MODERN ROUNDABOUTS – THE OPERATIONAL ASPECTS

Presented by
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ASCE | KNOWLEDGE & LEARNING

Other Key Design Elements

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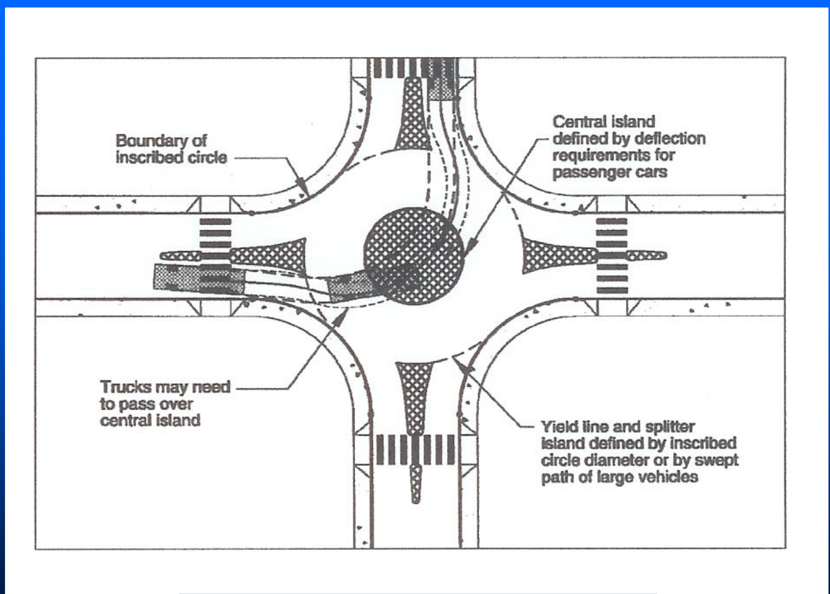
Trucks

3



Left-turning truck problem

Source: FHWA Roundabout Guide

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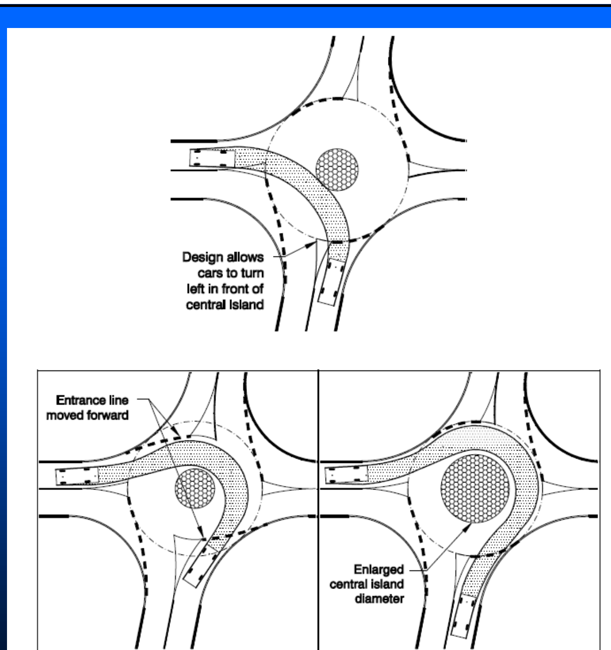

Source: NCHRP 672

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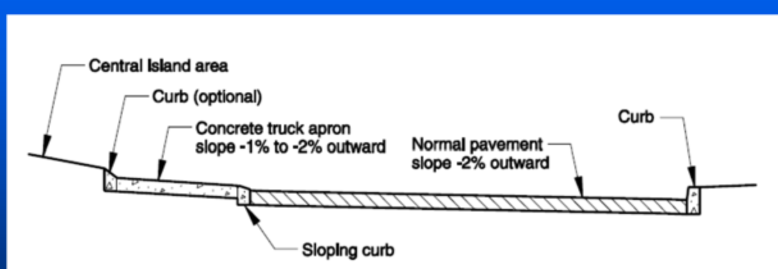

Source: NCHRP 672

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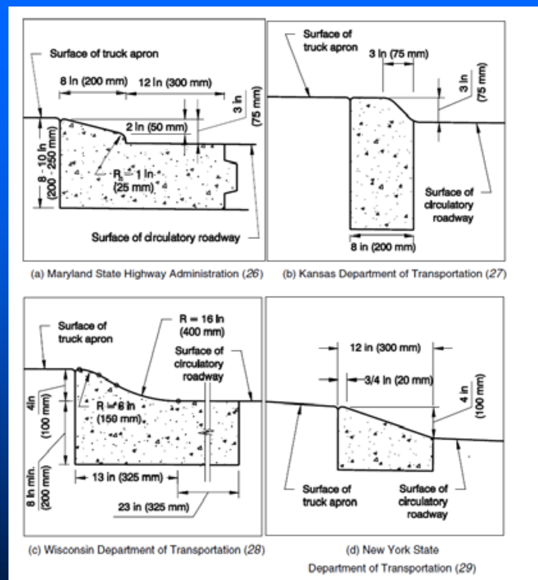

Source: NCHRP 672

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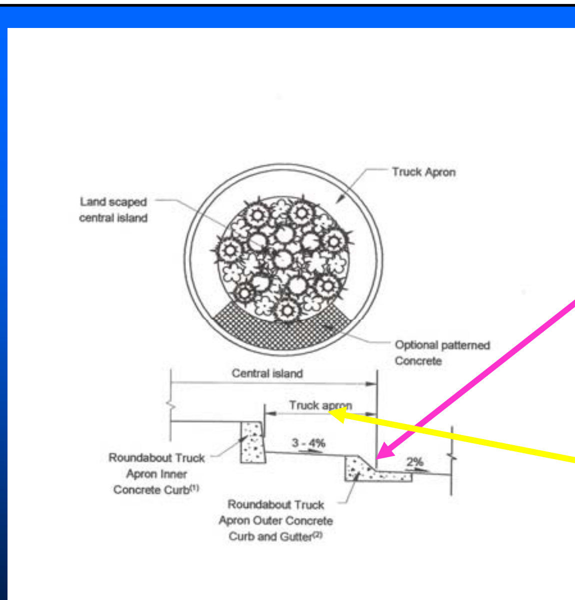

Height ~ 2"

Width will depend on design vehicle turning radius

Truck Apron Design

Source: WA DOT Design Manual – Chapter 915

8

Rear wheels mount the truck apron

Video at www.traffexengineers.com

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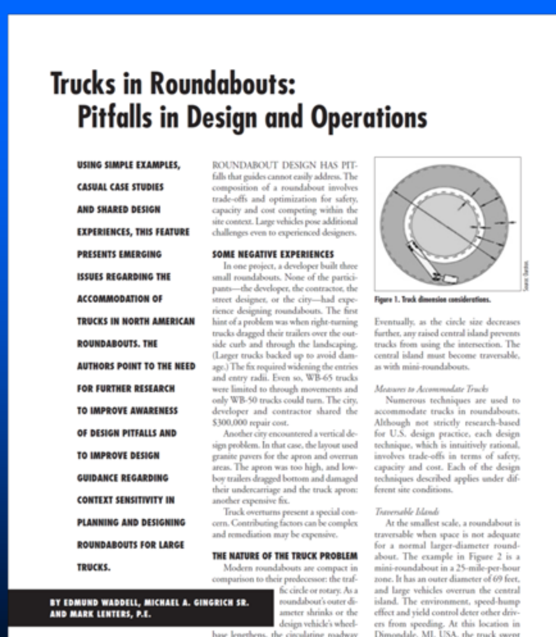

Trucks in Roundabouts: Pitfalls in Design and Operations

USING SIMPLE EXAMPLES, CASUAL CASE STUDIES AND SHARED DESIGN EXPERIENCES, THIS FEATURE PRESENTS EMERGING ISSUES REGARDING THE ACCOMMODATION OF TRUCKS IN NORTH AMERICAN ROUNDABOUTS. THE AUTHORS POINT TO THE NEED FOR FURTHER RESEARCH TO IMPROVE AWARENESS OF DESIGN PITFALLS AND TO IMPROVE DESIGN GUIDANCE REGARDING CONTEXT SENSITIVITY IN PLANNING AND DESIGNING ROUNDABOUTS FOR LARGE TRUCKS.

BY EDMUND WADDELL, MICHAEL A. GINGRICH SR. AND MARK LENTERS, P.E.

ROUNDABOUT DESIGN HAS PITFALLS that guides cannot easily address. The composition of a roundabout involves trade-offs and optimization for safety, capacity and cost competing within the site context. Large vehicles pose additional challenges even to experienced designers.

SOME NEGATIVE EXPERIENCES

In one project, a developer built three small roundabouts. None of the participants—the developer, the contractor, the street designer, or the city—had experience designing roundabouts. The first hint of a problem was when right-turning trucks dragged their trailers over the outside curb and through the landscaping. (Larger trucks backed up to avoid damage.) The fix required widening the entries and entry radii. Even so, WB-65 trucks were limited to through movements and only WB-50 trucks could turn. The city, developer and contractor shared the $300,000 repair cost.

Another city encountered a vertical design problem. In that case, the layout used granite pavers for the apron and overrun areas. The apron was too high, and lowboy trailers dragged bottom and damaged their undercarriage and the truck apron: another expensive fix.

Truck overturns present a special concern. Contributing factors can be complex and remediation may be expensive.

THE NATURE OF THE TRUCK PROBLEM

Modern roundabouts are compact in comparison to their predecessor: the traffic circle or rotary. As a roundabout's outer diameter shrinks or the design vehicle's wheelbase lengthens, the circulating roadway must widen and the central island must

Figure 1. Truck dimension considerations.

Eventually, as the circle size decreases further, any raised central island prevents trucks from using the intersection. The central island must become traversable, as with mini-roundabouts.

Measures to Accommodate Trucks

Numerous techniques are used to accommodate trucks in roundabouts. Although not strictly research-based for U.S. design practice, each design technique, which is intuitively rational, involves trade-offs in terms of safety, capacity and cost. Each of the design techniques described applies under different site conditions.

Traversable Islands

At the smallest scale, a roundabout is traversable when space is not adequate for a normal larger-diameter roundabout. The example in Figure 2 is a mini-roundabout in a 25-mile-per-hour zone. It has an outer diameter of 69 feet, and large vehicles overrun the central island. The environment, speed-hump effect and yield control deter other drivers from speeding. At this location in Dimondale, MI, USA, the truck swept paths require use of paint and rumble

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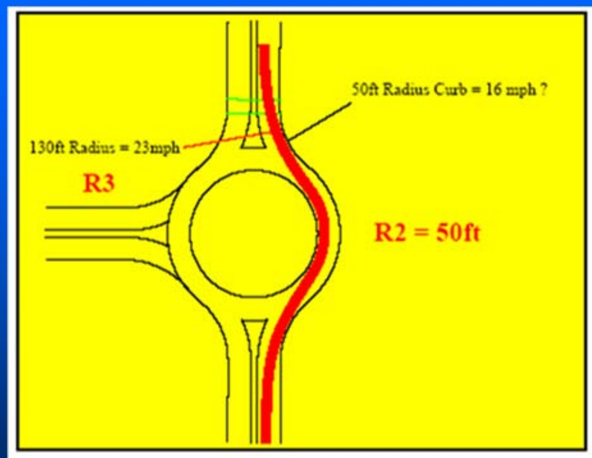

To accommodate trucks, exit needs to be 17' wide so R3 does not govern exit speed

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Illumination

14

Overhead area wide lighting (not oriented to pedestrians)

15

Type of Lighting Assembly	Typical Wattage	Typical Distribution	Common Mounting Height
Cobra-style	75 W–400 W HPS	Type II or III (full or semi cutoff)	30 to 50 ft (9 to 15 m)
Ornamental	75 W–200 W HPS	Type V (360° spread)	14 to 20 ft (4 to 6 m)
High-Mast	400 W–1,000 W HPS	Type V (360° spread)	50 to 100 ft (15 to 30 m)

W = watts; HPS = High Pressure Sodium
Source: Kansas Roundabout Guide (*9*)

Source: NCHRP 672

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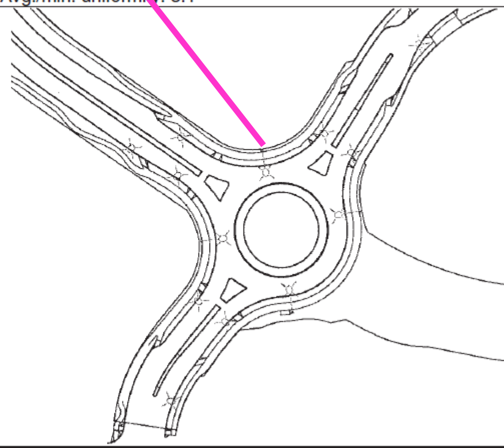
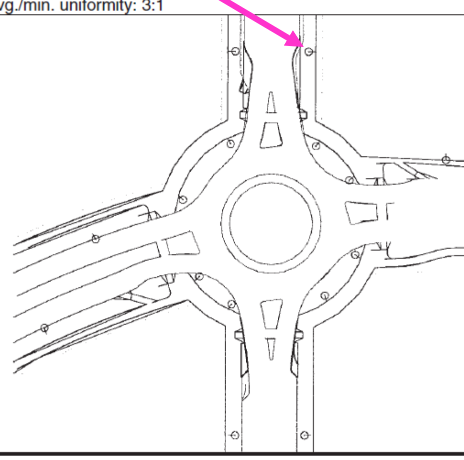
Inscribed Circle Diameter:	140 ft (43 m)
Equipment:	Cobras over circulatory roadway: 200 W HPS, Type M-C-III, 30 ft (9.1 m) mounting height Pedestrian-level luminaires: 200 W HPS, Type V,14 ft (4.3 m) mounting height
Photometric Requirements:	Avg. illuminance: 2.0 fc (20 lux) Avg./min. uniformity: 3:1
Layout:	

