. Absent proper enforcement, over time this sub-standard bicycle accommodation became overrun with two-way bicycle and pedestrian traffic, creating conflicts and confusion for all road users.

BACKGROUND

Pedestrian and bicycle safety concerns were first identified in the Allegheny County Parks system in the late 1980's. In response to those concerns, the County completed a Trail Improvement Feasibility Study in 1990. However, the recommendations of the study were never implemented.

In the spring of 2001 an accident occurred in another county park, South Park, which killed three pedestrians, the driver of an errant car, and a passenger in the vehicle. This accident brought the safety of pedestrians and bicyclists to the forefront in Allegheny County. As a result, the County revived its commitment to increasing the safety of pedestrians and bicyclists in each of the county parks.

Specific safety concerns for North Park included the following:

- Wrong way bicycle riding and the use of vehicular lanes by bicyclists due to congestion in the designated bicycle lane.
- Bicycle and pedestrian conflicts in the designated bicycle lane.
- The presence of only one bicycle lane on a two-way road.
- The presence of dangerous intersection crossings.

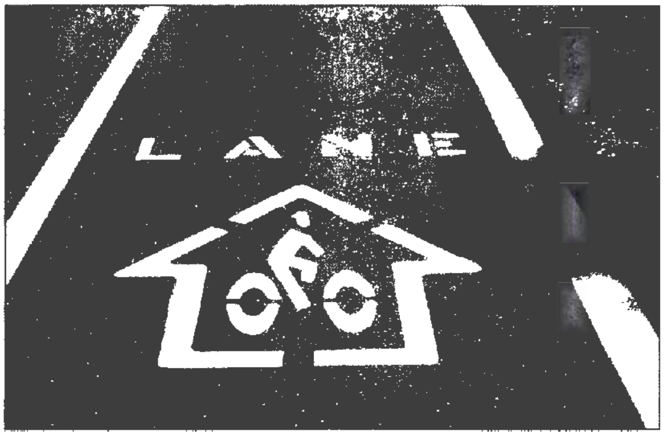
Prepared by John Buerkle, Pashek Associates, Pittsburgh, PA.

SOLUTION

Recommendations in the 2001 Master Plan for North Park were built upon the concerns raised in the 1990 plan. To reduce conflict, the County designed and built separate facilities for each travel mode. Bicycle lanes were provided on each side of Lakeshore Drive, giving cyclists the opportunity to travel with the direction of motor vehicle traffic (a requirement of the Motor Vehicle Code). In addition, a 1.5 m (5 ft) pedestrian pathway for walkers and joggers was located adjacent to the bicycle lane on the right hand side of the road.

Where space was limited and traffic patterns permitted, the roadway was designated as one-way, allowing continuation of all three travelways for the bicyclists and pedestrians. In this case, a bicycle lane with an adjacent pedestrian path

Striping of three travelways—center lane for one-way vehicle flow, a parallel flow bicycle lane on the right, and a contra-flow bicycle lane on the left.



Bicycle lanes are marked with words and symbols as shown to indicate proper travel direction. Note that this symbol is not what is currently recommended in the MUTCD.

was striped on the right side of the road and a contra flow bicycle lane was striped on the left side of the road.

Lane widths were also adjusted. To free up space to accommodate wider bicycle lanes and pedestrian pathways, the width of the vehicular lane was reduced to 3.1 m (10 ft). In order to ensure that the width of the bicycle and pedestrian lanes were able to accommodate changes in peak demand, the master plan recommended taking regular peak period pedestrian and bicycle counts.

Finally, signs and markings were added to designate the respective corridors created for each mode and to educate travelers on proper use of the facility. This was accomplished through painting traditional traffic markings on the pavement as well as posting rules and regulations that establish what is expected of each trail user.

RESULTS

Approximately 1.6 km (1 mi) of striped pedestrian and bicycle lanes on Lakeshore Drive were installed in the summer of 2001 for a total cost of approximately $150,000 (for planning, design and construction). The project was designed and implemented in-house, by the Allegheny County Department of Public Works. Similar improvements were made later in South Park.

Given the short time the improvements have been in place, it is difficult to scientifically validate the results. However, field observations made in August of 2001 indicate the improvements have been successful. Mode separation, wider bicycle and pedestrian lanes, and better signage have made the North Park roadway safer and more comfortable for pedestrians. Not only have the changes resulted in reducing the conflicts between the various non-motorized modes, but the implementation of the recommendations has also resulted in calming traffic in the adjacent vehicle lanes and has made drivers more aware of the other transportation modes operating within the roadway corridor. Response from the public has been very positive.

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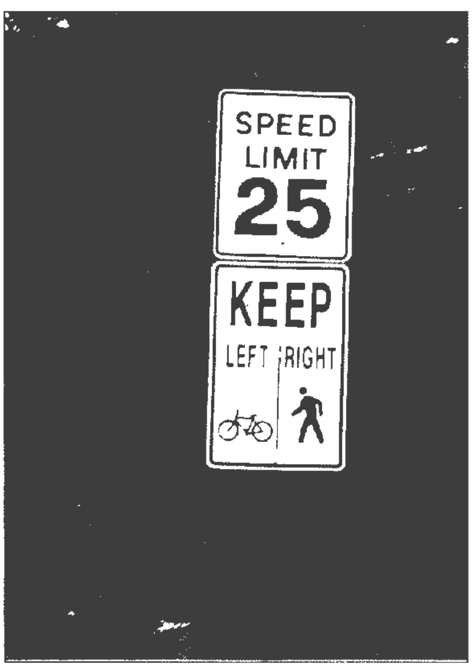

Informational signs educate patrons about traffic safety in the park.

CLEMSON, SOUTH CAROLINA **CASE STUDY NO. 4**

Downtown Revitalization Partnerships

PROBLEM

Downtown Clemson was once the vibrant cultural center of a college town. As the downtown lost many of the qualities that made it a desirable destination, pedestrian safety was jeopardized along with the aesthetic appeal and charm of the area.

BACKGROUND

The City of Clemson is a distinctive small town adjacent to Clemson University. This relationship attracts thousands of students to the City of Clemson daily, for shopping, dining, and entertainment needs. In the late 1980s several of the well-known old brick storefronts of downtown had disappeared under heavy coats of paint, wood and aluminum facades. Crosswalks were faded, worn, and practically non-existent. Citizen surveys indicated concerns with the impression left by the area, especially the bleak appearance coupled with increased vandalism, trash and litter problems. Walking is the primary means of access to the restaurants and retail establishments within the corridor for both students and visitors, and there were many potential pedestrian and vehicle conflicts to be addressed.

SOLUTION

Recognizing downtown Clemson as a major component of the city's image, citizens, merchants, and local government officials jointly established the Downtown Development Corporation with the mission to improve the downtown business area for businesses, patrons, and pedestrians. An Appearance Review Board was established along with performance standards and design guidelines for the downtown area and for other major corridors in the city.

Prepared by Arzu Yilmaz, City Planner, City of Clemson, SC.

As part of the initial efforts, a resource team presented a detailed report outlining the strengths and weaknesses of the downtown business district and the necessary revitalization steps. In general terms, the major recommendations of the report included:

- Improve the physical appearance of downtown, including unification of design and streetscape improvements, providing more green spaces, and alleviating trash and litter;
- Improve pedestrian safety, including installing brick surfaced pedestrian crosswalks, mandatory "stop for pedestrian in crosswalk" warning signs, enforcement of existing on-street parking regulations, enforcement of motorist yielding to pedestrians, and advancing ADA accessibility;
- Identify a retail mix that meets all existing markets using input from the focus groups, market data, and retail market feasibility studies;
- Investigate the possibility of extending the university parking shuttle system route to include stops within the downtown area.

Pedestrian activity on College Avenue.

Although it seemed to be an ambitious program, these recommendations had the backing of City officials, the University, and the Chamber of Commerce. The first two phases of improvements took place during 1990 and 1991 and cost approximately $500,000. The City matched a $250,000 grant from the South Carolina Governor's Office with $220,000 in public funds and the remainder $30,000 came from donations by residents, students, and alumni. Thirty trees and fourteen outdoor benches were private gifts. In addition, a $2.25 million dollar, low interest, revolving loan pool was established by the local banks to expedite building renovations in accordance with the development plans that were approved by the Appearance Review Board

Pedestrian enhancements on College Avenue at Sloan Street include brick pavers, curb ramps, and new landscaping.

Since then, improvements have expanded beyond the downtown boundaries into the adjacent areas. Projects have included the beautification of the area through the extension of streetscape improvements, realignment of streets, installation of mast-arm signals, decorative pedestrian crossings, and landscaping. In the early 1990s a complementary unified entrance to downtown Clemson and the University's campus was created, and the city improvements were mirrored on the university property directly across from downtown as an alumni class project. Also during this time, private downtown merchants invested in extensive facade improvements.

RESULTS

The City of Clemson was able to identify the need for revitalizing downtown and providing a safe pedestrian environment for local patrons. After the revitalization effort was completed, downtown Clemson reduced the amount of pedestrian and vehicle conflicts, slowed traffic through the downtown area, and significantly increased the awareness of pedestrian safety via design and regulation in its revived aesthetic and economic corridor.

Today downtown is an attractive, safe, and pedestrian friendly urban space. A healthy mix of clothiers, music stores, bookstores, florists, banks, restaurants, and coffee houses provide numerous shopping options, personal services, and dining opportunities for residents, students, and tourists. The pedestrian improvements support the economic revitalization effort and also increase the safety and comfort of pedestrians in downtown Clemson, SC.

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Accessibility During Construction

PROBLEM

Providing accessible pathways for all pedestrians during roadway construction and maintenance projects.

BACKGROUND

The N. Pearl Street Reconstruction project was an element of "The Capitalize Albany Economic Development Plan" to rebuild the city's roadway infrastructure and establish a pedestrian-friendly streetscape. The reconstruction site was within close proximity of I-787's exit and entry ramps, and it remains a major generator of vehicular and pedestrian traffic within Downtown Albany. Substantial pedestrian traffic is generated by employees, tourists, and residents whose destinations include a federal office building, off-street parking lots, a historic district, a major theater, and popular eateries.

The Americans with Disabilities Act (28 CFR Part 35) and the Americans with Disabilities Act Accessibility Guidelines require that temporary pedestrian facilities, including those associated with construction and maintenance, must provide safe and convenient access for persons with disabilities. FHWA regulations (23 CFR 652.5) require that provision for safe accommodation of pedestrians (and bicyclists) is given full consideration during construction.

The 1996 New York State Department of Transportation (NYSDOT) Bicycle And Pedestrian Policy extends this requirement to maintenance and protection of traffic (MPT) for pedestrians in work zones during highway construction and other construction activities. NYSDOT, through a number of pedestrian safety initiatives, is currently upgrading its standard specifications for the

Prepared by James M. Ercolano, Pedestrian Specialist, New York State Department of Transportation.

"Sidewalk Closed" and "Sidewalk Open" (with direction arrow) signs were posted on N. Pearl Street.

ADA compliant channelization to a pedestrian crossing was provided at N. Pearl and Clinton Street.

MPT. The work zone at N. Pearl Street, Albany reveals that practices have already advanced significantly.

SOLUTION

Pedestrian-related MPT at the N. Pearl Street site included the use of signs to indicate closed sidewalks and crossings as well as alternate sidewalk routes and

Cane-detectable fences were installed beside sidewalk widening and new curb work on N. Pearl Street.

crossings. Cane-detectable orange construction fences were intended to channel pedestrians to temporary and existing sidewalks and street crossings. Orange fencing was also installed to enclose the entire site and create a barrier between building stoops, their sidewalks, and new sidewalk widening and curb construction. A temporary mid-block crossing with a curb ramp was also constructed to improve access to the federal building.

RESULTS

The N. Pearl Street site passed NYSDOT inspection for pedestrian accommodation, and scored above average for retention of ADA-related public right-of-way accessibility. The cost of the specific pedestrian accommodations was not available, but NYSDOT is exploring separating costs by mode for future construction and maintenance projects. NYSDOT's pedestrian-oriented MPT plan successfully provided a level of pedestrian safety consistent with the type of work zone, location, duration of activity, and pedestrian and other traffic volumes operations. The plan also reduced the number of conflicts between pedestrian, motorist, and bicycle traffic movements on N. Pearl Street in Albany.

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EUREKA, CALIFORNIA | CASE STUDY NO. 6

Old Town Improvements

PROBLEM

Improvements were needed to make Eureka's Old Town District more pedestrian friendly.

BACKGROUND

Inspired by Sacramento, CA and other cities in the region that had beautified their historic districts, the City of Eureka Planning and Engineering Departments and concerned citizens of Eureka began to work together in 1972 to revitalize the City's "Old Town" District. The area included a wide variety of Victorian shops, homes, and the historic Carson Mansion. A conceptual plan and constuction drawings were developed, and over the years, a variety of streetscape improvements were made to beautify the area, making it more friendly to pedestrians, shoppers, and tourists.

SOLUTION

The City of Eureka has installed a variety of treatments along 2nd Street from "C" Street to "M" Street including bulb-outs, S-curves, raised islands, trees, benches, pedestrian lighting, exposed aggregate/brick sidewalks, and special features to crosswalks and intersections. Additionally, parking was removed from portions of each side of the street where sidewalks and planters were installed. The City of Eureka has been working on this concept through the years and expanding this treatment on the side streets from Humboldt Bay to 3rd Street with the last portion being completed in 1997.

Prepared by Laurie Actman, Patrick McMahon, Henry Renski, University of North Carolina Highway Safety Research Center, and Gary Boughton, City of Eureka, CA.

Looking down Second Street from L Street showing bulb-outs, brick crosswalks, brick and exposed aggregate sidewalks, traffic island, lighting, trees, street, and the famous Carson Mansion in the background.

Since the early 1970s the average cost has been about $150,000 per block, which has included sidewalks, planters, lighting, streets, underground utilities, etc. Approximately 27 blocks were completed. In addition, Clark Plaza, the Gazebo, and numerous parking lots in Old Town were also added. The Eureka Redevelopment Agency funded the improvements.

RESULTS

The 2nd Street portion of "Old Town" is now a significant attraction for tourists and local residents to visit, walk and shop. The area has a variety of establishments with sidewalk seating and high pedestrian volumes. Many activities, including an annual Fourth of July festival, weekly farmers markets, free weekly summer concerts, and monthly Saturday Night Arts Alive programs are now centered in "Old Town".

Traffic volume on the corner of 2nd and "L" Streets is now 2,500 ADT, and Traffic Engineering Analyst Dan Moody estimates it to be higher in the more developed portions of the "Old Town" district. Despite the success of the project, there has been some discussion of tearing out parts of the pedestrian improvements to install additional on-street parking. Moody believes that this pedestrian environment took some time to create and would be sadly missed if removed.

Pedestrian improvements continue to be used to complement Eureka's historic district revitalization efforts. With the help of pedestrian-friendly design, some art gallery and studio businesses that closed after the development of a mall in the late 1980s are coming back, and new office space is being developed. Some of the same pedestrian treatments built in the 1970s are being extended towards downtown Eureka, with curb bulb-outs on 4th, 5th, "E", "F" and "G" Streets. Although these projects are not identical to the 2nd Street improvements, they have similar curb bulb-outs and incorporate brick pavers, trees, and pedestrian-scale lighting.

Looking west on Second Street from L Street showing curved street, bulb-outs, streetlights, trees, brick crosswalks, and bollards.

The City is currently constructing a boardwalk along the Eureka Waterfront between "C" and "G" Streets. This boardwalk incorporates many pedestrian-friendly features, including bricks, sidewalk embossing, planters, benches, pedestrian lighting, banners, arts, and historic interpretive signing.

Although issues still complicate the redevelopment of Eureka's waterfront and many parts of downtown and the historic district, the director of Eureka's Main Street program believes that the pedestrian-supportive environment of the area contributes greatly to the revitalization process.

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Solutions from Citizen Input

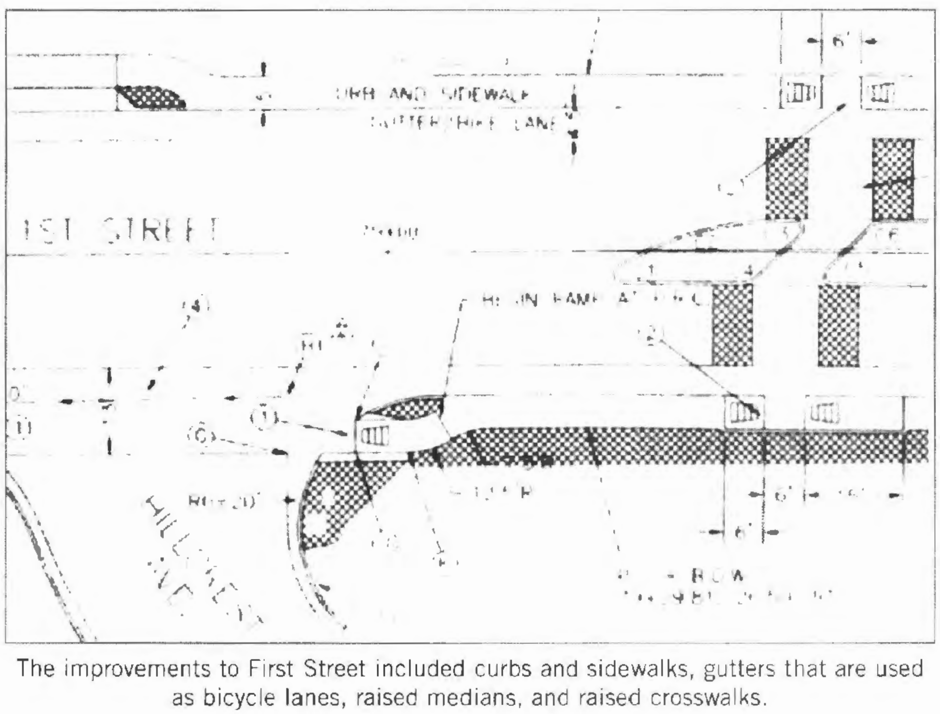
PROBLEM

As urban growth expanded, a quiet country road became a major north-south street, and residents became concerned about increased vehicle speeds and heavy truck traffic, difficulty entering and exiting driveways, and the safety of bicyclists and pedestrians.

First Street was a two-lane road with no curb, gutter, or sidewalks before it was improved.

BACKGROUND

The Grand Junction Public Works Department recognized several years ago that First Street, a rural two-lane road with no curb, gutter, or sidewalks, was beginning to develop speed and congestion problems. Though there was a posted speed limit of 56 km/h (35 mi/h), it was common for vehicles to travel at over 81 km/h (50 mi/h) on First Street. A 1992 road use study suggested accommodating the increasing volume on the street by adding a center left-turn lane to remove turning traffic from the through lanes.



The improvements to First Street included curbs and sidewalks, gutters that are used as bicycle lanes, raised medians, and raised crosswalks.

Initially, the plans to redesign First Street by expanding the right-of-way for the road (most of which was already owned by the city) was strongly opposed by many of the residents. Although most residents recognized that the congestion and speeds were out of proportion with the road's capacity and that there was only a paved shoulder for pedestrian access, they did not want to encourage any more vehicles to use their residential street as a way into town. A black walnut tree, which stood in the right-of-way needed to widen the road, became the symbol of project opponents.

Prepared by Laurie Actman, Patrick McMahon, Henry Renski, University of North Carolina Highway Safety Research Center, and Jody Kliska, Grand Junction, CO Transportation Engineering Department.

SOLUTION

Several public meetings were held and two newsletters were distributed describing the issues surrounding the city's plans for the First Street reconstruction. Through this process, traffic calming features were incorporated into the project. To reduce the project's impact on residents, the city offered to narrow the travel lanes to 3.36 m (11 ft), rebuild the stone walls in several residents' yards, build retaining walls, and move a driveway.

The final design involved the construction of two lanes plus a center turn-lane with raised medians in four locations to slow traffic and provide for safer pedestrian crossings along a 0.81 km (0.5 mi) section of First Street. Curbs and 1.5 m (5 ft) sidewalks were added adjacent to the road on both sides of the street, cutting back 1 m (3 ft) at driveways to insure a level cross-grade. Gutters were added with a width of 1.5 m (5 ft) to double as bicycle lanes. Three speed tables were installed, two of which function as crosswalks. These raised crosswalks pass diagonally through a median, forcing pedestrians to look toward oncoming vehicles before crossing the second half of the street. At the same time as the road reconstruction, all of the local utilities and irrigation systems were diverted underground and replaced by "historic" lighting fixtures.

RESULTS

After the project's construction, traffic volume rose from 10,372 ADT to 12,313 ADT. The roadway successfully accommodated this traffic increase, which was primarily due to the overall population growth of Grand Junction. Although vehicle crashes also increased slightly from five in the 22 months before the project to seven in the 20 months afterward, four of the post-project crashes occurred when a vehicle struck a median island and the project effectively reduced speeds. The 85th percentile speed decreased from 63 km/h (39 mi/h) before the project to 55 km/h (34 mi/h) afterwards. The total cost of the project was approximately $850,000.

Medians, speed tables, and raised crosswalks have been effective at reducing vehicle speeds.

Pedestrian and bicycle use of the roadway also increased. Before the project, one resident wondered, "Why are you putting in sidewalks? Nobody ever walks on this street." Now many pedestrians and bicyclists use the roadway to go to a middle school at the south end of the project, and many residents walk for recreation. According to a resident, the pedestrian and bicycle improvements inspired other residents to take more interest in walking around the neighborhood and maintaining their property. Not only had he observed significantly more pedestrians on the street, but he saw lifelong neighbors out walking for the first time.

The sidewalks, raised medians, and raised crosswalks on First Street accommodate pedestrians effectively.

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Curb Extensions in Rural Village

PROBLEM

A more pedestrian-oriented design was desired for the downtown area of a rural village, particularly along two state highways with heavy truck volumes.

BACKGROUND

Fort Plain, New York is a small village along the Erie Canal between Utica and Albany New York. The village is located within the Mohawk Valley Heritage Corridor, a region that is redefining its local economy with an emphasis on tourism. The downtown includes the crossing of two State Highways, Route 80 and Route 5-S. Both have a posted speed limit of 48 km/h (30 mi/h). Route 5-S runs down Main Street, has an ADT of about 6,000, and carries a high percentage of truck traffic. Route 80 has an ADT of about 10,000. Since the construction of the Interstate system in the 1960s and 1970s, rural Main Streets like Fort Plain have been effectively bypassed by a majority of motor vehicle traffic. This has provided an opportunity to revisit the design of these streets from a more pedestrian-oriented perspective. Since Main Street is a part of the New York State touring route system, maintenance of the street is shared, with the village responsible for sidewalks and NYSDOT responsible for the roadway.

SOLUTION

When Route 5-S was programmed for reconstruction in the early 1990s, New York State DOT's Region 2 office saw the opportunity to incorporate a series of pedestrian enhancements. NYSDOT and the community worked together on a solution that created wide sidewalks, new marked pedestrian crossings, and a new fountain set in recycled brick pavers in the village green. What may look like a relatively simple project when completed was actually a complex effort that involved the relocation of utilities, new street lighting, sidewalks, and new pavement within the context of a historic village.

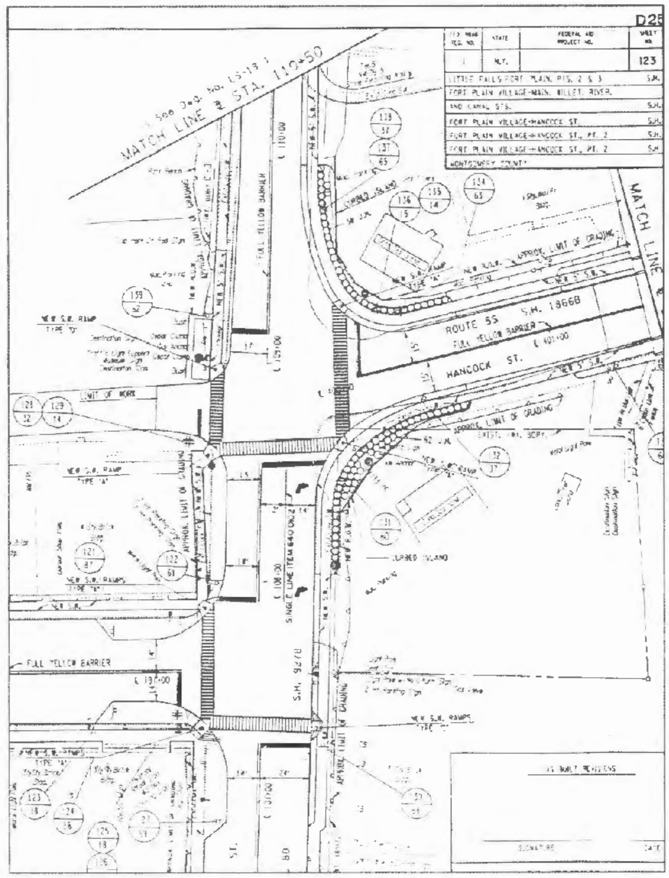

FIGURE PROVIDED BY PAUL EVANS

These construction documents show the curb extensions at the intersection of State Route 80 and State Route 5S.

One of the key elements of the project requiring a design compromise was the use of curb extensions at pedestrian crossings. While a common feature in many New York State communities, curb extensions were new to Fort Plain. NYSDOT snowplow operators were concerned

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Paul Evans, Regional Landscape Architect, NYSDOT Utica Office.

about hitting the extensions during the winter season. Even with extensive training and participation in snowplow rodeo competitions, a design compromise was needed before the extensions could be installed.

The solution reached in Fort Plain required the curb extensions to be designed approximately 0.6 m (2 ft) less than the full width of the adjacent parking bays. This allowed snowplows to drive parallel to the rows of parked cars without coming into potential contact with the leading edge of the curb extensions.

Benefits of the curb extensions included shortening the crossing distance and reducing the amount of time pedestrians were exposed to traffic when crossing the street. The curb extensions also provided additional sidewalk space. Within this additional space, curb ramps and period street lighting were installed, which otherwise would have intruded on the sidewalk because of adjacent front steps at various building entrances.

RESULTS

The installation of curb extensions has provided simple but important benefits to the Village of Fort Plain. The total cost of the project, paid by New York state transportation funds, was approximately $3.2 million. The Village was responsible for maintaining the sidewalks and street lighting. After more than five years, the installation still looks well maintained, with no evidence of damage to the curbing or other materials. Pavement markings are worn but not significantly different from other locations in the region. Traffic volumes and large vehicle movements have not been adversely affected by the new design, and pedestrian movements are enhanced by the improvements provided. One resident who was interviewed during a recent field visit said he was a disabled veteran who liked to go the post office each day, and that the new sidewalks and curb ramps were the best thing that ever happened in the village.

PHOTO BY JEFF OLSON

Curb extensions provide significant increased sidewalk space on Main Street.

PHOTO BY JEFF OLSON

Recycled brick pavers from Main Street were used in sidewalk setbacks and for the paving surface around the restored fountain on the village green.

New design guidelines not in place at the time of this project would suggest a few minor modifications, such as an improved pattern for ladder-style pavement markings, the use of separate ramps for each side of the pedestrian crossings, and the addition of tactile warnings for pedestrians with visual impairments. It is also possible that a more aggressive traffic calming treatment could be applied in a village of this scale, possibly including a median and pedestrian refuge islands. However, knowing the budget, location, and conditions of this street prior to the project, the pedestrian enhancements provided on Main Street in Fort Plain are a significant achievement.

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REFERENCES

Field visit notes and photographs, Fall 1996 NYSDOT/FHWA Mohawk Valley Enhancements Tour, J.Olson, with thanks to NYSDOT Region 2, Utica.

Safe Routes to School Program

PROBLEM

A low percentage of children were walking or bicycling to school, which contributed to poor physical health in children, traffic congestion, and air pollution.

BACKGROUND

Marin County is located across the Golden Gate Bridge from San Francisco. It has been the home to many well-known bicycle and pedestrian advocacy initiatives, including the Safe Routes to School Program of the Marin County Bicycle Coalition (MCBC). In 1999, the California Legislature passed a significant Safe Routes to School law, Assembly Bill 1475, which established a statewide, $1,000,000 program which required "...the Department of Transportation, in consultation with the Department of the California Highway Patrol, to establish and administer a Safe Routes to School Construction Program." Marin County has quickly developed a model program that is already yielding significant changes in the mode share of children walking and bicycling to school.

SOLUTION

MCBC's Safe Routes to Schools program combines promotional and educational programs with locally-based design solutions to improve physical conditions for children walking and bicycling to school, provide skills training, and offer mode choice incentives. Developed in nine pilot communities, education/promotion and engineering/infrastructure are the principal components of the program.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Wendi Kallins, Program Director, Marin County Bicycle Coalition.

EDUCATION/PROMOTION

Throughout the school year, MCBC provides pedestrian and bicycle safety skills training along with curriculum materials to help students understand modal choices and the impact of their choices on the environment. Events such as Walk and Bike to School Day are tailored by each school to meet their needs. Some schools schedule events weekly; others schedule them once a month. Two schools use volunteers as crosswalk monitors on these days.

A significant success of the program is the Frequent Rider Miles contest that rewards students for walking and bicycling to school. Students use pre-made tally cards to keep track of the number of times they walk, bicycle, car-

PHOTO CREDITS

Fairfax children walk and bike to school on International Walk to School Day October 8, 2003.

pool, or bus to school. Points are earned for each trip, and a raffle is held with prizes at the end of the school year. The grand prize at each school is a new bicycle.

ENGINEERING/INFRASTRUCTURE

Schools in two communities, Mill Valley and Fairfax, mapped typical routes that students used to walk and bicycle to school and proposed safety improvements along these routes. Using this analysis, Fairfax applied for and received a Transportation Enhancements grant from the County Congestion Management Agency to complete the gaps in the sidewalks along a major school route. Mill Valley has applied for funding to improve access to and from a local bicycle path and to provide enhanced pedestrian crossings throughout the community.

RESULTS

Significant changes in student modal shares have been documented by MCBC for the 2000-2001 school year. Data collected through student surveys in 2000 show that about 23 percent of students walked or bicycled to and from school. Surveys given at the end of the school year in 2001 found that the mode share for walking and bicycling had increased to 33 percent. This amounts to more than 3,500 children walking or bicycling to and from the nine schools included in the pilot program. Equally significant, the data show that carpooling increased from 12 percent to almost 20 percent, and the percentage of children being driven alone in their parents' cars decreased from about 66 percent to 48 percent.

Advantages favoring Marin County include a climate that is generally mild and conducive to outdoor recreation, a progressive-minded population that is open to change and innovation, the well-organized efforts of MCBC advocates, and the resources provided through the State of California Safe Routes to Schools legislation. The statewide program has received significant support, and was recently re-authorized with a substantial budget appropriation.

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REFERENCES

Marin County Bicycle Coalition Safe Routes to Schools Web site: www.saferoutestoschools.org.

High Volume Pedestrian Crossings

PROBLEM

A methodology was needed to guide the design of pedestrian crossings in areas with very high pedestrian volumes.

BACKGROUND

Pedestrian crossings are commonly designed to meet existing conditions. Pavement markings are generally aligned to match the existing locations of curb ramps or to match sidewalk widths, not considering the potential for large volumes of pedestrians at high traffic intersections. The sidewalks and crossings may not allow sufficient space for large volumes of people, causing pedestrians to walk outside of the marked crossing in adjacent motor vehicle lanes, and creating unsafe conditions for both pedestrians and motorists.

PHOTO BY SPRINKLE CONSULTING, INC.

The Las Vegas Strip serves large volumes of both vehicles and pedestrians.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Richard Romer, Orth-Rogers Consulting.

Clark County, Nevada includes the famous Las Vegas Strip and many other locations with high pedestrian traffic in its jurisdiction. Many of the roadways in these areas are six lanes and the intersections of the arterial roadways are very wide, creating dangerous conditions where pedestrians mix with vehicles. Therefore, safer and more comfortable sidewalks and pedestrian crossings were needed.

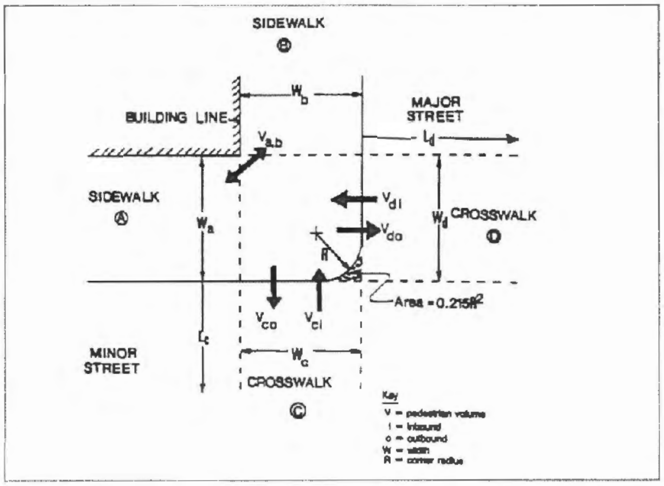
SOLUTION

In the mid-1990's, Clark County engineers and planners developed a methodology for sizing pedestrian crossing facilities based on pedestrian traffic volumes. This methodology is described in a 1997 Transportation Research Board paper, entitled, "Integrated Systems Methodology for Pedestrian Traffic Flow Analysis."

The technique takes an analytical perspective to quantify and assess the safety and comfort of pedestrians. It requires three basic elements of the pedestrian transportation system to be considered: 1) sidewalks or walkways; 2) mid-block or intersection corner, holding, or queuing areas; and 3) pedestrian crossings of roads, railway lines, or other physical features of the transportation network. The methodology takes a systems approach that identifies key relationships between these three pedestrian elements at a signalized intersection. It can be used to evaluate existing pedestrian conditions at an intersection, and to develop decision support tools to evaluate the potential need for new signalized at-grade intersection pedestrian elements or a grade-separated pedestrian facility.

At the same time that this methodology was being developed, the Nevada Office of Traffic Safety and Clark County hosted a weeklong charrette entitled "Creating a More Walkable Las Vegas" in April, 1996. Using the proposed model and a variety of analytical tools, a broad-based series of recommendations were made through a professional team led by Dan Burden of Walkable Communities, Inc.

TAKEN FROM TRANSPORTATION RESEARCH RECORD 1578.



This graphic shows the relationships between pedestrian elements at the corner of an intersection as defined in the Romer/Sathisan "Integrated Systems Methodology for Pedestrian Traffic Flow Analysis."

RESULTS

While no single event or technical document can be solely responsible for creating change, the past decade has seen considerable changes in the pedestrian environment in Las Vegas. Public and private investments have enhanced pedestrian movements, yet in some cases, they have made them more difficult. At several major intersections, pedestrian bridges have been developed linking large casino properties on all four corners of the intersection at the second floor level, and prohibiting at-grade pedestrian crossings. New landscaped medians have been provided along the strip, enhancing mid-block crossings in some locations, but restricting pedestrian crossings at others.

The methodology has been used in Las Vegas to improve the design of pedestrian facilities at all the new mega-resorts constructed over the last few years. This systems analysis has been used on several public roadway projects, such as the ones for Flamingo Road and Tropicana Road. Also, the concept has been used to establish a public safety perspective to support an ordinance that regulates the placement of newsracks. Similarly, it was used in an Obstructive Use ordinance that establishes a specific threshold standard for sidewalk pedestrian traffic flow and regulates and prohibits mobile activities, such as handbill solicitation and t-shirt vendor tables, on segments of sidewalks that cannot adequately support those activities.

PHOTO BY SPRINKLE CONSULTING, INC.

Pedestrian bridges are provided across all four legs of the intersection of Tropicana and Las Vegas Boulevard South. Pedestrians may not cross at-grade.

According to Richard Romer, one of the engineers who developed the analytical technique, the method was created recognizing the need to design pedestrian circulation systems that provided appropriate levels of service and comfort, especially relative to land uses that generate high volumes of pedestrians. This systems approach can also be used in the planning and design of other pedestrian facilities, such as median or refuge island areas for pedestrians and grade-separated facilities.

While there are few communities with the same roadway and pedestrian environment as the Las Vegas Strip, many communities have transit stations, busy urban streets, and suburban growth corridors with high pedestrian volumes and many pedestrian-vehicle conflicts. These areas can benefit from an analytical approach to determining the appropriate facilities for pedestrians crossings. Therefore, the tools developed for high traffic pedestrian intersections in Las Vegas can be used to improve the safety and comfort of pedestrians at crossings in other communities.

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REFERENCES

Integrated Systems Methodology for Pedestrian Traffic Flow Analysis, Romer, RT; Sathisan, SK., Transportation Research Board (TRB), Transportation Research Record 1578–Pedestrian and Bicycle Research, 1997, pp. 30-37. ISBN: 0309061687.

Creating a More Walkable Las Vegas, Final Report from the April, 1996 Las Vegas Pedestrian Safety Workshop, Walkable Communities, Inc., November 1996.

Small Town Traffic Calming

PROBLEM

In the 1970s, residents of Oneonta wanted a pedestrian-friendly alternative to urban renewal projects that had resulted in narrow sidewalks, high volumes of vehicle traffic, and the demolition of historic buildings in the downtown area.

BACKGROUND

Oneonta is a small upstate New York city located approximately 96.6 km (60 mi) southwest of Albany. It has two colleges (Hartwick and SUNY Oneonta) and a surrounding region of working agricultural landscapes. In the late 1970s, Urban Renewal was an unpopular program in Oneonta. The federal program to "renew urban blight" often resulted in streets with features that were not pedestrian friendly, such as narrow sidewalks, four lane sections designed for high volumes of motor vehicle traffic, and the demolition of historic buildings. Frustrated by this approach, Oneonta took a step back with its final round of urban renewal funding, hired a local landscape architect and conducted surveys of what people wanted downtown. The result was that people wanted a place to walk, cross the street easily, and sit down in the shade. They wanted slow traffic, with easy places to park that were safe and pleasant.

SOLUTION

Based on this input, the City redesigned Main Street with neckdowns, protected on-street parking, only two lanes of traffic, wide sidewalks, and mid-block slow points, all on a street with a 21 m (70 ft) right-of-way

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Joe Bernier, City of Oneonta Director of Community Development.

PHOTO BY J.OLSON

A wide sidewalk is combined a with curb extension to provide space for benches and shade trees.

from building to building. The first phase opened in 1980 and over the years, Oneonta has continued to improve the design of Main Street, adding period street lighting and developing a detailed palette of paving materials. The original traffic calming features of the early design have remained and are now an integral part of the streetscape. The primary federal funding used for the improvements has been the HUD Small Cities Program, which involves a revolving loan payback system. Most recently, in the year 2000, a Clarion hotel has been built on one of the former urban renewal sites, and the city has created a new urban square linking the hotel to Main Street. Approximately $1 million dollars has been invested in Oneonta's Main Street program over the past 20 years.

Joe Bernier, Oneonta's Director of Community Development, describes the evolution of Main Street as an alternative to converting downtown into a car-free pedestrian mall, and a compromise between merchants who want parking, people who want to sit in a common space, and traffic engineers who want through traffic. He adds that the city has learned a lot about building materials--they had done concrete crosswalks and replaced them with stamped asphalt because the con-


PHOTO BY J.OLSON

A mid-block curb extension on Main Street in Oneonta, NY narrows the street to two lanes and cuts the pedestrian crossing distance in half.

crete became slippery and was subject to frost movement. They are currently using brick pavers, set in a sand sub-base, as a decorative border for the concrete sidewalks. However, they generally try to minimize the use of too many materials due to maintenance concerns. He adds that ornamental lights are required to be high quality fixtures and that it would be ideal if these lights were maintained by the local electric utility company in order to minimize the City's maintenance costs.

RESULTS

Main Street in Oneonta carries approximately 14,000 ADT, according to a current NYSDOT corridor study. The perception of the street as a safe place for pedestrians is confirmed by traffic safety data. The 85th percentile speeds are consistently maintained near the 40 km/h (25 mi/h) posted speed limit. Ground floor commercial occupancy is near 100%, and the design of the street is helping the city evolve from a retail center to a new market as a college town with close-to-home tourism destinations including the National Soccer Hall of Fame and National Baseball Hall of Fame. With the support of the Intermodal Surface Transportation Efficiency Act (ISTEA) and Transportation Equity Act for the 21st Century (TEA-21), the NYSDOT has played an increasing role. A recently funded corridor study recommended funding for an Oneonta Greenway to connect with Main Street as well as several downtown Gateway projects.

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REFERENCES

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Park Trail Bridges

PROBLEM

Four creek crossings were crucial to development of a 1.6 km (1 mi) trail in the heart of Prescott, and the development of the trail was central to implementation of the community's citywide bicycle and pedestrian transportation plan. However, severe funding constraints and significant engineering challenges put completion of the project at risk.

BACKGROUND

Prescott is located near the center of Arizona. This community of 35,000 residents is joined by two smaller cities, Prescott Valley and Chino Valley, to create a tri-city area of just over 100,000. Prescott was Arizona's first Capitol, settled around seven creeks that descend from the surrounding mountains into this lush basin. With five colleges, a growing retirement community, picturesque open spaces and innumerable amenities, the Prescott tri-city area population is projected to balloon to over 200,000 by the year 2015.

West Granite Creek Park (WGCP) is a wild riparian area that surrounds the confluence of Miller and Granite Creeks. Owned by the City, the park is just a few blocks from Prescott's downtown, seven schools, many churches, and neighborhoods. Many pedestrians and bicyclists did not use the park to travel between the east and west halves of the city because a 56 km/h (35 mi/h), five-lane connector road with 25,000 ADT passed through WGCP blocking pedestrian and bicycle passage.

Since the 1980s, many local groups had requested trail improvements through WGCP. After the connector road was built in the early 1990s, WGCP became the only potential non-motorized access route across town. In its unimproved condition, pedestrian and bicycle traffic increased in WGCP despite slippery and often impassable water crossings, primitive trails, and a transient population that had taken up shelter in the overgrowth.

In 1997, Prescott Alternative Transportation (PAT), a non-profit organization, began working toward a pedestrian and bicycle friendly city. Early on, PAT worked with the City of Prescott to develop safer trail access through WGCP and support Prescott's pedestrian and bicycle transportation system.

In 1998, City Council approved Prescott's first bicycle plan, developed by the Prescott Bicycle Advisory Committee and PAT. The plan described the existing bicycle and pedestrian use of West Granite Creek Park and the key connecting role that the planned WGCP multi-use trail would play in Prescott's proposed Bicycle and Pedestrian Transportation System. As a result, WGCP was identified as a target area for the first trail improvements.

Prepared by Sue Knaup, Executive Director, Prescott Alternative Transportation.

SOLUTION

In 1999, City of Prescott Trails and Open Space Coordinator, Eric Smith, organized groups and individuals, including PAT, into the WGCP Master Plan Team and created a facility master plan to guide the development of the trail system within the park. The comprehensive plan was passed by City Council in July 2000, but without dedicated funding. Bolstered by the Council's political support and undaunted by a lack of funds, trail development began immediately with Mr. Smith directing volunteer trail builders.

The first phase of trail to be built was approximately 1.6 km (1 mi) long. It was constructed at a variable width, 2.4 to 3 m (8 to 10 ft), of hard-packed crushed stone. Leach rock was used as a base along with rock edging. It was built with 1,100 hours of volunteer labor over six months at a cost of $8,000. In addition to the land trail,

The Miller Creek permanent bridge provides pedestrian access across West Granite Creek Park.

four creek crossings were crucial to ensure that the trail system connected to all of the adjacent neighborhoods. A lack of dedicated funding presented a challenge to prospective bridge builders.

Fortunately, PAT found ways to pay for the trail and creek crossings with limited funds. One new crossing is the Miller Creek permanent bridge. This bridge was constructed using 18.3 m (60 ft) glue-laminated wood beams, set on stone abutments, with Douglass Fir decking. When first installed, this bridge bounced wildly when a pedestrian or bicyclist crossed. Mr. Smith and the Parks Department staff built a tension frame from scrap rebar and plate steel. The plate steel supports the center of the bridge from below, holding tension at the two ends by way of bolts welded to the rebar tightened with nuts. They jacked up the center of the bridge with car jacks until it could not bow any further, installed the tension frame and tightened the nuts before releasing the jacks. The tension frame removed 80 percent of the bounce

The Miller Creek permanent bridge tension frame was used to steady the bridge for pedestrians and bicyclists

and made the Miller Creek bridge a sturdy water-crossing without further expense. It is not anchored and thick cables allow the bridge to pivot in case of flood. While a prefabricated bridge would have cost over $20,000, the total cost of this bridge was $3,500.

Another bridge was also created over Granite Creek using an existing sewer pipe. When Granite Creek water levels rose above a few feet, this abandoned sewer pipe served as the only possible creek crossing for pedestrians. Though unsafe in its original form, it offered a sturdy foundation for the Granite Creek Eagle Scout sewer pipe bridge. This bridge is constructed by anchoring 9.1 m (30 ft) of 51 mm x 305 mm (2 in x 12 in) wooden boards to the concrete sides and abutments of the sewer pipe structure. These provided the base for the 1.2 m (4 ft) wide Trek artificial wood decking. The narrow pipe prevented the bridge from being widened beyond 1.2 m (4 ft). Concrete curbing for the trail approaches preserves the trail surface where it connects to the bridge. The Eagle Scouts donated their labor, and the total cost was $2,000.

The Granite Creek bridge takes advantage of an existing sewer pipe as its foundation.

Two temporary bridges, one across Miller Creek and the other across Granite Creek, were also constructed. Their combined construction cost was $200, and one of the bridges will eventually be moved and used for another trail project.

RESULTS

By keeping the out-of-pocket costs as low as $13,700 for the 1.6 km (1 mi) trail and four bridge crossings, the City staff found previously budgeted and approved funds in the Parks budget for the projects. City commitment to use already budgeted funds was strengthened by a very successful fundraising event, which garnered over $12,000 for the WGCP in one night. In the end, these funds did not have to be used for phase one project costs and were combined with other individual donations and foundation grants. PAT also received a $500,000 Transportation Enhancement award and hired a greenway coordinator to spearhead development of an additional 3.1 km (5 mi) of trail along Granite Creek.

This project was successful because it was fully supported by the community. Since the day the last water crossing was installed, there has been a constant flow of pedestrian and bicycle traffic through WGCP.

By offering a safe route under the connector road, the completion of the WGCP trails has prompted the development of Prescott's on-street bicycle and pedestrian transportation system. It also represents the cornerstone of Prescott's future greenway trails system that will some day stretch to Prescott's borders and connect the tri-cities via a rails-to-trails conversion project.

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TEMPE, ARIZONA — CASE STUDY NO. 13

Fifth Street Traffic Calming

PROBLEM

Neighborhood residents were concerned about increasing traffic volumes, excessive speeds, and air pollution on a major collector street. They wanted the street to be redesigned to maintain the character of the neighborhood, and improve the safety of pedestrians, bicyclists, and bus patrons.

BACKGROUND

A goal of Tempe's transit program is to provide a livable community with a transportation system that is environmentally sustainable and preserves neighborhoods. To enhance and preserve the physical character of Tempe and promote accessible transportation options, the City of Tempe instituted the Fifth Street Pedestrian Enhancement and Traffic Calming Project.

Fifth Street is a major collector street in the middle of the Riverside and Sunset neighborhoods, and is adjacent to destinations such as a neighborhood market, Scales Elementary School, Jaycee Park, and the Tempe Boys and Girls Club and Community Center. In 1995, residents of the neighborhoods approached the City of Tempe with concerns about increasing traffic volumes and speeds on Fifth Street. The residents wanted to move around their neighborhood safely and easily by bicycle, bus, or walking; reduce high-speed, cut-through traffic and vehicle emissions; and maintain the character of the neighborhood.

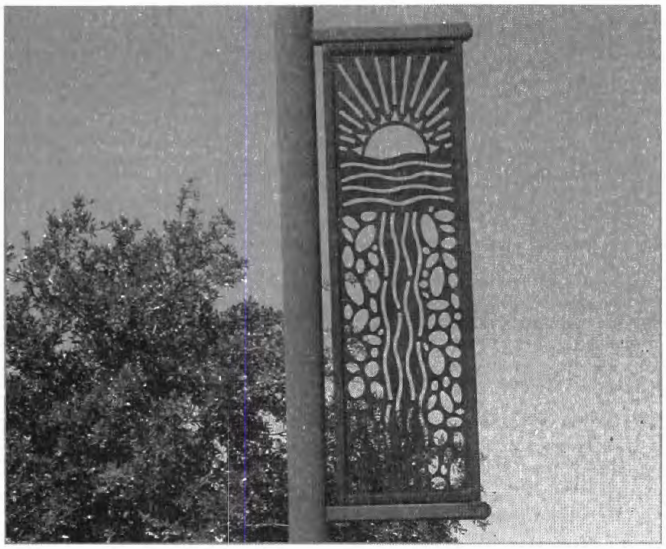
SOLUTION

The City obtained a federal grant to add traffic calming and pedestrian enhancements to the street. Temporary traffic calming devices were placed on Fifth Street so residents could envision the look and operation of the final project design. Following a successful test period that included narrowed lanes and traffic chokers, the City, with the help of neighborhood input, constructed permanent traffic calming and artistic features on Fifth Street.

Prepared by City of Tempe, Arizona.

A median island and bicycle lanes encourage slow vehicle speeds and wide sidewalks provide pedestrian access along Fifth Street.

In the final project design, the existing sidewalks were widened to between 1.8 and 2.4 m (6 and 8 ft) to allow

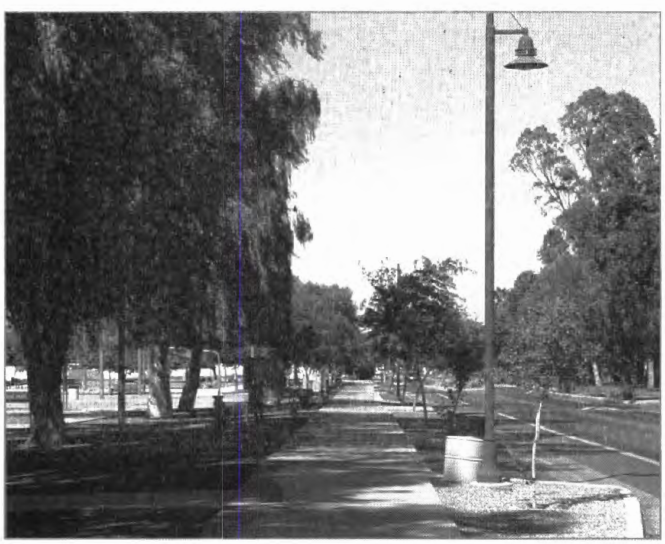


Artistic features were incorporated throughout the project to improve the pedestrian environment.

greater pedestrian comfort, and 1.5 m (5 ft) bicycle lanes meeting national standards were provided. The street was redesigned to include traffic chokers, intersection bulb-outs, pedestrian-level street lighting, shade trees, and low shrubs. Median chicanes, speed tables, and on-street parking were added next to Jaycee Park. In addition, artistic features were added throughout the project. The design elements were approved by a majority of residents at a series of neighborhood meetings.

RESULTS

In 1995, after the widening of a nearby major arterial street and the opening of a nearby freeway entrance, traffic counts on Fifth Street were nearly 10,000 ADT. The narrowed lanes and traffic chokers cut traffic by 40 percent to 6,000 ADT.



The Fifth Street Project has received a positive reaction from the community.

Traffic counts conducted after completion of the project indicated significant reductions in average daily vehicle traffic. For example, volumes on Fifth Street east of Ash Avenue dropped 21 percent from 9,898 ADT before to 7,789 ADT after the project, and volumes between Roosevelt and Wilson fell 63 percent from 10,186 ADT to 3,804 ADT.

Following implementation of the long-awaited pedestrian and traffic calming improvements to Fifth Street, the City received numerous positive comments from residents praising the enhanced walkability and increased safety due to reductions in traffic speed and volume. Cut-through traffic and speeds have decreased, bus service to the area has increased, and the character of the neighborhood remained intact.

The Fifth Street Pedestrian Enhancement and Traffic Calming Project has become a model for many other cities across the country. The City ofTempe and its residents used pedestrian enhancements to promote aesthetically-pleasing, environmentally-friendly transportation alternatives while making Tempe a more livable community.

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FORT PIERCE, FLORIDA CASE STUDY NO. 14

Roundabout for Downtown Revitalization

PROBLEM

High vehicle speeds, limited sight distances, and inadequate sidewalk facilities made it unsafe for pedestrians to walk between Ft. Pierce's historic downtown and waterfront areas. The poor pedestrian environment negatively impacted downtown businesses.

BACKGROUND

Fort Pierce is a seaside community located along the intercoastal waterway on the Atlantic Coast of Florida. By the early 1990's, the once-vibrant street life in downtown Fort Pierce had faded.

A major block to downtown revitalization was an inhospitable pedestrian environment, especially at the intersection of Avenue A and Indian River Drive, the gateway between the historic downtown and the waterfront area. Pedestrians found crossing the intersection difficult due to high vehicle speeds, blind corners, and poor sidewalk design.

SOLUTION

In the mid-1990's, private and public leaders decided to rebuild the community. A community charette, sponsored jointly by the City of Fort Pierce, the Main Street Fort Pierce program, and the Treasure Coast Regional Planning Council, was organized in January of 1995. A vision and plan for reconstructing the downtown was developed at the meeting, and directives were adopted to make the downtown more pedestrian friendly by slowing traffic, widening sidewalks, and providing more on-street parking.

Prepared by Laurie Actman, Patrick McMahon, Henry Renski, University of North Carolina Highway Safety Research Center, and Ramon Trias, City of Fort Pierce, FL.

The roundabout included splitter islands, colored crosswalks with median refuges in the splitter islands, curb extensions, curb ramps, and landscaping to slow motor vehicles and provide a safe and enjoyable pedestrian environment.

Part of the plan included the construction of a roundabout at the intersection of Avenue A and Indian River Drive. Located on a Florida Department of Transportation road, the roundabout cost around $200,000 and was the first to be constructed according to new state guidelines for roundabouts. The completed roundabout is both beautiful and functional, built with stone details, palm trees, historic lights, and brick pavers, and designed to accommodate a large amount of intersecting vehicular and pedestrian traffic.

Curb extensions and median refuge islands were built on each approaching leg of the roundabout to make pedestrian crossing safer and easier. The crosswalks are clearly contrasted against the black pavement by light colored brick pavers.

Indian River Drive, which winds along the waterfront, was shifted inland slightly at its southern end to terminate at the roundabout. From the roundabout to the water, a large surface-level parking lot was partially converted into a circular extension of Avenue A. At its far end, Indian River Drive opens to a new waterfront park with wide brick sidewalks and curb extensions.

RESULTS

Before the project, vehicles often traveled through the area at 56 to 64 km/h (35 to 40 mi/h) although the speed limit on Indian River Drive was 40 km/h (25 mi/h). The roundabout and curb extensions have been designed to keep speeds to a maximum of 16 km/h (10 mi/h) as cars enter or leave the waterfront area, setting a leisurely pace for downtown driving.

The roundabout accommodates about 14,000 vehicles each day which is similar to the volume that passed through the traditional intersection before the project; however, the pedestrian volume at the intersection increased dramatically after the construction of the roundabout, from approximately 50 pedestrians per day to about 1,000 pedestrians per day. Slower speeds, complemented by the curb extensions and refuge islands, makes crossing the street safer for pedestrians and allows them to enjoy the downtown environment.

The roundabout, curb extensions, and improved sidewalks also helped re energize the economic vitality of downtown Fort Pierce. The roundabout itself is considered a memorable landmark within the town, enhancing the entire downtown area. With the increase in pedestrian traffic, new restaurants, outdoor cafés and stores have opened in once vacant spaces. City officials and business representatives consider the project a huge success and consider the pedestrian-friendly design as the cornerstone of their effort to bring downtown back to life.

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Redesign for Streetcar Access

PROBLEM

Pedestrians experienced conflicts with motor vehicles and bicyclists as they attempted to board streetcars at a transit stop.

BACKGROUND

Between the 1950s and 1980s, streetcar networks in many European countries disappeared. But in towns where light rail survived, the existing lines were improved and new lines were built. In Bern, the capital of Switzerland, the planning and civil engineering departments sought to improve the safety for pedestrians and cyclists along the Thunstrasse, a main street near the city center. Before the reconstruction, the street had 3.6 m (12 ft) sidewalks, 2.3 m (7.5 ft) tree-lined medians, a 11.1 m (36 ft) street surface, and 3 light rail lines that were each 1 m (3.3 ft) wide. A train passed every 6 minutes, and 5,000 motor vehicles used the street per day. Each weekday, approximately 1,350 pedestrians boarded the trains between 6 a.m. and midnight in the direction of downtown. Passengers waited on the sidewalks until the streetcars stopped, but the train tracks were in the middle of the street, so passengers were forced to enter the street before boarding the streetcars. This created conflicts between pedestrians running for the streetcars and motor vehicles and bicycles that did not wait while the streetcars stopped.

SOLUTION

Due to limited space, it was not possible to add more car lanes and/or build separate transit stops. Instead the sidewalks were widened and the light rail tracks were moved to the curbs along a 45 m (148 ft) stretch of the roadway to serve light rail vehicles that are between 30 m (98 ft) and 42 m (138 ft) long. The street width between the curbs is now only 7.9 m (26 ft). Space was marked between the tracks which allowed pedestrians to cross the street in two steps. Metal poles were placed in the middle of the street and on the sidewalk at the transit stop to prevent cars from passing waiting streetcars. The narrow street width also prevents cars from passing the transit vehicles.

Zebra crosswalk lines are marked at both ends of the transit stop. According to the Swiss traffic law, pedestrians have priority over cars when they stand at the curb and, "obviously intend to cross the street." Because of the narrow street, no special facilities (bicycle lanes, bicycle paths) for cyclists are provided. In general, the cyclists share the road with cars. Only in the case of a waiting streetcar are cyclists allowed to use the combined sidewalk/transit stop area.

RESULTS

The new transit stop was built in the summer of 2001 at a cost of $380,000 for planning and construction. Observations show that the traffic has slowed but congestion has not increased. Typically, 2 to 5 cars and 1 to 2 cyclists must wait for 30 to 60 seconds when a streetcar is stopped. During that time disembarking passengers cross the street on the zebra lines in front of and behind the waiting light rail vehicle. The City, residents, streetcar passengers, and the transit company view this project as a success because it has increased safety and comfort. Together with newly installed shelters for waiting passengers, ticket machines, and public transport information (timetables, network plan, fares) that make transit travel more comfortable for pedestrians, the Thunstrasse in Bern is a positive example of a redesigned transit stop.

