Chapter 8 Contents

8. ROUNDABOUTS 3

8.1. Introduction 3

8.2. Roundabout Validation 4

8.2.1. Planning Level Assessments 4
8.2.2. Roundabout Feasibility Studies 7
8.2.3. Review of Feasibility Studies 9
8.2.4. Lighting 10
8.2.5. Public Involvement 10

8.3. Design Guidelines 11

8.3.1. Review of Construction Plans 12
8.3.2. Design Vehicle 12
8.3.3. Alignment of Approaches 13
8.3.4. Splitter Islands 13
8.3.5. Pedestrian Accommodations 13
8.3.6. Bicycle Accommodations 13
8.3.7. Treatments for High Speed Approaches 14
8.3.8. Drainage 14
8.3.9. Curbing 14
8.3.10. Pavement 14
8.3.11. Staging of Improvements 15
8.3.12. Traffic Control Devices 15
8.3.13. Landscaping 15
8.3.14. Construction 15

8.4. References 16

8.4.1. Primary References 16
8.4.2. Additional References 16

8.5. Definitions 17

8.5.1. Roundabout Physical Features 17
8.5.2. Roundabout Design Elements 19

List of Tables

Table 8.1. Planning-level Thresholds for Single-Lane and Two-Lane Roundabouts. 7

List of Figures

Figure 8.1. Roundabout Validation Process 5

Figure 8.2. Key Roundabout Physical Features 17

Figure 8.3. Key Roundabout Design Elements 19

8. ROUNDABOUTS

8.1. Introduction

A modern roundabout is a type of circular intersection characterized by channelized approaches, yield control at entry, counterclockwise circulation around a central island, and geometric features that create a low-speed environment. Roundabouts have been demonstrated to provide a number of safety, operational, and other benefits when compared to other types of intersections. Specifically, they have fewer conflict points, lower speeds, and have been found to reduce crashes, traffic delays, fuel consumption, and air pollution. Information regarding roundabouts in Georgia can be found on the GDOT Roundabouts web page at http://www.dot.state.ga.us/travelingingeorgia/trafficcontrol/roundabouts/Pages/default.aspx

Roundabouts are categorized into three basic types: mini-, single-lane, and multilane roundabouts. A detailed introduction to each is provided in Chapter 1 of the National Cooperative Highway Research Program (NCHRP) *Report 672, Roundabouts: An Informational Guide, 2nd Edition*. This chapter of the GDOT Design Policy Manual specifically addresses single-lane and multilane roundabouts; for the design of mini-roundabouts refer to NCHRP 672.

In 2008 FHWA released *Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures*, which identifies roundabouts as one of nine safety countermeasures recognized and supported by FHWA. This document states the following:

> ***Roundabouts are the preferred safety alternative for a wide range of intersections. Although they may not be appropriate in all circumstances, they should be considered as an alternative for all proposed new intersections on federally-funded highway projects, particularly those with major road volumes less than 90 percent of the total entering volume. Roundabouts should also be considered for all existing intersections that have been identified as needing major safety or operational improvements. This would include freeway interchange ramp terminals and rural intersections.***

GDOT also considers roundabouts as the preferred safety and operational alternative for a wide range of roadway intersections. Specifically, a roundabout shall be considered in the following situations:

- for any intersection being designed on new location or to be reconstructed;
- for any existing intersection that has been identified as needing major safety or operational improvement (or where improvements are otherwise planned); and
- for all intersections where a request for a traffic signal has been made.

The consideration of a proposed roundabout begins with a planning level assessment. If the finding of the planning level assessment is that a roundabout is expected to perform acceptably, a roundabout feasibility study should be prepared to verify this decision and to define a footprint.

The addition of a roundabout to a project requires approval by the State Traffic Engineer. This often occurs with the review and approval of a concept report or revised concept report. The addition of a roundabout after concept report approval will require a revision of the concept report.

Each proposal for a roundabout should be evaluated and designed based on the guidelines contained in NCHRP 672, and the guidelines presented in the following sections of this chapter. Additional guidance documents are listed in Section 8.4.1.

8.2. Roundabout Validation

When considering a roundabout, a variety of alternatives should be evaluated to determine whether or not a roundabout is the most appropriate alternative. The alternatives evaluated should include all appropriate conventional intersection forms, which may include two-way stop control, all-way stop control, and/or signal control. A signalized intersection is an appropriate alternate only if signal warrants are met. Chapter 3 of NCHRP 672 provides guidance for comparing the performance of a roundabout to conventional intersection forms.

Figure 8.1 presents a validation process for confirming the selection of a roundabout alternate. This process includes: (1) obtaining agreement from local government to participate in lighting costs; (2) preparing a planning level assessment; (3) preparing a roundabout feasibility study; and (4) implementing a program of public outreach. The final result is a decision to proceed with either a roundabout design, a conventional intersection design (i.e., no roundabout), or to suspend project development.

For stand-alone intersection projects, the roundabout validation process should be completed prior to submission of the concept report for review and approval. Where the intersection is part of a larger project this process should be completed prior to requesting the preliminary field plan review.

A GDOT Roundabout checklist is available on the ROADS web site and should be completed and provided along with feasibility studies/concept reports for peer review, and submission of a concept report for review and approval.

8.2.1. Planning Level Assessments

The roundabout validation process begins with a planning level assessment to evaluate the suitability of constructing a roundabout at an intersection. A planning level assessment may be incorporated into the feasibility study if both are prepared by the same engineer. A list of items to be considered as part of a planning level assessment is provided on the Roundabout Design Checklist - Concept Development, Part 1 located on the GDOT ROADS web page. http://www.dot.ga.gov/doingbusiness/PoliciesManuals/roads/Pages/OtherResources.aspx Exhibit 3-1 of NCHRP 672 provides an excellent overview of key planning level principles.

