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Roundabouts and Channelized Turn Lanes: Access for Pedestrians, Particularly Those with Vision Disabilities

APBP Workshop
August 27, 2019
Portland, Oregon

Photo: Lee Rodegerdts

KITTELSON & ASSOCIATES

Accessible Design for the Blind

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Structure of Workshop

Time	Topic
9:45-10:00	Introduction (Lee)
10:00-10:30	General Principles for Travel (Janet)
10:30-10:45	Design Concepts and Possible Crossing Treatments (Lee)
10:45-11:15	Wayfinding Assessment Overview (Janet)
11:15-11:45	Crossing Assessment Overview (Lee)
11:45-12:15	Conclusion and Q&A

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Disclaimer

- The photographs in this module as used as illustrations and are not necessarily complete representations of desirable or undesirable practices in all aspects visible in the photograph.
- In many cases the sites included were designed before current good practices were developed and thus may not include what would be considered good practice today.
- In all cases, the context of the specific site location may have dictated the decisions that were made.
- That said, there may be opportunities to improve the accessibility of existing sites that fall short of desirable practices today.

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INTRODUCTION

Roundabout and Channelized Turn Lane
Accessibility Challenges

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Roundabout and CTL Accessibility Challenges

- **The crossing task for blind pedestrians**
  - Finding the crosswalk
  - Aligning to cross
  - Deciding when it is safe to cross
  - Maintaining alignment during crossing
- **Confounding challenges**
  - Uninterrupted flow (no signal)
  - Potentially high speeds
  - Ambient noise at crosswalk
  - Non-straight geometry
  - Low driver yield compliance
- **Treatments are available and can help**

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Americans with Disabilities Act (1990)

- **Civil rights law**
- **Title II applies to state and local government services**
- **Applies to all programs and activities regardless of funding source**
- **Key phrases:**
  - "New construction and alterations…"
  - "…accessible to and usable by…"
  - "…to the maximum extent feasible…"

Adapted from www.apsguide.org, Module A, Slide 20;
https://www.ada.gov/pubs/adastatute08.htm

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Americans with Disabilities Act Accessibility Guidelines (ADAAG) (1991/2010)

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- Adopted as a final rule (enforceable standard) by DOJ and DOT in 1992, updated in 2010
- Minimum technical provisions for access
- Equivalent Facilitation
  - "Nothing… prevents the use of designs…as alternatives to those prescribed, provided they result in substantially equivalent or greater accessibility and usability."
  - "The responsibility for demonstrating equivalent facilitation in the event of a challenge rests with the covered entity."
- Section on public rights-of-way, originally Section 14 of ADAAG, was not issued as a final rule at that time

Adapted from www.apsguide.org, Module A, Slide 21

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Proposed Guidelines for Public Rights-of-Way (2011)

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- R306.3.1, Separation
  - Detectable separation between sidewalk and street between crosswalks at roundabouts
- R306.3.2, Pedestrian Activated Signal
  - Pedestrian-activated signals with accessible pedestrian signals (APS) required for pedestrian crossings across each multilane segment
- R306.3.4, Channelized Turn Lanes at Roundabouts
  - Pedestrian-activated signals with APS required for pedestrian crossings at multilane channelized turn lanes
- R306.3.5, Channelized Turn Lanes at Other Signalized Intersections
  - Pedestrian-activated signals with APS required for pedestrian crossings at multilane channelized turn lanes
- http://www.access-board.gov/prowac/

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What Does This Mean for Practice?

- ADA requires newly constructed or altered facilities to be accessible to the maximum extent feasible, even if specific minimum technical standards are not finalized
- ADA compliance is a civil rights issue
- FHWA encourages use of the proposed PROWAG as best practice
- Professional responsibility obligates us to follow applicable standards or, in their absence, best practice in our obligation to the safety, health, and welfare of the public

Adapted from www.apsguide.org, Module A, Slide 28

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Prior Research and Literature on Roundabout Accessibility

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NCHRP Report 834 - Goals and Objectives

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- Provide useful and implementable guidance
- Define feasible range of geometric and traffic operational conditions
- Target planning and preliminary design stage
- Supported by empirical data and modeling – 4,400+ street crossings with blind participants studied since 2004
- Useful for a broad audience
- Decision-support tool for practicing engineers

Photo: Janet Barlow

PHB in Oakland County, MI

Photo: Bastian Schroeder

Speed Hump in Kissimmee, FL

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NCHRP Report 834 and Web-Only Document 222 (Published Jan 2017)

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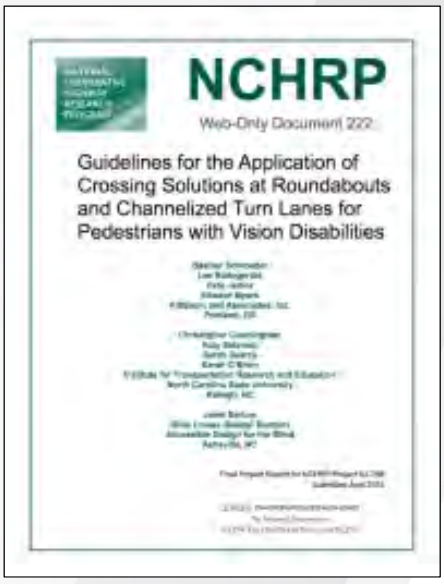

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NCHRP Report 834 - Outline

1. Introduction
2. Design Process
3. General Principles for Pedestrian Wayfinding and Crossing Tasks
4. Design Principles for Pedestrian Access at Roundabouts
5. Design Principles for Pedestrian Access at Channelized Turn Lanes
6. Wayfinding Assessment
7. Crossing Assessment
8. References
9. Appendix A – Discussion of Audible Environment and Noise Effects
10. Appendix B – Summary of Crossing Treatments

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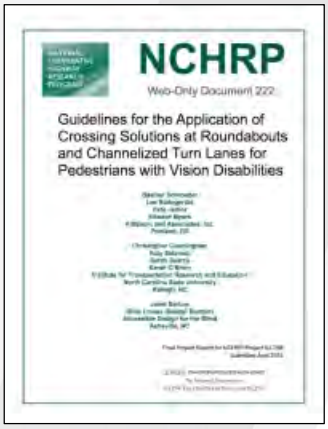
NCHRP Web-Only Document 222 - Outline

1. Introduction
2. Literature Review
3. Methodology
4. Field Study Results
5. Modeling and Applications
6. Conclusions and Recommendations
7. Appendix A: Wayfinding Data Details
8. Appendix B: Yield Model Details
9. Appendix C: Risk Model Details
10. Appendix D: Crossing Sight Distance Details
11. Appendix E: Site Photo Logs
12. Appendix F: Detailed Field Study Results



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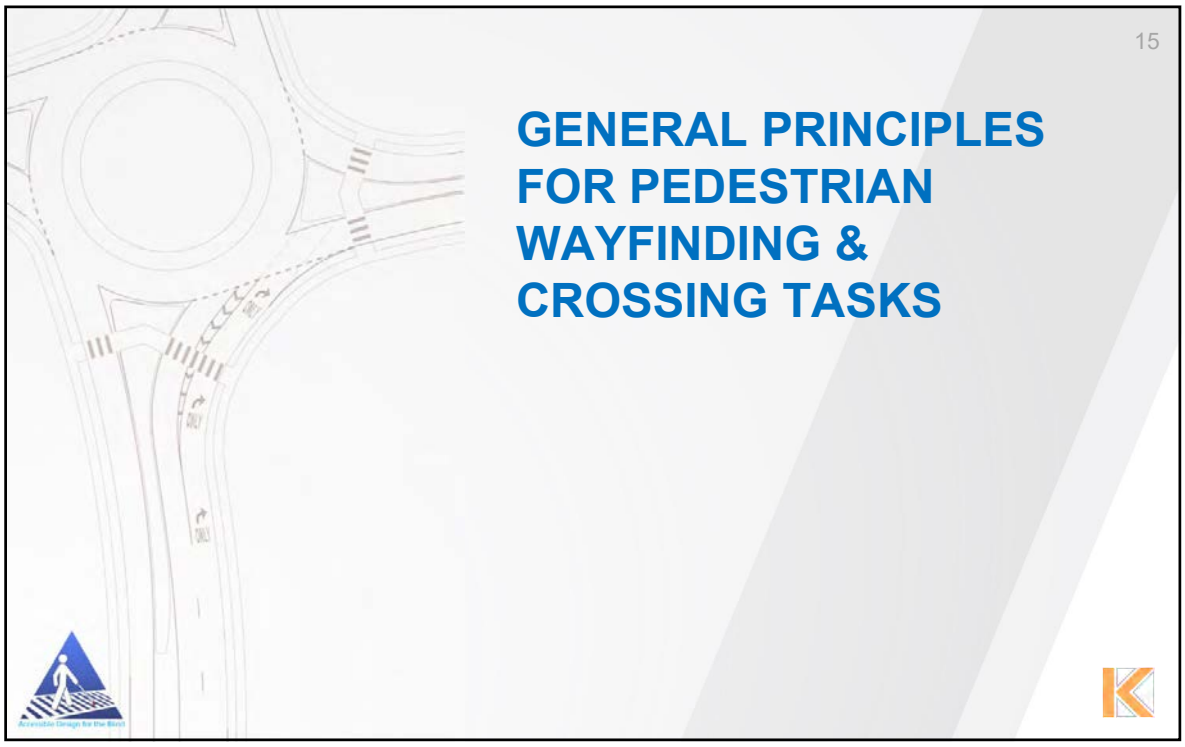
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GENERAL PRINCIPLES FOR PEDESTRIAN WAYFINDING & CROSSING TASKS

