

Maine Department of Transportation

Highway Program

Design Guidance

Title: Roundabout Design

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Originator: Jonathan French, P.E., Atlee Mousseau, P.E.

Approved By: Bradford Foley, P.E.

Background:

The design of roundabouts has evolved significantly since Maine's first roundabout was constructed in 1997. This guidance captures the latest practices and procedures for roundabout design for MaineDOT projects and has numerous references to NCHRP Report 672: *Roundabouts: An Informational Guide, Second Edition* from the Transportation Research Board.

Guidance:

Roundabout Types

See Section 1.3 Categories of Roundabouts in NCHRP Report 672.

The design of mini roundabouts is not covered in this Guidance, however information on the design can be found in Section 6.6 Mini-Roundabouts in NCHRP Report 672.

Capacity Analysis

The Scoping Division of the Bureau of Planning will be providing all capacity analysis to determine lane configuration.

Geometric Design – Horizontal

The horizontal design of a roundabout is the most critical portion of the design process, as the geometry is the main control for speed and vehicle movement in the roundabout. Design of roundabouts is not a matter of geometric conformance, but is a performance driven design process of sketching, assessing impacts and performance iteratively. Expect to create several iterations to be reviewed as part of the horizontal design process so that is a geometric layout is optimized to account for constraints and desired performance. The following subsections will cover the different aspects of horizontal design.

Conceptual Sketch

The first step in the horizontal design of a roundabout is to create a conceptual sketch either on paper, then scanned, or electronically. The goal of the sketch is to approximate a circle size, location and the alignment of the legs to account for constraints and the existing alignments of each approach. The sketch doesn't have to be precise, but gives an illustration of what the roundabout will look like and how it will fit the surrounding area.

An example sketch is shown in Figure 1 below:



Figure 1 – Example Sketch

Tips for sketching:

- It is helpful to have a drawing with just a proposed inscribed circle diameter (ICD), central truck apron and central island, and then sketch the various exits and entries in that order. Approaches should have a baseline alignment to the left of the center of the ICD as that is the preferred option for MaineDOT.
- Placing the ICD centered on the existing intersection uses, if practical, as much of the existing intersection footprint as possible. Utilizing the existing footprint will reduce construction and property acquisition costs.
- Multiple sketches may need to be created to achieve an optimal configuration with varying ICD locations, shapes and sizes. Each option may vary the ICD size and location and the alignment of the legs.

Once an optimal configuration is reached with a sketch, the sketch should be used as a basis for a refined design.

Selection of Shape and Placement

Inscribed Circle Diameter

See Section 6.3.1 Inscribed Circle Diameter in NCHRP Report 672.

The ICD should be placed in the same location as what was provided in the sketch. If not already optimized in the sketch, different shapes and sizes should be examined to determine what fits the intersection.

Elliptical shapes may be most optimal if the existing intersection is skewed (less than 80 degrees).

Alignment of Approaches

See Section 6.3.2 Alignment of Approaches in NCHRP Report 672.

The baseline alignments should be similar to what was provided in the sketch and should be curved to tie into the center point of the roundabout. However, the segments before the last curves should remain left of the center point when extended into the circulatory roadway.

See Figure 2 below:

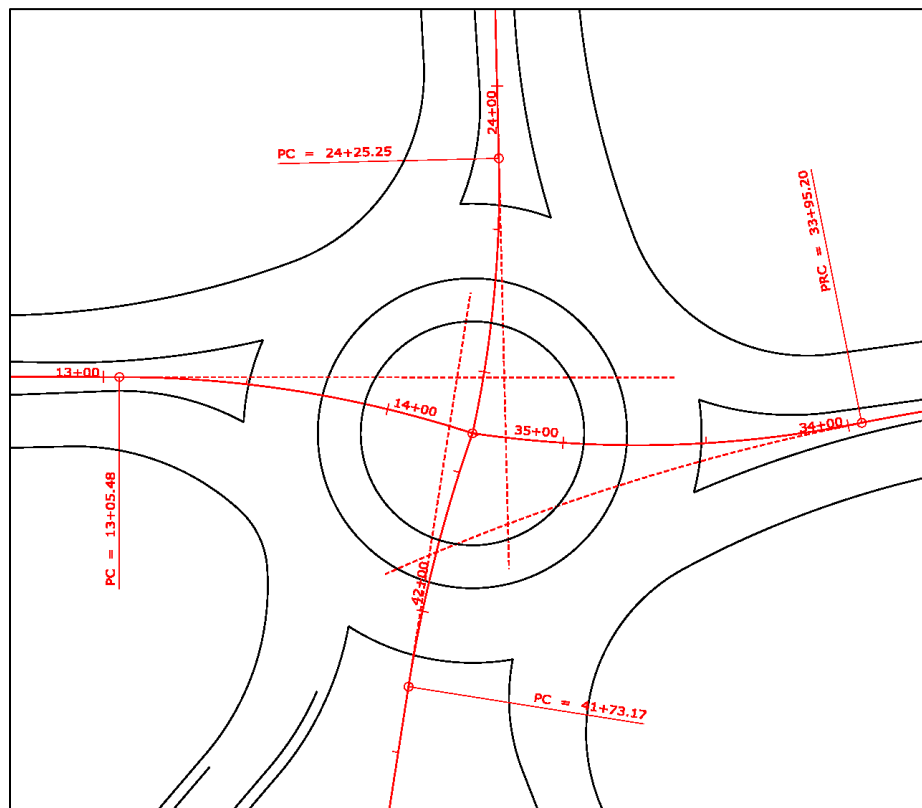


Figure 2 – Alignment of Approaches

Roundabout Design Elements

Circulatory Roadway Width

See Section 6.4.3 Circulatory Roadway Width for single lane configurations and Section 6.5.3 Circulatory Roadway Widths for multi-lane configurations in NCHRP Report 672.

