Maryland State Highway Administration

Roundabout Design Guidelines

Supplement to the NCHRP Report 672 “Roundabouts: An Informational Guide”, Second Edition (2010)

The Maryland State Highway Administration (SHA) has adopted the NCHRP Report 672 “Roundabouts: An Informational Guide” Second Edition as our Roundabout Design Guideline. The information contained in this document is considered a Supplement to the NCHRP Report 672 and is intended to document SHA’s approach to the design of roundabouts. Any reference to AASHTO, unless otherwise noted, should be considered a reference to the 2001 AASHTO “A Policy on Geometric Design of Highways and Streets” Unless otherwise noted, the references throughout this supplement are found in the NCHRP Report 672 “Roundabouts: An Informational Guide” Second Edition.

The NCHRP Report 672 is available for downloaded for free from the NCHRP website. The direct link is: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf

<u>Introduction</u>

The Maryland State Highway Administration (SHA) began implementing modern roundabouts (RAB), circular at-grade intersections, in 1993. They are an effective intersection design which reduces the numbers of intersection conflict points while operating at slower speeds. This type of intersection has successfully replaced many traditional intersections that had exhibited recurring crash problems and/or operational problems. Roundabouts operate continuously, but at much slower speeds than traditional intersections and normally result in very little delay. Normal operating speeds within roundabouts are between 20 and 30 mph.

SHA has expanded the implementation of roundabouts and they are now routinely placed on facilities that typically operate at higher speeds. Crash reduction results in these environments have been positive as well (refer to *Maryland’s Roundabouts; Accident Experience & Economic Evaluation, March 2007, Office of Traffic and Safety).* However, as consideration is given to placement of objects (landscaping or fixed objects) within the central island, special care must be taken to slow traffic down in advance of the roundabout entry. The best way to achieve this speed reduction is through the use of self-enforcing roadway.

This supplement is intended to document SHA’s approach to the design and/or redesign of central island and approach alignments where approach speeds (design speed, prevailing speed or posted speed) are greater than 30 mph.

Every roundabout design is unique in that the engineer must seek a design and document the decisions that address the proper balance of approach alignment, approach speeds, operating speed, traffic volumes, pedestrian and bicyclist accommodations and site constraints. This guideline is formatted around and is to be utilized as an extension of the NCHRP Report 672.

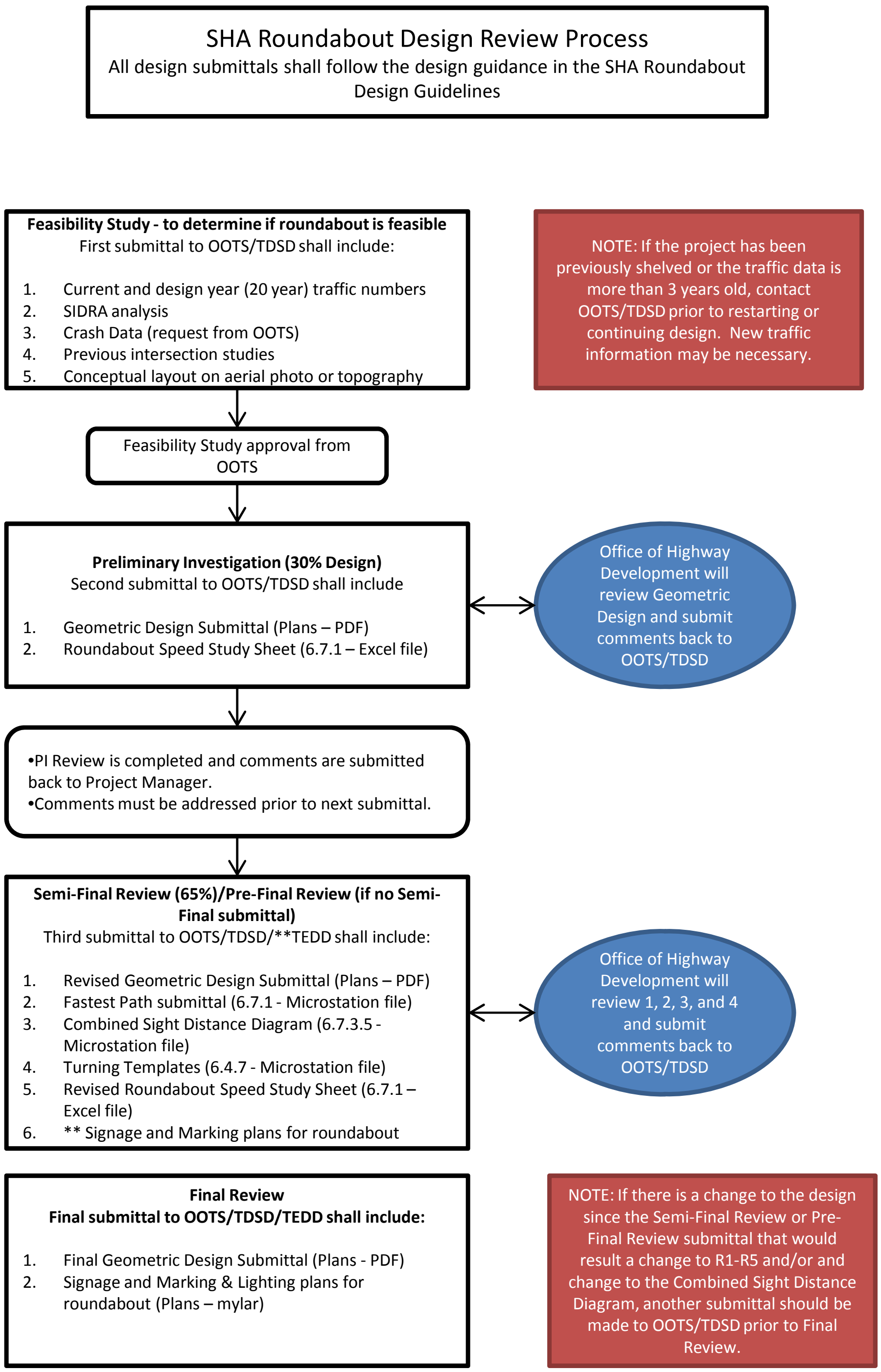
NOTE: The contents of this document are intended to serve as guidance, not as a standard or rule.

In addition to design precautions, and to ensure the intended outcomes (speed reduction, operations, and safety) have been achieved, SHA shall conduct post-construction speed studies to confirm that all constructed roundabouts with approach speeds of greater than 30 mph are exhibiting the desired deceleration characteristics. Appropriate adjustments shall be made to operating roundabouts where higher than desirable approach speeds are encountered. If adjustments are needed, please see Section 6.8.5.5 for adjustment strategies and coordinate with the Office of Traffic and Safety and District Traffic to ensure the proper adjustment strategies are considered.

Since the focus of this guidance is specific to the central island design of a roundabout and approach alignments, it is important to note that SHA, specifically District Offices, must refer to the design guidance provided in this supplement and the *Policy for Placing Fixed Objects in SHA Roundabouts* (see attached) before making any decisions on placement of a fixed object in a roundabout.

This document does not serve as a directive for providing funding sources for any improvements or betterments that are derived from this guidance. Funding sources should be identified through the appropriate fund managers or SHA senior management.

The SHA Roundabout Design Review Process flow chart has been developed to show the basic steps for roundabout design from concept development to final design. This flow chart is included on the next page and should be used for all new roundabout designs, including those designs that have been on hold and are being reconsidered.

