Countermeasure Strategies for Pedestrian Safety

Marked Crosswalks

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Today's Presentation

- **Introduction and housekeeping**
- **Audio issues?**
  Dial into the phone line instead of using "mic & speakers"
- **PBIC Trainings and Webinars**
  www.pedbikeinfo.org/training
- **Registration and Archives at**
  pedbikeinfo.org/webinars
- **PBIC News and updates on Facebook**
  www.facebook.com/pedbike
- **Questions at the end**

Countermeasure Strategies for Pedestrian Safety Webinar Series

Upcoming Webinars

Curb Extensions

Tuesday, October 27 (1:00 – 2:30 PM Eastern Time)

Rectangular Rapid Flashing Beacons

Thursday, November 5 (1:00 – 2:30 PM Eastern Time)

Pedestrian Hybrid Beacons

Thursday, November 12 (2:00 – 3:30 PM Eastern Time)

To view the full series and register for the webinars, visit
www.pedbikeinfo.org/training/webinars_PSAP_countermeasurestrategies.cfm

MARKED CROSSWALKS & ENHANCEMENTS

DPS 201

UVC – CROSSWALK DEFINITION

1-118 – Crosswalk

- (a) 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; and in the absence of a sidewalk on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the existing sidewalk at right angles to the centerline.
- (b) Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface.

MARKED AND UNMARKED CROSSWALKS

Intersection 1

Intersection 2

WHY ARE MARKED CROSSWALKS PROVIDED?

- To indicate to pedestrians where to cross
- To indicate to drivers where to expect pedestrians
- At mid-block locations, crosswalk markings legally establish the crosswalk.

WHEN ARE MARKED CROSSWALKS PROVIDED?

MUTCD Section 3B.18 Crosswalk Markings

Guidance:

- *At locations controlled by traffic control signals or on approaches controlled by STOP or YIELD signs, crosswalk lines should be installed where engineering judgment indicates they are needed to direct pedestrians to the proper crossing path(s).*

MUTCD SECTION 3B.18 CROSSWALK MARKINGS

Guidance

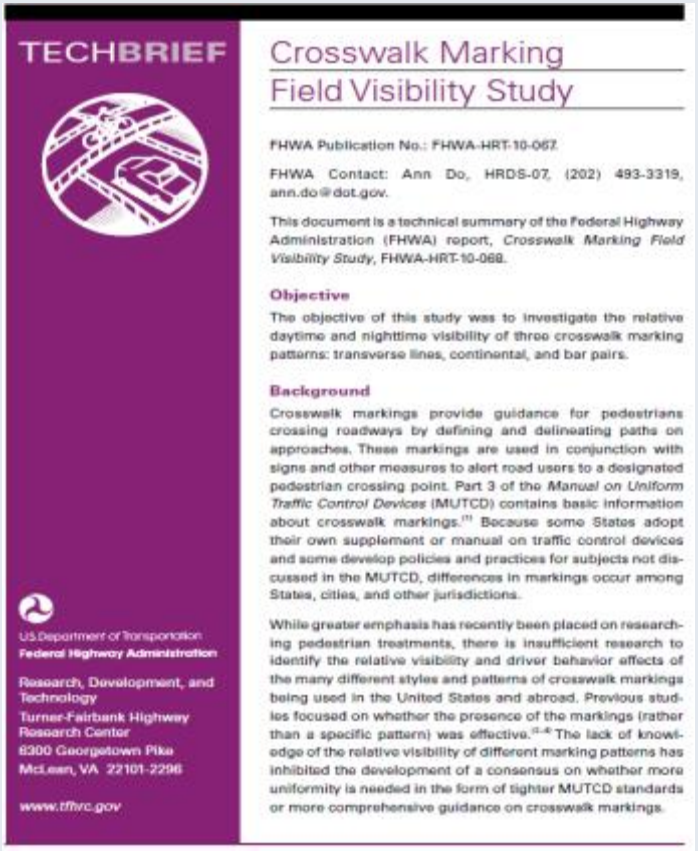
- Crosswalk lines should not be used indiscriminately.
- An engineering study should be performed before a marked crosswalk is installed at a location away from a traffic control signal or an approach controlled by a STOP or YIELD sign

The engineering study should consider:

- Number of lanes
- Presence of a median
- Distance from adjacent signalized intersections
- Pedestrian volumes & delays
- Average daily traffic (ADT)
- Posted speed limit or 85th-percentile speed
- Geometry
- Possible consolidation of multiple crossing points
- Street lighting
- Other appropriate factors

SAFETY RESEARCH

http://www.fhwa.dot.gov/publications/research/safety/04100/



http://www.fhwa.dot.gov/publications/research/safety/pedbike/10067/10067.pdf

CROSSWALK INSTALLATION RECOMMENDATIONS

Table 11. Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations.*

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT ≤ 9,000			Vehicle ADT >9,000 to 12,000			Vehicle ADT >12,000–15,000			Vehicle ADT > 15,000		
	Speed Limit**											
	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)
Two lanes	C	C	P	C	C	P	C	C	N	C	P	N
Three lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multilane (four or more lanes) with raised median***	C	C	P	C	P	N	P	P	N	N	N	N
Multilane (four or more lanes) without raised median	C	P	N	P	P	N	N	N	N	N	N	N

C = Compliant
P = Possibly compliant
N = Not compliant. Markings should not be installed without additional safety treatments

MUTCD SECTION 3B.18 CROSSWALK MARKINGS

Guidance

- New marked crosswalks without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph **and** either:
  - The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater; or
  - The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater.