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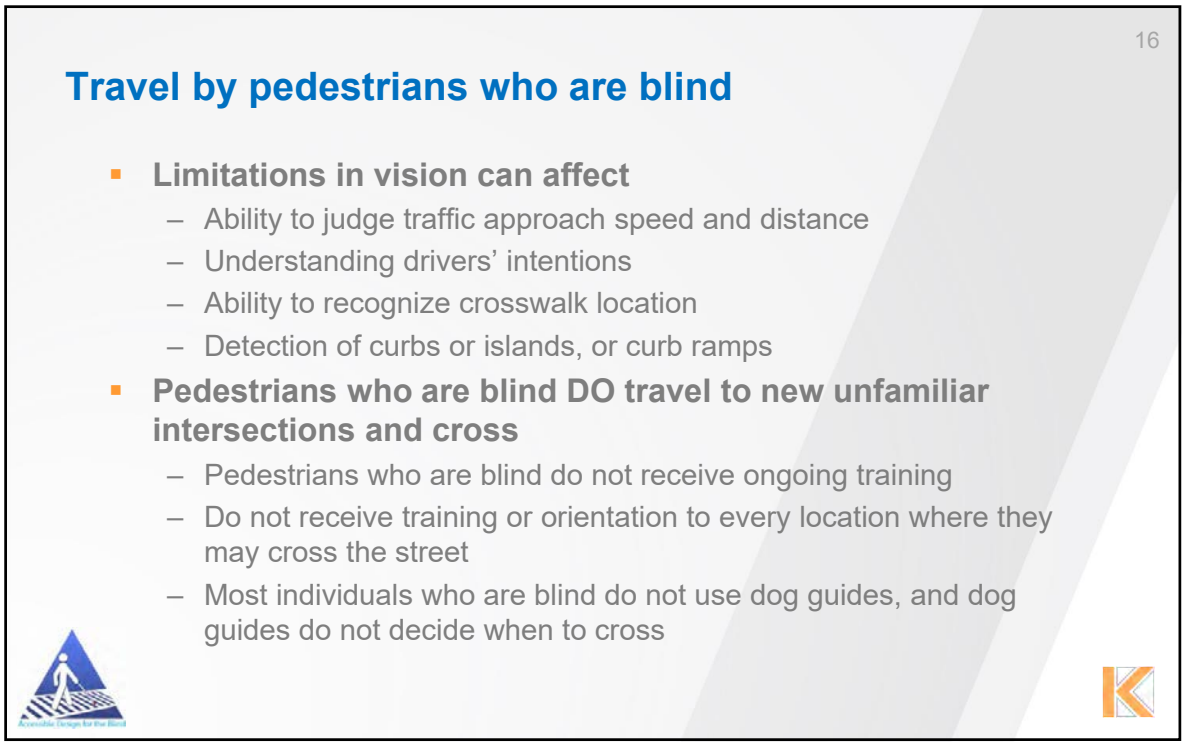
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Travel by pedestrians who are blind
Limitations in vision can affect
– Ability to judge traffic approach speed and distance
– Understanding drivers' intentions
– Ability to recognize crosswalk location
– Detection of curbs or islands, or curb ramps
Pedestrians who are blind DO travel to new unfamiliar intersections and cross
– Pedestrians who are blind do not receive ongoing training
– Do not receive training or orientation to every location where they may cross the street
– Most individuals who are blind do not use dog guides, and dog guides do not decide when to cross

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What is Detectable by Cane or Foot for People Who Are Blind?

- **Detectable:**
  - Curb edges
  - Gravel (loose or embedded in concrete)
  - Grass and landscaping areas
  - Truncated domes (detectable warning surfaces, or DWS)
    - **When ramps were introduced to assist wheelchairs, DWS were established to replace the curb previously used by blind people to edge detection**
- **NOT Detectable (or not detectably different from a normal sidewalk):**
  - Small changes in grade (e.g., top and bottom of ramp)
  - Changes from asphalt to concrete
  - Scoring in concrete
  - Paint, thermoplastic, or other striping materials
  - Colored concrete
  - Stamped concrete

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What Can Dog Guides Do and Not Do?

- **Dog Guides Can:**
  - Follow directions from their handler
  - Follow a path
  - Stop at curbs, usually stop at ramps
- **Dog Guides CANNOT:**
  - Make decisions about when to cross
  - Follow crosswalk lines

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What is Detectable to People with LOW Vision?

- **Detectable**
  - High-visibility crosswalk markings (ladder, zebra)
- **NOT Reliably Detectable**
  - Low-visibility crosswalk markings (parallel lines)
  - Colored concrete

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Two categories of street crossing tasks

- **Wayfinding tasks**
  - Determining the appropriate crossing location
  - Aligning to cross (establishing a correct heading)
  - Maintaining the correct heading while crossing (staying in the crosswalk)
- **Crossing tasks**
  - Determining when to initiate crossing (accepting an appropriate gap or yield crossing opportunity)

Photo: Janet Barlow

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Determining the appropriate crossing location

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- **Typical techniques**
  - Stop when contact curb or edge of street in front of them
  - Some people may search for a curb ramp and/or detectable warning surface to confirm crossing location
  - Follow along landscape strip looking for any opening toward street

Photo: Janet Barlow

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Landscaping or fencing may provide guidance to crosswalk location

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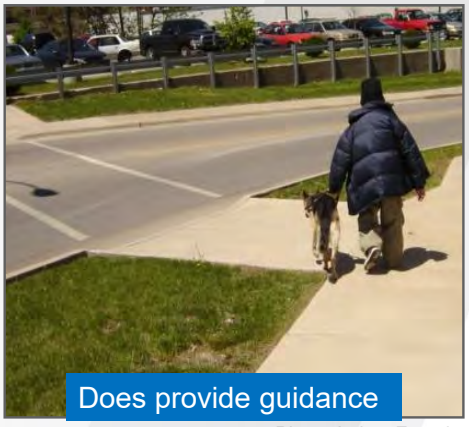
Doesn't provide adequate guidance

Photo: Janet Barlow



Does provide guidance

Photo: Lukas Franck

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Guidance needed to crossing location on islands too

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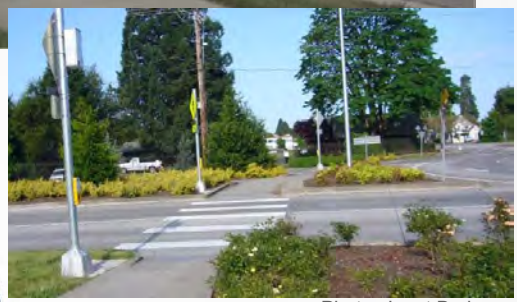

Photo: Janet Barlow

- Island may be cut-through or ramped
- Detectable warnings to indicate location of street at edge of street at cut-through paths or at base of ramp
- Gravel or grass outside of walking area to indicate area is not the walking path

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Aligning to cross (establishing a correct heading)

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- Typical techniques
  - Maintain approach alignment
  - Align with parallel traffic (traffic on the street beside them)
  - Align with perpendicular (traffic on the street they are crossing)
  - May try to use slope of ramp, alignment of curb or gutter, or detectable warning surface (truncated domes)

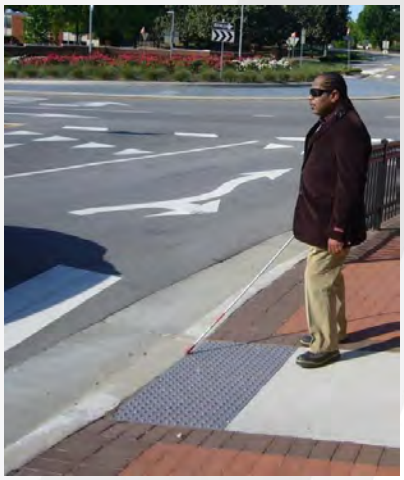

Photo: Janet Barlow

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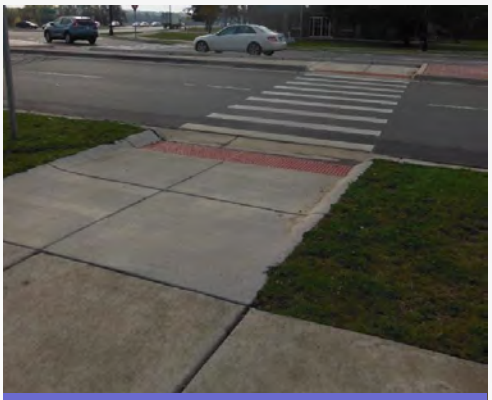
Alignment cues



Using returned curb, DWS, and gutter on ramp may help with alignment

Using returned curb, DWS, and gutter will result in poor alignment for this crossing

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Maintaining the correct heading while crossing (staying in the crosswalk)

Photo: Beezy Bentzen

- Typical techniques
  - Travel parallel to straight-ahead traffic on the street beside them as they cross
- **Not possible at roundabouts or CTLs since no traffic traveling parallel to crosswalk**
  - Somewhat mitigated by shorter crossings, if the starting heading is correct

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Typical Crossing Decision Strategies

- **At signalized crossings**
  - Cross with the surge of traffic on the street parallel to their crosswalk
  - Confirm with accessible pedestrian signal, if present
- **At unsignalized crossings**
  - Cross when there is no traffic audible on the street they are crossing
    - **Less effective as traffic volume increases and large gaps become rare**
    - **Audible environment at roundabouts makes "all-quiet" unlikely due to masking sounds from other traffic**
  - Cross when yielding traffic is detected
    - **Difficulty detecting and confirming yields without vision**
    - **Vehicles may begin moving again just as pedestrian who is blind detects yielding vehicle**

