Consultant Prequalification for Roundabout Design

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INDOT Roundabout Design Policy

• FHWA Guide (NCHRP 672)
• 2009 MUTCD
• HCM 2010
• IDM Chapter 51-12.0
• Soon to be replaced by IDM 305-5.0
Roundabout Design Checklist

Purpose: To provide guidance to designers and reviewers on many of the major items to be considered during the design of roundabouts
Roundabout Design Checklist

• Not a comprehensive list nor a set of hard and fast rules
• Documentation is critical for reviewers to understand the designer’s intentions
• Diverging from the ranges outside of the desirable ranges shown is acceptable but needs to be justified with design documentation
• Take notes! Reviewers will be using this as a guide, so designers should as well.
Roundabout Design Checklist

• Divided into four major categories
  – Planning
  – Design Documentation
  – Roundabout Design
  – Design Plans

• Eventually, designers will be asked to submit completed checklist with all roundabout submittals
Roundabout Planning
Scoping and Justification of Alternatives

“A comparison of roundabout practicality/feasibility vs. other intersection types should be conducted, taking into consideration safety, traffic operations, capacity, ROW impacts, and cost.”
Roundabout Planning

Evaluation Criteria

- High-speed rural intersections
- Locations with mediocre/poor crash history
- Locations with traffic operational problems
- Closely spaced intersections
- Near structures, including freeway interchange ramps
- Access management
- Gateway or transition locations
- Where community enhancement is desired
Roundabout Planning
Evaluation Criteria (cont’d)

• Driveway accommodation/access management opportunities
• Near schools
• Corridors
• Public input
• Constructability
• Maintenance of traffic
• Social impacts
• Economic impacts
• Noise and environmental impacts
Roundabout Planning
Location – Good Locations

• High-speed rural intersections
• Locations with mediocre/poor crash history
• Locations with traffic operational problems
• Closely spaced intersections
• Near structures, including freeway interchange ramps
• Access management
• Gateway or transition locations
• Where community enhancement is desired
• Near schools
• Corridors
• NCHRP currently performing research to analyze roundabout corridors
• Our experience: work very well when all roundabouts are operating under capacity
• No need to coordinate timings
• Every vehicle on every approach must slow down to enter the roundabout
• Slower speeds increase motorist and pedestrian safety
Roundabout Planning
Location – Proceed with Caution

- Within a system of coordinated signals
- On a steep grade
- Where stopping sight distance cannot be achieved
- Near rail crossings
- Closely spaced intersections
Roundabout Planning Documentation

Memo or report with the following, where applicable:

– Traffic volumes and crash history
– 10- & 20-year traffic projections
– Capacity analysis
– Conceptual geometric design
– Public involvement
– Comparison to other intersection types, including “Do Nothing”
– Crash analysis
– Selection of preferred option
Roundabout Planning

Traffic Data

- 10- & 20-year forecasts
  - May be beneficial to phase construction
- Turning movements critical
  - Roundabout capacity dependent on conflicting movements
Roundabout Planning

Traffic Data – Calculating Volumes

Figure 2 – Roundabout Capacity in Year 2030: AM Peak

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Mason Road and Hickory Woods Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Year</td>
<td>2006</td>
</tr>
<tr>
<td>Forecast Year</td>
<td>2030</td>
</tr>
<tr>
<td>Annual Growth Rate (%)</td>
<td>2.0%</td>
</tr>
<tr>
<td>Analyst</td>
<td>TW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YEAR</th>
<th>LEFT</th>
<th>THRU</th>
<th>RIGHT</th>
<th>LEFT</th>
<th>THRU</th>
<th>RIGHT</th>
<th>LEFT</th>
<th>THRU</th>
<th>RIGHT</th>
<th>LEFT</th>
<th>THRU</th>
<th>RIGHT</th>
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<tbody>
<tr>
<td>2006</td>
<td>140</td>
<td>51</td>
<td>12</td>
<td>2</td>
<td>116</td>
<td>144</td>
<td>46</td>
<td>10</td>
<td>154</td>
<td>33</td>
<td>41</td>
<td>2</td>
</tr>
<tr>
<td>2030</td>
<td>200</td>
<td>70</td>
<td>20</td>
<td>0</td>
<td>170</td>
<td>200</td>
<td>60</td>
<td>10</td>
<td>220</td>
<td>50</td>
<td>60</td>
<td>0</td>
</tr>
</tbody>
</table>