Source: Kansas Roundabout Guide (*9*)

Inscribed Circle Diameter:	120 ft (37 m)
Equipment:	Pedestrian-level luminaires: 250 W HPS, Type V, 18 ft (5.5 m) mounting height
Photometric Requirements:	Avg. illuminance: 2.7 fc (27 lux) Avg./min. uniformity: 3:1
Layout:	

Source: Kansas Roundabout Guide (*9*)

Source: NCHRP 672

Developing Effective Standards and Guidelines for Roundabout Lighting

John Beery, P.E., PTOE and Andrew Rodewald
ElNoblesville, Indiana

1. Identify and establish a standard luminaire and mounting height to provide consistent and cost effective illumination. Attempt to accommodate both aesthetics and function.
2. Establish preliminary lighting locations adjacent to the conflict points of the roundabout, including crosswalks.
3. Single lane roundabouts can typically be lit from the exterior of the intersection. Two-lane roundabouts typically require pole placement within the inner circle near the 45°, 135°, 225°, and 315° points for the inner circle conflict points.
4. Two-lane roundabouts may require closer pole spacing or more intense luminaires when lit from the inner circle to improve intensity and to reduce the number of lights.
5. Observe IES guidelines for illumination levels based on the type of intersection.
6. Adjust the type of pole, its location, and the base depending on clear zone requirements

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Pedestrian oriented lighting at crosswalks

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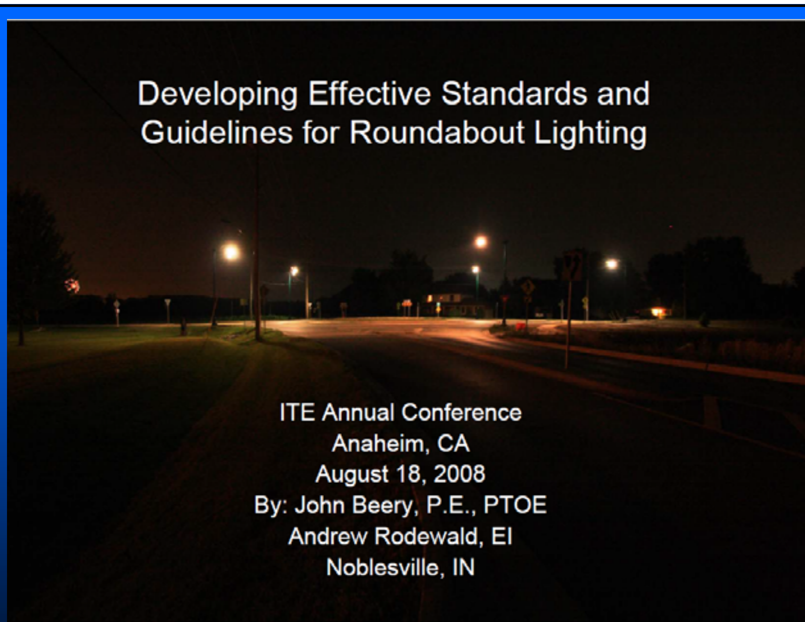

http://www.ite.org/meetings/2008AM/Session%202_John%20M.%20Beery.pdf

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Landscaping/Drainage

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Why Provide Landscaping?

- Make the central island more conspicuous
- Improve the aesthetics of the area
- Minimize introducing hazards to the intersection
- Avoid obscuring roundabout or the signing to the driver
- Maintain adequate sight distances
- Clearly indicate drivers not to pass straight through
- Discourage pedestrian traffic through the central island
- Help visually blind pedestrians find sidewalks/crosswalks

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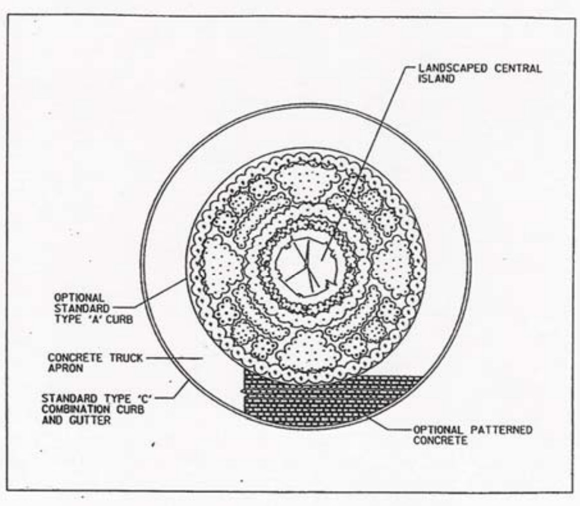

Figure 5.13: Plan of Landscaped Central Island *(Maryland 1995)*

Curbing and planting detail

Source: Modern Roundabouts for Oregon (WSDOT)

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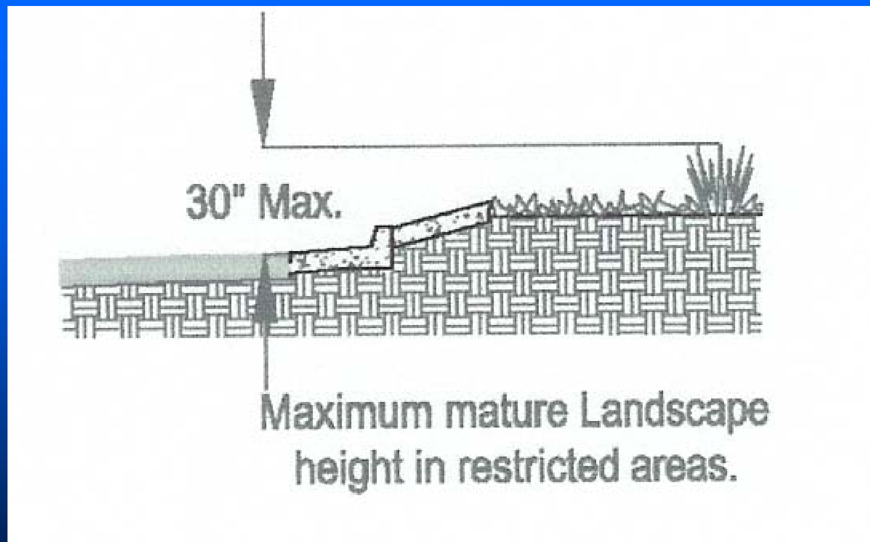

Curbing and planting detail

Source: Roundabout Design Standards - City of Colorado Springs

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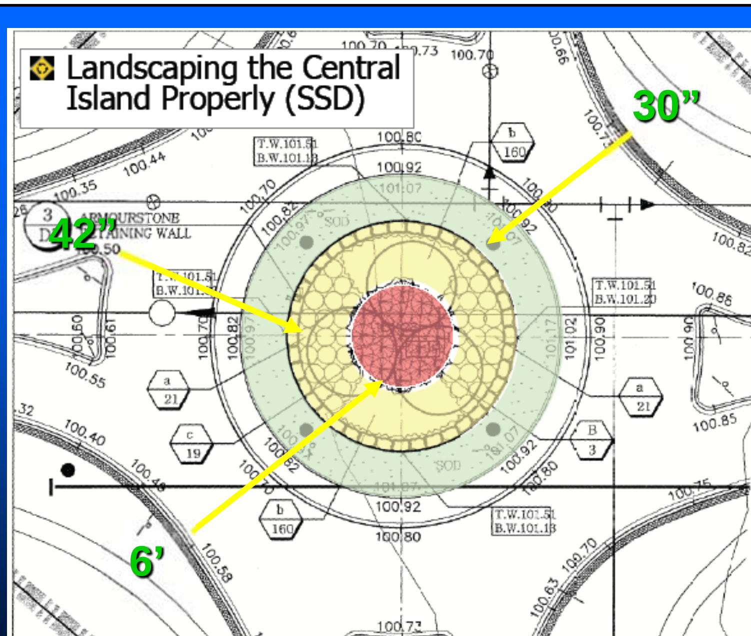

Source: www.roundabouts.us (Scott Ritchie)

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Landscaping design for roundabouts

Source: www.roundabouts.us (Scott Ritchie)

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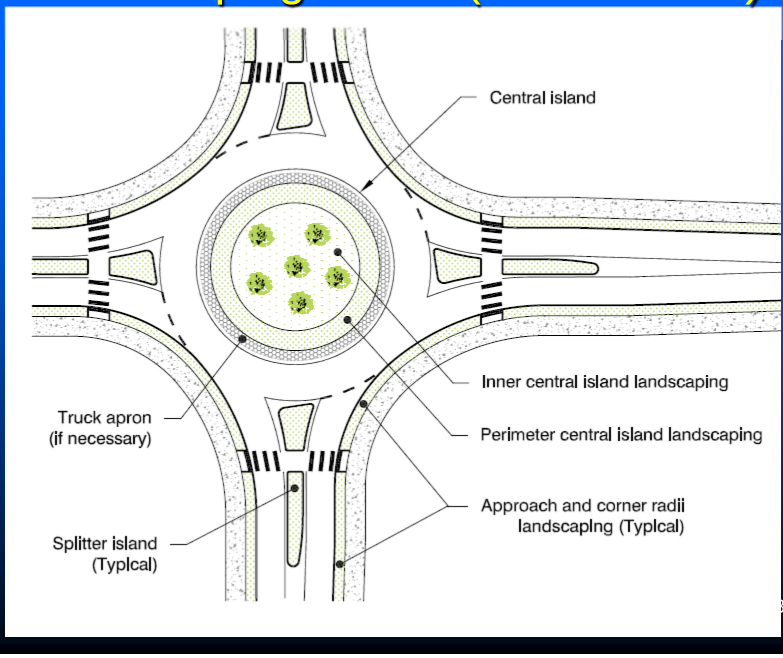
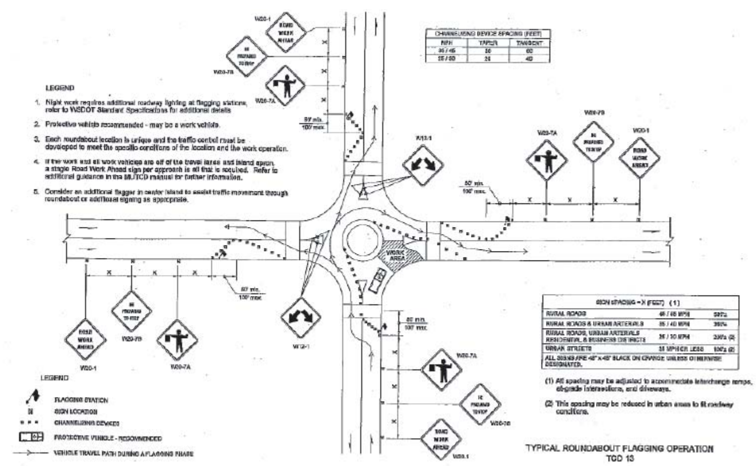
Landscaping Zones (NCHRP 672)



Maintenance Project Staging Area (NCHRP 672)



Source: Washington State Department of Transportation (*5*)

Poor sight distance caused by landscaping and signage on the center island

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Signing and Striping

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Why is Signing so Important?

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Skid marks provide a hint!

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Roundabout Signing

- Yield signs mandatory
- Black and white chevrons
- W1-6 large black arrow on yellow background not allowed on island
- Advance guide signs
- Place ped crossing signs in splitter island to improve visibility of yield signs.

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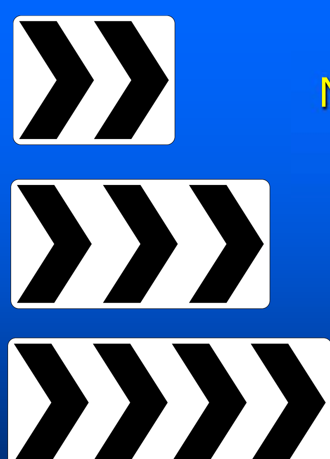
New regulatory signs for use at roundabouts



Roundabout Directional Arrow signs (on central island)

Roundabout Circulation sign (with YIELD sign at mini-roundabouts)

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Drivers' Understanding of Innovative Roundabout Traffic Control Devices

THE 2009 EDITION OF THE *MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES* CONTAINS INNOVATIVE SIGN AND PAVEMENT MARKING TREATMENTS TO ASSIST DRIVERS WITH NAVIGATING ROUNDABOUTS. THE HUMAN FACTORS LABORATORY STUDY DESCRIBED IN THIS PAPER WAS UNDERTAKEN TO DETERMINE DRIVER UNDERSTANDING OF THE NEW DEVICES.

