

FINAL REPORT
DEVELOPMENT OF GUIDELINES FOR THE INSTALLATION
OF MARKED CROSSWALKS

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ABSTRACT

The *Manual on Uniform Traffic Control Devices* (MUTCD) provides little guidance on the installation of marked crosswalks, especially at locations other than intersections, i.e., mid-block locations. Crosswalks have typically been installed and designed on the basis of engineering judgment. The MUTCD is a good resource for information on the design aspects of crosswalk pavement markings, pedestrian signals, and signage. However, the MUTCD does not provide explicit guidance for determining where and when to install a marked crosswalk if a need exists.

The purpose of this research was to develop guidelines for the installation of marked crosswalks that the Virginia Department of Transportation (VDOT) could use statewide. The scope of the research was limited to a review of the literature on marking crosswalks. The author postulated that the information found in the literature could be used to develop guidelines acceptable to VDOT, thus saving an extensive and costly field-based research effort.

A task group consisting of VDOT planners and traffic engineers from VDOT's central office and district offices was established to provide oversight, guidance, and, as appropriate, approval of the developed draft guidelines. Based on the findings and conclusions of the literature review, draft guidelines were compiled and synthesized and then presented to the task group for review and discussion. Revised guidelines were then developed and recommended for pilot implementation.

The guidelines developed address where and under what conditions marked crosswalks should be installed at controlled locations, uncontrolled locations, and unconventional intersections and locations. Controlled locations include locations where the approaches to an intersection are controlled by signals, stop signs, or yield signs. Uncontrolled locations include approaches to an intersection and mid-block locations where traffic control devices are absent. Unconventional intersections and locations include T, skewed, and offset intersections; hills; and curves.

FINAL REPORT

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INTRODUCTION

There has been considerable controversy in the United States regarding the safety benefits of marking crosswalks.¹ Some believe that marked crosswalks can give pedestrians a “false sense of security” when crossing a roadway and therefore create hazardous pedestrian environments. Others believe that marked crosswalks help channel pedestrians to a crossing location and are a beneficial means of alerting motorists to the presence of a pedestrian, therefore creating safer pedestrian environments. Most agree, however, that when considering safety, the location of a marked crosswalk is a major factor.

In states and localities where crosswalk guidelines do not exist, crosswalks have been designed and installed on the basis of engineering judgment and guidance provided by the *Manual on Uniform Traffic Control Devices* (MUTCD).² The MUTCD is a good resource for information on the design aspects of crosswalk pavement markings, pedestrian signals, and signage. However, the MUTCD does not provide explicit guidance for determining where and when to install a marked crosswalk if a need exists, especially at locations other than intersections, i.e., mid-block locations. Section 3B.17 of the MUTCD states:

Crosswalks should be marked at all intersections where there is substantial conflict between vehicular and pedestrian movements. Marked crosswalks also should be provided at other appropriate points of pedestrian concentration, such as at loading islands, mid-block pedestrian crossings, or where pedestrians could not otherwise recognize the proper place to cross.²

Therefore, the practice regarding where to install crosswalks differs considerably from one jurisdiction to another across the United States, and engineers have been left with using their own judgment (sometimes influenced by political and/or public pressure) in reaching decisions.¹

Crosswalks typically exist at intersections and at locations between intersections, i.e., mid-block locations. The *Code of Virginia*, Section 46.2-100, defines a crosswalk as:

that part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or, in the absence of curbs, from the edges of the traversable roadway; or any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface.³

Therefore, crosswalks legally exist in Virginia at locations as defined by the *Code of Virginia* and can be either marked or unmarked. By definition, unmarked crosswalks can exist only at intersections and all mid-block crosswalks must be marked.

The Virginia Department of Transportation's (VDOT) *Policy for Integrating Bicycle and Pedestrian Accommodations* states that VDOT will accommodate bicyclists and pedestrians, including pedestrians with disabilities, along with motorized transportation modes in the planning, funding, design, construction, operation, and maintenance of Virginia's transportation network to achieve a safe, effective, and balanced multimodal transportation system.⁴ Currently, VDOT has no uniform guidelines for the installation of marked crosswalks. Consequently, VDOT determined that guidelines were needed as to under what conditions it should consider crosswalk installation and where the most appropriate placement of marked crosswalks is when considering pedestrians, bicyclists and motorists.

PURPOSE AND SCOPE

The purpose of this research was to develop guidelines for the installation of marked crosswalks that VDOT could use statewide. The scope of the research was limited to a review of the literature on marking crosswalks so as to avoid an extensive and costly field-based research effort.

METHODOLOGY

A literature review provided the basis for the development of the guidelines for VDOT. Much of the literature reviewed was current state DOT guidelines, city and local guidelines and Federal Highway Administration (FHWA) guidelines. Resources included the Virginia Transportation Research Council's library, University of Virginia's library, TRANSPORT (online catalogue database), TRIS (the Transportation Research Board's library database) and the Institute of Transportation Engineer's (ITE) list serve. The MUTCD was used as a resource for design guidelines.

A task group of VDOT engineers and planners was assembled to provide insight into the needs of VDOT. Appendix A provides a listing of the members.

Based on the findings of the literature review and the recommendations of the task group, guidelines for the installation of marked crosswalks were developed and presented to the task group for review and discussion.

RESULTS AND DISCUSSION

Literature Review

Emphasis was placed on planning guidelines, in particular, information on the difference between marked and unmarked crosswalks and guidance on the conditions under which the installation of crosswalk markings should be considered. Since the design features of

crosswalks, including design criteria for additional crossing treatments, are covered in the MUTCD,² they were not included as part of the presentation material to the task group.

Marked/Unmarked Crosswalks

Many pedestrians consider marked crosswalks a tool that enhances their safety and mobility. They view the markings as proof that they have a right to share the roadway, and in their opinion, the more the better. Many pedestrians do not understand the legal definition of *crosswalk* and think no crosswalk exists unless it is marked. They may also think that drivers will be able to see crosswalk markings as well as they do, and they may assume that it is safer to cross where drivers can see the white crosswalk lines.¹

According to the *Code of Virginia*, both marked and unmarked crosswalks can exist at intersections, but at mid-block locations, the crosswalk must be marked. In either case, applicable right-of-way laws protect pedestrians. Section 46.2-924.A of the *Code* states that the driver of any vehicle on a highway shall yield the right of way to any pedestrian crossing such highway:

1. at any clearly marked crosswalk, whether at mid-block or at the end of any block
2. at any regular pedestrian crossing included in the prolongation of the lateral boundary lines of the adjacent sidewalk at the end of the block
3. at any intersection when the driver is approaching on a highway or street where the legal maximum speed does not exceed 35 miles per hour.⁵

Crosswalk Marking Justification

The Federal Highway Administration (FHWA), through sponsored research by Zegeer et al.,¹ gives specific guidance as to when to consider marking crosswalks (see Table 1). According to this research, marked 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 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.*¹

Table 1. Recommendations for Installing Marked Crosswalks at Uncontrolled Locations

Roadway Type (# of Travel Lanes and Median Type)	ADT ≤ 9,000			ADT 9,000 - 12,000			ADT 12,000 - 15,000			ADT > 15,000		
	Speed Limit**											
	≤30 mph	35 mph	40 mph	≤30 mph	35 mph	40 mph	≤30 mph	35 mph	40 mph	≤30 mph	35 mph	40 mph
2 Lanes	C	C	P	C	C	P	C	C	N	C	P	N
3 Lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multi-Lane (4 or More Lanes) With Raised Median +	C	C	P	C	P	N	P	P	N	N	N	N
Multi-Lane (4 or More Lanes) Without Raised Median	C	P	N	P	P	N	N	N	N	N	N	N

*These guidelines include intersection and mid-block locations with no traffic signals or stop sign on the approach to the crossing. They do not apply to school crossings. A two-way center turn lane is not considered a median. Crosswalks should not be installed at locations that could present an increased safety risk to pedestrians, such as where there is poor site distance, complex or confusing designs, substantial volumes of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make a crossing safer, or necessarily result in more vehicles stopping for pedestrians. Whenever marked crosswalks are installed, it is important to consider other pedestrian facility enhancements, as needed, to improve the safety of the crossing (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic calming measures, curb extensions). **These are general recommendations; good engineering judgment should be used in individual cases for deciding where to install crosswalks.**

**Where speed limit exceeds 40 mph, marked crosswalks alone should not be used at unsignalized locations.

C = Candidate sites for marked crosswalks. Marked crosswalks must be installed carefully and selectively. Before installing new marked crosswalks, an engineering study is needed to show whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volumes, vehicle speeds, sight distance, vehicle mix, etc., may be needed at other sites. It is recommended that a minimum of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians) exist at a location before placing high priority on the installation of a marked crosswalk alone.