Prepared by Juerg Tschopp, Verkehrs-Club der Schweiz VCS/Swiss Association for Transport & Environment T&E.

Slower vehicle speeds in the area of the transit stop make crossing safer and more comfortable for pedestrians.

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Street Redesign for Revitalization

PROBLEM

The West Palm Beach area was considered blighted and unpleasant for pedestrians.

BACKGROUND

By 1993, West Palm Beach's downtown was considered to be a quintessential blighted community. Roughly 80% of Downtown property was vacant, the streets were overrun with criminal activity, and the wide multi-lane one-way streets, designed so that drivers could move quickly through town without having to stop. At the time, the City was also $10 million in debt and had only $6,000 in capital reserves.

Aerial view of CityPlace along Okeechobee Boulevard.

Prepared by Natalie Rush, Transportation Planner, City of Sarasota, FL, Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center.

Information provided by Chuck DeLeuw, City of Berkeley, CA and Mourad Bouaouina, University of California at Berkeley.

Intersection of Clematis Street and Narcissus Avenue, eastern view.

SOLUTION

West Palm Beach wanted to rejuvenate its economy and community by redesigning downtown to accommodate and attract pedestrians. So in 1993, Mayor Nancy Graham turned her focus to an ambitious downtown revitalization, including traffic calming measures to entice pedestrians to linger in the area.

In the heart of the blighted Downtown area, two legs of Clematis Street intersect with the North-South Narcissus street forming a "K" shaped intersection. The intersection was rebuilt as a raised intersection emphasizing the pedestrian priority. Clematis Street was converted from a three-lane, one-way street with parking to a two-lane, two-way street with parking. Mid-block narrowings, intersection bulb-outs, a raised intersection, and streetscaping reduced the physical and visual road width of Clematis Street resulting in slower vehicle traffic, a narrower pedestrian crossing distance, wider sidewalks and a general softening of the harsh tone of the street. Narcissus Street was also narrowed from 9 to 6 m (30 to 20 ft) and redesigned so that on every block, the entire street shifts twice laterally. The narrow road and lateral shifts reduce drivers' lines of sight and force vehicles to travel slower through the turns. Large palm trees were also incorporated into the design to create an optical narrowing that further reduced vehicle speeds.

RESULTS

At the "K" intersection, the City built a pedestrian plaza, with a fountain at the center, and drastically modified the façade of the City's Library at the east end of the plaza. The fountain attracted adults and children who began returning to the Downtown area and patronizing the nearby business. Business owners began renovating their facades through a government grant program. New businesses opened, and the area attracted more pedestrians as a shopping and cultural center developed. The City also started a weekly block party with music, food, and craft vendors at the plaza, known as "Clematis By Night," held every Thursday that brings approximately 3,000 to 5,000 visitors downtown every week.

Interactive fountain at the Nancy M. Graham Centennial Plaza, eastern terminus of Clematis Street.

Today, the area has an 80 percent commercial occupancy rate, and pedestrian activity has increased tremendously since the beginning of the revitalization effort. Property values, which once sold at \$64 m^2 (\$6 ft^2), rose to over \$430 m^2 (\$40 ft^2). The City is now planning to create a 24-hour Downtown by encouraging new mixed use and residential development to enhance the pedestrian-orientation of the area.

Through the use of traffic calming and pedestrian amenities, West Palm Beach rebuilt its Downtown into a safe, social, and vital center for community activities. There are several successful projects that have already been completed, and many more are either in the planning or construction phases of implementation.

The success of the Narcissus & Clematis area has opened the gates on a flood of new traffic calming projects around the City. The City and State are currently collaborating on a \$55 million project to reconstruct U.S. Highway 1 through the City. The effort consists of eight sections that will include various traffic calming elements. In the Downtown, the project will narrow a pair of three-lane one-way streets to two lanes and provide raised intersections at eight key pedestrian intersections.

Slightly west of the Clematis & Narcissus area, the City purchased a 31 hectare (77 acre) plot of land, which had been left vacant by a bankrupt developer in the 1970s. The property has recently attracted the attention of \$500 million worth of redevelopment and investment, known as "CityPlace," that includes retail, residential, office, townhouses, a 20-screen theater, grocery store, and over 4,000 structured parking spaces. The project opened October 2000. Part of the redevelopment project includes the creation of pedestrian-friendly streets based upon traffic calming principles. The development has a Mediterranean theme and the sidewalk will be covered with arcades as outdoor places where pedestrians can stay dry during rainy days. The project also includes a public plaza in front of the refurbished historic church that sits in the heart of the project. Another key component of the effort includes the reconstruction of Rosemary Avenue to connect CityPlace to Clematis Street. Rosemary Avenue is the main street of

Rosemary Avenue

CityPlace and Clematis Street is the historic main street of Downtown West Palm Beach.

In an effort to connect the two districts, the City reconstructed Rosemary Avenue to improve the pedestrian environment. The result is spectacular. The street has no curbs. The crown of the road is inverted and drainage runs to the center. The entire street was constructed with brick pavers. Street trees separate the parking stalls. All intersections are raised providing pedestrian priority. Many of the design elements were created due to the limited right-of-way and the location of existing buildings. The ultimate goal of the project was to increase the sidewalk widths and create an inviting pedestrian environment.

In addition to the newly redeveloped Downtown, the city of West Palm Beach now installs traffic calming measures every time the city performs an underground utility project that involves reconstructing the street. Traffic calming measures are now required as standard when streets are developed, redesigned, or under construction. The pedestrian environment has been improved immensely by the revitalization of the Downtown area and the traffic calming strategies.

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Bridgeport Way Corridor Improvement

PROBLEM

A 1.6 km (1 mi) stretch of Bridgeport Way, a central arterial road in this small community, was the site of hundreds of traffic accidents between 1995 and 1998, many involving pedestrians. Pedestrian travel through the corridor was made difficult and dangerous by narrow gravel shoulders.

BACKGROUND

In the summer of 1996, the City of University Place decided to design and construct safety improvements along a portion of Bridgeport Way, a major arterial roadway running through the heart of the city. Bridgeport Way provides access to City Hall, a library, senior housing, a medical facility, and multiple retail centers.

Bridgeport Way carries the largest daily traffic volumes in the city, ranging from 18,800 vehicles per day at the south end of the city to 24,100 vehicles per day near the city center. This 1.6 km (1 mi) stretch of Bridgeport Way was the site of 301 accidents resulting in one fatality and 91 injuries between 1995 and 1998. Ten crashes involved pedestrians. Prior to construction of the improvements, pedestrian travel through the corridor was made difficult by narrow, 0.6 m (2 ft) wide gravel shoulders that placed pedestrians dangerously close to vehicular traffic.

SOLUTION

With a desire to pursue the goals outlined in the City's adopted Vision Statement, the City of University Place saw an opportunity to rebuild and transform Bridgeport Way into an inviting main street that would allow pedestrians and bicyclists to move about comfortably and safely while still accommodating vehicular movement through the corridor.

Prepared by Ben Yazici, City Manager, City of Sammamish, WA; Former Assistant City Manager/ Director of Public Works for City of University Place, WA and Steve Sugg, University Place, WA.

Brigeport Way before the redesign.

The proposed roadway design included the following:

- Replacement of the existing two-way-left-turn-lane with a raised, landscaped median, which would prevent left turns out of driveways.
- Construction of wide sidewalks on both sides of the roadway.
- Construction of bicycle lanes on both sides of the roadway.
- Placement of planter strips on both sides of the road, between the sidewalk and bicycle lane.
- Street lighting.
- Permission of U-turns at the signalized intersections.
- Placement of utility lines underground.

Although access to local businesses was severely affected by construction of raised median islands, the local Chamber of Commerce worked with the City to convince business owners that the new roadway would provide a much better business climate than the existing

Bridgeport Way after the redesign.

road. With this collaborative approach between the City and the Chamber of Commerce, most business owners donated the needed right-of-way to construct this project. The City spent less than $30,000 on right-of-way acquisition to obtain an average 3.1 m (10 ft) strip of the front edge of each commercial property along the roadway. Without cooperation from the businesses, it would have cost the City $500,000 to obtain the right-of-way at fair market value.

University Place also worked with the local utility company to place utility lines underground. The utility company agreed to pay half of the cost, if the City could provide a utility trench as part of the City's construction project. This lowered the City's cost of burying the utility lines by as much as $1 million.

The project was completed in 1999 at a total cost of $2.5 million, including design, right-of-way and construction.

RESULTS

The City has analyzed speed, accident, and economic development data collected before and after the construction of the Bridgeport Way improvements between 35th and 40th Streets. The project's traffic calming features reduced speeds and crashes while increasing business activity. Average speed decreased by 13 percent and traffic accidents were reduced by 60 percent (see table below).

Prior to the project's implementation, very few pedestrians walked along or crossed the roadway because there were no sidewalks, crosswalks, or paved shoulders. Increased pedestrian activity is evidenced by the over 3200 pedestrians per month usage levels found at the two new mid-block crosswalks. The south crosswalk has 100 pedestrians per day, which is enough activity to warrant a pedestrian signal. The City is considering upgrading the south crosswalk warning sign flasher to a fully signalized crosswalk to improve safety at that location. Yet, despite a dramatic increase in the level of pedestrian activity on the street and the increased exposure to motor vehicle traffic, the frequency of pedestrian crashes has remained constant at about 2.5 crashes per year.

The Bridgeport Way project has also contributed to economic development. Citywide sales tax data indicate that sales revenues increased by 5 percent citywide. Yet, the businesses around the project corridor experienced an increase of approximately 7 percent.

When the Bridgeport Way project was first presented to the public it included a number of roundabouts at key intersections. Public reaction to these bold new facilities was mixed, and to achieve public consensus, the design was modified to include standard intersections with left-turn pockets and a median. Making this design modification and creating a stronger community consensus before construction helped the project gain positive community support. Moreover, the project has been a great success for the City of University Place based on the fulfillment of its key goals:

- To help reduce vehicle crashes.
- To contribute to the economic vitality of the Bridgeport Way Corridor.
- To provide improved safety and convenience for pedestrians.

Safety Measures	Before	After	Change
Posted Speed Limit	56 km/h (35 mi/h)	56 km/h (35 mi/h)	Same
Average Actual Speed	61 km/h (37.6 mi/h)	52 km/h (32.6 mi/h)	–13 %
Average Annual Crashes	19	8 (first year)	–60 %

Table 1. Data from before and after the Bridgeport Way redesign.

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AUSTIN, TEXAS CASE STUDY NO. 18

ADA Curb Ramps

PROBLEM

The City wanted to build curb ramps that were compliant with the Americans with Disabilities Act while guidelines were not yet finalized.

BACKGROUND

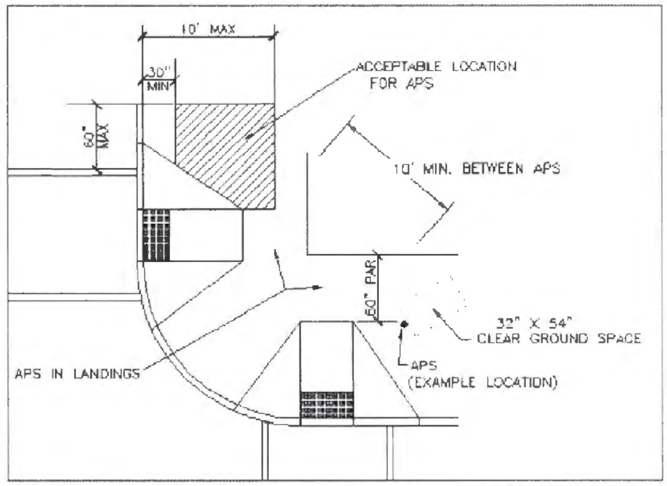
Austin, Texas has an extensive curb ramp program that takes a systematic approach to creating ADA-compliant street crossings. The City's Americans with Disabilities Office has a full time Public Works and ADA Compliance coordinator, and a multi-million dollar program guided by a citywide ADA Task Force, as well as an ADA Work Group within the Public Works Department.

The "state of the art" in designing curb ramps can be understood by a comparison of Austin's program with current guidelines and regulations. As many communities actively work towards ADA compliance, new design guidelines, standards, and regulatory processes continue to evolve.

The City of Austin has worked closely as the guidelines have evolved, and the City is continually adapting its designs, not only achieve ADA compliance, but to create the best possible street designs for all modes of transportation.

This case study provides useful background on both Austin's program and the current "state of the practice" to inform professionals, agencies, and citizens about the available resources and models which can lead to the development of new best practices.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Barbara McMillen, FHWA Office of Civil Rights and Dolores Gonzalez, ADA Coordinator, Austin, TX.



Curb ramps at an intersection with Accessible Pedestrian Signal (APS) zones indicated in plan.
Source: Building a True Community: Final Report, Public Rights-of-Way Access Advisory Committee.

SOLUTION

Austin, Texas has had a proactive curb ramp program since the passage of the ADA. This program was featured in the U.S. Conference of Mayors 1995 report, *Implementing the ADA: Case Studies of Exemplary Local Programs*. Austin has a population of 500,000, of which 15% are people with disabilities. The city appointed an ADA program manager in 1991 and has 23 additional coordinators in each of the city's departments, along with a Mayor's Committee for People with Disabilities. More than 4,000 curb ramps have been installed as part of a multi-year, multi-million dollar program. The program was developed with the following process:

- Held public hearing to solicit input from persons with disabilities.
- Met with transition plan review group to evaluate data and set priorities.
- Scheduled development based on personnel and funds available.
- Developed a map showing highest priority facilities services by walkways.

- Prioritized areas based on map, in descending order radiating from the downtown area.
- Divided the city into 12 sections.
- Gave the highest priority to the downtown areas with the most government buildings and pedestrian activity.
- Determined that the older part of city had higher pedestrian activity than newer areas.
- Identified the need for access along major roadways, especially along major bus routes.
- Assigned the highest priority ramps and routes to facilities to be handled through the building modification program.
- Established a citizen request program to handle specific identified needs.
- Set an initial goal through the Plan to provide ramps at intersections with sidewalks.

While Austin was creating its initial ADA Compliance program, new federal regulations and guidelines were under development. Public rights-of-way are covered by the ADA under Title II, subpart A. The U.S. Access Board initiated a rulemaking process in 1992, which is still in process towards establishing a final version of Section 14: Public Rights of Way. The Access Board initially issued the Americans With Disabilities Act Accessibility Guidelines (ADAAG) in 1991 (36 CFR 1191, Appendix A). In 1994, the Access Board published an interim final rule in the Federal Register that added several sections to the ADA, including Section 14. The response to the interim final rule clearly indicated a need for substantial education and outreach regarding the application of guidelines in this area. A Public Rights-of-Way Access Advisory Committee (PROWAAC) was established in 1999, as a step towards resolving these issues.

Throughout this process, the City of Austin Curb Ramp program worked with the evolving guidelines. Important changes, such as requirements for separate curb ramps for each direction of pedestrian travel, and the provision of detectable warning surfaces required adjustments to both designs and budgets. A recent City of Austin evaluation of the Curb Ramp program identified the following challenges based on their experience in developing ADA compliant street crossings:

- The number of ramps required was updated from 1,500 to more than 6,000 based on an on-the ground survey of the city's roads.
- Driveways cutting across walkways are included under ADA, but needs for these have not been estimated.
- Existing utilities in the right-of-way create potential costs due to relocation and removal.
- Curb ramp installations can conflict with traditional placements for storm drains.
- Existing sidewalks are in need of maintenance and repair.
- Lack of sidewalks.
- Coordination with other agencies, including Texas DOT, and public transit provider CMTA (Capital Metropolitan Transportation Authority).
- Lack of funding resources and an increasing scope of work.
- Meeting compliance deadlines under ADA.
- Very complex logistical coordination of curb ramp work.
- Initial lack of product availability to achieve detectable warnings.
- Agency resistance to change.
- Obtaining high visual contrast between ramps and adjacent surfaces.

Austin's experience shows that a coordinated, pro-active approach can result in significant public benefits, even if important guidelines are part of an evolving process. The city successfully involved teams of individuals and organizations across institutional boundaries. To its credit, the City proceeded with the installation of thousands of curb ramps based on the best information available at the time. While early designs may not have included every feature of a "perfect" curb ramp (such as detectable warning surfaces), they provided important benefits to the public.

It is important to note that curb ramps, even if they are not absolutely "state of the art," are a major positive step towards creating accessible communities. Parents pushing strollers, postal carriers, children riding bicycles, seniors, and many other citizens benefit from curb ramps. Most curb ramp installations can be characterized as "good" design; even if they are less than perfect, they are a significant improvement over the prior condition of not having ramps at all.

RESULTS

Federal policy is often best evaluated in terms of its implementation at the local level. Austin's experience shows that the seemingly simple task of providing curb ramps requires a detailed understanding of legal requirements, intergovernmental coordination, and technical best practices. Coordinating slopes, drainage, traffic signal operations, utilities, concrete, asphalt, and pavement markings demands a considerable amount of coordination, often involving multiple agencies and interests.

The community has been supportive of the curb ramp program. In a 1999 report, the City of Austin quantified its ramp construction program as follows:

Estimated Number of Curb Ramps Built by Various Entities or Programs	
Citizen Requests	150
City Crews	700
General Contractors under contract to the City	850
Roadway infrastructure alteration / improvements	450
Building Modification program	35
New construction by private developers	2,000
Estimated Total	4,185

Table 1. Estimated Number of Curb Ramps Built by Various Entities or Programs.

Actual construction costs have averaged $972 per ramp, with a total program cost of $2.25 million, funded by City bonds. A 1999 budget request called for an additional $4 million in program funding.

Ongoing activities of the Austin Curb Ramp program include meetings of the ADA Work Group, disseminating information about Construction Standards for public rights-of-way and the ADA, continuing a Citizen Request Program for curb ramps in the public rights-of-way, and curb ramp construction in compliance with the approved Transition Plan.

One of Austin's challenges was the implementation of curb ramps while the national ADA regulatory process was still evolving. The difficulty in developing and implementing complete ADA guidelines comes from the intent of accommodating people of all abilities throughout a nation of varied climates and construction conditions. This is part of the process initiated with passage of the Americans With Disabilities Act of 1990, which is a civil rights statute. The United States Access Board, the U.S. Department of Transportation and other organizations have cooperatively developed a series of vital new documents that address curb ramps as an integral part of street design. Austin's experience and these new tools help define the continually evolving state of the practice in curb ramp design. The most recent versions of these documents are:

1. *Building a True Community: Final Report*, Public Rights-of-Way Access Advisory Committee, January 10, 2001, U.S. Architectural & Transportation Barriers Compliance Board, 1331 F Street, NW, Suite 1000, Washington, DC 20004-1111, www.access-board.gov.
2. *Designing Sidewalks and Trails for Access, Part I of II: Review of Existing Guidelines and Practices*, U.S. Department of Transportation Publication No.: FHWA-HEP-99-006, July 1999. Available online at http://www.fhwa.dot.gov/environment/bikeped/publications.htm#Design
3. *Designing Sidewalks and Trails for Access, Part II of II: Best Practices Design Guide*, U.S. Department of Transportation, Publication No.: FHWA-EP-01-027, September 2001. Available online at http://www.fhwa.dot.gov/environment/bikeped/publications.htm#Design

Document 3, The Best Practices Design Guide, provides an excellent overview of the state of the practice in curb ramp design with Table 7-1, which includes the following BEST PRACTICE/Rationale:

1. PROVIDE A LEVEL MANEUVERING AREA OR LANDING AT THE TOP OF THE RAMP. Landings are critical to allow wheelchair users space to maneuver on or off of the ramp. Furthermore, people who are continuing along the sidewalk will not have to negotiate a surface with a changing grade or cross slope.
2. CLEARLY IDENTIFY THE BOUNDARY BETWEEN THE BOTTOM OF THE CURB RAMP AND THE STREET WITH A DETECTABLE WARNING. Without a detectable warning, people with vision impairments may not be able to identify the boundary between the sidewalk and the street.
3. DESIGN RAMP GRADES THAT ARE PERPENDICULAR TO THE CURB. Assistive devices for mobility are unstable if one side of the device is lower than the other or if the full base of support (e.g. all four wheels on a wheelchair) are not in contact with the surface. This commonly occurs when the bottom of a curb ramp is not perpendicular to the curb.
4. PLACE THE CURB RAMP WITHIN THE MARKED CROSSWALK AREA. Pedestrians outside of the marked crosswalk are less likely to be seen by drivers because they are not in the expected location.

5. AVOID CHANGES OF GRADE THAT EXCEED 11 PERCENT OVER A 610mm (24 in) INTERVAL. Severe or sudden grade changes may not provide sufficient clearance for the frame of a wheelchair, causing the user to tip forward or backward.

6. DESIGN RAMPS THAT DON'T REQUIRE TURNING OR MANEUVERING ON THE RAMP SURFACE. Maneuvering on a steep grade can be very hazardous for people with mobility impairments.

7. PROVIDE A CURB RAMP GRADE THAT CAN BE EASILY DISTINGUISHED FROM SURROUNDING TERRAIN: OTHERWISE, USE DETECTABLE WARNINGS. Gradual slopes make it difficult for people with vision impairments to detect the presence of a curb ramp.

8. DESIGN THE RAMP WITH A GRADE OF 7.1 +/- 1.2 PERCENT. (DO NOT EXCEED 8.33 PERCENT OR 1:12) Shallow grades are difficult for people with vision impairments to detect but steep grades are difficult for those using adaptive devices for mobility.

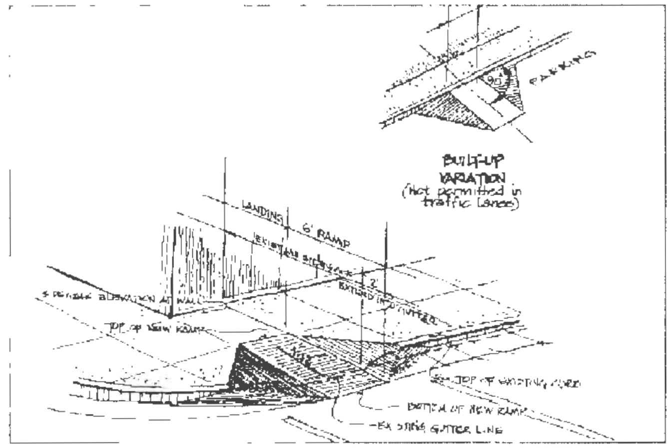
9. DESIGN THE RAMP AND GUTTER WTH A CROSS SLOPE OF 2.0 PERCENT. Ramps should have minimal cross slope so users do not have to negotiate a steep grade and cross slope simultaneously.

10. PROVIDE ADEQUATE DRAINAGE TO PREVENT THE ACCUMULATION OF WATER OR DEBRIS ON OR AT THE BOTTOM OF THE RAMP. Water, ice or debris accumulation will decrease the slip resistance of the curb ramp surface.

11. TRANSITIONS FROM RAMPS TO GUTTER AND STREETS SHOULD BE FLUSH AND FREE OF LEVEL CHANGES. Maneuvering over any vertical rise such as lips and defects can cause wheelchair users to propel forward when wheels hit this barrier.

12. ALIGN THE CURB RAMP WITH THE CROSSWALK, SO THERE IS A STRAIGHT PATH OF TRAVEL FROM THE TOP OF THE RAMP TO THE CENTER OF THE ROADWAY TO THE CURB RAMP ON THE OTHER SIDE. People using wheelchairs often build up momentum in the crosswalk to get up the curb ramp. This alignment may also be useful for people with vision impairments.

13. PROVIDE CLEARLY DEFINED AND EASILY IDENTIFIED EDGES OR TRANSITION ON BOTH SIDES OF THE RAMP TO CONTRAST WITH SIDEWALK. Clearly defined edges assist users with



Source: *Building a True Community: Final Report*, Public Rights-of-Way Access Advisory Committee. This illustration shows many of the features that should be incorporated a curb ramp. However, it does not show detectable warnings, which are an important component.

vision impairments to identify the presence of the ramp when it is approached from the side.

These concepts are consistent with the experience many communities have in developing successful curb ramp programs. In the Summary to her 1999 Urban Symposium presentation, Dolores Gonzales summarized both Austin's perspective on these issues (and a point of view likely to be representative of similar efforts nationwide), as follows:

- Much work remains before our roadways will be fully accessible.
- Technological solutions specifically targeted for persons with disabilities could help defray costly and complicated concrete solutions.
- Continuing education of the public and building professionals are needed for effective implementation of the ADA.

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REFERENCES

Implementing the Americans with Disabilities Act: Case Studies of Local Programs, The United States Conference of Mayors, April 1995.

Public Works and ADA Compliance, presentation at the Urban Symposium, Dallas Texas, June 29, 1999, Dolores Gonzales, City of Austin Americans With Disabilities Office.

U.S. Architectural & Transportation Barriers Compliance Board, 1331 F Street, NW, Suite 1000, Washington, DC 20004-1111, www.access-board.gov.

Large Intersection Solutions

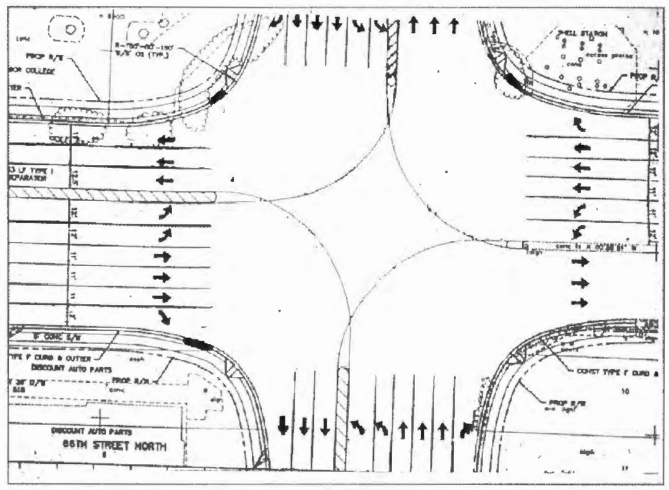
PROBLEM

As roads are made wider, the crossing distances for pedestrians increase, creating a significant exposure of pedestrians to the high volumes of motor vehicles. With a typical pedestrian crossing speed of approximately 1 m (3.2 ft) per second, streets with four or more lanes in each direction can result in crossing times that require more than 30 seconds. In addition, lengthy crossings can make it impossible for pedestrians to see signal indicators on the far side of the crossing. Confusing multiple turning movements (often with protected signal phases) increase the potential for pedestrian crashes.

BACKGROUND

In St. Petersburg, Florida, the intersection of Highway 98 at 74th Avenue North presented an extreme version of these conditions in the early 1990's. Widened to nine lanes in each leg of the intersection, this intersection created a serious challenge for engineers to design a solution which could accommodate both pedestrians and motorists. The adjacent land included St. Petersburg Community College, a convenience store, an auto parts store, and a training center for the disabled. Some communities would have tried to build expensive solutions (such as overhead pedestrian bridges, for example) or simply ignored the problem, however, the designers of this project applied a combination of common sense, innovation, and creativity to create a solution that works within the available resources.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Michael Wallwork, Alternative Street Design.



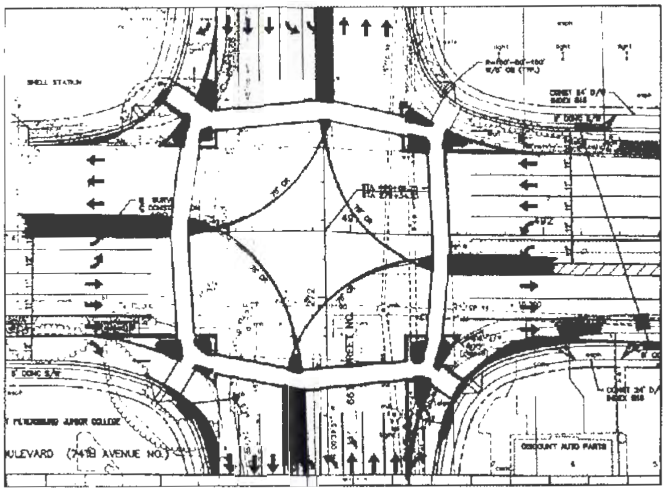
Provided by Dan Burden of Walkable Communities, Inc. and Jeff Olson, R.A.
Initial Conditions, Highway 98 at 74th Avenue, St. Petersburg, Florida.

SOLUTION

Michael Wallwork, the street's designer, was asked by several community representatives to look at the intersection and explore alternatives to make it more pedestrian friendly. Accessibility was an important issue because a training center for wheelchair users was in the area. Since the designer was Australian, many of the design features came from Australia's best practices.

The important issues included the following:

- Provide median noses that extend beyond the crosswalk to provide refuges for pedestrians.
- Narrow the lanes to minimize speeds, to shorten pedestrian crossing distances, and to widen the median.
- Add Australian standard right turn slip lanes, which are designed to keep pedestrians in the drivers' line-of-sight, slow right turn vehicles to around 29 km/h (18 mi/h), and minimize the angle between turning vehicles and approaching vehicles to increase capacity and to reduce the angle drivers must to turn their heads.



Provided by Dan Burden of Walkable Communities, Inc. and Jeff Olson, R.A.
Design Solution for Highway 98, St. Petersburg, Florida.

- Add a bend in the middle of the crosswalk to meet the above requirements.
- Meet ADA standards with cut-throughs and ramps.

RESULTS

For a retrofit of existing conditions, the pedestrian features of the Highway 98 intersection provide an excellent balance between pedestrian and motor vehicle needs. By reducing the pedestrian crossing time, providing right turn slip lanes, and reducing the all-red signal phase slightly, the 'green' time made available to motorists was actually increased and pedestrian safety was improved. With reduced lane widths, refuge islands at each corner and median refuges in the middle of each intersection leg, the maximum distance that a pedestrian has to cross is now only five lanes, or approximately 15 m (50 ft). This is a significant improvement over the prior conditions of crossing nine lanes of traffic in one signal phase. Overall crossing distances were reduced from over 55 m (180 ft) to approximately 40 m (130 ft).

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REFERENCES

Background provided through e mail interview with Michael Wallwork of Alternative Street Design. Original graphics provided by Dan Burden of Walkable Communities, Inc. and Jeff Olson, R.A.

CAMBRIDGE, MASSACHUSETTS **CASE STUDY NO. 20**

Granite Street Traffic Calming

PROBLEM

Neighborhood residents were concerned about speeding on Granite Street, a neighborhood collector used by children to access a school and a park.

BACKGROUND

Granite Street is located in the Cambridgeport neighborhood, and is bordered by the Morse Elementary School, a playground, ballfields on the south side, and houses on the north. In 1998, the Morse School was closed for major renovation. In conjunction with the school renovation, the roadway and sidewalk on Granite Street was reconstructed.

In response to neighbors' concerns about speeding on Granite Street and to improve the safety of neighborhood children going to and from school, the City worked with residents to implement a comprehensive traffic calming design during the roadway reconstruction. Funding for the traffic calming measures came from the City.

SOLUTION

Several traffic calming measures improved the pedestrian environment in the Granite Street area. Curb extensions were installed at the intersections of Granite and Magazine Street, Granite and Pearl Street (at the main entrance to the school) and at Granite and Rockingham Street (at the entrance to the park). A raised crosswalk was also constructed across Granite Street at Magazine Street, and a raised intersection was built at Granite and Pearl Streets. The raised devices were intended to provide a strong visual cue to drivers entering the corridor from Magazine Street and Pearl Street to be aware of non-motorized users. Further, vehicles would be slowed, and pedestrians would be provided with a level crossing area.

The raised crosswalk and the raised intersection were constructed with concrete pavers to replicate the look and feel of brick. Pavers are slip-resistant and durable under traffic. Both raised devices used color contrast to increase their effectiveness--the red color of the crosswalk and intersection highlighted the pedestrian area against the black asphalt of the street.

The approach slopes to the raised devices were lined with highly visible, reflective, slip resistant, and long lasting inlay tape. And, both of the raised devices (the raised crosswalk at Magazine Street and the raised intersection at Pearl Street) were combined with curb extensions, giving pedestrians the the added benefit of crossing a much narrower street.

The raised devices and curb extensions were part of a comprehensive traffic calming plan for Granite Street. Additional elements of the project were truncated domes, zebra crosswalk markings, and the removal of a traffic signal. All of the various measures were intended to work together to change the nature of the roadway and to reduce vehicle speeds.

Prepared by Cambridge Community Development Department.

RESULTS

As part of the ongoing evaluation of this project, the City conducted before and after speed studies. The speed limit on Granite Street is 48 km/h (30 mi/h). Before the improvements, the 85th percentile speed on Granite Street was 45 km/h (28 mi/h). The 85th percentile speed was reduced to 38.5 km/h (24 mi/h) after the improvements.

On most residential streets in Cambridge, residents do not feel comfortable coexisting with traffic going 48 km/h (30 mi/h). A speed of 40 km/h (25 mi/h) feels more comfortable and is safer for residents, pedestrians, motorists and cyclists. Before the improvements were made 39 percent of vehicles were exceeding 40 km/h (25 mi/h). Only 14 percent of vehicles were exceeding 40 km/h (25 mi/h) after the improvements.

The goal of traffic calming is to make streets safer for people to bike, walk, and drive, not to shift traffic from one street onto another street. The City conducted volume counts to determine if traffic was inadvertently shifted and found that traffic has not diverted off Granite Street. Granite Street carried 4,470 vehicles per day before the project and 4,440 vehicles per day afterward.

Although no major maintenance problems have occurred, the City continues to monitor the improvements closely, particularly through the winter. Bollards were installed to help the snowplow operators locate the raised crosswalk and raised intersection. The effects of snow removal and other maintenance issues will continue to be monitored.

In April 1999, the City conducted a non-scientific survey to determine residents' perceptions of the completed traffic calming project. Over 70 percent of residents who responded liked the project, while only 10 percent disliked it. More than half of Granite Street residents perceived that the traffic calming treatments had reduced traffic speeds and improved pedestrian safety. Also, 87 percent thought that the project improved the look of the street, and 65 percent approved of the City doing similar projects in other locations.

The City and residents view this project as a success because the goals of reducing speeds and improving safety were met. The project is visually pleasing and is an enhancement to the community. Residents strongly support the traffic calming project and support more projects like this in Cambridge.

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Pedestrian-Friendly Redesign

PROBLEM

A high rate of pedestrian and vehicle conflicts were occurring along a section of Highway 111 through downtown Cathedral City, CA.

BACKGROUND

Highway 111 is the major state highway linking the desert cities of the Coachella Valley from Palms Springs to Indio and beyond to the Imperial Valley. Many of the cities in the desert have developed around this highway, including Cathedral City, which lies to the east of Palm Springs. Most of Highway 111 has been configured with two travel lanes in each direction, and in accordance with California Department of Transportation (Caltrans) plans, most cities along the 111 corridor have plans that show it eventually widened to three lanes in each direction.

The City of Cathedral wanted to redevelop its downtown area, through which Highway 111 passes. As part of this redevelopment, the City wanted to narrow Highway 111, also known as East Palm Canyon Drive through the city, and provide for a more pedestrian-friendly street through the downtown area. This section of Highway 111 had also had one of the highest rates of pedestrian conflicts and accidents in the corridor.

SOLUTION

In order to plan for a design that would make Highway 111 safer and more pedestrian friendly, the city needed to coordinate with Caltrans to determine who owned the road. The process for starting the design of the downtown area began in 1991 when the City crafted a

Looking west toward the San Jacinto Mountains after the installation of landscaped medians and enhanced parkways.

broad vision for the new pedestrian-friendly environment, which included measures to slow traffic along the highway. This vision included plans to keep Highway 111 at two lanes in each direction and narrow the roadway to increase pedestrian accessibility across the traffic lanes and shorten crossing distances. With its plans to eventually widen the highway to three lanes in each direction, Caltrans vetoed the City's plans.

Faced with a firm rejection of their plans by Caltrans, Cathedral City successfully sought to have the section of Highway 111 that ran through Cathedral City relinquished to the City. With East Palm Canyon Drive (no longer Highway 111 after the relinquishment) owned by the municipality, the City was able to go forward with its vision of a pedestrian-friendly redesign of its downtown area. Throughout the process, the city worked with a resident/business design committee and a consultant.

The final step in the process of moving forward with the City's plans for its downtown area included securing funding from the Riverside County Transportation Commission for the redesign of East Palm Canyon Drive (formerly Highway 111). The entire project cost

Prepared by Jerry Jack, City of Cathedral City.

approximately $3.2 million (of which storm drain and right-of-way acquisition were a large share). This was funded through the City's RDA, city bonds, and regional transportation funds.

The new design for the roadway included a landscaped center median, two travel lanes in each direction 3.7 and 4.0 m (12 and 13 ft) wide, a side landscaped median separating a new parking aisle with angled parking, and the elimination of numerous angular driveways and streets, which had previously compromised the smooth traffic operation of the street. New bus shelters were provided and new traffic signals with pedestrian crossings were installed to better connect the businesses on the south side of the roadway with the north side, which would eventually include a new shopping complex, movie theater, and community park. The speed limit on East Palm Canyon Drive was reduced from 72 km/h (45 mi/h) to 56 km/h (35 mi/h) in order to emphasize the traffic calmed nature of the new redesigned roadway and promote the pedestrian-friendliness of the new downtown area.

Looking east showing the use of protected/separated right turn and bus lanes.

RESULTS

While many commuters who regularly traveled through the downtown area were not pleased with the roadway's new design and traffic calmed characteristics, pedestrians and city officials were very pleased with the end result. A study of pedestrian crashes was conducted after the redesign of the roadway was completed. From 1993-95, there were nine pedestrian crashes, and since the new roadway opened in 1998, no crashes have been reported. In terms of pedestrian safety, the redesign of the street has been an overwhelming success. The redesign has improved the aesthetic character of the downtown area, and it has also served as the first step toward remaking the downtown area into a pedestrian-friendly, culturally vibrant commercial and civic district.

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Berkshire Street Traffic Calming

PROBLEM

Motorists traveling at high speeds and refusing to stop at stop signs on residential and mixed-use neighborhood streets, especially those populated with large volumes of pedestrians (including children), had consequently led to many pedestrians being hit my motor vehicles.

BACKGROUND

Berkshire and York Streets are located in the Wellington/Harrington neighborhood of Cambridge, a residential area with a mix of businesses and retail shops. Berkshire is a neighborhood street with a 40 km/h (25 mi/h) posted speed limit and 2,000-2,500 ADT count. A school, a playing field, a youth center, and a library are adjacent to Berkshire Street. The mix of uses generates a large volume of pedestrian traffic, especially from children. Berkshire Street is also a popular cut-through for motorists, particularly as an alternative to Cardinal Medeiros Avenue, a much larger arterial which carries high traffic volumes during peak hours.

Neighborhood residents had complained over a long period of time about speeding vehicles. Police checks confirmed the persistent speeding problem along Berkshire and also found a large number of drivers running the stop sign at the intersection of York and Plymouth. Several incidents between children and drivers motivated parents and other residents to tackle the traffic problems in their neighborhood, making the streets safer for children to walk.

Prepared by Cambridge Community Development Department.

Raised intersection at Berkshire and Marcella Streets.

SOLUTION

The City of Cambridge chose the Berkshire/York Street area to demonstrate the benefits of traffic calming for addressing neighborhood transportation problems. Working jointly with the City Traffic Department and the Public Works Department, the Community Development Department publicized and facilitated an open planning process, involving many neighborhood residents, school personnel, and emergency services personnel. The collaboration produced several traffic calming design alternatives, with the community and city agencies eventually using the design presented here. The Public Works Department implemented the improvements using city funds.

The Berkshire and York Street improvements were part of a comprehensive traffic calming plan. Under this plan, a particular area is blanketed by a variety of treatments, which work together to change the nature of roadways, slow down vehicles, and improve pedestrian safety.

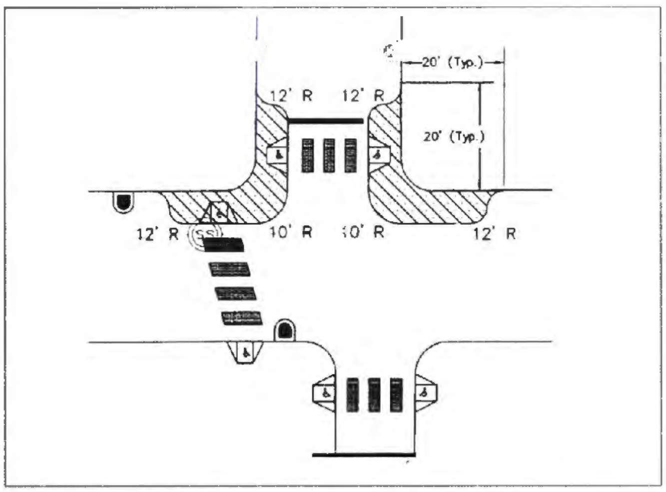
The traffic calming measures used in this project include the following:

- Curb extensions at three intersections: 1) Berkshire and York Streets, 2) Berkshire and Cambridge

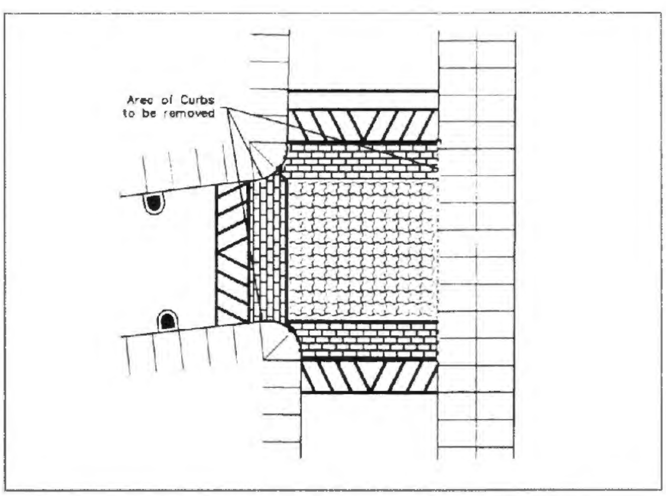
Streets, and 3) Webster Avenue, Hamlin Street, and Plymouth Street.

- Hamlin Street was made one-way to alleviate the problem of drivers entering Plymouth Street the wrong way at Webster Avenue to get to Hamlin Street.
- A raised crosswalk was added across Berkshire Street at Hardwick Street.
- Raised intersections were constructed at York & Hamilton and Berkshire & Marcella.
- A chicane was added on Berkshire Street, which reduces the street width by 2.1 m (7 ft) on each side and introduces a shift in the roadway alignment.
- The fence openings for Donnelly Field were relocated to line up with the enhanced pedestrian crossings, encouraging pedestrians, especially children, to cross where it is safest to do so.

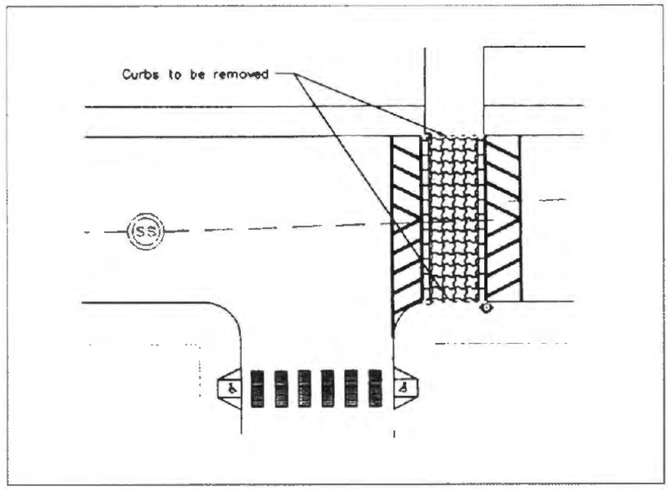
In addition to the newly constructed treatments, all street-level crosswalks were repainted with zebra markings to emphasize the presence of a pedestrian crossing for both drivers and pedestrians.



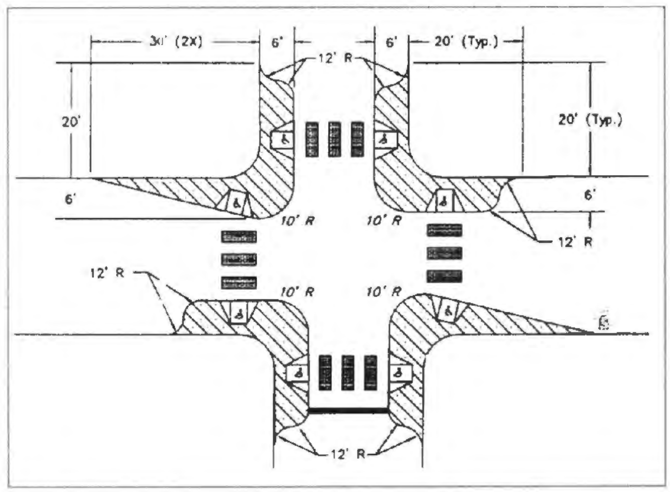
Concept drawing of curb extensions at Berkshire & York Streets.



Raised intersection used at York and Hamilton and Berkshire and Marcella.



A raised crosswalk used on Berkshire Street at Hardwick Street.



A chicane was added on Berkshire Street between York and Cambridge.

The raised crosswalk and intersections were constructed with concrete pavers that replicate the look and feel of brick but are more durable and have a slip resistant finish. The approaching slopes for the vertical changes were constructed at 8 percent. The approaching slopes are clearly marked, using highly visible, reflective, and slip resistant inlay tape as pavement markings.

RESULTS

Overall, the Berkshire/York street neighborhood is now a much safer place for young pedestrians in the neighborhood. While all of the measures combined to change the driving atmosphere of the street, the vertical traffic calming measures have the most direct effect on travel speeds.

Before the improvement, the 85th percentile speed on Berkshire Street was 48 km/h (30 mi/h), and only 41

Raised crosswalk at Berkshire and Hardwick.

percent of vehicles surveyed were traveling at or below the 40 km/h (25 mi/h) speed limit. After the improvements, the 85th percentile speed was reduced to 34 km/h (21 mi/h) at the vertical traffic calming devices and 38.6 km/h (24 mi/h) in between, and 95 percent of vehicles were going at or below the speed limit.

The chicane provides an area for landscaping, and for motorists, it disrupts the visual continuity of the street without a measurable impact on traffic. Curb extensions reduce the width of the pedestrian crossing distance, limit pedestrian exposure time, improve visibility, and slow the turning vehicles. While there have not been any major maintenance problems, the City continues to monitor the improvements closely, particularly through the winter.

A post-improvement survey of neighborhood residents found that 44 percent of respondents liked the improvements while only 28 percent disliked them. Forty-seven percent reported a perceived increase in pedestrian safety and 39 percent reported feeling an improvement in the safety for children playing. However, 61 percent reported that it was harder to find on-street parking, despite the net loss of only one on-street parking space.

The City of Cambridge considers the project a major success, both for the implementation of effective traffic calming measures and for the ability of the public participation process to mobilize the neighborhood and generate support for the improvements. The Berkshire/York street project has led to the development of several other neighborhood projects throughout the city.

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Exclusive Pedestrian Phasing

PROBLEM

A high number of conflicts between pedestrian and vehicles were occurring at busy downtown intersections.

BACKGROUND

The residential population of Beverly Hills is about 35,000. However, the daytime population is estimated at about 150,000, mostly concentrated in the Business District, which is informally called the "Business Triangle." Daytime pedestrian activity is very heavy in the Business District due to the concentration of businesses and services and the high volume of tourists visiting the area around famous Rodeo Drive. The primary concern for the City was the high number of conflicts between pedestrians and vehicles at many of the intersections, especially during holidays and peak tourist seasons. Large pedestrian flows were blocking crosswalks to turning traffic during the entire green signal phase. A review of the accident history revealed several reported vehicle-pedestrian accidents. Numerous field observations also concluded many "close calls" occurred.

SOLUTION

In 1987, the City of Beverly Hills modified traffic signals at eight intersections within the Business Triangle to include an exclusive pedestrian phase where all approaches would stop to let pedestrians cross the intersection either diagonally or conventionally. The intersections included:

- Brighton and Canon
- Brighton and Beverly
- Brighton and Rodeo
- Brighton and Camden
- Brighton and Bedford
- Dayton and Canon
- Dayton and Beverly
- Dayton and Rodeo

Table 1 shows the pedestrian volumes at each of the eight intersections compared to vehicular volumes.

Staff analysis indicated that if no pedestrians were in the intersection during the vehicular signal phase, that traffic would flow more smoothly. The addition of an exclusive pedestrian signal phase to the signal timing was considered to clear the intersection of pedestrians during the vehicular phase, allowing better movement of vehicles and permitting pedestrians to cross without vehicle interference. This would improve the safety of pedestrians and reduce the potential for auto/pedestrian conflicts and accidents. At the time of implementation, very few jurisdictions were known to have this type of signal operation.

With exclusive pedestrian phases in place, pedestrians were allowed to cross diagonally as well as conventionally. In that case, the longer diagonal pedestrian path was used to determine the optimal clearance time for that signal phase. A range of 20-22 seconds of total pedestrian signal phase was determined to be appropriate. At the time, all Business Triangle signals were operating on 50-second cycles, and the introduction of the pedestrian phase increased the cycle to 60 seconds to clear vehicles through the intersections.

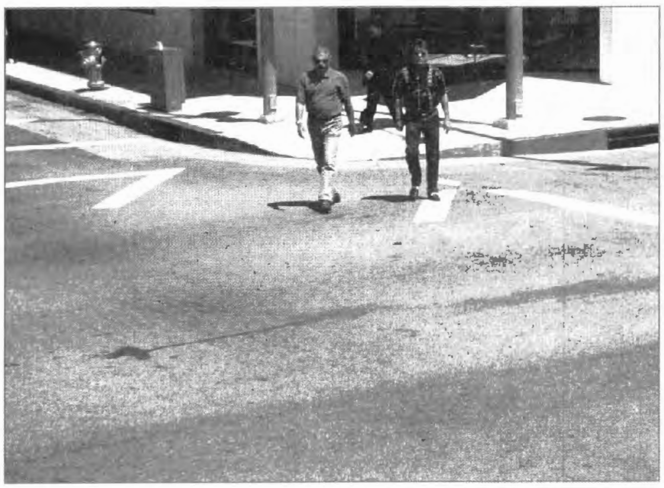
Pavement markings were added to indicate that diagonal crossing was permitted at each of the intersections, and special "diagonal crossing OK" signs were added to each corner. For better visibility, pedestrian signal heads were added to face the diagonals of the intersection so they could be seen for diagonal crossings.

Information provided by Bijan Vaziri, City of Beverly Hills.

Intersection Veh/hr	NB Veh/hr	SB Veh/hr	WB Veh/hr	EB Veh/hr	Total approach	East Leg Peds/hr	West Leg Peds/hr	South Leg Peds/hr	North Leg Peds/hr	Total Peds. Cross/hr
Brighton/Canon (1)	500	550	300	0	1350	270	250	400	230	1150
Brighton/Beverly (2)	750	700	750	0	2200	500	500	600	400	2000
Brighton/Rodeo (3)	450	650	600	0	1700	500	800	650	550	2500
Brighton/Camden (4)	500	0	500	0	1000	350	450	600	400	1800
Brighton/Bedford (5)	0	700	550	0	1250	300	280	370	400	1350
Dayton/Canon (6)	250	350	0	550	1150	150	200	200	300	850
Dayton/Beverly (7)	700	750	0	550	2000	400	300	250	450	1400
Dayton/Rodeo (8)	350	500	0	300	1150	400	550	450	500	1900

Table 1. Vehicle and Pedestrian Volumes.

The average cost per intersection was very low compared to other improvements, ranging from $500-$700 per intersection.



With exclusive pedestrian signal phases, diagonal crossings are allowed as well as conventional crossings.

RESULTS

During the planning of this project, there was concern that an exclusive pedestrian phase would be confusing for both motorists and pedestrians. After implementation, it seemed that people became accustomed to the new operation. Public opinion has been very favorable, and other communities have contacted the City about their successful operation.

A capacity analysis was conducted as part of the evaluation of the new signal operation. Using the "ICU" method, a level of service (LOS) was calculated before and after the implementation of the exclusive pedestrian phase. The following table shows the summary of the LOS calculations.

Intersection	Before LOS	After LOS
Brighton / Canon	.40 A	.63 B
Brighton / Beverly	.69 B	.92 E
Brighton / Rodeo	.48 A	.71 C
Brighton / Camden	.40 A	.66 B
Brighton / Bedford	.34 A	.57 A
Dayton / Canon	.31 A	.54 A
Dayton / Beverly	.55 A	.81 D
Dayton / Rodeo	.34 A	.57 A

Table 2. LOS Calculations Before and After Implementation.

The analysis indicated that for most intersections, the change in LOS would be within an acceptable range. However, for two intersections, Brighton/Beverly and Dayton/Beverly, the LOS would be dropping to unacceptable levels (LOS E and D respectively). City staff had concerns about the successful operation of these two intersections. Staff noted that implementation was very successful at the other six intersections, and the aforementioned two experienced an increase in delays on the

Intersection	Before		After	
	# of accidents	% of total accidents	# of accidents	% of total accidents
Brighton/Canon	3	18%	1	10%
Brighton/Rodeo	5	18%	3	11%
Brighton/Camden	2	22%	0	00%
Brighton/Bedford	2	11%	2	18%
Dayton/Canon	4	31%	0	00%
Dayton/Rodeo	2	13%	0	00%
Total	18	19%	6	7%

Overall percent reduction of auto/pedestrian accidents = (18-6)/18 = 66%

Table 3: Summary of Auto/Pedestrian Accidents Before and After the Pedestrian Phase.

major north-south street through the Business District, Beverly Drive. This analysis resulted in the pedestrian signal being removed at these two intersections. The remaining six continue to be operational today.

Since the primary objective of this project was to improve safety, detailed evaluation of accidents of all eight intersections was conducted. Accident data from the years 1978, 1987, and 1996 were used for comparison. The primary focus was to examine the auto/pedestrian type accidents before and after the implementation of the project. The following table shows the average change in accidents over the comparison periods.

The table indicates a reduction in auto/pedestrian accidents by 66% between 1987 and 1996 for the six intersections that maintained the pedestrian phase. Data have suggested unequivocally that this project was a success. Further, overall accidents in the Business Triangle were reduced by 26%. However, at those two intersections where the pedestrian phase was eliminated (Brighton/Beverly and Dayton/Beverly), auto/pedestrian accident rates remained the same or even increased.

In general, exclusive pedestrian signal phasing is a low cost and effective tool to improve safety and reduce the potential for automobile and pedestrian conflicts.

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REFERENCES

Vaziri, Bijan. "Exclusive Pedestrian Phase for the Business District Signals in Beverly Hills, 10 Years Later." City of Beverly Hills, California, 1996."

Main Street Redesign

PROBLEM

Pedestrians in the downtown shopping district had a difficult time crossing a wide street with heavy traffic. The vitality of the downtown shopping district was threatened because of this uncomfortable environment for pedestrians and the addition of new shopping opportunities on the outside of town.

BACKGROUND

In the mid-1970's, the mountain town of Hendersonville faced a dilemma common to many rural American communities. Strip shopping centers were beginning to locate on the outskirts of town, and there was a concern that a large regional shopping mall would be developed in the future that might lure more shoppers away from downtown businesses. On Main Street, the traditional commercial and social center of the community, 17 businesses had closed their doors and Main Street was declining. At night Main Street became a racetrack, where teenagers would drag race their cars down the wide and straight roadway. During the day the roar of traffic on Main Street endangered pedestrians trying to cross four lanes of traffic and parked cars.

SOLUTION

City Council members, community leaders, and downtown merchants traveled to Grand Junction, Colorado which had successfully revived its downtown using traffic calming and pedestrian-oriented design. Inspired by Grand Junction, the town leaders returned to North Carolina ready to implement some of their own ideas for the rebirth of downtown. In order to provide a

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center and the City of Hendersonville, NC.

Lateral shifts in the roadway slowed vehicles traveling on Main Street, making the street safer for pedestrians and giving drivers a chance to see the local businesses.

competitive shopping environment, the leaders determined that certain improvements and amenities needed to be provided, including slower traffic, easier pedestrian crossings, parking, and beautification.

Located at the junction of several major mountain roads, Hendersonville had plenty of automobile traffic from traveling vacationers. The community wanted to develop Main Street into an environment where travelers would be enticed out of their cars to stroll around comfortably and shop. Main Street was originally designed with a right-of-way in excess of 32 m (100 ft), wide enough for a team of oxen to turn around without backing up. Prior to its redesign, Main Street had two lanes of travel in both directions and parallel parking on both sides of the street. The conversion to a one-way pair of two streets on either side of Main Street reduced the traffic-load on Main Street, gave through travelers a convenient alternative route, and allowed the town leaders to pursue their new vision for downtown.

The improvements to the downtown area were financed by a special tax district requested by the merchants themselves. Main Street was narrowed from four lanes to two. In the middle of each block a quick bend

Curb extensions, or "bulb-outs" reduced the crossing distance and the amount of time that pedestrians were exposed to traffic while crossing Main Street.

in the street creates a lateral shift of the entire street. The street winds back and forth through a six-block area, with transition blocks at each end. The mid-block curves are formed by curb bulb-outs that open onto marked crosswalks at the peak of each curve. At these points traffic moves slowly and the pedestrian crossing distance is reduced to two lanes. The alternating lateral shifts also opened space for diagonal parking, while the opposite side of the street offers parallel parking.

Each intersection is also marked with crosswalks on all four legs, with curb bulb-outs on the two Main Street legs. The bulb-outs shorten pedestrian crossing distance at intersections, improve pedestrian visibility, force tighter and slower right turns onto Main Street, and reinforce the notion that the driver has entered a traffic calmed area. The entire area has been enhanced with landscaping maintained by contract. Brick planters were installed along the length of street and are filled with spectacular flower displays that change throughout the year. Street trees planted 25 years ago have grown tall and provide a sidewalk canopy and shade for pedestrians.

The Main Street Pedestrian environment has been enhanced by street furniture and landscaping.

RESULTS

According to the Executive Director of Downtown Hendersonville, Inc., the serpentine layout of Main Street offers many aesthetic and safety advantages. The layout slows traffic, making the street safer for pedestrians, and gives drivers a chance to see the local businesses. Vehicles now tend to travel at or near the 32 km/h (20 mi/h) speed limit on Main Street. In addition, the mid-block crosswalks on Main Street are shorter than regular street crossings, making crossing the street safer and more comfortable for pedestrians. The improvements to the six-block section of Main Street were achieved at an initial cost of about $235,000 in 1975 and approximately $72,000 per year for maintenance.