BY FRED R. HANSCOM, P.E.

INTRODUCTION

The 2009 edition of the *Manual on Uniform Traffic Control Devices* (MUTCD) contains a number of innovative signing and pavement marking options for application at roundabouts.[1] These devices are designed with the specific intent to convey geometric features to assist drivers in the navigation of roundabouts. Figures 1 and 2 illustrate the use of fishhook pavement markings and curved-stem guide sign arrows, respectively.

Due to the absence of preexisting data regarding driver understanding of the roundabout traffic control device concepts that were considered in the development of the 2009 MUTCD, a relevant human factors study was funded by the National Cooperative Highway Research Program (NCHRP). This study was based on research needs identified by the MUTCD authoring committee. Key devices of interest were fishhook roundabout-entry pavement markings, curved-stem arrows on advance guide signs, and specific central island signing characteristics (e.g., black-on-yellow warning and black-on-white chevrons regulatory signs).

LABORATORY STUDY PROCEDURE

Twenty-eight combinations of advance guide signs and pavement marking alternatives were tested in a laboratory study. The laboratory consisted of a theater-type surrounding that projected high-resolution images that replicated traffic control device legibility (e.g., sign letter height to driver distance ratio) found in actual highway driving. Laboratory participants viewed sequen-

priate to reach an intended destination and (2) confidence in choice decisions (i.e., not sure, somewhat sure, or very sure). These confidence ratings provided an added degree of sensitivity to the evaluation procedure.

The study methodology was based on a classical Federal Highway Administration (FHWA) study that determined the design of diagrammatic guide signs.[2] This study utilized short time-exposure presentations depicting highway scenes, whereby laboratory participants made lane-choice decisions based on their intended destination. A recent FHWA roundabout signing study applied similar measures (i.e., decision choice and confidence ratings by laboratory subjects) in response to brief exposures to highway scenes.[3]

Specific traffic control device conditions, based on candidates for inclusion into the MUTCD, were selected for laboratory testing and are listed below. Device treatments were separately tested under right, left and through intersection-movement driver route-choice conditions. Tested devices were the following:

1. **Pavement Marking Conditions**
   a. Fishhook;
   b. Turn and through-lane arrows, both entry lanes;
   c. Left-turn only arrow, left lane; right-turn, and through-lane arrows, right lane;
   d. Through lane-use arrow, left lane; turn and through-lane arrows, right lane; and
   e. No pavement markings.
2. **Guide Sign Conditions**
   a. Conventional arrows; and

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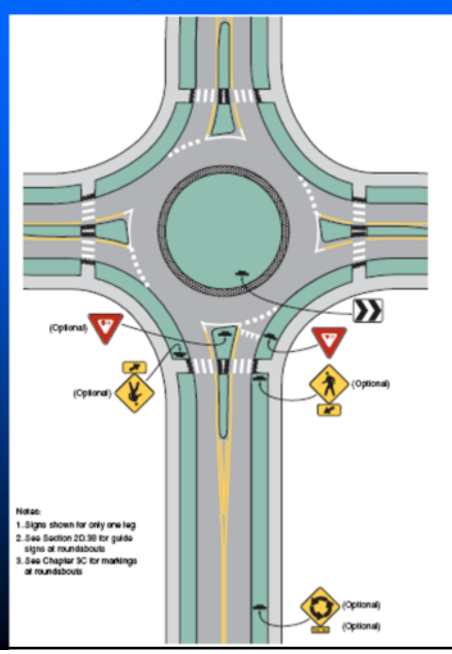
Regulatory and Warning Signs for a One -lane Roundabout



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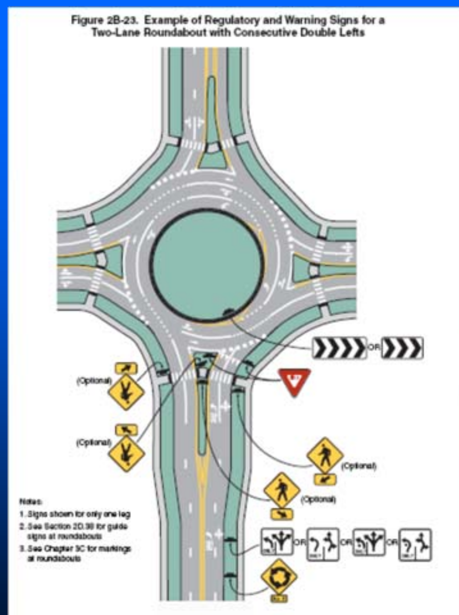
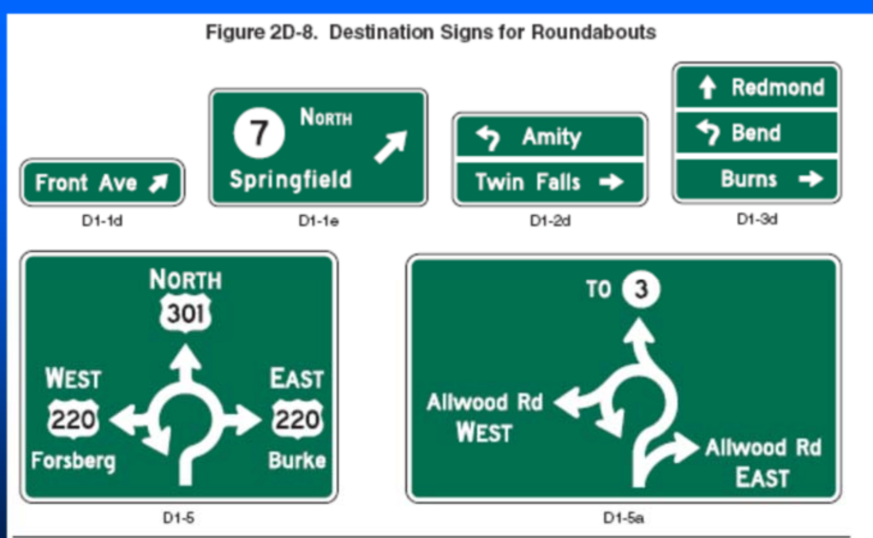


Regulatory and warning signs for use at a two-lane roundabout

Source: 2009 MUTCD



Source: 2009 MUTCD

Diagrammatic destination sign

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Mini Roundabouts

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Mini-Roundabouts for the United States

THIS FEATURE EXAMINES THE HISTORY, SUCCESS AND SOME FAILURES OF MINI-ROUNDABOUTS IN THE UNITED KINGDOM. THE MAIN PRINCIPLES REGARDING DESIGN, SAFETY AND GENERAL OPERATION ARE DISCUSSED FOR THEIR POTENTIAL APPLICATION IN THE UNITED STATES. THE BASIS FOR SITE SELECTION IS CLARIFIED, INCLUDING SINGLE AND MULTIPLE USE OF MINI- OR SMALL ROUNDABOUTS IN SMALL NETWORKS. EFFECTS ON VULNERABLE USERS ARE ALSO CONSIDERED.

BY CLIVE SAWERS, MA, MICE, C.ENG.

INTRODUCTION

Many Americans have been fascinated by the United Kingdom's large numbers of modern roundabouts, particularly mini-roundabouts. Americans have often found them difficult to drive because they are not used to living with roundabouts. What are mini-roundabouts? Why might their development apply to the United States?

A mini-roundabout may be considered at an intersection where the available right of way is not sufficient to install a normal roundabout with a solid central island.

A mini-roundabout is a small form of modern roundabout that is fully over-runnable, where all traffic should yield on entry to vehicles circulating around it. On entering the circulation, all vehicles must pass to the correct side of the central island unless they physically cannot do so, when the trailing part of the vehicle may pass over and to the "wrong" side of the central island.

A mini-roundabout is the same as a modern roundabout but there is no solid central island, only a truck apron. The only other difference is the scale of the intersection; the inscribed circle is less than around 28 meters (90 feet). Otherwise the operational characteristics are much the same as a normal modern roundabout with a central island. This is dependent upon making the truck apron—now a stand-alone device—work properly. That is where problems have arisen in the United Kingdom because the overrunnable island is limited to a 4-meter diameter.

BRIEF HISTORY

because they were no longer locked up. Tests in 1971 showed that large roundabout layouts did not work well even with the yield rule. Further tests on smaller three-arm roundabouts proved that the mini-roundabout with its nominal central island would work at appropriate sites and would yield much higher capacity than equivalent traffic signals.

Mini-roundabouts proved easy and inexpensive to install. They reduced the numbers and severity of crashes and had a good local speed reduction effect. They replaced "priority" junctions effectively, particularly where these tended to become knotted up. In the United States, many all-way stop intersections do not perform well. These repesent opportunities for mini-roundabout retrofits.

BACKGROUND IN THE UNITED STATES

Historically, there are many circular intersections of various sizes in the United States and Canada. Commonly known as traffic circles, those with small solid islands in residential road intersections operate well for their intended purpose, i.e., to allow turning movements at slow speeds. Their larger relations—rotaries—have become notorious. They operate too fast and have poor capacity and a poor crash rate.

For these and other reasons, the modern roundabout, with its very different actual operation but its apparent similarity to traffic circles, is viewed with skepticism in the United States. It is only a matter of time before sufficiently well-designed modern roundabouts confirm the benefits that are so different from the rotaries that preceded them. Compared with traffic signals, roundabouts can operate with much

"At mini-roundabouts the situation is somewhat better, but all two-wheelers remain vulnerable at mini-roundabouts, mostly where deflection has not been adequately provided. The two-wheeled casualty has usually been the one with priority while the other vehicle has usually failed to yield. However, this does not mean bicyclists are in grave danger at mini-roundabouts. Correctly designed schemes have casualty rates among two-wheeled machines that are no higher than other forms of control."

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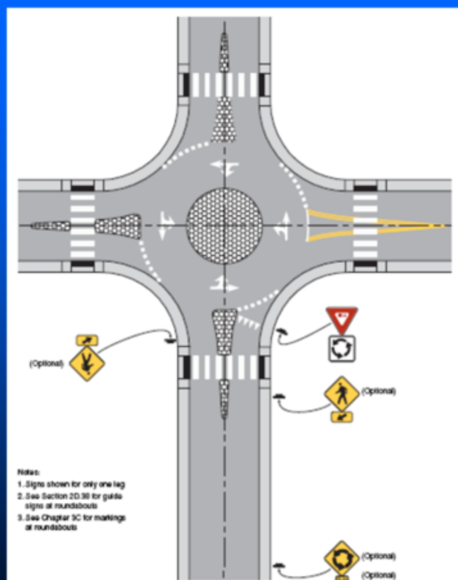
Mini Roundabouts

Hillary Isebrands, PE
FHWA Resource Center

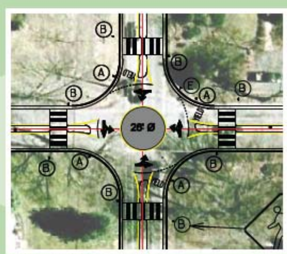
Signing for mini roundabout



NACTO URBAN STREET DESIGN GUIDE

"A mini roundabout on a residential street is intended to keep speeds to a minimum. Provide approximately 15 feet of clearance from the corner to the widest point on the circle"

Mini-Roundabouts



Aerial View (24 ft pavement)

Application Criteria

- Lower speed roads (max 35 mph).
- Total entering intersection volumes from all approaches less than 1,600 veh/hr.
- Junctions of two-lane roads.
- Junctions without nearby commercial entrances.
- Low truck and bus volumes.
- Expected lower construction costs since footprint is within existing travelway boundaries.

Perspective view of a reverse curve splitter island

FHWA Research Contract

The Federal Highway Administration (FHWA) has sponsored a research project, entitled "Field Testing, Marketing, and Crash Analyses for Mini-Roundabouts," Contract No. DTFH61-09-C-00027. The objectives of the contract include before vs. after evaluation of 10 mini-roundabouts to be implemented in the United States. FHWA is looking for Agencies who are willing to fund and construct mini-roundabouts soon. The traffic operational and safety effects of the mini-roundabouts will then be evaluated by the research team for FHWA.

Perspective view of flush approach splitter islands and flush central island with post-mounted delineators

If you wish to participate or need more information please contact:

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Federal Highway Administration
6300 Georgetown Pike
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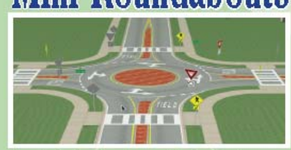
Ram Jagannathan - VHB, Inc.
703-847-3071
703-847-0298 fax
ram@vhb.com



Properly designed modern roundabouts have been demonstrated worldwide to be effective in reducing intersection crashes. One version of roundabouts that has not yet been implemented widely in the U.S. is the mini-roundabout.

The mini-roundabout features a much smaller inscribed diameter, on the order of 50 to 80 ft, and a relatively small circular central island (e.g., 16 ft to 45 ft diameter) that is traversable. One of the promising aspects of a mini-roundabout is its small footprint and relatively low implementation cost, which allows it to be a viable treatment for urban and suburban intersections of lower speed, two-lane roads. In most cases, mini-roundabouts can fit within existing travelway boundaries. All channelizations will be added within existing boundaries.

