The National Academies of SCIENCES • ENGINEERING • MEDICINE

TRANSPORTATION RESEARCH BOARD

Accessibility Guidance for Roundabouts and Channelized Turn Lanes

Wednesday, July 26, 2017 1:00pm to 2:30pm ET The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.



REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Discuss <u>NCHRP Research Report 834</u>.

Learning Objectives

At the end of this webinar, you will be able to:

- Describe the objectives and contents of the guidebook
- Describe accessibility challenges for blind pedestrians at roundabouts and channelized turn lanes
- Distinguish between crossing and wayfinding challenges
- Identify treatments geared to enhancing accessibility of new sites and retrofits

NCHRP Research Report 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians, with Vision Disabilities: A Guidebook

NCHRP Project 03-78c

NCHRP is a State-Driven Program

- Sponsored by individual state DOTs who
 - Suggest research of national interest
 - Serve on oversight panels that guide the research.



 Administered by TRB in cooperation with the Federal Highway Administration.



Practical, ready-to-use results

- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, syntheses
- Can be applied in planning, design, construction, operations, maintenance, safety, environment



Join us for a TRB Webinar

Development of Crash Modification Factors for Pedestrian Crossing Treatments

August 23, 2017 from 2:00 PM to 3:30 PM ET

Learn more at:

http://www.trb.org/Calendar/Blurbs/176213.aspx



Additional NCHRP Publications Available on this Topic

- TRB's Transportation Research Record, No 2586: Pedestrians
- NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways
- NCHRP Synthesis 488: Roundabout Practices

Webinar Outline

- Introduction and State DOT Perspective
 - Howard McCulloch, New York State Department of Transportation
- Background and Design Process
 - Pete Jenior, Kittelson & Associates, Inc.
- Wayfinding Principles and Assessment
 - Janet Barlow, Accessible Design for the Blind
- Crossing Principles and Assessment
 - Bastian Schroeder, Kittelson & Associates, Inc.
- Wrap-Up and Questions & Answers
 - Bastian Schroeder, Kittelson & Associates, Inc.

INTRODUCTION AND STATE DOT PERSPECTIVE

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians, with Vision Disabilities: A Guidebook

ONL

BACKGROUND AND DESIGN PROCESS

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians, with Vision Disabilities: A Guidebook

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



US Access Board Position

- Proposed Guidelines for Public Rights-of-Way DRAFT
 - Pedestrian crossing easily located for wayfinding
 - Signalization Requirement for Two-Lane Approaches
 - <u>http://www.access-board.gov/prowac/</u>



Prior Research and Literature on Roundabout Accessibility

2

NATIONAL COOPERATIVE HIGHWAY

RESEARCH



Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities



TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES US Department of Particulation Federal Highway Administration Effectiveness of Rectangular Rapid-Flashing Beacon Treatments at Multi-Lane Roundabouts

Sale Roads for a Saler Future

Volume I of VII Accelerating Roundabout Implementation in the United States Publication No. FHWA-SA-15-069 Road Commission for Oakland County – HAWK and RRFB Study



NCHRP Report 834 - Goals and Objectives

- 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
- Useful for a broad audience
- Decision-support tool for practicing engineers





PHB in Oakland County, MI



Speed Hump in Kissimmee, FL

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

NCHRP RESEARCH REPORT 834

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities

A Guid book



NCHRP

Web-Only Document 222:

Guidelines for the Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities

> Bastian Schroeder Lee Rodegerdts Pete Jenior Edward Myers Kittelson and Associates, Inc. Portland, OR

Christopher Cunningham Katy Salamati Sarah Searcy Sarah O'Brien Institute for Transportation Research and Education North Carolina State University Raleigh, NC

> Janet Barlow Billie Louise (Beezy) Bentzen Accessible Design for the Blind Asheville, NC

> > Final Project Report for NCHRP Project 03-78B Submitted April 2016

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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



Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities

A Guid book

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



NCHRP

Web-Only Document 222:

Guidelines for the Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities

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Design Process for Roundabouts

- NCHRP Report 672: Roundabouts: An Informational Guide, Second Edition
- Key attributes:
 - Performance-based
 - Iterative





