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- Zegeer, C.V. (1990). "Engineering and Physical Measures to Improve Pedestrian Safety." In *Symposium on Effective Highway Accident Countermeasures. Proceedings*. Washington, DC: Federal Highway Administration in cooperation with the National Highway Traffic Safety Administration.

Scanned and uploaded on
February 21, 2012

ENGINEERING AND PHYSICAL MEASURES TO IMPROVE PEDESTRIAN SAFETY

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An engineering or physical facility change to the roadway is often the most appropriate solution to a pedestrian safety hazard. Physical facility improvements work best when they are tailored to an individual location and traffic problem. Factors to consider when choosing an improvement are location characteristics, pedestrian and vehicle volume, vehicle speed, design of a given location, city laws and ordinances, and financial constraints.

The following engineering measures should be examined as a part of a community's WALK ALERT effort.

SIDEWALKS

Sidewalks have been shown to reduce the number of pedestrian accidents in residential and business areas. They separate pedestrians from the roadway. They also provide paved places for children to play rather than play in the street.

Sidewalks exist in most urban areas, but they are not usually constructed in rural areas because of low pedestrian volumes and relatively high construction costs. Sidewalk construction is often funded by property owners.

Recommended Guidelines for Sidewalk Installation

Recommended general sidewalk requirements shown are dependent on the land use, roadway functional classification, and, in the case of residential areas, dwelling unit density. These recommended guidelines are detailed in table 1.[1]

The guidelines indicate where sidewalks should be installed. Obviously the width of a sidewalk should depend on where it is installed and the anticipated usage. The following are suggested minimum specifications for the width of the sidewalk to be installed:[1]

*This report (with minor editing) is from the 1988 WALK ALERT Program Guide, which is part of the National Pedestrian Safety Program, National Safety Council (NSC). Mr. Zegeer was the original author of this paper, and it was revised by NSC prior to appearing in the program guide.

Reprinted from: Symposium on Effective Highway Accident Countermeasures. Proceedings. June 12-14, 1990. Washington, DC.

Table 1. Guidelines for installing sidewalks.

Land-Use/Roadway Functional Classification Dwelling Unit	New Urban and Suburban Streets	Existing Urban and Suburban Streets
Commercial and Industrial (All Streets)	Both sides.	Both sides. Every effort should be made to add sidewalks where they do not exist and complete missing links.
Residential (Major Arterials)	Both sides.	Both sides.
Residential (Collectors)	Both sides.	Multifamily—both sides. Single-family dwellings—prefer both sides; require at least one side.
Residential (Local Streets) More than 4 Units Per Acre	Both sides.	Prefer both sides; require at least one side.
Residential (Local Streets) 1 to 4 Units Per Acre	Prefer both sides; required at least one side.	One side preferred, at least 4-ft shoulder on both sides required.
Residential (Local Streets) Less Than 1 Unit Per Acre	One side preferred; shoulder both sides required.	At least 4-ft shoulder on both sides required.

NOTES:

1. On any local street within two blocks of a school site that would be on a walking route to school, a sidewalk is required on at least one side.
2. Sidewalks may be omitted on one side of new streets where that side clearly cannot be developed and where there are no existing or anticipated uses that would generate pedestrian trips on that side.
3. Where there are service roads, the sidewalk adjacent to the main road may be eliminated and replaced by a sidewalk adjacent to the service road on the side away from the main road.
4. For rural roads not likely to serve development, a shoulder at least 4 ft wide—preferably 8 ft on primary highways should—be provided. Surface material should provide a stable, mud-free walking surface.

Proposed Minimum Sidewalk Widths

1. Central business districts: Conduct level of service analysis according to methods in *1985 Highway Capacity Manual.*

2. Commercial/industrial areas outside a central business district: Minimum 5 ft wide with 2-ft planting strip or 6 ft wide with no planting strip.

3. Residential areas outside a central business district: Arterial and collector streets—Minimum 5 ft with minimum 2-ft planting strip.

4. Local streets:

   - Multifamily dwellings and single-family dwellings with densities greater than 4 dwelling units per acre—Minimum 5 ft with minimum 2-ft planting strip.

   - Densities up to 4 dwelling units per acre—Minimum 4 ft with minimum 2-ft planting strip.