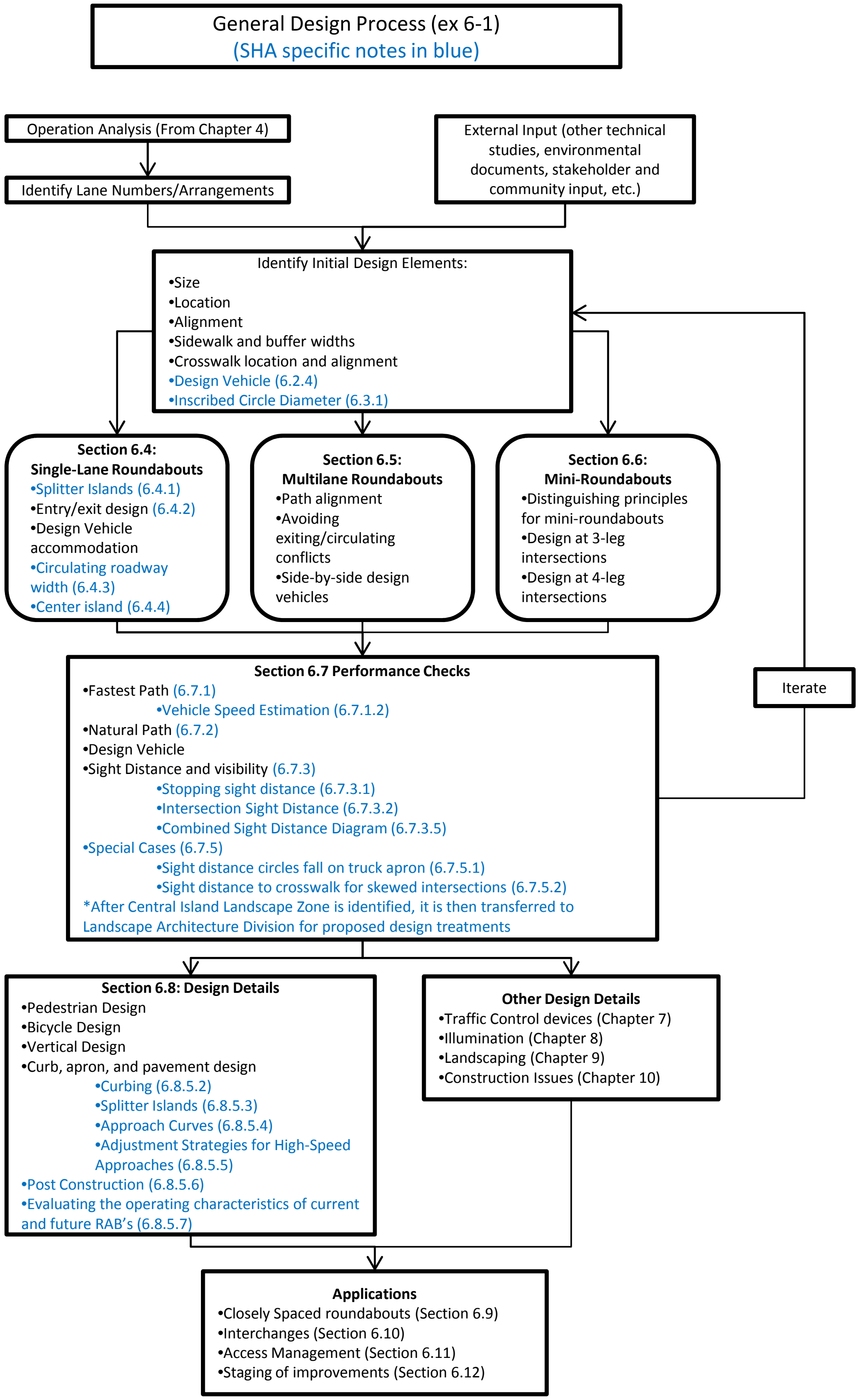

SHA Roundabout Design Review Process
All design submittals shall follow the design guidance in the SHA Roundabout Design Guidelines
Feasibility Study - to determine if roundabout is feasible
First submittal to OOTS/TDSD shall include:
1. Current and design year (20 year) traffic numbers
2. SIDRA analysis
3. Crash Data (request from OOTS)
4. Previous intersection studies
5. Conceptual layout on aerial photo or topography
NOTE: If the project has been previously shelved or the traffic data is more than 3 years old, contact OOTS/TDSD prior to restarting or continuing design. New traffic information may be necessary.
Feasibility Study approval from OOTS
Preliminary Investigation (30% Design)
Second submittal to OOTS/TDSD shall include
1. Geometric Design Submittal (Plans – PDF)
2. Roundabout Speed Study Sheet (6.7.1 – Excel file)
Office of Highway Development will review Geometric Design and submit comments back to OOTS/TDSD
•PI Review is completed and comments are submitted back to Project Manager.
•Comments must be addressed prior to next submittal.
Semi-Final Review (65%)/Pre-Final Review (if no Semi-Final submittal)
Third submittal to OOTS/TDSD/**TEDD shall include:
1. Revised Geometric Design Submittal (Plans – PDF)
2. Fastest Path submittal (6.7.1 - Microstation file)
3. Combined Sight Distance Diagram (6.7.3.5 - Microstation file)
4. Turning Templates (6.4.7 - Microstation file)
5. Revised Roundabout Speed Study Sheet (6.7.1 – Excel file)
6. ** Signage and Marking plans for roundabout
Office of Highway Development will review 1, 2, 3, and 4 and submit comments back to OOTS/TDSD
Final Review
Final submittal to OOTS/TDSD/TEDD shall include:
1. Final Geometric Design Submittal (Plans - PDF)
2. Signage and Marking & Lighting plans for roundabout (Plans – mylar)
NOTE: If there is a change to the design since the Semi-Final Review or Pre-Final Review submittal that would result a change to R1-R5 and/or and change to the Combined Sight Distance Diagram, another submittal should be made to OOTS/TDSD prior to Final Review.

6.1 INTRODUCTION

Exhibit 6-1 shows the general outline for the design process for new roundabout designs. This outline can also be used to analyze existing roundabouts.

If the existing roundabout is being analyzed because of operational issues, the engineer should coordinate with the District Traffic Office, the Office of Traffic and Safety (OOTS) and the Travel Forecasting and Analysis Division (TFAD). Before reviewing the geometry of the existing roundabout, it should be verified that the roundabout will function properly based on the traffic volumes.

When an engineer is reviewing an existing roundabout for geometric layout, it is important that all performance checks in section 6-7 are completed and documented. If survey and/or design information is not available, the engineer should research as-builts and aerial imagery information that can be found on eGIS. This information can then be referenced into Microstation to complete the performance checks.


General Design Process (ex 6-1)
(SHA specific notes in blue)
Operation Analysis (From Chapter 4)
Identify Lane Numbers/Arrangements
External Input (other technical studies, environmental documents, stakeholder and community input, etc.)
Identify Initial Design Elements:
•Size
•Location
•Alignment
•Sidewalk and buffer widths
•Crosswalk location and alignment
•Design Vehicle (6.2.4)
•Inscribed Circle Diameter (6.3.1)
Section 6.4:
Single-Lane Roundabouts
•Splitter Islands (6.4.1)
•Entry/exit design (6.4.2)
•Design Vehicle accommodation
•Circulating roadway width (6.4.3)
•Center island (6.4.4)
Section 6.5:
Multilane Roundabouts
•Path alignment
•Avoiding exiting/circulating conflicts
•Side-by-side design vehicles
Section 6.6:
Mini-Roundabouts
•Distinguishing principles for mini-roundabouts
•Design at 3-leg intersections
•Design at 4-leg intersections
Section 6.7 Performance Checks
•Fastest Path (6.7.1)
•Vehicle Speed Estimation (6.7.1.2)
•Natural Path (6.7.2)
•Design Vehicle
•Sight Distance and visibility (6.7.3)
•Stopping sight distance (6.7.3.1)
•Intersection Sight Distance (6.7.3.2)
•Combined Sight Distance Diagram (6.7.3.5)
•Special Cases (6.7.5)
•Sight distance circles fall on truck apron (6.7.5.1)
•Sight distance to crosswalk for skewed intersections (6.7.5.2)
*After Central Island Landscape Zone is identified, it is then transferred to Landscape Architecture Division for proposed design treatments
Iterate
Section 6.8: Design Details
•Pedestrian Design
•Bicycle Design
•Vertical Design
•Curb, apron, and pavement design
•Curbing (6.8.5.2)
•Splitter Islands (6.8.5.3)
•Approach Curves (6.8.5.4)
•Adjustment Strategies for High-Speed Approaches (6.8.5.5)
•Post Construction (6.8.5.6)
•Evaluating the operating characteristics of current and future RAB's (6.8.5.7)
Other Design Details
•Traffic Control devices (Chapter 7)
•Illumination (Chapter 8)
•Landscaping (Chapter 9)
•Construction Issues (Chapter 10)
Applications
•Closely Spaced roundabouts (Section 6.9)
•Interchanges (Section 6.10)
•Access Management (Section 6.11)
•Staging of improvements (Section 6.12)

6.2 PRINCIPLES AND OBJECTIVES

6.2.4 DESIGN VEHICLE

Selection of the appropriate design vehicle is crucial when laying out and analyzing the geometrics of a roundabout. It is important that the designer should clearly document the design vehicle prior to progressing into final design. If the design vehicle changes once the design has started, it is likely that the designer will need to start the design over in order to address the geometrics to accommodate the design vehicle.

When considering a design vehicle, the designer will need to coordinate with District Traffic Offices and Travel Forecasting and Analysis Division to understand the need for special design vehicles that may dictate the geometrics of the roundabout. For instance, in eastern Maryland, there may be significant farm equipment that utilizes the corridor the roundabout is being designed for. If this is the case, the geometrics of the roundabout may need to be adjusted to accommodate the farm equipment. This is a local situation that will likely be known by District Traffic.

When documenting the decision for the design vehicle, it is important to understand the movement that the design vehicle will be making. For instance, if the design vehicle is a WB-67, and the side streets prohibit trucks, it may not be appropriate to design the roundabout to accommodate all movements of the design vehicle to all legs of the roundabout. This can have significant impacts on the design of the roundabout and the size of the inscribed diameter and mountable truck aprons.

For most situations throughout Maryland, the designer should consider a WB-67 as the preferred design vehicle for all roundabouts, unless the roundabout is in an urban setting which prohibits trucks along the side roads. In those cases, it is important that the designer coordinates with the District Traffic office and local jurisdictions to understand the design vehicle needed.