Excluded

Year 2030 Traffic Volumes
Mason Road and Hickory Woods Drive
AM Peak

North Leg
200
170
0

West Leg
60
10
220

Approach-Based Totals For Peak Hour

<table>
<thead>
<tr>
<th>Leg</th>
<th>Direction</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>Leaving</td>
<td>130</td>
</tr>
<tr>
<td>North</td>
<td>Approaching</td>
<td>320</td>
</tr>
<tr>
<td>East</td>
<td>Leaving</td>
<td>50</td>
</tr>
<tr>
<td>East</td>
<td>Approaching</td>
<td>110</td>
</tr>
<tr>
<td>South</td>
<td>Leaving</td>
<td>440</td>
</tr>
<tr>
<td>South</td>
<td>Approaching</td>
<td>290</td>
</tr>
<tr>
<td>West</td>
<td>Leaving</td>
<td>480</td>
</tr>
<tr>
<td>West</td>
<td>Approaching</td>
<td>280</td>
</tr>
</tbody>
</table>

South Leg
200
70
20

NORTH
310

330

NORTH

0
60
60
Roundabout Planning
Capacity Analysis - Tools

Capacity Analysis (Macroscopic):
• RODEL / ARCADY
• aaSIDRA
• Equations from FHWA Roundabout Guide
• Equations from NCHRP Report 572 “Roundabouts in the United States” (published in 2007)

Simulations (Microscopic):
• Vissim
• Paramics
Roundabout Planning
Capacity – Approach vs. Circulating

Figure 4-6 NCHRP 672
(Based on HCM)
Roundabout Planning
Capacity – Approach vs. Circulating

Rule of Thumb -> Single lane approach volume = 1,100 – 1,200 vph

NCHRP Report 572
(based on limited US data)
Roundabout Planning
Capacity – Rules of Thumb

• Single-lane roundabouts – up to 25,000 vpd
• Two-lane roundabouts – up to 40,000 vpd
• Three-lane roundabouts – in excess of 55,000 vpd
• Highly dependent upon turning movement percentages
• Rule of Thumb -> Single lane approach volume = 1,100 – 1,200 vph
## Roundabout Planning

### Capacity – LOS Requirements

<table>
<thead>
<tr>
<th>Control Delay (s/veh)</th>
<th>Level of Service by Volume-to-Capacity Ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>v/c ≤ 1.0</td>
</tr>
<tr>
<td>0–10</td>
<td>A</td>
</tr>
<tr>
<td>&gt;10–15</td>
<td>B</td>
</tr>
<tr>
<td>&gt;15–25</td>
<td>C</td>
</tr>
<tr>
<td>&gt;25–35</td>
<td>D</td>
</tr>
<tr>
<td>&gt;35–50</td>
<td>E</td>
</tr>
<tr>
<td>&gt;50</td>
<td>F</td>
</tr>
</tbody>
</table>

* For approaches and intersection-wide assessment, LOS is defined solely by control delay.

NCHRP Report 672 – Exhibit 4-9  
(based on HCM)

- Level of service should meet the IDM for the given facility type.
Roundabout Planning

Queue Length

- Roundabout geometrics used in design should match those in the Capacity Analysis

- Calculated queue lengths should not cause blocking of nearby drives or intersections
Design Documentation

Speeds Appropriate / Fastest Paths

- Definitions of paths per FHWA Guide
- Refer to NCHRP Sections 6.7.1 and 6.7.2
- R1-R2-R3 movement is typically fastest path
Design Documentation
Speeds Appropriate / Fastest Paths

<table>
<thead>
<tr>
<th>Roundabout Type</th>
<th>Recommended Fastest Path Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini Roundabout</td>
<td>20 mph</td>
</tr>
<tr>
<td>Single Lane Roundabout</td>
<td>25 mph</td>
</tr>
<tr>
<td>Multi Lane Roundabout</td>
<td>25 – 30 mph</td>
</tr>
</tbody>
</table>

- Speeds can exceed these recommendations
- Engineering judgment must be used
- Documentation must be provided
Design Documentation
Speed Differential / Consistency