FACILITIES FOR DISABLED PEOPLE AND OLDER ADULTS

People with disabilities who experience higher than normal levels of risk include developmentally restricted persons (mostly children), users of wheelchairs, people with impairments to lower extremities who walk with special aids, and people with severe visual impairments. Special types of engineering improvements for disabled people include: [2]

- Signal-related improvements such as audible pedestrian signals and longer "WALK" intervals activated by pedestrians.

- Sidewalk-related facilities like curb ramps, guidestrips, handrails, widened sidewalks, and careful placement of street furniture.

- Special signs, such as those warning motorists of the possible presence of blind or deaf pedestrians.

The use of special facilities for the handicapped is often required on projects constructed with Federal funding. The effectiveness of such facilities is relatively unknown. However, such facilities become more feasible at locations used by a large number of disabled people.

A recently updated implementation manual published by the Federal Highway Administration (FHWA), *Accessibility for Elderly and Handicapped Pedestrians—A Manual for Cities, 1987*, describes the four planning stages and provides guidance for planners and other officials to follow in developing an accessibility program in Part I. Part II: Design provides explanations of the details necessary to preparing the accessibility plans of Part I. Each design chapter provides definitions, Federal and other standards if they exist, illustrations, and extensive information on problems and recommended solutions.[3]

BUS STOP RELOCATION

Buses stopped on the near side of intersections may severely block the pedestrian's view of approaching traffic, and the approaching driver's view of pedestrians. Approaching motorists are often unable to stop when a pedestrian steps out into traffic from behind the front end of a bus.

Relocation of a transit or school bus stop to the far side of an intersection can improve pedestrian safety because it eliminates the sight restriction posed by the bus. There are situations where far-side bus stops are less practical, such as at intersections with heavy turning volumes.

GRADE SEPARATION

Pedestrian overpasses and underpasses allow for the free, uninterrupted flow of pedestrians, separate from vehicular traffic. Most pedestrians will not use a grade-separated facility unless it is easily accessible, provides a feeling of personal safety, and requires less time to cross than the time to cross the road at street level. Grade-separated crossings may be highly effective when pedestrian use is high. Because of their high cost, installations of grade-separated crossings are most feasible at locations with one or more of the following characteristics: [4]

- High-vehicle speed and/or traffic volumes, particularly near elementary schools.
- Wide roadways, such as freeways.
- Areas of extreme hazard to pedestrians.

PHYSICAL BARRIERS

Roadway barriers include chains, fences, or other devices that physically separate pedestrians from motor vehicles. The use of physical barriers can be a feasible method to improve pedestrian safety at intersection or midblock locations, particularly where pedestrians frequently dart out into the roadway. Physical barriers are helpful in channelizing pedestrians to intersection crosswalks. They may be less effective near high school or college campuses where students may maneuver over or under them.

Median barriers such as fences or plantings are employed where nonintersection crossings are to be prevented.

LIGHTING

Overhead street lights are often installed in urban areas to aid motorists at night and to deter crime. Well-lighted streets may also help pedestrians. Drivers can more readily avoid accidents with pedestrians when they can see them soon enough to stop on time. Although installation of roadway lighting is relatively expensive, it may be justified in areas with high nighttime pedestrian activity.

ONE-WAY STREETS

Conversion from two-way to one-way street systems has consistently been found to reduce pedestrian accidents. These systems simplify crossings for pedestrians and allow motorists to give more attention to pedestrians.

TRAFFIC SIGNALS

Traffic signals can create gaps in traffic flow so that pedestrians may cross while motor vehicles are stopped. However, traffic signals are not always programmed to provide adequate time for pedestrians to safely cross the street. Traffic signals may be highly beneficial in providing crossing opportunities for pedestrians. However, pedestrians should not rely totally on the signals as a guarantee that it is safe to cross. They must still search for traffic before leaving the curb. For additional information on traffic signals, see the *Manual on Uniform Traffic Control Devices* (MUTCD), published by the Government Printing Office.[5]

PEDESTRIAN SIGNALS

The use of "WALK"/"DON'T WALK" signals is often assumed to reduce pedestrian accidents. However, research studies have found no difference in pedestrian accidents for sites with no pedestrian signals versus those with standard-timed pedestrian signal phasing (that is, timed so pedestrians have a "WALK" interval while vehicles travel parallel to pedestrians and may turn right or left across pedestrian's paths). The use of exclusive-timed pedestrian intervals (that is, intervals of the signal cycle where all vehicle movements are given a red signal while pedestrians may cross in any direction) show fewer pedestrian accidents, but greatly increase vehicular delay.[6]