P = Possible increase in pedestrian crash risk may occur if crosswalks are added without other pedestrian facility enhancements. These locations should be closely monitored and enhanced with other pedestrian crossing improvements, if necessary, before adding a marked crosswalk.

N = Marked crosswalks alone are not recommended, since pedestrian crash risk may be increased with marked crosswalks. Consider using other treatments, such as traffic signals with pedestrian signals, to improve crossing safety for pedestrians.

+The raised median or crossing island must be at least 4 feet wide and 6 feet long to adequately serve as a refuge for pedestrians in accordance with MUTCD and AASHTO guidelines.

Source: Zegeer, C.V., Stewart, R.J., Huang, H.H., and Lagerwey, P.A. *Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines.* FHWA-RD-01-075. Federal Highway Administration, Washington, D.C., 2002.

Controlled Locations

The literature on marking crosswalks at controlled locations is limited. Some of the literature recommended marking crosswalks on all approaches of a controlled intersection where pedestrian activity is significant except where a crossing is discouraged or prohibited.^{1,6,7,8,14} The use of “engineering judgment” was also found to be a key element in deciding whether to use marked or unmarked crosswalks at controlled intersections.^{1,6,7,8,14} The MUTCD defines *engineering judgment* in Section 1A.13 as:

the evaluation of available pertinent information, and the application of appropriate principles, Standards, Guidance, and practices as contained in [the MUTCD] and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required.²

Engineering judgment should be applied with regard to controlled intersections when considering:

- *The effectiveness of a marked crosswalk.* Crosswalk markings should not be used at all intersections. If used extensively, many marked crosswalks would be underused and motorists would tend to be desensitized to their presence. This could lead to problems at heavily used crosswalks and detract from potential safety value at these locations. Crosswalks should be used in general only at locations where pedestrian activity is significant. This will ensure that motorists come to associate crosswalks and pedestrian activity.⁶
- *Alternative treatments to be used in conjunction with crosswalk markings.* Crosswalks can serve to channel pedestrian traffic through an intersection, as well as heighten the awareness of motorists of possible pedestrian crossing movements. It is important to note that although crosswalks are an important element in intersection design, a crosswalk alone does not ensure the safety of a pedestrian. Too often, crosswalks are the sole provision for pedestrians at intersections when other safety measures are also needed.⁷ These safety measures include, but are not limited to, warning signage, bulbouts or curb extensions, median and slip lane refuge islands, pedestrian signal enhancements, and enhanced signal phasing to incorporate pedestrian activity.
- *Adequate sight distance of pedestrians, relative to vehicular speed.* If it is not feasible to provide advance warning to motorists, crosswalks should not be provided.⁸
- *Parking prohibitions near a crosswalk.* Vehicles parked close to an intersection block a driver’s view of pedestrians.⁹
- *Alternate crossing locations.* In some instances, complex signal phasing, dual vehicle turning movements, and the width of roadway pose potential safety hazards to

pedestrians at intersections. In these cases, safer crossing locations should be explored (K. Fricke, unpublished data).

Uncontrolled Locations

Literature on marking crosswalks at uncontrolled locations is abundant. The MUTCD recommends that an “engineering study” be performed when considering installing crosswalks at uncontrolled locations.² The MUTCD defines *engineering study* in Section 1A.13 as:

the comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, Standards, Guidance, and practices as contained in (the MUTCD) and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented.²

There has been debate and controversy regarding whether providing marked crosswalks will increase or decrease pedestrian safety at crossing locations that are not controlled by a traffic signal, stop sign, or yield sign.¹ City traffic engineers receive numerous requests for marking uncontrolled crosswalks. At least since 1970, these requests have been reviewed on a case-by-case basis using a minimal approach. The engineer or agency evaluating the request must normally perceive some significant benefit to the establishment of crosswalk markings or else the request is normally denied.¹⁰

In situations where a mid-block crossing formalizes a pedestrian activity that is already occurring frequently, mid-block crossing provisions can be used to improve the visibility of the pedestrian. Mid-block crossings are most appropriate at locations where a high pedestrian traffic generator is located directly across the street from a significant source of pedestrians. Examples are a commercial area with fast food restaurants across the street from a university and a shopping center across from a high school. However, because of the increased safety risk of a pedestrian crossing in midstream traffic, mid-block crossings are generally discouraged unless one or more of the following conditions apply:

- The location is already a source of a substantial number of mid-block crossings or it is anticipated to generate mid-block crossings (for a new development).
- The land use is such that a pedestrian is highly unlikely to cross the street at an adjacent intersection, and when mid-block crossings would be frequent.
- The safety and capacity of adjacent intersections create a situation where it is dangerous to cross the street except at a designated mid-block location.
- Spacing between adjacent signals exceeds 600 ft.⁷

In addition to the general guidance, state and local agencies have developed guidelines to assist engineers and planners in evaluating when and where to mark crosswalks at uncontrolled locations. Factors that can influence the decision-making process include, but are not limited to:

- *Adequate sight distance for the motorist and pedestrian.* Any obstacles that would interfere with visibility at the crossing location (mailboxes, utility poles, street furniture, signs, landscaping, etc.) should be removed or relocated. On-street parking should be set back from the crossing point for improved visibility.¹⁰ Localities such as San Jose, California, and Stockton, California, require a minimum sight distance of 10 times the speed limit upon approaching a crosswalk.^{7,15}
- *Distance to the nearest protected crossing.* The minimum distance from a signal for installing a marked crosswalk should be determined by 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. However, pedestrian crossing behavior may be difficult to control merely by adding 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.¹ Some guidelines use 300 ft as the minimum distance to the nearest protected crossing for mid-block crosswalks.^{8,11,12,13} Other guidelines recommend that the spacing between signals (or block length) should be equal to or greater than 600 ft for mid-block crosswalks.^{7,14}
- *Pedestrian delay and acceptable gaps in the vehicle traffic stream.* Some guidelines use pedestrian delay and acceptable gaps in the vehicle traffic stream as influencing factors for marking crosswalks.

The MUTCD uses availability of gaps only for warranting a mid-block pedestrian signal.² *Gap* is defined as the amount of time that elapses from the point when the rear of a vehicle passes a spot on the roadway until the front of the next arriving vehicle (from either direction) passes that same spot. The minimum gap for a pedestrian to cross a street is a function of crossing distance, walking speed, predominant number of rows in the group, time headway between rows, and the group start-up time.

$$G = W/S + (N - 1)*H + R$$

where:

G = minimum safe gap in traffic, sec

W = crossing distance or roadway width, ft

S = walking speed (ft/sec)

N = predominant number of rows (group size, typically 1)

H = time headway between rows, sec (standard value H = 2 sec)

R = pedestrian start-up time, sec (standard value R = 3 sec).¹³

By definition, an adequate gap will be of sufficient length to accommodate the safe crossing of 85 percent of the pedestrians when the 15th percentile pedestrian walking speed is used in the calculation.