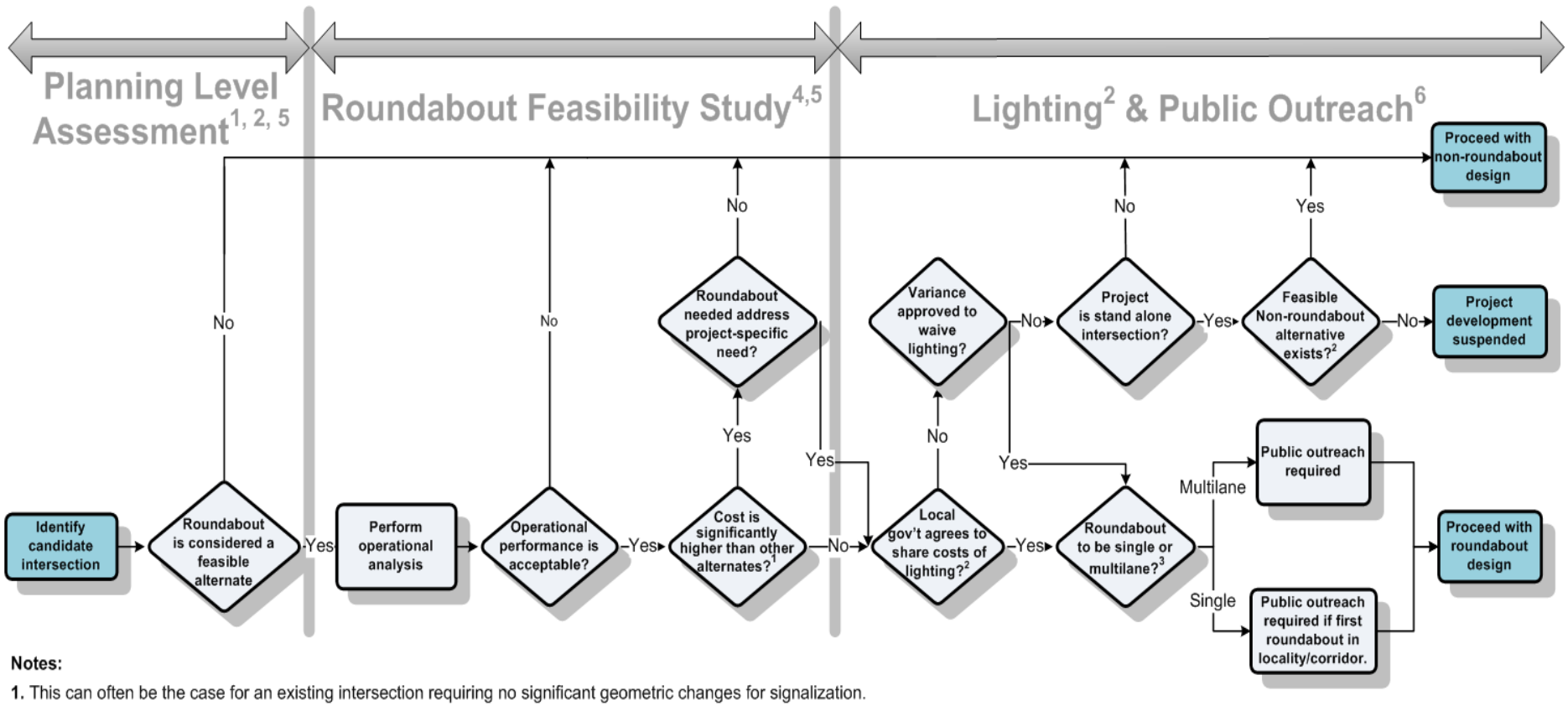
An overview of common advantages and disadvantages of roundabouts is presented in Exhibit 2-5 of NCHRP 672. Listed below are conditions where roundabouts are commonly found to be advantageous over other forms of intersection control.

Safety

- Intersections with historically high crash rates.
- Roads with historical problems of excessive speed.
- Intersections with more than four legs or with difficult skew angles.

Operations

- Intersections with a high percentage of turning movements and intersections that must accommodate a high number of U-turns.
- Intersections with high traffic volumes at peak hours but relatively low traffic volumes during non-peak hours.



Notes:

1. This can often be the case for an existing intersection requiring no significant geometric changes for signalization.
2. A written commitment letter must be received from a local government agreeing to share the costs of lighting (by funding the energy, operation and maintenance of the lighting system) for the proposed roundabout to move forward to detailed design
3. If a single-lane roundabout is found to be adequate up to 10 years after the opening year, a single-lane roundabout should be constructed. If a multilane roundabout is required before the design year, the single-lane roundabout should be constructed having the footprint of a multilane roundabout and be designed to be easily retrofitted to a multilane roundabout.
4. For a stand-alone intersection project where a complex roundabout is proposed, the feasibility study should be peer reviewed prior to the concept team meeting. Complex roundabouts include all multilane roundabouts; and single lane roundabouts having more than four legs, with approach skews less than 60 degrees, or closely spaced roundabouts where the operations of one impacts the operations of another. For other roundabouts, peer reviews should be performed no later than the early part of the preliminary design phase.
5. A list of items to be considered as part of a planning level assessment is provided on the Roundabout Design Checklist (Concept Development, Part 1) located on the GDOT ROADS web page. http://www.dot.ga.gov/doingbusiness/PoliciesManuals/roads/Pages/OtherResources.aspx. A list of items to be considered as part of the concept report for a stand-alone intersection project is provided on the Roundabout Design Checklist (Concept Development, Parts 2 - 5).
6. The public involvement process should include outreach to local government officials and the local community and should be initiated as soon as practical during concept development. At minimum, a public information open house (PIOH) should be held for all multilane roundabouts and for single-lane roundabouts where there are no other well-functioning roundabouts in the community or nearby along the corridor.

Figure 8.1. Roundabout Validation Process

- Intersections where the construction of turn lanes for a signal would have significant impacts on adjacent property or require significant reconstruction of structures. While roundabouts may have a larger footprint on the corners of the intersection, the overall space requirement for a roundabout is often less than for a conventional intersection. This is due to the elimination or reduction of storage lanes on approach roadways. Some examples include the following:
  - intersections where widening one or more approach, to add turn lanes, would be difficult or cost-prohibitive; and
  - ramp terminals for freeway interchanges. Roundabouts often make more efficient use of an existing bridge by eliminating or reducing the storage requirements on the bridge.
- Intersections where traffic growth is expected to be high and future traffic patterns are uncertain. The expansion of a single-lane roundabout to a multilane (to accommodate increased traffic volumes) will often result in a smaller increase in footprint than changing to or reconstructing a signalized intersection. Also, a roundabout often has a greater flexibility to accommodate changes to traffic patterns.
- Intersections where signalization provides an unacceptable delay.
- Existing two-way stop-controlled intersections with high side-street delays, particularly those that do not meet signal warrants.
- Locations where the speed environment or number of through lanes of a road changes, for instance, at the transition to an urban environment.
- Intersections or corridors where traffic calming is a desired outcome of the project.

Aesthetics

- Intersections at a gateway or entry point to a campus, neighborhood, commercial development, or urban area. These may be locations with a need to provide a transition between land-use environments such as between residential and commercial areas.
- Intersections where community enhancement are desirable.

The presence of any of the following conditions will normally be unfavorable for a roundabout. These conditions do not preclude a roundabout from further consideration, but should be carefully considered when selecting a roundabout.

- Intersections in close proximity to a signalized intersection where queues may spill back into the roundabout.
- Locations with steep grades and unfavorable topography that may limit visibility of the roundabout from a distance.
- Intersections where an unacceptable delay to the major road could be created. Roundabouts introduce some geometric delay to all through and left turning traffic entering the intersection, including the major road.
- Intersections with an interconnected signal system.
- At locations where the pedestrian traffic signal warrant is met (i.e., Warrant No. 4 in MUTCD, Pedestrian Volume)
- Signalized intersections in close proximity to an at-grade railroad crossing requiring preemption.