6.3 SIZE, POSITION, AND ALIGNMENT OF APPROACHES

6.3.1 INSCRIBED CIRCLE DIAMETER

SHA projects should be designed to accommodate the appropriate design vehicle. As stated in 6.2.4, the preferred design vehicle for SHA is a WB-67. In some cases, the design vehicle will be a WB-50. The minimum suggested inscribed diameter for a WB-50 (105 ft.) may be appropriate if there are design constraints that prohibit a larger diameter and if there are low-speed approaches to the roundabout. It is recommended that the designer should consider a diameter of at least 120 ft. when laying out the roundabout using a WB-50. If the design vehicle is larger than a WB-50, a larger inscribed diameter will be required.

Roundabouts with inscribed circle diameters less than 120 ft. but greater than 90 ft., although not considered mini-roundabouts, are not preferred by SHA. Inscribed circle diameters in this range can lead to very small to no area in the central island for landscaping. Little to no landscaping in the central islands leads to a greater visibility for approaching vehicles which is not considered favorable. The process to determine the appropriate sight distance can be found in section 6.7.

Roundabouts less than 90 ft. are considered mini-roundabouts. Mini-roundabouts should only be considered for existing low speed urban conditions where environmental and right-of-way impacts preclude the use of a larger roundabout. Central islands on mini-roundabouts are typically traversable and must remain free of landscaping and fixed objects in all cases.

6.4 SINGLE-LANE ROUNDABOUTS

6.4.1 SPLITTER ISLANDS

Splitter islands should be a minimum length of 100 ft. on SHA projects. See Section 6.8.5.3 for more details.

Preferably, splitter islands should be raised using Standard Type A Curb and Gutter (Standard No. MD-620.02). The corners of the splitter island should be nosed down as shown in Figure 6.4.1-1 below.

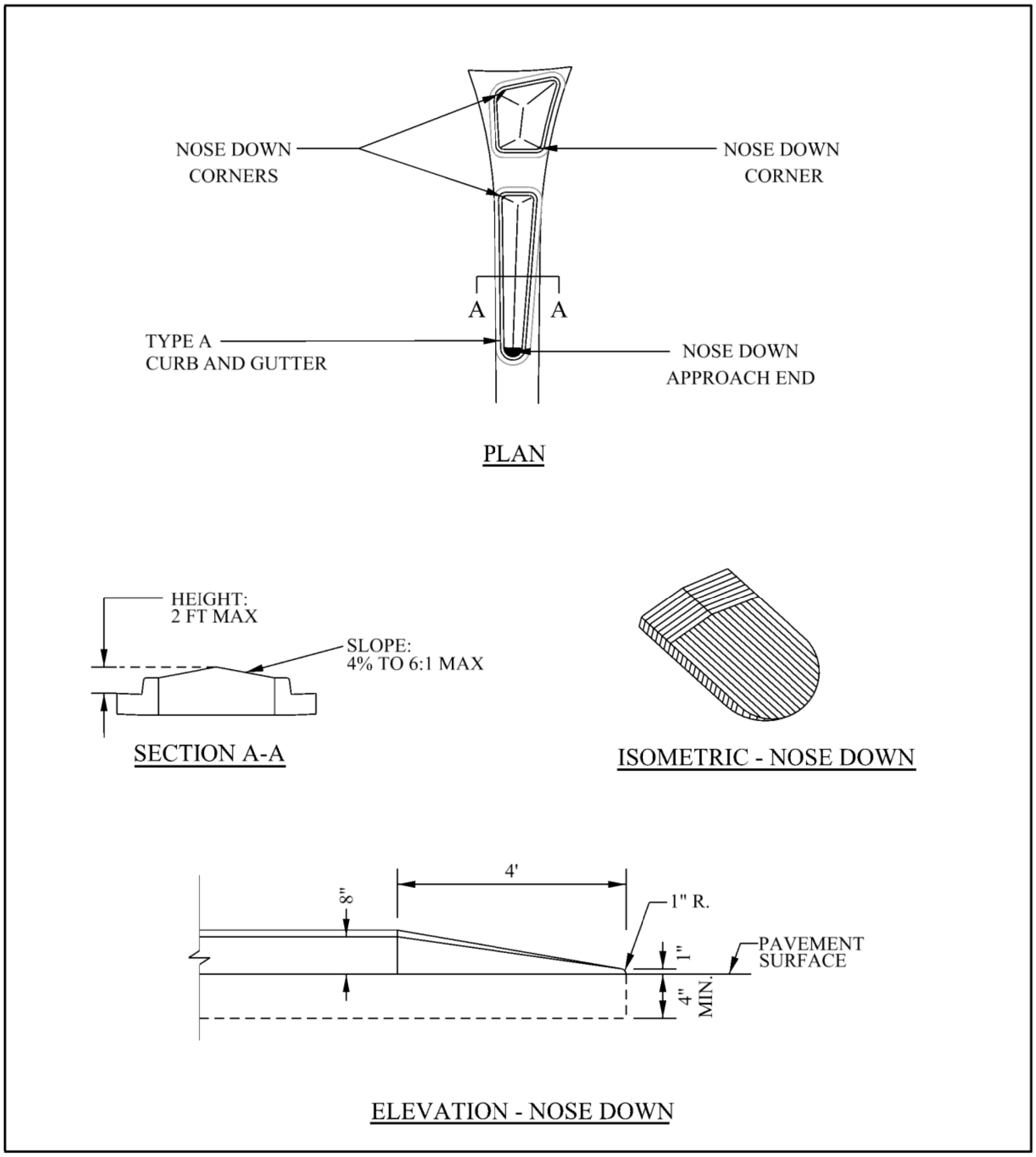


FIGURE 6.4.1-1

At intersections with restricted right-of-way, it may be necessary to use Type C Curb and Gutter when the design vehicle cannot pass through the entry or exits with at least 2 ft. of clearance to the face of vertical curb. In that case, use Figure 6.4.1-2 shown below for the splitter islands.

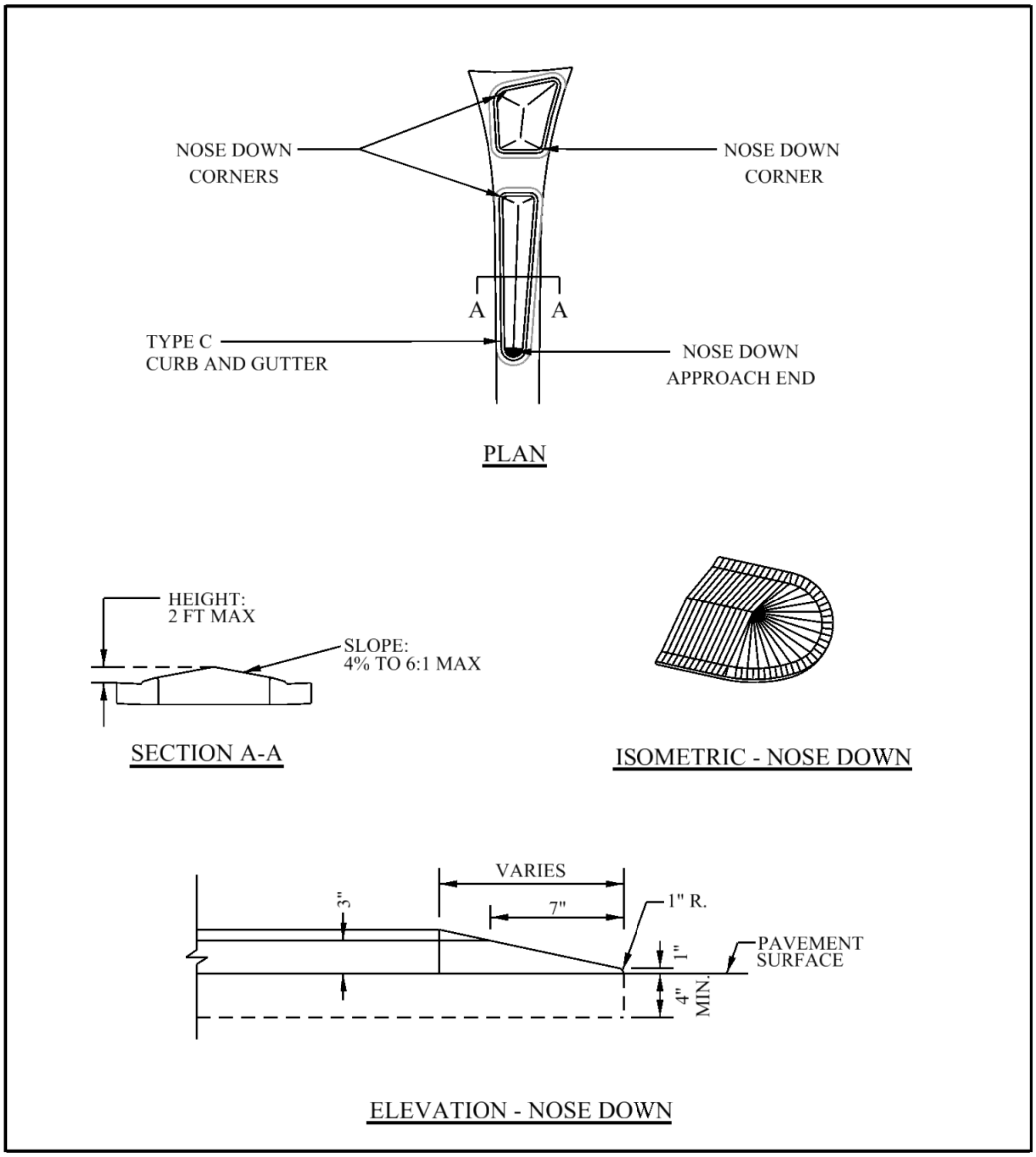


FIGURE 6.4.1-2

The portion of the splitter island that is narrower than 6 ft. wide should be hardscaped with traffic-bearing, context sensitive treatments. The area that is wider than 6 ft. may be landscaped with turfgrass or appropriate plantings in conformance with sight distance requirements and other safety considerations as approved by the Office of Environmental Design.