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DESIGN CONCEPTS AND POSSIBLE CROSSING TREATMENTS

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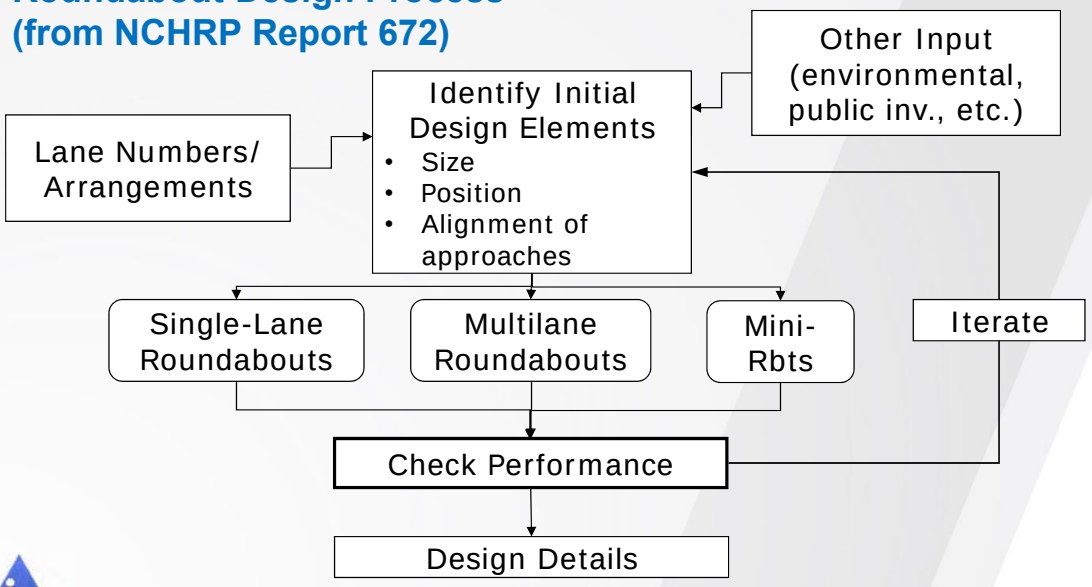
Roundabout Design Process (from NCHRP Report 672)



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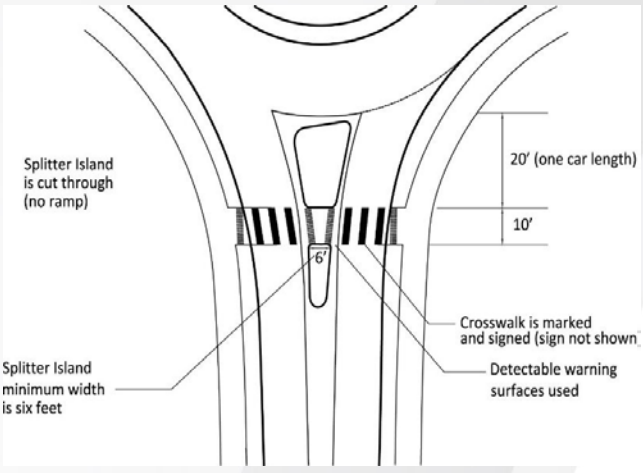
Typical Crosswalk Design at Single-Lane Roundabout

- **Key features:**
  - Crosswalk set back to separate conflicts
  - Two-stage crossing
  - Detectable warnings at all hazard boundaries



NCHRP Report 834, Figure 4-1

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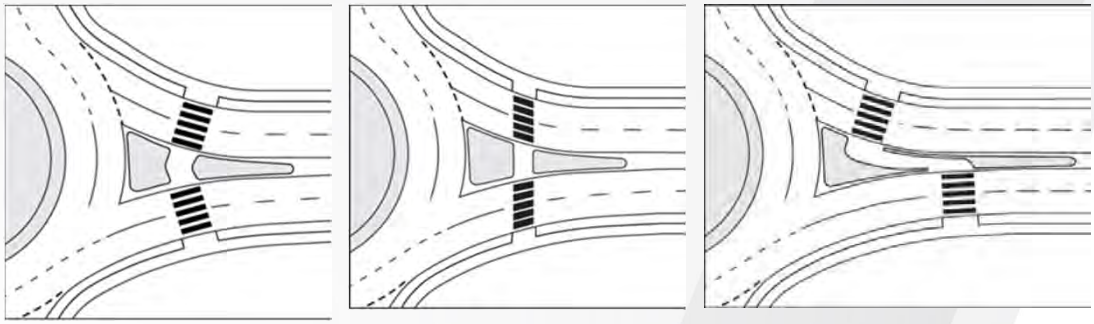
Alignment Options for Multilane Crosswalk

- Benefits and disbenefits to each option
- Need to consider ramp slope, crossing distance, visibility of crossing, maintenance, and other factors



NCHRP Report 834, Figures 4-2, 4-3, 4-4

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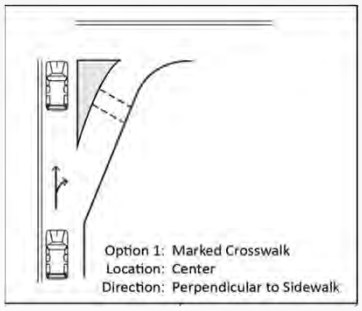
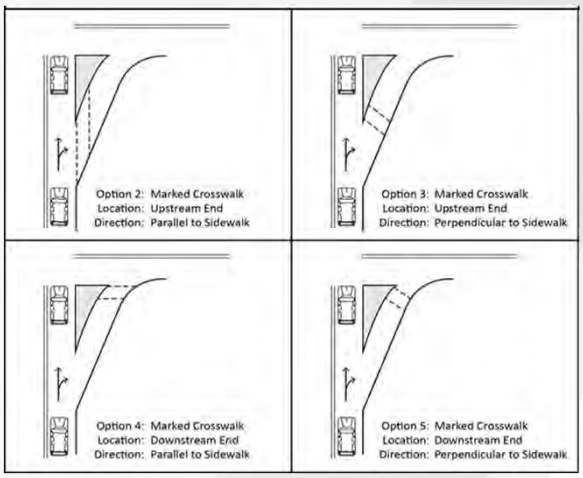
CTL Crosswalk Alignment Options Considered





NCHRP Report 834, Figure 5-7

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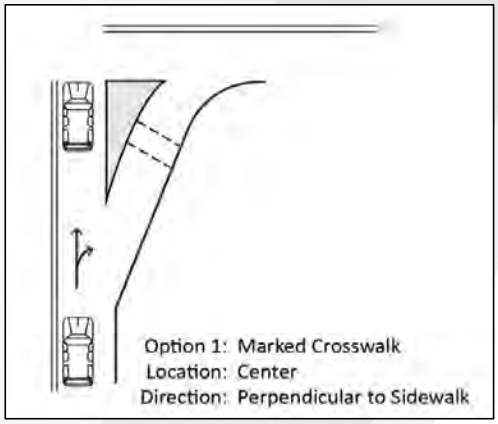
General CTL Design Recommendations (1/2)

- Centered crosswalk location is generally preferred
- Crossing is at a 90 degree angle
- Out-of-direction travel equally distributed
- Ramps perpendicular to the sidewalk and aligned with the crosswalk
- Good visibility
  - Crosswalk is visible to approaching drivers
  - Clear line of sight is provided between pedestrians and approaching drivers



NCHRP Report 834, Figure 5-8

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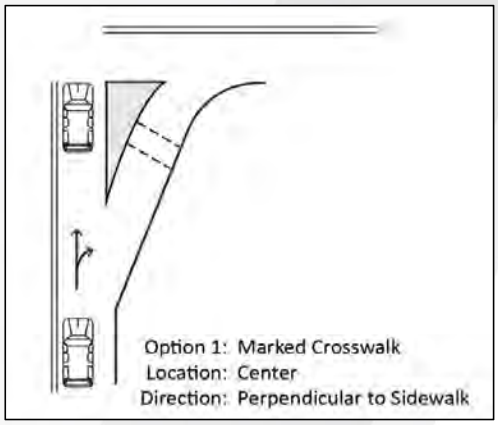
General CTL Design Recommendations (2/2)

- One vehicle length of storage past crosswalk
- Separate driver decision points
  1. Interacting with the pedestrian
  2. Interacting with downstream vehicle traffic.
- Better for wayfinding
  - Island provides sufficient raised area on either side of the crosswalk
  - Minimizes the chance of veering



NCHRP Report 834, Figure 5-8

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Treatments can enhance accessibility

1. **Treatments geared at reducing vehicle speeds through geometric modifications**
   - Includes speed humps, raised crosswalk, or geometric changes
2. **Treatments geared at enhancing the visibility of the crosswalk and alerting drivers**
   - Includes pedestrian actuated flashing beacons and other beacons
3. **Treatments geared at providing additional audible information to blind pedestrians**
   - Includes sound and rumble strips
4. **Treatments geared at stopping traffic and creating crossing opportunities**
   - Includes pedestrian hybrid beacons and other pedestrian signals

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Raised Crosswalk

Photo: Bastian Schroeder

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Pedestrian Actuated Flashing Beacon

- Governed by MUTCD Chapter 4L, Flashing Beacons
- One or more circular yellow indication
- If two indications are used, may be flashed simultaneously or alternately
- Flash rates of 50 to 60 flashes per minute
- Audible message: "Yellow lights are flashing, yellow lights are flashing."

