

MARKED CROSSWALKS & ENHANCEMENTS

DPS 201



CASE STUDY: CROSSWALKS & ENHANCEMENTS (LAS VEGAS, NV)

Problem and Background

- High pedestrian crash rate due to wide, fast roadways
- Six- to eight-lane roads
- 45 mph speed limits
- Among the highest ped fatalities in the nation
- Wanted to improve pedestrian infrastructure and provide a safer environment for vulnerable road users

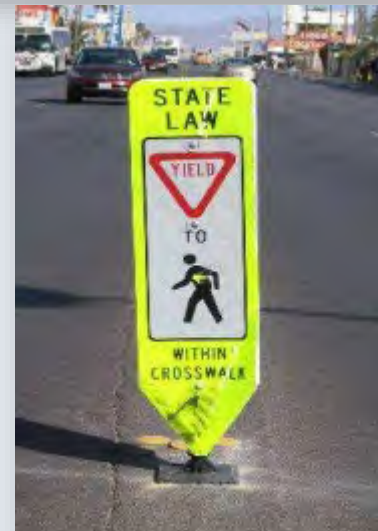


Source: Pedro Venda, panoramio.com

CASE STUDY: CROSSWALKS & ENHANCEMENTS (LAS VEGAS, NV)

Solution

- City worked with the FHWA to identify, install & evaluate various safety countermeasures
- 18 sites identified
 - 14 received countermeasures
 - 4 served as control locations
- Multiple countermeasures deployed at each site:
 - warning signs, advance yield markings, lighted pedestrian pushbuttons, high-visibility crosswalks, median refuges, automated pedestrian detection, speed trailers



CASE STUDY: CROSSWALKS & ENHANCEMENTS (LAS VEGAS, NV)

Results

- Motorist yielding rates & pedestrian safety improved
- At one site, **11%** of vehicles blocked the crosswalk before turning
 - After a "TURNING VEHICLES YIELD TO PEDESTRIANS" sign installed, no motorists blocked the crosswalk
- Number of pedestrians who looked for turning vehicles during the WALK increased with the sign
- Combining pedestrian safety countermeasures led to major increases in pedestrian safety
- City encouraged by results and hopes to further implement improvements



TEXAS TRANSPORTATION CODE

Sec. 541.302. TRAFFIC AREAS. In this subtitle:

(2) "Crosswalk" means:

- (A) the portion of a roadway, including an intersection, designated as a pedestrian crossing by surface markings, including lines; or
- (B) the portion of a roadway at an intersection that is 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.

TEXAS TRANSPORTATION CODE

Sec. 541.302. TRAFFIC AREAS. In this subtitle:

(16) "Sidewalk" means the portion of a street that is:

(A) between a curb or lateral line of a roadway and the adjacent property line; and

(B) intended for pedestrian use.

TEXAS TRANSPORTATION CODE

Sec. 541.303. INTERSECTION. (a) In this subtitle, "intersection" means the common area at the junction of two highways, other than the junction of an alley and a highway.

(b) The dimensions of an intersection include only the common area:

- (1) within the connection of the lateral curb lines or, in the absence of curb lines, the lateral boundary lines of the roadways of intersecting highways that join at approximate right angles; or
- (2) at the place where vehicles could collide if traveling on roadways of intersecting highways that join at any angle other than an approximate right angle.

HOW MANY CROSSWALKS DO YOU SEE?



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

WHERE SHOULD MARKED CROSSWALKS BE PROVIDED?

- Uncontrolled locations?
- Stop controlled locations?



- Signalized locations?



BRUCE HERMS, 1972

PEDESTRIAN CROSSWALK STUDY

Herms, Bruce. 1972. Pedestrian Crosswalk Study: Accidents in Painted and Unpainted Crosswalks, Transportation Research Record No. 406, Transportation Research Board, Washington, DC.

- This oft-quoted, and usually misinterpreted study examined pedestrian crash rates of marked versus unmarked crosswalks in San Diego
- Herms' speculation that marked crosswalks confer a "false sense of security" and therefore causes higher pedestrian crash rates has been disproven
- Still, the paper serves as a warning not to paint a crosswalk without carefully considering whether the location will require additional safety features to make the crossing safe

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.

