



1.1 General

This section and its sub-sections are comprised of roundabout design and operations guidelines developed through research and experience. Much of the prescribed guidance has been proven through application, evaluation and refinement - a truly continuous improvement process.

The Department has updated previous versions of this guide to account for changes in national roundabout guidelines made possible through research, namely NCHRP 572 - Roundabouts in the United States, 2006 and NCHRP 672, Roundabouts: An Informational Guide, Second Edition. The NCHRP guidelines and research are heavily relied upon in this chapter. Where appropriate and justified by local experience, exceptions for use by the Wisconsin Department of Transportation are noted. Where both references are cited but differences exist, the Facilities Development Manual guidance shall govern.

The modern roundabout is a subset of many types of circular intersections. The term modern roundabout and roundabout are used interchangeably throughout this document. The roundabout is a one-way circular intersection where circulating traffic is given priority over entering traffic and where entry speeds are low relative to older unconventional circular intersections. The term "modern roundabout" is used in the United States to differentiate roundabouts from the older and often large diameter nonconforming traffic circles, rotaries or very small traffic calming circles used on residential streets.

Traffic circles fell out of favor in this country by the mid 1950's because they encountered safety and operational problems as traffic volumes increased beyond their operational thresholds. However, substantial progress has been achieved in the subsequent design of circular intersections, and the modern roundabout should not be confused with the traffic circles of the past.

Roundabouts may be considered for a wide range of intersection types including but not limited to freeway interchange ramp terminals, state route intersections, and state route/local route intersections. Roundabouts generally process high volume left turns more efficiently than all-way stop control or traffic signals and will process a wide range of side road volumes. Roundabouts can improve safety by reducing vehicle speeds and eliminating crossing conflicts that are present at conventional intersection. The required intersection sight distance is greatly reduced from what is required for a signalized intersection due to the reduced intersection speeds.

The modern roundabout is defined by three basic principles:

1. Yield-at-Entry - Vehicles approaching the roundabout must wait for a gap in the circulating flow, or yield, before entering the circle.
2. Deflection - Traffic entering the roundabout is directed or channeled to the right with a curved entry path into the circulating roadway.
3. Geometric Curvature - The radius of the circular road and the angles of entry are designed to slow the speed of vehicles.

The following is a list of locations where a roundabout may be feasible:

1. Intersections with a high-crash rate or a higher severity of crashes
2. High-speed rural intersections
3. Freeway ramp terminals
4. Transitions in functional class or **typical** speed change (including rural to urban transitions)
5. Existing intersections that are failing
6. Aesthetics is an objective
7. Intersections of dissimilar functional class (arterial-arterial, arterial-collector, arterial-local, collector-collector, collector-access)
8. Four-leg intersections with entering volumes less than 5,000 vph or approximately 50,000 ADT
9. Three-leg intersections
10. Intersection of two signalized progressive corridors where turn proportions are heavy (random arrival is better than off-cycle arrival)
11. Closely spaced intersections where signal progression cannot be achieved
12. Locations where future access will be added to the intersection

13. Replacement of all-way stops
14. Intersections near schools
15. Intersections where safety is a major concern

FHWA and AASHTO have made intersection safety a high priority. The objective is to improve the safety and operation of intersections. When compared to signalized intersections, studies by the Insurance Institute for Highway Safety [1] show that roundabouts typically reduce overall delay and congestion, increase capacity, and improve safety. For example, right-angle collisions are a prominent cause of death at signalized intersections. Studies by the Insurance Institute for Highway Safety show that signalized intersections converted to roundabouts experienced on average: 75% fewer injury crashes, 90% fewer fatality crashes, and fewer crashes overall.

Wisconsin roundabout safety has been studied with encouraging results. In a study of roundabout collision history, prepared by the University of Wisconsin Traffic Operations and Safety Laboratory [4], local researchers analyzed 24 roundabouts that were built in Wisconsin in 2007 or before. Three years of before and after crash data were gathered as well as geometric and volume data. An Empirical Bayes (E-B) analysis was used to examine the safety benefits for total crashes and injury crashes. A simple before-and-after crash analysis was also completed to analyze specific types of injury crashes for each roundabout. The E-B analysis was performed using Safety Performance Functions (SPFs) from both the Highway Safety Manual (HSM) and Wisconsin specific data. The results from both values were very similar adding strength to the numbers. Using the HSM SPFs, researchers found mixed results for total crash frequency but a significant decrease in crash severity. Nationally, a 35% reduction was observed for all crashes as noted in NCHRP Report 572 while Wisconsin roundabouts showed a 9% decrease across the 24 roundabouts. Wisconsin roundabouts had a decrease of 52% for fatal and injury crashes. Roundabouts nationwide are also experiencing a significant decrease in severe crashes.

When looking at predictor variables, the speed limit of the approaches did not show a significant impact on the safety of the roundabout. While multilane roundabouts seem to be safer than single lane roundabouts when looking at fatal and injury crashes, single lane roundabouts saw a larger decrease in total crashes. Two-way stop-controlled conversions had the highest safety benefit as compared to All-way stop controlled and signalized.

According to FHWA, some or all of the following safety benefits can be realized with proper roundabout design and implementation:

- Provide more time for entering drivers to judge, adjust speed for, and enter a gap in circulating traffic, allowing for safer merges
- Reduce the size of sight triangles needed for users to see one another
- Increase the likelihood of drivers yielding to pedestrians (compared to an uncontrolled crossing)
- Provide more time for all users to detect and correct for their mistakes or mistakes of others
- Make crashes less frequent and less severe, including crashes involving pedestrians and bicyclists
- Make the intersection safer for novice users

Critical to the acceptance of the roundabout intersection is overcoming the internal and external skepticism of its advantages and value compared to stop controlled or signalized intersections. Meet with local officials and adjoining property owners early in the process to address potential political or economic impacts. Designers and traffic engineers should also coordinate presentation materials with region staff as well as the Bureau of Project Development to present a consistent unified approach for roundabout implementation throughout the State.

1.2 Modern Roundabout vs. Other Circular Intersections

On the surface, modern roundabouts, old traffic circles and rotaries look similar; however, there are subtle differences that distinguish the two intersection concepts. The fundamental difference is their differing design philosophies. Modern roundabouts control and maintain low speeds for entering and circulating traffic. This is achieved by small diameters and low-speed entry geometry. By contrast, traffic circle geometry encourages high-speed merging and weaving, made possible by larger diameters and large high-speed entry radii. Modern roundabouts control vehicle speed by geometric design elements that allow only slow speeds therefore creating safer driving conditions. The common characteristics distinguishing a modern roundabout from a traffic circle or a rotary type intersection are summarized in [Table 1.1](#).

Table 1.1 Distinguishing Characteristics of Modern Roundabouts

Feature	Modern Roundabout	Traffic Circle or Rotary
Control at Entry	Yield at all entries. The circulatory roadway has no control	Stop, signal, or give priority to entering vehicle. Circulating vehicles yield to entering traffic.
Operational Characteristics	Vehicles are sorted by destination at the approach. Weaving within the circulatory roadway is minimized. Using proper lane line markings, lane changes are strongly discouraged in the circulatory roadway.	Weaving is unavoidable and weaving sections are provided to accommodate conflicting movements
Deflection	Large entry angle helps to create entry deflection to control speed through the roundabout	Entry angle likely to be reduced to allow higher speed at entry
Speed	Maintain relatively low circulating speeds (<25 mph)	Higher circulating speeds allowed (>25 mph)
Circle Diameter	Smaller diameters improve safety	Larger diameters allowed. Small diameter circle sometimes used for traffic calming
Pedestrian Crossing	No pedestrian activity on central island	Some large traffic circles allow pedestrian crossing to and from the central island
Splitter Island	Required	Optional
Parking	No parking on the circulatory roadway or in close proximity of the yield line	On large traffic circles, occasional parking permitted within circulating roadway

A roundabout can provide a possible solution for locations that experience high crash rates or crash trends by reducing the number of conflict points where the paths of opposing vehicles intersect. For example, over half of the crashes at conventional intersections occur when a driver either; misjudges the distance or speed of approaching vehicles while making a left turn or violates a red light or stop sign resulting in a right-angle collision. Such crashes would be eliminated with a roundabout, where left turns and crossing movements are prohibited. Furthermore, collisions at roundabouts involve low speeds and low angles of impact, and therefore, are less likely to result in serious injury for all road users. Crash evaluation is an important process to complete for any intersection improvement alternative. Crash evaluation will consist of reviewing individual crash records and will typically include factors such as location, date, type of crash, time of day, age of driver, weather conditions, severity of crash, and other important information to assess the problem(s), patterns and potential improvement need.

When considering methods to increase the capacity of an intersection, a roundabout can be an alternative to stop or signal controlled intersections. With conventional signal controls, only alternating streams of vehicles are permitted to proceed through an intersection at one time, which means a loss of capacity when the intersection clears between phases. In contrast, the only restriction on entering a roundabout is the availability of a gap in the circulating flow. The reduced speeds within the roundabout will typically allow the approaching driver to safely select a gap that is relatively small. By allowing vehicles to enter simultaneously from multiple approaches using short headways, a possible advantage in capacity can be achieved with a roundabout. This advantage becomes more prominent when the volumes of left or right turning movements are relatively high.

By constructing a pair of roundabouts at ramp terminal intersections, capacity improvements to the interchange can be accomplished without the cost of widening the structure to carry additional lanes over or under a freeway, or expressway (see [FDM 11-30-1](#) and NCHRP Report 672, Chapter 6.10 for more information on interchanges).

Roundabouts can produce operational improvements in locations where the space available for queuing is limited. Roadways are often widened to create storage for vehicles waiting at red lights, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes between intersections. One possible application can be found at diamond interchanges, where high left turn volumes can cause signals to fail.

Conventional forms of traffic control are often less efficient at intersections with a difficult skew angle, significant offset, odd number of approaches, or close spacing to other intersections. Roundabouts may be a good fit for such intersections, because they do not require signal phasing. The ability of a roundabout to accommodate high turning volumes, make them especially effective at "Y" or "T" junctions. Roundabouts may also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout.

Intersection sight distance for roundabouts is about half what it is for other intersection treatments because of reduced intersection speeds.

Another possible application is where access is controlled with raised medians. Roundabouts would facilitate left turns and U-turns to access properties on the opposite side of the highway.

1.3 Advantages and Disadvantages

[Table 1.2](#) lists advantages and disadvantages of roundabouts versus other intersection alternatives.

Table 1.2 Advantages and Disadvantages of Roundabouts vs. Other Alternatives.

Category	Advantages	Disadvantages
Safety	<p>Reduced number of conflict points compared to other non-circular intersections. Left-turn conflicts are removed.</p> <p>Elimination of high angles of conflict and high operational speeds; fewer and less severe accidents.</p> <p>Reduction in conflicting speeds passing through the intersection.</p> <p>Reduced decision making at point of entry.</p> <p>Long splitter islands and other geometric features provide good advanced warning of the intersection.</p> <p>Raised level of consciousness for drivers.</p> <p>Facilitate U-turns that can substitute for more difficult midblock left turns.</p>	<p>Crashes may temporarily increase due to improper driver education.</p> <p>During emergencies, signalized intersections can preempt control.</p> <p>Multilane roundabouts present more difficulties for pedestrians with blindness or low vision due to challenges in detecting gaps and determining that vehicles have yielded at crosswalks.</p> <p>May reduce the number of available gaps for midblock unsignalized intersections and driveways</p>
Operations	<p>Traffic yields, nonstop, continuous traffic flow.</p> <p>Generally higher capacities experienced.</p> <p>Can reduce the number of lanes required between intersections, including bridges between interchange ramp terminals.</p> <p>During off-peak hours, signal timing can create undue delay at signalized intersections.</p>	<p>Coordinated signal systems can increase capacity of the network.</p> <p>As queues develop, drivers accept smaller gaps, which may increase crashes.</p> <p>Equal priority for all approaches can reduce the progression for high volume approaches.</p> <p>Cannot provide explicit priority to specific users (e.g., trains, emergency vehicles, transit, pedestrians) unless supplemental traffic control devices are provided.</p>
Cost	<p>No maintenance of signals (heads, loop detectors, controllers).</p> <p>Lower accident rate and severity; reduced accident costs.</p>	<p>Central island landscaping maintenance.</p> <p>Illumination cost.</p> <p>May have significant real estate impacts</p>
Pedestrians & Bicyclists	<p>Splitter islands provide pedestrian refuge and shorter one-directional traffic crossing. Pedestrians only need to consider one direction of traffic at a time.</p> <p>Low speed conditions improve bicycle and pedestrian safety.</p> <p>Depending on their skills and level of comfort, bicyclists have the option to take a lane to negotiate through a roundabout.</p>	<p>Pedestrians, especially children, elderly, and handicapped may experience increased delay and reduced safety in securing acceptable gaps to cross. Pedestrians with vision impairments may have the most trouble establishing safe opportunities to cross.</p> <p>Longer travel path.</p> <p>Bicycle ramps could be confused for pedestrian ramps.</p>
Environmental	<p>Reduced starts and stops; reduced air pollution.</p>	<p>Possible impacts to natural and cultural resources due to potentially greater spatial requirements at the intersection.</p>

Category	Advantages	Disadvantages
OSOW Truck Route (OSOW-TR)	Reduction of potential obstacles at intersections (traffic signals, signing, median islands).	The geometric design may be challenging to allow the navigation of OSOW vehicles. Additional right-of-way and paved areas may be needed to accommodate OSOW vehicles.
Aesthetics	Provide attractive entries or centerpieces to communities. Used in tourist or shopping areas to separate commercial uses from residential areas. Provide opportunity for landscaping or gateway to enhance the community.	May create a safety hazard if hard objects are placed in the central island directly facing the entries.

1.4 Defining Physical Features

The defining features of a roundabout are shown in [Figure 1.1](#) and [Figure 1.2](#), and described in [Table 1.3](#).

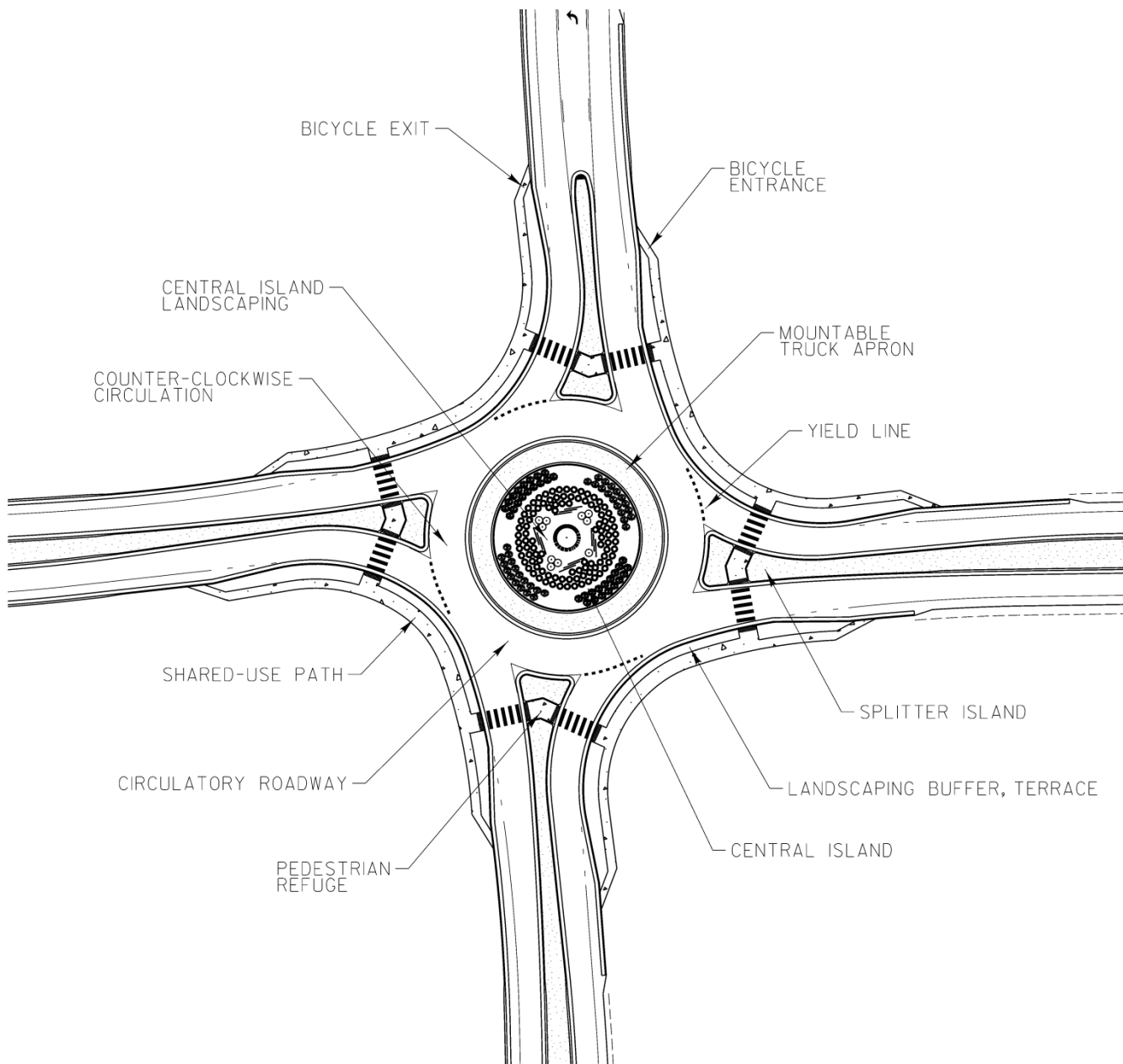


Figure 1.1 Single-lane Roundabout Features

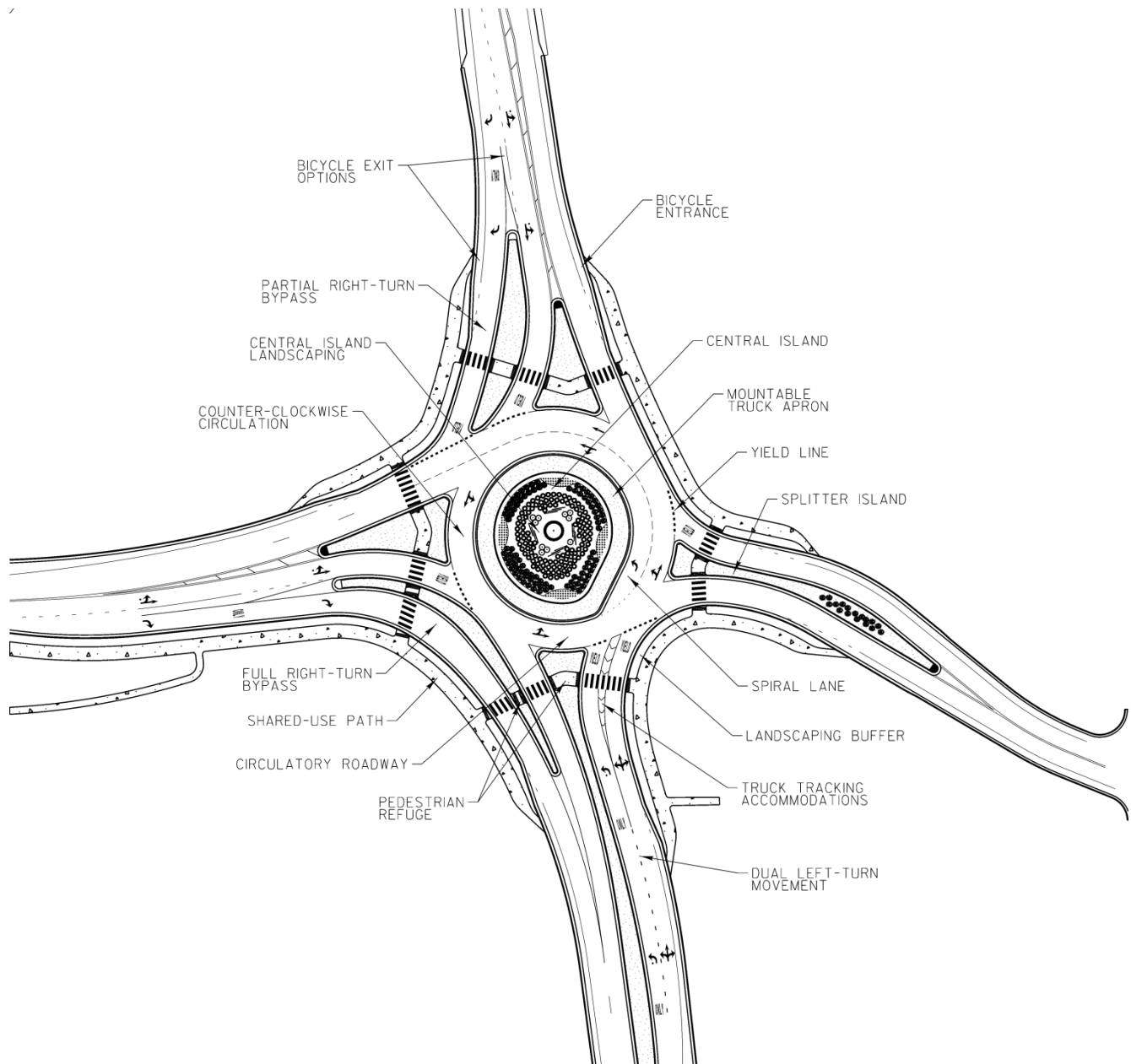


Figure 1.2 Multilane Roundabout Features

Table 1.3 Roundabout Features

Feature	Description
Central island	The raised area in the center of a roundabout around which traffic circulates. The central island does not necessarily need to be circular in shape.
Splitter island	A raised curb island (special situations may be painted) area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and to provide refuge for pedestrians crossing the road in two stages.
Circulatory roadway (counter clockwise circulation)	The curved path used by vehicles to travel in a counterclockwise fashion around the central island. The width of the circulatory roadway is typically 1.0 to 1.2 times the width of the widest entry width.
Truck Apron	The traversable portion of the central island adjacent to the circulatory roadway and widened pavement area adjacent to outside curbs. It is required to accommodate snow plows and the wheel off-tracking of large trucks, and OSOW vehicles. It is usually paved with a contrasting color (red) to delineate the apron from the normal vehicle path.
Yield Line	A point of demarcation separating traffic approaching the roundabout from the traffic already in the circulating roadway. The yield point is usually defined by a thick, (typically 18-inch wide), dotted edge line pavement marking.
Accessible pedestrian crossings	Provide accessible pedestrian crossings at all roundabouts. The crossing location is set back from the yield line, typically one car length. The splitter island is cut to allow pedestrians, wheelchairs, strollers, and bicycles to pass through.
Bicycle treatments	Bicycle treatments at roundabouts provide bicyclists the option of traveling through the roundabout either by riding in the travel lane as a vehicle, or by exiting the roadway and using the crosswalk as a pedestrian, or as a cyclist using the shared-use path, depending on the bicyclist's level of comfort. Bicycle exit ramps should generally leave the roadway within a 25 to 35-degree angle range. Bicycle entrance ramps should generally enter the roadway within a 25 to 35-degree angle range. The entrance and exit ramps should be located approximately 50-150 feet from the circulating traffic to allow the bicyclist an opportunity to transition onto a path away from the circulatory roadway.
Landscaping buffer	Landscaping buffers are provided at most roundabouts to separate vehicular and pedestrian traffic and to encourage pedestrians to cross only at the designated crossing locations. Landscaping buffers can also significantly improve the aesthetics of the intersection as long as they are placed outside the required sight limits.
Shared-use path	Pathway for pedestrians to walk. In the urban environment, it is common to provide a shared-use path at the perimeter of the roundabout to accommodate pedestrians and bicyclists.

1.5 Roundabout Categories

Roundabouts are categorized by size and environment. The following is a list of basic categories explained in FHWA, Roundabouts: An Informational Guide [3]. (FHWA Roundabout Guide). There may be situations where categories are not applicable. The planning process and final design methodologies for roundabouts are to be based on “principles” versus strict rules or one-size fits all **criteria**. For example, there are no categories for transitional areas and the final design will depend on various factors.

1.5.1 Single-Lane Roundabout

1.5.1.1 Urban Single-Lane Roundabouts

A single lane roundabout is the most efficient and **typical** roundabout category for urban applications. This type of roundabout is characterized as having a single-lane entry at all legs and one circulatory lane. The roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a non-traversable central island, and may include an apron surrounding the non-traversable part of the central island to accommodate long trucks. The minimum inscribed diameter to accommodate a WB-65 is 120 feet. Where long trucks are anticipated, verify that the circulating roadway width and the truck apron can accommodate off-tracking of a WB-65 design vehicle. A truck apron is included to allow the semi-tractor to stay in the circulating roadway while the trailer off-tracks onto the apron. If the roundabout is located on the OSOW Truck Route, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle. Refer to [FDM 11-25-2](#) for further discussion.

1.5.1.2 Rural Single-Lane Roundabouts

Rural single-lane roundabouts generally have high speeds on the approach roadway in the range of 45 to 55 mph. They require supplementary geometric and traffic control device treatments on the approach roadway to encourage drivers to slow to an appropriate speed before entering the roundabout. Such treatments include raised and extended splitter islands, a non-traversable central island, and adequate horizontal deflection. Rural roundabouts may have larger diameters than urban roundabouts which may allow slightly higher speeds at the entries, on the circulatory roadway, and at the exits. This is permissible if few pedestrians are expected at these intersections, currently and in the future.

Rural roundabouts which may one day become part of an urbanized area should be designed as urban roundabouts, with slower speeds and pedestrian accommodations. In the interim, design them with supplementary approach and entry features to achieve safe speed reduction. If the roundabout is located on the OSOW Truck Route, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle. Refer to [FDM 11-25-2](#) for further discussion.

1.5.2 Multilane Roundabouts

1.5.2.1 Urban Multilane Roundabouts

Urban multilane roundabouts are roundabouts in urban areas that have at least one approach leg with two or more entry lanes. These require wider circulatory roadways to accommodate more than one vehicle traveling side by side. Again, it is important that the vehicular speeds be consistent throughout the roundabout. The geometric design includes raised splitter islands, a non-traversable central island, and appropriate horizontal deflection, and may include an apron surrounding the non-traversable part of the central island to accommodate long trucks. A truck apron should be included to allow the semi-tractor to stay in the inner lane and the trailer to off-track onto the apron. When long trucks are anticipated, or if the roundabout is located on the OSOW Truck Route, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle. Refer to [FDM 11-25-2](#) for further discussion.

1.5.2.2 Rural Multilane Roundabouts

Rural multilane roundabouts have speed characteristics similar to rural single-lane roundabouts with approach speeds in the range of 45 to 55 mph. They differ in having two or more entry lanes, or entries flared from one or more lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural multilane roundabouts mirror those of their urban counterparts. The main design differences are designs with higher entry speeds, larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that may one day become part of an urbanized area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. In the interim, design them with approach and entry features to achieve safe speed reduction. A truck apron should be included to allow the semi-tractor to stay in the inner lane and the trailer to off-track onto the apron. When long trucks are anticipated, or if the roundabout is located on the OSOW Truck Route, verify that the roundabout geometry, splitter islands, truck apron, and off-tracking can accommodate the appropriate OSOW check vehicle. Refer to [FDM 11-25-2](#) for further discussion.

1.5.3 Combination Roundabouts

Combination roundabouts are roundabouts that combine single and multilane entries. This combination usually occurs when roads of different approach volumes intersect roads of two different classifications; a State Trunk Highway (STH) with a local road. These roundabouts are commonly found in suburbanized locations but can also be found in rural locations.

1.99 References

- [1] Insurance Institute for Highway Safety publications, May 13, 2000; July 28, 2001; November 19, 2005; www.iihs.org
- [2] Insurance Institute for Highway Safety publications, March 2001; July 17, 2011; www.iihs.org/research/qanda/roundabouts.html
- [3] NCHRP 672, Roundabouts: An Informational Guide, Second Edition, December 2010, <http://www.trb.org/Publications/Blurbs/164470.aspx>
- [4] Comprehensive Evaluation of Wisconsin Roundabouts, Volume 2: Traffic Safety, Wisconsin Traffic Operations and Safety (TOPS) Laboratory, Department of Civil and Environmental Engineering, University of Wisconsin-Madison, September 2011

FDM 11-26-5 Design Process and Qualifications

August 15, 2019

5.1 Roundabout Design Process and Qualifications

Due to modern roundabouts' status as a relatively new and unique design form as well as the inherent complexity of their geometric and operational aspects, WisDOT has developed a roundabout design process

which requires a qualified designer participate in each roundabout design.

This section describes the 3-stage design process and the critical design elements. A qualified designer must be involved with each stage of the process. In addition, this procedure describes the various roles the qualified designer may take in completing a roundabout design.

5.2 Roundabout Designer Requirements

A qualified designer must meet the skills, knowledge and experience level determined appropriate by the Wisconsin Department of Transportation for roundabout design. A list of qualified designers for each of the following 3 levels of roundabout complexity is available from the Division of Transportation Systems Development, Bureau of Project Development.

1. Level 1 Roundabout - The design complexity at this level is limited to roundabouts where all legs (not to exceed 4 legs) are single lane entries without bypass lanes. A Level 1 designer must have an understanding of roundabout design with high confidence in designing truck aprons, developing a design with appropriate values for the six geometric parameters, design for appropriate fastest speed paths, design for truck turning paths, have the ability to properly assess the basic capacity requirements of single lane roundabouts from traffic turning movements using the approved analysis software per [FDM 11-26-20](#). The Level 1 qualified designer shall inform the region when the roundabout design exceeds the complexity stated above for a Level 1.
2. Level 2 Roundabout - The design complexity at this level is limited to roundabouts where legs are dual lane entries or less and may have bypass lanes. A Level 2 designer must be proficient in roundabout design with ability to design truck aprons, developing a design with appropriate values for the six geometric parameters, design for appropriate fastest speed paths, design for truck turning paths, and develop special signing and pavement marking needs. The designer will have the ability to properly run the approved capacity analysis software (see [FDM 11-26-20](#)) evaluate alternative lane configurations and output from the software program. The Level 2 qualified designer shall inform the region when the roundabout design exceeds the complexity stated for a Level 2. See discussion below about dual lane roundabouts in close proximity and the potential for Level 3 involvement.
3. Level 3 Roundabout - The design complexity at this level involves all roundabout designs to include 3 or 4-lane entries or has closely spaced roundabouts where the operations of one may have an impact on the operations, signing or marking of another. See discussion below about dual lane roundabouts in close proximity and the potential for Level 3 involvement. A Level 3 designer must have the skills and knowledge for the most complex roundabout designs.

The region will use the best traffic data available to select the appropriate qualified designer (Level 1, 2, or 3). This is typically determined prior to project solicitation by the Project Development Section.

The project team will select either a Level 2 or 3 qualified designer if the region anticipates that the project will include a dual lane roundabout. There are certain situations when it is desirable for the region to involve a Level 3 qualified design on dual lane roundabout projects. Some examples include situations where:

- There are other multilane roundabouts in close proximity
- Lane assignment or lane continuity is difficult to achieve without adding another lane
- Reduction in weaving between roundabouts is desired
- Queue backup into an adjacent multilane roundabout is possible
- Other special needs that have been identified

The region will discuss the involvement of a Level 3 qualified designer for dual lane roundabout projects to determine if expertise is needed beyond that provided by a Level 2 qualified designer.

WisDOT regions, consultants, local agencies such as a counties, townships, municipalities, and developers, etc. shall have a qualified designer on staff, or contract with an approved designer, to provide the required sign-off on the Critical Design Parameters document for roundabout designs, as described below, for both WisDOT and WisDOT oversight projects.

Qualified designers may participate in different ways in order to provide the required sign-off on the Critical Design Parameters document.

1. Independently complete the roundabout design. When a WisDOT region, consultant, local agency such as a county, township, municipality etc. or a developer has a roundabout on a project they must have a qualified designer to oversee or complete all aspects of the plans, specifications and estimate (PS & E) package for the roundabout according to the 3-Stage Design Process described below.
2. Assist and mentor the project team in their completion of the roundabout design. A WisDOT region, consultant or local agency such as a county, township, municipality etc. or developer has a roundabout on the project may prefer to contract for assistance or mentoring from a qualified designer in the plans preparation process. The qualified designer must directly assist the project team

addressing the critical design elements in the 3-Stage Design Process described below.

- Independently review the roundabout design prepared by a project team. A WisDOT region, consultant, local agency such as a county, township, municipality etc. or developer has a roundabout on the project and the design is prepared without any assistance from a qualified designer. The roundabout designer is responsible to contract with one of the qualified designers to review the critical elements of the design at each stage of the 3-Stage Design Process described below. The information to be provided to the qualified designer at each stage of plans complete is provided below.

Coordinate the proposed roundabout design with a qualified designer early in the design process. It is better to allow the qualified designer to be proactive and in a position to suggest modifications rather than to be reactive and lose design options because the design or commitments on the project are too far along.

The qualified designer's review comments shall be submitted to the project team and the WisDOT region at each Stage. The critical design recommendations from the qualified designer should be identified clearly so the roundabout design team knows what to modify on the plans. Less critical comments will likely improve the design more toward optimal and should not be taken lightly. A discussion between the qualified designer, design team, and region may be needed to properly address recommendations in the plans or document the dismissal of the comment(s).

The qualified designer in consultation with WisDOT will determine which elements of the design are critical in the situation where a dispute may take place. Department personnel are responsible to ensure that the qualified designer recommendations and comments are properly addressed by the design team.

5.3 Intersection Control Evaluation, Program Level Scoping Phase

For an explanation of the required level of analysis see [FDM 11-25-3](#). The Program Level Scoping phase typically does not yield the final determination on the selected intersection control. However, there are early screening criteria some of which are identified in [FDM 11-25-3](#) and typically evaluated during the Program Level Scoping phase that may eliminate the roundabout from further consideration.

A qualified designer is not required for the Program Level Scoping phase of an Intersection Control Evaluation.

5.4 The 3-Stage Roundabout Design Process

The following information, including [Figure 5.1](#), describes each of the stages of development where it is critical to have a qualified designer involved in the roundabout design. There may be a project schedule delay or adverse cost ramifications associated with a roundabout design if each stage of the evaluation is not followed in sequence.

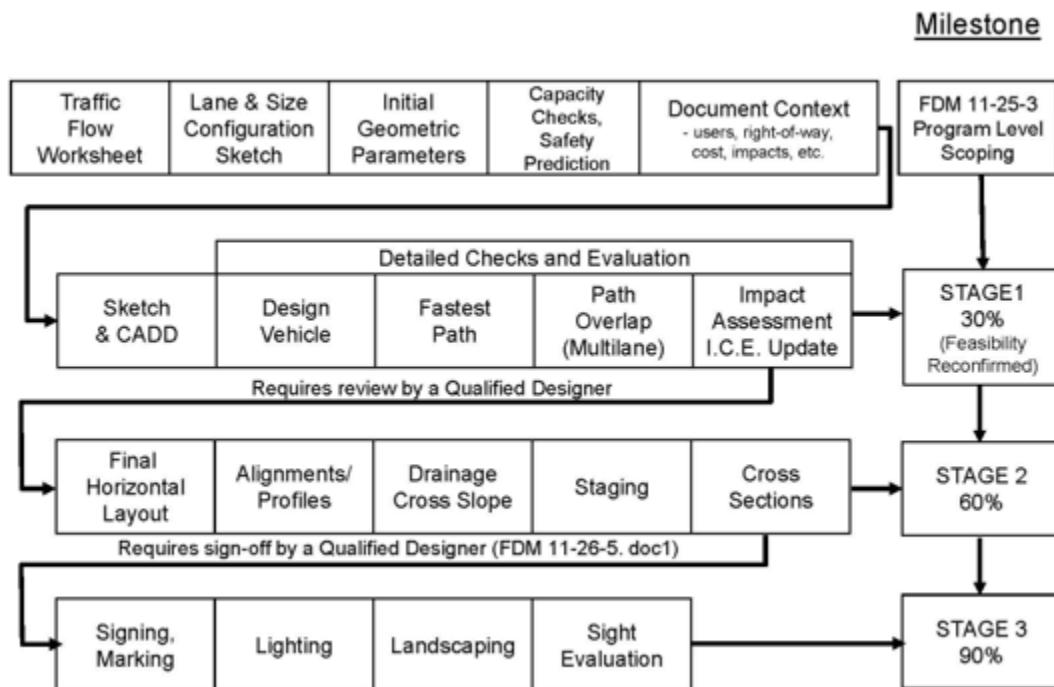


Figure 5.1 WisDOT 3-Stage Design Process

5.4.1 Stage 1, Roundabout Design Process

Prior to 30% plans complete. While the **typical** type of intersection control may still be undetermined; the roundabout has been identified as one of the viable alternatives from the Program Level Scoping phase. Complete Stage 1, requires qualified designer involvement, prior to the 30% plans complete level so the comments and design adjustments are incorporated and ready with the typical 30% plan review discussion/meeting conducted by the region. For designs prepared outside the region, submit Stage 1 plans to the region in .dgn format. Generally, it is preferred to have the roundabout design developed far enough to have an idea of right-of-way needs, raised median locations identified, access, major utilities and other potential impacts prior to a Public **Involvement** Meeting (PIM) so relatively accurate information can be presented and discussed with property owners to include Level of Service (LOS), or delay, comparisons with other intersection control alternatives. It is advisable to include a roundabout expert or other highly experienced roundabout designer at the initial PIM. At the very least, they should be consulted in the planning process for the initial PIM. Initial project acceptance and understanding by the project stakeholders and users is key for a smooth project development process. There may be situations where the design is accurate and detailed enough showing the proper size and location of the roundabout, LOS, extent of the splitter island curb locations and type of access along the roadway that a more detailed design could be completed after the PIM.

This is a list of critical elements of design that the qualified designer needs to address at this stage of plans complete.

1. Determine optimum location of circle with inscribed diameter.
2. Use Traffic Flow Worksheet, [FDM 11-26, Attachment 20.1](#). Completed with existing volumes, design year volumes for AM and PM peak and midday if a tourist area that may have higher mid-day than AM or PM peaks.
3. Establish lane configuration(s) and analyze the existing and forecasted traffic turning movements using the approved analysis software per [FDM 11-26-20](#)
4. Complete lane markings and pavement arrows for multilane only.
5. Complete a highly developed design that shows face of curb locations, crosswalks, splitter islands, shared-use path, bike ramps, truck apron etc. with appropriate widths.
6. Verify design vehicle movement and required check vehicles Refer to [FDM 11-25-1.4](#) for discussion on truck routes and routes for oversized-overweight (OSOW) vehicles. Refer to [FDM 11-25-2](#) and [FDM 11-25 Attachment 2.1](#) for OSOW vehicle inventories and [FDM 11-25 Table 2.1](#) for required OSOW design vehicle checks.
7. Show the fast path with speed calculations for R1 thru R5.
8. Fill out [Attachment 5.1](#).
9. Prepare preliminary stopping sight distance for - approach, circulatory roadway, crosswalk and exit, and the intersection sight distance.
10. Prepare preliminary centerline profile of circulatory and approach roadway.
11. Prepare preliminary typical sections on the mainline roadway.

5.4.2 Stage 2, Roundabout Design Process

Prior to 60% plans complete. Complete design revisions recommended by the qualified designer from the previous 30% design. At this stage, a qualified designer is required to complete the design/review of the critical design elements identified below. Prepare the plans such that the environmental documents may be completed, DSR approved and plat work may begin. Complete Stage 2, including all qualified designer involvement prior to the 60% plans complete level so the review comments and design adjustments are incorporated and ready for the region in preparing for the typical 60% plan review discussion/meeting. For designs prepared outside the region, submit Stage 2 plans to the region in .dgn format. At this stage, the qualified designer shall sign the Critical Design Parameters document ([Attachment 5.1](#)) for attachment to the DSR. One of the primary critical elements of design at this stage is the vertical control with each leg having vertical profiles, circulating roadway profile, crown location, slope intercepts, central island grading, drainage consideration with inlet locations, and spot elevations.

This is a list of critical elements of design that the qualified designer needs to address at this stage of plans complete.

1. Finalize horizontal design changes implemented
2. Establish roadway profiles on each leg
3. Establish circulating roadway profile
4. Show crown location, cross slopes, spot elevations
6. Consider central island grading design

7. Consider drainage design/inlet locations
8. Show preliminary light standard locations
9. Identify the need for large green and white guide signs, overhead guide signs, or other non-typical installations
10. Finalize lane pavement marking and lane assignment pavement marking for multilane roundabouts
11. Identify major utility conflicts (i.e. utility conflicts that may result in relocating the circle)
12. Prepare preliminary typical sections
13. Consider preliminary construction staging layout and identify potential staging conflicts, such as access control, large grade differences between stages, etc. that may impact the design

5.4.3 Stage 3, Roundabout Design Process

Prior to 90% plans complete. Finalize the vertical, drainage, pavement marking, signing, lighting, landscaping plans, work zone traffic control, and utility coordination. In preparation for PS & E complete Stage 3, including all qualified designer involvement, prior to the 90% plans complete level so the review comments and design adjustments are incorporated and ready for the region in preparing for the typical 90% plan review discussion/meeting. This is the final design with construction staging or detour plan.

This is a list of critical elements of design that the qualified designer needs to address at this stage of plans complete.

1. Complete final plan and profile with any vertical and horizontal control details included for field layout
2. Prepare final signing and pavement marking plan
3. Prepare final landscaping and lighting plan (refer to [TEOpS 11-1](#) for lighting policy)
4. Prepare final construction staging plan.

LIST OF ATTACHMENTS

[Attachment 5.1](#) Roundabout Critical Design Parameters Document

FDM 11-26-10 User Considerations

August 15, 2019

10.1 Pedestrian and Bicyclist Accommodations

Accommodating non-motorized users is a Department priority. Therefore, give special consideration to locations where:

- Pedestrian volumes are high
- There is a presence of young, elderly or blind or low vision impaired citizens wanting to cross the road
- Pedestrians are experiencing particular difficulty in crossing and being delayed excessively

Also, consider the adjacent land use near the roundabout location, such as schools, playgrounds, hospitals, and residential neighborhoods. These sites may warrant additional treatments as presented below. Prior to determining whether bicycle or pedestrian concerns will be a factor in the design of the roundabout, the designer is strongly encouraged to contact the region or state bicycle and pedestrian coordinator for their guidance.

10.1.1 Pedestrians

Research conducted in the U.S. and Europe as presented in the NCHRP 672 [1] indicates fewer pedestrian accidents with less severity occur at roundabout intersections when compared to signalized and unsignalized intersections with comparable volumes. Design principles need to be applied that provide for slow entries and exits for pedestrian safety.

Due to relatively low operating speeds of 15 to 20 mph, pedestrian safety is generally better with a roundabout design than with other intersection types. [Table 10.1](#) lists the advantages and disadvantages of roundabouts as related to pedestrians.

Table 10.1 Roundabout Advantages and Disadvantages for Pedestrians

Advantages	Disadvantages
Vehicle speed is reduced as compared to other intersections.	Vehicle traffic is yield controlled so traffic does not necessarily come to a full stop. Therefore, pedestrians may be hesitant to use the cross walk at first.
Pedestrians have fewer conflict points than at other intersections. Pedestrians are responsible for judging their crossing opportunities. This requires more alertness and may be considered an advantage.	May be unsettling to the pedestrian, depending on age, mobility, visual impairments, and ability to judge gaps in traffic.
The splitter island gore allows pedestrians to resolve conflicts with entering and exiting vehicles separately and simplifies the task of crossing the roadway. Crossing is often accomplished with less wait than at signalized intersections.	Pedestrians at first glance may have to adjust to the operation of a roundabout. Part of this adjustment includes the crosswalk location, which is behind the first stopped vehicle or approximately 20 feet from the yield point.