Hybrid multilane roundabouts will require multiple widths for different sections of the circulatory roadway. Generally the circulating width downstream of the entry is slightly wider than the associated entry.

Truck Aprons

- Central – See Section 6.4.7.1 Truck Aprons in NCHRP Report 672 and [Performance Checks – Design Vehicle Accommodation](#).

A 15-foot width is preferred for easier snow removal. Other widths may be considered but care should be taken to ensure that the truck apron is not so wide as to invite vehicles to drive straight through the roundabout, nor should it be so narrow that snow removal is difficult.

- Side – Side truck aprons may be necessary to accommodate larger vehicles without increasing the entry width. If used adjacent to pedestrian facilities, a cut-through should be provided at any crossings of the apron and detectable warnings should be placed behind the apron.

Central Island

The central island is the raised, non-traversable and landscaped island in the middle of the roundabout. The horizontal dimensions are defined by the combination of the central truck apron and circulatory roadway widths. The shape of the central island may also need to be designed to accommodate oversized and overweight (OSOW) vehicles.

Entries and Exits

For general information on entry and exit design for single lane roundabouts, see Section 6.4.5 Entry Design and 6.4.6 Exit Design, and for information about entries for multi-lane roundabouts see Section 6.5.4 Entry Geometry and Approach Alignment in NCHRP Report 672.

- Entry angle – The angle between the entry and adjacent exit, 2θ should be between 40 and 80 degrees and the angle between the entry and circulatory roadway, θ should be between 20 and 40 degrees. Smaller or larger angles may create undesirable speed differentials between entry, circulating and exiting speeds.

To measure 2θ , select three points, approximately an equal distance apart along the outer entry and exit radius and draw three perpendicular lines from each point to the inner radius. Fit an arc to intersect the midpoint of each line and then extend the arc from the last midpoint to intersect the edge of the circulatory roadway. Then extend a

tangent line from that intersection into the circulatory roadway. The resulting angle, 2θ is measured as shown in Figure 3 below:

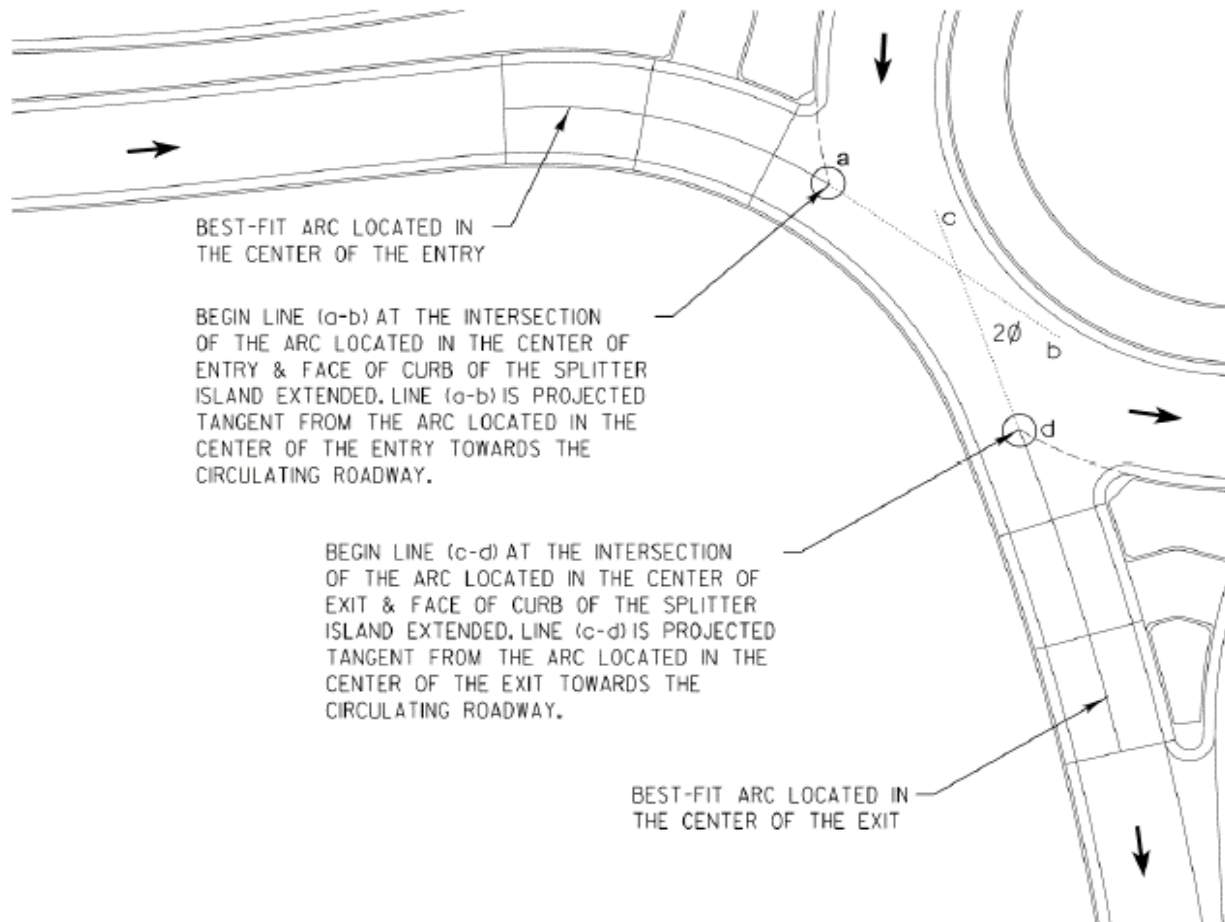


Figure 3- Figure 30.21 from the Wisconsin Department of Transportation Facilities Development Manual, Section 11-26 Roundabouts