• Desirable to have all speeds within roundabout 10mph – 15mph

• Refer to NCHRP 6.7.3.1

• Should be balanced with other roundabout needs. All variances should be explained in documentation
Design Documentation
Stopping Sight Distance

• All SSD calculations must be shown graphically

• Refer to NCHRP 6.7.3.1

• SSD is a level 1 criteria
Design Documentation
Stopping Sight Distance

• Three locations should be checked:
  – Approach sight distance
  – Sight distance on circulatory roadway
  – Sight distance to crosswalk on exit
Design Documentation
Intersection Sight Distance

• All ISD calculations must be shown graphically
• Refer to NCHRP 6.7.3.2
• ISD is soon to be a level 1 criteria
• Too much ISD can increase roundabout speeds
• Use equations found in NCHRP 672
Design Documentation
Intersection Sight Distance – Revisions to IDM

- MAXIMUM to be determined 50’ in advance of yield with critical headway of 5.0s
- MINIMUM to be determined 18’ in advance of yield with critical headway of 6.5s
Design Documentation
Allowable Landscaping Areas

• Include an overlay of graphical checks of ISD and SSD

• Overlays will reveal areas where landscaping height is not restricted

• Good to perform checks even if landscaping is not part of original plans

• Refer to NCHRP Chapter 9
FHWA Roundabout Guide:
“For a roundabout to operate satisfactorily, a driver must be able to enter the roundabout, move through the circulating traffic, and separate from the circulating stream in a safe and efficient manner. To accomplish this, a driver must be able to perceive the general layout and operation of the intersection in time to make the appropriate maneuvers. Adequate lighting should therefore be provided at all roundabouts.”
Design Documentation
Lighting Design

• Present guidance and resources
  – NCHRP 672, Chapter 8
  – IESNA Publication DG-19-08
  – AASHTO
  – Proprietary methods and vendor assistance
Design Documentation
Lighting Design

• Several studies have been completed to determine the best lighting practices at roundabouts.
  – Approaches
  – Circulatory Roadway
  – Exits

• Light placement in advance of pedestrian facilities is critical

• Pavement markings, signs, and lighting designs go hand-in-hand
Design Documentation
Lighting Design – Conflict Points and Luminaire Placement

- Initial Locations
  - Crosswalks
  - 45°, 135°, 225°, 315° quadrant points
- Accommodate luminaire capability, and illumination and uniformity requirements
- Consider clear zone
- Evaluate arm lengths
Design Documentation

Lighting Design

• The absence of lighting can be better than poorly designed lighting

• Place one light in advance of each approach crosswalk

• Additional lighting at roundabouts should be considered to better illuminate the roundabouts and eliminate dark spots

• Light pollution to neighboring residents can be a concern

• Center island landscaping can incorporate uplighting for additional visibility
Roundabout Design
Geometry

• Roundabout geometry plays a major role in the capacity and safety of the roundabout

• Geometry of roundabout should match geometry in Engineer’s report

• If geometry is different than engineer’s report, it is beneficial to re-run capacity analysis
## Roundabout Design

### Inscribed Circle Diameter

<table>
<thead>
<tr>
<th>Roundabout Type</th>
<th>Low End</th>
<th>High End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lane</td>
<td>90’</td>
<td>180’</td>
</tr>
<tr>
<td>Two Lane</td>
<td>150’</td>
<td>220’</td>
</tr>
<tr>
<td>Three Lane</td>
<td>200’</td>
<td>300’</td>
</tr>
</tbody>
</table>

- Refer to NCHRP 6.3.1
- Exhibit 6-9 provides better detail of inscribed diameters
- Document rationale if larger or smaller sizes are used
Roundabout Design

Approach Alignment

- Right offset should be avoided.
- Left offset is preferred because it typically improves deflection
- Justification of right offset should be provided with documentation
- Refer to NCHRP 6.3.2
### Roundabout Design

#### Circulatory Roadway Width

<table>
<thead>
<tr>
<th>Roundabout Type</th>
<th>Low End</th>
<th>High End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lane</td>
<td>16’</td>
<td>20’</td>
</tr>
<tr>
<td>Two Lane</td>
<td>28’</td>
<td>32’</td>
</tr>
<tr>
<td>Three Lane</td>
<td>42’</td>
<td>48’</td>
</tr>
</tbody>
</table>