6.4.2 ENTRY WIDTH

Entry widths should range from 14-18 ft. and should not exceed the width of the circulatory roadway.

6.4.3 CIRCULATORY ROADWAY WIDTH

The circulatory roadway width should be as wide as the maximum entry width and up to 120% greater than the maximum entry width. The circulatory roadway should also be wide enough to accommodate a bus without the use of a truck apron. Where truck traffic is considered high (10% or greater), it is advised to have the circulatory roadway wide enough to accommodate a WB-50 without the use of a truck apron so capacity of the roundabout is not compromised. Increasing the inscribed circle diameter will also aid in this accommodation.

A truck apron is standard on all SHA projects to accommodate the turning movements of a WB-67 design vehicle.

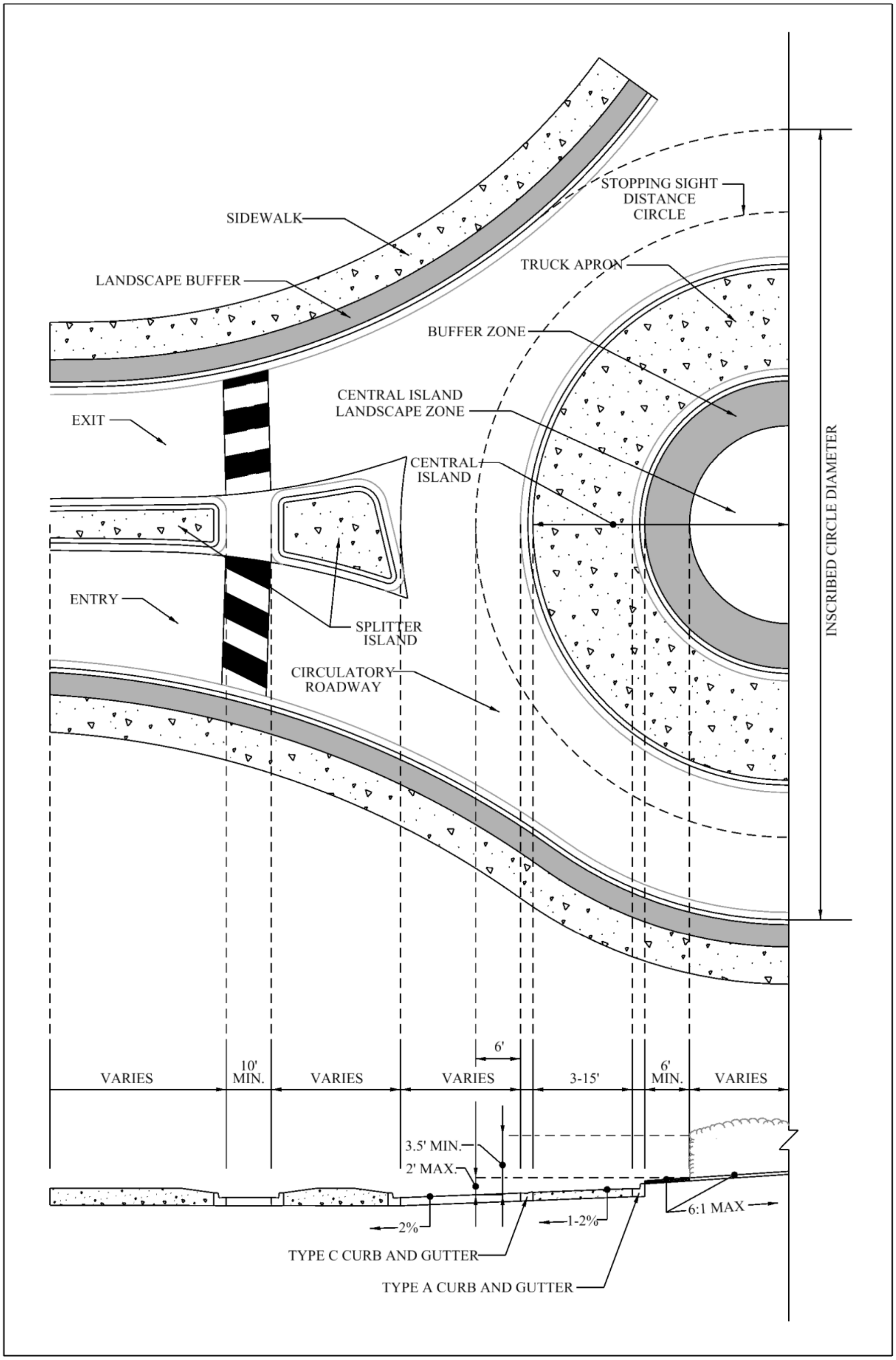
6.4.4 CENTRAL ISLAND

The central island consists of 3 zones which are the truck apron, buffer zone, and landscape zone. Raised central islands are preferred over depressed central islands since depressed central islands are difficult for approaching drivers to recognize and drainage can become an issue. The central island grading and landscaping should be designed to provide the minimum required sight distance. Providing more than the minimum sight distance may result in excessive speeds within the roundabout and should not be considered. Follow the guidance set forth in Section 6.7.3 in order to obtain the limits of the Central Island Buffer and Landscape Zones.

The Central Island Buffer Zone should be a minimum 6 ft. wide behind the Type A Curb and Gutter to allow for vehicle overhang. The width of the zone may increase in accordance with Section 6.7.3 as necessary to provide the minimum required sight distance. Within this zone, the combined height of the grading and the landscaping should be less than 2 ft. in height from circle which the stopping sight distance along the circulatory roadway is measured. This circle is shown in Exhibit 6-56 and is offset 6 ft. from the flowline of the truck apron (See Figure 6.4.4-1). Preferred treatments for the Central Island Buffer Zone are turfgrass or hardscape.

The Central Island Landscape Zone should be graded and landscaped to obtain a combined height of 3.5 ft. or greater above the elevation of the circulatory roadway also from the circle which the stopping sight distance along the circulatory roadway is measured. When designing landscaped central islands within areas of existing pavement, consideration should be taken to remove paving and subbase material unsuitable for plant growth, scarify compacted subgrade, and place necessary subsoil and topsoil.

All landscaping treatments must be coordinated with the Office of Environmental Design.



SIDEWALK
LANDSCAPE BUFFER
STOPPING SIGHT DISTANCE CIRCLE
TRUCK APRON
BUFFER ZONE
CENTRAL ISLAND LANDSCAPE ZONE
CENTRAL ISLAND
EXIT
ENTRY
SPLITTER ISLAND
CIRCULATORY ROADWAY
INSCRIBED CIRCLE DIAMETER
6'
VARIES
10' MIN.
VARIES
VARIES
3-15'
6' MIN.
VARIES
3.5' MIN.
2' MAX.
2%
1-2%
6:1 MAX
TYPE C CURB AND GUTTER
TYPE A CURB AND GUTTER

FIGURE 6.4.4-1

The central island should not contain features which are likely to attract pedestrians. Examples of such features are flagpoles, memorial plaques, pedestrian-scale statues or artwork, benches, etc. When requests are received for the placement of such features, SHA shall identify the appropriate locations in the vicinity of the roundabout that can be considered in lieu of the central island. The costs of installation, lighting and maintenance of such features shall be the responsibility of the municipality. Please refer to the latest SHA adopted *AASHTO Roadside Design Guide* when placing any fixed objects near the roadway.

Any requests be considered by SHA for the placement of features mentioned above or any fixed object within the central island of a roundabout shall be in compliance with the *SHA Policy for Placing Fixed Objects in SHA Roundabouts.* Before any final decision is made on whether or not fixed objects can be placed in the central island of the roundabout, coordination with the District Office and the Office of Traffic and Safety is required.

Identification of the Central Island Landscape Zone as described in 6.7.3.5 must be completed prior to a final decision on the location of any proposed fixed object within the central island of the roundabout.

6.4.5 ENTRY DESIGN

The outside curb line of the entry should be designed cuvilinearly tangential to the outside edge of the circulatory roadway. The inside roadway edge of entry should be curvilinearly tangential to the truck apron.

The minimum entry radii should be 65ft. so that capacity of the roundabout is not affected.

Entry angles (phi) should be between 20 and 40 degrees with 30 degrees desired. Figures 6.4.5-1 and 6.4.5-2 on the next page are derived from the WisDOT Roundabout Guide. Figure 6.4.5-1 is to be used to find phi when distance from the entry to the next exit is not more than 100 ft. Use Figure 6.4.5-2 to find phi when the distance from the entry to the next exit is greater than 100 ft. such as at 3 legged roundabouts.