If there is no adjacent exit present, repeat the procedure for constructing the tangent from the entry to the circulatory roadway to measure 2θ , then draw a tangent line in both directions at the point where the middle of the circulatory roadway intersects with the projected line from the entry and measure θ as shown in Figure 4 below:

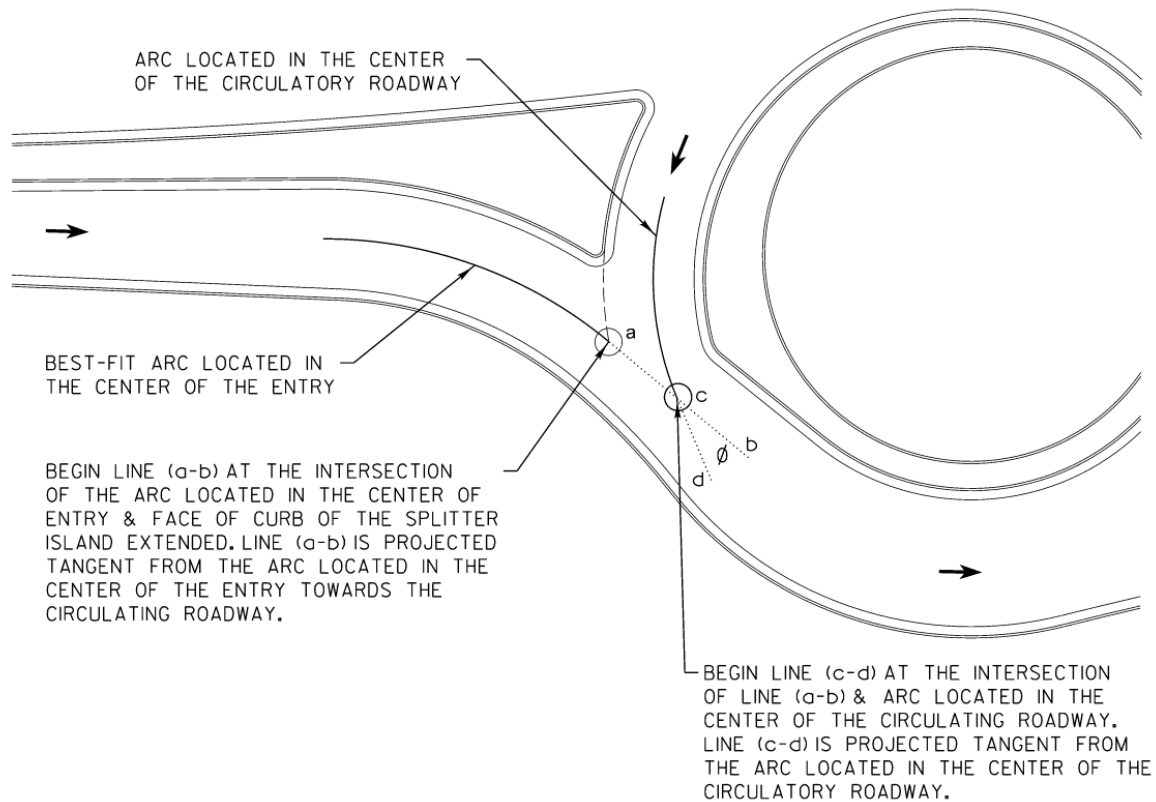


Figure 4 - Figure 30.22 from the Wisconsin Department of Transportation Facilities Development Manual, Section 11-26 Roundabouts

- **Width** - The minimum width for single lane entries and exits is 19 feet from curb to curb with 20 feet preferred. For multilane entries, each lane width should be 12 to 14 feet in width and the total width for a two-lane entry should be no more than 34 feet including any gore areas for truck accommodation.

A side truck apron should be utilized for right turning vehicles on single lane entries if the width of the entry to accommodate turning trucks could encourage two passenger vehicles to be side by side in the entry.

- **Entry-Path Overlap (multi-lane entries)** – See Section 6.5.4 Entry Geometry and Approach Alignment of NCHRP Report 672.

For a hybrid multi-lane roundabout, the nose of the central truck apron should be offset 5 feet from the splitter island radius extended into the circulatory roadway, to reduce the possibility of entry-path overlap. See Figure 5 below:

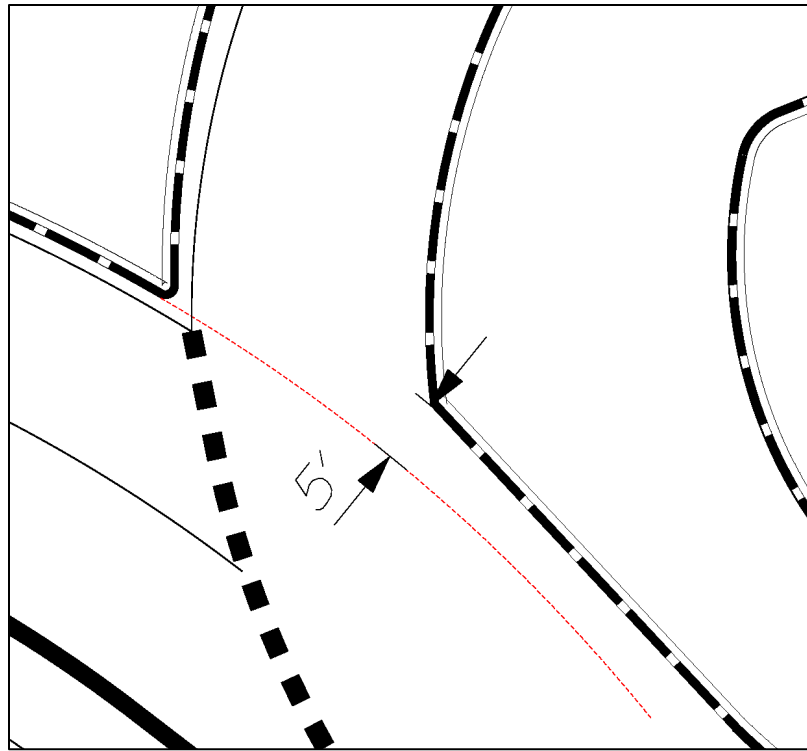


Figure 5 – Offset of Central Truck Apron Nose

Chicanes

These are a series of successive curves with decreasing radii that should be considered for speed reduction, especially for roundabouts located in high speed corridors. See Section 6.8.5.4 Approach Curves of NCHRP Report 672 for more information.

Right-Turn Bypass Lanes

See Section 6.8.6 Right-Turn Bypass Lanes in NCHRP Report 672

Turning volumes and available lane storage will determine whether a free-flow or yielding bypass is required.

When a free-flow bypass is required and there are right of way constraints that limit the area for merging on the exit, an alternate merge can be used to shorten the overall merging length.

Splitter Islands

Refer to the following references in NCHRP Report 672:

- Single lane roundabouts – Section 6.4.1 Splitter Islands
- Multilane roundabouts – Section 6.5.5 Splitter Islands
- High-speed approaches – Section 6.8.5.3 Splitter Islands

Splitter island cut-through widths should be 6 to 8 feet.

For information about maintaining access to entrances, see [Entrances](#).

Performance Checks

These checks should be completed after every iteration of the horizontal design to see if any further adjustments are necessary.

- **Fastest Path** - The geometric entry path deflection or “fastest path” is a critical performance check in the horizontal design of roundabouts. Entry-path deflection is best represented by continuous spline curves because this best approximates a vehicle’s fastest path through a roundabout.

The fastest path is drawn beginning 165 feet from the entrance line with an offset of 5 feet from curbs and 3 feet from other pavement markings or striping. The critical entry path radius (R1) occurs for 65 to 80 feet at the sharpest curvature of the spline. See Figures 6 to 8 below to see an illustration of fastest path movements for different types of roundabouts.

