

Appendix E: Pedestrian Crossing Design Considerations

The Bicycle and Pedestrian Master Plan in Chapter 5 identifies the network of existing pedestrian facilities in Norfolk and highlights existing sidewalk gaps and streets where marked pedestrian crossings are spaced far apart. Specific recommendations for new and improved pedestrian facilities are included in the program of projects in Chapter 13.

The following sections provide best practices for designing pedestrian crossings on multimodal corridors at intersections and mid-block locations.

Pedestrian Crossing Design Considerations at Intersections

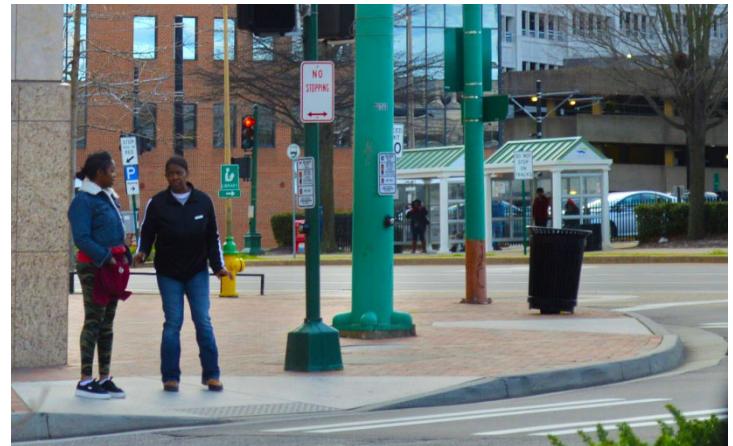
Intersections are areas of complex interaction between different modes and between different movements. When designing pedestrian facilities at intersections, designs should focus on providing clear and safe paths for pedestrians to cross the street and making pedestrians as visible as possible to oncoming vehicles from all directions. Pedestrian safety and visibility should be considered paramount to vehicular throughput.

The following elements are key to designing safe pedestrian crossing facilities at intersections. The design guidance presented here comes from a combination of industry-standard resources, including:

- *Multimodal System Design Guidelines* published by the Virginia Department of Rail and Public Transportation and last updated in 2020.
- *Manual on Uniform Traffic Control Devices* published by the Federal Highway Administrationⁱ
- *Urban Street Design Guide* published by the National Association of City Transportation Officials

Crosswalks at Signalized Intersections

Marked crosswalks are one of the most critical elements for pedestrian safety. 87 percent of pedestrian crashes that resulted in injury or fatality in Virginia in 2016 occurred at locations where no marked crosswalk was present.ⁱⁱ



Designing pedestrian crossing facilities on multimodal corridors requires a focus on providing clear and safe paths for pedestrians to cross the street and making pedestrians as visible as possible to oncoming vehicles from all directions.



Pedestrians cross Military Highway just north of Azalea Garden Road.

Crosswalks should be striped on all approaches at all signalized intersections along all Multimodal Corridors, unless a particular approach leads to a roadway where pedestrians are prohibited.

Accessible pedestrian countdown crossing signals indicate how much time is left during the 'flashing don't walk' phase and provide audible and vibratory cues for pedestrians who are visually impaired or hearing impaired. More information on pedestrian crossing signals is provided in a subsequent section.

Crosswalks at Unsignalized Intersections

Generally, marked crosswalks are recommended at stop-controlled and yield-controlled intersections where traffic volumes exceed 3,000 vehicles per day, speeds exceed 20 mph, or there are more than two vehicle lanes.ⁱⁱⁱ

Marked crosswalks may not be necessary on lower volume and lower speed streets with few lanes. However, designers must use professional judgment considering multiple factors including land uses, present and future demand, pedestrian compliance, speed, safety, and crash history.^{iv} VDOT's *Pedestrian Crossing Accommodations at Unsignalized Locations* Instructional and Informational Memorandum^v (VDOT IIM TE-384) provides additional guidance on when to install marked crosswalks across stop-controlled and yield-controlled approaches.

Marked crosswalks alone may not be sufficient at unsignalized intersections with higher speeds, higher traffic volumes, and more than two vehicle lanes. VDOT IIM TE-384 provides recommendations for identifying situations where marked crosswalks alone are insufficient - generally roads with posted speed limits of 40 mph or greater, or with more than 15,000 vehicles per day, although there are variations depending on the number of lanes and the specific combination of speed and volume. When marked crosswalks alone are insufficient, warning signs, warning signals, geometric improvements, traffic calming improvements, safety islands, or some combination thereof may be needed.



An overhead pedestrian warning sign accompanies the traffic signal.

Crosswalk Pavement Markings

The figure to the right shows different types of crosswalk markings that are mentioned in various design guidance resources.

Continental, Bar Pairs, Zebra, and Ladder crosswalk markings are all considered to be “high visibility” crosswalk markings.