Roundabout Design Process



Channelized Turn Lane Design Process



WAYFINDING PRINCIPLES AND ASSESSMENT

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians, with Vision Disabilities: A Guidebook

ONLY

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
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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

Street Crossing Tasks for pedestrians who are blind or who have low vision

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



Photo: Janet Barlow

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)

Determining the appropriate crossing location

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

Landscaping or fencing may provide guidance to crosswalk location



Photo: Janet Barlow



Guidance needed to crossing location on islands too



Photo: Janet Barlow

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

Aligning to cross (establishing a correct heading)

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

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

Maintaining the correct heading while crossing (staying in the crosswalk



Photo: Beezy Bentzen

- Typical techniques
 - Travel parallel to straightahead 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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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

Crossing Location



- Sidewalk leads to crosswalk?
- Separation between sidewalk and curb?
- Detectable warning surfaces?
- Other features that could be mistaken for ramps?
- Traffic control devices accessible?
Aligning to cross and establishing a correct heading



- Is curb ramp width the same as crosswalk width?
- Is curb ramp slope aligned with crossing?
- Are ramp edges aligned with crossing?
- Is detectable warning aligned with the slope of the curb ramp?
- Are pushbuttons in correct location?

Maintaining correct heading while crossing (staying within the crosswalk)

- Is the crossing configured at the shortest distance practical?
- Is the crossing aligned perpendicular to the curb and splitter edges?

Are markings clearly visible?



Crossings from Channelization and Splitter Islands

- Are islands wide-enough to provide safe refuge?
- Are transitions to roadway clearly defined?
- Are paths through islands clearly defined?
- Are push-buttons accessible?



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

CROSSING PRINCIPLES AND ASSESSMENT

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians, with Vision Disabilities: A Guidebook

Typical crossing strategies

- At signals
 - 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

Multilane crossings

- Need pedestrian activated signal or equivalent, per proposed PROWAG 2011 NPRM
 - Pedestrian Hybrid Beacon (PHB) with accessible pedestrian signals



PHB in Oakland County Michigan

Potential alternative treatments tested in 3-78b and prior research





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- **10.** Appendix B: Summary of Crossing Treatments

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





Check 1: Crossing Sight Distance

- Provide clear lines of sight between the driver and the pedestrian waiting to cross
 - to provide appropriate reaction and braking time for driver
 - to inform gap acceptance decisions
 - to enhance auditory information at crosswalk



Check 2: Pedestrian Delay

- Evaluate the level and quality of service
- Provide quantitative performance assessment
- Function of the availability of crossing opportunities and the rate of utilization of these opportunities
 - Crossable gaps
 - Yielding Vehicles
- Models calibrated from field data at roundabouts and channelized turn lanes.



Check 3: Level of Risk

- Most important performance measure
- Predict rate of expected rate of *interventions* through models calibrated from field data at roundabouts and channelized turn lanes.
- An intervention is an event, in which participants were physically stopped from stepping into the roadway by a Certified Orientation and Mobility Specialist



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
- Methods can be used to conduct *relative* accessibility evaluations in the context of PROWAG

Value of Direct Field Measurements

- Like any analysis (e.g. HCM or HSM), direct field observations at a given site should always supersede the model estimations from NCHRP Report 834
- NCHRP Web-Only Document 222 provides details on the Accessibility Audit data collection protocols used to derive and develop the models contained here



Method Overview

- 13 Step Methodology
- Iterative Procedure until three performance checks are met
- Each step contains models and/or defaults to assist with the estimation