Choosing the appropriate crossing location for pedestrians is a delicate balance between their safety and convenience, and operation of the roundabout. Pedestrians want crossing locations as close to the intersection as possible to minimize out-of-direction travel. The further the crossing is from the roundabout, the more likely that pedestrians may choose a shorter route that may put them in greater danger. Both crossing location and crossing distance are important. Minimize crossing distance to reduce exposure to pedestrian-vehicle conflicts. The continual movement of traffic, and the inability of some pedestrians to judge gaps in an oncoming travel stream, reduces the perception of safety for pedestrians at roundabouts. This is especially true of children, the elderly or the disabled. These types of pedestrians generally prefer larger gaps in the traffic stream and walk at slower speeds than other pedestrians. In recognition of pedestrians with disabilities, pedestrian crossings at roundabouts should be designed to comply with Americans with Disabilities Act (ADA) mandated accessibility standards. Refer to the following guides for further information:

- [FDM 11-26-35.5.13](#), for non-motorized users
- NCHRP 672, Chapter 6, §8.1
- NCHRP 672, Chapter 7, §5.3
- MUTCD, §3B.18
- Wisconsin MUTCD (WMUTCD), 3B.18

The pedestrian hybrid beacon (also commonly referred to as High-Intensity Activated Crosswalk or HAWK) may be considered for installation at roundabouts where there is an identified need to facilitate pedestrian crossings, such as accommodating blind or low-vision pedestrians. Contact the regional traffic operations unit and the Bureau of Traffic Operations if considering the pedestrian hybrid beacon to determine if appropriate and to complete a permit. A factor for installation may be the distance the device is set back from the entrance and installed upstream from the exit. At this time, the guidance for set back at the entrance may be up to 165 feet in advance of the yield line, and the distance upstream from the theoretical exit (end of the splitter island) may also be up to 165 feet.

10.1.2 Bicyclists

The experience in other countries with bicyclists at roundabouts has been mixed with regard to safety. The Insurance Institute for Highway Safety reports that roundabouts provide a 10 percent reduction in bicycle crashes at 24 signalized intersections that were converted to roundabouts in the U.S. Multilane entry roundabouts may be more problematic than single lane entries.

The complexity of vehicle interactions within a roundabout could leave a cyclist vulnerable, and for this reason, designated bike lane markings within the circulatory roadway shall not be used (WMUTCD, 9C.04). Effective designs that constrain motorized vehicles to speeds more compatible with bicycle speeds, around 15 - 20 mph, are much safer for bicyclists.

The operation of a bicycle through a roundabout presents challenges to the bicyclist similar to that of traditional signalized intersections especially for turning movements. As with pedestrians, one of the difficulties in accommodating bicyclists is their wide range of skills and comfort levels. While experienced bicyclists may have no difficulty maneuvering through a roundabout, less experienced bicyclists may have difficulty and discomfort mixing with vehicles and may feel safer on a roundabout sidepath.

Design features such as proper entry curvature and entry width help slow traffic entering the roundabout. Providing a ramp from the roadway to a roundabout sidepath or shared-use path prior to the intersection allows

a bicyclist to exit the roadway and proceed around the intersection safely through the use of crosswalks.

Bicyclists are often less visible and therefore more vulnerable when merging into and diverging from multilane roundabouts. Therefore, it is recommended that a wider shared-use pedestrian-bicycle path, separate from the circulatory roadway, be built where bicycle use is expected. While this will likely be more comfortable for the casual bicyclist, the experienced commuter bicyclist will be slowed down by having to cross as a pedestrian at the cross walk and may choose to continue to traverse a multilane roundabout as a vehicle. Refer to [FDM 11-26-30.5.13](#) for design guidance.

10.2 Transit, Large Vehicle, Oversize Vehicles and Emergency Vehicle Considerations

10.2.1 Transit

Transit considerations at roundabouts are similar to those for any other intersection configuration. A properly designed roundabout will readily accommodate buses. For rider comfort, transit vehicles should not have to use the truck apron.

Bus stops on the far side are preferred and should be constructed with pull-outs. They should be located beyond the pedestrian crossing to improve visibility of pedestrians to other exiting vehicles. Far-side stops result in the crosswalk being behind the bus, which provides for better sight lines for vehicles exiting the roundabout to pedestrians and keeps bus patrons from blocking the progress of the bus when they cross the street.

The use of bus pull-outs has some trade-offs to consider. A positive feature of a bus pullout is that it reduces the likelihood of queuing behind the bus into the roundabout. A possible negative feature is that a bus pullout may create sight line challenges for the bus driver to see vehicles approaching from behind when attempting to merge into traffic. It may also be possible at multilane roundabouts in slow-speed urban environments to include a bus stop without a bus pullout immediately after the crosswalk, as exiting traffic has an opportunity to pass the waiting bus. In a traffic-calmed environment, or close to a school, it may be appropriate to locate the bus stop at a position that prevents other vehicles from passing the bus while it is stopped.

If a bus stop must be located upstream of the roundabout (near side), it should be placed far enough away from the splitter island, such that a vehicle overtaking the stationary bus has adequate space. If the approach is a single lane and capacity is not an issue, the bus stop could be placed at the pedestrian crossing. Nearside stops provide the advantage of having a potentially slower speed environment where vehicles are slowing down, compared to a far-side location where vehicles may be accelerating upon exiting the roundabout. Nearside stops are not recommended for entries with more than one lane because vehicles in the lane next to the bus may not see pedestrians.

The decisions in regard to transit stop location must be coordinated with the local transit authority.

10.2.2 Legal Large Vehicles

Design roundabouts for the largest vehicle that is anticipated to use the roundabout on a regular basis. All roundabouts on the State Highway system must accommodate a WB-65 design vehicle, which is the largest vehicle allowed on the State Highway system without a permit (legal large vehicle). Refer to [FDM 11-25](#) and [FDM 11-25 Attachment 2.1](#) for description of OSOW-MT design vehicles and their inventories. Refer to [FDM 11-25 Table 2.1](#) for required intersection design vehicle checks for various trucking route scenarios. Designing a roundabout for a large legal semi to stay in-lane at entry and within the roundabout presents challenges such as the possibility of:

- A larger diameter
- Wider entries
- Wider circulating lanes
- Increased right-of-way needs
- Increases in certain types of crashes
- Other unique design features

In rare cases, roundabouts have been designed with a gated bypass roadway to accommodate turns.

Load shifting may be problematic for the contents of any vehicle while navigating a turning maneuver. Load shifting is a common concern for liquid or semi-liquid loads where the weight of the load may shift in a manner to exacerbate overturning. It is not uncommon for a vehicle with a high center of gravity to overturn when navigating a turn at speeds that exceed the laws of mechanics. A roundabout is designed to minimize load-shifting problems with larger vehicles however speed is major factor related to overturning. Problems such as minimal entry deflection may lead to high entry speeds, long tangents leading into tight curves, sharp turns at exits, excessive cross slopes, and adverse cross slopes have been the principle causes of load shifting. See [FDM 11-26-30.5](#) for geometric design of roundabouts.

10.2.3 Permitted Oversized Overweight (OSOW) Vehicles

During the preliminary design, check with local officials and the public to determine if there are any special OSOW vehicles that regularly use the route and refer to the WisDOT OSOW vehicle inventory in [FDM 11-25 Attachment 2.1](#). Coordinate OSOW Truck Route (OSOW-TR) and routing activities with the regional freight operations engineer.

Review the truck guidance provided in [FDM 11-25-1.4](#) and [FDM 11-25-2](#), which includes additional information related to truck routes, the OSOW-TR and intersection design guidance. The Department produced a map showing designated state and federal truck routes, and the OSOW-TR in Wisconsin which is available on the web, see the link in [FDM 11-25-1](#). This map may experience updates and changes therefore use the most current on-line version.

It is becoming somewhat common to widen the truck apron along the sides to accommodate OSOW vehicle through movements. Additional pavement (behind a mountable curb) may also be provided along the right side of the entries to accommodate wheel off-tracking. Sign posts may also have to be mounted in removable sleeves to provide additional lateral space for OSOW vehicles (see [FDM 11-26-35.1.12](#)).

10.2.4 Emergency Vehicles

Emergency vehicles passing through a roundabout encounter the same problem as other large vehicles and may require the use of the truck apron. On emergency response routes, compare the delay for the relevant movements with alternative intersection types and controls.

Roundabouts provide the benefit of lower vehicle speeds, which may make them safer for emergency vehicles to negotiate than conventional intersections.

The Wisconsin Motorist's Handbook provides information on what to do when the driver encounters an emergency vehicle. The driver must yield the right-of-way for emergency vehicles using a siren, air horn or a red or blue flashing light. The driver in the circulatory roadway should exit the roundabout before pulling over. Emergency vehicles will typically find the safest and clearest path to get through an intersection. This may include driving the emergency vehicle, with caution and with lights and siren on, in the opposing lane(s) or however the operator sees as the most desirable alternative path.

10.99 References

[1] NCHRP 672, Roundabouts: An Informational Guide, Second Edition

FDM 11-26-15 Agency & Public Coordination

August 15, 2019

15.1 Public Meetings

Public meetings provide an excellent opportunity to bring the public into the design process. It is generally desirable to take the 30% preliminary plans of all feasible alternatives on an equal basis to a public meeting and explain that a roundabout appears to be a reasonable alternative. Inform the public that no preference to any alternative is indicated at that stage, but that input to all alternatives is being gathered. Try to be as specific as possible about the real estate impacts, access impacts and anticipated operations (LOS) between the various alternatives. At this level of design, it may be important to let the public know that you do not have all the answers about the various impacts. Roundabouts are a new form of intersection control that most people are not familiar with. An effective education and communication method applicable to some projects with roundabouts includes scheduling a specific time at each PIM of approximately 10-20 minutes to explain the following:

- The project time-line
- Source(s) of funding
- Concept of roundabouts
- Why the Department has included the roundabout as an alternative
- Construction duration and possible detours or road closures
- Illustrations of how pedestrians, bicyclists, and vehicles should travel through the roundabout
- Holding an open house and public information "exchange" meetings, and attending village and town board meetings or local service organizational meetings are good formats for education and consensus building

After the initial public meeting, a screening evaluation accounting for public support can be completed. Refer to [FDM 11-25-3](#). At the next public meeting, the preferred alternative can then be presented.

15.2 Public Outreach Resources & Methods

The success or failure of a project can often be attributed to how well the Department included the public in its development. This can be particularly true when introducing the modern roundabout due to its confusion with

past circular intersections. There are excellent resources to assist the designer in explaining roundabouts to the public and to help educate drivers:

<https://wisconsin.gov/Pages/doing-bus/eng-consultants/cnslt-rsrcs/design.aspx>

Typically, in the project planning process, alternatives are considered. The alternatives generally include traffic signal, stop sign, or roundabout control; some of which are familiar to drivers and pedestrians. Presenting a comparison of traffic operations and safety between alternatives is a good way to introduce roundabouts. It is essential to inform the public of the planning process that led to the decision favoring a roundabout as the preferred traffic control. A traceable transparent planning process engenders trust and validates the process of wise investment in infrastructure. Designers are encouraged to generate project-specific roundabout outreach materials on their region's web site. Coordination of this effort must be through the Central Office (IT) coordinator and the web site content coordinator.

The common dilemmas for most agencies that want to start using roundabouts are:

- Recognized public perception of roundabouts vs. their proven performance
- Driver education: way-finding and lane choice
- Pedestrian perception of safety vs. proven conditions
- Bicyclist education
- Permitted trucking (typical large trucks)

Pitfalls in the initial push for roundabouts can be avoided by developing detailed components of project outreach resources for internal (local agency) and externally (public outreach) early and continuously. A public acceptance and education campaign is critical to the successful implementation of roundabouts at the State level and for local communities. A successful project oriented public outreach campaign involves assembling a collection of educational and acceptance resources of a general nature. Many of these are readily available through the department's website:

<https://wisconsin.gov/Pages/doing-bus/eng-consultants/cnslt-rsrcs/design.aspx>

but some require adaptation to the project location and context. Examples of the kinds of resources that should be collected and distributed through various media include:

- Case studies
- Testimonials
- National and Wisconsin-specific statistics
- How-to videos
- Web-cam
- Driver training
- Website
- Brochures
- Talking points/discussion bulletins for legislators and staff to respond to calls
- Vulnerable user training materials

A strategy to apply these components requires starting with internal staff (planning, design and maintenance operations); State legislators; District Attorney, State Patrol; then moving to external stakeholders, e.g. interest groups, trucking associations and mobility advocacy groups. Finally, once a consensus is reached with internal and external stakeholders a general public meeting or outreach contact can be arranged.

Prior to any general public outreach, a local officials meeting should be held with local council members, police and fire services, senior staff, and maintenance operations staff. The general education process is exercised with this group and the project specific presentation of the engineering study that led to the choice of a roundabout as an alternative control is made. A consensus must be the goal of the local officials meeting in order that the subsequent public contact, e.g. open house goes smoothly with upper and lower tier agency agreement on why the use of a roundabout and how the project will be implemented, including proposed education for the locally affected.

Preparation for the local project public contact requires development of context specific education and outreach components. An inventory of resources that have proven effective for local project outreach is as follows:

- Scale model (1:87, 1 inch = 7.25 feet) of the layout accompanied by scale model trucks and cars
- Animation/simulation of the expected operation of the roundabout and possibly a comparison to the alternative
- Renderings or visualizations
- A project location brochure

- How-to driver, pedestrian and bicycle user resources
- Talking points bulletins for local councilors that give a summary of the planning process, traces the results of studies and documents funding sources, schedule and staging of construction

15.99 References

[1] National Safety Council. Estimating the Costs of Unintentional Injuries, 2008. National Safety Council Website:

www.nsc.org/news_resources/injury_and_death_statistics/Pages/EstimatingtheCostsofUnintentionalInjuries.aspx

[2] Boardman, A., Greenberg, D., Vining, A., and Weimer, D. Cost Benefit Analysis: Concepts and Practice. Prentice Hall; 3rd Edition, 2005.

[3] Gómez-Ibáñez, J. A., Tye, W. B., and Winston, C. Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Mayer. Brookings Institution Press, 1999

FDM 11-26-17 System Considerations

August 15, 2019

17.1 System Considerations

Roundabouts may need to fit into a network of intersections with the traffic control functions of a roundabout supporting the function of nearby intersections and vice versa. Because the design of each roundabout generally follows the principles of isolated roundabout design, this guidance is at a conceptual and strategic level and generally complements the planning of isolated roundabouts. In many cases, site-specific issues will determine the appropriate roundabout design elements. Closely spaced roundabouts are characterized by the operations of one roundabout having an impact on the operations of an adjacent roundabout and may have overhead lane signs and spiral designs with additional lanes for lane balance and lane continuity issues that arise with closely spaced roundabouts in a series.

17.2 Adjacent Intersections and Highway Segments and Coordinated Signal Systems

It is generally undesirable to have a roundabout located near a signalized intersection. A strategic level traffic assessment of system conditions of a series of roundabouts analysis is needed to determine how appropriate it is to locate a roundabout within a coordinated signal network. There may be situations where an intersection within the coordinated signal system requires a very long cycle which is caused by high side road traffic or large percentage of turning movements and is dictating operations and reducing the overall efficiency for the coordinated system. On rare instances, replacing a signalized intersection with a roundabout may allow for the system to be split into two systems thus improving the efficiency of both halves while also improving the efficiency of the entire roadway segment. A traffic analysis is needed to evaluate each specific location.

17.3 Roundabouts in an Arterial Network

In order to understand how roundabouts operate within a roadway system, it is important to understand their fundamental arrival and departure characteristics and how they may interact with other intersections and highway features. Lane use and lane balance on an approach can vary from ideal conditions where roundabouts are in a system and at times closely spaced. Sensitivity testing of alternative lane use patterns and lane designation alternatives in geometric design is necessary. Simulation of traffic patterns using micro simulation software is recommended for roundabouts being treated as a system.

17.3.1 Planned Network, Access Management

Rather than thinking of roundabouts as an isolated intersection or replacement for signalization, identify likely network improvements early in the planning process. This is consistent with encouraging public and other stakeholder interaction to prepare or update local comprehensive or corridor plans with circulation elements. Project planning and design are likely to be more successful when they are part of a larger local planning process. Then, land-use and transportation relationships can be identified, and future decisions related to both.

Roundabouts may be integral elements in village, town, and city circulation plans with multiple objectives of improving circulation, safety, pedestrian and bicycle mobility, and access management. Roundabouts rely on the slowing of vehicles to process traffic efficiently and safely which results in a secondary feature of “calming” traffic. It can be expected that local studies and plans will be a source of requests for roundabout studies, projects, and coordination on State arterials. A potential use of arterial roundabouts is to function as gateways or entries to denser development, such as villages or towns, to indicate to drivers the need to reduce speed for upcoming conflicts including turning movements and pedestrian crossings.

Retrofit of suburban commercial strip development to accomplish access management objectives of minimizing conflicts can be a particularly good application for roundabouts. Raised medians are often designed for State arterials to minimize left turn conflicts; and roundabouts accommodate U-turns. Left-turn exits from driveways onto an arterial that may currently experience long delays and require two-stage left-turn movements could be replaced with a simpler right turn, followed by a U-turn at the next roundabout. Again, a package of

improvements with driveway consolidation, reverse frontage, and interconnected parking lots, should be planned and designed with close local collaboration. Also, a roundabout can provide easy access to corner properties from all directions.

17.3.2 Platooned Arrivals on Approaches

Vehicles exiting a signalized intersection tend to be grouped into platoons. Platoons, however, tend to disperse as they move down-stream. Roundabout performance is affected by its proximity to signalized intersections and the resulting distribution of entering traffic. If a signalized intersection is very close to the roundabout, it causes vehicles to arrive at the roundabout in closely spaced platoons. The volume of the arriving platoon and the capacity of the roundabout will dictate the ability of the roundabout to process the platoon. Analyze these situations carefully to achieve a proper design for the situation. Discuss proposed roundabout locations with the regional traffic section staff.

17.3.3 Roundabout Departure Pattern

Traffic leaving a roundabout tends to be more random than for other types of intersection control. Downstream gaps are shorter but more frequent as compared to a signal. The slower approach and departing speeds along with the gaps allow for ingress/egress from nearby driveways or side streets. The slowing effects are diminished as vehicles proceed further downstream. However, the gaps created at the roundabout are carried downstream and vehicles tend to disperse again providing opportunities for side street traffic to enter the main line roadway.

Sometimes traffic on a side street can find it difficult to enter a main street at an un-signalized intersection. This happens when the side street is located between two signalized intersections and traffic platoons from the signalized intersections arrive at the side street intersection at approximately the same time. If a roundabout replaced one of these signalized intersections, then its traffic platoons would be dispersed, and it may be easier for traffic on the side street to enter the main street. Alternatively, when signals are well coordinated they may provide gaps at nearby intersections and mid-block for opportunities to access the main line.

If a roundabout is used in a network of coordinated signalized intersections, then it may be difficult to maintain the closely packed platoons required. If a tightly packed platoon approached a roundabout, it could proceed through the roundabout as long as there was no circulating traffic or traffic upstream from the left. Only one circulating vehicle would result in the platoon breaking down. Hence, this hybrid use of roundabouts in a coordinated signalized network needs to be evaluated carefully.

Another circumstance in which a roundabout may be advantageous is as an alternative to signal control at a critical signalized intersection within a coordinated network. Such intersections are the bottlenecks and usually determine the required cycle length or are placed at a signal system boundary to operate in isolated actuated mode to minimize their effect on the rest of the surrounding system. If a roundabout can be designed to operate within its capacity, it may allow a lowering of the system cycle length with resultant benefits to delays and queues at other intersections.

17.4 Closely Spaced Roundabouts

It is sometimes desirable to consider the operation of two or more roundabouts near each other. Closely spaced roundabouts can potentially reduce queues and balance traffic flows. The spacing between any two roundabouts is considered closely spaced if they are less than 1,000 feet from center to center (see [FDM 11-26-30.5.13](#)). They also can accommodate a wide range of access, both public and private. In any case, the expected queue length at each roundabout becomes important. Compute the expected queues for each approach to check that sufficient queuing space is provided for vehicles between the roundabouts. If there is insufficient space, then drivers may occasionally queue into the upstream roundabout, potentially causing a reduction from the **typical** operations. However, the roundabout pair can be designed to minimize queuing between the roundabouts by limiting the capacity of the inbound approaches.

Closely spaced roundabouts may improve safety and accessibility to business or residential access or side streets by slowing the traffic on the major road. Drivers may be reluctant to accelerate to the expected speed on the arterial if they are also required to slow again for the next close roundabout. This may benefit nearby residents.

For additional information, see NCHRP 672, §6.9.

17.5 Roundabout Interchange Ramp Terminals

Freeway ramp junctions with arterial roads are potential candidates for roundabout intersection treatment. This is especially true if the subject interchange typically has a high proportion of left-turn flows from the off-ramps and to the on-ramps during certain peak periods, combined with limited queue storage space on the bridge crossing, off-ramps, or arterial approaches. In such circumstances, roundabouts operating within their capacity are particularly amenable to solving these problems when compared with other forms of intersection control. Refer to [FDM 11-25](#) and [FDM 11-25 Attachment 2.1](#) for OSOW vehicle inventories and [FDM 11-25 Table 2.1](#) for required intersection OSOW design vehicle checks, including at the junction of OSOW truck routes.

Occasionally, an OSOW vehicle may have to bypass a bridge by taking the off-ramp and making a through movement and entering the on-ramp (a.k.a. “ramp-on/ramp-off”). Design the median island to accommodate the OSOW through movement. Refer to [FDM 11-30-1](#) for additional guidance on interchange design.

The benefits and costs associated with this type of interchange also follow those for a single roundabout. Some potential benefits of roundabout interchanges are:

- The queue length on the off-ramps may be less than at a signalized intersection. In almost all cases, if the roundabout would operate below capacity, the performance of the on-ramp is likely to be better than if the interchange is signalized.
- The intersection site distance is much less than what it is for other intersection treatments.
- The headway between vehicles leaving the roundabout along the on-ramp is more random than when signalized intersections are used. This more random ramp traffic allows for smoother merging behavior onto the freeway and a slightly higher performance at the freeway merge area similar to ramp metering.

There are no unique design parameters for roundabout interchanges. They are only constrained by the physical space available to the designer and the configuration selected. Several geometric configurations for ramp terminals with roundabouts exist:

- The raindrop form, which does not allow for full circulation around the center island, can be useful if grades are a design issue since they remove a potential cross-slope constraint on the missing circulatory road segments. However, raindrop shapes lack the operational consistency, because one entry will not be required to yield to any traffic. Because of this, an undesirable increase in speed may occur. If an additional road connects to the ramp terminal, the raindrop form should not be used.
- A single-point diamond interchange incorporates a large-diameter roundabout centered either over or under the freeway. While remaining somewhat compact, this solution may not be cost-effective, especially for retro-fit locations, as existing overpass structures may not be adequately sized or oriented.
- Dual roundabouts are the common choice for interchange locations. This design may delay or eliminate the need for overpass reconstruction, while also allowing for easier future roundabout expansion. It offers the greatest flexibility in location of the roundabouts while improving ramp geometry and minimizing the need for retaining walls. It may require additional right of way to be acquired, as this design typically requires the most space.

For additional information, see NCHRP 672, §6.10.

17.6 Traffic Signals at Roundabouts

Roundabouts typically are not planned to include metering or signalization. The “pedestrian hybrid beacon” sometimes referred to as the HAWK crosswalk signal, is discussed in [FDM 11-26-10.1.1](#).

For additional information, see NCHRP 672, §7.5.

17.7 At-Grade Rail Crossings

Locating any intersection near an at-grade railroad crossing is generally discouraged. However, due to necessity, intersections are sometimes located near railroad grade crossings. When considering locating a roundabout within 1000 feet of a railroad, contact the region railroad coordinator early in the process. It is preferable to cross one of the legs of a roundabout and leaving a **typical** distance of at least 100 feet from the center of the track to the yield line. Treatment should follow the recommendations of the Wisconsin MUTCD whenever possible. Consider allowing the railroad track to pass directly through the circle center of the roundabout rather than through another portion of the circular roadway if the at-grade crossing is not on one of the legs. Also, consider the design year traffic on the roadway, the number of trains per day, speed of trains, length of trains, type of crossing warning devices, and anticipated length of vehicular queues when evaluating the intersection control needed in close proximity to the railroad.

Refer to [FDM 17-1-1](#) for additional railway information. Expert assistance is required to address rail pre-emption requirements of roundabouts in close proximity.

17.99 References

- [1] NCHRP 672, Roundabouts: An Informational Guide, Second Edition, Chapter 7, Section 6.

FDM 11-26-20 Operations

August 15, 2019

20.1 Operational Analysis References and Methods

The growing number of roundabouts in the United States (US) has led to an increase in national and local research of roundabout operations and capacity. The National Cooperative Highway Research Program

(NCHRP) published the first major study in the US on roundabout operations in the 2007 NCHRP Report 572[1]. The findings of the NCHRP Report 572 reflect 2003 data from approximately 300 roundabouts. A Federal Highway Administration (FHWA) sponsored project [5], completed in 2015, built upon the methodologies of NCHRP Report 572[1]. The 2015 FHWA report [5] incorporates 2012 data collection efforts and significantly increases the number of useable data points as compared to the NCHRP Report 572 [1].

This research found that driver behavior and the number of entry lanes has the largest effect on the performance of US roundabouts. The capacity and operations of US roundabouts is more sensitive to the interaction between drivers entering and circulating the roundabout and the number of entry lanes than the detailed geometric parameters (e.g. lane width, entry radius, phi angle, and inscribed circle diameter) used in the Australian [2] and UK models [3]. Although important to ensure the safety and efficiency of travel through a roundabout, the fine details of geometric design are secondary and less significant than variations in driver behavior when analyzing capacity at roundabouts in the US.

The Highway Capacity Manual 6th Edition (HCM6), Chapter 22, provides analytical procedures for the analysis of planned and existing roundabout. The 2015 FHWA report [5] provides the foundation for the HCM6, Chapter 22 roundabout methodology. The methods of the HCM allow traffic engineers and designers to assess the operational performance of a roundabout, given information about the demand levels for motor vehicles, pedestrians and bicycles. The following sections provide guidance on operational analysis for Wisconsin DOT projects considering the installation of a new roundabout or evaluating the capacity of an existing roundabout.

20.2 Roundabout Operation

A roundabout brings together conflicting traffic streams at reduced speeds, allowing the streams to cross paths safely, traverse the roundabout, and exit. Modern roundabouts do not have merging or weaving between conflicting traffic streams. Compactness of circle size and geometric speed control make it possible to establish priority to circulating traffic. The geometric elements, signage and pavement markings of the roundabout reinforce the rule of circulating traffic priority and provide guidance to drivers approaching, entering, and traveling through a roundabout.

Gap acceptance (i.e., headway) behavior determines the operation of vehicular traffic at a roundabout. Drivers at each approach look for and accept gaps in circulating traffic. The low speeds of a properly designed roundabout facilitate this gap acceptance process. The width of the approach roadway, the curvature of the roadway, and the volume of traffic present on a given approach govern this speed. As drivers approach the yield point, they must first yield to pedestrians and then to conflicting vehicles in the circulatory roadway. The size of the inscribed circle affects the radius of the driver's path, which in turn determines the speed at which drivers travel in the circulatory roadway.

20.2.1 Planning Level Analysis and Space Requirements

The inscribed circle diameter needed for a roundabout is one of the most critical space requirements when considering impacts to right of way, costs, design vehicle and others. The following table gives general inscribed circle diameters and daily service volumes for the different types of roundabouts. The typical daily service volumes ranges described in [Table 20.1](#) are derived from Exhibit 3-12 in the NCHRP 672 report and are dependent on the left turn percentage of the daily service volume. For a planning level analysis, it may be appropriate to assume that three-leg roundabouts will have a capacity that is 75% of the service volumes shown in Exhibit 3-12 of the NCHRP 672 report for a planning level analysis. Use [Table 20.1](#) for inscribed circle diameter values to help in the initial steps of considering a roundabout as a feasible alternative. Diameters will vary, and in some situations, may fall outside these typical ranges.

Table 20.1 Typical Inscribed Circle Diameters and Estimated Daily Service Volumes

Roundabout Type	Typical Inscribed Circle Diameter ¹	Typical Daily Service Volume ^{2,3} (vpd) 4-leg roundabouts
Single-Lane	120 -160 ft (35 – 50 m)	less than 25,000
Multilane (2-lane entry)	160 - 215 ft (50 – 65 m)	25,000 to 45,000
Multilane (3 lane entry)	215 - 275 ft (65 – 85 m)	45,000 or more

¹ For additional guidance based on design vehicle see Exhibit 6-9 Inscribed Circle Diameter Ranges in NCHRP Report 672

² Capacities vary substantially depending on entering traffic volumes and turning movements.

³ Consult with Exhibit 3-12, "NCHRP Report 672, Roundabouts: An Informational Guide, Second

Edition” to estimate the ADT for a specific left-turn percentage.

The capacity of each entry to a roundabout is the maximum rate at which vehicles can reasonably be expected to enter the roundabout during a given time period under prevailing traffic and geometric conditions. An operational analysis considers entering and circulating traffic flow rates defined for the morning and evening peak periods for each lane at a roundabout. Analysis of the peak hour period is critical to assess the level of performance at each approach and the roundabout as a whole.

For a properly designed roundabout, the entry area is the relevant point for capacity analysis. The approach capacity is the capacity provided at the yield point. The interaction between entering and circulating streams of traffic, the basic number of entry and circulating lanes and to a lesser degree by the geometric parameters, signage and pavement markings that control entry and circulating speed determine approach capacity.

The maximum flow rate that a roundabout entry can accommodate depends on two factors: the circulating flow in the roundabout that conflicts with the entry flow, and the number of entering lanes on the approach to the circulatory roadway. When the circulating flow is low, drivers at the entry can enter the roundabout without significant delay. The larger gaps associated with low circulating flows make it easier for drivers to enter the roundabout and provide the opportunity for more than one vehicle to enter each gap. As the circulating flow increases, the size of the gaps in the circulating flow decreases, thus the rate at which vehicles can enter also decreases.

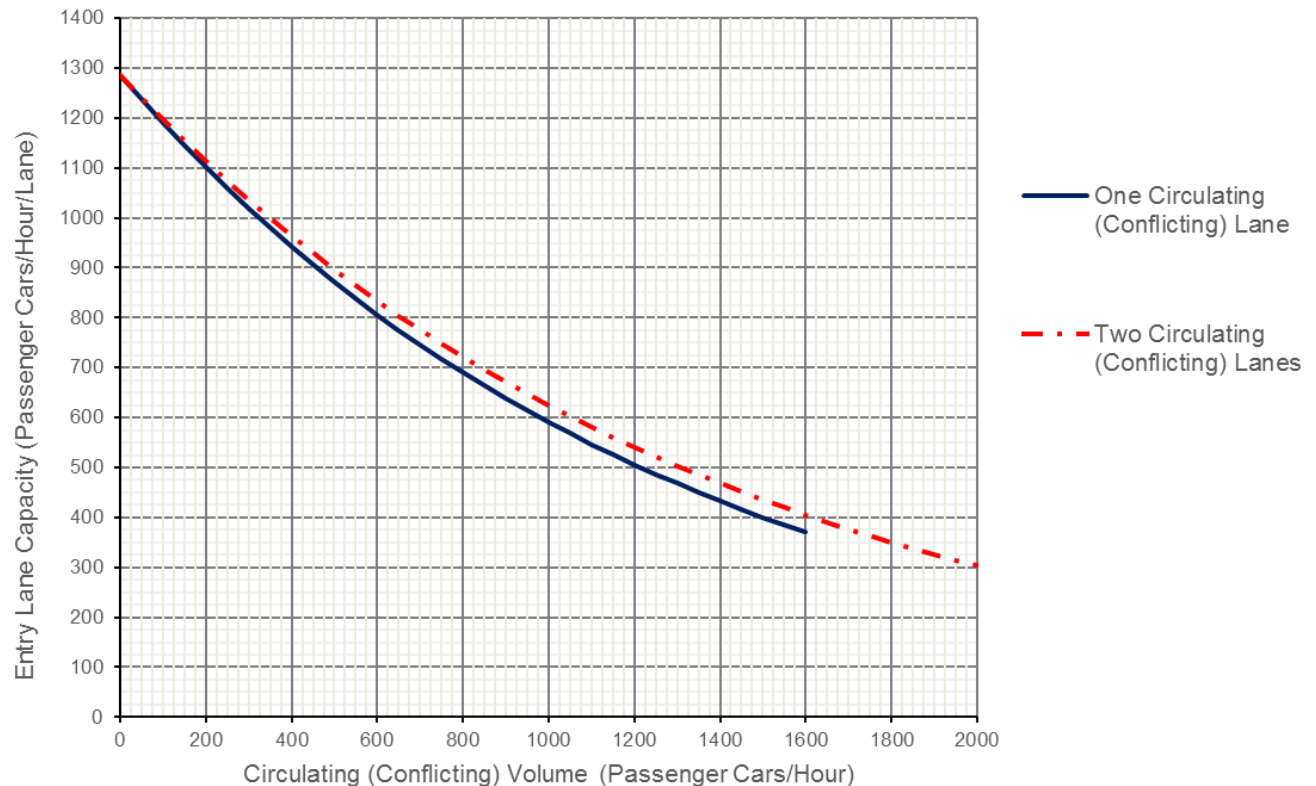
Evaluate each approach leg of the roundabout individually to determine the number of entering lanes that are required based upon the conflicting flow rates. Base the number of lanes within the circulatory roadway on the number of lanes needed to provide lane continuity. More detailed lane assignments and refinements to the lane configurations must be determined through a more formal operational analysis as described later in this section.

On multilane roundabouts, it is important to balance the traffic use of each lane to avoid overloading some lanes while underutilizing other lanes. In addition, poorly designed exits may influence driver behavior and cause lane imbalance and congestion on the opposite leg.

20.2.2 Planning Estimates of Lane Requirements

If existing or projected turning-movement data is available at the planning level, the analyst should estimate the potential lane configurations of the roundabout prior to performing detailed operational analysis. [Figure 5.2](#) shows the capacity curves for one and two-lane roundabouts. WisDOT developed the capacity curves shown in [Figure 5.2](#) based on a 2011 research study, conducted by the University of Wisconsin - Madison Traffic Operations and Safety (TOPS) Laboratory, on the operations of Wisconsin Roundabouts [6]. As shown in [Figure 5.2](#), the capacity of each entry lane of the roundabout is based on the conflicting traffic flow in the circulatory roadway, which comprises the various turning movements from other approaches that pass in front of (and thus conflict with) the subject entry. For planning purposes, the analyst can use the capacity curves shown in [Figure 5.2](#) to identify the potential lane configurations of the roundabout. As an example, for a given circulatory (conflicting) flow rate of 600 passenger cars per hour (pc/h) a one-lane roundabout could accommodate an entry capacity of approximately 810 pc/h/lane while a two-lane roundabout could accommodate an entry capacity of approximately 830 pc/h/lane.

HCM6, Chapter 22 provides additional details on how to approximate capacity and lane requirements for a roundabout, including sample calculations of roundabout volumes, conversion of vehicles per hour (vph) to passenger cars per hour (pc/h), lane use, capacity, and performance measures. Use [Figure 5.2](#) for preliminary estimation of the number of entry and circulatory lanes per approach when considering a roundabout during the scoping phase of the Intersection Control Evaluation (ICE) and during planning studies.



Source: *Comprehensive Evaluation of Wisconsin Roundabouts, Volume 1: Traffic Operations*, Wisconsin TOPS Lab,

Figure 5.2 WisDOT Roundabout Capacity Curves (for planning purposes) [6]

20.3 Pedestrian Effects on Entry and Exit Capacity

Pedestrians crossing at a marked crosswalk have priority over entering motor vehicles. As such, pedestrian traffic can have a significant effect on the capacity of a roundabout entry, especially if there are high pedestrian volumes. To approximate the effect of pedestrian traffic, multiply the vehicular capacity by the entry capacity adjustment factor for pedestrians (f_{ped}) according to the relationship shown in Exhibit 22-18 and 22-20 of HCM6 Chapter 22 for single-lane and two-lane entry roundabouts, respectively.

Note that the effects of conflicting pedestrians on the approach capacity decrease as conflicting vehicular volumes increase, as entering vehicles become more likely to have to stop regardless of whether pedestrians are present. Consult the HCM for additional guidance on the capacity of pedestrian crossings if the capacity of the crosswalk itself is an issue. A similar effect in capacity may occur at the pedestrian crossing on the roundabout exit.

20.4 Operational Analysis Methodology

As is shown in [Figure 20.1](#), the first steps to roundabout analysis and design are to gather traffic data for the existing intersection and to complete an HCM analysis. The lane configuration selected for **typical** operations with design year traffic conditions should be the basis of the roundabout design. Typically, a lane configuration for **typical** operations means that all or most movements operate at LOS D or better with a volume to capacity ratio less than one. See [FDM 11-5-3.2](#) for further discussion on intersection LOS. For further discussion on the **typical** level of service evaluation, see [FDM 11-5-3.5](#).

If the capacity analysis results in the need for a multi-lane roundabout, in the design year, the analyst should consider an interim layout with fewer circulatory lanes (i.e. 10 to 15 years traffic projection). The interim design should accommodate the future conversion to the ultimate design (e.g., the interim design may provide a large center island diameter which, when reduced, can accommodate additional circulating lane(s) in the future). This approach offers safety and operational advantages during the early years, including reduction in fastest-path maneuvers and a simpler layout that is easier for unfamiliar drivers to navigate. The determination of whether to construct the interim layout should consider the extent to which drivers in the project area already have roundabout driving experience. Additionally, the need to provide an interim layout should consider the level of uncertainty in the traffic forecasts (design-year forecasts often assume full build-out of nearby real estate

development projects, but in many cases those projects are unable to proceed as quickly as anticipated). In all cases, utilities should be cleared, and real estate should be acquired to accommodate the ultimate design.

Supplemental software analysis tools include microsimulation traffic models (see [FDM 11-5-3.7.1.4](#)); and three deterministic models SIDRA Standard, Roden and ARCADY. Depending on the purpose and need of the project, the use of microsimulation may be appropriate for operational analysis that does not fit within the methodological limitations of the HCM (see [FDM 11-5-3.7.3.5](#) and [FDM 11-26-20.5](#) for additional details). Designers may use SIDRA Standard, Roden, ARCADY or other design-aid tools to refine the roundabout geometric design. Prior to using supplemental design-aid tools, the analyst should first determine the basic lane configuration using the HCM-based operational analysis and any other pertinent considerations. Use of supplemental software tools may also be appropriate for evaluating operations for in-service roundabouts whereby collection of data under capacity conditions are available to calibrate the capacity equations. [FDM 11-26-20.5](#) and [FDM 11-26-20.6](#) discuss the application of supplemental tools in more detail.

Only after the analysis is completed, and the preferred lane configuration determined, should the detailed design of the roundabout begin. Exhibit 22-10 from HCM6 provides an overview of the HCM roundabout analysis. Chapter 22 of the HCM6, starting on page 22-15, provides detailed descriptions and equations for each step. Chapter 33, Roundabouts Supplemental of the HCM6 (Section 3) goes through each of the computational steps for two example problems: one for a single lane roundabout with bypass lanes and one for a multilane roundabout. These steps describe how to calculate the capacity, LOS, and queue for a roundabout by hand. The use of software makes analyzing the operations of a roundabout much quicker. [Figure 20.1](#) provides a diagram illustrating WisDOT's approved method for analyzing roundabouts using HCM guidance with additional detail provided in the following sections.

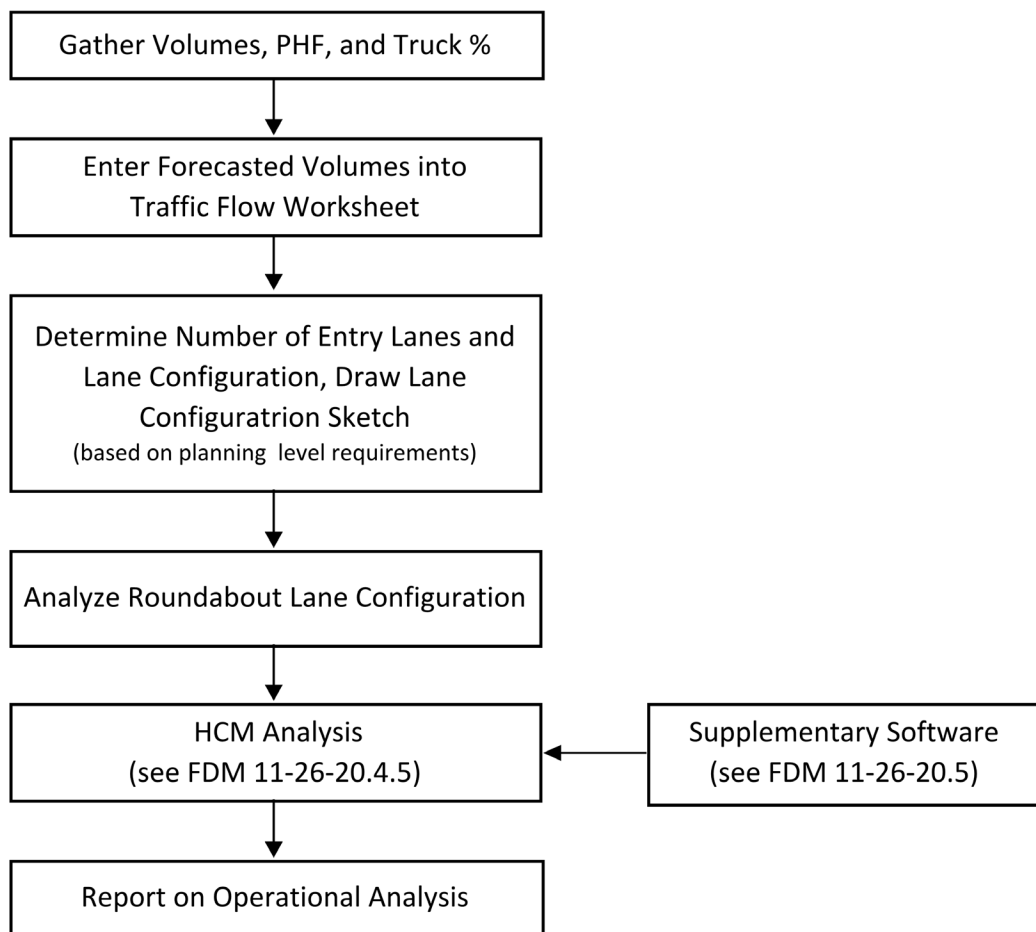


Figure 20.1 WisDOT Approved Method for Analyzing Roundabouts

20.4.1 Gather Traffic Volumes, Peak Hour Factors, and Truck Percentages

Obtain existing 12-hour traffic counts for the intersection and establish the peak traffic hours for analysis. Gather counts for off peak, midday, or special event times as applicable. Traffic counts shall be no older than the most recent three years. Note any special lane utilizations or imbalances, especially if the existing intersection is a roundabout. Calculate the peak hour factor for each peak period. Determine percentages of trucks by approach, if present, be sure to include the number and percentage of bicycles and pedestrians, if present.

Submit the existing traffic turning counts to the traffic forecasting section in accordance with [FDM 11-5-2](#) for development of design year traffic volumes. Consider intermediate design year forecasts in preparation for sensitivity analysis to determine staged improvement or capacity expansion (e.g. one to two lane entries or two to three lane entries).

20.4.2 Enter Forecasted Traffic Volumes into Traffic Flow Worksheet

A volume diagram can be developed using [Attachment 20.1](#) to provide existing peak hour turning volumes (AM, PM, Weekend/Special Event) and design year peak hour turning volumes. Before starting the capacity analysis, a person who is familiar with the site should check the traffic forecasts for reasonableness.

For example, growth rates throughout the intersection should be consistent, unless local factors such as new development are expected to increase specific movements disproportionately. Similarly, the dominant movements in the forecasted volume set should be similar to the existing pattern, unless changes in land use or highway routing are expected. In areas with high commuter traffic, corresponding AM and PM movements should be compared, for example a high westbound left turn movement in the morning is usually accompanied by a high northbound right turn movement in the afternoon.

If the intersection is part of a corridor project, the consistency of forecasts along the corridor should also be reviewed, since the outputs of one intersection are usually the inputs to the next, plus or minus the driveway traffic in between. [Attachment 20.1](#) provides a format for summarizing the traffic volumes at a 3-leg, 4-leg, or interchange ramp roundabout.

20.4.3 Determine Number of Entry Lanes and Lane Configuration, Draw Lane Configuration Sketch

Based on planning level capacity requirements determine how many entry lanes a roundabout would require to serve the traffic demands (see [Table 20.1](#) and [FDM 11-26-20.3.1](#)). Determine the entry volumes for each lane of the roundabout approach. Adjust lane volumes based on observed or estimated lane utilization patterns or imbalances, if applicable. If no lane utilization patterns are observed, the HCM6 default values are 47% of entry flow in the left lane and 53% of entry flow in the right lane for left/through and left/through/right and left/through/right-right lane configurations, and 53% in the left lane and 47% in the right lane for left-left/through/right lane configurations.

