Roundabout Design & Operations

I. Background

A. Roundabouts are circular intersections with

1. Yield control on all entering vehicles

2. Channelized approaches

3. Appropriate geometric curvature to ensure travel speeds in the roundabout of 30 mph or less

B. Safety of Roundabouts

1. United States Experience – percent change in annual crashes at 11 intersections in US converted to roundabouts

<table>
<thead>
<tr>
<th>Type of Roundabout</th>
<th>Percent Change*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Single-lane</td>
<td>-51%</td>
</tr>
<tr>
<td>Multilane</td>
<td>-29%</td>
</tr>
<tr>
<td>Total</td>
<td>-37%</td>
</tr>
</tbody>
</table>

* Comparing before to after installation of roundabout

2. Reduction in Mean Crashes

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Crashes</td>
</tr>
<tr>
<td>Australia</td>
<td>41-61%</td>
</tr>
<tr>
<td>France</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>36%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>47%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>37%</td>
</tr>
</tbody>
</table>

3. Pedestrian Crashes Comparing Signals to Roundabouts

<table>
<thead>
<tr>
<th>Intersection Type</th>
<th>Pedestrian Crashes per Million Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signals</td>
<td>0.67</td>
</tr>
<tr>
<td>Mini-Roundabouts</td>
<td>0.31</td>
</tr>
<tr>
<td>Conventional Roundabouts</td>
<td>0.45</td>
</tr>
<tr>
<td>Flared Roundabouts</td>
<td>0.33</td>
</tr>
</tbody>
</table>
4. Bicyclist Crash Rates Comparing Signals to Roundabouts

<table>
<thead>
<tr>
<th>Intersection Type</th>
<th>Cyclist Accidents per Million Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bicyclist</td>
</tr>
<tr>
<td>Signals</td>
<td>1.75</td>
</tr>
<tr>
<td>Mini-Roundabouts</td>
<td>3.11</td>
</tr>
<tr>
<td>Conventional Roundabouts</td>
<td>2.91</td>
</tr>
<tr>
<td>Flared Roundabouts</td>
<td>7.85</td>
</tr>
</tbody>
</table>

C. Conflicts

The conflicts show the effectiveness and safety of intersections and roundabouts

1. Total vehicular conflicts

Figure 1 shows there are 32 conflicts at 4-way intersections, and only eight at roundabouts

Figure 1 – Intersection and Roundabout Conflicts

*Source: FHWA Roundabouts*
2. Vehicle-Pedestrian Conflicts

Figure 2 shows that the vehicle-pedestrian conflicts at normal intersections are 16. At roundabouts, there are only eight vehicle-pedestrian conflicts, as shown in Figure 3.

![Figure 2 – Vehicle-Pedestrian Conflicts at Full Intersection](source: FHWA Roundabouts)

![Figure 3 – Vehicle-Pedestrian Conflicts at Roundabouts](source: FHWA Roundabouts)
D. Operational Benefits

Figure 4 – Annual Savings in Delay of Single-Lane Roundabout versus AWSC, with 50% of Volume on Major Street

Source: FHWA Roundabouts

Figure 5 – Annual Savings in Delay of Single-Lane Roundabout versus AWSC, with 65% of Volume on Major Street

Source: FHWA Roundabouts
Figure 6 – Annual Savings in Delay for Roundabout versus Signal, 65% Volume on Major Street

Source: FHWA Roundabouts
E. Operations and Capacity

The basic operation of roundabouts is governed by the entering vehicle yielding right-of-way to vehicles in the roundabout.

1. **Logic for Capacity – 2000 HCM**

   Unsignalized intersection capacity in estimated for each individual entry controlled by a yield sign.

   Capacity is found for a critical gap of 7.5 s for the yield controlled entry.

   Circulating Volume or Conflicting Volume for Entry A =
   
   \[ V^L_C + V^L_D + V^T_D \quad \text{or} \quad V_{CB} + V_{DC} + V_{DB} \]

2. **Single Lane Roundabout Capacity**

   a) Circulatory flows should not exceed 1800 veh/hr at any point in the roundabout. Exceeding this limit implies that a double lane roundabout is required.

   b) Exiting flows of 1200 veh/hr may also indicate that a double lane roundabout is needed.

   c) Analysis should be based on peak 15 min flow rates.
3. Capacity Analysis

a) Capacity of single lane roundabout
   Based on HCM Unsignalized Capacity Analysis