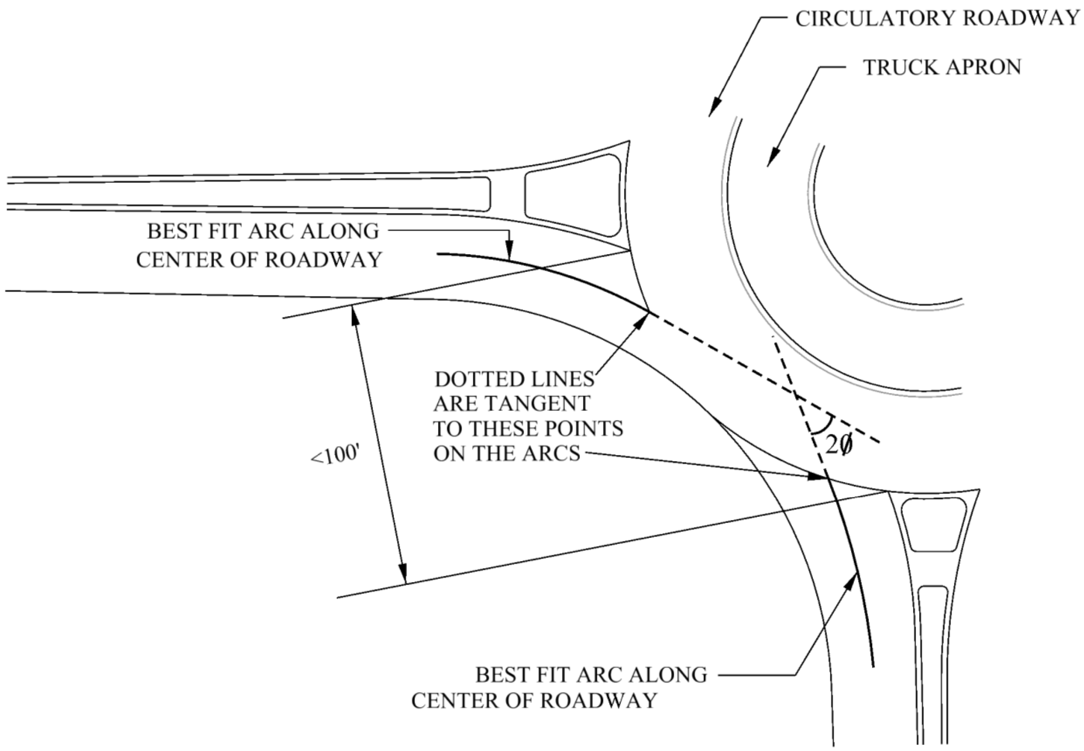


FIGURE 6.4.5-1

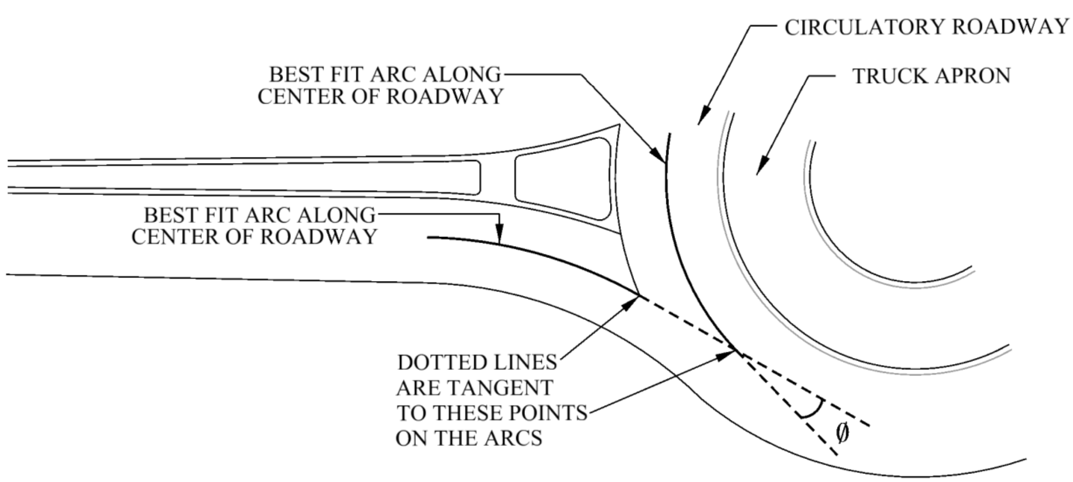


FIGURE 6.4.5-2

6.4.6 EXIT DESIGN

The outside curb line of the exit should be designed cuvilinearly tangential to the outside edge of the circulatory roadway. The inside roadway edge of the exit should be curvilinearly tangential to the truck apron.

A large-radius or tangential type exit design as illustrated in Exhibit 6-16 should only be used in rural environments where no pedestrian traffic is expected since it increases exit speeds.

6.4.7 DESIGN VEHICLE

The design vehicle for SHA projects is a WB-67. It may be occasionally appropriate to choose a smaller design vehicle for turning movements and a larger design vehicle for through movements. For example, if a roundabout is placed at the intersection of a state route and a county route, it may be reasonable to design so that a WB-50 can easily make left turns, right turns, and through movements, but a WB-67 vehicle can only travel straight through the roundabout along the state route. This technique can be used at the discretion of the engineer and should be discussed and approved by the Office of Traffic and Safety, District Traffic Office, and the Travel Forecasting and Analysis Division.

CAD-based vehicle-turning-path simulation software should be used to determine if the roundabout design appropriately accommodates the design vehicle. Roundabout design is iterative so the software should be used each time a design is changed or modified. The final circulating paths generated by the CAD-based vehicle-turning-path simulation software should be archived with the project documents.

6.4.7.1 TRUCK APRONS

Truck aprons should be designed so they are traversable to trucks but discourage use by passenger vehicles. To discourage use by passenger vehicles, truck aprons should be designed with Type C Curb and Gutter between the circulatory roadway and the truck apron. The apron should be constructed of reinforced concrete or other traffic bearing material as approved by the Office of Materials and Testing. The material used should differentiate it from both the circulatory roadway and sidewalk if present. To minimize damage by design vehicles to the central island signs and landscaping, truck aprons should be separated from the Central Island Buffer Zone by Type A Curb and Gutter.

Truck apron width is dictated by the tracking of the design vehicle using CAD-based vehicle-turning-path simulation software. They should generally be 3 to 15 ft. wide and have a cross slope of 1 to 2% away from the central island. When the minimum truck apron width is less than a typical shoulder width, the truck apron may be increased to provide a full shoulder for maintenance activities in the central island.

6.5 MULTILANE ROUNDABOUTS

6.5.1 LANE NUMBERS AND ARRANGEMENTS

Lane numbers and arrangements should be provided to the Office of Highway Development from Travel Forecasting and Analysis Division.

6.5.2 ENTRY WIDTH

A two lane entry should be 24 to 30 ft. wide and a three lane entry should be 36 to 45 ft. wide with individual lanes ranging from 12 to 15 ft. in both cases depending on the turning requirements of the design vehicle.

In cases where a single lane enters a multilane roundabout, the entry width should be flared from the upstream roadway width, but the flare length should not exceed 330 ft. as any length greater than that has no effect on capacity (WisDOT Roundabout Guide 11-26-30, pg 10). If additional capacity is required, a lane should be added as shown in Exhibit 6-24.

6.5.3 CIRCULATORY ROADWAY WIDTH

Circulatory roadway lane widths should range from 14 to 16 ft. Where truck traffic is high (greater than 10%), the roadway width may need to be increased to accommodate simultaneous passage of a truck and a car (See Section 6.5.7 for more information).

6.5.4 ENTRY GEOMETRY AND APPROACH ALIGNMENT

For multilane roundabouts, it is important to avoid vehicle path overlap between the lanes. One design aspect for avoiding vehicle path overlap is a compound curve entry design. The first entry curve radius should be 65 to 120 ft. followed by the larger curve with a radius greater than 150 ft. A tangent section instead of the large radius curve may be used if necessary. The first entry curve should be set back from the circulatory roadway by at least 20 ft. (6-40). See Exhibit 6-30 for more details.

Another important aspect for multilane roundabouts is providing sufficient deflection on the entry. This can be achieved by offsetting the approach to the left of the center of the roundabout typically by 20 to 30 ft.

Guidance for checking path overlap does not exist in NCHRP 672; however WisDOT provides a clear method. Figure 6.5.4-1 on the next page shows the desirable entry path tangent being 40 to 50 ft. and the desirable exit path tangent being greater than 40 ft. It is also important to note that providing 5 ft. between the face of the central island curb and the extension of the face of curb on the splitter island usually results in avoiding vehicle path overlap.

