Roundabout Geometric Design

by

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Introduction

This course is a summary of the geometric design process for modern roundabouts. The contents of this document are intended to serve as guidance and not as an absolute standard or rule.

When you complete this course, you should be familiar with the general design guidelines for modern roundabouts. The course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing roundabouts.

For this course, Chapter 6 of the FHWA Roundabout Guide (NCHRP Report 672 – Roundabouts: An Informational Guide, 2nd Edition) will be used primarily for the fundamental design principles of modern roundabouts. This document is intended to explain some principles of good design and show the potential trade-offs that the designer may have to face in a variety of situations.

Further guidelines specific to multi-lane roundabouts are provided in the latter part of Chapter 6. This type of design is significantly more challenging and many of the techniques used in one-lane entry roundabout design do not directly transfer to multi-lane design. Therefore, it is important that engineers and designers become very familiar with Chapter 6 in the FHWA Roundabout Guide.

What is a Modern Roundabout?
Traffic circles or rotary intersections have been part of the U.S. transportation system since the early 1900’s. The main design concepts allowed high-speed merging and weaving of traffic with priority given to entering vehicles. In the mid-1950s, rotaries became unpopular in the U.S. due to high crash rates and congestion from increasing traffic volumes.

The “modern roundabout” was a British response to fix the problems associated with rotary intersections. The resulting design is a one-way, circular intersection where the traffic flows around a central island. It is defined by a set of basic principles:
1) **Yield control at all entry points** – All approaching traffic is required to yield to vehicles on the roundabout’s circulatory roadway before entering the circle. Yield signs are used primarily as entry control. Weaving maneuvers are not considered a design or capacity factor.

2) **Traffic deflection** – Entering vehicles are directed to the right by channelization or splitter islands onto the roundabout’s circulating roadway avoiding the central island. No entrance traffic is allowed to travel a straight route through the roundabout.

3) **Geometric curvature** – Entry design and the radius of the roundabout’s circulating roadway can be designed to slow the speeds for entering and circulating traffic.

Designing a roundabout involves balancing operational and capacity performances with the safety enhancements. Roundabouts operate best when approaching vehicles are forced to enter and circulate at slow speeds. By using low-speed design elements such
as horizontal curvature and narrow pavement widths for slower speeds, the capacity of the roundabout may be negatively affected. Many of the geometric criteria used in design of roundabouts are also governed by the accommodation of over-sized vehicles expected to travel through the intersection.


Roundabout design is a creative, site specific process for each individual intersection. There is no standard template or “cookie-cutter” method that exists for all locations. Geometric designs can range from easy (mini-roundabouts) to moderate (single lane roundabouts) to very complex (multi-lane roundabouts). How the intersection functions as a single traffic control unit is more important than the actual values of the individual design components. It is crucial that these individual geometric parts interact with each other within acceptable ranges in order to succeed.
Exhibit 6-1 of NCHRP Report 672 (Roundabouts: An Informational Guide) illustrates one possible outline of the roundabout design process, involving elements of planning and design into an iterative process. Data from an operational analysis will be used to determine the required sizing and many other design considerations.
The key is to conduct an adequate number of iterations to check the optimum size, location, and approach alignments to determine if adjustments are necessary. Additional features can then be added to the basic design after more detailed analysis.

The use of another design technique, or results that fall outside typical values do not automatically create an unacceptable roundabout design. There is no standard design template for this process.

Principles and Objectives

Speed Management
The design speed of vehicles is widely considered to be a critical factor in designing a roundabout. Speed management is often a combination of managing speeds at the roundabout itself and on the approaching legs. The ability to predict these vehicular speeds when traveling through a proposed roundabout is fundamental for attaining good safety performance.

Maximum entering design speeds of 20 to 25 mph are recommended for single-lane roundabouts. For multi-lane roundabouts, maximum entering design speeds of 25 to 30 mph are recommended (based on the theoretical fastest path). Exhibit 6-4 shows the recommended design speeds for different types of roundabouts.

Exhibit 6-4. Recommended maximum entry design speeds.
(FHWA. Roundabouts: An Informational Guide. 2000)

<table>
<thead>
<tr>
<th>Site Category</th>
<th>Recommended Maximum Entry Design Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini-Roundabout</td>
<td>25 km/h (15 mph)</td>
</tr>
<tr>
<td>Urban Compact</td>
<td>25 km/h (15 mph)</td>
</tr>
<tr>
<td>Urban Single Lane</td>
<td>35 km/h (20 mph)</td>
</tr>
<tr>
<td>Urban Double Lane</td>
<td>40 km/h (25 mph)</td>
</tr>
<tr>
<td>Rural Single Lane</td>
<td>40 km/h (25 mph)</td>
</tr>
<tr>
<td>Rural Double Lane</td>
<td>50 km/h (30 mph)</td>
</tr>
</tbody>
</table>

Another important objective is to produce consistent speeds for all roundabout movements which along with overall speed reduction can help to minimize the crash
rate between conflicting traffic. For any design, it is desirable to minimize the relative speeds between consecutive geometric elements and conflicting traffic streams.

**Lane Arrangements**

The entry movements assigned to each lane within a roundabout are critical to its overall design. Results from an operational analysis will determine the required number of entry lanes for each approach. Pavement marking layouts may also be used in the preliminary phase to ensure lane continuity through the various design iterations.