In addition, the pedestrian improvements in downtown Hendersonville have helped Main Street achieve economic success. While the mall has arrived—and has gone through two bankruptcies—downtown Hendersonville has experienced a renaissance. It was named a "Main Street City" by the National Trust for Historic Preservation in 1985, and was entered in the National Register of Historic Places in 1989. Property values increased after the roadway was improved, and many downtown buildings were renovated and restored. There are currently 100 retail businesses downtown, including 14 restaurants, specialty shops, and regionally-oriented anchor stores, and a waiting list exists for Main Street locations. Offices and apartments occupy many of the second floors in two-story buildings, and most buildings have been renovated. New buildings have been built as well. Today, over 25 years later, the stores are all occupied and downtown Hendersonville is alive and bustling with pedestrians and shoppers. Once virtually empty, Main Street now averages 1,750 pedestrians per day.

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Illuminated Crosswalk

PROBLEM

The New Jersey Department of Transportation (NJDOT) needed to improve pedestrian safety adjacent to State Route (SR) 46 in Denville, New Jersey. In Denville, SR 46 is a major highway that includes a jug-handle style intersection adjacent to the entrance of a large recreation facility. NJDOT needed concepts that were easy to install in a short timeframe, to mitigate this high vehicle/pedestrian crash location.

BACKGROUND

As part of an on-call planning assignment with NJDOT, The RBA Group was asked to develop methods to improve pedestrian crossing accommodations at the Savage Road/SR 46 jug-handle and Franklin Road. Near this location, SR 46 carries over 40,000 vehicles per day along its four- to six-lane cross-section. The posted speed limit on SR 46 is 80 km/h (50 mi/h). The posted speed limits on Savage and Franklin Roads are 56 km/h (35 mi/h). The surrounding area has residential and commercial land uses, public and private schools, as well as the recreation facility mentioned above.

There are signalized intersections along the highway, including a signal at one of the subject intersections. Westbound left turns off of the highway are accommodated via a jug-handle that connects to Savage Road, a local street. Savage Road and Franklin Road form a three-legged, or "T- intersection" adjacent to the recreation facility, which generates a large volume of pedestrian traffic. This intersection is just a half a block from the four-legged, signalized intersection of Franklin Road and SR 46.

A field inventory of the site revealed that westbound traffic on SR 46 seeking to turn south (left) onto Franklin Road, first exits SR 46 to the right onto the jug-handle, which uses a short one-way portion of Savage Road to access the Savage/Franklin intersection. This westbound approach has two travel lanes, one for left turns headed south on Franklin and one for through traffic onto Savage Road and other local destinations. East of the Franklin/Savage T-intersection, Savage Road is one-way westbound; west of the intersection, Savage Road is two-way. ADT on Savage Road is 7,000.

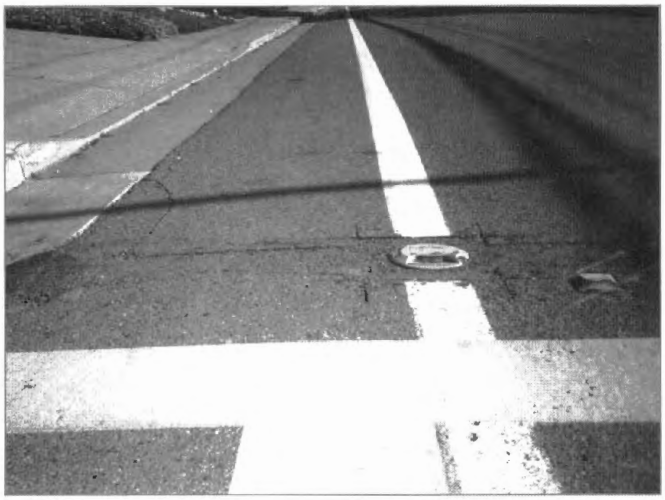
This creates a multiple threat situation for pedestrians attempting to cross the jug-handle leg of the intersection to the recreation facility (northbound), because the left turning traffic on the jug-handle is often backed-up at this intersection (from the Franklin/SR 46 intersection back through this intersection), blocking the pedestrian's view of the fast-moving traffic on the jug-handle. Interviews reported that motorists traveling through the intersection along the jug handle were not likely to yield to pedestrians, due to poor visibility and a lack of awareness to pedestrians crossing the road. The frequency of pedestrians crossing Savage Road is estimated at approximately 25 per hour.

Prepared by Mike Dannemiller, RBA Group.

SOLUTION

To better inform motorists when pedestrians are attempting to cross this multiple threat intersection, an illuminated crosswalk treatment was proposed. Public participation included a presentation before the Town Council, which passed a resolution in support of the proposal.

The proposed design was installed as a test location for NJDOT to determine if this treatment would generate a more appropriate sharing of the roadway, over more traditional high-visibility crosswalk striping. This system is extremely useful at stop controlled or mid-block crossing locations, but it is not appropriate at signalized intersections because of the potential for conflicting messages being presented to the motorists, such as a green traffic



In-pavement lighting at crosswalk

light instructing the motorist to proceed, and yellow flashing pavement lights instructing the motorists to yield.

The chosen system uses ultrasonic passive actuation, which does not require pedestrian users to take any action for the system to understand that they are there. This ensures that the pedestrians are detected by the system without having to push a signal activator. When the signal detects the presence of a pedestrian, the pavement-mounted lights illuminate. The lights stay on for 10 sec, flashing at a frequency of about 4 pulses/sec. These lights are similar in size to the typical highway pavement mounted reflectors, and are directed towards the oncoming motorists.

When the system is illuminated, motorists are presented with a series of flashing amber lights spaced several feet apart along either side of the crosswalk. These lights are easy to see, even in direct sunlight, and inform motorists that a pedestrian is actively crossing the roadway at that moment.

Project costs are estimated at $20,000 for materials, and $12,000 for installation equipment (labor is excluded from this estimate, as installation was done in-house by NJDOT).

Illuminated crosswalk at night.

RESULTS

While a full conflict analysis has not yet been completed, personal experience has shown that conflicts between motorists and pedestrians have been greatly reduced at the two crosswalks retrofitted with the illuminated crosswalk systems. Research conducted by the University of North Carolina Highway Safety Research Center in 1999 on a Florida DOT installation showed motorists yielding or stopping for pedestrians staged to cross the roadway increased from 13 percent to 35 percent after a flashing crosswalk was installed.

It is expected that illuminated crosswalks will be used to encourage motorists to more appropriately share the road with pedestrians by improving awareness for motorists that they are, indeed, sharing the roadway with non-motorized users.

After installation, feedback gathered from the local transportation agency suggested that Denville residents are very pleased with the improved "high-tech" crosswalk.

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REFERENCES

Huang, Herman; Hughes, Ronald; Charles Zegeer and Marsha Nitzburg. "An Evaluation of the LightGuard™ Pedestrian Crosswalk Warning System." Prepared by University of North Carolina Highway Safety Research Center and Center for Applied Research for Florida Department of Transportation Safety Office, June 1999.

Traffic Calming and Emergency Vehicles

PROBLEM

A traffic calming device to accommodate emergency vehicles was needed to reduce speeds near a school and park in Clark County, Washington.

BACKGROUND

In 1998, Clark County approved and implemented a neighborhood traffic calming project for an approximate 1 mi (0.3 m) segment of NW 93rd/94th Street between NW 21st Avenue and NW Lakeshore Drive. NW 93rd/94th Street is a collector street (lowest arterial classification) located in an unincorporated area outside of the City of Vancouver in Clark County, Washington. This street was eligible for traffic calming because of its location near a school and a park in a residential neighborhood.

No bicycle lanes existed along the street corridor. In the older eastern half of the corridor, no sidewalks existed. In the newer sections, sidewalks were present, but little direct driveway access to the street existed. Before traffic calming was implemented, the street appeared to have functioned as an arterial roadway instead of a neighborhood street.

The posted speed limit on this road is 40 km/h (25 mi/h). While the incidence of speeding was generally lower for this street segment than for others on the traffic calming project list, NW 93rd/94th Street was added because of its proximity to the school and park resulting in higher amounts of pedestrian and bicycle traffic and safety concerns than on typical neighborhood streets.

The NW 93rd/94th Street project was innovative because it was Clark County's first test of emergency vehicle-type traffic calming design on a collector roadway. Another street, NE 76th Street, also had similar design treatments, but it was a lower classification roadway.

SOLUTION

A traffic calming treatment was installed that consisted of an emergency response speed bump and a median slow point. The bump has a median and wheeltrack channel cut in the center of the bump to allow emergency vehicles to pass unimpeded through the center while general traffic must legally use the bump, and thus slow down. Bumps have been offset by direction within the device to allow for a pedestrian crosswalk to be installed adjacent to the bump.

Prior to installation, the devices were tested in a closed-environment at the Clark County Maintenance and Operations facility. A fire truck was used to test different wheeltrack and channel layouts using railroad ties. Spacing and median width specifications were developed from these tests. A closed-environment test was also conducted using a similar fire truck at the County Maintenance yards. These results indicated that with the specified design wheeltrack/median width, fire trucks would be slowed by, at most, 1-2 s per device while the driver aligned and maneuvered through the channel.

Clark County Public Works and Clark County Fire District 6 staff also tested the speed bumps in 1996-97. Speed runs were conducted before and after regular speed bump installations on NE 129th Street in the Salmon Creek area. The results indicated that a typical speed bump slowed fire trucks 4-6 s per device.

Prepared by Charles P. Green, Parsons Brinckerhoff, Portland, Oregon.

Information provided and contributions made by Charles P. Green, Parsons Brinckerhoff; Jennifer Green; Steve Green; Don Williams, Clark County; Gerald Morris, formerly with Clark County Public Works, now with Collier County, Florida Public Works; Carl Switzer, Parsons Brinckerhoff.

View of the median slow point with pedestrian crossing in the center of the median.

The project cost approximately $40,000 and was funded through the county's Neighborhood Traffic Program.

RESULTS

Prior to installation, a speed study was conducted in August 1996 by Clark County. The results were:

- Mean speeds varied from 37-42 km/h (23-26 mi/h) on the project's east end to 42 km/h-45 km/h (26-28 mi/h) on the west end.
- 85th Percentile speed was 48-52 km/h (30-32 mi/h) along the entire street.
- Speeds ranged from 24-55 km/h (15-34 mi/h) on the east end to 24-63 km/h (15-39 mi/h) on the west end.
- The 16 km/h (10 mi/h) pace speed, or the 16 km/h (10 mi/h) range which included the most vehicles varied from 32-47 km/h (20-29 mi/h) on the east end to 40-55 km/h (25-34 mi/h) on the west end.

The variation in speeds reflects differences in street character. On the west end of the project segment, the street is more of a typical "collector" because few driveways exist to provide direct access, and no special pedestrian trip generators, such as schools or parks, are present. The east end features land uses, including a school, a park, and an athletic club, which generate pedestrian, bicycle, and vehicle traffic.

A speed study was conducted in October 2001 following installation of the devices. The results were:

- Mean speed was 35-39 km/h (22-24 mi/h) measured between devices.
- 85th Percentile speed was 42-43 km/h (26-27 mi/h).
- The speed range was generally 27-42 km/h (17 to 26 mi/h).
- The 16 km/h (10 mi/h) pace speed was 26-40 km/h (16-25 mi/h).

Fourteen households fronting NW 93rd/94th Street, representing approximately 50 percent of the households along the calmed street segment, were surveyed to measure public opinion of the improvements.

The residents who lived on the street prior to the calming project felt that speeds were somewhat slower than before. On a scale of 1 to 5, with 1 being "dislike very much" and 5 being "like very much," their opinion of the speed bumps was 3.4 with a standard deviation of 1.3 (like somewhat).


View of the emergency response speed hump on the east end of the project.

Opinion was mixed on the worthiness of the crosswalk in the center of the speed bumps. Many felt that pedestrian safety was improved, especially for school children and those walking to or from the adjacent park on the north side of 94th Street. Others felt that the crosswalk may be somewhat hidden by the bumps themselves, or that vehicles would be watching for the bumps and ignore the crosswalk. Still others felt that the crosswalk did improve safety but did somewhat encourage users to "dart across the street."

The devices achieved their goals of slowing traffic speeds to match the neighborhood character, providing for a safer pedestrian crossing of the roadway, and allowing for emergency response vehicles to travel through unimpeded. According to field observations and the opinions of neighbors, the amount of pedestrians and school children crossing the street has also increased as well as the number of bicycle trips to the adjoining houses, schools, and park.

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School Zone Improvements

PROBLEM

Between 1995 and 1997, 32 traffic collisions occurred in the McClellan Road corridor. Given the confluence of commuter, school, and other traffic generated from a nearby junior college and a junior high school, the City and its residents were concerned about pedestrian safety for the students of an elementary school and a high school located on the busy roadway.

BACKGROUND

Lincoln Elementary School and Monta Vista High School, with an enrollment of almost 3000 students, are adjacent to each other on McClellan Road, a collector with single-family residential frontage. McClellan Road is a three-lane major collector with bicycle lanes, two 3.1 m (10 ft) wide travel lanes and a narrow center left-turn lane. The speed limit is 40 km/h (25 mi/h) in the school zone. McClellan Rd carries about 8,500 vehicles per day traveling at speeds (85th percentile) of 58 km/h (36 mi/h), and it has a high traffic accident rate.

A crossing guard helps Lincoln Elementary School students cross McClellan Road.

Prepared by Michelle DeRobertis, Wilbur Smith Associates, San Francisco, CA and Raymond D. Chong, Assistant Director of Public Works, City of Fairfield, CA.

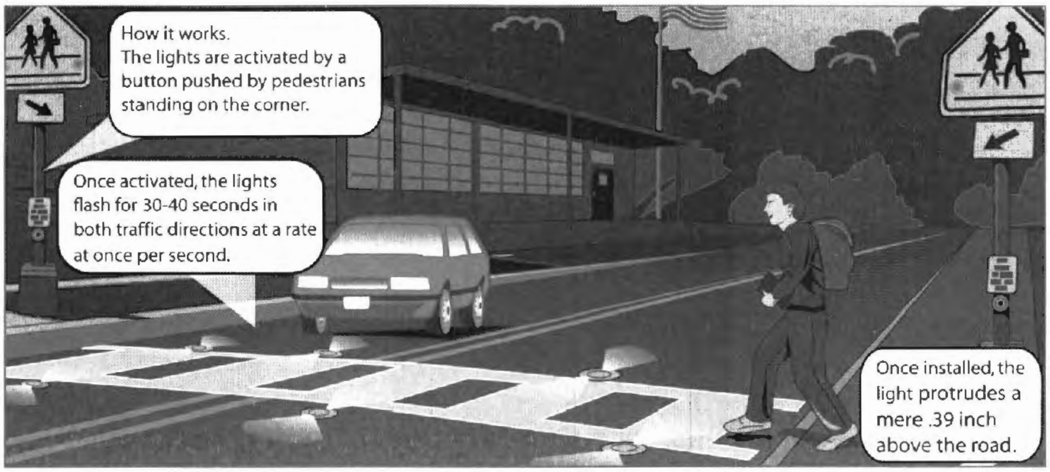
SOLUTION

The City developed a multi-pronged project to improve pedestrian safety for students in the school zone. The objectives of the project were:

- Reduce traffic collisions.
- Reduce vehicle speeds.
- Promote driver awareness of the school zone, including crosswalks and speed limit.
- Educate students on pedestrian safety at school zone crossings.
- Obtain public opinion about the pedestrian safety improvements.
- Collect data before and after installation of pedestrian safety improvements.

The project was conducted in partnership with the Cupertino Union School District, Fremont Union High School District, Santa Clara County Sheriff Department, and the Santa Clara County Health Department. Engineering, education and enforcement activities were implemented simultaneously with partner agencies leading the activities that fell under their jurisdiction, such as enforcement of traffic laws during peak hours, educating students on pedestrian safety, collecting before and after data, and conducting a public opinion survey.

For engineering changes, the City proposed the installation of In-Roadway Warning Lights (IRWLs) as the best way to increase protection for students crossing the street. IRWL systems include lights that are located in the roadway along the edges of the crosswalk markings. The lights create higher visibility crosswalks to improve crossings and reduce vehicle speeds.



Under direction of the City Traffic Engineer, the design chosen for the IRWL system utilized high intensity bi-directional halogen lights. The IRWLs at the crosswalks are in operation 24 hours per day, 7 days per week, and are activated automatically using "Smart Walk" pedestrian detectors, a microwave technology to detect the presence of pedestrians waiting to cross or in the crosswalk.

Flashing school zone beacons complement the in-roadway crosswalk warning lights.

In addition to installing IRWL systems at two crosswalks in the school zone, other engineering measures included placing flashing school zone beacons to indicate 40 km/h (25mi/h) signs and enhancing roadway signs and pavement markings.

Total cost for the two IRWL systems was $68,000 and the Traffic Safe Communities Network (TSCN) of Santa Clara County provided funding for the IRWL systems. The TSCN, sponsored by the Santa Clara County Health Department, is a consortium of public agencies, organizations, and businesses working together to improve traffic safety.

RESULTS

The City collected data on motor vehicle speeds before the project, in May 1999, and after, in May 2000. The results showed a reduction of 85th percentile speeds from 58 km/h (36 mi/h) to 53 km/h (33 mi/h). Median speeds were reduced from 50 km/h (31 mi/h) to 43.5 km/h (27 mi/h). Because a reduction in vehicular traffic volume or anincrease in pedestrian traffic was not a specific goal of the project, data was not collected on these factors.

The installation of the two crosswalk IRWL systems on McClellan near Lincoln Elementary School and Monta Vista High School has successfully improved pedestrian safety. Response from the community and users has been positive.

The supplemental use of speed limit warning flashers has enhanced the effectiveness of the IRWLs by drawing driver attention to the pedestrian crossing, thereby reducing speeds. In addition to improving the pedestrian environment by slowing traffic speeds, vehicle crashes decreased from 11 per year before the project to 7 in the year afterward.

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REFERENCES

California Traffic Control Devices Committee.

Manual of Uniform Traffic Control Devices, 2000 Edition, and *In Roadway Flashing Lights at Crosswalks*, an Informational Report published by the Institute of Transportation Engineers.

Pedestrian Crossing Devices

PROBLEM

Pedestrians were not safe or comfortable crossing in crosswalks at unsignalized intersections and mid-block locations due to traffic congestion.

BACKGROUND

The real and perceived inability of pedestrians to safely and comfortably cross unsignalized intersections and mid-block crossings on Main Streets and in Central Business Districts (CBD's) throughout New York State was, and continues to be, a growing problem due to vehicular traffic congestion. While signalized pedestrian crossings and separate rights-of-way were more appropriate in major cities and metropolitan areas, many retail- and tourism-oriented main streets in suburban and rural centers were seeking low cost, flexible, and seasonal pedestrian-oriented traffic control measures that would enhance their sidewalk-based economy and restore "curb appeal" for residents and tourists alike.

Since no statewide standards or specifications for such devices' use on state and local roadways existed before 1997, many municipalities custom-designed or purchased their own stand-alone devicesand/or signs to place near crosswalks within the centerline of the road. Many of these "non-conforming/non-standardized channelization devices" were either manufactured from materials that could become a hazardous or potentially deadly projectile if hit by a motorist. Often the signs contained language that was inconsistent with New York State vehicle and traffic laws.

Prepared by James M. Ercolano, Pedestrian Specialist, New York State Department of Transportation.

SOLUTION

Based on a device tested by the New Jersey State Police, the NewYork State Department ofTransportation (NYSDOT) developed specifications for Supplementary Pedestrian Crossing Channelization Devices (SPCCD's) in 1996. An SPCCD is a pedestrian safety cone placed in the centerline of the road, immediately in advance of, or immediately beyond, a marked crosswalk. It is used to communicate pedestrian right-of-way laws. Initially, SPCCD's were deployed in Upstate New York and on Long Island to assist FHWA-sponsored testing of the effectiveness of pedestrian safety cones by the University of North Carolina Highway Safety Research Center. When this device and a miniature version of the STATE LAW sign explaining the New York State Vehicle and Traffic Law regarding pedestrian right-of-way at marked crosswalks were approved for use in 1997, a two-year SPCCD permit was required to install the devices on state-owned roads.

NYSDOT was initially concerned the devices might become a projectile if struck by a motorist, but testing did not find this to be a problem. The agency also found the presence of the devices made motorists aware of their responsibilities when encountering pedestrians crossing a roadway. Therefore, SPCCD permits issued for installation and renewals after June 1999 have been extended for a five-year duration, and the devices

A SPCCD was placed at a ladder crosswalk on Fall Street in Downtown Seneca Falls, New York.

have been authorized for inclusion in the New York State Manual on Uniform Traffic Control Devices.

RESULTS

One of the most remarkable features of NYSDOT's SPCCD design and material specifications (especially the "soft-shell" traffic cone standards) is the resilience of these devices and their ability to take occasional hits by motorists. Most SPCCD hits require only replacement of the cones, and the soft-shell sign panels are often reused. Since their initial testing five years ago, no incidents of the devices causing harm or injury to either pedestrians or motorists have been reported on two-lane, slow-speed roadways with less than a posted 40 km/h (30 mi/h) speed limit. Vehicle hits that do occur only reinforce the public health and traffic safety justification for their appropriate and specified use.

While a formal study of SPCCD effectiveness was not conducted exclusively for New York State, positive public response continues to warrant support for "Main Street," school zone, temporary seasonal, and work zone crossing applications. At a cost of $200 to $300 per device, SPCCD's are a cost-effective, portable countermeasure.

The satisfactory performance of the devices were further supported by an FHWA report, "The Effects of Innovative Pedestrian Signs at Unsignalized Locations: A Tale of Three Treatments," FHWA-RD-00-098, August 2000. The study collected data on motorist and pedestrian behavior at seven crosswalks in New York State and Portland before and after SPCCDs were installed. Overall, more than 2000 pedestrians crossed during both the before and the after periods. The proportion of pedestrians who ran, aborted, or hesitated in the crosswalk decreased from 35.4 percent before to 33.3 percent after the cones were installed. A statistically significant increase in motorists yielding to pedestrians was also observed. Only 69.8 percent of motorists yielded in the before period, but 81.2 percent yielded after the SPCCD's were added.

Vehicles yield to a pedestrian near an SPCCD on New York Avenue in Downtown Huntington, New York.

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REFERENCES

Huang, H., C. Zegeer, R. Nassi, and B. Fairfax. "The Effects of Innovative Pedestrian Signs at Unsignalized Locations: A Tale of Three Treatments." Federal Highway Administration, FHWA-RD-00-098, August 2000.

BELLEVUE, WASHINGTON **CASE STUDY NO. 29**

Gateway Treatments

PROBLEM

Over the past fifteen years, the significant business and residential population growth in Bellevue, Washington has resulted in negative traffic impacts, especially where congested arterial streets surround residential neighborhoods. The City has found that motorists carried their high driving speeds and risky behavior from arterial roadways into residential neighborhood streets, decreasing the safety and comfort of pedestrians.

BACKGROUND

The study of streetscapes and traffic calming has shown increasingly that motorists'speeds and driving characteristics are greatly influenced by cues given in the street design and surrounding environment.The City addressed this problem through its Neighborhood Traffic Calming Program. To protect neighborhood streets that connect directly to arterials, the City decided to look for a treatment that would indicate to motorists they were leaving an arterial street and entering a residential neighborhood. Gateway treatments such as neighborhood signs and physical roadway features such as landscaped islands or colored-textured pavement were considered.

SOLUTION

The City began experimenting with the use of gateway treatments in the late 1980's. Although developers were using gateway treatments to identify their subdivisions, little was being done with this concept by local agencies. In 1989, the City worked with the Surrey Downs Community to develop a plan that would help reduce vehicle speeds and make conditions safer for pedestrians, while at the same time, identify a neighborhood.

Neighborhood signs are located on this landscaped median island at the entrance to the Surrey Downs neighborhood.

The Surrey Downs Neighborhood is located one block south of the Central Business District (CBD).The community is surrounded by a collector street on the west and by minor arterial streets on the north, east, and south, which serve as access to several freeway interchanges. Because of these roadways and the neighborhood's close proximity to the CBD, the protection and preservation of the neighborhood's walkability and livability was very important to the residents.

Plans were made to use physical changes to the roadway environment to reduce traffic impact and improve pedestrian conditions in the neighborhood. Landscaped medians and colored-textured pavement treatments were designed. The medians were approximately 2.40 m (8 ft) wide by 9.15 m (30 ft) long, which narrowed the travel lanes to 3 m (10 ft). Colored-textured pavement set behind the crosswalk area adjacent to the median measured 10 ft (3 m) wide, and sloped to a 50 mm (2 in) vertical rise at its center to make drivers feel a slight rise as they travel over the colored pavement and enter the neighborhood.

Prepared by Karen Gonzalez, City of Bellevue, WA.

A landscaped island with pavement treatments at the entrance to the Surrey Downs neighborhood.

Five gateway treatments were designed for the Surrey Downs neighborhood. Three locations included landscaped medians with pavement treatments, while two others received only pavement treatments to allow on-street parking. Posted speed limits for the neighborhood streets remained 40 km/h (25 mi/h). At the time this project was developed, design and construction averaged $10,000 for each entrance with a landscaped median and approximately $5,000 for the colored-textured pavement treatment. Two budget lines in the City's Capital Investment Program, Neighborhood Enhancements (NEP) and Neighborhood Traffic Calming (NTCP), provided funding, and the design was completed in-house.

RESULTS

The project's effectiveness was determined more on public perception than on actual speed reduction. Speed studies conducted at the gateway treatments with landscaped medians showed speeds reduced 3.5 km/h (2 to 3 mi/h), possibly attributed to the narrowing of the travel lanes. Vehicle speeds did not change at locations where colored-textured pavement was installed despite the slight rise of the pavement.

Although the speed studies showed limited impact, public perception of the positive benefits produced by the project was widespread. Like other median projects in Bellevue, residents feel that the gateway intersections to the Surrey Downs neighborhood are safer for pedestrians because they must only cross one lane of traffic at a time. Further, residents' concerns about vehicles cutting corners as motorists entered the neighborhood were eliminated by the medians. Residents also felt the gateway treatments helped to identify the vitality of their community, enhancing the residential character, and improving the pedestrian environment by making it less appealing to non-local traffic. The success of this project has led to the construction of many more gateway treatments as part of traffic calming efforts throughout Bellevue.

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Raised Crosswalk at School

PROBLEM

The City of Bellevue, Washington identified lack of sidewalks, excessive vehicle speeds in school zones and vehicles parked too close to crosswalks as three primary problems that reduce safety on city streets for children walking to and from school.

BACKGROUND

Improving safety for child bicyclists and pedestrian is just one of many issues addressed by Bellevue's long standing bicycle and pedestrian program. Since, the early 1980's the City has been an advocate for planning and development of pedestrian and bicycle facilities, including education programs promoting traffic safety. To address safety issues for kids walking and biking to school the City formed a partnership with residents, school administrators and PTSA representatives to focus on these issues. Two elementary schools--Somerset and Bennett Elementary--were chosen for a demonstration project, referred to as the School Crosswalk Enhancement Project.

At both of these schools the majority of students live within walking distance. As a result, the crosswalks adjacent to the schools are heavily used. Both locations have a history of motorists speeding and vehicles parking too close to the crosswalk areas, creating an unsafe situation for pedestrians, primarily children. Target enforcement by police helped, but there was an ongoing concern that physical changes to the roadway environment were needed.

Prepared by Karen Gonzalez, City of Bellevue.

SOLUTION

After review of the roadway conditions and discussions with stakeholders, a plan was developed. This plan included the installation of a raised crosswalk to reduce vehicle speeds and improve pedestrian visibility. The raised crosswalk is a 3-inch high (76 mm), 22-foot long (6.7 meter), in the direction of travel, asphalt speed hump with crosswalk markings. Standard crosswalk signs are located at the raised crosswalk, but the advanced warning sign reads "Raised Crosswalk Ahead" with a "15 MPH" advisory speed sign. There are also "Bump" pavement markings on both sides of the crosswalk, notifying drivers that the roadway is raised.

A raised crosswalk and curb extension along a street in the Bennett Elementary School Area.

Curb extensions were also included in the plan to serve two purposes. First, the curb extensions shorten pedestrian crossing distance. Second, they eliminate parking on and near the crosswalk, improving sight distance for pedestrians, especially children. The curb extensions narrow the roadway by bumping the curb into the parking lane. These were built in concrete and finished with a one-foot (.3 m.) scoring pattern for aesthetics. Drainage included a 3-inch (76 mm) PVC drainpipe installed to have water flow through the curb extension at the original curb line. In addition to the raised crosswalk and curb extensions, bollards were installed in the curb extension to keep young pedestrians from huddling around the crosswalk.

In addition to the physical changes made to the roadway environment, an education campaign was launched at Somerset Elementary School. A safety day was planned, which included staff from the City's Transportation and Police Departments. This effort included working with the school safety patrol and parents. Together, the children were taught traffic safety basics, such as crossing the street safely. At the time the new crosswalks and bollards were installed, an educational plaque was placed on the bollards, which depicted the City of Bellevue's pedestrian mascot "PedBee" and safety tips on how to cross the street safely. PedBee also made an appearance on safety day and gave out prizes.

The cost to build the crosswalks was approximately \$20,500 with an additional \$9,500 spent in project design and public involvement activities. Overall, the average cost for each location was \$15,000.

This crossing has a student-oriented pedestrian safety informational plaque with "PedBee," the City of Bellevue's pedestrian mascot.

RESULTS

The project was designed and built in three months. Since the installation of the raised crosswalk and curb extensions, speed studies have been conducted and compared to before speeds at one of the locations. The roadway's posted speed limit is 25 mph (40 kph) with a 20 mph (32 kph) limit when children are present. During the hours before and after school, the 85th percentile speed dropped from 29 to 26 mph (47 to 42 kph). Over a 24-hour period the 85th percentile speed after installation was 28 mph (45 kph). Field observations also confirm that the project successfully eliminated parking near the crosswalk, giving pedestrians increased sight distance and improving their visibility to drivers. Many positive comments were received from parents and school district officials showcasing the overwhelming success of this project.

Evaluation of this project is continuing, however the success to date has resulted in similar installations being designed and constructed at several other elementary schools in Bellevue.

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BALTIMORE/WASHINGTON INTERNATIONAL AIRPORT, MARYLAND CASE STUDY NO. 31

Speed Tables at BWI Airport

PROBLEM

Safe, highly visible pedestrian crossings were needed between airport terminals and parking structures.

BACKGROUND

As many airport passengers know, traversing the departure and arrival roadways between the terminal and the parking lot, hotel, or ground transportation can be a challenge. Busy passenger drop-off and pick-up zones for buses, taxis, and private vehicles can create a chaotic roadway environment. Crossing such a road, especially when carrying luggage or when traveling with a family, can be an unpleasant experience. Traditionally, airports have turned to costly pedestrian bridges over their roadways or have attempted to provide better surface crossings and enhanced signing. Such treatments are an improvement over unmarked, unsigned crossing locations, but their abilities to safely and easily manage large volumes of travelers and vehicles are still limited.

SOLUTION

Several airports, including Reno-Lake Tahoe International, Las Vegas McCarran, and Baltimore/Washington International (BWI) constructed speed tables to more effectively handle passenger and vehicle movements at pedestrian crossings. The speed tables at BWI are located between the baggage claim area and the main parking garage. The roadway at this location has two through traffic lanes plus two parking/loading area lanes. Curbside parking and drop-off zones include shuttle buses to parking and transit connections along with taxi/limousine services and personal car access.

PHOTO BY JEFF OLSON

This speed table at Reno/Lake Tahoe International Airport provides a level crossing for pedestrians and makes them more visible to drivers. It also requires vehicles to drive more slowly. Pedestrian crossings at BWI airport provide similar pedestrian benefits.

Originally, the airport terminal roadway had stop signs at certain locations with conventional marked pedestrian crossings and standard yellow pedestrian safety crossing signs. In 1999, airport management was concerned about drivers speeding through the terminal area and wanted to improve visibility, safety, and accessibility for pedestrians crossing between the new structure and the terminal baggage claim area.

Since traffic calming guidelines were still under development at that time, BWI and their consultants worked with both State and MUTCD-based design guidelines. The chosen design included raised speed table crosswalks supplemented by fluorescent yellow-green pedestrian crossing signs. The STOP signs were maintained at the speed tables along with corresponding pavement markings, although these are not typically installed in combination with speed tables in other locations.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Ali Logmanni, BWI Airport Authority and Timothy Ryan, URS Consulting.

PHOTO BY T. RYAN, URS CONSULTING

The speed tables at BWI improve crossing conditions for pedestrians. Note that the speed table is complemented by strong yellow-green pedestrian markings and STOP signs with flashing lights and pavement markings, which typically are not used in combination with speed tables.

RESULTS

Although detailed data on cost and pedestrian use are not available, BWI Airport staff are satisfied with the speed table installation. Motorists drive more slowly through the terminal area and pedestrian visibility is greatly enhanced. Not moving up and down across ramps or curbs is a noticeable improvement for passengers with luggage, and is the added benefit in terms of ADA compliance. The application of speed tables at airport passenger terminals is an innovative use of traffic calming that demonstrates sound transportation planning and traffic engineering.

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REFERENCES

Maryland Department of Transportation: *Traffic Calming Manual*, MDOT 1999.
Baltimore International Airport website: http://www.bwiairport.com.
Reno/Tahoe Airport website: http://www.renoairport.com.

Trail Intersection Improvements

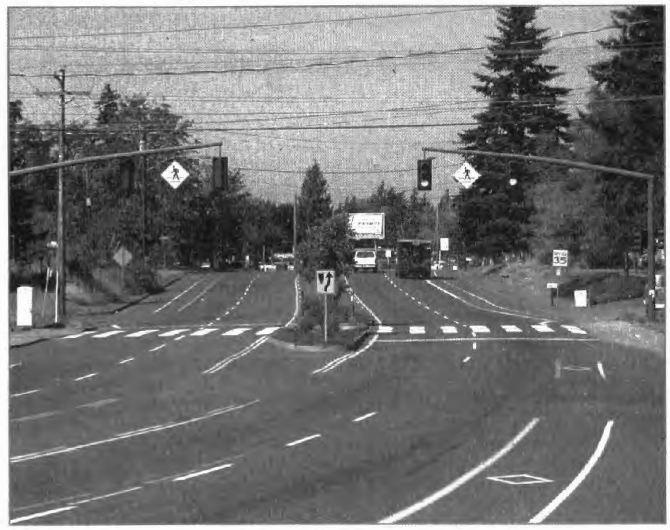
PROBLEM

Safe intersection crossings were needed for a trail that intersects with several roads.

BACKGROUND

The Springwater Corridor is a 16.8 mi former rail corridor converted into a recreational non-motorized commuter trail in 1996. Located in southeast Portland, Oregon, the corridor extends eastward to the City of Gresham and links to the small, unincorporated community of Boring. The route it travels features a variety of landscapes and includes industrial, commercial, and residential areas.

Master planning for the project began in 1992 after the Intermodal Surface Transportation Efficiency Act (ISTEA) was passed in 1991. Based upon 1990 census data, surrounding population densities, and a recent City of Portland Parks & Recreation Department park user survey, use levels were projected for the corridor at an annual rate of approximately 400,000 people per year. Anticipated uses included bicycling (56%), walking (36%), jogging (9%), and equestrian (3%). The trail would be multiuse, and include a 3.7 m (12 ft) wide paved surface with 0.6 m (2 ft) wide soft shoulders and a separated equestrian trail wherever feasible.



A typical major intersection treatment.

A typical minor intersection treatment.

The Springwater Corridor is unusual because it does not fall into a road right-of-way. This eliminates the conflicts between trail users and automobiles found on most roadway bicycle lanes. The corridor, however, does intersect with several roads. Addressing these intersections was essential to ensure trail user safety and to minimize automobile and trail user conflicts. With growth in the Portland metropolitan region projected to increase automobile traffic, the situation would only become more aggravated.

Information provided by George M. Hudson, Landscape Architect, former City of Portland Park Planner, Trail Program Manager.

A bicycle-activated Signal Loop Detector.

A pedestrian-activated signal button in a refuge island.

SOLUTION

The intersections were broken into three categories—major intersections, minor intersections, and private driveway crossings—based upon type of use, roadway width, traffic gaps available for pedestrian crossings, automobile volume, and automobile speed.

Minimal improvements at all intersections included:

- Vehicle control bollards to prevent vehicles from accessing the trail.
- Center removal bollard to allow for maintenance and emergency service vehicle access to the trail.
- Removal or thinning of vegetation to increase visibility at the intersection.
- Use of natural stone basalt boulders as needed to prohibit vehicle access into the trail right-of-way.
- Stop signs.
- Striping.
- Crossing warning signs.

MAJOR INTERSECTIONS

Due to high automobile traffic volume resulting in a high degree of crossing difficulty, six major intersections were identified along the Springwater Corridor at Johnson Creek Boulevard—SE 45th, 82nd Avenue, 92nd Avenue, Foster Road, 122nd Avenue, and Eastman Parkway in the City of Gresham. Eighty-second Avenue is a State-owned route. The Oregon Department of Transportation required meeting traffic signal warrants to justify the installation of a signal at the trail and roadway intersection at 82nd Avenue. User counts of a minimum of 100 trail users per hour for any 4 hours within a day had to be met. Trail user counts were carried out on an existing improved segment of the trail within the City of Gresham. Warrants were met and the state approved a signal installation.

Improvements installed at major intersections included pedestrian- and bicyclist-activated signals, median refuge islands with a signal-activating button, signage forewarning both the trail users and motorists of the approaching intersection, and crosswalk striping. In addition, curb extensions and a realignment of the trail to minimize crossing distance were incorporated into the intersection design.

MINOR INTERSECTIONS

Defined as crossings at public roadways that present a low to moderate degree of difficulty in crossing, 28 minor intersections along the Springwater Corridor were identified due to their low traffic volume and minimal width. Minor intersections were treated similar to major intersections with the deletion of the pedestrian-activated signals. A few intersections deemed challenging to cross received overhead flashing yellow pedestrian warning signs.

PRIVATE DRIVEWAYS

Private driveways were defined as vehicle crossings providing access to private property and businesses adjacent to the trail, which serve a private citizen or a group of citizens. Improvements installed to prevent a private property from being land locked included fixed and removal bollards, stop signs for automobile traffic, a raised trail surface with warning striping to act as a speed table for motorists, and placement of locally found basalt boulders to restrict vehicle access to the corridor. The City decided to restrict future additions of private driveway crossings and to combine private driveway crossings wherever feasible.

RESULTS

The installation of trail improvements was completed in 1996. Since that time, there has been only one reported accident at an intersection resulting in an injury. This single accident was between an equestrian and a car. The horse became startled, bucked off its rider, and bolted into an intersection. The accident clearly was not due to a faulty design, but perhaps an inexperienced rider.

Based on the interim user counts to establish warrants at the 82nd Avenue intersection, use levels of the Springwater Corridor are now exceeding the use level projections made during the master planning effort. Plans currently underway to link the Springwater Corridor from southeast Portland to downtown Portland with a Class I bikeway are anticipated to be in place by early 2003. User projections at that time are expected to exceed one million users per year.

In conclusion, the intersection designs along the Springwater Corridor adequately addressed public safety and reduced potential conflicts between trail users and automobiles.

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Safe School Route Mapping

PROBLEM

The City of Rochester School District needed a systematic and cost effective method to confirm and upgrade maps of children's walking routes to school each year as part of its pedestrian safety program for school children.

BACKGROUND

Rochester, New York is the third largest city in the State. The City's diverse urban public school district serves more than 35,000 students in addition to the over 5,000 students in private and parochial schools. Rochester has established a highly successful long-term partnership for improving pedestrian transportation safety for children. A School Traffic Safety Committee with representatives from the school district, law enforcement, transportation, and safety organizations, coordinates a multifaceted safety program. Unlike many new "Safe Routes to Schools" programs, Rochester has been managing this program continuously since 1984, and its roots were established in the 1960s.

SOLUTION

Through cost-effective use of existing resources and planning, the routes that children walk to school are systematically confirmed and upgraded each year, providing the necessary infrastructure for a safe community. It is not the mapping technology that makes this a "Best Practice," but the integrated process that has created long-term success.

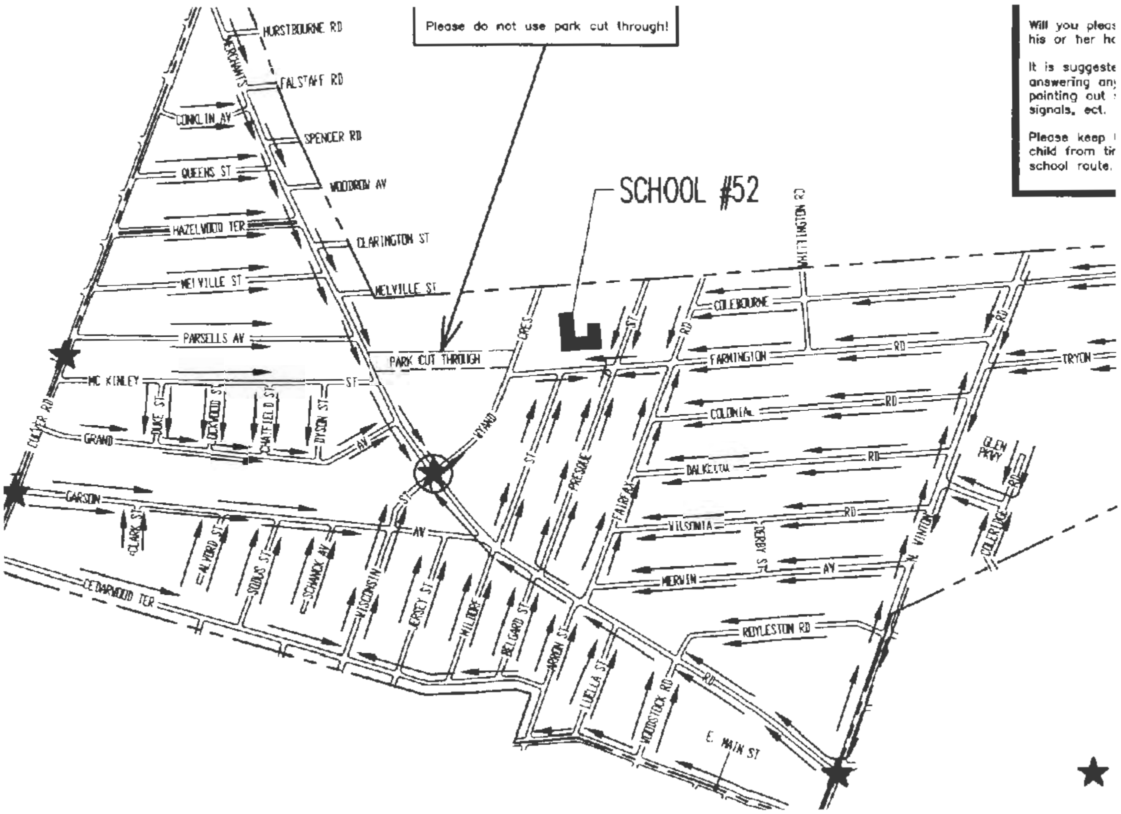
Prepared by Jeff Olson, R.A., Trailblazer.

Information provided by Andy Wheatcraft, Rochester City School District.

In 1965, the City of Rochester Traffic Engineering Division, the Rochester Police Department, and the Rochester City School District developed a program to plan safe walking routes to schools, to identify appropriate locations for crossing guards and control signs, and to provide traffic safety education in school classrooms. The program was reorganized in 1984 and expanded the partnership to include the Rochester City School District, Monroe County Department of Transportation, Rochester Police Department, Automobile Club of Rochester/AAA, and the Roman Catholic Diocese of Rochester. The program played an important role in planning and training for safe student pedestrian activities and continues to provide leadership in educational programming.

The School Traffic Safety Committee was established to perform traffic, facility, and educational functions supporting the safe passage of school students between their homes and schools. An analysis and study of children's routes to school are performed in preparation for the monthly Committee meetings. The Committee is charged with the following tasks:

- Develop recommended policies and safe walking routes for school walk trip safety.
- Provide periodic review of safe walk route conditions and supporting programs and policies.
- Coordinate suggestions and concerns regarding school pedestrian safety.
- Serve as a provider, communicator, and coordinating group regarding pedestrian safety education, programs and improvements.
- Provide input to the decision-making process for school facility improvements.
- Assist in developing recommended school bus/pedestrian service area boundaries based on proposed safe school routes.
- Maintain a good public relations program regarding school pedestrian safety.



Sample School Safety Map. Provided by Rochester School Safety Committee.

The School Traffic Safety Committee produces the the products discussed below to implement, promote, and improve the program.

SAFE WALKING ROUTE MAPS

Safe walking routes for children have been mapped for each of the 49 elementary schools and five middle schools in the City. The maps are updated annually and distributed to the schools in the fall of each year along with a cover letter outlining safe walking habits, safe driving by parents, and encouraging parent participation in the review of safe routes with their children. The letters are provided in both English and Spanish. The maps include the locations of all traffic signals and crossing guards. Students mark their routes on hand-drawn maps, which the County translates into color-coded AutoCAD files.

Rochester develops its maps based on the actual "feeder pattern" of children walking to each school, not based on specified radii for the area surrounding each school. The feeder method reduces the number of locations that need to be reviewed each year, while the radius method would require all streets within a certain distance from the school to be evaluated. Recent improvements based on the Committee's ongoing process include installation of approximately 8 new flashing beacon school zone warning signs each year, installation of strong yellow-green warning signs at school crossings, the annual placement of 160 school crossing guards, and creating high-visibility crosswalks at certain locations.

EDUCATIONAL LITERATURE AND PROGRAMS

The Rochester Automobile Club/AAA administers local programs at the schools and distributes safety literature to all elementary schools for their use. The delivery of this service supports the Walk Safely to School Program.

CROSSING GUARD LOCATIONS

The Committee analyzes and recommends crossing guards for the City of Rochester. Recommendations are forwarded to the Police Department who coordinates the placement of the guards. Locations are noted, and safe walking routes are adjusted to reflect changes in the crossing guard locations.

STREET SIGN AND IMPROVEMENT RECOMMENDATIONS

The Committee recommends traffic improvements affecting schools and safe walking routes. The Committee reviews street parking regulations, street construction projects, and other signals and signage. Changes are reflected on the safe walking route maps.

RESULTS

After more than 15 years of effort, the City of Rochester has not had a student traffic fatality or serious injury among children who walk to school. This is impressive, because it is estimated that approximately 90% of elementary school children walk or take the bus to school in Rochester. Detailed mode share data is not available, but anecdotal evidence indicates the high mode share and safety record are a combination of neighborhood-based school locations and the Safe Routes to Schools program. Rochester's Walk Safe to School Program was nominated by NYSDOT for the 1996 U.S. Secretary of Transportation Community Partnership Award, and receives continued recognition as a model program.

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REFERENCES

1988 Administrative Regulations, School Safety Committee, Rochester, New York

TUCSON, ARIZONA CASE STUDY NO. 34

Staggered Median

PROBLEM

A five-lane urban arterial with heavy traffic created difficult crossing conditions for high school students. Moreover, student crossing behavior was varied and erratic, and a number of minor collisions involving students and motorists had occurred. Student use of a nearby intersection crosswalk was neither the norm nor in a direct line between the school and an after-school, restaurant hangout across the street.

BACKGROUND

Twelfth Avenue is a four-lane arterial with a center two-way left-turn lane that carries approximately 19,500 vehicles per day. The posted speed limit is 56 km/h (35 mi/h). Over 220 pedestrians per day cross nearby, but not necessarily at the intersection of 12th Avenue and Veterans' Boulevard. The side of Pueblo High School closest to 12th Street contains one of the school's major pedestrian exits as well as student pick-up and drop-off areas. A restaurant is located across the roadway from the school and attracts a large number of students before and after school.

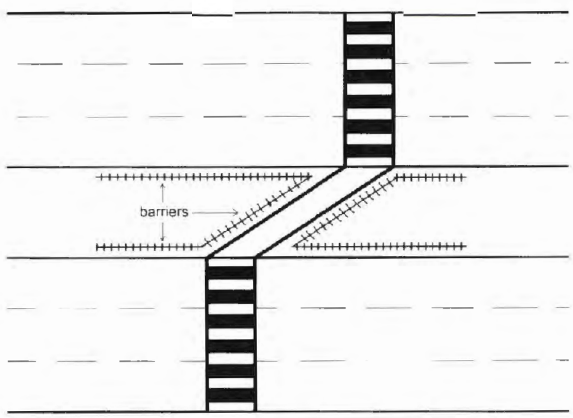
In the years prior to installation of the improvement, conflicts between pedestrians and motorists became a significant problem. Several minor collisions involving students and motorists had occurred along with other instances of vehicles quickly braking for students in the roadway. The area was also aggravating for 12th Avenue drivers because students would often meander or stop in the roadway, delaying traffic in both directions. Officials were concerned that this situation would eventually lead to serious confrontations between students and aggravated drivers.

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center.

SOLUTION

The City Traffic Engineering Department worked closely with the school administrators and the school transportation committee to analyze the problems and develop alternatives.

Staggered median with HAWK beacon (MUTCD experimental device) at bus stop.



Design drawing of a staggered median and split crosswalks.

In order to address the diverse issues, the existing crosswalk between the high school and the restaurant was removed and replaced by a split crosswalk, each leg approximately 24.5 m (80 ft) from the other. The sections of the split crosswalk were connected by a fenced pedestrian refuge median, installed in the center turning lane. At one end of the island, the fence opens to the crosswalk connecting to the high school exit. At the other end, the fence opens onto the second leg of the crosswalk, which connects to a transit stop waiting area, just south of the restaurant parking area. The fence itself works successfully as a channeling barrier. Because the crosswalk is staggered, crossing pedestrians are forced to look at on-coming traffic while walking down the fenced median.

The crosswalk is clearly marked in both directions with overhead mast-arm crosswalk signs and flashing lights that are turned on by quick-response crossing buttons. Traffic is halted only on one half of the roadway when the flashers are activated. The City and school district split the cost of the project, and the material used by the City to construct the median fence replicates a fence that surrounds the school.

RESULTS

The split crosswalk successfully addresses several of the site's previous problems. Most importantly, it gives pedestrians a safe haven from automobiles in the road's center and forces pedestrians to look at oncoming traffic while crossing. It also helps to minimize the number of students meandering back and forth across the street, giving them a place to socialize in the fenced median, rather than in the street. Unfortunately, because the fence is the only median constructed on this straight five-lane road, a few drivers who were not paying attention have run into the fence at the end of the median. Despite this problem, the Council Member from this district and Pueblo High School administrators are very pleased with the result.

Close-up of fenced pedestrian refuge median.

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Curb Extensions For Transit Access

PROBLEM

Heavy traffic and high vehicle speeds made it difficult for pedestrians to cross Wilson and Clarendon Boulevards near Court House Station on the Metrorail Orange line.

BACKGROUND

In the summer of 1999, the Arlington County Department of Public Works launched a Pedestrian Initiative in the Rosslyn-Ballston Corridor, a high density, mixed-use area within the County. The Initiative was developed as a response to direct public interest in street improvements around this corridor and Countywide concern for overall pedestrian safety.

The corridor is served by five underground Metrorail Orange line stations as well as Wilson and Clarendon Boulevards, surface arterials that form a one-way couplet, each of which were comprised of three lanes prior to the pedestrian initiative. The initiative envisioned a series of small projects to improve conditions for pedestrians. Heavy traffic and high vehicle speeds made it difficult for pedestrians to cross each of the roadways to reach the nearby transit station. The first project reduced the number of vehicle travel lanes on these roadways from three to two, which created space for the construction of curb extensions.

SOLUTION

In the fall of 2000, Arlington County built seven curb extensions on major roads within 152 m (500 ft) of the Court House Metrorail station. The station has 11,000 to 12,000 users per day, and 80 percent of these people arrive by foot. Thousands of people work in the Court House area and walk to the numerous restaurants and other services in the area. The curb extensions were intended to improve pedestrian safety by shortening crossing distances, calming traffic, and providing more visible crossing points for pedestrians. In addition, the curb extensions left space for transit buses to pull to the side of the roadway out of the travel lanes rather than on the edge of the travel lane to load and unload

Curb extension and crosswalk on Wilson Boulevard.

Clarendon Boulevard and N. Wayne intersection, where a conflict with delivery vehicles was eliminated.

Prepared by Richard Viola, Arlington County Department of Public Works.

passengers. Higher-visibility ladder crosswalks were installed to supplement the curb extensions. Strong yellow-green pedestrian crossing warning signs and new "Yield to Pedestrians, $100 to $500 Fine for Violations" signs were also installed.

Finally, the pedestrian initiative eliminated an unneeded driveway that intersected the 15th Street sidewalk and addressed the problem of stopped delivery vehicles blocking the crosswalk at Clarendon Boulevard and N. Wayne Street.

RESULTS

The total project, which included the curb extensions, crosswalk markings, and pedestrian crossing warning signs, cost approximately $50,000. Before and after measures of pedestrian conditions are not available, but Arlington County staff and others report a noticeable increase in the number of cars yielding to pedestrians in crosswalks in the Court House Area. Community reaction has been very positive and County Board members have commented that the project provides a good example of how a relatively small expenditure can result in clear improvements for pedestrian safety and comfort.

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SALT LAKE CITY, UTAH | CASE STUDY NO. 36

Double-Ladder Crosswalks

PROBLEM

On wet and icy days, the Salt Lake City Division of Transportation frequently received calls from pedestrians concerned about ladder style crosswalks being slippery. The marked surfaces of ladder crosswalks can be slippery when wet, especially as the crosswalk surface wears smooth. Complaints about the crosswalks often came from school crossing guards because many of the ladder crosswalks were near schools in Salt Lake City.

Alternate views of double ladder crosswalks.

SOLUTION

To resolve this problem, the Salt Lake City Division of Transportation tested a new crosswalk design. After listening to the concerns raised by the crossing guards, city engineers brainstormed and then tried an experiment with an alternate design.

This new design eliminates the markings from the middle third of the crosswalk so that there is 1.2 m (4 ft) of white crossbar, 1.2 m (4 ft) of smooth pavement, then 1.2 m (4 ft) of additional crossbar. This design is called a "double ladder" crosswalk. The double ladder crosswalk maintains the same visual appearance of the single ladder crosswalk from the driver's point of view, but allows pedestrians to walk in the paved surface between the two ladders of the crosswalk. It is used only at mid-block locations and around schools.

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center, and Kevin Young, Salt Lake City, UT Division of Transportation.

RESULTS

The separation between the longitudinal lines does not decrease the advance visibility of the crosswalk for motorists. Salt Lake City tests have shown that the double ladder crosswalk appears the same to a motorist as a standard ladder crosswalk until the motorist is within 46 m (150 ft) of the crosswalk. By the time the motorist notices the difference, they are already aware of the existence of the crosswalk.

The separation between the longitudinal lines of the double ladder crosswalk provides pedestrians an unmarked area to walk during those times when the crosswalk is wet and the potential for a pedestrian to slip is increased. The separation removes the hazard of the slippery surface at the crosswalk and improves the safety for pedestrians using the crosswalk.

Salt Lake City has had great success with the use of double ladder crosswalks. The new marking process is less expensive and does not take more time than previous crosswalk installations. Use of the double ladder design began in the mid 1990's. Since their initial test and adoption, city crews have been routinely replacing worn crosswalks of the old style with the new design at appropriate locations on repaving projects and newly constructed roads.

Comments received from the traveling public regarding double ladder crosswalks have been universally favorable. School crossing guards, who are often older, like the new crosswalk design and have reported feeling that they are less likely to slip during wet and icy weather.

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Zebra Crosswalk Markings

PROBLEM

Incremental improvements to crosswalk design and increase of aggressive driving throughout New York City created a situation where the crosswalk marking used to delineate safe walk-to-school routes (the MUTCD "ladder") was the same as the marking for dangerous intersections, sending a conflicting message to school children and others using the city's sidewalks. Moreover, neither crosswalk was providing adequate safety for the large volumes of pedestrians found on many New York City streets.

Overlapping delineating crosswalks sent conflicting messages to New York City pedestrians.

BACKGROUND

Delineating crosswalks with thermoplastic striping is intended to communicate a message to both drivers and pedestrians. For years there were only two types of markings used by the New York City Department of Transportation—simple parallel lines and the ladder. Parallel lines were used at signalized intersections and other locations where drivers are expected to stop for pedestrians. The ladder was used to highlight a particular location such as a preferred route to school or a dangerous crossing point. Initially, crosswalks warranting ladder treatments (school or dangerous) occurred in separate parts of the city so there was little overlap.

The use of the ladder crosswalk to mark dangerous intersections increased, with the spread of aggressive driving behaviors, changed attitudes about crosswalks, and the Department's increased response to the concerns of the walking public. The different crosswalks created conflicting messages and made it impossible for the public to determine whether one should cross at a ladder crosswalk or avoid it altogether.

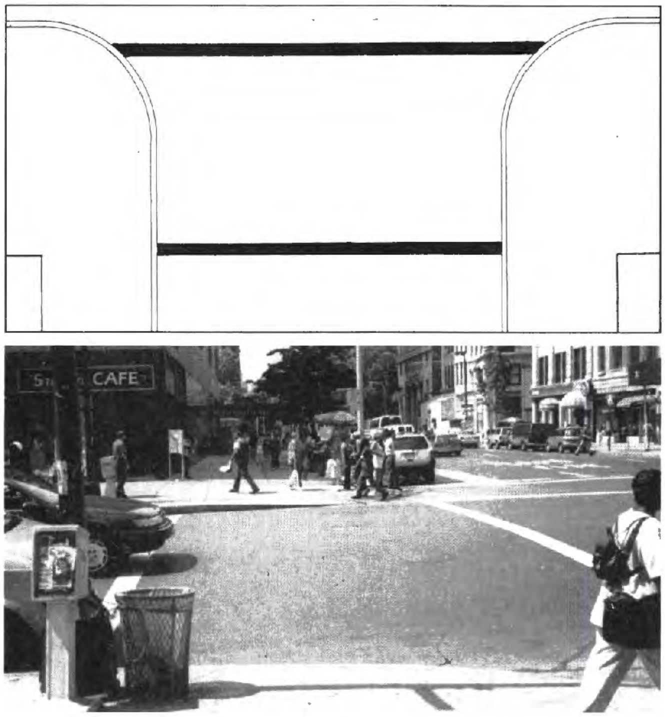
Prepared by Michael King.