A lane configuration sketch of the roundabout should accompany the traffic volumes to facilitate the selection of the number of lanes and the lane assignments. This step precedes the roundabout capacity analysis and the layout process and is critical because it affects the geometry. In [Figure 20.2](#), the assessment of lane assignments for the example traffic flows could include three different options. Unless traffic demand for a given approach is indicative of the potential need for an exclusive left turn lane, option 1 is preferred for its simplicity of design and because the configuration should accommodate both peak and off-peak traffic demand. In the example Options 2 and 3 would require spiral geometry and marking treatment for the upstream entry left turn. Additionally, Options 2 and 3 imply a single lane exit for lane continuity of the through movement. These alternatives complicate the design and may influence driver behavior by causing confusion when navigating the circulatory roadway. [Figure 20.3](#) is an example of the roundabout lane-configuration sketch employing Option 1.

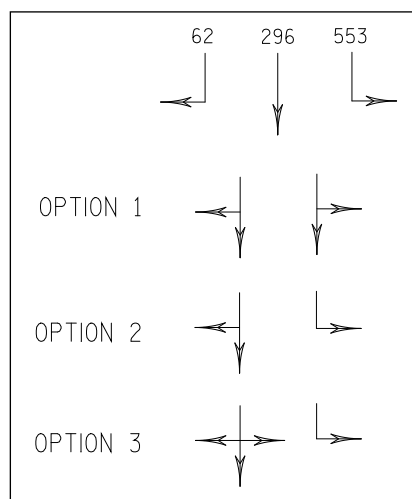


Figure 20.2 Lane Configuration Options

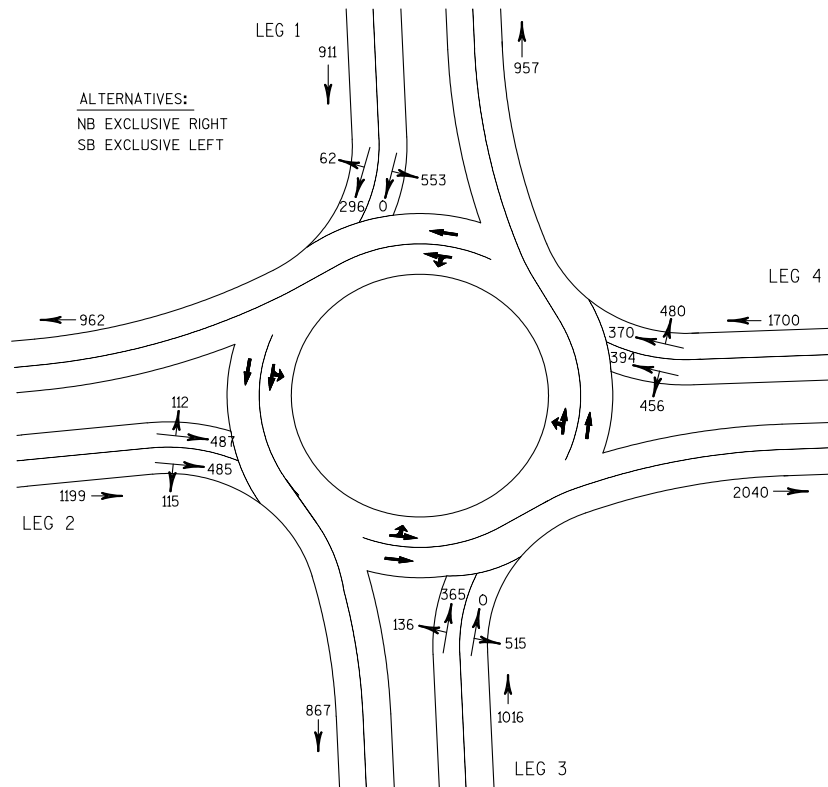


Figure 20.3 Lane Configuration Sketch

20.4.4 Analyze Roundabout Lane Configuration

Evaluate the preliminary lane configuration estimated in [FDM 11-26-20.4.3](#) with HCM procedures using one of two WisDOT supported analysis tools: Highway Capacity Software (HCS) or SIDRA Intersection ([see FDM 11-5-3.7.1](#) for the version of HCS and SIDRA Intersection that WisDOT currently supports). Consistent with the limitations of the HCM6, HCS7 is limited to no more than four approaches and two entry lanes with one or more bypass lanes. Partial right turn bypasses are restricted to single lanes. The software requires calibration with the recommended Wisconsin headway values listed in [Table 20.3](#).

SIDRA Intersection can analyze roundabouts with multiple models. When analyzing Wisconsin roundabouts, the analyst shall use the HCM capacity and delay models. The limitations of the HCM methodology on lane configuration has been expanded by SIDRA (U.S. mode) and the analysis can be used for all roundabouts but is specifically required for evaluating roundabouts with three entry lanes, dual partial right turn bypass lanes, **or** five or more approaches. SIDRA applies the basic HCM procedures and provides essentially the same results HCS. Within SIDRA, there is the option to apply an HCM Roundabout Capacity Model extension to address unbalanced flow conditions. Additionally, SIDRA has an Extra Bunching parameter, that when checked, adjusts the proportion of platooned vehicles in the traffic stream according to the proximity of and level of queuing at an upstream signalized intersection. Prior to utilizing either the unbalanced flow model extension or the extra bunching parameter for operational analysis, the analyst should verify the appropriateness of their use with the regional traffic engineer or BTO-TASU. SIDRA (U.S. HCM6 mode) also requires calibration with the headway values listed in [Table 20.3](#).

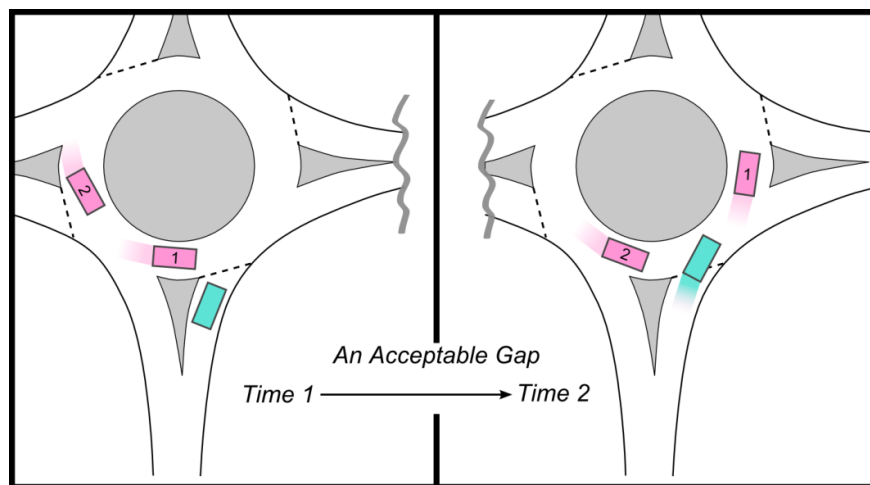
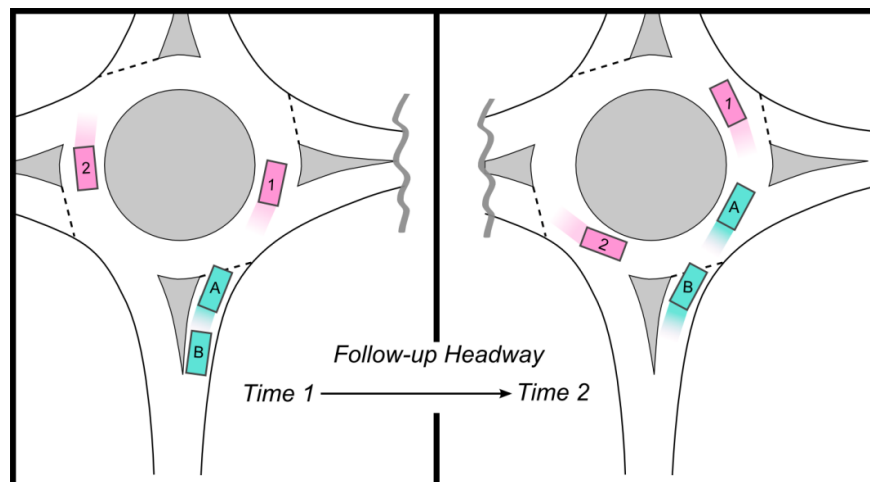
Use [Table 20.2](#) as guidance in choosing the most appropriate approved analysis tool to use for the specific roundabout lane configuration under consideration. Refer to [FDM 11-26-20.4.5](#) for additional details on completing the operational analysis.

Table 20.2 Choosing Appropriate Analysis Tool

Analysis Tool	Appropriate Situations
HCS	One or two-lane entries, single lane partial bypasses, no more than four approach legs
SIDRA Intersection	One, two or three lane entries, one or two lane partial bypasses, up to 8 approach legs
See FDM 11-5-3.7.1 for the version of HCS and SIDRA Intersection that WisDOT currently supports.	

20.4.5 HCS Analysis

Critical headway (also referred to as ‘critical gap’) and follow-up headway are the driver behavior parameters that influence the capacity of a roundabout approach and the roundabout as a whole. Critical headway is the smallest gap in circulating traffic that an entering driver would accept to enter the roundabout. Follow-up headway is the time between two successive entering vehicles accepting the same gap in circulating traffic. [Figure 20.4](#) diagrams the concept of critical headway and [Figure 20.5](#) diagrams the concept of follow-up headway.

**Figure 20.4 Critical Headway****Figure 20.5 Follow-up Headway**

As part of the NCHRP Report 572 [1] and the 2015 FHWA-sponsored report FHWA-SA-15-070[5], researchers collected and analyzed critical and follow-up headways at several roundabouts across the US. The NCHRP Report 572[1] and FHWA-SA-15-070[5] report reflect 2003 and 2012 data collection efforts, respectively. Both of these research efforts found that an exponential gap-acceptance theory combined with field determined headway values could provide an acceptable empirical capacity equation for estimating the operations of a U.S. roundabout (see HCM6 Chapter 22 and HCM6 Supplemental Chapter 33 for additional details). This method of

analyzing roundabouts is the basis for Wisconsin's driver behavior-based approach to analyzing roundabout operations.

The general form of the capacity equation for a roundabout follows below provided in Equation 20.1 - Equation 20.3:

$$c_{pce} = Ae^{(-Bv_c)} \quad [\text{Equation 20.1}]$$

$$A = \frac{3,600}{t_f} \quad [\text{Equation 20.2}]$$

$$B = \frac{t_c - (t_f/2)}{3,600} \quad [\text{Equation 20.3}]$$

where

c_{pce} = entry lane capacity, adjusted for heavy vehicles (pc/hr/ln)

v_c = lane capacity, adjusted for heavy vehicles (pc/hr)

t_c = critical headway (s), and

t_f = follow-up headway (s).

Adjusting the critical and follow-up headways allow the capacity equation in Equation 20.1 to be calibrated to reflect local site conditions. The HCM6 provides default capacity equations based on observations of critical and follow-up headways made at US roundabouts in 2012 [5].

In an effort to calibrate the HCM capacity equations to reflect conditions in Wisconsin, in 2011, WisDOT funded a research project conducted by the TOPS Lab at the University of Wisconsin - Madison to observe headways at Wisconsin roundabouts [6]. Table 20.3 lists the recommended headway values and the corresponding parameters A and B that were developed based on the findings of the study. The analyst shall use the values listed in Table 20.3 for roundabout capacity analyses statewide. The values shown in Table 20.3 represent the headway numbers based on Wisconsin research conducted in 2011.

Table 20.3 Recommended Headway Values

Number of Circulating (Conflicting) Lanes	Critical Headway, t_c	Follow-up Headway, t_f	Parameter A	Parameter B
One	4.2* sec	2.8 sec	1286	0.000778
Two or Three	4.0 sec	2.8 sec	1286	0.000722

* Based on NCHRP 572, not Wisconsin Research

The resulting capacity equations for Wisconsin roundabouts using the headways listed in Table 20.3 follow in Equation 20.4 for roundabout entries with one lane circulating past the entry and Equation 20.5 for roundabout entries with two lanes circulating past the entry. In theory, entries with two lanes circulating past the entry have higher capacities than entries with one lane circulating.

$$c_{e,1,pce} = 1286e^{(-0.000778)v_{c,pce}} \quad [\text{Equation 20.4}]$$

$$c_{e,2,pce} = 1286e^{(-0.000722)v_{c,pce}} \quad [\text{Equation 20.5}]$$

where;

$c_{e,1,pce}$ = entry capacity for one lane conflicting, adjusted for heavy vehicles (pc/hr),
 $c_{e,2,pce}$ = entry capacity for two lanes conflicting, adjusted for heavy vehicles (pc/hr), and
 $v_{c,pce}$ = conflicting flow rate, total of all lanes, adjusted for heavy vehicles (pc/hr).

The HCM6 includes separate capacity equations for the left lane and the right lane. The capacity equations listed above are appropriate for the left and right lanes of a two-lane entry and for single partial right turn bypass lanes.

In order to calibrate the model within HCS, the analyst will need to enter the headway values (both critical and follow-up) for each travel lane under the Roundabout Traffic Tab. Critical and follow-up headway values shall match the accepted Wisconsin headways listed in [Table 20.3](#). The headway values entered depend on the number of lanes circulating past a given entry. The left lane and right lane of a two-lane entry will have the same headway values. See the HCS Users Guide for additional details on how to modify the critical and follow-up headway values.

To calibrate the model within SIDRA Intersection, the analyst, after entering the intersection geometry, will need to revise the default Parameter A and Parameter B values (located under the Roundabouts - Input - HCM6 Data tab) to reflect the Wisconsin-specific values shown in [Table 20.3](#). Note that both the dominant and subdominant lane of the multi-lane roundabout will have the same Parameter A and B values. See the SIDRA User Guide for additional details on how to modify the Parameter A and Parameter B values.

After obtaining traffic forecasts for the study intersection, the general approach to analyzing, building, and adjusting existing roundabouts begins by establishing the general footprint of a new roundabout.

Following FDM guidance and HCM methodologies, a lane configuration for acceptable operations is determined and the detailed design completed. Existing roundabouts may need to be field adjusted to improve capacity; use of supplemental tools may be appropriate to help determine potential improvements for an existing roundabout. [Figure 20.6](#) provides an overview of the general procedures.

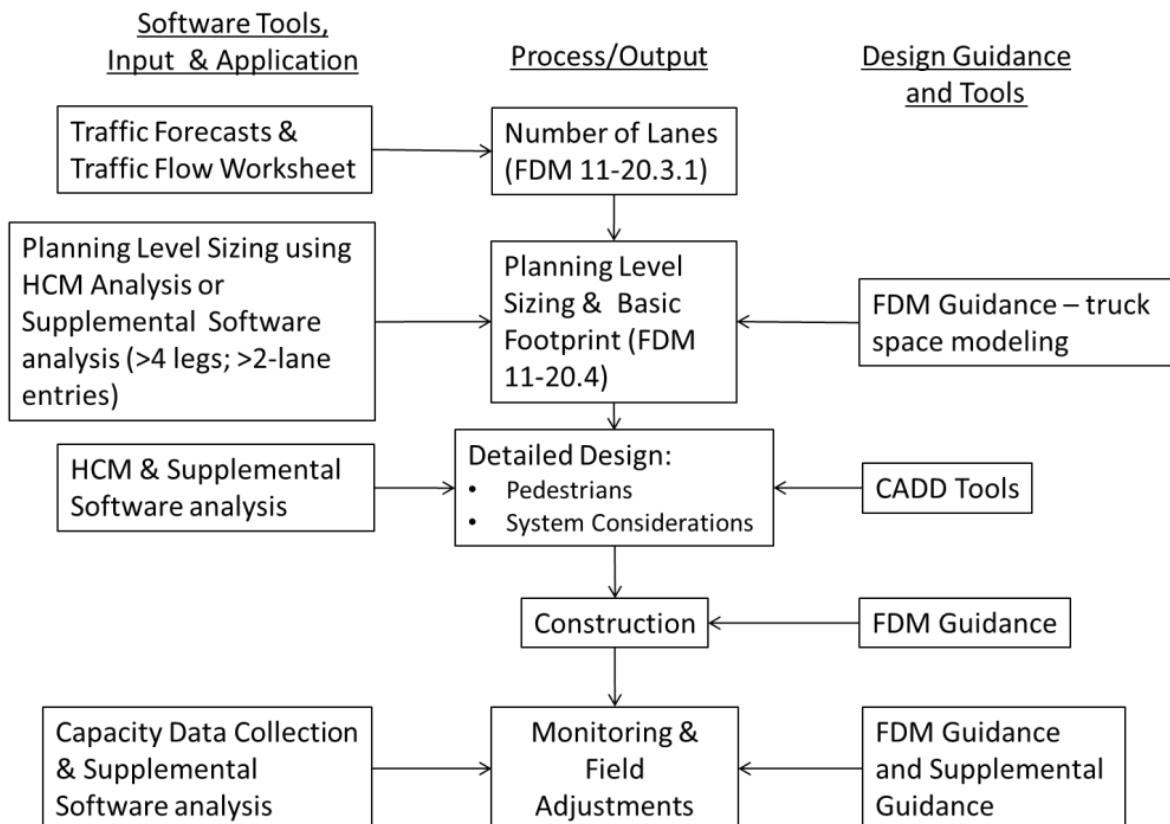


Figure 20.6 Operational Analysis Process, Inputs, and Outputs

Review the results of the analysis and adjust the lane configuration if needed. Remember to revise the headway values or Parameter A and B values if the number of circulating lanes changes. Once an acceptable lane configuration is achieved, print the formatted report. The format for results should follow the intersection control evaluation (ICE) FDM policy ([FDM 11-25-3](#)) and the Traffic Impact Analysis (TIA) guidelines for reporting on operational analysis. Include the analysis files as attachments and report all queues in feet.

Contact the regional traffic engineer or BTO-TASU via the DOT Traffic Model Peer Review (DOTTrafficModelPeerReview@dot.wi.gov) mailbox for specific guidance on how to conduct the roundabout operational analysis within any of the WisDOT supported analysis tools.

20.5 Supplemental Tools for Operational Analysis and Design

When performing roundabout operational evaluations, analysts should recognize and account for the methodological limitations of the HCM6 Chapter 22 methods. Roundabouts that are not isolated, that are part of a system or corridor of roundabouts or are located within the influence area of an adjacent signal should be analyzed with a combination of the roundabout methods of HCM6 Chapter 22 and the urban street segment procedures outlined in HCM6 Chapter 18. For closely spaced roundabouts, such as those found at freeway ramp terminals, the analyst should follow the methodology presented in HCM6 Chapter 23 for interchange ramp terminals. Depending on the scope and need of the project, the analyst may want to supplement the HCM analysis with microsimulation. Microsimulation is capable of system level analysis and allows the analyst to adjust roundabout designs indirectly. Additionally, analysis with microsimulation may help identify lane imbalances or lane use problems within a series of intersections allowing for a more robust design of any single roundabout. Since microsimulation requires significantly more time, resources and effort than HCM-based analysis, it is not appropriate to use for all roundabout analysis or design.

There are cases that may not fit within the analytical framework of the HCM, including but not limited to: volume-to-capacity ratio exceeding 0.80, high level of pedestrian or bicycle activity, priority reversal under extremely high flows and flared entry lanes. The analyst should consider the limitations of the HCM methodology when reporting results. In particular, when the volume-to-capacity ratio exceeds 0.80, the analyst should carefully consider predicted queues and delays and perform additional sensitivity analysis. Further analysis with microsimulation or design-aid tools such as SIDRA Standard, Rodel or ARCADY can supplement the study if the effort is justifiable based on the site conditions. Refer to [FDM 11-5-3.7](#) for additional guidance on determining whether the use of a microsimulation tool would be appropriate.

SIDRA Standard, Rodel, ARCADY and any other tool that designers have available to assist them in the design process can prove beneficial for the final geometric design of the roundabout. These programs provide for geometric sensitivity testing, allowing the user to test the effects of size and key geometric parameters (i.e., inscribed circle diameter, entry radius, phi angle, lane width and flared entry) along with varied flows on an existing or proposed roundabout design.

Rodel and ARCADY apply UK research producing a model that relates geometry to capacity, for roundabout capacity calculations. The analyst may also use a calibrated microsimulation traffic model to refine the roundabout design. Microsimulation that provides for animation and visualization of operating predictions is useful for assessing lane utilization and capacity, especially when considering closely spaced roundabouts. Microsimulation may also prove beneficial for public outreach. SIDRA Intersection, when used in Standard mode, implements a capacity estimation method that assumes a dependence of gap acceptance parameters on multiple factors. Roundabout geometry, circulating flows, entry lane flows, and model designation of dominant or subdominant lanes all influence gap acceptance parameters to account for lane-by-lane capacity variation. SIDRA Standard utilizes what they call the Environment Factor as one of the main parameters to calibrate the capacity model. The recommended Environment Factor for U.S. roundabouts is 1.05 for one-lane roundabouts (approach road or circulating road has one lane) and 1.2 for two-lane roundabouts (both approach road and circulating road have two lanes). See the SIDRA Intersection User Guide for Version 7, Section 5.6.4 Calibration Parameters for Roundabout Capacity Models for details on how to apply the Environment Factor in the SIDRA capacity model.

20.5.1 Special Considerations

Lane designation or lane assignments are critical to the success of the roundabout lane configuration and design. Conditions can be very complex with subtle problems that can reduce capacity and cause severe lane imbalance. Great care and sensitivity are required to achieve lane utilization balance. Supplementary software is especially suited to these situations.

Unbalanced Conflicting Flows:

At a roundabout with unbalanced conflicting flow patterns, a traffic stream with a low flow rate enters the roundabout having to yield to a circulating stream with a high flow or visa-versa.

Unbalanced circulating flows highlight an operational condition that, in order to inform the findings on the analysis, traffic engineers and designers should understand and interpret by taking into consideration all aspects including but not limited to the results of the analysis, the existing and future field conditions and traffic patterns in order to better inform the findings on the analysis. The SIDRA Standard capacity model is sensitive to the ratio of entering to circulating flow, and therefore may be able to reflect expectations of capacity when unbalanced flow conditions are expected. A microsimulation model can also supplement the analysis, but

the level of data and effort to calibrate this model can be significant and may not be appropriate for an isolated roundabout analysis.

Capacity Considerations of Flared Entries:

In some situations, the use of appropriate lane arrows can encourage balanced lane use, thus improving capacity. Traffic often has a bias towards the right-most lane. Lane arrows either can encourage this bias or can encourage lane balance. [Figure 20.7](#) shows the pavement marking scheme preferred to encourage balanced lane demand. It is important for the analyst not to assume that flared entries at roundabouts will always provide for balanced lane use and therefore add capacity to that entry as HCS and SIDRA will predict. This scenario may occur on the approach to a roundabout that has little to no conflicting circulating traffic (e.g. a roundabout at an interchange ramp or any roundabout with a one-way street). The suitable marking for an approach will depend on the turning volume proportions. A methodology similar to that described in [FDM 11-26-20.4.3](#) is used to assess lane designation alternatives.

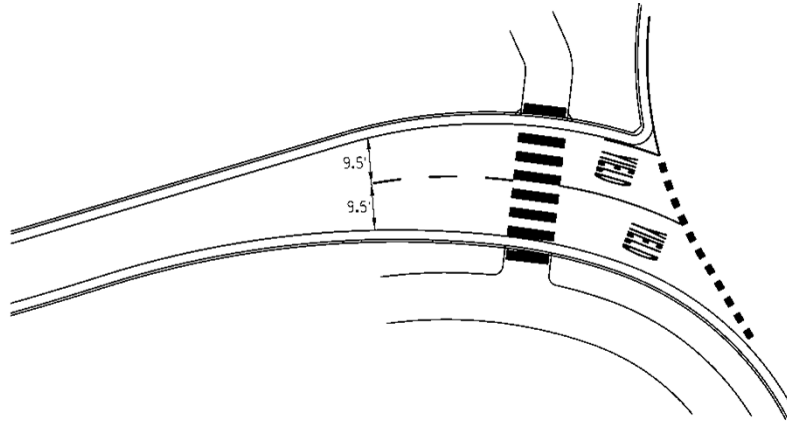


Figure 20.7 Capacity Considerations of Flared Entries

In addition, assessment of the potential for one lane to fill and block back across the flared lane is necessary to achieve the predicted levels of service, (i.e. the geometry must be effective to match the capacity prediction). Lane starvation is a primary failure mechanism for flared entries. Microsimulation models have various forms of lane-by-lane simulation features, which allow the analyst to test alternative lane configurations with visualization of the simulated flows accumulating and filling the flared lanes.

20.6 Capacity Analysis of an Existing Roundabout

The analyst shall use the HCM procedure to evaluate the capacity of existing roundabouts. For existing roundabouts experiencing delays or significant queuing, the analyst should collect the headway data to calibrate the HCM model. Consult with the BTO-TASU for the specifications on how to collect capacity data at existing roundabouts. The results of the HCM procedure may indicate that the existing roundabout requires additional lanes to achieve increased capacity; however, depending on the site-specific conditions, it may be possible to add capacity through changes in pavement markings, signage, geometry, or a combination of the three. Changes to pavement markings, signage and geometric parameters are often less expensive and easier to implement than the construction of additional lanes. The analyst can conduct geometric sensitivity testing using SIDRA Standard, Rodel, ARCADY or other geometric sensitive tools to determine if geometric changes will increase the capacity of the existing roundabout without adding more lanes. Although geometry is secondary to driver behavior in terms of its impact on the capacity of the roundabout, it may be beneficial to conduct geometric sensitivity testing. The ability to measure the capacity of an existing roundabout in the field allows the analyst to calibrate the models (HCM-based models, microsimulation models, and other design-aid tools) to verify the true influence of geometric parameters such as radius at the entry, inscribed circle diameter, conflict angle and flare length.

20.99 References

- [1] NCHRP 572, *Roundabouts in the United States*, 2007
- [2] Akcelik, R., E. Chung, and M. Besley. *Roundabouts: Capacity and Performance Analysis*. Research Report ARR No. 321, 2nd ed. ARRB Transport Research Ltd, Australia, 1999
- [3] *The Traffic Capacity of Roundabouts* TRRL Report LR 942, 1980. Kimber, R.M.
- [4] From *Highway Capacity Manual 2010*, Copyright, National Academy of Sciences, Washington, D.C., Exhibit 21-7, p. 21-9, reproduced with permission of the National Research Board

- [5] Rodederdt, L.A., A. Malinge, P.S. Marnell, S.G. Beaird, M.J. Kittelson, and Y.S. Mereszczak. *Assessment of Roundabout Capacity Models for the Highway Capacity Manual: Volume 2 of Accelerating Roundabout Implementation in the United States*. Report FHWA-SA-15-070. Federal Highway Administration, Washington, D.C., Sept. 2015
- [6] Wisconsin Traffic Operations & Safety Laboratory, *Comprehensive Evaluation of Wisconsin Roundabouts Volume 1: Traffic Operations*, Sept. 2011

LIST OF ATTACHMENTS

[Attachment 20.1](#) Roundabout Traffic Flow Worksheet

FDM 11-26-25 Access Control

August 15, 2019

25.1 Access Management

Management of access to arterial roads is vital to creating a safe and efficient transportation system for motorists, bicyclists, and pedestrians. Access guidance is provided through the region access coordinator, [Chapter 7](#) of the FDM, and the WisDOT Traffic Impact Analysis (TIA) Guidelines.

The operational characteristics of roundabouts may offer advantages when compared to existing conventional approaches to access management. Some roundabout benefits include:

- Increased capacity along arterial roads
- Reduction of traffic congestion and delay
- Improved safety
- More efficient use of land
- Savings on infrastructure investments

For example, connecting two roundabout intersections with a raised median will preclude lefts in/out from the side street or business access to protect main-line capacity and improve safety. U-Turns are not problematic at roundabouts and can increase safety. This provides the **typical** capacity protection and safety along the mainline with less impact to business accessibility.

The preliminary planning phase for any intersection including roundabouts should include a comprehensive access management plan for the site. Consider the possible need to realign/relocate existing driveways and include their associated costs in the project's preliminary estimate. Account for pedestrian accessibility and safety during all stages in the development of a comprehensive access management plan.

25.2 Functional Intersection Area

As addressed in [FDM 11-25-2](#), the functional area of an intersection includes the physical area, but also extends upstream and downstream, along all of the intersection roadways, from the physical area. The functional area for a roundabout is generally less restrictive due to low speeds and less queuing, when compared to a traditional signalized intersection. Roundabouts will reduce queuing and minimize the need for exclusive turning lanes that may be required at a signalized intersection. Also, different sight requirements at a roundabout require drivers to judge gaps at higher perception-reaction time (PRT) than stated in [FDM 11-25 Table 2.4](#). A roundabout's functional intersection area should be determined by the length of the splitter island and the estimated queue length back from the yield line. Use the approved analysis software to analyze the length of queue as discussed in [FDM 11-26-20](#). Also, consider the sight distance and high-speed approach requirements discussed in [FDM 11-26-30.5.15](#).

25.3 Corner Clearance and Driveway Location Considerations

Corner clearance represents the distance that is provided between an intersection and the nearest driveway. [FDM 11-25-2.5](#) discusses the four types of corner clearance and corner clearance distances for STHs. Corner clearance for roundabouts is generally less restrictive than a signalized intersection because a roundabout reduces speed and queuing. On a case by case basis it may be feasible to consider a full access driveway closer to a roundabout than would be considered for other types of control, e.g. a traffic signal. There are three main considerations for driveway location relative to a roundabout entry or exit:

1. Volume of the driveway: If it is only occasional traffic during the peak hour, entering the driveway from the highway, i.e. a low volume case, there may be no storage required for left turns in advance of the roundabout. The driveway may be located closer to the roundabout subject to criteria 2 and 3. If the volume entering the driveway from the highway is moderate and the arterial flow impeding the driveway results in a predicted queue spillback then the queue length must be accounted for in the driveway location. In cases where a driveway location is downstream of a roundabout exit, there is a potential for the left turning traffic to back up into the roundabout.
2. Operational impacts of the roundabout (queue spillback from the entry across the driveway opening):

From the queue prediction results generated from the approved capacity analysis software, the designer can assess how often the entry queue will spill back across the driveway.

3. Sight distance between users: The driveway exit must have proper sight distance of the roundabout exit, the speed of exiting traffic from the roundabout and to the left of the approaching upstream traffic. The approach sight to the driveway from the roundabout or approaches to the roundabout must also meet intersection sight criteria for the approach speeds.

Major commercial driveways may be allowed as one leg of the roundabout. However, installation of a signal or roundabout strictly for access to private development is discouraged. They may be designed at a public road access point as an intersecting leg of a roundabout. Moreover, the roundabouts may reduce the need for additional through-lanes thus narrowing the overall footprint of the roadway system.

Minor commercial and residential driveways are not recommended along the circulating roadway unless designed as a leg of the roundabout. Some situations may dictate the need for a driveway and must be analyzed on a case-by-case basis. For a driveway to be located with direct access into the circulatory roadway of a roundabout, the following items should exist:

- No alternative access points are feasible.
- Traffic volumes are low enough that the likelihood of erratic vehicle behavior is minimal; driveways with higher traffic volumes, or higher proportion of unfamiliar drivers should be designed as a regular roundabout approach with a splitter island.
- Drivers must be able to exit facing forward; no backing into the roundabout.
- Driveways may be located along entrances and exits but need to be set back to not interfere with pedestrian movements in the crosswalks, and to minimize the number of conflict points with vehicles approaching or exiting the roundabout. Driveways located along entrances and exits may be blocked by the splitter island and will have restricted access, (right-in/right-out). Generally, these should be avoided unless minimal impacts are expected, or no other feasible alternatives exist.

25.4 Parking near Roundabouts

Prohibit on-street parking; within 75 feet of the roundabout entry/exit or further depending on site-specific conditions. Factors that influence the decision to prohibit on-street parking near a roundabout may include: adjacent access, location of pedestrian crossing, and approach or departing curvature. Generally, it is not **typical** to allow parking on either side of the roadway within the splitter island area or in the transition to the splitter island.

25.5 Interchange Ramps

According to [FDM 11-5-5](#), a distance of 1320 feet between a ramp terminal and any adjacent intersection is required. This distance (1320 feet) is typically needed to provide progression for a series of signalized intersections. Roundabouts need less space between adjacent intersections to operate at a high level of service. Operational concerns at an interchange resulting from reduced access spacing, such as traffic blocking adjacent intersection, can be better understood through the analysis of forecasted queue lengths. Queue lengths for a roundabout should be predicted with the use of traffic modeling and the impacts to the adjacent intersections reviewed using other appropriate traffic modeling software. A traffic analysis is required to justify a less **typical** distance (1320 feet) of access control.

25.99 References

- [1] A Policy on Geometric Design of Highways and Streets, AASHTO, 2004.

FDM 11-26-30 Principle Based Design Guidance

August 15, 2019

30.1 Introduction

In a general sense, roadway engineering is often an iterative process of design exploration against a set of project constraints. The geometric design of a roundabout requires the balancing of competing interests. Design considerations of safety, capacity and cost. Roundabouts operate most safely when their geometry positively guides traffic to enter and circulate at slow speeds. Poor roundabout geometry has been found to negatively impact roundabout operations by affecting driver lane choice and behavior through the roundabout. Roundabout layouts are also governed by the space and swept path requirements of the design vehicle.

Thus, designing a roundabout is a process of determining the optimal balance between safety provisions, operational performance, and accommodation of the design vehicle.

Even though a step-by-step design process is presented in this section, the designer must understand that adherence to design principles, awareness and understanding of the inherent design tradeoffs are the central points of design regardless of whether any design procedure is followed.

The geometric design, signage and pavement markings of roundabout intersections can influence their capacity

and operational performance. Therefore, it is essential that a roundabout be properly designed to ensure that its expected capacity is not limited by the design.

30.2 Design Principles

This section describes the principles and objectives common to the design of all categories of roundabouts. Note that some features of multilane roundabout design are significantly different from single-lane roundabout design, and some techniques used in single-lane roundabout design may not apply to multilane design. However, several overarching principles should guide the development of all roundabout designs. With the primary goal of an operationally adequate facility that also provides good safety performance.

The principles that should be applied to achieve a safe and efficient roundabout design are:

- The roundabout should be clearly visible from the approach sight distance at the road operating speed in advance of the roundabout approach (See [FDM 11-26-30.5](#)).
- The number of legs should **typically** be limited to four (although up to six may be used at an appropriately designed roundabout).
- Legs should **typically** intersect at approximately 90-degrees, especially for multilane roundabouts (See also NCHRP 672, §6.3).
- It is essential that appropriate entry curvature is used to limit the entry speed (See also NCHRP 672, §6.2.1 and [FDM 11-26-30.5.2](#)).
- Exits should be designed to enable large vehicles to enter, circulate and depart efficiently either using a large exit radius or more tangent exits (See also NCHRP 672, §6.2.4). The circulating roadway with truck apron should be wide enough to accommodate the swept paths of the design vehicle (generally 1.0 to 1.2 times the widest entry).
- Entering drivers must be able to see from the left early enough to safely enter the roundabout. However, excessive intersection sight distance can lead to higher vehicle speeds that reduce the safety of the intersection for all road users (motorists, bicyclists, pedestrians). Landscaping within the central island can be effective in restricting sight distance to the minimum requirements while creating a terminal vista on the approach to improve visibility of the central island (See also NCHRP 672 and [FDM 11-26-30.5](#)).
- Provide the appropriate number of lanes and lane assignment to achieve adequate capacity, lane volume balance, and lane continuity to ensure that the roundabout operates at an appropriate level of service. (See also NCHRP 672, §6.2.2).
- Design such that the driving task is as simple as possible, avoiding the use of spiraled designs unless it's clearly warranted by traffic (i.e. high left turning traffic volume).
- Provide smooth channelization that is intuitive to drivers and results in vehicles naturally using the intended lanes. (See also NCHRP 672, §6.2.3 and [FDM 11-26-30.5](#)).
- Design to meet the needs of pedestrians and cyclists. (See also NCHRP 672, §6.2.5)

The design criteria for potential non-motorized roundabout users (e.g., bicyclists, pedestrians, skaters, wheelchair users, strollers) should be considered when developing many of the geometric components of a roundabout design. These users span a wide range of ages and abilities and can have a significant effect on the design of a facility. There are two general design principles that are most important for non-motorized users.

First, slow motor vehicle speeds make roundabouts both easier to use and safer for non-motorized users.

Second, one-lane roundabouts are generally easier and safer for non-motorized users than multilane roundabouts; therefore, if a single lane roundabout is feasible for most of the design life of the intersection that has pedestrian traffic then due consideration is given for the sake of pedestrian comfort and safety.

While the basic form and features of roundabouts are usually independent of their location, many of the design outcomes depend on the surrounding speed environment, **typical** capacity, available space, required number and arrangements of lanes, design vehicle, and other geometric attributes unique to each individual site. In rural environments where approach speeds are high and bicycle and pedestrian use may be minimal, the design objectives are significantly different from roundabouts in urban environments where bicycle and pedestrian safety are a primary concern. Additionally, many of the design techniques are substantially different for single-lane roundabouts than for roundabouts with two or more lanes. Maximizing the operational performance and safety for a roundabout requires the engineer to think through the design rather than rely upon a design template.

For additional information, see NCHRP 672, §6.2.

30.2.1 Designing with Trade-offs in Mind

The selection and arrangement of geometric design elements and their relationships to one another is referred to as design composition. Minor adjustments in geometry can result in significant changes in safety or operational performance. The relationship between safety and capacity, that exists for a roundabout is in most

cases inverse that of a **typical** intersection. [Table 30.1](#) below identifies the trade-offs of adding to one element at the expense of another. When composing an initial layout, the tradeoffs of safety, capacity and cost must be recognized and assessed throughout the design process. The effect of improving one aspect of design impacts another.

Table 30.1 Effects of Design Elements on Safety and Operations

Element	Safety	Capacity	Speed
Wider entry (gore area)	Less safe	Increase	Increase
Wider Circulatory lanes	Less safe	Better	Increase
Larger entry radius	Less safe	Better	Increase
Larger inscriber circle diameter	Less safe	Better	Increase
Larger angle between approach legs	Safer	Decrease	Neutral
Smaller entry angle (phi)	Poorer sight	Better	Increase
Longer flare length	Neutral	Better	Neutral

30.2.2 Staging and Expandability

Providing excess capacity at **typical** intersections usually has very little (if any) negative effect on safety or crash rate and usually improves safety. Inadequate capacity, at a **typical** intersection could result in reduced safety and increased crash rates. These traits of **typical** intersections have encouraged traffic engineers to estimate future traffic volumes conservatively high. The process of providing safe roundabouts, for the public, would benefit from conservatively low traffic volume projections, design criteria which requires satisfactory levels of service for ten-year or fifteen-year projected traffic volumes (with phased designs which allow cost effective expansion, if needed).

The design and analysis process should consider the potential to stage improvements to reduce excessive capacity in the early years and improve safety, and driver/public acceptance. The capacity analysis evaluates the duration of time that for example a single-lane or dual-lane roundabout would operate acceptably before requiring additional lanes. When sufficient capacity is provided for much of the design life of a roundabout, designers should evaluate whether it is best to first construct a roundabout that is easy to convert when traffic volumes dictate the need for expansion and additional capacity. Reducing the number of entry and exit lanes reduces the number of potential conflicts and reduces navigation complexities associated with multilane roundabouts. Minimizing the necessary entry, exit and circulating lanes improves safety for all modes. Pedestrian safety is improved by minimizing the crossing distance and limiting their exposure time to vehicles while crossing an approach.

When considering an interim roundabout that may be converted, the designer should evaluate the right-of-way and geometric needs for both the interim and multilane configurations as part of the initial design exercise. Consideration should also be given to the future construction staging for the additional lanes.

Specific expansion design is a function of many variables. Some situations will dictate that expanding from the inside is more advantageous while other locations may benefit from widening to the outside.

For additional information, see NCHRP 672, §6.12.

30.2.3 Impact of Cost Reduction on Roundabouts

In many cases, the process of developing and designing a roundabout involves many design modifications, which are intended to effect cost savings. While this is common to conventional design practices it can have a hidden detrimental effect on design and operations of roundabouts.

Landscaping is often considered an aesthetic feature, which can be removed from the plan to reduce cost savings. Reduction of right-of-way take is often seen as an obvious cost reduction measure, but the trade-offs of safety and operations may not be apparent to the deciding authority. Other elements such as overhead signing (on approaches) is similarly looked at as excessive and is often replaced with terrace signing, despite the rationale that these features improve the function and safety of the intersection. Designers should be sensitive to the need for cost savings and should strive to effectively document and communicate the impact that the proposed design modifications will have on the function and safety of the roundabout. The designer should be given the opportunity to recommend an alternate modification, which will provide required cost savings while having the minimum amount of impact on function and safety.

30.3 Roundabout Design Process

The process of designing roundabouts may require a considerable amount of iteration among geometric design, operational analysis, and safety evaluation (refer to [Figure 30.1](#)). Minor adjustments in geometry can result in significant changes in safety or operational performance. Thus, the designer often needs to revise and refine the initial design to enhance the roundabouts capacity and safety. It is not typically possible to produce an optimal geometric design on the first attempt.

It is advisable to prepare the initial concept drawings at a sketch level detail. It is important that the individual components are compatible with each other so that the roundabout will meet its overall performance objectives. Before the details of the geometry are finalized, three fundamental elements must be determined in the Scoping and Feasibility stage.

1. The optimal size
2. The optimal position
3. The optimal alignment and arrangement of the approach legs

An initial estimate of the space (footprint) required for a roundabout is a common question at the planning stage and may affect the feasibility of a roundabout at any given location. At this planning level, important questions may begin to be explored including:

- Is sufficient space available to accommodate an appropriately sized roundabout?
- What property impacts might be expected?
- Is additional right-of-way likely to be required?
- Are there physical constraints that may affect the location and design of the roundabout?

Due to the need to accommodate large trucks through the intersection, roundabouts typically require more space than conventional intersections. However, this may be offset by the space saved compared with turning lane requirements at alternative intersection forms. The key indicator of the required space is the inscribed circle diameter.

There are no easy ten-steps to roundabout design. Much of the knowledge in roundabout design is counter-intuitive to the technically minded engineer. Designing roundabouts can range from easy to very complex.

Although it may appear inherently otherwise and extensively attempted, roundabouts are not homogeneous and cannot be standardized. There are many different types of roundabouts, such as single lanes, two-lanes, three-lanes, circles, ellipses, bypass lanes, “snagged” partial bypass lanes, double roundabouts, spirals, etc., in which a number of combinations or multiple combinations of the above can be in one roundabout (See [Figure 1.2](#)). Each roundabout is unique where each potential “type” of roundabout is applied in different situations in which site-specific problems require special and distinctive solutions. The major differences in design techniques and skill levels fall between single-lane roundabouts and multilane roundabouts where different principles apply.

[Figure 30.1](#) depicts the steps and process that guide a designer through the entire Roundabout Design Process (see also NCHRP 672, Exhibit 6-1).

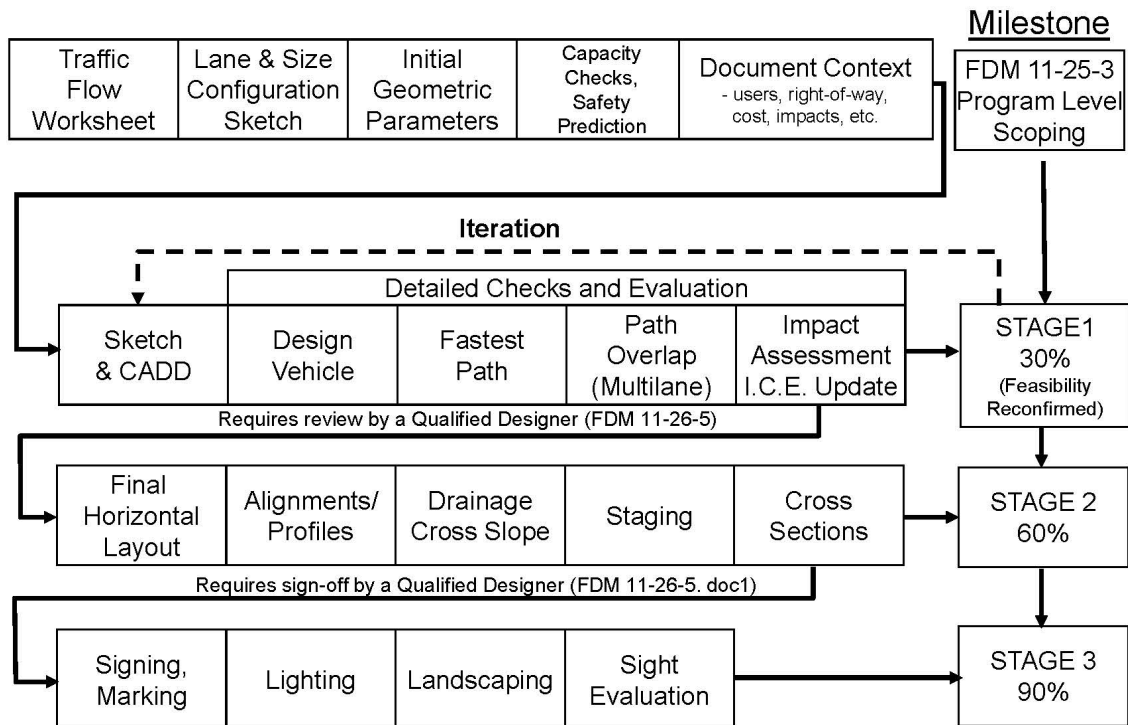


Figure 30.1 Roundabout Evaluation & Design Process

For additional information, see NCHRP 672, §6.3.