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

Treatment A

Treatment B

Treatment C

Treatment D

Parallel Crosswalk and/or W11-2 assembly

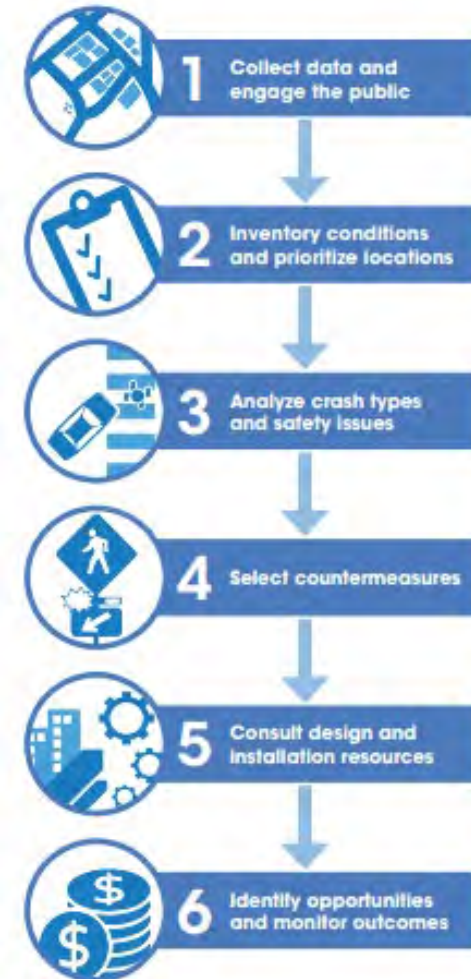
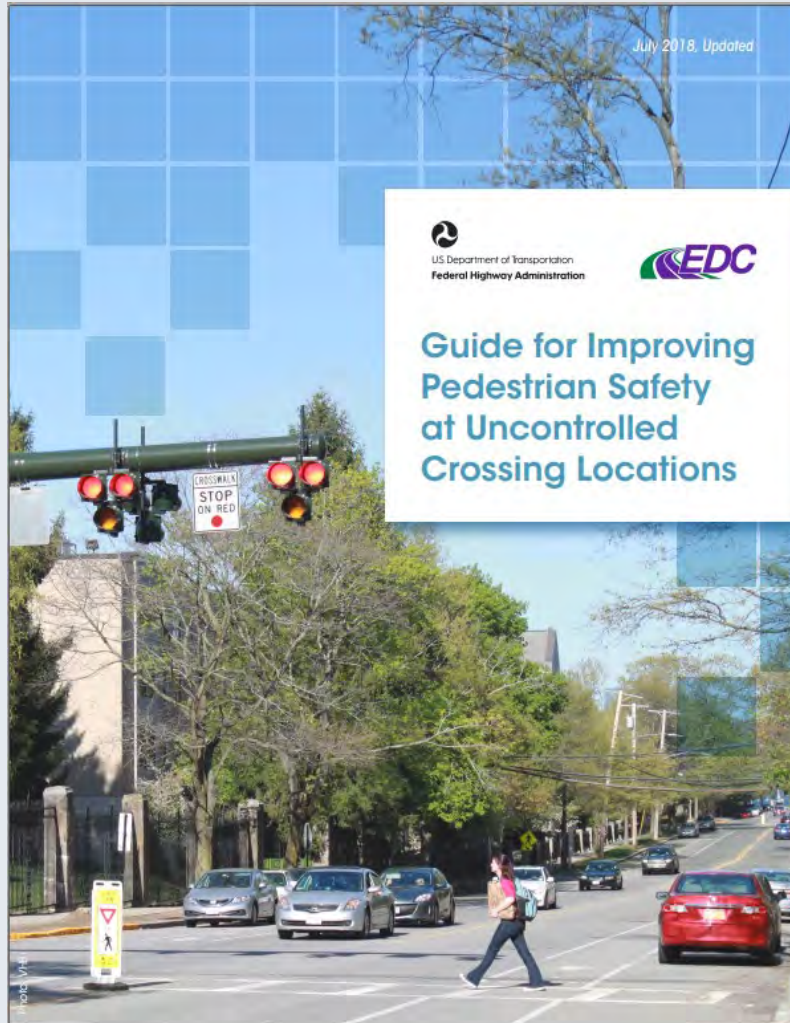
High Visibility Crosswalk and Side of Street Ped Law Sign

In-Street Stop For Peds Sign and/or Traffic Calming

Activated Pedestrian Device (RRFB, In-road LEDs, etc.)

Something with a red signal (Ped Hybrid, Full Signal)

FHWA STEP GUIDE (JULY 2018)



COUNTERMEASURE SELECTION

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	① 2 4 5 6	① 5 6 7 9	① 5 6 7 9	① 4 5 6 7 9	① 5 6 7 9	① 5 6 7 9	① 4 5 6 7 9	① 5 6 7 9	① 5 6 7 9
3 lanes with raised median (1 lane in each direction)	① 2 3 4 5	① 5 7 9	① 5 7 9	① 3 4 5	① 5 7 9	① 5 7 9	① 3 4 5	① 5 7 9	① 5 7 9
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	① 2 3 4 5 6	① 5 6 7 9	① 5 6 7 9	① 3 4 5 6	① 5 6 7 9	① 5 6 7 9	① 3 4 5 6	① 5 6 7 9	① 5 6 7 9
4+ lanes with raised median (2 or more lanes in each direction)	① 3 5	① 5 7 8 9	① 5 8 9	① 3 5	① 5 7 8 9	① 5 8 9	① 3 5	① 5 7 8 9	① 5 8 9
4+ lanes w/o raised median (2 or more lanes in each direction)	① 3 5 6	① 5 6 7 8 9	① 5 6 8 9	① 3 5 6	① 5 6 7 8 9	① 5 6 8 9	① 3 5 6	① 5 6 7 8 9	① 5 6 8 9

<p>Given the set of conditions in a cell,</p> <ul style="list-style-type: none"> # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location. ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location. ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.* <p>The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.</p>	<ol style="list-style-type: none"> 1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs 2 Raised crosswalk 3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line 4 In-Street Pedestrian Crossing sign 5 Curb extension 6 Pedestrian refuge island 7 Rectangular Rapid-Flashing Beacon (RRFB)** 8 Road Diet 9 Pedestrian Hybrid Beacon (PHB)**
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BEST PRACTICES

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

DISCUSSION: LOCAL AGENCY PROCESS

- What factors are taken into consideration for installation of marked crosswalks in your agency/region?



SAFETY

CMF

RESEARCH

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.