PROPOSED REVISION TO MUTCD 3B.18

New marked crosswalks alone, without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways where any of the following apply:

A. The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater; or

B. The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater, or

C. The posted speed limit is 40 mph or greater, or

D. A crash study reveals that multiple-threat crashes are the predominant crash type on a multi-lane approach or when adequate visibility cannot be provided by parking prohibitions.

ADDITIONAL ENHANCEMENTS MARKINGS AND SIGNS

MARKED CROSSWALKS AND ENHANCEMENTS - SAFETY

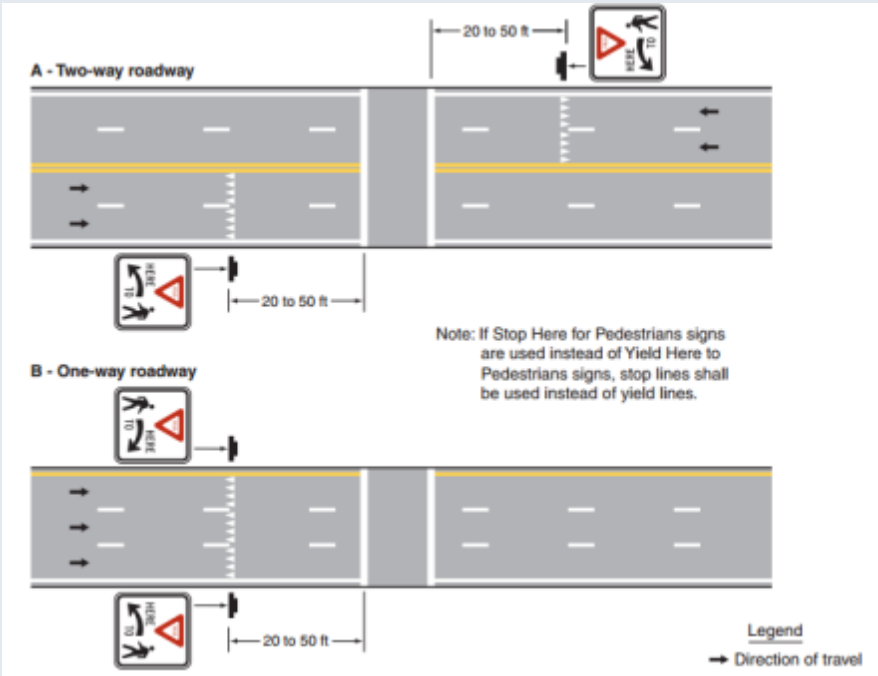
- High-visibility crosswalks have been associated with a 40% decrease in pedestrian crashes (Signal and Non-signal in NYC).(1)
- In school zones, a decrease of 37% observed in San Francisco.(2)

RESEARCH

- (1) Chen, L., Chen, C., Ewing, R., McKnight, C. E., Srinivasan, R., & Roe, M. (2013). Safety countermeasures and crash reduction in New York City—Experience and lessons learned. *Accident Analysis & Prevention*, *50*, 312-322.
- (2) Feldman, M., Manzi, J. G., & Mitman, M. F. (2010). Empirical Bayesian Evaluation of Safety Effects of High-Visibility School (Yellow) Crosswalks in San Francisco, California. *Transportation Research Record: Journal of the Transportation Research Board*, *2198*(1), 8-14.

ADVANCE STOP AND YIELD LINES

- Optional for uncontrolled crosswalks
- 20 to 50 ft in advance of crosswalk
- YIELD vs. STOP – must match State law
- Stop line for “Stop Here For Pedestrians”, Yield line for “Yield Here for Pedestrians”



CROSSING ISLAND

RECTANGULAR RAPID FLASH LED BEACON

- MUTCD Interim approval July 2008
  - Must submit a written request to the FHWA
  - http://mutcd.fhwa.dot.gov/resources/interim_approval/ia11/fhwamemo.htm
- Studies indicate motorist yield rates increased from about 20% to 80%
- Beacon is yellow, rectangular, and has a rapid "wig-wag" flash
- Beacon located between the warning sign and the arrow plaque
- Must be pedestrian activated (pushbutton or passive)