Typically, roundabouts are designed to accommodate design year traffic volumes, which are normally projected 20 years in the future. This design can result in more entering, exiting, and circulating lanes than needed at the start of operation. It may be necessary to use a phased design that initially uses fewer entering and circulating lanes while maximizing potential safety. In order for lane expansion at a later phase, an optimal roundabout configuration (including horizontal and vertical design) needs to be considered as early as possible in the initial design. Lanes can then be removed from the optimal roundabout design to provide the necessary initial capacity. This phased method ensures that adequate right-of-way is acquired and any alteration to the original roundabout is minimized.

**Appropriate Path Alignment**

The fastest speed path is a basic principle in the geometric design of roundabouts. It is defined as the fastest and smoothest path possible for a single vehicle to travel through the entry, around the central island, and out the exit of a roundabout. Its purpose is to restrict operating speed by deflecting the paths of entering and circulating vehicles. In most cases, the through movement will be the critical fastest path. However, in some situations it may be a right turn movement.
A good entry and exit design allows drivers appropriate lane alignment throughout the roundabout. Engineers can improve the operations and safety of a roundabout design by analyzing the path alignments of traffic. Approaching traffic to a roundabout will be channelized by lane markings to the entry. Vehicles will continue onto the circulatory roadway. Natural path interference or overlap will reduce the roundabout’s safety and efficiency. Exit geometry also affects the natural travel path and possible vehicle overlap.

**Design Vehicle**
A primary factor in determining the design of a roundabout is the choice of the largest vehicle (design vehicle) that will use the intersection. The requirements of its turning path will have a direct effect on many of the dimensions of the roundabout (inscribed circle diameter, approach re-alignment, etc.).

Appropriate design vehicle consideration will depend on the following:
(1) Roadway classification
(2) Input from local authorities
(3) Surrounding environmental characteristics
For rural areas, agricultural machinery may determine design vehicle requirements while emergency, mass transit and delivery vehicles should be considered in urban environments. Local emergency agencies need to be involved in any plans to construct a roundabout in their area.

The AASHTO Green Book recommends using the following guidelines when choosing a design vehicle:

- **Passenger Car (P)** – parking lots or series of parking lots
- **Single-unit Truck (SU)** – residential streets and park roads
- **City Transit Bus (CITY-BUS)** – highway intersections with city streets designated bus routes
- **Large or Conventional School Bus (S-BUS36 or 40)** – highway intersections with local roads under 400 ADT
- **Interstate Semitrailer (WB-65 or 67)** – freeway ramps with arterial crossroads or high volume traffic roadways

For most cases, the Intermediate Semi-trailer (WB-50) is the largest design vehicle for urban collectors/arterials and is considered the minimum design vehicle for all turning movements for roundabouts on the state highway system.

**Non-motorized Design Users**

The safe and efficient accommodation of all non-motorized users is as important as the considerations made for vehicles. Roundabouts are designed to meet the needs of all facility users—bicyclists, drivers, pedestrians, disabled or impaired persons, strollers, skaters, etc. By forcing roundabout traffic to enter or exit only through right turns, the chance of any conflicting traffic or severe crashes is substantially reduced. The low speeds through roundabouts allow more reaction time for both drivers and pedestrians resulting in fewer crashes involving pedestrians.
Exhibit 6-7. Key Dimensions of Non-Motorized Design Users  
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

<table>
<thead>
<tr>
<th>User</th>
<th>Dimension</th>
<th>Affected Roundabout Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bicyclist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>5.9 ft</td>
<td>Splitter island width at crosswalk</td>
</tr>
<tr>
<td>Minimum operating width</td>
<td>4 ft</td>
<td>Bike lane width on approach roadways; shared use path width</td>
</tr>
<tr>
<td><strong>Pedestrian (walking)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>1.6 ft</td>
<td>Sidewalk width, crosswalk width</td>
</tr>
<tr>
<td><strong>Wheelchair user</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum width</td>
<td>2.5 ft</td>
<td>Sidewalk width, crosswalk width</td>
</tr>
<tr>
<td>Operating width</td>
<td>3.0 ft</td>
<td>Sidewalk width, crosswalk width</td>
</tr>
<tr>
<td><strong>Person pushing stroller</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>5.6 ft</td>
<td>Splitter island width at crosswalk</td>
</tr>
<tr>
<td><strong>Skaters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical operating width</td>
<td>6 ft</td>
<td>Sidewalk width</td>
</tr>
</tbody>
</table>

**Pedestrian Design Considerations**

Pedestrian needs should be addressed and controlled to maximize safety and minimize conflicts with other traffic flows. Typical pedestrian crosswalks should be located at intersections, have appropriate curb ramps for accessibility, and be highly visible. Some type of striping inside the crosswalk area is recommended to improve safety. Many cities and suburban areas have gone to the next level and added aesthetic treatments to their crosswalk designs.

Pedestrians are accommodated by pedestrian crosswalks and sidewalks around the perimeter of the roundabout. Any sidewalks (5 ft minimum, 6 ft recommended) should be set back from the edge of the circulatory roadway (2 ft minimum, 5 ft recommended) with a landscape strip. It is best to plant low shrubs or grass in this strip between the sidewalks and curb. By providing this setback, pedestrians are discouraged from cutting across the roundabout’s central island and visually-impaired pedestrians are guided to the designated cross-walks. Fencing or other barriers may be necessary in areas of heavy pedestrian traffic to guide users to the appropriate crossings.

The location of the pedestrian crossing is generally recommended to be a minimum setback of 20 ft (one vehicle length) from the edge of the circulatory roadway. For some
designs, it may be necessary to put the crosswalk two or three car lengths back from
the circle (always use a 5 ft gap between car lengths when using this type of queued
distance). Closer pedestrian crossings may reduce roundabout capacity due to
potential back-ups and longer waiting times at the entry. Placing crosswalks further
away from the entrance of the roundabout increases walking distances and may expose
pedestrians to higher vehicle speeds.