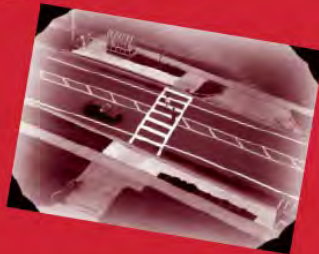
SAFETY RESEARCH

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations

Final Report and Recommended Guidelines

FHWA PUBLICATION NUMBER: HRT-04-100

SEPTEMBER 2006



U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296



Pedestrian and Bicycle Safety

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

TECHBRIEF



Crosswalk Marking Field Visibility Study

FHWA Publication No.: FHWA-HRT-10-067.

FHWA Contact: Ann Do, HRDS-07, (202) 493-3319,
ann.do@dot.gov.

This document is a technical summary of the Federal Highway Administration (FHWA) report, *Crosswalk Marking Field Visibility Study*, FHWA-HRT-10-068.

Objective

The objective of this study was to investigate the relative daytime and nighttime visibility of three crosswalk marking patterns: transverse lines, continental, and bar pairs.

Background

Crosswalk markings provide guidance for pedestrians crossing roadways by defining and delineating paths on approaches. These markings are used in conjunction with signs and other measures to alert road users to a designated pedestrian crossing point. Part 3 of the *Manual on Uniform Traffic Control Devices* (MUTCD) contains basic information about crosswalk markings.⁽¹⁾ Because some States adopt their own supplement or manual on traffic control devices and some develop policies and practices for subjects not discussed in the MUTCD, differences in markings occur among States, cities, and other jurisdictions.

While greater emphasis has recently been placed on researching pedestrian treatments, there is insufficient research to identify the relative visibility and driver behavior effects of the many different styles and patterns of crosswalk markings being used in the United States and abroad. Previous studies focused on whether the presence of the markings (rather than a specific pattern) was effective.⁽²⁻⁴⁾ The lack of knowledge of the relative visibility of different marking patterns has inhibited the development of a consensus on whether more uniformity is needed in the form of tighter MUTCD standards or more comprehensive guidance on crosswalk markings.



U.S. Department of Transportation
Federal Highway Administration

Research, Development, and
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www.tfhrc.gov