Section 4C.05 of the MUTCD requires fewer than 60 adequate gaps per hour to comply with its pedestrian crossing warrant criteria.² The City of Boulder, Colorado, recommends 120 adequate gaps per hour (averaging 1 acceptable gap every 30 sec) as a minimum.¹³ British Columbia uses crossing opportunities (based on available gaps) per hour as a crosswalk marking warranting tool. Crossing opportunities are calculated as a function of traffic volume (veh/hr), cross-sectional width of the roadway, and perception-reaction time.¹⁵

- *Pedestrian volume.* This criterion varied between agencies and localities. In San Jose, California, the criterion is at least 10 pedestrians crossing the street during a 1-hour period or 30 pedestrians crossing during the highest consecutive 4-hour period.¹⁶ Boulder, Colorado, requires a minimum of 50 pedestrians during any hour. San Luis Obispo, California, requires a pedestrian volume of 40 or more per hour during the peak hour of pedestrian usage or 30 groupings of 2 or more pedestrians for a continuous 2-hour period twice a day.¹⁷
- *Vehicle volume, vehicle speed and crossing distance/lane configuration.* The guidance set forth by Zegeer et al. recommends that in situations where crosswalks alone are acceptable, a higher priority be placed on their use at locations having a minimum of 20 pedestrians crossing per peak hour (or 15 or more elderly and/or child pedestrians per peak hour). Further, crosswalks alone are insufficient (i.e., without traffic-calming treatments, traffic signals, and pedestrian signals when warranted, or other substantial crossing improvement) and should not be used under the following conditions:
 1. Where the speed limit exceeds 40 mph.
 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.¹

Unconventional Intersections and Locations

In many instances, the geometries of an intersection are not conventional, i.e., in the form of two intersecting perpendicular lines. The task group asked that literature be reviewed pertaining to “unconventional intersections” such as T, offset, and skewed intersections. Further, literature was reviewed pertaining to “unconventional locations.” An unconventional location is one where crosswalk installations are typically discouraged, such as a hill or curve. The guidance provided for these types of intersections and locations was limited and can be found in Appendix B.

DEVELOPMENT OF GUIDELINES

Draft guidelines were developed and presented to the task group for review. Following this review, revised guidelines were developed. The final guidelines provide guidance for determining when and where to install marked crosswalks and are presented in Appendix B, *Guidelines for the Installation of Marked Crosswalks*.

The three main components of the guidelines are (1) guidance for marking crosswalks at controlled locations, (2) guidance for marking crosswalks at uncontrolled locations, and (3) guidance for marking crosswalks at unconventional intersections and locations. Controlled locations are typically intersections controlled by a stop sign, a yield sign, and/or a signal. Uncontrolled locations are typically mid-block locations (crossing locations between intersections) and intersections that do not have a control feature at the approach. Unconventional intersections include T, offset, and skewed intersections; unconventional locations include areas such as hills and curves. In some instances, the use of marked crosswalks alone are not recommended without additional crossing treatments, such as signage, flashing beacons, refuge islands, pedestrian signals, etc., and the guidelines address when such treatments should be considered.

SUMMARY OF FINDINGS

Based on the findings from the literature review and the recommendations of the task group, the following points were incorporated into the *Guidelines for the Installation of Marked Crosswalks*:

1. *Guidelines need to be straightforward and easy to follow.* Using the headings “controlled locations,” “uncontrolled locations,” and “unconventional intersections” achieved this. The task group determined that some of the guidelines in the literature were lengthy and could be confusing at times. Every effort was made to simplify and be concise with the guidelines.
2. *Published guidelines for marking crosswalks at controlled locations are limited.* Many of the guidelines simply stated that crosswalks should be marked at controlled locations. The City of Stockton, California, however, provided in-depth guidelines on marking crosswalks at controlled locations, and they were used as the basis for this portion of the guidelines.
3. *Some guidelines for marking crosswalks at uncontrolled intersections require extensive and costly field studies.* The task group recommended that the focus of the guidelines be on the research conducted for FHWA by Zegeer et al.¹ The guidelines set forth in Table 1 were found to be uncomplicated and straightforward and not to require costly and extensive field studies. The Stockton, California, guidelines for marking crosswalks at uncontrolled intersections incorporated the guidelines by Zegeer et al. and were used as a basis for this portion of the guidelines.

4. The guidelines include statutes set forth in the *Code of Virginia*, especially pertaining to the definition of *crosswalks* and *pedestrian* and *vehicular right of way*.
5. Crosswalk and special treatment design features found in published guidelines are consistent, and most use guidance from the MUTCD.
6. Regardless of how comprehensive guidelines are, there will be locations and situations that are not specifically covered; therefore, engineering judgment is used, in all cases, for determining when and where to install crosswalks.
7. Specific conditions considered at the site of the proposed crosswalk installations are:
 - proximity of pedestrian generators to the crossing location
 - site characteristics of the crossing
 - proximity of other crosswalks and distance between crosswalks
 - roadway width and geometry
 - vehicle speed on the street being crossed
 - average daily traffic (ADT) on the street being crossed
 - pedestrian volumes
 - adequate sight distance.

RECOMMENDATION

Appropriate VDOT district staff should use the guidelines presented in Appendix B for 1 year on a pilot basis. This time frame may need adjustment depending on the number of cases for which the guidelines are employed. After the pilot, a round of review and comment should be undertaken as a means of further refining the guidelines where needed. Members of the Crosswalk Task Group, as well as appropriate VDOT central office and district personnel, should be involved in this review, and a finalized set of guidelines should be developed.

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APPENDIX A
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APPENDIX B

GUIDELINES FOR THE INSTALLATION OF MARKED CROSSWALKS

**Virginia Department of Transportation
Mobility Management Division**

TABLE OF CONTENTS

List of Tables and Figures.....	21
Introduction.....	23
Background.....	23
General Guidance.....	24
Applicable Sections of the <i>Code of Virginia</i>	25
Guidelines for Marking Crosswalks at Controlled Locations.....	26
Guidelines for Marking Crosswalks at Uncontrolled Locations.....	29
Guidelines for Marking Crosswalks at Unconventional Intersections and Locations.....	41
References.....	43

LIST OF TABLES

Table B1.	Recommendations for Considering Marked Crosswalks and Other Needed Pedestrian Improvements at Uncontrolled Locations.....	31
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LIST OF FIGURES

Figure B1.	Standard Crosswalk Markings on All Approaches of an Intersection.....	27
Figure B2.	Pedestrian Crossing Warning Sign	27
Figure B3.	Flowchart for Justifying Installation of Marked Crosswalks at Uncontrolled Intersections	30
Figure B4.	Standard Crosswalk	32
Figure B5.	Raised Mid-block Crossing.....	33
Figure B6.	Example of a Textured Pavement Crosswalk	34
Figure B7.	“Zebra” Crosswalk and “Continental” Crosswalk.....	34
Figure B8.	“Triple-Four” Crosswalk	35
Figure B9.	Typical Median Refuge Island at an Intersection, with Median Nose and At-Grade Passage for Crosswalk	35
Figure B10.	Typical Median Refuge Island at Mid-Block, with At-Grade Passage for a Crosswalk	36
Figure B11.	Example of a Split Pedestrian Crossover.....	36
Figure B12.	Bulbouts at an Intersection.....	37
Figure B13.	Bulbouts at a Mid-block Location	37
Figure B14.	Overhead Sign with Flashing Beacons	38
Figure B15.	Pedestrian Pushbutton for Flashing Beacon Operation	38
Figure B16.	In-Roadway Warning Lights at a Mid-block Crosswalk	39
Figure B17.	Pedestrian-Actuated Mid-block Signal	39
Figure B18.	Grade-Separated Crossing (Bridge) Over a Major Highway.....	40
Figure B19.	Grade-Separated Crossing (Tunnel) Under a Roadway.....	40
Figure B20.	Typical Offset Intersection Showing All Legal Crosswalks and a More Practical and Effective Crosswalk Application	41
Figure B21.	All Legal Crosswalks at a T Intersection.....	42