The Americans with Disabilities Act requires that all new or modified roundabouts be
accessible to and usable by disabled individuals. Visually impaired pedestrians with
vision impairments may have more difficulty crossing roundabouts since these
intersections do not typically include the normal audible and tactile cues used to
successfully maneuver crosswalks.

Pedestrian signals should be coordinated with traffic lights at all signalized intersections
where pedestrian activity is present. Push buttons can be used for isolated intersections
or locations where traffic warrants maximum vehicle travel time through the intersection.
Fixed time traffic signals with short cycle lengths are more suited for urban or downtown
environments.

Bicycle Design Considerations
Research has proved that bicyclists are the most vulnerable users of roundabouts.
Over 50 percent of bike crashes at roundabouts involve entering vehicles and
circulating bicycles.

Modern roundabouts are typically designed to accommodate bicyclists of different skills
and experience levels.

When designing a roundabout for bicycle safety and travel, there are two general
methods to accommodate bicyclists:

1) **Motor Vehicle Method** - mixed flow with regular traffic
Typical bicycle (12 – 20 mph) and design vehicle entry (20 – 30 mph) speeds are similar
and compatible for low-speed, single-lane roundabouts with low potential conflicts.

2) **Pedestrian Method** - shared use paths.
Bicycle safety tends to deteriorate at high-speed, multiple lane roundabouts and many
cyclists may be more comfortable and safer using bike ramps connected to a sidewalk.
or shared use path around the outside of the roundabout. The typical sidewalk width should be a minimum of 10 ft in order to accommodate both pedestrians and bicyclists.

Bicycle lanes or shoulders used on approach roadways, should end at least 100 feet before the edge of the circulatory roadway. A taper rate of 7:1 is recommended to transition the combined travel/bike lane width down to the appropriate width for the desired vehicle speeds on the approach. Bicycle ramps may be provided to allow access to the sidewalk or a shared use path at the roundabout. These ramps should only be used where the design complexity or vehicle speed is incompatible for some cyclists.

**Sight Distance and Visibility**
Adequate visibility and sight distance for approaching vehicles is needed for providing safe roundabout operation. Stopping sight distance should be evaluated for every point within a roundabout and on each entry and exit. The required distance is based on speed, as determined from the fastest path speed checks.

*Exhibit 3-1.* Stopping Sight Distance (AASHTO Green Book, 2004)

<table>
<thead>
<tr>
<th>Design speed (mph)</th>
<th>Brake reaction distance (ft)</th>
<th>Braking distance on level (ft)</th>
<th>Stopping sight distance (ft)</th>
<th>Calculated Design (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>55.1</td>
<td>21.6</td>
<td>76.7</td>
<td>80</td>
</tr>
<tr>
<td>20</td>
<td>73.5</td>
<td>38.4</td>
<td>111.9</td>
<td>115</td>
</tr>
<tr>
<td>25</td>
<td>91.9</td>
<td>60</td>
<td>151.9</td>
<td>155</td>
</tr>
<tr>
<td>30</td>
<td>110.3</td>
<td>86.4</td>
<td>196.7</td>
<td>200</td>
</tr>
<tr>
<td>35</td>
<td>128.6</td>
<td>117.6</td>
<td>246.2</td>
<td>250</td>
</tr>
<tr>
<td>40</td>
<td>147</td>
<td>153.6</td>
<td>300.6</td>
<td>305</td>
</tr>
<tr>
<td>45</td>
<td>165.4</td>
<td>194.4</td>
<td>359.8</td>
<td>360</td>
</tr>
<tr>
<td>50</td>
<td>183.8</td>
<td>240</td>
<td>423.8</td>
<td>425</td>
</tr>
<tr>
<td>55</td>
<td>202.1</td>
<td>290.3</td>
<td>492.4</td>
<td>495</td>
</tr>
<tr>
<td>60</td>
<td>220.5</td>
<td>345.5</td>
<td>566</td>
<td>570</td>
</tr>
<tr>
<td>65</td>
<td>238.9</td>
<td>405.5</td>
<td>644.4</td>
<td>645</td>
</tr>
<tr>
<td>70</td>
<td>257.3</td>
<td>470.3</td>
<td>727.6</td>
<td>730</td>
</tr>
<tr>
<td>75</td>
<td>275.6</td>
<td>539.9</td>
<td>815.5</td>
<td>820</td>
</tr>
<tr>
<td>80</td>
<td>294</td>
<td>614.3</td>
<td>908.3</td>
<td>910</td>
</tr>
</tbody>
</table>

Note: Brake reaction distance predicated on a time of 2.5s; deceleration rate of 3.4 m/s² used to determine calculated sight distance.
For stopping sight distances, the height of the driver’s eye is assumed to be 3.5 ft. and the object height of the hazard seen by the driver is 2.0 ft. (average passenger car taillight height).

Sight distance at roundabouts includes both intersection and stopping sight distances. Intersection sight distance is evaluated at each approach entry so drivers can see and safely react to potential conflicts. Adequate intersection sight distance ensures drivers can safely enter the circulatory roadway without impeding traffic flow. The distance between the entering vehicle and the circulatory roadway is fixed while the other legs of the sight triangle are based on two conflicting approaches:

1. **Entering stream of vehicles from the immediate upstream entry.** The approximate speed can be calculated using the averages of the entering and circulating speeds.

2. **Circulating stream of vehicles entering the roundabout prior to the immediate upstream entry.** The speed can be approximated from the speed of left turning vehicles.