30.4 General Design Steps & Explanation

The following general design steps will typically apply to most roundabout design practices. However, each roundabout requires a different design and thinking process depending on the unique design constraints, traffic volumes, roadway speeds, existing topography, and geometric alignments of the roadways. Not all aspects of design or the design process are included herein, however, the provided general design steps should be sufficient to get most designers started in an initial conceptual roundabout design.

Step 1 - Document Existing Conditions

Review the most recent site plans and roadway alignment information in an electronic format (e.g. CAD-based software). Review existing roadways with respect to surrounding topography, centerlines, curb faces, edge of pavement, roadway lane markings, existing or proposed bike lanes, nearby crosswalks, environmental constraints, buildings, drainage structures, adjacent access points, shared-use paths, rail crossings, school zones, and right of way constraints. This should include any special design constraints such as specific properties that cannot be encroached or specific lane widths. Review any traffic study, which should include final future design year traffic volumes and assumptions of the proposed intersection or corridor project.

These items should provide adequate background traffic conditions, existing traffic conditions within and outside the project area, as well as the level of detail, design parameters, right-of-way constraints, restricted historical or wetland areas, and location for the proposed roundabout.

Step 2 - Document Future Conditions

The future traffic flows of the existing roadways should be reviewed and possibly discussed with the lead jurisdiction for project understanding and existing operational issues. These operational issues, including potential excessive delay, should be recognized in the design process and geometric criteria. In addition, any potential changes to adjacent sites, access points, or roadway cross-sections that may affect the roundabout design should be provided, reviewed, and incorporated.

Review the future AM & PM peak-hour, and off-peak turning movement volumes (also include mid-day in tourist areas) at the intersection developed from the design year projected traffic volume data. Use the Traffic Flow Worksheet in [FDM 11-26 Attachment 20.1](#) and a simple schematic diagram consisting of the final future peak hour turning movement volumes at the intersection(s). In order to accurately identify the roundabout geometric and capacity needs, the

following are required:

- Traffic Conditions
 - Future turning movement volumes: AM & PM peak, off-peak, and mid-day (in tourist areas)
 - Future percent heavy vehicles (by type and approach) for each peak hour
 - OSOW truck route (OSOW-TR) considerations
 - Design vehicle type by turning movement Refer to [FDM 11-25-2](#) and [FDM 11-25 Attachment 2.1](#) for description of OSOW-MT and OSOW-ST design vehicles and their inventories. Refer to [FDM 11-25 Table 2.1](#) for required intersection design vehicle checks for various trucking route scenarios.
- Constraints
 - Vertical constraints
 - Right-of-way constraints
 - Existing and proposed roadway alignment base map (with travel lanes, proposed curb tie-in, pavement marking, bike lanes, right-of-way, etc.)
- Other Modes
 - Pedestrian volumes (if significantly high)
 - Identify if bike lanes and sidewalks will be needed

Step 3 - Understand the Specific Design Problem(s)

Prior to commencing a design, the designer must first understand the basic intersection problem; is it safety, congestion, or a combination of both and what is the design problem(s) to be solved (right-of-way issues, acute angles, grades, approach legs, roadway alignment, etc.)? After evaluating the traffic volumes, the designer should understand how many lanes may be initially required.

A general roundabout diameter can then be chosen based on the traffic needs, proximity to constraints, design vehicle, and the relative speeds of the roadways (i.e. if high speed approaches present). The designer must be conscious of the design vehicle when choosing a diameter. Refer to [FDM 11-25 Table 3.1](#) as a first step in the evaluation process if no other values have been stated.

Step 4 - Perform Capacity Analysis for Lane Configuration Development (also refer to [FDM 11-26-20](#))

After obtaining all of the pertinent information regarding the roadways, site, and traffic volumes, and a general roundabout diameter has been initially identified, the designer should perform a geometric analysis of the proposed roundabout using roundabout design software. Refer to [FDM 11-26 Attachment 20.1](#) Traffic Flow Worksheet to assist with traffic volume data entry. The capacity analysis results will assist in developing the initial lane geometry and capacity requirements for the roundabout based on the future design volumes.

This will set the design requirements for the conceptual roundabout design. The AM and PM, and sometimes a weekend peak, traffic volumes will need to be analyzed at the intersection. This analysis should ensure that the roundabout will operate appropriately under all peak hour traffic conditions. The results of this analysis will produce key information to include in the roundabout design, some of which are:

Geometry	Operations
<ul style="list-style-type: none"> - Initial roundabout diameter (estimated size) - Entry lane configurations at each approach - Minimum approach widths and entry radii of the roundabout 	<ul style="list-style-type: none"> - Future traffic volume capacity by approach - Delay of each approach and the overall delay of the intersection - Predicted 95th percentile queue lengths for each approach - Future level of service

The allowed movements assigned to each entering lane are key to the overall design. Basic pavement marking layouts should be considered integral to the preliminary design process to ensure that lane continuity is being provided. In some cases, the geometry within the roundabout may be dictated by the number of lanes required or the need to provide spiral transitions (see [FDM 11-26-30.5.22](#) for more information). Lane assignments should be clearly identified on all preliminary designs to retain the lane configuration information through the various design iterations. In some cases, a roundabout designed to accommodate design year

traffic volumes, typically projected 20 years from the construction year, can result in substantially more entering, exiting, and circulating lanes than needed in the earlier years of operation. To maximize the potential safety during those early years of operation, the engineer may wish to consider a phased design solution that initially uses fewer entering and circulating lanes. As an example, the interim design would provide a single-lane entry to serve the near-term traffic volumes with the ability to cost-effectively expand the entries and circulatory roadway to accommodate future traffic volumes. To allow for expansion at a later phase, the ultimate configuration of the roundabout needs to be considered in the initial design. This requires that the ultimate horizontal and vertical design be identified to establish the outer envelope of the roundabout. This method helps to ensure that sufficient right-of-way is preserved and to minimize the degree to which the original roundabout must be rebuilt.

Step 5 - Sketch

Once the minimum design requirements have been established, a modern roundabout design can be sketched by initially identifying the flow of traffic, lane configuration, and approach lane assignment requirements, the circulatory roadway width and the exits of the roundabout. This task includes the placement of the roundabout's circle to roughly determine its location. Special consideration should be taken for any skewed intersection or right-of-way constraints. A general roundabout diameter can then be chosen based on the traffic needs, proximity to constraints, design vehicle, and the relative speeds of the roadways.

Step 6 – Refine the Initial Layout

The hand sketch or initial conceptual layout should be refined. The designer should refine the concept iteratively to suit the site constraints while attending to the design performance criteria of speeds, truck space and site distance. The purpose of this process is to achieve an optimal layout that serves the design objectives without excessive CAD effort. Often designers are wrongly focused on details and do not have the patience to produce multiple iterations of a CAD design.

Step 7 - Formalize the Preliminary Design

Once the general location and roundabout configuration has been developed and all of the design issues have been resolved, a full conceptual design can be initiated.

In multilane designs, the lane pavement marking is applied to establish natural entry and exit paths, i.e. to minimize entry and exit path overlap. Applying the lane pavement marking ensures proper lane widths and widening and confirms the lane designations and possible spiraled lane movements.

Step 8 - Safety and Fastest Path Review

Fastest path design speeds as well as a number of other safety factors and design features, such as the phi angle, must be checked. The fastest paths should be developed and reviewed to see if they are adequate and reasonable. If deficiencies or deviations in any of the design features or safety factors are found, the design must be modified, either with many small changes or by shifting alignments, geometry, or placement of the circle. This is an iterative process which may require an entire redesign.

Step 9 - Design Vehicle Check & Modifications

A CAD-based software program such as AutoTURN or AutoTrack should be used to verify proper accommodations are provided through the roundabout for each approach and every truck turning movement. In addition, the truck apron minimum width is 12-feet and may be wider in some situations to better accommodate OSOW vehicles. All truck movements should have a buffer space between the swept path of trucks and the face of curb equal to 2 feet. Contact the regional Freight Operations Unit for the OSOW vehicle.

Step 10 - Accessorize the Design

When a preliminary design (and pavement marking for multilane roundabouts) has been completed, additional amenities should such as crosswalks, detached sidewalks, bike paths and ramps, truck aprons, disabled access (ADA) ramps, etc. should be added. All efforts should be made to avoid any right-of-way issues.

At the 30% stage of the design process, some form of approval or review consultation should be performed by a qualified designer. Once a roundabout design has been properly designed with respect to horizontal geometry, there are many other geometric and non-geometric design components that must now be completed for a roundabout to function as it was designed. These design components are key to the public driving the roundabout as it was intended without further safety or operational issues. These items are identified in the three stages of the

design process ([Figure 30.1](#)).

The 60% and 90% design aspects of roundabout design including horizontal geometry, vertical profiles, signing, pavement marking layout, landscaping, lighting, and construction materials should either be designed by or reviewed by a qualified roundabout designer. Nothing can replace real-world design and field experience.

Continual practice, mentoring from experts, training & education, and quality roundabout review greatly assists the designer in understanding all aspects of the design of modern roundabouts. However, all designers must spend time in the field reviewing roundabout construction and completed roundabouts in order to understand roundabouts and their design completely. After years of daily practice, one can still learn. Small changes in roundabout design elements can influence the operation and safety of a modern roundabout.

30.5 Design Considerations

This section provides guidelines for each geometric element. Further guidelines specific to two-lane entries are provided in the latter part of Chapter 6 of NCHRP 672. Note that two-lane entry roundabout design is significantly more challenging than one-lane entry design. Many of the techniques used in one-lane entry roundabout design do not directly transfer to multilane design. This procedure provides recommended changes to NCHRP 672, Chapter 6. Therefore, designers must become very familiar with Chapter 6 in the NCHRP 672.

30.5.1 Alignment of Approaches and Entries

Adherence to the principles of deflection is crucial to the operation and safety of roundabouts. WisDOT considers this design element to be of the utmost importance. Figure 30.2 shows the typical composition of approach alignment and curves to generate **typical** speed reduction at entries. It is not good practice to generate entry deflection by sharply curving the approach road to the left close to the roundabout and then to the right at entry.

It is recommended design practice (especially in multilane roundabouts) to provide an offset to the left of the center of the central island. In some situations, it may be appropriate to provide an offset of approximately 20 to 30 feet (or more), left of the center of the roundabout to achieve proper deflection and appropriate entry speeds. For additional information, see NCHRP 672, §6.2.1 & 6.7.1.

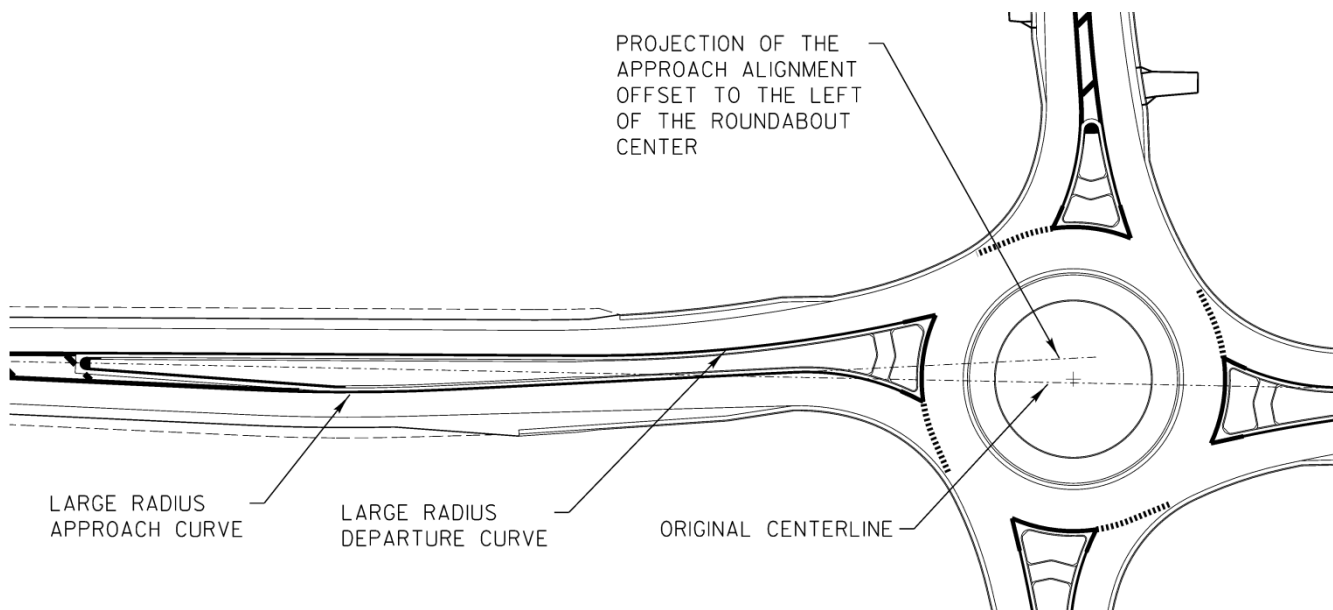


Figure 30.2 Entry Deflection

30.5.2 Assessing Vehicle Paths

Determine the smoothest, fastest path (using a spline curve) possible for a single vehicle, in the absence of other traffic and ignoring all lane line markings, traversing through the entry, around the central island, and out the exit. A step by step process for creating AutoCAD Civil 3D and MicroStation spline curve are provided in [FDM 11-26 Attachment 50.1](#) and 50.2. Usually the critical fastest path is the through movement; but, depending on the angle between arms, in some situations it may be a right turn movement.

Fastest speed path is a critical performance measure in the design of roundabouts. Use NCHRP 672, Exhibit 6-46 for the definition of vehicle path radii. NCHRP 672 Exhibit 6-48 and Exhibit 6-49 illustrate the definition of fastest vehicle path for single-lane and multilane designs. Use [Figure 30.3](#) to determine the radii values for R1 based on the arc and spline definitions. Vehicle speed estimation is in accordance with NCHRP 672, Section

6.7.1.2 Equations 6-1 and 6-2. Equation 6-3 may be used to estimate actual entry speed, but it will not govern the design.

R2 and R4 are determined using the same vehicle path offsets for R1. The R3 exit radius fastest speed path is determined based on the R2 speed plus acceleration over the distance to the point where R3 is measured. Use NCHRP Exhibit 6-50 to determine the radius value for R5 fastest speed path. The vehicle path offsets of 5 feet, as shown in Figure 30.3, are measured from the curb face (not the flange line). In the situation where the approach to the roundabout has centerline pavement marking on the left side with no curb face, then the offset is 3 feet from the centerline pavement marking.

- The radius should be measured over a distance of 65 to 80 feet. It is the minimum that occurs along the approach entry path near the yield point but not more than 165 feet in advance of it.
- The beginning point is 3 feet from a pavement marking (if no raised median), or 5 feet from the left curb face (if raised curb median) at a point approximately 165 feet from the yield line. This point is a continuation of a vehicle path spiraling from tangent to a curve, not a point with deflection.
- Vehicle entry path curvature.

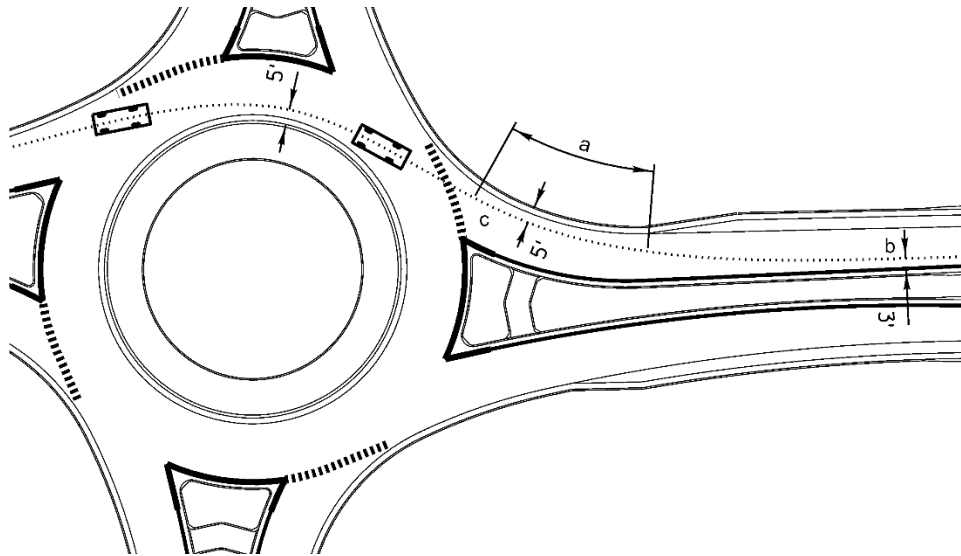


Figure 30.3 Determination of Entry Path Curvature
(See NCHRP 672 Exhibit 6-49 for multilane entries and Exhibit 6-50 for right turns)

The radii described in [Table 30.2](#) are used to define the fastest path through a roundabout. They are illustrated in Exhibit 6-12 of NCHRP 672.

Table 30.2 Roundabout Radii

Radius	Description	Range of Speeds
Entry Path Radius, R_1	The minimum radius on the fastest through path prior to the yield line. This is not the same as Entry Radius.	Single Lane 20 to 25 mph* Multilane 25 to 30 mph*
Circulating Path Radius, R_2	The minimum radius on the fastest through path around the central island.	15 to 25 mph
Exit Path Radius, R_3	The minimum radius on the fastest through path into the exit.	R_2 + Acceleration over the path to the exit crosswalk*
Left Turn Path Radius, R_4	The minimum radius on the path of the conflicting left-turn movement.	10 to 20 mph
Right Turn Path Radius, R_5	The minimum radius on the fastest path of a right-turning vehicle.	15 to 20 mph*

* Notes: Under conditions where sufficient numbers of pedestrians are present, values of fast path speeds should be lower than maximum values shown in the table. Check the design speed control of sensitive designs that may have high entering or circulating speeds or where the pedestrian activity is anticipated to be medium to high, check for a conservative design by determining the fastest speed paths using a 3.28 ft. (1 m) offset to each of the critical

controlling feature locations (i.e. raised curb face on the approach and exit median, curb face at the central island, or centerline pavement marking between opposing traffic).

For additional information, see NCHRP 672, §6.2.3 & 6.7.1.

30.5.3 Speed Consistency

In addition to achieving the appropriate design speed for the fastest path movements, the relative speeds between consecutive geometric elements should be minimized as well as between conflicting traffic streams. Ideally, the relative differences between all speeds within the roundabout will be no more than 10 to 15 mph. Typically, the R2 values are lower than the R1 values. With either single or multilane entries, R2 values should be lower than the R3 values.

The **typical** maximum R1 radius is 250 ft. Generally, for urban roundabouts with pedestrian accommodations a lower speed entry is desirable. A typical R1 may range between 150 and 230 feet. Rural roundabouts typically allow slightly higher entry speed than urban roundabouts. The R1 and R2 should be used to control exit speed. Typically, the speed relationships between R1, R2, and R3 as well as between R1 and R4 are of primary interest. Along the through path, the **typical** relationship is $R1 > R2 < R3$, where R1 is also less than R3. Similarly, the relationship along the left-turning path is $R1 > R4$.

For most designs, the R1 - R4 relationship will be the most restrictive for speed differential at each entry. However, the R1 - R2 - R3 relationship should also be reviewed, particularly to ensure the exit speed is not overly restrictive. Design criteria in past years advocated relatively tight exit radii to minimize exit speed; recent best practice suggests a more relaxed exit radius for improved drivability.

30.5.4 Design Guidance for all Trucks

WisDOT is a transport friendly state and accommodates not only for the **typical** large legal-size trucks, but also the OSOW vehicles that use our highways. The **typical** design vehicle for the STH system in Wisconsin is the WB-65.

Additionally, intersections of two state trunk highways and state highways that make an abrupt turn at an intersection should accommodate these check vehicles, the WB-92 (formerly WB-67 Long), farm combine, and 80-foot mobile home transport vehicles. If the existing intersection geometrics did not accommodate a Multiple-Trip (OSOW MT) permitted vehicle by staying within the curb face prior to the proposed improvement then it does not have to accommodate that vehicle after the improvement is completed, except as stated below.

The WB-92 (formerly WB-67-Long) is a very challenging vehicle to accommodate at an intersection because of its length and its lack of rear steering. Typically, the right turn movement is most problematic in trying to keep all wheels within the curb lines, especially at single lane entrances to a roundabout but may impact **typical** intersections as well depending on intersection skew. Check the existing intersection to see which movements can be made with the OSOW-MT vehicles without encroaching beyond the curb/shoulder line of the existing intersection. Once the various movements of the existing intersection have been evaluated and a determination has been made on which future movements are needed a WisDOT decision is needed. Either perpetuate existing turning movements or it may be **typical** to accommodate all movements, generally preferred, or maybe just certain movements. If a right turn movement is needed the designer will have to balance the entry throat width, circulating roadway width and the possible need for a small truck apron behind the outside curb for off-tracking. It is generally a safer design to keep the roundabout entry lane throat width on the narrow side, usually less than 22 feet. Check movement of the WB-92 vehicle to fit through an intersection or make turns at an intersection without having to remove signals, light poles or sign posts.

Refer to [FDM 11-25-2](#) and [FDM 11-25 Attachment 2.2](#) for additional information on OSOW MT permitted vehicles and Single Trip (OSOW ST) permitted vehicles. See the OSOW maps for routes designated as OSOW-TR available at:

<https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrcs/tools/planning-maps.aspx>

1. Slope truck apron at 1% toward the roadway on all roundabouts. In order to ensure that light vehicles encounter sufficient entry deflection at normal roundabouts, a truck apron (i.e. a raised low-profile area around the central island) is necessary. It should be capable of being mounted by the trailers of large goods vehicle, but unattractive to cars and SUVs.
2. The truck apron width is a minimum of 12 feet wide on single lane, as well as, multilane roundabouts. Sometimes additional space is needed for trucks to off-track onto the truck apron that may exceed the 12-foot width. Additionally, provide a 12-inch thick truck apron, as this will provide ample structural integrity while providing adequate tie bar clearances along back of curbs. Apply ties where required per [FDM 11-26-30.5.21.2](#). The 12-inch truck apron also minimizes constructability issues between compaction levels and is expected to improve long-term performance.
3. Widen the truck apron as needed to accommodate the anticipated OSOW turning maneuver. Discuss with the regional Truck Route coordinator.
4. Roundabouts must have the recommended circulatory roadway crown installed, 2/3 inward and 1/3

outward on all roundabouts, not just those on the OSOW-TR. Refer to [Figure 30.8](#) for cross-section clarification.

5. Install a Type A or D 4-inch sloped curb and gutter modified with 8" minimum flange thickness along the outside of the approach where large vehicles may off-track onto the curb, and when necessary install an outside concrete pad.
6. Install a reddish-colored concrete truck apron behind the back of curb along the outside entrance area where off-tracking is anticipated. The slope of the pad should be a maximum of 1%. Evaluate the entrance for pedestrian crossings and placement of the concrete pad to prevent these areas from overlapping. The width of this pad will depend on the amount of off-tracking anticipated. The same reddish colored concrete pad, without stamping, should be installed in the splitter islands where OSOW vehicles may drive to negotiate the roundabout. Consider projected vehicle loadings and constructability issues (tie bar and base construction considerations) when determining concrete truck apron thickness. Provide a 12-inch thick truck apron, as this will provide ample structural integrity while providing adequate tie bar clearances along backs of curbs. The 12-inch truck apron also minimizes constructability issues between compaction levels and is expected to improve long-term performance. Provide tie bars when the adjacent truck apron width is less than 3 feet along its entire length. To limit pavement stress and crack propagation, do not tie the outside truck apron to the back side of curb when the variable-width truck apron is 3 feet wide or greater at any location.

The following items are a reminder for additional roundabout design guidance:

- Keep drainage structures away from the travel path of the possible OSOW vehicle wheel tracking.
- The compaction levels under the concrete pad along the back of curb near the entrance and in the splitter island areas must be equal to the compaction levels under the roadway and truck apron.
- With the wider 12-foot minimum truck apron required by WisDOT for single-lane and multilane entries, it is rare that additional intersection sight distance is needed directly in back of the curb on the inside of the truck apron. If a central island landscape buffer area located adjacent to the back of the most inside curb and gutter is **typical**, avoid the use of hard surfaces that look like concrete sidewalk.
- 2% cross-slope is the maximum in the roadway area.
- Avoid approach vertical break-over grades over 3% within 200 feet of the entry yield line location.
- Provide a note to the construction engineer that the plans, including the vertical and horizontal design, shall not be adjusted in the field without the design engineer's approval.
- Refer to [FDM 11-26-35.1.12](#) for guidance on removable signs at roundabouts.
- For the roundabouts located on the OSOW Truck Route, their grading plans should be verified with 3D design software for any conflict points. The tractor should be placed 100 feet back from the yield line.
- Produce a swept path diagram showing the vehicle movements and directions for the purpose of supplying the permitting office with diagrams to aid route choice.

30.5.5 Geometric Design Guidance for Legal Trucks

The inscribed circle diameter, the width of the circulatory roadway and the central island diameter are interdependent. Once any two of these are established, the remaining measurement can be determined. However, the circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles also play a significant role in accommodating the design vehicle and providing deflection.

In all cases, the designer will test swept paths and iterate through combinations of circle size and lane widths. A recent roundabout design study identified three cases or categories for accommodating trucks. Case 1, Case 2, and Case 3 categories are determined by a number of factors, primarily whether a truck can stay in lane or not, as explained below.

Roundabouts are designed with a truck apron. Truck drivers that use the inside lane are expected to off-track onto the truck apron. Regardless of the case category the outside lane of a dual lane roundabout is typically wider than the inside lane to better accommodate trucks. Multilane roundabouts can be designed in three different ways to accommodate legal size large trucks. Three categories of design for legal trucks have been identified as Case 1, Case 2, and Case 3:

- **Case 1:**
Roundabouts which are designed to allow trucks to encroach into adjacent lanes as they approach, enter, circulate, and exit the intersection. Refer to [Figure 30.4](#) for an example of a Case 1 design.
- **Case 2:**
Roundabouts which are designed to accommodate trucks in-lane as they approach and enter the roundabout but may require trucks to encroach into adjacent lanes as they circulate and exit the intersection. Case 2 roundabouts have a painted "gore" area between lanes on the approaches. Refer

to [Figure 30.5](#) for an example of a Case 2 design.

- **Case 3:**

Roundabouts which are designed to accommodate trucks in-lane as they approach and traverse the entire intersection. Case 3 roundabouts have a painted “gore” area between lanes on the approaches. Case 3 roundabouts typically are designed to allow trucks to stay in lane for through and left turning movements, while right turning trucks may occupy multiple lanes as they exit. With few Case 3 roundabouts implemented to date, these designs typically require significantly more designer skill than other case types to ensure proper operations, geometrics, speeds, and safety. Refer to [Figure 30.6](#) for an example of a Case 3 design.

Well-designed Case 2 and Case 3 roundabouts do not compromise accepted design principles, as outlined in this chapter. [Tables 30.3](#), [Table 30.4](#), and [Table 30.5](#) show the advantages and disadvantages of Case 1, Case 2, and Case 3 roundabout designs.

Table 30.3 Advantages and Disadvantages for Case 1 Roundabout Designs

Advantages	Disadvantages
Wide variety of approach alignment design methods can be used	May result in increased delays due to trucks occupying both lanes on entries and while circulating
More likely to fit in tight right-of-way locations, including built-up urban environments	Trucks may off-track over outside curbs, resulting in more damage and maintenance
Potentially lower costs in some situations	May result in additional truck-car crashes
Less pavement marking maintenance	

Table 30.4 Advantages and Disadvantages for Case 2 Roundabout Designs

Advantages	Disadvantages
Surveys indicate this entry design is preferred over Case 1 by truck drivers	Fewer approach alignment design methods can be used
Safety benefits at entries due to no truck encroachment	May require geometry with more right-of-way
Potentially less damage to curbs	Potentially higher cost in some situations
Trucks can maneuver more freely at entries	May require more pavement marking maintenance
May have greater entry capacity/less delay	Slightly higher circulating speeds and worse lane discipline possible
Can be used in urban or rural environments	Requires greater designer and contractor skill
May have greater public acceptance	Poor design could result in more crashes
	Possibly lower safety in circulatory roadway due to truck encroachment

Table 30.5 Advantages and Disadvantages for Case 3 Roundabout Designs

Advantages	Disadvantages
Surveys indicate this design is preferred by truck drivers and the trucking industry	Fewer approach alignment design methods can be used
Safety benefits at entries and in circulatory roadway due to no truck encroachment	May require larger geometry with more right-of-way
Less damage to curbs	Potentially higher cost in some situations
Trucks can maneuver more freely at entries and in the circulatory roadway	May require more pavement marking maintenance
May have greater entry capacity/less delay	Slightly higher circulating speeds and worse lane discipline possible
Can be used in urban or rural environments	Requires greater designer and contractor skill
Better operations in the circulatory roadway	Poor design could result in more crashes
No truck/trailer encroachment required for turning movements - more lateral clearance	
May have greater public acceptance	

Case 3 design is a priority where practical and feasible and there are approximately 100 large trucks (forecasting classification 3S2) per day using the intersection. In general, it is believed that a well-designed Case 3 roundabout which meets applicable geometric design requirements will provide safe and efficient operations while providing optimal truck accommodations. Where costs or right-of-way impacts are prohibitively expensive or at locations where design truck numbers are very low, other design case types may be more advantageous.

Certain specific locations should warrant additional consideration of a Case 3 design. These would include locations where designated OSOW routes exist, multilane approaches on arterial routes, at interchange ramps, near truck stops, and in industrial/warehouse districts. If a Case 3 is an alternative based on large truck numbers but there are serious adverse impacts, such as environmental, historic, real estate or other impacts then evaluate a Case 2. Consider a step-down approach to the evaluation process and perhaps a Case 1 is all that will fit into the intersection without serious adverse impacts. In the end evaluate the selected roundabout case number option appropriate for the intersection and compare it to the other intersection alternatives such as a signal, or other type.

In the case of three lane entries, off-tracking is assumed to overlap lane lines. If high volumes of large trucks are present and capacity is a concern, a painted gore width of 4 to 6 feet may be placed between the right two lanes.

[Table 30.6](#) depicts typical design parameters for each of the three design cases. Refer to [FDM 11-25-1.4](#), [FDM 11-25-2](#) and [FDM 11-26-10.2](#) for additional information on OSOW routes and vehicles.

Table 30.6 Typical Design Parameters for Two-Lane Roundabouts*

	Case 1 - No lane discipline entering or circulating	Case 2 – Lane discipline entering only	Case 3 – Lane discipline entering and circulating
ICD ^A	150-190 ft	160-210 ft	180-220 ft
Inner Circulatory Lane Width ^B	11-13 ft		12-14 ft
Outer Circulatory Lane Width ^B	13-15 ft		15-18 ft
Approach Gore Widths	Not used	2-6 ft	4-8 ft
Entry Width ^A	28-32 ft	32-34 ft	32-34 ft
Entry Radius	65 ft or greater		
Controlling Radius	65 ft or greater	65 ft. or greater, 100-130 ft. typical	
Controlling Radius Length	No MAX.—typically 70 ft or less	No MAX.—typically 80 ft or greater	
Entry Angle (measured per FDM 11-26-30.5.2)	16-30 degrees		
Flared Entry Lane Addition (based on 95%ile Queue)	> 100 ft Generally, 100 ft to 300 ft		
Exit Widths ^A	28-32 ft		28-32 ft (where large radius or tangential exit is used)

* Based on site conditions, right-of-way constraints, specific design vehicle, and other factors, designers may choose to implement geometries outside these recommended ranges; however, the overall design should comply with WisDOT general roundabout design practices

^A Measurements are from the face of curb to face of curb, (includes 2-ft gutter pans on each side)

^B Measurements are from flange line to lane line

30.5.5.1 Geometric Design Guidance for Case 1 Roundabouts

Case 1 roundabouts are designed with a single solid white paint line dividing the entry lanes. Trucks encroach on adjacent lanes at the approaches and when circulating and exiting the roundabout. Designers should consider implementing features that would result in a clear encroachment by trucks into adjacent lanes rather than a subtle encroachment (such an approach would typically include avoiding wide lanes, long sweeping curves, large ICDs, and large radii).

Additionally, Case 1 designs can allow for the approaching roadways to have more tangential alignments with short, tighter entry radii. In some rare Case 1 design locations, implementing outside curb truck aprons (i.e., a sloped/mountable curb with a concrete/pavement area behind the curb) may be beneficial to repair and prevent rutting behind the entry radius curb, curb damage or damage to signs and landscaping from truck off-tracking. The implementation of outside truck aprons in new designs is discouraged due to potential concerns about pedestrian safety and optimal operations. As such, designers should not typically consider outside truck aprons as a preferable option when sidewalks or shared-use paths are present. The width of this apron should be determined through the use of software that generates swept paths for trucks. Figure 30.4 shows the basic design features of a Case 1 roundabout.

A sub-option for Case 1 designs is to use a short flare from a single lane approach to a two-lane entry. With approximately a 100-foot flare, the design may be acceptable without the gore pavement marking. If the flare is long, e.g. approaching 250 feet to 300 feet, then a Case 2 design with the gore area between lanes would be **typical**.

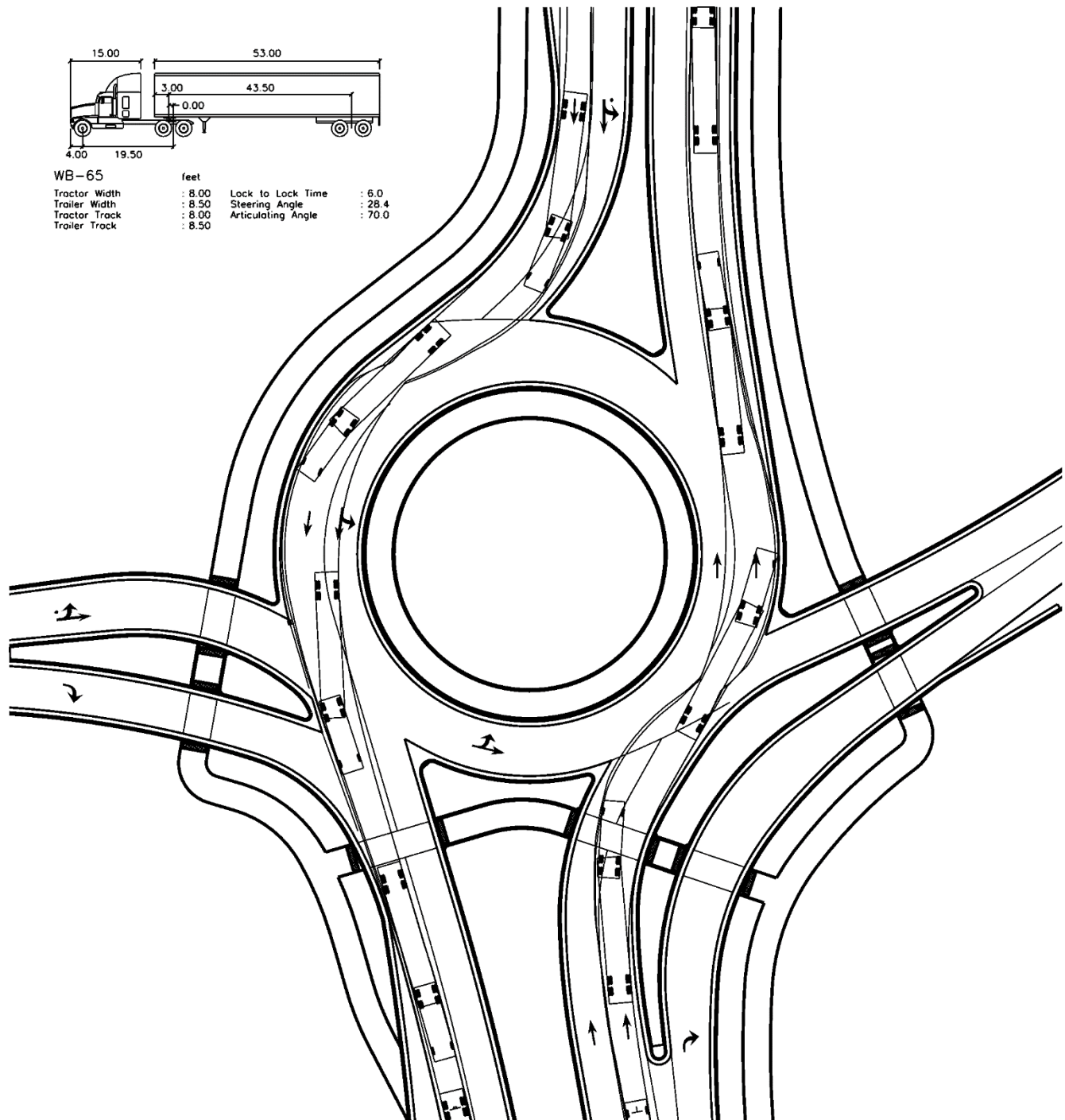


Figure 30.4 Case 1 Roundabout Design (Single lane line dividing the entry lanes)

30.5.5.2 Geometric Design Guidance for Case 2 Roundabouts

Once the primary design principles from this guidance have been met (speed control, sight distance, adequate space for a design vehicle), the designer will typically revise the design iteratively to allow trucks to stay in lane at the entry while still maintaining the primary design. Although there are some specific design characteristics which are unique to Case 2 roundabouts, the overall approach, methods, and iterative design process remain the same as multilane roundabouts in general.

Case 2 roundabout ICDs are typically 10-20 feet smaller than for Case 3 roundabouts. Designers must maintain appropriate fastest path entry speeds and speed differentials between entering and circulating traffic. Figure 30.5 shows the basic design features of a Case 2 roundabout.

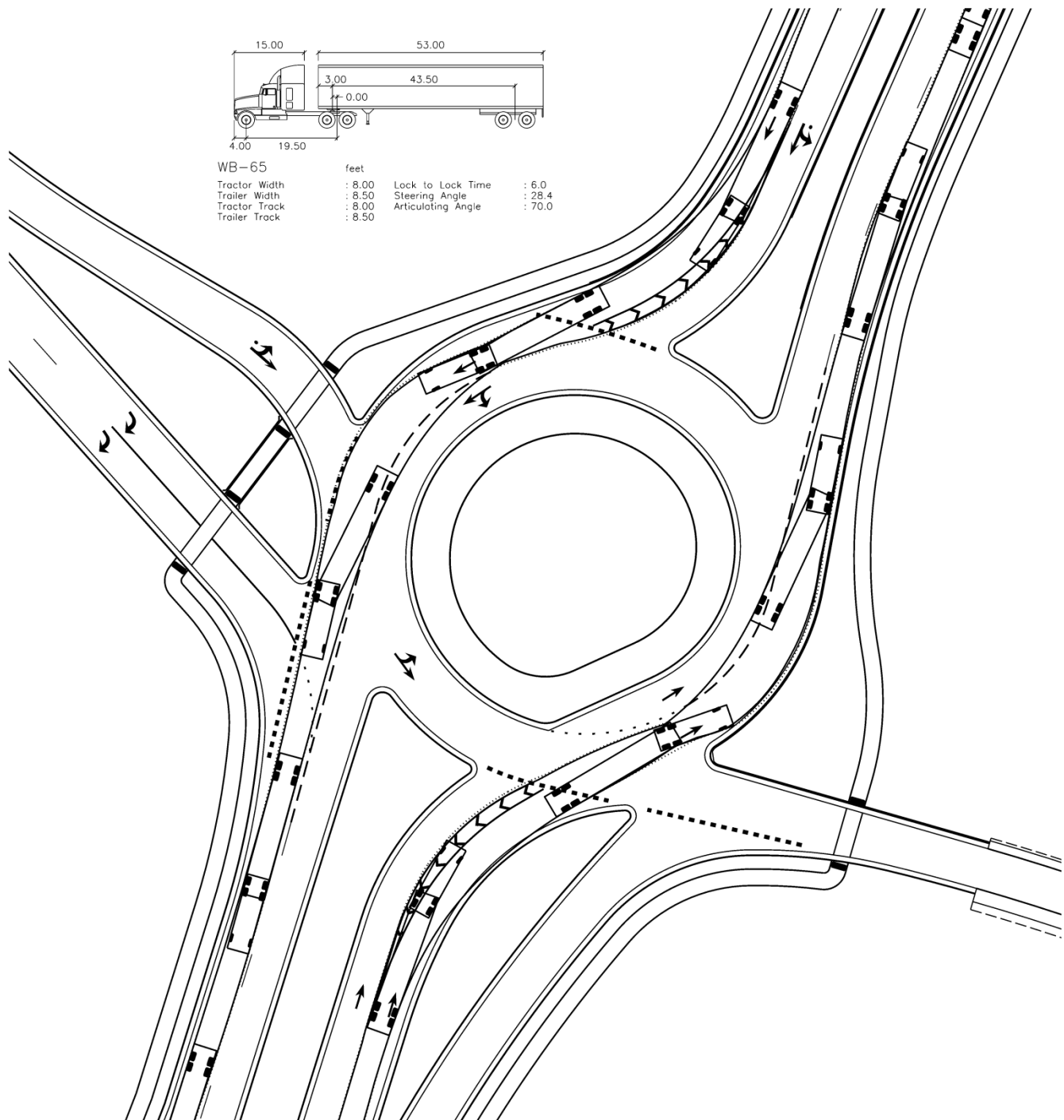


Figure 30.5 Case 2 Roundabout Design (6-ft gore pavement marking between lanes)

30.5.5.3 Geometric Design Guidance Common to Case 2 and Case 3 Roundabouts

1. Often have slightly wider entries (typically 2 to 6 feet wider) than a comparable Case 1 roundabout at the same location. For example, a Case 1 roundabout may have an entry width of 28 to 32 feet (including gutter pan width) wherein a typical Case 2 or 3 roundabout could increase the entry width to about 32 to 34 feet (including gutter pan width and gore pavement marking area) to allow trucks to stay in lane in entry.
2. Usually have longer curve lengths than Case 1 roundabouts on the approach geometry and within the entries. Offset left alignments (i.e., alignment directed to the left of the center of the ICD) are generally preferred where possible.
3. Should avoid tight entry radii curves and closely spaced curves in opposite directions. Instead, larger, longer radii with straight tangent sections between curves are common at Case 2 and 3 roundabouts, resulting in gradual sweeping curvature which makes it easier for trucks to stay in lane. Optimal entry radii values will vary based on the ICD, approach alignment, and entry design method. Typically, an

urban Case 2 or 3 design may have a controlling curb radius value of 100 feet or greater, while a larger rural Case 3 design may range as high as 120 feet or more (note: per definition above, controlling radius is not the same as the R_1 radius). Regardless of the actual values (which are site specific), the designer still must maintain other design requirements such as appropriate fast path speeds, while still accommodating for trucks in-lane. Considerable designer skill is typically needed to accomplish these competing objectives.

4. Use of width transitions. With Case 2 and 3 roundabouts relatively long width transitions may be needed to allow trucks to use more roadway width to stay in lane. Designers should ensure that the total length of the combination of the taper and the second full lane width utilized accommodates the design truck as well as queuing and capacity needs. Not including the gore area between entry lanes, the lanes should typically have continual tapers between the normal width upstream location and the entry, ([Figure 30.5](#) and [FDM 11-26-35.2.1](#)), and at no point should lane widths become narrower over this distance. The design of the gore area may require variable widths, including narrowing toward the entry as needed.
5. A slightly wider entry width than usually provided at Case 1 roundabouts. The designer should keep the entry width as narrow as possible while still allowing trucks to stay in lane. Total two-lane entry width should typically not exceed 34 feet (from curb face to curb face, including painted gore area) unless special circumstances are present. Lane widths at the entry typically vary from 12 to 14 feet, not including the two-foot gutter or gore area.
6. The relationship between width transitions, entry widths, lane widths, and gore widths should be carefully considered by the designer when determining how to optimally serve trucks and passenger vehicles. As a general principle, widths should be minimized while still accommodating the design truck.
7. Typically, a Case 1 design would have a controlling radius value of 65 feet or greater, while a more common range is 100 to 130 feet for Case 2 and 3 designs.