Table 8.1 can be used to estimate the number of circulatory lanes required for single- or two-lane roundabouts. In most cases one and two-lane roundabouts should operate acceptably below these thresholds. Actual performance is significantly affected by the percentage of left turning traffic.

Where turning movement data is available an evaluation of capacity should be performed using the GDOT Roundabout Analysis Tool. Alternately, an estimate of the required number of entry lanes at each approach can be obtained using Exhibit 3-14 of NCHRP 672. Sample calculations are provided in Exhibits 3-15 and 4-3 of NCHRP 672.

For a roundabout to be a reasonable solution, the opening and design year volumes for traffic entering the roundabout from the major road should be less than 90% of the total volume entering the roundabout.

Table 8.1. Planning-level Thresholds for Single-Lane and Two-Lane Roundabouts.

No. of Circulatory Lanes	ADT[1] (design year)	% Traffic on Major Road[2] (opening & design year)
Single-lane	< 25,000	< 90
Two-lane	< 45,000	< 90

[1]Based on traffic entering the circulatory roadway for a four-leg roundabout. A reasonable approximation for a three-leg roundabout is 75% of the values shown above.
[2]The volume of traffic entering the roundabout from the major road divided by the total traffic volume entering the roundabout, as a percentage.

If traffic volumes exceed the maximum ADT thresholds shown in Table 2.1 (i.e., 45,000 and 90%), or if site conditions are unfavorable to a roundabout, an acceptable conventional intersection form may be selected without further evaluation. Nevertheless, a roundabout may still operate better than a conventional intersection and may be carried forward for more detailed consideration as part of a roundabout feasibility study.

8.2.2. Roundabout Feasibility Studies

A feasibility study must be prepared for all proposed roundabouts. The objective of the feasibility study is to document the decision-making process which demonstrates that a roundabout is (or is not) the most appropriate intersection control form. The feasibility study includes a geometric layout of the selected roundabout.

In many cases, the components of the feasibility study can be incorporated into the concept (or revised concept) report and no separate feasibility study prepared. A list of items to be considered as part of the concept report, for a stand-alone intersection project, is provided on the Roundabout Design Checklist - Concept Development, Parts 2 - 5.

The scope of a feasibility study will vary depending on project conditions and the type and complexity of the proposed roundabout. For example, an intersection having a significant history of injury crashes may not require a detailed cost comparison, considering the greater reduction in injuries that can be expected with a roundabout as compared to a signal. On the other hand, the use of a roundabout within an urbanized corridor having closely spaced intersections may require a feasibility study that goes beyond the scope of what is outlined below.

A feasibility study should include the following components:

- **Section 1, Project Background & Site Conditions**: include a description of the corridor, a vicinity map, and an aerial photo showing existing conditions at the intersection. The aerial photo should show land-use, access, existing right-of-way, environmental resources, and any other physical constraints that may affect the location and configuration of a roundabout.

- **Section 2, Safety Assessment:** include a tabulated analysis of intersection crash data for the five most recent years for which data is available and a comparison to statewide intersection averages. Crash data and statewide averages can be requested from the Crash Reporting Unit of the GDOT Office of Traffic Operations by contacting Mr. Norm Cressman at ncressman@dot.ga.gov.

  If the purpose of considering a roundabout is to improve the safety at an existing intersection, it is suggested that a crash diagram be prepared. The crash diagram should show the types of crashes and the direction each car was travelling. A roundabout is particularly effective for addressing crashes involving crossing and turning traffic.

  Crash reductions factors should be obtained either from the FHWA Report No. FHWA-SA-08-01,1 *Desktop Reference for Crash Reduction Factors* or the Crash Modification Factors Clearinghouse web site at http://www.cmfclearinghouse.org/. Further information regarding safety and roundabouts is presented in Chapter 5 of NCHRP 672 and in the AASHTO Highway Safety Manual.

  Section 3, Alternate Sketches: include sketches of all design alternates being considered. These can be effectively presented on the aerial photo base map for the intersection.

- **Section 4, Operational Analyses:** include operational analyses using peak hour traffic volumes for each design alternate, for opening and design years. The results of each analysis should be presented by lane group in terms of volume-to-capacity ratio, average control delay, level of service, and 95th percentile queue. Based on the results of these analyses the performance of each alternate should be evaluated, and intersection types providing adequate performance identified. Further guidance on evaluating the operational performance of roundabouts can be found in HCM 2010. See also Chapter 4 of NCHRP 672.

  Analyses should be performed using more than one analysis methodology to identify a range of expected performance during the design period (i.e., opening to design years). For example, analyses can be performed using the GDOT Roundabout Analysis Tool to implement the HCM 2010 method and the "SIDRA Standard" method (suggest environmental factor of 1.1 for the design year) using the software package SIDRA Intersection or the empirical method using the software package ARCADY. An environmental factor of 1.2 is suggested for opening year analyses.

  A simulation software package, such as VISSIM, should be used when modeling of a network of closely spaced intersections is necessary.

- **Section 5, Cost Comparison:** where multiple alternates are expected to provide adequate operational performance, a cost comparison should be prepared. This analysis should consider significant benefits relating to safety, operational, and environmental factors and significant costs relating to construction, required right-of-way, operations, and maintenance.

  Further guidance on estimating benefits and costs can be found in Section 3.7 of NCHRP 672. A detailed benefit-to-cost analysis can be helpful for communicating the benefits of a roundabout to local governments and the public.

- **Section 6, Alternate Selection:** include a brief summary of the findings of the above studies (usually in a bulleted form) followed by a recommendation of the most favorable alternate. Key assumptions and constraints important to this decision should be included.

- **Section 7, Conceptual Roundabout Design:** include a concept level geometric layout of the roundabout and approaches. This layout should include the size and location of the roundabout and the alignment and arrangement of approaches. Major geometric

components should be shown including splitter islands, circulatory roadway, truck aprons (if required), center island, and bypass lanes (if required).

A list of the criteria used to develop the selected layout and key dimensions should be provided. Provide dimensions for: (1) inscribed diameter; (2) entry and exit radii; and (3) entry, circulatory, roadway, and truck apron widths. It is noted that the selection of the most favorable roundabout location and configuration may require the development and comparison of multiple roundabout layouts.

Geometric and performance checks should be included, including fastest path, design vehicle swept paths, and stopping sight distance for approaches. Operational analyses prepared for Section 4 should be updated, if required. Other performance checks can be completed during preliminary design (See Section 6.7 of NCHRP 672).

If a single-lane roundabout is found to be adequate up to 10 years after the opening year, a single-lane roundabout should be constructed. If a multilane roundabout is then required before the design year, the single-lane roundabout should be constructed having the footprint of a multilane roundabout and be designed to be easily retrofitted to a multilane roundabout (See Section 6.12 of NCHRP 672).