Studies have shown that high visibility crosswalk markings improve pedestrian safety because they are more visible to motorists and improve driver yielding behavior.^{vi,vii}

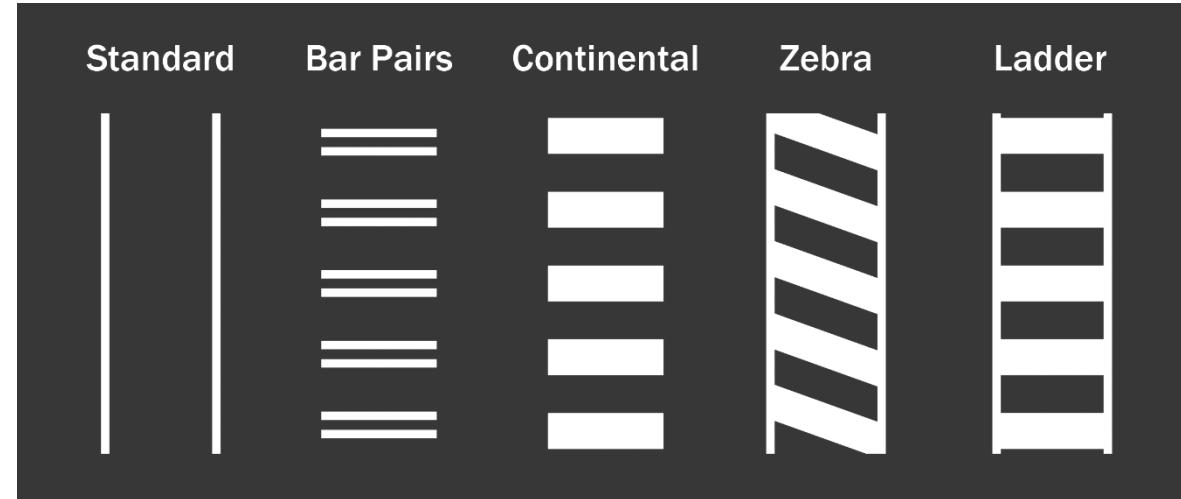
VDOT permits three types of crosswalk markings on VDOT-maintained roadways:

- Standard (aka Transverse Lines)
- Continental (aka Longitudinal Lines)
- Bar Pairs

Zebra and Ladder crosswalk markings have transverse side stripes, which can require increased maintenance. Continental and Bar Pairs lack the side stripes, and can be installed such that wheel paths avoid the longitudinal stripes.

Although any type of high visibility crosswalk markings are preferred from a pedestrian safety standpoint, Continental and Bar Pairs may be most preferable because they require lesser main tenance.

Aesthetic treatments, such as StreetPrint pavement texturing that simulates brick lattice and mosaic stone designs through



Continental and Bar Pairs are the two types of high visibility crosswalk markings that VDOT permits on VDOT-maintained roads. This diagram illustrates other types of crosswalk markings. VDOT permits Standard markings on VDOT-maintained roads, but they are not high-visibility. Zebra and Ladder are two other types of high-visibility crosswalk markings; these have increased maintenance needs since vehicle wheel paths cannot avoid the side stripes.



Bar Pairs are a common crosswalk marking type in Norfolk.



Stamped asphalt treatments with brick designs are common in downtown Norfolk.

stamped asphalt are another option for crosswalk markings and may be desired to match the surrounding streetscape motif.

A brick or stone alone, however, does not provide enough contrast with the asphalt to draw drivers' attention. The white transverse (i.e. parallel) lines must be

present on the outside of the crosswalk and should be retroreflective.

The design within the transverse lines should be uniform and repetitive patterns, monotone earth tones, and non-retroreflective. FHWA guidance states that designs that have bright or multiple colors, display symbols, or represent artwork should not be used for crosswalk markings because they can present a distraction to drivers and degrade the contrast with the white transverse lines.

Pedestrian Crossing Signals

Pedestrian crossing signals can be either fixed or push-button activated. The Manual on Uniform Traffic Control Devices provides standards and guidance for locating push-buttons for activated pedestrian signals.