Step 1: Gather Data and Required Inputs

Step	Equation/Table	Required User Input
Step 2: Predict speed at crosswalk	Equation 7-1 Table 7-2 and Table 7-3	Fastest path radius Treatment effect
Step 3: Calculate crossing sight distance	Equation 7-2 Equation 7-3	Vehicle speed at crosswalk (from Step 2) Approach geometry Pedestrian walking speed
Step 4: Check Sight Distance Provisions	Expert judgment	CAD drawing Crossing sight distance (from Step 3)
Step 5: Calculate crossing opportunity (gaps and yields)	Equation 7-4 Equation 7-5 Equation 7-6 Equation 7-7	Approach geometry and Treatment, Gap acceptance parameters Pedestrian walking speed Traffic volume on approach Vehicle speed at crosswalk (from Step 2)
Step 6: Estimate utilization of gaps and yields	Table 7-4 Table 7-5	Approach geometry
Step 7: Evaluate audible environment and noise effect	Expert judgment Appendix A	Local observation Surrounding lane uses
Steps 8 and 9: Estimate pedestrian delay	Equation 7-9 through Equation 7-11	Gap and yield opportunities (from Step 5) Gap and yield utilization (from Step 6)
Steps 10 and 11: Estimate crossing risk	Equation 7-12	Vehicle speed at crosswalk (from Step 2) Noise (from Step 7) Sight distance (from Step 4)

Step 2: Predict Speed at Crosswalk

- Predict the free-flow speeds that can be expected in the vicinity of the crosswalk
- Required for calculating:
 - crossing sight distance
 - driver yielding rate at the crosswalk
 - prediction of rate of intervention and risk events
- Use Fastest Path Radius Calculation from RBT Guide (and Green Book)
- Exiting speeds constrained by acceleration (like RBT Guide)



 $FFS = 3.4415 R^{0.3861}$, for e = +0.02

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



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

Step 5: Predict Crossing Opportunities

Crossable Gap Opportunities

- Function of traffic volume and critical gap
- Critical gap function of crosswalk length, walking speed, and clearance time

Yield Crossing Opportunities

- Yielding is function of fastest path radius (proxy for speed) and presence of treatment
- Use field data or other research to calibrate yield estimate



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
- Report gives sample statistics by site type from field data
 - 1-lane RBT Entry
 - 1-lane RBT Exit
 - 2-lane RBT Entry
 - 2-lane RBT Exit
 - Channelized Turn Lane



Step 7: Evaluate Audible Environment and Noise Levels

- Qualitative assessment of ambient noise levels
- An accessible site requires an adequate signal to noise ratio for a blind traveler to make informed crossing decisions
- No quantitative method, but guidance provided in Appendix



Step 8 and 9: Estimate and Check Pedestrian Delay

- Function of crossing opportunities (crossable gaps and yields) and utilization of these opportunities
- Models provided for singlelane CTL, single-lane RBT, and two-lane RBT
- Check pedestrian delay against HCM and/or local policy



Steps 10 and 11: Estimate and Check Crossing Risk

- Function of vehicle speed, ambient noise, and sight distance
- Predict the expected number of interventions
- Check against local policy or TOPR34 final report on two-lane roundabouts
 - 3 percent or less is similar to the rate of interventions at single-lane roundabouts, and may be considered accessible in many cases.
 - above 5 percent were considered as likely present a significant barrier for blind travelers crossing at these locations,
 - above 10 percent were considered as representing a challenging and risky crossing environment.



Step 12: Visibility of Traffic Control Devices

- Assure traffic control devices can be seen and understood by drivers approaching the crosswalk
- Consistent with national guidelines in MUTCD, ITE Traffic Control Devices Handbook, and NCHRP Report 672 (Roundabout Guide)
- Signs and Marking
 - Sufficient separation between crosswalk and yield line
 - Separation of crosswalk signs from yield line

Signals and Beacons

- Provide stopping sight distance per MUTCD
- Check adequate mounting heights
- Stop bar placement and set-back
- Signal/Beacon placement and separation from other traffic control devices
- Provisions of audible messages at signal/beacon

Step 13: 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



WRAP-UP

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians, with Vision Disabilities: A Guidebook

Implications for Practice

- Treatment of all modes holistically is necessary
 - Assessment of pedestrian (and bicycle) performance should be 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 add to our ability to make these assessments

Geometry Matters



 Larger Radii contribute to greater vehicle speeds, lower yielding, and more risky crossing environment

Speed Matters

- Faster Speeds linked to reduced yielding and increased risk
- Prior research also linking higher speeds to greater injury risk and reduced driver attentiveness to pedestrians