INTRODUCTION

The *Manual on Uniform Traffic Control Devices* (MUTCD) gives little guidance regarding when and where to mark crossing locations. Section 3B.17 of the MUTCD states that:

Crosswalks should be marked at all intersections where there is substantial conflict between vehicular and pedestrian movements. Marked crosswalks also should be provided at other appropriate points of pedestrian concentration, such as at loading islands, mid-block pedestrian crossings, or where pedestrians could not otherwise recognize the proper place to cross.¹

The Virginia Department of Transportation's (VDOT) *Policy for Integrating Bicycle and Pedestrian Accommodations* states that VDOT will accommodate bicyclists and pedestrians, including pedestrians with disabilities, along with motorized transportation modes in the planning, funding, design, construction, operation, and maintenance of Virginia's transportation network to achieve a safe, effective, and balanced multimodal transportation system.²

The following guidelines for the installation of marked crosswalks are intended to serve engineers and planners responsible for planning and designing pedestrian facilities in Virginia. These guidelines are not to be used as warrants, as circumstances can vary depending on location and no set of guidelines can cover every condition or guarantee improved safety.

Designers, engineers, and planners all share a responsibility to find ways for vehicles, pedestrians, and bicyclists to coexist conveniently and safely. Accommodating pedestrians with disabilities is required in the design and planning of pedestrian facilities, and compliance with the Americans with Disabilities Act (ADA) is a federal law. This law is designed to ensure that all Americans have the same access to services and facilities. The ADA requires pedestrian facilities used by the general public to be planned, designed, constructed, and maintained with the understanding that a wide range of people, including people with disabilities, will be using them and relying on them for their daily travel. By providing pedestrian facilities that are fully accessible, people with various degrees of mobility and disability may be as self-sufficient and independent as possible.³ The ADA applies to all new construction and improvements to existing facilities.

The purpose of this document is to give more guidance than what is offered in the MUTCD for determining the best engineering solutions to pedestrian safety concerns, particularly with regard to the location of marked crosswalks. Specifically, this document describes guidelines relating to the marking of crosswalks at controlled locations (those controlled by signals, stop signs, and yield signs), uncontrolled locations (intersections and mid-block), and unconventional intersections and locations. It describes various crosswalk treatments and guidance as to when to use them. This document should also serve as guidance for retrofit crosswalk marking installations and installations at new and future construction projects.

BACKGROUND

A *crosswalk* is generally defined as the portion of roadway designated for pedestrians to use in crossing the street. Crosswalks may be marked or unmarked. At intersections, a sidewalk

or pedestrian walkway extension across a street defines a crosswalk (refer to the *Code of Virginia*, Section 46.2-100 for a complete definition of *crosswalk*).⁴ There is no legal difference between marked or unmarked intersection crosswalks; however, at times, markings can be used to designate a wider crosswalk or a mid-block crosswalk.

Marking 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 may be used to delineate preferred pedestrian paths across roadways under the following conditions:

- *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.
- *At non-signalized street crossing locations where an engineering study 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.*⁵
- *At approved school crossings or for crossings on recommended school routes.*

Further, a marked crosswalk helps to create reasonable expectations for motorists with regard to where pedestrians may cross a roadway and the predictability of pedestrian actions and movement.

There are both advantages and disadvantages of marking crosswalks. Advantages include:

- helping pedestrians find their way across complex intersections
- designating the shortest path
- directing pedestrians to location of best sight distance.

Disadvantages include:

- possibly creating a “false sense of security” for pedestrians
- generating a greater number of pedestrian collisions at uncontrolled locations on multi-lane streets with high traffic volumes
- higher maintenance costs.⁶

GENERAL GUIDANCE

As with any installation of traffic control devices, the most essential tool for crosswalk installation is the use of engineering judgment. Engineering judgment should be used and, if applicable, an engineering study performed when considering the marking of crosswalks. Section 1A-13 of the MUTCD describes *engineering judgment* and *engineering study* as follows:

Engineering Judgment - the evaluation of available pertinent information, and the application of appropriate principles, Standards, Guidance, and practices as contained in (the MUTCD) and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required.¹

Engineering Study - the comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, Standards, Guidance, and practices as contained in (the MUTCD) and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented.¹

Crosswalk markings should not be used at all intersections. If used extensively, many marked crosswalks would be underused and motorists would tend to be desensitized to their presence. This could lead to problems at heavily used crosswalks and detract from potential safety value at these locations. Crosswalks should be used, in general, only at locations where pedestrian activity is significant. This will ensure that motorists come to associate crosswalks and pedestrian activity.⁷

Intersection design is also extremely important for the safety of pedestrians. However, no single feature creates a safe intersection for pedestrians.⁸ The first step in identifying candidate marked crosswalk locations is to identify the places people would like to walk (pedestrian desire lines) that are affected by local land uses (homes, schools, parks, commercial establishments, etc.) and the location of transit stops. This information forms a basis for identifying pedestrian crossing improvement areas and prioritizing such improvements, thereby creating a convenient, connective, and continuous walking environment.

The second step is identifying where it is safest for people to cross. Of all road users, pedestrians have the highest risk accidents because they are the least protected. National statistics indicate that pedestrians represent 14 percent of all traffic incident fatalities, whereas walking accounts for only 3 percent of total trips. Vehicle-pedestrian collisions occur most often when a pedestrian is attempting to cross the street at an intersection or mid-block location.⁶

APPLICABLE SECTIONS OF THE *CODE OF VIRGINIA*

The following excerpts from the *Code of Virginia* should be referenced when defining a crosswalk or a crossing location and when determining pedestrian and vehicular right of way.

Definition of a Crosswalk⁴

Section §46.2-100 defines a crosswalk as “that part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or, in the absence of curbs, from the edges of the traversable roadway; or any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface.”

How and Where Pedestrian Are to Cross Highways⁹

Section §46.2-923 states: “When crossing highways, pedestrians shall not carelessly or maliciously interfere with the orderly passage of vehicles. They shall cross, wherever possible, only at intersections or marked crosswalks. Where intersections contain no marked crosswalks, pedestrians shall not be guilty of negligence as a matter of law for crossing at any such intersection or between intersections when crossing by the most direct route.”

Pedestrian and Vehicular Right of Way¹⁰

Section §46.2-924.A states that the driver of any vehicle on a highway shall yield the right-of-way to any pedestrian crossing such highway:

1. At any clearly marked crosswalk, whether at mid-block or at the end of any block.
2. At any regular pedestrian crossing included in the prolongation of the lateral boundary lines of the adjacent sidewalk at the end of the block.
3. At any intersection when the driver is approaching on a highway or street where the legal maximum speed does not exceed 35 miles per hour.

Section §46.2-924B states: “No pedestrian shall enter or cross an intersection in disregard of approaching traffic. The drivers of vehicles entering, crossing, or turning at intersections shall change their course, slow down, or stop if necessary to permit pedestrians to cross such intersections safely and expeditiously. Pedestrians crossing highways at intersections shall at all times have the right-of-way over vehicles making turns into the highways being crossed by the pedestrians.”