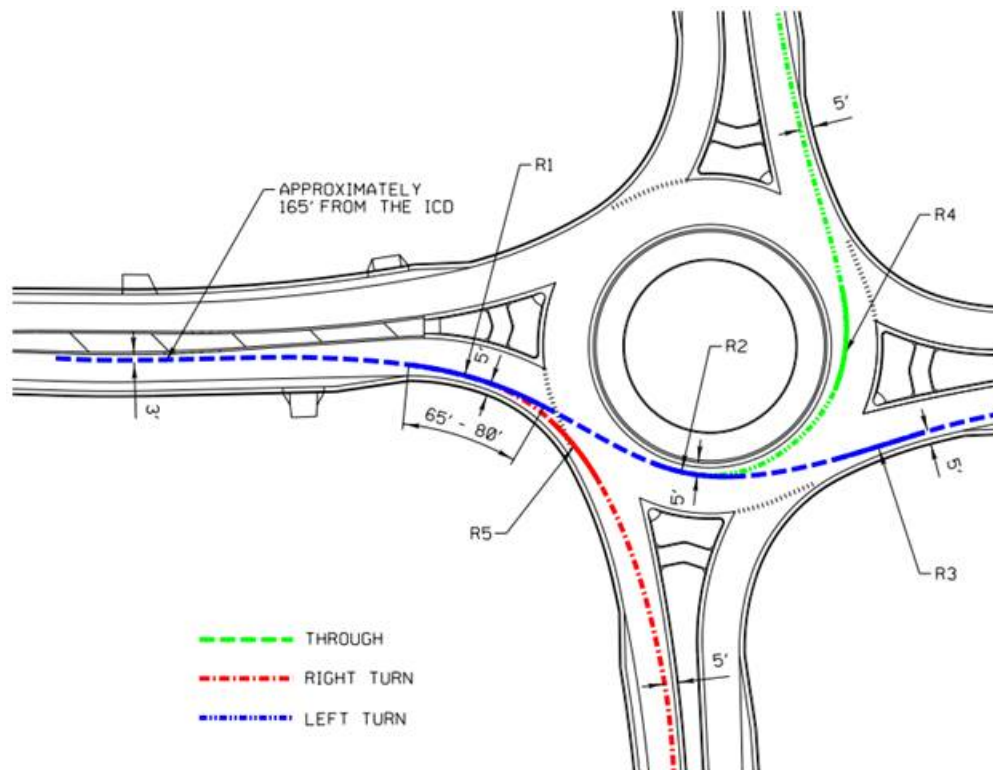


Figure 6 – Fastest Path Through a Single Lane Roundabout

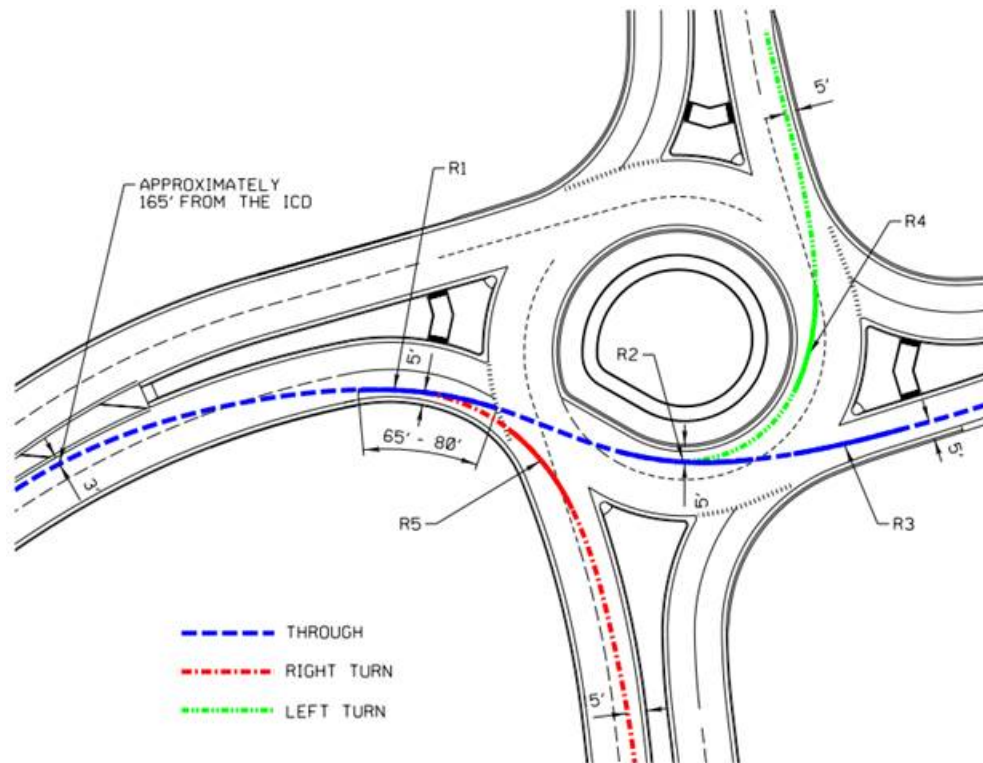


Figure 7 – Fastest Path Through a Multilane Roundabout

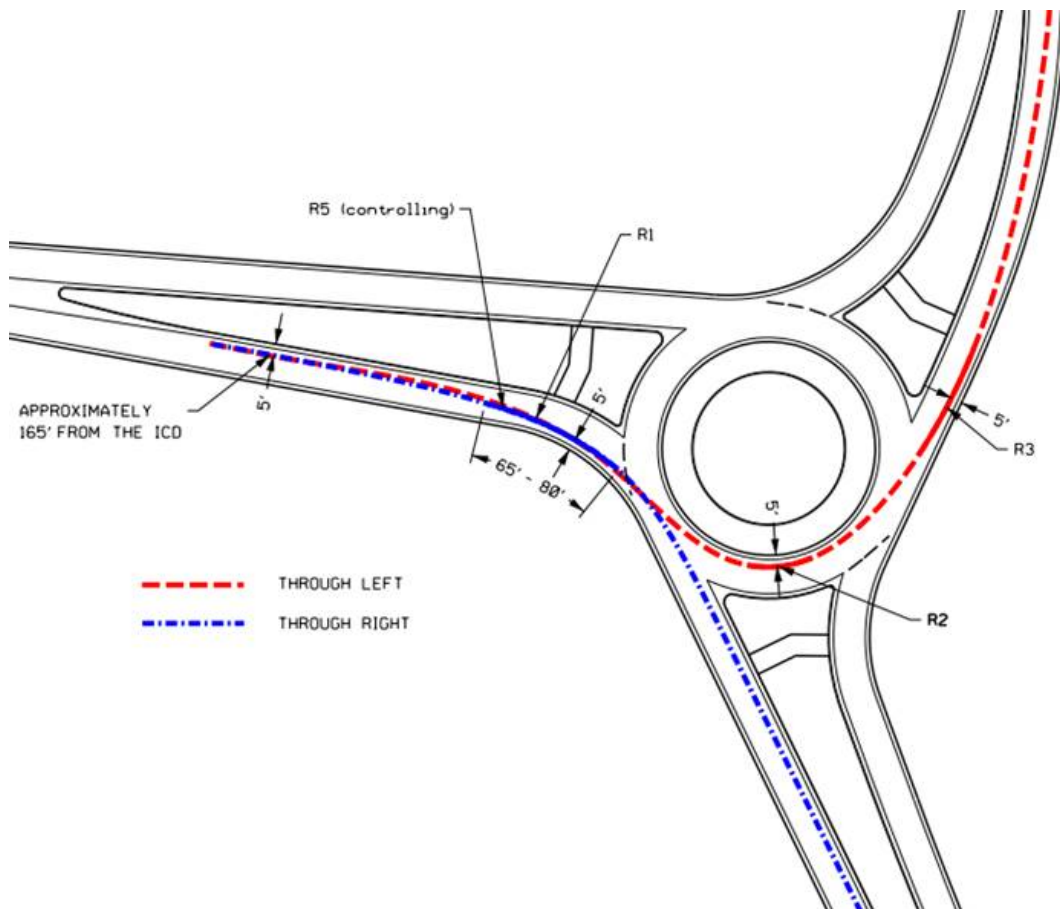


Figure 8 – Fastest Path Through a Three-Leg (Y) Roundabout

To create the fastest path in CAD, see this documentation from WisDOT:

[FDM 11-26 Attachment 50.2 Creating Roundabout Fastest Paths \(Spline Curves\) in MicroStation Version 8i](#)

Vehicle speeds are estimated from Equations 6-1 and 6-2 found in Section 6.7.1.2 of NCHRP 672. Equation 6-3 may be used to estimate actual entry speed but does not govern the design.