There are certain situations where pedestrian signals are necessary, such as (1) when vehicle signals are not visible to pedestrians, (2) when signal timing is complex, (3) at established school zone crossings, (4) when an exclusive pedestrian interval is provided. However, indiscriminant use of pedestrian signals is not recommended, because it may give pedestrians a false sense of security at locations where no special need exists. The use of symbolic pedestrian signals, like man and hand symbols, is acceptable as an alternative to the "WALK"/"DON'T WALK" signals. For additional information on pedestrian signals, see the MUTCD.[5]

SIGNS

Guidelines for types and placement of highway signs, signals, and markings are provided in the MUTCD. Signs are usually mounted on a post or pole and may be classified as (1) regulatory, such as "WALK ON LEFT FACING TRAFFIC" or "NO TURN ON RED" or (2) warning, such as "WATCH FOR TURNING VEHICLES" or (3) guides, such as "PUSH BUTTON FOR WALK SIGNAL." [5]

One of the primary advantages of all types of pedestrian-related signing is their low cost. In many dangerous crossing locations such as complex intersections, signs may be effective in alerting drivers or pedestrians to use extra caution, and thus could improve pedestrian safety. Some disadvantages of signs are that they are often overused, which breeds noncompliance and disrespect for signing in general; some signs are not easily understood; and new signs may require community education and publicity programs.[4]

SCHOOL ZONE IMPROVEMENTS

Numerous roadway improvements have been used in an attempt to improve the safety of children in school zones. The use of adult crossing guards, separated pedestrian paths or sidewalks, and police enforcement of vehicle speeds have been found to be quite effective in many instances. However, the use of signs like, "SLOW SPEED LIMIT 25 MPH WHEN FLASHING," and markings like "SLOW SCHOOL," are of limited or unknown effectiveness. Numerous other programs that may be useful include safe route to school programs, parking prohibitions near intersections adjacent to schools, increased supervision of children, and vehicle speed regulations. Pedestrian education programs can be of considerable value in improving child pedestrian safety in conjunction with the measures mentioned above.

SAFETY ISLANDS

Safety or refuge islands are usually constructed between opposing directions of traffic or within an intersection for use by pedestrians when crossing wide or busy streets. They are commonly used at sites where pedestrians are not provided with adequate time to completely cross wide intersections during a "WALK" phase.

They permit pedestrians to look for approaching traffic from only one direction at a time. However, there is always some risk of motorists driving onto safety islands and striking pedestrians, particularly when the islands are narrow and located on high-speed arterials.

PARKING

Many dart-out and intersection dash accidents are due to visual obstructions from vehicles parked along the curb. Restricting curb parking near crossing locations can reduce visual obstructions and improve pedestrian safety. Resistance from nearby business owners sometimes makes it difficult to eliminate parking spaces.

MARKED CROSSWALKS

Marked crosswalks are intended to do two things. First, they should indicate a location for drivers to pay attention to pedestrians. Second, they mark a location for pedestrians to cross the street, rather than crossing anywhere. Large numbers of crosswalks and advance pedestrian crossing signs may increase motorist noncompliance with these traffic control devices. Pedestrians tend to use the shortest and easiest routes in crossing, and will not use inconvenient crosswalks.

Crosswalk markings can consist of two solid parallel lines, stripes running parallel to the directions of vehicle flow (ladder type), diagonally slanted stripes (zebra), or "solid" markings made by painting the entire crosswalk areas or constructing it of material different than the roadway surface. Crosswalks can be located at midblocks or at signalized or nonsignalized intersections and may be signed with advance warning signs. Minimum striping is 6 in parallel lines.[5]

Marking a crosswalk does not always improve safety of pedestrians. There are clearly some locations where marked crosswalks are useful, such as where large pedestrian volumes cross at low-speed signalized intersections or at school crossing locations controlled by crossing guards. However, marked crosswalks may present a false sense of security to pedestrians at other location types and be harmful to pedestrian safety. An example of such locations may include uncontrolled midblock crossings with high vehicle speeds and limited sign distance.[4,8]

Recommended Guidelines for Crosswalk Markings

Crosswalk markings should be installed at:[1]

- All signalized intersections with pedestrian signal heads.
- All locations where a school crossing guard is normally stationed to assist children in crossing the street.
- All intersections and midblock crossings satisfying the minimum vehicular and pedestrian volume criteria in figure 1.[1] As long as the basic criteria governing sight distance, speed limit, etc., are met, a crosswalk is deemed appropriate if the pedestrian and vehicular volumes place it above the appropriate curve in figure 1. Each crosswalk is analyzed by approach leg, indicating that a crosswalk might be warranted on one side of an intersection and not the other. If each approach warranted a crosswalk, then all would be marked. If only peak hour volume is used in figure 1 the threshold must be increased. For streets with a median, use the one-way average daily traffic (ADT) volume.
- All other locations where there is a need to clarify the preferred crossing location when the proper location for crossing would otherwise be confusing.