SOLUTION

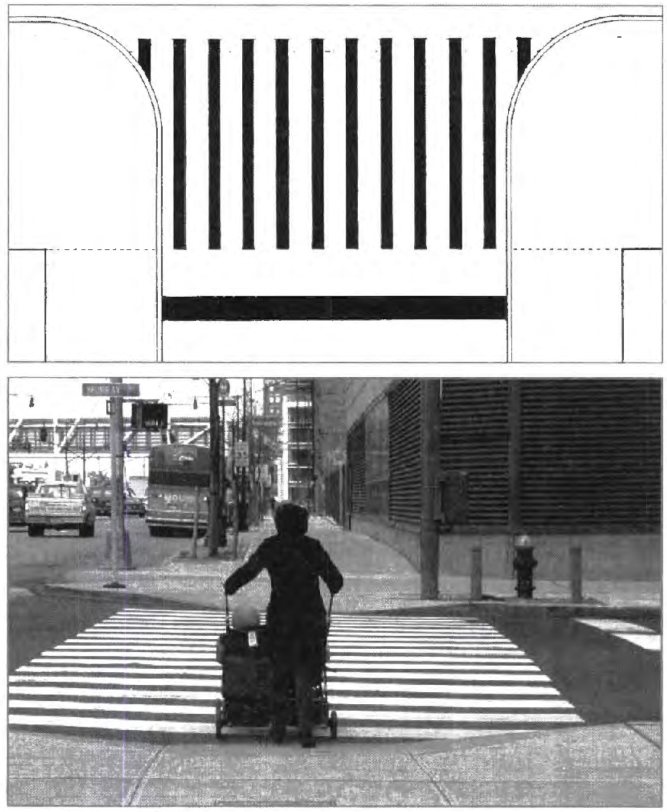
In 1995, the Pedestrian Projects unit of the Department of Transportation worked with the Roadway Engineering Division to introduce a third crosswalk marking called the "zebra," solely for dangerous locations. This involved altering the width, use, and warrants for stop lines. In addition, it was one of the first instances where an ISTEA-funded unit created specifically to address pedestrian issues affected a change in citywide policy.

The "zebra" crosswalk is an adaptation of the ladder, which has two 305 mm (12 in) lines running the length of the crosswalk that close each end of the 305 mm (12 in) bars. In contrast, the zebra crosswalk has open-ended bars and uses a 610 mm (24 in) stop-line in advance of the crosswalk. This stop line is set back at least 1.5 m (5 ft) from the crosswalk. Ladder markings are now reserved solely for the school route network.

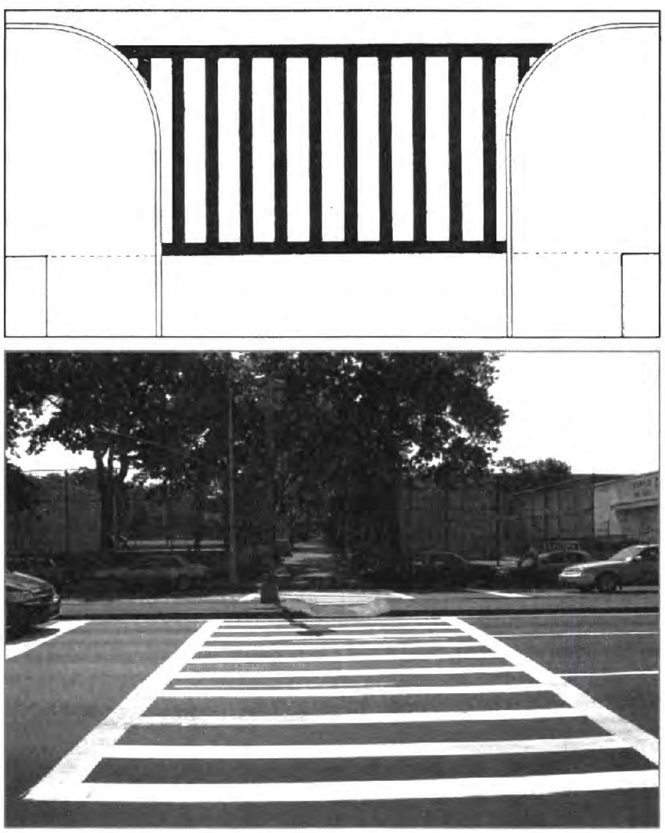
Previously, a dangerous location was defined when two or more pedestrians had been hit by vehicles for three years in a row in a specific crosswalk. To account for data irregularities and underreporting, the definition was changed to an average of two injuries per year



Standard Parallel Line Crosswalk



Zebra Crosswalk (dangerous location)



Ladder Crosswalk (school routes)

within a five year period for an entire intersection. This also made it possible to install zebra crosswalks for an entire intersection instead of singling out a specific crosswalk. In new or reconstructed locations, intersections that were considered potentially dangerous could receive zebra crosswalks. Each of these policy changes allowed the agency to act proactively.

The issue of competing pedestrian platoons within a given crosswalk width was also addressed. Crosswalks in New York City are defined by law as the extension of the sidewalk across the road. Generally, the width of this extension is from the building or fence line to the parallel curb, though there are some instances when this width is not sufficient to handle all of the pedestrians using a crosswalk, such as when two opposing platoons of pedestrians meet in the middle of the street.

When a signal turns green, pedestrians cross en masse and meet their counterparts in the middle of the street. With larger platoons of 7,000 per hour, the sheer quantity of people exceeds a standard crosswalk's capacity and people are forced to walk into traffic. This condition is exacerbated when vehicles block the crosswalk, a frequent occurrence.

Roughly two out of every three people hit by vehicles at signalized intersections in New York City are crossing

Opposing pedestrian platoons meet in the middle of a street. Volumes such as this represent 7000 pedestrians per hour.

with the light. If a pedestrian is crossing with the light, he or she may be struck when a vehicle is turning (most common), when a driver runs a red light (most deadly), or when he or she is walking in traffic because the crosswalk is too narrow.

Stop lines address each of these situations. They effectively widen the crosswalk without altering the legal definition of a crosswalk. Further, by removing the stop line from the crosswalk, it is free to be positioned independent of the crosswalk. It can be placed relative to the travel lane, aligned with a stop sign, street furniture or corner radius, or set further back to allow a larger truck turning radius. Essentially the design is now more adaptive to the situation, and stop lines are being used more often in the city at all types of crosswalks.

Stop lines solve many of the city's various crosswalk problems.

RESULTS

PEDESTRIAN SAFETY

To evaluate the impact of crosswalk striping on pedestrian safety, a very limited test was conducted at nine intersections in lower Manhattan. Each of these intersections qualified as a high crash location where the vehicle-pedestrian crash rate averaged 4.2 per year, yet none were marked with either ladder or zebra type crosswalks. The speed limit on the streets was 48 km/h (30 mi/h) and ADT and functional classification varied.

Four of the intersections received ladder crosswalks, while five received zebra crosswalks with stop lines. A year later crash data were compared.

Vehicle-pedestrian crashes decreased from 16 in the year before the ladder crosswalks were installed to 8 in the year after. Crashes at intersections that received zebra crosswalks decreased from 20 to 13 over the same study period. Before the ladder crosswalks were added, pedestrian incidents represented 11.6 percent of all crashes. This proportion shrunk to 7.2 percent after the crosswalks were added. At the zebra crosswalk locations, pedestrian crashes made up 7.5 percent of all crashes before, but only 5.3 percent after the markings were added.

The value of both ladder and high visibility markings in terms of absolute crash reduction is positive; the number of vehicle-pedestrian incidents at the nine test intersections fell from 36 to 21, a decrease of 42 percent.

VEHICLE STOPPING POINT

To evaluate the effectiveness of markings in keeping vehicles out of the crosswalk area, a limited survey was conducted at three intersections in lower Manhattan. Except for the marking type, all of the sites were similar in terms of direction, volume, lanes, and turning movements. The stopping locations of 72 total vehicles were noted.

The ladder crosswalk was the most effective marking for keeping vehicles out of the crosswalk area. While only 20 percent of vehicles at the unmarked crosswalk and 23 percent at the standard double line crosswalk stopped behind the crosswalk area, 59 percent of vehicles at the ladder crosswalk stopped at the appropriate location. Additionally, drivers did not seriously encroach upon the ladder crosswalk (7 percent) as much as the others (31 percent at the double line crosswalk and 60 percent at the unmarked crosswalk). A stop line would likely improve driver behavior further. The marked crosswalks also provided greater room for pedestrian platoons where it was needed the most, in crosswalks.

PROJECT COSTS

Typical thermoplatic costs (not including planning, design and installation):

• Double Line Crosswalk	$50
• Ladder Crosswalk	$250
• Zebra Crosswalk on two-way St.	$200
• Zebra Crosswalk on one-way St.	$250

The project was funded using federal Congestion Mitigation and Air Quality (CMAQ) funds programmed for Pedestrian Network Development.

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School Zone Traffic Calming

PROBLEM

Through its routine technical analysis of pedestrian safety around Portland's public schools, the City's Traffic Calming program proactively identified Sabin Elementary School as a high priority for intervention. In particular, safety issues existed at two arterial streets that were crossed by many of the children walking and bicycling to the school.

BACKGROUND

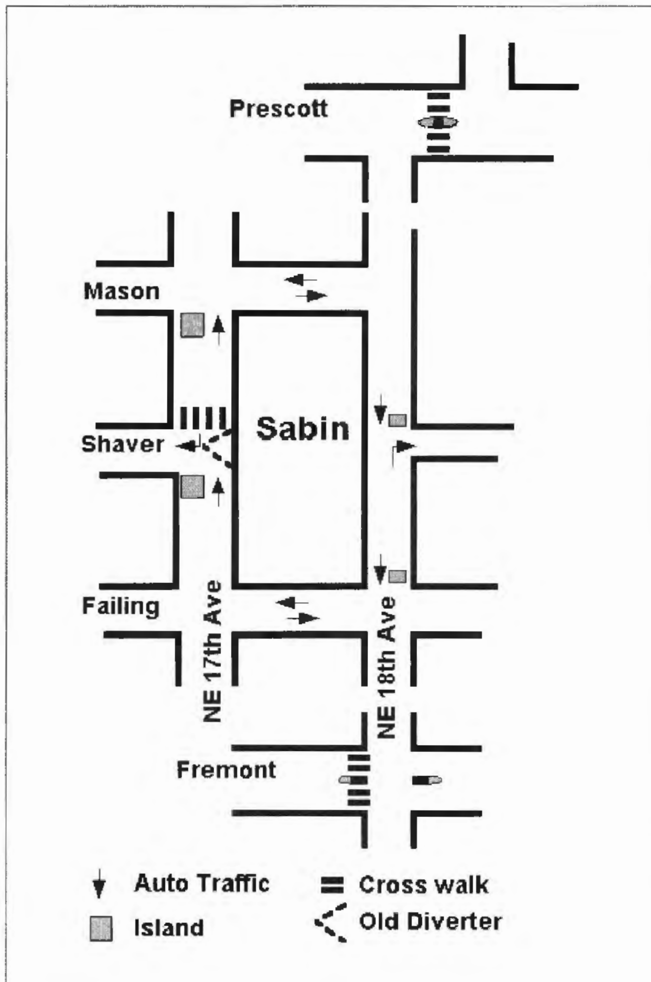
Over 500 children attend Sabin Elementary School. The school is located in an older, predominantly low- to middle-income neighborhood that is experiencing some revitalization. The neighborhood is generally well served by a traditional grid street pattern, with both north-south and east-west arterials well-spaced among the narrower residential streets in the grid. However, the school itself is not located on an arterial street.

In 1997, the Portland Traffic Calming Program (TCP) undertook a School Safety Project on the streets adjacent to Sabin Elementary School to improve student pedestrian safety. After initial discussions with the school staff, parents, and neighborhood residents, it became clear that those using the school everyday had identified additional traffic safety hazards that TCP assessment had not identified, including school-related bus and auto traffic congestion directly in front of the school and on its surrounding streets. Another concern was parking problems, such as the screening of kids crossing the street to/from school by parents parking in no-parking zones to drop-off, or pick-up, their own children.

Prepared by Scott Batson, City of Portland Office of Transportation.

SOLUTION

To start the planning process, City staff convened the Sabin School Safety Committee. The committee was made up of various stakeholders from the community, including the school principal, interested persons from the community, and representatives of the Sabin School PTA, Site Council, Local School Advisory Committee, Portland Police, Portland Fire Bureau, Sabin Community Association. The committee was particularly sensitive to the adverse effects of automobile congestion on pedestrian safety.



Working together, the TCP staff and committee established goals for the school safety project, which included the overall goals of minimizing traffic congestion and enhancing the safety of younger pedestrians associated with the elementary school. Additionally, the committee adopted the specific objectives of decreasing speeds on 17th and 18th Avenues, improving visibility at 17th and Shaver, and improving crossing safety at the nearest arterial streets of Prescott and Fremont.

To achieve these objectives the committee proposed several strategies:

- Semi-diverters would be installed on 17th and 18th to encourage a clockwise circulation pattern around the school. This would create predominant northbound traffic on 17th and southbound traffic on 18th in the two-block region between Mason and Failing Streets. The expected increase in speeding due to the clockwise circulation would be mitigated by including speed bumps on 17th and 18th, between Mason and Failing.
- Parking restrictions would be modified on the west side of 18th between Mason and Failing.
- An older semi-diverter at 17th and Shaver that obscured pedestrians crossing the street would be removed and a marked school crosswalk would be added at this location.
- A pedestrian refuge islands would be added at the school crosswalks on both Prescott and Fremont Streets near 18th Avenue.

Residents around Sabin Elementary were invited to an open house to review and comment on the proposed project. The open house was converted into a regular community forum for discussing the project and obtaining citizen input.

Concerns were expressed during neighborhood meetings that the modification of the traffic would force drivers to shift to adjacent streets, increasing the traffic volumes on these streets to unacceptable levels. Concerns were also articulated that the devices would not be effective in modifying the behavior of parents and guardians and the clockwise pattern might actually result in more speeding.

Test diverters were installed for three months before follow-up data were collected. In February 1998, advisory ballots were mailed to residents and non-resident property owners on the affected streets. To ensure that a sufficient number of the affected residents expressed their opinion regarding the construction of permanent structures, committee members circulated a second ballot. Out of 41 affected properties, 30 responses were obtained and 22 favored permanent construction.

Construction costs were paid for by the City of Portland using funds budgeted for neighborhood traffic calming. Total cost for the project was $54,000. A project breakdown follows:

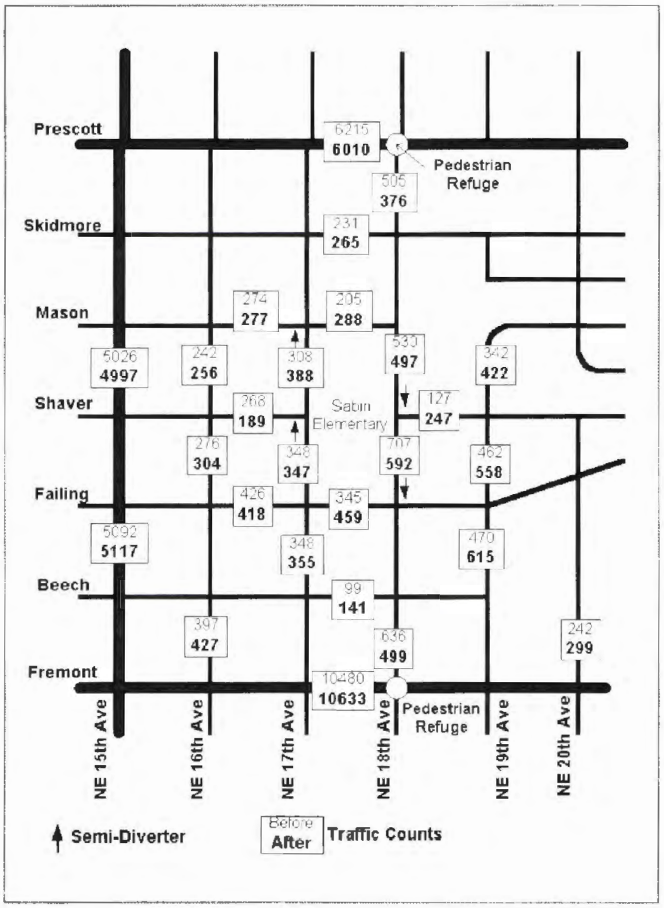
- Traffic Diverters and Circulation around the school, $25,000
- Improvements at 17th & Shaver, $5,000
- Fremont Crossing Improvement, $16,000
- Prescott Crossing Improvement, $ 8,000

RESULTS

Because traffic diverters were installed, traffic volume data was collected from several streets that are parallel to the streets around Sabin Elementary. This data collection provides a better picture of what effect diversion had on the general neighborhood.

The Sabin Elementary School Safety Project has succeeded in meeting its primary goals. Traffic flow around the school has been changed from a two-way pattern to a predominantly clock-wise pattern. The potential for two-way traffic conflict, where space exists for only one vehicle, has been significantly reduced. This change also allows pedestrians to cross only one direction of traffic at a time instead of trying to negotiate two separate flows.

As a result of testing the diverters, it was determined that speed did not increase as feared, so speed bumps were eliminated from the project. Vehicle speeds remain similar to pre-project measurements. On 17th Street, 85th percentile speeds changed from 42.6-44.3 km/h (26.5-27.5 mi/h) south of Shaver, and from 45-42



km/h (28-26 mi/h) north of Shaver. On 18th Street, 85th percentile speeds changed from 45–36.2 km/h (28 mi/h-22.5 mi/h) south of Shaver, and speed remained at 41 km/h (25.5 mi/h) north of Shaver.

Pedestrians also benefited from the removal of an older semi-diverter that obscured pedestrian visibility on 17th Avenue. The new diverter does not have the same intensity of landscaping that was the cause of the previous visibility problems.

Finally, median refuge islands were installed at two intersections on 18th Avenue to improve crossing safety on Prescott and Fremont Streets, the two major arterial streets surrounding the school. The primary benefit of median refuge islands is to allow pedestrians to concentrate on crossing one direction of traffic at a time. When a gap appears in the nearest lane, they can safely cross to the middle of the street, where they can shift their attention to traffic coming from the other direction. Refuges are also very helpful for the elderly, people with a variety of disabilities, or any pedestrian, because they help organize the crossing task into a simpler two-step process and provide some physical protection in the interim. This is especially important for elementary-aged children who are just learning to accurately judge the speed of oncoming vehicles, and are placed at serious risk when they are required to judge the speed of multiple vehicles from two directions and/or turning into the street at the intersection.

After implementation, the Sabin Elementary School principal discussed the project with several adjacent residents. They agreed that the new traffic pattern has reduced congestion and speeds at the opening and closing time of school. Parking has improved, and conflicts between buses and automobile traffic have been reduced. Overall, traffic calming at Sabin Elementary has enhanced street safety, livability, and pedestrian conditions.

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Third Street Promenade

PROBLEM

A pedestrian mall in downtown Santa Monica had become unsafe and lacked economic activity.

BACKGROUND

The Third Street Promenade was a commercial district made into a pedestrian mall in the 1960s. Over the years it had become neglected and had fallen into disrepair. By the early 1980s, competition emerged from a new regional shopping center nearby. Twenty years after it was created, the Third Street Mall, or "The Old Mall," as it was known, was unsafe, blighted, and considered an economic disaster. Efforts to restore economic health to the district and the greater "Bayside District" community surrounding it were badly needed.

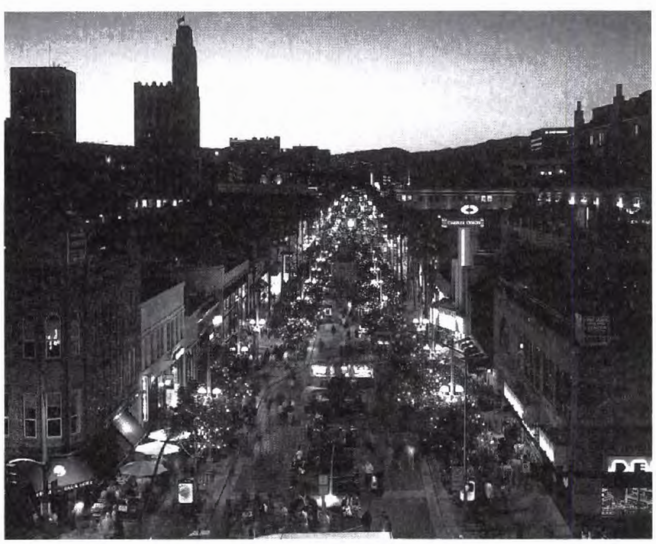

PHOTO BY ROBERT LANDAU

Third Street Promenade.

Prepared by Kathleen Rawson, Bayside District Corporation.

SOLUTION

The Third Street Promenade was developed in the late 1980's by the City of Santa Monica to revitalize the deteriorated downtown area and create a vibrant center for community life and retail activity. Financed through a citywide bond measure, the Third Street Development Corporation hired architectural firm Roma Design Group to plan the redesign the 25-year-old outdoor Santa Monica Mall. The renamed Third Street Promenade opened on September 16, 1989.

A three-block segment of Third Street was closed to vehicle traffic to enhance the pedestrian experience on the Promenade. Shop owners said that they initially felt that preventing cars from accessing their front doors was destroying their business. As a result, when the project was built, the City constructed a road through the Promenade, but placed removable bollards at the ends of each block. The bollards were put in place the first weekend to test it as a pedestrian mall, and the experiment was so successful that it was eventually closed for good. Now, Third Street competes with local shopping centers by providing a festive pedestrian space protected from auto traffic in the heart of downtown Santa Monica, which is a frequent destination for tourists visiting the Los Angeles area.

The Bayside District Corporation was created by the City of Santa Monica to ensure that the Promenade is maintained. On behalf of the City, Bayside promotes economic stability, growth and community life with the area through responsible planning, development, management and coordination of programs, projects and services. The nonprofit is funded through several assessments on businesses in the district. The City appoints the Board of Directors and the Board employs the staff. The Bayside District Corporation maintains the City's improvements, assists in the implementation of the design guidelines, and represents the entire Downtown Santa Monica area in marketing, promotions, special events, The majority of the project involved the creation of a set of design guidelines, which promote the preservation of historic buildings along Third Street, mandate a pedestrian scale to new development, and encourage the addition of pedestrian amenities by property owners. Some of these amenities include street trees,

New design guidelines mandate a pedestrian scale to new development and encourage pedestrian amenities.

benches, fountains, landscaping, decorative and functional lighting, lampposts, banners, textured pavement, street vendors, outdoor dining, and street performers. Street vendors and performers are regulated by the City and are licensed for business on the Promenade.

RESULTS

The District has more than surpassed the City's original objectives and has become one of the most successful award-winning downtown revitalization projects in the country. Not only has the Third Street Promenade been an economic boost to downtown businesses, its outstanding success has made Santa Monica a major Southern California destination. The Bayside District includes more than 70 restaurants, 17 movie screens in 4 cinemas, and more than 160 specialty shops, services, and entertainment venues open year round.

The District has become an award-winning downtown revitalization project.

Local residents and tourists from around the country come to Santa Monica to enjoy the pedestrian experience on the Promenade. Weekend crowds are often very dense with a swarm of pedestrian activity radiating from the Promenade to other downtown establishments, Palisades Park, and the Santa Monica Pier. Parking in various City lots surrounding the Third Street Promenade is plentiful but can be difficult to find during peak hours.

It is often said that nobody walks in Los Angeles, but at the Third Street Promenade in Santa Monica, pedestrian activity is everywhere. Don't be surprised to find a crowd, especially on a Friday or Saturday night, although practically any time of the day it is a popular place for both locals and tourists.

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Vermont Street Footbridge

PROBLEM

In 1979, the City of San Diego had to demolish the aging Vermont Street footbridge for safety reasons. Absent an immediate replacement, pedestrians were required to cross Washington Street, a high-speed commuter artery, at grade. This route was especially dangerous for many elderly residents and shoppers with small children. Additionally, local controversy emerged around issues of crime and neighborhood connectivity.

BACKGROUND

San Diego's grid street pattern in pre-war neighborhoods is frequently interrupted by what are known locally as "finger canyons," of steep, often wooded ravines. Wooden pedestrian bridges, built in the early 1900's by streetcar companies, knit these neighborhoods together and provided them with streetcar service to the rest of the city.

The Vermont Street footbridge had served the community for 60 years. Crossing over Washington Street, it linked a residential community, University Heights, with its closest commercial district, Hillcrest. Washington Street, classified as a Primary Arterial, had a posted speed limit of 65 km/h (40 mi/h), but actual speeds of 65-90 km/h (40-55 mi/h). ADT counts totaled 38,000. Adjacent land uses were highly urbanized and the roadway was depressed in a canyon with steep sides and had freeway-type access ramps located immediately under the old bridge. The at-grade route required a 0.25 mi (400 m) detour on each side of the road to reach a small commercial strip where an at-grade crossing existed.

Prepared by Andy Hamilton, WalkSanDiego, Kirk Whitaker, City of San Diego, and Stone/Paper/Scissors, San Diego, CA.

At the time the bridge was removed, the neighborhood debated whether to request the city to replace it. Some argued it provided easy access for criminal activity. The city proceeded, commissioning a design in 1982, but a lack of funding delayed the project. In 1990, the city launched a program to integrate public art into new infrastructure. Pro-bridge residents seized the opportunity to show their skeptical neighbors how a new bridge could be an artistic landmark for the neighborhood.

SOLUTION

The city agreed to make the bridge its first public art infrastructure project. However, the selected art consultant, Stone/Paper/Scissors, initially did not enjoy unanimous support. First, the opponents preferred to "hide" the bridge by keeping it plain and painting it green to match the eucalyptus groves at either end. Second, since the bridge had already been completely designed, the structural engineering consultant resisted changes that might weaken the structure.

To overcome these obstacles, the artists worked closely with the residents to select design themes. After gaining the residents support, the artists suggested that the bridge should stand out as a gateway to the community. Their concept won out, and a bold cobalt blue color was chosen. Positive themes of bipedal, historical, and transformative movement would be incorporated as quotes and artistic flourishes, sandblasted into the deck, and carved into the stainless steel panels on the railings. Gateway columns at either end would reflect the two neighborhoods, one modern, the other historic. The artists then worked at length with the engineering consultant to ensure these elements could be incorporated without compromising structural integrity.

The project cost of $1.2 million was funded through TransNet, a regional half-cent sales tax for transportation projects passed by the region's voters in 1988 (expires in 2008).

The new Vermont Street Pedestrian Bridge over Washington Street.

Anticipating the new bridge, a large Sears department store at the southern end of the bridge was redeveloped as Southern California's first New Urbanist development, known as the Uptown District. The project includes a mix of trendy shops, a major grocery store, small offices, and 310 dwelling units. All residential parking and 37 percent of the commercial parking is underground, leaving much of the surface for sidewalk cafes, plazas, and landscaping. Uptown's inviting pedestrian orientation and mix of uses became an instant draw for nearby residents.

Artistic details and the cobalt blue color add intrigue to the structure.

The Vermont Street Pedestrian Bridge gateway.

RESULTS

At the bridge's December 1994 unveiling, 450 people attended. A year later, the bridge received a coveted "Orchid" design award from the San Diego Council of Design Professionals. The Uptown District owes much of its success to the bridge and to the mix of pedestrian access and pleasant walking environment within the development a combination which resulted in a 10 percent lower vehicle trip generation rate and a correspondingly higher pedestrian mode-share than comparable shopping centers in the region. The grocery store is consistently in the top five in sales volume of its locations in California, although the footprint is only 75 percent of the chain's standard square-footage only generates 110 vehicle trips weekly per 93 m^2 (1000 ft^2) of store, as compared to the typical 120 vehicle trips per 93 m^2 (1000 ft^2).

Community support for the project is strong. The neighborhood sponsors bridge clean up and repair by providing both funding and volunteers. What began as a "replacement bridge" project has become a key part of the neighborhood's identity.

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Greenway Pedestrian Bridge

PROBLEM

A safer crossing was needed for school children to reach a school located near a new seven-lane parkway.

BACKGROUND

In the early 1990s, two elementary schools in Phoenix needed pedestrian bridges to accommodate students' daily commute to school. Near Mercury Mine Elementary School, Squaw Peak Parkway was under construction to replace a four-lane divided highway, which made an existing pedestrian bridge too narrow for the new roadway width.

At roughly the same time, Greenway Parkway was also under construction through an open field where students previously enjoyed direct access to Aire Libre Elementary School. After the Parkway was built, students had no safe way to cross the busy seven-lane arterial.

To address this situation, Aire Libre Elementary School hired two crossing guards to assist children across the street during peak school commute periods and the City established a 24 km/h (15 mi/h) school zone in the area; two measures that did not provide sufficient safety for those crossing the street. The crossing guards were in a difficult position of slowing and/or stopping vehicles that had been traveling 80 km/h (50 mi/h) or more. Many close calls occurred, and an opportunity to make improvements was presented with the removal of the pedestrian bridge at Mercury Mine Elementary School.

Prepared by Mike Cynecki and Ralph Goodall, City of Phoenix, Arizona.

SOLUTION

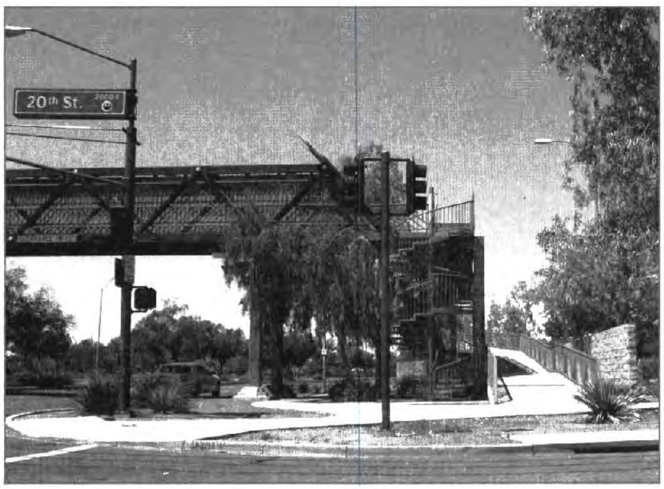
To address the problem at Aire Libre Elementary School, Phoenix Mayor Skip Rimsza, at the time a City Councilman, led efforts to begin what a local newspaper labeled as one of the world's largest recycling projects. The City opted to move the 14-year old, 65.3 Mg (72 T), steel-truss bridge from the Mercury Mine School to a new site over the Greenway Parkway near Aire Libre Elementary School 9.6 km (6.0 mi) away. The process involved closing a major road for two hours before dawn on June 21, 1992. The total cost of the bridge relocation project was only $12,000.

The Greenway Pedestrian Bridge at its new location near Aire Libre Elementary School.

New ramps, spiral staircases, and footings were designed to comply with ADA standards. The bridge was reconstructed, and minor artistic additions designed by a local artist improved aesthetic appeal and created the appearance as though the bridge had always been located there. The ramps cantilever over an adjacent drainage channel to make efficient use of the available space. Additionally, a block wall was built to mitigate concerns of the neighboring property owners about privacy and to reduce traffic noise of the Parkway.

RESULTS

The project is an excellent example of how cooperation between different public agencies and community members can produce creative solutions that improve quality of life while saving valuable public funds. According to the Aire Libre Elementary School's principal, over 60 students use the pedestrian bridge every school day. The "recycled" bridge is not only useful and visually pleasing, but cost approximately $500,000 less than building an entirely new bridge. The primary costs of the bridge relocation were the construction of the spiral staircase and ramp, aesthetic improvements to the structure, decorative walls, and extensive landscaping, which totaled $484,000.



New ramps, spiral staircases, and footings were constucted to comply with ADA standards.

Before the installation of the bridge, two crossing guards were stationed at the 20th Street intersection. Now only one crossing guard is stationed for the morning and afternoon school commute periods to ensure that students are crossing Greenway Parkway via the pedestrian bridge rather than crossing at the intersection. Several years after the bridge was placed, a traffic signal was installed at the intersection of Greenway Parkway and 20th Street, but pedestrian crossings at the signal are prohibited. Signs are posted alerting pedestrians to cross via the pedestrian bridge.

Because the Parkway was built roughly at the same time that the bridge was installed, no before and after accident or speed comparison data is available. However, safety appears to have been significantly improved, especially for the dozens of students crossing the busy Parkway every day.

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Pfluger Pedestrian-Bicycle Bridge

PROBLEM

An existing historic bridge had high traffic congestion and sidewalks too narrow to accommodate pedestrians safely. A pedestrian and bicycle access across the river was needed without affecting the historic character of the bridge.

BACKGROUND

One of the major bridge crossings in downtown Austin is the Lamar Bridge. This four-lane, art deco bridge constructed in 1941-1942 crosses a 210 m (700 ft) section of the Colorado River. Until 2001, the bridge provided an important link in the City's main hiking and cycling trail system, but it was not an ideal crossing. The bridge had high levels of automobile congestion, and both of its sidewalks were only 1.1 m (3.5 ft) wide. The nearest river crossing for pedestrians and bicyclists was over 1.61 km (1 mi) away in either direction. Pedestrians who used the bridge were forced to walk single-file, and bicyclists often dismounted for the crossing. Because pedestrians were so close to the heavy traffic, there were many near misses and occasionally automobiles scraped people's arms. Tragically, a bicyclist was killed in 1991 when struck from behind by a drunk driver and a pedestrian was killed in 2000 when a vehicle jumped the 0.31 m (1 ft) curb.

The local community initially wanted to expand the bridge and provide cantilevered pathways for pedestrians and bicyclists at the sides of the bridge. However, the bridge had been designated as a historic site by the Texas Historical Commission in 1994; therefore, the existing bridge structure could not be modified.

Prepared by Robert J. Schneider, Sprinkle Consulting, Inc. (SCI).
Information provided by Kalpana Sutaria, City of Austin.

The sidewalk on the congested Lamar Bridge was only 1.1 m (3.5 ft) wide. Photo provided by the City of Austin.

SOLUTION

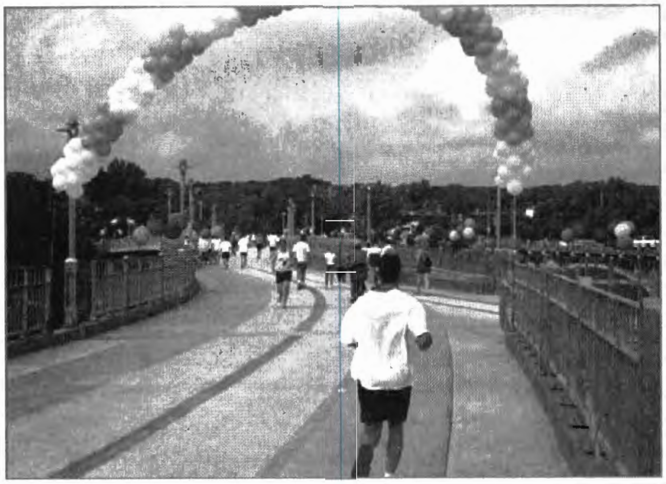
In 1998, the City of Austin held public and design workshops to generate ideas for a new pedestrian and bicycle bridge to be constructed about 61 m (200 ft) east of the Lamar Bridge. After the workshops were held, four design options were presented to the City Council, and the final design was chosen. Construction began in May 2000 and the Pfluger Pedestrian/Bicycle Bridge was completed in June 2001.

The bridge is accessible to all pedestrians, and is wide enough to serve a large number of pedestrian and bicycle commuters as well as recreational trips. Observation decks and benches were included in the design so that the bridge itself is an enjoyable destination for pedestrians and bicyclists.

RESULTS

Pfluger Pedestrian/Bicycle Bridge has been extremely successful. The bridge design and construction won awards from the American Council of Engineering Companies, the Texas Council of Engineering Companies, and the Austin Chapter of American General

PHOTO BY CITY OF AUSTIN



The Pfluger Pedestrian/Bicycle Bridge allows pedestrians and bicyclists to avoid crossing Lamar Bridge. After opening, it was used by 4000 to 5000 people per day, numbers which continue to rise.

Contractors. The total construction cost of the bridge was about $7 million, with $1 million provided by federal Intermodal Surface Transportation Efficiency Act (ISTEA) funds and $6 million paid by the City of Austin's Capital Improvement Program.

Some people have complained that the bridge came at an extremely high cost, providing accommodations for pedestrians and bicyclists while doing little to relieve automobile congestion on Lamar Bridge.

Pedestrians and bicyclists use Pfluger Pedestrian/ Bicycle Bridge for commuting and recreation and also enjoy it as a destination. Photo provided by the City of Austin.

Yet, most of the public reaction to the bridge has been very positive. The City has received many calls and e-mails from citizens saying how much they enjoy the bridge. People who had stopped using the river crossing portion of the City's hiking and cycling trail system because it was so dangerous are now using it again.

One of the most notable impacts of the bridge has been the increase in the number of pedestrians and bicyclists who cross the river. Approximately 700 to 1000 pedestrians and bicyclists crossed the Lamar Street Bridge each day before the Pfluger Pedestrian/Bicycle Bridge was built. Counts taken after the pedestrian/bicycle bridge was opened found that it was used by 4000 to 5000 pedestrians and bicyclists each day, and this number continues to rise. The dramatic increase in river crossings is the most obvious benefit of a bridge constructed to be both safe and enjoyable for bicyclists and pedestrians.

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Grade-Separated Trail Crossing

PROBLEM

An at-grade crossing of a busy arterial road exposed users on one of the most heavily used recreational trails in West Virginia to potentially dangerous motor vehicle traffic.

BACKGROUND

Residents, visitors, and students from Marshall University enjoy the mature shade trees and beautiful views of nearby hills from the flatlands of Ritter Park on the southern edge of Huntington, West Virginia. One of the most popular attractions of the park is a pathway that circles the lower portion of the flatlands along Four Pole Creek. In its application for a Recreational Trails Program grant, the Greater Huntington Park and Recreation District stated, "The pathway circling Ritter Park and extending westward to Harveytown Road constitutes 4.8 km (3.0 mi) of argumentatively the most heavily used walking/jogging trail in West Virginia."

However, the trail crossed Eighth Street, the main traffic artery leading south of Huntington to the city's hilltop residential neighborhood and the Huntington Museum of Art. When the Greater Huntington Park and Recreation District was confronted with the issue of pedestrian and vehicle conflicts at this crossing, creative solutions were needed.

SOLUTION

Challenges facing this approach included mitigating the potential flooding of Four Pole Creek and providing long approach ramps to keep the angle of descent reasonable for disabled individuals. Brast Thomas, design engineer for this project, supplied a creative solution to both the flooding problem and access challenge by designing the trail structure to rest on the bridge's arched concrete supports. This allowed the pathway underpass to be at an elevation only inches below the 100-year flood height.

The pedestrian trail bridge utilizes the space beneath the Eighth Street roadway bridge at Four Pole Creek.

Work began in September 1999 and was financed by a Recreational Trails Program grant totaling $24,360 from the West Virginia Division of Highways with $12,180 from federal grant funds, and $12,180 provided

Prepared by William Robinson, West Virginia Department of Transportation.

by a local sponsor match. A work crew from the local park district, under the supervision of Thomas Company and Ankrom Associates (now Environmental Design Group, Inc.), constructed the trail structure.

From an engineering standpoint, no unusual methods or materials were employed, but the economy of design was evidenced in linking the two structures.

To resolve the safety issue presented by trail users crossing Eighth Street at-grade, James McClelland, Director/Secretary of the Greater Huntington Park and Recreation District and a regular jogger on the pathway, suggested building a bridge to take the pedestrian traffic under Eighth Street, using the space beneath the Eighth Street roadway bridge at Four Pole Creek.

The extensive use of wood made the structure strong, practical, inexpensive, and aesthetically pleasing.

RESULTS

Public response to the new bridge has been very positive. The trail itself enjoys strong public support as a grass roots project originally born from the efforts of local trail users and advocates.

The design was severely tested when, just weeks after completion, floodwaters assaulted the new structure. Even though the flood nearly reached one hundred-year levels, washing and clearing a small amount of flood debris was all that was required to return the bridge to service, and interference with stream flow was minimal.

When the people of Huntington come to Ritter Park to see the rose garden, the stone bridge, and the artist-designed playground, they also discover a new secret—the Pedestrian Bridge beneath Eighth Street over Four Pole Creek.

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State Street Pedestrian Mall

PROBLEM

Many cities in the United States have attempted to create pedestrian malls, but few have been successful.

BACKGROUND

Throughout Europe, pedestrian streets and malls are a relatively common feature. Cities as diverse as Trondheim, Norway; Florence, Italy; and Graz, Austria have pedestrian zones that act as central features of the community. In the United States, numerous communities have attempted to create similar environments, but with much less success. Many cities have recently removed pedestrian and transit malls in favor of conventional street designs for motorized traffic. Ithaca, New York; Boulder, Colorado; Burlington, Vermont; and Madison, Wisconsin are among the few places that have successfully managed their downtown pedestrian malls. This case study looks at Madison, Wisconsin's pedestrian mall, in place since the 1970s, which continues to enhance the area as a vital part of the city.

SOLUTION

State Street is eight blocks long, connecting the University of Wisconsin Campus with the State Capitol. It is Madison's "Main Street" in terms of downtown shopping and, increasingly, dining and entertainment. In the early to mid-1970s, State Street and the Capitol Concourse (the streets around the perimeter of the Capitol) were converted to a transit mall in the 100-600 blocks, and a pedestrian mall in the 700 and 800 blocks near the University of Wisconsin campus.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Arthur Ross, Pedestrian/Bicycle Program Manager, Madison WI.

PHOTO FROM STATE STREET STRATEGIC PLAN, 1999, PREPARED BY JJR, INC.

The 100–600 blocks of State Street are closed to vehicle traffic, with the exception of buses, bicycles, and authorized vehicles. At the end of the street is the State Capitol.

The State Street right-of-way is 20 m (66 ft) wide from building face to building face. In the 100 - 600 blocks, the street is 7.3 m (24 ft) wide and centered in this right-of-way with 6.4 m (21 ft) of sidewalk on each side. Half of each sidewalk in this area is the pedestrian zone, and the other half has been designed to have pedestrian amenities, such as street furniture, sidewalk cafes, public art, bus shelters, light poles, and trees. The 100 - 600 blocks are not completely closed to vehicles, but vehicular use of the street in this area is restricted to buses, bicycles, and authorized vehicles. Authorized vehicles include delivery vehicles, taxis, and vehicles of contractors and business owners. These vehicles are closely regulated to minimize the impact on the pedestrian environment of the street.

The 700 and 800 blocks of State Street near the University of Wisconsin campus are a pedestrian mall. Bicycles in these blocks are to be walked, and bike park-

PHOTO FROM STATE STREET STRATEGIC PLAN, 1999, PREPARED BY JJR, INC.

The 700 and 800 blocks of State Street are a pedestrian mall. At the end of the street is the University of Wisconsin campus.

ing is only permitted at bike racks. The 700 block is typically full of food and crafts vendors.

The restaurant, entertainment, and shopping establishments on State Street are supported by activities taking place nearby. Free concerts are given one night each week during the summer on the Capitol lawn, a farmer's market is open around the Capitol Square every Saturday morning, and other weekend events are often combined with the farmer's market on Saturdays or Sundays. Portions of State Street are often closed completely for these special weekend shopping or entertainment events. This allows pedestrian traffic, vendors, and others to use the entire right-of-way for the activity.

PHOTO FROM STATE STREET STRATEGIC PLAN, 1999, PREPARED BY JJR, INC.

The State Street sidewalk provides a pedestrian zone and a zone for sidewalk cafes, bus shelters, trees, and other pedestrian amenities.

RESULTS

As has been the experience of most U.S. pedestrian streets, there have been attempts to re-open State Street to general car traffic, get rid of the buses, and add on-street parking. Yet, State Street continues to be successful. Ground floor occupancy rates are consistently near 100 percent, and lunchtime restaurant business has been excellent. The success of the street has provided continued support to keep pedestrians, bicycles, and buses as the primary means of mobility on State Street.

When the City's current plan to improve State Street was drafted, it indicated that the character of State Street should remain much as it is, but with fewer bus shelters, more flexible street furniture, a cleaner look, and new trees. The plan was reviewed by 12 City boards, commissions, committees, and local neighborhood and business associations. This plan was unanimously approved on April 9, 2002, and calls for funding from City, Federal, State, private, University, Business Improvement District, and foundation sources.

State Street's success is due in part to supportive land use in the surrounding areas. The University of Wisconsin Campus on the west end and the Capitol Square (a major employment center) and Capitol Building on the east end act as anchors on both ends of the street. The distance between these two anchors is less than 1.6 km (1 mi), so the entire length is a comfortable walking distance.

State Street is a unique public space that attracts both residents and tourists, and its pedestrian-friendly orientation is an essential component of its success. The pedestrian-only environment in close proximity to the University and downtown residential neighborhoods creates a place where people can enjoy an evening out without worrying about drinking and driving. In addition, holding special events on State Street and in the surrounding areas helps maintain the street's reputation as one of the cultural centers of Madison.

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REFERENCES

Madison's State Street 2000 website: http://www.ci.madison.wi.us/statestreet/statestreet.htm

State Street Strategic Plan, 1999: http://www.ci.madison.wi.us/planning/statest.pdf

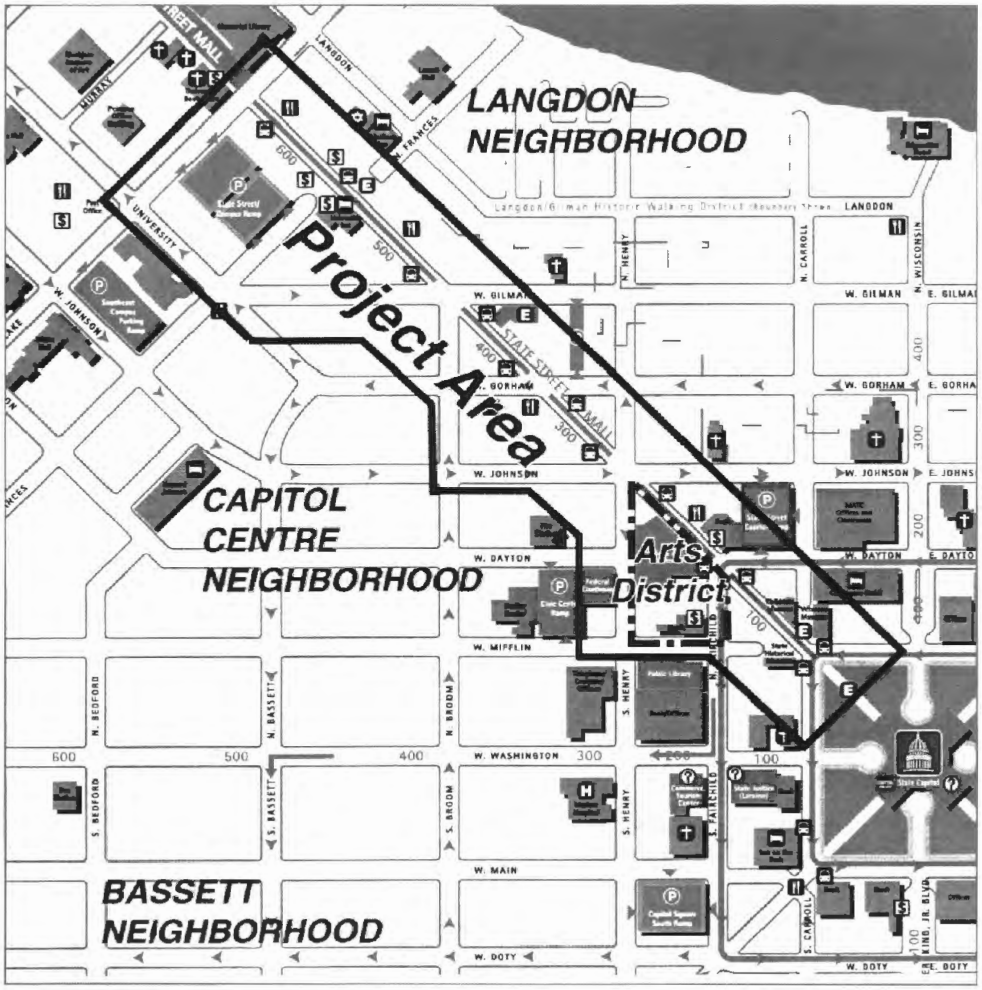


PHOTO FROM THE STATE STREET 2000 WEB SITE

This Plan of the State Street reconstruction project shows how the street runs between the State Capitol (lower right) and the University of Wisconsin Campus (upper left).

PHOTO BY FROM THE CITY OF MADISON WEB SITE

State Street looking towards the State Capitol.

Elm Street Traffic Calming

PROBLEM

Pedestrian safety and comfort suffer when a neighborhood street designated as a collector must carry significant bicycle, pedestrian, and motor vehicle traffic as a continuation of an arterial road, gateway to a major university, and access route for a luxury hotel.

BACKGROUND

As an extension of Pima Street, a heavily traveled collector in the city of Tucson, Elm Street was designated a collector road. Although much of the traffic on Pima Street had diverted before it becomes Elm Street, average daily traffic (ADT) for Elm still totaled 8,000 vehicles. The street also carried heavy and constant bicycle and pedestrian traffic.

At the far end of Elm Street was an entrance to the University of Arizona campus. The street was located in a high-end residential neighborhood also home to the Arizona Inn, one of the City's most exclusive hotels. The property owners along Elm Street were concerned with speeding traffic on the street and battled over how to reduce speeds. The posted speed limit was 40 km/h (25 mi/h), and because of the street's designation as a collector, speed humps were not allowed. A traffic light was installed at the Pima intersection, but travel volumes increased as even more drivers began using the street as an alternative entrance to the University. Some property owners wanted to close its far end and eliminate the street as a route for through traffic; however, surrounding neighborhoods were concerned that the diverted traffic would merely shift onto their streets. Forced turn devices were installed, but emergency service vehicles had difficulty getting onto the street.

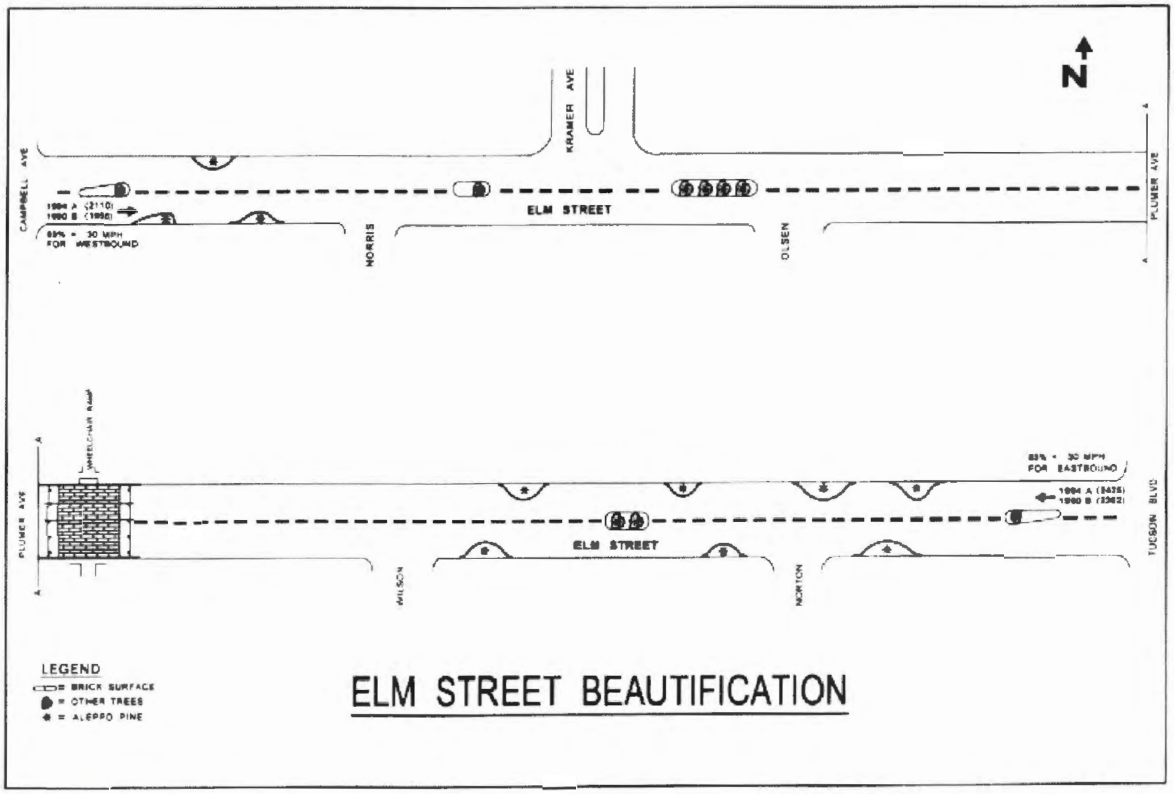
Prepared by Laurie Actman, Patrick McMahon, Henry Renski, University of North Carolina Highway Safety Research Center, and Vincent Catalano, City of Tucson.

SOLUTION

After 20 years of controversy, the property owners on Elm Street petitioned to initiate the Neighborhood Traffic Management Program for their street. The program allows a majority of residents in a neighborhood to designate a Neighborhood Improvement District and charge a special assessment upon property owners in the district to fund improvements or other projects. Upon City approval of the request, a neighborhood traffic program was instituted for Elm Street. The residential Traffic Advisory Committee then hired a local architect to design a traffic mitigation plan.

The Traffic Advisory Committee worked with the property owners, surrounding neighborhood associations, the University of Arizona, the bicycle advisory committee, and the City of Tucson. All agencies and committees approved the final plan. Data was collected

The slight slope and contrasting brick design of the raised crosswalk indicates the designated space for pedestrian crossing to approaching motorists.



Drawing of the approved plan for Elm Street's traffic calming and beautification.

in 1990 prior to construction and after construction in 1994. Speed data was also collected from counters set after construction.

The design's goal was to use beautification along with direct engineering measures to reduce the speed of traffic without diverting it into adjacent neighborhoods. The approved plan consisted of several small chicanes on both sides of the street, several tree-lined medians, and a raised crosswalk. Parking is allowed on both sides of the street. The chicanes extend slightly further than the side street parking to provide greater visibility for pedestrians wishing to cross the street and to change drivers' perceived speed of the street by fracturing its straightness. The medians were added mainly to further fracture the perceived speed of the street rather than to act as pedestrian refuge islands.

Tree-lined medians and small chicanes reduce drivers' perceived speeds on Elm Street.

Trees were planted along the street and in the chicanes to create a canopy for the street. The tree canopy provides shade for parked cars, pedestrians, and bicyclists while enhancing the appearance of the street and keeping speeds down. The raised crosswalk is slightly sloped and at grade with the sidewalk causing many drivers to slow while approaching the crosswalk. The brick design adds to the streetscape and provides contrast against the pavement, indicating to drivers the designated space for pedestrian crossings. At night, the crossing is illuminated by reflectors. The neighborhood refused to install the usual pedestrian crossing signage, stating that it would detract from the landscape and scenery of the street.

RESULTS

The traffic volume after construction has increased only a small percentage since 1990. The 85th percentile speed is 48 km/h (30 mi/h), which is desirable for this type of street. No before speeds or volumes were recorded, but speed reductions have been noticeable. Although no reduction in volume has been noticed, traffic volumes have not increased at pace with the rest of the city, and surrounding neighborhoods have not experienced any increase in traffic.

After 20 years of dispute, the Elm Street controversy ended with the construction of a beautiful and effective project. To pay for projects of this nature, which are over and above what the city can provide as routine traffic calming and streetscape enhancement, Tucson establishes local Improvement Districts (IDs). The $120,000 cost for the project was bonded over ten years, and is funded by the property taxes of local property owners. Because the luxury hotel owns the largest property in this ID, it funded 40 percent of the overall costs.

According to Vincent Catalano of the Tucson Traffic Engineering Department, pedestrians crossing between a nearby hotel and parking lot have reported feeling safer and more comfortable when using the raised crosswalk. With an improved pedestrian environment, walking continues to be a popular activity in the neighborhood.

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Leland Street Redesign

PROBLEM

High vehicle speeds posed a safety hazard for local residents and pedestrians on an arterial roadway located in a densely settled inner-ring suburb populated primarily by single family homes with driveways.

BACKGROUND

Leland Street is an arterial roadway with closely concentrated residential frontage less than .81 km (0.5 mi) from the Bethesda Metro Station outside of Washington, DC. Leland Street serves as a backdoor to Bethesda, an access route between Woodmont Avenue and Bradley Boulevard, two busy commercial streets. While ADT is not high on Leland Street (approximately 1200-2000), prior to its redesign in 1999, the street had experienced problems with excessive motor vehicle speeds. Although the posted speed limit is 40 km/h (25 mi/h), vehicles frequently traveled down the street in excess of 56 km/h (35 mi/h). Residents often experienced difficulty backing cars out of their driveways and walking across the street. Pedestrians traveling along both Woodmont Avenue and Bradley Boulevard to access the transit station and downtown Bethesda, faced a dangerous crossing at the Leland Street intersections.

When a new eight-story apartment building was proposed on nearby Woodmont Avenue the potential increase in traffic along Leland Street gave neighborhood residents an opportunity to raise their concerns about pedestrian and traffic safety. A series of meetings allowed residents, the developer, the Maryland-National Capital Park and Planning Commission, and the Montgomery County Department of Public Works and Transportation to begin working together to reduce traffic speeds and improve the safety of the street.

Prepared by Robert J. Schneider, Sprinkle Consulting, Inc. (SCI).
Information provided by David A. Loughery, Montgomery County, MD Public Works and Transportation.

SOLUTION

Residents initially requested speed humps, but Montgomery County policy prohibits humps on arterials. This obstacle led designers to a more creative solution. Five center traffic islands, two serving as gateways at Woodmont Avenue and Bradley Boulevard, and six curb extensions were constructed to create a serpentine traffic flow along the street. At the intersection of Leland Street and Woodmont Avenue, the curb radius was reduced from 15 m (50 ft) to 9 m (30 ft) to slow vehicles making right turns from Woodmont Avenue onto Leland Street. This also shortened the crosswalk distance at the Leland Street intersection for pedestrians walking along Woodmont Avenue. The curb radius reduction was complemented by the center island gateway to Leland Street, ensuring that right-turning vehicles did not swing wide to make a faster turn into the street.