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

Manual on Uniform Traffic Control Devices

for Streets and Highways

2009 Edition



U.S. Department of Transportation
Federal Highway Administration

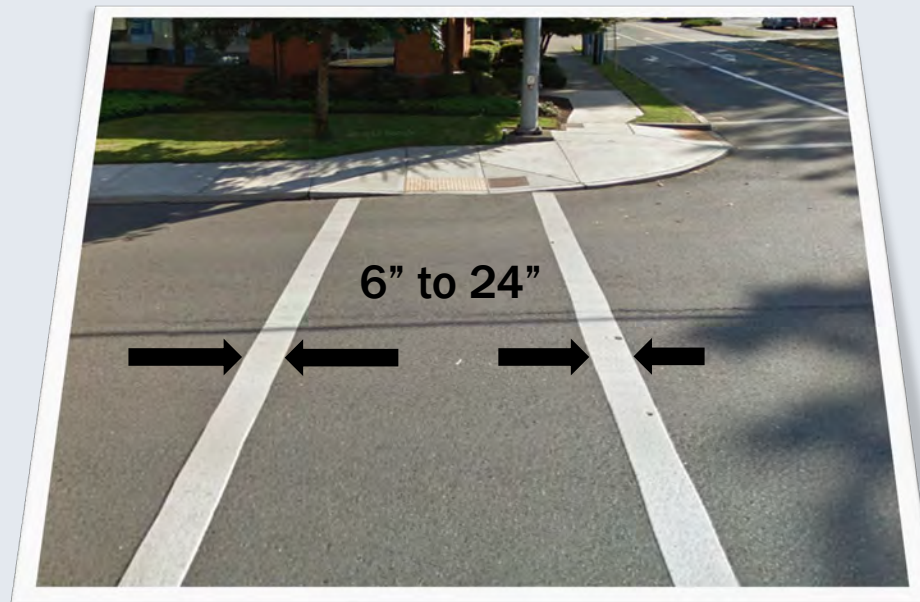
MUTCD

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

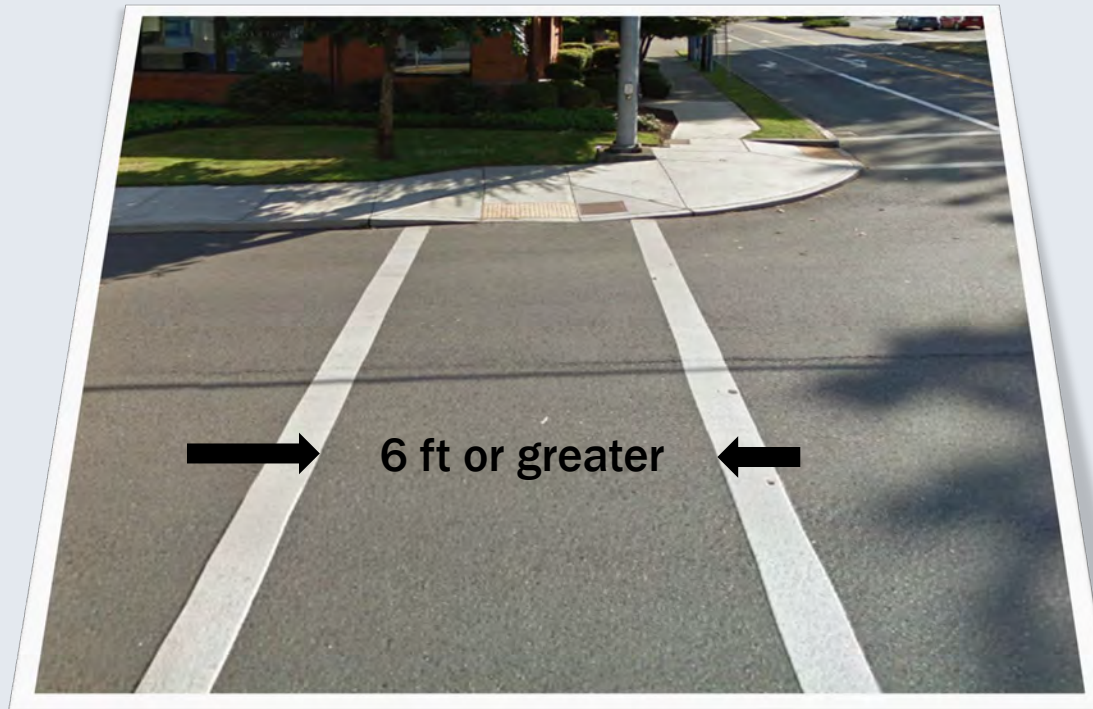


SECTION 3B.18

CROSSWALK MARKINGS

Guidance

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

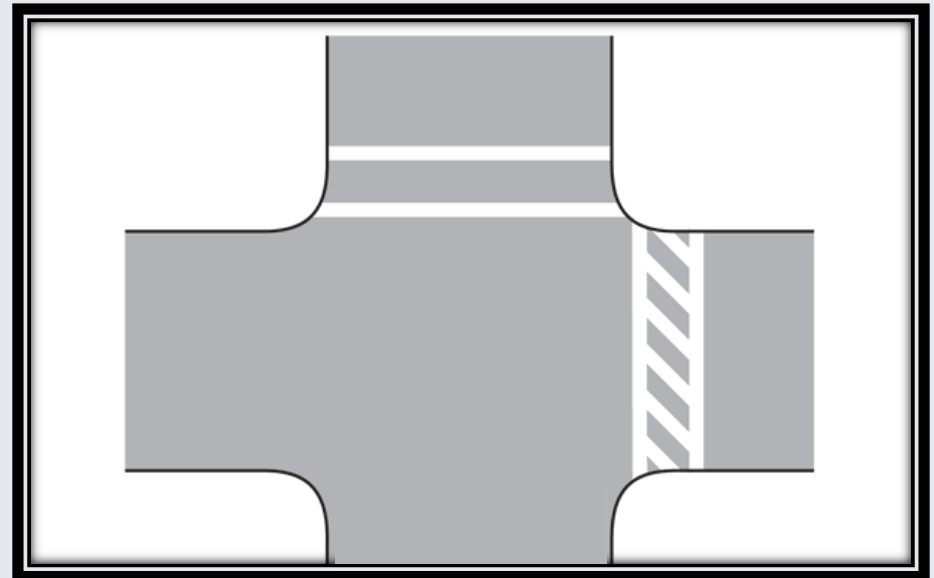
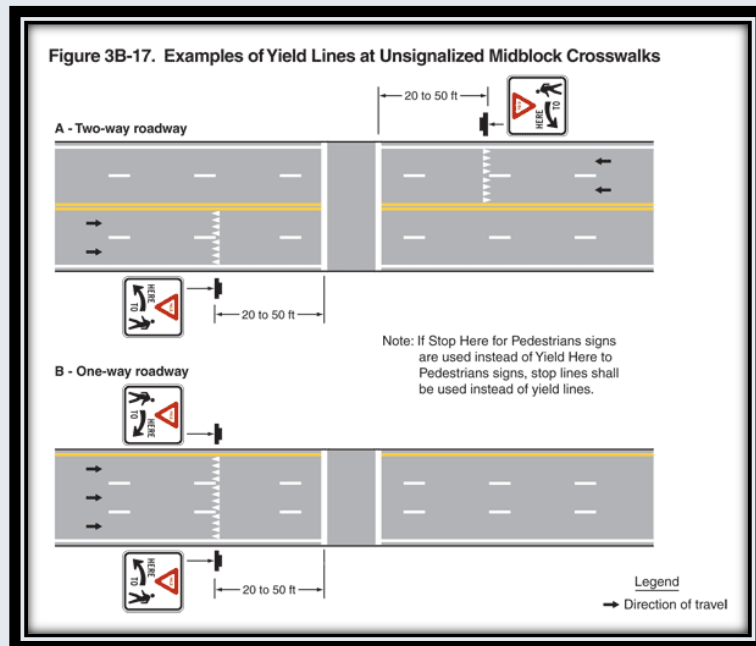


SECTION 3B.18

CROSSWALK MARKINGS

Guidance

- Transverse lines, if used on both sides of the crosswalk, should extend across the full width of pavement or to the edge of the intersecting crosswalk to discourage diagonal walking between crosswalks (see [Figures 3B-17](#) and [3B-19](#)).