Intersections with activated pedestrian phases and median refuges should include push-buttons in the median to prevent pedestrians from becoming stranded in a median refuge with no way to activate the pedestrian phase and finish crossing the street.^{viii}

Signal Timing Strategies

Pedestrians are more likely to disregard pedestrian crossing signals when waits are too long. Delays exceeding 40 seconds at signalized crosswalks, especially where countdown signals are not provided, may cause risk-taking behavior.^{ix}

Keeping cycle lengths between 60 and 90 seconds are ideal for urban areas. Longer cycle lengths, especially when in succession over multiple intersections, make walking even a short distance frustrating and prohibitive. However, cycle lengths should be long enough for pedestrians to cross the entire street without getting stuck in the median.^x

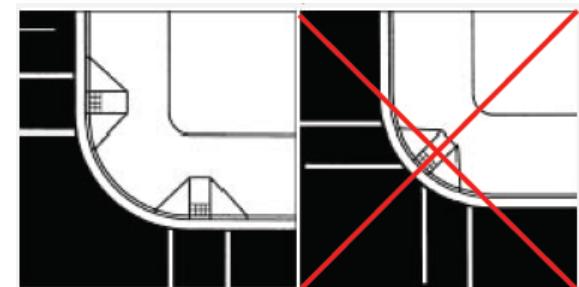
Reducing the minimum green time is another strategy to reduce pedestrian delay, especially for signalized intersections that are not coordinated with other adjacent signalized intersections.^{xi}

When signalized intersections are coordinated, strategies to decrease pedestrian delay can include increasing the permissive window, adjusting signal timing for responsiveness at certain times of day, and setting the signal to recall on the pedestrian phase.

A Leading Pedestrian Interval (LPI) is a signal timing strategy that gives pedestrians a 3-7 second head start to cross the intersection while all vehicular approaches are held with a red light. LPIs allow pedestrians to proceed into the intersection where they are more visible to drivers. LPIs have been shown to decrease collisions between vehicles and pedestrians by as much as 60 percent. LPIs can be made more effective with curb extensions at high-conflict intersections.^{xii}



Intersections with actuated pedestrian phases and median refuges should have push-buttons in the median to prevent pedestrians from becoming stranded in the median.



The preferred design for curb ramps at intersections is to align two separate curb ramps with each crosswalk. Image Source: Federal Highway Administration.

Curb Ramps

Curb ramps are critical for people who use wheelchairs or other mobility devices, people with strollers, and others who are unable to step down from the curb to cross the street easily and safely. It is best practice and required by VDOT at all new and redesigned intersections to provide two

separate curb ramps at each intersection corner, each aligned across from the curb ramp on the opposite side and aligned directly with the crosswalks.

Curb Extensions

Curb extensions (aka bulb-outs) are recommended as a best practice for the design of multimodal corridors, especially on corridors in Multimodal Centers. Curb extensions shorten the crossing distance for pedestrians and bring pedestrians waiting to cross the street into a more direct view of oncoming motorists. They decrease the effective turning radius and should be considered carefully on corridors with special freight considerations, along with drainage and stormwater considerations.

Raised Intersections

Raised intersections are considered a vertical speed control element that can slow traffic speeds and create a more pedestrian-friendly street environment by encouraging motorists to yield to crossing pedestrians.

Raised intersections are most widely applied on low-speed residential neighborhood streets at minor intersections where freight traffic and cut-through vehicles are discouraged.^{xiii}

Streets with speed limits of 30 mph and lower may be candidates for raised

intersections, which typically reduce a street's target speed to 20 mph or less,^{xiv} although raised intersections may be difficult to implement as a retrofit project.

Pedestrian Crossing Design Considerations at Midblock Locations

People have different tolerances for the extra time it may take to go out of one's way to use a marked crosswalk to cross a street, and this tolerance varies depending on the street width, traffic volume, and traffic speed, as well as other personal and environmental factors. Generally speaking, if using a marked crosswalk will add more than three minutes to a person's walk, he or she may decide to cross along a more direct, but unsafe or unprotected route.^{xv}

Midblock pedestrian crossings are important, especially within Multimodal Centers, when marked crosswalks at intersections are spaced far apart, generally when the spacing between adjacent intersections or pedestrian crossings exceeds 660 feet.^{xvi} However, motorists generally do not expect midblock crossings, and when installed should be well-signed, well-marked, and clearly visible. Restricting parking or installing curb extensions can help make pedestrians waiting at midblock crossing more visible to oncoming motorists.

When spacing between pedestrian crossings at intersections exceeds 660 feet, midblock pedestrian crossings should be considered to prevent pedestrians from crossing at unmarked locations.

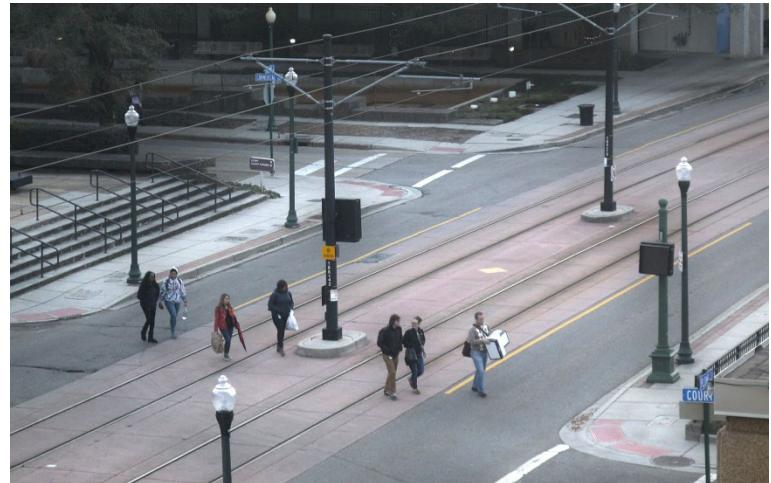
Midblock pedestrian crossings can be particularly useful at midblock transit stops, parks, building entrances, midblock passageways, plazas, other outdoor public spaces, and other locations that may generate pedestrian demand to cross the street.