Table 1 below gives the radii and corresponding range of speeds for the desirable fastest path through a roundabout as illustrated in Figures 6 to 8 above.

Table 1 – Roundabout Paths and Speed Tolerances

Critical Radius	Description	Desirable Range of Radii and Corresponding Speeds*
Entry Path Radius, R4	The minimum radius on the fastest through path prior to the entrance line. (This is not the same as Entry Radius.)	Single Lane $R1 \leq 170'$; $V1 = 20$ to 25 mph Multilane $R1 \leq 275'$; $V1 = 25$ to 30 mph Multilane in-lane 20 to 22 mph
Circulating Path Radius, R2	The minimum radius on the fastest through path around the central island.	$R2 \leq 170'$; $V2 = 15$ to 25 mph
Exit Path Radius, R3	The minimum radius on the fastest through path into the exit. See NCHRP 672, Section 6.7.1.2 Equation 6-4	$V3 = V2 + \text{Acceleration to the exit crosswalk}$ Desirable < 25 mph
Left Turn Path Radius, R4	The minimum radius on the path of the conflicting left-turn movement.	$R4 \leq 95'$; $V4 = 10$ to 20 mph
$R1 - R4$	The difference between entry and circulating speed	10 to 12 mph
Right Turn Path Radius, R5	The minimum radius on the fastest path of a right-turning vehicle.	$R5 \leq 170'$; $V5 = 15$ to 25 mph

**Note: Under urban conditions where pedestrians are present, desirable values of fast path speeds should be in the low range of values shown in Table 1. Check the design speed control of sensitive designs that may have high entering or circulating speeds. Entry radii values correspond with the speeds and 2 percent cross slope and nominal pavement friction values.*

- Stopping Sight Distance (SSD) – See Section 6.7.3.1 Stopping Sight Distance in NCHRP Report 672.
- Intersection Sight Distance (ISD) – See Section 6.7.3.2 Intersection Sight Distance in NCHRP Report 672.
- Sight Distance Diagram – This diagram should be created in CAD from SSD and ISD triangles. See 6.7.3.5 Combined Sight Distance Diagram in NCHRP Report 672 for more information.
- Design Vehicle Accommodation – The design vehicle for a roundabout is typically a WB-67. See Section 6.4.7 Design Vehicle Considerations in NCHRP Report 672 for

single lane roundabouts and Section 6.5.7 Design Vehicle Considerations for multi-lane roundabouts.

The roundabout should be designed so that a tractor portion of a tractor trailer design vehicle can remain in the circulatory roadway while the trailer tracks over the truck apron if necessary.

- Oversized and Overweight Vehicle (OSOW) Accommodation – See Section 6.4.7 Design Vehicle Considerations in NCHRP Report 672.

Geometric Design – Vertical

See Section 6.8.7 Vertical Considerations in NCHRP Report 672.

If possible, raise the circulatory roadway and approaches above the existing profile to minimize excavation and incorporate existing base gravel.

Template Design

Cross Slope

Circulatory Roadway

The circulatory roadway should be sloped at 2 percent in general but that slope may need to vary from plus 2 percent to minus 2 percent based on the approach grades and drainage requirements.

Truck Apron

All truck aprons should have a cross slope of 1 percent sloping away from the central island.

Approach and Exit Transition to Circulatory Roadway

Rideability and drainage should be considered when transitioning from the approach or exit to the circulatory roadway.

Pavement Structure

See Section 8.2.04 Intersections in Pavement Design

Curb Usage

Central Island

Curb surrounding the central island should be sloped and have a reveal no greater than 4 inches.

Truck Aprons

Truck apron curb adjacent to the circulatory roadway shall have a reveal no greater than 3 inches and shall either be sloped granite or concrete slipform curb. See the sample typical section details below in Figures 6 and 7 for each type.