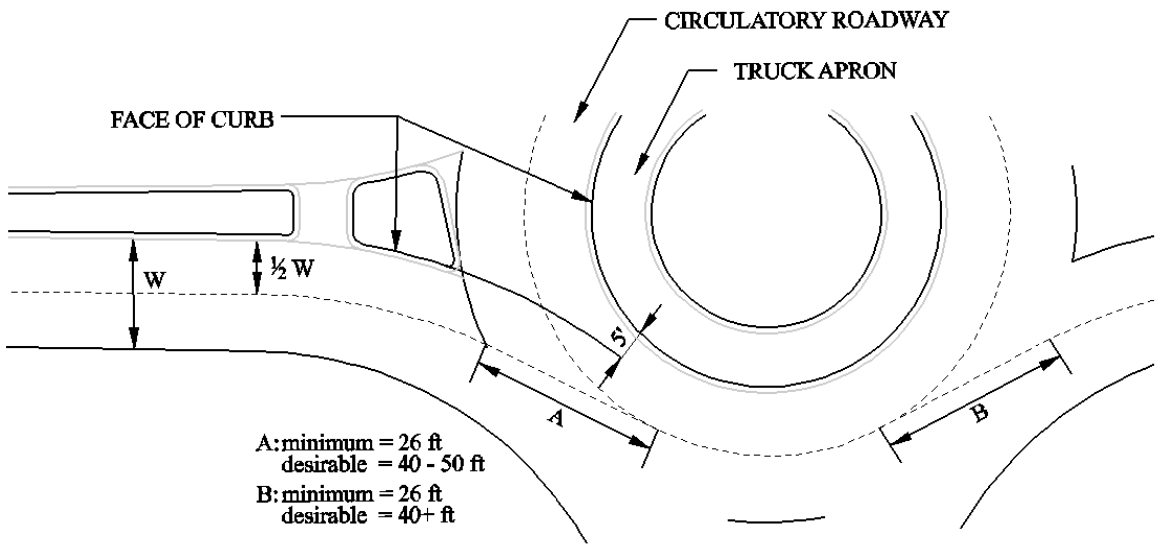


FIGURE 6.5.4-1

6.5.7 DESIGN VEHICLE CONSIDERATIONS

Side by side navigation through the roundabout must be considered for multilane roundabouts. In areas where truck traffic is low, a WB-67 can be allowed to claim both lanes to navigate through the roundabout. In this case, it may be appropriate to design for the side by side navigation of a single unit truck or bus and a passenger car. However, allowing a WB- 67 to claim both lanes in areas where truck traffic is high will result in reduced capacity. See page 6-44 of the NCHRP Guide for design techniques for accommodating large design vehicles.

6.7 PERFORMANCE CHECKS

It is necessary for the project engineer to properly document the design decisions along with the performance checks discussed in this section for every roundabout project. This information should be stored with the project files and included in the appropriate design milestone report.

6.7.1 FASTEST PATH

Every SHA project that contains a roundabout within the project limits ***MUST*** check the roundabout for entry speed and sight distance. This applies to new design as well as existing roundabouts. The method for checking a roundabout begins with drawing the fastest paths for each leg in order to obtain the R values (see Exhibits 6-46 thru 6-50). Once the R values are obtained, the corresponding speeds, V, for each R value can be calculated. Download the Roundabout Speed Study Sheet for the roundabout calculations from the Office of Highway Development Intranet site \Design Resources\eLibrary\roundabout speed study sheet\.

6.7.1.2 VEHICLE SPEED ESTIMATION

For normal approaches and normal roundabout cross slope calculate the corresponding speeds, V, as follows:

For R1, R3, and R5	use Equation 6-1
For R2 and R4	use Equation 6-2

If the approach and roundabout cross slopes are not 2%, please refer to Appendix D for information on how to derive the speed equation.

The speeds associated with the R1 values are considered entry speeds. The maximum entry speeds must be as follows:

25 mph	for single lane roundabouts
30 mph	for multilane roundabouts

If any one of the entry speeds exceeds the limit for that type of roundabout, the geometry should be modified so that the entry speed is reduced to meet the guidelines.

6.7.3.1 STOPPING SIGHT DISTANCE

When calculating the three types of stopping sight distances use Equation 6-5 and consider the following:

1. For ***approach sight distance***, V is equal to the design speed of the roadway prior to the roundabout. The distance, d, that is calculated is used to draw the sight triangles to both the yield line and the beginning of the crosswalk. Use Exhibit 6-55 for drawing the sight triangles to the yield line and use Figure 6.7.3.1-1 to draw the sight triangles to the crosswalk.

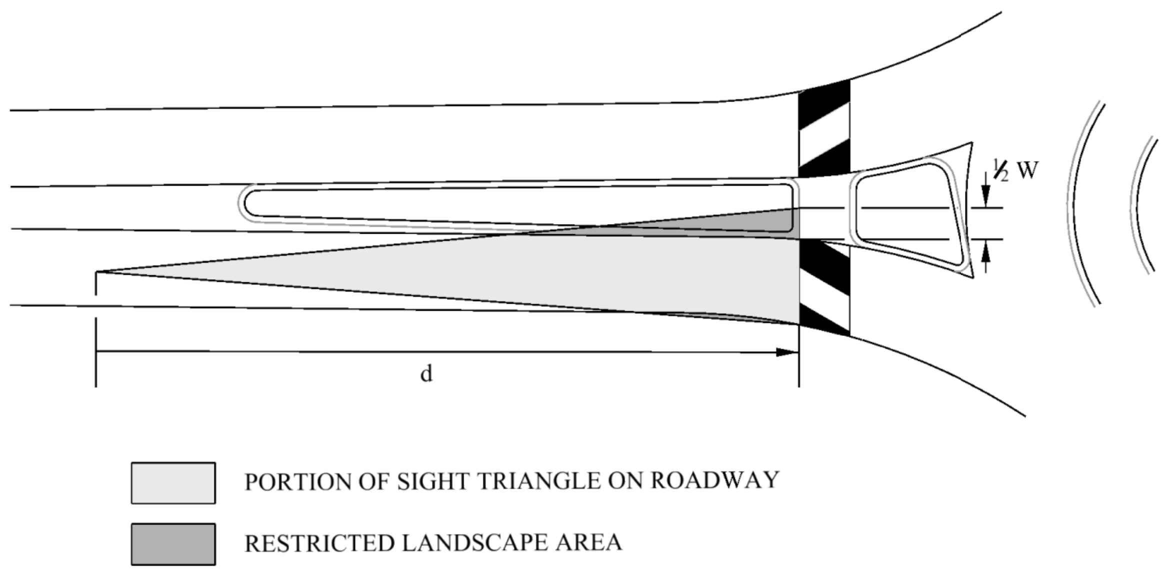


FIGURE 6.7.3.1-1

2. For ***sight distance on circulatory roadway***, use the V that corresponds to the largest of all R2 and R4 values. The distance, d, that is calculated is used to draw the stopping sight distance line as shown in Exhibit 6-56. d and the corresponding stopping sight distance line should be drawn for each leg and placed on the same diagram similar to Figure 6.7.3.1-2. The stopping sight distance lines will form a box in which the Stopping Sight Distance Landscape Buffer can then be drawn. The Stopping Sight Distance Landscape Buffer should be concentric to the central island and a minimum of 6 ft. from the back of the Type A Curb and Gutter.