30.5.5.4 Additional Geometric Design Guidance for Case 3 Roundabouts

The Case 3 design is preferred as the initial consideration at intersections that experience 100 or more large trucks (traffic forecast classification 3S2). When preparing a Case 3 design, once the primary design principles from this guide have been met (speed control, sight distance, adequate space for a design vehicle), the designer will typically revise the design iteratively to allow trucks to stay in lane at the entry and circulating road while still maintaining the primary design principles. Although there are some specific design characteristics that are unique to Case 3 roundabouts, the overall approach, methods, and iterative design process remain the same as multilane roundabouts in general.

Overall, Case 3 roundabouts embody similar geometric characteristics as Case 1 and 2 roundabouts. However, there are specific geometric elements where Case 3 roundabouts differ from Case 1 and 2 designs.

1. The outside circulating lane is often in the range of 15 to 18 feet (from edge of gutter flange line to lane line). Inside lanes range from 13 to 15 feet (from edge of central island gutter flange line to nearest lane line).
2. Usually include relatively large or flat exit radii which allow trucks to depart from the circulating road with minimal curvature to the right, thus allowing them to stay in lane more easily. Case 3 roundabouts may have larger ICDs in some situations where a double left turn is required. This type of design may be quite complex. [Figure 30.6](#) shows the basic design features of a Case 3 roundabout.

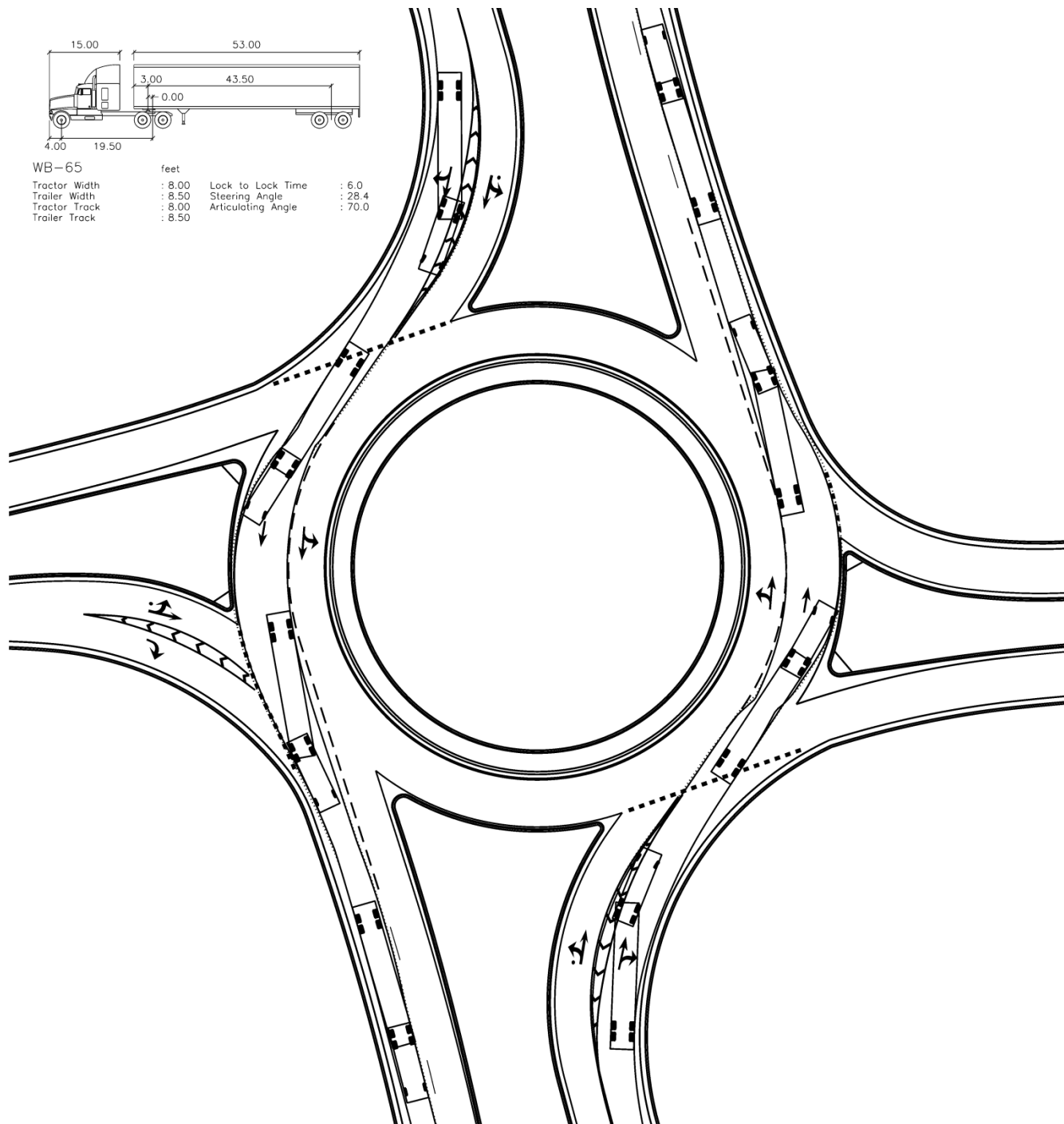


Figure 30.6 Case 3 Roundabout Design (6-ft to 8-ft gore pavement marking between lanes)

30.5.6 Vertical Considerations for OSOW Vehicles

Prior to the preliminary design, check with local officials, the public and the State freight engineer in the Bureau of Highway Maintenance to determine if there are any special OSOW vehicles that regularly use the intersection and refer to the WisDOT OSOW vehicle inventory in [FDM 11-25 Attachment 2.1](#).

See the OSOW maps for routes designated as OSOW-TR available at:

<https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrcs/tools/planning-maps.aspx>

If a roundabout is located on the OSOW Truck Route or it is thought that OSOW vehicles may use the intersection, conduct a vehicle horizontal turning and a low vertical clearance check with the OSOW vehicle inventory. AutoTurn or AutoTrack software may be used for the horizontal checks. AutoTURN Pro may be used for horizontal analysis and is required to determine if low vertical clearance conflict points are present. Use a low clearance of 5 inches for the DST lowboy evaluation. If clearance issues are found, reconfigure the slopes within the conflict areas and check the surrounding area (i.e. approaches) for additional conflict points. Refer to [Figure 30.7](#) for typical ground clearance problem areas.

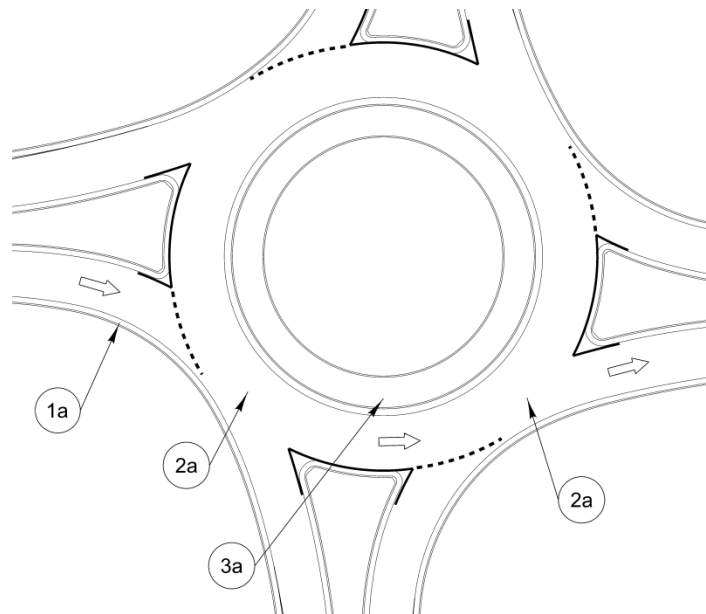


Figure 30.7 Typical Ground Clearance Problem Areas

1. Off-tracking at the entry curve/lowboy hitting the outside curb head
 - a. Consider a Type A or D 4-inch sloped curb and gutter modified with 8" minimum flange thickness and concrete truck apron behind the back of curb along the outside entrance area. The slope of the truck apron should be a maximum of 1%. Evaluate the entrance for pedestrian crossings and placement of the concrete pad to prevent these areas from overlapping.
2. Entry and exit rollover
 - a. Consider flattening the circulatory roadway crown in these areas if needed, while providing approximately 2/3 sloped inward and 1/3 sloped outward.
 - b. Avoid break-over grades over 3% within 200 feet of the entry yield line location and exiting the roundabout
3. Truck Apron
 - a. Slope truck apron 1% toward the roadway on all roundabouts (not 2% as in the past). Consider a pill shaped central island or other shape where appropriate to accommodate the anticipated OSOW turning maneuver.
 - i. See if the vehicle can track more on the circulatory roadway. In rare situations, the designer may consider a 3-inch height R/T type curb and gutter. This will require an evaluation of the inlet casting height/location (out of the vehicle path) and will require a C & G special detail.
 - b. Look at the circulatory roadway profile
 - i. Keep it as flat/gentle as possible and still maintain drainage (0.75% - 1.0%)
 - ii. Locate the crest away from the area(s) of concern

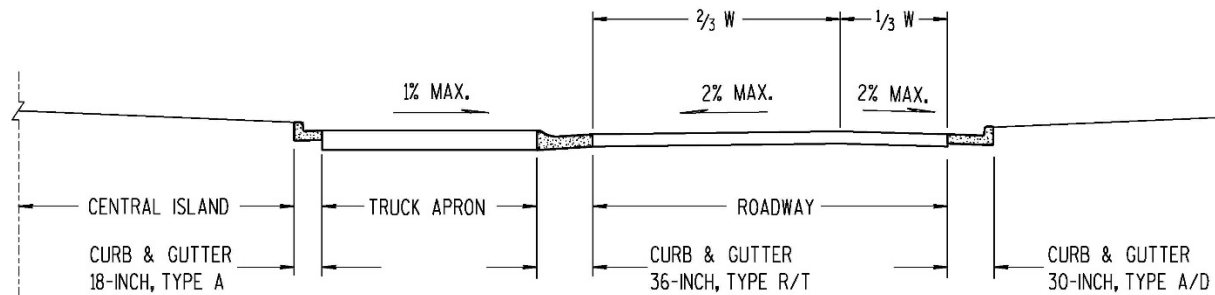


Figure 30.8 Cross-Section Example

In some cases, abnormally long vehicles may not be able to negotiate roundabout regardless of geometric adjustments to the truck apron and approaches when making left turns. In some cases, special median crossings may be required, which allow the vehicle to bypass the circle portion of the roundabout by traveling the opposite direction down a right turn bypass. Such maneuvers should be avoided, if possible, due to the extra planning required for escorting a vehicle in such a maneuver. Discuss such alternatives with the regional traffic section and the OSOW-TR coordinator and document route testing produced by turn analysis software for future use by the OSOW Permitting Unit.

30.5.7 Overturning Considerations for Large Vehicles

A further consideration associated with large trucks in roundabouts is the potential for overturning or shifting of loads. There is no simple solution in relation to layout geometry to completely prevent load shifting and roll-overs. Experience suggests that at roundabouts where these problems persist, there are frequently combinations of the following geometric features:

- Long straight high-speed approaches
- Inadequate entry deflection or too much entry deflection
- Low circulating flow combined with excessive visibility to the left
- Significant tightening of the turn radius partway around the roundabout (spirals with arcs that are too short).
- Cross-slope changes on the circulatory roadway or the exit
- Outward sloping cross-slope on the entire width of the circulatory roadway

A problem for some vehicles may be present even if speeds are low because of a combination of grade, geometry, sight distance and driver responsiveness. Research has shown that an articulated large goods vehicle with a center of gravity height of 8 feet above the ground can overturn on a 65-foot radius curve at speeds as low as 15 mph. See Transport Research Laboratory Report LR788.

Layouts designed to mitigate the above noted characteristics will be less prone to load shifting or load shedding. In addition, pay attention during design and construction to ensure that pavement surface tolerances are complied with and that abrupt change in cross-slopes are avoided.

30.5.8 Roadway Width

The width of the roadway at locations with curb and gutter on both sides should accommodate the design vehicle and allow for passing a stalled vehicle. The design width for entries, exits and bypass lanes is shown in Exhibit 3-51, page 220, GDHS 2004 as a 19-foot face-face minimum and 20-foot face-face **typical** to allow a stalled vehicle to pass.

30.5.8.1 Entry Width

Entry width is measured perpendicularly from the outside curb face to the inside curb face nose P.C. at the splitter island point nearest to the inscribed circle.

Narrow entries tend to promote lower speeds and improved safety. However, a WB-65 may require a 19 to 22-foot-wide entry path for single lane approaches to be able to make a right turn. Design single lane roundabouts to accommodate a WB-65 without encroachment onto the truck apron or the curb and gutters. Wide entries may cause concerns about whether to pavement mark the entry as a multilane or keep as a single lane. Increasing the flare length without changing entry width will increase entry capacity and is crash-neutral (see NCHRP 672 Exhibit 6-25). Increasing both flare width and entry width may produce a substantial increase in capacity but will degrade safety by promoting higher entry speeds. Effective flare length may be as short as 15 feet or as long as

330 feet. Once the effective flare length exceeds 330 feet it will have a minimal benefit to capacity; therefore, adding a full approach lane would be advised.

30.5.8.2 Entry Flare

Flaring an entry from one lane to two or from two to three creates additional entry capacity without extensive mid-block widening. When lane choice options are even, or no preference is given to either lane, it is ideal to split the approach width at a point where the lane width reaches 9.5 feet or 19 feet overall (flange of curb dimensions).

The development of horizontal geometry and pavement marking of a flared entry is balanced and smooth making lane choice options obvious and entry paths clear.

30.5.9 Exit Tapers

Tapering the number of lanes on an exit from two lanes to one lane or from three lanes to two lanes allows for additional roundabout capacity without extensive mid-block widening. The continuous flow nature of roundabouts typically results in less saturated traffic streams exiting the intersection. This is in sharp contrast to a signalized intersection where platoons of traffic are much more concentrated, and consequently typically require more downstream distance to merge. Speeds are also much slower for traffic exiting roundabouts which eliminates the need for long parallel section downstream of the roundabout exit.

Design exit tapers from roundabouts based on the anticipated in lane exiting speed, not the fastest path, typically in the range of 15 to 25 mph. Merging taper rates should be based on the lengths shown in [FDM 11-25 Attachment 2.3](#), typically 20:1 to 30:1. The length of full width lanes beyond the circulating roadway to beginning the merging taper may vary between 100 and 300 feet depending on volume, potential for upstream lane choice, and other factors that may be unique to the site. Consider the farther the full lane widths are extended upstream, the potential for increase in speed and the potential for a longer merge taper. See [Figure 30.9](#).

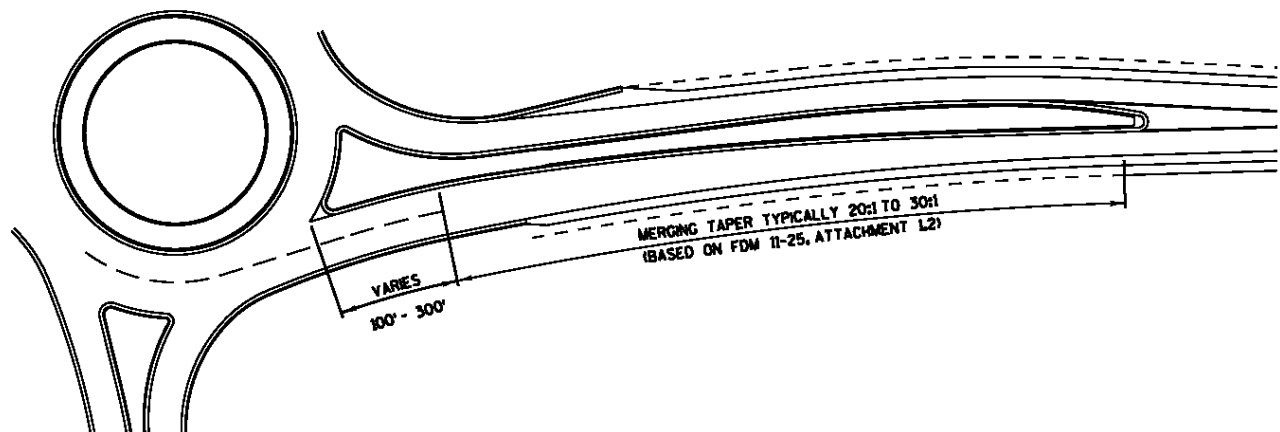


Figure 30.9 Exit Lane Taper

30.5.10 Circulatory Roadway Width

Circulatory roadway width is the width between the outer edge of the inscribed diameter at the curb face and the central island curb face. It is typically 1.0 to 1.2 times the width of the widest entry with potential exceptions for Case 2 and Case 3 designs. It does not include the width of any traversable apron, which is defined to be part of the central island. The circulatory roadway width defines the roadway width, curb face to curb face, for vehicle circulation around the central island. The circulatory roadway width does not need to remain constant. A two-lane entry may be appropriate for the major through highway, however, the minor side road may be single lane approaches. The circulating roadway may often have a different width to accommodate the through traffic than for the side road traffic. Alternative lane configurations also produce varying circulatory widths as shown on NCHRP 672 Exhibit 6-27.

30.5.11 Central Island

The central island of a roundabout is always a raised, non-traversable area encircled by the roundabout circulatory roadway. The central island is stepped up from the traversable truck apron to the non-traversable island area. The central island is raised and landscaped to enhance driver recognition of the roundabout upon approach and to limit the ability of the approaching driver to see through to the other side. The inability to see through the roundabout reduces or eliminates headlight glare at night and driver distraction by other vehicles on the circulating roadway.

The center or highest portion of the central island ground surface elevation should be raised a minimum of 3.5 feet and maximum of 6 feet from the circulatory roadway surface. The ground slope in the central island shall

not exceed 6:1.

Concrete, stone, wood or other non-forgiving material used to make a wall within the central island is prohibited. Landscaping the central island and the roundabout area is further addressed in [FDM 11-26-40](#).

The outside 6 feet of the central island should be a low mowed grass surface or low maintenance surface to maintain good visibility to the left upon entry as well as good forward and circulatory visibility on the circulatory roadway.

30.5.12 Entry Curves

The minimum entry radii should be approximately 65 feet. Capacity will increase with increased entry radii, but so may the entry speed. Entry radius is not R1.

NCHRP 672 Exhibit 6-14 illustrates the composition of entry curves to produce natural entry paths. This method is useful but has limitations where large trucks making right turns will require even larger outside radii, particularly on single lane roundabouts with narrow entry widths. In such cases, the larger outside radius may increase entry speeds undesirably. A preferred design technique for single-lane roundabouts is not to make the inside radius/arc tangential to the central island, but to create a flare in the entry such that the large truck path can preserve the outside radius which controls entry speed. The effect gives the entry a flare, typically ranging from 18ft to 24ft. To avoid misleading drivers to expect multilane operation at wider single-lane entries, the left-hand side of the entry may be pavement marked as shown in [Figure 30.10](#) to reinforce single lane operation. Also refer to [FDM 11-26-35.2.1](#), and [Attachment 35.1](#) for further pavement marking procedures.

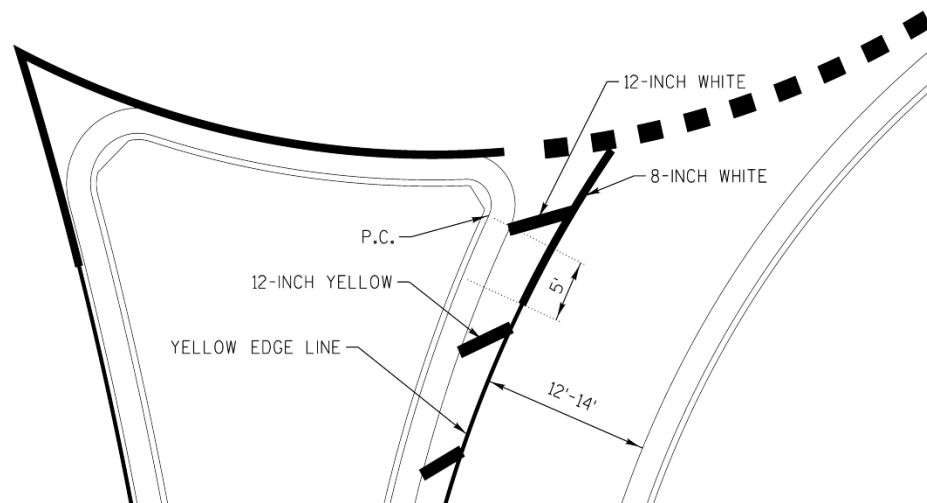


Figure 30.10 Example of alternative pavement marking design for single entrance lane not in the NCHRP Report 672

30.5.13 Non-motorized Users

Roundabouts like other intersections need to accommodate bicyclists and pedestrians. The types of facilities provided vary based on the existing urban, suburban and rural conditions as well as future land uses. Evaluate regional and local land use plans including stand-alone bike and pedestrian plans for communities when determining the appropriate bike and pedestrian facilities at a roundabout. See [FDM 11-46-1](#) for guidance on including bike and pedestrian facilities on projects.

Pedestrian accommodations include sidewalks, shared-use paths and roundabout sidepaths.

Bicycle accommodations include bike lanes, wide curb lanes, urban paved shoulders, rural paved shoulders, shared-use paths and roundabout sidepaths. Although a shared roadway is not a bicycle accommodation, shoulders or bike lanes taper down and end just prior to the entrance to a roundabout. Tapers are necessary to help achieve proper speed control for vehicles at entry. Design requirements do not allow bike lanes or shoulders at the yield line or within the circulatory roadway of a roundabout. Bicyclists in Wisconsin have the right to use the roadway in the same manner as motor vehicles. Bicyclists may have concerns when traveling into, through, or around roundabouts depending on traffic volume, vehicle type composition, experience of the bicyclist, lighting or other factors. Therefore, a bicyclist approaching a roundabout may proceed in a travel lane ("take the lane") or exit the roadway by way of a ramp and ride on a roundabout sidepath (or a shared use path, if applicable). See [FDM 11-26-30.5.13.1](#) and [Figure 30.11](#) for guidance on bike exit and entrance ramps). These ramps are where the shoulder or bike lane tapers and a typical 5-foot sidewalk transitions to/from a roundabout sidepath.

A sidewalk transitions to/from a roundabout sidepath as it approaches/departs an isolated roundabout. At

locations with consecutive closely spaced roundabouts, a sidewalk transitions to a roundabout sidepath at the first upstream roundabout, and transitions from a roundabout sidepath at the last downstream roundabout. See [FDM 11-20-1](#), [FDM 11-46-5](#) and [FDM 11-46-10](#) for design guidance on sidewalks.

Shared-use paths are typically community or regional facilities in their own corridors that may extend for miles. Shared-use paths support a wide variety of non-motorized travelers like bicyclists, in-line skaters, roller skaters, wheelchair users, walkers, runners, people with baby strollers or people walking dogs (typically not equestrian users or motorized users - although some state trails in Wisconsin allow snowmobiles). Shared-use paths are designed for bi-directional bicycle travel. Continue a shared-use path around roundabouts (and between consecutive roundabouts if applicable) following shared-use path design [criteria](#). See [FDM 11-46-15.6](#) and the Wisconsin Bicycle Facility Design Handbook for more guidance on shared-use paths. Also, see [FDM 11-35-1.6](#) and [FDM 11-35 Attachment 1.1](#).

Roundabout sidepaths are a variant of shared-use paths that apply specifically to roundabout intersections and between consecutive closely spaced roundabouts. A roundabout sidepath is a sidepath around the perimeter of an isolated roundabout, or a sidepath between two consecutive closely spaced roundabouts and around their perimeters. Consecutive roundabouts are closely spaced if they are 1,000-feet or less from center to center. Roundabout sidepaths are designed with the expectation that bicyclists will travel in a unidirectional manner (i.e., one-way bicycle travel in the same direction as traffic flow on that side of the roadway) and do not connect to shared-use paths. If bicyclists choose to leave the roadway and enter the path, they must yield the right-of-way to pedestrians. If bicyclists stay on the roadway they are expected to position themselves near the middle of the travel lane to circulate around the roundabout.

The roundabout splitter islands provide pedestrian refuge and pedestrian crossings. At roundabouts with high traffic volumes, or where pedestrian or bicyclist volumes are high, consider accommodating both users by enhancing the pedestrian crossings with features such as:

- 6-inch white crosswalk marking next to colored concrete (Wisconsin MUTCD (WMUTCD), 3B.18, 3G.01, 7C.02)
- Colored concrete with 6-inch wide patterned borders with white crosswalk markings, note main walking surface is smooth
- Activated (push button or automatic detection) warning beacons (e.g. Rectangular Rapid Flashing Beacon or pedestrian hybrid beacon)

30.5.13.1 Bike Ramp Entrance and Bike Ramp Exit Design Guidance

End the on-road bicycle accommodations approximately 75 to 150 feet upstream of the yield line and allow the bicyclist an opportunity to leave the roadway by way of a bicycle exit ramp. More distance is needed when a right turn bypass lane is provided. The bike ramp exit should have relatively flat angles as shown so that bicyclists are not directed into the path of pedestrians. The bike ramp entrance should have relatively flat angles as shown so that bicyclists are not directed into the travel lane of motorized vehicles. The bike entrance ramp should not be directed parallel to the bike lane.

The location of bike ramps and driveway aprons need to be spaced as not to conflict with each other. It is not [typical](#) for bicyclists and is a last resort to leave or re-enter the roadway by way of a driveway apron.

Design the bike ramps 4 feet wide between the roadway and the multi-use path such that they angle up (25 to 35 degrees) to the path where the bicycles exit the roadway, Figure 30.11. Angle down (25 to 35 degrees) toward the roadway where the bicycles re-enter the roadway, Figure 30.11.

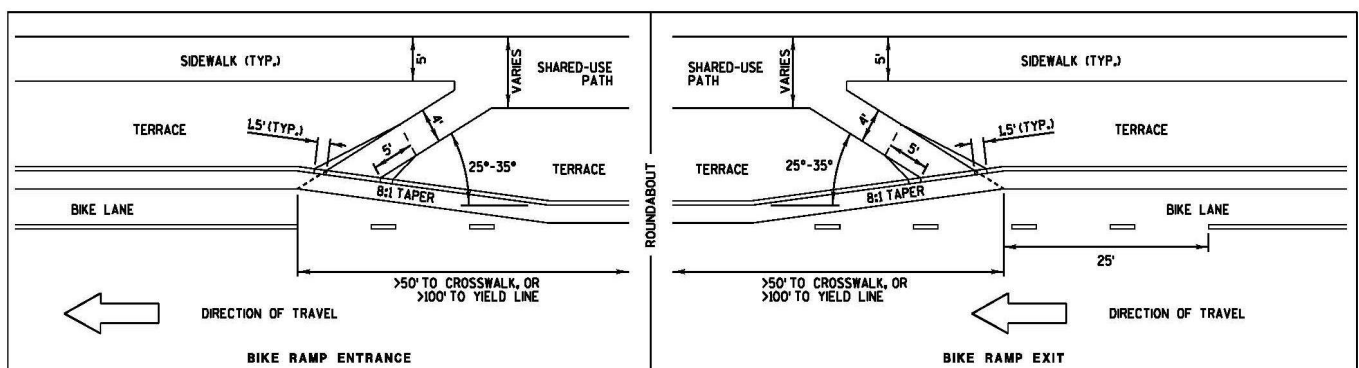


Figure 30.11 Bike Ramp Entrance and Exit

30.5.13.2 Pedestrian Facilities, Shared-Use Paths, and Roundabout Sidepaths

Isolated roundabouts and roundabouts in a series that are closely spaced, which is defined as a distance of

1000' or less between the centers of any two consecutive roundabouts, have design criteria that is different than other at-grade intersections. The following procedures include design guidance for these facilities near and between roundabouts. See [FDM 11-46-5](#) for additional information on Pedestrian Facilities. See [FDM 11-46-15](#) and Wisconsin Bicycle Facility Design Handbook for additional information on **typical** shared use paths. See [FDM 11-46-1](#) on providing bicycle and pedestrian accommodations on projects.

In most urban and suburban areas sidewalks on both sides of the roadway are common and expected. These sidewalks lead up to and transition into roundabout side path as these facilities approach a roundabout. This typically is a 5 ft sidewalk and a 5 ft terrace, or if there are trees planted in the terrace the minimum terrace width is 6-foot wide minimum.

When an existing or proposed sidewalk approaches either end of a roundabout, provide at least an 8-foot-wide roundabout side path with a terrace when sidepath use is anticipated to be low or medium around and between the roundabout(s). The width of the sidepath (and terrace) remains consistent through the roundabout(s). When the sidepath use is anticipated to be high (frequent passing of users), install a 10-foot-wide sidepath with a terrace. There are many reasons to anticipate high use such as parks close by, elementary and high schools, universities, gas/convenience stores, restaurants, etc.

In an outlying district or rural area, there may be locations with on-road bicycle accommodations but without sidewalks (existing or proposed) (see [FDM 11-46-1.3.1.4](#)). In this case, 6-foot wide roundabout sidepaths are appropriate. Work with the regional bike and pedestrian coordinator to determine the appropriate widths.

When a shared-use path approaches the roundabout carry the shared-use path around the roundabout. The **typical** width is 10 feet with a 5 ft. terrace, or if there are trees planted in the terrace the minimum terrace width is 6-foot wide minimum.

For a series of closely spaced roundabouts, extend the roundabout side path or shared use path from the first bicycle exit ramp to the last bicycle entrance ramp, for the bicyclist to leave the roadway and travel through all roundabouts on the roundabout sidepath. Do not provide entrance ramps for bicyclists to re-enter the roadway between closely spaced roundabouts (1,000 feet or less between roundabout centers). However, provide exit ramps from the roadway to the sidepath prior to the approaching roundabout.

When the distance between any two roundabouts is greater than 1,000 feet, center to center, then the roundabout side path may be discontinued beyond the last roundabout. Provide entrance ramps for bicyclists to re-enter the roadway downstream from each roundabout as well as exit ramps from the roadway to the sidepath. Provide sidewalk(s) between the roundabouts if there is sidewalk on the roundabout approaches (see [FDM 11-46](#)).

A roundabout sidepath might not be built during the initial construction if the location meets the criteria under [FDM 11-46-1](#). If a roundabout sidepath around a roundabout is not installed with the initial roundabout construction, it is important to construct the appropriate platform by grading for future facilities (e.g in rural or outlying area 5-foot terrace and a 6-foot width for the roundabout sidepath around the roundabout) and provide pedestrian crossings in the splitter islands. Maintenance may not be required until the perimeter facilities are installed.

30.5.13.3 Roadway Width, Clear Roadway Width of Bridges, and Underpasses between Closely Spaced Roundabouts

At a minimum, multi-lane roadways with a raised curb median between opposing roadways and between closely spaced roundabouts require a 2-foot median shoulder, two or more 12-foot lanes, and a 4-foot minimum outside shoulder, a 5-foot terrace adjacent to a shared-use path or roundabout sidepath. If there are trees planted in the terrace the minimum terrace width is 6-foot wide.

At a minimum, single lane roadways with a raised curb median between opposing roadways and between closely spaced roundabouts require 19 feet minimum from curb face to curb face. This typically allows for a 2-foot median shoulder, one 12-foot lane and a 5-foot minimum shoulder on the outside, followed by a 5-foot terrace and either a roundabout sidepath or a shared-use path. If there are trees planted in the terrace the minimum terrace width is 6-foot wide. A single lane roadway between opposing roadways and between closely spaced roundabouts without a raised curb median requires a minimum 32 feet from curb face to curb face.

If there is an overpass structure between two closely spaced roundabouts (1,000 feet or less between roundabout centers), and a roundabout sidepath is provided around the outside of the roundabouts, then the roundabout sidepath is at least 2 ft wider on the structure ([Figure 30.12](#)). A roundabout sidepath will typically not have a barrier wall separating the path from the roadway. Vehicle travel speeds between closely spaced roundabouts is considered a low speed environment (40 mph or less) and bicycle travel is expected to be unidirectional thus barrier walls between the roadway and path are not required. When there is a barrier proposed between the roadway and a roundabout sidepath, the sidepath is level with the roadway (not a raised sidewalk). See [Figure 30.12](#) and [FDM 11-35-1.6](#) and [FDM 11-35 Attachment 1.1](#) pages 1 and 2. Section B-B shows a section view of a raised curb roundabout sidepath. A barrier between the roadway and roundabout sidepath is unique and maybe a provision requested **that** requires WisDOT approval, including the regional

bicycle and pedestrian coordinator.

When a shared-use path is provided around the outside of roundabouts, the shared-use path **design criteria** on structures are followed. See [FDM 11-46-15](#), [FDM 11-35 Attachment 1.1](#) pages 1 and 2. Section B-B shows a section view of a raised curb shared-use path, and Section C-C shows a section view of the barrier wall between the roadway and the path. See [FDM 11-35-1.6.3](#) for required separation distance between outside travel lane and front face of barrier wall to determine the minimum barrier wall height.

The roadway and structure width will depend on the median width, lane width, number of lanes, shoulder width, and path width requirements.

For the STH system, the WisDOT minimum roadway width and clear roadway width of bridge from curb face to curb face, between two closely spaced roundabouts that are less than 1,000 feet apart, is:

- 2 lane divided (each side) - 2' median shoulder, 12' lane, 5' outside shoulder = 19'.
- 2 lane undivided - 4' shoulder width, + 12' lane + 12' lane + 4' shoulder width = 32', independent of ADT.
- 4 lane divided (each side) - 2' median shoulder, + 12' inside lane, + 12' outside lane, + 4' shoulder = 30'.
- 4 lane undivided - 4' shoulder, 12' outside lane, + 12' inside lane + 12' inside lane, + 12' outside lane, + 4' shoulder = 56'.
- 6 lane divided (each side) - 2' median shoulder, + 2 inside lanes at 12', + 12' outside lane, + 4' shoulder = 42'

The above widths provide a minimum roadway width between closely spaced roundabouts.

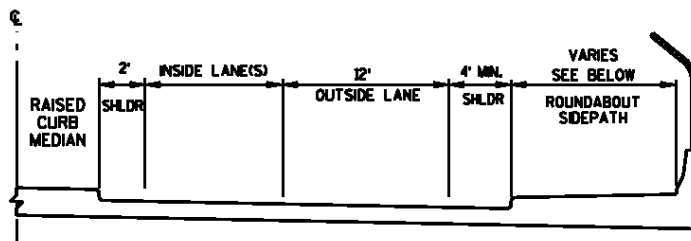
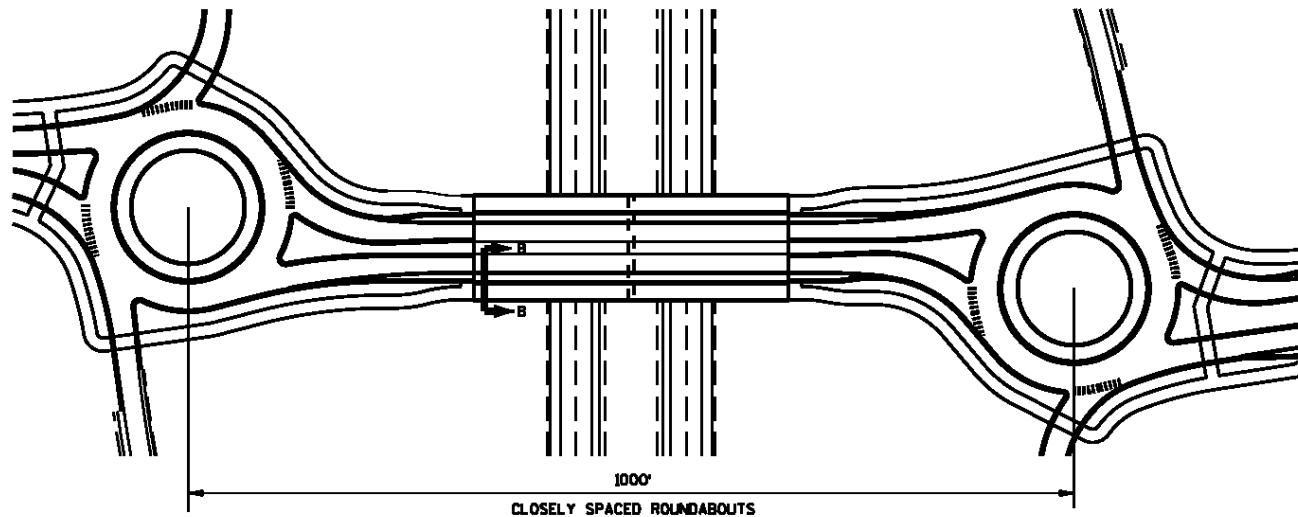
To reduce structure width, the designer should consider a narrow-raised median between the splitter islands. A 4-foot raised curb median face to face will provide an 8-foot median measured from flange line to flange line with 2-foot gutters just off the end of the structure. The distance between roundabouts should be sufficient to allow for any curved curb and gutter portion that is formed at the ends of the splitter islands to remain off the structure. The tangent narrow section in the middle between splitter islands could be 4-foot-wide face to face providing there are no signs or other road side elements in that area.

Under structures the roundabout sidepath and terrace widths are consistently provided through and between the roundabouts. If there will be road signs, power poles, light poles or other fixtures installed along the roadside then provide at least a 5-foot-wide terrace between the curb face at the outside of the shoulder and the front of the path. The cross-section under the structure provides at least the median shoulder width, lane width(s), outside shoulder width and path width plus 2 ft. if no obstructions are in the terrace. Follow shared-use path **design criteria** for under structures.

The above minimum roadway widths between closely spaced roundabouts are not appropriate for rural highway applications or where the distance between consecutive roundabouts is greater than 1000 feet. If existing or proposed sidewalk approaches **between** consecutive roundabouts are not closely spaced (i.e. greater than 1,000-feet between roundabout centers), provide roundabout sidepath(s) around the roundabout(s) but not between them - provide bike and pedestrian accommodations see [FDM 11-46-1](#).

The roadway between the roundabouts transitions to a cross-section roadway width and clear roadway width of bridges based on the design class of the roadway (see [FDM 11-15-1](#), [FDM 11-20-1](#), [FDM 11-35-1.2](#), and [FDM 11-46-1](#)).

If bike or pedestrian facilities are omitted around or between roundabouts, discuss with the regional bicycle and pedestrian coordinator the need to provide an 8-foot roundabout sidepath on or under the structure. Structures have a longer life-span and even if a roundabout sidepath is not immediately included on a structure it is necessary to consider constructing a wider substructure to allow widening of the superstructure in the future to accommodate a roundabout sidepath. In such cases, the pedestrian refuge in the splitter islands should still be constructed.



Roundabout Sidepath on Structure

- 1.) 10' PATH ON APPROACH - 12' WIDE ON STRUCTURE (HIGH BIKE/PED. USE ANTICIPATED)
- 2.) 8' PATH ON APPROACH - 10' WIDE ON STRUCTURE (MEDIUM TO LOW BIKE/PED. USE ANTICIPATED)
- 3.) 6' PATH ON APPROACH - 8' WIDE ON STRUCTURE (NO SIDEWALK CONNECTED TO PATH, RURAL OR OUTLYING AREA)

SECTION B-B ROUNDABOUT SIDEPATH

Figure 30.12 Roundabout Sidepath

30.5.14 Splitter Islands

For WisDOT roundabout projects crosswalk alignment is not optional as shown on NCHRP 672 Exhibit 6-66. The angled crosswalk produces shorter perpendicular crossing paths and discourages bicyclists from crossing without stopping in the refuge area.

The splitter island **lower** minimum width within the pedestrian refuge area is 6 feet, **typically it** is 8 feet, (face of curb to face of curb). The **lower** minimum crosswalk width in the splitter island is 7 feet, **typically it** is 10 feet. See NCHRP 672, Exhibit 6-12 except design the curbing to have a continuous gutter through the crosswalk as shown on [Figure 30.13](#).

In general, locate the pedestrian crossing one car length or approximately 20-25 feet upstream from the yield line (WMUTCD, Figure 3C-1). [FDM 11-26-30.5](#) provides additional guidance on pedestrian crossing placement and design. This helps to reduce decision-making problems for drivers and avoids creating a queue of vehicles waiting to enter the roundabout. However, for pedestrian safety the crossing should not be located too far back from the yield line such that entering vehicle speeds are insufficiently reduced or exiting vehicles are accelerating. It may be appropriate to design the pedestrian crossing at two or three car lengths from the yield line on some multilane entries. Make the crossing perpendicular to the direction of traffic on multilane entrances and exits to minimize pedestrian travel and exposure time as shown on [Figure 30.13](#). On single-lane roundabouts it may be appropriate to provide a crosswalk straight through the splitter island (See NCHRP 672, Exhibit 6-66).

Splitter islands can be crowned upward with a slope toward the center of the island area using between a 4 percent slope to as much as a 6:1 slope. This improves visibility of the splitter island for rural conditions. The

maximum overall height above the top of the curb within the splitter island area should be approximately 18 inches from top of curb to the top of any concrete/asphaltic surface. Some islands may become quite wide near the circulating roadway however limit the height to 18 inches. The approach nose separating the entering traffic and the exiting traffic shall be a Concrete Median Sloped Nose, Type 1. This splitter island nose should be 6-foot face-to-face where the R4-7 (KEEP RIGHT) sign is located. The other noses at the edge of the circulatory roadway and the splitter island shall be Concrete Median Sloped Nose, Type 2. Both nose types are shown in [SDD 11B2](#). Where there is a divided highway approaching the roundabout the approach nose is eliminated. For additional information, see NCHRP 672, §6.4.1.

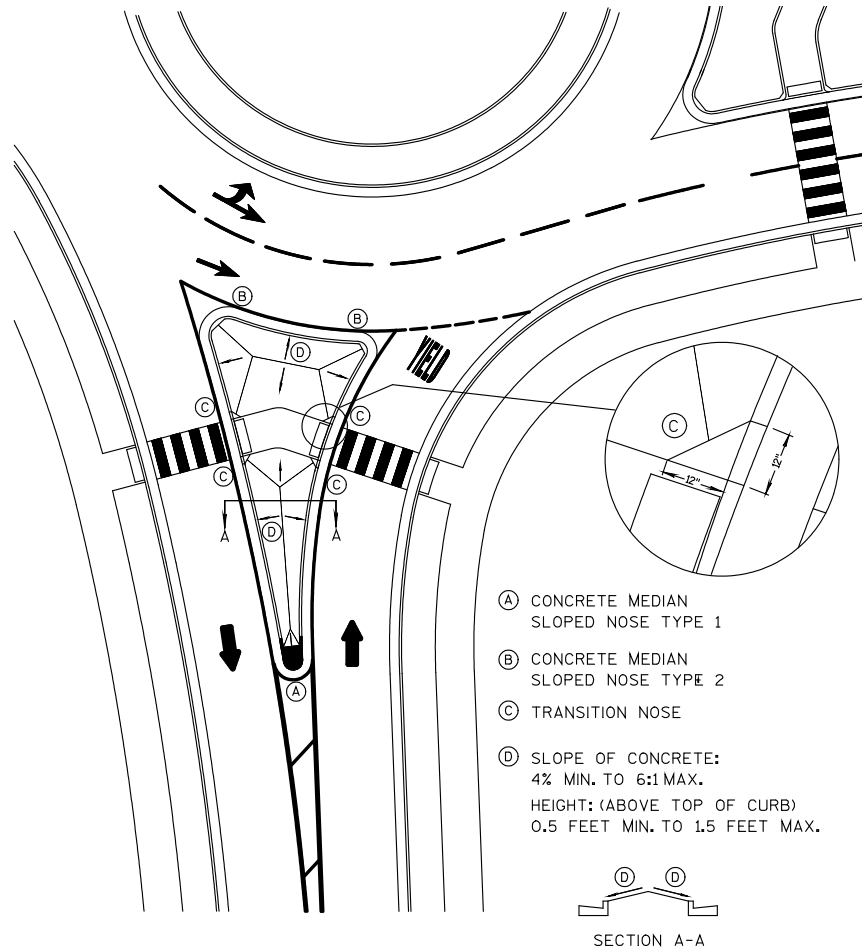


Figure 30.13 Typical Splitter Island

30.5.15 Intersection Sight Distance (ISD) and Length of Conflicting Leg of Sight Triangle

See NCHRP Report 672 starting on page 6-63 for guidance on Intersection Sight Distance (ISD) for roundabout approaches. The basis for ISD in NCHRP Report 672 is providing the critical headway time gap (t_c) for entering the roundabout. The critical headway time gap (t_c) for entering the roundabout is based on the amount of time required for a vehicle to safely enter the conflicting stream. If the perceived available headway time gap is less than t_c then most drivers will slow down or stop and wait for an acceptable gap. The critical headway time gap will possibly change over time. WisDOT has revised this time gap per [FDM 11-26-20.4.5](#) however at this time WisDOT will use the critical headway time gap (t_c) equal to 5 seconds as stated in NCHRP Report 672 for intersection sight distance. This is less than the 6.5 second required by the 2000 FHWA Roundabout Guide, but greater than the previous FDM requirement of 4.5 seconds. [Table 30.7](#) shows computed distance for various speeds based on a critical headway time gap (t_c) = 5.0.