In both cases the distance is a function of vehicular speed and a reasonable design value of the critical headway for the drivers.

Sight distance needs may limit the height of any objects around the perimeter of the central island. For each approach, it is recommended to provide no more than the minimum required intersection sight distance. Excessive intersection sight distance may result in higher speeds and a reduction in roundabout safety.

In some cases, sight distance at the roundabout can be increased at the expense of the roundabout’s visibility.
Size, Position, and Alignment of Approaches

The design of a roundabout involves optimizing the following design decisions to balance design principles and objectives:

(1) size  
(2) position  
and (3) the alignment of the approach legs.

Creating the best design will often be based upon the constraints of the project site balanced with the ability to control traffic speeds, accommodate over-sized vehicles, and meet other design criterion.

Inscribed Circle Diameter
The inscribed circle is the entire area within a roundabout between all approaches and exits. Its diameter includes the distance across the central island (including the truck apron) bordered by the outer curb of the circulatory roadway. A number of design objectives determine the inscribed circle diameter and designers often have to experiment with varying dimensions before determining the optimal roundabout size.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

<table>
<thead>
<tr>
<th>Roundabout Configuration</th>
<th>Typical Design Vehicle</th>
<th>Common Inscribed Circle Diameter Range*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini-Roundabout</td>
<td>SU-30 (SU-9)</td>
<td>45 to 90 ft (14 to 27 m)</td>
</tr>
<tr>
<td>Single-Lane Roundabout</td>
<td>WB-50 (WB-15)</td>
<td>105 to 150 ft (32 to 46 m)</td>
</tr>
<tr>
<td></td>
<td>WB-67 (WB-20)</td>
<td>130 to 180 ft (40 to 55 m)</td>
</tr>
<tr>
<td>Multilane Roundabout (2 lanes)</td>
<td>WB-50 (WB-15)</td>
<td>150 to 220 ft (46 to 67 m)</td>
</tr>
<tr>
<td></td>
<td>WB-67 (WB-20)</td>
<td>165 to 220 ft (50 to 67 m)</td>
</tr>
<tr>
<td>Multilane Roundabout (3 lanes)</td>
<td>WB-50 (WB-15)</td>
<td>200 to 250 ft (61 to 76 m)</td>
</tr>
<tr>
<td></td>
<td>WB-67 (WB-20)</td>
<td>220 to 300 ft (67 to 91 m)</td>
</tr>
</tbody>
</table>

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

For single-lane roundabouts, the inscribed circle’s size is dependent on the design vehicle’s turning requirements – circulatory roadway width, entry/exit widths, radii and angles.
or multilane roundabouts, the size is dependent on balancing deflection with aligning natural vehicle paths.

**Alignment of Approaches**
The entry alignment of the approaching legs to a roundabout affects the deflection and speed control achieved, accommodation for the design vehicle, sight angles to drivers, and property impacts/costs.

Although it is desirable for these alignments of the roundabout approaches to pass through the center of the inscribed circle, it is not mandatory for a successful design. Exhibit 6-10 Entry Alignment Alternatives (NCHRP Report 672) provides 3 major alternatives for roundabout approach alignments shown below.

**Alternative 1: Offset Alignment to the Left of Center**

**ADVANTAGES:**
- Allows for increased deflection
- Beneficial for accommodating large trucks with small inscribed circle diameter—allows for larger entry radius while maintaining deflection and speed control
- May reduce impacts to right-side of roadway

**TRADE-OFFS**
- Increased exit radius or tangential exit reduces control of exit speeds and acceleration through crosswalk area
- May create greater impacts to the left side of the roadway
Alternative 2: Alignment through Center of Roundabout

ADVANTAGES:
- Reduces amount of alignment changes along the approach roadway to keep impacts more localized to intersection
- Allows for some exit curvature to encourage drivers to maintain slower speeds through the exit

TRADE-OFFS
- Increased exit radius reduces control of exit speeds/acceleration through crosswalk area
- May require a slightly larger inscribed circle diameter (compared to offset-left design) to provide the same level of speed control

Alternative 3: Alignment to Right of Center

ADVANTAGES:
- Could be used for large inscribed circle diameter roundabouts where speed control objectives can still be met
- Although not commonly used, this strategy may be appropriate in some instances (provided that speed objectives are met) to minimize impacts, improve view angles, etc.

TRADE-OFFS
- Often more difficult to achieve speed control objectives, particularly at small diameter roundabouts
- Increases the amount of exit curvature that must be negotiated
Angle between Approach Legs
For roundabouts, it is preferable for approach legs to intersect at near perpendicular intersection angles. Two approach legs at an angle greater than 90° often results in excessive speeds for right turns. For angles less than 90°, large vehicles may have difficulty navigating the roundabout. Perpendicular approaches usually produce the desired slow and consistent operating speeds for roundabouts.

Single-Lane Roundabouts

This type of roundabout design consists of single-lane approaches at all legs and a single-lane circulatory roadway around a central island. Distinguishing geometric design characteristics include larger inscribed circle diameters, raised splitter islands, a non-traversable central island, crosswalks, and a truck apron. This design allows slightly higher operation speeds for the entry, exit and the circulatory roadway. Like any roundabouts, the size of single-lane design is largely dependent on the type of design vehicle and available right-of-way.

Exhibit 1-12 illustrates the distinguishing features of typical single-lane roundabouts.