GUIDELINES FOR MARKING CROSSWALKS AT CONTROLLED LOCATIONS

The following should be considered when determining the need to mark crosswalks at signalized intersections, approaches controlled by stop signs, and approaches controlled by yield signs. Engineering judgment should be used when considering the installation of marked crosswalks at controlled locations.

Basic Justification for Marking a Crosswalk

- *Marked crosswalks should be considered on all approaches⁶ near pedestrian generators.* This should be done using standard crosswalk markings (Figure B1) or high-visibility markings (see types of high-visibility crosswalks in the *Guidelines for Marking Crosswalks at Uncontrolled Locations* of these guidelines). Markings must be white and retroreflective (visible at night). For further guidance on crosswalk markings, refer to Section 3B.17 of the MUTCD.¹

The installation of stop lines at crosswalk locations controlled by traffic signals or stop signs is recommended as an effective measure in reducing vehicle encroachments on the

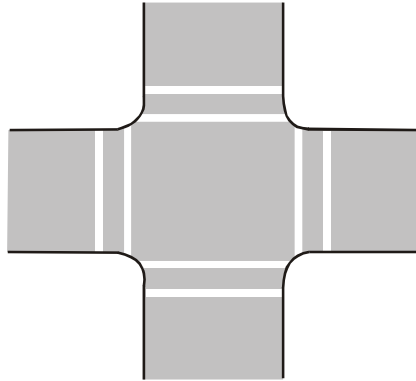


Figure B1. Standard Crosswalk Markings on All Approaches of an Intersection

crosswalk. Where the crash data or observations of conflicts identify a crosswalk of particular concern, consider special treatments (refer to *Special Treatments* in this section) and warning signs (Figure B2). Refer to Section 2C.41 of the MUTCD for further guidance on warning signs.¹



Figure B2. Pedestrian Crossing Warning Sign. Source: MUTCD, Section 2C.41.

- *The following is an exception for considering marking crosswalks on all approaches:*

Where crossing locations have conflicting heavy right- or left-turn traffic volumes.⁶ There are dilemmas with regard to pedestrian crossings on multi-lane, high-speed, high-volume suburban arterials. The introduction of marked crosswalks alone would essentially communicate to the pedestrian that it is reasonably safe to attempt a crossing. Typically, under these conditions, marked crosswalks alone are not sufficient to facilitate safe crossings at complex, multi-phase intersections.

In order to make at-grade pedestrian crossings as safe as they need to be at signal-controlled intersections on wide, high-volume, high-speed roadways, the incorporation of pedestrian signals, refuge medians, slip lane refuge islands, and fully protected pedestrian phasing may be considered (K. Fricke, unpublished data).

Where other solutions are infeasible, an alternative pedestrian crossing should be identified. It may be necessary to install barrier treatments to reinforce that pedestrians should not cross at the location without a marked crosswalk. Prohibiting crossing should be considered only in very limited circumstances, for example:

- where it would be very dangerous for pedestrians to cross, as where visibility (for pedestrians and motorists) is obstructed and the obstruction cannot be reasonably removed
- where so many legal crosswalks exist that they begin to conflict with other modes, as on an arterial street with multiple offset or T intersections.
- where there are unique considerations at a particular intersection and pedestrian mobility is not disproportionately affected by the closure.¹¹

Special Treatments

There are a number of innovative treatments for pedestrians at controlled intersections, mostly related to pedestrian signals. At locations with a high number of pedestrian-vehicle conflicts, the following measures are means to enhance the safety of pedestrian crossings.

- At locations where there are high numbers of turning vehicles, special treatments that may be considered include⁶:
 - installing animated eye light emitting diode (LED) signals
 - equipping signals with early release or pedestrian lead time
 - installing special pavement stencils onto the pavement such as “Pedestrians Look Left” and “Watch for Turning Vehicles”
 - designing or retrofitting intersections with reduced corner radii.
- At locations where there are high numbers of pedestrians around or near an intersection, special treatments that may be considered include⁶:
 - equipping signals with pedestrian “scramble” phases
 - implementing “No Right Turn on Red” restrictions
 - installing STOP lines or YIELD lines in advance of crosswalks.
- At locations where there are wide intersections, special treatments that may be considered include⁶:
 - installing additional pedestrian signal heads in a median (if possible), if the width of the crossing is greater than 60 feet
 - installing countdown signals
 - installing pedestrian refuge islands and medians
 - installing bulbouts or curb extensions.

GUIDELINES FOR MARKING CROSSWALKS AT UNCONTROLLED LOCATIONS

This section describes guidance for the installation of marked crosswalks at uncontrolled approaches of intersections and mid-block locations. Crosswalk lines should not be used indiscriminately. An engineering study should be performed before crosswalk markings are installed at uncontrolled locations.

Pedestrian crossing warning signs should always be installed in advance of mid-block crossings. Placement of advance warning signs depends on the speed of motor vehicle traffic and other conditions, such as available sight distance. If yield lines are used in advance of a mid-block crosswalk, “Yield Here to Pedestrians” signs shall be placed 20 to 50 feet in advance of the crosswalk.¹ Refer to Sections 3B.17 and 2B.11 of the MUTCD for further guidance.¹ In-street pedestrian crossing signs can also be used at crosswalk locations to remind road users of laws regarding right of way at an unsignalized pedestrian crossing.¹ Refer to Section 2B.12 of the MUTCD for further guidance on in-street pedestrian crossing signs.¹

Basic Justification for Marking a Crosswalk

Crossings should be marked where *all* of the following are the case⁶:

- Sufficient demand exists to justify the installation of a crosswalk. Uncontrolled crossings should be identified as a candidate for marking if there is a demonstrated need for a marked crosswalk. Need can be demonstrated by either of the following:
 - The crosswalk would serve 20 pedestrians per hour during the peak hour, 15 elderly and/or children per hour, or 60 pedestrians total for the highest consecutive 4-hour period; or
 - The crossing is on a direct route to or from a pedestrian generator, such as a school (refer to section 7C.03 of the MUTCD)¹, library, hospital, senior center, shopping center, park, employment center, and transit center or service.
- The location is 300 feet or more from another crossing location or a controlled crossing location.
- The location has sufficient sight distance (sight distance in feet should be greater than 10 times the speed limit) and/or sight distance will be improved prior to crosswalk marking.
- Safety considerations do not preclude a crosswalk.

Figure B3 and Table B1 should be used to determine if special treatments are needed to ensure safe crossing at uncontrolled locations.