PEDESTRIAN HYBRID BEACON

ADDITIONAL ENHANCEMENT
PHB

1

Blank for drivers

2

Flashing yellow

3

Steady yellow

4

Steady red

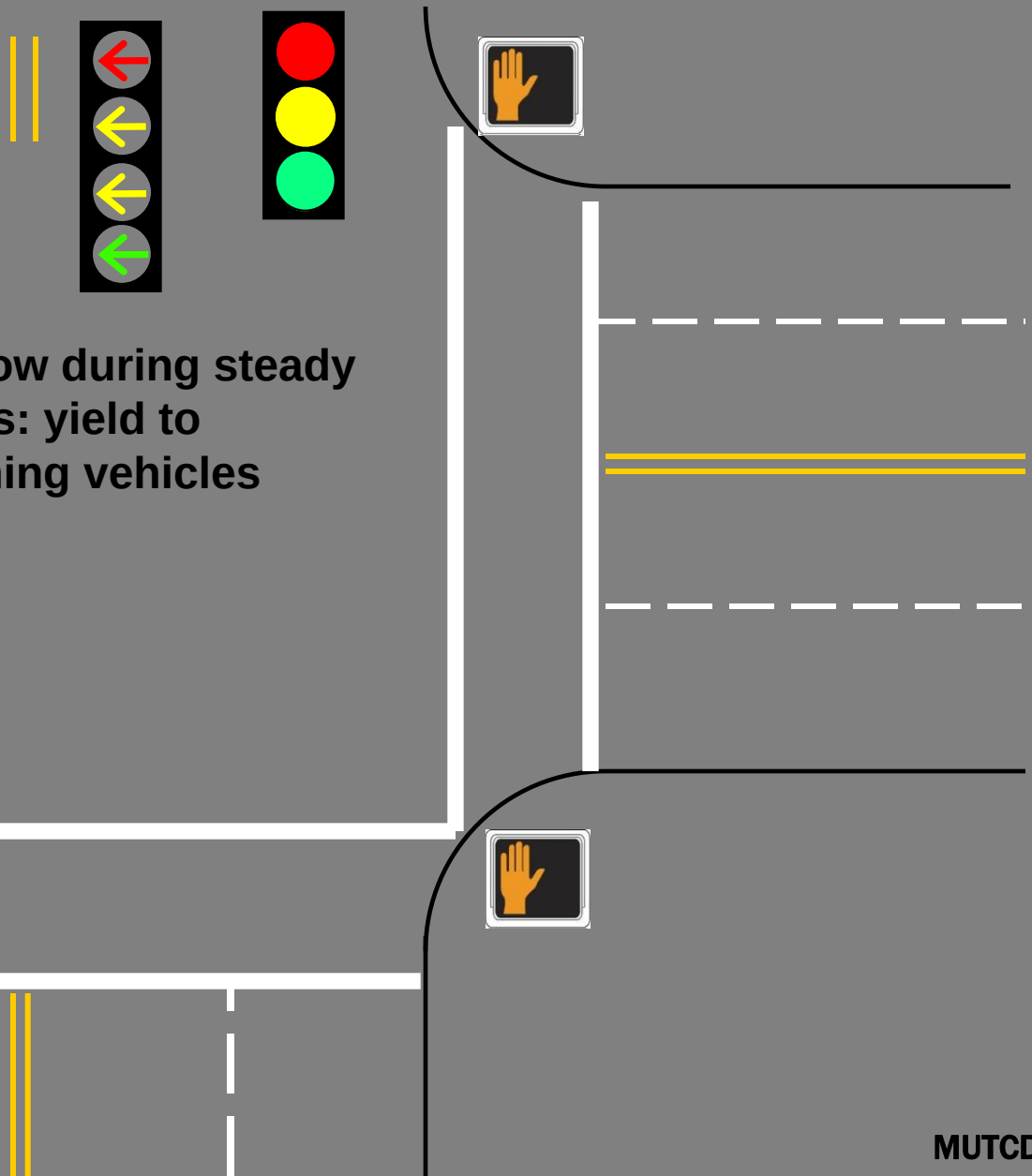
5

Wig-Wag

Return to 1

MUTCD Section 4F.02

FLASHING YELLOW ARROW



Flashing left yellow arrow during steady green ball warns drivers: yield to pedestrians and oncoming vehicles