The most important elements of the guidelines are the basic criteria, which place some restrictions on crosswalk applications to prevent their

being placed in locations that would be extremely hazardous to the pedestrian. Placing crosswalks in locations with high speeds or poor sight distance is never advisable. A crosswalk is not a solution to situations such as this, and other preventive measures should be carefully considered.

The volume thresholds are reduced for locations where young, elderly, or handicapped pedestrians are a significant proportion of the pedestrian population. A value of 50 percent or more is suggested, but this is best left to the judgment of the engineer.[1]

At uncontrolled intersection legs and midblock crossings with operating speeds greater than 35 mi/h, the guidelines suggest the placement of more visible markings for greater conspicuity for drivers. All crossings at uncontrolled intersection legs and midblock crossings should be supplemented with crosswalk signs, as indicated in the MUTCD.

- Crosswalks should not be marked where crossing the street may be unusually dangerous (e.g., locations with high traffic speeds, poor sight distance, or poor illumination).

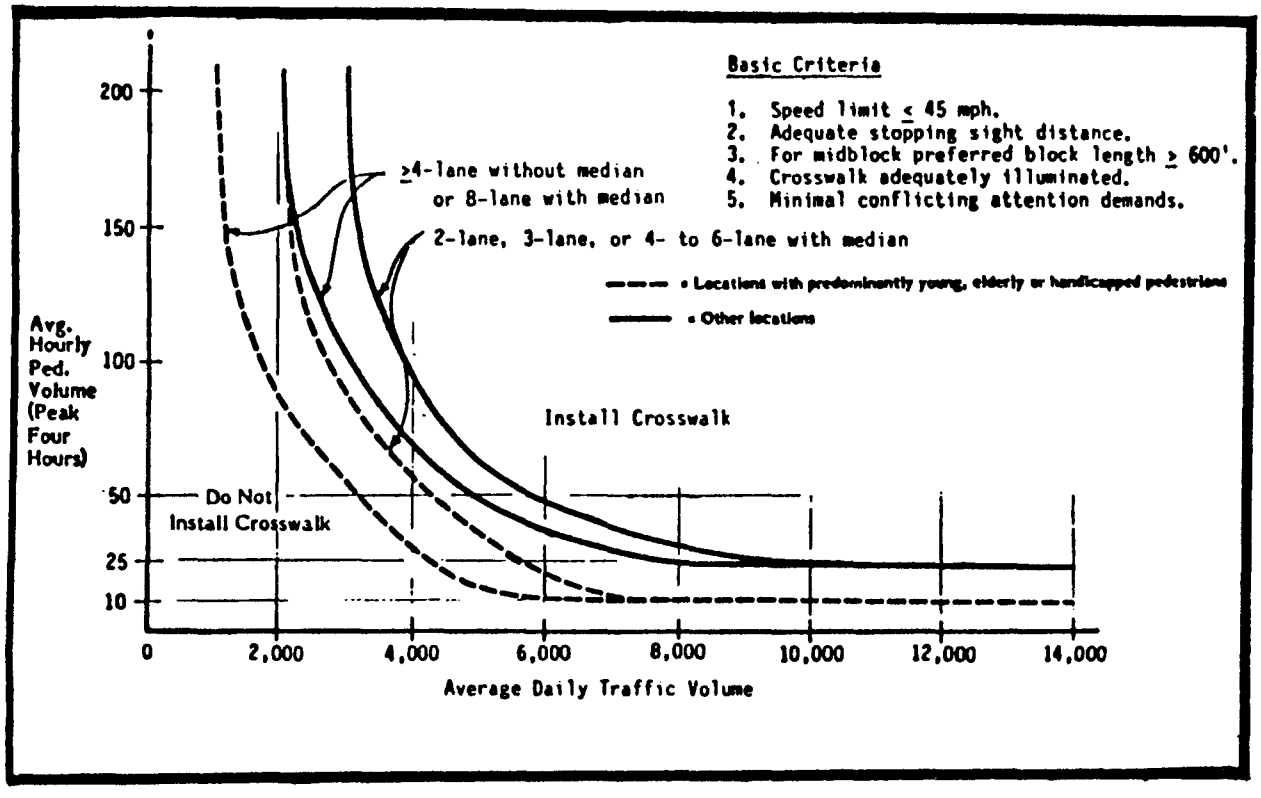

Figure 1. Guidelines for crosswalk installation at uncontrolled intersection legs, midblock crossings, and signalized intersections without ped heads.[1]