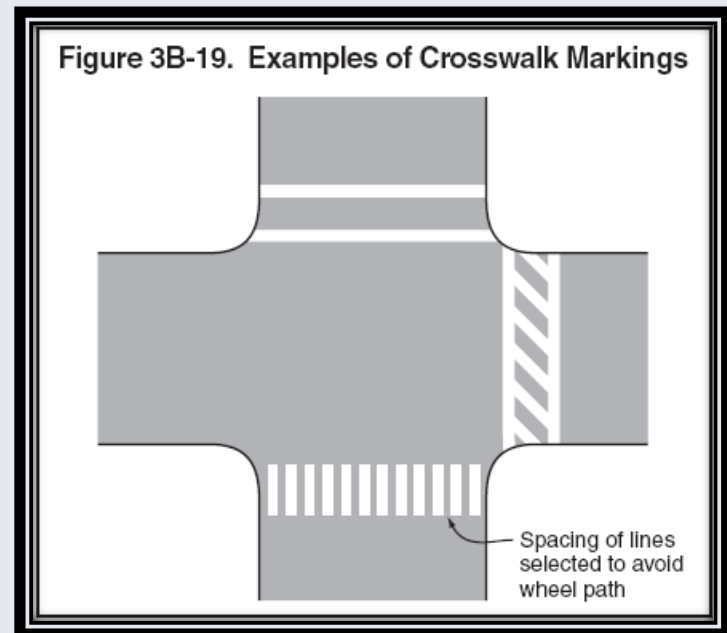


SECTION 3B.18

CROSSWALK MARKINGS

Option:

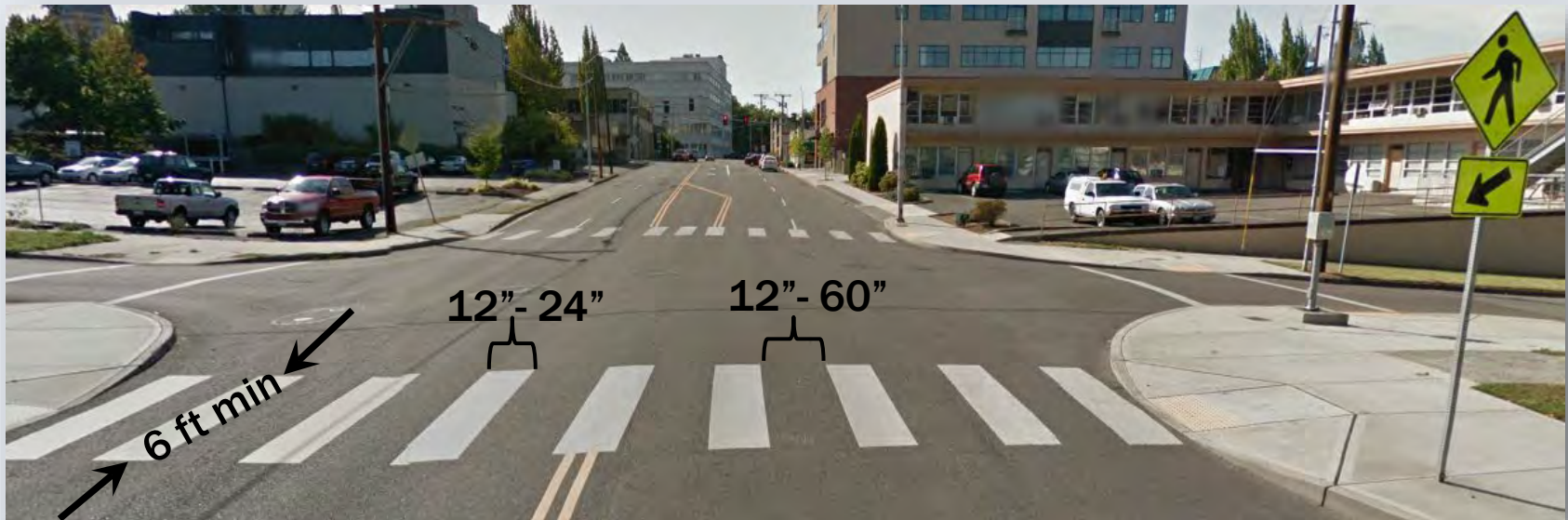
- For added visibility diagonal or longitudinal lines may be used to mark the crosswalk
- When diagonal or longitudinal lines are used, transverse lines may be omitted



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*

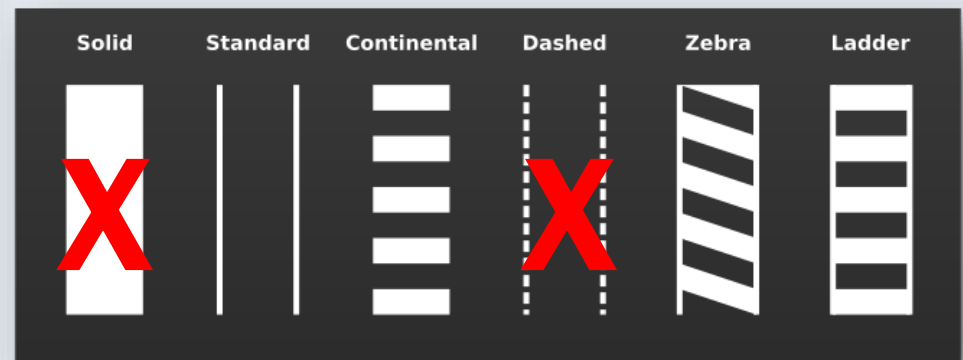
Benefits

- 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



NATIONAL MUTCD COMPLIANT?