Table 30.7 Roundabout Intersection Sight Distance

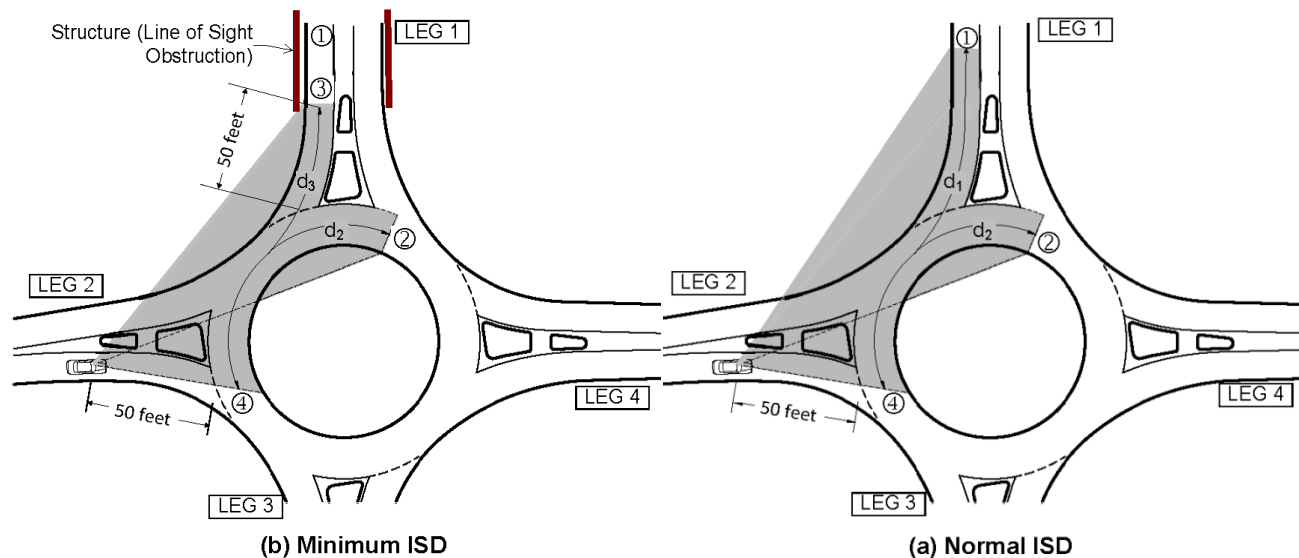
Conflicting Approach Speed (mph)	* Computed Distance (ft) for $t_c = 5.0s$
10	74
15	110
20	147
25	184
30	221

*distance in feet = speed (mph) multiplied by time (seconds) multiplied by a factor of 1.468.

The “clear sight window” requirements for critical headway time gap (t_c) are shown on Exhibit 6-58 of NCHRP Report 672. Use an eye height above the roadway surface of 3.5 feet for passenger cars and 7.6 feet for trucks in establishing sight lines through a clear sight window. Use an object height above the roadway surface of 3.5 feet.

[Figure 30.14a](#) shows “Normal ISD” for a roundabout approach; [Figure 30.14b](#) shows “Minimum ISD” for a roundabout approach. Use the following guidance when designing the ISD “clear sight window” for a roundabout approach:

- **[Normal ISD & Minimum ISD - driver’s eye position on approach]** Set the initial position of the driver’s eye at 50 feet behind the yield line, as depicted on Exhibit 6-58 of NCHRP Report 672, and as shown in [Figure 30.14a and b](#) or the vehicle approaching on Leg 2.
- **[Normal ISD & Minimum ISD - to circulating roadway]** Provide ISD based on [$t_c=5.0$ seconds \times “circulating speed \times factor”] for the circulating stream distance d_2 , as depicted on Exhibit 6-58 of NCHRP Report 672, and shown on [Figure 30.14a and b](#) as the distance from point 2 to point 4. For example, if the circulating speed is 20 mph, the distance between point 2 and point 4, per [Table 30.7](#), is 147 feet.
- **[Normal ISD - to adjacent leg to the left]** Provide ISD based on [$t_c=5.0$ seconds \times “fastest path speed \times factor”] for the entering stream distance d_1 , as depicted on Exhibit 6-58 of NCHRP Report 672, and shown on [Figure 30.14a](#) as the distance from point 1 to point 4. For example, if the “fastest path speed” is 25 mph, the distance between point 1 and point 4, per [Table 30.7](#), is 184 feet.
- **[Minimum ISD - to adjacent leg to the left]** It may not be possible to provide “Normal ISD” at some approaches because of a sight obstruction whose removal would cause unacceptable impacts. For these locations, provide ISD to at least 50-feet behind the yield line of the adjacent leg to the left - as shown on [Figure 30.14b](#). The resulting reduced entering stream distance d_3 from point 3 to point 4 is less than [$t_c=5.0$ seconds \times “fastest path speed \times factor”]. However, it is unlikely that all vehicles will be traveling at the “fastest path speed” between points 3 and 4 because some drivers will slow down or stop behind the yield line if there is an unacceptable gap.



Legend

- d₁ Entering Stream Distance
- d₂ Circulating Stream Distance
- d₃ Reduced Entering Stream Distance starting at least 50-feet behind the Leg 1 yield line
- ISD Clear Sight Window for vehicle on Leg 2

**Figure 30.14 Example of Roundabout ISD Clear Sight Window
(Leg 2 ISD shown - other legs are similar)**

Designer experience and judgment is needed to balance the impacts where ISD is severely restricted or where excess ISD is available. More is not better when it comes to Intersection Sight Distance for roundabouts. Research on sight distance has determined that excessive intersection sight distance results in a higher frequency of crashes because excessive forward visibility at entry or visibility between adjacent entries can result in approach and **greater typical** entry speeds for intersection geometry.

Consider limiting visibility **using** selective landscaping. This refers to landscaping or a visual block down the side road or median to restrict visibility between adjacent entries, as well as the forward visibility through the central island. Limiting visibility in this way helps encourage drivers to slow down on the roundabout approach, which provides a safer environment for both drivers and pedestrians.

Forward visibility for the driver entering to have sight of the circulatory roadway ahead of the driver's entering path can also be checked but is generally accounted for by ensuring sight to the left of circulating vehicle upstream (see [Figure 30.14b](#) for vehicle along path d₂).

30.5.16 Angles of Visibility

The intersection angle between consecutive entries must not be overly acute in order to allow drivers to comfortably turn their heads to the left to view oncoming traffic from the immediate upstream entry. The intersection angle between consecutive entries, and the angle of visibility to the left for all entries, should conform to the same design guidelines as for conventional intersections. Based on guidance for designing for older drivers and pedestrians, the recommended angle for visibility to the left at entry is $90^\circ \pm 15^\circ$. NCHRP 672 Exhibit 6-62 illustrates an example of a visibility angle for a roundabout entry at a ramp terminal.

Designers should also be aware of the visibility angle for conditions when the entering traffic does not yield, i.e. drivers looking left upstream of the yield line when not needing to yield or stop, a common condition for off-peak traffic conditions. The view to the left is then executed when the driver is well upstream of the roundabout entry unlike what NCHRP 672 Exhibit 6-62 shows. Thus, visibility angles must also be checked for non-yielding driving conditions from a distance upstream of the point of entry. The designer is cautioned not to provide generous sight to the left as this can contribute to failure to yield conflicts and collisions.

For additional information, see NCHRP 672, §6.7.4.

30.5.17 Right Turn Lanes

Right turn lanes should only be used when capacity needs dictate or when other geometric layouts fail to provide acceptable traffic operations or accommodations for the design vehicle. The decision to use right turn lanes should consider pedestrian and right-of-way constraints. Choosing the proper alternative is dictated by the volume of right turns and the available space. See NCHRP 672, §6.8.6 for additional information.

Three alternatives exist to provide for heavy right turn demand:

30.5.17.1 Free Flow Right Turn Lane (Figure 30.15 and NCHRP 672 Exhibit 6-72)

Free flow bypass lanes allow vehicles to bypass the roundabout and then merge into the exiting stream of traffic. A high right-turn demand when coupled with other approaching traffic may indicate the need for a full bypass lane to avoid a wider, faster entry. Roadway right-turn free-flow lanes are not recommended for pedestrians and bicyclists and should be avoided, if possible, in high pedestrian/bike use areas. If free flow right turn lanes are used keep vehicle speeds slow by using a small right turn radius.

30.5.17.2 Partial Bypass Right Turn Lane (Figure 30.15b or c and NCHRP 672 Exhibit 6-73)

A partial bypass lane with a curbed vane island requires approaching vehicles to yield to traffic leaving the adjacent exit. This alternative 'snags' the right turner from making a through movement while preserving good sight to the left for circulating/exiting traffic. Generally, an intersection angle of 70 degrees or higher is **typical**.

Dual partial right turn bypass lanes with a curbed vane island may also be an appropriate alternative to accommodate heavy right turn demand, especially at interchange ramp terminals. Dual partial bypass lanes maybe problematic for pedestrians and should only be used at locations where there is not a crosswalk near the exit receiving the dual right turning vehicles. Pedestrians may have a hard time seeing a vehicle turning right from the left lane of the dual right turn entry.

When designing dual partial right turns, special attention is required to ensure that vehicles in both right turning lanes have adequate sight of vehicles in the circulatory roadway. Speed of vehicles in the right turn lanes also need to be well controlled. Use a smaller entry radius to help reinforce that vehicles exiting the roundabout have the right of way. This will also minimize the potential for rear end crashes associated with larger right turn radii. Like the guidance provided for a Case 1 design, allow the design vehicle to encroach into adjacent lanes on the entry and exit while making the right turn.

30.5.17.3 Exclusive Right Turn Lane (Figure 30.15a and NCHRP 672 Exhibit 6-74)

Exclusive right turn lanes with or without a painted gore help to keep the overall roundabout layout compact while accommodating the heavy right turning movement. An exclusive right turn lane should be 'snagged' from making a through movement while preserving good sight to the left for circulating/exiting traffic.

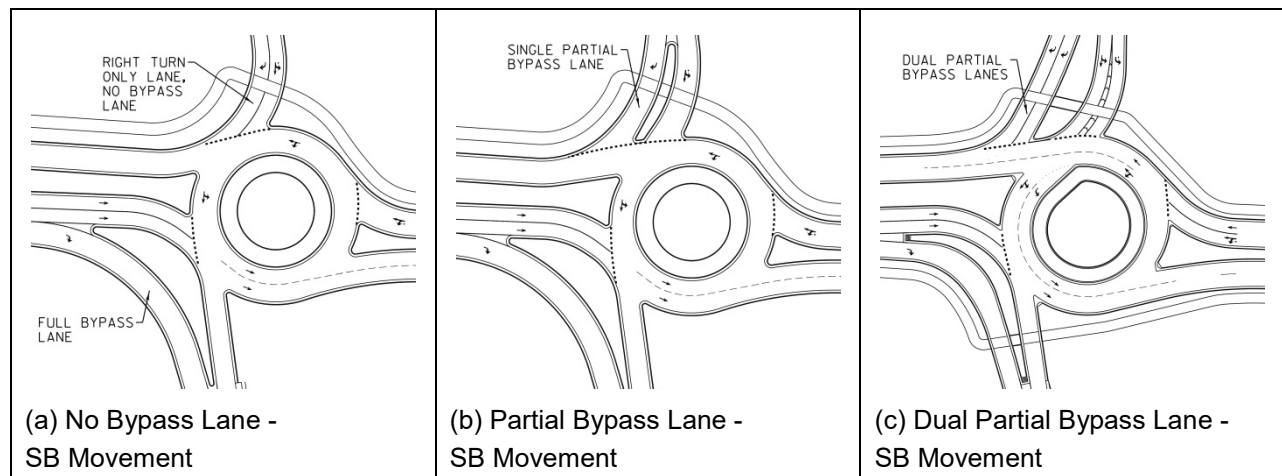


Figure 30.15 Right Turn Bypass Lanes
(See also NCHRP 672 Exhibit 6-74)

30.5.18 Vehicle Path Overlap and Methods to Avoid Path Overlap

Designing multilane roundabouts is significantly more complex than single-lane roundabouts due to the additional conflicts present with multiple traffic streams entering, circulating and exiting the roundabout in adjacent lanes. The natural path of a vehicle is the path it will take based on the speed and orientation imposed by the roundabout geometry. While the fastest path assumes a vehicle will intentionally cut across the lane markings to maximize speed, the natural path assumes there are other vehicles present and all vehicles will attempt to stay within the proper lane.

Designers should determine the natural path by assuming the vehicles stay within their lane up to the yield

point. At the yield point, the vehicle will maintain its natural trajectory into the circulatory roadway. The vehicle will then continue into the circulatory roadway and exit with no sudden changes in curvature or speed. If the roundabout geometry tends to lead vehicles into the wrong lane, this can result in operational or safety deficiencies.

Path overlap occurs when the natural paths of vehicles in adjacent lanes overlap or cross one another. It occurs most commonly at entries, where the geometry of the right-hand lane tends to lead vehicles into the left-hand circulatory lane. However, vehicle path overlap can also occur at exits, where the exit geometry or pavement marking of the exit tends to lead vehicles from the left-hand lane into the right-hand exit lane. [Figure 30.16](#) illustrates an example of entry path overlap at a multilane roundabout where the left lane geometry directs the approaching vehicle into the central island, while the right lane geometry directs the approaching vehicle toward the inside circulatory lane, thus creating entry path overlap.

For additional information, see NCHRP 672, §6.2.3 & 6.5.4.

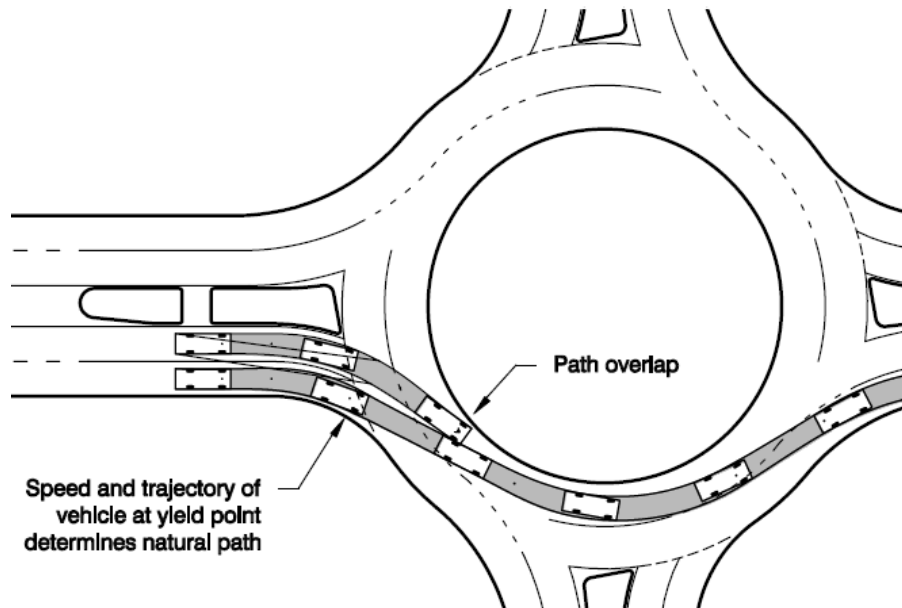


Figure 30.16 Entry Path Overlap

30.5.18.1 Method for Checking Path Overlap

[Figure 30.17](#) provides a method for checking entry and exit path overlap. To avoid path, overlap the **typical** tangent length is 40-ft to 50-ft or two car lengths for the entry path tangent and 40-ft and greater for exit path tangent. The minimum tangent length to avoid entry and exit path overlap is 26-ft or one car length.

As a rule of thumb path overlap can be avoided if there is typically 5 feet between the face of the central island curb and the extension of the face of curb on the splitter island, see [Figure 30.17](#).

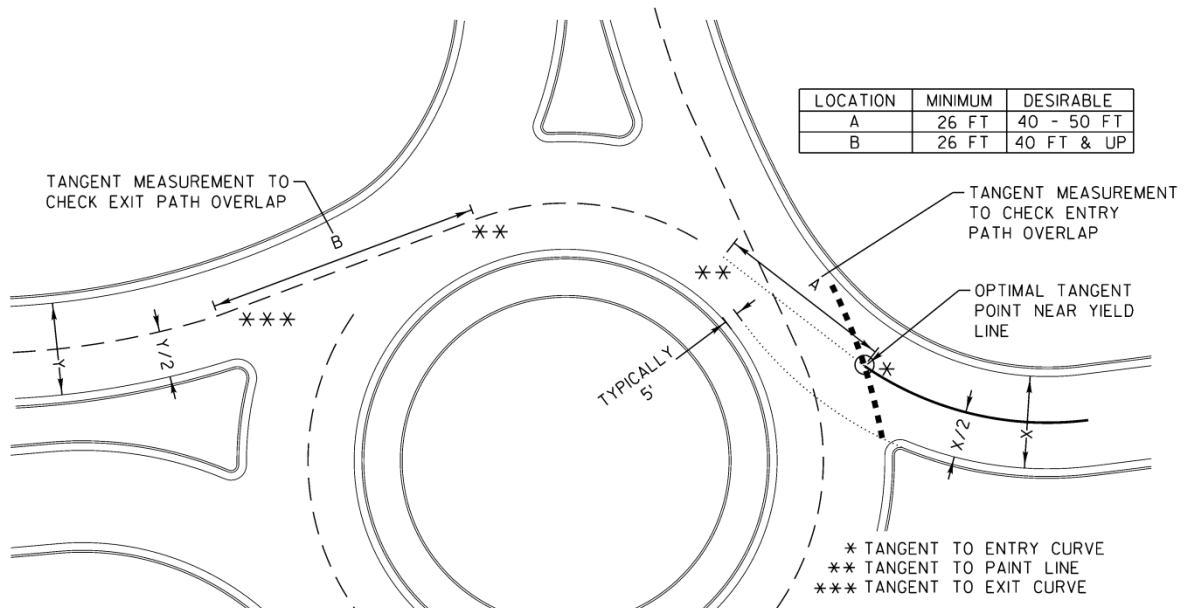


Figure 30.17 Method for checking path overlap

30.5.18.2 Design Method to Avoid Path Overlap

[Figure 30.18](#) shows the preferred method to avoid path overlap in multilane entries. Start with an inner entry curve designed so when the edge of the splitter island curve is extended across the circulatory roadway the line is tangent to the central island as shown. Once the lane geometry is determined to avoid path overlap then design the adjacent lane(s). The small radius entry curve will vary depending on the approach geometry and the fastest speed path but will typically range from 65-110 feet. A large-radius (greater than 150 feet) curve is then fitted between the entry curve and the outside edge of the circulatory roadway.

The primary objective of this design technique is to locate the entry curve at the optimal placement so that the projection of the inside entry lane at the yield point forms a line tangent to the central island. This inner curve design concept is essential for multilane design and is recommended for single lane entries as well. [Figure 30.18](#) illustrates the result of proper entry design.

The location of the entry curve directly affects path overlap. If it is located too close to the circulatory roadway, it can result in path overlap. However, if it is located too far away from the circulatory roadway, it can result in drivers accelerating to the yield point.

For additional information, see NCHRP 672, §6.4.3.

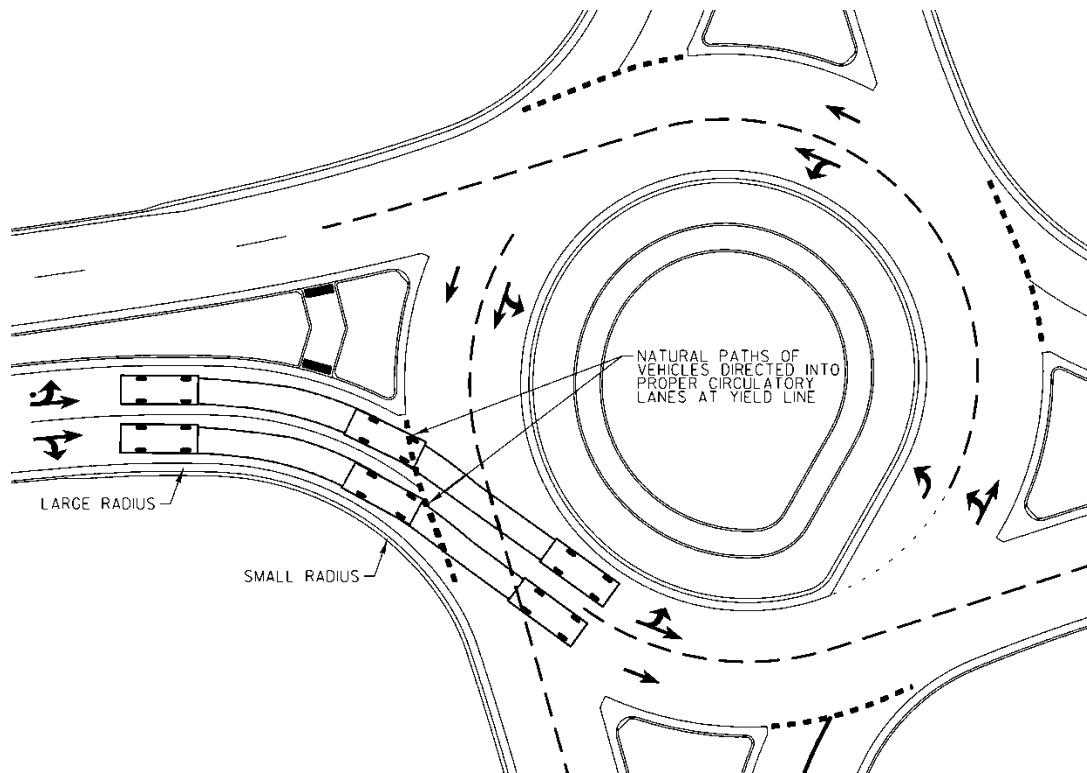


Figure 30.18 Multilane Entry Design

30.5.19 Approach Design

The primary safety concern in high-speed context is clarity of the driving situation, that is, to make drivers aware of the roundabout with ample distance to comfortably decelerate to the appropriate speed. Therefore, designs should follow these principles:

- Provide the **typical** stopping sight distance of the entry point based on approach operating speed.
- Align approach roadways and set vertical profiles to make the central island conspicuous.
- Splitter islands should extend upstream of the yield line to the point at which entering drivers are expected to begin decelerating - a minimum length of 200 feet is recommended.
- Approach curves should be gentle, become successively smaller and should be sized based on the design speed and expected speed change.
- Tangents should be used between reverse curves.
- Use landscaping on extended splitter islands and roadside to create a tunnel effect.
- Provide illumination in transition to the roundabout.
- Use signs and pavement marking effectively to advise of the appropriate speed and path for drivers.

The consequences of an inconspicuous central island or splitter island is mainly loss of control crashes as motorists unfamiliar with the roundabout are not given sufficient visual information to elicit a change in speed and path. See [Figure 30.19](#).

30.5.19.1 Low Volume, Non-STH Side Road Approaches

For an intersection having non-STH side road approaches with low traffic volumes, a reduction in roundabout approach construction length - including the splitter island length - may be appropriate if meeting all these side road conditions:

- Design year AADT is less than 2,000
- Must be single-lane roundabout entry
- Existing side road intersection control is stop-controlled, as motorists are already conditioned to yield to mainline traffic
- **Typical** stopping sight distance (SSD) is attained or exceeded at all approaches
- Pedestrians are not present at transitional and high-speed approaches (posted speed 45 mph and greater)

If all the above conditions are met, continue evaluating the non-STH roundabout approaches based on post-construction side road posted speeds and other considerations cited below.

Where side road roundabout approaches have posted speeds 45 mph and higher, provide a combination of alignment deflection or offset and non-superelevated curvature that spans the deceleration distance from the entry. This will produce gradual deceleration to avoid forcing all the reduction in speed to be completed through the curvature at the roundabout. The length of roundabout splitter island should be minimum 200 feet as explained in the FHWA Roundabout Guide [4]. Always verify that the side road approach and entry condition, including the roundabout splitter island, provide deflection per the design principles of [FDM 11-26-30.5](#) to safely and effectively slow traffic.

Where side road roundabout approaches have posted speeds 40 mph and lower, use a **lower** minimum 50-foot raised splitter island (**typical** 100-foot) length to alert drivers of the upcoming roundabout as described in NCHRP 672 [2]. A splitter island also provides refuge for crossing pedestrians and needs to be long enough to contain the pedestrians. Always verify that the side road approach and entry condition, including the roundabout splitter island, provide deflection per the design principles of [FDM 11-26-30.5](#) to safely and effectively slow traffic.

During preliminary design, consider whether any major development is planned along the side road. Any significant development may result in additional trips and more unfamiliar drivers. Field running speed assessments may be used to ascertain current side road speed conditions and determine prudent splitter length selection. Additionally, assess current access locations along with the real estate, environmental and utility impacts with the selected side road approach lengths. Document all findings in the DSR, including any known future local land development plans and whether access control is planned along the side road.

For non-STH roundabout approaches with medium and high traffic volumes (greater than 2,000 AADT) or with high-speed STH mainline roundabout approaches, apply the high-speed roundabout approach design principles as prescribed under [FDM 11-26-30.5.19](#), [FDM 11-26-30.5.20](#) and [Figure 30.19](#).

30.5.20 Vertical Design

Super elevation of curves on approaches to roundabouts is counterproductive to the objective of transitional speed reduction. Design super elevation on approaches based on the low-speed urban street criteria outlined in [FDM 11-10-5.3.2](#). Speed for the curve being designed is based on its distance from the yield line and the deceleration length determined from AASTHO Figure 2-25.

Example: For a posted speed of 55 mph with deceleration to 0 mph, the distance is approximately 410 feet. Curves prior to 410 feet should be designed for 55 mph; curves within 410 feet should be based on a prorated estimated speed based on distance from the yield line.

30.5.20.1 Approaches/Departures (Intersection Legs)

The most critical vertical design area of the roundabout is the portion of roadway from the approach end of the splitter island to the circulatory roadway. This area requires special attention by the designer to ensure that the user can safely enter the circulatory roadway, especially for OSOW vehicles. This area usually requires pavement warping or cross-slope transitions to provide an appropriate cross-slope transition rate through the entire transition area and within the circulatory roadway.

Entry grade profiles (approximately 2 car lengths from the ICD) are not to exceed 3%, with 2% being the **typical** maximum. It is **typical** to match the exit grades and the entry grades. Adjustments to the circulatory roadway cross-slope may be required to meet these criteria but should be balanced with the effects on the circulatory roadway.

30.5.20.2 Circulatory Roadway

Roundabouts typically should be constructed on relatively flat or rolling terrain with an approach grade that is **typically** less than 3%, but not greater than 5%. Grades approaching 4% and steeper terrain may require greater transitions to provide an appropriate grade through the intersection. The profile grades along the central island should generally not exceed 4%, (**typically** 3% or less).

- Single-lane Roundabout - crown the roundabout circulating roadway with a 2% cross-slope with approximately 2/3 width sloping toward the central island and 1/3 width sloping outward.
- Multilane Roundabout - Same crown guidance applies where possible. However, when considering factors such as paver screed width, contraction joint location for concrete pavement, pavement marking location, and the total width of the circulatory roadway, it may be a challenge to comply with the 2/3 sloping inward and 1/3 sloping outward. Therefore, another alternative (independent of material type) on dual lane roundabouts is to slope the inside lane, or left lane, toward the central island and slope the outside lane (typically wider lane) to the outside. This alternative will allow the contraction joint on concrete pavement to generally coincide with the lane line pavement marking and allow asphalt pavement roundabouts to be similar in design. On triple lane roundabouts, it may be possible to slope the two inside lanes toward the central island and slope the outside lane to the outside.

The crown vertical design feature provides good drivability, keeps water from draining across the circulating roadway which is particularly important in a northern climate with freeze-thaw cycles, and provides a smooth transition in/out of the approaches and departures. This 'crown' also reduces the probability of load shifting or truck over turning.

The preferred truck apron slope is between one and two percent toward the circulatory roadway. Greater than one percent slope should not be used on OSOW routes. However, it may vary between 1 and 2 percent when justified on other routes.

30.5.21 Curbing

30.5.21.1 Approach Curbs

Low speed approaches should incorporate 6-inch vertical face curbs, on both sides of the roadway. The purpose of the vertical face curbs is to control the fastest speed paths at the roundabout entrances and exits. On the OSOW a 4-inch mountable curb and gutter may be used in limited situations to better accommodate truck tires that may have to go over the curb or the splitter island. Refer to [FDM 11-26-30.5.4](#) and [FDM 11-26-30.5.6](#) for suitable curb type along the outside and [FDM 11-26-30.5.21.2](#) for curb type adjacent to the truck apron.

High speed approaches to roundabouts usually occur where there is a rural cross-section. This rural cross-section for undivided highways will have shoulders without curb on the outside. When the highway is divided there will be shoulders on the inside, sometimes with sloped curbs, the outside will have shoulders typically without curb leading up to the roundabout. High speed approach design will require a transition section to the roundabout where the shoulders will narrow, and vertical curb will be introduced. See [Figure 30.19](#) for an example of the high-speed approach layout.

In rural areas, the pavement marked gore and the curbs serve to alert the driver approaching a roundabout of the changing conditions and that a speed reduction is expected. Driver awareness that conditions are changing is accomplished through a combination of roadway curvature, channelization, lighting, landscaping, and signing.

[Figure 30.19](#) shows the layout of the gore area for the beginning of the splitter island and the curb and gutter layout as the driver approaches the yield line. The pavement marked gore area transitions into a raised curb median nose (Type 1) followed by a 4-inch sloping curb and gutter for a short distance. The curb transitions in two ways as it approaches the roundabout. At the nose, the curb face is offset 4 to 6 feet from the driving lane or has a 4 to 6-foot shoulder on the left side of the approach. The shoulder narrows (according to the minimum shifting taper shown in [FDM 11-25 Attachment 2.2](#) as the vehicle is anticipated to decelerate to 40 mph. When the vehicle speed is anticipated to be 40 mph the 4-inch sloped curb and gutter transitions into a 6-inch vertical curb and gutter. Both curb and gutter types should have a 24-inch gutter, therefore the flow line and gutter flange are consistent. Total curb length starting from the yield line should be the deceleration distance required to reduce from the approach speed to the fastest path design speed (R_1).

Example: The posted speed is 55 mph and decelerating to approximately 20 mph produces a total raised curb length distance of approximately 350 feet for the splitter island side of the roadway. Approximately 250 feet of that 350 feet is 4-inch sloped face curb and gutter and approximately 100 feet is 6-inch vertical face curb and gutter (may be 6-inch sloped face on OSOW network, or 4-inch sloped in limited situations). At a posted speed of 40 mph and decelerating to 20 mph produces a total raised curb length of approximately 200 feet and all of the length is 6-inch vertical face curb and gutter (may be 6-inch sloped face on OSOW network, or 4-inch sloped in limited situations). Deceleration distance guidance can be found in the 2011 AASHTO GDHS, Exhibit 2-25, page 2-35. Use the posted speed as the AASHTO design speed. Differing approach conditions may produce different deceleration distances.

For the roundabout approach, the minimum length of vertical face curb on the right side of the travel way should be the greater of; 25 feet prior to the bike ramp or 100 feet prior to the yield line (may be 6-inch sloped face on OSOW-TR or 4-inch sloped). The vertical face curb installation will enforce the fastest speed path geometry.

The curb on the right side at the exit from the roundabout needs to be long enough to control exit speed and generally should be the greater of: 25 feet past the bike ramp or 100 feet past the exit measured from the ICD.

Consider drainage in the area of the curb/gutter by providing a flume or inlet structure.

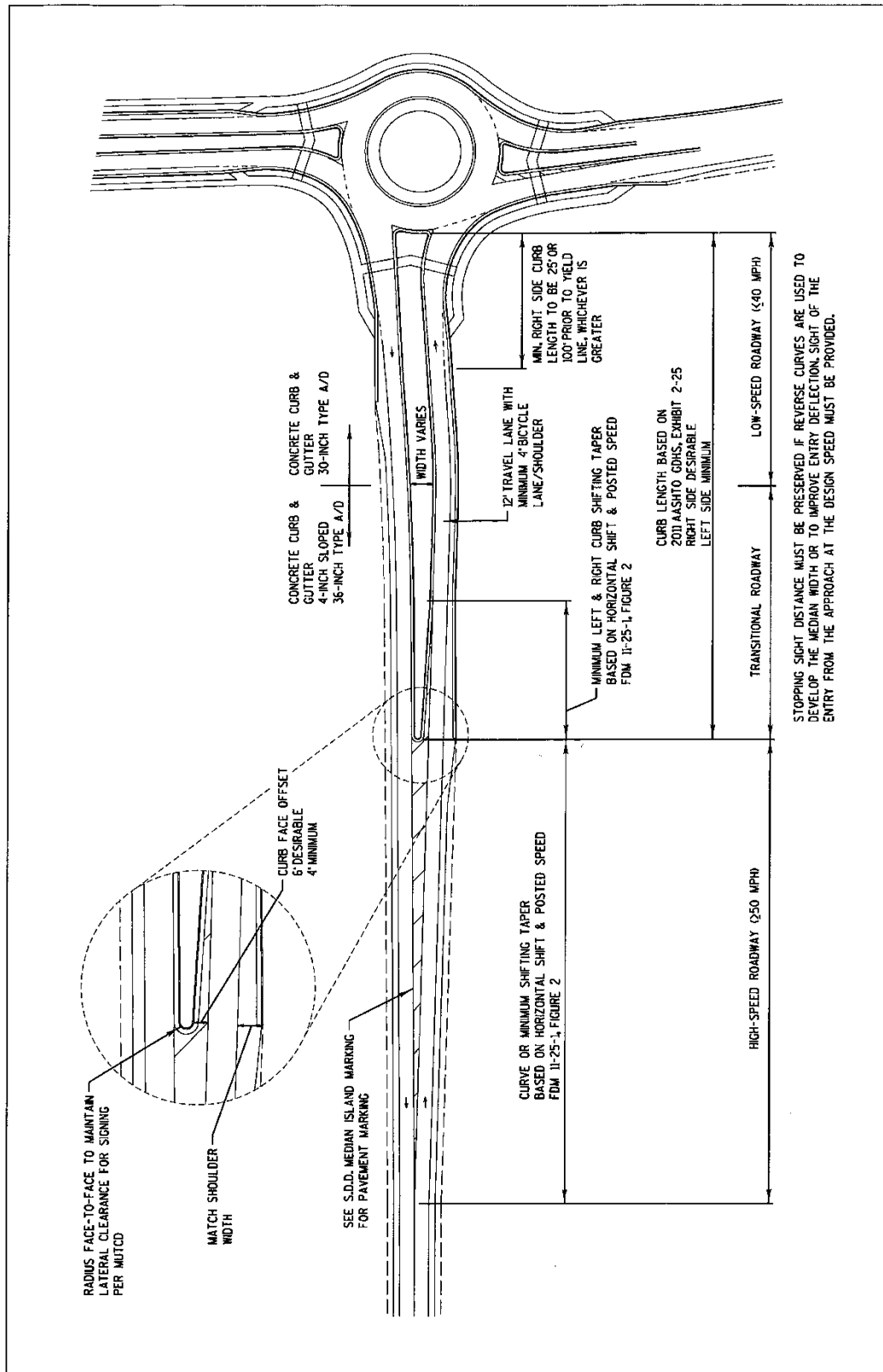


Figure 30.19 High-Speed Roundabout Approach

30.5.21.2 Curb and Gutter Separating the Circulatory Roadway from the Truck Apron

Use Type R or T curb and gutter, 4-inch sloped, between the circulating roadway and the truck apron shown in [SDD 8D1](#). Use a Type T inlet casting on the drainage structure, as shown in [SDD 8A5](#). This curb and gutter is gentle to large truck tires but should be unfriendly for SUVs and autos to traverse. When the circulatory roadway is concrete it shall be tied to the gutter flange with tie-bars, but not to the truck apron. When the circulatory

roadway is asphalt, the apron shall be tied to the back of curb with tie-bars. See [FDM 14-10-35](#) for pavement related topics.

30.5.21.3 Curb at the Inside of the Truck Apron or Edge nearest the Central Island

This curb shall be a reverse-slope 18-inch curb and gutter. The adjacent pavement will be a concrete truck apron. There may be situations when this inside curb could be deleted, but this is rare and should be addressed in the DSR.

30.5.22 Spirals

A spiral system involves a series of lane gains and lane drops around the circulatory roadway to lead drivers into the appropriate lane for their desired exit. Spirals guide drivers that enter the roundabout on the inside lane to shift to the outside lane at the appropriate location within the circulatory roadway to exit from the outside lane, unless there are dual lefts then the two inside lanes could be shifted. The spiral is designed to prevent vehicles from becoming trapped on the inside lane and then drivers making a quick lane change to exit all while maximizing the use of the circulating space and reducing potential conflicts between adjacent vehicles. Spirals can also accommodate for heavily biased turning movements. Spirals should only be considered where the circulatory roadway has sufficient width to provide two or more lanes of traffic and where the geometry and traffic volumes are determined to warrant the use of spirals. Circulatory roadway spirals require considerable engineering judgment to design and locate properly, although they are intended to guide drivers, they may be confusing to properly understand and not always intuitive to the driver. Small compact two-lane circles do not function as well with spiral designs because the lengths of arcs are too short to guide drivers to 'spiral out'. In such cases speed reduction occurs in the circulatory roadway where the spiral often begins. Drivers are more likely to turn tight across the spiral rather than follow it to the next outside lane. Spirals can be very effective on larger circles where the spiraling curves are longer, intuitive to drivers and more easily detectable.

A spiral should be developed from the central island by curb and gutter until a full lane width is available. Observations of previously installed spiral crosshatch pavement markings without a 'hard surface' indicate that some drivers ignore the pavement markings, which increases the potential for vehicle conflict in the circulatory roadway.

An example of a curbed spiral is shown in [Figure 30.20](#). This spiral is used to shift the westbound left turn to the outside lane. The spiral is used because the southbound exit is only a single lane exit and the southbound entrance allows dual left turns. To exit without conflict, the westbound left turn needs to be spiraled to the outside lane. Without the spiral, the left turn would be trapped on the inside lane and would do a U-turn or have to crossover lanes.

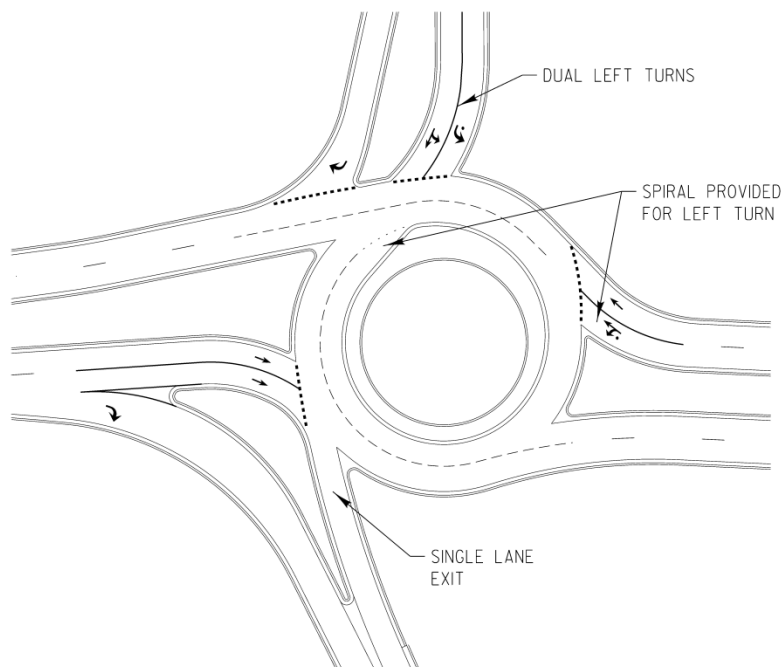


Figure 30.20 Spiral

30.5.23 Entry Angle, ϕ

Phi is not discussed in detail in NCHRP 672. This angle is not a controlling design parameter but instead a gauge of sight to the left and ease of entry to the right. This affects both capacity and safety at the intersection.

The typical range for the Phi angle is between 20 and 30-degrees with 25-degrees or greater being the optimal, although there are designs that operate safely and efficiently with a Phi angle as low as 16 degrees. Designers may find it difficult to attain Phi angle values in the **typical** range, but provided that the fast path speeds are relatively low, the Phi angle is not a controlling criterion.

There are three situations or design conditions in which Phi can be measured. They are:

1. Condition 1: $\Phi = 2 \frac{\Phi_i}{2}$ where the distance between the left sides of an entry and the next exit are NOT more than approximately 100 feet. In Condition 1, the acute angle is denoted as 2 PHI in which the actual value must be divided by two to obtain Phi (see [Figure 30.21](#), Method 1).
2. Condition 2: $\Phi = \Phi_i$ if the distance between the left sides of an entry and the next exit are more than approximately 100 feet (see [Figure 30.22](#), Method 2).
3. Condition 3: Applicable when an adjacent exit does not exist, or an exit located at such a distance or obtuse angle to render the circulatory roadway a dominating factor of an entry (such as in a “3-leg” intersection). Used at “T” intersections or where the adjacent entrance and exit lane(s) are far apart (see [Figure 30.22](#), Method 2).

The two methods of measuring Phi are described below in [Figure 30.21](#) and [Figure 30.22](#).

Method 1 phi is measured by dividing the entry and exit radii into three segments. The midpoint of the lane for each segment is best fit with a curve that extends to the face of curb of the splitter island extended. Begin line (a-b) and (c-d) at the intersection of the best fit arc and face of curb of the splitter island extended. Line (a-b) and (c-d) are then projected tangent from the best fit arc towards the circulating roadway, the angle formed by the intersection of the two lines is twice the value of Phi see [Figure 30.21](#).

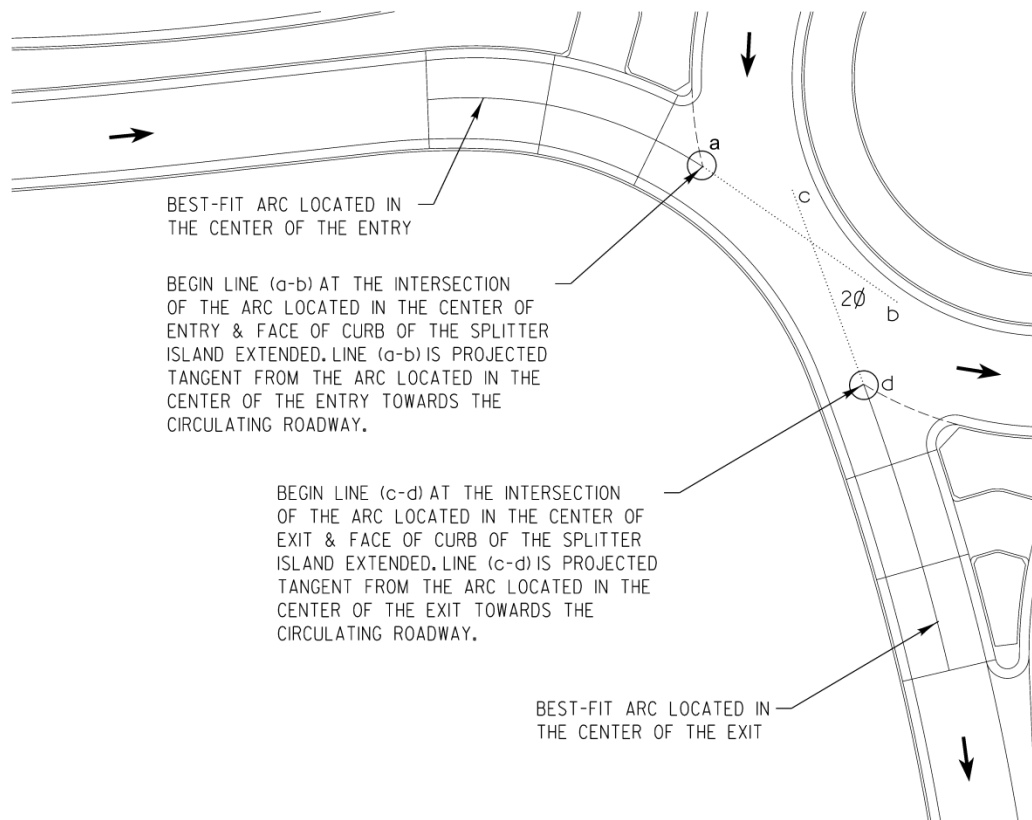


Figure 30.21 Method 1 Phi Measurement

Method 2 Phi is measured by dividing the entry radii into three segments. The midpoint of the lane for each segment is best fit with a curve that extends to the face of curb of the splitter island extended. Begin line (a-b) at the intersection of the best fit arc and face of curb of the splitter island extended. Line (a-b) is then projected tangent from the best fit arc towards the circulating roadway. Begin line (c-d) at the intersection of line (a-b) and the arc located at the center of the circulating roadway. Line (c-d) is then projected tangent from the arc located in the center of the circulating roadway. The angle formed by the intersection of (a-b) and (c-d) is Phi.