The mini-roundabout should be primarily designed for passenger cars that are expected to use the circular roadway around the central island, which can be raised or flush. Buses and trucks may traverse over the central island to complete turning maneuvers due to restricted intersection geometry. For flush central islands, additional physical deterrent boundaries, such as raised pavement markers or rumble strips, are needed to enhance conspicuity and encourage drivers of passenger cars to stay within the circular travelway of the mini-roundabout. It is also desirable to narrow lanes to 10 ft on the approach to a mini-roundabout to ensure a reduction in speed.

U.S. Department of Transportation
Federal Highway Administration

Pavement Markings

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Markings

Section 3C.02 <u>White Lane Line Pavement Markings for Roundabouts</u>

Standard:

01 **Multi-lane approaches to roundabouts shall have lane lines.**

02 **A through lane on a roadway that becomes a dropped lane (mandatory turn lane) at a roundabout shall be marked with a dotted white lane line in accordance with Section 3B.04.**

Guidance:

03 *Multi-lane roundabouts should have lane line markings within the circulatory roadway to channelize traffic to the appropriate exit lane.*

Standard:

04 **Continuous concentric lane lines shall not be used within the circulatory roadway of roundabouts.**

Support:

05 Section 9C.04 contains information regarding bicycle lane markings at roundabouts.

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Markings

Section 3C.03 Edge Line Pavement Markings for Roundabout Circulatory Roadways

Guidance:

01 *A white edge line should be used on the outer (right-hand) side of the circulatory roadway.*

02 *Where a white edge line is used for the circulatory roadway, it should be as follows (see Figure 3C-1):*

A. A solid line adjacent to the splitter island, and
B. A wide dotted line across the lane(s) entering the roundabout.

Standard:

03 **Edge lines and edge line extensions shall not be placed across the exits from the circulatory roadway at roundabouts.**

Option:

04 A yellow edge line may be placed around the inner (left-hand) edge of the circulatory roadway (see Figure 3C-1) and may be used to channelize traffic (see Drawing B of Figure 3C-4).

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Markings

Section 3C.04 Yield Lines for Roundabouts

Option:

01 A yield line (see Section 3B.16) may be used to indicate the point behind which vehicles are required to yield at the entrance to a roundabout (see Figure 3C-1).

Section 3C.05 Crosswalk Markings at Roundabouts

Standard:

01 **Pedestrian crosswalks shall not be marked to or from the central island of roundabouts.**

Guidance:

02 *If pedestrian facilities are provided, crosswalks (see Section 3B.18) should be marked across roundabout entrances and exits to indicate where pedestrians are intended to cross.*

03 *Crosswalks should be a minimum of 20 feet from the edge of the circulatory roadway.*

Support:

04 Various arrangements of crosswalks at roundabouts are illustrated in the figures in this Chapter.

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Markings

Section 3C.06 Word, Symbol, and Arrow Pavement Markings for Roundabouts

Option:

01 Lane-use arrows may be used on any approach to and within the circulatory roadway of any roundabout.

02 YIELD (word) and YIELD AHEAD (symbol or word) pavement markings (see Figure 3C-1) may be used on approaches to roundabouts.

03 Word and/or route shield pavement markings may be used on an approach to or within the circulatory roadway of a roundabout to provide route and/or destination guidance information to road users (see Figure 3C-14).

Guidance:

04 *Within the circulatory roadway of multi-lane roundabouts, normal lane-use arrows (see Section 3B.20 and Figure 3B-24) should be used.*

05 *On multi-lane approaches with double left-turn and/or double right-turn lanes, lane-use arrows as shown in Figures 3C-7 and 3C-8 should be used.*

December 2009 Sect. 3C.02 to 3C.06

Option:

06 If used on approaches to a roundabout, lane-use arrows may be either normal or fish-hook arrows, either with or without an oval symbolizing the central island, as shown in Figure 3C-2.

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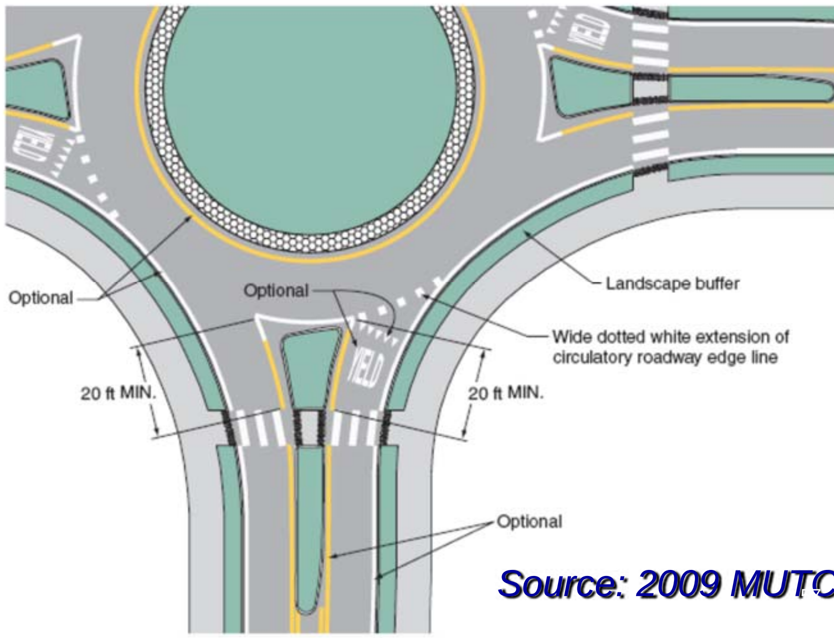
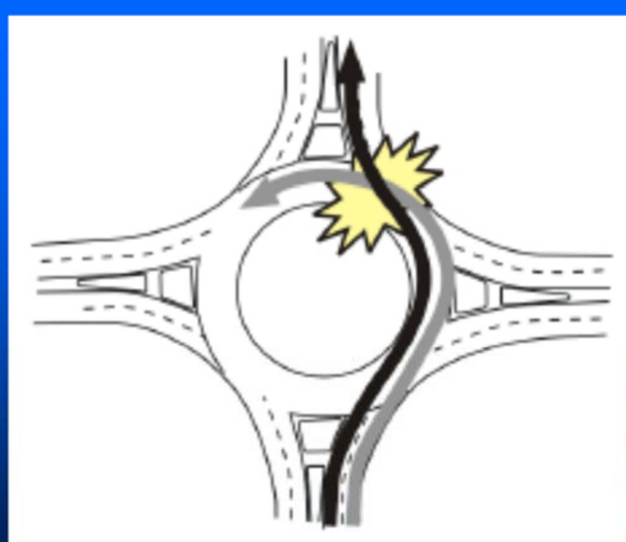
Figure 3C-1. Example of Markings for Approach and Circulatory Roadways at a Roundabout





Exits at multilane roundabout are problematic and require special treatments

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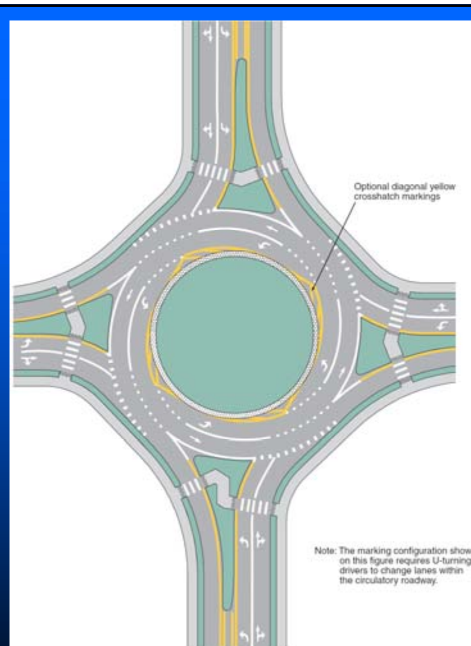
Two-lane roundabouts



Source: 2009 MUTCD

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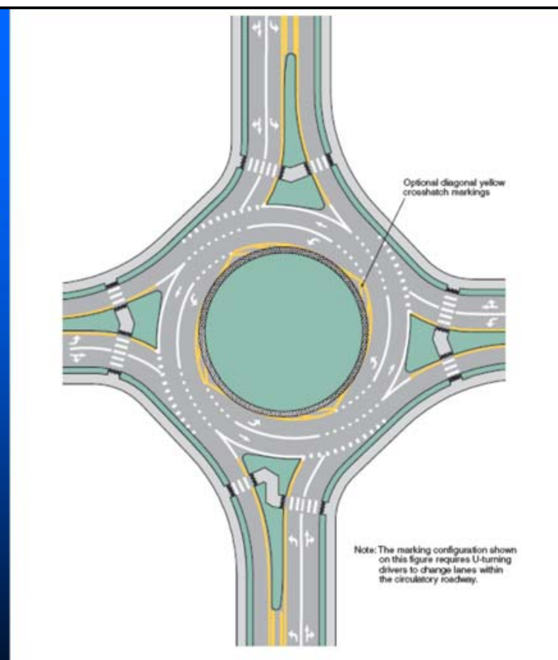
Two-lane roundabouts with one lane exits



Source: 2009 MUTCD

60

Two-lane exits have higher crash rates 61

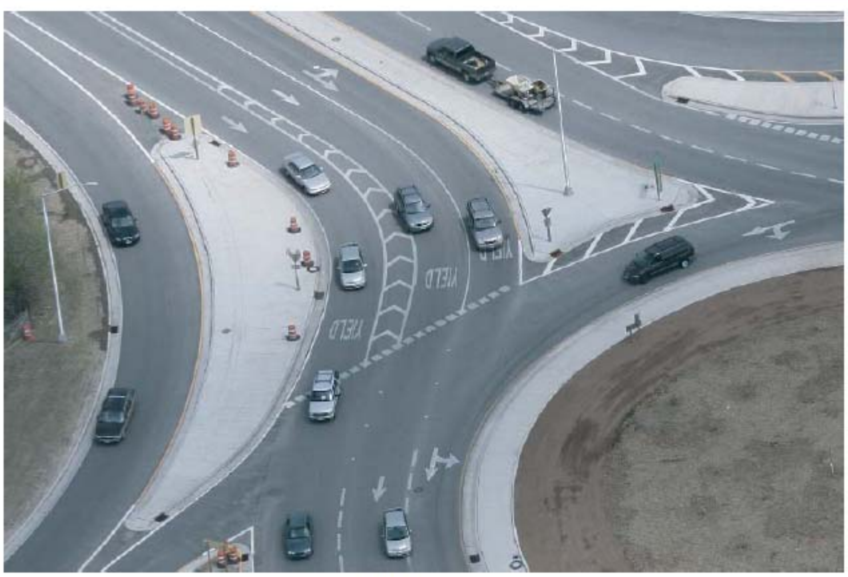
Approach markings to guide drivers to select correct lane at a multilane roundabout 62

Reduction from 2 lanes to 1 lane is much too abrupt 63

Approach markings narrowed to a single lane on multi-lane roadway 64

Circulatory road is narrowed to one lane to guide drivers to select correct lane

65



Wisconsin

Vane Striping for multi-lane roundabout (NCHRP 672)

66

Roundabout in Wisconsin with
MUTCD spiral striping

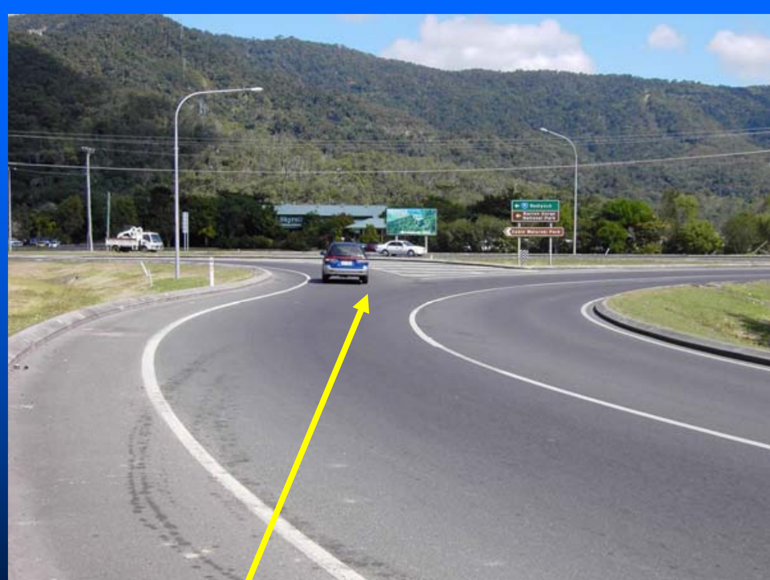
67

Keeping markings visible in snowy
climates may be a challenge

68

Circulatory road is narrowed to one lane to guide drivers to select correct lane

69



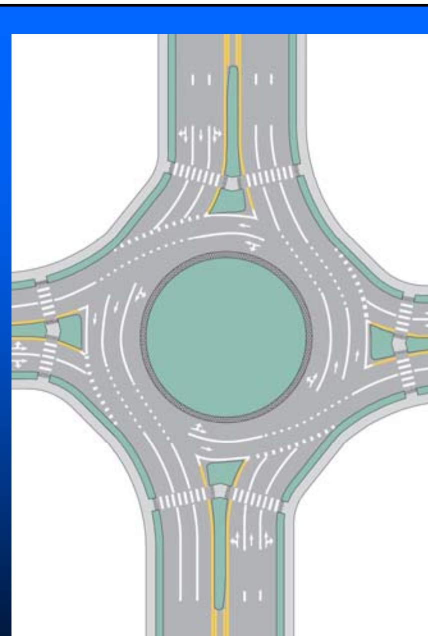
Exit is narrowed to one lane to restrict the inner lane from exiting