- **Section 8, Recommendations:** briefly state the reasons for selecting the recommended alternate. Specific requirements or constraints to be considered during preliminary design should be listed and the expected approach for staging briefly described.

The preparation of a feasibility study may be suspended at any time during the process, if it becomes evident that a roundabout is either not feasible or is not the most appropriate intersection form. In this case, documentation should be organized and retained to maintain a record of this decision.

8.2.3. Review of Feasibility Studies

Feasibility studies prepared by GDOT engineers must be reviewed in accordance with the Department's QC/QA Manual, and studies prepared by consultants in accordance with their own approved QC/QA procedures. Informal reviews by the Office of Design Policy and Support or the Office of Traffic Operations can be requested at any time during the plan development process. by sending an e-mail to either Mr. Scott Zehngraff (Operations) at szehngraff@dot.ga.gov or Mr. Daniel Pass (Design Policy) at dpass@dot.ga.gov.

Peer review of feasibility studies must be performed for all roundabout projects, unless approval to omit this review is received from the State Design Policy Engineer. Peer reviews are performed by a consultant peer reviewer having extensive experience with the planning, analysis, and design of single-lane and multilane roundabouts. For a list of prequalified roundabout peer reviewers contact the Office of Design Policy and Support.

For a stand-alone intersection project where a complex roundabout is proposed, the feasibility study should be peer reviewed prior to the concept team meeting. Complex roundabouts include all multilane roundabouts; and single lane roundabouts having more than four legs, with approach skews less than 60 degrees, or closely spaced roundabouts where the operations of one impacts the operations of another. For other roundabouts, peer reviews should be performed no later than the early part of the preliminary design phase.

Any peer review recommendations not implemented should be coordinated with the Office of Design Policy and Support. Specifically, if the design engineer proposes not to implement a peer review recommendation, a written response will be submitted along with the peer review report to the Office of Design Policy and Support. If an accepted peer review recommendation is not

implemented by the time the concept report is submitted, written explanations (for each recommendation) along with the peer review report must be attached to the concept report.

8.2.4. Lighting

The lighting of a roundabout has been identified by the Department as having substantial importance to the operational performance and safety of a roundabout such that special attention should be given to the design decision. Therefore, GDOT has defined the illumination levels in Table 1 of the Illuminating Engineering Society (IES) DG-19-08, *Design Guide for Roundabout Lighting* (IES DG-19-08) as standard for the design of roundabout lighting. If it is not practical to provide the illumination levels defined in this table, then a decision to deviate from this table shall require a comprehensive study by the engineer and prior approval of a Design Variance by the GDOT Chief Engineer.

NCHRP 672 emphasizes the safety importance of roundabout lighting for all users of roundabouts and includes the below statements.

> ***For a roundabout to operate satisfactorily, a driver must be able to enter the roundabout, move through the circulating traffic, and separate from the circulating stream in a safe and efficient manner. Pedestrians must also be able to safely use the crosswalks. To accomplish this, a driver must be able to perceive the general layout and operation of the intersection in time to make the appropriate maneuvers. Adequate lighting should therefore be provided at all roundabouts***. [NCHRP 672 Section 8.1]
>
> ***It provides visibility from a distance for users approaching the roundabout.*** [NCHRP 672 Section 8.2]
>
> ***It provides visibility of the key conflict areas to improve users' perception of the layout and visibility of other users within the roundabout.*** [NCHRP 672 Section 8.2]

Pedestrians are the most vulnerable users of a roundabout. Thus, an important function of lighting at a roundabout is to ensure that any pedestrian in the crosswalk is visible to vehicles approaching, entering, and exiting the roundabout. Roadway lighting also provides increased safety to cyclists, at the approach to the roundabout where they begin to mix with vehicular traffic and throughout the circulatory roadway where they may be integrated into the traffic stream.

A written commitment letter must be received from a local government agreeing to share the costs of lighting (by funding the energy, operation and maintenance of the lighting system) in order for the proposed roundabout to move forward to detailed design (See Figure 8.1). Lighting plans should be developed consistent with the guidelines presented in IES DG-19-08.

8.2.5. Public Involvement

The public involvement process should include outreach to local government officials and the local community and should be initiated as soon as practical during concept development. At minimum, a public information open house (PIOH) should be held for all multilane roundabouts and for single-lane roundabouts where there are no other well-functioning roundabouts in the community or nearby along the corridor. This includes minor projects for which a PIOH may not otherwise be required.

In communities where there is little familiarity with roundabouts, it is recommended that a meeting be held with local government officials prior to a PIOH. A roundabout subject matter expert or an individual with considerable knowledge of roundabouts should be present at this meeting.

Below are suggested "best practices" for preparing for a PIOH.

- Prepare several large color displays that show the proposed location and layout of the roundabout. The display should include aerial photography and property lines. The following may also be included:
  - proposed pavement markings with lane arrows;
  - proposed landscaping in the central and splitter islands (if required); and
  - truck turning paths (on a separate display).
- In urban areas special attention should be given to minimizing right-of-way impacts. Where possible, use construction easements to reduce project costs and impacts to adjacent properties.
- Be prepared with a comparison of cost, safety, and operational performance of the roundabout and other feasible alternates. Accordingly, the following information should be made available at the meeting:
  - construction cost estimates for feasible alternates (e.g., roundabout and signal);
  - crash history and an assessment of roundabout safety benefits; and
  - operational and signal warrant analyses.
- Bring visual aids (e.g. videos, posters, VISSIM 2-D or 3-D simulations, and brochures) to help familiarize the public with how to drive through a roundabout.

Some visual aids are available on GDOT's roundabout website (http://www.dot.state.ga.us/travelingingeorgia/roundabouts/pages/default.aspx) and on FHWA's roundabout website (http://safety.fhwa.dot.gov/intersection/roundabouts/). Additional information regarding public involvement as well as public education is presented in Section 3.8 of NCHRP 672).

8.3. Design Guidelines

This section presents design guidelines which should be used along with NCHRP 672 for the design of roundabouts. Exhibit 6-1 of NCHRP 672 provides an excellent overview of the design process.

A roundabout should be designed with appropriate geometric features to ensure optimal safety and operational performance for users entering, circulating, and exiting the intersection. The following key principles are taken from Section 6.2 of NCHRP 672:

- provide slow entry speeds and consistent speeds through the roundabout by using deflection;
- provide the appropriate number of lanes and lane assignment to achieve adequate capacity, lane volume balance, and lane continuity;
- provide smooth channelization that is intuitive to drivers and results in vehicles naturally using the intended lanes;
- provide adequate accommodation for design vehicles;
- design to meet the needs of pedestrians and cyclists; and
- provide appropriate sight distance and visibility for driver recognition of the intersection and conflicting users.