Exhibit 1-12
Features of Typical Single-Lane Roundabout
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)
The size of the inscribed circle must be large enough to accommodate the design vehicle’s turning requirements and maintain adequate deflection curvature for safe travel speeds. Close selection of circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles may allow a smaller inscribed circle diameter to be used in constrained locations. For a WB-50 (Intermediate Semitrailer Truck) design vehicle, the inscribed circle diameter needs to be in the 105 ft to 150 ft range. Smaller single-lane facilities can be used for other intersections, where the design vehicle may be a bus (BUS-40) or single-unit truck (SU). For a larger WB-67 (Interstate Semitrailer Truck) design vehicle, a larger inscribed circle diameter within the range of 130 to 180 ft is typically required. Larger inscribed circles may also be appropriate for roundabout locations with more than four legs. Truck aprons are used to accommodate larger design vehicles and keep the inscribed circle diameter within reasonable limits.

**Splitter Islands**

Splitter islands should be provided on all roundabouts unless visibility of the central island is obstructed. Their purpose is to provide refuge for non-motorized users, control vehicle speeds, guide traffic through the intersection, physically separate entry and exit traffic, deter wrong-way movements, and provide a location for signage.

The total length of the raised splitter island should be a minimum of 50 ft. with a desirable value of 100 ft. to provide adequate visibility and refuge. Splitter island lengths of 150 ft or more may be required for high speed approaches. By extending the island beyond the end of the exit curve, exiting vehicles will be prevented from accidentally meeting oncoming traffic. The splitter island should have a minimum width of 6 feet at the crosswalk to adequately meet non-motorized user needs.
Exhibit 6-12
Minimum Splitter Island Dimensions
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Entry Width
A roundabout’s entry width is designed to reduce vehicle speeds and maximize the visibility of the central island. It is measured from outside curb face to inside curb face at the splitter island point nearest the inscribed circle. The entry width is the key determinant of the roundabout’s capacity and is dependent on the width of the roadway and the design vehicle. Entry capacity increases as entry width increases. The circulatory roadway should be at least as wide as the widest approach and should maintain constant throughout the roundabout.
It is recommended to keep entry widths to a minimum in order to maximize a roundabout’s safe and efficient operation. Optimal capacity and operational balance should also be considered in determining the width and number of approaches.

Typical entry widths range from 14 ft to 18 ft with a common starting value of 15 ft for a single-lane roundabout. Higher or lower entry widths may be acceptable for site-specific design vehicle and speed requirements. However, entry widths greater than 18 ft or those wider than the circular roadway should be avoided in order to prevent driver confusion as to the correct number of lanes. The use of a mountable apron around the central island’s perimeter may be needed to provide additional width needed to accommodate off tracking by combination trucks.

When capacity needs can only be accommodated by increasing the entry width, design options include: (1) adding a full lane upstream of the intersection and maintaining parallel lanes through the roundabout, or (2) widening the approach lane gradually through the entry.

Circulatory Roadway Width
The circulatory roadway width is the distance between the outer edge of the inscribed diameter (curb face) and the central island curb face (not including the width of any truck apron). The width of the circulatory roadway defines the roadway width for vehicle circulation around the central island.

The circulating roadway design width within the roundabout is dependent on the number of entry lanes and the radius of vehicle paths. The circulating width should be constant with the minimum width being at least as wide as the maximum entry width and not exceeding 1.2 times the maximum entry width.

For single lane roundabouts, the constant widths of the circulating roadway range from 16 to 20 ft. Designers should make every effort to avoid making the circulatory width too wide to prevent drivers from interpreting the roundabout as a multilane design.

Central Island
The central island is the raised, non-traversable area in the center of a roundabout that is surrounded by the circulatory roadway. This island is typically landscaped for aesthetic reasons and may include a traversable apron for large vehicles. Central
islands should always be raised to enhance visibility of the roundabout upon approach. The size of the central island is dependent on the inscribed circle diameter and the circulatory roadway width.

Although the central island should be circular, other shapes may be required to meet unusual site conditions. A circular island with a constant-radius roadway helps promote constant speeds around the center of the roundabout. Irregular shapes are more challenging to drive and can promote higher speeds on the straight sections and reduced speeds on the curved portions. This difference in speed can make it difficult for approaching traffic to judge the speed and availability of gaps resulting in more loss-of-control crashes.

**Entry Design**

A roundabout entry is bordered by a curb with one or more curves connected to the circulatory roadway. The entry curb radius affects both capacity and safety by controlling the amount of deflection imposed on a vehicle’s entry path. Too small (below 50 ft) entry curb radii may lead to single-vehicle crashes while too large radii may produce higher entry speeds but have little effect on capacity.

**Exhibit 6-14**

Single-Lane Roundabout Entry Design

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)
The goal in selecting an entry curb radius is to meet appropriate speed requirements for the design vehicle. For an urban single-lane roundabout, entry radii typically range from 50 – 100 ft. A common starting point is in the 60 to 90 ft range.

For rural locations, if the speed differential between the approaches and entries is greater than 12 mph, it may be advantageous to add features to reduce the speed of approaching vehicles.

The angle of visibility is another important roundabout design consideration. This angle to the left should allow drivers to view oncoming traffic from the upstream entry or the circulatory roadway. The typical values for entry angles range between 20 to 40 degrees. Severe entry angles produce poor visibility, driver strain, and merging behavior. Shallow entry angles may not produce successful lane alignment and prevent wrong-way movements.

**Exit Design**

The exit width is the width of the exit where it meets the inscribed circle. It is measured perpendicularly from the right curb to the intersection of the left curb and the inscribed circle. The exit radius is the curvature of the outside curb face at the exit.