Impact of Speed on Driver Yielding at Two-Lane Roundabouts from 6 sites in 4 states

(Source: Geruschat, Salamati and Schroeder, in press)

Sight Distance and Visibility Matter

- Open sight lines and good visibility can contribute to increased driver awareness and yielding
- Limited sight lines impact gap acceptance and yielding propensity
- Limited sight lines also impact audible information available at the crosswalk



Traffic Volume Matters

- Higher traffic volume can contribute to more yielding (vehicles slow and already delayed)
- But higher traffic are also linked to higher likelihood of multiple-threat events (at multi-lane crossings)
- And, higher traffic volume can also increase the ambient noise level



Photo: Janet Barlow

Wayfinding Provisions Matter

- Deciding when to cross is only one of four tasks at roundabouts; others are
 - Finding the crosswalk
 - Aligning to cross
 - Maintaining alignment during crossing
- Landscaping, fencing, tactile surfaces, and audible beacons have proven effective to assist with wayfinding



Next Steps

- NCHRP Project 03-78c
 - Outreach and training
 - Potential further refinement of analysis techniques as outcome of learning from implementation
 - www.intersectionaccess.org
- Future potential integration into other documents
 - Roundabouts: An Informational Guide, Third Edition (funding requested)
 - Public Rights of Way Accessibility Guidelines
 - AASHTO Policy on Geometric Design of Highways and Streets
 - FHWA Manual on Uniform Control Devices

www.intersectionaccess.org

ACCESSIBLE ROUNDABOUT AND CHANNELIZED TURN LANE WORKSHOP

HOME	WORKSHOP INFORMATION	REGISTRATION	RESEARCH LINKS	TRAINING MATERIALS	FLYER	SUBSCRIBE	CONTACT

Roundabout and Channelized Turn Lane Accessibility Workshops

TRB is offering reduced price workshops on analyzing and designing roundabouts and channelized turn lanes to be usable by people who are blind or have low vision.

Workshop content will be based on the findings and methodologies of NCHRP Report 834 — Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook. Workshops will be presented by members of the NCHRP Report 834 team.

THE ACCESSIBILITY CHALLENGE

All newly constructed or renovated facilities must meet the accessibility requirements of the Americans with Disabilities Act (ADA), to be "accessible to and usable by persons with disabilities" (Title II, 35.151 New Construction and Alterations). Within public rights-of-way, facilities such as sidewalk and street crossings, including signal equipment, should be designed in accordance with the proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (2011) (proposed PROWAG), or subsequent finalized guidance or standards that may be published in the future.

Upcoming Workshops

CITY	STATE
Raleigh	NC
Atlanta	GA
Orlando/Tampa	FL
Portland	OR
Oakland/Sacramento	CA
Phoenix/Tucson	AZ
Minneapolis/St. Paul	MN
Kansas City	MO
Austin	ТХ
Columbus	ОН
Boston	MA
Albany	NY
Questions and Discussion



RRFB in Olympia, WA

Today's Participants

- Howard McCulloch, New York State Department of Transportation, <u>howard.mcculloch@dot.ny.gov</u>
- Bastian Schroeder, *Kittelson & Associates, Inc.,* <u>BSchroeder@kittelson.com</u>
- Pete Jenior, *Kittelson & Associates, Inc.,* <u>pjenior@kittelson.com</u>
- Janet Barlow, Accessible Design for the Blind, jmbarlow@accessforblind.org



Panelists Presentations

http://onlinepubs.trb.org/onlinepubs/webinars/170726.pdf

After the webinar, you will receive a follow-up email containing a link to the recording



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- Become a Friend of a Committee http://bit.ly/TRBcommittees
 - Networking opportunities
 - May provide a path to become a Standing Committee member
- For more information: <u>www.mytrb.org</u>
 - Create your account
 - Update your profile

97th TRB Annual Meeting: January 7-11, 2018



Get involved with NCHRP

- Suggest NCHRP research topics
- Volunteer to serve on NCHRP panels
- Lead pilot projects and other implementation efforts at your agency
- For more information: <u>http://www.trb.org/nchrp/nchrp.aspx</u>