According to David Loughery of Montgomery County Department of Public Works and Transportation, the

Gateway island at intersection.

Chicane with median island creating serpentine design.

county's primary strategy was to reduce turning speeds onto Leland and reinforce slower speeds with a serpentine traffic flow: "If you can get vehicles to enter the street slowly, safe speeds can be maintained along the street."

The project, which cost around $40,000, would not have been possible without the help of several different groups. Residents talked to the developer who agreed to fund construction of the improvements and landscaping. The Montgomery County Department of Permitting Services created the design and pulled the major players together to streamline the implementation process. The County provided a contractor to reconstruct the street and retained turning restrictions during peak hours. The residents arranged for delivery of the landscape plantings and materials for the islands, planted them, and continue to maintain the plants and shrubbery.

RESULTS

The redesigned street resulted in slower speeds and safer conditions for pedestrians walking along the street and crossing at the intersections of Leland Street with Woodmont Avenue and Bradley Boulevard. Before and after traffic speed studies showed that the highest speed was lowered from 71 to 61 km/h (44 to 38 mi/h), 85th percentile speed was reduced from 52 to 44 km/h (32 to 27 mi/h), and mean speed dropped from 48 to 38 km/h (30 to 24 mi/h). Because traffic volume was not determined to be a critical element in the safety evaluation and decision process, full before and after ADT counts were not generated for the project. Two one-day, peak-hour counts were taken to confirm the low volumes.

Prior to the project, approximately 60 households, or over two-thirds of the neighborhood, signed a petition in support of the design. Opponents of the design were concerned about loss of parking and obstructing emergency vehicles, but only one resident complained openly about the project after it was completed. Constant feedback from the neighborhood during the design process resulted in a design that is supported by residents and will not require expensive retrofitting.

Keys to the success of this project were good street design and community partnership. The design used a combination of traffic calming measures to slow traffic at the entry points. The partnership included residents, a developer, and two public agencies working together in every phase from planning to design and throughout construction. In the end, traffic speeds were reduced to levels more appropriate for a residential community, safety was enhanced for motorists and pedestrians, and the streetscape was improved with no negative impacts on traffic operations.

Curb extension.

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NAPLES, FLORIDA | CASE STUDY NO. 47

7th Avenue Traffic Calming

PROBLEM

Cut-through traffic and speeding was a problem in this coastal residential community.

BACKGROUND

Naples is a relatively affluent coastal residential community that stretches 11.3 km (7 mi) along the beach in Florida; however it is only 1.6 km (1 mi) wide. Seventh Avenue is an east-west residential street that historically had problems with high traffic volumes and speeding. Beach-bound east-west auto travelers often cut through residential neighborhoods at excessive speeds. Before the improvements, 7th Avenue had approximately 8,000 vehicles per day, with average speeds of approximately 53 km/h (33 mi/h).

SOLUTION

In response, Naples completed numerous traffic calming projects in order to slow down speeds and improve the aesthetic appearance of the community. The City's approach to traffic calming was a response to the demands of residents in the affected neighborhoods. The residents were required to circulate petitions and hold public hearings to initiate the process.

After the neighborhood residents had decided that action must be taken, they approached the City for assistance. The City conducted a study of the traffic conditions of the street and presented the information to the residents along with potential alternative traffic solutions. The City also determined that the traffic calming treatments would not only slow down through

Median island and intersection roundabouts were installed on 7th Avenue.

traffic, but residential traffic as well. After presenting the neighborhood residents with information and alternatives, the neighborhood chose what types of improvements would be installed.

A number of different treatments were implemented along 7th Avenue. Three medians were added to narrow the 1.6 km (1.0 mi) street and reduced its perceived design speed. A median was added at the street's

Intersection roundabouts slow traffic on 7th Avenue.

Information provided and contributions made by Dick Gatti, City of Naples, Florida.

entrance along with brick pavers to narrow the street and indicate to drivers that they were entering a residential neighborhood. Some intersection roundabouts were installed along the street. Another intersection was raised 0.9 m (3 ft) into a speed table and was enhanced by brick paving. Intensive landscaping was also added to make the street appear narrower and more aesthetically pleasing.

RESULTS

After the implementation of the improvements, the area experienced an initial drop in traffic volume although volumes were soon back to pre-improvement levels. However, traffic speeds dropped significantly by 18 km/h (11 mi/h) to an average of 35 km/h (22 mi/h). Despite the drop in average vehicle speeds, the community's reaction was mixed about the traffic calming treatments. The neighborhoods were very pleased with them, but motorists, particularly those driving service vehicles destined for the many expensive residences that are located in the area, found the improvements burdensome.

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Main Street Roundabout

PROBLEM

An intersection in Montpelier, Vermont had a confusing traffic pattern and lacked a pedestrian crosswalk for one of the streets. A group advocating the benefits of roundabout design asked the City to do a roundabout demonstration project.

BACKGROUND

In the early 1990s, the Montpelier City Council was approached by a locally stationed state transportation planner and some local residents who wished to find a location to do a roundabout demonstration project. In response to this request, the City Council organized a roundabout steering committee to determine a location to test this intervention.

The group initially considered a signalized intersection under construction for the roundabout, but a demonstration project using lumber and pavement markings revealed numerous geometric and utility relocation issues at the site. The roundabout steering committee had to consider other intersections.

The unsignalized intersection of Main and Spring Streets was another option because it was on the construction consideration list, but it was a low priority. The vehicle flow at the intersection functioned within reasonable levels, but the intersection did have a confusing traffic pattern and the pedestrian accommodations were very poor. No crosswalk was provided for pedestrians to cross Spring Street. The committee selected this location for the demonstration project and successfully lobbied the City Council for funds based on their own cost estimate.

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center, and Thomas J. McArdle, Montpelier, VT Department of Public Works.

SOLUTION

After working with the roundabout steering committee, a roundabout was installed in August of 1995 and paid for entirely by local funding. It consisted of a single roundabout with a radius ranging from 16.1 m to 16.5 m (52.7 ft to 54.2 ft), three single lane approaches, a commercial driveway, and a single circulating lane. The roundabout has a wide asphalt apron to accommodate the roughly 40 heavy trucks passing through the intersection on weekdays, a landscaped center with a tree, and a granite curb. Splitter/deflector islands on the branches are intended to force vehicular traffic to enter the roundabout using only right turns. The approaches were designed to slow vehicular traffic to yield to pedestrians in the crosswalks. The crosswalks are painted 6.1 m (20 ft) back from the yield line and cross through the splitter islands at all three approaches.

RESULTS

Construction of the roundabout, originally estimated by the roundabout steering committee to cost $62,000, had a final cost totaling $160,000. The committee's original estimate was low because drainage systems had to be relocated and the City had to purchase property to fit the circular roundabout where the "T" intersection was located. Some residents did not like the roundabout because of its cost and the fact that it was a "project looking for a place to happen." Further, some truck drivers avoid it because of its restrictive approaches and its abrupt edges of granite curb, and some elderly drivers have complained because they are intimidated by the yield rules.

Overall, the roundabout improved conditions for both pedestrians and vehicles at the intersection of Main Street and Spring Street.

Yet, the overall reaction to the roundabout has been positive. In a follow-up survey conducted one year after the project's completion, 85 percent of the respondents had a favorable or neutral opinion of the roundabout. Unfortunately some automobile tires were damaged when drivers cut too close to the granite edge of the roundabout or passed through at speeds higher than intended. After completion of the project, citizens suggested installing signs that require lower speeds within the roundabout and providing more effective landscaping to the apron to clarify the roundabout's size.

In many ways, the roundabout is working better for vehicular traffic than a signalized intersection. All three approaches to the intersection have a posted speed limit of 40 km/h (25 mi/h), and actual speeds may be even slower because of the approach and departure geometry of the roundabout. While most area drivers still use the same routes (the average daily traffic levels continue to be about 5,000 on Main Street south of the roundabout, 2,500 on Main Street north of the roundabout, and 6,000 on Spring Street), the median peak hour delay reduced from 11.6 s to 2.2 s and average peak hour delay dropped from 6.3 s to 2.7 s at the intersection. Also, the roundabout was one of the only design alternatives for the intersection that could accommodate a commercial driveway without creating inconvenient turning restrictions. A number of vehicles have been observed making "U-turns" around the roundabout and obeying the no U-turn sign on Main Street itself. Additionally, an adjacent street, Elm, was temporarily closed due to a rockslide and the roundabout effectively absorbed this traffic, proving its effectiveness at higher volumes.

The benefits of the roundabout have also extended to pedestrians, especially students and staff who walk to Main Street Middle School. The school, with roughly 340 students and 50 staff members, is located down the street from the roundabout. While the "T" intersection created conflicts between fast-moving vehicles and pedestrians using the intersection to go to school, the roundabout improved safety for the students and staff because vehicles were slowed within the roundabout and entered Main Street at slower speeds. In addition, the pedestrians used the new marked crosswalks to cross the approaches to the roundabout.

According to Assistant Principal Tom Lever, the pedestrian crossings at the roundabout are significantly safer for his students. Because the roundabout is built to prevent drivers from speeding through the intersection, they are better prepared to yield at the pedestrian crossing. He also estimated that this intersection, previously avoided by most pedestrians, now has 30 to 50 students walking through the roundabout in the morning and roughly 150 walking through in the afternoon.

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School Zone Roundabout

PROBLEM

A highway near a school complex contributed to high vehicle speeds and the proposed solution of adding two modern roundabouts was met with public skepticism.

BACKGROUND

Prior to 1999, BayView Middle School and Forest Glen Elementary School in the Green Bay suburb of Howard, WI were bounded to the south by a county highway that carried vehicles at very high speeds. Since the county highway runs directly in front of the middle school and very close to the elementary school, a 24 km/h (15 mi/h) school zone had been in place for several years. However, the regular posted speed limit was 72 km/h (45 mi/h), and many motorists traveled closer to this speed when children were present and well above it when children were not. For this and other reasons, the county sheriff's department designated the highway as a hazardous area to force the school district to bus kids across the road. To make a bad situation worse, the high school that was to be built on the campus in 2000 was expected to add hundreds of inexperienced drivers to the hazardous highway's growing daily traffic load, so the county needed to act quickly.

The county could have simply accommodated the new traffic by expanding the highway to four lanes, constructing turning lanes and signals at the intersections, and adding several other features that would maintain the high vehicle speeds and virtually guarantee that children would never walk or bike to the schools. But the Brown County Planning Commission instead recommended a solution that would slow traffic and make the highway safe and accessible for pedestrians and bicyclists of all ages. The solution was to install a narrow street and two modern roundabouts.

Prepared by Cole Runge, Principal Planner/MPO Director, Brown County Planning Commission.

SOLUTION

In 1998 and 1999, the county planning commission worked with the county highway department and two communities to plan, design, and build Wisconsin's first modern roundabouts at the east and west ends of the school campus. The roundabouts were believed to be the best method to slow drivers in the school zone and enable children to reach the schools safely on foot or by bicycle.

An approach to one of the modern roundabouts near the Howard school campus.

Even when supported by enforcement, the mere identification of a school zone does not guarantee that motorists will travel at or below 24 km/h (15 mi/h) because people tend to drive at speeds that feel comfortable to them. The best method of ensuring that drivers will travel at a lower speed is to design streets that discourage higher speeds and make them feel comfortable when traveling slower. This goal was accomplished by retaining the highway's two lanes, adding bicycle lanes and sidewalks, and constructing two roundabouts to force drivers to travel at low speeds when approaching and traveling through the campus intersections. In addition to lowering vehicle speeds, roundabouts make intersections safer for pedestrians of all ages by minimizing conflicts, eliminating crashes caused by drivers disregarding red lights and stop signs, and minimizing pedestrian exposure to traffic by enabling people to cross narrow travel lanes that are separated by a median refuge at each approach.

RESULTS

During the year between the planning commission's recommendation for the roundabouts and the project's completion in the fall of 1999, people protested this locally untested device. Despite years of success throughout the world, some residents were convinced that the roundabouts—often confused with much larger traffic circles—would create traffic congestion, cause severe crashes, and lead to the injury or death of the children they were designed to protect. But this resistance began to disappear as they were being built and people had the chance to see that the roundabouts were much smaller, efficient, and more attractive than they had thought.

Three months after the project was completed, the planning commission found that congestion did not exist at the intersections even though the vast majority of vehicles approaching the roundabouts were traveling at or below 32 km/h (20 mi/h) before reaching the crosswalks throughout the entire day. Increased traffic volume was also accommodated effectively. At one of the roundabout locations, the number of vehicles entering the intersection increased from 5,600 per day in 1998 before the roundabout construction to 10,800 per day in 2001.

Reportable crashes and injuries also decreased significantly when the roundabout was constructed. Between 1996 and 1998, the intersection averaged three crashes and five injures per year as a two-way stop. Although the number of entering vehicles increased significantly after the high school opened in August 2000, no crashes were reported at the roundabout between August 1999 and October 2001.

Before long, the planning commission and Howard began receiving letters and calls from the sheriff's department, middle school, school bus company, and others directly affected by the project that expressed how pleased they were with the project's results. In fact, the sheriff's department was so pleased that it removed the highway's hazardous designation in 2000. Students are now able to walk and bike to school instead of being forced to be bused or driven by their parents.

The cost of one roundabout was about $180,000 and the other was slightly less. The costs were shared by Brown County, the Village of Howard, and the Town of Suamico. The success of this project has turned many critics into supporters and has led to the construction of three additional roundabouts next to a middle school and high school in the metropolitan area communities of De Pere and Ledgeview. Roundabouts are also being planned or discussed for school zones in other parts of Brown County because the roundabouts do more than just tell people to drive safely in school zones – they force them to drive safely.

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PORTLAND, OREGON **CASE STUDY NO. 50**

Harold Street Traffic Calming

PROBLEM

Residents identified problems including excessive speeds, cut-through traffic and unsafe bicycle and pedestrian conditions.

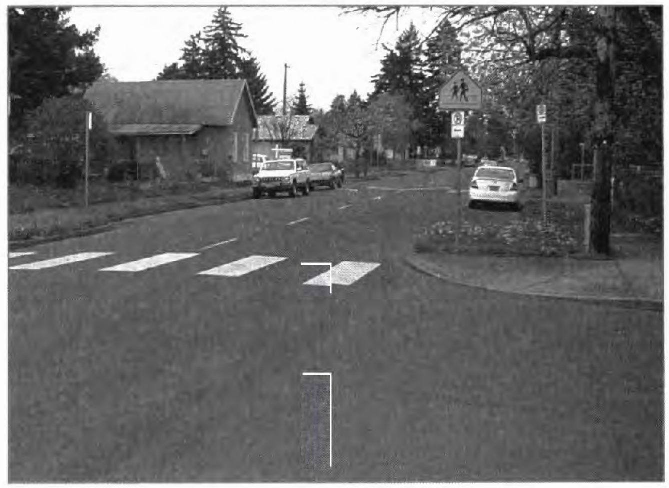
BACKGROUND

The Traffic Calming Section of the Portland Office of Transportation began a project in January of 1991 to address problems identified by residents along SE Harold between 52nd Avenue and 72nd Avenue. Further investigation prompted the expansion of the project to include SE Harold between 72nd Avenue and Foster Road.

The project's goals were to reduce traffic speeds on SE Harold Street, to improve safety for vehicles, bicyclists, and pedestrians, and to reduce non-local traffic volume. Traffic calming strategies would include measures that encourage slower vehicle speeds, increase pedestrian crossing opportunities, and improve sight distances for drivers, cyclists, and pedestrians alike.

The speed limit on SE Harold is 48 km/h (30mi/h); however, over the length of the street, SE Harold's 85th percentile speed was measured to be 60–64 km/h (37-40 mi/h). The daily traffic volume was measured in the range of 3400 to 4800 vehicles per day. This volume of traffic is considered high for a street like SE Harold. The volume of traffic, combined with retail uses and pedestrian generators, made the excessive speeds on SE Harold a significant concern. In addition, a large portion of the average daily traffic on SE Harold, prior to this project, was believed to be cut-through traffic.

Information obtained from the City of Portland's official Web site and reviewed by Scott Batson, City of Portland.



Curb extension on Harold Avenue.

SOLUTION

A traffic committee was formed from residents in the surrounding neighborhoods to discuss planning. Input was also gathered through required open houses and ballots from residents and landowners of properties adjacent to the street. Bureau of Traffic Management staff developed several alternatives for strategically locating devices to achieve the project goals.

The median island on Harold east of 52nd Avenue slows turning vehicles.

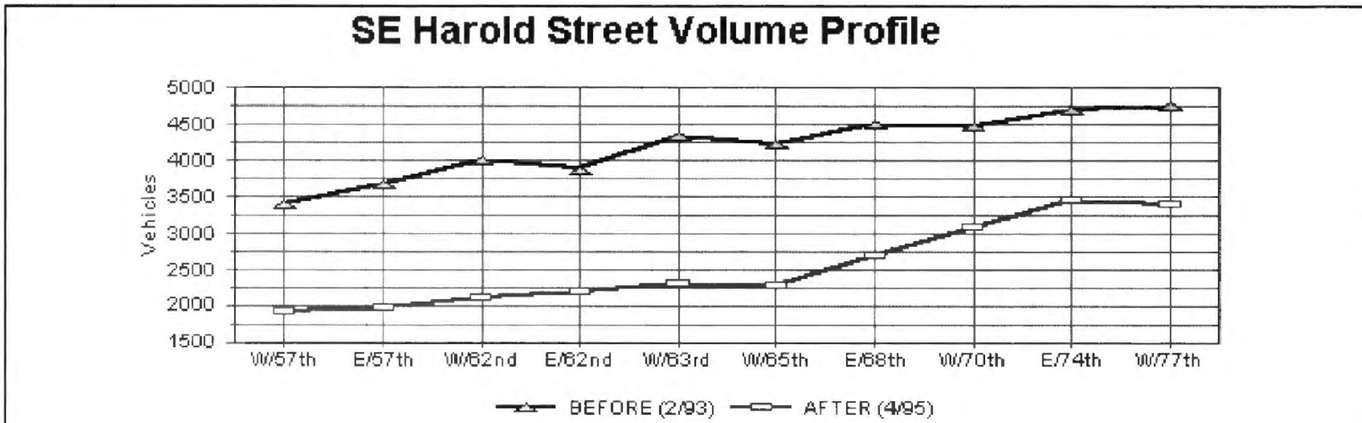
The devices chosen for SE Harold included one median island to reduce corner cutting and turning speed from SE 52nd, eleven 6.7 m (22 ft) speed bumps spaced 91–275 m (300-900 ft) apart, and curb extensions at 5 intersections.

The Bureau of Maintenance constructed the speed bumps between July of 1993 and May of 1994. Copenhagen Utilities and Construction, Inc. constructed the project's median island and curb extensions between July and October of 1994, at a cost of approximately $117,000.

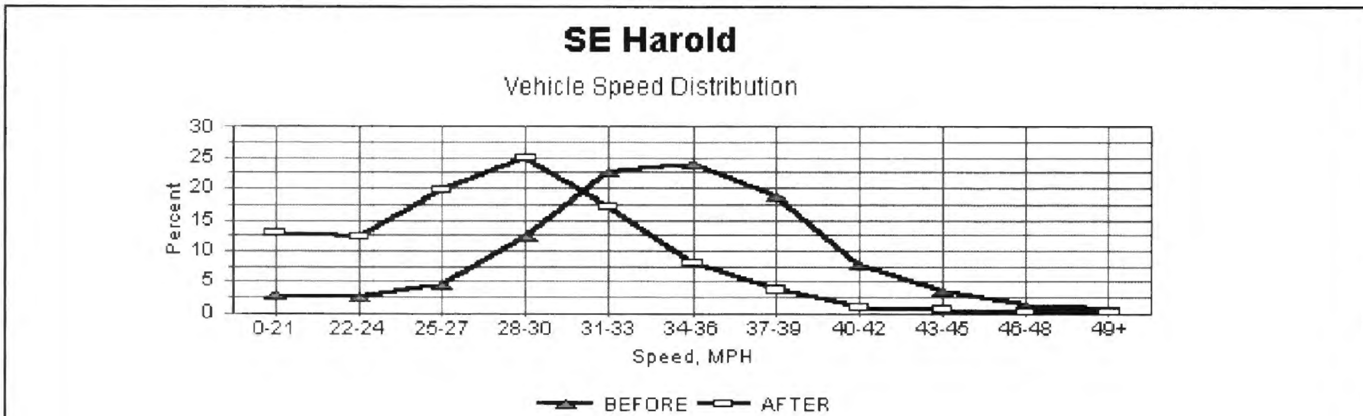
RESULTS

Traffic Volume on SE Harold, prior to project construction ranged from 3400 to 4800 vehicles per day with a steady increase in volume toward the East end of the project segment. This increase in volume is likely due to Foster Avenue's higher classification and the fact that the closest freeway, I-205, is to the East.

Total volumes on SE Harold have decreased to the range of 2000 to 3500 vpd. The trend of traffic volume to increase toward the East has not changed since the reasons for the increase, Foster and I-205, have also not changed. The 1600 vehicle per day (average) drop in daily traffic volume is a reduction of 37 percent. This drop presumably represents cut-through drivers who found the speed bumps to be inconvient. This amount of volume decrease is considered very significant. However this level reduction is unusual and most likely due to the numerous adjacent and more appropriate alternative routes. Measurements of traffic volumes on adjacent streets show an increase on the streets adjacent to SE Harold, while the total traffic volumes, including Harold, have decreased. None of the adjacent side streets showed an identifiable traffic volume increase exceeding allowable thresholds. The 85th percentile speed on SE Harold prior to project construction ranged 60-64 km/h (between 37-40 mi/h). Measurement since speed bump construction shows an average decrease in the 85th percentile speed of 10 km/h (6



Traffic Volumes along the length of SE Harold before and after project construction.



Distribution of vehicle speeds along SE Harold before and after project construction.

mi/h). The graph above shows that the peak in speeds has shifted from 55–58 km/h (34-36 mi/h) to 45–48 km/h (28-30 mi/h). The shape of the after curve indicates a concentration of the vehicle speeds. Also, a higher percent of vehicles are now traveling below the posted speed limit, which remained at 48 km/h (30 mi/h). A check of available Department of Motor Vehicle records for the 15 months before the speed bumps were constructed as compared to the same time period after construction shows the number of reported accidents dropped from 17 to 13. The number of injuries reported in those accidents also dropped from 16 to 8.

A 6.7 m (22 ft) speed bump on SE Harold.

Traffic Calming on SE Harold has been very successful and neighborhood livability has been enhanced. Whenever the average speeds and volumes of vehicles are reduced an associated reduction in the number and severity of accidents can be anticipated. Additionally, a reduction in speed allows drivers more time to observe the roadway for conflicts and permits shorter stopping distances. Fewer drivers using the street creates more and longer gaps for pedestrians to cross.

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CORVALIS, OREGON CASE STUDY NO. 51

Curb Bulbouts with Bicycle Parking

PROBLEM

The rate of crashes involving pedestrians experienced a sharp increase in the downtown area.

BACKGROUND

In 1995, Corvallis had a total of six pedestrian crashes, the majority of which took place within the downtown area. In 1996, the number of pedestrian crashes rose unexpectedly to 22, again with the majority in the downtown area. The City needed to devise a plan to increase the safety of the downtown area for pedestrians as well as address the needs of the numerous cyclists who live there.

Monroe Avenue at 21st Street.

Information provided and contributions made by Steve Rodgers, City of Corvallis and Jim Bowey, former chair of the Bicycle/Pedestrian Advisory Commission.

SOLUTION

The Bicycle/Pedestrian Advisory Commission determined that curb extensions furnished with covered bicycle racks would help both pedestrians and cyclists while slowing down traffic. The City decided to install three curb extension bulb-outs on Monroe Street, the main commercial strip next to the Oregon State University campus, to maximize the impact in an area with heavy bicycle and pedestrian traffic. The total cost of the three intersection bulbs and covered bike racks was $140,000. The Oregon Department of Transportation funded $100,000 of the project and the City of Corvallis funded the remaining $40,000. The bike rack coverings were designed specifically to blend in with the area's architectural style. The Bike lanes already in existence along Monroe Street prior to this project were not changed.

Sidewalk bulb-out with covered bike parking.

The new bulb-outs were the beginning of an attempt to focus on pedestrian safety within the downtown area. As such, the City has been pleased with the curb extensions, and is already considering funding for three more. They City is also very pleased with the current design for the covered bike parking and bulb-out.

Initially, some of the business owners along this street were not enthusiastic about the bulb-outs and bike parking, but now, they are quite supportive of these projects. In fact, Jim Bowey, former chair of the Bicycle/Pedestrian Advisory Commission, said that he has never heard anyone say anything bad about the project since its implementation.

RESULTS

Steve Rodgers, Project Manager with the Public Works Department of the City of Corvallis, believes the project had a positive impact in the community. The bulb-outs helped direct pedestrians to crosswalks, instead of crossing at more dangerous mid-block locations. Two of the bike racks are constistantly full and one is regularly half full. Locating the bike racks on bulb-out corners also encouraged users to cross at the crosswalk adjacent to the bike racks. And, in a surprise to all involved, the covered areas for bike parking have seen regular use as transit stops by partons of the bus service, some of whom thought that they were designed as transit stops. Although no specific data is available to measure the effectiveness of this project, anecdotal evidence supports the project's success in contributing to the safety of pedestrians in the downtown area of Corvallis.

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Traffic Calming Program

PROBLEM

Residents of Sarasota were concerned about speeding vehicles, motorists cutting through residential streets instead of using arterials, and pedestrian safety while crossing streets. Specifically, the Gillespie Park neighborhood was concerned about the safety of children crossing the street to play at the local park.

BACKGROUND

Sarasota was one of the first communities in the country to develop a traffic calming program. The City's Traffic Calming brochure states:

The function of local residential streets is not just to act as a corridor for vehicular traffic. They are also for social interaction, walking and bicycling. Each residential street will have these ingredients in different proportions but no one function should dominate over all others. Traditional Traffic Calming adheres to this assumption and can be defined as: the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street use. Traffic Calming changes the look and feel of a street. It does not discourage vehicle travel but it encourages automobile drivers to operate safely with consideration for others on the street. It works to improve the quality of neighborhood life by creating safe attractive streets, and providing, and promoting pedestrian and cyclist activities.

Prepared by Natalie Rush, Transportation Planner, City of Sarasota, FL.

SOLUTION

The Sarasota Traffic Calming Program involves public participation in the planning and design process. Residents also conduct before and after studies to ensure that the devices are effective. When speeding and pedestrian safety problems arise in a neighborhood, the Engineering Department forms a list of neighborhood residents that would like to participate in a Traffic Calming Task Force to help design a neighborhood Traffic Calming Master Plan.

To aid them in creating the plan, this Task Force is presented with design options, such as speed tables, neck outs, medians, etc., and is given a significant amount of baseline information, including: traffic counts, resident and business input, current street design dimensions and conditions, funding guidelines, and traffic calming warrants. Upon approval by consensus of the Task Force, the plan is presented to the neighborhood at an open house for the community to view, comment, and vote on the plan. Finally, a public hearing is held before the City Commission. If the plan is approved at the hearing and funding is available, the plan is implemented.

One location where residents identified the need for traffic calming was near Gillespie Park. Using the process described above, the neighborhood Task Force decided to install raised crosswalks at the intersections near the park and speed tables at a mid-block location on an adjacent street. In addition to slowing vehicle speeds, raised speed tables improve the visibility of children crossing the street and provide a highly accessible crosswalk for pedestrians with disabilities. The improvements near Gillespie Park cost $31,500 and were paid with City funds. Similar projects have been completed throughout the City.

RESULTS

TRAFFIC CALMING PROGRAM

To date, the City has planned and implemented 12 traffic calming projects, including more than 90 speed humps on its streets. In recent years, the public has requested more traffic calming projects than can be accommodated by the budget of the program, only $150,000 per year.

Public response to traffic calming measures has been predominantly positive. In several cases, residents of one neighborhood have heard about the pedestrian safety benefits and speed reduction effects of traffic calming projects in another neighborhood, and started the process in their own area.

In addition to budget constraints, one challenge for the program is determining the best placement of speed tables on roads fronted by narrow, 15.2 m (50 ft) wide residential lots. It can be difficult to avoid placing the devices in front of driveways, mailboxes, and next to drainage inlets in neighborhoods with lot sizes this small or smaller.

SPEED TABLE EFFECTIVENESS

Between 1996 and 2000, the City documented the effects of speed table projects on traffic speeds, traffic volumes, and cut-through traffic at nine locations throughout the city. All streets had a posted speed limit of 25 mi/h (40 km/h) and carried between 240 and 1460 vehicles per day.

Traffic speeds decreased at all nine locations. Considering all sites, the average 85th percentile speed before the speed table installation was 56 km/h (35.1 mi/h). Afterward, speed lowered to 48 km/h (28.9 mi/h), a decrease of 17 percent.

Speed tables had a mixed effect on traffic volumes, increasing at three and decreasing at six of the locations. Although the change in traffic level at each site ranged from a 29 percent decrease to a 42 percent increase, over all nine locations the traffic levels decreased by about 11 percent.

Finally, Sarasota studied the effects of the speed tables on cut-through traffic. Before the speed tables were constructed, the proportion of traffic using the street for cutting through ranged between 10 and 88 percent. While cut-through traffic increased at three of the sites, it decreased at the other six. Change in cut-through traffic ranged from a decrease of 49 percent to an increase of 87 percent.

In summary, this study showed mixed results with regard to speed table impacts on traffic volumes and cut-through traffic, but significant benefits in the area of speed reduction. Slower speeds and lower traffic volumes should contribute to a safer environment for pedestrians, especially in areas where many people cross the street, such as near Gillespie Park.

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Chicanes for Traffic Control

PROBLEM

As the City of Seattle's arterial routes become more congested, motorists look for quicker routes and often choose to use non-arterial streets through residential neighborhoods. Communities have increasingly called for traffic calming device installations on their neighborhood streets to discourage cut-through traffic, reduce vehicle speeds and improve pedestrian safety and comfort.

BACKGROUND

Seattle's Neighborhood Transportation Services (NTS) began as an outgrowth of programs to improve deteriorating neighborhoods. Residents of Seattle approved the Forward Thrust Bond Issue in 1968 with a major emphasis reducing traffic impacts and supporting for street improvements to re-vitalize deteriorating neighborhoods. Demonstration projects testing a variety of traffic control devices, such as traffic circles, diverters, chicanes and partial and full closures began in 1973 and continued throughout the 1970s and 1980s.

Since then, the NTS continues to emphasize citizen participation and has grown into a popular and highly visible program. Chicanes are one device used by the City's Neighborhood Traffic Control Program to reduce vehicle speeds and improve pedestrian safety and comfort. To date, Seattle has installed chicanes at 13 locations.

SOLUTION

Seattle's chicanes are a series of two or three curb bulb-outs, placed on alternating sides of the street and staggered to create a curved one-lane segment of roadway.

Prepared by John C. Marek and Shauna Walgren
City of Seattle, WA.

Chicanes on NE 70th Street.

Chicanes help reduce vehicular speeds by requiring motorists to maneuver through the curb bulb-outs, one vehicle at a time. The spacing between the curb bulb-outs and the distance they extend into the roadway determine how easily motorists will be able to maneuver through the chicanes. These devices have a calming effect on streets (particularly if they are landscaped) by creating a visual narrowing of the street. They also enhance the local neighborhood appearance and improve comfort and safety for pedestrians using the roadway.

The City of Seattle studied three chicane installations for their effectiveness at reducing vehicle speeds and discouraging cut-through traffic.

In 1984, two sets of chicanes were installed on NE 70th Street between 12th Avenue NE and 15th Avenue NE. Each set consisted of three curb bulb-outs extended approximately 4 m (13 ft) into the street. The bulb-outs were spaced 15-24 m (50–80 ft) apart, with the two sets of chicanes located 128 m (420 ft) apart.

Two sets of chicanes were also installed on NW 55th Street and NW 56th Street between 3rd Avenue NW and 1st Avenue NW in 1992. These chicane curb bulb-outs are spaced approximately 18 m (60 ft) apart,

Chicanes on NE 98th Street.

narrowing the travel lane to 3.6 m (12 ft). The distance between the sets of chicanes is approximately 91 m (300 ft).

A single chicane was installed on NE 98th Street between 20th Avenue NE and 23rd Avenue NE in 1994. This device has 23 m (75 ft) between curb bulb-outs.

RESULTS

The chicanes have significantly reduced the speeds of vehicles traveling on the streets. At all the study locations, there was an initial reduction in 85th percentile speeds of 13–21 km/h (8-13 mi/h). Results of follow-up studies for NE 70th, NW 55th, and NW 56th Streets show that over time initial speed reductions eroded by only 1.6–5 km/h (1-3 mi/h) after the chicanes had been in place for a few years. Overall, speeds remained 18-35 percent lower than before installation. The slight increase may reflect motorists' familiarity with the devices after driving through them repeatedly.

Chicanes also reduce speeds between sets of devices. While not as great as within the device itself, the speeds between sets of chicanes were reduced by up to 13 km/h (8 mi/h), or 28 percent. Northwest 55th and 56th Streets showed the greatest change with reductions of 10-13 km/h (6-8 mi/h) perhaps due to the relatively close spacing between the curb bulbs and the short distance between chicanes at these locations.

Vehicle volumes on NE 70th, NW 55th, and NW 56th Streets ranged between approximately 1400 Average Weekday Traffic (AWDT) and 2000 (AWDT) before the chicanes were installed. AWDT decreased by 48 percent on NE 70th, 32 percent on NW 55th, and 43 percent on NW 56th after installation. Interestingly, the volume on NE 98th Street remained relatively unchanged (increase from 1965 AWDT to 1993 AWDT) perhaps because no easy alternative routes exist.

Overall, Seattle has found that the chicanes have been very effective at reducing speeds and bringing mid-block speeds closer to the non-arterial limit of 40 km/h (25 mi/h). This benefits pedestrians because slower speeds reduce the probability of serious injury in the event of a collision and increase comfort for pedestrians walking along or crossing the street. Chicanes have also encouraged motorists to use nearby arterial routes, thereby lowering cut-through traffic.

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Mid-Block Speed Table

PROBLEM

Residents felt it was unsafe to cross a city street in their neighborhood and requested a mid-block signal and crosswalk. An engineering study showed that existing signal warrants could not be met to justify the signal.

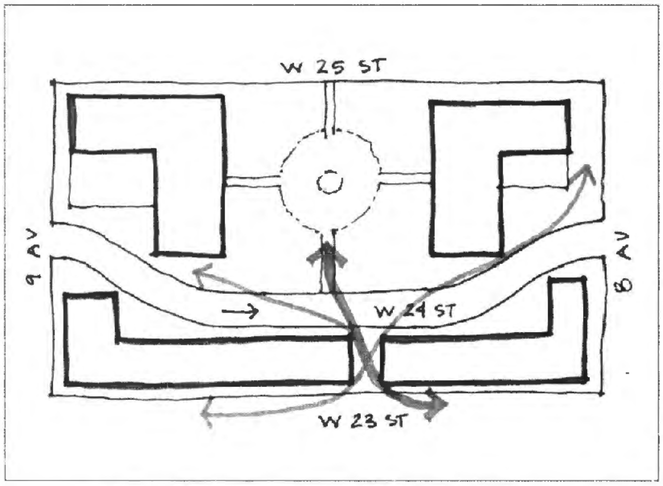
BACKGROUND

In 1997, the Penn South Co-op Board, on the upper West side of Manhattan, requested a mid-block signal and crosswalk on West 24th Street to improve the safety of pedestrians crossing the street destined for a playground in one direction or a subway station in the other. New York City's Department of Transportation (NYC DOT) found that the crossing location did not meet warrants for a signalized, mid-block crossing. However, observational studies and neighborhood testimony confirmed that a significant number of crossings were made at the location of interest and along the entire block.

The Penn South housing development is characterized by towers set back from the street in park-like superblocks. To create the superblocks, West 24th and West 28th Streets between Eighth and Ninth Avenues were widened to 15 m (50 ft), as opposed to the normal 9.2 m (30 ft). The posted speed limit on West 24th (classified as a local road) was 48 km/h (30 mi/h) and weekday ADT was 5450 vehicles. The street's extraordinary width meant more lanes and more capacity, but actual vehicle volumes were similar to unwidened streets in the neighborhood. The result: drivers drove faster.

On West 24th Street two heavily traversed mid-block passages intersect—one leads to the Penn South playground, the other to a subway station. In addition, other

Prepared by Michael King.



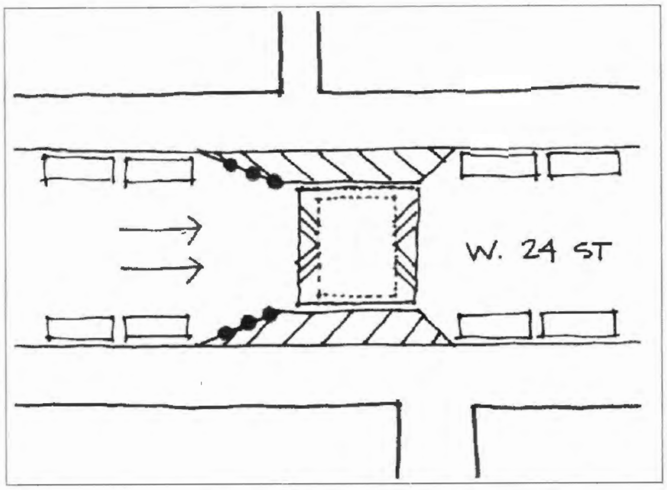
This diagram shows pedestrian desire lines in the Penn South area.

pedestrians take advantage of the bend in the road to shave time off their journeys. Taken together—wider road, faster cars, reduced visibility due to the bend, mid-block passages and desire lines, and multiple crossing points proved the location was ripe for intervention.

A year prior, NYC DOT had begun a comprehensive speed hump program. In a three-year period, about 300 humps were installed, mostly at mid-block locations using a flat-top design (a speed table). DOT planners looked to the traffic calming program for a solution that could be applied to a mid-block location.

SOLUTION

A flat-top speed hump was proposed for 24th Street, and the project was recognized as a test case for a raised mid-block crossing. NYC DOT's acceptance of the speed table design enabled creation of a de facto mid-block crosswalk, without formally and legally creating a crosswalk at a mid-block location. The concept design was presented to the Penn South Coop Board and they approved the proposal.



This is an initial diagram of the proposed speed table crossing area.

The speed table is 102 mm (4 in) high and 9.2 m (30 ft) long with 1.5 m (5 ft) ramps. By locating it where the two mid-block passages meet, drivers would be slowed at the point where most people cross the street and at all hours of the day and night. By not establishing a formal crosswalk, other pedestrians would still be free to cross the 240 m (800 ft) long street according to their desire lines. By using a speed table, which is wider than a normal crosswalk, the two opposing mid-block passageways could be connected, even though they did not line up exactly as a perpendicular intersection; and the pedestrian inclination to cross on a diagonal line would be accommodated by the table's generous length.

Pedestrians use the speed table as a raised crosswalk.

Additionally, the street was narrowed at the crossing point to reduce pedestrian exposure. And to increase visibility, "No Parking" zones were established before the crossing. Flexible bollards were installed to reinforce the parking regulations.

The project cost was approximately $5500, including planning, design and construction, and was funded through the CMAQ program (federal ISTEA/TEA-21 funds earmarked for congestion relief and pollution reduction).

24th Street was narrowed at the crossing point to complement the speed table.

RESULTS

A post construction study was conducted. Comparing prior speeds measured along the street with speeds taken at the speed table, showed mean speeds and maximum speeds were reduced by 43 percent. Speed at the crossing point fell 40 percent, between the 85th Percentile Speed of 53.1 km/h (33 mi/h) for the entire street with the 85th Percentile Speed at the new speed table of 32.2 km/h (20 mi/h). A person hit by a vehicle traveling 53.1 km/h (33 mi/h) has an 80 percent likelihood of death or serious injury, while 32.2 km/h (20 mi/h), the likelihood drops to 35 percent. By this measure, one can infer that pedestrian safety more than doubled at the West 24th Street raised-crossing.

The 85th percentile speed along the entire street was reduced by 15 percent, improving pedestrian safety even beyond the bounds of the improvement. Speeds for the entire street in the after condition were calculated by averaging the low speeds at the hump with the high speed elsewhere on the block.

The project successfully demonstrated the effectiveness of the treatment to improve pedestrian safety, as well as proving that innovative traffic calming devices can be tested within existing policy and liability constraints.

Speed Measurements Over the Entire Street	Before Speed Table Installation (Entire Street)		After Speed Table Installation (Entire Street)		After Installation (At the Speed Table)	
	mi/h	*km/h*	mi/h	*km/h*	mi/h	*km/h*
Maximum Speed:	40	*64*	34	*55*	23	*37*
85th Percentile:	33	*53*	28	*45*	20	*32*
Mean Speed:	28	*45*	21	*34*	16	*26*

Table 1. Speed data before and after installation.

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Emergency Vehicles and Traffic Calming

PROBLEM

Clark County needed traffic calming measures that would slow speeds on neighborhood streets, yet accommodate emergency response vehicles.

BACKGROUND

NE 76th Street is a neighborhood collector (non-arterial classification) in Clark County, Washington, an unincorporated area outside of the City of Vancouver. The street is an eastern extension of an arterial roadway at Ward Road, and it connects two arterials, Ward and 162nd Avenue, at each end. The posted speed limit is 40 km/h (25 mi/h).

The street is a community place, a transportation facility not only for motor vehicles but for bicycles and pedestrians. Since the neighborhood street lacks continuous sidewalks and has no bike lanes or pathways, it was critical to improve pedestrian and bicyclist safety and comfort by maintaining slow vehicle speeds along the street. Children are frequently observed walking or riding on or across the street and to school (and school bus stops).

SOLUTION

In 1997-98, Clark County approved and implemented a neighborhood traffic calming project for an approximate 1.9 km (1.2 mi) segment of NE 76th Street

Prepared by Charles P. Green, Parsons Brinckerhoff, Portland, Oregon.

Information provided and contributions made by Charles P. Green, Parsons Brinckerhoff; Jennifer Green; Steve Green; Don Williams, Clark County; Gerald Morris, formerly with Clark County Public Works, now with Collier County, Florida Public Works; Carl Switzer, Parsons Brinckerhoff.

An emergency response speed hump.

between Ward Road and NE 162nd Avenue. The NE 76th Street project is innovative in that it has Clark County's first two tests of emergency vehicle-type traffic calming design. The first device, an emergency response speed bump, has a median and wheeltrack channel cut into the center of the bump to allow emergency vehicles to pass through the center, unimpeded, while general traffic is to legally slow down and use the bump. The second device, an emergency response traffic circle, has wheeltrack channels cut through the center of the traffic circle to also allow for emergency vehicle passage, while general traffic must travel around the circle. The circle's emergency vehicle channel is offset 15 degrees to discourage general vehicles from illegally shortcutting through the center of the device.

Prior to installation, these devices were tested in a closed-environment test as well as a field test. The closed-environment test was at the Clark County Maintenance and Operations facility, where a fire truck was used to test different wheeltrack and channel layouts using railroad ties. The spacing and median width specifications were developed from these tests.

Speed bump testing was also conducted in a field test by Clark County Public Works and Clark County Fire District 6 staff. A set of speed runs was made before and after regular speed bump installations on NE 129th Street in the Salmon Creek area. The result of the speed run indicated that a typical speed bump slowed fire trucks between 4-6 per device (5 per device, on average).

A closed-environment test was made using a similar fire truck at the County Maintenance yards. The results indicated that with the specified design wheeltrack/ median width, fire trucks should be slowed, at most, by 1-2 sec per device to allow the driver to align and maneuver through the channel.

RESULTS

Prior to installation, a speed study was conducted in July 1996 by Clark County.

The result was:

- Mean speed was 45 km/h (28 mi/h).
- 85th Percentile speed was 52 km/h (32 mi/h).
- The speed range was generally 24-63 km/h (15-39 mi/h). The 16.1 km/h (10 mi/h) pace speed (range which included the most vehicles) was 40–55 km/h (25-34 mi/h).

SPEED BUMPS

- Mean speed was 35–39 km/h (22-24 mi/h) measured between devices.
- 85th Percentile speed was 40–42 km/h (25-26 mi/h).
- The speed range was generally 27–47 km/h (17-29 mi/h).
- The 16.1 km/h (10 mi/h) pace speed was 26–40 km/h (16-25 mi/h).

TRAFFIC CIRCLE

A speed study was conducted in September 2001. The results were:

- Mean speed was 35 km/h (22 mi/h) measured between devices.
- 85th Percentile speed was 40 km/h (25 mi/h).
- The speed range was generally 27-40 km/h (17-25 mi/h).
- The 10 mi/h pace speed was 26-40 km/h (16-25 mi/h).

Both types of devices slowed traffic speeds to match the neighborhood character and street designation, and allowed for emergency response vehicles to travel through them unimpeded. The devices have reduced speeding, thereby improved pedestrian and bicyclist safety and comfort. The only point of concern for bicycles and pedestrians appears to be the traffic circle. Some residents have remarked that the circle requires vehicles to maneuver around it, passing through what would be considered the pedestrian crosswalk. Additionally, some residents mentioned that the traffic circle appears to be an attractive "play area" for neighborhood children, which is a safety concern.

With the reduced speeds around the traffic circle and the improved around the device, there does not appear to be any evidence that the circle has increased conflicts between vehicles and pedestrians. The circle's design is similar to the design used in nearby Portland, Oregon and elsewhere, which also experience vehicle maneuvering in the crosswalk area. To date, there is no known data that would indicate that pedestrian safety is compromised by the circle's design.

The results of the testing are critical. Emergency services agencies generally set a response rate from time of call to time of arrival at the site varying from 3-6 minutes. Clark County adopted a policy on emergency response routes that traffic calming devices should not delay emergency response times by more than 30 seconds per emergency route. This policy was supported by the local emergency service providers. At a 5-second delay per speed bump, this allows for only 6 regular-design speed bumps to be installed on any given response route. This would essentially prohibit placing additional traffic calming devices on that route or on intersecting streets, as they would extend emergency response times beyond the desired 30-second threshold.

Measure	Before Installation	After Installation: Emergency Response Calming Devices	
		Speed Bump	Traffic Circle
Posted Speed (mi/h)	25	25	25
Mean Speed (mi/h)	28	22-24	22
85th Percentile Speed	32	25-26	25
Pace Speed (mi/h)	25-34	16-25	16-25

Table 1. Before and after traffic speeds with the two case study devices.

With the testing results shown above, a minimal delay of 1-2 sec per device over the length of the emergency response route was experienced. This allows for traffic calming devices to be installed on adjacent streets, or on an emergency response route, while still preserving emergency response times.

Public opinion, compared to the "after" results of the devices, seems to indicate that the county lacks an educational program to inform residents about the effectiveness of the devices. Some residents believe that speeding has not been controlled after the installation of these devices. While speeding has been shown to be significantly reduced, often below the posted speed limit, there is a prevailing perception amongst residents that the devices could be more effective.

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Neighborhood Traffic Circles

PROBLEM

Maintaining pedestrian and traffic safety on neighborhood streets requires addressing the dual problems of speeding traffic and intersection accidents.

BACKGROUND

Seattle's Neighborhood Transportation Services (NTS) began as an outgrowth of programs to improve deteriorating neighborhoods. Residents of Seattle approved the Forward Thrust Bond Issue in 1968 with a major emphasis on reducing traffic impacts and supporting street improvements to re-vitalize deteriorating neighborhoods. Demonstration projects testing a variety of traffic control devices, such as traffic circles, diverters, chicanes and partial and full closures began in 1973 and continued throughout the 1970s and 1980s. The NTS emphasizes citizen participation and has grown into a popular and highly visible program with its most successful device being the traffic circle.

Of all the devices used in Seattle, traffic circles have proven to be the most effective at solving neighborhood concerns about speeding traffic and traffic accidents with a minimum of controversy. In addition, by slowing vehicle speeds, these devices make streets safer for pedestrians. Since 1973, over 600 traffic circles have been constructed in Seattle and the NTS staff receive about 700 requests for traffic circles each year. The program is currently funded to construct 30 traffic circles per year.

Prepared by Jim Mundell, P.E., City of Seattle, WA.

SOLUTION

Potential traffic circle locations are identified through community requests or investigation of high accident intersections. In order to ensure that the City's traffic safety funding is allocated to the intersections with the greatest need, a priority point system is used to rank the intersections where traffic circles are requested. The ranking is based on the number of accidents that have occurred at the intersection in the last three years, the speed of traffic (85th percentile speed), and the volume of traffic. Residents are required to submit a petition with signatures representing 60 percent of the households within one block of the proposed traffic circle in order to compete for funding. Funding is allocated starting with the intersection with the worst combination of problems and proceeds as funding allows. The cost to construct each circle ranges from $3,000 to $6,000.

Each traffic circle is individually designed to fit the intersection without having to modify the street width or corner radii. Most of Seattle's local streets are 7.5 m (25 ft) wide or less, and traffic circles are usually 3.6-4.9 m (12-16 ft) in diameter. While traffic circles are designed so that fire trucks should be able to pass around them, they are constructed with a 0.6 m (2 ft) wide mountable curb that allows fire trucks or larger vehicles, such as moving vans, to run over the curb without damaging the vehicle or the circle.

Ground cover and one to three trees are included in all the traffic circles currently being constructed. The pavement inside the traffic circle is removed during construction to allow for drainage and accommodate tree roots. The landscaping makes the circle more attractive to the neighborhood residents less appealing for high speed driving. The local residents are required to maintain the plantings and are allowed to add their own low growing plants that won't block visibility of pedestrians or traffic.

RESULTS

Between 1991 and 1994, a total of 119 traffic circles were constructed through Seattle's NTS. The number of automobile accidents at these intersections fell 94 percent from 187 in the year before to 11 in the year after construction. The reduction in injuries was even more dramatic, dropping from 153 injuries in the year before construction to a single injury in the year following construction. Accident reduction was also found in subsequent years. The reduction in accidents is even more impressive, most of the intersections had experienced an was an increase in the number of accidents during the years prior to the installation of the traffic circle.

In addition to reducing accidents, traffic circles have been found to be effective at reducing vehicle speeds but have not significantly reduced traffic volumes. The effect on speed generally continues to the middle of the block.

The reductions in vehicle speeds also benefit pedestrians. According to Shauna Walgren, Senior Planner in the NTS Division, community residents often request traffic circles from the City because they are concerned about children who live in the neighborhood. "When motor vehicle speeds are reduced, the frequency and severity of collisions involving pedestrians are also reduced. We work with a great many schools, and the safety of children crossing the street is their main concern. Traffic circles are a solution that works."

Seattle's traffic circles have also received strong community support. Responses on surveys mailed to residents following construction of traffic circles indicate 80 percent to 90 percent of residents feel the circles have been effective and want to keep them permanently. Only two circles have been removed out of more than 600 constructed, and none have been removed in the last 12 years.

After nearly 25 years of experience installing traffic circles, Seattle has found them to be an effective device for controlling neighborhood traffic and improving safety and comfort for the residents of residential streets.

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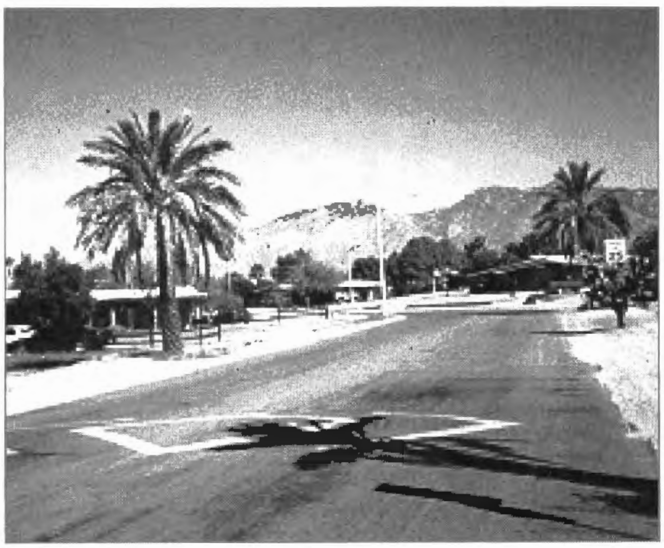
TUCSON, ARIZONA CASE STUDY NO. 57

Speed Humps for Cut-Through Traffic

PROBLEM

Two residential streets provided a classic cut-through situation for motorists avoiding a major arterial intersection. Moreover, late-night drinking drivers used the route to avoid police on the arterial streets and several accidents occurred, involving speeding vehicles crashing onto lawns and into houses.



BACKGROUND

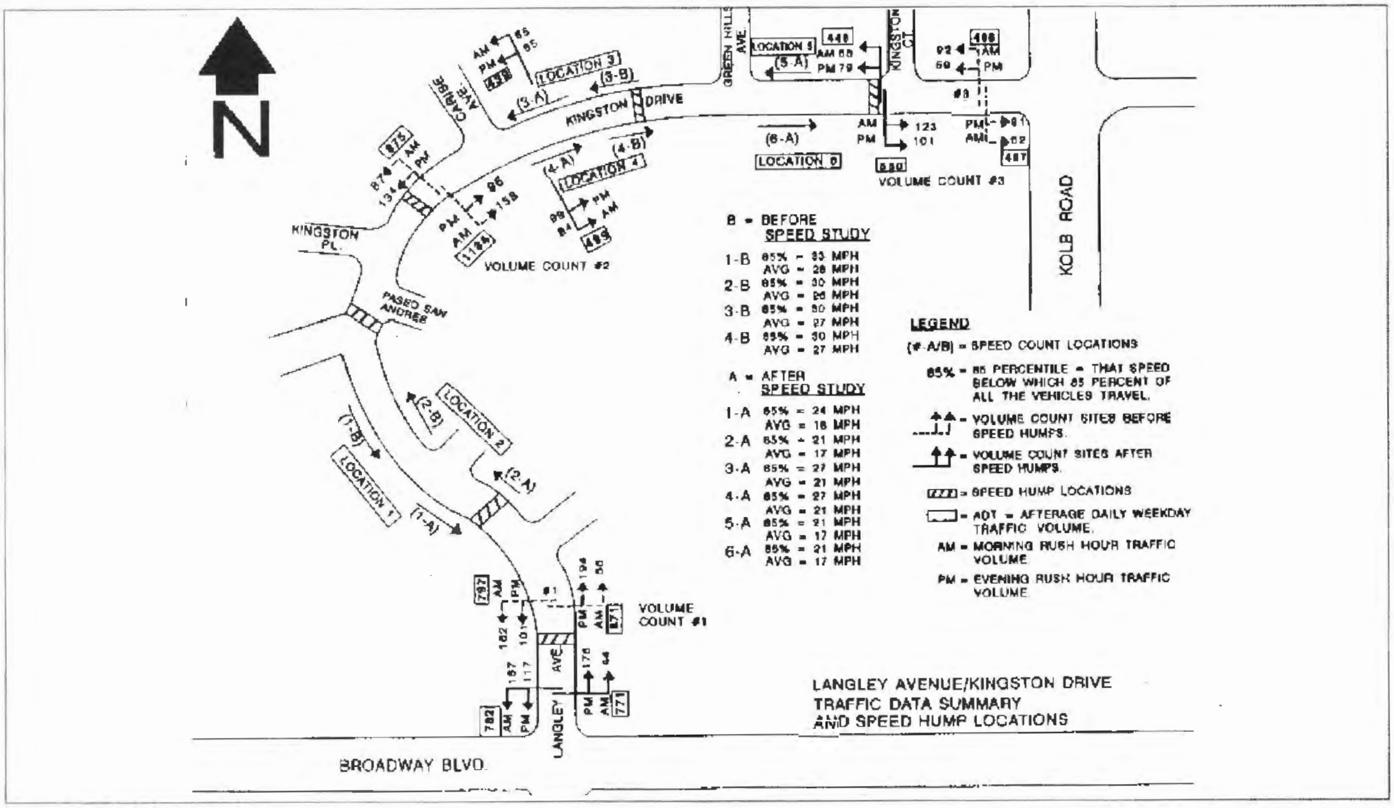
Langley Avenue and Kingston Drive are connecting residential streets that are often used as a cut-through route for commuters. Using the two connecting streets allowed motorists to bypass one of the busiest intersections in town, the Broadway Boulevard/Kolb Road intersection, where there were estimated volumes of 100,000 vehicles per day and almost daily accidents, further increasing delay. Volumes through the Langley/Kingston neighborhood were roughly 2,000 ADT with 85th percentile speeds of 50 km/h (31 mi/h). The neighborhood streets have no sidewalks, and the residents were so afraid of speeding motorists that they avoided walking or biking on their own streets.

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center, and Vince Catalano, Tucson, AZ Traffic Engineering Division.

SOLUTION

In Tucson, neighborhoods are responsible for funding their own neighborhood improvements. The City facilitates a neighborhood process where residents are able to participate in the planning and design of appropriate solutions. Originally, the neighborhood residents originally wanted stop signs, but the City's Engineering Department recommended speed humps as a more effective solution. The City provides planning assistance and technical support, which includes professional expertise for the engineering of effective traffic calming solutions. In addition to the Neighborhood Association, City outreach included involvement of the Council Member who represents the neighborhood. Residents agreed to try the speed humps.

The project cost was $12,000. Financing is usually done



in one of two ways: 1) through resident contributions to pay for installations by a licensed contractor, or 2) through a special tax assessment added to the annual property tax bill the city sends property owners.

RESULTS

The addition of the speed humps produced an overall reduction of speeding vehicles. Before the project, 85th percentile speed was 50 km/h (31 mi/h) at three locations 53 km/h (and 33 mi/h) at another. Average speeds were between 43-45 km/h (27-28 mi/h). After the speed humps were added, the 85th percentile speed reduced to 39 km/h (24 mi/h) and the average speed dropped to 31 km/h (19 mi/h).

Neighborhood traffic volumes were also reduced because commuters chose to stay on the arterial streets, Kolb and Broadway, instead of cutting through the neighborhood. The volumes on the south end of Langley Avenue dropped by 100 vehicles for northbound travel, but there was no significant change for southbound travel. In the middle locations, volumes dropped by more than 50 percent for both northbound and southbound traffic. Volumes on Kinston Drive decreased by 50 vehicles westbound and increased by 50 vehicles eastbound, which was not a significant change.

Slower speeds and fewer vehicles have improved comfort for pedestrians. The neighborhood has no sidewalks, but residents now feel safe walking, pushing strollers, and letting children ride bikes in the street. The speed hump program has been well received, the traffic engineering office has not had to return to the neighborhood with one request to re-address the problem or remove the humps.