- In light of the installation and maintenance costs of pavement markings, crosswalk markings should be located at places expected to receive sufficient benefit. This suggests that crosswalks with low vehicular volume and/or low pedestrian volume do not warrant markings. The determination of minimum pedestrian and vehicle volume thresholds are an important part of establishing reasonable guidelines for installation of crosswalk markings.

- Guidelines for installing crosswalks should include the type of pedestrians expected to be crossing the street. Lower volume thresholds should be considered for areas where there is a greater proportion of less experienced and less agile pedestrians (e.g., near schools and/or elderly housing areas).

- Crosswalk markings in higher-risk crossing areas (higher traffic volumes and speeds) should be supplemented by advance warning signs, and, in some cases, advance warning pavement markings.

- Crosswalks should be used selectively. Allowing a proliferation of crosswalks reduces the overall effectiveness of each crosswalk.

- Specific variables that should be considered when locating crosswalks include activities located nearby (e.g., schools, shopping), pedestrian volume, vehicular volume, sight distance, vehicular speeds, street width and presence of a median, one-way versus two-way operation, and geometrics of the highway or intersection being crossed.[1]

With such a wide variety of engineering countermeasures applicable to pedestrian safety problems, it is often difficult to decide which countermeasure is appropriate for a specific local pedestrian problem. Table 2 from the *Model Pedestrian Safety Program User's Guide* matches specific accident types to potential engineering treatments.[9]

This table lists possible countermeasures that may be helpful for a particular problem. There is usually no single cure for a specific safety problem. At this state, it is important to keep an open mind and consider all possible solutions before making a choice. The next step will involve selecting the best alternative from among the full range of possible countermeasures.

PEDESTRIAN MALLS

An ideal solution to pedestrian safety is the construction of exclusive pedestrian malls, which provide a separated environment between pedestrians and vehicles. Pedestrian malls have been constructed in many cities, primarily in an effort to revitalize activity in downtown areas. Although pedestrian malls are rarely constructed based on pedestrian safety alone, safety may be an important result. Pedestrian malls must be planned with respect to the surrounding traffic flow network, as well as the city's plans for local development.[4]

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Table 2. Pedestrian accident types and potential engineering countermeasures.[9]

Accident Type \ Countermeasures	Engineering and Physical																						
	Barrier: Median	Barrier: Roadway/Sidewalk	Barrier: Street Closure	Bus Stop Relocation	Crosswalk: Intersection	Crosswalk: Midblock	Diagonal Parking-1 Way Street	Grade Separation	Facilities for Handicapped	Lighting: Crosswalk	Lighting: Street	One-Way Streets	Retroreflective Materials	Safety Islands	Sidewalk/Pathway	Signal: Ped. (Shared)	Signal: Ped. (Delayed)	Signal: Ped. (Separated)	Signal: Traffic	Signs and Markings	Urban Ped. Environment	Vehicular Traffic Diversion
Dart-out (First Half)	●	●				●	●														●	●
Dart-out (Second half)	●	●				●	●					●		●							●	●
Midblock Dash	●	●				●								●							●	●
Intersection Dash					●			●		●	●			●			●	●		●		
Turn-Merge Conflict								●									●	●				
Turning Vehicle								●									●	●				
Multiple Threat								●		●	●					●	●	●	●		●	
Bus Stop Related				●																	●	
School Bus Stop Related				●																		
Ice Cream Vendor																				●		
Trapped					●			●						●		●	●	●				
Backup																						
Walking on Roadway		●									●		●		●					●		
Result Vehicle-Vehicle Crash																				●		
Hitchhiking											●		●									
Working in Roadway																				●		
Disabled Vehicle Related																				●		
Nighttime Situation										●	●		●									
Handicapped Pedestrians									●													

*Dots designate countermeasures believed to positively affect the indicated behavior/accident types.

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