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Rectangular Rapid Flashing Beacon (RRFB)

- NOTE: Interim Approval 21 (IA-21) for optional use of RRFBs issued on March 20, 2018. This replaces the IA terminated by FHWA on December 21, 2017

Photo: Bastian Schroeder

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Pedestrian Hybrid Beacon (PHB)

- **Audible messages:**
  - Slow tick (locator tone) and "wait" when button is pressed
  - Rapid tick or "Walk sign is on to cross Maple Road"

Photos: Bastian Schroeder

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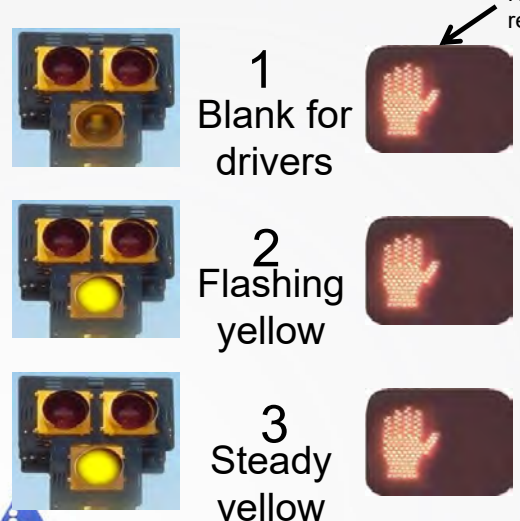
Pedestrian Hybrid Beacon (PHB) Operation

Note: 2009 MUTCD allows option of pedestrian display to rest in dark at roundabouts (Section 4F.03)



1 Blank for drivers

2 Flashing yellow

3 Steady yellow

4 Steady red

5 Wig-Wag

Return to 1

Note: No green ball to cause possible confusion with yield sign

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Other Treatments Considered in NCHRP Project 3-78b Research

- In-pavement signs
- Stop-controlled CTL

Photos: Bastian Schroeder

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WAYFINDING ASSESSMENT

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Guidebook

1. Introduction
2. Design Process
3. General Principles for Pedestrian Wayfinding & Crossing Tasks
4. Design Principles for Pedestrian Access to Roundabouts
5. Design Principles for Pedestrian Access to CTLs
6. **Wayfinding Assessment**
7. Crossing Assessment
8. References
9. Appendix A: Discussion of Audible Environment and Noise Effects
10. Appendix B: Summary of Crossing Treatments

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Format of Wayfinding Assessment

- **Series of questions about each task**
- **Brief text information about each question**
- **Table**
  - Questions, with reference to section of guide for details
  - Note if feature is required

1. Do sidewalks lead to the crosswalks?	• See Section 4.1 and 5.1 for details
2. Is separation provided between sidewalk and curb?	• See Section 4.1 and 5.1 for details • Required by PROWAG-NPRM at roundabouts; good practice at CTLs
3. Is the edge of the street clearly defined by detectable warning surfaces?	• See Section 4.1 and 5.1 for details • Required by Department of Transportation ADA regulations and PROWAG-NPRM

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Wayfinding Assessment Question Categories

6.1. Determining the crossing location
6.2. Aligning to cross and establishing a correct heading
6.3. Maintaining correct heading while crossing (staying within the crosswalk)
6.4. Crossings from channelization and splitter islands

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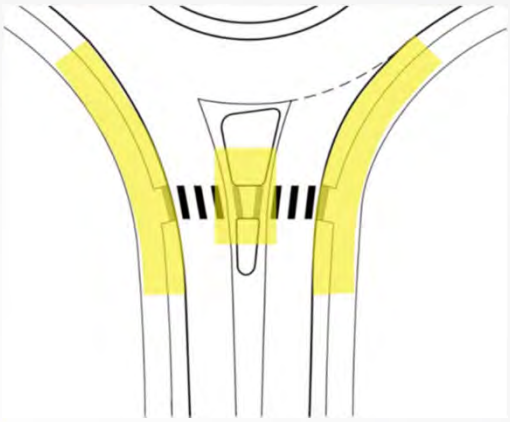
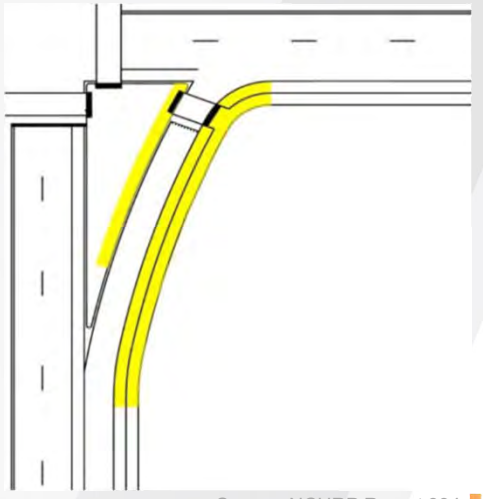
6.1. Determining the Crossing Location



Source: NCHRP Report 834



Source: NCHRP Report 834

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6.1.1. Do sidewalks lead to the crosswalks? (1/2)

Desirable

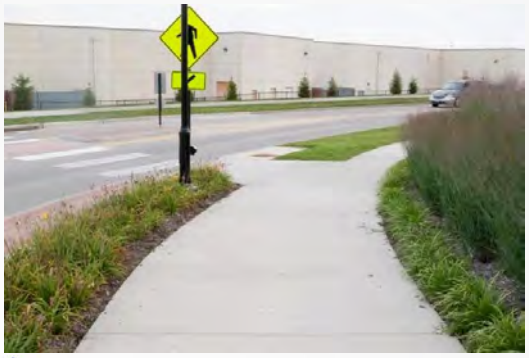

Photo: Lee Rodegerdts

Undesirable

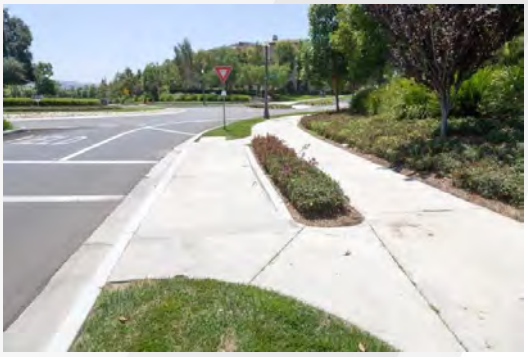

Photo: Lee Rodegerdts

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6.1.1. Do sidewalks lead to the crosswalks? (2/2)

Desirable

Source: © Google 2017

Undesirable

Source: © Google 2017

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6.1.2. Is separation provided between sidewalk and curb? (1/3)

Desirable: Detectable buffer

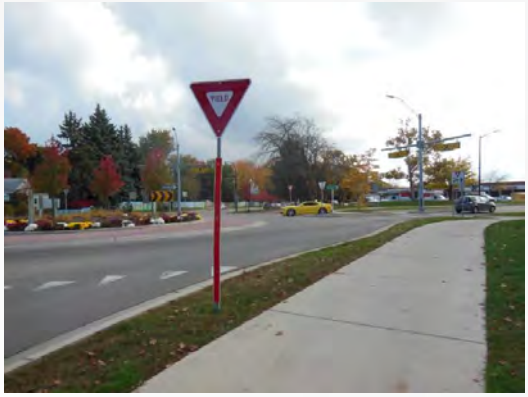

Photo: Katy Salamati

Undesirable: No detectable buffer

Photo: Lee Rodegerdts

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6.1.2. Is separation provided between sidewalk and curb? (2/3)

Undesirable: No detectable buffer

Photo: Lee Rodegerdts

Undesirable: No detectable buffer

Photo: Lee Rodegerdts

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6.1.2. Is separation provided between sidewalk and curb? (3/3)

Desirable: Fence provides separation where buffer is not feasible

Photo: Lee Rodegerdts

Undesirable: Space between bollards not detectable

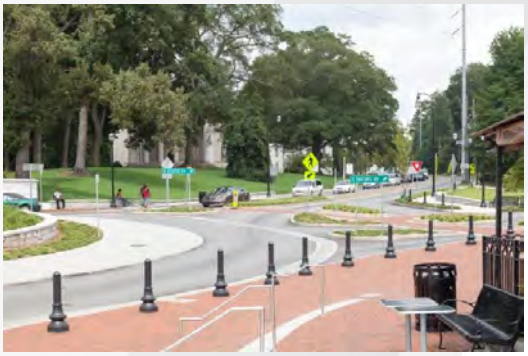

Photo: Lee Rodegerdts

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6.1.3. Is the edge of the street clearly defined (outside edge)? (1/2)

Desirable: Detectable warning surface (truncated domes) at edge of street

Photo: Janet Barlow

Undesirable: DWS is not the full width of the area that is level with the street

Photo: Janet Barlow

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6.1.3. Is the edge of the street clearly defined (outside edge)? (2/2)

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Undesirable: External truck apron makes edge ambiguous and DWS not provided

Photo: Lee Rodegerdts

Undesirable: External truck apron makes edge ambiguous and DWS not provided

Photo: Lee Rodegerdts

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6.1.4. If other ramps or driveways are nearby, are they adequately delineated and separated?* (1/3)