- California
 - 4'x4'x4'
- Benefits
 - Higher friction than some markings materials
 - Wheelchairs, walkers don't have the slight bump



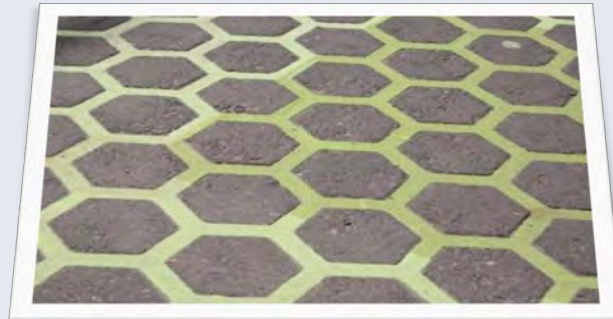
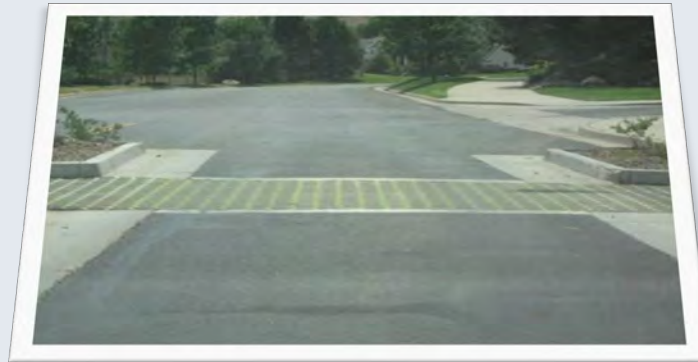
NATIONAL MUTCD COMPLIANT?



ANY ISSUES WITH THESE CROSSWALKS?



NATIONAL MUTCD COMPLIANT?



INLAID THERMOPLASTIC AFTER A FEW YEARS



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*



SECTION 3B.18

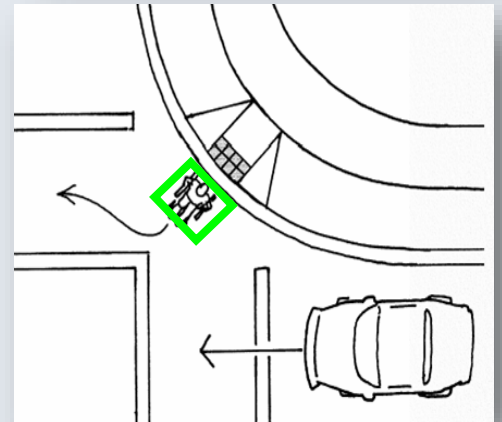
CROSSWALK MARKINGS

- 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.



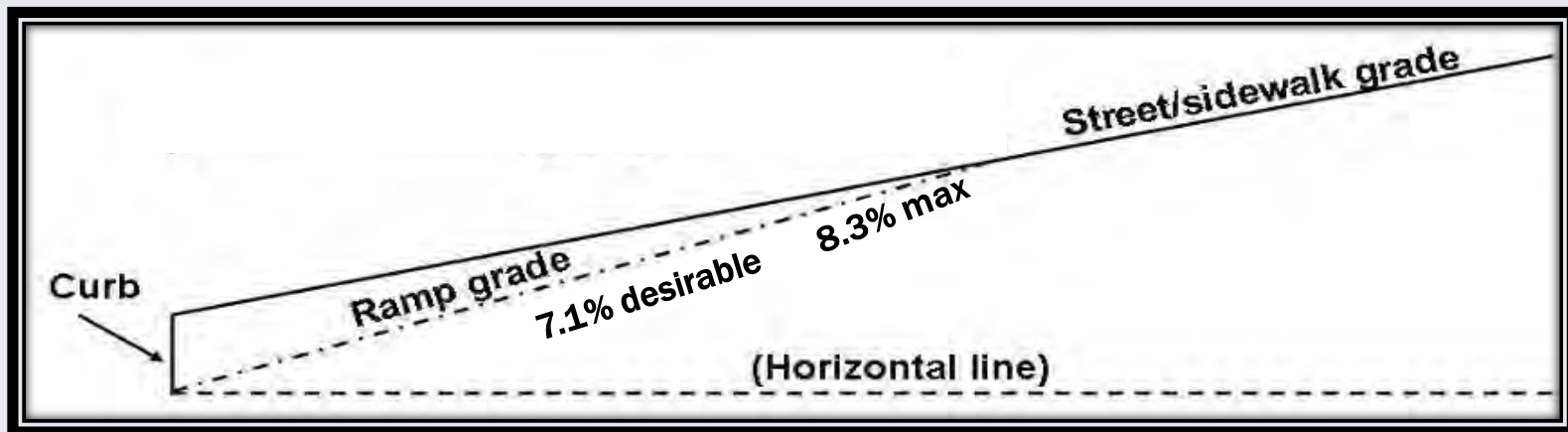
ADA

- 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'