MUTCD Sec. 4D.20

DISTRICT DOT'S UNCONTROLLED CROSSWALK POLICY

Table 1 - Proposed DC Uncontrolled Crosswalk Engineering Treatments

For roadways posted 30mph or less

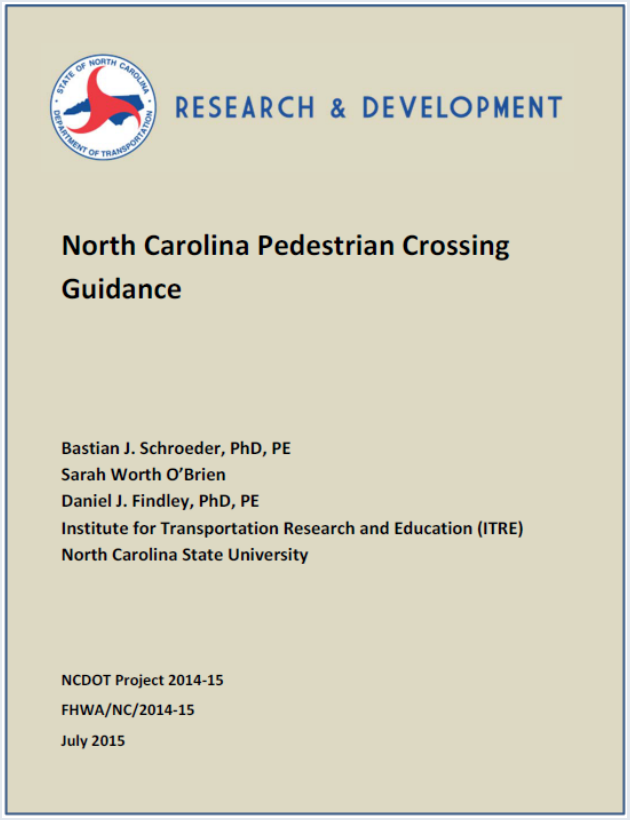
Roadway Configuration	1,500 - 9,000 vpd	9,000 - 12,000 vpd	12,000 - 15,000 vpd	> 15,000 vpd
2 Lanes[1]	A	A	A or B	B or C
2 Lanes with CTL[1]	A	A	B	B or C
2 Lanes One Way	B	B	C	C
4 Lanes w/Raised Median[2]	B	B	C	C
3 Lanes No Median[3]	B	B	C	C
5 Lanes w/Raised Median[3]	B	B	C	C
6 Lanes w/Raised Median[4]	B	B	C	D
4 Lanes No Median[4]	B	B or C	C	D
5 Lanes No Median[3]	B	B or C	D	D
6 Lanes No Median[4]	B	B or C	D	D

Volumes Below 1500 vpd	Parallel Crosswalk and/or W11-2 assembly
Treatment A	High Visibility Crosswalk and Side of Street Ped Law Sign
Treatment B	In-Street Stop For Peds Sign and/or Traffic Calming
Treatment C	Activated Pedestrian Device (RRFB, In-road LEDs, etc.)
Treatment D	Something with a red signal (Ped Hybrid, Full Signal)

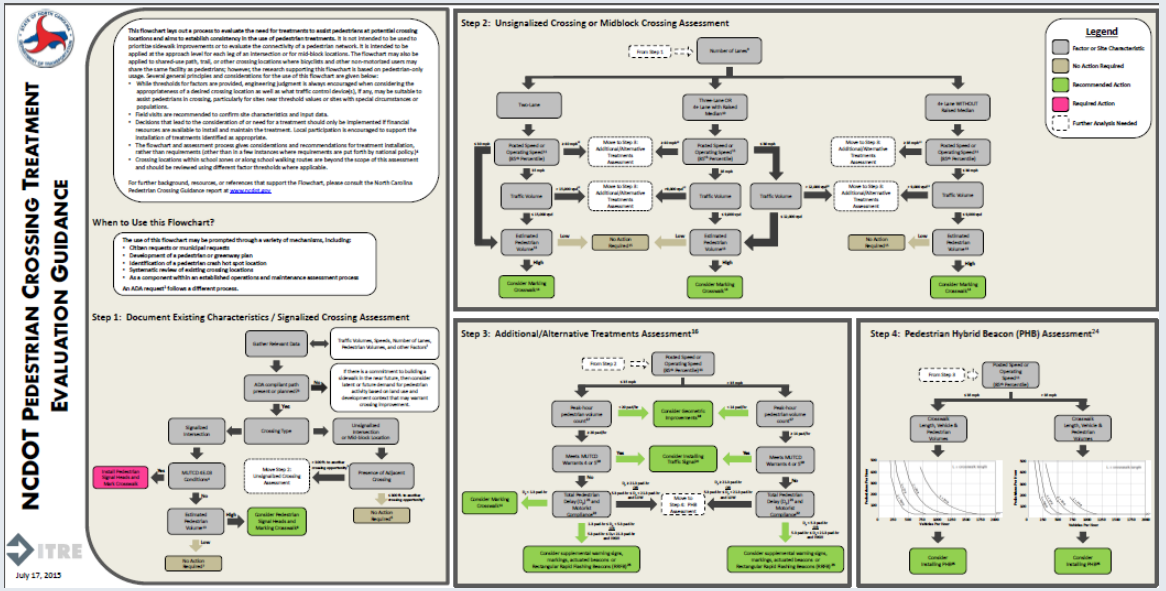
Page 25 Appendix C DDOT Ped Master Plan

http://ddot.dc.gov/sites/default/files/dc/sites/ddot/publication/attachments/pedestrianmasterplan_2009.pdf