Below are a list of additional considerations for multilane roundabouts (See Section 6.5 of NCHRP 672):

- lane arrangements to allow drivers to select the appropriate lane on entry and navigate through the roundabout without changing lanes;
- alignment of vehicles at the entrance line, into the correct lane within the circulatory roadway;
- accommodation of side-by-side vehicles through the roundabout (e.g., a truck traveling adjacent to a passenger car);
- alignment of the legs to prevent conflicts between exiting and circulating traffic; and
- accommodation for all travel modes.

Satisfying these key principles involves balancing the sometimes competing needs for safety and operational performance. Accordingly, engineers preparing roundabout designs should be familiar with NCHRP 672 and apply a high level of Quality Control/Quality Assurance (QC/QA) throughout the design process.

8.3.1. Review of Construction Plans

As with feasibility studies, GDOT prepared construction plans must be reviewed in accordance with the Department's QC/QA Manual, and construction plans prepared by consultants in accordance with their own approved QC/QA procedures.

Specifically, a peer review of Final Field Plan Review (FFPR) construction plans should be performed and comments incorporated in to the FFPR report. This should include: (1) the horizontal layout; (2) vertical design elements (e.g., typical sections, profiles and grading); (3) drainage; (4) signing and marking plans; (5) landscaping plans; (6) lighting plans; and (7) staging plans. This review may be performed on Preliminary Field Plan Review construction plans, in which case a peer review of FFPR plans would not be required.

The objective of the peer review is to verify that all design information necessary for construction and operation of a roundabout is provided. Careful consideration is given to verifying that design details that can significantly affect performance of the roundabout are consistent with "best practices" for design and construction.

Peer reviewer comments will be added to the field plan review (FPR) report by Engineering Services and red-lined FPR plans provided to the project manager.

8.3.2. Design Vehicle

The design vehicle for all roundabouts on state routes and interchange ramp terminals should be an AASHTO WB-67. The roundabout geometry should accommodate the swept path of the design vehicle tires and body and should be evaluated using a CAD-based vehicle turning path program for each of the turning movements. For further information on the selection of a design vehicle refer to Section 3.2 of this design policy manual. See also Sections 3.5.4.1, 6.2.4. 6.4.7, and 6.5.7 of NCHRP 672.

In addition to accommodating the design vehicle, Buses (BUS-40) in urban areas and single-unit trucks (SU) in rural areas should be accommodated within the circulatory roadway without tracking over the truck apron.

To accommodate oversized vehicles (where needed), roundabouts can be designed with a gated roadway through the central island or wider truck apron.

8.3.3. Alignment of Approaches

The centerline of the roundabout approaches are often either aligned through the center of the roundabout (or radial) or offset to the left of the roundabout center point (i.e., left offset). The left offset enhances deflection of the entry path. Approach alignments offset to the right of the roundabout center point should be avoided unless other geometric features can be applied to produce acceptable fastest path speeds. An offset to the left is preferred for high speed approaches.

See Section 6.3.2 of NCHRP 672 for a more in-depth discussion on the alignment of approaches.

8.3.4. Splitter Islands

Splitter islands should be incorporated into all roundabouts and should include cut-throughs to accommodate pedestrian traffic.

The total length of the raised island should be at least 100 ft. This minimum may be reduced to 50 ft on urban roadways with design speeds less than 45 mph. For high speed approaches splitter islands should be lengthened as described in Section 6.8.5.3 of NCHRP 672. See Sections 6.4.1 and 6.5.5 of NCHRP 672 for more information on the design of splitter islands.

8.3.5. Pedestrian Accommodations

Pedestrians should be considered and accommodated at all roundabout intersections. Pedestrian accommodations should include cut-throughs on splitter islands, two-stage perpendicular crossings, curb ramps and accessibility features such as detectable warning surfaces. Pedestrian activated signals should be considered for multi-lane roundabouts with high pedestrian traffic volumes.

Sidewalks should be set back from the edge of the circulatory roadway with a landscape buffer. Landscape buffers should have a minimum width of 2 ft, with 6 ft being desirable. Stamped and colored concrete should be considered for 2-ft wide landscape buffers to assist sight-impaired pedestrians.

At single–lane approaches and departures, the pedestrian crossing should be located one car length (approximately 20 ft) away from the inscribed circle. At multilane approaches and departures, the pedestrian crossing should be located one or two car lengths away from the inscribed circle.

Further information on the design of pedestrian accommodations is provided in Section 6.8.1 of NCHRP 672.

8.3.6. Bicycle Accommodations

Where bicycle lanes are used on approach roadways, they should be terminated in advance of roundabouts using tapers to merge cyclists into traffic for circulation with other vehicles. For bike routes, where cyclists remain within the traffic lane, it can be assumed that cyclists will continue through the roundabout in the travel lane.

At multi-lane and high speed roundabouts, consider providing bicycle ramps to allow bicyclists to exit the roadway onto the sidewalk and travel as pedestrians. Ramps normally should not be used at urban, one-lane roundabouts except where the complexity of the roundabout would make circulating like other vehicles more challenging for bicyclists.

Further information on the design of bicycle accommodations is provided in Section 6.8.2 of NCHRP 672.

8.3.7. Treatments for High Speed Approaches

The primary safety concern in rural locations where approach speeds are high (i.e., > 45 mph) is to make drivers aware of the roundabout with sufficient advance distance to comfortably decelerate to the appropriate speed for entering the roundabout. Where possible, the geometric alignment of approach roadways should be constructed to maximize the visibility of the central island and the shape of the roundabout.

Speed reduction treatments should be used for all high speed approaches. These treatments may include geometric and/or nongeometric techniques. Examples of geometric treatments include the use of horizontal curvature on approaches and the extension of splitter islands upstream of the entry yield line - for a distance equal to the length required to decelerate from the approach roadway design speed to the entry speed of the roundabout. Examples of nongeometric treatments include the addition of successive sets of rumble strips placed in advance of the roundabout, speed reduction markings placed transversely across travel lanes, advance warning signs supplemented by warning beacons, and landscaping of splitter islands to increase their prominence.

Further information on treatments for high speed approaches is provided in Section 6.8.5 and 7.4.4 of NCHRP 672.

8.3.8. Drainage

Drainage structures should normally be placed on the outer curb line of the roundabout and upstream of crosswalks, but should not be placed in the entry and exit radii of the approaches. Drainage structures located on the outer curb line of the circulatory roadway should be designed to withstand vehicle loading (e.g., Type E, Standard Drop Inlet with Hood shown on GDOT Standard Drawing 1019A). Maximum gutter spreads should match the requirements for the approach roadways, as outlined in the GDOT manual Drainage Design for Highways.

Refer to Section 6.8.7 of NCHRP 672 for a discussion of vertical alignment considerations, which includes drainage.

8.3.9. Curbing

Concrete curb and gutter with a Type 2 curb face should be used along the outside edge of all roundabouts which includes the entry radius, the circulatory roadway, and the exit radius. For rural roadways it is desirable to extend outside curbing along approaches to the length of the required deceleration distance to the roundabout entry.