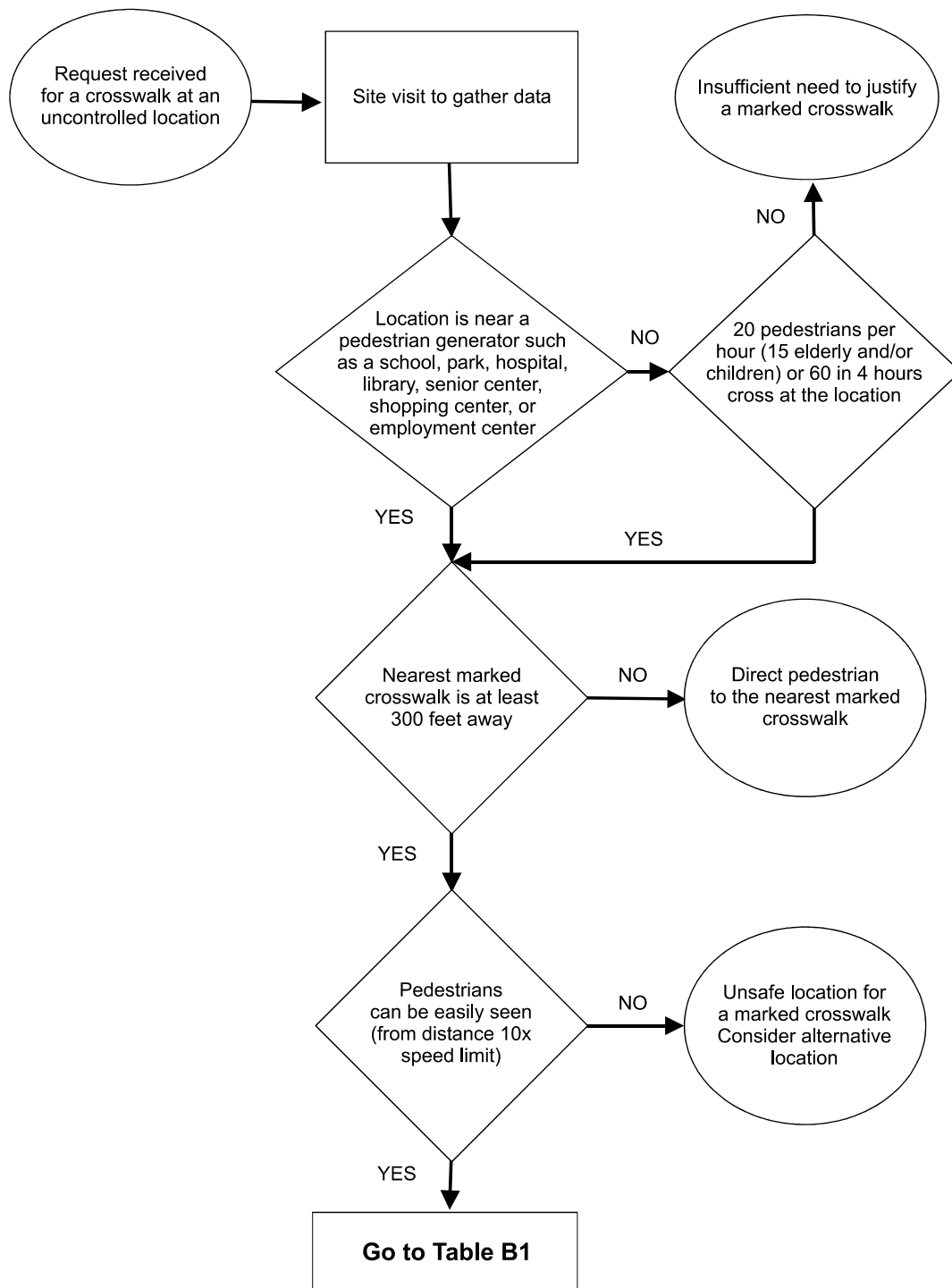





Figure B3. Flowchart for Justifying Installation of Marked Crosswalks at Uncontrolled Intersections.
 Adapted from City of Stockton Public Works Department, *Pedestrian Safety and Crosswalk Installation Guidelines*.
 Stockton, California, 2003.

Table B1. Recommendations for Considering Marked Crosswalks and Other Needed Pedestrian Improvements at Uncontrolled Locations^a

	≤ 9,000 ADT			> 9,000 ADT to ≤ 12,000 ADT			> 12,000 ADT to ≤ 15,000 ADT			> 15,000 ADT		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph ^b
2 lanes												
3 lanes												
+ +4 lanes, raised median ^c												
+ +4 lanes, no median												

 **Candidate sites for marked crosswalks.** Marked crosswalks must be installed carefully and selectively. First, an engineering study is needed to determine whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, but a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, etc., may be needed at other sites. If the speed limit is less than or equal to 30 mph, use **Level 1** or **Level 2** devices. If the speed limit exceeds 30 mph, use **Level 2** devices. *Refer to Level 1 and Level 2 devices in the Special Treatments section.*

 **Probable candidate sites for marked crosswalks.** Pedestrian crash risk may increase if marked crosswalks are added without other pedestrian facility enhancements. Add **Level 3** or **Level 4** devices if feasible. *Refer to Level 3 and Level 4 devices in the Special Treatments section.*

 **Marked crosswalks alone are insufficient, since pedestrian crash risk may increase if only marked crosswalks are provided.** Consider using **Level 5** devices if feasible. If not feasible, use multiple treatments from **Level 2**, **Level 3**, or **Level 4** devices. *Refer to Level 5 devices in the Special Treatments section.*

^aThese guidelines include intersection and mid-block locations with no traffic signal or stop sign on the approach to the crossing. They do not apply to school crossings. A two-way center turn lane is not considered a median. Crosswalks should not be installed at locations that could present an increased safety risk to pedestrians, such as where there is poor site distance, complex or confusing designs, substantial volumes of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make a crossing safer or necessarily result in more drivers stopping for pedestrians. Whenever marked crosswalks are installed, it is important to consider other pedestrian facility enhancements, as needed, to improve the safety of the crossing (for example, raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic calming measures, curb extensions). **These are general recommendations; an engineering study should be performed to determine where to install marked crosswalks.**

^bWhere the posted speed limit or 85th percentile speed exceeds 40 mph, marked crosswalks alone should not be used at uncontrolled intersections with an ADT greater than 15,000.

^cThe raised median or refuge island must be at least 4 feet (1.2 meters) wide and 6 feet (1.8 meters) long to adequately serve as a refuge area for pedestrians.

Adapted from Zegeer, C.V., Stewart, R.J., Huang, H.H., and Lagerwey, P.A. *Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines*. FHWA-RD-01-075. Federal Highway Administration, Washington, D.C., 2002.

Special Treatments

There are a number of innovative treatments for pedestrians at uncontrolled crossing locations. Level 1 devices are typically less costly to install and are found at locations with potentially lower levels of vehicle/pedestrian conflict. Level 2 through 5 devices can be more costly to install and are used at locations with an ascending order of potential vehicle/pedestrian conflicts.

Level 1 Devices

Standard Crosswalk

Standard crosswalks (Figure B4) consist of two parallel lines and can be used at uncontrolled intersections. They are not to be used at mid-block crossings. Refer to section 3B.17 of the MUTCD for further guidance on standard crosswalks¹.

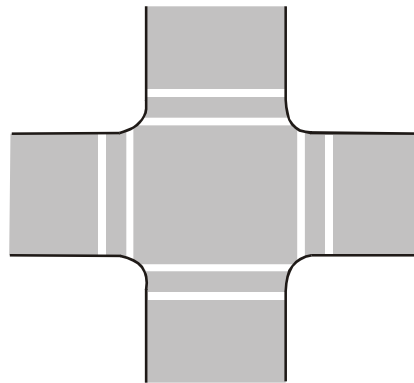


Figure B4. Standard Crosswalk

Raised Mid-Block Crosswalk

Raised mid-block crossings (Figure B5) are sometimes constructed to provide a well-defined pedestrian crossing and to calm traffic. This type of crossing is suitable for only low-speed, low-volume local streets, since the raised crossing is essentially functioning as a speed table or hump.

Raised crossings enhance pedestrian safety by creating a vertical pavement undulation that forces motorists to slow down when approaching. They can function as an extension of the sidewalk and allow pedestrians to cross at a constant grade without the need for curb ramps or median cut-throughs. Raised crossings should have a 6-foot (1.8-meter) parabolic approach transition, raising the vehicle to 3 to 4 inches (7.6 to 10.2 centimeters) above the nominal pavement grade. The flat section of the crossing table should be 10 to 12 feet (3.0 to 3.7 meters) wide. Raised crossings need to be highly visible, either striped as a mid-block crossing or constructed of a contrasting pavement design. Raised crossings should be signed with advance warning signs and pedestrian crossing signs in the same manner as other mid-block crossings.¹²



Figure B5. Raised Mid-block Crossing. From <http://pedbikeimages.org/> / Portland Office of Transportation. Reprinted with permission.

