MODERN ROUNDABOUTS – THE OPERATIONAL ASPECTS

Presented by
Nazir Lalani
NazirLalani1@gmail.com

Other Key Design Elements
Trucks

Left-turning truck problem
Source: FHWA Roundabout Guide
Truck Apron Design

Source: WA DOT Design Manual – Chapter 915
Trucks can be handled by providing a truck apron.

Rear wheels mount the truck apron.

Video at www.traffexengineers.com
Truck apron 6 inches high!
To accommodate trucks, exit needs to be 17’ wide so R3 does not govern exit speed.

Illumination
Overhead area wide lighting (not oriented to pedestrians)

Source: NCHRP 672

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

W = watts; HPS = High Pressure Sodium
Source: Kansas Roundabout Guide (II)
### 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)

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### 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
EINoblesville, 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.

Pedestrian oriented lighting at crosswalks
Developing Effective Standards and Guidelines for Roundabout Lighting

ITE Annual Conference
Anaheim, CA
August 18, 2008
By: John Beery, P.E., PTOE
Andrew Rodewald, EI
Noblesville, IN

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

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

Curbing and planting detail

Source: Modern Roundabouts for Oregon (WSDOT)
Curbing and planting detail
Source: Roundabout Design Standards - City of Colorado Springs

Landscaping the Central Island Properly (SSD)
Source: www.roundabouts.us (Scott Ritchie)
Landscaping design for roundabouts

Source: www.roundabouts.us (Scott Ritchie)
Landscaping Zones (NCHRP 672)
Poor sight distance caused by landscaping and signage on the center island
Signing and Striping

Why is Signing so Important?
Skid marks provide a hint!
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.

New regulatory signs for use at roundabouts

Roundabout Directional Arrow signs (on central island)
Roundabout Circulation sign (with YIELD sign at mini-roundabouts)
Regulatory and warning signs for use at a two-lane roundabout

Source: 2009 MUTCD

Source: 2009 MUTCD
Diagrammatic destination sign

Mini Roundabouts
“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.”
“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”
Make sure the deflection is done correctly

FHWA Research Contract

The Federal Highway Administration (FHWA) has sponsored a research project entitled "Traffic Calming, Marking, and Design Alternatives for Mini-Roundabouts" Contract No. DTFH61-00-C-00007. The objectives of the contract included the testing and evaluation of mini-roundabouts to be implemented in the United States. Initial testing for aggressive drivers and cyclists, and conduct an economic analysis of the mini-roundabouts will then be evaluated by the research team for FHWA.

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

We Zhang, Ph.D., P.E.  
202-493-0217  
202-493-0249 fax  
we.zhang@fhwa.dot.gov

Joe Bared, Ph.D., P.E.  
202-493-0214  
202-493-0419 fax  
joe.bared@fhwa.dot.gov

Federal Highway Administration  
700 Pennsylvania Ave, N.W.  
Washington, D.C. 20590

Ram Jaganathan - VHB, Inc.  
760-457-2000  
760-447-8296 fax  
ram@vhb.com

Mini-Roundabouts

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

The mini-roundabout features a much smaller insulated island on the outside of 50 ft. (15 m), and an overall island (central island, e.g., 1/2 to 4 (4 m/m) island) that is loanable. One of the appealing aspects of a mini-roundabout is its small footprint and relatively low implementation cost, which allows the他表示s to be a viable treatment for urban and suburban intersections of lower speed, local roads. In most cases, mini-roundabouts can refresh existing roadway alignments. All finalizations will be added within existing boundaries.

The mini-roundabout should primarily be designed for passenger cars that are expected to use the circular roadway around the central island, which is the half of the traffic lane or travels and makes right turns near the central island to complete turning maneuvers due to reduced intersection geometry. For busy central islands, additional physical delineation boundaries, such as raised pavement markers or yellow stripes, are needed to help keep pedestrians and bicyclists clear of the central island. The speed limit is to lower to 15 mph on the approach to a mini-roundabout to ensure a reduction in speed.
Pavement Markings

Markings

Section 3C.02 White Lane Line Pavement Markings for Roundabouts

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.
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).