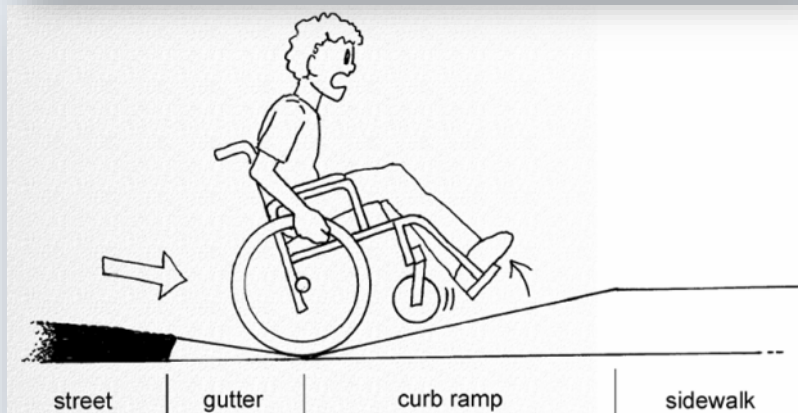
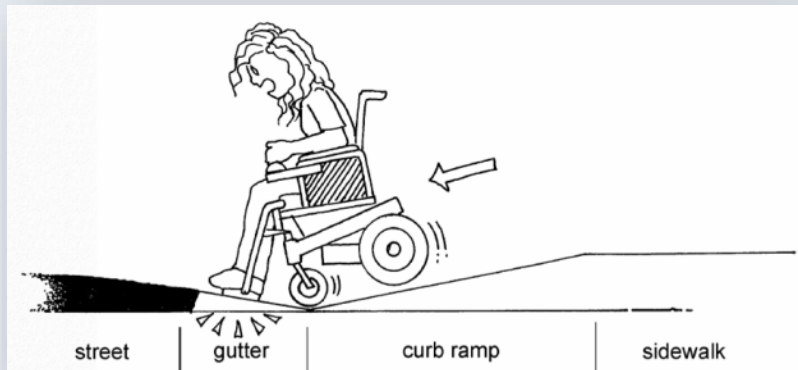
RAMP GRADE

- Recommended maximum grade to allow for construction tolerance - 7.1%
- Maximum grade - 8.3%
- Least slope possible is preferred
- When “chasing grade,” ramp length need not exceed 15’, but slope must be uniform (PROWAG)



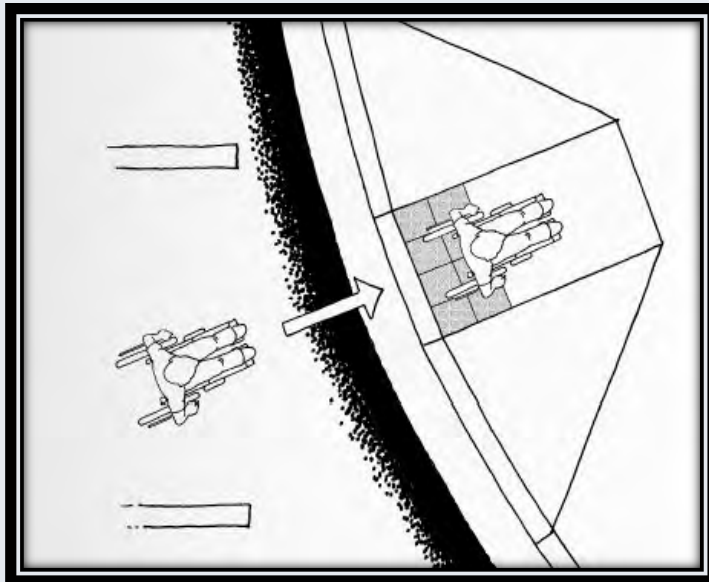
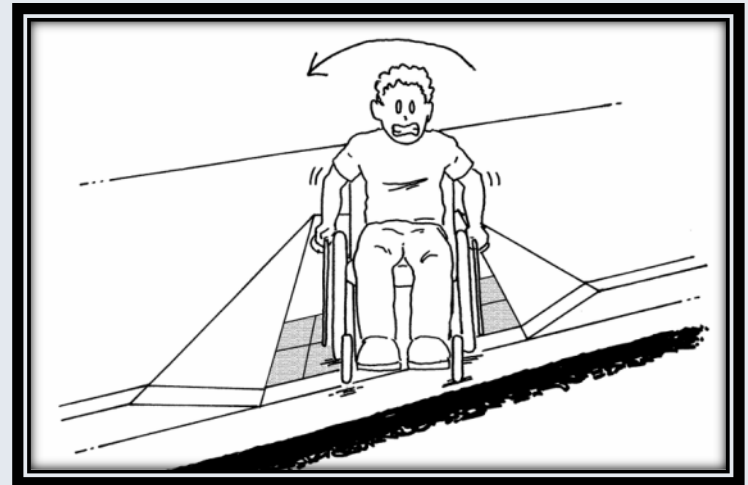
CHANGE OF GRADE

- Abrupt changes of grade are difficult to use and can cause wheelchairs to flip over backward or forward



RAMP ALIGNMENT

- Ramp alignment is important to the stability of the wheelchair.
- Important grade changes take place at right angles
 - If not, a wheelchair becomes unstable and may tip



PROWAG CROSS SLOPE

- **R302.6 Cross Slope.** Except as provided in R302.6.1 and R302.6.2, the cross slope of pedestrian access routes shall be 2 percent maximum.
 - **R302.6.1 Pedestrian Street Crossings Without Yield or Stop Control.** Where pedestrian access routes are contained within pedestrian street crossings without yield or stop control, the cross slope of the pedestrian access route shall be 5 percent maximum.
 - **R302.6.2 Midblock Pedestrian Street Crossings.** Where pedestrian access routes are contained within midblock pedestrian street crossings, the cross slope of the pedestrian access route shall be permitted to equal the street or highway grade.



GUTTER SLOPE (PARALLEL TO THE CURB AND THE ROADWAY)

- Slope should not exceed 2% at the curb ramp*
 - But some slope is needed for drainage



MARKED CROSSWALKS AND ENHANCEMENTS – COST (2013)

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.