NORTH CAROLINA PEDESTRIAN CROSSING GUIDANCE



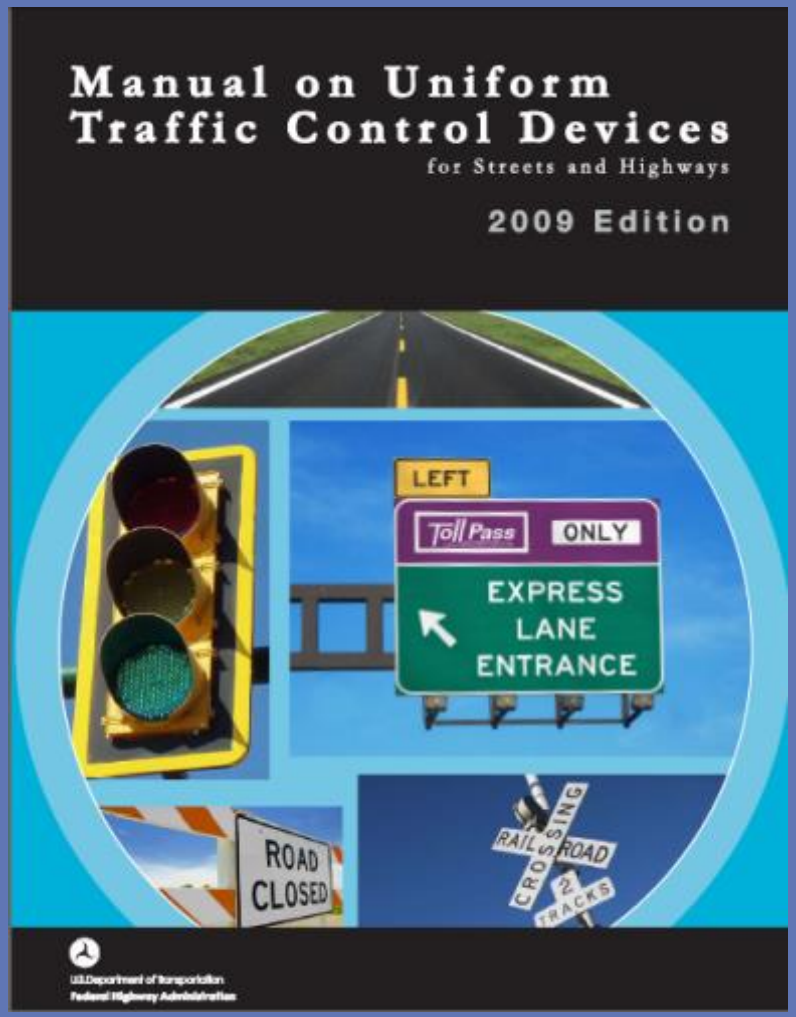
https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/Pedestrian_Crossing_Guidance.pdf



https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/FlowChart.pdf

BEST PRACTICES

- Do a crosswalk Inventory based on set criteria
  - Consistency
  - Seattle, WA did evaluation of all crosswalks after Zegeer study published
  - Helps manage risk
- District of Columbia crosswalk reviews
  - Resurfacing projects
  - System wide evaluations
  - Corridor Analysis
  - Individual requests