- Refer to NCHRP 6.4.3 and 6.5.3
- “Rule of Thumb” is that circulatory roadway is 100% to 120% of entry width
## Roundabout Design
### Approach Radii

<table>
<thead>
<tr>
<th>Roundabout Type</th>
<th>Low End</th>
<th>High End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lane</td>
<td>50’</td>
<td>100’</td>
</tr>
<tr>
<td>Multi-Lane</td>
<td>65’</td>
<td>120’</td>
</tr>
</tbody>
</table>

- Design should match the geometry used in the capacity analysis
- A wide range may be appropriate depending upon the components of the design
- Refer to NCHRP 6.4.5 and 6.5.4
## Roundabout Design

### Entry Width

<table>
<thead>
<tr>
<th>Roundabout Type</th>
<th>Low End</th>
<th>High End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lane</td>
<td>14’</td>
<td>18’</td>
</tr>
<tr>
<td>Two Lane</td>
<td>24’</td>
<td>30’</td>
</tr>
<tr>
<td>Three Lane</td>
<td>36’</td>
<td>45’</td>
</tr>
</tbody>
</table>

- Measured perpendicular to left and right curb lines
- Refer to NCHRP 6.4.2 and 6.5.2
Roundabout Design
Exit Radii

• Typically 100’ to 800’
• 300’ to 600’ is desirable
• Refer to NCHRP 6.4.6 and 6.5.6
• Exit radii as small as 50’ can be used if necessary to control speeds at crosswalk
• Smaller exit radii can affect natural flow of traffic through roundabout and reduce capacity
Roundabout Design
Entry Path or Exit Overlap

• Only affects multi-lane roundabouts
• Refer to NCHRP 6.2.3
• WISDOT’s roundabout design guide offers additional details on checking for overlap
Roundabout Design
Truck Apron Width

• Truck apron allows large vehicles to track to the inside of the roundabout
• Minimum effective/constructible width is 3’, minimum width of 5’ is desirable
• No maximum width – based on turning templates
• Refer to NCHRP 6.4.7.1 and 6.8.7.4
• Documentation illustrating adequate width should be included with design submittals
Roundabout Design

Pedestrian Crossing

• Crosswalk should be placed 20’-40’ behind Yield Line (one to two car lengths)

• Refer to NCHRP 6.4.1 and 6.8.1.2

• Ample length and width of splitter island should be designed to provide a safe refuge for pedestrians

• Placement should coincide with a vehicle’s slowest speed on approach

• Pay attention to cross-slope
Roundabout Design
Pavement Markings & Signs

- Pavement markings and signs are critical to the function of roundabouts
- Pavement marking schematics should be submitted with Stage 1 plans to illustrate design intent
- Pavement markings should be designed in accordance with MUTCD 3C and NCHRP 7.3
- Signs should be designed in accordance with MUTCD 2B.43-45 and NCHRP 7.4
Roundabout Design
Lighting Structures Placement

• Lights must be located in advance of crosswalks to avoid pedestrian back-lighting

• Refer to NCHRP Chapter 8 & IESNA Publication DG-19-08

• Light poles can be placed in central island if necessary but should not be placed in splitter islands
Roundabout Design

Entry Grade Profile

• Entry grade profile should be leveled out so as not to exceed 3%

• Entry grade profile is defined as the area approximately two car lengths from the outer edge of the circle

• Refer to NCHRP 6.8.7.5
Roundabout Design

Drainage Structures

• Avoid drainage structures within circulatory roadway

• Desirable location is between circulatory roadway and curb ramps

• Primary reason for concern is maintenance difficulties

• Refer to NCHRP 6.8.7.6

• In some situations, this can not be avoided to meet spread/encroachment requirements
Design Plans

• Spot elevations and/or grading plans should be clear and concise
• Sign types and locations should be clearly defined
• Specialty pavement markings must be clearly detailed
• Radii should be clearly labeled
• For early plan submittals – Provide the reviewer ample information to identify the critical elements (ICD, Approach & Exit Radii, etc.)
• For Stage 3 plans - Can a contractor build the roundabout with the information provided?
Policy Updates

• Roundabout review checklist – Jan. 2013
• Indiana Design Manual Updates – Soon!
  – Significantly reduced
  – Largely relies on NCHRP 672
  – Incorporated into intersections chapter
• Roundabout design prequalification is imminent