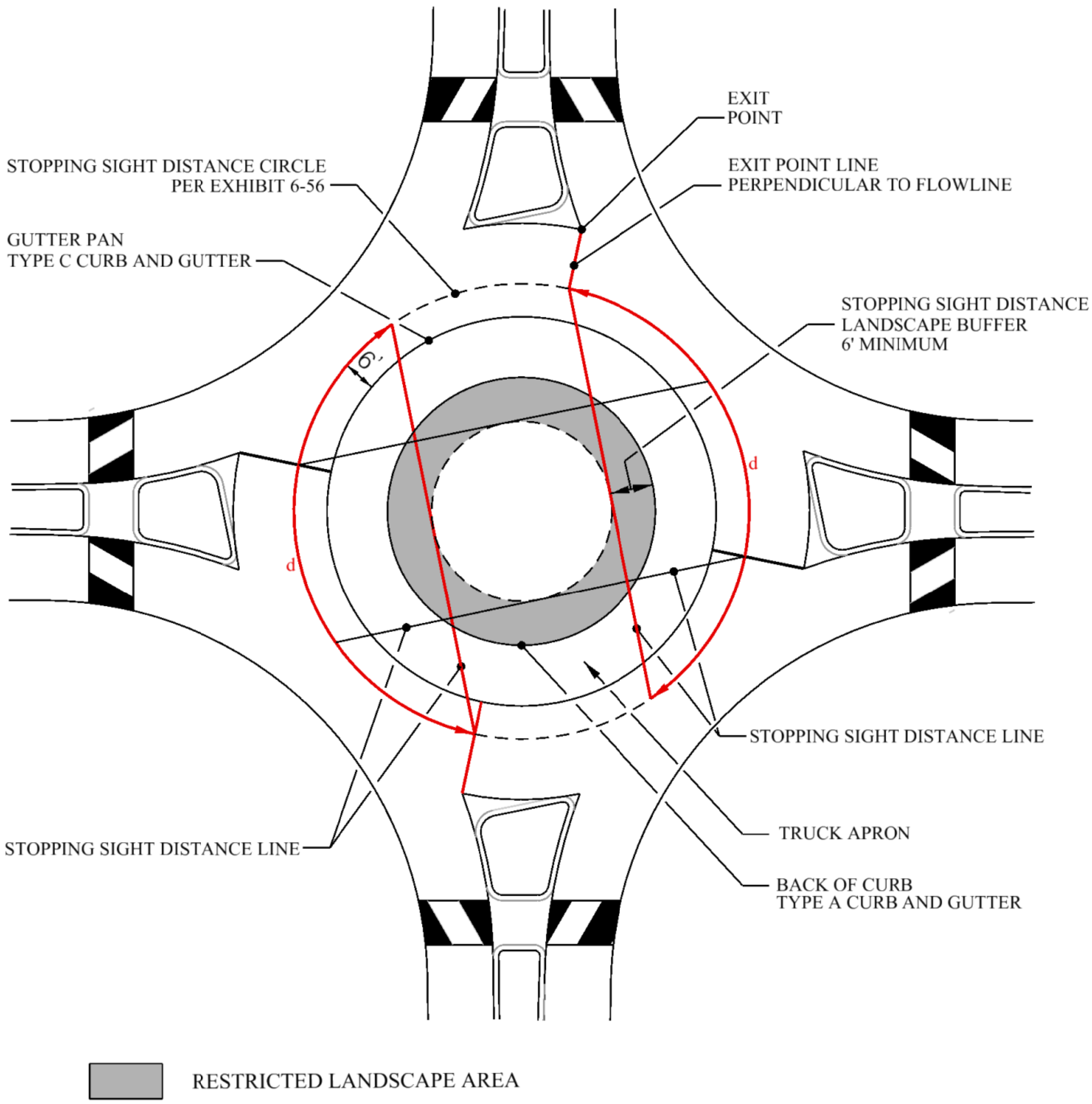


FIGURE 6.7.3.1-2

3. For ***sight distance to crosswalk on exit***, use the V that corresponds to the R5 value from the leg to the left of the crosswalk to calculate d. Draw the sight distance to crosswalk lines as shown in Figure 6.7.3.1-3.

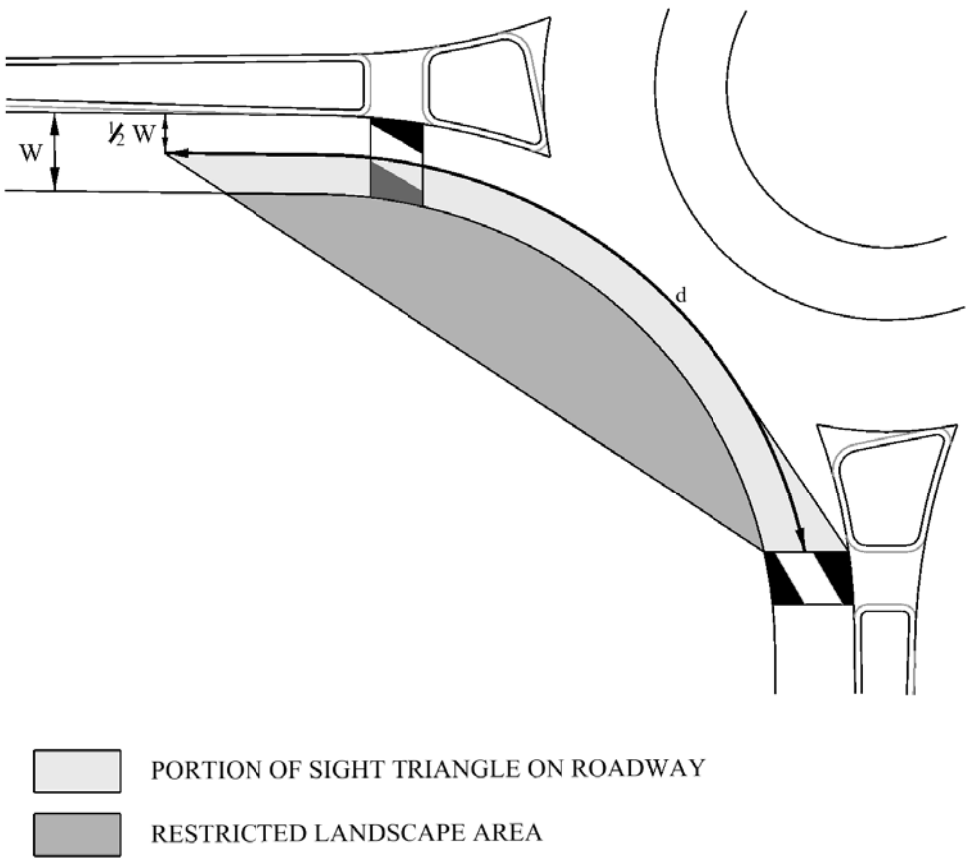


FIGURE 6.7.3.1-3

6.7.3.2 INTERSECTION SIGHT DISTANCE

Intersection sight distance requires calculating d_1 and d_2 for each leg by using Equations 6-6 and 6-7, respectively. When calculating d_1 for a specific leg of the roundabout, the V is based on an average of the R1 and R2 values from the leg to the left (see Exhibit 6-58). When calculating d_2, use the V that corresponds to the largest of all R2 and R4 values. The d_2 value is the same for all legs. All of the intersection sight lines for each leg should be put on a single diagram similar to Figure 6.7.3.2-1 below.

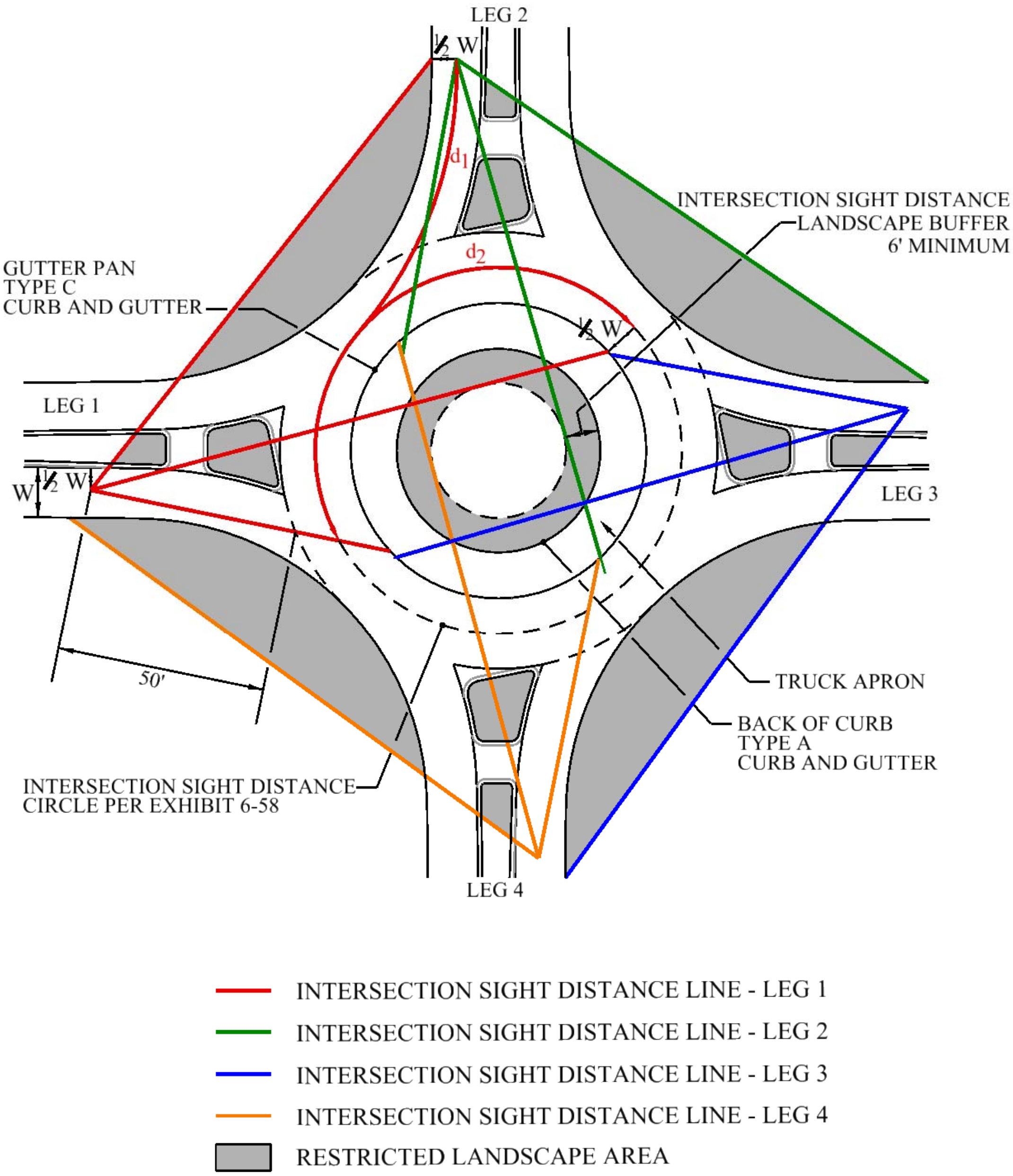


FIGURE 6.7.3.2-1

6.7.3.5 COMBINED SIGHT DISTANCE DIAGRAM

In order to create a Combined Sight Distance Diagram (CSDD), overlay all of the stopping sight distance and intersection sight distance lines on the roundabout drawing. See Figure 6.7.3.5-1.