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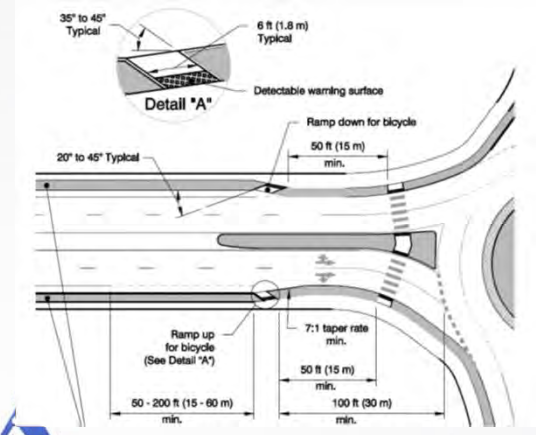
Desirable: Bike ramp separated from pedestrian ramp, DWS at top of ramp



NCHRP Report 672, Exhibit 6-67

Desirable (mostly): Bike ramp separated from pedestrian ramp (but needs DWS)

Photo: Lee Rodegerdts

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6.1.4. If other ramps or driveways are nearby, are they adequately delineated and separated?* (2/3)

Undesirable: Pedestrian ramp and driveway indistinguishable

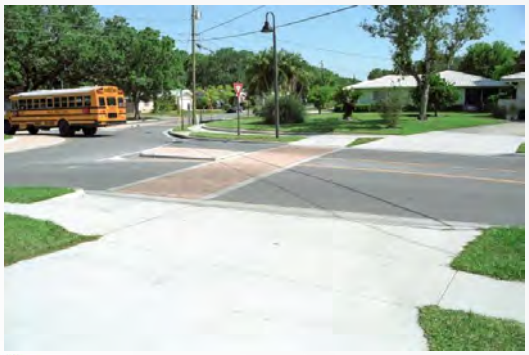

Photo: Lee Rodegerdts

Undesirable: Bike ramp too close to pedestrian ramp

Photo: Lee Rodegerdts

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6.1.4. If other ramps or driveways are nearby, are they adequately delineated and separated?* (3/3)

Undesirable: Bike ramp could be mistaken for pedestrian ramp

Photo: Janet Barlow

Undesirable: Bike ramp aligned directly with sidewalk

Photo: Janet Barlow

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6.1.5. Are traffic control devices accessible?

Desirable: level beside pushbutton, reachable from sidewalk

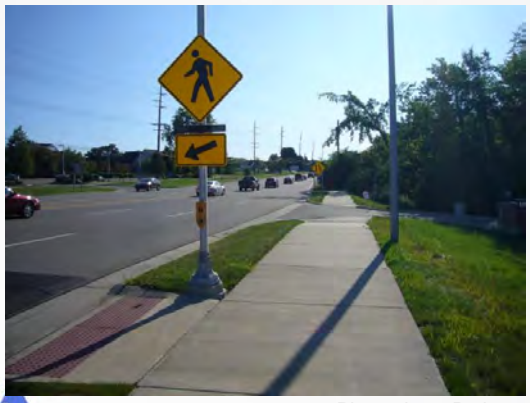

Photo: Janet Barlow

Undesirable: Push button and display too far from crosswalk

Photo: Lee Rodegerdts

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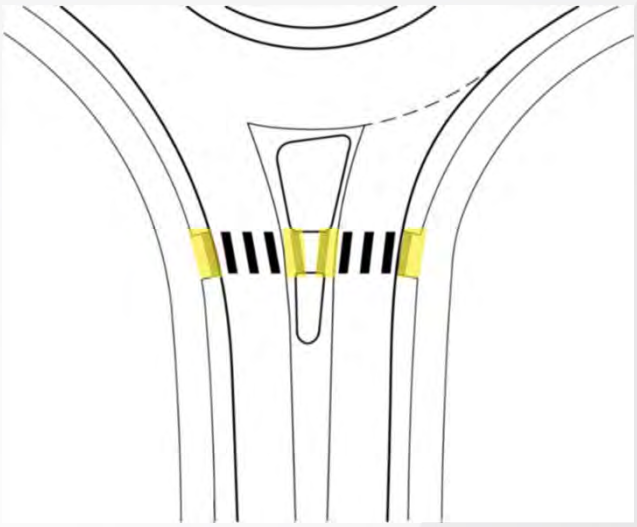
58

6.2. Aligning to Cross and Establishing a Correct Heading



Source: NCHRP Report 834

58

59

6.2.1. Is curb ramp width the same as crosswalk width? (1/2)

Desirable

Photo: Janet Barlow

Desirable

Photo: Lee Rodegerdts

59

60

6.2.1. Is curb ramp width the same as crosswalk width? (2/2)

Undesirable: Ramp and gap in island unnecessarily narrow

Photo: Janet Barlow

Undesirable: Curb ramp unnecessarily narrow

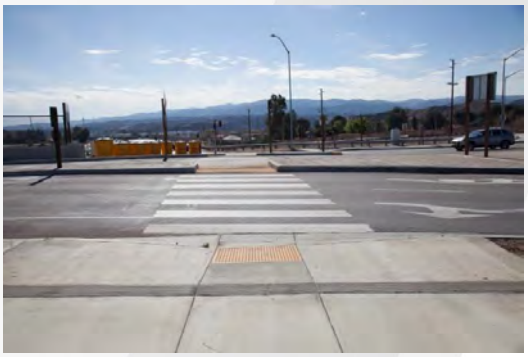


Photo: Lee Rodegerdts

60

61

6.2.2. Is curb ramp slope aligned with crossing? (1/3)

Desirable

Photo: Lee Rodegerdts

Desirable

Photo: Janet Barlow

61

62

6.2.2. Is curb ramp slope aligned with crossing? (2/3)

Undesirable: Curb ramp aims away from crosswalk

Photo: Lee Rodegerdts

Undesirable: Curb ramp aims away from crosswalk

Photo: Janet Barlow

62

63

6.2.2. Is curb ramp slope aligned with crossing? (3/3)

Undesirable

Photo: Janet Barlow

Undesirable

Photo: Janet Barlow

63

64

6.2.3. Are ramp edges aligned with crossing? (1/2)

Desirable

Photo: Lee Rodegerdts

Undesirable: Ramp edges aim away from crosswalk

Photo: Lee Rodegerdts

64

65

6.2.3. Are ramp edges aligned with crossing? (2/2)

Undesirable: Ramp edges aim away from crosswalk

Photo: Lee Rodegerdts

Undesirable: Edges in splitter island aim away from crosswalk

Photo: Lee Rodegerdts

65

66

6.2.4. Is detectable warning aligned with slope of the curb ramp?

Desirable

Photo: Janet Barlow

Undesirable

Photo: Janet Barlow

66

67

6.2.5. Are pushbuttons in correct location?

Desirable

Photo: Janet Barlow

Undesirable: Two pushbuttons on same pole and arrows not aligned with direction of travel on crosswalk

Photo: Janet Barlow

67

68

6.2.6 Is there a sufficiently level landing and turning space where the pedestrian is waiting to cross?

Undesirable: no level landing or turning space

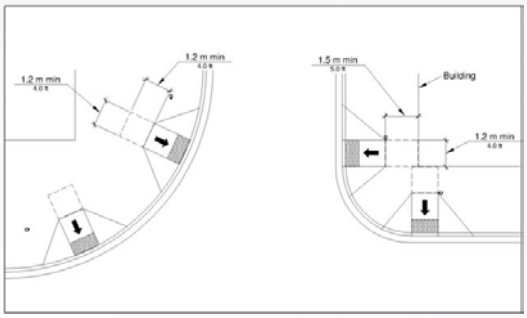
Desirable:

68

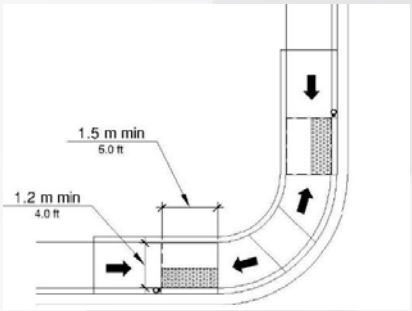
69

6.2.6 Is there a sufficiently level landing and turning space where the pedestrian is waiting to cross?

Desirable: Level landing area required at top of ramp



Source: PROWAG R304.2.1



Source: PROWAG R304.3.1

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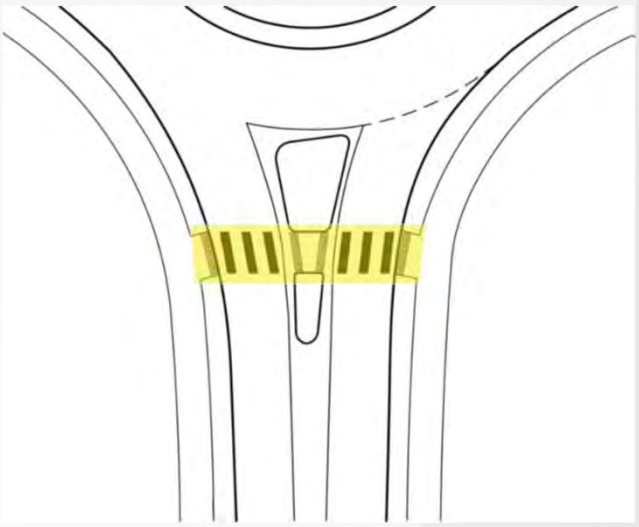
6.3. Maintaining Correct Heading While Crossing (Staying within the Crosswalk)



Source: NCHRP Report 834

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71

6.3.1. Is the crossing configured at the shortest distance practical?

Desirable

Photo: Lee Rodegerdts

Undesirable

Photo: Lee Rodegerdts

71

72

6.3.2. Is the crossing aligned perpendicular to the curb and island edges?

Desirable

Photo: Lee Rodegerdts

72

73

6.3.3. Are markings clearly visible?

Desirable: High-visibility marking (zebra or ladder preferred)