**ENHANCEMENTS:
VIEW ADDITIONAL
MODULES IN
WORKSHOP**

**Modules:
Medians
Curb Ext.
RRFB
PHB**

ADVANCE MARKINGS

- Advance PED XING or SCHOOL pavement stencils
- Advance solid lane lines



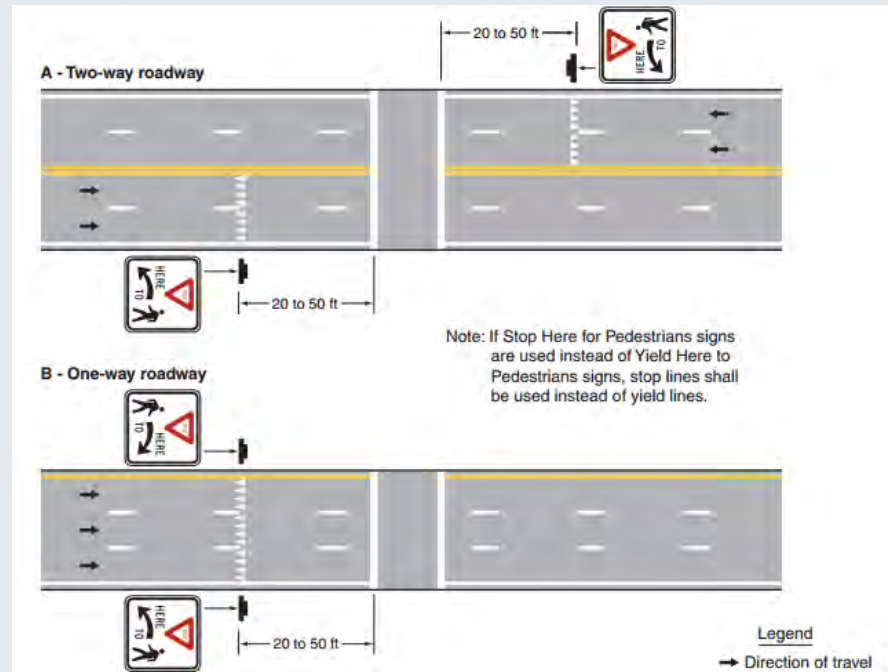
ADVANCE, OVERHEAD & CROSSWALK SIGNS



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”



TWO-STAGE CROSSING ISLAND



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.

LIGHTING

- Coordinate streetlights with crosswalk markings
- Lights on both sides of street provide better uniformity
- Street lights should be installed on approaches to crosswalks for best results



DESIGN AND OPERATION ISSUES LIGHTING BOTH SIDES OF CROSSING

Informational Report on Lighting Design for Midblock Crosswalks FHWA-HRT-08-053 April 2008

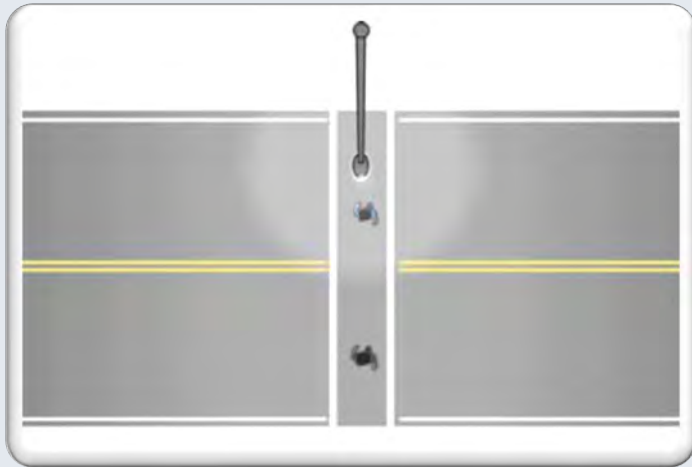


Fig 11. Traditional midblock crosswalk lighting layout

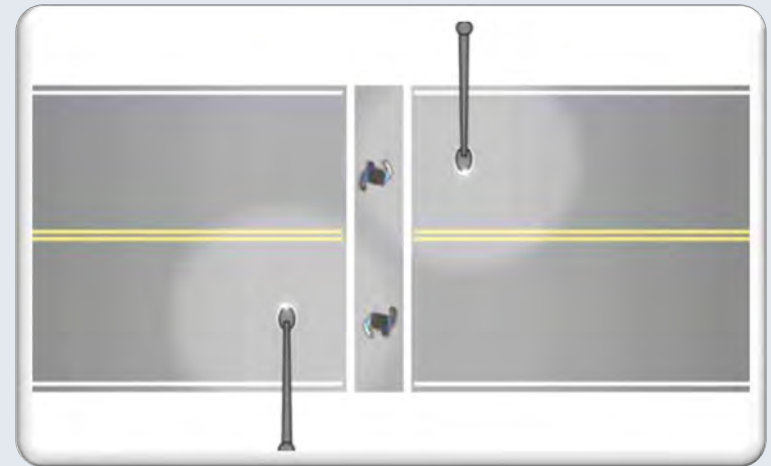


Fig 12. New design for midblock crosswalk lighting layout

Recommended lighting level: 20 lux at 5' above pavement

FHWA Report <http://www.tfhrc.gov/safety/pubs/08053/08053.pdf>

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



PEDESTRIAN CROSSING FLAGS

- NCHRP Report 562 Page 20
 - Moderately effective Salt Lake City UT and Kirkland WA
 - Yielding rates from 46% to 79%
 - Speed limits of 30 mph or less
 - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_562.pdf

Things to consider

- Flags get stolen
- Redistribution at corners
 - Neighborhood or business volunteers
- Some flag holder designs are used as garbage cans



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>