Rumble Strips

Rumble strips are series of intermittent, narrow, transverse areas of a rough-textured, slightly raised, or depressed road surface that are installed to alert road users to unusual traffic conditions.¹ They can be used as a temporary traffic control device in areas of temporary, unexpected crosswalks. Rumble strips should be placed in advance of a crosswalk. Because of maintenance issues, rumble strips should be used only in special circumstances.

Level 2 Devices⁶

High-Visibility Crosswalks

High-visibility crosswalks should be white and retroreflective (visible at night). They include the textured pavement crosswalks (Figure B6), “zebra” and “continental” crosswalks (Figure B7), and “triple-four” crosswalks (Figure B8). Textured pavement crosswalks are composed of stamped concrete or asphalt or brick pavers placed in a pattern and are outlined with white, retroreflective markings. These types of crosswalks can increase driver awareness of pedestrian activity by improving visibility and creating a different audible tone. The treatment can also improve the aesthetics of crosswalk installations. Disadvantages include higher construction and maintenance costs and the lack of smooth, accessible surfaces for pedestrians.¹³



Figure B6. Example of a Textured Pavement Crosswalk. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

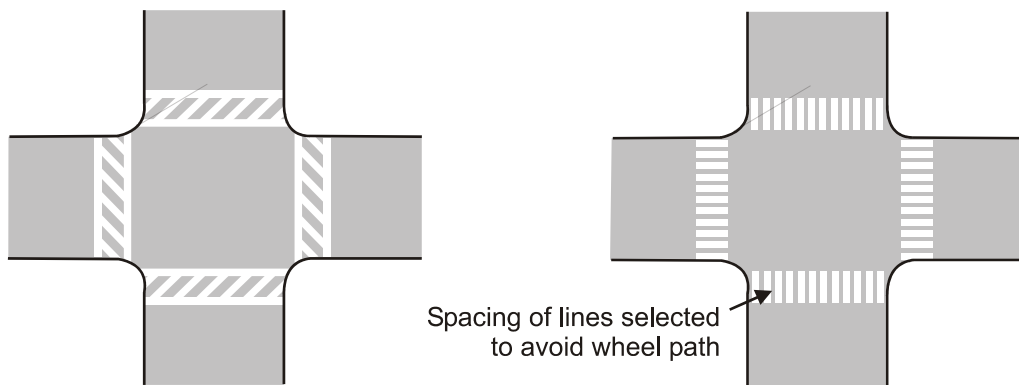


Figure B7. “Zebra” Crosswalk (Left) and “Continental” Crosswalk (Right).



Figure B8. “Triple-Four” Crosswalk. From www.pedbikeimages.org/ Dan Burden. Reprinted with permission.

Level 3 Devices⁶

Refuge Islands

Refuge islands (Figures B9 and B10) allow pedestrians to cross one segment of the street to a relatively safe location out of the travel lanes and then continue across the next segment in a separate gap. At unsignalized crosswalks on a two-way street, a median refuge island allows the crossing pedestrian to tackle each direction of traffic separately. This can significantly reduce the time a pedestrian must wait for an adequate gap in the traffic stream.¹¹ A pedestrian pushbutton should be placed in the median of signalized mid-block crossings where the crossing distance exceeds 60 feet (18.2 meters). Curb ramps or cut-throughs should be provided for accessibility.¹⁴ Refer to VDOT’s *Guidelines for the Placement of Curb Ramps for Accessible Routes and Continuous Passages* on when and how to use curb ramps.¹⁵

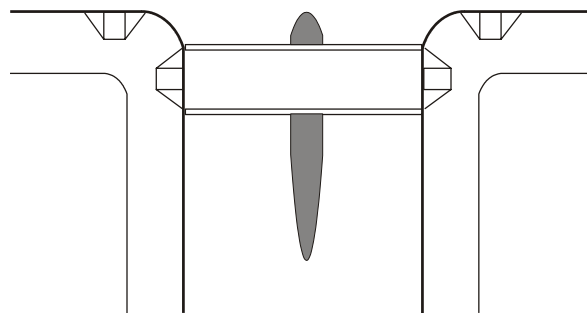


Figure B9. Typical Median Refuge Island at an Intersection, with Median Nose and At-Grade Passage for a Crosswalk.

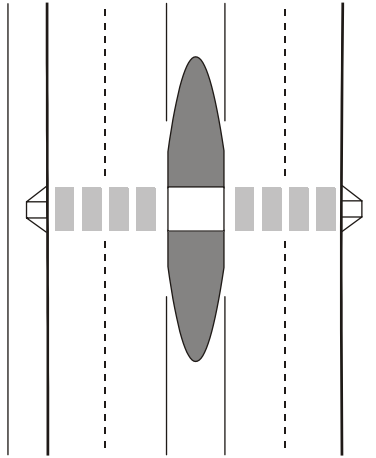


Figure B10. Typical Median Refuge Island at Mid-Block, with At-Grade Passage for Crosswalk.

Split Pedestrian Crossover (SPXO)

The SPXO (Figure B11) is a pedestrian refuge that channels pedestrians to cross one half of the street; enter the island at one end; walk toward the flow of traffic; and exit at the other end to cross the second half of the street. This special treatment is primarily used at mid-block locations and is especially beneficial at or near transit connections.



Figure B11. Example of a Split Pedestrian Crossover. From www.pedbikeimages.org/ Dan Burden. Reprinted with permission.

Bulbouts

Intersections

At an intersection, each corner of the bulbout (Figure B12) is extended into the intersection by approximately 7 to 8 feet to shorten the crossing distance for pedestrians and raise their visibility to motorists.

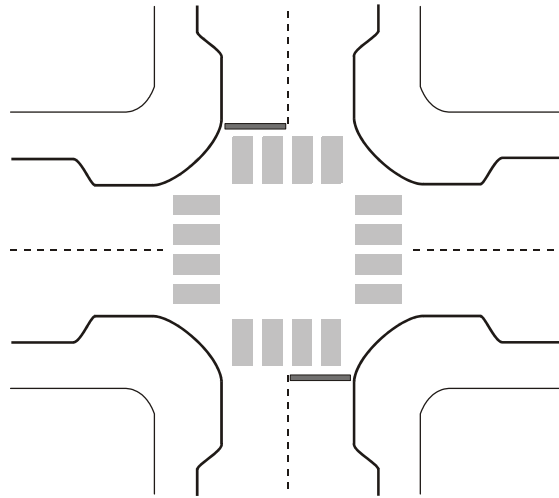


Figure B12. Bulbouts at an Intersection.

Mid-Block Locations

At mid-block locations, bulbouts (Figure B13) are extended into the street by approximately 7 to 8 feet to shorten the crossing distance for pedestrians and raise their visibility to motorists.

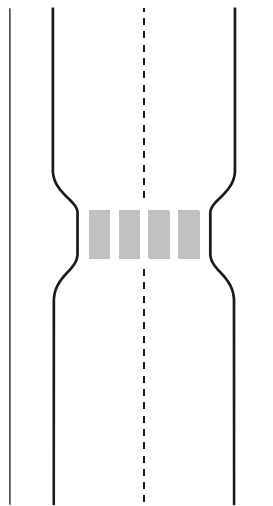


Figure B13. Bulbouts at a Mid-Block Location.