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

Option:

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

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

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:

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

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

Secs. 3C.07 to 3C.08

Option:

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.
Exits at multilane roundabout are problematic and require special treatments
Two-lane exits have higher crash rates

Approach markings to guide drivers to select correct lane at a multilane roundabout
Reduction from 2 lanes to 1 lane is much too abrupt

Approach markings narrowed to a single lane on multi-lane roadway
Circulatory road is narrowed to one lane to guide drivers to select correct lane

Vane Striping for multi-lane roundabout (NCHRP 672)
Roundabout in Wisconsin with MUTCD spiral striping.

Keeping markings visible in snowy climates may be a challenge.
Circulatory road is narrowed to one lane to guide drivers to select correct lane

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

Three-lane roundabouts

Source: 2009 MUTCD
Findings:

- Overhead signing reduces inappropriate lane changes

- “Turbo” type treatments may be needed to eliminate such movements – discussed later in the webinar

Source: 2009 MUTCD
Approach Speed Reduction Strategies

Highly visible chevron signs provide advance warning of central island

Source: www.roundabouts.us (Scott Ritchie)
Circulatory roadway cannot be seen
Chevrons on splitter island?

Source: Janet Kennedy, Transport Research Laboratory, UK

Transverse yellow bar markings
Source: www.roundabouts.us (Scott Ritchie)
Section 3B.22 – Speed reduction markings added as an Option

Bicycles

Source: Bicycles at Roundabouts
State of the Practice (Moule)
Some cyclists use the road

This Bike Ramp Detail *is no longer recommended*
Oregon DOT Bike Ramp Detail

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

Photo of ramp with ODOT design (Bend, Oregon)
45° angle; short taper, located in taper

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

Bicycle lane on perimeter in The Netherlands
Vehicles do not yield to pedestrians
Pedestrians should cross in two stages

Source: 2009 MUTCD
Crosswalk 1-2 vehicle lengths back

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

Offset Crosswalks

Source: 2009 MUTCD
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

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
**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?

Roundabout without landscape strip does not provide proper guidance
Detectable warnings at splitter island
Grass landscaping provides guidance

Pedestrian/bicycle underpass at a roundabout
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.
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.

- Raised Crosswalks

- Pedestrian Hybrid Beacons
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
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.

Snow Removal and Maintenance
Snow Removal from Center island outward - (NCHRP 672)

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

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

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
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 theplans 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.
Specialized Roundabout Operations

Roundabouts at Interchanges
Roundabouts used at interchanges

Source: 2009 MUTCD

Roundabout at an interchange in Vail, CO
Roundabout at an interchange
In Series

Roundabout series
Golden and Avon, CO
Signalized Roundabouts

Signals on approaches and on roundabout

Signalized roundabout/gyratory
Scoot operated - one stop on roundabout
Turbo Roundabouts

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
**Conflicts Comparison**

*Dual lane roundabout with 2 dual lane exits*

- 12 conflicts + 2 weaving conflicts + 2 cut off conflicts

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**Conflicts Comparison**

*Turbo roundabout*

- 10 conflicts
Challenge:
- Develop roundabout with high capacity but keep it safe
- Drivers must select lane

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

Turbo roundabout

CASE STUDIES
CASE STUDY I

How many design errors can you find?
At night the problems are exacerbated!

CASE STUDY II
(Avenida Navarro and Avenida Montezuma)
What is wrong here?

Contra flow by pass lane
Stop signs
Flat islands

Contra Flow By Pass Road Removed
Raised Center Island
Raised Splitter Islands
CASE STUDY III
(Interstate 10 at Cabazon)
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
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
What's wrong here with the signage?

Case Study IV
(Railroad Crossing Near Salt Lake City)
When a long train uses the crossing, traffic backs up into the roundabout all traffic comes to a standstill.

View video at: www.traffexengineers.com
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

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_2n
d_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

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
Sign too high for headlights