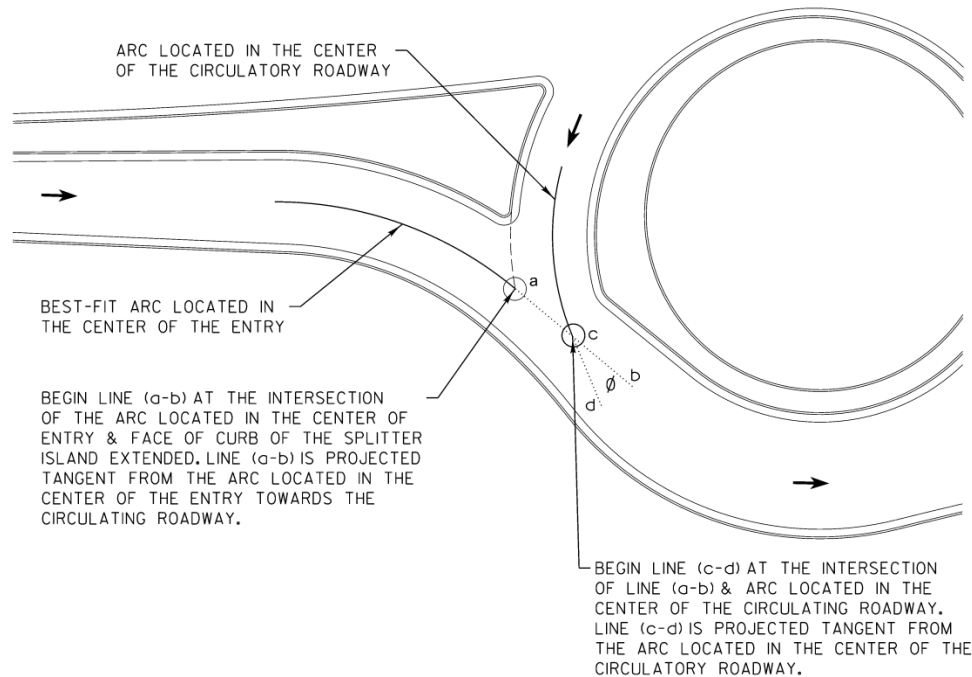


Figure 30.22 Method 2 Phi Measurement

30.5.24 Clear Zone

Clear zone guidance for roundabout installations requires consideration of the approach speeds, fastest path speeds, adjacent side slopes leading into and through the roundabout, and average daily traffic on the facility. The guidance for the determination of clear zone is provided in the current AASHTO Roadside Design Manual and [FDM 11-15](#), Attachments 9 and 10.

The vehicle speed approaching an intersection and the speed allowed through an intersection, along with the ADT and side slopes, will determine the required clear zone. A traffic signal-controlled intersection allows vehicles to go through the intersection at the posted speed, does not require the vehicle to reduce speed as it approaches the intersection, and therefore the clear zone is maintained through the intersection. A stop sign controlled intersection located in a high speed rural condition will require less clear zone as the vehicle slows down to stop. As the approaching vehicle reduces speed it may be appropriate and **typical** to reduce the corresponding clear zone. The designer has the responsibility to balance the need for clear zone and right-of-way acquisition.

The yield condition for a roundabout and the fastest path design speed approaching and traveling through the roundabout are similar to the stop sign controlled intersection. The horizontal geometrics leading to and through the roundabout intersection requires the vehicle to slow down leading to the approach and through the roundabout. The approaching speed transition distance for a roundabout is determined by the posted highway speed and the deceleration needed to enter the roundabout in accordance with the fastest speed path calculation, R_1 value. [FDM 11-26-30.5.21.1](#) and [Figure 30.19](#) show how to determine the roundabout approach layout for high-speed highways. The design speed to use for clear zone around the perimeter of the roundabout is the average of the entry speed (R_1) and the circulating path speed (R_2) values. The maximum average entry speed (R_1) and circulating speed (R_2) for any type of roundabout is approximately 25-30 mph. The average fast

path, $\left(\frac{R_1 + R_2}{2}\right)$, of approximately 25-30mph will produce a clear zone between 7 and 18 feet depending on ADT.

The exit ramps from an interchange are also considered to be low speed in close proximity of the approach to the roundabout. In an urban environment, lateral clearance is typically used rather than clear zone to determine the minimum distance to fixed objects such as power poles, light poles, fire hydrants, trees etc. In a rural environment, it is typical to use a clear zone based on the design speed, ADT and slopes. The side slopes adjacent to a roundabout are generally quite flat to accommodate a small terrace and a shared-use path around the perimeter. When the shared-use path is not installed at the time of the roundabout the area should be graded such that at some time in the future the path could be installed. The side slopes in the approach area having an approach speed of 40mph or less and the perimeter of the roundabout, outside of the shared-use path, should be 4:1 (recoverable slope) but may be steeper depending on meeting the clear zone requirement and local impacts.

Central island clear zone is considered to be within a low speed environment therefore needs to meet the lateral

clearance for urban streets, typically 2 feet back from the face of curb. Having stated this WisDOT believes there are precautions, which are dependent upon the approach speed that need to factor into the central island landscaping design. See [FDM 11-26-40](#), for additional guidance on central island landscaping.

30.5.25 Coloring and Stamping Concrete

The truck apron shall be reddish colored, concrete conforming to [Standard Spec 405](#).

For shared-use paths that are colored use a reddish colored concrete pavement. Colored pavement materials are a community and designer agreed upon preference. Do not stamp pedestrian areas that will result in an uneven surface as this may aggravate back injuries or violate other ADA considerations. Refer to [TEOpS 3-2-3](#), and WMUTCD Section 3B.18, for additional information on marking crosswalks and use of reflective materials. The colored concrete pavement could be used for terrace areas and may be stamped, if not a walking surface, but stamping must be specified in the special provisions. Colored or uncolored concrete in the terrace adjacent to the corner radii where there is the possibility of truck off-tracking shall be 8-inch thickness or thicker (12-inch thick truck aprons per [FDM 11-26-30.5.4](#)) depending on anticipated loading.

See [FDM 14-10-35](#) for additional information relating to colored concrete, pavement design, tie bar location, dowel bar location, contraction joint layout, and other pavement guidance.

30.6 Plan Preparation

30.6.1 Plan Preparation Considerations

The overall concept of roundabout plan preparation is similar to other intersection types (see example plan sheets in [FDM 11-26-50](#)). The designer should provide the following plan information when designing roundabouts. At a minimum, roundabout plans should include the following plan details:

- Layout details for any alignments utilized for the roundabout
- Layout details for any crosswalks and bike ramps if utilized
- Elevation at low points, high points, island noses, and 25-foot intervals within circulatory roadway
- Provide one 1" = 40' scale plan sheet for each concrete roundabout in the plans (1" = 20' scale is preferred if it will fit on one sheet). Plan sheet will be used by the contractor to prepare the concrete transverse joint details. This plan sheet must show all curb and gutter lines, longitudinal joint lines, proposed pavement marking lane lines, surface utilities such as manhole covers, valve box covers, and inlet covers in the concrete circulatory roadway and concrete truck apron.
- Storm sewer plans
- Landscaping and erosion control plans
- Permanent signing plans
- Lighting plans
- Pavement marking, and pavement marking-layout plans

30.6.2 Alignment Plans

When considering the location of alignments, the designer should consider their usefulness in generating cross-sections, profiles, layout details, and ease of use during construction layout. Alignments along both flange lines of the splitter islands are required. The designer should also consider additional alignments for the following locations:

- Along the curb and gutter flange line located between the truck apron and the circulatory roadway
- Along the curb and gutter flange lines at locations where the width is varying from the main alignments (usual from bike ramp to bike ramp)
- Along the curb and gutter flange lines for both sides of right turn bypass lanes
- Along the back of sidewalks or shared use paths where the distance from the back of curb varies
- On OSOW routes: Along the inside of the central island and along the back of additional pavement placed outside the entry/exit curbs

30.6.3 Profile Information

The designer should consider placing profiles on all of the alignments mentioned above. Some general guidelines for creation of the profiles are:

- It is ideal from a drivability and safety perspective to design and construct the circular component of the roundabout in one plane (planar) with one low point and one high point around the circle.
- Once the circulatory roadway profile is established, the approach and exit leg profiles can be adjusted to match the outside edge of the circulatory roadway.
- Varying of cross-slopes may be done on the circulating lane(s), but the variance from 2% should

generally be minimized where possible except where OSOW profile and grading design governs (see [FDM 11-26-30.6.1](#)). Varying of cross-slopes may require the approach and exit profiles to be modified.

- The designer should also complete a profile on the outside edges to verify a smooth transition from the approach roadway, roundabout and exit roadway. The designer may have to adjust profiles or cross-slopes on the approach, in the roundabout or on the roundabout exit if there are major kinks in the profile.

30.6.4 Typical Sections

At a minimum, roundabout plans should include typical sections at the following:

- Approaches and exits to the roundabout
- Within the splitter island
- Within the central island

The plans should include a sufficient number of cross-sections through the roundabout to allow for accurate construction of the roundabout.

30.99 References

- [1] Roundabout Design Guidelines, Ourston Roundabout Engineering, page 36 and 37
- [2] NCHRP 672, Roundabouts: An Informational Guide, Second Edition, December 2010
- [3] Joint Roundabout Truck Study, Minnesota DOT and Wisconsin DOT, June 2012
- [4] FHWA-RD-00-067, Roundabouts: An Informational Guide. FHWA, June 2000, p. 177

FDM 11-26-35 Signing and Pavement Marking

August 15, 2019

35.1 Signing

The overall concept for roundabout signing is similar to general intersection signing. Proper regulatory control, advance warning, and directional guidance are required to provide positive guidance to roadway users. Locate signs where roadway users can easily see them when they need the information in advance of the condition. Sign location should be checked so they are not in conflict with vehicle turning movements, the swept path of vehicles with a long overhang, or vehicle navigation on the OSOW Truck Route. Signs should never obscure pedestrians, motorcyclists or bicyclists. Signing needs differ for urban and rural applications and for different categories of roundabouts. On connecting highways coordinate sign selection with the Region Traffic Section and local agency to maintain consistency on the facility.

The signing and pavement marking can get complex on roundabout projects. To assist project managers and contractors, the designer should use a minimum of 40 scale drawings for signing and pavement marking plan sheets.

The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), the Wisconsin Manual on Uniform Traffic Control Devices (WMUTCD), Wisconsin DOT Traffic Engineering, Operations and Safety Manual (TEOpS) and appropriate sign plate details govern the design and placement of signs. To the extent possible, this text follows the principles outlined in the 2009 MUTCD and the WMUTCD.

35.1.1 Regulatory Signs

Several regulatory signs are appropriate for roundabouts and are described below and shown in [Figure 35.1](#).

1. Install a YIELD sign (R1-2) on both the left (in splitter island) and the right side of all approaches, single lane and multilane entrances, to the roundabout. Attention should be given to ensure that the left side YIELD sign and right-side YIELD sign are mounted at the same height. Place a note on the signing plans directing the contractor to make sure the YIELD signs are at the same mounting height (7' - 3" ± to bottom of YIELD signs). During the first six months of operation of the roundabout, install 18" x 18" orange flags on top of the YIELD signs to emphasize the yield movement. Install a ONE WAY sign, R6-2R, under the left side yield sign on all approaches, single and multilane entrances, to the roundabout to establish the direction of traffic flow within the roundabout. Install a TO TRAFFIC FROM LEFT sign, R1-54, under the right-side yield sign on all approaches, single and multilane entrances, to the roundabout to reinforce the yielding required at a roundabout.
2. A chevron sign (series of 4 chevrons, R6-4b) shall be used in the central island opposite the entrances in combination with the ONE WAY sign (R6-1R). The mounting height to the bottom of the Chevron sign is 48-inches, measured from the surface of the truck apron to the bottom of sign. Specify the four (4) foot mounting height from the surface of the truck apron in the Miscellaneous Quantities.
3. Install a ONE WAY sign, R6-1R, in the central island opposite each entrance and mounted above the chevron sign (R6-4b) to emphasize the direction of travel within the circulatory roadway.
4. Install a KEEP RIGHT sign (R4-7) at the nose of raised curb splitter islands. The mounting height of

the R4-7 ranges from 5-feet to 7-feet to the bottom of the sign. In urban areas where pedestrians or bicyclists are expected to use the crosswalk it is recommended to use the 7-foot mounting. The Down Arrow, W12-1R, may be used but is less **typical** for consistency and driver expectancy but may be mounted 2-feet to the bottom of the sign. Attention should be given to the location of the KEEP RIGHT sign and light poles on the right side to ensure that conflicts do not occur with larger width vehicles. This is especially critical with single lane entry roundabouts.

Lane use signs such as the R3-8 sign are not used for single-lane entries. For multilane entries consult the Regional Traffic Engineer for sign placement. Roundabout operation will dictate which R3-8 sign is installed.

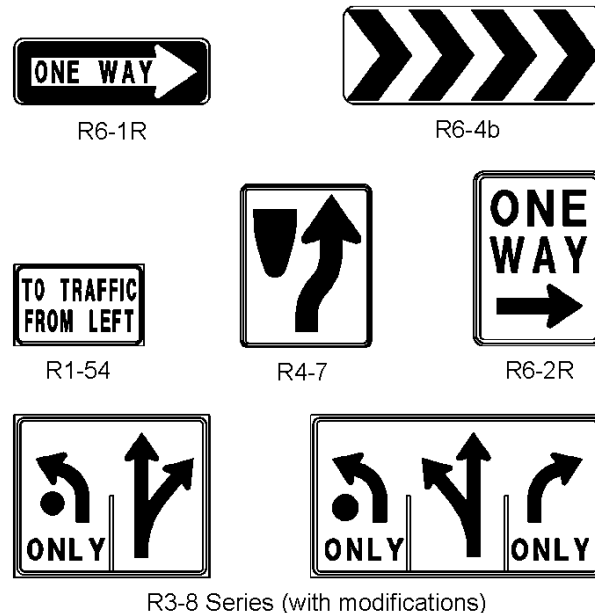


Figure 35.1 Regulatory Signs

* The R3-8 sign is modified to show the placement of a dot under the left arrow, which graphically helps depict the presence of a roundabout. Use the dot under the left arrow, only for the left most lane.

35.1.2 Warning Signs

Several warning signs are appropriate for roundabouts and are described below and shown in [Figure 35.2](#). The amount of warning a motorist needs is related to site-specific intersection conditions and the vehicular speeds on approach roadways. The applicable sections of the MUTCD and WMUTCD govern the specific placement of warning signs.

1. Install a circular intersection sign (“chasing arrows”, W2-6) on each approach in advance of the roundabout. Below the W2-6 sign, install an advisory speed plate (W13-1). Rural roundabouts have a typical advisory speed of 20 mph, urban roundabouts have a typical advisory speed of 15 mph. Check with the Regional Traffic Engineer before assigning an advisory speed. The speed given on the advisory speed plate should be no greater than the design speed of the circulatory roadway. Advisory speeds are posted in multiples of 5 mph. For conventional highways with posted approach speeds of 45 mph or greater or 3 or more approach lanes, use size 3 W2-6, and W13-1 signs and double up the placement of the W2-6, and W13-1 signs. For expressways, use size 4 W2-6, and W13-1 signs and double up the placement of the W2-6, and W13-1 signs. Coordinate with the Region Traffic Section on the proper sign sizes and type of roadway (conventional highway or expressway). For closely spaced roundabouts, these signs may be omitted, see [FDM 11-26-35.1.6](#) below for guidance as to when these signs may be omitted.
2. Use a YIELD AHEAD sign (W3-2) on each approach to a roundabout if the approach speed is 45 mph or greater. If the approach speed is less than 45 mph, the YIELD AHEAD (W3-2) would only be needed if the yield sign is not readily visible for a sufficient distance per [Table 35.1](#) (Minimum Visibility Distance). For closely spaced roundabouts, this sign may also be omitted, see [FDM 11-26-35.1.6](#) for guidance as to when these signs should be omitted.
3. The usage of the pedestrian crossing sign assembly is optional per the 2009 MUTCD and is generally used if the visibility of the pedestrian crossing is poor. The designer needs to coordinate the usage of pedestrian crossing signs with the Region Traffic Section. In general, rural roundabouts will not have pedestrian accommodations and therefore would not require signing. For closely spaced roundabouts,

the pedestrian crossing sign assemblies may be omitted, see [FDM 11-26-35.1.6](#) below for guidance as to when these signs may be omitted, when used. If used, the pedestrian crossing sign assembly shall be placed at the actual pedestrian crossing as well as in advance for locations where the posted speed is 45 mph or greater. If there is a school crossing at the roundabout, the school warning sign assembly with arrow (S1-1 and WF16-7L) is required at the crosswalk location. In addition, install the school warning sign, AHEAD plaque and FINES HIGHER plaque (S1-1, WF16-9P and R2-6P) in advance of the school crosswalk assembly. Install the pedestrian crossing sign (W11-2 and W16-7L) or school crossing sign assembly (S1-1 and WF16-7L) just in front of the crosswalk for approaching traffic at entries and exits. School crossing signs are required if there are any school pedestrians. If the crosswalk at a roundabout is not considered to be part of the intersection and is instead considered a marked mid-block crossing, pedestrian crossing signs are required.

The Combination Bike/Pedestrian Crossing sign (W11-15 and W16-7L) may be used in lieu of the pedestrian crossing sign assembly if there are recreational trails crossing the roundabout, where the primary trail users are bicyclists and pedestrians. The TRAIL CROSSING word message sign (W11-15A and W16-7L) may be used in lieu of the pedestrian crossing sign assembly if there are multi-use recreational trails crossing the roundabout. The usage of these signs is optional per the 2009 MUTCD and the designer is encouraged to coordinate the usage of these signs with the Region Traffic Section. Placement criteria for these signs are the same as that of the pedestrian crossing signs mentioned above.

4. A bicycle sign may be needed to designate the exit to the bike path (D11-1a and M7-2, federal sign plate).

Locate pedestrian crossing signs in such a way to not obstruct the approaching driver's view of the YIELD sign or pedestrians standing at the crosswalk.

Flashing beacons may be used above some warning signs as a long-term awareness technique for areas with approach speeds of 45 mph or higher.

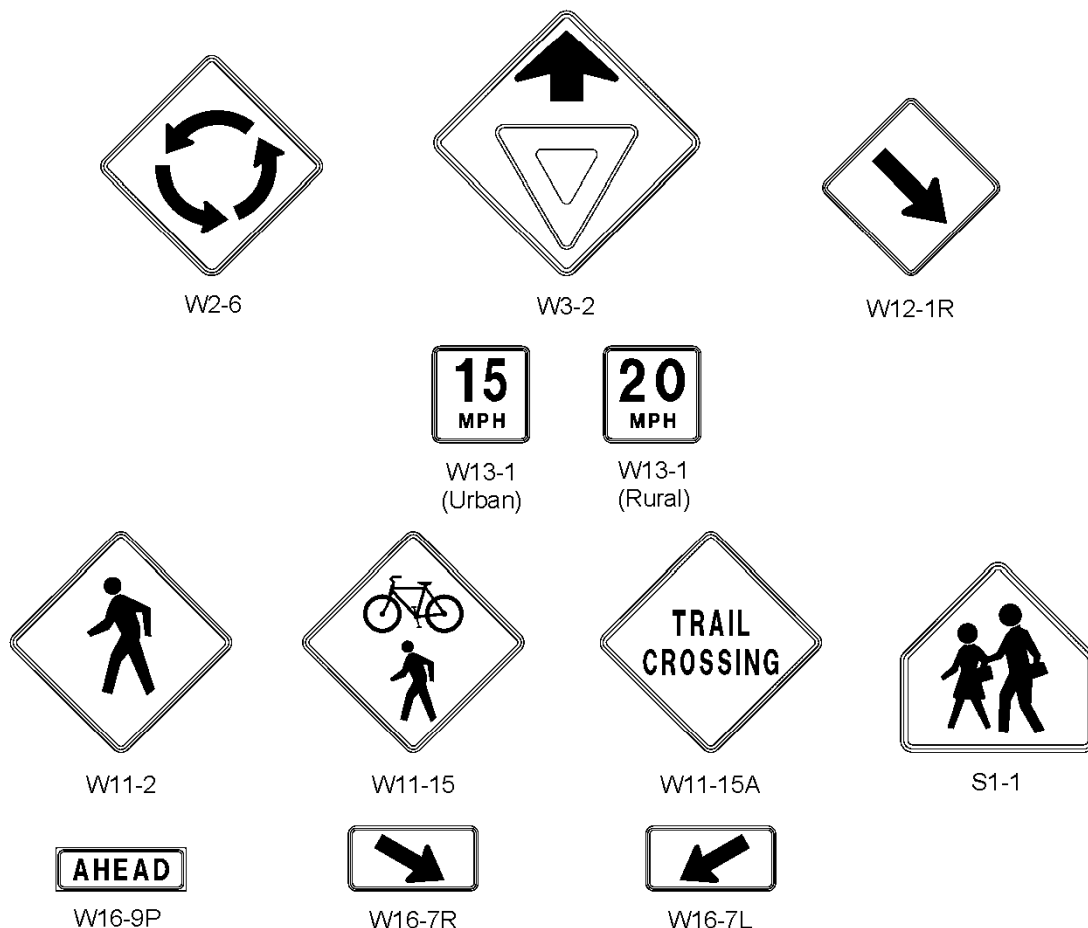


Figure 35.2 Warning Signs

35.1.3 Guide Signs

Guide signs provide drivers with needed navigational information. They are particularly needed at roundabouts

since circular travel may disorient unfamiliar drivers. Overhead guide signs should be considered at multilane roundabout approaches to guide motorists into the proper travel lane in order to navigate the roundabout properly and help avoid lane changing within the roundabout. A number of guide signs are appropriate for roundabouts and are described below.

35.1.3.1 Intersection Destination/Direction Signs

Use intersection destination/direction style signs in all single lane approach roundabouts for rural locations and in urban/suburban areas where space allows and is appropriate. The diagrammatic style guide sign is preferred over the text style sign (D1 series sign); examples of both are shown in Figure 35.3. The circular shape in a diagrammatic guide sign provides an important visual cue to all users of the roundabout. Diagrammatic guide signs are preferred because they reinforce the form and shape of the approaching intersection and make it clear to the driver how they are expected to navigate the intersection. If lack of terrace space or longitudinal location spacing are issues, use a text style sign or overhead diagrammatic guide sign.

Use 4 1/2" lower case / 6" upper case letters with 18" Interstate, U.S. and State route shields and 15" County route shields for ground mounted signs in urban and rural areas where posted speed is less than 45 mph, and 2 or less approach lanes. Use 6" lower case / 8" upper case letters with 24" Interstate, U.S. and State route shields and 20" County route shields for signs in urban and rural areas if the signs are overhead, posted speeds are 45 mph or greater or there are 3 or more approach lanes. In general, the lettering height rule of thumb is to provide approximately 1-inch in letter height for each 40-foot of distance from the sign. All capital letters are harder to read than the first letter capitalized with the following letters small case. Cardinal directions shall be all capital letters with the first letter slightly larger.

The arrow direction conventions for the text signs follow the same convention as that for conventional intersections as shown in the WMUTCD, 2D.37. The ahead destination is on top, the left destination in the middle and the right destination on the bottom. The curved-stem arrow (D1-1d signs) shown in the WMUTCD, 2D.38 shall not be used.

Occasionally, Specific Information Signs (SIS - GAS, FOOD, LODGING, CAMPING or ATTRACTIONS) may need to be included on roundabout approaches. The arrow direction convention and placement of SIS signs follows the WMUTCD, 2J.09.

Sample dimensioned details on the designs of diagrammatic signs, including the arrow and shaft dimensions are shown on the Bureau of Traffic Operations A11-12 sign plate.

Intersection destination signs may not be necessary at local street roundabouts or in urban settings where there are no significant destinations and the majority of users are familiar with the site.

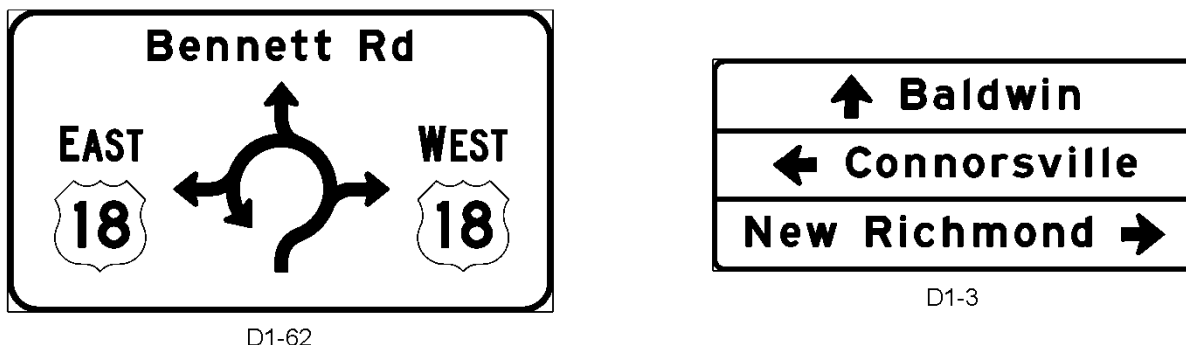


Figure 35.3 Destination Signs

35.1.3.2 Overhead Lane Guide Signs

In general, overhead lane guide signs are encouraged at roundabouts with multiple approach lanes. By giving destination guidance to the motorist in advance, the motorist will be able to be in the correct lane at the roundabout approach and be discouraged from making a lane change within the roundabout. Qualifying criteria for overhead lane guide signs would include two or more approach lanes, higher vehicle ADT's, lane splits approaching roundabouts, dual turn lanes, if the major route is turning, closely spaced roundabouts, narrow terrace widths, unfamiliarity of drivers, and lane drops within the roundabout. Since these are lane use guide signs, they would have an up arrow. A sign is placed over each travel lane (see multilane layout example in [Attachment 35.3](#)) and the arrow is typically placed over the center of the lane. Coordinate sign designs with the Region Traffic Operations section and the Bureau of Traffic Operations Traffic Design unit. If overhead guide signs are used on an approach, then the circular diagrammatic guide sign may not be needed. The circular diagrammatic guide sign is good for showing destinations and directions, however it does not depict proper lane assignments like the overhead lane guide signs do.

There may be situations in urban, multilane roundabout approaches where the overhead lane guide signs (Type I) may not be feasible, (space constraints). Options for the overhead guide signs are shown in [Attachment 35.2](#) to 35.5. Region Traffic Section approval is required to use these options.

The 2009 MUTCD allows the usage of combination lane-use / destination overhead guide signs (D15-1 and D15-2). The advantage of these types of overhead signs is that they show both the route/destination with the regulatory lane-use arrows, thus eliminating the need for additional installations of the ground mounted regulatory lane control signs. It should be noted that these signs shall not be used for lanes that have optional movements. They shall be used only for lanes that have an exclusive ahead, left or right turn movement. If the roundabout approach has a lane that has an optional movement, then all signs on the approach should be the Overhead Lane guide signs with separately mounted regulatory lane control signs. If the roundabout is part of a closely-spaced corridor of roundabouts, (i.e., ramp terminals), the design of all Overhead Lane guide signs in each direction shall match. If designs are mixed along the same direction, motorists may become confused by the change in location of lane control information. Refer to [Attachment 35.3](#) for further design guidance in addition to consulting the Regional Traffic Engineer.

Use 8" lower case / 10.67" upper case letters with 24" Interstate, U.S. and State route shields and 20" County route shields for all overhead signs. For situations with overhead structure loading limitations or on approaches with posted speeds of 35 mph or less, 6" lower case / 8" upper case letters with 18" Interstate, U.S. and State route shields and 15" County route shields may be used. Use a dot with the left arrow to designate the roundabout. The dot shall only be used to depict the left-most lane of the approach. Use an ONLY plaque over thru lanes that become turn lanes. The ONLY plaque is optional elsewhere. Consult the Regional Traffic Engineer for further design guidance.

Sample details of overhead lane guide signs are shown in Figure 35.4. Additional dimensioned details on the designs of diagrammatic signs, including the arrow and shaft dimensions are shown on the Bureau of Traffic Operations A11-13 sign plate.

Generally, use overhead sign supports, not sign bridge trusses. See [FDM 11-55-20](#) for overhead sign support design guidance.

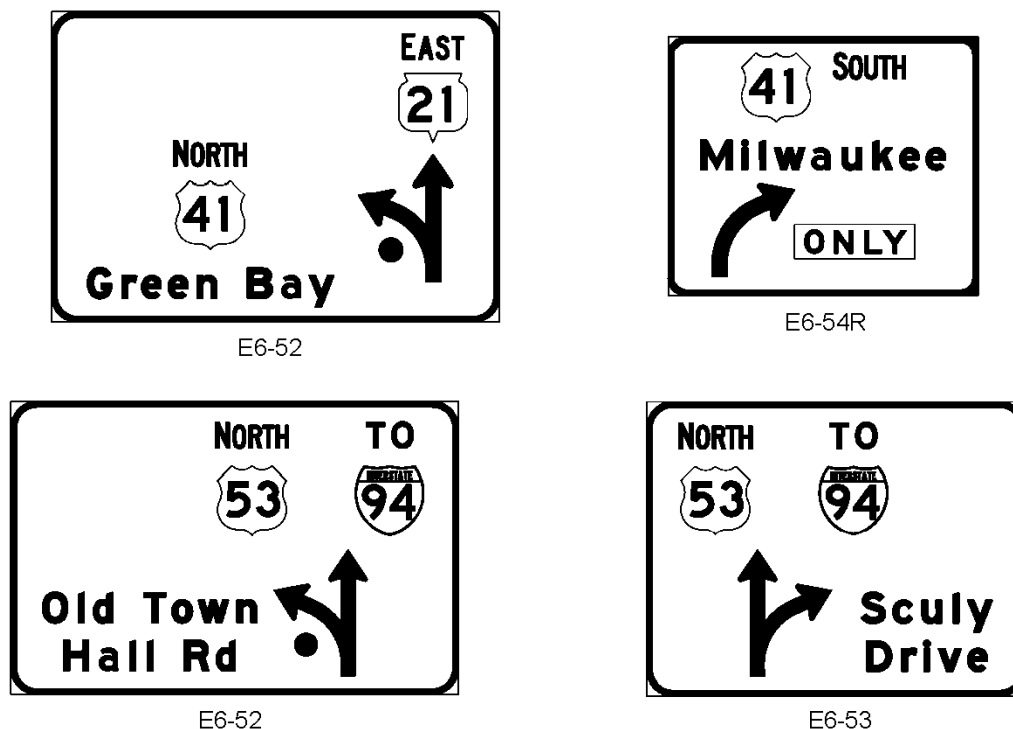


Figure 35.4 Overhead Lane Guide Signs

35.1.3.3 Exit Guide Signs - In Splitter Island

Exit guide signs reduce the potential for disorientation. Use them to designate the destinations of each exit from the roundabout. These signs are conventional intersection direction signs (D1 series signs). Exit guide signs with route shields should have the shield incorporated into the sign with cardinal direction and arrow. If the same route marker is used in more than one direction, the route shield should be accompanied with the cardinal direction. The arrow is slanted up and to the right. At freeway ramp situations utilize the route continuation with exit on the exit guide sign. Letter heights for signs are 4 1/2" lower case / 6" upper case with 12" route shields.

Signs are placed in the splitter island facing the circulating traffic. The mounting height is to be a minimum of 60-inches from the ground to the bottom of the sign. Specify the revised mounting height in the special provisions. Sample details of exit guide signs are shown in [Figure 35.5](#). Additional dimensioned details on the designs of the exit guide signs are shown on the Bureau of Traffic Operations A11-14 sign plate.

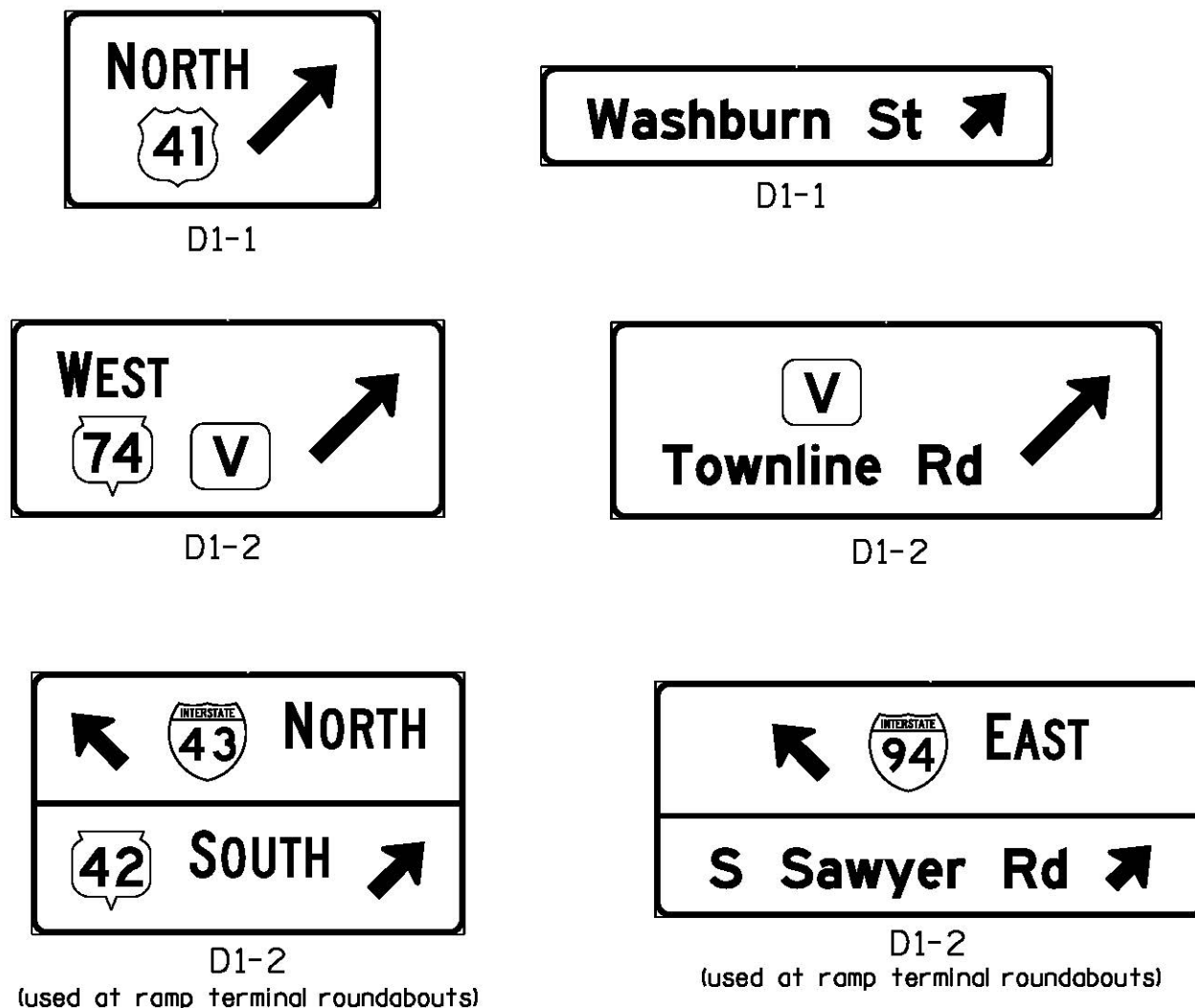


Figure 35.5 Exit Signs

35.1.3.4 Junction Assemblies

As with traditional intersections, consider using junction assembly consisting of either a “JCT” (M2-1) auxiliary sign with the appropriate route markers or a junction (J1-1) assembly in advance of the roundabout.

35.1.3.5 Route Confirmation Signs

For roundabouts involving the intersection of one or more numbered routes, install confirmation assemblies (J4's) directly after the roundabout exit to reassure drivers that they have selected the correct exit at the roundabout. Locate confirmation assemblies no more than 500 feet beyond the intersection in urban or rural areas. If possible, locate the assembly's close enough to the intersection so drivers in the circulatory roadway can see them.

35.1.4 Urban Signing Considerations

Urban intersections tend to exhibit lower speeds. Consequently, the designer can, on a case-specific basis, consider using fewer and smaller signs in urban settings than in rural settings. However, include some indication of street names in the form of exit guide signs or **typical** street name signs. Also review proposed signing to ensure that sign clutter will not reduce its effectiveness. Avoid sign clutter by prioritizing signing and eliminating or relocating lower priority signs.

There are sometimes situations with multilane approach urban roundabouts where the right-of-way is tight and

there is no physical room for typical overhead sign structures. There may be aesthetic considerations for multilane approach urban roundabouts where large overhead guide signs may not fit in. Scaled-down versions of overhead guide signs or J-assemblies may be utilized for these situations that may show route assembly panels instead of large guide signs as shown in [Attachment 35.3](#).

35.1.5 Rural and Suburban Signing Considerations

Route guidance emphasizes destinations and numbered routes rather than street names. The exit guide sign needs to be visible (but discrete) from within the roundabout and much smaller than the typical rural shields and lettering size. Six-inch upper case and 4-1/2-inch lower case lettering height is the maximum needed.

35.1.6 Closely-spaced Multiple Roundabouts

Often multiple roundabouts may be installed in close proximity to each other (roundabouts 1,000 feet apart center to center, or less). This can often happen at interchange ramp terminals and roundabouts beyond ramp terminals at frontage roads. Multiple roundabouts in close proximity to each other can cause signing challenges due to longitudinal space constraints between the roundabouts. As a result, some signing may be eliminated between the roundabouts. Visibility distance is based on stopping sight distance of vehicles. The roundabout warning assembly signs (W2-6, W2-6P and W13-1), pedestrian warning signs (W11-2, W11-15, W11-15A, W16-9P and W16-7L/R) and YIELD AHEAD (W3-2) may be eliminated between roundabouts if the visibility distance between the roundabouts exceed the minimum visibility distance shown in [Table 35.1](#). Other signs may be eliminated with consultation with the Region Traffic Section. The roundabout warning assembly signs and YIELD AHEAD would continue to be placed at the approaches to the first roundabouts in the series.

Table 35.1 Minimum Visibility Distance*

Posted or 85 th Percentile Speed	Minimum Visibility Distance
25 mph	280 ft
30 mph	335 ft
35 mph	390 ft
40 mph	445 ft
45 mph	500 ft
50 mph	555 ft
55 mph	610 ft

* Minimum Visibility Distances are from Section 2C.36 of the WMUTCD

35.1.7 Roundabouts in Close Proximity to Railroad Crossings

Railroad crossings in close proximity to roundabouts can present additional signing challenges due to safety concerns involving railroad crossings and the installations of additional signs in spaces already containing numerous signs. Because each railroad crossing is unique, roundabout designers need to contact the Bureau of Traffic Operations Traffic Design unit and the appropriate Region Traffic Operations section for the proper signing and marking layout if the railroad crossing is 1000 feet or less from the roundabout.

35.1.8 Wrong Way Movements in Roundabouts

There is a potential for wrong way movements at roundabouts, especially roundabouts that are new in an area. The typical signing applications include the usage of a chevron sign (series of 4 chevrons, W1-8a) in the central island with a One Way sign (R6-1R sign) mounted above it. In addition, a One Way sign is mounted below the left side YIELD sign. If wrong way movement problems persist, there are some signing options that can be employed:

- Oversize ONE WAY (R6-1R) sign in the central island, above the chevron sign
- DO NOT ENTER (R5-1) signs mounted in the circular island to face potential wrong way traffic
- DO NOT ENTER (R5-1) and NO RIGHT TURN (R3-1) signs is required for roundabouts at ramps per [TEOpS 2-15-12](#) mounted on the outside radius of roundabout as shown in the detail in 2-15-12

35.1.9 Wide Turning Trucks in Roundabouts

As large trucks maneuver a multilane roundabout, often times they need to encroach into the adjacent travel lanes. In many multilane roundabouts, this happens by design. Occasionally there may be issues resulting from

large trucks encroaching into the adjacent travel lanes as they make the turn. For these problem areas, it may be necessary to warn the motorist that the large trucks will encroach into the adjacent travel lanes in the roundabout circle. The WATCH FOR WIDE TURNING TRUCKS (W8-73) sign may be installed on the roundabout approaches for multilane roundabouts exhibiting these problems

35.1.10 Short Term Awareness Techniques

Some of the following bullet items are listed as short-term awareness techniques and others are mitigation considerations after field problems have been identified. In either situation contact the Region Traffic Engineer for guidance. Do not expect traffic control devices to accomplish what the geometric design cannot.

- Provide portable changeable message signs.
- Install orange flags on top of the YIELD signs during the first six months of operation.

35.1.11 Maintenance of Signs

For roundabouts on the STH System with county highway approaches or local road approaches, it is recommended that early in the design process, a Maintenance Agreement needs to be developed. By having the Maintenance Agreement developed early in the design process, the county or local unit of government will clearly have knowledge of what they are to maintain.

Some particular items that should be included in the Maintenance Agreement would include:

- Specific signs that WisDOT would maintain and what the locals/county would maintain. This would also include signposts.
- Specific overhead sign supports (if any), that WisDOT would maintain, and what the locals would maintain.
- Recommended inspection frequencies for overhead sign supports that the locals would maintain.

Further guidance on the maintenance of signs for roundabouts is included in the Traffic Engineering, Operations and Safety Manual, policy [TEOps 2-15-52](#).

35.1.12 Sign Installation for OSOW Vehicle Routes

Give careful attention to signs that are installed for roundabouts on OSOW vehicle routes. Periodically signs and posts may need be temporarily removed to accommodate the vehicles as they pass through the roundabout and turns properly. The designer should review the OSOW truck route maps in [FDM 11-25-1.4](#) and contact the Region freight coordinator to confirm if the roundabout is located on an OSOW vehicle route. Confirm the proposed post usage type on these routes with the Region Traffic Operations.

For roundabouts on OSOW routes, install tubular steel sign post assemblies or a comparable system (approved by the Project Engineer) for the following signs:

1. Left side YIELD (R1-2) - ONE WAY (R6-2R) sign assembly
2. Right side YIELD (R1-2) - TO TRAFFIC FROM LEFT (R1-54) sign assembly
3. Exit Guide signs (D1 series) in the splitter islands
4. PEDESTRIAN CROSSING (W11-2m W16-7R or similar) sign assemblies at the intersection crosswalks
5. Roundabout chevron bank (R6-4b) and ONE WAY (R6-1R) sign assembly in the circular island
6. Any signs located on the median island separating a right turn lane from the through lane(s)
7. Any additional signs on the outer portion of the roundabout circle, if directly impacted by OSOW vehicles.
8. Additional consideration should be given to sleeving, all signs on single lane roundabout approaches with clear width less than 20'.