At urban single-lane roundabouts, exits should be designed for a curved exit path with a design speed under 25 mph in order to maximize safety for pedestrians. Exit radii should normally be no less than 50 ft. But at locations with low speeds, low traffic and pedestrian activity, these radii may be as low as 33 to 39 ft. resulting in a very slow design speed which maximizes safety and comfort for pedestrians. Such low exit radii should only be used with a similar entry design for urban compact roundabouts with inscribed circle diameters less than115 ft.

In rural locations with few pedestrians, larger exit radii may be used to allow vehicles to exit quickly and accelerate back to normal speeds. Any straight paths tangential to the central island should be avoided many existing rural locations may become urban in the future. It is recommended to consider pedestrian activity at all exits except where conditions eliminate the likelihood of any future pedestrian activity.
Design Vehicle Considerations
The design vehicle is the controlling factor for most of the following roundabout considerations:

- **Entry width**
- **Entry radii**
- **Inscribed circle diameter**
- **Circulatory roadway width**

Roundabouts may need to accommodate both over-sized vehicles and passenger vehicles. Location constraints can limit the ability to provide adequate deflection for small vehicles while accommodating large trucks or emergency vehicles. The use of a truck apron can be used to provide additional area around the central island for trucks and discourage overtopping by passenger vehicles.

A roundabout’s location may determine its specific design vehicle. Rural agricultural areas may need to use farm equipment. Urban cities may need large semi-trailer combinations. Recreational areas may use motor homes or buses. The design vehicle’s needs should be used in the preliminary stages of the roundabout design since it impacts size, position, and approach alignments.

**Multilane Roundabouts**

Multilane roundabouts contain a minimum of one entry with two or more lanes and require wider circulatory roadways to accommodate more than one vehicle traveling side by side. The roundabouts may have a different number of lanes or transitions on one or more legs. The number of lanes should be the minimum needed for the anticipated traffic demand. The design speeds at the entry, on the circulatory roadway, and at the exit may be slightly higher than those for single-lane roundabouts. Multilane roundabouts include raised splitter islands, truck aprons, a non-traversable central island, and appropriate entry path deflection.

The size of multilane roundabouts is typically determined by balancing two critical design objectives: the need to achieve deflection; and providing sufficient natural vehicle path alignment. To achieve both of these objectives requires a larger diameter than those used for single-lane roundabouts. Generally, the inscribed circle diameter of
a multilane roundabout ranges from 150 to 220 ft (two-lane) and 200 to 300 ft (three-lane) to achieve adequate speed control and alignment. Truck aprons are recommended to accommodate larger design vehicles and keep the inscribed circle diameter reasonable.

Exhibit 1-11
Typical Urban Double-Lane Roundabout
(FHWA. Roundabouts: An Informational Guide. 2000)

**Entry Width**
The entry width is determined by the number of lanes required and the turning needs of the design vehicle. Typical entry lane widths range from 12 to 15 ft, two-lane entry widths range from 24 to 30 ft, and three-lane entries range from 36 to 45 ft.

Unless the entry can be fully utilized by traffic, any excessive entry width may not benefit capacity.

Where additional entry capacity is needed, the following designs may be used:

- Gradually widening the approach
- Adding a lane for parallel entry

Research shows that flared entries are an effective means of increasing capacity with less land required and little impact on safety.
Minimal entry widths with maximum flare lengths should produce desired capacity and acceptable safety.

In multi-lane roundabouts, over-sized vehicles may travel the entire width of the circulatory roadway. Roundabouts with truck aprons or gated roadways through the central island accommodate large trucks, emergency vehicles, or trains.

**Circulatory Roadway Widths**
For a multilane roundabout circulatory roadway, the width is dependent on the types of vehicles that need to be accommodated side-by-side through the roundabout. Where traffic is mainly passenger cars (P) and single-unit trucks (SU), the appropriate width may be either two passenger cars or a car/truck combination. For semi-trailer traffic (WB-50) greater than 10%, it may be acceptable to design for a semi-trailer/passenger vehicle combination.

Typical lane widths for multilane circulatory roadways range from 14 to 16 ft, resulting in total widths of 28 to 32 ft for two-lane and 42 to 48 ft for three-lane circulatory roadways.

**Entry Geometry and Approach Alignment**
For multilane roundabouts, the designer should ensure the proposed entry design directs vehicles to stay within the appropriate lanes of the circulatory roadway and exits. Path overlap occurs when the natural vehicle paths overlaps or cross one another.

![Exhibit 6-44](https://www.suncam.com/images/exhibit6-44.png)

*Exhibit 6-44*  
Sketched Natural Paths Through a Double-Lane Roundabout  
(FHWA. Roundabouts: An Informational Guide. 2000)
However, creating an optimal design with good path alignment within multilane roundabouts and controlling entry speeds with adequate deflection can be difficult. Designs that improve path alignment may also increase fastest path speeds. An optimal geometric design for a multilane roundabout should balance the entry speed, path alignment, design vehicle, and other needs.

One possible design technique is to locate the entry curve for the projection of the inside entry lane at the entrance line connects tangentially to the central island. Exit design should also provide sufficient large exit radii and alignment to allow drivers to maintain their proper lane. Other techniques involving changes to approach alignment, entry curvature, and/or inscribed circle diameter may result in creating trade-offs.

Problems can also occur when a design has for too much distance between entries and exits. Large separations between approaches cause entering vehicles to join next to circulating traffic and can create conflicts at the exit point between exiting and circulating vehicles.

Possible solutions include changes to lane configurations, changes to inscribed circle diameter, and realignment of the approaches. Realignment of the approach legs to have the paths of entering vehicles cross the paths of the circulating traffic (rather than merging) minimize conflict. This increases the likelihood that entering drivers will yield to both conflicting lanes.