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Raised Intersection

PROBLEM

Cut-through traffic that did not obey stop signs and traveled at unsafe speeds jeopardized local residents on a neighborhood street in Brooklyn.

BACKGROUND

Residents of Brooklyn's Prospect Park South neighborhood had long complained of drivers using their streets to avoid congested arterials. In 1996, the New York City Department of Transportation (NYC DOT) began a comprehensive speed hump program, using mostly flat-topped speed tables at mid-block locations. In 1997, Slocum Place, in Prospect Park South, was identified as a location needing traffic calming and a disincentive for cut-through traffic. Slocum Place was chosen because it was one of the few entries into the neighborhood and one of the most used cut-through routes.

Slocum had 75 vehicles per hour at peak times, and an estimated 750 ADT. Stratford Road, one of its cross streets, had 150 vehicles at the peak hour and an estimated 1500 ADT. Both roads were classified as local and had a 48 km/h (30 mi/h) posted speed limit.

A site visit to investigate placement of a NYC DOT-standard speed table on Slocum Place, revealed problems with installing speed tables at mid-block locations, including shortness of the blocks, closely spaced utility openings, driveways, and stop signs. Yet, the intersection of Slocum Place and Stratford Road presented an opportunity for a creative traffic calming measure, especially because it lacked the typical utility openings common to most city street intersections.

Prepared by Michael King.

SOLUTION

The intersection of Slocum Place and Stratford Road is all-way stop controlled, but the community perceived the stop signs to be often ignored. It did not meet warrants for a signal, so a speed table was installed in the middle of the intersection creating a de facto raised intersection.

The raised intersection at Slocum Place and Stratford Road followed similar contours of other speed tables in the city, 102 mm (4 in) high with 1.5 m (5 ft) long ramps. Instead of tapering the sides and offsetting them from the curb, all four sides have ramps. This ensures that a vehicle cannot avoid the hump by driving in the crosswalk, yet even a turning vehicle must have one set of wheels on the hump to round the corner. Furthermore, because curbs were not affected, drainage was not an issue.

Because the standard speed table could not be used, it became a test case for a raised intersection. Its success has shown that innovative traffic calming devices can be tested within existing policy and liability constraints.

RESULTS

A post-improvement survey was conducted in 1997. It showed that 89 percent drivers stopped at the stop line after the raised intersection was installed, as opposed to only 64 percent before the improvement for a 25 percent increase. Additionally the number of peak hour vehicles decreased from a combined 227 for both streets to 152 after for a 33 percent reduction, showing this route to be less attractive as a cut-through.

In terms of pedestrian safety, drivers in the habit of obeying stop signs are more apt to yield to pedestrians. More importantly, the raised intersection physically forces all drivers to moderate their speed. Even the 11 percent of drivers that ignored the stop line had to slow

The raised intersection reinforces the all-way stop.

Turning vehicles must round the corner with one set of wheels on the hump.

down in the intersection area or risk a serious jolt to car and driver. Because the incidence of death or serious injury as a result of being hit by a vehicle decreases exponentially as speed is reduced, we infer that the slow vehicle speeds the raised intersection requires, greatly reduces the potential for serious injury to pedestrians at and near this intersection.

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BOULDER, COLORADO

CASE STUDY NO. 59

Woonerf-Style Developments

PROBLEM

There was a need to create residential neighborhoods that supported pedestrian activity.

BACKGROUND

Many residential developments built in Boulder and throughout the United States during the 1960s and 1970s were constructed with wide streets, deep building setbacks, and with low-density housing, conditions that allow vehicles to travel at fast speeds through neighborhoods and discourage pedestrian activity. However, in the mid-1980s, two moderate-income housing developments were built in Boulder based upon the Dutch woonerf, or "living street." Both were built by Wonderland Hill Development Company and consisted of loop streets connecting dense, condominium-style housing. The Cottages was built first. It was solely a product of Wonderland Hill. Bridgewalk was built later in conjunction with the Boulder Housing Authority.

Jim Leach, an engineer and President of Wonderland Hills Development Corporation, says that when designing projects he tries to ensure that "the car doesn't have a negative impact on the neighborhood." He incorporated the woonerf framework within the design of these two housing projects. The lanes through each of these housing developments are fairly narrow concrete surfaces bordered by landscaping and bollards to provide an edge. The streets meander back and forth to encourage slow speeds, making conditions safer for pedestrians. In each case, the housing is at moderate densities (seven units per acre in The Cottages).

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center.

SOLUTION

The Cottages, built in 1983, consists of a single lane that loops in a half circle from Utica Avenue. It is located within three blocks of Boulder's Foothills Park and includes 40 units of owner-occupied, moderate income housing. The sidewalk along Utica remains level across both branches of Cottage Lane so drivers entering the

The narrow street and landscaping of The Cottages development encourage slow vehicle speeds.

The curves in Walden Circle were designed to slow vehicles traveling through the Bridgewalk development.

development must drive up an incline. This is intended to give the perception of entering a calmed environment. Slow vehicle speeds are encouraged because the street is fairly short and curves slightly.

Bridgewalk, built in 1986, is significantly larger than The Cottages, with 123 rental units. Its street, Walden Circle, is a loop attached to Tantra Drive with a short extension. Because of the project's proximity to large parks and a planned office building, it was intended to be pedestrian-oriented while also functioning as a neighborhood with a sense of community. The design also prevents cut-through traffic.

RESULTS

Bridgewalk has had some difficulties with the street design over the last dozen years. The concrete bollards were built in such a way that when vehicles (usually moving vans) hit and crack them, the concrete surface of the roadway also cracks. Finally, unlike European woonerfs, where the shared pedestrian/vehicle space becomes the primary area for residents to play and relax, Bridgewalk included backyards, a pond, porches, and other areas for people to congregate. As a result, the shared automobile/pedestrian space tends to be used almost exclusively by cars. Finally, Walden Circle is fairly long in circumference and there are some portions that are relatively straight and free of obstructions. In these areas drivers naturally accelerate and the managers of Bridgewalk are considering the installation of speed bumps to deal with excessive speeds.

The dense housing and narrow streets of the Bridgewalk development are intended to encourage pedestrian activity and create a tight-knit community.

In the past 10 years, there was only one reported crash on Cottage Lane and one reported crash on Walden Circle. Neither of these collisions involved pedestrians. Despite some difficulties, both of these developments create the feeling of a tight-knit community and provide some guidance for future woonerf-style projects. Marty Frick, Project Director of the Boulder Housing Authority during the construction of Bridgewalk, said that the use of woonerfs in developments must be well thought out. She felt that the provision of sufficient parking space was essential, as was creating some walking areas that are distinguished by the pavement color or texture. Roger Lewis, of Diversified Properties, which manages Bridgewalk, said that the landscaping improvements over the past decade have shown that creating an edge is essential in a project without curb and gutter. Finally, Jim Leach of the Wonderland Hill Development Company feels that for these types of projects to work, it is essential that cities have flexible standards to allow site-specific variation and innovations.

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ASHEVILLE, NORTH CAROLINA | CASE STUDY NO. 60

Wall Street Revitalization

PROBLEM

The city was looking for ways to revitalize its aging downtown and take advantage of an alley behind a major commercial street that was already evolving into a pedestrian-friendly space with both retail and commercial orientations.

BACKGROUND

Wall Street in downtown Asheville, North Carolina, located between Otis Street and Battery Park Avenue, originated as a delivery alley, servicing the backs of the buildings facing Patton Avenue. It is one block long with a sharp bend on the east end and was opened to through traffic in the first part of the 20th Century. During the second half of the 20th Century, Wall Street became home to several businesses and developed a reputation as an entertainment enclave. The narrow street and human scale supported one-way motor vehicle traffic traveling at slow speeds and Wall Street gained a pedestrian-friendly reputation. However, the aesthetic ambience was defined more by its life as an aging alley than as a charming urban enclave.

SOLUTION

The mid-1980s and revitalization of the buildings on Patton Avenue and Wall Street led the comeback. A downtown-wide emphasis was placed on preserving Asheville's historic and architecturally significant buildings. A development company specializing in historic renovation rehabilitated the buildings fronting Wall Street as well as the facades facing Patton Avenue and College Street. The developer raised $3.6 million for the project and the City appropriated $450,000 for landscaping, street and sidewalk improvements as well as a pedestrian pass-through to connect Wall Street with Patton Avenue and College Street.

Prepared by Laurie Actman, Patrick McMahon, and Henry Renski, University of North Carolina Highway Safety Research Center and Christy Edwards, City of Asheville, NC and Leslie Anderson, Leslie Anderson Consulting, Inc., Asheville, NC.

Glave Newman Anderson Architects.

The redevelopment of buildings along the street began in 1986. A streetscape plan was adopted, which led to the complete resurfacing of the streets with cobblestone paving, placing electric service and wires underground,

and providing new storm drainage system. Sidewalks, brick paved areas, historic era streetlights, benches, and landscaping were installed shortly thereafter.

In addition, the historic wall of Wall Street, which collapsed during construction, was repaired and replaced. The final stage of Wall Street's evolution was construction of a parking garage at the end of the street, giving easy walking access for patrons of the businesses on the street.

Upon request of Wall Street's merchants metered on-street parking was added in 1993 on one side of the street, helping to lower driving speeds and making the street accessible to more visitors.

RESULTS

The grand re-opening of Wall Street occurred in 1988 featuring approximately 6417 m2 (69,000 ft2) of retail shops and restaurants at street level and additional office space on the upper levels of the buildings. Wall Street is now a charming shopping district, catering to locals and tourists alike.

Wall Street continues to have a friendly pedestrian environment. It averages 402 ADT, with an average vehicle speed consistently below 32 km/h (20 mi/h). The street is home to many unique shops, restaurants, an outdoor climbing wall which was placed by a merchant on the parking deck with the City's permission, and a church. A section of Asheville's Urban Trail interpreting Wall Street's history was added in 2000.

Its quaintness attracts heavy pedestrian traffic, making Wall Street a popular shopping and dining destination in downtown Asheville. "Wall Street is truly one of downtown Asheville's gems," stated Leisa Barnette, Executive Director of the Asheville Downtown Association. "On any given day, the street is crowded with locals and tourists alike making it a great people watching spot and simply a wonderful place to be."

The physical characteristics of the street that are conducive to slow automobile speeds combined with the pedestrian friendly streetscape elements enable Wall Street to prosper.

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Church Street Marketplace

PROBLEM

The City of Burlington wanted to create a commercially viable center of pedestrian activity in the downtown area.

BACKGROUND

What began as a one-day experiment blossomed into one of the most successful and widely emulated urban pedestrian malls in the country. The redevelopment of the downtown area that eventually included the Church Street Marketplace began in the years of urban renewal projects in the 1950s and 1960s. Burlington,VT sought to revitalize its downtown area during this time.

SOLUTION

In January 1959, major urban renewal projects were approved for downtown Burlington and two through streets were permanently closed. In July 1970, the business community hosted a one-day street fair on Church Street to explore the feasibility of a multi-block, open-air pedestrian mall in the heart of the city. An estimated 15,000+ people took part in the day's festivities. A second midsummer street fair the following year was a full week long, entailed traffic rerouting, increased public transportation, and created outdoor retail displays, and temporary aesthetic enhancements on Church Street. The fair attracted 50,000 people downtown.

In 1976, the City of Burlington received $1.6 million from the federal government for the construction of a 400-space parking garage near Church Street. Burlington was awarded design and planning money after being chosen as an auto-restricted zone demonstration site by the Urban Mass Transit Administration (UMTA), which is now called the Federal Transit Administration. The city turned down the funding, partly because stipulations attached to it would have required the city to repeat a significant portion of the planning that had already been completed. In a series of actions during 1978-1979, Burlington officials appealed to UMTA, the U.S. Environmental Protection Agency, Housing and Urban Development Agency, and Heritage Conservation and Recreation Service for financial support for a mall concept. The name "Church Street Marketplace" was chosen. A new, one-level mall design was unveiled and in May 1979, the Church Street Steering Committee applied to UMTA for a $5.4 million grant. The grant was awarded in June.

Prepared by Ron Redmond, Executive Director, Church Street Marketplace.

In a special election in August, city voters approved the creation of the Church Street Marketplace District and Commission, but failed by the slimmest of margins to pass a $1.5 million bond issue with the required two-thirds of the vote. The bond issue was needed to fund the city's share of the Marketplace construction costs. Acting on what appeared to be increasing public support, Mayor Paquette asked for another election and, in October, voters passed the bond issue with the required two-thirds majority. In 1980, the Church Street Mar-

ketplace Commission was formed in January. In March, the Marketplace Commission approved the final plans for Church Street.

Construction of the Church Street Marketplace pedestrian mall began. Simultaneous with the startup of construction, CCTA bus routes through the city center were also rerouted.

The Church Street Marketplace opened in September, 1981, as a culmination of a 10-year collaborative effort between Burlington's business community, City Hall, city residents, and the State and national governments.

RESULTS

The Church Street Marketplace has been called "the gem in the crown" of Burlington. Framed by two National Registry historic districts, this four-block jewel in the heart of the city has recently celebrated its Emerald Anniversary, marking 20 years as a nationwide role model for downtown development.

Today, more than 20 years after its completion in September 1981, the original vision has become an exciting reality that is a touchstone for downtown redevelopment nationwide. The Marketplace draws 3 million visitors to downtown Burlington each year, fueling the City's economic engine and effectively meeting the challenge of suburban "sprawl" that threatens to damage precious natural environment and the vitality and livability of our downtown centers.

Both the Church Street Marketplace and the City of Burlington have consistently garnered nationwide acclaim for quality, both in the form of awards and of citations in national media. Burlington has been listed near the top of a wide range of "Top Ten Cities" lists in recent years—and the community's vibrant downtown and its centerpiece pedestrian Marketplace are frequently cited for their essential roles in making Burlington distinctive. Some examples of the acclaim the City of Burlington has received are listed below.

June, 1988—Tied for first place as Most Liveable City by U.S. Conference of Mayors for populations under 100,000 (Portland, OR for larger cities.)

June, 1991—Voted "Best in the Northeast" by *Inc. Magazine* as one of the top five cities in the nation in which to grow a successful business.

June, 1993—Burlington rates as the best place in the nation for raising children in a report released by Zero Population Growth.

1995—The book A Good Place to Live touts Burlington as one of the fourteen most livable cities in the United States.

April, 1997—Burlington receives the prestigious Great American Main Street Award from the National Trust for Historic Preservation. The unique collaboration between the government, business community, and private citizens that led to the rejuvenation of Church Street and the development of the Marketplace is central to the city's being honored.

1997—Burlington is one of 10 great places to raise a family according to the magazine *Parenting*.

1997—One of the 25 Most Livable Cities in America (with populations under 100,000) by U.S. Conference of Mayors.

May, 1998—Cited "one of 15 Best Walking Cities in America" by *Walking Magazine*.

May/June, 2000—One of the "50 Best Places to Live," *Maturity Magazine*.

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Pedestrian Countdown Signals (1 OF 2)

PROBLEM

Confusion and conflict between pedestrians and motorists existed at intersections with high pedestrian volumes.

BACKGROUND

The City of Monterey has a downtown area that experiences a high volume of pedestrian activity. Some of the intersections in the city are also rather large and create large distances for pedestrians to cross. Accidents had not been an abundant concern, but confusion and conflicts between pedestrians and motorists were a common problem during periods of high pedestrian traffic.

Countdown signals show pedestrians how many seconds of crossing time remain.

SOLUTION

The City of Monterey decided to take advantage of an experimental program by the Federal Highway Administration to test pedestrian countdown signals at selected intersections. The new experimental device was designed to enhance the effectiveness of pedestrian signals to clear the crosswalk before the signals changed.

Initially, two intersections were chosen for the experimental pedestrian signal countdown. These were Del Monte Avenue at Washington Street and Del Monte Avenue at Figueroa Street. The first intersection has an extraordinarily long crosswalk that is 38 m (124 ft) long. It also serves as an access between the downtown area and the Monterey Recreational Trail, a Rails-to-Trails project. The existing median on Del Monte Avenue provides a good refuge area with a pedestrian push button to activate pedestrian signals.

The crosswalk at the intersection of Del Monte Avenue and Figueroa Street is 32 m (105 ft) across and guides pedestrians between the downtown area and the commercial fishing wharf. The Monterey Recreational Trail can also be accessed at this intersection. Both of the intersections had the minimum amount of crossing time allotted to the signal, making them good candidates for a signal countdown.

The first two signal countdowns were installed in early 1999. A study of pedestrian and motorist behavior in response to the new device was conducted shortly after installation.

RESULTS

Since the conclusion of this study, seven more intersections were equipped with the devices. A study of the pedestrian and motorist responses to the signal countdown was performed by Dessau-Soprin, Inc. for the City of Monterey. Previous studies indicated that a large number of pedestrians began crossing during the flashing "don't walk" phase and become caught in the crosswalk when the solid "don't walk" indication lights up. After observing pedestrians using the crosswalk

Prepared by Dessau-Soprin, Inc. and Rich Deal, City of Monterey.

locations with the new signal countdown, most pedestrians that arrived at the intersection with less than 10 s showing on the countdown at Washington/Del Monte and less than 6-7 s at Figueroa/Del Monte did not initiate crossing and decided to wait for the next phase to come up. Of these pedestrians, the majority were seniors (13 percent) and adults (83 percent).

Another purpose of the countdown device is to invite pedestrians to stop on the median refuge strip and wait for the next phase if they find the time left to be too short to finish crossing. This behavior was observed 28 times during the study observation. However, most of them did not wait for the next pedestrian phase to walk the remaining distance and crossed as soon as there was a sufficient gap in the flow of traffic. Very few people either got caught in the crosswalk with no time left (2 percent) or showed no concern for the pedestrian signal indication.

Most people misinterpret the meaning of the flashing hand of the signal. According to previous studies, most people think that it means to hurry up or to turn back to the sidewalk, instead of not to initiate crossing if not already in the crosswalk. Of those pedestrians interviewed, 87 percent said that having the pedestrian countdown device helped in understanding the pedestrian signals.

The results of the study indicate that pedestrian countdown signals do not represent any significant safety hazards. The countdown signal did not prevent pedestrians from initiating a crossing at the beginning of the clearance interval any more than conventional signals; however, it was successful in discouraging some pedestrians from crossing with few seconds left. This would not have been possible with conventional signals. The countdown feature also demonstrated benefits in encouraging pedestrians to wait on the median refuge for the next phase or accelerate their pace when time was running out, preventing them from being stranded in the middle of the crosswalk.

From this study, some guidelines were outlined for the future implementation of pedestrian signal countdown devices. The following situations would justify the use of this device:

- Any crosswalk requiring a clearance interval of more than 15 seconds.
- The following circumstances may justify the use of signal countdowns even if the interval is less than 15 seconds.
- High pedestrian volume.
- High levels of vehicular traffic presenting hazardous pedestrian crossing.
- High percentage of pedestrians with walking disabilities and/or senior citizens, for example near health centers, hospitals, and retirement communities.
- School zones.

Monterey's countdown signals have been successful in discouraging some pedestrians from crossing with only a few seconds left in the phase.

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Pedestrian Countdown Signals (2 OF 2)

PROBLEM

Pedestrian and vehicle conflicts were occurring almost daily at several intersections in San Francisco.

BACKGROUND

The City and County of San Francisco, along with other cities around the country, has been concerned about pedestrian safety at intersections in the City. The City is home to a bustling pedestrian-scaled landscape where thousands walk to work, shopping, dining, and other activities. The thousands of tourists that come to San Francisco each year increase the number of people walking in the City. After a time when pedestrian conflicts with cars were occurring almost on a daily basis, the City's Department of Parking and Traffic looked into ways to increase the safety of pedestrian crossings at signalized intersections.

Pedestrian interviewees found the countdown signals helpful in understanding the amount of time left for crossing.

Information provided and contributions made by DKS Associates and Frank Markowitz, Department of Parking and Traffic, City and County of San Francisco.

SOLUTION

San Francisco Department of Parking and Traffic (DPT) is currently conducting a test of pedestrian countdown signals citywide. The pilot program involves 14 intersections, with a range of physical and socio-cultural environments. Installation began in late March 2001. As of June, installation had been completed at nine intersections. Two were added in August 2001. The remaining three locations were to be installed in fall 2001 under a City and County of San Francisco signal modification contract.

The California State Auto Association (CSAA) is the primary funding entity of the pilot program and also is taking responsibility for installation and maintenance at 10 intersections. CSAA also assisted with public information, and the organization is working on a video and Public Service Announcement about pedestrian intersection safety, which will address countdown signals.

As a condition of CTCDC and FHWA approval, DPT was required to do an evaluation of the effectiveness of the countdown signals (CDS). DPT did substantial pre-

Pedestrian countdown signal heads show the time remaining for each phase.

installation and post-installation data collection regarding pedestrian behavior and attitudes, as well as driver behavior. Data collection was performed by DPT employees, primarily college student interns, under the direction of DPT professional staff. With assistance from the Metropolitan Transportation Commission (MTC), the consulting firm of DKS Associates was retained to perform the evaluation. This case study is a brief summary of their preliminary evaluation. A more extensive evaluation is expected to take place 6 to 12 months after installation.

RESULTS

"Before and after" comparisons may have been affected by seasonal factors and field crew differences that were impossible to avoid. The pre-installation data collection was chiefly done in May 2001, while schools were still in session, while post-installation data collection was primarily done in June and July 2001, during peak vacation periods. Changes in the proportion of students and tourists at some intersections could have influenced the results. It was also not possible to use the same personnel for pre- and post-installation field work, and results could be affected by differences in field workers' interview style and attentiveness.

PEDESTRIAN CROSSING BEHAVIOR

The most important findings of the study are the following:

- The percentage of pedestrians still in the crosswalk when the signal turned red showed a statistically significant decrease after CDS installation.
- The percentage of pedestrians leaving during the Flashing Red Hand decreased slightly.
- The percentage of pedestrians running or aborting their crossings showed a statistically significant decrease.
- The percentage of observed vehicle/pedestrian conflicts decreased.

Each of these results is positive. While it is too soon to make a statistical analysis of improved pedestrian safety resulting from these behavioral results, it is reasonable to conclude that the number of pedestrian collisions is likely to decrease.

The number of pedestrians who finished crossing on red dropped from 14 percent to 9 percent at eight observed intersections. This result is due mostly to walkers hurrying across (more often finishing on the yellow), rather than being more compliant with pedestrian signals. There was little change in when pedestrians started crossing. There was a slight decrease in pedestrians starting to cross during the flashing red hand (flashing DON'T WALK) and a similar, slight increase in pedestrians crossing during the solid red hand.

The proportion running or aborting their crossing significantly decreased, dropping from combined 13 percent to 8 percent. Observed vehicle/pedestrian conflicts also dropped from 6 percent to 4 percent of pedestrians. The latter is consistent with separate set of observations of vehicle/pedestrian conflicts, showing a reduction in the proportion of motorists in conflict with pedestrians.

Data collection was complicated by the change in pedestrian signal timing that accompanied countdown signal installation. San Francisco is gradually changing signal timing so that the solid red hand begins at the start of the yellow vehicle indication, rather than at the end of the yellow, as has been the historic practice. However, this change was taken into account in data analysis.

Pedestrian behavior findings varied significantly depending on location. This could have been due to actual differences--due to different walking populations and different physical environment--or to unintentional changes in data collection procedures.

PEDESTRIAN INTERVIEWS

Interviewees finding pedestrian signals "very helpful" increased substantially with the countdown signals—only 34 percent with conventional signals, but 78 percent with countdown signals. About 92 percent of post-installation interviewees explicitly said the countdown signals were "more helpful" than conventional pedestrian signals, primarily because they showed the time remaining to cross. This is consistent with recent FHWA research that showed that a pedestrian sample strongly preferred the countdown signal to actual and theoretical versions of pedestrian signals, and that the countdown version was "most easily understood." Only 6 percent said the conventional pedestrian signal was more helpful. In these few cases, one likely reason was the decreased size and clarity of the walking person/red hand symbol.

Also, 82 percent of post-installation interviewees had noticed the countdown signals before the interview started. Some 69 percent said they were crossing differently. Few (17 percent) understood that it is a violation of the vehicle code to start crossing during the countdown (flashing red hand). This compares to 40 percent in the pre-installation study. This suggests that pedestrians are using the countdown signals to decide when to

start to cross, which is not its official purpose in San Francisco. Also, it underscores that a substantial proportion of pedestrians do not understand pedestrian signals.

These figures illustrate the confusion that exists nationally about the meaning of the flashing red hand as documented in a recent ITE study. The City and County of San Francisco urges further study of the flashing red hand, comparing its use in the U.S. and abroad, as well as pedestrian attitudes. While the understanding of the meaning of the flashing red hand is a concern, the City and County of San Francisco believes that the behavioral improvements brought about by the countdown signals outweigh the issue of whether pedestrians understand the legal interpretation of the flashing red hand. The finding that, behaviorally, pedestrians are not more likely to leave the curb during the flashing red hand is especially important in this regard.

Interview findings were extremely consistent across all locations. For example, at all nine intersections, at least 87 percent of respondents stated that the countdown signals were "more helpful" than conventional pedestrian signals.

DRIVER BEHAVIOR

There was a small decrease in the reported incidence of red light running (drivers entering the intersection on red), from 2 percent to 1 percent (not statistically significant). A less important finding was a slight decrease in drivers finishing crossing the intersection on the red reported after CDS installation.

A more rigorous study of driver behavior and human factors in Monterey found that unsafe driver behavior was not a problem, although concerns have been raised that drivers will use the countdown to decide whether to speed up on a "stale green." The Monterey study found that by the time drivers could see and interpret the countdown signal, it would be generally too late for them to change their behavior.

GUIDELINES FOR HIGH PRIORITY LOCATIONS

The impact at different intersections needs to be compared in order to identify at which locations, the devices are most effective. DKS Associates suggested that the highest priority should be for the following type of intersections:

- Those that are over four traffic lanes wide.
- Those that provide relatively short crossing times relative to the street width.
- Those that have high pedestrian volumes.
- Those that are ranked high in pedestrian collisions over the last five years.

NEXT STEPS

With California's energy crisis, San Francisco and other cities face major financial incentives to replace existing traffic and pedestrian signals with more energy-efficient LED (Light Emitting Diode) versions. Since there are LED countdown signals available, this presents an opportunity to change to countdown signals at many or most signalized intersections with no incremental cost. In fact, the incremental cost is roughly $1,000 per intersection ($130 per signal head) for countdown versus conventional LED pedestrian signals, which can be absorbed from in-kind state grant and County sales tax funds. Therefore, San Francisco seeks permission to expand the countdown signal experiment to all locations with existing or planned pedestrian signals, with the exception of narrow streets of less than 12.2 m (40 ft) between curbs or possibly a very few industrial locations with minimal pedestrian volumes.

San Francisco will continue and expand the countdown signal evaluation.This will also be useful in determining how effective the devices are when they are so widespread that there is no novelty factor. This case study is a preliminary evaluation of San Francisco's pedestrian signal countdown program.

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Animated Eyes Signal

PROBLEM

Pedestrians are placed at risk when the motorist's view of them is blocked by parked cars, other motorists exhibiting pedestrian-safe driving behavior, or the architectural elements of buildings at the exits of parking garages or retail services.

BACKGROUND

Visual screening is particularly problematic in urban areas. At least four screening settings are typical, including the following situations:

- A pedestrian crossing point along a multilane roadway when a motorist yields to crossing pedestrians at a point very close to the crosswalk, and screens the pedestrian from motorists in other lanes traveling in the same direction.
- Where parked cars along a roadway screen pedestrians preparing to cross the street.
- Where structural supports or walls at the exits of indoor parking garages screen pedestrians using sidewalks in front of the exit.
- At exits for retail drive-throughs, such as at fast-food restaurants, banks or pharmacies.

Hunter, Stutts, Pein, and Cox (1996) reported that nearly 1 in 7 pedestrian crashes (in a population based sample drawn from California, Florida, Maryland, North Carolina and Utah) occurred on private property, most often in a commercial or other parking lot. The exits of parking garages and retail drive-throughs are particularly dangerous because at these locations it is often difficult for exiting motorists to see pedestrians using the sidewalk that crosses the exit. Visual screening is also a major contributing cause to pedestrians crashes on multilane roads where the vehicle yielding to the pedestrian can block motorists in other lanes from seeing the pedestrian in the crosswalk. These situations are often referred to as multiple threat locations for pedestrians.

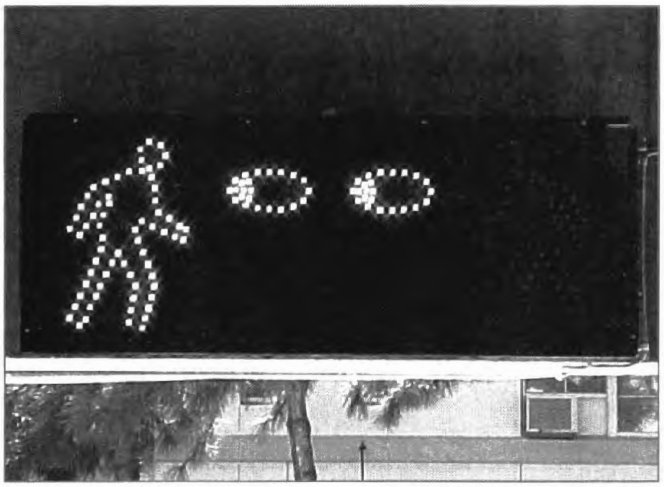
Prepared by Ron Van Houten, Ph.D., Center for Education and Research in Safety, Dartmouth, Nova Scotia.

SOLUTION

One way to alert motorists to the presence of a pedestrian who may be screened is the use a Light Emitting Diode (LED) electronic sign that shows the direction from which the pedestrian is crossing and prompts the motorists to look in that direction before proceeding. To determine the effectiveness of this type of Intelligent Transportation System (ITS) technology, an LED sign that included animated eyes and pedestrian icons was evaluated at two locations--a mid-block crosswalk and an exit ramp of a structured parking garage.

The study was funded by the Transportation Research Board of the National Academy of Sciences (USA), using $100,000 from its Intelligent Transportation Systems IDEA program.

Study locations included a mid-block crossing of Central Avenue, a two-way four lane arterial and a parking garage exit in St. Petersburg. The garage exit crossed a sidewalk providing access to Third Street, a four lane, one-way street. Posted speed limits on both of these streets was 48 km/h (30 mi/h) and traffic volumes were classified as high. Pedestrian crossing activity at the mid-block site was approximately 70 per hour. The focus of the study was to evaluate the effectiveness of the animated-eyes sign at reducing the number of pedestrian/motor vehicle conflicts by 1) alerting motorists to the presence of pedestrians crossing in front of them; 2) indicating the direction the pedestrian is crossing; and 3) prompting them to look for the pedestrians.



Illuminated eyes look back and forth at a rate of 1 cycle per second; the illuminated pedestrian icon (right, left or both) indicates from which direction(s) pedestrians are approaching.

The sign used a pair of animated 'eyes' positioned between two pedestrian symbols for two purposes. Directional microwave derectors were used to detect the presence and travel direction of pedestrians. The eyes prompt the motorist to look for the pedestrian about to cross in front of their vehicle and provide a reference point for locating the pedestrian.

When a pedestrian approaches from the right, a LED pedestrian symbol is displayed on the right side of the eyes. When a pedestrian approaches from the left, a mirror image pedestrian symbol is displayed on the left side of the eyes. When a pedestrian was detected approaching from only one side, the icon on that side was illuminated and the eyes looked back and forth at a rate of 1 cycle per second. When pedestrians were detected approaching from both sides, both pedestrian icons were illuminated.

The garage LED electronic sign was mounted in the lower portion of the concrete header wall just above the sidewalk. The mid-block signs were mounted over the lane line in each direction on two span wires with a downward angle of five degrees. Yellow flashing beacons were installed next to the electronic sign in order to allow a comparison of the two treatments at the same site.

RESULTS

The LED electronic sign significantly increased yielding at both locations and was associated with reduced conflicts. Before the electronic 'eyes' were installed, less than 21 percent of drivers yielded to pedestrians in all but one of eleven observation periods, with some periods as low as 5 percent. In the nine observation periods after installation of the 'eyes,' between 50 and 70 percent of drivers yielded. Further, the animated eyes were consistently more effective at increasing motorist yield rates than a flashing yellow beacon—62 percent of drivers yielded to the LED, while only 36 percent of motorists yielded to beacon.

A formal study of user opinion about the technology was not conducted, however informal comments gathered by the data collectors and local officials garnered only positive reactions and no complaints. After examining study results, local authorities in both study locations opted to keep the LED signs in place after the study was concluded. Eventually, the 'eyes' at the mid-block location were removed because a bus stop generating the pedestrian crossings was relocated, however the city is actively considering other locations for installation of the "animated eyes."

Follow-up data, collected one year after the ITS "animated eyes" sign was installed, show no reduction in treatment effectiveness. These data are currently being replicated at a number of additional sites.

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REFERENCES

Hunter, W.W., Stutts, J.C., Pein, W.E., and Cox, C.L. (1996). "Pedestrian and bicycle crash types of the early 1990's." FHWA-RD-95-163. Washington, DC: U.S. Department of Transportation.

Van Houten, R. & Malenfant, J.E.L. (in press). ITS Animated LED Signals Alert Drivers to Pedestrian Threats, ITE Journal.

Zegeer, C.V., Stewart, J.R., & Huang, H. (In press). Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Analysis of Pedestrian Crashes in 30 Cities. Transportation Research Record.

ORLANDO, FLORIDA **CASE STUDY NO. 65**

Leading Pedestrian Interval (1 OF 2)

PROBLEM

The intersection of South Street and Orange Avenue in Downtown Orlando experienced a relatively high incidence of pedestrian/motorist conflicts.

BACKGROUND

Right-turn-on-red maneuvers made by motorists were particularly dangerous for pedestrians crossing an intersection. The intersection of South Street and Orange Avenue in Downtown Orlando experienced a relatively high incidence of pedestrian/motorist conflicts, especially after a municipal parking facility was relocated away from municipal buildings. A new office tower being constructed on the old parking lot site, and many municipal workers parked at a parking facility 0.4 km (0.25 mi) away. The walk to municipal offices required the crossing of the intersection of South and Orange.

A leading pedestrian interval at the intersection of South Street and Orange Avenue gives pedestrians a 4 second head start in crossing.

Information provided and contributions made by Ken Stygerwal, Tommy Holland, and Bob Faris, City of Orlando.

The increase of pedestrian traffic through this intersection and the occurrence of a pedestrian accident in the crosswalk in 1997 prompted the City to examine the operation of the traffic signal to improve pedestrian safety.

SOLUTION

The intersection of South Street and Orange Avenue in Downtown Orlando was the site for what is called a leading pedestrian interval. At a cost of only hundreds of dollars and taking only 2 hrs to install, the leading pedestrian interval was simply a change in signal phasing that allowed for a pedestrian phase to begin 4 s before the green phase for motor vehicle traffic. This allowed pedestrians a head start to cross in the crosswalk of the intersection. It provided significant visibility to those crossing, gave extra time for pedestrians to cross, and alerted motorists to the existence of pedestrians in the crosswalk. An illuminated sign was installed on the overhead signal post reminding motorists to "yield to peds" in the crosswalk while the signal was green. When the signal was red, the sign changed to read "no turn on red" to prevent pedestrian collisions from this action.

With the 4 second lead time given by the leading pedestrian interval, pedestrians are able to cross part of the intersection before vehicles begin turning.

The extra time for the pedestrian phase was gained from the introduction of a third signal phase at that particular intersection. The intersection was operating on two phases, and a third 6-second phase was added in order to accommodate the additional pedestrian walk time while all other approaches were red. The walk signal is maintained as the green phase begins for motorists.

RESULTS

Although the primary impetus for the introduction of the leading pedestrian interval was due to a highly publicized accident involving a municipal employee, a review of pedestrian accidents reveals no decrease since the new signal phase began operating in 1998. Accident rates remain unchanged at this intersection.

The new signal phase enhances the visibility of pedestrians crossing in the crosswalk and alerts motorists to the existence of pedestrians in their right-of-way as they cross the busy intersection. City staff note that, because of the reduction in pedestrian/auto conflicts, the leading pedestrian interval has also improved the vehicular level of service despite the decrease in green time for vehicles. Both motorists and pedestrians alike became accustomed to the new situation rather quickly, and both groups seem to be undisturbed by the new signal operation. Pedestrians benefit from the increased safety and visibility the new signal phase provides.

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Leading Pedestrian Interval (2 OF 2)

PROBLEM

At signalized intersections, right and left turning vehicles present a danger to pedestrians crossing during the WALK interval, and crash statistics show that pedestrians are especially vulnerable to left turning vehicles (left turning vehicles are overrepresented in pedestrian crashes).

BACKGROUND

One practical solution to this problem is to program the traffic signals to allow the pedestrian to begin crossing before the vehicle traffic on the parallel street is given the green light. This is commonly referred to as a leading pedestrian interval (LPI). One of the most effective ways to decrease crashes that involve motor vehicles and pedestrians is to separate them in time. Pedestrians and motor vehicles can be separated in time by providing a leading pedestrian interval, which permits pedestrians to gain a head start before turning vehicles are released.

Research has shown that this treatment is associated with a decrease in pedestrian/motor vehicle conflicts and an increase in the percentage of motorists that yield right of way to pedestrians. This study examined the influence of a three-second LPI on pedestrian behavior and conflicts with turning vehicles (Van Houten, Retting, Farmer, Van Houten, & Malenfant, 2000).

SOLUTION

A leading pedestrian interval was created for study at three signalized intersections in downtown St. Petersburg, Florida where pedestrian crossings occurred at the average rate of 60 per hour. To insure unbiased results no public outreach or awareness was conducted prior to execution of the study. The Insurance Institute for Highway Safety funded the study at cost of $30,000.

In order to collect baseline data, prior to the installation of the LPI, each intersection was configured to provide simultaneous onset of the WALK signal and GREEN phase for turning vehicles. During the experiment the LPI was installed to release pedestrians 3 seconds ahead of turning vehicles by extending the duration of the all red signal phase by three seconds. Sites 1 and 2 were each at intersections where one street carried four lanes of one-way traffic and the other two-way traffic (two lanes in each direction), while site 3 was an intersection where both streets carried two-way traffic (each street had a total of 4 lanes). These streets had 30 mph (48 kph) posted speed limits and carried high volumes of traffic.

Observers collected data on three items: a) pedestrian/motor vehicle conflicts, b) pedestrians beginning to cross during the five second period at the start of the WALK interval, and c) pedestrians starting to cross during the remainder of the WALK interval. They also noted the percentage of pedestrians yielding right of

Pedestrians are given a WALK signal three seconds before parallel traffic is given a green light.

Prepared by Ron Van Houten, Ph.D., Center for Education and Research in Safety, Dartmouth, Nova Scotia.

way to turning vehicles and the number of half-lanes traversed by the lead pedestrian during the 3 seconds the LPI was in effect. Data were collected separately for pedestrians 65 and older at all three sites.

RESULTS

Following the introduction of the LPI, conflicts were virtually eliminated for pedestrians departing during the start of the WALK interval. There were 44 total pre treatment observation periods at all three sites. During each of these sessions, the sites averaged between 2 and 3 conflicts per 100 pedestrians, with some periods having up to 5 conflicts per 100 pedestrians. After the LPI was installed, 34 of the 41 sessions had no conflicts, and no session had more than 2 conflicts per 100 pedestrians.

This effect held up for senior citizens and non seniors alike. There was also a smaller reduction in conflicts during the remainder of the WALK interval. This reduction was likely the result of pedestrians claiming the right-of-way during the earlier portion of the WALK interval. The percentage of pedestrians yielding to vehicles also declined following the introduction of the LPI, and data showed that pedestrians tended to cross more lanes during the 3 second LPI the longer the intervention was in effect. This was likely the result of regular users discerning the presence of the LPI and modifying their behavior to utilize it to the fullest extent possible.

Over a period of four months at these three sites, no reduction in intersection effectiveness for motor vehicles was detected. Moreover, local authorities opted to retain the LPI in places where the range of permitted turning movements governed by the signal cycles allows safe use of the LPI. This intervention was shown to increase pedestrian safety and improve pedestrian com fort and perceived safety levels as well.

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REFERENCES

Van Houten, R., Retting, R.A., Farmer, C.M., Van Houten, J. & Malenfant, J.E.L. (2000).
Field evaluation of a leading pedestrian interval signal phase at three urban Intersections.
Transportation Research Record. No 1734, p. 86–91. National Academy Press.

Red Light Camera Enforcement

PROBLEM

A high number of red light violation crashes were occurring at several city intersections.

BACKGROUND

Across the country, cities have begun to tackle the problem of red light running from a technological perspective. Red light running has been the cause of numerous fatal accidents involving motorists, passengers, bicyclists, and pedestrians. In fact, these accidents often have a higher chance of being fatal due to the fact that the running vehicles are more likely to be traveling at high speeds to race through the intersection. The City of Boulder began to address the issue in 1998 after recording a high number of accidents at some of the city's intersections.

SOLUTION

Since August 1998, the city of Boulder has been using photo enforcement technology to enforce traffic laws and improve safety at a few designated signalized intersections. Camera housing costs between $10K and $20K depending on site specifics. The Cameras Rent for about $2,350 plus another $375 for field maintenance. The city program for red light running includes four photo red light cameras. The photo red light cameras have been in operation since August 1998.

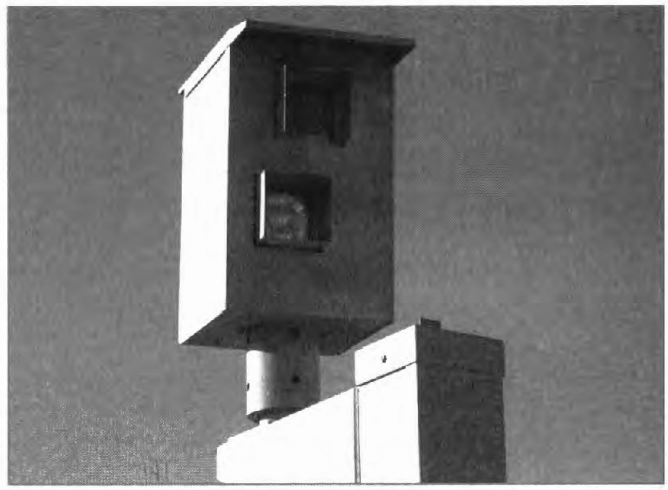
The Photo red light cameras were intially located at the following intersections:

- Arapahoe Avenue/28th Street Westbound.
- Arapahoe Avenue/28th Street Southbound.
- Valmont Road/47th Street Westbound.
- Table Mesa Drive/Foothills Parkway West Ramp Westbound.

Two additional intersections were added in 2001:

- 28th Street/Canyon Boulevard Northbound.
- 28th Street/Canyon Boulevard Southbound.

Prepared by Bill Cowern, Transportation Operations.



Enforcement cameras are used
for red light and speed enforcement.

RESULTS

In the thirty months since its inception, the program has demonstrated substantial benefit in the reduction of red light running at the four locations where it is currently deployed. In 1998, after implementation of photo red light cameras, there was an average of 69 violations daily. In 1999, there was a 9 percent reduction with an average of 62 daily red light violations. This improvement increased in 2000 with a 21 percent reduction from 1998 to 54 daily red light violations. The first quarter of 2001 shows further improvement with a 34 percent reduction from 1998 levels to an average of 45 daily violations. Table 1 summarizes these results.

Year	Average Daily Red Light Violations	Percent Reduction (to 1998)
1998	69	—
1999	62	9%
2000	54	21%
2001 (1st Quarter)	45	34%

Table 1. Photo Red Light Enforcement Program.

An intersection with camera enforcement.

Staff examined the accident history of intersection approaches using the photo red light technology. Prior to the cameras, the intersection approaches of westbound Valmont Road at 47th Street and westbound Table Mesa Drive at the Foothills Parkway off-ramp-RTD driveway both had significant accident rates associated with red light violations. Since the use of photo red light on these approaches began, the accident rates have dropped significantly at both locations. Table 2 details the average accident rates per year at these two intersection approaches before and after the use of photo red light technology.

The two intersection approaches listed in the table were chosen to have photo red light enforcement installed due to the high numbers of red light violation-related accidents that occurred there. At these two intersection approaches, red light violation accidents were reduced by between 50 percent and 75 percent. These findings are consistent with national findings on the accident reduction benefits of the photo red light technology.

The four approaches not listed in the table above are located at the intersection of 28th Street and Arapahoe Avenue and at the intersection of 29th Street and Canyon Boulevard. These approaches did not have a significant accident problem of this type prior to or during the use of the photo red light technology.

From the data presented here, the photo red light enforcement program had a significant effect of reducing the number of accidents caused by red light runners. This has a benefit to pedestrians who are more likely to sustain fatal injuries in these types of pedestrian/motor vehicle conflicts.

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Intersection Approach	Average Red Light Violation Accidents per Year		
	Before Photo Red Light	After Photo Red Light	Difference (Percentage Difference)
WB Valmont Road at 47th Street	5.8	2.7	-3.1 (-53.4%)
WB T.Mesa Drive at FHP off-ramp	5.1	1.3	-3.8 (-74.5%)

Table 2. Historic Red Light Violation Accident Statistics.

WEST HOLLYWOOD, CALIFORNIA | **CASE STUDY NO. 68**

Red Light Photo Enforcement

PROBLEM

Traffic accidents and congestion due to red light violators occurred at intersections in West Hollywood.

BACKGROUND

Many locations in West Hollywood have a large amount of pedestrian traffic. Red light running has been the cause of numerous fatal accidents involving motorists, passengers, bicyclists, and pedestrians. In fact, red light running accidents often have a higher chance of being fatal due to the fact that the running vehicles are more likely to be traveling at high speeds to race through the intersection. The City of West Hollywood began to address this problem in 1999.

Signs inform motorists of intersections where red-light photo enforcement is in place.

Information provided by Joyce Rooney, City of West Hollywood.

SOLUTION

The goal of the City's Photo Enforcement Program is to improve traffic safety and pedestrian safety in West Hollywood by increasing compliance with traffic regulations and by reducing traffic accidents and gridlock caused by red light violators. West Hollywood residents are very supportive of the public safety program and have requested specific locations for photo enforcement.

The City Council approved the photo enforcement concept in October 1998 and directed staff to prepare and issue a Request For Proposal (RFP). The Transportation and Public Safety Commissions both endorsed the concept of photo enforcement. The RFP was issued December 29, 1998 with a response deadline of January 20, 1999.

The City received a proposal from Lockheed Martin, IMS. Pursuant to California Vehicle Code 21455.5, the City Council held a public hearing and awarded the operation contract to Lockheed Martin, IMS on March 15, 1999 and approved a two-year agreement with Lockheed Martin, IMS. The City Council amended the agreement November 6, 2000 by adding cameras and intersections and extending the agreement period through June 30, 2004.

The intersections initially selected for photo enforcement included the following locations:

- Fountain Avenue at Crescent Heights Boulevard
- Sunset Boulevard at La Cienega Boulevard.
- Fountain Avenue at Fairfax Avenue.
- Melrose Avenue at La Cienega Boulevard.
- Fountain Avenue at La Brea Avenue.
- Beverly Boulevard at Robertson Boulevard.

In November 2000, the City Council amended the agreement by adding cameras at some of the intersections

Red light cameras in place at Fountain Avenue.

and also added intersection locations. Cameras at the two following locations began operating in July 2001.

- Santa Monica Boulevard and Fairfax Avenue.
- Santa Monica Boulevard and La Brea Avenue.

RESULTS

Intersection selection was determined by staff based on accident statistics, violation analysis and intersection infrastructure. Prior to the implementation of the program, baseline accident data was established as an average from the previous five years for the highest accident locations. Actual accident data through August 2000 for these same intersections shows that the accident ratio is lower for four of the locations, the same for one and higher for one. The following table shows the number of accidents recorded at each of the intersections that have had red light cameras installed. The data in Table 1 suggests that accident rates have been reduced since installation of the red light cameras at most of the intersection locations.

The West Hollywood program statistics show only about 4 percent of the citations are issued to West Hollywood residents, which indicates that the city has a large amount of through traffic. The city is small, roughly 5.7 km2 (2.2 mi2) and is surrounded by the cities of Los Angeles and Beverly Hills.

A successful photo enforcement program will see reductions in violations recorded over time. The number of actual citations issued is roughly 50 percent lower than the number of violations recorded due to technicalities, such as the driver not having a front license plate or the driver not being able to be correctly identified. Table 2 shows the percentage of violations that result in actual citations being issued. These results are comparable to other cities' experiences with red light camera enforcement programs.

Table 3 shows the number of violations recorded during two time periods, October 1999–June 2000 and October 2000–June 2001. These time periods were chosen due to irregularities in camera deployment during the other months of those years. One intersection, Sunset at La Cienega Boulevards, had irregularities during the time periods evaluated. This intersection was left out of the comparative analysis. Two other intersections, Santa Monica at La Brea and Santa Monica at Fairfax, were also not included because cameras were installed there in July 2001, and no comparative data was available to evaluate these two intersections.

Table 3 shows that at all but one analyzed location, the number of violations decreased from the first year of camera operation to the next. Overall, of the locations analyzed, there was a 15.5 percent reduction in the

	Violations Recorded	Citations Issued	Percentage Issued
June 1999-Aug 2000	39,907	18,897	47%
Sept 2000-Aug 2001	31,564	18,360	52%

Table 1. Violations and citations before and after the red light cameras were installed.

Intersection	Previous Accident Average per year	# Accidents April–August 2000	# Accidents September 2000–July 2001
Sunset/La Cienega	10	2	5
Fountain/La Brea	4	3	3
Fountain/Fairfax	6	8	4
Fountain/Crescent Heights	8	8	9
Santa Monica/La Brea	NA	1	2
Santa Monica/Fairfax	NA	1	5
Melrose/La Cienega	7	1	8
Beverly/Robertson	7	3	6

Table 2. Accidents before and after the red light cameras were installed.

Intersection	Directions Enforced	Violations Recorded October 1999-June 2000	October 2000-June 2001	Change in Violations
Fountain/La Brea	2	9,384	8,048	-14.2%
Fountain/Fairfax	3	3,685	2,498	-32.2%
Fountain/Crescent Heights	4	3,680	3,030	-17.7%
Melrose/La Cienega	3	3,771	3,869	+2.6%
Beverly/Robertson	2	3,757	3,074	-18.2%
TOTAL		24,277	20,519	-15.5%

Table 3. Number of violations recorded before and after the cameras were installed.

number of violations recorded. It is important to note that part of the reduction in the number of violations recorded is due to construction activities along Santa Monica Boulevard during the winter of 2000 and spring of 2001. This construction had the effect of reducing traffic volumes on surrounding streets because three major intersections were closed to all traffic for various weeks. However, it is very likely that the red light cameras did discourage drivers from running red lights enough to create a downward trend in violations seen in the table above.

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Advance Yield Markings

PROBLEM

Crosswalks on streets with multilane, uncontrolled approaches are often associated with a type of high-energy pedestrian crash termed a multiple threat crash (Snyder, 1972; Zegeer, et. al., in press). Multiple threat crashes involve a vehicle in one lane stopping to allow a pedestrian to cross the street while the driver of an oncoming vehicle travelling in the same direction, in an adjacent lane, strikes the pedestrian. A major factor contributing to this kind of crash is the fact that the yielding vehicle stops (or slows) too close to the crosswalk, screening the pedestrian from the view of another motorist fast approaching in the lane that the pedestrian is crossing next.

BACKGROUND

Problems with screening and multiple threat situations have always been a safety issue on urban streets and highways, and some rural roads. For example, buses and trucks have always been capable of totally screening the pedestrian, however the popularity of ever larger sport utility vehicles and minivans has increased the percentage of vehicles on the road that can completely screen the view of pedestrians crossing the street. Moreover, children and persons of short stature can be completely screened by even small- or medium-sized passenger cars.

Traditionally, crosswalks have been painted to increase pedestrian safety and level of service, where previously legal crossing areas were unmarked. Zegeer, Stewart, and Huang (in press) compared 1000 marked and 1000 unmarked crosswalks in 30 U.S. cities. They observed no significant difference in crashes between marked and unmarked crosswalks with one exception: crosswalks on multilane roads which are not controlled by a traffic signal or stop sign were associated with significantly more crashes than unmarked crosswalks if the road had an average daily traffic volume (ADT) above 12,000. It has been suggested that marking crosswalks can lead to a false sense of security (Herms, 1972). However, behavioral data collected before and after crosswalks were installed at a number of sites contradict this hypothesis. These data show that marked crosswalks were associated with somewhat higher levels of pedestrian observing behavior by motorists and somewhat lower driving speeds (Knoblauch, Nitzburg, & Seifert, 1999).

Zegeer et. al. (in press) found that the greatest difference in pedestrian crash types between marked and unmarked crosswalks involved multiple threat crashes. This makes sense because multilane roads with a high ADT are more likely to have cars approaching in adjacent lanes than roads with a low ADT, and therefore, provide greater exposure for multiple threat crashes. Zegeer et. al. recommended that marked crosswalks should not be installed alone on multilane roads with a high ADT. Instead crosswalks should be enhanced with other traffic engineering improvements.

Prepared by Ron Van Houten, Ph.D., Center for Education and Research in Safety, Dartmouth, Nova Scotia.

SOLUTION

One treatment that addresses the issue of multiple-threat crashes is the use of yield markings placed 10-15 m (30-50 ft) in advance of the crosswalks along with a "YIELD HERE TO PEDESTRIANS" sign placed adjacent to the markings. Data show that this treatment can produce a marked reduction in multiple threat conflicts.

Prior research (Van Houten, 1988; Van Houten & Malenfant, 1992, Van Houten, McCusker, and Malenfant, in press) has demonstrated that the use of advance stop lines or yield markings in conjunction with signs directing motorists to yield 15 m (50 ft) in advance of

A YIELD HERE TO PEDESTRIANS sign.

the crosswalk will reduce motor vehicle/pedestrian conflicts and increase motorists yielding to pedestrians at multilane crosswalks with an uncontrolled approach.

When motorists yield in advance of the crosswalk, they enhance pedestrian safety in three ways. First, the yielding vehicle does not screen the view of motorists in the pedestrian's next lane of travel. Second, they reduce the likelihood that a vehicle travelling behind the yielding vehicle will cross the centerline to pass it striking the pedestrian. Third, they reduce the chance that an inattentive driver who strikes the yielding vehicle from behind will push it into the pedestrian.

In a recently completed study conducted in Halifax, Nova Scotia, Canada, 24 crosswalks were randomly assigned to a treatment or control condition. Following a baseline measurement period, twelve of the streets had advance yield markings and the "YIELD HERE TO PEDESTRIAN" sign installed, 7-20 m (23-65 ft) in advance of the crosswalk. The remaining half of the crosswalks remained in the baseline condition and served as control sites. Each of the streets used in the study included multiple travel lanes in both directions or multiple lanes on a one way street. The posted speed limit was 48 km/h (30 mi/h), yet actual speeds were higher on some streets, up to 65 km/h (40 mi/h). Street settings included urban and suburban contexts.

The study cost was $25,000 and was funded by the Halifax Regional Municipality and Province of Nova Scotia. To ensure unbiased road user behavior, no public outreach or education was conducted.

RESULTS

The sign and markings increased the percentage of motorists yielding to pedestrians and decreased the percentage of motor vehicle/pedestrian conflicts at all 12 sites. For the control crosswalks, driver-yielding behavior remained almost unchanged between the before- and after-treatment measurements. However the percentage of drivers who yielded to pedestrians at crosswalks with the added sign and markings increased from around 70-75 percent to around 80-85 percent. Further, vehicle-pedestrian conflicts remained nearly constant for the control sites but declined from about 10 to 15 conflicts per 100 crossings to under 5 conflicts per 100 crossings at the treatment sites.

Follow-up data collected six months after the markings and signs were introduced show no reduction in treatment effectiveness. These data are in accord with previous findings, which show that effects are maintained over time.

The success of the "YIELD HERE TO PEDESTRIAN" sign and advanced stop bar is underscored by the decision of the local government to retain the treatments installed for the study. While a formal user opinion survey was not conducted, data collectors and study principals received favorable reactions from roadways users and more people were aware of multiple threat crashes and conditions.

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REFERENCES

Knoblauch, R.L., Nitzburg, M., & Seifert, R.L. (1999). Pedestrian Crosswalk Case Studies. Center for Applied Research, for Federal Highway Administration.

Snyder, M.B. "Traffic engineering for pedestrian safety: Some new data and solutions." Highway Research Record. 406, 21-27. 1972.

Van Houten, R. (1988). The effects of advance stop lines and sign prompts on pedestrian safety in crosswalk on a multilane highway. Journal of Applied Behavior Analysis, 21, 245-251.

Van Houten, R. & Malenfant, L. (1992). The Influence of signs prompting motorists to yield 50 ft (15.5 m) before marked crosswalks on motor vehicle-pedestrian conflicts at crosswalks with pedestrian activated flashing lights. Accident Analysis and Prevention, 24, 217-225.

Van Houten, R., McCusker, D., & Malenfant, J.E.L. (in press). The Use of Advance Yield Markings to Reduce Conflicts at Intersections with Unsignalized Approaches. Transportation Research Record.

Zegeer, C.V., Stewart, J.R., & Huang, H. (In press). Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Analysis of Pedestrian Crashes in 30 Cities. Transportation Research Record.

Radar Trailers In Neighborhood

PROBLEM

Excessive vehicle speed is a top complaint received by transportation departments, and one of the primary contributors to both vehicular and pedestrian crashes. Although agencies may have a number of tools available for addressing speeds, effective educational tools may be hard to come by.

BACKGROUND

Protecting and preserving neighborhood livability is a priority for the City of Bellevue. In 1985, the City developed and implemented a Neighborhood Traffic Calming Program to address citizen concerns with excessive vehicle speeds, cut-through traffic, accidents and pedestrian safety. Bellevue's experience has shown that the majority of speeders in a neighborhood are the residents themselves. Although engineering and enforcement measures are important to curtail speeding, one of the keys to reducing vehicle speeds is changing driver behavior. To this end, the City's Police and Transportation Departments partnered to educate the community on traffic safety basics, including pedestrian safety.