Install tubular steel sign post assemblies in accordance with Standard Spec 634.3.2 and standard sign plat A4-9. Refer to the sign plate manual at:

<https://wisconsin.gov/Pages/doing-bus/local-gov/traffic-ops/manuals-and-standards/signplate/signplate.aspx>

To help prevent bending of the anchor tube and potential puncturing of vehicle tires, place the top of the 2 1/4" x 2 1/4" anchor level with the top of the 18" diameter PVC box-out (which is at ground level). The box-out is typically filled with gravel or dirt which will require about 2" of it to be removed in order to access the corner bolt when removing/reinstalling the post. The designer will need to ensure that notes are placed on the permanent signing plan to notify contractors of the required height of the top of the anchor system.

35.2 Pavement Marking

Pavement marking is needed on single and multilane roundabouts. The more complex the roundabout and the higher the volume, the greater the need for proper pavement marking. Pavement marking must be closely evaluated when designing a roundabout. Pavement marking is part of a "whole system" to consider, meaning

that various design concepts from geometric design, to signing, and pavement marking should complement each other.

Typical pavement marking for roundabouts consists of delineating the entries, exits, bike lane accommodations (only on approaches and exits), and marking the circulatory roadway. Single lane roundabouts need no lane arrows or circulatory roadway pavement marking, except for edge line marking. [Attachment 35.1](#) shows various combinations of common roundabout lane configurations, including full and partial right-turn bypass situations. In order for roundabout markings to be effective and sustainable, they must:

- Be integrated with and preferably designed at the same time as the roundabout geometry
- Be configured to guide proper usage of the roundabout
- Help the motorist identify the correct lane as early as possible using lane arrows on multilane approaches and circulatory roadways
- Be designed and implemented collaboratively between Regional Traffic Operations and project development staff with expertise in roundabouts and knowledge of maintenance considerations

Based on findings from the Department's pavement making evaluation, mark all roundabouts and their approaches with epoxy pavement marking. Epoxy pavement marking replaces preformed thermoplastic and grooved tape applications.

Refer to [TEOpS 3-10-1](#) of the Traffic Engineering, Operations and Safety Manual (TEOpS) for further guidance with roundabout pavement marking applications, including pavement marking preparation and installation at existing roundabouts.

Markings not covered in this policy shall follow practices established by standard detail drawings or require the approval of the Regional Traffic Engineer in collaboration with others who have knowledge of the design of roundabouts. On connecting highways, (local jurisdiction), coordinate pavement marking with the Regional Traffic Engineer and the local agency to maintain consistency on the facility.

It is just as important to make sure field layout and pavement marking application on the circulatory pavement is located and positioned correctly. A pavement marking layout detail showing the exact locations is required on all multilane roundabouts. Consider wheel tracking when developing the pavement marking layout detail.

Proper pavement marking within the circulatory roadway will help prevent left turns from the outer lane and thus reduce exit crashes. Complex lane configurations should be reviewed by an experienced roundabout designer and the Regional Traffic Engineer.

35.2.1 Approach Markings

1. Centerline marking on the approach to the splitter island may require a minimum of 500-foot segment no passing barrier line as shown in [SDD 15C18](#) "Median Island Marking". Refer to [Attachment 35.1](#) item O.
2. Lane lines on the approach shall be 4 inches wide. The markings are at the **typical** spacing of 12.5-ft segment, 37.5-ft gap, unless an even segment of 12-ft segment, 12-ft gap is needed. Start when flare widens to 9.5 feet for each lane. Match the width of line extended. Refer to items *T* and *X* in [Attachment 35.1](#).
3. A lane line on the approach *may be either 4 inches or 8 inches wide* when it separates two through lanes. The line shall be solid for a length of 50 feet in advance of the Point of Curve (P.C.) or as far as possible in advance of the P.C. to allow minimum marked lane widths of 9.5 feet, whichever is shorter. Refer to items *B* and *I* and its various marking width applications in [Attachment 35.1](#).
4. When an approach lane is a turn only lane, the channelizing line *may be either 4 inches or 8-inches wide and solid*. A R3-8 series Lane Control sign *shall* be placed for this type of approach. Refer to [FDM 11-26-35.1.1](#). The line shall be solid for a length of 50 feet in advance of the P.C., or as far as possible in advance of the P.C. to allow minimum marked lane widths of 9.5 feet, whichever is shorter. Refer to item *B* and its various marking width applications in [Attachment 35.1](#).
5. When the left approach lane is a dropped lane/exclusive turn lane, the approach dotted marking *shall be 4-inches wide with 3-ft segment, 9-ft gap*. Consult with the Regional Traffic Engineer on the start of this marking. Refer to item *D* in [Attachment 35.1](#).
6. The painted median splitter island marking on the approach *shall be double yellow with 12-inch yellow diagonal marking*. Do not place diagonal marking if the island is less than 6-ft wide. When the island nose width is greater than 6 feet, the diagonals shall be spaced every 25-ft if the median gore is longer than 50-ft; spaced every 10-ft if the median gore length is 50-ft or less. Refer to items *J* and *K* in [Attachment 35.1](#).
7. Lane separation markings (truck gores) *shall be outlined by 8-inch white lines*. Refer to item *U* in [Attachment 35.1](#). When the separation is greater than 6-ft, *12-inch white chevrons shall be placed and spaced every 25-ft if the truck gore length is longer than 50-ft; spaced every 10-ft if the truck gore*

length is 50-ft or less. Do not install chevrons when the truck gore is 6 feet wide or less. The point of the chevron shall 'point' upstream. Refer to item *U* for chevron application in [Attachment 35.1](#).

8. The edge line marking on the circle end of the splitter island will be white. Refer to [Attachment 35.1](#) which shows the breakpoint from 8-inch white to 4-inch yellow markings 5 feet in advance of the curb/splitter island P.C (items M and N of the *Special Case* in [Attachment 35.1](#)). Refer to [TEOps 3-10-1](#) and consult the Regional Traffic Engineer for further placement guidance of the yellow edge line upstream of the roundabout.

When the yellow edge line marking is used to narrow the width of an entry or exit, 12-inch yellow diagonal markings should be placed. When used, the diagonals shall be spaced at 10-foot spacing. Place diagonal markings only if distance between curb flange and edgeline is greater than 3 feet. Refer to item W of the *Special Case* in [Attachment 35.1](#). Also see [FDM 11-26-30.5.12](#) for its application with wide entry flares only.

9. When two or more lanes approach a roundabout, lane use arrows shall be marked in each lane to denote proper lane usage. Full complement of signing *shall be installed* as shown in [Figure 35.1](#), Regulatory Signs. Refer to item V in [Attachment 35.1](#). *Lane use arrows should not be used on single-lane approaches.* Left turn arrows *with the oval (Type 2R or Type 3R) shall only be placed in the left most lane.* Refer to [SDD 15C7-d](#) for typical detail of a dot with left pavement marking arrow. *The fish-hook arrow shall not be used.*

In addition to approach lane lines, appropriate lane arrows encourage balanced lane use, which improves capacity and safety. Left turn arrows are important on multilane approaches, since traffic otherwise has a bias towards the right-most lane. Place arrows to show the movements for each lane, and to indicate permitted dual right or left turns. Place the arrows at or just before the point where the channelizing or lane line begins or when the road widens to allow minimum lane widths of 9.5 feet. This is intended as a visual cue to the motorist to select an appropriate lane for entering the roundabout. Refer to [SDD 15C8-e](#) and Regional Traffic Engineer for guidance for multiple sets of arrows.

10. Crosswalk markings should be placed such that vehicles approaching the roundabout are not likely to stop on the crosswalk. A distance of 20 to 25 feet per stored vehicle back from the yield point is typically appropriate. Refer to [Attachment 35.1](#) as well as crosswalk policy in [TEOps 3-2-3](#) or selection guidance of appropriate crosswalk markings.
11. The word, "YIELD" placed prior to the dotted edge line extension is encouraged as an educational tool initially as part of a project. It should typically be used on multilane approaches when necessary as a tool for enforcement or where there are unusual geometrics, visibility problems, or crashes caused by motorists failing to yield. An example is an approach with a high volume of through traffic that was not required to stop or yield prior to the construction of the roundabout, especially where there is no side road leg 90 degrees to the right. When used on a multilane approach, the "YIELD" word should be placed in each approach lane. After initial placement, this marking should only be maintained as necessary based upon crash data. Refer to item S in [Attachment 35.1](#) and [SDD 15C7-b](#), Yield Markings.
12. Dotted Edge Line Extensions *shall be 18-inch-wide dotted white at 2-ft segment, 2-ft gap.* Place markings to avoid conflict between the entering vehicle and internal roundabout traffic, this is the point where entering traffic must yield. Refer to item A in [Attachment 35.1](#).

Approach and entry pavement markings consist of lane line, channelization marking, dotted edge line extension marking (yield line) and symbol markings. Consider high durability markings on the approaches. Refer to [TEOps 3-10-1](#) for approved pavement marking materials and their locations at a roundabout. Consult with the Regional Traffic Engineer before determining final pavement marking materials.

35.2.2 Circulatory Roadway Marking

13. Lane lines within the roundabout *shall be 4-inch or 8-inch width, with a 6-ft segment, 3-ft gap marking cycle.* These lines shall be the same width as the lines they extend. Lane lines in the circle can have a spiral effect and together with proper lane assignment guide motorists through the roundabout to the appropriate exit eliminating the need to change lanes. Refer to item C in [Attachment 35.1](#) along with guidance in selecting either the 4-inch or 8-inch width. For longevity, place the markings to avoid wheel paths of the intersecting traffic.
14. When used, dotted line markings shall be the same width **as** the lane lines and 1-ft segment, 3-ft gap marking cycle. Refer to item E in [Attachment 35.1](#).
15. When two lanes are allowed to proceed around the circle, Lane use arrows *shall* be marked in each lane within the roundabout adjacent to each splitter island to denote proper lane usage. Arrows placed within the circulatory roadway *shall not* include the oval. Refer to item Q in [Attachment 35.1](#).

35.2.3 Exit Marking

16. Avoid chevron markings at the exit point adjacent to the splitter island and at the exit **or** on the approach. This former special case application has been discovered to provide limited benefits in speed control and directional guidance versus curb and gutter.
17. *Do not paint the noses of the splitter island yellow* (where the splitter island meets the circulatory roadway, unless there is a documented crash problem). Yellow nose paint is intended to separate opposing directions of traffic such as the approach nose.

35.2.4 Bicycle Marking

18. When required, bike lane markings should be placed as per [Figure 35.6](#).

Bike lane marking within the circulatory roadway is not permitted on any roundabouts. Refer to [Figure 35.6](#) for Bike Lane markings on roundabout approaches.

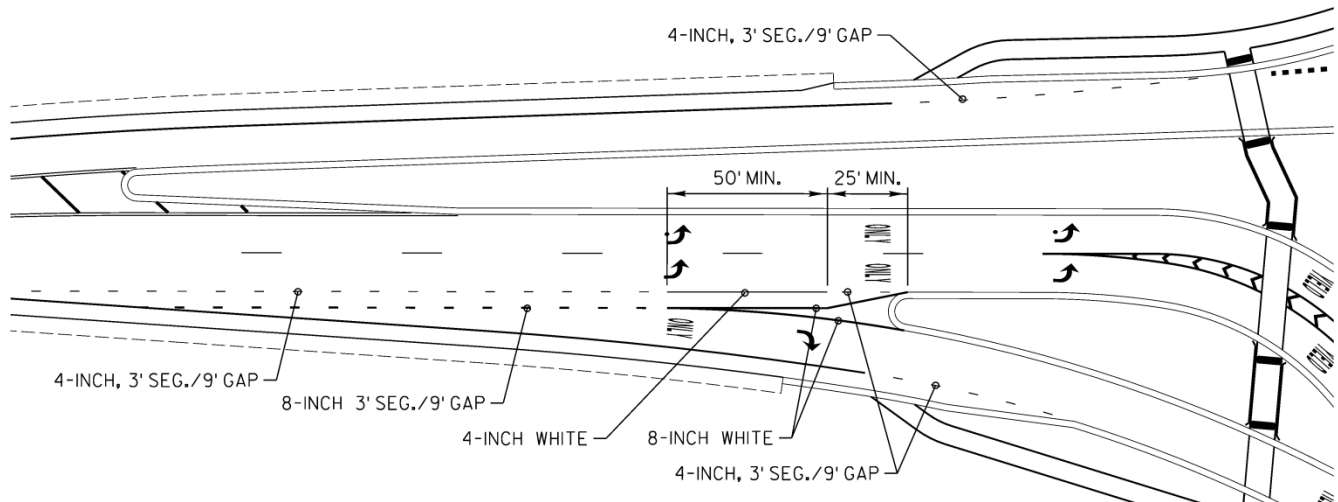


Figure 35.6 Bike Lane Roundabout Marking

35.2.5 Maintenance of Pavement Marking

For roundabouts on the STH System with county highway approaches or local road approaches, it is recommended that early in the design process no later than the time of the design study report, a Maintenance Agreement be developed. By having the Maintenance Agreement developed early in the design process, the county or local unit of government will clearly have knowledge of what they are to maintain.

LIST OF ATTACHMENTS

Attachment 35.1	Example Pavement Markings for Typical Designs
Attachment 35.2	Sample Signing Layout for Single-Lane Roundabout
Attachment 35.3	Sample Signing Layout for a Multilane Roundabout
Attachment 35.4	Sample Signing Plan for Roundabout Ramp Terminals
Attachment 35.5	Sample Signing Plan for Roundabout Ramp Terminals

FDM 11-26-40 Landscaping and Maintenance

August 15, 2019

Illumination can be found in chapter 11 of the Traffic Engineering, Operations and Safety Manual ([TEOpS 11-1](#)).

40.1 Central Island Landscaping

Landscape elements are vital to the proper operation of a roundabout and needs to be in place when the roundabout is opened to traffic. The purposes of landscape elements in the roundabout are to:

- Make the central island conspicuous to drivers as they approach the roundabout
- Clearly indicate to drivers that they cannot pass straight through the intersection. Restrict the ability to view traffic from across the roundabout through mounding of the earth and plantings. This will lead to slower entering speeds, which increases safety.
- Require motorists to focus toward on-coming traffic from the left
- Help break headlight glare
- Discourage pedestrian traffic through the central island

- Help blind or low vision pedestrians locate sidewalks and crosswalks
- Improve and complement the aesthetics of the area

When designing landscaping for a roundabout it is important to:

- Minimize driver distraction and provide central island crashworthiness
- Consider maintenance requirements early in the program stages of development
- Develop a formal municipal agreement describing the landscaping and maintenance requirements for roundabouts elements early in the scoping process and prior to design of the facility.
- Maintain adequate sight distances
- Avoid obscuring the view to signs
- Minimize fixed objects such as trees, poles, or guard rail
- Apply the guidance below relative to approach speeds and the permissible use of fixed objects such as trees, poles, non-hazard walls, non-hazard rocks/boulders, or guard rail

The Department takes a proactive approach toward minimizing driver distraction. Avoid items in the central island that may be considered an attractive nuisance and may encourage passersby to go to the central island for pictures, or other objects that might distract drivers from the driving task. Decorative features that may attract pedestrians within the central island or lead to distracted driving include (not all inclusive):

- Decorative statues
- Water fountains/features
- Artwork
- Decorative walls
- City logos or community welcome signs
- Commemorative plaques or monuments
- Banners and flags
- Roundabout sponsorship signing
- Street furniture (decorative and non-decorative)
- Combination of these above features

Any decorative features planned to be added to the central island should be of vegetative nature or natural-looking and close to ground level. Refer to [FDM 11-26-40.2.1](#) for reference to Department-approved plant materials.

Crashworthiness is a key element of roundabout central island landscaping design. While central island crashes are rare, they are often the most severe crashes. Optimize the crashworthiness of the central island design while balancing a community's desire to implement aesthetic treatments. Further discussion regarding allowable central island aesthetic treatments for low speed environments is cited below. Designers need to be mindful when considering non-hazardous aesthetic treatments. Consider an object's potential adverse influence to an errant vehicle, including vehicle abrupt deceleration, underside fuel tank or oil pan tears, launching and rollovers and their effects to occupants and pedestrians.

The Department's **typical** approach to central island landscaping is mounding the earth and providing plantings. Refer to [Figure 40.1](#) for the general layout of the central island. Design the slope of the central island with a minimum grade of 4% and a maximum of 6:1 sloping upward toward the center of the circle. The earth surface in the central island area forms an earth mound that is a minimum of 3.5-feet to a maximum of 6-feet in height, measured from the circulating roadway surface at the curb flange. As an absolute minimum, keep the outside 6 feet of the central island free from landscape features to provide a minimum level of roadside safety, snow storage, and unobstructed sight distance. In some situations, this central island area may need to maintain a low profile beyond 6-feet to allow OSOW vehicle loads to pass over the central island without the axles passing over the central island, (i.e. 165-foot girder, wind turbine parts).

The combination of the earth mound and plantings in the central island shall provide a visual blocking such that drivers will not be able to see through the roundabout central island. The central island area is considered a low speed environment, however errant vehicles occasionally end up in the central island or crossing the central island. The inner portion of the central island is typically most vulnerable to drivers/vehicles that for some reason leave the roadway and drive headlong into the central island. If a driver is driving too fast to negotiate a curved approach to a roundabout, or otherwise distracted and is not aware of the upcoming roundabout, the impact angle entering the central island typically will be much greater than 25 degrees and outside the realm of roadside design. The consequence of hitting a fixed object at an angle greater than 25 degrees is severe.

The approach highway speed is an indicator of the probability of an errant vehicle entering the central island. The following items are prohibited within the central island regardless of approach speed:

- Hazardous material - such as concrete, stone, boulders or wood walls
- Fixed objects - including trees having a mature diameter greater than 4-inches

Where all approach legs to a roundabout have a posted speed of 35 mph or less there may be objects that appear to be hazardous such as walls or rocks, but they are to be constructed with materials and in a manner that is not hazardous to errant vehicles. It is important to minimize the consequences of an errant vehicle that may impact these features.

Minimize the consequence of hitting a wall by following these guidelines:

1. Do not allow any walls in the central island with cast in-place or reinforced concrete or natural boulders.
2. When all roundabout approach legs have posted speeds of 35 mph or less, walls may be constructed with light-weight, Styrofoam type, artificial bricks/blocks typically used in landscaping and boulders with chicken wire and stucco. No mortar or reinforcing between the bricks/blocks. Minimize the wall thickness while maintaining stability.
3. If light-weight walls are desired for aesthetic reasons then construct at a height 20-inch or lower. This will tend to keep flying debris at a lower level as not to penetrate a windshield, or impact other vehicles.
4. Do not allow fill material in back of the light-weight brick/block wall for approximately 2 feet. Then at ground level begin to slope the earth up and away from the non-hazardous wall at a 6:1 slope or flatter.

Communities desiring to include decorative, lightweight fiberglass boulders with the central island landscaping design may use these boulders for low-speed urban environments up to 35 mph posted roundabout approach speeds by following these additional guidelines:

1. Decorative boulder wall thickness is 1/8" or less
2. Decorative boulders are not anchored to concrete base or pad
3. Use decorative boulders sparingly and strategically locate them as to minimize potential striking by errant vehicle
4. Keep larger diameter decorative boulders (max 24") toward the top of the central island berm

Diamond interchange exit ramps departing from high speed freeways and expressways will be considered as having a posted ramp termini approach speed exceeding 35 mph. On a case-by-case basis, designers may consider slower ramp termini approach speeds of 35 mph or less for exit ramps with sharper ramp curvature (e.g. loop ramp) that reduce operational speeds prior to the ramp termini.

Early in the design process, consult within the region and with Bureau of Project Development for input on local community's landscaping plans and possible decorative solutions. Options may be realized with various material treatments and applications on a case-by-case basis.

Landscape design elements requested by municipalities/communities that exceed costs of typical Department guidelines will need to be funded by the municipality. Refer to Program Management Manual for specific cost share policies. A maintenance agreement with the municipality will be required. Address any roundabout utility needs requested by the municipality, such as water and electrical costs and maintenance, in the agreement.

40.2 Landscape Design

Landscape design is an important aspect of roundabout operation. Before starting the landscape design first determine the maintaining authority and comply with the intersection sight distance as described in [FDM 11-26-30.5.15](#). More flexibility is allowed on projects that are not maintained by WisDOT.

Low-to-the-ground landscape plantings in the splitter islands and approaches can both benefit public safety and enhance the visual quality of the intersection and the community. In general, unless the splitter islands are very long or wide they should not contain trees, planters, or light poles.

Landscape plantings on the approaches to the roundabout can enhance safety by making the intersection more conspicuous and by countering the perception of a high-speed through traffic movement. Avoid landscaping within 50 feet in advance of the yield point. Plantings in the splitter islands (where appropriate) and on the right and left side of the approaches (except within 50 feet of the yield point) can help to create a funneling effect and induce a decrease in speeds approaching the roundabout. Low profile landscaping in the corner radii can help to channelize pedestrians to the crosswalk areas and discourage pedestrian crossings to the central island.

40.2.1 Owned, Operated, and Maintained by WisDOT

The goal for State-owned and maintained roundabouts is to achieve a landscape design that enhances the safety around the central island and splitter islands with little or no landscape maintenance required over time. Landscape design elements should minimize areas of mulch and the planted vegetation that requires maintenance.

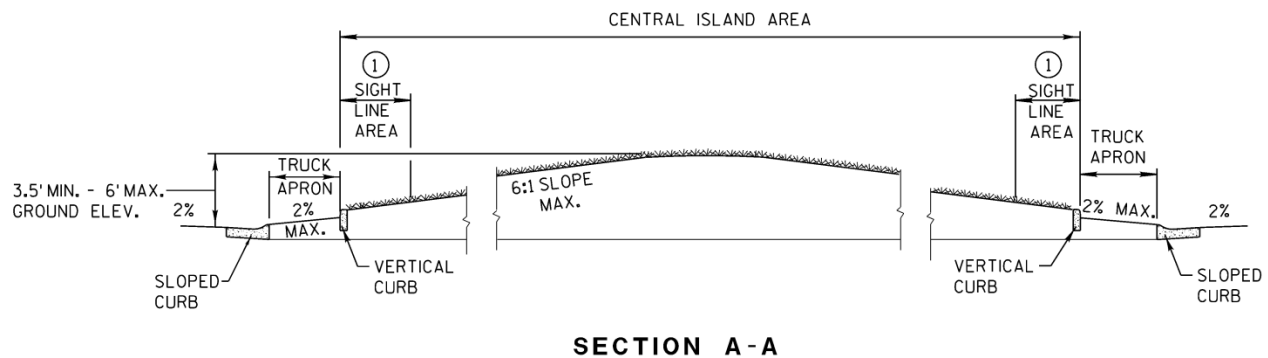
Low maintenance planting plans for roundabout landscapes are required. Vegetation approved for use by the department requires minimum maintenance and has been demonstrated to tolerate highway site conditions.

The central island earth berm may be planted with trees and shrubs, a prairie grass mixture that doesn't require mowing, or both. Plant materials approved for use by the Department, including trees and shrubs listed in [FDM 27-25 Attachment 1.3](#) are approved for use on roundabouts owned, operated and maintained by the Department. Certain native grasses are also approved at roundabouts and are included in the grasses portion of the "Table of Native Seed Mixtures" in [Standard Spec 630](#).

Locations of plant materials shall be selected for salt tolerance and be located to allow for sufficient snow storage in the winter. Snow removal operations typically radiate out from the central island. Plant materials shall not be placed to impede snow removal practices.

The uses of pre-emergent herbicides are recommended for use in plant bed and "hardscape" areas. Follow label instructions provided on the product container for use and application procedures.

Contact the Highway Maintenance and Roadside Management Section in the Bureau of Highway Operations for additional landscape design guidance.



- ① THE SIGHT LINE AREA SHOULD BE 6' - 10' JUST INSIDE THE CENTRAL ISLAND AREA TO PROVIDE INTERSECTION SIGHT DISTANCE TO THE LEFT FOR APPROACHING VEHICLES (EXHIBIT 6-58, NCHRP 672).

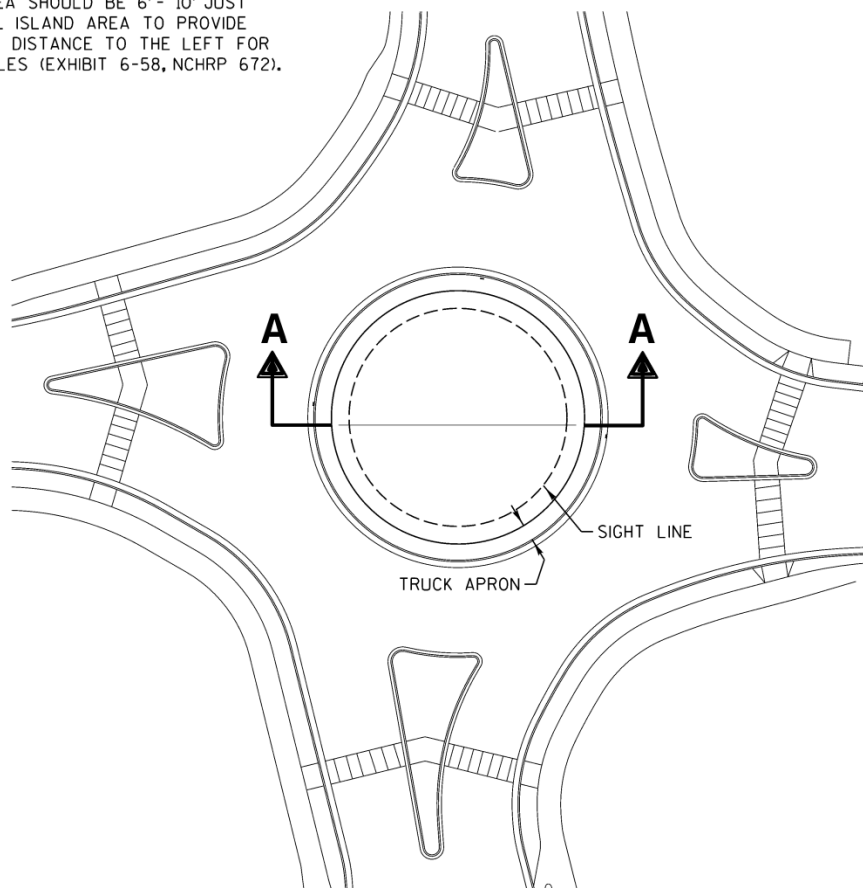


Figure 40.1 Low-Maintenance Central Island Landscaping

40.2.2 Owned by WisDOT but Maintained by Others

Landscape design requests in excess of [FDM 11-26-40.2.1.1](#) will be considered only upon receipt of a formal, signed project agreement prior to design of the facility and are the sole responsibility of the requesting municipality. These agreements are to be obtained in the planning stages of the project.

40.2.3 Local Roads and Connecting Streets

Landscape design costs in excess of department's **design criteria** described in [FDM 11-26-40.2.1.1](#) on local roads and connecting streets are the sole responsibility of the municipality.

40.3 Landscape Maintenance

Maintenance responsibilities for roundabouts will vary by ownership. Roundabouts are located on the local road system, on connecting state highways, and state highways.

40.3.1 Owned, Operated, and Maintained by WisDOT

All maintenance costs and operations of roundabout landscaping owned, operated and maintained by the department are the responsibility of the department, except as provided below. Landscape design elements and guidance have been outlined to minimize maintenance and operational costs to the department. Plants shown on the approved list have been selected to best meet these needs, [FDM 27-25 Attachment 1.3](#), [FDM 11-26-30](#) and [Figure 40.1](#) provide detailed layout dimensions of the area to be planted within the central island area.

Only those landscape maintenance operations necessary to maintain the safe operation of the department roundabout will be undertaken.

40.3.2 Owned by WisDOT but Maintained by Others

Municipalities often request special landscaping. Landscape requests in excess of requirements contained in [FDM 11-26-40.2.1.1](#) are the responsibility of the requesting municipality. Such requests will be considered only upon receipt of a formal, signed municipal agreement approved by the department prior to the design of those roundabouts. This procedure shall be completed early in the planning stages of project development.

40.3.3 Local Roads and Connecting Streets

Maintenance and operating costs of roundabouts located on local roads and connecting streets are the responsibility of the local government.

40.4 Shared-Use Path Maintenance

For urban, suburban, outlying and rural locations for roundabouts, a roundabout sidepath or shared-use path is provided accordingly; see [FDM 11-26-30.5.13](#). Facilities may be omitted if conditions are met as described in [FDM 11-46-1](#). Appropriate cost share policies apply and maintenance agreements with the local unit of government are required, unless refusal to maintain omission conditions are met see [FDM 11-46-1](#). If conditions are met to omit facilities, grading for future facilities apply as detailed in [FDM 11-26-30.5.13](#) and cut-through crossing are to be provided in splitter islands. The cost of the path installation and maintenance after the original roadway improvement is the responsibility of the local unit of government. There have been situations where land uses change, the local government leaders change, attitudes about such improvements change, or that pedestrian or bicycle volumes increase over time, and later there is a strong desire to install the path.

FDM 11-26-45 Work Zone Traffic Control

March 28, 2014

45.1 Work Zone Traffic Control

Roundabouts pose unique challenges when maintenance work is performed in or around these facilities. Each roundabout is unique so develop the traffic control plan to meet the specific conditions of the location, traffic volumes, duration, and work operation. Consider detour and staging as alternatives since they may provide better service for traffic movement.

During the design of temporary traffic control in roundabout work zone it is essential that the intended travel path for motorists, bicyclists, and pedestrians is clearly identifiable. Ensure turning radii can accommodate tractor-trailer vehicles. [SDD 15D21](#) and [SDD 15D31](#) show example device spacing at turning radii and curve transitions. Accomplish this through the temporary traffic control part 6 of WMUTCD

<https://wisconsindot.gov/dtsdManuals/traffic-ops/manuals-and-standards/wmutcd/mutcd-ch06.pdf>

compliant traffic control channelizing devices, signing, delineation, and temporary pavement markings. There are occasions when guidance may be provided by law enforcement personnel or using flagging operation depending on the complexity of the work in the roundabout. Schedule work during off-peak hours to minimize traffic within the roundabout if feasible. A roundabout is not designed to hold stopped or waiting traffic during roadwork. Flagging or a detour may be required if it is likely that work may block traffic from using the circular roadway of a roundabout. Notify emergency services and law enforcement if work is anticipated to cause delays.

[SDD 15D37](#) provides general guidance on the signing and device requirements for maintenance work in and around a roundabout location.

Work in a roundabout may involve any of the situations listed below.

- If work is within the roundabout, initial advance warning (ROAD WORK AHEAD) signs are required for each approach leg.
- If work occurs within the roundabout island and all work vehicles are out of the travel lanes and center island apron, a single "ROAD WORK AHEAD" sign is required per approach.
- If any of the roadway approaches cannot access the intersection due to workspace, a detour may be required. For short closures of less than 15 minutes or less, traffic may be held in place.
- If the center island apron will be impacted by the work or equipment, treat it as a shoulder closure for the duration of the work but consider diverting semi-trailer truck traffic due to large vehicle wheel tracking.
- If work occurs in an approach leg, a minimum of two flaggers should be used to control traffic. High approach volumes may require additional flaggers in the remaining legs. Use the "ROAD WORK AHEAD, BE PREPARED TO STOP" and the Flagger symbol signs in advance of each leg.
- If travel width of at least 10' can be maintained for shoulder work on an approach lane, the lane can remain open to traffic. Close the workspace with shoulder taper and tangent cones/drums. An initial advance sign and a "SHOULDER (SIDEWALK) CLOSED" sign are required unless the work lasts less than 15 minutes.
- If work is in a multi-lane roundabout, and work can be done without closing both travel lanes, flaggers may not be needed. Appropriate signs for the lane closure at each entry are required. Merge traffic into one lane prior to entry into the roundabout. See the details in [SDD 15D12](#) and part 6 of the WMUTCD

<https://wisconsindot.gov/dtsdManuals/traffic-ops/manuals-and-standards/wmutcd/mutcd-ch06.pdf> for merging details.

- If the splitter islands are raised, cones may not be needed along the approaches. In these situations, the flagger may have to move ahead on the splitter island so that traffic can maneuver into the roundabout.

When establishing the limits of the work zone ensure maximum possible sight distance to the flagger station, based on the posted speed limit. Motorists should have a clear line of sight from the flagger symbol sign to the flagger.

If sidewalks are impacted, provide a detour or temporary walkway that is a smooth, continuous hard surface (firm, stable and slip resistant) throughout the entire length of the temporary walkway. The following examples are typical work activities expected to occur in/around a roundabout.

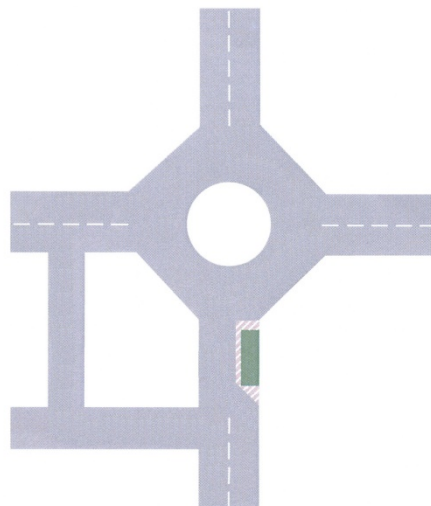


Figure 45.1 Work Zone at Entrance to Roundabout

Case A - Work Zone at the Entrance to a Roundabout

Two-way traffic should be maintained if possible. If not, entering traffic should be stopped using a flagger or a detour route provided.

In the case of a work zone illustrated in [Figure 45.1](#), use channelizing devices to direct traffic to the proper travel path and restrict traffic to one lane going towards the roundabout. Advance warning signs “ROAD WORK AHEAD, NARROW LANES (if lanes are less than 10’), barricade with Lane Closed signs should be used. If no suitable detours are available, it may be necessary to adopt an alternating one-way layout.

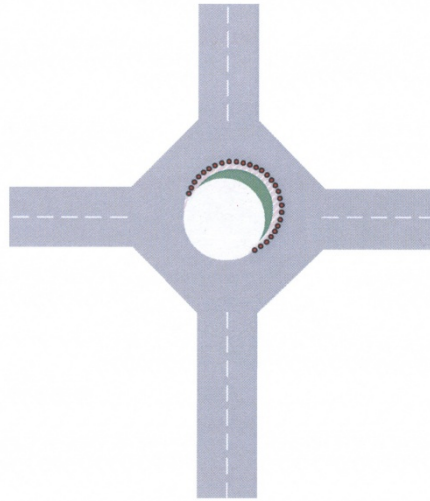


Figure 45.2 Work Zone in the Circulatory Area of a Roundabout

Case B - Work Zone in the Circulatory Area of a Roundabout

If possible maintain all movements. Separate the work area from traffic using channelizing devices and advance warning sign such as “ROAD WORK AHEAD.”

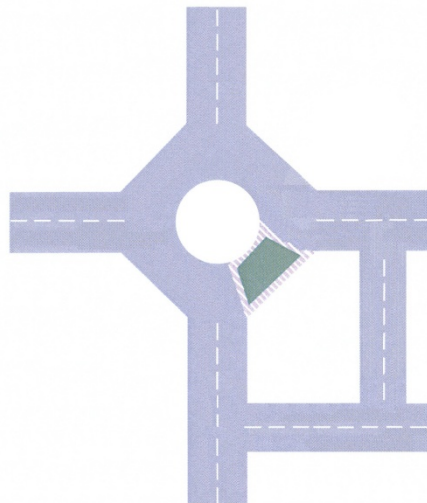


Figure 45.3 Work Zone Completely Obstructing the Circulatory Area of a Roundabout

Case C - Work Zone Completely Obstructing the Circulatory Area of a Roundabout

Refer to [Figure 45.3](#) and the traffic control, 2-lane roundabout information in [SDD 15D37](#).

At night, flagger stations should be illuminated except in emergencies. Portable changeable Message Signs should be considered as part of the traffic control plan to provide clear guidance to motorists on all approaches of the roundabout.

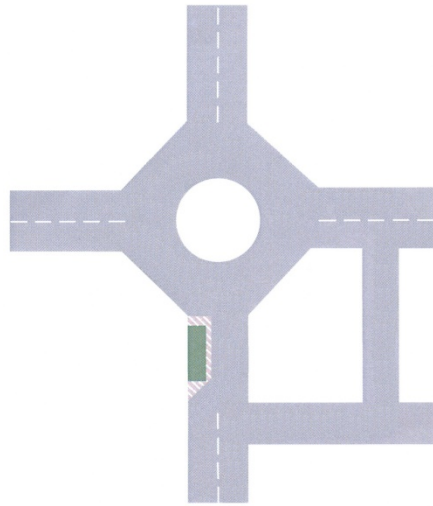


Figure 45.4 Work Zone at the Exit from a Roundabout

Case D - Work Zone at the Exit from a Roundabout

Channelize traffic around the work area using appropriate channelizing devices. Provide buffers space if roadway width allows. Two-way traffic past the work area should be maintained if possible, otherwise the road should be operated as an exit only from the roundabout, and a signed detour route provided.

45.1.1 Pavement Markings

Because of the confusion of a work area and the change in traffic patterns, pavement markings must clearly show the intended travel path. Misleading pavement markings shall be removed or covered in accordance with the Wisconsin Standard Specifications. As new pavement courses are placed consider specifying in the plans that splitter island delineation and broken white lines on the outside edge of the circulatory roadway be marked the same day the pavement course is placed according to Wisconsin Standard Specifications. When pavement markings are not practical, or misleading markings cannot be adequately deactivated, use closely spaced channelizing devices to define both edges of the travel path. When possible, pavement markings used within the work zones should be the same layout type and dimension as those to be used in the final layout. Additional pavement markings may be necessary to avoid confusion from changing traffic patterns used in staging.

45.1.2 Signing

Construction signing for a roundabout should conform to the WMUTCD and the Standard Detail Drawings. Provide all necessary signing for the efficient movement of traffic through the work area, including pre-construction signing advising the public of the planned construction, and any regulatory and warning signs necessary for the movement of traffic outside of the immediate work area. The permanent roundabout signing may be installed, where practicable, during the first construction stage so that it is available when the roundabout is operable, but these signs must be covered until they are needed. Consider using portable changeable message signs when traffic patterns change.

45.1.3 Lighting

Illuminate the temporary construction area through the intersection where possible. Consider adjacent lighting conditions, traffic volumes during the evening when the roundabout is illuminated, and mixture of use such as pedestrians and trucks.

45.1.4 Construction Staging

The Transportation Management Plan, [FDM 11-50-5](#), will consider detouring traffic away from the intersection during construction of the project. A detour will significantly reduce the construction time and cost, increase the safety of the construction personnel and will provide for an overall better finished product

It is **typical** to complete construction as soon as possible to minimize the time the public is faced with an unfinished layout or where the traffic priority may not be obvious. If possible, all work, including the installation of splitter islands and pavement marking, should be done before the roundabout is open to traffic.

If it is not possible to detour all approaches, detour as many approaches as possible. Carefully consider construction staging during the design of the roundabout if it must be built under traffic. Minimize the number of stages if at all possible. Staging should accommodate the design vehicle and maintain sightlines.

Prior to the work that would change the traffic patterns to that of a roundabout, certain peripheral items may be

completed including permanent signing (covered), lighting, and some pavement markings that reflect actual conditions. These items, if installed prior to the construction of the central island and splitter islands, would expedite the opening of the roundabout and provide additional safety during construction.

As is the case with any construction project, install appropriate traffic control devices as detailed in the project plans and the Standard Specifications. This traffic control shall remain in place as long as it applies and be removed when it no longer applies to the condition. Maintain consistent traffic control; do not change between stop and yield control multiple times during construction.

Stage the construction as follows unless a different staging plan is approved during design:

- Install and cover proposed signing
- Remove or mask pavement markings that do not conform to the intended travel path
- Construct outside widening if applicable
- Reconstruct approaches if applicable
- Construct splitter islands and delineate the central island. Uncover the signs at this point and operate the intersection as a roundabout
- Finish construction of the central island

If it is necessary to leave a roundabout in an uncompleted state overnight, construct the splitter islands before the central island. Any portion of the roundabout that is not completed must be marked, delineated, and signed in such a way as to clearly outline the intended travel path. Remove or mask pavement markings that do not conform to the intended travel path. Consider adding temporary lighting if the roundabout will be used by traffic in an unfinished state overnight or install the permanent lighting that is in operational condition.

45.1.5 Public Education

The Transportation Management Plan, [FDM 11-50-5](#), will advise the public whenever there is a change in traffic patterns. Education and driver awareness campaigns are especially important for a roundabout because a roundabout will be new to most motorists. The Regional Communication Manager coordination through both design and construction is typically vital to the success of a project. Provide brochures on how to drive, walk and bicycle through a roundabout. The following are some specific suggestions to help alleviate initial driver confusion:

- Hold public information meetings prior to construction
- Prepare news releases/handouts detailing what the motorist can expect before, during, and after construction
- Consider the creation of a project website, flash animation graphics, traffic simulation recording (such as Paramics, etc.) or the use of social media before and during construction
- Install portable changeable message signs or fixed message during construction and before construction begins. Advise drivers of anticipated changes in traffic patterns for about one week prior to the implementation of the new pattern.
- Use Wisconsin 511, news media (and Highway Advisory Radio, if available) to broadcast current status of traffic patterns and changes during construction. Also, if appropriate, establish a web site, to post up-to-date traffic and construction information.

45.99 References

1. Federal Highway Administration (2009), Manual on Uniform Traffic Control Devices, (MUTCD), U.S. Department of Transportation, Washington, D.C.
2. Washington State Department of Transportation, Work Zone Traffic Control Guidelines, M54-44.04, February 2012, <http://www.wsdot.wa.gov/publications/manuals/fulltext/M54-44/Workzone.pdf>.
3. American Traffic Safety Services Association (ATSSA), Temporary Traffic Control for Building and Maintaining Single and Multi-Lane Roundabouts, November 2012
4. Oregon Department of Transportation, "Temporary Traffic Control Handbook for Operations of Three Days or Less," December 2011.
5. Maryland Department of Transportation, State Highway Administration; "Work Zone Traffic Control, Roundabout Flagging Operation Greater than 40 MHP/Over24 hrs."

FDM 11-26-50 Design Aides

June 24, 2016

50.1 Example Plan Sheets

Several example plan sheets of the above information have been provided as an aide to the designer when completing roundabout plans. The plan sheets provided are examples and should only be used as guidance. [FDM 11-26 File 1](#) is a .pdf of the various plan sheets. The PDF attached has bookmarks for the various plan

sheets as noted above to assist you in viewing the sheets.

- Project Overview
- Typical Section
- Construction Details
- Pavement Elevation (Concrete)
- Pavement Elevation (Asphalt)
- Erosion Control
- Storm Sewer
- Landscaping
- Permanent Signing
- Lighting
- Pavement Marking
- Construction Staging
- Plan and Profile
- Cross-Sections

50.2 Creating Roundabout Fastest Paths (B-spline Curves) and Using AutoTurn software

Spline curves can be created in both AutoCAD and MicroStation. In AutoCAD, they are called polylines and in MicroStation they are called B-spline curves.

Instructions for creating roundabout fastest paths B-spline in AutoCAD 3D is in [Attachment 50.1](#), and for creating roundabout fastest paths B-spline in Microstation Version 8 is in [Attachment 50.2](#).

Instructions for using AutoTurn software in AutoCAD Civil 3D and MicroStation is in [Attachment 50.3](#).

50.3 OSOW Vehicle Inventory Evaluation Overview

Use AutoTurn, AutoTurn Pro 3D or Autodesk Vehicle Tracking (AVT) software for OSOW horizontal evaluation with the exception of the Wind Tower 80M MID and Wind Tower 205'. For these vehicles, only use AutoTurn or AutoTurn Pro 3D. Use AutoTurn Pro 3D or Autodesk Vehicle Tracking for low clearance evaluation (DST lowboy). Refer to these links for videos and assistance in using these tools.

This is the link to the AutoTurn Pro 3D tutorial videos:

<http://www.c3dkb.dot.wi.gov/Content/c3d/dsn-chk/swept-pth/swept-pth-grnd-clrnc.htm>

Refer to [FDM 11-25 Attachment 2.1](#) for OSOW vehicle inventories. Additionally, refer to [FDM 11-25-2.1.1.3](#) for OSOW vehicle inventory evaluations overview for further guidance in evaluating the OSOW vehicle tracking.

LIST OF ATTACHMENTS

Attachment 50.1	Creating Roundabout Fastest Paths (Spline Curves) in AutoCAD Civil 3D
Attachment 50.2	Creating Roundabout Fastest Paths (Spline Curves) in Microstation Version 8i
Attachment 50.3	Guide for Using AutoTURN in AutoCAD Civil 3D and MicroStation Version 8i