   ![Figure 7 – Approach Capacity for Single Lane Roundabout](source: FHWA Roundabouts)

b) Capacity of double lane roundabout

   ![Figure 8 – Approach Capacity for Double Lane Roundabout](source: FHWA Roundabouts)

b) Capacity of double lane roundabout
c) Capacity comparison of various controls versus roundabouts with single-lane approaches

![Diagram showing capacity comparison]

**Example Data**
- 60% major street
- 40% minor street
- 20% left turns
- 10% right turns

Source: *Florida Roundabout Guide (1996)*

**Figure 9 – Comparison of Roundabout Capacity with Various Types of Control**

F. Level of Service

The level of service for an unsignalized approach is based on “control delay”

<table>
<thead>
<tr>
<th>LOS</th>
<th>Control Delay</th>
<th>LOS</th>
<th>Control Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤10</td>
<td>D</td>
<td>&gt;35 &amp; ≤55</td>
</tr>
<tr>
<td>B</td>
<td>&gt;10 &amp; ≤20</td>
<td>E</td>
<td>&gt;55 &amp; ≤80</td>
</tr>
<tr>
<td>C</td>
<td>&gt;20 &amp; ≤35</td>
<td>F</td>
<td>&gt;80</td>
</tr>
</tbody>
</table>
II. Design

A. Geometric Elements

1. Determine following elements first
   a) Optimal roundabout size
   b) Optimal roundabout location
   c) Optimal alignment and arrangement of approach legs

Figure 10 – Basic Geometric Elements

Source: FHWA Roundabouts
B. Design Speeds

Recommended maximum entry design speeds for roundabouts are in the following table

Table 1 – Recommended Maximum Entry Design Speed

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum Entry Design Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini-Roundabout</td>
<td>15 mph</td>
</tr>
<tr>
<td>Urban Compact</td>
<td>15 mph</td>
</tr>
<tr>
<td>Urban Single Lane</td>
<td>20 mph</td>
</tr>
<tr>
<td>Urban Double Lane</td>
<td>25 mph</td>
</tr>
<tr>
<td>Rural Single Lane</td>
<td>25 mph</td>
</tr>
<tr>
<td>Rural Double Lane</td>
<td>30 mph</td>
</tr>
</tbody>
</table>

C. Vehicle Paths

The roundabout speed is determined from the vehicle path that allows the highest travel speed through the roundabout. The “fast path” may be:

A through movement through the

- roundabout
- a right turn movement

Assumed Minimum Design Dimensions:

- Vehicle Width: 6 ft
- Minimum Clearance: 2 ft
- Distance to Concrete Curb: 5 ft
- Distance to Centerlines: 5 ft
- Distance from Painted Edgeline: 3 ft
1. Design Concept

Construct a path for the fastest vehicle for the:

- through vehicle (Figure 11)
- right turn movement (Figure 12)

Draw the fastest path for each approach

Figure 11 – Fastest Vehicle Path: “Through Movement”

Source: FHWA Roundabouts
2. Speed Consistency

Speeds of all the fastest paths should be consistent.

a) High speed differentials contribute to increased accident potential

b) Maintain speed differentials between paths within acceptable ranges:

(1) Desirable – 6 mph

(2) Maximum – 12 mph
3. Avoiding Vehicle Path Overlap

a) "Natural path" for drivers should not overlap the path of another vehicle. "Natural path" is the path a driver would take when no conflicting vehicle is present.
b) Vehicle path overlap is especially problematic for double lane roundabouts

c) Design Conflict

Providing a small entry radius (following an initial flat curve) produces low entry speeds, but may cause drivers to take a more direct path, causing path overlap

Solution

Use an initial small radius entry curve, to control speed, followed by a larger radius entry curve

Figure 15 – Design Encourages Path Overlap

Source: FWHA Roundabouts

Figure 16 – Design Discourages Path Overlap

Source: FWHA Roundabouts
4. Superelevation

Typically, the cross slope away from the central island is 2%.

Off-tracking of large trucks requires a wider pavement. A truck apron accommodates that. The truck apron may slope more to -3 or -4%.

Figure 17 – Circulatory Roadway Section

Source: FWHA Roundabouts

Figure 18 – Typical Section with a Truck Apron

Source: FWHA Roundabouts
III. Control

Signs and markings for roundabouts according to the MUTCD are shown in the following figures.

Figure 3b-27 – Examples of Markings for Roundabout Intersections with One-Lane Approaches

Source: 2003 MUTCD
Figure 3b-28 – Examples of Markings for Roundabout Intersections with Two-Lane Approaches

Source: 2003 MUTCD