A Type 2 curb face should also be used for splitter islands. A Type 9 concrete header curb should be used between the truck apron and the circulatory roadway, as detailed on GDOT Construction Standard 9032B.

Further information on the principles for using curbs is provided in Sections 6.8.7.4 and 6.8.8.1 of NCHRP 672.

8.3.10. Pavement

Asphalt or dark colored concrete are the recommended materials for the circulatory roadway to differentiate it from the concrete truck apron. A proposed pavement design should be prepared for each roundabout and be submitted for review and approval in accordance with the GDOT PDP.

Further information on the design of pavements is provided in Section 6.8.8 of NCHRP 672.

8.3.11. Staging of Improvements

If capacity analysis demonstrates that a single-lane roundabout is adequate for at least 10 years after the opening year, a single-lane roundabout should be constructed. If a multilane roundabout is required before the design year, the single-lane roundabout should be constructed having the footprint of a multilane roundabout and be designed to be easily retrofitted to a multilane roundabout (See Section 6.12 of NCHRP 672).

To allow for this future expansion, the right-of-way and geometric needs of both the single-lane and multilane roundabout must be defined. For further information refer to Section 6.12 of NCHRP 672.

8.3.12. Traffic Control Devices

Traffic control devices for roundabouts shall be in accordance with the 2009 Manual on Uniform Traffic Control Devices. Chapter 7 of NCHRP 672 provides a helpful presentation of the application of traffic control devices to roundabouts.

8.3.13. Landscaping

Landscaping should be installed with the construction of most roundabouts. Landscaping of the central island provides for visual awareness of the roundabout location from a distance. Landscaping in the central island also limits the amount of excess sight distance for drivers to help encourage slower speeds. Consequently, landscaping should adequately block the through sight lines of an approaching driver so that the driver sees the central island rather than the roadway beyond. Landscaping within the central island should discourage pedestrian traffic to and through the central island.

Any landscaping that is provided along the perimeter of the central island should consist of low-lying shrubs, grass or groundcover so that stopping and intersection sight distance requirements are maintained for vehicles. The width of this perimeter central island landscaping should be based on sight distance calculations and be shown on construction plans.

Shrubs and columnar growing species may be appropriate within the inner portion of the central island. Consideration should be given to the size and shape of mature plants.

GDOT Construction Detail RA-1 provides a layout and details that may be used for landscaping a roundabout central island. Landscaping is recommended for all roundabouts and is required where one or more approaches have a design speed greater than 45 mph. A Right-of-Way Mowing and Maintenance Agreement is required for on-system roundabouts.

Further information on landscaping principles is provided in Chapter 9 of NCHRP 672.

8.3.14. Construction

Construction time and cost can be reduced by constructing a roundabout while maintaining traffic outside the footprint of the roundabout (e.g. a detour). Presented below is one possible sequence for construction where traffic must pass through the work zone.

1. Install signing and lighting (signing should initially be covered).
2. Maintain traffic on existing roadways. Construct the portion of the roundabout located outside the existing intersection footprint. This should include drainage structures and a portion of the circulatory roadway but not the shoulder outside the circulatory roadway.

Construct temporary pavement outside the final circulatory roadway for maintaining traffic in the next stage.

3. Remove covered signage and shift traffic from the existing roadways to the temporary circulatory roadway. The intersection should function as a roundabout, the temporary circulatory roadway should be wide enough to accommodate the design vehicle.
4. Construct splitter islands and central island (including the truck apron). Complete the construction of the circulatory roadway and any pavement markings.
5. Shift traffic from the temporary circulatory roadway to the final circulatory roadway.
6. Remove temporary pavement and construct shoulders. Complete drainage structures and relocate signing to appropriate locations within the islands.

The above is a brief explanation meant to illustrate one possible sequence of construction. Actual staging narratives for construction plans will vary considerably from one project to another, and must be specific to the design and constraints of each project. Further information including other staging sequences is presented in Section 10.3 of NCHRP 672.

8.4. References

8.4.1. Primary References

For the planning and design of roundabouts refer to the most current edition of the following publications.

- *2010 Highway Capacity Manual*, Transportation Research Board, National Academies of Science, Washington DC, 2010.
- *Design Guide for Roundabout Lighting*, DG-19-08, Roundabout Lighting Committee, Illuminating Engineering Society of North America, New York, NY, June 2009.
- *Manual on Uniform Traffic Control Devices*, Federal Highway Administration, US Department of Transportation, 2009.
- *Roundabouts: An Informational Guide*, 2nd Edition, NCHRP 672, National Cooperative Highway Research Program, Transportation Research Board, National Academies of Science, Washington, DC, 2010.

8.4.2. Additional References

- *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*, NCHRP Report 674, National Cooperative Highway Research Program, Transportation Research Board, National Academies of Science, Washington, DC, 2011.
- *Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures – 5. Roundabouts*, Federal Highway Administration, US Department of Transportation, July, 1, 2009.
- *Highway Design Handbook for Older Drivers and Pedestrians*, Publication No. FHWA-RD-01-103, Federal Highway Administration, US Department of Transportation, May 2001.
- *Mini-Roundabout Technical Summary*, Report FHWA-SA-10-007, Federal Highway Administration, US Department of Transportation, Feb. 2010.
- *Pedestrian Access to Modern Roundabouts: Design and Operational Issues for Pedestrians Who are Blind*, US Access Board.

- *Roundabouts in the United States*, NCHRP Report 572, National Cooperative Highway Research Program, Transportation Research Board, National Academies of Science, Washington DC, 2007.
- *Roundabout Technical Summary*, Report FHWA-SA-10-006, Federal Highway Administration, US Department of Transportation, Feb. 2010.
- *Signalized Intersections: An Informational Guide*, Publication No. FHWA-HRT-04-091, Federal Highway Administration, US Department of Transportation, August 2004.

8.5. Definitions

Figures 8.2 and 8.3 illustrate key roundabout physical features and design elements. These figures were modified from the report, *Technical Memorandum: Planning-Level Guidelines for Modern Roundabouts* prepared by the Center for Transportation Research and Education at Iowa State University [2008]. Definitions for key terms are provide below each figure and most are taken or adapted from either the above report or NCHRP 672.

