MARKED CROSSWALKS & ENHANCEMENTS
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 pedestrian 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
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
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.
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.
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.
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).
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?

- 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>
<thead>
<tr>
<th>Roadway Type (Number of Travel Lanes and Median Type)</th>
<th>Vehicle ADT ≤ 9,000</th>
<th>Vehicle ADT &gt; 9,000 to 12,000</th>
<th>Vehicle ADT &gt; 12,000–15,000</th>
<th>Vehicle ADT &gt; 15,000</th>
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<tbody>
<tr>
<td></td>
<td>≤ 48.3 km/h (30 mi/h)</td>
<td>56.4 km/h (35 mi/h)</td>
<td>64.4 km/h (40 mi/h)</td>
<td>≤ 48.3 km/h (30 mi/h)</td>
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<tr>
<td>Two lanes</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Three lanes</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Multilane (four or more lanes) with raised median***</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Multilane (four or more lanes) without raised median</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>P</td>
</tr>
</tbody>
</table>

C = Compliant
P = Possibly compliant
N = Not compliant. Markings should not be installed without additional safety treatments
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.
Table 1 - Proposed DC Uncontrolled Crosswalk Engineering Treatments
For roadways posted 30mph or less

<table>
<thead>
<tr>
<th>Roadway Configuration</th>
<th>1,500 - 9,000 vpd</th>
<th>9,000 - 12,000 vpd</th>
<th>12,000 - 15,000 vpd</th>
<th>&gt; 15,000 vpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lanes</td>
<td>A</td>
<td>A</td>
<td>A or B</td>
<td>B or C</td>
</tr>
<tr>
<td>2 Lanes with CTL</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B or C</td>
</tr>
<tr>
<td>2 Lanes One Way</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>4 Lanes w/Raised Median</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>3 Lanes No Median</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>5 Lanes w/Raised Median</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>6 Lanes w/Raised Median</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>4 Lanes No Median</td>
<td>B</td>
<td>B or C</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>5 Lanes No Median</td>
<td>B</td>
<td>B or C</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>6 Lanes No Median</td>
<td>B</td>
<td>B or C</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

| 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
## COUNTERMEASURE SELECTION

### Posted Speed Limit and AADT

<table>
<thead>
<tr>
<th>Roadway Configuration</th>
<th>Vehicle AADT &lt; 9,000</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>≤30 mph</td>
<td>35 mph</td>
<td>≥40 mph</td>
<td>≤30 mph</td>
<td>35 mph</td>
<td>≥40 mph</td>
<td>≤30 mph</td>
<td>35 mph</td>
<td>≥40 mph</td>
<td>≤30 mph</td>
<td>35 mph</td>
</tr>
<tr>
<td>2 lanes (1 lane in each direction)</td>
<td>1 2 4 5 6</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
</tr>
<tr>
<td>3 lanes with raised median (1 lane in each direction)</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
</tr>
<tr>
<td>3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
</tr>
<tr>
<td>4+ lanes with raised median (2 or more lanes in each direction)</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
</tr>
<tr>
<td>4+ lanes w/o raised median (2 or more lanes in each direction)</td>
<td>1 2 3 4 5</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
</tr>
</tbody>
</table>

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Given the set of conditions in a cell,

- # 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.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

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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* Pedestrian visibility enhancements should always occur in conjunction with other identified countermeasures.

** RRFB and PHB are advanced technologies and may not be available in all locations.
- 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
What factors are taken into consideration for installation of marked crosswalks in your agency/region?
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**


SAFETY RESEARCH

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations
Final Report and Recommended Guidelines


TECHBRIEF
Crosswalk Marking Field Visibility Study

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.
Guidance

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

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

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

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

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
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.
- 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

Interpretation Letter 2-563(I)
Pedestrian Flags for Crosswalks
April 27, 2005  Refer to: HOT0-1
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

Things to consider
- Flags get stolen
- Redistribution at corners
  - Neighborhood or business volunteers
- Some flag holder designs are used as garbage cans
Marked vs. Unmarked Crosswalks at Uncontrolled locations

Crosswalk Marking Field Visibility Study

MUTCD Section 3B.18

NCHRP Report 562 Page 20
- Crossing flags

The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior – 2001
- Raised Crosswalks

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

PedSafe
- Case Studies
  - http://www.pedbikesafe.org/PEDSAFE/casestudies.cfm