70

Exit is narrowed to one lane to restrict the inner lane from exiting

71

Three-lane roundabouts



Source: 2009 MUTCD

72

SUMMARY REPORT

An Evaluation of Signing for Three-Lane Roundabouts

FHWA Publication No.: FHWA-HRT-10-030

FHWA Contact: Joe Bared, HRDS-05, (202) 493-3314, joe.bared@dot.gov

Introduction

Since the introduction of the modern roundabout to North America nearly two decades ago, roundabout acceptance has continued to grow. As of 2007, there are more than 1,000 roundabouts in North America, and that number is growing rapidly.[1] This acceptance is attributed to the superior operational and safety performance of roundabouts relative to conventional signalized intersections in appropriate conditions.[2-4] Although multilane roundabouts have been found to be safer than conventional alternatives, especially with respect to injury and fatal crashes, they are not without safety challenges. One of these challenges is getting motorists to select and stay in their proper lanes as they navigate the roundabout. Some motorists take the fastest path through roundabouts by entering in the right lane, crossing to the center lane midway through the circular roadway, and then crossing back into the right lane at the exit.[5,6] This behavior creates a risk of sideswipe crashes. Another challenge for both safety and operational efficiency is that motorists sometimes have difficulty interpreting lane-control arrows in the roundabout context.[7,8] Even with these unresolved issues, the safety and operational advantages of one- and two-lane roundabouts are so substantial that engineers have begun to introduce three-lane roundabouts where traffic cannot be accommodated in one or two lanes.[9] Figure 1 shows a three-lane roundabout in Michigan.

Figure 1. Michigan three-lane roundabout.

Source: Michigan Department of Transportation Photography Unit

U.S. Department of Transportation
Federal Highway Administration

www.tfhrc.gov

Research, Development, and Technology Turner-Fairbank Highway Research Center 300 Georgetown Pike, McLean, VA 22101-2296

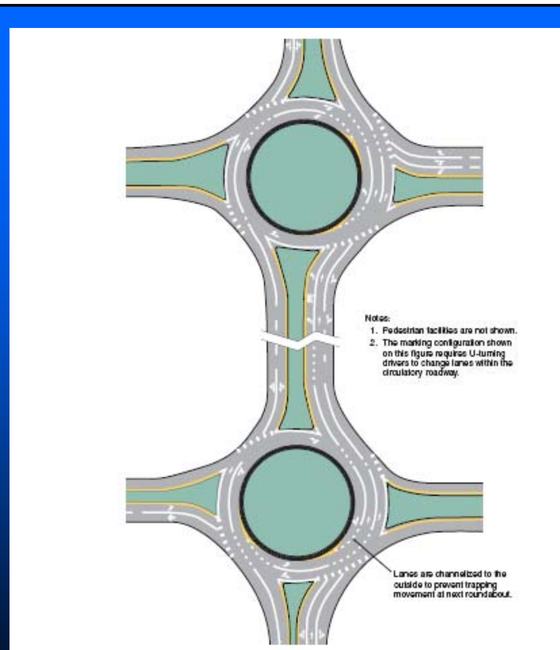
FHWA-HRT-10-030

Findings:

- Overhead signing reduces inappropriate lane changes
- “Turbo” type treatments may be needed to eliminate such movements – discussed later in the webinar

73

Linked roundabouts



Source: 2009 MUTCD

74

Approach Speed Reduction Strategies

75

Highly visible chevron signs provide advance warning of central island

Source: www.roundabouts.us (Scott Ritchie)

76

Circulatory roadway cannot be seen

Chevrons on splitter island?

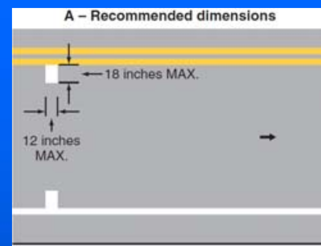
Source: Janet Kennedy, Transport Research Laboratory, UK

Transverse yellow bar markings

78

Source: www.roundabouts.us (Scott Ritchie)

Section 3B.22 – Speed reduction markings added as an Option



79

Bicycles

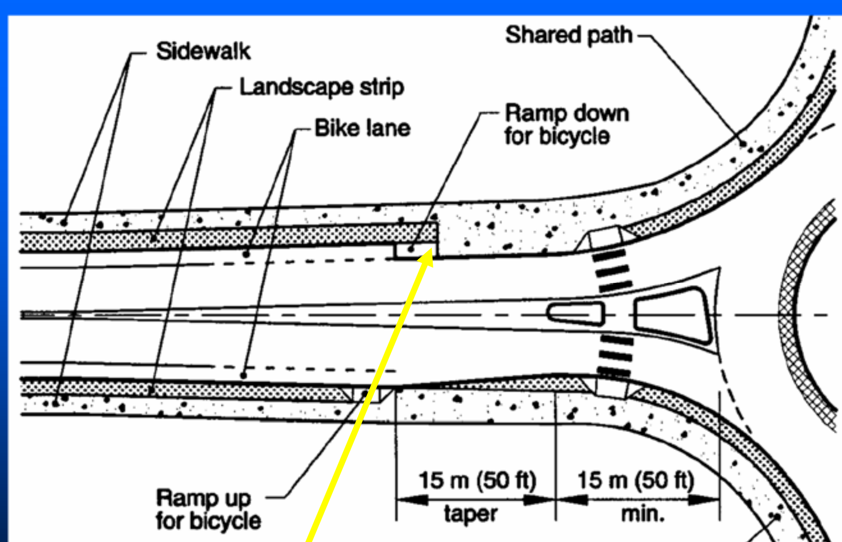
Source: Bicycles at Roundabouts

State of the Practice (Moule)

80

Some cyclists use the road

81

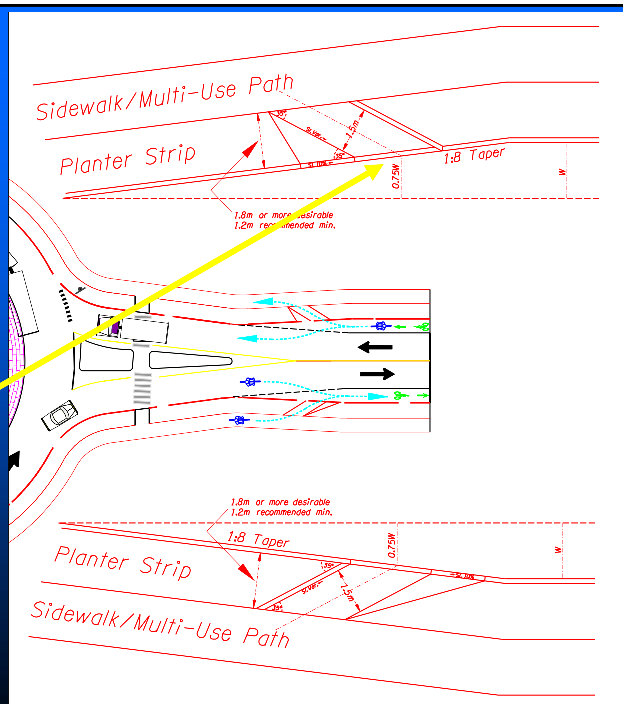


This Bike Ramp Detail

is no longer recommended

82

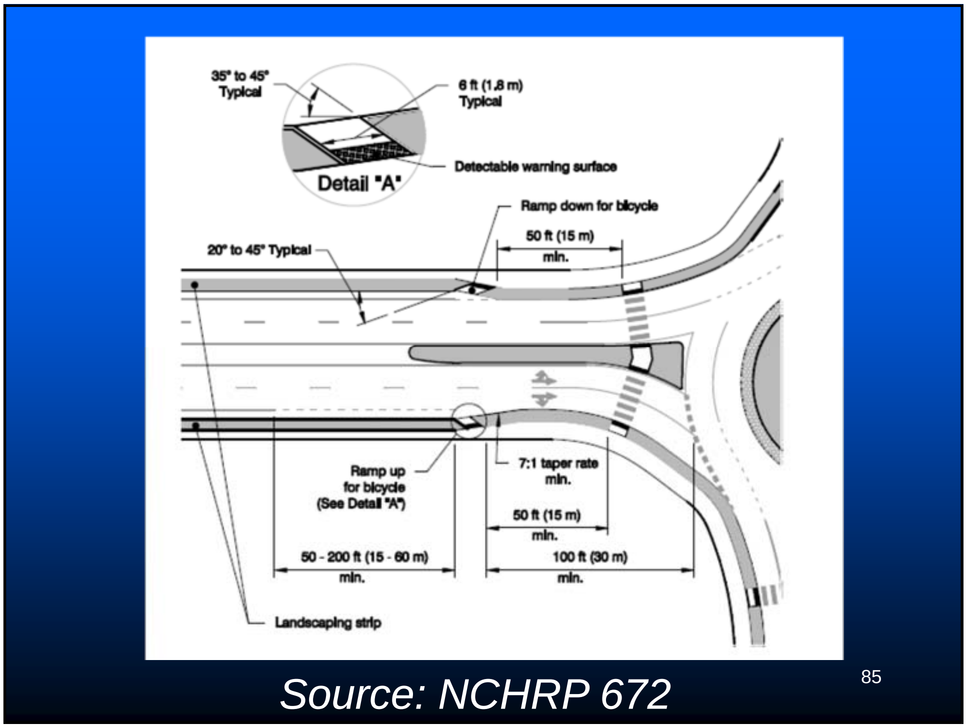
Oregon DOT Bike Ramp Detail



35° angle; 1:8 taper, located after taper starts

Photo of ramp with ODOT design (Bend, Oregon)

84


35° to 45° Typical
6 ft (1.8 m) Typical
Detectable warning surface
Detail "A"
Ramp down for bicycle
50 ft (15 m) min.
20° to 45° Typical
Ramp up for bicycle (See Detail "A")
7:1 taper rate min.
50 ft (15 m) min.
50 - 200 ft (15 - 60 m) min.
100 ft (30 m) min.
Landscaping strip
Source: NCHRP 672
85

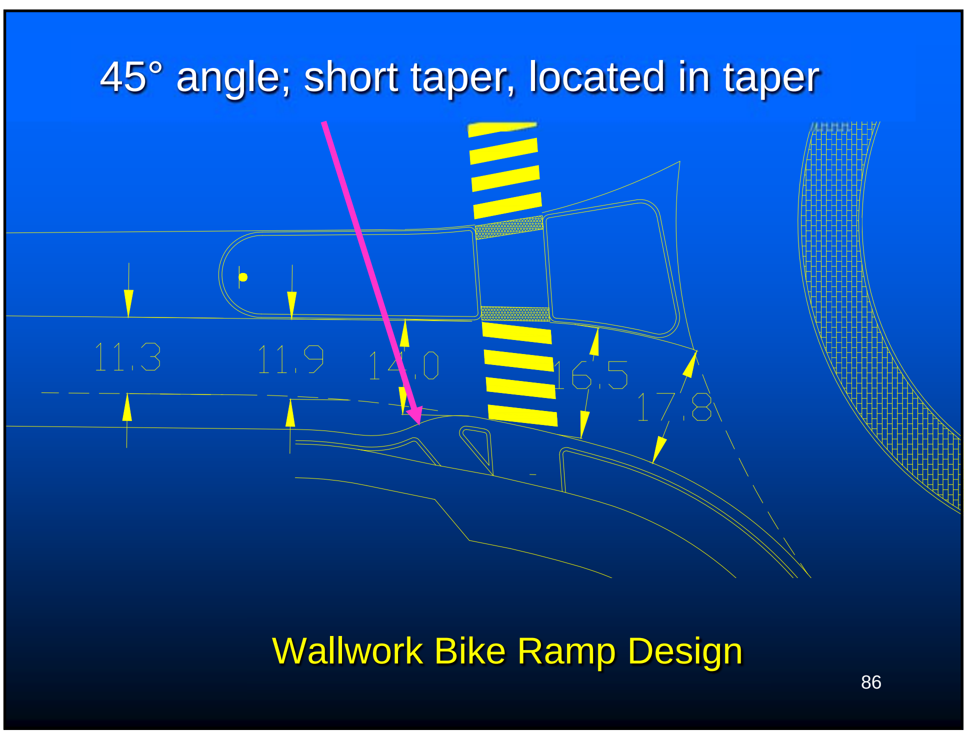
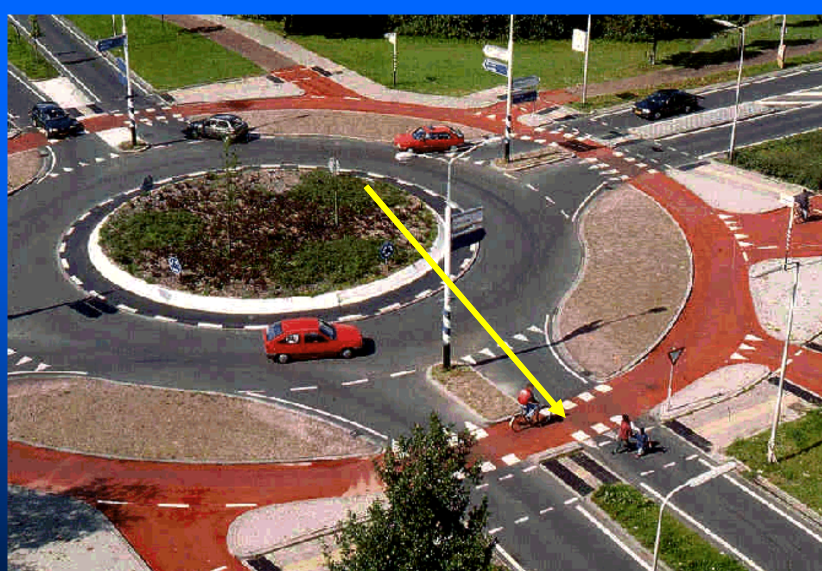