Excessive vehicle speed was the number one complaint received by the City's Transportation Department. Although Bellevue has a number of tools in its toolkit for addressing speeds, the City is always looking for new and innovative approaches to addressing this ongoing concern. In 1990, the City found a success story from a police agency in southern California, experimenting with a new technique—a radar trailer. This new technique appealed to the City, and a pilot program began.

Prepared by Karen Gonzalez, City of Bellevue, WA.

SOLUTION

A radar trailer is a self-contained portable trailer that houses a radar unit and reader board. As a vehicle passes the trailer, the vehicle's speed is detected by the radar unit and displayed on the reader board. The idea is to bring a motorist's attention to the speed they are traveling and how it compares to the posted speed limit. With the help of its electronics staff, the City purchased and constructed its first radar trailer. The next step was to select locations throughout the City for its pilot program, which included both neighborhoods streets and streets in school zones. Typical speed limits on these local and collector streets were 40 km/h (25 mi/h), or 32 km/h (20 mi/h) in the school zones.

Prior to setting out the trailer, speed studies were conducted at several sites and used as the baseline for determining the effectiveness of this new tool. Each morning, the radar trailer was placed by the Police Department's Parking Enforcement Officer and picked up each afternoon, taken back to the City for storage and battery recharging.

Two weeks following placement of the radar trailer, the Police Department conducted target speed enforcement. This approach provided residents with an oppor-

tunity to correct their driving habits and reduce their speed before enforcement began.

The initial cost of purchasing equipment and building radar trailer was approximately $6,000 in 1990. Since that time, the popularity of these units has increased, and manufacturers are now producing them for purchase. Today's costs range between $7,000 and $10,000, depending on the unit's features. Funds from the Neighborhood Traffic Calming Program were used to fund the project.

RESULTS

The community response to the radar trailer pilot project was extremely positive. As evidence of this support, many residents and neighborhood groups requested radar trailers in other neighborhood locations throughout Bellevue. Over the past ten years, trailers have been used as a tool for addressing vehicle speeds in residential neighborhoods. When citizens request a trailer, they are placed on a list and are responded to on a first-come, first-serve basis. At times, this creates a backlog of up to three months for placement. To meet this high demand, the City has partnered with local tow-companies to donate their time and help move the trailers around Bellevue.

In addition to their popularity, the radar trailers helped reduce vehicle speeds. Speeds were collected at several of the pilot sites before, during and after placement of the radar trailer. The results showed that vehicles traveled 5-8 km/h (3-5 mi/h) slower than before the unit was placed in-service. Several days following the placement, vehicle speeds increased slightly. However, when adding the element of enforcement vehicle speeds again decreased. Though the trailers were most effective when they were in place, yet they reduced speeds and continue to increase the safety of pedestrians traveling along and crossing streets in the neighborhoods and school zones of Bellevue.

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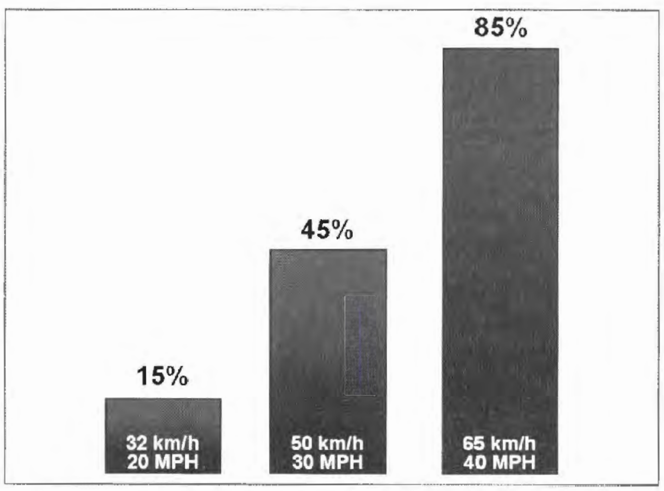
Neighborhood Speed Watch Programs

PROBLEM

Speeding on neighborhood streets and the resulting safety hazards for pedestrians were a concern for many Phoenix residents. Documenting the incidence of speeding was needed to increase education about the problem and to support future speed management measures such as traffic calming.

BACKGROUND

In many neighborhoods, the failure of motorists to obey posted speed limits is a major concern for pedestrian safety. The relationship between pedestrian injuries and fatalities and motor vehicle speeds has been well documented. The faster a motor vehicle is traveling when it hits a pedestrian, the greater the likelihood of a pedestrian fatality. The following chart from the United Kingdom Department of Transportation report "Killing Speed and Saving Lives" indicates this relationship:



Pedestrians' chances of death if hit by a motor vehicle. Source: Killing Speed and Saving Lives, UK Department of Transportation.

Prepared by Jeff Olson, R.A., Trailblazer.
Information provided by Mike Cynecki, City of Phoenix.

Because speeding motorists and local pedestrians are often residents of the same neighborhood or adjacent communities, education and enforcement activities can be part of a local initiative for speed reduction. If motorist speeds can be kept within posted speed limits through these programs, the potential exists for improving pedestrian safety without capital construction. Several communities, including Kirkland, Washington; San Jose, California; and Phoenix, Arizona have developed local responses to this issue.

SOLUTION

Neighborhood Speed Watch (NSW) programs provide residents with hand-held radar guns and ask them to record speeds, makes, models, and license plate numbers of vehicles that are speeding in the neighborhood. This can be done in conjunction with placing radar speed trailers in the field and as part of a broader community traffic safety campaign. Local law enforcement then sends warning letters to owners of the offending vehicles, advising them of the posted speed limits and neighborhood concerns with speeding. Advantages include the potential for reducing the number of law enforcement responses to complaints of speeding and the involvement of the community in local traffic safety solutions.

RESULTS

In Phoenix, neighborhood speed watch programs have had marginal lasting impacts on 85th percentile speeds. Data provided for 1999 report provide the following overview:

The use of residents in community involvement and understanding of safety issues may be more important than the measured results in this case. Since the appli-

PHOENIX, ARIZONA NEIGHBORHOOD SPEED WATCH DATA			
LOCATION	85 PERCENTILE SPEED (mi/h)	VOLUMES (VEHICLES/DAY)	COMMENTS
	BEFORE / AFTER % CHANGE	BEFORE / AFTER % CHANGE	
71st Avenue	36 / 36 0	1,016 / 737 -27	Speeds Tend to Return to Prior Levels
Campbell Ave East of 71st	39 / 39 0	878 / 861 -2	Speeds Tend to Return to Prior Levels
Campbell Ave West of 71st	36 / 33 -8	940 / 970 +3	Speeds Tend to Return to Prior Levels
Utopia Road	32 / 33 +3	993 / 872 -12	Most Violators Non-Local
24th Street	41 / 40 -2	8,403 / 9189 +9	Most Violators Non-Local

Source: USDOT, Traffic Calming: State of the Practice, p.234.

Table 1. Speed data before and after implementation of the neighbor speed watch programs.

cation of NSW programs is labor intensive, radar speed trailers and photo radar may prove more effective as community enforcement tools, but long term gains using these methods may also be difficult to achieve. Since the City Council started to subsidize traffic calming, NSW is now used sparingly by residents in Phoenix. Speed humps are now the primary speed controlling request among residents.

The experience of NSW programs can provide support for the use of physical traffic calming measures for neighborhood speed management. While NSW can be a useful part of a community initiative, the labor costs and the ongoing need to maintain the program limit its overall effectiveness. Traffic calming installations, which may require a potentially higher initial cost, can provide long-term speed reductions and reduce the labor costs associated with traffic law enforcement.

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REFERENCES

Traffic Calming: State of The Practice, Reid Ewing, U.S. Department of Transportation / Institute of Transportation Engineers, 1999. Publication No.: FHWA-RD-99-135. ISBN 0-935403-36-1.

Implementation and Resources
Chapter 7

PHOTO BY CARA SEIDERMAN

Getting Started

Construction Strategies

Funding

Web Sites

Guides, Handbooks and References

Communities are asking that motor vehicle speeds be reduced on their neighborhood streets, that streets be made accessible to persons with disabilities, and that streetscapes be improved to make them more inviting to pedestrians. Some of the most important issues to the public are safety, access, and aesthetics. This chapter discusses some of the issues related to setting priorities and implementing needed pedestrian improvements.

GETTING STARTED

"Getting started" can be daunting—the needs are overwhelming, resources are scarce, and staff time is limited. Every community is faced with the questions of "Where do I start?" and "How do I get going?" While it is not the intent of this guide to provide an exhaustive discussion of implementation strategies, some direction is useful.

PRIORITIES

Since all pedestrian needs will not be able to be addressed immediately, project priorities need to be established. To create priorities requires several program objectives:

- **Safety—** One objective should be to reduce the number and severity of crashes involving pedestrians. To accomplish this will require: (1) a good understanding of the types of crashes that are occurring in your community, and (2) application of appropriate countermeasures to address these crashes. The information provided in this guide is intended to help select the countermeasures that will be most effective in addressing selected types of crash problems.
- **Access—** A second objective should be to create an accessible community where all pedestrians, including those with disabilities, can reach their desired destinations. Typically, this begins with being able to walk safely along streets (i.e., sidewalks) and across streets at intersections and other appropriate locations.
- **Aesthetics—** It is not enough to simply have a safe, accessible community—it should also be an aesthetically pleasing place to live and work. Landscaping, lighting, and other pedestrian amenities help create a "livable community" and should be considered when making pedestrian improvements.

ONE STEP AT A TIME

To create a safe, walkable community, take one step at a time. Sidewalks, curb bulb-outs, and other pedestrian improvements are installed intersection by intersection, block by block. Individually, they do not create a safe, livable community. Collectively, they create the infrastructure needed for a great place to work, play, and do business. In other words, the whole pedestrian system is greater than the sum of its parts.

COMMUNITY CONCERNS

Be very sensitive to community concerns. Public participation will build community pride and ownership that is essential to long-term success. Some of the problems identified in this guide will not be an issue in your community and some of the tools may be perceived as too expensive (at least initially). There probably will be measures that your community puts on hold for a few years until a community consensus is reached. Conversely, there probably will be measures that your community would like to pursue that are not even mentioned in this planning guide.

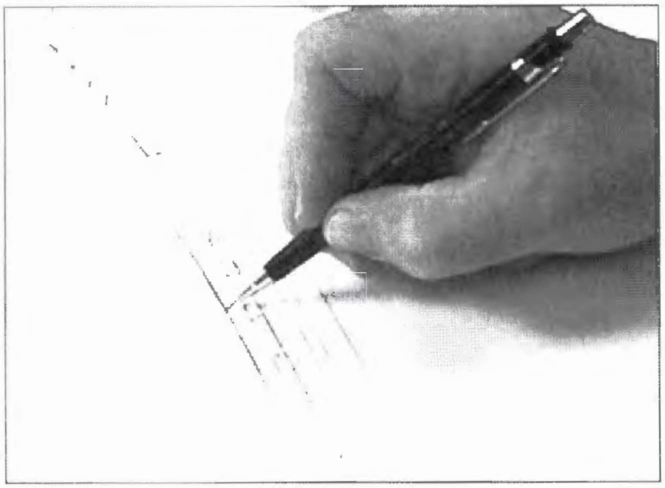

PHOTO BY DAN BURDEN

DELIVERABLES

It is very important to produce immediate deliverables that people can see. For example, a new section of sidewalk or a freshly painted crosswalk is visible, while a transportation plan is a paper document that may never be seen or appreciated by the public. To keep its momentum, a program needs some "quick wins." They create the sense that something is happening and that government is responsive.

ADDITIONAL RESOURCES

The Walkability Checklist can quickly identify some of the more obvious deficiencies in your community.

http://www.rwjf.org/news/video/walkabilityTV.jhtml

Another useful tool to get things started is to host a walkability audit in your community.

http://www.walkable.org/services/wcaudit.htm

Access issues: A good introduction to accessibility and universal design.
http://www.fhwa.dot.gov/environment/bikeped/access-1.htm

A more comprehensive set of guidelines for achieving full accessibility from the US Access Board:
http://www.access-board.gov/news/prowaac.htm

Aesthetics: California's Local Government Commission has some great resources on street design and livability.
http://www.lgc.org/transportation/street.html
http://www.lgc.org/center/index.html

CONSTRUCTION STRATEGIES

There are many ways to accomplish projects. Be creative; take advantage of opportunities as they present themselves. Here are some suggestions:

REGULATION OF NEW DEVELOPMENT AND REDEVELOPMENT

Developers can be required to install public infrastructure such as sidewalks, curb ramps, and traffic signals. In addition, zoning requirements can be written to allow for or require narrower streets, shorter blocks, and mixed-use development. Encouraging developers and community leaders to focus on basic pedestrian needs will benefit the community and increase the attractiveness of the developments themselves.

ANNUAL PROGRAMS

Consider expanding/initiating annual programs to make small, visible improvements. Examples include sidewalk replacement programs, curb-ramp programs, annual tree-planting programs, etc. This creates momentum and community support. Several considerations should be made when developing these programs:

- Give priority to locations that are used by schoolchildren, the elderly, those with disabilities, and locations that provide access to transit.
- Consider giving preference to requests from neighborhood groups, especially those that meet other priorities, such as addressing a crash problem.
- Evaluate your construction options. Consider having city crews do work requested by citizens to provide fast customer service while bidding out some of the staff-generated projects.

CAPITAL PROJECTS

"Piggybacking" pedestrian improvements onto capital projects is one of the best ways to make major improvements in a community. Sidewalks, pedestrian ramps, landscaping, lighting, and other amenities can be included in road projects, utility projects, and private construction in public rights-of-way (e.g., cable television, high-speed fiber optics, etc.). To accomplish this, there are several things that can be done:

- Contact all State and regional agencies, and local public and private utilities that do work in public rights-of-way. Secure their 5-year project plans as well as their long-range plans. Then, work with them to make sure that the streets are restored in the way that works for your city.
- Look internally at all capital projects. Make sure that

every opportunity to make improvements is taken advantage of at the time of construction.

- Consider combining small projects with larger capital projects as a way of saving money. Generally, bid prices drop as quantities increase.

PUBLIC/PRIVATE PARTNERSHIPS

Increasingly, public improvements are realized through public/private partnerships. These partnerships can take many forms. Examples include: Community Development Corporations, neighborhood organizations, grants from foundations, direct industry support, and involvement of individual citizens. In fact, many public projects, whether they are traffic-calming improvements, street trees, or the restoration of historic buildings, are the result of individual people getting involved and deciding to make a difference. This involvement doesn't just happen, it needs to be encouraged and supported by local governmental authorities.

ADDITIONAL RESOURCES

Cities such as Seattle, WA, Portland, OR, and Cambridge, MA, have adopted plans and procedures to ensure that pedestrian improvements become a routine activity in new development projects, reconstruction work, and retrofits.

City of Cambridge
http://www.ci.cambridge.ma.us/~CDD/envirotrans/walking/index.html

City of Portland
http://www.trans.ci.portland.or.us/pedestrians/default.htm

City of Seattle
http://www.seattle.gov/transportation/pedestrian.htm

FUNDING

Pedestrian projects and programs can be funded by federal, State, local, private, or any combination of sources. A summary of federal pedestrian funding opportunities can be viewed at http://www.fhwa.dot.gov/environment/bikeped/bp-broch.htm#funding. Communities that are most successful at securing funds often have the following ingredients of success:

- **Consensus on Priorities—** Community consensus on what should be accomplished increases the likelihood of successfully funding a project. A divided or uninvolved community will find it more difficult to raise funds than a community that gives broad support to pedestrian improvement programs.

- **Dedication—** Funding a project is hard work; usually, there are no shortcuts. It usually takes a great amount of effort by many people using multiple funding sources to complete a project successfully. Be aggressive; apply for many different community grants. While professional grant-writing specialists can help, they are no substitute for community involvement and one-on-one contact (the "people part" of fund raising).

- **Spark Plugs (Change Agents)—** Successful projects typically have one or more "can do" people in the right place at the right time, who provide the energy and vision to see a project through. Many successful "can do" politicians get their start as successful neighborhood activists.

- **Leveraging—** Funds, once secured, should always be used to leverage additional funds. For example, a grant from a local foundation could be used as the required match for a Transportation Equity Act for the 21st Century (TEA-21) Enhancement grant.

ADDITIONAL RESOURCES

America Walks, a national coalition of pedestrian advocacy groups, has developed a variety of resources that focus on results and implementation.
http://www.americawalks.org/resources/index.htm

WEB SITES

There are dozens of web sites that contain information on pedestrian safety and mobility. The Pedestrian and Bicycle Information Center (PBIC) maintains an up-to-date list of national and international government agencies, state and local government agencies, professional organizations, advocacy groups, and other sites as listed in the following sections. Refer to http://www.walkinginfo.org/links for the latest information.

GOVERNMENT AGENCIES AND OFFICES

Danish Road Directorate
http://www.vejdirektoratet.dk/roaddirectorate.asp?page=dept&objno=1024

Federal Highway Administration (FHWA)
http://www.fhwa.dot.gov

FHWA Office of Highway Safety
http://safety.fhwa.dot.gov

FHWA/NHTSA National Crash Analysis Center
http://www.ncac.gwu.edu

House Committee on Transportation and Infrastructure
http://www.house.gov/transportation

National Highway Traffic Safety Administration (NHTSA)
http://www.nhtsa.dot.gov

Transportation Association of Canada
http://www.tac-atc.ca

U.S. Architectural and Transportation Barriers Compliance Board (Access Board)
http://www.access-board.gov

U.S. Department of Transportation (U.S. DOT)
http://www.dot.gov

GOVERNMENT PROGRAMS AND INITIATIVES

FHWA Bicycle and Pedestrian Program
http://www.fhwa.dot.gov/environment/bikeped

FHWA Pedestrian and Bicycle Safety Research Page-
http://www.tfhrc.gov/safety/pedbike/pedbike.htm

FHWA Pedestrian/Bicyclist Crash Analysis Tool (PBCAT)
http://www.walkinginfo.org/pc/pbcat.htm

NHTSA Fatality Analysis Reporting System (FARS)
http://www-fars.nhtsa.dot.gov/main.cfm

NHTSA Pedestrian Safety Toolkit Resource Catalog
http://safety.fhwa.dot.gov/fourthlevel/pdf/G014-031ResourceCatalog.pdf

NHTSA Pedestrians, Bicycles, and Motorcycles Pages
http://www.nhtsa.dot.gov/people/injury/pedbimot/ped
http://www.nhtsa.dot.gov/people/injury/pedbimot/bike
http://www.nhtsa.dot.gov/people/injury/pedbimot/motorcycle

Office of Highway Safety Pedestrian/Bicyclist Safety Program
http://safety.fhwa.dot.gov/programs/ped_bike.htm

Pedestrian and Bicycle Information Center (PBIC) Web Sites
http://www.pedbikeinfo.org
http://www.walkinginfo.org
http://www.bicyclinginfo.org
http://www.pedbikeimages.org
http://www.iwalktoschool.org
http://www.walktoschool.org

Pedestrian Safety Roadshow
http://safety.fhwa.dot.gov/roadshow/walk

Transportation Equity Act for the 21st Century (TEA-21)
http://www.fhwa.dot.gov/tea21

Walkability Checklist
http://www.rwjf.org/news/video/walkabilityTV.jhtml

PROFESSIONAL ORGANIZATIONS

American Association of State Highway and Transportation Officials (AASHTO)
http://www.transportation.org/aashto/home.nsf/FrontPage

American Planning Association (APA)
http://www.planning.org/

American Public Works Association
http://www.apwa.net/

American Traffic Safety Services Association
http://www.atssa.com/

Association of Pedestrian and Bicycle Professionals (APBP)
http://www.apbp.org/

Bicycle Federation of America/National Center for Bicycling and Walking
http://www.bikewalk.org/

Human-Powered Transportation Committee of the American Society of Civil Engineers
http://www.ascehpt.homestead.com/

Institute of Transportation Engineers
http://www.ite.org/

League of American Bicyclists
http://www.bikeleague.org/

National Center for Bicycling and Walking
http://www.bikewalk.org/

National Safety Council
http://www.nsc.org/

Partnership for a Walkable America
http://www.walkableamerica.org

Transportation Research Board
http://www.trb.org/

OTHER ORGANIZATIONS (INCLUDING ADVOCACY ORGANIZATIONS)

AAA Foundation for Traffic Safety
http://www.aaafoundation.org/home/

America Walks
http://www.americawalks.org

American Council of the Blind — Pedestrian Safety-
http://www.acb.org/pedestrian

Bicycle Helmet Safety Institute
http://www.bhsi.org

Better Environmentally Sound Transportation
http://www.best.bc.ca

Chainguard — Bicycle Advocacy Online
http://probicycle.com/

Conservation Law Foundation
http://www.clf.org

Massachusetts Bicycle Coalition
http://www.massbike.org

National Transportation Enhancements Clearinghouse
http://www.enhancements.org

Partnership for a Walkable America
http://www.walkableamerica.org

Pedestrians Educating Drivers on Safety, Inc. (PEDS)
http://www.peds.org

Rails to Trails Conservancy
http://www.railtrails.org

Surface Transportation Policy Project
http://www.transact.org

Transportation Alternatives Citizens Group (New York City Area)
http://www.transalt.org

Travis County (Austin, TX) SuperCyclist Project
http://www.ci.austin.tx.us/bicycle/super.htm

Tri-State Transportation Campaign (New York/New Jersey/Connecticut)
http://www.tstc.org

Vermont Bicycle and Pedestrian Coalition
http://www.vtbikeped.org

Victoria Policy Institute
http://www.vtpi.org

WALK Austin
http://www.io.com/~snm/walk

Walkable Communities, Inc.
http://www.walkable.org/

LOCAL/STATE SITES

City of Boulder, CO, Transportation Planning
http://www3.ci.boulder.co.us/publicworks/depts/transportation.html

City of Cambridge, MA, Environmental and Transportation Division
http://www.cambridgema.gov/~CDD/envirotrans

City of Portland, OR, Pedestrian Transportation Program
http://www.trans.ci.portland.or.us

City of Tallahassee, FL, Bicycle and Pedestrian Program
http://talgov.com/citytlh/planning/trans/bikeped/transbp.html

Florida Department of Transportation Pedestrian and Bicycle Safety Program
http://www.dot.state.fl.us/Safety/ped_bike/ped_bike.htm

Missouri Department of Transportation Bicycle/Pedestrian Program
http://www.modot.state.mo.us/othertransportation/bicyclepedestriangeneralinformation.htm

Montgomery County, MD, Residential Traffic-Calming Program
http://www.dpwt.com/TraffPkgDiv/triage.htm

New York City Department of Transportation Pedestrian Information
http://www.nyc.gov/html/dot/home.html

Oregon Department of Transportation Bicycle and Pedestrian Program
http://www.odot.state.or.us/techserv/bikewalk/

Wisconsin Department of Transportation Bicycle and Pedestrian Information
http://www.dot.wisconsin.gov/modes/pedestrian.htm

PEDESTRIAN AND BICYCLE LINK PAGES

Bicycle advocacy websites provided by Chainguard-
http://probicycle.com/mainnet.html

Bicycle education and safety sites provided by Chainguard
http://probicycle.com/mainedu.html

Bicycling sites provided by Cyber Cyclery
http://www.cyclery.com/directories

Pedestrian and bicycle sites provided by TransAct
http://www.transact.org/issues/intro_hss.asp

Pedestrian issues and organization provided by PEDS
http://www.peds.org/links.htm

State bicycle laws provided by Bicycle Coalition of Massachusetts
http://www.massbike.org/bikelaw

PEDESTRIAN AND BICYCLE STUDIES AND STATISTICS

Bike Plan Source Hot Topics provided by Tracy-Williams Consulting
http://www.bikeplan.com/traxq.htm

BTS National Transportation Library Links to Bike/Pedestrian Transportation Research
http://www.transtats.bts.gov/Databases.asp?Mode_ID=7&Mode_Desc=Bike/Pedestrian&Subject_ID2=0

Bureau of Transportation Statistics
http://www.bts.gov

Consumer Product Safety Commission Recreational Safety Publications
http://www.cpsc.gov/cpscpub/pubs/rec_sfy.html

National Bicycling and Walking Study Five-Year Status Report
http://www.fhwa.dot.gov/environment/bikeped/study.htm

Nationwide Personal Transportation Survey
http://www.fhwa.dot.gov/policy/ohpi/nhts/index.htm

Northwestern University Traffic Institute
http://server.traffic.northwestern.edu/

PedSMART — Application ITS Technology to Pedestrian Safety
http://www.walkinginfo.org/pedsmart/home.htm

University of Michigan Transportation Research Institute
http://www.umich.edu/~industry/pedvis.html

University of North Carolina Highway Safety Research Center
http://www.hsrc.unc.edu/

GUIDES, HANDBOOKS AND REFERENCES

There are a significant number additional resources related to the topic of pedestrian safety and mobility. Provided in this section are many of the national and international guides, practitioner handbooks, research reports, and other general references.

DOMESTIC GUIDES AND HANDBOOKS

American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Washington, DC, 2001.

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

American Association of State Highway and Transportation Officials, *Guide Specifications for Bridge Railings*, Washington, DC, 1989.

American Association of State Highway and Transportation Officials, *Roadway Design Guide*. 3rd Edition, Washington, DC, 2002.

American Association of State Highway and Transportation Officials, *Standard Specifications for Highway Bridges*, 17th Edition, Washington, DC, 2002.

American Planning Association, *Bicycle Facility Planning*, Planning Advisory Service Report 459, Chicago, IL, 1995.

Axelson, P.W., D.A. Chesney, D.V. Galvan, J.B. Kirschbaum, P.E. Longmuir, C. Lyons, and K.M. Wong, *Designing Sidewalks and Trails for Access, Part I of II: Review of Existing Guidelines and Practices*, Federal Highway Administration, Washington, DC, 1999, available online at http://www.fhwa.dot.gov/environment/bikeped/access-1.htm, accessed June 10, 2004.

Bowman, B.L., J.J. Fruin, and C.V. Zegeer, *Handbook on Planning, Design, and Maintenance of Pedestrian Facilities*, Report No. FHWA-IP-88-019, Federal Highway Administration, Washington, DC, March 1989.

Federal Highway Administration, *Implementing Pedestrian Improvements at the Local Level*, Washington, DC, 1998.

Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways*, Washington, DC, 2003, available online at http://mutcd.fhwa.dot.gov, accessed August 2, 2004.

Federal Highway Administration, *Pedestrian/Bicyclist Safety Resource Set* (CD-ROM), Report No. FHWA-SA-00-005, U.S. Department of Transportation, 2000, available online at http://safety.fhwa.dot.gov/fourthlevel/newprod.htm#set, accessed April 24, 2004.

Federal Highway Administration, *Priorities and Guidelines for Providing Places for Pedestrian to Walk Along Streets and Highways*, Washington, DC, September 15, 1999 (draft).

Florida Department of Transportation, *Florida's Pedestrian Planning and Design Guidelines*, Tallahassee, FL, 1996.

Florida Department of Transportation, *Florida School Crossing Guard Training Guidelines*, available online at http://www.dot.state.fl.us/Safety/ped_bike/brochures/pdf/xingguard.pdf.

Harkey, D., J. Mekemson, M. Chen, and K. Krull, *Pedestrian and Bicycle Crash Analysis Tool (PBCAT) User's Manual*, Report No. FHWA-RD-99-192, Federal Highway Administration, Washington, DC, June 2000.

Hawley, L., C. Henson, A. Hulse, and R. Brindle, *Towards Traffic Calming: A Practitioners' Manual of Implemented Local Area Traffic Management and Blackspot Devices*, Report No. CR 126, Federal Office of Road Safety, Canberra, Australian Capital Territory, Australia, 1992.

Institute of Transportation Engineers, *Design and Safety of Pedestrian Facilities: A Recommended Practice of the Institute of Transportation Engineers*, Washington, DC, March 1998.

Institute of Transportation Engineers, "Guidelines for Prohibition of Turns on Red," *ITE Journal*, Vol. 54, No. 2, February 1984, pp. 17-19.

Institute of Transportation Engineers, *Guidelines for Residential Subdivision Street Design: An ITE Recommended Practice*, Washington, DC, 1993.

Institute of Transportation Engineers, *Guidelines for Urban Major Street Design: An ITE Recommended Practice*, Washington, DC, 1984.

Institute of Transportation Engineers, *The Traffic Safety ToolBox: A Primer on Traffic Safety*, Washington, DC, 1994.

Institute of Transportation Engineers, *Traditional Neighborhood Development Street Design Guidelines: Recommended Practice*, Washington, DC, 1999.

Institute of Transportation Engineers, *Traffic Engineering Handbook*, Prentice Hall, Englewood Cliffs, NJ, 1999 (draft).

Institute of Transportation Engineers, *Transportation and Traffic Engineering Handbook*, Washington, DC, 1990.

Karplus, K., *Guidelines for Choosing a Safe Bicycle Route to School*, available online at http://www.cse.ucsc.edu/~karplus/bike/safe-route-to-school.html, accessed April 06, 2004.

Kirschbaum, J.B., P.W. Axelson, P.E. Longmuir, K.M. Mispagel, J.A. Stein, and D.A. Yamada, *Designing Sidewalks and Trails for Access, Part II of II: Review of Existing Guidelines and Practices*, Federal Highway Administration, Washington, DC, 2001, available online at http://www.fhwa.dot.gov/environment/sidewalk2/, accessed June 10, 2004.

Maricopa Association of Governments, *Pedestrian Area Policies and Design Guidelines*, Phoenix, AZ, October 1995.

National Committee on Uniform Traffic Laws and Ordinances, *Uniform Vehicle Code*, 1992.

National Cooperative Highway Research Program, *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas*, Report No. 294B, Washington, DC, June 1987.

National Research Council, Transportation Research Board, *Highway Capacity Manual 2000*, Washington, DC, 1999 (draft).

Office of Transportation Engineering and Development, Pedestrian Program, *Pedestrian Design Guidelines Notebook*, Portland, OR, 1997.

Oregon Department of Transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

Planning Division, *Median Handbook*, Florida Department of Transportation, Tallahassee, FL, 1997, available online at http://www.dot.state.fl.us/planning/systems/sm/accman/pdfs/mhb_2.pdf, accessed April 23, 2004.

Pline, J., ed., "Chapter 13: Pedestrians," *Traffic Control Devices Handbook*, Institute of Transportation Engineers, Washington, DC, 2001.

Public Rights-of-Way Access Advisory Committee, *Building a True Community*, U.S. Access Board, 2001, available online at http://www.access-board.gov/prowac/commrept/index.htm.

Puget Sound Regional Council, Association of Washington Cities, and County Road Administration Board, *Pedestrian Facilities Guidebook: Incorporating Pedestrians Into Washington's Transportation System*, Washington State Department of Transportation, September 1997.

"School Trip Safety Guidelines," *ITE Journal*, Institute of Transportation Engineers, Washington, DC, 1985.

Traffic Engineering Council Speed Humps Task Force, *Guidelines for the Design and Application of Speed Humps*, Institute of Transportation Engineers, Washington, DC, 1997.

U.S. Access Board and the Federal Highway Administration, *Accessible Rights-of-Way: A Design Guide*, Washington, DC, available online at http://www.access-board.gov/publications/PROW%20Guide/PROWGuide.htm, accessed May 19, 2004.

U.S. Department of Justice, *The Americans With Disabilities Act Title II Technical Assistance Manual, Covering State and Local Governments*, November 1993.

Zegeer, C.V., C. Seiderman, P. Lagerwey, M. Cynecki, M. Ronkin, and R. Schneider, *Pedestrian Facilities User Guide: Providing Safety and Mobility*, Federal Highway Administration, McLean, VA, 2002, available online at http://www.walkinginfo.org/pdf/peduserguide/peduserguide.pdf, accessed April 23, 2004.

Zegeer, C.V., *Portland Pedestrian Crossing Toolbox for Pedestrian Program*, Bureau of Transportation Engineering and Development, City of Portland, June 1995.

INTERNATIONAL GUIDES AND HANDBOOKS

Cairney, P., *Pedestrian Safety in Australia*, Federal Highway Administration, Washington, DC, January 1999.

Davies, D.G., *Research, Development, and Implementation of Pedestrian Safety Facilities in the United Kingdom*, Federal Highway Administration, Washington, DC, 1999.

Denmark Ministry of Transport, *An Improved Traffic Environment—A Catalogue of Ideas*, Report 106, Road Data Laboratory, Road Standard Division, Road Directorate, Copenhagen, Denmark, 1993.

Denmark Ministry of Transport, *Speed Management: National Practice and Experiences in Denmark, The Netherlands, and in the United Kingdom*, Report No. 167, Traffic Safety and Environment, Road Directorate, 1999.

Devon County Council Engineering and Planning, *Traffic-Calming Guidelines*, Great Britain, 1991.

Dutch Centre for Research and Contract Standardization in Civil and Traffic Engineering, *Sign Up for the Bike: Design Manual for a Cycle-Friendly Infrastructure*. The Netherlands, September 1994.

Federal Highway Administration, *FHWA Study Tour for Pedestrian and Bicyclist Safety in England, Germany, and the Netherlands*, Report No. FHWA/PL-95/006, Washington, DC, 1994.

Gilleran, B.F. and G. Pates, *Bicycling and Walking in the Nineties and Beyond: Applying Scandinavian Experience to America's Challenges*, Federal Highway Administration, Washington, DC, January 1999.

Hummel, T., *Dutch Pedestrian Safety Research Review*, Federal Highway Administration, Washington, DC, January 1999.

Standards Association of Australia, *Australian Standard: Manual of Uniform Traffic Control Devices, Part 13: Local Area Traffic Management*, North Sydney, Australia, 1991.

Transportation Association of Canada and the Canadian Institute of Transportation Engineers, *Canadian Guide to Neighbourhood Traffic Calming*, December 1998.

Van Houten, R. and L. Malenfant, *Canadian Research on Pedestrian Safety*, Federal Highway Administration, Washington, DC, January 1999.

ARTICLES, RESEARCH REPORTS AND GENERAL REFERENCES

American Association of State Highway and Transportation Officials, Right-Turn-on-Red Task Force, *Safety and Delay Impacts of Right-Turn-on-Red*, Washington, DC, 1979.

American Society for Testing and Materials, *Standard No. ASTM1501-99e1, Standard Specification for Nighttime Photometric Performance of Retroreflective Pedestrian Markings for Visibility Enhancement*, West Conshohocken, PA, 2003, available online at http://www.astm.org, accessed July 23, 2004.

Appleyard, D., *Livable Streets*, University of California Press, Berkeley, 1981.

Barlow, J.M., B.L. Bentzen, and L. Tabor, *Accessible Pedestrian Signals: Synthesis and Guide to Best Practice*, Transportation Research Board, Washington, DC, August 2003, available online at http://www.walkinginfo.org/aps, accessed August 2, 2004.

Bentzen, B.L., J. Barlow, and L. Franck, "Addressing Barriers to Blind Pedestrians at Signalized Intersections," *ITE Journal*, September 2000.

Bentzen, B.L., J. Barlow, and L.S. Tabor, *Detectable Warnings: Synthesis of U.S. and International Practice*, U.S. Access Board, Washington, DC, 2000.

Blomberg, R.D., A. Hale, and D.F. Preusser, *Conspicuity for Pedestrians and Bicyclists: Definition of the Problem, Development and Test of Countermeasures*, Report No. DOT HS 806 563, NHTSA, Washington, DC, 1984.

Blomberg, R.D., D.F. Preusser, A. Hale, and W.A. Leaf, *Experimental Field Test of Proposed Pedestrian Safety Messages*, NHTSA, Washington, DC, 1983.

Bowman, B.L. and R.L. Vecellio, "Effects of Urban and Suburban Median Types on Both Vehicular and Pedestrian Safety," *Transportation Research Record 1445*, TRB, National Research Council, Washington, DC, 1994, pp. 169-179.

Bowman, B.L., J.J. Fruin, and C.V. Zegeer, *Planning, Design, and Maintenance of Pedestrian Facilities*, Report No. FHWA-IP-88-019, Federal Highway Administration, 1988.

Britt, J., A. Bergman, and J. Moffat, "Law Enforcement, Pedestrian Safety, and Driver Compliance with Crosswalk Laws: Evaluation of a Four-Year Campaign in Seattle," *Transportation Research Record 1485*, TRB, National Research Council, Washington, DC, 1995.

"Bronx 'Safe Routes To School' Campaign Blazes New Path," *Transportation Alternatives Magazine*, September/October 1998, pp. 12-13, available online at http://www.transalt.org/press/magazine/985SepOct/12-13saferoutes.html, accessed April 6, 2004.

Brookline Transportation Department, *Neighborhood Traffic Calming Program for Residential Streets*, Town of Brookline, MA, 1996.

Brownfield, D.J., "Environmental Areas: Interim Report on a Before-After Accident Study," *Traffic Engineering and Control*, Vol. 21, No. 5, May 1980.

Burden, D., *Walkable and Bicycle-Friendly Communities*, Florida Department of Transportation, 1996.

Burrington, S.H., "Restoring the Rule of Law and Respect for Communities in Transportation," *Environmental Law Journal*, Vol. 5, No. 3, New York University, 1996.

Campbell, B., C.V. Zegeer, H. Huang, and M. Cynecki, *A Review of Pedestrian Safety Research in the U.S.*, Submitted to Federal Highway Administration, March 2002.

Campbell, B., C.V. Zegeer, H. Huang, and M. Cynecki, *Pedestrian Safety Research in the U.S. Federal Highway Administration*, Washington, DC, 1999.

Carroll, J. and B. Bentzen, *The Braille Forum*, Vol. 38, American Council of the Blind Survey of Signalized Intersection Accessibility, 1999, pp. 11-15.

Centre D'Études Techniques de l'Equipment de l'Ouest, *Evolution de la Sécurité Sur Les Carrefours Giratoires*, Centre D'Etudes Techniques de l'Equipment de l'Ouest, Nantes, France, 1986.

Citizens Advocating Responsible Transportation (CART), *Traffic Calming—The Solution to Urban Traffic and a New Vision for Neighborhood Livability*, Ashgrove, Australia, 1989 (reprinted by Sensible Transportation Options for People (STOP), Oregon, 1993).

City of Cambridge, MA, *Preliminary Results: Effects of Columbia Street Traffic Calming Project on Driver Behavior*, 2000.

City of Portland, Offices of Transportation, Transportation Engineering and Development, Pedestrian Transportation Program, *Portland Pedestrian Master Plan*, Portland, OR, June 1998.

Clarke, A. and M.J. Dornfeld, "Case Study No. 19: Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques – Their Effects on Bicycling and Pedestrians," *National Bicycling and Walking Study*, Report No. FHWA-PD-93-028, Federal Highway Administration, Washington, DC, January 1994.

Cleven, A.M. and R.D. Blomberg, "Case Study No. 12: Incorporating Consideration of Bicyclists and Pedestrians into Education Programs," *National Bicycling and Walking Study*. Report No. FHWAPD-92-036, Federal Highway Administration, Washington, DC, 1992.

Cline, E., "Design of Speed Humps...Or The Kinder, Gentler Speed Hump," Presented at the *45th California Symposium on Transportation Issues*, May 12-14, 1993.

Conservation Law Foundation, *City Routes, City Rights: Building Livable Neighborhoods and Environmental Justice by Fixing Transportation*, June 1998.

Conservation Law Foundation, *Road Kill: How Solo Driving Runs Down the Economy*, May 1994.

Conservation Law Foundation, *Take Back Your Streets: How to Protect Communities From Asphalt and Traffic*, May 1995.

County Surveyors Society, *Traffic Calming in Practice*, Landor Publishing Ltd., 1994.

Delft Ministry of Transport, Public Works and Water Management, *Cities Make Room for Cyclists*, Delft, The Netherlands, August 1995.

Denmark Ministry of Transport, *An Improved Traffic Environment: A Catalogue of Ideas*, Traffic Safety and Environment, Road Directorate, 1993.

Denmark Ministry of Transport, *Bicycle Markings: Safety Effects at Signalized Intersections*, Traffic Safety and Environment, Road Directorate, 1996.

Denmark Ministry of Transport, *Safety of Cyclists in Urban Areas: Danish Experiences*, Traffic Safety and Environment, Road Directorate, 1994.

Denmark Ministry of Transport, *The Traffic Safety Effects of Bicycle Lanes in Urban Areas*, Traffic Safety and Environment, Road Directorate, 1996.

Design Commission, Engineering Department and Strategic Planning Office, *Making Streets that Work*, Seattle, Washington, April 1995.

Duperrex, O., I. Roberts, and F. Bunn, "Safety Education of Pedestrians for Injury Prevention," *Cochrane Review*, The Cochrane Library, 2002.

Engwicht, D., *Reclaiming Our Cities and Towns: Better Living With Less Traffic*, New Society Publishers, Philadelphia, PA, 1993.

Engwicht, D., "What Is Second-Generation Traffic-Calming?" *Creative Communities International*, available online at http://www.lesstraffic.com/Articles/Traffic/SGTC.htm, accessed April 06, 2004.

Environmental Working Group, Bicycle Federation of American and Surface Transportation Policy Project, *Share the Road: Let's Make America Bicycle Friendly*, May 1997.

Federal Highway Administration, *A Review of Pedestrian Safety Research in the U.S. and Abroad*, Washington, DC, February 1999.

Federal Highway Administration, *Bicycle Safety-Related Research Synthesis*, Washington, DC, April 1995.

Federal Highway Administration, *Bicycling & Walking in the Nineties and Beyond: Applying the Scandinavian Experience to America's Challenge*, Washington, DC, November 1994.

Federal Highway Administration, "Case Study No. 12: Incorporating Consideration of Bicyclists and Pedestrians into Education Programs," *National Bicycling and Walking Study*, Report No. FHWA 343 120, 85904, Washington, DC, 1993.

Federal Highway Administration, "Case Study No. 19: Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques," *National Bicycling and Walking Study*, Washington, DC, 1994

Federal Highway Administration, "Case Study No. 21: Integrating Bicycle and Pedestrian Considerations Into State and Local Transportation Planning, Design, and Operations," *National Bicycling and Walking Study*, Washington, DC, 1994.

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

Federal Highway Administration, *Older Pedestrian Characteristics for Use in Highway Design*, Report No. FHWA-RD-93-177, Washington, DC, 1993.

Federal Highway Administration, *Safety Effectiveness of Highway Design Features, Volume VI: Pedestrians and Bicyclists*, Washington, DC, 1991.

Freedman, M., M.S. Janoff, B.W. Koth, and W. McCunney, *Fixed Illumination for Pedestrian Protection*, Report No. FHWA-RD-76-8, Federal Highway Administration, 1975.

Gehl, J., *Life Between Buildings*, Van Nostrand Reinhold Company, New York, 1987.

Gliewe R., M. Limbourg, and B. Pappritz, "German Examples of Safer Routes to School," Paper presented at the *Road Safety Education Conference* in York, United Kingdom, June 1998, available online at http://www.uni essen.de/~qpd400/texte.ml/york.html, accessed April 7, 2004.

Greatrix, G. and J. Smithies, *Factors Which Affect the Conspicuity of Pedestrians*, available online at http://www.spods.co.uk/~greatrix/Pubs2.htm, accessed April 23, 2004.

Hoxie, R.E., L.Z. Rubenstein, H. Hoenig, and B.R. Gallagher, "The Older Pedestrian," *Journal of the American Geriatric Society*, Vol. 42, No. 4, 1994, pp. 444-450.

Hu, P.F. and J. Young, *1990 Nationwide Personal Transportation Survey: Summary of Travel Trends*, Report No. FHWA-PL-92-027, Washington, DC, Federal Highway Administration, March 1992, available online at http://npts.ornl.gov/npts/1990/.

Hu, P.F., and J. Young, *1990 NPTS Databook: Nationwide Personal Transportation Survey*, Report No. FHWA PL-94-010A, Federal Highway Administration, Washington, DC, November 1993.

Huang, H.F., C.V. Zegeer, R. Nassi, and B. Fairfax, *The Effects of Innovative Pedestrian Signs at Unsignalized Locations: A Tale of Three Treatments*, Federal Highway Administration, McLean, VA, 2000, available online at http://www.walkinginfo.org/task_orders/to_11/3signs00.pdf, accessed April 23, 2004.

Huang, H.F. and C.V. Zegeer, *The Effects of Pedestrian Countdown Signals in Lake Buena Vista*, Prepared for the Florida Department of Transportation, November 2000.

Hughes, R., H. Huang, C.V. Zegeer, and M. Cynecki, *Evaluation of Automated Pedestrian Detection at Signalized Intersections*, Report No. FHWA-RD-00-097, Federal Highway Administration, McLean, VA, 2000.

Hunter, W., J. Stutts, W. Pein, and C. Cox, *Pedestrian and Bicycle Crash Types of the Early 1990's*, Report No. FHWA-RD-95-163, Federal Highway Administration, Washington, DC, 1995.

Institute of Transportation Engineers and the Federal Highway Administration, *Traffic Calming State of the Art*, Washington, DC, August 1999.

Institute of Transportation Engineers, *Residential Street Design and Traffic Control*, Wolfgang Hamburger et al., Washington, DC, 1989.

Insurance Institute for Highway Safety, "Three-Second Head Start Gives Pedestrians Advantage at Intersections," *Status Report*, Vol. 32, No. 7, August 30, 1997, p.5.

Jacobs, A., *Great Streets*, MIT Press, Cambridge, MA, 1994.

Jacquemart, G., *NCHRP Synthesis 264: Modern Roundabout Practice in the United States*, National Cooperative Highway Research Program, Synthesis of Highway Practice 264, TRB, National Research Council, Washington, DC, 1998.

Japan Road Association, *Accident Prevention Effects of Road Safety Devices: Annual Report*, 1969.

Klik, M., and A. Faghri, "A Comparative Evaluation of Speed Humps and Deviations," *Transportation Quarterly*, Vol. 47, No. 3, July 1993, pp. 457-469.

Knoblauch, R.L., B.H. Tustin, S.A. Smith, and M.T. Petrucha, *Investigation of Exposure-Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets and Major Arterials*, Report No. FHWA/RD-87-038, Federal Highway Administration, Washington, DC, 1987.

Lalani, N., Institute of Transportation Engineers, *Alternative Treatments for At-Grade Pedestrian Crossings*, Institute of Transportation Engineers, Pedestrian and Bicycle Task Force, Washington, DC, 2001.

Loughery, D.A. and M. Katzman, *Montgomery County, Maryland Speed Hump Program Evaluation Report*, Prepared for presentation to the Montgomery County Council, January 1998.

Lovemark, O., *Pedestrians in Town Centers: A Summary of Some Research Projects*, Pedestrian Safety Project, Report No. 27, North American Treaty Organization Committee on the Challenge of Modern Society, National Highway Traffic Safety Administration, March 1974.

Macbeth, A., "Balliol Street," *Traffic Calming 1995*, Proceedings from 21 papers, Ontario Traffic Conference, November 1995.

Malenfant, L. and R. Van Houten, "Increasing the Percentage of Drivers Yielding to Pedestrians in Three Canadian Cities with a Multifaceted Safety Program," *Health Education Research*, Vol. 5, 1989, pp. 274-279.

McDonald, P.E. and J.R. Jarvis, *The Use of Road Humps on Residential Streets in the Shire of Corio*, ARRB Internal Report, Report No. AIR 335-2, Australian Road Research Board, 1981.

McGee, H.W., "Accident Experience with Right-Turn-on-Red," *Transportation Research Record 644*, TRB, National Research Council, Washington, DC, 1976, pp. 66-75.

McMahon, P.J., A.J. Khattak, C. Duncan, J.R. Stewart, and C.V. Zegeer, *An Analysis of Factors Contributing to "Walking along Roadway" Crashes: Research Study and Guidelines for Sidewalks and Walkways*, Report No. FHWA-RD-01-101, Federal Highway Administration, 2002.

Moore, R.L. and Older, S.J., "Pedestrians and Motorists are Compatible in Today's World," *Traffic Engineering*, Institute of Transportation Engineers, Washington, DC, 1965.

National Highway Institute, U.S. Department of Transportation, Federal Highway Administration, and National Highway Traffic Safety Administration, *Pedestrian and Bicyclist Safety and Accommodation*, Report No. FHWA-HI-96-028, May 1996.

National Highway Traffic Safety Administration, *Fatal Accident Reporting System*, Washington, DC, 1992.

National Highway Traffic Safety Administration, *Gener-*

al Estimates System 1989: A Review of Information on Police-Reported Traffic Crashes in the United States. Washington, DC, 1990.

National Highway Traffic Safety Administration, *National Drunk and Drugged Driving (3D) Prevention Month Program Planner,* available online at http://www.nhtsa.dot.gov/people/outreach/safesobr/17qp/contents.html.

National Highway Traffic Safety Administration, *Pedestrian Safety: The Identification of Precipitating Factors and Possible Countermeasures,* Report No. FH-11-73/2, Washington, DC, 1971.

National Highway Traffic Safety Administration, *Traffic Safety Facts,* National Highway Traffic Safety Administration, Washington, DC, 2000.

National Highway Traffic Safety Administration, "Zone Guide for Pedestrian Safety Shows How to Make Systematic Improvements," *Traffic Tech,* No. 181, May 1998, available online at http://www.nhtsa.dot.gov/people/outreach/traftech/pub/tt181.html.

Nee, J. and M.E. Hallenbeck, *A Motorist and Pedestrian Behavioral Analysis Relating to Pedestrian Safety Improvements,* Final Report, Research Project T1803, Task 16 Pedestrian Safety Prepared for the Washington State Transportation Commission by the Washington State Transportation Center, 2003.

Nitzburg, M. and R. L. Knoblauch, *An Evaluation of High-Visibility Crosswalk Treatments— Clearwater, Florida,* Federal Highway Administration, McLean, VA, 2001, available online at http://www.walkinginfo.org/task_orders/to_11/clearwtr.PDF, accessed April 23, 2004.

Owens, D.A., R.J. Antonoff, and E.L. Francis, "Biological Motion and Nighttime Pedestrian Conspicuity," *Human Factors,* Vol. 36, No. 4, 1994, pp. 718, 732.

Pedestrian Facilities for Transit Access Project, Evaluation of Needs and Constraints, Cambridge Systematics, Inc., June 1996.

Pegrum, B.V., *The Application of Certain Traffic Management Techniques and Their Effect on Road Safety,* National Road Safety Symposium, March 1972.

Polus, A. and A. Katz, "An Analysis of Nighttime Pedestrian Accidents at Specially Illuminated Crosswalks," *Accident Analysis and Prevention,* Vol. 10, No. 3, September 1978.

Preusser, D.F. and A.K. Lund, "And Keep on Looking: A Film To Reduce Pedestrian Crashes Among 9 to 12 Year Olds," *Journal of Safety Research,* Vol. 19, No. 4, 1988, pp. 177-195.

Preusser, D.F., W.A. Leaf, K.B. Debartla, and R.D. Blomberg, *The Effects of Right-Turn-on-Red on Pedestrian and Bicycle Accidents,* Report No. NHTSA DOT/HS-806/182, Dunlap and Associates, Inc., Darien, CT, 1981.

Pucher, J. and L. Dijkstra, "Making Walking and Cycling Safety: Lessons from Europe," *Transportation Quarterly* Vol. 54 No. 3, Summer 2000.

Reploge, M. and H. Parcells, *Linking Bicycle/Pedestrian Facilities With Transit,* October 1992.

Replogle, M., "Case Study 17: Bicycle and Pedestrian Policies and Programs in Asia, Australia, and New Zealand," *National Bicycling and Walking Study,* Report No. FHWA-PD-93-016, Federal Highway Administration, Washington, DC, April 1992.

Reschovsky, C., "Journey to Work: 2000," *Census 2000 Brief,* US Department of Commerce, Census Bureau, Washington, DC, March 2004, available online at http://www.census.gov/prod/2004pubs/c2kbr-33.pdf, accessed April 23, 2003.

Richardson, E. and J.R. Jarvis, *The Use of Road Humps on Residential Streets in the City of Stirling, Western Australia,* ARRB Internal Report, AIR 335-3, Australian Road Research Board, 1981.

Roberts, I., T. Ashton, R. Dunn, and T. Lee-Joe, "Preventing Child Pedestrian Injury: Pedestrian Education or Traffic Calming?" *Australian Journal of Public Health,* Vol. 18, 1994, pp. 209-212.

Rodale Press, Inc., *Pathways for People,* June 1992.

Route 50 Corridor Coalition, *A Traffic-Calming Plan for Virginia's Rural Route 50 Corridor,* Middleburg, VA, 1996.

Schieber, R.A. and M.E. Vegega, *National Strategies for Advancing Child Pedestrian Safety,* Centers for Disease Control and Prevention and National Highway Traffic Safety Adminis tration, October 2001, available online at http://www.cdc.gov/ncipc/pedestrian/.

Schieber, R.A. and M.E. Vegega, eds., "Reducing Childhood Pedestrian Injuries: Summary of a Multidisciplinary Conference," *Injury Prevention, Supplement I,* June 8, 2002.

Schoon, C. and J. Van Minnen, *The Safety of Roundabouts in the Netherlands,* SWOV Institute for Road Safety Research, Traffic Engineering and Control, 1994.

Seiderman, C., "Traveling at the Speed of Life," *Conservation Matters*, No. 4, Fall 1997, pp. 20-23.

Shankar, U., *Pedestrian Roadway Fatalities*, National Highway Traffic Safety Administration, Report No. DOT HS 809 456, Washington, DC, 2003, available online at http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rpts/2003/809-456.pdf, accessed April 23, 2004.

Smith, D. et al., *State-of-the-Art Residential Traffic Management*, Report No. FHW-RD-80-092, Federal Highway Administration, Washington, DC, December 1980.

Smith, S. et al., *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.

Snyder, M.B. and R.L. Knoblauch, *Pedestrian Safety: The Identification of Precipitating Factors and Possible Countermeasures*, Report No. DOT-FH-11-7312, U.S. Department of Transportation, Washington, DC, 1971.

Troutbeck, R.J., "Capacity and Design of Roundabouts in Australia," *Transportation Research Record 1398*, TRB, National Research Council, Washington, DC, 1993, pp. 68-74.

U.K. Department of Transport, *Killing Speed and Saving Lives*, London, 1987.

Untermann, Richard K., *Accommodating the Pedestrian*, Van Nostrand Reinhold Company, Inc., New York, 1984.

U.S. Department of Transportation and Rails to Trails Conservancy, *Improving Conditions for Bicycling and Walking: A Best Practices Report*, January 1998.

U.S. Department of Transportation, *1995 Nationwide Personal Transportation Survey*, Bureau of Transportation Statistics, Washington, DC, 1995.

U.S. Department of Transportation, *National Bicycling and Walking Study Five Year Status Report*, Federal Highway Administration, Washington, DC, 1999.

U.S. Department of Transportation, National Highway Traffic Safety Administration, *Law Enforcement Pedestrian Safety*, DOT-HS 808 008, NTS-23.

Van Houten, R. and L. Malenfant, "ITS Animated LED Signals Alert Drivers to Pedestrian Threats," *ITE Journal*, Vol. 71, 2001, pp. 42-47.

Van Houten, R. and L. Malenfant, "The Influence of Signs Prompting Motorists to Yield 50 feet (15.5 m) before Marked Crosswalks on Motor Vehicle-Pedestrian Conflicts at Crosswalks with Pedestrian Activated Flashing Lights," *Accident Analysis and Prevention*, Vol. 24, 1992, pp. 217-225.

Van Houten, R., B. Blasch, and L. Malenfant, "Use of Animated Eyes in Pedestrian Signals Increases WALK Sign Recognition Distance of Low Vision Pedestrians," *Journal of Rehabilitation Research and Development*, Vol. 38, 2001, pp. 443-448.

Van Houten, R., D. McCusker, S. Huybers, L. Malenfant, and D. Rice-Smith, "Advance Yield Markings and Fluorescent Yellow Green Ra 4 Signs at Crosswalks with Uncontrolled Approaches," *Transportation Research Record 1818*, TRB, National Research Council, Washington, DC, 2003, pp. 119-124.

Van Houten, R., D. McCusker, and L. Malenfant, "Advance Yield Markings: Reducing Motor Vehicle-Pedestrian Conflicts at Multilane Crosswalks with Uncontrolled Approach," *Transportation Research Record 1773*, TRB, National Research Council, Washington, DC, 2001, pp. 69-74.

Van Houten, R. et al., *Field Evaluation of a Leading Pedestrian Interval Signal Phase at Three Urban Intersections*, Insurance Institute for Highway Safety, Arlington, VA, April 1997.

Van Houten, R., K. Healey, L. Malenfant, and R.A. Retting, "Use of Signs and 1999 Symbols to Increase the Efficacy of Pedestrian Activated Flashing Beacons at Crosswalks," *Transportation Research Record 1638*, TRB, National Research Council, Washington, DC, 1999, pp. 92-95.

Van Houten, R., L. Malenfant, and R. Steiner, "Scanning 'Eyes' Symbol as Part of the WALK Signal: Examination Across Several Intersection Geometries and Timing Parameters," *Transportation Research Record 1773*, 2001, pp. 75-81.

Van Houten, R., L. Malenfant, J. Van Houten, and R.A. Retting, "Using Auditory Pedestrian Signals to Reduce Pedestrian and Vehicle Conflicts," *Transportation Research Record 1578*, TRB, National

Research Council, Washington, DC, 1997.

Van Houten, R., R.A. Retting, J. Van Houten, C.M. Farmer, and L. Malenfant, "Use of Animation in LED Pedestrian Signals to Improve Pedestrian Safety," *ITE Journal*, Vol. 69, 1999, pp. 30-38.

Van Schagen, I., ed., *Traffic Calming Schemes: Opportunities and Implementation Strategies*, Report No. R-2003-22, SWOV Institute for Road Safety Research. Leidschendam, The Netherlands, 2003, available online at http://www.swov.nl, last accessed April 23, 2004.

Walter, C.E., "Suburban Residential Traffic Calming," *ITE Journal*, Vol. 65, No. 9, September 1995, pp. 44-48.

Whyte, W.H., *City: Rediscovering the Center*, Anchor Books, Doubleday, 1988.

Zegeer, C.V., and M. Cynecki, *Methods of Increasing Pedestrian Safety at Right-Turn-on-Red Intersections*, Final Report, Report No. FHWA/IP-86/10, Federal Highway Administration, Washington, DC, 1986.

Zegeer, C., J.H. Havens, and R. Deen, "Speed Reductions in School Zones," *Transportation Research Record 597*, TRB, National Research Council, Washington, DC, 1978, pp. 39-40.