Photo: Lee Rodegerdts

Undesirable: Change in pavement color not substitute for markings

Photo: Lee Rodegerdts

73

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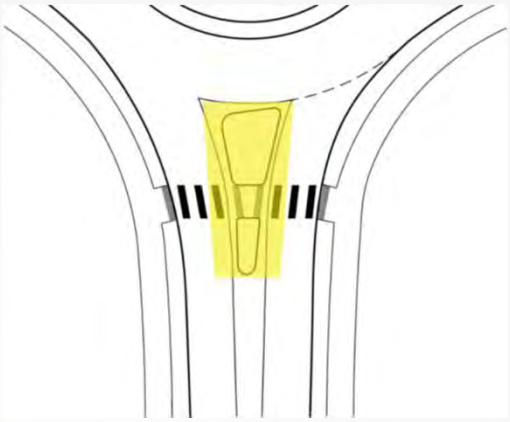
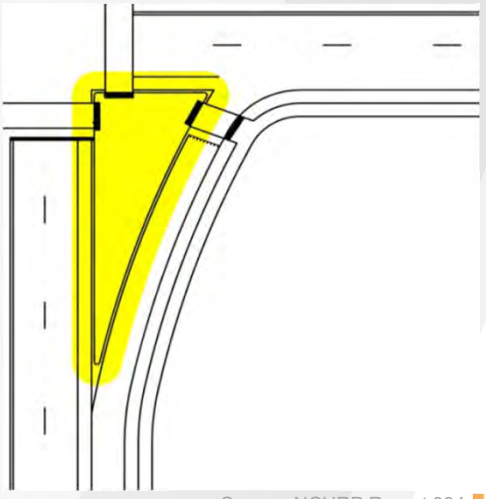
6.4. Crossings from Channelization and Splitter Islands



Source: NCHRP Report 834



Source: NCHRP Report 834

74

75

6.4.1. Are islands wide enough to provide safe refuge?

Desirable

Photo: Lee Rodegerdts

Undesirable: DWS suggest refuge within splitter island but too narrow

Photo: Lee Rodegerdts

75

76

6.4.2. Are transitions to roadway clearly defined (within the island)?

Desirable: DWS at edge of street for full width of area that is level with the street (crosswalk)

Photo: Janet Barlow

Undesirable: No detectable warnings

Photo: Pete Jenior

76

77

6.4.3. Are paths through island clearly identifiable? (1/2)

Desirable: Surface materials distinguishable under foot between path and rest of island.

Photo: Janet Barlow

Undesirable: Path indistinguishable under foot from rest of island.

Photo: Janet Barlow

77

78

6.4.3. Are paths through island clearly identifiable? (2/2)

Desirable

Photo: Pete Senior

Undesirable: Areas outside of path may be mistaken for walking surface

Photo: Janet Barlow

78

79

6.4.4. Are pushbuttons accessible? (1/2)

Desirable

Photo: Janet Barlow

Undesirable: too far back from street and too far away from sidewalk

Photo: Janet Barlow

79

80

6.4.4. Are pushbuttons accessible? (2/2)

Undesirable: Push buttons too far from pedestrian path

Photo: Janet Barlow

Undesirable: Push button behind guard rail

Photo: © Google 2017

80

81

How can this be communicated to the blind?

Photo: NC State

- We have samples!

81

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Conclusion

- Wayfinding issues are challenging
- Need to consider these issues in design
- Often relatively easy to modify design slightly to work better for pedestrians who are blind or who have low vision
- Some features are required
  - Separation between sidewalk and curb at roundabouts
  - Detectable warnings at crossings
  - Accessible pedestrian signals or audible information devices (if signal or beacon)
- May not be able to resolve all issues

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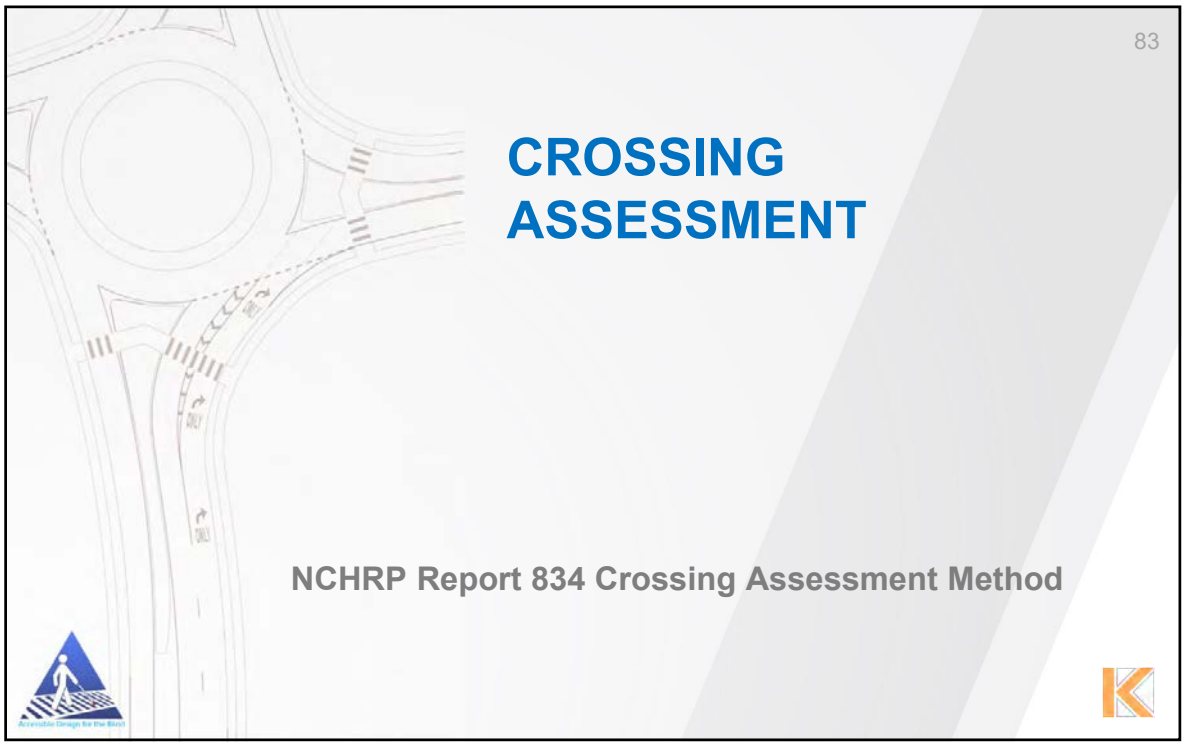
83
CROSSING ASSESSMENT
NCHRP Report 834 Crossing Assessment Method

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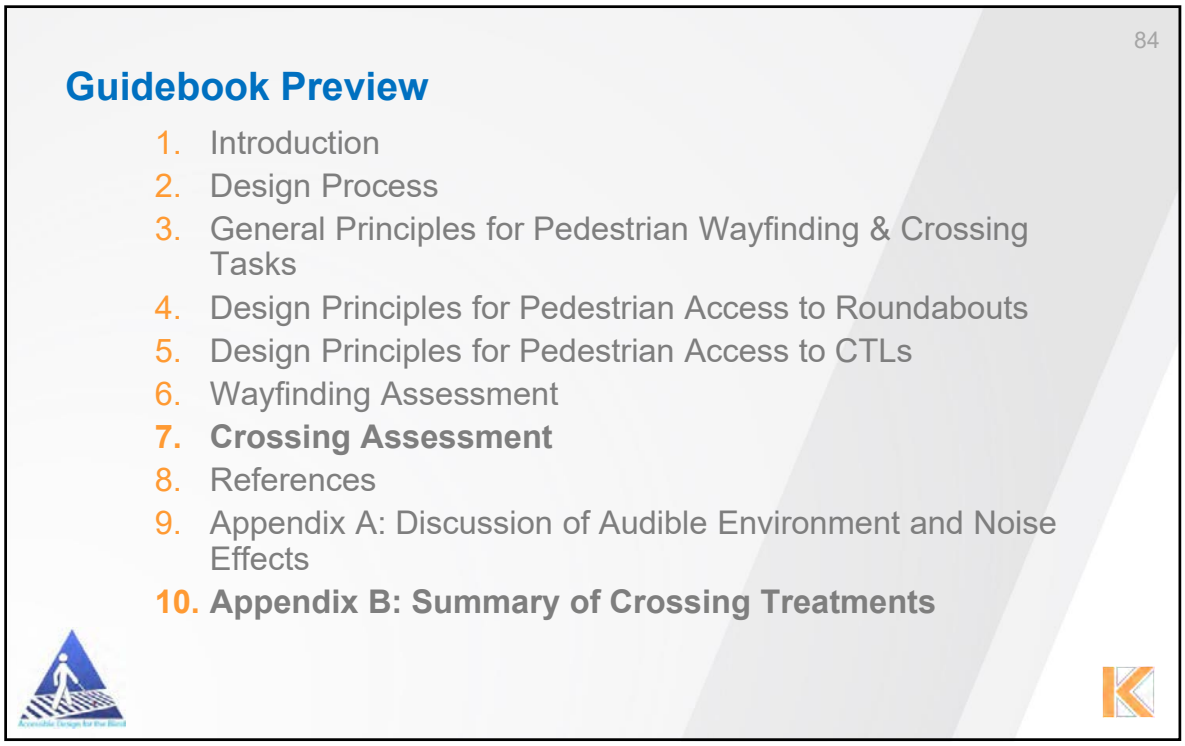
84
Guidebook Preview
1. Introduction
2. Design Process
3. General Principles for Pedestrian Wayfinding & Crossing Tasks
4. Design Principles for Pedestrian Access to Roundabouts
5. Design Principles for Pedestrian Access to CTLs
6. Wayfinding Assessment
7. Crossing Assessment
8. References
9. Appendix A: Discussion of Audible Environment and Noise Effects
10. Appendix B: Summary of Crossing Treatments