45° angle; short taper, located in taper
11.3
11.9
14.0
16.5
17.8
Wallwork Bike Ramp Design
86

Photo of ramp with Wallwork design (Grand Junction, CO)

87



Bicycle lane on perimeter in The Netherlands

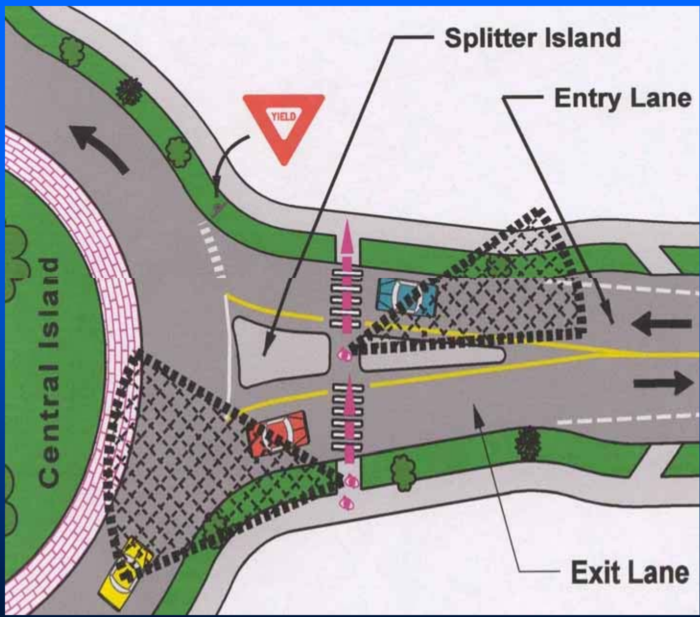
88

Pedestrians

89

Vehicles do not yield to pedestrians

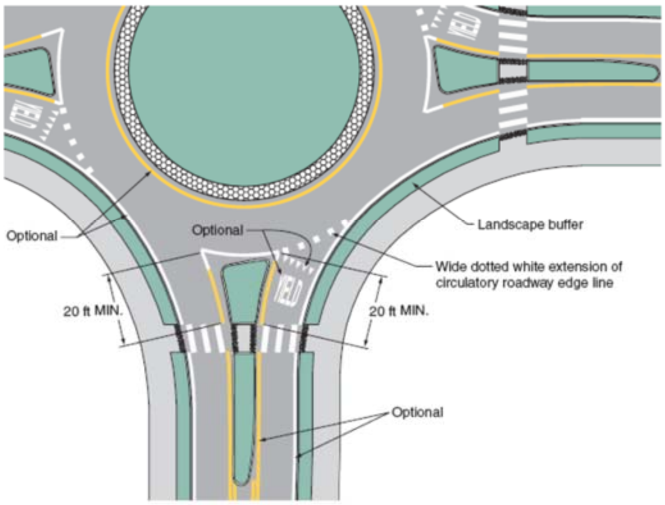
90



Pedestrians should cross in two stages

91

Figure 3C-1. Example of Markings for Approach and Circulatory Roadways at a Roundabout



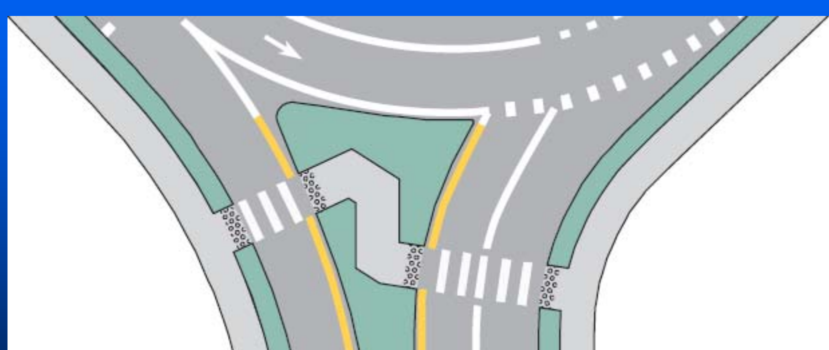
Source: 2009 MUTCD

92

Source: Conflicts and Accidents at Multilane Roundabouts in WA (Brian Walsh)

93

Offset Crosswalks



Source: 2009 MUTCD

94

Pedestrian Friendly Design:

- Well-defined crossings; single lane preferred
- Entry speeds less than 20 mph
- One car length from the circulatory roadway
- Splitter islands; slow speeds/adequate deflection
- No pedestrian access to central island
- Prohibit parking to improve sight distance
- Signs/landscaping should not block sight distance
- Lighting illuminates roundabout and approaches

95

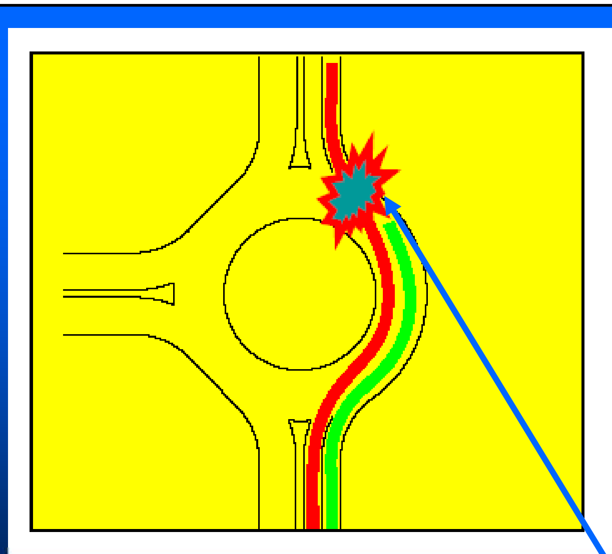
Pedestrian Studies:

- Tight-exit design shows little benefit for pedestrians by reducing speed
- Studies in Europe show that most pedestrian crashes occur at roundabout entries
- No relationship has been reported between pedestrian collisions and exit radius.
- Both British and Australian roundabout collision studies show significant reduction in pedestrian injury and fatal collisions with roundabouts

96

Pedestrian Studies:

- Pedestrian accident rates increase with traffic volumes and pedestrian volumes
- As pedestrian/vehicle crossing conflicts increase, crosswalk treatments should be improved
- Designed correctly, roundabout exits with less tight R3s can improve capacity/reduce vehicle crashes, without increasing exit speeds or harming pedestrians
- U.S. Access Board has continuing concerns about roundabouts safety for visually impaired pedestrians



Exit crash due to overlap at MLR with tight R3 radius

Source: Alternate Design Methods for Pedestrian Safety at Roundabout Entries and Exits (Baranowski)

How does a blind person cross?

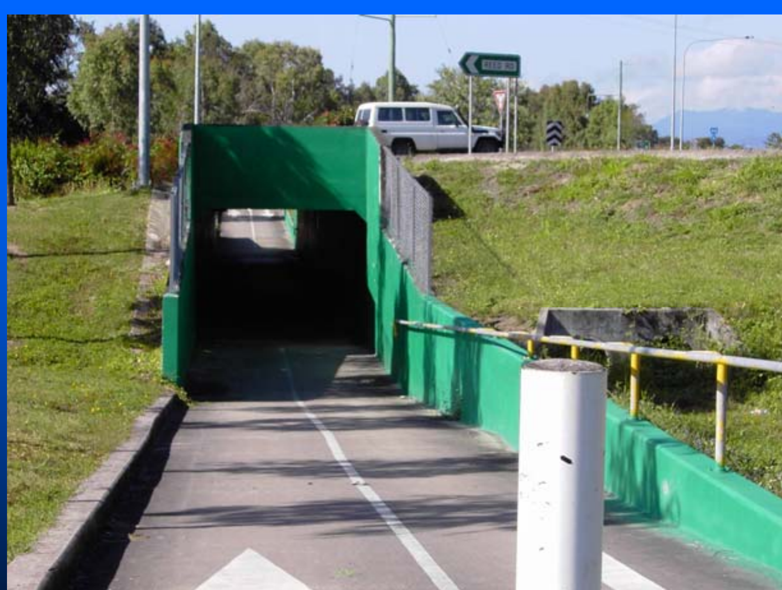
99

Roundabout <u>without</u> landscape strip does not provide proper guidance

100

Detectable warnings at splitter island
Grass landscaping provides guidance

101



Pedestrian/bicycle underpass at a roundabout

102

Pedestrian crossing at roundabout

103

US Access Board Concerns

- Motorists in the U.S. have a poor yield rate at free flow lanes, less than 5 %
- Even when drivers yield, blind pedestrians have difficulty detecting the yield
- Landscaping and other design features should direct blind pedestrians to the crosswalks
- Webinar on Pedestrian Safety and Accessibility available at http://www.walkinginfo.org/training/pbic/collateral/pedfocus_webinar_03-07-2012_slides.pdf

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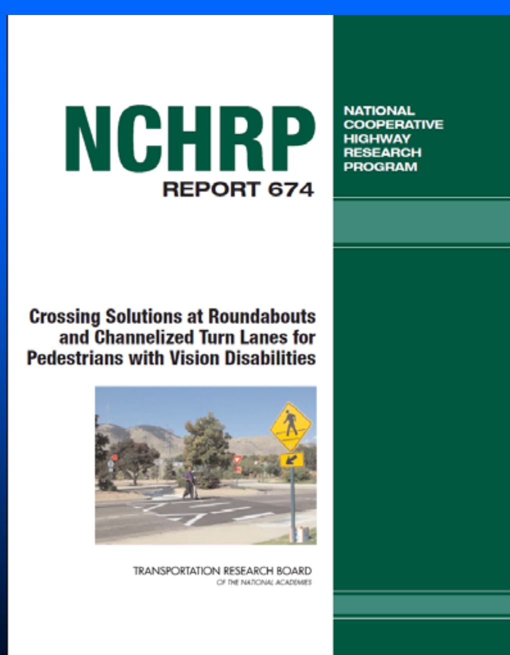
Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way

- Pedestrian crossing easily located for way finding at all roundabouts
- Where pedestrian crossings are multi-lane; pedestrian-activated signals shall be provided.
- Section 4F.03 of the MUTCD provides additional provisions for the use of pedestrian hybrid beacons (HAWKS) at roundabouts. In particular, the pedestrian signal heads may be dark (rather than displaying the upraised hand) while the pedestrian actuated signal is also dark. This allows pedestrians to cross the roadway without activating the pedestrian signal if they so desire, which can further reduce delay to motor vehicles.

105



- Raised Crosswalks
- Pedestrian Hybrid Beacons

106

U.S. Department of Transportation
Federal Highway Administration

Pedestrian and Bicycle Information Center

Pedestrian Safety and Accessibility Considerations at Modern Roundabouts

Presented by:

Dr. Bastian Schroeder
Institute for Transportation Research and Education (ITRE) at North Carolina State University

Dr. Hillary Isebrands
Safety and Design Technical Service Team, FHWA Resource Center

March 7, 2012

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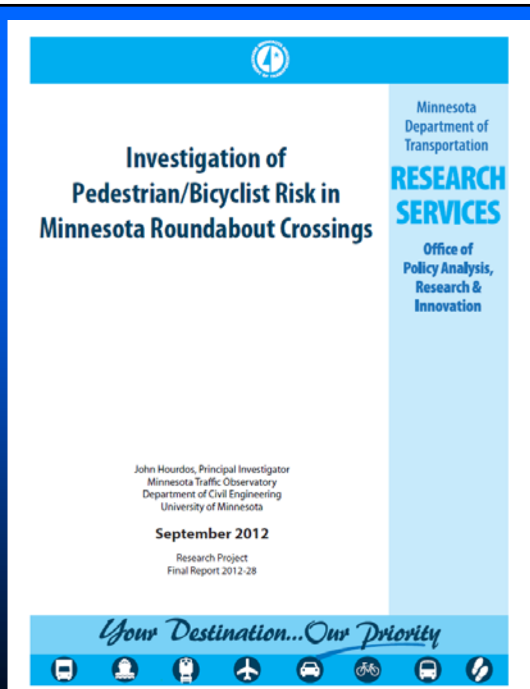

Minnesota Department of Transportation

RESEARCH SERVICES

Office of Policy Analysis, Research & Innovation

Investigation of Pedestrian/Bicyclist Risk in Minnesota Roundabout Crossings

John Hourdos, Principal Investigator
Minnesota Traffic Observatory
Department of Civil Engineering
University of Minnesota

September 2012

Research Project
Final Report 2012-28

Your Destination...Our Priority

108

Current Status:

- ✓ Access Board Notice of Proposed Rulemaking (NPR) received extensive comments which are being reviewed
- ✓ Treatment alternatives (non-signalized) need more research to solidify results
- ✓ Capitalizing on momentum of national accessibility debate and existing treatment installations
- ✓ More research is forthcoming and should emphasize compatibility with the 674 framework
- ✓ FHWA is looking for municipalities willing to assist with RRFB accessibility evaluation.