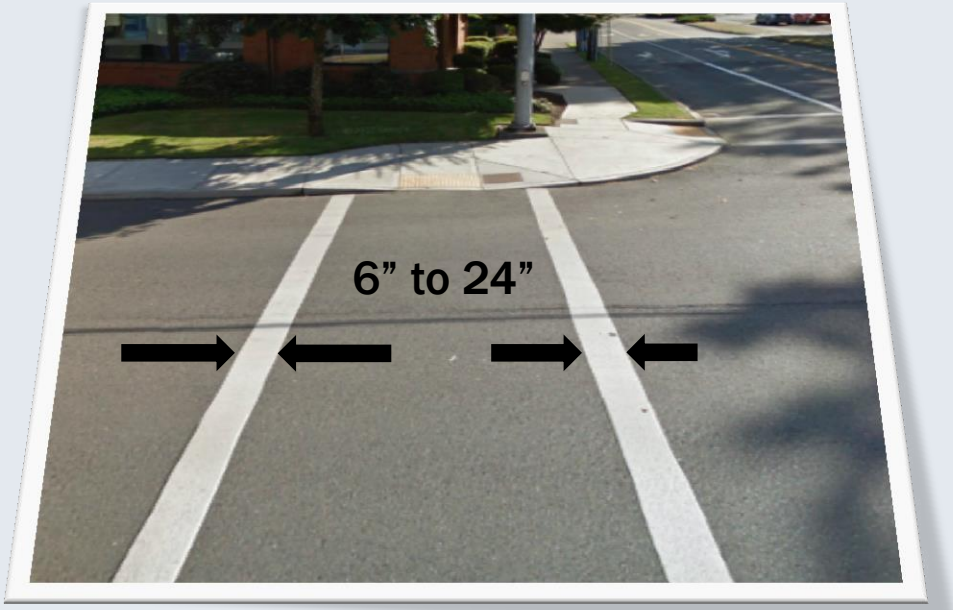


MUTCD

Section
3B.18

SECTION 3B.18
CROSSWALK MARKINGS

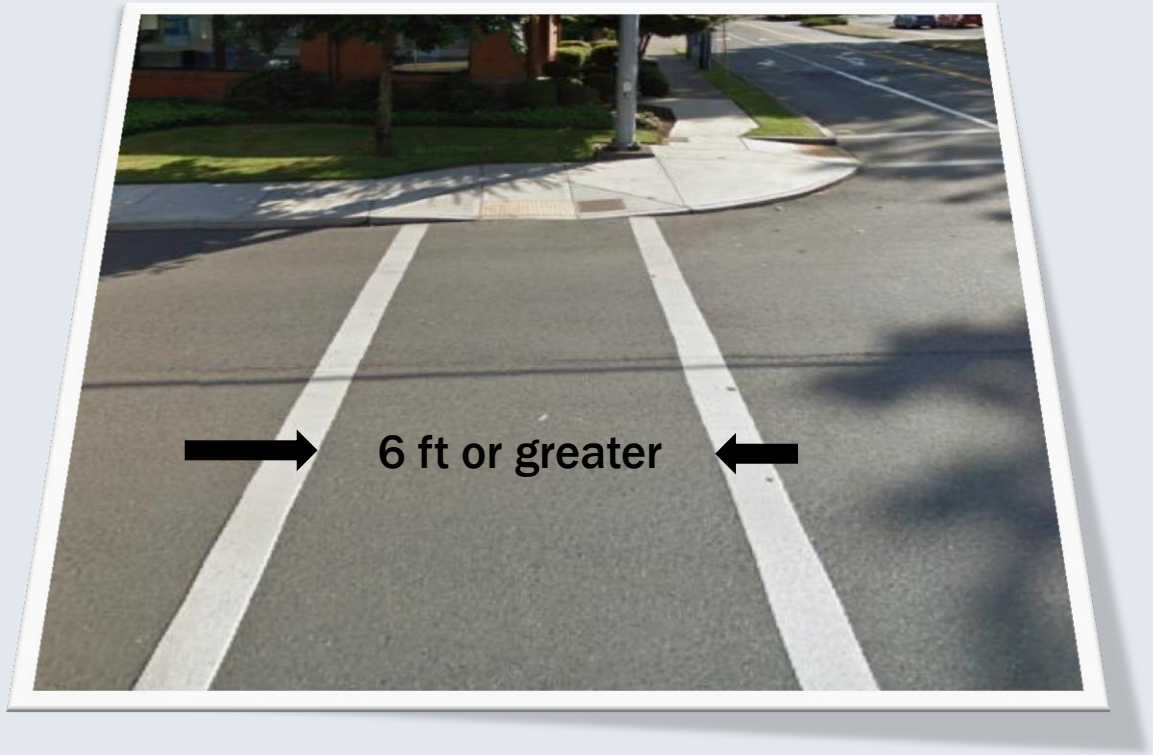
- **Standard:**
  When crosswalk lines are used, they shall consist of solid white lines that mark the crosswalk. They shall not be less than 6 inches or greater than 24 inches in width



SECTION 3B.18
CROSSWALK MARKINGS

Guidance

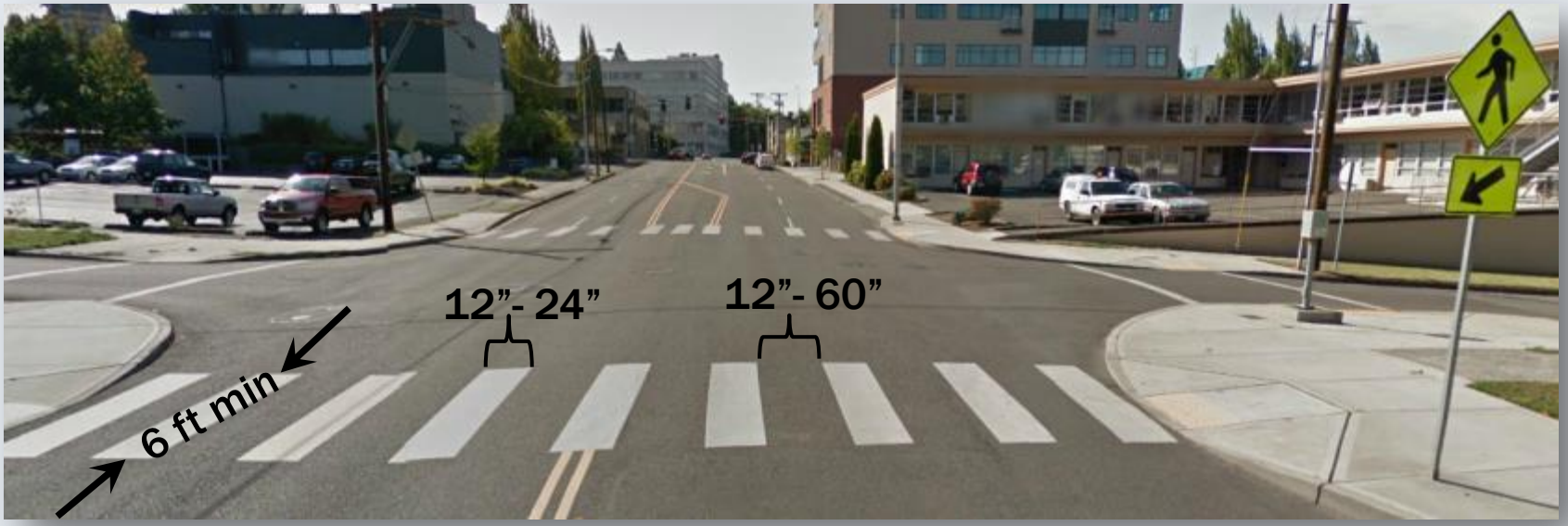
- If transverse lines are used to mark a crosswalk, the gap between the lines should not be less than 6 feet.