8.5.1. Roundabout Physical Features

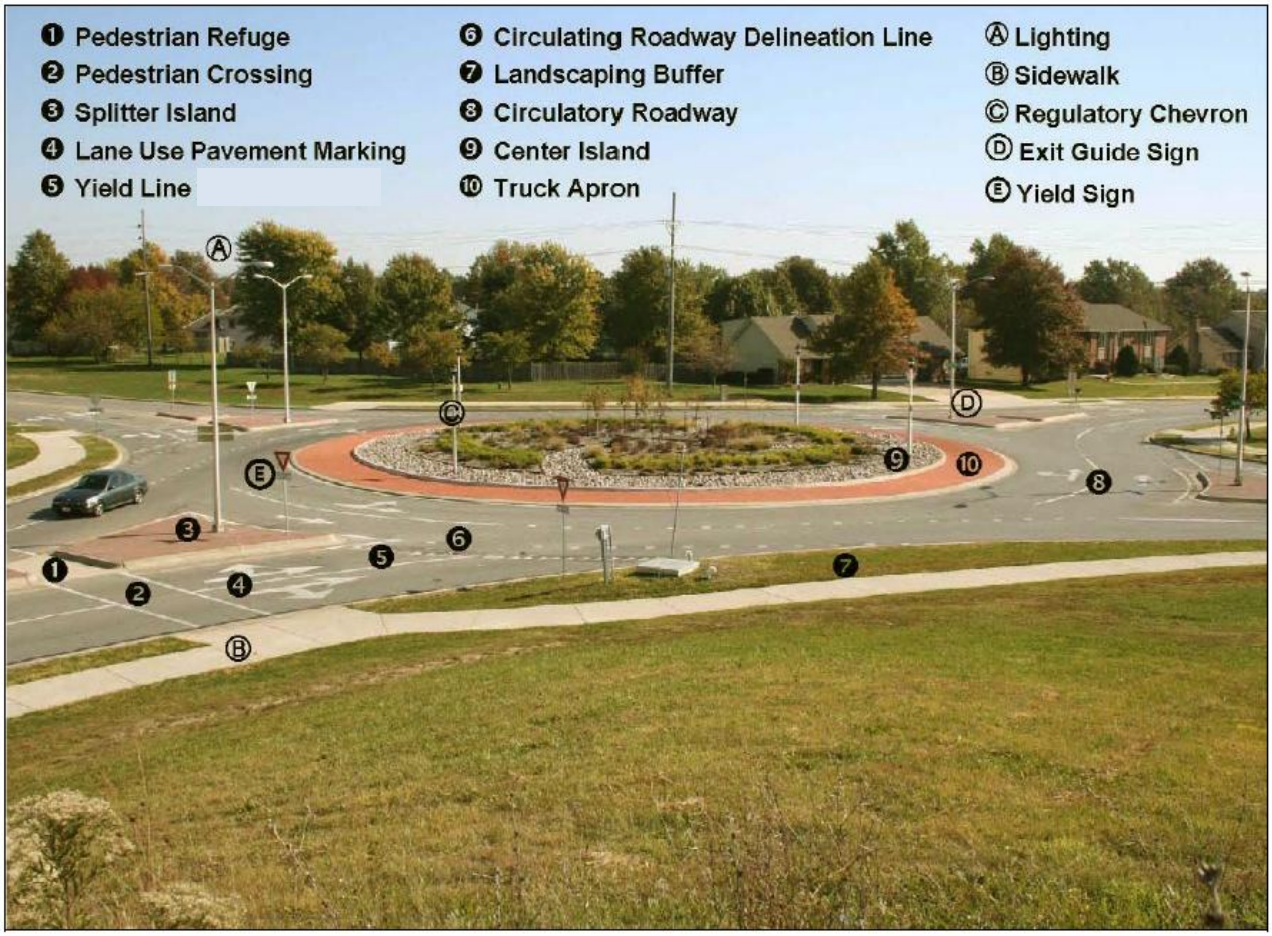


Figure 8.2. Key Roundabout Physical Features

Truck Apron – the mountable portion of the central island adjacent to the circulatory roadway. Used on many roundabouts to accommodate the wheel tracking of large vehicles.

Bike Ramp – Allows for bicyclists to exit the traveling lane, to use the sidewalk and crosswalk as a pedestrian would. It is recommended that only experienced bicyclists be encouraged to use the roadway and that novice riders exit the roadway, dismount their bikes and use the sidewalk and crosswalks. **[See *Section 6.8.2.2 of NCHRP 672* for further reference.]**

Central Island – the raised area in the center of a roundabout around which traffic circulates and which includes the truck apron. The central island does not necessarily need to be circular in shape. In the case of a mini-roundabout the central island is fully traversable.

Circulatory Roadway – the curved path used by vehicles to travel in a counterclockwise fashion around the central island.

Entrance Line (or Yield Line) – a pavement marking used to delineate the point of entry from an approach into the circulatory roadway and generally marked along the inscribed circle. Entering vehicles must yield to any circulating traffic coming from the left before crossing this line into the circulatory roadway.

Landscaping Buffer – Landscape buffers separate vehicular and pedestrian traffic and assist with guiding pedestrians to the designated crossing locations. This feature is particularly important as a wayfinding cue for individuals who are visually impaired. Landscape strips can also significantly improve the aesthetics of the intersection.

Lighting – Provides illumination for all potential conflict areas, including the beginning of the splitter island, all crosswalks, and entries and exits to the circulatory roadway. Also, provides illumination to make the roundabout visible from a distance, for users approaching the roundabout.

Mini-roundabout – small roundabouts used in low-speed urban environments. The central island is fully mountable, and the splitter islands are either painted or otherwise mountable. **[See Exhibit 1-10 of NCHRP for a layout showing the features of a typical mini-roundabout.]**

Modern Roundabout – a term used to distinguish newer circular intersections, conforming to the characteristics of roundabouts, other types of circular intersections. **[See Section 1.2 of NCHRP 672 for a detailed explanation of the characteristics of a modern roundabout and comparison to other types of circular intersections.]**

Multilane roundabout – a roundabout that has at least one entry with two or more lanes, and a circulatory roadway that can accommodate more than one vehicle travelling side-by-side. **[See Exhibit 1-16 for examples of multilane roundabouts.]**

Outside Curbing – Non-mountable curb defining the outside edge of the pavement on each approach, around the circulatory roadway, and continuing outside the adjacent exit. Curbs improve delineation and discourage corner cutting, which helps to maintain lower speeds. Ideally begins at the deceleration point on each approach. **[See Section 6.8.5.2 of NCHRP 672 for further reference.]**

Right-Turn Bypass Lane – a lane provided adjacent to, but separated from the circulatory roadway, that allows right-turning or through movements to bypass the roundabout. Also known as a right-turn slip lane. A right turn bypass lane can be used to improve capacity for heavy right-turning volumes and when the geometry is too tight to allow trucks to turn with the roundabout, but should only be proposed where needed. **[See Section 6.8.6 of NCHRP 672 for a description of alternate forms of right-turn bypass lanes.]**

Sidewalk – used in urban areas to accommodate pedestrians.

Splitter Island – the raised or painted area on an approach, used to separate entering from exiting traffic, deflect and slow entering traffic, and provide storage space for pedestrians crossing the intersection approach in two stages.