**Splitter Islands**
For multilane roundabouts, the entry geometry is typically developed to control fastest-path entry speeds, avoid entry path overlap, and accommodate the design vehicle. The splitter island is designed to provide sufficient median width for pedestrian needs and sign placement.

**Exit Curves**
Exit curvature design for multilane roundabouts is more complex and larger than the other types. Exit conflicts may occur if appropriate lane assignments for exiting and circulating vehicles are not provided. If the exit radius is too small, vehicles on the inside of the circulatory roadway may exit in the outside exit lane.
To prevent potential problems from too much separation between entries and exits, two possible design alternatives are available:

1) Using a combination of striping/ physical modifications for compatible traffic volume
2) Realignment of approaches for entry vehicle paths to cross (and not merge with) circulatory traffic

### Mini-Roundabouts

Mini-roundabouts are small intersection designs with a fully traversable central island that are commonly used in low-speed urban environments with average operating speeds of 30 mph or less. With an inscribed circle diameter less than 90 ft, the small footprint of a mini-roundabout can be useful in such environments where conventional roundabout design is limited by right-of-way constraints. The small diameter is made possible by using a fully traversable central island for accommodating heavy vehicles. Passenger cars should be able to exit the mini-roundabout without running over the central island. The overall design should naturally guide entering vehicles along their intended path and minimize traversing the central island of the mini-roundabout.

Mini-roundabouts are very popular for retrofit applications due to their low cost from requiring minimal additional pavement at the intersecting roads and minor widening at the corner curbs. Small, mini-roundabouts are also seen as pedestrian-friendly with short crossing distances and very low vehicle entry/exit speeds.

However, mini-roundabouts also have limitations due to the reduced ability control speeds with the traversable central island. Therefore, it is important to consider the advantages and limitations of mini-roundabouts versus the larger-diameter roundabouts and intersection designs based upon site-specific conditions.

Figure 1 (Mini-Roundabouts Technical Summary) shows the distinctive features for a typical mini-roundabout.
General Design Criteria for Mini-Roundabouts

The geometric design of a mini-roundabout, as with other types of roundabouts, requires the balancing of competing design objectives with different emphasis areas. Substandard designs may result in speeding, improper yielding, left turn movements at the intersection, or vehicles running over the central island.

Size

A major benefit of using a mini-roundabout versus a larger, single-lane roundabout is minimizing the impacts to the existing intersection footprint. For a mini-roundabout, the existing intersection curb line is a typical starting point for establishing the inscribed circle diameter. Mini-roundabouts should be made as large as possible within existing conditions with a maximum inscribed circle diameter of 90 ft. Any inscribed circle diameter greater than 90 ft will be large enough for a single-lane roundabout design.
which accommodates traffic navigating around a raised central island and provides physical channelization to control vehicle speeds.

**Design Vehicle**
As with other roundabouts, it is desirable to accommodate buses within the circulatory roadway rather than traveling over the central island within a mini-roundabout. However, the turning radius of a bus is typically too large to navigate around the central island while staying within the circulatory roadway with very small inscribed circle diameters. Using a bus for the design vehicle instead of a passenger car may result in a geometric design with a wider circulatory roadway and smaller central island.

**Central Island**
The central island location should be at the center of the left-turning inner swept paths which will be near the center of the inscribed circle. Large design vehicles should be accommodated by the footprint of the central island while passenger cars should be able to safely navigate counterclockwise through the intersection without over-tracking.

By designing the central island size and location to provide deflection through the roundabout, proper circulation and reduced speeds through the intersection will its results.

The central island is typically a small, conspicuous and fully traversable island composed of asphalt concrete, Portland cement concrete, or other paving material. The central island should be domed or raised with a mountable curb using 5 to 6 percent cross slope, with a maximum height of 5 in. The mountable curb for a mini-roundabout should be designed in a similar manner to truck aprons on other roundabouts.

**Entrance Line Placement**
The entrance line is defined as the edge line extension across the approach leg of a mini-roundabout, and incorrect placement can result in unsafe driver behavior.

Two common designs are used for entrance line placement:

(a) *Advancing the entrance line forward,*
The outer path of passenger cars and the largest vehicle likely to use the intersection are identified for all turning movements. The entrance line is placed a minimum of 2 ft outside the vehicle paths.

\[ (b) \text{ Simultaneously enlarging the central island and reducing the circulatory roadway width, with the entrance line coincident with the inscribed circle of the roundabout.} \]

Advancing the entrance line may be used to discourage vehicles from making left-turns in front of the central island but it may reduce capacity due to yielding behavior at the entry.

\textbf{Splitter Islands}

For mini-roundabouts, splitter islands are used to provide pedestrian refuge, to encourage deflection and proper circulation, and to align vehicles. These islands may be raised, mountable, or flush depending upon their size and whether trucks will need to mount the splitter island in order to successfully navigate the intersection.

\textbf{NCHRP Report 672 (FHWA) provides the following are general guidelines for the types of splitter islands under various site conditions:}

\begin{itemize}
  \item Consider a \textbf{raised (non-traversable)} island if one or more of the following conditions exists:
    -- All design vehicles can navigate the roundabout without tracking over the splitter island area
    -- Sufficient space is available to provide an island with a minimum area of 50 ft², and/or
    -- Pedestrians are present at the intersection with regular frequency.
  \item Consider a \textbf{mountable (traversable)} island if:
    -- Some design vehicles must travel over the splitter island area and truck volumes are minor, and
    -- Sufficient space is available to provide an island with a minimum area of 50 ft².
  \item Consider a \textbf{flush (painted)} island if:
    -- Vehicles are expected to travel over the splitter island area with relative frequency to navigate the intersection
    -- An island with a minimum area of 50 ft² cannot be achieved, and
\end{itemize}
-- The approach has low vehicle speeds (preferably no more than 25 mph).