Level 4 Devices⁶

Overhead Signs and Flashing Beacons

Overhead signs can be various signs showing the universal pedestrian symbol, including standard yellow, fluorescent yellow, and LED displays that hang from a mast arm and extend over the street. Flashing beacons should accompany the overhead signs (Figure B14). A flashing beacon provides a relatively low-cost treatment for mid-block pedestrian crossings. The flashing light alerts drivers in advance of potential pedestrians without forcing them to stop unless there is actually a pedestrian in the crosswalk. This sort of device can be used on roadways with higher vehicular volumes without causing undue delay to drivers. Flashing beacons are most effective if they are operating only during times when there is a clear need to alert motorists, such as when pedestrians are actually present (rather than constantly flashing).³ This can be done by using pedestrian pushbuttons (Figure B15) or passive activation. Refer to Section 4K.03 in the MUTCD for further guidance on flashing beacons.¹



Figure B14. Overhead Sign with Flashing Beacons. From www.pedbikeimages.org/ ITE Pedestrian Bicycle Council. Reprinted with permission.



Figure B15. Pedestrian Pushbutton for Flashing Beacon Operation. From www.pedbikeimages.org/ Dan Burden. Reprinted with permission.

In-Roadway Warning Lights (IRWLs)

IRWLs (Figure B16) should be installed with a flashing sign at the crosswalk and an advanced flashing sign ahead of the crosswalk. They should also be installed with advance audible warning devices for motorists, such as rumble strips. Refer to VDOT's *Guidelines for the Installation of In-Roadway Warning Lights* for further guidance.¹⁶



Figure B16. In-Roadway Warning Lights at a Mid-block Crosswalk. From www.pedbikeimages.org / ITE Pedestrian Bicycle Council. Reprinted with permission.

Level 5 Devices⁶

Pedestrian-Actuated Signals

Pedestrian-actuated signals (Figure B17) should be placed at mid-block locations where vehicle and pedestrian volumes warrant a signal. Refer to Section 4C.05 Warrant 4, Pedestrian Volume of the MUTCD for further guidance on mid-block pedestrian-actuated signals.¹



Figure B17. Pedestrian-Actuated Mid-block Signal. From www.pedbikeimages.org / ITE Pedestrian Bicycle Council. Reprinted with permission.

Grade-Separated Crossings

The purpose of grade-separated crossings is to separate pedestrian travel from vehicular travel completely. These crossing facilities should be used only where it is not possible to provide an at-grade facility. Examples are crossing a freeway or major highway (Figures B18 and B19), a rail yard, or a waterway. Grade-separated crossings should:

- be accessible.
- have minimal grade changes
- have a clear passage width of at least 3.7 meters (12 feet).¹¹



Figure B18. Grade-Separated Crossing (Bridge) Over a Major Highway. From www.pedbikeimages.org/ Dan Burden. Reprinted with permission.



Figure B19. Grade-Separated Crossing (Tunnel) Under a Roadway. From www.pedbikeimages.org/ Dan Burden. Reprinted with permission.

GUIDELINES FOR MARKING CROSSWALKS AT UNCONVENTIONAL INTERSECTIONS AND LOCATIONS

The geometric characteristics of an intersection are very important to the safe movement of pedestrian and vehicular traffic. There are many instances where the geometries of an intersection are not conventional, i.e., in the form of two intersecting perpendicular lines. The following guidelines describe additional treatments and/or practices for crosswalk markings at T, offset, and skewed intersections at controlled and uncontrolled approaches of an intersection. Guidance is also provided for the placement of crosswalks on hills and curves.

T and Offset Intersections

At closely spaced T and offset intersections, overall pedestrian safety and convenience may be increased by selectively enhancing some crosswalks while eliminating others. The offset intersection on the left of Figure B20 shows a typical offset intersection with all legal crosswalks marked. The offset intersection on the right of Figure B20 shows a more practical and effective application of marked crosswalks at offset intersections. In general, enhancement of the outer crosswalks and elimination of the inner crosswalks would be the preferred design at most offset intersections. However, other configurations may be chosen based on the particular site.¹¹

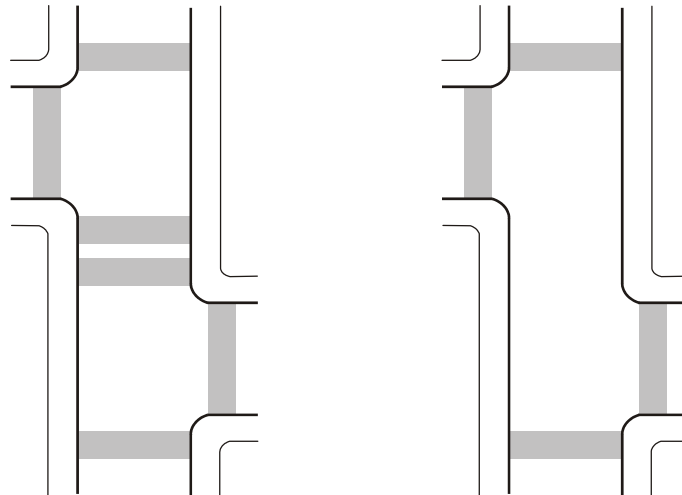


Figure B20. Typical Offset Intersection Showing All Legal Crosswalks (left) and a More Practical and Effective Crosswalk Application (right).

Figure B21 shows all legal crosswalks at a T intersection. This crosswalk design is useful in highly urbanized areas with heavy pedestrian volumes and heavy right turns from the eastbound leg of the T. In rural areas or in situations where vehicular and pedestrian volumes are low, it may be appropriate to mark only the right portion of the upper leg of the T and across the lower portion of the T.

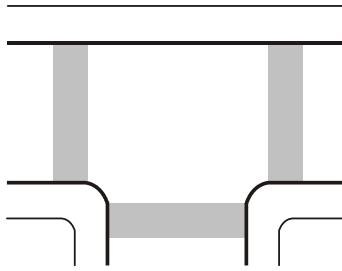


Figure B21. All Legal Crosswalks at a T Intersection.

Skewed Intersections

At skewed intersections, crosswalks should, whenever possible, be installed so that they form 90-degree angles with the curb. Perpendicular (90 degree) crosswalks minimize the walking distance and, therefore, the pedestrian exposure to vehicle conflicts. They also better accommodate the needs of pedestrians with visual disabilities who are usually accustomed to perpendicular crossings.¹⁷

On highly skewed roadways, there is a trade-off between making a 90-degree crossing of a roadway and matching the junction of the roads. This skew adds another 10 to 30 feet (3.1 to 9.2 meters) to the crossing width. By dropping back to a 90-degree crossing, the crosswalk may end up 10 feet (3.1 meters) or even 30 feet (9.2 meters) from the intersection. This creates one of two problems. Either the motorist tends to move closer to the intersection, thus blocking the intersection, or he or she picks up high speed that endangers the pedestrian on the right-turn leg of the intersection. Therefore, crosswalks need to be kept close to the turning traffic so that pedestrians stay within the driver's line of sight. If this cannot be achieved, it is essential to stay as close as practicable.¹⁴

Hills and Curves

If at all possible, crosswalks should not be placed on hills where vertical stopping sight distances are restricted. Motorists need at least 4 seconds to detect, react, and slow down for a pedestrian in a crosswalk. At locations where crosswalks are needed, placement at the top of a hill is much better than just below the crest.

Likewise, if at all possible, crosswalks should not be placed on curves where horizontal stopping sight distances are restricted. Placement where the motorists have been slowed by a curve and are therefore able to view the pedestrian is desirable. However, there will be locations where crosswalks are needed along a corridor with curves. In these instances, installation of a refuge or median island will help slow the motorist and provide a low conflict crossing for pedestrians. The refuge or median island should begin before the curve. If inadequate vertical or horizontal stopping sight distances exist, the use of traffic calming measures (such as the refuge or median island) to reduce a vehicles speed or special signing, beacons, and signalization should be considered.¹⁴

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