8.5.2. Roundabout Design Elements

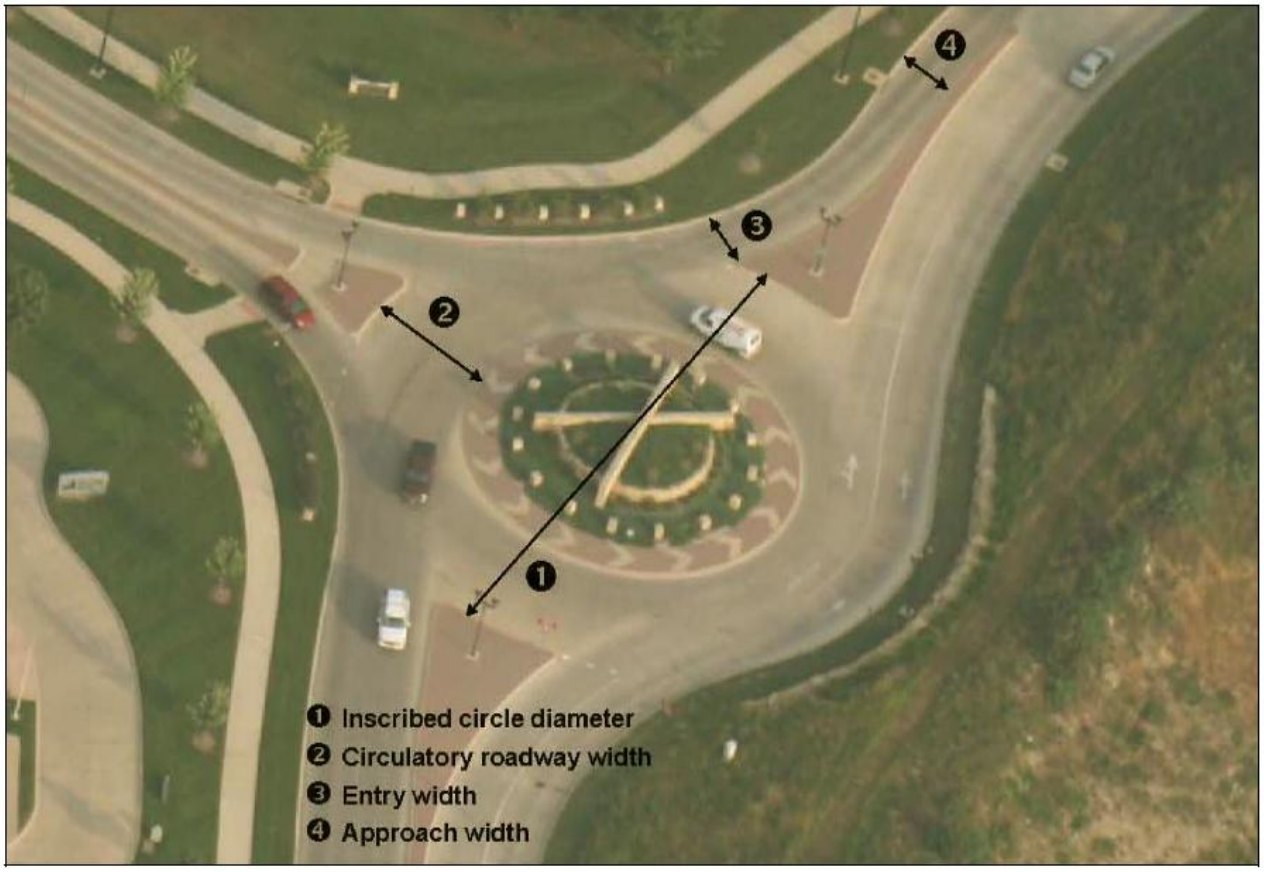


Figure 8.3. Key Roundabout Design Elements

Approach Width – the width of the roadway used by approaching traffic upstream of any changes in width associated with the roundabout.

Circulatory Roadway Width – the width between the outer edge of the circulatory roadway and the central island.

Conflict Point – a location where the paths of two vehicles, or a vehicle and a bicycle (or pedestrian), merge, diverge, cross, or queue behind each other. **[See Exhibits 5-1 and 5-2 of NCHRP 672 for illustration of vehicle conflict points at 3- and 4-leg roundabouts and a conventional intersection.]**

Deflection – the change in trajectory of a vehicle imposed by geometric features of the roadway. Entry deflection helps control vehicle speeds and discourages wrong-way movements on the circulatory roadway. **[See Exhibit 6-10 of NCHRP 672 for a comparison on entry alignments with and without deflection.]**

Entry Flare – the widening of an approach to multiple lanes to provide additional capacity at the yield line and storage. **[See Exhibit 1-8(e) of NCHRP 672 for an example of an entry flare and Section 6.5.2 of the same report for further reference.]**

Entry Speed – the speed a vehicle is traveling as it crosses the yield line.

Entry Width – the width of the entry where it meets the inscribed diameter, measured perpendicularly from the right edge of the entry to the intersection point of the left edge line and the inscribed circle.

Fastest Path – The fastest path allowed by the approach and roundabout geometry determines the negotiation speed for that particular movement into, through, and exiting the roundabout. It is the smoothest, flattest path possible for a single vehicle, in the absence of other traffic and ignoring all lane markings. **[See Section 6.7.1 of NCHRP 672 for a detailed presentation. Exhibit 6-46 for of NCHRP 672 illustrates the five critical path radii that must be checked for each approach.]**

Geometric Delay – the delay caused by the alignment of the lane or the path taken by the vehicle on a roadway or through an intersection. **[See Section 4.5.8 of NCHRP 672 for further reference.]**

Inscribed Circle Diameter – the basic parameter used to define the size of a roundabout, measured between the outer edges of the circulatory roadway. It is the diameter of the largest circle that can be inscribed within the outline of the intersection.

Locking – stoppage of traffic on the circulatory roadway caused by queuing backing into the roundabout from one of the exits, resulting in traffic being unable to enter or circulate.

Natural Path – The path an approaching vehicle will take through a multi-lane roundabout, assuming traffic in all lanes. The speed and orientation of the vehicle at the yield line determines the natural path. **[See Section 6.7.2 of NCHRP 672 for further reference.]**

Path Alignment – a roundabout should naturally align entering lanes into their appropriate lane within the circulatory roadway and then to the appropriate lanes on the exit. **[See Sections 3.5.4.2 and 6.2.3 of NCHRP 672 for further reference.]**

Roundabout Capacity – the maximum number of entering vehicles that can be reasonably expected to be served by a roundabout during a specified time period.

Vehicle Path Overlap - Path overlap occurs on multi-lane roundabouts when the natural path through the roundabout of one vehicle overlaps that of another vehicle. Occurs most commonly on the approach when a vehicle in the right lane cuts off a vehicle in the left lane as the vehicle enters the circulating lane. **[See Exhibits 6-28 and 6-33 of NCHRP 672 for illustrations of entry and exit vehicle path overlap, and Section 6.2.3 of the same report for a discussion of appropriate path alignment.]**

View Angle - View angle is measured as the angle between a vehicle's alignment at the entrance line and the sight line required according to intersection sight-distance guidelines. 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. **[See Section 6.7.4 of NCHRP 672 for further guidance.]**