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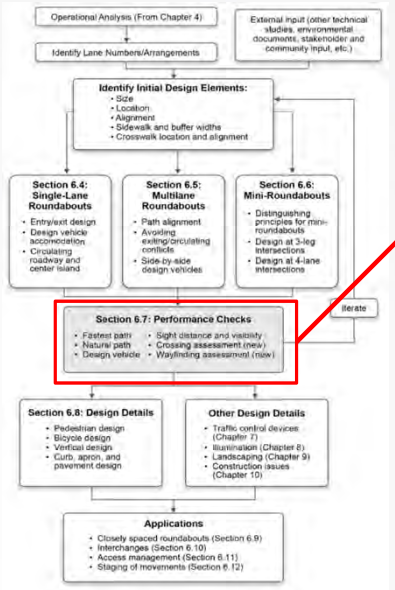
Tying into Existing Roundabout Design Process (NCHRP Report 672 – FHWA Roundabout Guide)



Section 6.7: Performance Checks

- Fastest path
- Natural path
- Design vehicle
- Sight distance and visibility
- Crossing assessment (new)
- Wayfinding assessment (new)

- **New Performance Checks**
  - Wayfinding Assessment
  - **Crossing Assessment**
    - **Crossing Sight Distance**
    - **Pedestrian Delay**
    - **Level of Risk**

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Setting Performance Targets

- **Through the quantitative nature of the performance checks, it is generally possible to**
  1. conduct a *relative* comparison of two sites, or
  2. conduct a before-and-after assessment of the same site.
- **Guidebook does not provide performance targets or thresholds, which is a policy decision**
  - Agencies may set targets
- **Methods can be used to conduct *relative* accessibility evaluations in the context of PROWAG**

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Methodology Source

- Updated version of NCHRP Report 834, Chapter 7
- Web-only publication of Revised Chapter 7 anticipated

87

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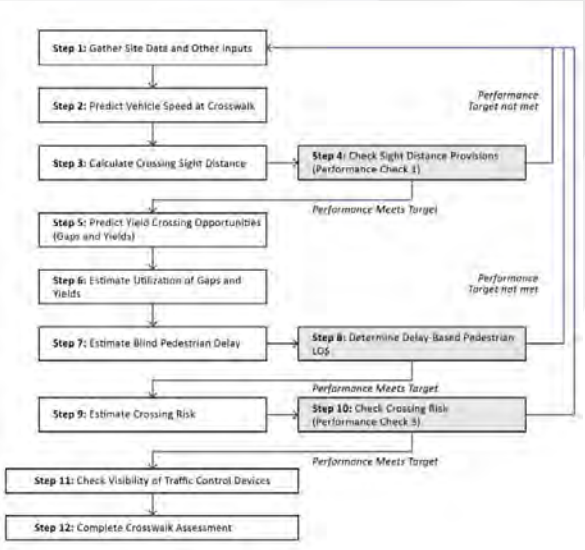
Method Overview

- 12-step methodology
- Iterative procedure until three performance checks are met
- Each step contains models and/or defaults to assist with the estimation



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Step 1: Gather Site Data and Other Inputs

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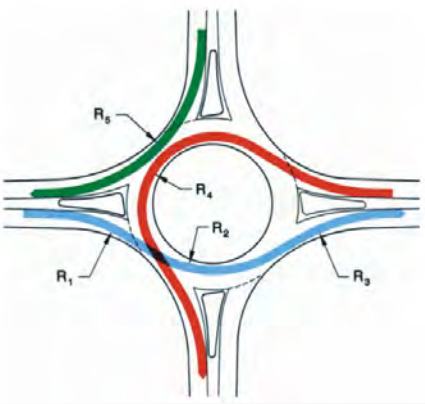
Step 2: Predict Vehicle Speed at Crosswalk

- Roundabouts – Use same method/equations in NCHRP Report 672
- CTLs – Use method developed in this project



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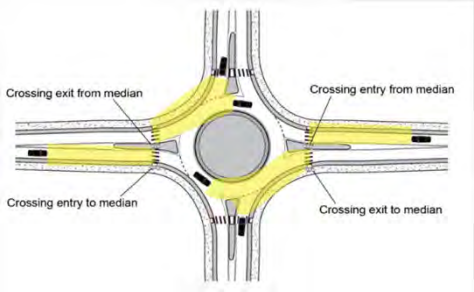
Step 3: Calculate Crossing Sight Distance

- **Function of vehicle speed and pedestrian critical gap (crossing time)**
- **Vehicle speed from Step 2**
- **Critical gap from HCM, function of**
  - Crosswalk length
  - Walking speed
  - Clearance time

Once a car comes into view, is there enough time for a pedestrian to cross? OR

Once a pedestrian comes into a driver's view, is there enough time for them to complete a crossing that is just beginning?



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Step 4: Check Sight Distance Provisions

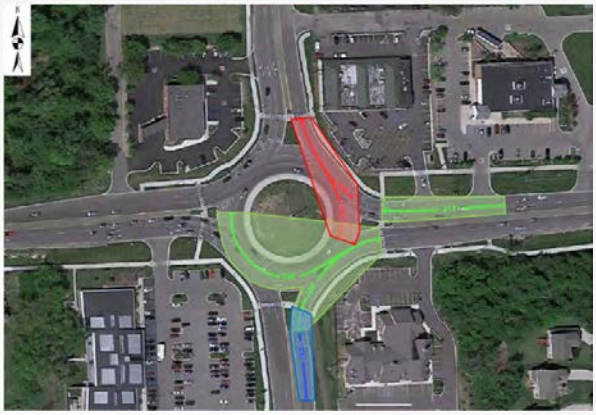

Illustration of Sight Distance for Two-Lane and Three-Lane Roundabout Approaches

Illustration of Sight Distance for CTL with and without raised crosswalk

Performance Check 1: Is Adequate Crossing Sight Distance Available?

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Step 5: Predict Crossing Opportunities (Gaps and Yields)

- **Compute the number of gaps**
  Eq. 5

$$P_g = e^{\frac{-t_{n,c} * N_{veh}}{3600}}$$

A pedestrian could cross because no conflicting vehicles are present

P_g = Probability of a pedestrian encountering a usable gap

$t_{n,c}$ = Critical headway for crossable gap on leg *n*, in seconds

N_{veh} = volume (vehicles per hour)

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Step 5 (cont.): Predict Crossing Opportunities (Gaps and Yields)

- **Compute the number of yields**
  Single-lane roundabouts and CTLs (Eq. 6):

$$P_Y = (0.6888 - 0.07688 * I_{ex} + 0.62954 * I_{en} + 0.37418 * I_{HC}) e^{-0.03465 * V}$$

P_Y = Probability of a driver yielding to a pedestrian

I_{ex} = Indicator variable for Exit (1 = Roundabout Exit, 0 = Roundabout Entry or CTL)

I_{en} = Indicator variable for Entry (1 = Roundabout Entry, 0 = Roundabout Exit or CTL)

I_{HC} = Indicator variable for high-compliance region (1 = high compliance, 0 = low)

V = Speed, in mph

A pedestrian could cross if the conflicting vehicle yields to them

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Step 5 (cont.): Predict Crossing Opportunities (Gaps and Yields)

- **Compute the number yields**

  Two-lane roundabouts (Eq. 7):

$$P_Y = (0.7259 + 0.2105 * I_{RRFB} - 0.2574 * I_{ex} + 0.3244 * I_{HC})e^{-0.0129*V}$$

P_Y = Probability of a driver yielding to a pedestrian

I_{RRFB} = Indicator variable for presence of RRFB (note: may not fully represent all pedestrian-actuated beacons)

I_{ex} = Indicator variable for Exit (1=Exit, 0=Entry)

I_{HC} = Indicator variable for high-compliance region

V = Speed, in mph

A pedestrian could cross if the conflicting vehicle yields to them

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Step 5 (cont.): Predict Crossing Opportunities (Gaps and Yields)

- **Driver Compliance**
  - Field data indicates major differences in driver yielding behavior based on environment
    - **Region of country**
    - **Urban vs. suburban**
    - **Campus vs. non-campus**
  - Subjective
  - High/low compliance choice must be made by analyst

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Step 5 (cont.): Predict Crossing Opportunities (Gaps and Yields)

- **Compute the number of crossing opportunities**

  Eq. 8

$$P_{YC} = P_Y * (1 - P_G)$$

P_{YC} = The probability of a yield crossing opportunity

Probability of a yield is adjusted to account for the probability that a pedestrian encounters a vehicle that could yield (ignore situations when vehicle not present)

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Step 6: Estimate Utilization of Gaps and Yields

- **Acknowledges that many blind travelers will not utilize all crossing opportunities due to**
  - Auditory confusion/clutter
  - Higher risk threshold
  - Personal preferences
- **Default values available from field data**

- **Probability of a blind pedestrian utilizing a gap = P_{UG}**
  - At roundabout crosswalks: 65%
  - At CTL crosswalks: 60%
- **Probability of a blind pedestrian utilizing a yield = P_{UY}**
  - At roundabout crosswalks: 70%
  - At CTL crosswalks: 35%

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Step 7: Estimate Blind Pedestrian Delay

- **Probability of pedestrian crossing each time there is a gap or yield**

  Eq. 9

$$P_C = P_{YC} * P_{UY} + P_G * P_{UG}$$

P_C = Probability that a blind pedestrian crosses at a crosswalk

Blind pedestrians don't use some gaps and yields because they are unaware they exist

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Step 7 (cont.): Estimate Blind Pedestrian Delay

- **Calculate Pedestrian Delay**
- **Eq. 10 for CTLs:**

$$d_p = 10.75 - 9.95 * ln(P_C)$$

- **Eq. 11 for single-lane roundabouts:**

$$d_p = 9.37 - 9.78 * ln(P_C)$$

- **Eq. 12 for two-lane roundabouts:**

$$d_p = 6.14 - 8.53 * ln(P_C)$$

d_p = Pedestrian delay, in seconds

100

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Step 8: Determine Delay-Based Pedestrian LOS

- Determine LOS based on HCM Table 7-6:
  - **Performance Check 2: Is the Ped LOS within the guidelines for your agency?**

Table 7-6. Pedestrian LOS thresholds for unsignalized intersections from the Highway Capacity Manual.