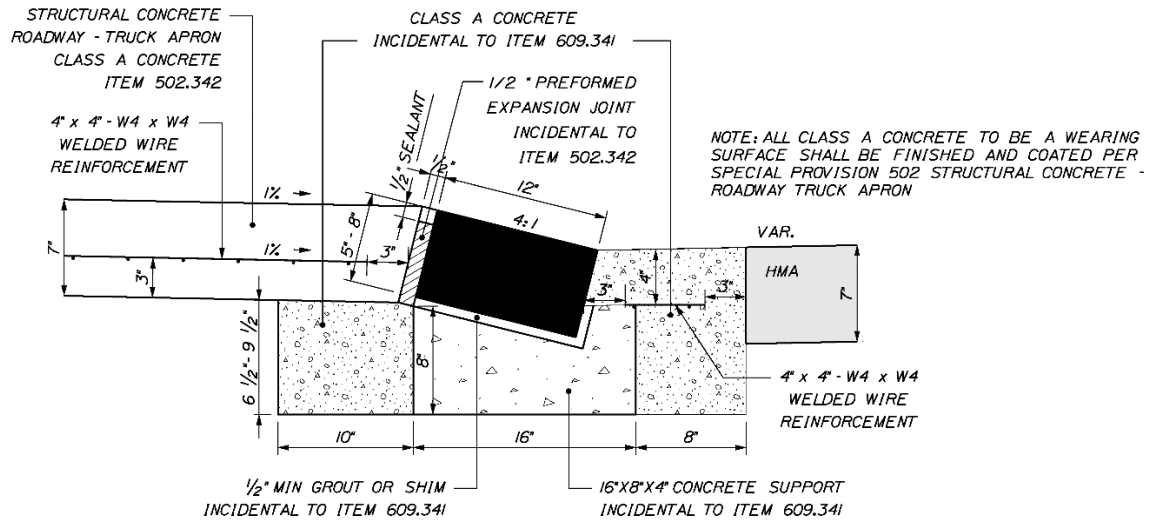


Figure 6 - Sloped Granite (Curb Type 5 – Truck Apron) Detail

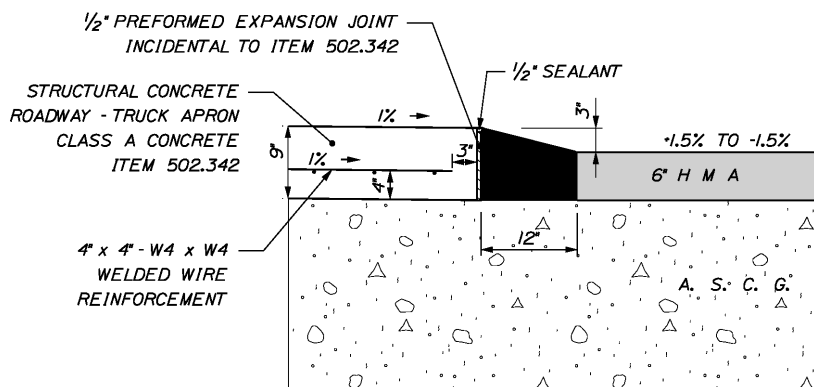


Figure 7 - Concrete Slipform Curb (Mold 6) Detail

Islands and Radii

All islands and outer radii shall have sloped curb.

General Reference

See Design Guidance – Curb Type and Mold Usage for more information on curb types and usage.

Materials

Circulatory Roadway and Approaches

The circulatory roadway and approaches shall all be paved. See Section 8.2.04 Intersections in Pavement Design for information on determining the pavement structure.

Truck Apron

All truck aprons are typically constructed with reinforced Portland cement concrete (Item 502.342 Structural Concrete - Roadway Truck Apron). The use of colored concrete is no longer preferable.

Other materials (such as hot mix asphalt with a contrasting surface treatment) can be considered if they provide a contrast with the circulatory roadway surface.

Curb

Both concrete slipform curb and granite curb are acceptable for use in roundabouts, however bituminous curb will not be used. Typically, granite curb is used for truck aprons.

Splitter Islands

All splitter islands shall be paved with hot mix asphalt and/or landscaped.

Traversable Islands

See Design Guidance – Medians and Islands.

Pedestrian and Bicycle Accommodation

Bicycle Lane Transitions

See Section 6.8.2 Bicycle Design Considerations in NCHRP Report 672.

Sidewalks and Shared Use Paths

See Section 6.8.1.1 Sidewalks in NCHRP Report 672.

Crosswalks

General:

See Complete Streets Design and the following policies:

[MaineDOT Guidelines on Crosswalks](#)

[MaineDOT ADA Compliance Policy for Construction and Maintenance](#)

Cut-throughs

For cut-throughs in the splitter islands, a staggered crossing, offset to the left is preferred. However, an angled crossing is acceptable where there is not enough room in the splitter island to accommodate a staggered design. See the illustration of both types in Figures 8 and 9 below:

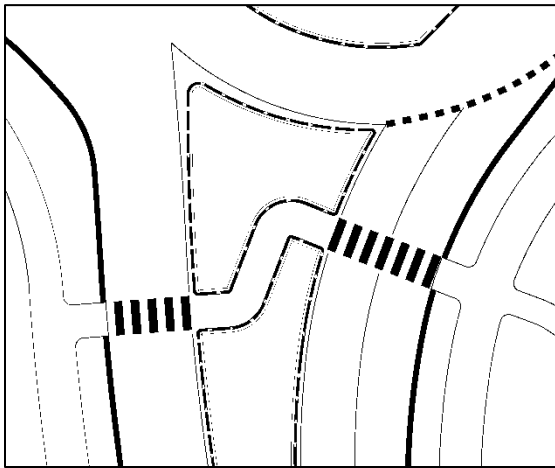


Figure 8 - Staggered crossing (preferred)

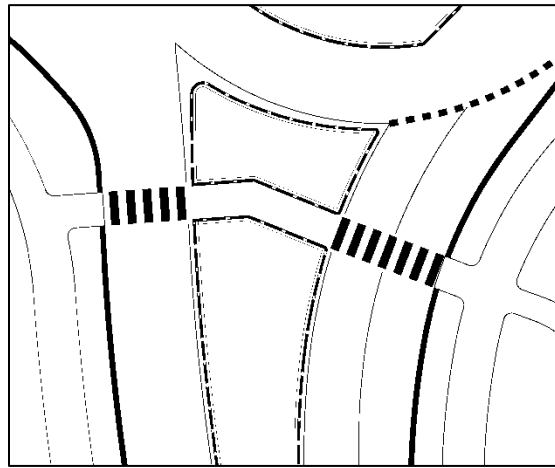


Figure 9 - Angled crossing (acceptable)

For both types of crossings, the crossing on the entry should be set back approximately 25 feet from the nose of the splitter island. For staggered crossings, the crossing on the exit should be set back approximately 50 feet from the nose of the splitter island. However, the presence of a side truck apron and/or right turn bypass lane may require the crossing to be set back slightly further. For angled crossings, the crossing on the exit should be 25 feet from the nose of the splitter island.

Raised Crosswalks

Raised crosswalks may also be a consideration to increase yielding to pedestrians at certain locations. See Section 6.8.1.2 Crosswalks of NCHRP Report 672 for more information.