SECTION 3B.18
CROSSWALK MARKINGS

Guidance:

- *If used, the diagonal or longitudinal lines should be 12 to 24 inches wide and separated by gaps of 12 to 60 inches*



STAGGERED LADDER
AKA PIANO KEYS

Guidance:

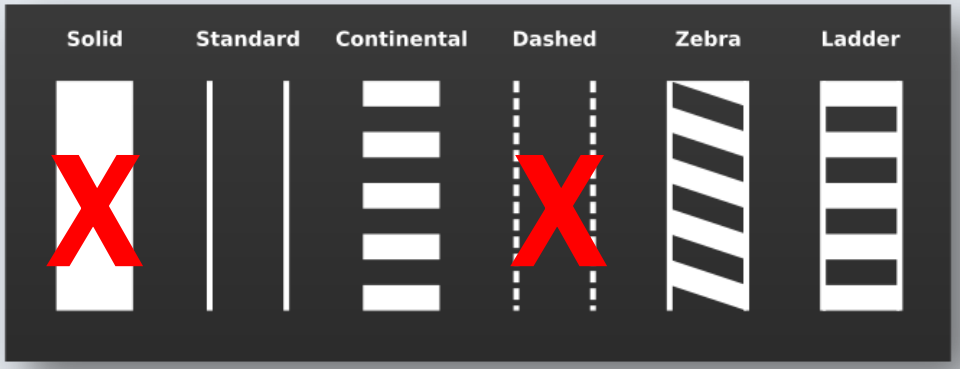
- *The design of the lines and gaps should avoid the wheel paths if possible, and the gap between the lines should not exceed 2.5 times the width of the diagonal or longitudinal lines*

Benefits

- Less maintenance
- Longer service life
- Ultimately lower cost

CROSSWALK MARKINGS

- Although the MUTCD provides for design options, research and observation indicate that the continental and ladder designs are the most visible to drivers
- These “longitudinal” markings also improve guidance for pedestrians with low vision and cognitive impairments



ANY ISSUES WITH THESE CROSSWALKS?

NATIONAL MUTCD COMPLIANT?

NATIONAL MUTCD COMPLIANT?

NATIONAL MUTCD COMPLIANT?

NATIONAL MUTCD COMPLIANT?

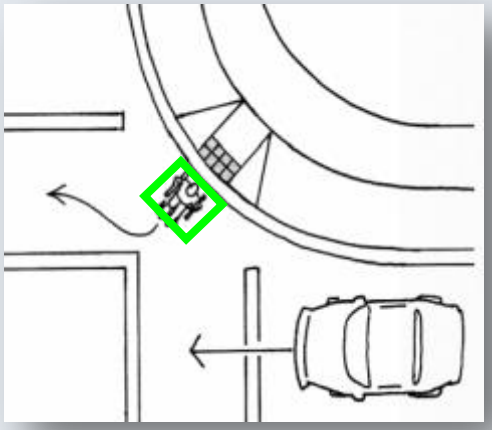
SECTION 3B.18
CROSSWALK MARKINGS

Guidance:

- *Crosswalk markings should be located so that the curb ramps are within the extension of the crosswalk markings*

ADA

- Two Ramps in line with pedestrian zone ideal
- PROWAG
  - 1 Ramp should be design exception
- Level landings:
  - Top - 4’x4’
  - Bottom - if single ramp making turn 4’x4’



SECTION 3B.18
CROSSWALK MARKINGS

- Detectable warning surfaces are required by 49 CFR, Part 37 and by the Americans with Disabilities Act (ADA) where curb ramps are constructed at the junction of sidewalks and the roadway, for marked and unmarked crosswalks.
- Detectable warning surfaces contrast visually with adjacent walking surfaces, either light-on-dark, or dark-on-light.

MARKED CROSSWALKS AND ENHANCEMENTS - COST

Infrastructure	Description	Median	Average	Minimum	Maximum	Cost Unit	No. of Observations
Crosswalk	High Visibility Crosswalk	$3,070	$2,540	$600	$5,710	Each	4(4)
Crosswalk	Striped Crosswalk	$340	$770	$110	$2,090	Each	8 (8)
Crosswalk	Striped Crosswalk	$5.87	$8.51	$1.03	$26	Linear Ft	12 (48)
Crosswalk	Striped Crosswalk	$6.32	$7.38	$1.06	$31	Sq Ft	5 (15)

For other crosswalk types, costs tend to vary by a large amount. For instance, for crosswalks using other materials such as brick or pavement scoring, costs range from $7.25 to $15 per square foot, or approximately $2,500 to $5,000 each. Ladder crosswalks cost range from $350 to $1,000 each and patterned concrete crosswalks cost $3,470 each or $9.68 per square foot on average.