109

Snow Removal and Maintenance

110

Snow Removal from Center island outward - (NCHRP 672)

Source: Roundabouts and Light Rail: An Innovative Intermodal Solution (Baranowski)

"Study on the Securement of Smooth Traffic Flow on Roundabouts in Cold, Snowy Regions"

111

Work Zone Traffic Control:

- With all traffic diverted away from the work area
- With some traffic diverted, or
- Under full traffic
- Example from Chapter 10 of NCHRP 672 shows stage construction with roads partially open

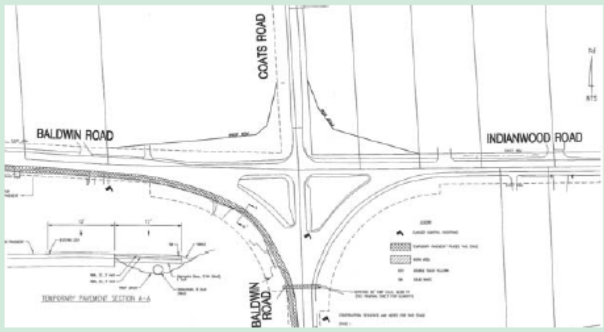
112

Baldwin Road/Coats Road/Indianwood Road

A single-lane roundabout was constructed at the intersection under partial traffic using four construction stages. Baldwin Road is the major roadway, which includes the west and south approaches of the intersection. The shaded portions of the plans represent the permanent pavement under construction, temporary pavement being placed for construction staging, or temporary pavement under traffic.

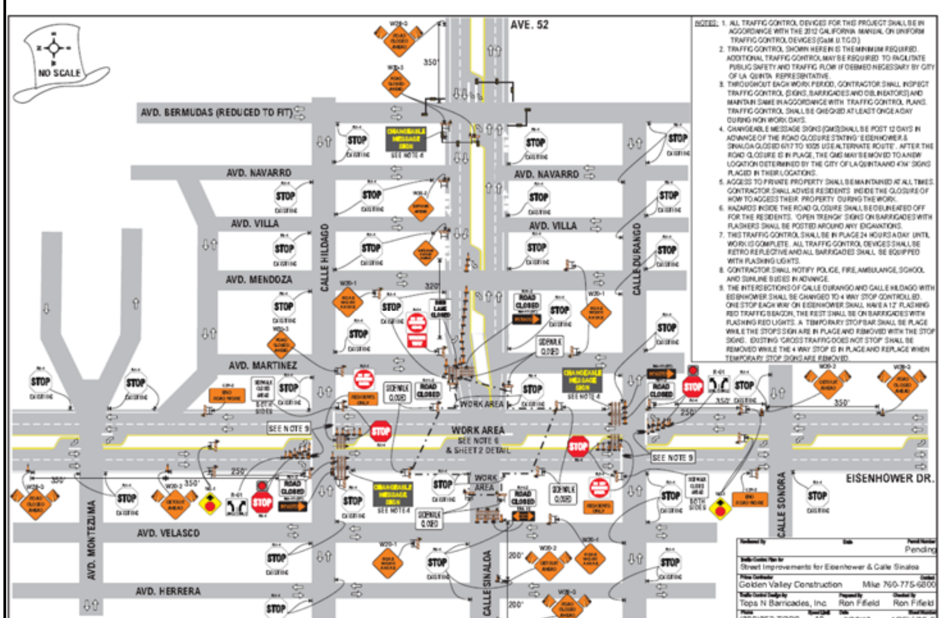
Stage I: Temporary Roadway Construction

- Construct a 12-ft (3.6-m) temporary roadway adjacent to the existing Baldwin Road for the east and south approaches of the intersection.
- Construct replacement culvert over the south approach.
- Maintain two-way traffic on the east, west, and north approaches.
- Maintain traffic on the south approach with partial lane closure controlled with flagging.



113

Stage II: Primary Roundabout Construction



Specialized Roundabout Operations

115

Roundabouts at Interchanges

116

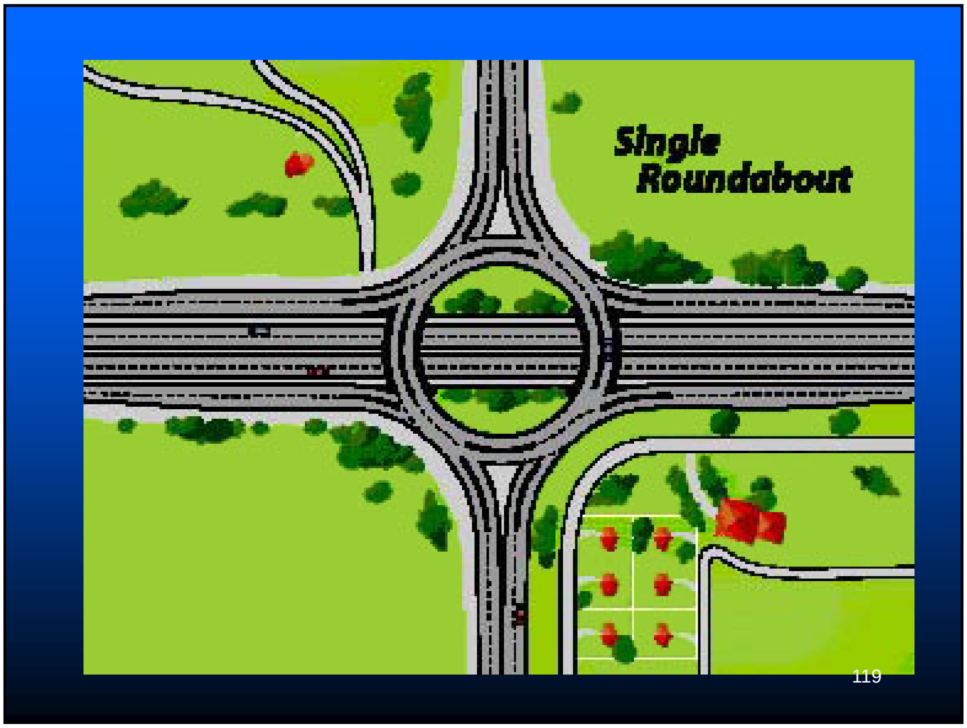
Roundabouts used at interchanges

Source: 2009 MUTCD

117

Roundabout at an interchange in Vail, CO

118


Single
Roundabout
119


70
WEST
RIGHT
LANE
ONLY
Roundabout at an interchange
120

In Series

121

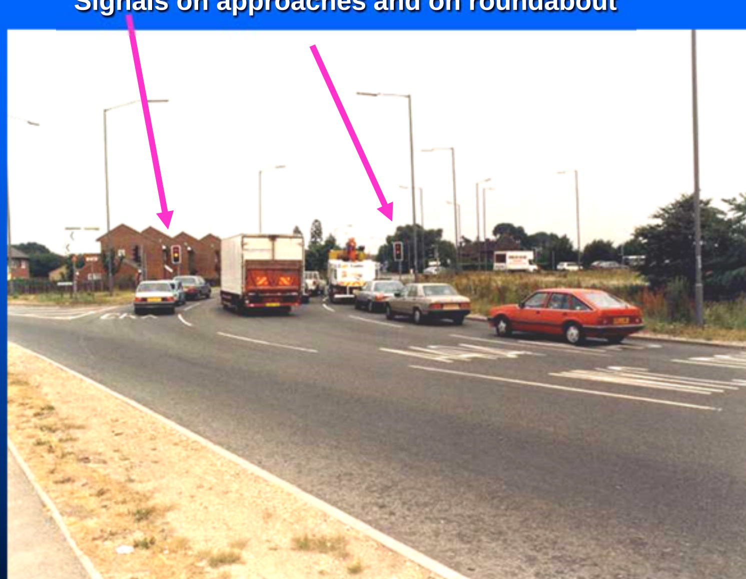
Roundabout series Golden and Avon, CO

122

Signalized Roundabouts

123

Signals on approaches and on roundabout



Signalized roundabout/gyratory

124

Scoot operated - one stop on roundabout

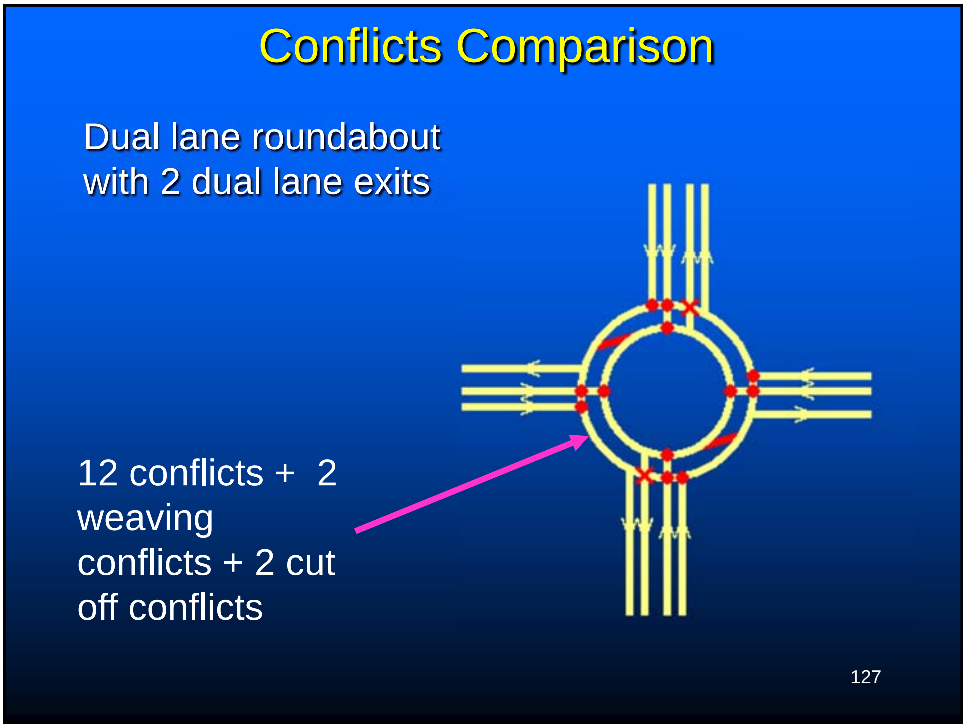
Turbo Roundabouts

125

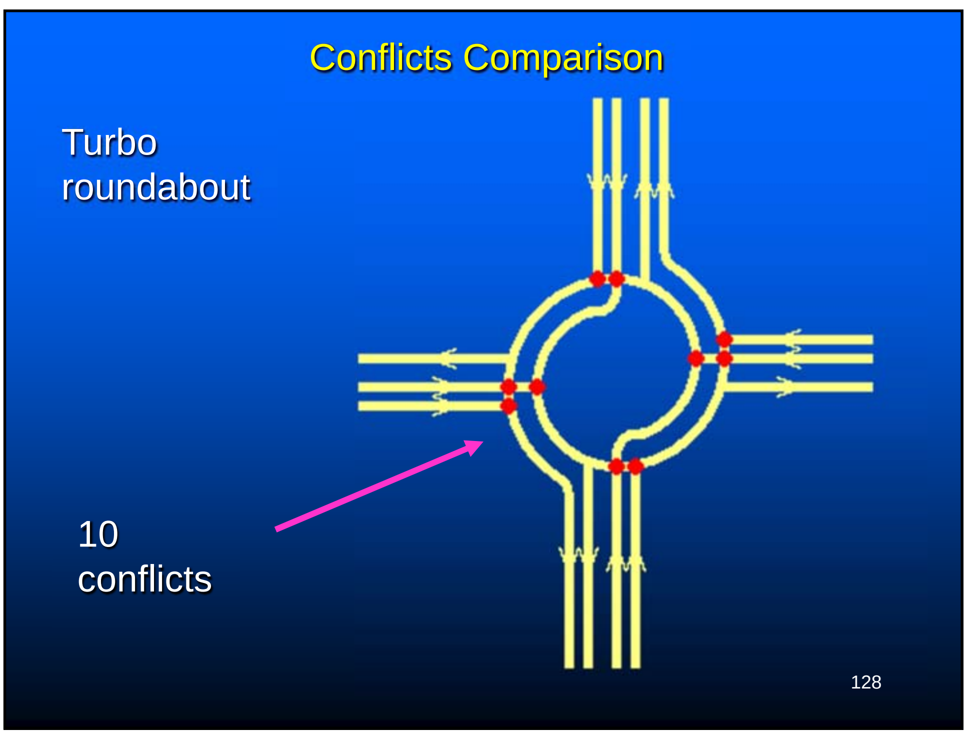
Problem Definition:

- Limited capacity single lane roundabout
- Bad safety record of traffic signals
- Standard dual lane roundabout
  – often not suited for traffic volume
  – weaving difficult on high traffic volume

126



Conflicts Comparison
Dual lane roundabout
with 2 dual lane exits
12 conflicts + 2
weaving
conflicts + 2 cut
off conflicts
127

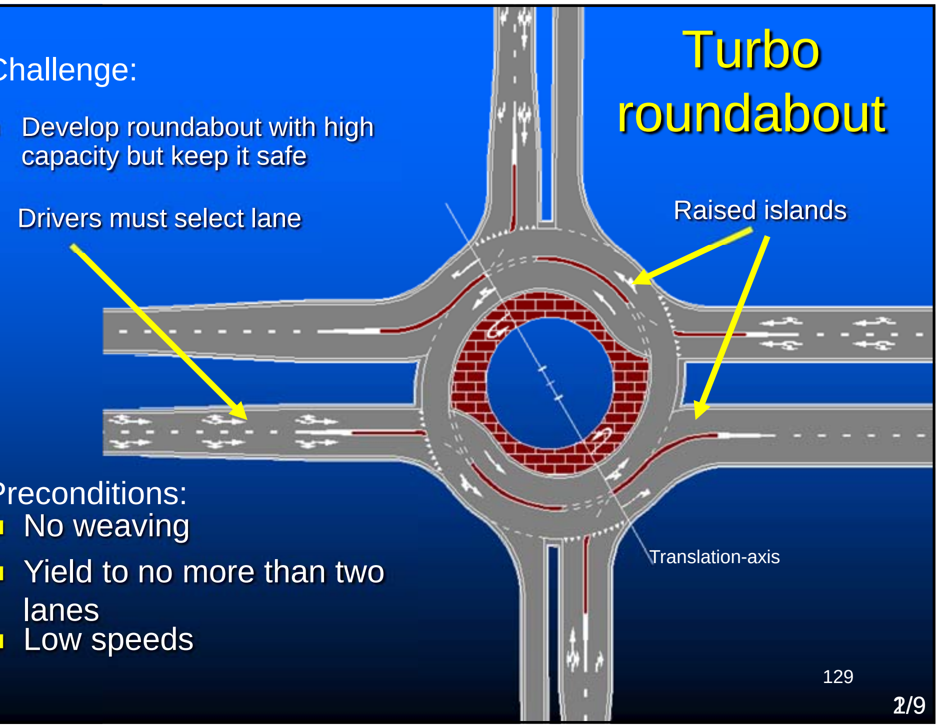


Conflicts Comparison
Turbo
roundabout
10
conflicts
128

Turbo roundabout

Challenge:

- Develop roundabout with high capacity but keep it safe



Preconditions:

- No weaving
- Yield to no more than two lanes
- Low speeds

129

2/9

CASE STUDIES

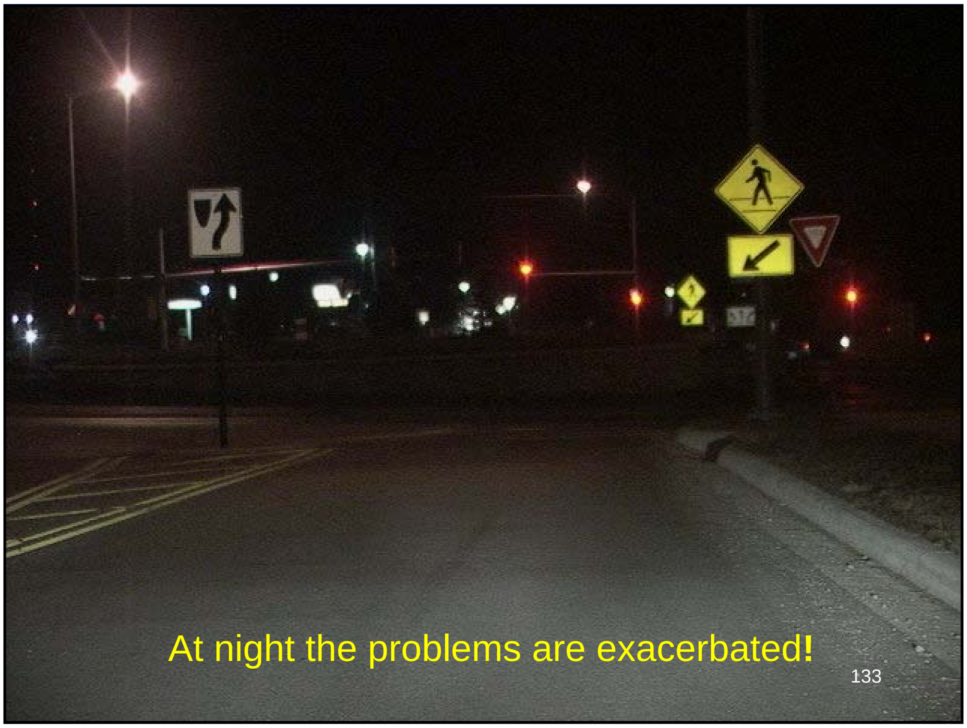
130

CASE STUDY I

131

How many design errors can you find?

132

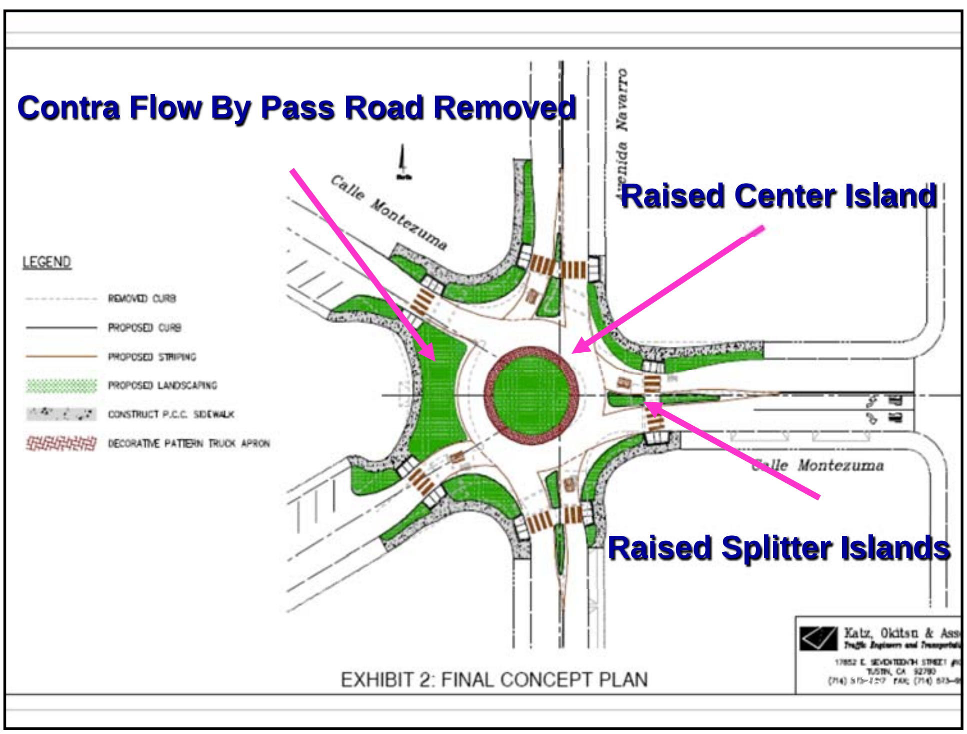


CASE STUDY II

(Avenida Navarro and Avenida Montezuma)

134


Contra flow by
pass lane
Stop signs
Flat islands
STOP
What is wrong here ?
135


Contra Flow By Pass Road Removed
Raised Center Island
Raised Splitter Islands
Calle Montezuma
Calle Montezuma
LEGEND
REMOVED CURB
PROPOSED CURB
PROPOSED STRIPING
PROPOSED LANDSCAPING
CONSTRUCT P.C.C. SIDEWALK
DECORATIVE PATTERN TRUCK APRON
EXHIBIT 2: FINAL CONCEPT PLAN

137

CASE STUDY III

(Interstate 10 at Cabazon)

138


139


No landscaping
Minimal signage
140

Good Features

- Existing multi-way stops operated at LOS F during peaks
- Perfect application of roundabouts for an interchange
- Underpass not widened
- Right of way available
- Access points kept back from roundabout
- Even with less than optimal design, they still work
- Diagrammatic signs provide better guidance

142

Problems

- Incorrect Signs Used at Crosswalks
- Severe grades reduce performance of roundabouts
- Dual lane exits cause frequent weaving conflicts
- Off ramp signing not adequate
- Signing on the center island constantly hit due to lack of any landscaping
- Roundabout have barren ugly look
- A lot of driver confusing continues

143

Major conflict point at this two lane roundabout

144

145

What's wrong here with the signage?

Case Study IV

(Railroad Crossing Near Salt Lake City)

146

SOURCES OF INFORMATION

148

Best Sources of Information

- Roundabout Guide – NCHRP Reports 572/672
- NCHRP Report 674 on Pedestrian Crossing Solutions at Roundabouts
- Florida, Kansas, Oregon and New York Roundabout Guides
- Section 915 of the WADOT Design Manual
- TRB Roundabout Conference Carmel, Indiana, 2011

http://www.teachamerica.com/RAB11/

Kansas City, 2008: http://www.teachamerica.com/RAB08/

- Webinar Reference List

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More Information on Web Sites

NYSDOT
www.dot.state.ny.us/roundabouts/round.html

Arizona DOT
www.dot.state.az.us/CCPartnerships/Roundabouts/index.asp

Kansas State University
www.ksu.edu/roundabouts/

Florida DOT
whttp://www.dot.state.fl.us/trafficoperations/Research/pdf/Florida_Roundabout_guide_2nd_Ed.pdf

Maryland DOT www.sha.state.md.us/safety/oots/roundabouts/index.asp

Oregon DOT
www.odot.state.or.us/techserv/engineer/pdu/Roundabouts/Rndbt index.htm

Federal Highway Administration www.fhwa.dot.gov www.tfhrc.gov/safety/00068.htm

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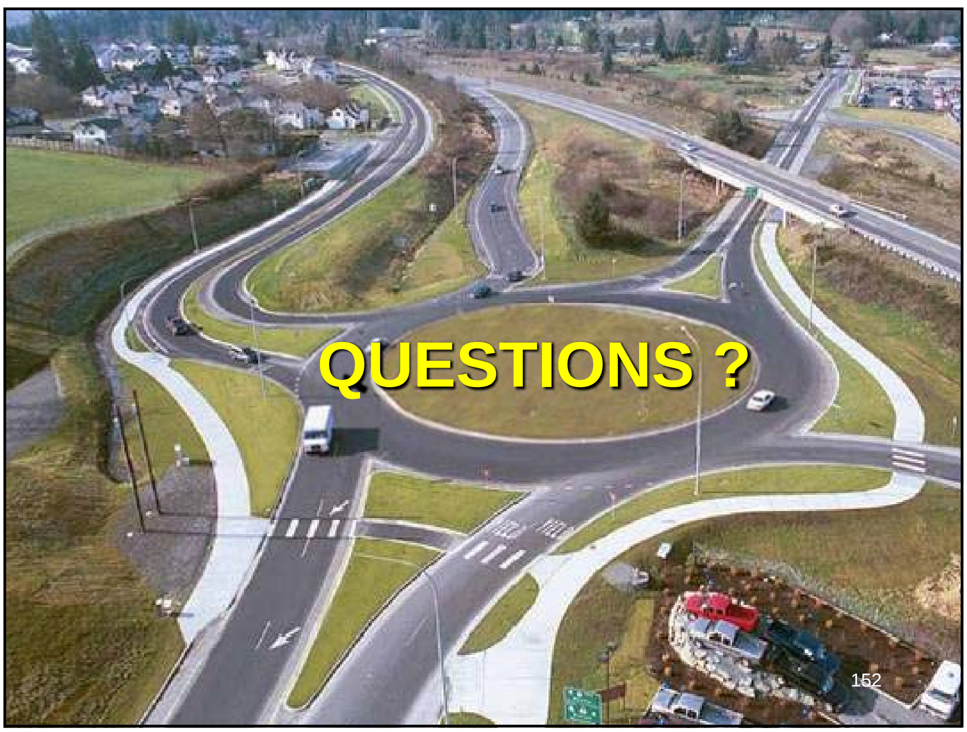
Future Webinars

- February 7: *Improving Pedestrian Safety at Uncontrolled Locations*
- February 13: *Clear Zones*
- February 21: *Work Zone Temporary Traffic Control*
- February 27: *Improving Safety at Railroad-Highway Grade Crossings*
- March 13: *Traffic Calming: Best Practices and Recent Trends*

151



Sign too high for headlights

153