Pedestrian Beacons

The use of rectangular rapid flashing beacons (RRFB) with accessible pedestrian systems is required for all multilane approaches and crossings with right turn bypass lanes. RRFBs are also acceptable for use at site-specific single lane crossings if approved by the Regional Traffic Engineer and the rest of the project team.

Entrances

Location

See Section 6.11 Access Management in NCHRP Report 672.

Splitter Island Openings

Splitter island openings should be considered when left turn access to and from a property is required but restricted due to the presence of the splitter island. Openings shall have only enough width to accommodate left turn access into and out of the property and they shall be considered to be traversable islands.

Pavement Striping and Markings

General

See Section 7.3 Pavement Markings in NCHRP Report 672.

Markings

MaineDOT uses “fishhook” arrows for lane designation. Word markings and yield lines are not typically used.

Striping

The circulatory roadway lines for multi-lane roundabouts should be as shown in Figure 7-10 of NCHRP Report 672.

The entrance line should be 18 inches wide and the dashes should be 2 feet long with a 2 foot gap in between. It should also be preformed thermoplastic that is recessed $\frac{1}{8}$ inch. In multilane roundabouts, the lane striping on a multilane approach and within the circulatory roadway should also be preformed thermoplastic that is recessed $\frac{1}{8}$ inch.

The gore area at the nose of the splitter island at the exit should be striped so that there is a white line from the edge of the circulatory roadway to the tangent point on the radius of the nose. See Figure 10 below for a diagram of the striping.

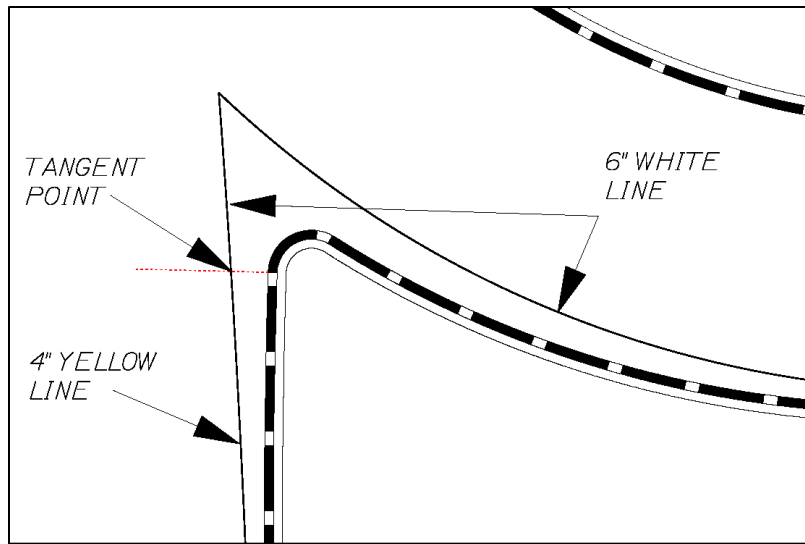


Figure 10 – Splitter Island Nose Gore Striping

Signs

See Section 7.4 Signing in NCHRP Report 672.

MaineDOT uses “fishhook” arrows for lane designation and overhead signs are preferable for multi-lane approaches.

Consideration should be given to the location of signage for visibility and the number of signs used to avoid “sign clutter.”

Lighting

All roundabouts shall have overhead lighting and shall be lit by perimeter illumination. See Chapter 8 Illumination in NCHRP Report 672 for more information.

The temperature of LED lighting and the use of cutoff fixtures should also be considered depending on the location of the roundabout.

Landscaping

General

See Chapter 9 Landscaping in NCHRP Report 672.

Central Island

The central island of a roundabout shall be landscaped and shall contain no fixed objects such as large trees, poles, walls, statues or monuments due to the possibility of errant vehicles crashing into the central island. This is especially critical for roundabouts that are located in high-speed corridors. Smaller caliper trees (less than 4 inches in diameter) are acceptable, however a maintenance agreement with the municipality to replace trees when they become larger is recommended so the central island remains free of fixed objects.

The earth shall be mounded a minimum of three feet in height from the top of the exterior curb and shall have a grassed swale to facilitate drainage within.

Splitter Islands

Landscaping may be provided on splitter islands but care should be taken that only low growth (less than 2 feet in height) landscaping is used within sight triangles. In addition, a minimum 2-foot-wide buffer of landscaping or grass should be provided along all pedestrian cut-throughs for better recognition of the cut-through by visually impaired or blind pedestrians.

Design Checks and Peer Review

Roundabout projects have a unique design check and review process compared to other projects in the Department.

See the following documents for more information:

Highway Program Check/Review Process

Roundabout HVAC Design Submittal Form

Roundabout Horizontal Alignment Complete Submittal Form Checklist

Roundabout Vertical Alignment Complete Submittal Form Checklist

Constructability

Maintenance of traffic during construction is a primary concern, in particular during operations that involve placing concrete and paving operations.

Phasing of the project should be discussed by the project team before the project is advertised.

Plan and 3D Model Development

Roundabout projects require extra sheets in the plans to provide detailed information about specific elements. These sheets include but are not limited to the following:

- Typical Sections – Circulatory Roadway
- Truck Apron Details
- Grading Plans
- Geometric Plans
- Lighting Plans
- Signing Plans
- Striping and Marking Plans
- Cross Sections and/or Representative Sections

Cross section and representative sections that are provided are for supplemental information only. The Grading and Geometric Plans are the primary plans used to construct the roundabout.

See the Preparation of Plans Guidance for more information on what to provide in the project plans and see the Sample Plans on the Highway Program Website for examples of specific sheets.

3D models should be developed and provided with every roundabout project due to the complexity of roundabout construction. See the Model and 3D Data section on the Highway Program Website for more information about deliverables.