CROSSWALK MARKING MATERIALS

Less Durable

- Paint
  - Water borne
  - Oil-based

More Durable

- Epoxy
- Polyurea
- Thermoplastic
- Pre-formed marking tape

Guide for Maintaining Pedestrian Facilities for Enhanced Safety

FACTORS FOR CHOOSING MATERIAL

- Cost to install and maintain
- Durability
- Retroreflectivity (6 lbs. of glass beads per gallon of paint)
- Friction coefficient (avoiding slippery surface)
- Applied using existing agency labor and equipment or contractor
- Ability to remove markings if changes occur

COMMON ISSUES WITH NON-DURABLE MARKINGS

- Maintenance
  - Re-striped several times a year based on the volume of traffic and the severity of weather
- To promote longer lifespan when using paint, a “high build grade” is recommended with glass beads for retroreflectivity.
- “High build” uses an acrylic cross-linking emulsion that allows for applications of up to 20 mils

COMMON ISSUES WITH DURABLE MARKINGS

- Less durable in cold weather climates
  - Where the roads are salted and sanded
  - Abrasiveness of these materials will cause more rapid deterioration of markings
  - Snow Plow Damage
- Some thermoplastic markings and some pre-formed marking tapes can become more slippery with wear
  - Manufacturers have significantly improved the friction factor of their materials
  - Slippery markings make it necessary to replace the markings sooner.

COMMON ISSUES WITH DURABLE MARKINGS: NIGHTTIME

- Large percentage of pedestrian fatalities occur in the evening when conspicuity is reduced.
- Crosswalk markings must retain their retroreflectivity, usually accomplished by adding beads or other retroreflective material to marking material.
- When the markings wear, the retroreflective quality of the material is often lost first.
- Recommend methods established in the MUTCD and described on this website to check for the proper retroreflectivity of crosswalks: http://safety.fhwa.dot.gov/roadway_dept/night_visib/pavementreg.cfm

COST COMPARISONS & LIFE-CYCLE COST

- A National Cooperative Highway Research Program (NCHRP) Synthesis 306: *Long-Term Pavement Marking Practices* provides cost comparisons and a life-cycle cost table
- In general, thermoplastics provide a life of two to three times that of paint for long lines,
  - Costs averaged almost five times that of paint
- Epoxy markings had a life of two to three times that of paint
  - Cost four times that of paint
- For life-cycle costs, paint was half the cost of thermoplastic
  - Costs and durability ranged significantly in this study.

RELATIVE COMPARISON

Figure 31: Relative comparison of crosswalk marking materials

Material	Relative Cost $=Low $$$$=High	Lifespan (months)	Retroreflectivity *=Low ***=High
Paint	$	3 – 24	*
Epoxy Paint	$$	24-48	**
Thermoplastic (sprayed)	$$$	48-72*	**
Pre-formed Tape	$$$$	36 – 96*	***

Note: Estimates based on minimum standard crosswalk treatment and updated to reflect 2013 comparative costs.[16,17] Thermoplastic and tape have shortened lifespans in snowy areas where they are often damaged by snowplows. Inlaid thermoplastic or pre-formed tape may last significantly longer than standard surface applications.

QUESTIONS?
RESOURCES

- Marked vs. Unmarked Crosswalks at Uncontrolled locations
  - http://www.fhwa.dot.gov/publications/research/safety/04100/
- Crosswalk Marking Field Visibility Study
  - http://www.fhwa.dot.gov/publications/research/safety/pedbike/10067/10067.pdf
- MUTCD Section 3B.18
  - http://mutcd.fhwa.dot.gov/htm/2009/part3/part3b.htm#section3B18
- NCHRP Report 562 Page 20
  - Crossing flags
  - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_562.pdf
- The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior – 2001
  - Raised Crosswalks
  - http://www.fhwa.dot.gov/publications/research/safety/00104/
- Informational Report on Lighting Design for Midblock Crosswalks FHWA-HRT-08-053 April 2008
  - http://www.tfhrc.gov/safety/pubs/08053/08053.pdf
- PedSafe
  - Case Studies
  - http://www.pedbikesafe.org/PEDSAFE/casestudies.cfm

QUESTIONS

RAISED CROSSWALKS

- FHWA Study "The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior" -2001
- Increase pedestrian visibility & more effective when combined with an overhead flashing light
- For low speed local streets
- Should not be used on emergency routes, bus routes, or high speed streets
- Storm water runoff and snow plowing considerations

Figure 6. Raised crosswalk and overhead flasher, Towerview Drive, Durham, North Carolina.

PEDESTRIAN CROSSING FLAGS

Interpretation Letter 2-563(I)

Pedestrian Flags for Crosswalks

April 27, 2005 Refer to: HOTO-1

Dear Ms. Varney:

Thank you for your February 15 request to experiment with the pedestrian flag education and awareness campaign to improve the safety of pedestrians at crosswalks. **We have reviewed your request and determined that the pedestrian flag is not a traffic control device. Therefore, you do not need to request approval from the Federal Highway Administration (FHWA) to experiment with the flag.** The flag concept described in your letter is similar to the concept of placing retroreflective material on clothing. Although it is not a traffic control device, it is a way to increase the visibility of pedestrians.

- http://mutcd.fhwa.dot.gov/resources/interpretations/2_563.htm

Thank You!

- **Archive at www.pedbikeinfo.org/webinars**
  - Downloadable/streaming recording and presentation slides
- **Questions?**
  webinars@hsrc.unc.edu