LOS	Control Delay (s/ped)	Comments
A	0-5	Usually no conflicting traffic
B	5-10	Occasionally some delay due to conflicting traffic
C	10-20	Delay noticeable to pedestrians, but not inconveniencing
D	20-30	Delay noticeable and irritating, increased likelihood of risk-taking
E	30-45	Delay approaches tolerance level, risk-taking behavior likely
F	>45	Delay exceeds tolerance level, high likelihood of pedestrian risk-taking

These thresholds were developed for mid-block crossings and major street crossings at two-way stop-controlled intersections

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Step 9: Estimate Crossing Risk

- Compute probability of an intervention
- Eq. 13

$$P_I = (0.011895 + 0.008443 * I_{ex} + 0.021915 * I_N - 0.007186 * I_{1L}) e^{0.027697 * V}$$

- I_{ex} = Indicator variable (1 = Exit, 0 = Entry/CTL)
- I_N = Indicator variable (1= noisy, 0 = low noise)
- I_{1L} = Indicator variable (1 = one-lane roundabout, 0 = two-lane roundabout/CTL)
- V = Speed at crosswalk (mph)

This model is not used for PHBs. They are assumed to be accessible.

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Step 9 (cont.): Estimate Crossing Risk

- **Intervention: A physical or audible action taken by a Certified Orientation and Mobility Specialist (COMS) to stop a blind pedestrian from entering a crosswalk because the COMS believed the blind pedestrian would be a risk of getting struck by a vehicle**

Blind pedestrians in field studies were always accompanied by a COMS

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Step 9 (cont.): Estimate Crossing Risk

- **Noise – Regardless of other conditions, high-noise sites without signalization were inaccessible to blind pedestrians. They could not hear gaps and yields. Examples include:**
  - Ramp terminal intersections
  - Sites near freeways
  - Sites with high volumes and heavy vehicle percentages
  - Subjective (except ramp terminal intersections)
  - High/low noise choice must be made by analyst

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Step 10: Check Crossing Risk

- **Performance Check 3: Is probability of an intervention within range allowable by your agency?**

Most important check

- **Note: PHB and R-Y-G pedestrian signal are assumed to have acceptable crossing risk. Method is used for other potential treatments.**

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Step 11: Visibility of Traffic Control Devices

- **Determine if Traffic Control Devices are installed properly and meet MUTCD visibility requirements.**

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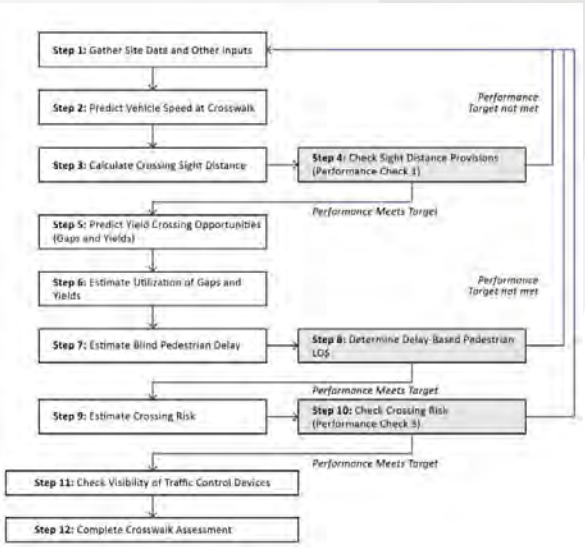
Step 12: Complete Crosswalk Assessment

- Assure that all three performance checks are met
- Consider interaction of pedestrian performance checks with other design checks
  - Fastest path
  - Design vehicle
  - …



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Implications for Practice

- Treatment of all modes holistically is necessary
  - Assessment of pedestrian (and bicycle) performance should done simultaneously with motor vehicle performance
- Design decisions create trade-offs
  - No one correct answer that works in all situations
  - Site-specific design is necessary
- Performance-based design allows assessment of these trade-offs
- The accessibility tools from NCHRP Project 03-78b/Report 834 add to our ability to make these assessments

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CONCLUSION
Roundabout and Channelized Turn Lane
Accessibility Challenges

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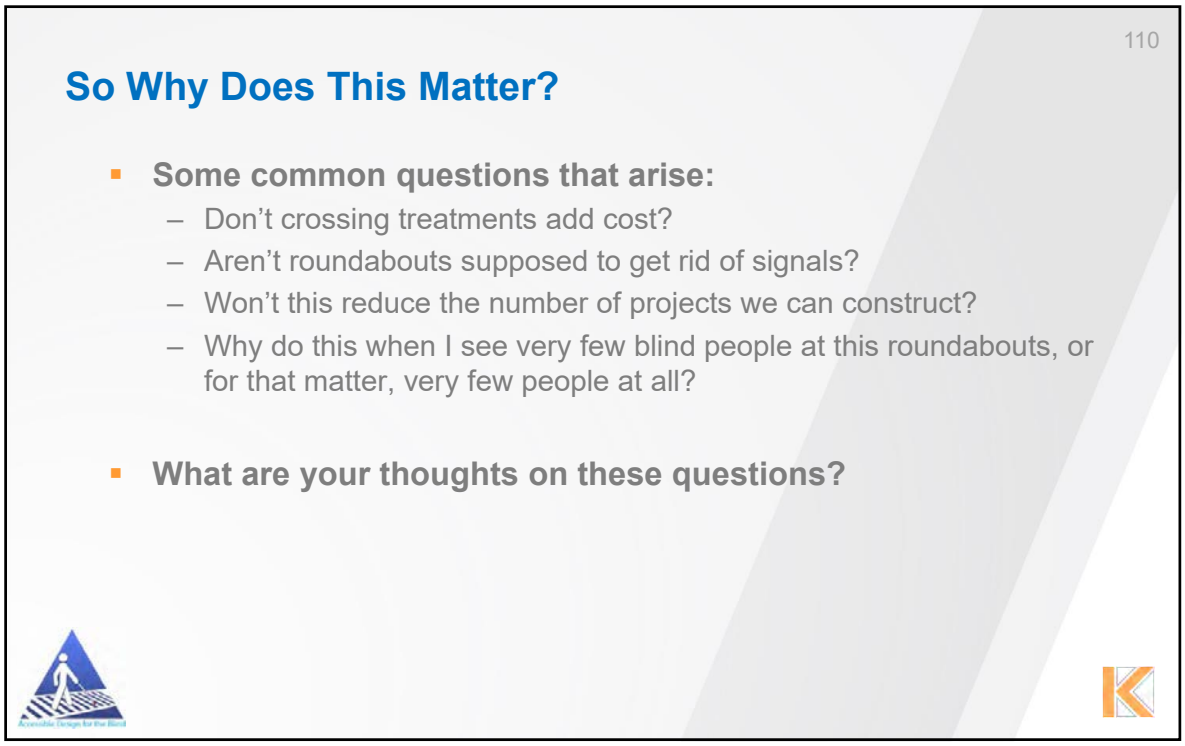
110
So Why Does This Matter?
Some common questions that arise:
Don't crossing treatments add cost?
Aren't roundabouts supposed to get rid of signals?
Won't this reduce the number of projects we can construct?
Why do this when I see very few blind people at this roundabouts, or for that matter, very few people at all?
What are your thoughts on these questions?

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111

Don't crossing treatments add cost?

- Yes, although some treatment types are significantly less expensive than others
- Important to look at life-cycle costs, not just initial construction costs
- The treatment costs may be a relatively small percentage of the total cost of construction, much less the total life-cycle cost

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Aren't roundabouts supposed to get rid of signals?

- Roundabouts and signals are not mutually exclusive
- Roundabouts' greatest strength:
  - Geometric shape that physically eliminates the most severe conflict types and minimizes the severity of others
  - Yield control at entry that allows efficient use of the intersection over a wide range of volumes from very low to quite high
- Signals' greatest strength:
  - Assignment of right-of-way in priority orders that we deem most important
  - Flexibility to control a wide range of situations
- The two together provide the best combination of safety and operational flexibility

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Won't this reduce the number of projects we can construct?

- It could, assuming the only metric of success is the number rather than the quality of the projects built
- A project that is built that provide access to one portion of the walking population but not to another portion should not be considered a success

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Why do this when I see very few blind people at this roundabouts, or for that matter, very few people at all?

- The provision of accessibility benefits all users of the intersection
- If the intersection and connecting system prove to be usable by everyone, the demand for the system will increase
- AND: It's a matter of civil rights

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Questions and Discussion

Photo: Bastian Schroeder

RRFB in Olympia, WA

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