Zegeer, C.V., J.R. Stewart, H.F. Huang, and P.A. Lagerwey, *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations - Executive Summary and Recommended Guidelines*, Report No. FHWA-RD-01-075, Federal Highway Administration, McLean, VA, March 2002, available online at http://www.walkinginfo.org/pdf/r&d/crosswalk_021302.pdf.

Zegeer, C.V., J. Stutts, and W. Hunter, *Pedestrian and Bicyclists, Volume VI: Safety Effectiveness of Highway Design Features*, Report No. FHWA-RD-91-049, Federal Highway Administration, Washington, DC, November 1992.

Zegeer, C.V., J. Stutts, H. Huang, M. Zhou, and E. Rodgman, "Analysis of Elderly Pedestrian Accidents and Recommended Countermeasures," *Transportation Research Record 1405*, TRB, National Research Council, Washington, DC, 1993, pp. 56-63.

Zegeer, C.V., K.S. Opiela, and M. Cynecki, "Effect of Pedestrian Signals and Signal Timing on Pedestrian Accidents," *Transportation Research Record 847*, TRB, National Research Council, Washington, DC, 1982, pp. 62-72.

Zegeer, C.V., K.S. Opiela, and M. Cynecki, *Pedestrian Signalization Alternatives*, Report No. FHWA/RD-83-102, Federal Highway Administration, Washington, DC, 1983.

Zegeer, C.V., *The National Bicycling and Walking Study: Transportation Choices for a Changing America*, Final Report, USDOT, FHWA, Washington, DC, 1994.

Field Investigation Form
Appendix A

PHOTO BY DAN BURDEN

The selection tool within the PEDSAFE expert system requires a number of inputs describing the geometrics and operations of the location in question. The system uses these inputs to refine the selection of applicable countermeasures. Included on the following page is a form that may be used in the field to acquire these data elements.

Pedestrian Safety Guide and Countermeasure Selection System
Field Investigation Form

Location:	**Completed by:**	
	Date:	

Area Type	
Urban CBD	
Urban Other	
Suburban	
Rural	

Location	
Intersection	
Mid-Block	

Roadway Functional Class	
Local	
Collector	
Minor Arterial	
Major Arterial	

Number of Through Lanes	
$\leq$ 2 lanes	
3 - 4 lanes	
$\geq$ 5 lanes	

Motor Vehicle Speed[A]
$\leq$ 45 mph
> 45 mph

Traffic Volume (Average Daily Traffic)	
< 10,000	
10,000 to 25,000	
> 25,000	

Signalization	
Traffic signal present (removal is NOT an option)	
Traffic signal present (removal IS an option)	
No signal present (installation is NOT an option)	
No signal present (installation IS an option)	

Comments

Notes

[A] Use 85th percentile speed if available. If not available, add 9 mi/h to the posted speed limit as a surrogate measure for the 85th percentile speed. Prior research has shown that 85th percentile speeds for vehicle traveling on many urban and suburban streets (including arterial, collector, and local classifications) generally exceed the posted limit by 6 to 14 mi/h. (D.L. Harkey, H.D. Robertson, and S.E. Davis, "Assessment of Current Speed Zoning Criteria," Transportation Research Record 1281, Transportation Research Board, Washington, DC 1990.)

Case Study Matrix
Appendix B

PHOTO BY MICHAEL KING

Included on the following pages is a matrix that shows the specific countermeasures addressed by each of the 71 case studies included in Chapter 6.

Case Study			Countermeasures																																															
Case Study #	Case Study Title	Total Applicable Countermeasures	1 Sidewalks and Walkways	2 Curb Ramps	3 Marked Crosswalks and Enhancements	4 Transit Stop Treatments	5 Roadway Lighting Improvements	6 Pedestrian Overpass/Underpass	7 Street Furniture	8 Adding Bicycle Lanes	9 Roadway Narrowing	10 Reducing Number of Lanes	11 Driveway Improvements	12 Raised Medians	13 One-way/Two-way Street Conversions	14 Curb Radius Reduction	15 Well Designed Right Turn Slip Lanes	16 Roundabouts	17 Modified T-Intersection	18 Intersection Median Barriers	19 Curb Extensions	20 Choker	21 Crossing Islands	22 Chicanes	23 Mini-Circles	24 Speed Hump	25 Speed Table	26 Raised Intersection	27 Raised Pedestrian Crossing	28 Gateways	29 Landscaping	30 Specific Paving Treatments	31 Serpentine Designs	32 Woonerf	33 Diverters	34 Full Street Closure	35 Partial Street Closure	36 Pedestrian Streets/Malls	37 Traffic Signals	38 Pedestrian Signals	39 Upgrade/Modify Pedestrian Signal Timing	40 Traffic Signal Enhancements	41 Right Turn on Red	42 Recessed Stop Lines	43 Add/Modify Signing	44 School Zone Improvements	45 Identify Neighborhood	46 Speed Monitoring Trailer	47 On-Street Parking	48 Pedestrian/Driver Education	49 Police Enforcement
41	Greenway Pedestrian Bridge	2						•																																							•					
42	Pfluger Pedestrian-Bicycle Bridge	1						•																																												
43	Grade-Separated Trail Crossing	1						•																																												
44	State Street Pedestrian Mall	4							•																											•	•	•														
45	Elm Street Traffic Calming	6												•										•			•		•		•	•																				
46	Leland Street Redesign	6														•					•		•	•						•			•																			
47	Seventh Avenue Traffic Calming	8												•				•									•	•	•	•	•	•																				
48	Main Street Roundabout	2																•					•																													
49	School Zone Roundabout	2																•																												•					
50	Harold Street Traffic Calming	3																			•		•			•																									
51	Curb Bulbouts with Bicycle Parking	1																			•																														
52	Traffic Calming Program	6																			•		•			•	•		•								•														
53	Chicanes for Traffic Control	2																			•			•																											
54	Mid-Block Speed Table	5																				•					•		•																•				•		
55	Emergency Vehicles and Traffic Calming	3																					•			•									•																
56	Neighborhood Traffic Circles	2																							•						•																				
57	Speed Humps for Cut-Through Traffic	2			•															•																															
58	Raised Intersection	3																									•	•	•																						
59	Woonerf-Style Developments	3																															•	•			•														
60	Wall Street Revitalization	2																																•				•													
61	Church Street Marketplace	2																																		•		•													
62	Pedestrian Countdown Signals (1 of 2)	2																																						•	•										
63	Pedestrian Countdown Signals (2 of 2)	2																																						•	•										
64	Antimated Eyes Signal	1																																						•											
65	Leading Pedestrian Interval (1 of 2)	3																																							•		•		•						
66	Leading Pedestrian Interval (2 of 2)	2																																							•	•									
67	Red Light Camera Enforcement	3																																								•						•			•
68	Red Light Photo Enforcement	11	•						•		•	•									•	•						•			•	•	•						•												
69	Advance Yield Markings	2																																										•		•					
70	Radar Trailers in Neighborhoods	3																																												•		•			•
71	Neighborhood Speed Watch Programs	1																																																	•

Case Study #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Case Study Title	Serpentine Street Design	55th Street Corridor Improvements	Park Road Restriping	Downtown Revitalization Partnership	Accessibility During Construction	Old Town Improvements	Solutions from Citizen Input	Curb Extensions in Rural Village	Safe Routes to School Program	High-Volume Pedestrian Crossings	Small Town Traffic Calming	Park Trail Bridges	Fifth Street Traffic Calming	Roundabout for Downtown Revitalization	Redesign for Streetcar Access	Street Redesign for Revitalization	Bridgeport Way Corridor Improvement	ADA Curb Ramps	Large Intersection Solutions	Granite Street Traffic Calming	Pedestrian-Friendly Redesign	Berkshire Street Traffic Calming	Exclusive Pedestrian Phasing	Main Street Redesign	Illuminated Crosswalk	Traffic Calming and Emergency Vehicles	School Zone Improvements	Pedestrian Crossing Devices	Gateway Treatments	Raised Crosswalk at School	Speed Tables at BWI Airport	Trail Intersection Improvements	Safe School Route Mapping	Staggered Median	Curb Extensions for Transit Access	Double-Ladder Crosswalks	Zebra Crosswalk Markings	School Zone Traffic Calming	Third Street Promenade	Vermont Street Footbridge
Total Applicable Countermeasures	8	7	5	9	3	11	10	6	3	5	7	2	13	6	3	2	5	1	5	8	3	8	4	9	1	4	5	2	6	8	5	7	4	1	5	1	3	6	5	1
Countermeasures																																								
1 Sidewalks and Walkways	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•																							
2 Curb Ramps	•			•	•		•	•										•	•	•																				
3 Marked Crosswalks and Enhancements				•		•	•	•							•					•		•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•		
4 Transit Stop Treatments																																								
5 Roadway Lighting Improvements						•	•	•			•		•				•																						•	
6 Pedestrian Overpass/Underpass		•								•		•																												•
7 Street Furniture				•		•				•			•											•															•	
8 Adding Bicycle Lanes		•	•				•						•				•															•								
9 Roadway Narrowing			•				•						•		•				•										•											
10 Reducing Number of Lanes											•													•											•					
11 Driveway Improvements							•																									•			•					
12 Raised Medians							•			•							•				•																			
13 One-way/Two-way Street Conversions			•																			•		•																
14 Curb Radius Reduction																																								
15 Well Designed Right Turn Slip Lanes																			•																					
16 Roundabouts														•																										
17 Modified T-Intersection																																								
18 Intersection Median Barriers																																								
19 Curb Extensions	•					•		•			•		•	•						•		•		•						•		•			•					
20 Choker											•		•												•															
21 Crossing Islands		•				•							•	•					•							•			•			•						•		
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Recommended Guidelines / Priorities for Sidewalks and Walkways Appendix C

PHOTO BY DAN BURDEN

INTRODUCTION

According to the American Association of State Highway and Transportation Officials' (AASHTO) A Policy on Geometric Design of Highways and Streets (also known as "the Green Book"): "Providing safe places for people to walk is an essential responsibility of all government entities involved in constructing or regulating the construction of public rights-of-way."

It is a basic principle that there be well-designed, safe places for people to walk along all public rights-of-way. How this will be accomplished will depend upon the type of road, whether it is new construction or a retrofitted area, and funding availability.

On February 24, 1999, Federal Highway Administration (FHWA) Administrator Kenneth R. Wykle, in a memorandum to FHWA field offices, stated, "We expect every transportation agency to make accommodations for bicycling and walking a routine part of their planning, design, construction, operations, and maintenance activities." Again, in February 28, 2000, Administrator Wykle sent a memorandum to the field offices in transmitting the new Design Guidance Language called for in the Transportation Equity Act for the 21st Century (TEA-21). The guidance, entitled "Accommodating Bicycle and Pedestrian Travel: A Recommended Approach—A U.S. DOT Policy Statement on Integrating Bicycling and Walking Into Transportation Infrastructure," states that bicycling and walking facilities will be incorporated into all transportation projects unless "exceptional circumstances" exist. The exceptional circumstances are spelled out, and he asked the division offices to work with State departments of transportation (DOTs) in the implementation of the guidance.

Government agencies at the State, regional, and local level are developing regulations for funding, installing, and retrofitting sidewalks. Because there is a great need to improve sidewalk facilities, it is important for these transportation agencies to direct funding to sidewalk improvement and installation projects that will be most beneficial to the safety and mobility of all citizens.

This document is intended to provide agencies at the State, regional, and local levels with tools they can use to develop guidelines for creating places for people to walk.

This document is limited to creating guidelines for sidewalks, which addresses only one major pedestrian need; other needs that merit further consideration include the ability to cross a street and intersection design.

BASIC PRINCIPLES

Many communities may wish to revisit their roadway planning and rehabilitation criteria. Policies, standard plans, subdivision regulations, and right-of-way requirements should be considered to make sure that sidewalks are included in new construction and rehabilitation projects.

A. GOALS AND OBJECTIVES

Typically, communities should focus on: (1) improving conditions for people who are currently walking (including improved accessibility to sidewalk facilities for pedestrians with disabilities), (2) increasing levels of walking, and (3) reducing the number of crashes involving pedestrians. Setting targets will help in the development of criteria for installing and retrofitting sidewalks.

B. PEDESTRIAN FACILITIES

There are several ways in which pedestrians can be accommodated in the public right-of-way:

1. **Sidewalks**— Sidewalks, provided on both sides of a street, are generally the preferred pedestrian facility. They provide the greatest degree of comfort for pedestrians and the presence of sidewalks has been associated with increased safety for pedestrians. The Uniform Vehicle Code defines a sidewalk as that portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines, intended for use by pedestrians. In most cases, sidewalks are paved, usually in concrete. To comply with Federal Americans with Disabilities Act (ADA) guidelines, newly constructed sidewalks must be accessible to people with disabilities.
2. **Off-Road Paths**— An off-road path—paved or unpaved—can be an appropriate facility in rural or low-density suburban areas. Paths are generally set back from the roads and separated by a green area or trees. Paths can be flexible in that they can deviate from the exact route of a road in order to provide more direct access for key destinations. Paths that generally follow the roadway alignment are sometimes known as "side paths."
3. **Shoulders**— Wide shoulders on both sides of a road are the minimum requirement for providing at least a possible place for people to walk. They are not as safe as paths or sidewalks, but they are better than nothing. Shoulders are also beneficial for motorists and bicyclists, and future sidewalks or paths should be created in addition to, not to replace the shoulders.

4. **Shared Streets**— In very limited unusual circumstances, it may be possible to allow shared use of a street for people walking and driving. These are usually specially designed spaces such as pedestrian streets or "woonerfs," and guidelines for developing these kinds of places can be found elsewhere in the FHWA's Pedestrian Facilities Users Guide: Providing Safety and Mobility.

C. NEW CONSTRUCTION AND RETROFITTING

Places for people to walk should be provided in all new construction. Retrofitting will require priorities to be set, and these guidelines are intended to help identify where the need is greatest for adding sidewalks and other facilities.

NEW CONSTRUCTION

A. NEW SIDEWALK INSTALLATION

All new construction must include places for people to walk, on both sides of a street or roadway. New construction in urban and suburban areas should provide sidewalks. Recommended guidelines for new sidewalk and walkway installation are given in Table 1 on the following page.

B. PHASED DEVELOPMENT OF SIDEWALKS

In developing areas and rural areas, it may be acceptable—although less desirable—to start with shoulders and unpaved paths and then phase in sidewalks as development accelerates. Criteria for installing sidewalks along with new development should be implemented with the following in mind:

1. **Space for Future Sidewalks**— Space for future sidewalks must always be secured and/or reserved when a new right-of-way is being created or an existing one is being developed. If roadways are to be widened, additional right-of-way must be acquired; existing sidewalks should not be narrowed to accommodate a wider roadway.

2. **"Triggers" for Future Sidewalks**— In rural settings, if sidewalks are not installed at the time of development, guidelines are needed to determine when sidewalks will be required and how they will be funded. For example, sidewalks might be required on residential streets once an area has a density of more than four dwelling units per acre and on arterial streets once they are within a school walking zone or have transit service.

3. **Funding for Future Sidewalks**— If sidewalks are not installed at the time of development, there need to be clear regulations as to who (developer, property owners, or governmental agency) will pay for the sidewalks. Whoever is paying for the road must pay for the sidewalk. If there is money for a road, there is money for a sidewalk. Developer contributions to sidewalks must be set aside in an account at the time of development.

C. RETAINING RURAL CHARACTER

There is a desire in some residential developments to retain a rural atmosphere. Very often this occurs in places that are not truly rural, but rather suburban or exurban (they may have been rural before being developed). Frequently, it is in such places that pedestrian crashes occur that are directly attributable to pedestrians not having places to walk. To address both the goal of having safe places to walk and that of the community to retain a certain atmosphere, path systems can be developed that do not look like traditional sidewalks, but do meet walking needs. Even in rural areas, people do want to walk and such facilities should be provided.

Developers in outlying areas may argue that the land use will never fully develop into a pedestrian area. Given that people walk despite not having facilities—for exercise, going to friends' houses, accessing transit, etc.—it is neither rational nor acceptable to build places that do not have places for people to walk. Residential developments that were added in suburban areas, until recently, typically had sidewalks and functioned very well.

Sidewalks may not be needed on short residential cul-de-sacs (61 m [200 ft] or less), if there is a system of trails behind the houses and driveway aprons are properly constructed for pedestrians with disabilities. However, it is not a good practice to have an entire neighborhood without sidewalks.

D. SIDEWALK CONTINUITY

Sidewalks should be continuous; interruptions may require pedestrians to cross a busy arterial street mid-block or at an unsignalized location to continue walking. Sidewalks should also be fully accessible to side streets and adjacent sidewalks and buildings.

RETROFITTING SIDEWALKS

Many of the streets built in recent decades do not have sidewalks, and these streets need to be retrofitted. In other cases, existing sidewalks need to be replaced.

Table 1. Recommended Guidelines for New Sidewalk/Walkway Installation.

Roadway Classification and Land Use	Sidewalk/Walkway	Future Phasing Requirements
Rural Highways (< 400 ADT)	Shoulders preferred, with minimum of 0.9 m (3 ft).	Secure/preserve right-of-way (ROW) for future sidewalks.
Rural Highways (400 to 2,000 ADT)	1.5-m (5-ft) shoulders preferred, minimum of 1.2 m (4 ft) required.	Secure/preserve ROW for future sidewalks.
Rural/Suburban Highway (ADT > 2,000 and less than 1 dwelling unit (d.u.) / .4 hectares (ha) [1 d.u. / acre])	Sidewalks or side paths preferred. Minimum of 1.8-m (6-ft) shoulders required.	Secure/preserve ROW for future sidewalks.
Suburban Highway (1 to 4 d.u. / .4 ha [1 to 4 d.u. / acre])	Sidewalks on both sides required.	
Major Arterial (residential)	Sidewalks on both sides required.	
Urban Collector and Minor Arterial (residential)	Sidewalks on both sides required.	
Urban Local Street (residential — less than 1 d.u. / .4 ha [1 d.u. / acre])	Sidewalks on both sides preferred. Minimum of 1.5-m (5-ft) shoulders required.	Secure/preserve ROW for future sidewalks.
Urban Local Street (residential — 1 to 4 d.u. / .4 ha [1 to 4 d.u. / acre])	Both sides preferred.	Second side required if density becomes greater than 4 d.u. / .4 ha (4 d.u. / acre) or if schools, bus stops, etc. are added.
Local Street (residential — more than 4 d.u. / .4 ha [4 d.u. / acre])	Sidewalks on both sides required.	
All Commercial Urban Streets	Sidewalks on both sides required.	
All Streets in Industrial Areas	Sidewalks on both sides preferred. Minimum of 1.5-m (5-ft) shoulders required.	

1 acre = 0.4 hectares (ha)

Establishing priorities for installing sidewalks involves three steps: (1) develop a prioritized list of criteria, (2) develop a methodology for using the criteria to evaluate potential sites, and (3) create a prioritized list of sites for sidewalk improvements.

A. CRITERIA

The following are suggested criteria for establishing priorities. Select three or more of them when developing your own set of criteria. The key is to select criteria that produce the outcomes desired for your community:

1. **Speed**— There is a direct relationship between speed and the number and severity of crashes; high-speed facilities may rank higher if speed is a criterion.

2. **Street Classification**— Arterial streets should take precedence because they generally have higher pedestrian use (due to more commercial uses), have a greater need to separate pedestrians from motor vehicles (due to higher traffic volumes and speeds), and are the main links in a community.

3. **Crash Data**— Pedestrian crashes seldom occur with high frequency at one location, but there are clearly locations where crashes occur due to a lack of sidewalks. Usually, there is a pattern of pedestrian crashes up and down a corridor, indicating a need to provide sidewalks throughout, not just at crash locations.

4. **School Walking Zones**— School walking zones typically extend from residential areas to an elementary school. Children are especially vulnerable, making streets (especially arterials) in these zones prime candidates for sidewalk retrofitting.

5. **Transit Routes**— Transit riders need sidewalks to access transit stops. Arterials used by transit are prime candidates for sidewalk retrofitting.

6. **Neighborhoods With Low Vehicle Ownership**— Twenty percent of the U.S. population has a disability and 30 percent of our population does not drive. Walking is the primary mode of transportation for many of the people in this country. People with disabilities live throughout the community. If they are not seen in the community, it may be due to the fact that adequate facilities are not provided. In addition, car ownership is lower and crash rates are often higher in low- and moderate-income neighborhoods with lots of children. Therefore, some locations with high pedestrian use (neighborhoods with more children and elderly persons and where vehicle ownership is low) should be given special consideration for sidewalks.

7. **Urban Centers/Neighborhood Commercial Areas**— Areas of high commercial activity generate high pedestrian use, even if they are primarily motorists who have parked their car. Sidewalks are needed to improve safety and enhance the economic viability of these areas.

8. **Other Pedestrian Generators**— Hospitals, community centers, libraries, sports arenas, and other public places are natural pedestrian generators where sidewalks should be given priority.

9. **Missing Links**— Installing sidewalks to connect pedestrian areas to each other creates continuous walking systems.

10. **Neighborhood Priorities**— Local residents may have a sense of where the most desirable walking routes exist. Neighborhood groups or homeowners associations can provide a prioritized list of locations where they see a need for sidewalks. Agencies should be cautious about using this criterion, as it is not desirable to let neighborhood pressure override addressing a key safety concern. However, it may be useful to monitor requests from pedestrians with disabilities.

B. METHODOLOGY

The two recommended methodologies for selecting loca tions for improvements are: (1) the overlapping priorities method, and (2) the points method. Establishing priorities should consume only a small percentage of a program budget—the level of effort put into prioritization should be proportionate to the size of the capital budget.

There is no single right way to select which criteria to use when developing priorities. The criteria and methodology should balance safety measures, such as vehicle speeds and pedestrian crash data; pedestrian usage measures, such as proximity to schools or commercial areas; continuity between origins and destinations; and accessibility for pedestrians with disabilities.

1. **Overlapping Priorities Method**— The easiest and cheapest way to identify overlapping priorities is through graphical representation; the intent is to identify locations that meet multiple criteria. This methodology is especially useful in cases where there is not a lot of staff time and funding for detailed analysis. It can be accomplished using a GIS system or it can be done by hand.

   The best way to describe this methodology is by example. Assume that priorities are going to be developed based on transit routes, proximity to schools, people with disabilities, and neighborhood commercial areas. Start with a map of your jurisdiction. Using a color pen, identify those arterials that have high transit use; draw a half-mile circle around every elementary school and around locations that attract people with disabilities; and color in the neighborhood commercial areas. This visual approach will make areas of overlapping priorities become immediately clear. The streets without sidewalks within the overlapping areas are the highest priority for retrofitting sidewalks.

2. **Points Method**— A weighted points system can be used where staff time and funding are available for more detailed analysis, or if there is a large amount of capital available for sidewalk construction. If there are a lot of competing projects, a more sophisticated point system can be used to explain to the public why certain projects were funded and others were not.

   A point system can be developed in many ways; the system should be simple and produce desired outcomes. Any and all of the criteria listed above can be assigned a range of numbers and then be used to analyze the need for improvement at given locations. For example, a corridor could be assigned points based on the number of "walking along roadway" crashes over a 5-year period, the number of buses that travel the corridor during peak times, and the proximity to elementary schools. This method is time-consuming because it will be necessary to analyze multiple locations with sidewalk needs to create a list of priority projects.

3. **Prioritized List**— Both the overlapping priorities and the points methods will produce an initial list of prioritized projects. The next step is to refine the list so that it works, using common sense. One important consideration is that when roadways are resurfaced, rehabilitated, or replaced, curb ramps must be added if there are pedestrian walkways. In addition, the U.S. Department of Justice considers bus stops to be pedestrian walkways requiring access for people with disabilities, so areas near

Seattle Example

Seattle recently completed an inventory of all sidewalks in the city using a three-step process:

1. An intern was hired to review aerial photographs to determine whether a sidewalk existed. This information was then recorded as a new layer on the existing GIS street database.
2. The intern field-checked all locations where there was some uncertainty regarding the presence of a sidewalk (about 10 percent of the aerial photographs were not clear).
3. Each of 13 neighborhood groups that cover the city were given a draft copy of the inventory and were asked to check for errors.

The total effort took the equivalent of one full-time person working for 6 months in a city of 530,000 population, 218.3 km^2 (84.3 mi^2) of land use and 2,659 roadway kilometers (1,652 roadway miles) [1,934 residential street kilometers (1,202 residential street miles) and 724 arterial kilometers (450 arterial miles)]. Once the inventory was completed, the information was combined on a map with three other types of information:

1. School Walking Zones: A colored circle identified a half-mile area around each school.
2. Pedestrian Generators: A second color was used to identify a half-mile area around key pedestrian generators, such as hospitals, libraries, and community centers.
3. Neighborhood Commercial Areas: A third color was used to identify the dozen neighborhood commercial areas in Seattle (about one for each of the major neighborhood areas).

Once the map was printed, it was very easy to see where the three colors overlapped, two colors overlapped, etc. The final step was to have the computer calculate the sidewalk deficiencies in the overlapping areas. They found, for example, that there were less than 3 km (2 mi) of arterial streets that were within school walking zones, a pedestrian generator area, and a neighborhood commercial area that did not have sidewalks on either side of the street.

There were nearly 4.8 km (3 mi) of arterial streets that were within school walking areas, but outside of neighborhood commercial areas and pedestrian generators that did not have sidewalks on either side of the street. This was compared to a citywide deficiency of more than 32 km (20 mi) of arterial streets that lacked sidewalks on both sides of the street.

By developing these and other numbers, the pedestrian program was able to put together packages of information that demonstrated what could be accomplished with additional funding. What everyone thought to be an unsolvable multi-million-dollar problem was reduced to a series of smaller, fundable projects that decisionmakers could endorse. The result was increased funding and a new optimism that meaningful progress could be made on solving Seattle's sidewalk deficiencies.

transit should be given priority accordingly. Improving pedestrian crossings, particularly on arterial streets, may also be an important part of some projects. Other important questions include: Are priority locations ones that might be expected? Are there many surprises? Are priority locations in line with community priorities and expectations? Are some priorities at locations with very low pedestrian use? If the answer to these questions is "yes," then the criteria or the methodology should be evaluated and possibly revised to create outcomes that better reflect expectations and desires. The methodologies should be used to prioritize known needs, not to create a new set of priorities that don't make sense.

The final step is to create packages of fundable projects. The prioritization process should result in reasonable packages that decision-makers can embrace and support. For example, it may be possible to install sidewalks on both sides of every arterial within a half-mile of every elementary school for $5 million over a period of 5 years. Or, it may be possible to replace sidewalks in neighborhood commercial areas for $2 million over a period of 3 years. The objective is to take what may appear to be an unsolvable problem (endless need for more funds) and to pack age it in such a way that it begins to address some of the most critical pedestrian needs in a community.

SIDEWALK DESIGN GUIDELINES

SIDEWALK PLACEMENT IN LARGE AND SMALL CITIES

Continuous sidewalks should be placed along both sides of all fully improved arterial, collector, and local streets in urban and suburban areas. Sidewalks should connect to side streets and adjacent buildings. Accessible crossings should be provided across median islands, frontage road medians, and other raised islands.

SIDEWALKS, WALKWAYS, AND SHOULDERS IN RURAL AREAS

A safe walking area must be provided outside the motor vehicle traffic travelway. Sidewalks along rural roads should be well separated from the travelway. Isolated residential areas should have a pedestrian connection to the rest of the rural community for school access, shopping, and recreational trips.

An off-road path—also known as a "side path"—is a type of walkway used in some rural settings. This path may be paved or unpaved, and is separated from the roadway by a grass or landscaped strip without curbing. This maintains a rural look, but is safer and more comfortable than a shoulder.

A paved or unpaved shoulder should be provided as a minimum along the road. Paved shoulders are preferred to provide an all-weather walking surface, since they also serve bicyclists and improve the overall safety of the road. A 1.5-m- (5-ft-) wide shoulder is acceptable for pedestrians along low-volume rural highways. Greater width, up to 2.4 to 3.0 m (8 to 10 ft), is desirable along high-speed highways, particularly with a large number of trucks. An edgeline should be marked to separate the shoulder from the travelway.

SIDEWALK WIDTH

The width of a sidewalk depends primarily on the number of pedestrians who are expected to use the sidewalk at a given time — high-use sidewalks should be wider than low-use sidewalks. "Street furniture" and sidewalk cafes require extra width, too. A sidewalk width of 1.5 m (5 ft) is needed for two adult pedestrians to comfortably walk side-by-side, and all sidewalks should be constructed to be at least this width. The minimum sidewalk widths for cities large and small are:

Local or collector streets	1.5 m (5 ft)
Arterial or major streets	1.8 to 2.4 m (6 to 8 ft)
CBD areas	2.4 to 3.7 m (8 to 12 ft)*
Along parks, schools, and other major pedestrian generators	2.4 to 3.0 m (8 to 10 ft)

*2.4-m (8-ft) minimum in commercial areas with a planter strip, 3.7-m (12-ft) minimum in commercial areas with no planter strip.

These widths represent a clear or unobstructed width. Point obstructions may be acceptable as long as there is at least 914 mm (36 in) for wheelchair maneuvering (no less than 1,219 mm (48 in) wide as a whole); however, every attempt should be made to locate streetlights, utility poles, signposts, fire hydrants, mail boxes, parking meters, bus benches, and other street furniture out of the sidewalk. When that is not possible, sidewalk furnishings and other obstructions should be located consistently so that there is a clear travel zone for pedestrians with vision impairments and a wider sidewalk should be provided to accommodate this line of obstructions.

Similarly, when sidewalks abut storefronts, the sidewalk should be built 0.6 m (2 ft) wider to accommodate window-shoppers and to avoid conflicts with doors opening and pedestrians entering or leaving the buildings.

Many 1.2-m (4-ft) sidewalks were built in the past. This width does not provide adequate clearance room or mobility for pedestrians passing in opposite directions. All new and retrofitted sidewalks should be 1.5 m (5 ft) feet or wider.

SIDEWALK BUFFER WIDTH

Buffers between pedestrians and motor vehicle traffic are important to provide greater levels of comfort, security, and safety to pedestrians. Landscaped buffers provide a space for poles, signs, and other obstructions; they serve as a snow storage area; and they protect pedestrians from splash. The ideal width of a planting strip is 1.8 m (6 ft). Minimum allowable landscape buffer widths are:

Local or collector streets	0.6 to 1.2 m (2 to 4 ft)
Arterial or major streets	1.2 to 1.8 m (4 to 6 ft)

With a landscaped buffer between the sidewalk and the street, care must be taken to ensure that the bus stops are fully accessible to wheelchair users and have connections to the sidewalk. Irrigation may be needed in areas of low precipitation.

Buffers also provide the added space to make curb ramps and landings accessible. When the ramps and landings are designed properly, they are also better utilized by those pushing strollers or pulling carts and luggage.

If a planting strip is not provided between the sidewalk and roadway, then the sidewalk width should be a minimum of 1.8 m (6 ft).

Where landscaped sidewalk buffers cannot be provided due to constraints, on-street parking, a shoulder, or a bike lane can serve to buffer pedestrians from motor vehicle traffic lanes.

SIDEWALK SURFACE

Concrete is the preferred sidewalk surface, providing the longest service life and requiring the least amount of maintenance. Asphalt is an acceptable walkway surface in rural areas and in park settings, and crushed granite may also be an acceptable all-weather material in parks or rural areas, but they generally require higher levels of maintenance and are less desirable for wheelchair users.

Sidewalks may be constructed with bricks and pavers if they are constructed to avoid settling; bricks should be easy to reset or replace if they cause a tripping hazard. Also, bricks and/or pavers can cause vibrations that are painful for pedestrians who use mobility aids and, therefore, it may be appropriate to use bricks or pavers only for sidewalk borders in certain situations. There are stamping molds that create the visual appearance of bricks and pavers; these have the advantages of traditional concrete without some of the maintenance issues and roughness associated with bricks and pavers. There are commercially available products that produce a variety of aesthetically pleasing surfaces that are almost impossible to distinguish from real bricks and pavers. However, stamped materials can also have maintenance issues, since, for example, the sidewalk may never look the same again after repairs are made.

It is also possible to enhance sidewalks aesthetics while still providing a smooth walking surface by combining a concrete main walking area with brick edging where street furniture (lights, trees, poles, etc.) can be placed. For example, in a CBD, a 4.6-m (15-ft) total sidewalk width might include a 2.4 m (8-ft) clear concrete sidewalk with a 2.1-m (7-ft) edge.

SIDEWALK GRADE AND CROSS-SLOPES

Sidewalks should be built to accommodate all pedestrians and should be as flat as practical. Sidewalks should be held to a running grade of 5 percent or less, if possible. However, sidewalks that follow the grade of a street in hilly terrain cannot meet this requirement, for obvious reasons, and may follow the grade of the street. The maximum grade for a curb ramp is 1:12 (8.3 percent).

The maximum sidewalk cross-slope is 1:50 (2 percent) to minimize travel effort for wheelchair users and still provide drainage. At least 0.9 m (3 ft) of flat sidewalk area is required at the top of a sloped driveway to accommodate wheelchair use. In some cases, it may be necessary to bend the sidewalk around the back of the driveway to achieve a level surface of 0.9 m (3 ft).

CURB RAMPS

Curb ramps must be provided at all intersection crossings (marked or unmarked) and midblock crosswalks for wheelchair access. These ramps also accommodate strollers, carts, the elderly, and pedestrians with mobility limitations. Curb ramps should be as flat as possible, but must have a slope no greater than 1:12 (8.3 percent). Abrupt changes in elevation at the top or bottom should be avoided. The minimum curb ramp width is 914 mm (36 in); however, 1,219 mm (48 in) is the desirable minimum. If a curb ramp is located where pedestrians must walk across the ramp, the ramp must have flared sides of no more than 1:10 (10 percent) slope. These flares are not needed where ramps are placed in a landscaped area. Curb ramps also require a minimum of 914 mm (36 in) of level and clear passage (1,219 mm (48 in) or more are desirable) at the top.

Two separate curb ramps, one for each crosswalk, should be provided at each corner of an intersection. Diagonal curb ramps provide no directional guidance to vision-impaired pedestrians, and force wheelchair users to maneuver in the crosswalk. Raised islands in a crossing must have at least a 1,219-mm (48-in) cut-through that is level with the street; this is generally preferable to curb ramps, which force wheelchair users to go up and down.

OBSTACLES ALONG THE SIDEWALK

The distance to the bottom of signs placed in or right next to a sidewalk should be at least 2 m (7 ft) above the sidewalk surface to avoid injury to pedestrians. Bushes, trees, and other landscaping should be maintained to prevent encroachment into the sidewalk. Jurisdictions should adopt ordinances requiring local property owners to trim the landscaping they place along their frontage to maintain clear and unobstructed sidewalks. The jurisdictions should provide an inspection procedure or a system of responding to sidewalk encroachment and maintenance complaints.

Guy wires and utility tie-downs should not be located in or across sidewalks at heights below 2 m (7 ft). When placed adjacent to sidewalks or pedestrian walkways, the guy wires should be covered with a bright yellow (or other high-visibility) plastic guard to make the wire more visible to pedestrians. Guy wires of any color will not be visible to blind pedestrians and must not be located within the pedestrian route. Other obstacles include signal controller boxes, awnings, temporary signs, news paper racks, fire hydrants, and similar items.

ACCESSIBILITY

The easiest way to visualize accessibility requirements (grade, cross-slope, and clear width) is with the concept of a "continuous passage." Sidewalks must provide a continuous route at a 2 percent maximum cross-slope at a minimum width of 0.9 m (3 ft). This does not mean that 0.9 m (3 ft) is an acceptable sidewalk width, just that at no point shall the level area be less than 0.9 m (3 ft) wide; this applies mainly at obstructions, driveways, and curb ramps.

SNOW

Municipalities that do not remove snow on sidewalks should have an ordinance requiring property owners to clear the snow and keep the sidewalks accessible to pedestrians. When the latter is the case, municipalities should educate property owners as to why this is important and have enforcement efforts in place to ensure compliance.

BUS STOPS AND SHELTERS

It is generally preferable to place bus shelters between the sidewalk and the street, or between the sidewalk and adjacent property, so that waiting passengers do not obstruct the flow of pedestrians along the sidewalk. Benches and other street furniture should be placed outside the walking paths to maintain the accessibility of the walkway and to provide good pedestrian service. In addition, curb ramps should be provided at bus stops because it is not always possible for the bus to pull close enough to the curb to deploy a lift.

LIGHTING

Good street lighting improves the visibility, comfort, and security of pedestrians. In urban areas, it is important to light at least the intersections and other pedestrian crossing areas. Lighting is also recommended in areas where there is a high concentration of nighttime pedestrian activity, such as churches, schools, and community centers. Where continuous lighting is provided along wide arterial streets, it is desirable to place the lights along both sides of the street. Continuous streetlights should be spaced to provide a relatively uniform level of light. In shopping districts or in downtown areas with high concentrations of pedestrians, it is desirable to provide pedestrian-level lighting in addition to the street lighting to improve the comfort and security of pedestrians. The preferred pedestrian-level lights are mercury vapor or incandescent. Low-pressure sodium lights may be more energy-efficient; however, they are undesirable because they create considerable color distortion. Pedestrian-level lighting may also be installed in selected areas of pedestrian activity to create a sense of intimacy and place.

OTHER DESIGN CONSIDERATIONS

Sidewalks should be built within the public right of-way or in a sidewalk easement along the right-of-way. This will provide access to the sidewalk for maintenance activities and will prevent the adjacent property owners from obstructing or removing the sidewalk in the future.

Care must be taken to avoid planting trees or large bushes in the landscape buffer area that will obscure the visibility between a pedestrian attempting to cross or enter a street and an approaching motorist. Trees with large canopies planted between the sidewalk and street should be generally trimmed up to at least 2.4 m (8 ft) high and bushes should be kept to about 762 to 914 mm (30 to 36 in) in height. Trees with large caliper trunks may not be appropriate near intersections and in other situations where they may block visual sight triangles.

Meandering sidewalks are sometimes used where a wide right-of-way is available and there is a desire to provide a high level of landscaping, such as in a park or along a waterway or other natural feature. It is often believed that meandering sidewalks create a more pleasant walking environment. The reality is that they unnecessarily create a longer walking distance and are inappropriate for sidewalks along a street.

Sidewalks should be built along both sides of bridges. Pedestrian rails or guard rail are required along the outside of the bridge. On bridges with high speeds, concrete barriers between the travelway and the sidewalk may be considered to shield pedestrians from errant vehicles. However, this adds cost, weight, and width to the bridge, and the transition from barrier to guard rail or curb at each end often creates an awkward transition for pedestrians, who must detour around the barrier to access the bridge sidewalk.

Rollover curbs should not be used next to sidewalks as they encourage motorists to park on planting strips or sidewalks. They may be problematic for some visually impaired people, since they don't create a definitive edge between the street and adjacent uses.

Sidewalk Depth: Concrete sidewalks should be built to a minimum depth of 101.6 mm (4 in), and to a minimum depth of 152.4 mm (6 in) at driveways.

SIDEWALK COST CONSIDERATIONS

The actual cost of providing sidewalks will be different for each region of the country and varies with the season. Actual bid prices are also influenced by how busy contractors are at the time of construction.

The cost of constructing sidewalks alone is relatively low; typical bids run between $24 and $36 per meters squared ($20 to $30 a square yard), which roughly translates to $43 to $64 per lineal meter ($12 to $20 per lineal foot) for 1.8-m- (6-ft-) wide sidewalks. Therefore, sidewalks on both sides of the roadway can run roughly between $93,000 and $155,000 per kilometer ($150,000 and $250,000 per mile) (costs from Oregon DOT, 1999).

Factors to consider when calculating the cost of sidewalks:

1. Presence of curb and gutter: The costs of providing curb and gutter, which presumes the need to also provide a street drainage system, run much higher than the cost of sidewalk alone. A standard perpendicular curb ramp and top landing need a minimum border width of almost 3.7 m (12 ft) at intersections if there is a 152.4-mm (6-in) curb. A 152.4-mm (6-in) curb reduces the minimum border width to 3 m (10 ft). Yet, on many urban streets, this work must be performed prior to installing sidewalks. If this is the case, only the cost of sidewalks and curb ramps should be attributed to expenditures for pedestrians – catch basins are provided to drain the roadway surface used by motor vehicle traffic.
2. Number of driveways: To comply with ADA, many existing driveways must be replaced with ones that provide a level passage at least 0.9 (3 ft) wide. It can also be advantageous to inventory all existing driveways to see if any can be closed, resulting in a cost-savings.
3. Number of intersections: While intersections represent a reduction in the sidewalk, curb ramps are required where sidewalks cross intersections and the cost of providing additional traffic control at each intersection should be considered.
4. Obstacles to be removed: The cost for moving or removing obstacles such as utility poles, signposts, and fire hydrants vary too much to be itemized here; however, they are required to be moved if they obstruct access. These costs must be calculated individually for each project.
5. Structures: While minor sidewalk projects rarely involve new structures such as a bridge, many projects with significant cuts and fills may require retaining walls and/or culvert extensions. The costs of retaining walls must be calculated individually for each project.
6. Right-of-way: While most sidewalk projects can be built within existing rights-of-way (especially infill projects), some may require some right-of-way easement. An alternative to acquiring right-of-way is to narrow the roadway, which should consider the needs of bicyclists (e.g., through bike lanes or shoulders, at a minimum of 1.5 m (5 ft).
7. Miscellaneous factors: Planters, irrigation, benches, decorative lampposts, and other aesthetic improvements cost money, but they are usually well worth it if the impetus for the project is to create a more pleasant and inviting walking environment.

When project costs appear to be escalating due to one or more of the above-listed items, especially retaining walls or acquiring right-of-way, consideration may be given to narrowing the sidewalk in constrained areas as a last resort. The full sidewalk width should be resumed in non-constrained areas—this is preferable to providing a narrow sidewalk throughout, or dropping the project because of one difficult section.

Tips to Reduce Total Costs:

1. Stand-alone vs. integrated within another project: Sidewalks should always be included in road construction projects. Stand-alone sidewalk projects cost more than the same work performed as part of a larger project. Sidewalks can be piggybacked to projects such as surface preservation, water or sewer lines, or placing utilities underground. Besides the monetary savings, the political fallout is reduced, since the public doesn't perceive an agency as being inefficient (it is very noticeable if an agency works on a road, then comes back to do more work later). The reduced impacts on traffic are a bonus to integration.

2. Combining Projects: A cost savings can be achieved by combining several small sidewalk projects into one big one. This can occur even if the sidewalks are under different jurisdictions, or even in different localities, if they are close to each other. The basic principle is that bid prices drop as quantities increase.

BIBLIOGRAPHY AND LIST OF REFERENCES

American Association of State Highway and Transportation Officials, A Policy on Geometric Designs of Highways and Streets, 1984.

Axelson, P. et al., Designing Sidewalks and Trails for Access, Federal Highway Administration, Washington, DC, July 1999.

Institute of Transportation Engineers, Design of Pedestrian Facilities—Recommended Practices: Providing Safety and Mobility, 2001.

Recommended Guidelines for Crosswalk Installation

Appendix D

PHOTO BY CARA SEIDERMAN

Guidelines and Caveats

Other Treatments

References

These guidelines were developed in an FHWA report entitled Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations.(1) This report may be found at: www.walkinginfo.org/rd/devices.htm. In developing these proposed U.S. guidelines for marked crosswalks and other pedestrian measures, consideration was given not only to the research results in this study, but also to crosswalk guidelines and related pedestrian safety research in Australia, Canada, Germany, Great Britain, Hungary, The Netherlands, Norway, and Sweden (see references 2-8).

Marked crosswalks serve two purposes: (1) they tell the pedestrian the best place to cross, and (2) they clarify that a legal crosswalk exists at a particular location.

Marked crosswalks are one tool to get pedestrians safely across the street. When considering marked crosswalks at uncontrolled locations, the question should not simply be: "Should I provide a marked crosswalk or not?" Instead, the question should be: "Is this an appropriate tool for getting pedestrians across the street?" Regardless of whether marked crosswalks are used, there remains the fundamental objective of getting pedestrians safely across the street.

In most cases, marked crosswalks are best used in combination with other treatments (e.g., curb extensions, raised crossing islands, traffic signals, roadway narrowing, enhanced overhead lighting, traffic-calming measures, etc.). Think of marked crosswalks as one of a progression of design treatments. If one treatment does not adequately accomplish the task, then move on to the next one. The failure of one particular treatment is not a license to give up and do nothing. In all cases, the final design must address the goal of getting pedestrians across the road safely.

GUIDELINES AND CAVEATS

Marked pedestrian crosswalks may be used to delineate preferred pedestrian paths across roadways under the following conditions:

1. At locations with stop signs or traffic signals. Vehicular traffic might block pedestrian traffic when stopping for a stop sign or red light; marking crosswalks may help to reduce this occurrence.

2. At non-signalized street crossing locations in designated school zones. Use of adult crossing guards, school signs and markings, and/or traffic signals with pedestrian signals (when warranted) should be used in conjunction with the marked crosswalk, as needed.

3. At non-signalized locations where engineering judgment dictates that the number of motor vehicle lanes, pedestrian exposure, average daily traffic (ADT), posted speed limit, and geometry of the location would make the use of specially designated crosswalks desirable for traffic/pedestrian safety and mobility. This must consider the conditions listed below.

Marked crosswalks should be supplemented with other treatments (i.e., without traffic-calming treatments, traffic signals, and pedestrian signals when warranted, or other substantial crossing improvement) when any of the following conditions exist:

1. Where the speed limit exceeds 64.4 km/h (40 mi/h).

2. On a roadway with four or more lanes without a raised median or crossing island that has (or will soon have) an ADT of 12,000 or greater.

3. On a roadway with four or more lanes with a raised median or crossing island that has (or will soon have) an ADT of 15,000 or greater.

Street crossing locations should be routinely reviewed to consider the following available options:

- Option 1—No special provisions needed.
- Option 2—Provide a marked crosswalk alone.
- Option 3—Install other crossing improvements (with or without a marked crosswalk) to reduce vehicle speeds, shorten crossing distances, increase the likelihood of motorists stopping and yielding, and/or other outcome.

The spacing of marked crosswalks should also be considered so that they are not placed too close together. A more conservative use of crosswalks is generally preferred. Thus, it is recommended that in situations where marked crosswalks alone are acceptable that a higher priority be placed on their use at locations having a minimum of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians per peak hour). In all cases, good engineering judgment must be applied.

Marked crosswalks should not be installed in close proximity to traffic signals, since pedestrians should be encouraged to cross at the signal in most situations. The minimum distance from a signal for installing a marked crosswalk should be determined by local traffic engineers based on pedestrian crossing demand, type of roadway, traffic volume, and other factors. The objective of adding a marked crosswalk is to channel pedestrians to safer crossing points. It should be understood, however, that pedestrian crossing behavior may be difficult to control merely by the addition of marked crosswalks. The new marked crosswalk should not unduly restrict platooned traffic, and should also be consistent with marked crosswalks at other unsignalized locations in the area.

OTHER TREATMENTS

In addition to installing marked crosswalks (or, in some cases, instead of installing marked crosswalks), there are other treatments that should be considered to provide safer and easier crossings for pedestrians at problem locations. Examples of these pedestrian improvements include:

- Providing raised medians (or raised crossing islands) on multi-lane roads.

- Installing traffic signals and pedestrian signals where warranted, and where serious pedestrian crossing problems exist.

- Reducing the exposure distance for pedestrians by:
  —Providing curb extensions.
  —Providing pedestrian islands.
  —Reducing four-lane undivided road sections to two through lanes with a left-turn bay (or a two-way left-turn lane), sidewalks, and bicycle lanes.

- When marked crosswalks are used on uncontrolled multi-lane roads, consideration should be given to installing advance stop lines as much as 9.1 m (30 ft) prior to the crosswalk (with a STOP HERE FOR CROSSWALK sign) in each direction to reduce the likelihood of a multiple-threat pedestrian collision.

- Bus stops should be located on the far side of uncontrolled marked crosswalks.

- Installing traffic-calming measures to slow vehicle speeds and/or reduce cut-through traffic. Such measures may include:
  —Raised crossings (raised crosswalks, raised intersections).
  —Street-narrowing measures (chicanes, slow points, "kinny street" designs).
  —Intersection designs (traffic mini-circles, diagonal diverters).
  — Others (see ITE Traffic-Calming Guide for further details).(1)

Some of these traffic-calming measures are better suited to local or neighborhood streets than to arterial streets:

- Providing adequate nighttime street lighting for pedestrians in areas with nighttime pedestrian activity where illumination is inadequate.

- Designing safer intersections and driveways for pedestrians (e.g., crossing islands, tighter turn radii), which take into consideration the needs of pedestrians.

REFERENCES

1. Zegeer, C., J. Stewart, and H. Huang, Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations, Report No. FHWA-RD-01-142, FHWA, Washington, DC, May 2001.

2. Safety of Vulnerable Road Users, Organisation for Economic Co-operation and Development (OECD), August 1998.

3. Ekman, L., Pedestrian Safety in Sweden, Report No. FHWA-RD-99-091, FHWA, Washington, DC, December 1999.

4. Hummel, T., Dutch Pedestrian Safety Research Review, Report No. FHWA-RD-99-092, FHWA, Washington, DC, December 1999.

5. Pedestrian Safety: Analyses and Safety Measures, Danish Road Directorate, Division of Traffic Safety and Environment, Copenhagen, June 1998.

6. Van Houten, R., Canadian Research on Pedestrian Safety, Report No. FHWA-RD-99-090, FHWA, Washington, DC, December 1999.

7. Cairney, P., Pedestrian Safety in Australia, Report No. FHWA-RD-99-093, FHWA, Washington, DC, December 1999.

8. Davies, D., Research, Development, and Implementation of Pedestrian Safety Facilities in the United Kingdom, Report No. FHWA-RD-99-089, FHWA, Washington, DC, December 1999.

References

CHAPTER 1 THE BIG PICTURE

1. United States Department of Transportation, Bureau of Transportation Statistics, *1995 Nationwide Personal Transportation Survey*.
2. *Design and Safety of Pedestrian Facilities*, A Recommended Practice, Institue of Transportation Engineers, Washington, DC, March 1998.
3. Appleyard, Donald, *Livable Streets*, University of California Press, Berkeley, 1981.
4. American Association of State Highway and Transportation Officials, *Roadside Design Guide*, Washington, DC, October 1988.
5. Axelson, P.W., D.Y. Chesney, D.V. Galvan, J.B. Kirshbaum, P.E. Longmuir, C. Lyons, and K.M. Wong, *Designing Sidewalks and Trails for Access*, Federal Highway Administration, Washington, DC, July 1999.

CHAPTER 2 PEDESTRIAN CRASH STATISTICS

1. Zegeer, C.V. and C.B. Seiderman, "Designing for Pedestrians," Chapter 19, *Traffic Safety Toolbox–A Primer on Traffic Safety*, Institute of Transportation Engineers, 1999.
2. National Highway Traffic Safety Administration, *Traffic Safety Facts 2003*, Washington, DC, 2004.
3. Zegeer, C., J. Stutts, H. Huang, M. Zhou, and E. Rodgman, *Analysis of Elderly Pedestrian Accidents and Recommended Countermeasures*, Transportation Research Board, Washington, DC, 1993.
4. Campbell, B., C. Zegeer, H. Huang, and M. Cynecki, *Pedestrian Safety Research in the U.S.*, Federal Highway Administration, Washington, DC, October 1999.
5. National Safety Council, *Injury Facts–2000 Edition*, Itasca, IL, 2000.
6. Staplin, L., K. Lococo, S. Byington, and D. Harkey, *Highway Design Handbook for Older Drivers and Pedestrians*, Report No. FHWA-RD-01 103, Federal Highway Administration, Washington, DC, October 2001.
7. National Highway Traffic Safety Administration, *Fatal Accident Reporting System 1989—A Decade of Progress*, Washington, DC, 1990.
8. National Highway Traffic Safety Administration, *General Estimates System 1989—A Review of Information on Police-Reported Traffic Crashes in the United States*, Washington, DC, 1990.
9. Zegeer, C., J. Stutts, and W. Hunter, Pedestrian and Bicycle, *Volume VI: Safety Effectiveness of Highway Design Features*, Report No. FHWA-RD-91-049, Federal Highway Administration, Washington, DC, November 1992.
10. U.K. Department of Transportation, *Killing Speed and Saving Lives*, London, 1987.

CHAPTER 3 SELECTING IMPROVEMENTS FOR PEDESTRIANS

1. Snyder, M., and R. Knoblauch, *Pedestrian Safety: The Identification of Precipitating Factors and Possible Countermeasures* (2 Vols.), Report No. DOT-HS-800-403, NHTSA, Washington, DC, January 1971.
2. Knoblauch, R., W. Moore, Jr., and P. Schmitz, *Pedestrian Accidents Occurring on Freeways: An Investigation of Causative Factors, Accident Data*, Report No. FHWA-RD-78-159/171, Federal Highway Administration, Washington, DC, 1978.
3. Knoblauch, R., *Causative Factors and Countermeasures for Rural and Suburban Pedestrian Accidents: Accident Data Collection and Analyses*, Report No. DOT HS-802-266, NHTSA, Washington, DC, June 1977.
4. Hunter, W., J. Stutts, W. Pein, and C. Cox, *Pedestrians and Bicycle Crash Types of the Early 1990s*, Report No. FHWA-RD-95-163, Federal Highway Administration, Washington, DC, June 1996.

5. D.L. Harkey, J. Mekemson, M.C. Chen, and K. Krull, *Pedestrian and Bicycle Crash Analysis Tool*, Product No. FHWA-RD-99-192, Federal Highway Administration, Washington, DC, December 1999.

6. Zegeer, C. and C. Seiderman, "Designing for Pedestrians," Chapter 19, *The Traffic Safety Toolbox–A Primer on Traffic Safety*, Institute of Transportation Engineers, 1999.

7. Zegeer, C.V. and S.F. Zegeer, *Pedestrians and Traffic Control Measures*, NCHRP Synthesis of Highway Practice No. 139, Transportation Research Board, November 1988.

8. Zegeer, C., "Engineering and Physical Measures to Improve Pedestrian Safety," in *Effective Highway Accident Countermeasures*, U.S. Department of Transportation, Washington, DC, August 1990.

9. Zegeer, C. and S. Zegeer, "Engineering: Designing a Safer Walking Environment," *Traffic Safety*, Vol. 88, No. 1 (January/February 1988).

CHAPTER 5 THE COUNTERMEASURES

PEDESTRIAN FACILITY DESIGN

1. Campbell, B., C. Zegeer, H. Huang, and M. Cynecki, *Pedestrian Safety Research in the U.S.*, Federal Highway Administration, Washington, DC, October 1999.

2. Institute of Transportation Engineers, *Design and Safety of Pedestrian Fatalities*, March 1998.

3. Kirschbaum, J. et al., *Designing Sidewalks and Trails for Access, Part II of II: Best Practices Design Guide*, Federal Highway Administration, Washington, DC, September 2001.

4. *Draft Guidelines for Accessible Public Rights of Way*, United States Architectural and Transportation Barriers Compliance Board, Washington, DC, June 2002.

5. Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways*, Federal Highway Administration, Washington, DC, 2003.

6. Zegeer, C., J. Stuart, and H. Huang, *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Crossing Locations*, Federal Highway Administration, Washington, DC, 2001.

7. *Accessible Rights-Way-: A Design Guide*, United States Architectural and Transportation Barriers Compliance Board, Washington, DC, November 1999.

8. Moore, R.L. and S.J. Older, "Pedestrians and Motorists Are Compatible in Today's World," *Traffic Engineering*, Institute of Transportation Engineers, Washington, DC, September 1965.

9. Bowman, B.L., J.J. Fruin, and C.V. Zegeer, *Planning, Design, and Maintenance of Pedestrian Facilities*, Report No. FHWA-IP-88-019, Federal Highway Administration, October 1988.

10. Robinson, B.W., et al., *Roundabouts: An Informational Guide*, Publication No. FHWA-RD-00-067, Federal Highway Administration, Washington, DC, June 2000.

ROADWAY DESIGN

1. Kirschbaum, J. et al., *Designing Sidewalks and Trails for Access, Part II of II: Best Practices Design Guide*, Federal Highway Administration, Washington, DC, September 2001.

INTERSECTION DESIGN

1. Robinson, B.W., et al., *Roundabouts: An Informational Guide*, Publication No. FHWA-RD-00-067, Federal Highway Administration, Washington, DC, June 2000.

TRAFFIC CALMING

1. Institute of Transportation Engineers, *Traffic Calming: State of the Practice*, August 1999.

2. Zegeer, C.V., J. Stuart, and H. Huang, *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Crossing Locations*, Federal Highway Administration, Washington, DC, 1999.

3. Institute of Transportation Engineers and the Federal Highway Administration, *Traffic Calming State of the Art*, August 1999.

4. City of Cambridge, MA, *Preliminary Results: Effects of Columbia Street Traffic Calming Project on Driver Behavior*, April 2000.

SIGNALS AND SIGNS

1. Federal Highway Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways*, Washington, DC, 2003.

2. Zegeer, C.V., K.S. Opiela, and M.J. Cynecki, *Pedestrian Signalization Alternatives*, Report No. FHWA/RD-83-102, Federal Highway Safety Administration, Washington, DC, 1983.

3. Van Houten, Ron et al., *Field Evaluation of a Leading Pedestrian Interval Signal Phase at Three Urban Intersections*, Insurance Institute for Highway Safety,

Arlington, VA. April 1997.

4. Van Houten, Ron et al., *Use of Animation in LED Pedestrian Signals to Improve Pedestrian Safety*, Insurance Institute for Highway Safety, Arlington, VA. 1998.

5. Hughes, Ronald, H. Huang, C.V. Zegeer, and M. Cynecki, *Evaluation of Automated Pedestrian Detection at Signalized Intersections*, Report No. FHWA/RD-00/097, Federal Highway Administration, Washington, DC. August 2000.

6. Zegeer, C.V. and M.J. Cynecki, *Methods of Increasing Pedestrian Safety at Right-Turn-on-Red Intersections*, Report No. FHWA/RD-85/047, Federal Highway Administration, Washington, DC, March 1985.

7. Van Houten, Ron and J.E. Louis Malenfant, Canadian Research on Pedestrian Safety, Report No. FHWA/RD-99/090, Federal Highway Administration, Washington, DC, 1999.

OTHER MEASURES

1. Zegeer, C.V. and S.F. Zegeer, *Pedestrians and Traffic Control Measures*, NCHRP Synthesis of Highway Practice No. 139, Transportation Research Board, November 1988.