Pedestrian Safety Islands

Pedestrian safety islands (aka crossing islands) or medians should be considered at marked midblock crossing locations where the crossing distance exceeds 60 feet. They shorten the crossing distance and create a two-stage crossing. Pedestrian safety islands are much shorter than long and continuous medians.^{xvii}

Raised Crosswalks

Raised crosswalks are speed tables that also function as marked crosswalks. Raised crosswalks may be appropriate on streets that are not more than 50-feet wide. Raised crosswalks are often designed in conjunction with curb extensions.^{xviii} Raised



Midblock pedestrian crossings should be considered when the distance between pedestrian crossings at intersections exceeds 660 feet.

crosswalks may be particularly useful at key access points to parks, schools, and waterfronts.

Pedestrian Warning Signs and Signals

Rectangular rapid flashing beacons (RRFBs) and pedestrian hybrid beacons (PHBs) may be appropriate treatments to accompany marked midblock crosswalks in certain circumstances.

RRFBs are flashing lights typically mounted to a roadside pedestrian-crossing sign that allow pedestrians to press a button and stop traffic while crossing at a mid-block crossing. PHBs are overhead traffic signals with a similar push-button activation to warn drivers that a pedestrian is using the mid-block crossing.

VDOT's Pedestrian Crossing Accommodations at Unsignalized Locations provides guidance on when RRFBs and PHBs are appropriate, which depends on the speed limit, traffic volume, and pedestrian demand.



A rectangular rapid flashing beacon (RRFB).
Image credit: pedbikeimages.org/ Shane Sawyer

ⁱ At the time of writing, the official current edition of the Manual on Uniform Traffic Control Devices is the 2009 Edition with Revision Numbers 1 and 2 incorporated, dated May 2012.

ⁱⁱ VDOT Pedestrian Safety Action Plan, 2018. Presentation by Mark Cole and Lauren Blackburn.

ⁱⁱⁱ NACTO Urban Street Design Guide. “Crosswalks and Crossings.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/crosswalks-and-crossings>.

^{iv} Ibid.

^v VDOT IIM TE-384: Pedestrian Crossing Accommodations at Unsignalized Locations was approved in 2016. VDOT is currently working on an update to this resource.

^{vi} FHWA, 2010. *Crosswalk Marking Field Visibility Study*. FHWA Publication Number: FHWA-HRT-10-068. Retrieved Jan 7, 2021 from <https://www.fhwa.dot.gov/publications/research/safety/pedbike/10068/index.cfm>.

^{vii} Sonduru Pantangi, et. al, 2020. “Do High Visibility Crosswalks Improve Pedestrian Safety? A Correlated Grouped Random Parameters Approach Using Naturalistic Driving Study Data.” *Analytic Methods in Accident Research*. Retrieved Jan 7, 2021 from <https://doi.org/10.1016/j.amar.2020.100155>.

^{viii} DRPT, 2020. Multimodal System Design Guidelines.

^{ix} NACTO Urban Street Design Guide. “Crosswalks and Crossings.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/crosswalks-and-crossings>.

^x NACTO Urban Street Design Guide. “Signal Cycle Lengths.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/signal-cycle-lengths>.

^{xi} NACTO Urban Street Design Guide. “Fixed vs. Actuated Signalization.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/fixed-vs-actuated-signalization>.

^{xii} NACTO Urban Street Design Guide. “Leading Pedestrian Interval.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/leading-pedestrian-interval>.

^{xiii} NACTO Urban Street Design Guide. “Raised Intersections.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersections/minor-intersections/raised-intersections>.

^{xiv} NACTO Urban Street Design Guide. “Vertical Speed Control Elements.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/street-design-elements/vertical-speed-control-elements>.

^{xv} NACTO Urban Street Design Guide. “Crosswalks and Crossings.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/crosswalks-and-crossings>.

^{xvi} AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, 2004.

^{xvii} Ibid.

^{xviii} NACTO Urban Street Design Guide. “Speed Table.” Retrieved Jan 7, 2021 from <https://nacto.org/publication/urban-street-design-guide/street-design-elements/vertical-speed-control-elements/speed-table>.