Figure 4 illustrates the recommended longitudinal dimensions for splitter islands at mini-roundabouts. In the case of narrow approach widths, it may be necessary to extend the islands between the entrance line and the crosswalk. For raised islands, it is important that they are highly visible to approaching motorists.

![Figure 4. Recommended Longitudinal Dimensions of a Mini-Roundabout](image)

(FHWA. Mini-Roundabouts Technical Summary. 2010)

### Performance Checks

**Fastest Path**
The fastest path through any roundabout is the flattest and most efficient traverse of the intersection – from entry to around the circulatory roadway and out the exit. These routes need to be determined for all approaches and traffic movements. The fastest path represents the theoretical design speed as opposed to expected traffic speeds.

Five critical path radii must be checked for each approach:

**R1** - *entry path radius*
minimum radius on the fastest through path prior to the entry

**R2 - circulating path radius**
minimum radius on the fastest path around the central island.

**R3 - exit path radius**
minimum radius on the fastest path to exit.

**R4 - left-turn path radius**
minimum radius on the path of conflicting left-turns

**R5 - right-turn path radius**
minimum radius on the fastest path of right-turn vehicles

Please note that these vehicular path radii are not the same as the curb radii.

*Exhibit 6-46*
Vehicle Path Radii (FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)
## Exhibit 6-47
Recommended Maximum Entry Design Speeds
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

<table>
<thead>
<tr>
<th>Site Category</th>
<th>Recommended Maximum Theoretical Entry Design Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini-Roundabout</td>
<td>20 mph (30 km/h)</td>
</tr>
<tr>
<td>Single Lane</td>
<td>25 mph (40 km/h)</td>
</tr>
<tr>
<td>Multilane</td>
<td>25 to 30 mph (40 to 50 km/h)</td>
</tr>
</tbody>
</table>

**Vehicle Path Assumptions**
- **Vehicle width**: 6 ft
- **Minimum lateral clearance**: 2 ft

**Centerline of Vehicle Path**
- **Distance from concrete curb**: 5 ft
- **Distance from roadway centerline**: 5 ft
- **Distance from edge line**: 3 ft

The fastest path should begin a minimum of 165 ft before the entrance line. $R1$ should be measured over a distance of 65 to 80 ft.

The maximum speed differential between conflicting traffic movements within roundabouts should be less than 10 to 15 mph which can be achieved from low absolute maximum speed for the fastest entry traffic.

**Sight Distance**
For roundabouts, the two most relevant parts of sight distance are stopping sight distance and intersection sight distance.

**Stopping sight distance** is the distance required for a driver to see and react to an object in the roadway and then brake to a complete stop. Stopping sight distance should be provided within a roundabout and on each entry and exit leg.
AASHTO recommends using an assumed height of driver’s eye of 3.5 ft and an assumed object height of 2 ft. for stopping sight distances. Three critical roundabout locations should be checked for sight distance: approaches; circulatory roadway; and exit crosswalk.

Exhibit 6-55
Stopping Sight Distance on the Approach
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)
Exhibit 6-30
Sight Distance on Circulatory Roadway
(FHWA. Roundabouts: An Informational Guide. 2000)

Exhibit 6-57
Sight Distance to Crosswalk on Exit
(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)
Intersection sight distance is the distance required for a driver to anticipate and avoid conflicting vehicles. The only locations requiring evaluation of intersection sight distance are the entry roadways to roundabouts.

Sight triangles are used to measure intersection sight distance. This triangle consists of a boundary defining a distance away from the intersection on each approach and by a line connecting those two limits. These sight triangle legs should follow the curvature of the roadway, and not be measured as straight lines but as distances along the vehicle path.

Exhibit 6-32
Intersection Sight Distance
(FHWA. Roundabouts: An Informational Guide. 2000)

The AASHTO “Green Book” recommends that intersection sight distance should be measured using an assumed height of driver’s eye of 3.5 ft and an assumed object height of 3.5 ft.
Angles of Visibility
The intersection angle at roundabouts is measured between the vehicular alignment at the entry and the sight line required. This angle must allow drivers to comfortably turn their heads to view oncoming traffic upstream. Current guidelines recommend using an intersection angle of 75° to design for older driver and pedestrian needs.

Closely Spaced Roundabouts

In some cases, it may be necessary to consider the operation of multiple roundabouts in close proximity to each other. A major design consideration is the expected queue length at each roundabout. For closely spaced intersections, the engineer should compute the 95th-percentile queues for each approach in order to determine if sufficient queuing space is available for vehicles between the roundabouts. Insufficient space may cause occasional queuing at the upstream roundabout and gridlock to the entire system.

A system of closely spaced roundabouts may also produce a traffic calming effect for arterial roadways. Drivers may be reluctant to speed on connecting roadways if they know that they will be required to slow down for the next roundabout.

Exhibit 6-11.
Chickamauga Dam Roundabouts
Chattanooga, TN
(Google Earth)
Exhibit 6-11 shows two closely spaced roundabouts at a high traffic intersection system connected to an interstate. The two roundabouts work together as a system to effectively serve the traffic demands. Serious consideration must be given to a system of roundabouts with this complexity in order to produce optimal geometric designs have sufficient capacity for each approach leg and driver-friendly intersections without lane changes or weaving.

REFERENCES


Florida Department of Transportation. *Florida Roundabout Guide. 2nd Ed.* Florida Department of Transportation, 1998.