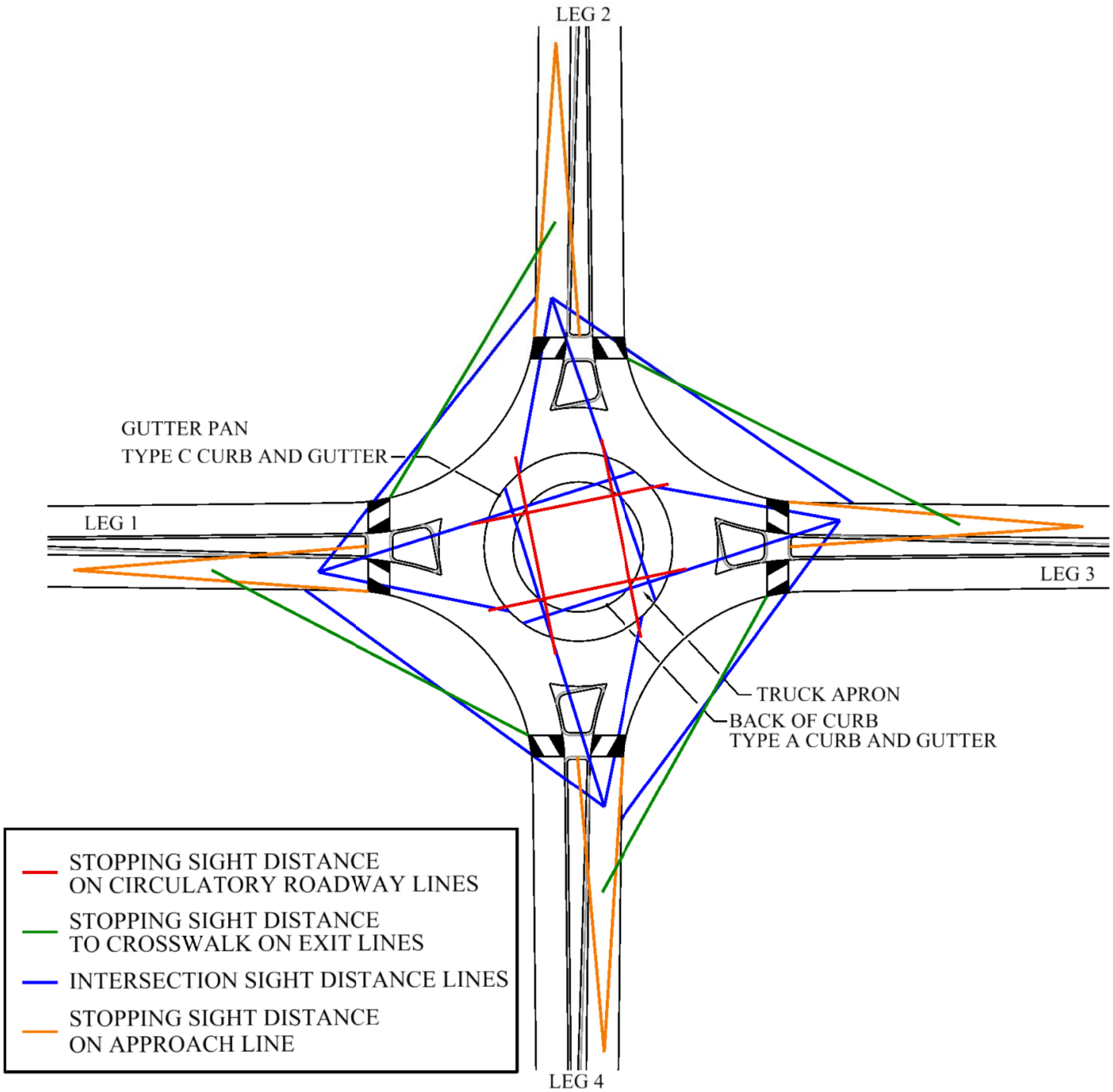


FIGURE 6.7.3.5-1

Keep the lines that provide the most conservative sight distance estimates in order to shade the areas that must remain clear of obstructions. See Figure 6.7.3.5-2.

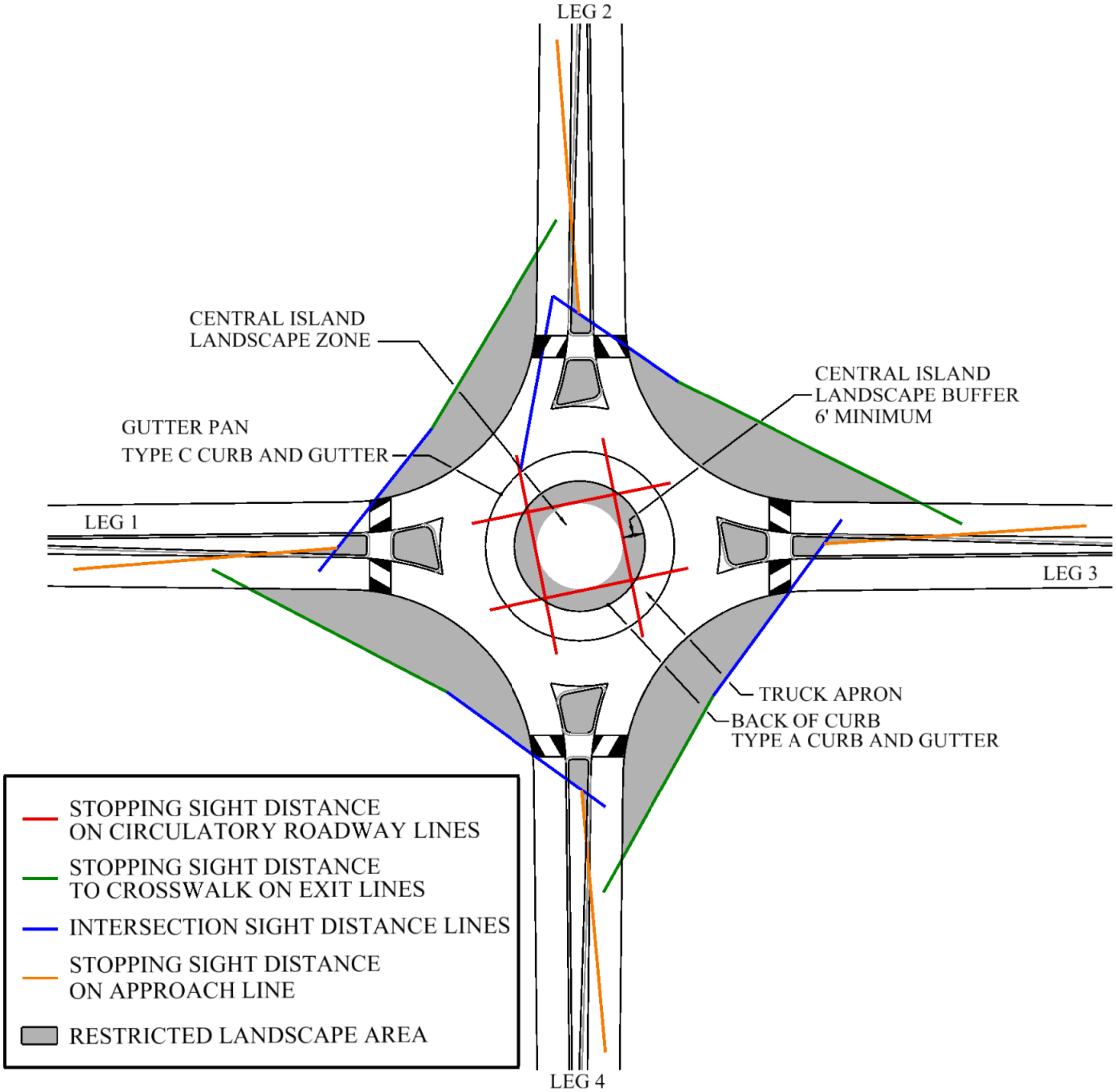


FIGURE 6.7.3.5-2

This diagram should be provided to the Landscape Architecture Division to ensure the roundabout landscaping and central island grading will be designed to maintain the required sight distance.

NOTE: providing more sight distance than shown in the diagram above may lead to higher vehicle speeds and reduce the safety of the intersection (NCHRP pg 6-64).

6.7.5 SPECIAL CASES

This section does not exist in the NCHRP manual; however there are a few special cases to clarify.

6.7.5.1 SIGHT DISTANCE CIRCLES FALL ON THE TRUCK APRON

Sometimes when the inscribed circle diameter of the roundabout is large and the speeds associated with the R values are low, the stopping sight distance and the intersection sight distance circles for the central island fall on the truck apron. This means that a Central Island Landscape Buffer is not necessary for sight distance; however, one should be provided at a 6 ft. minimum offset from the back of the Type A Curb and Gutter behind the truck apron. The Central Island Landscape Buffer is to remain free of obstructions and landscaping over 2 ft. in height above the circulatory roadway to minimize encroachment of larger landscaping into the truck apron, keep roundabout signs clear of vegetation, and simplify maintenance. See Figure 6.7.5.1-1.

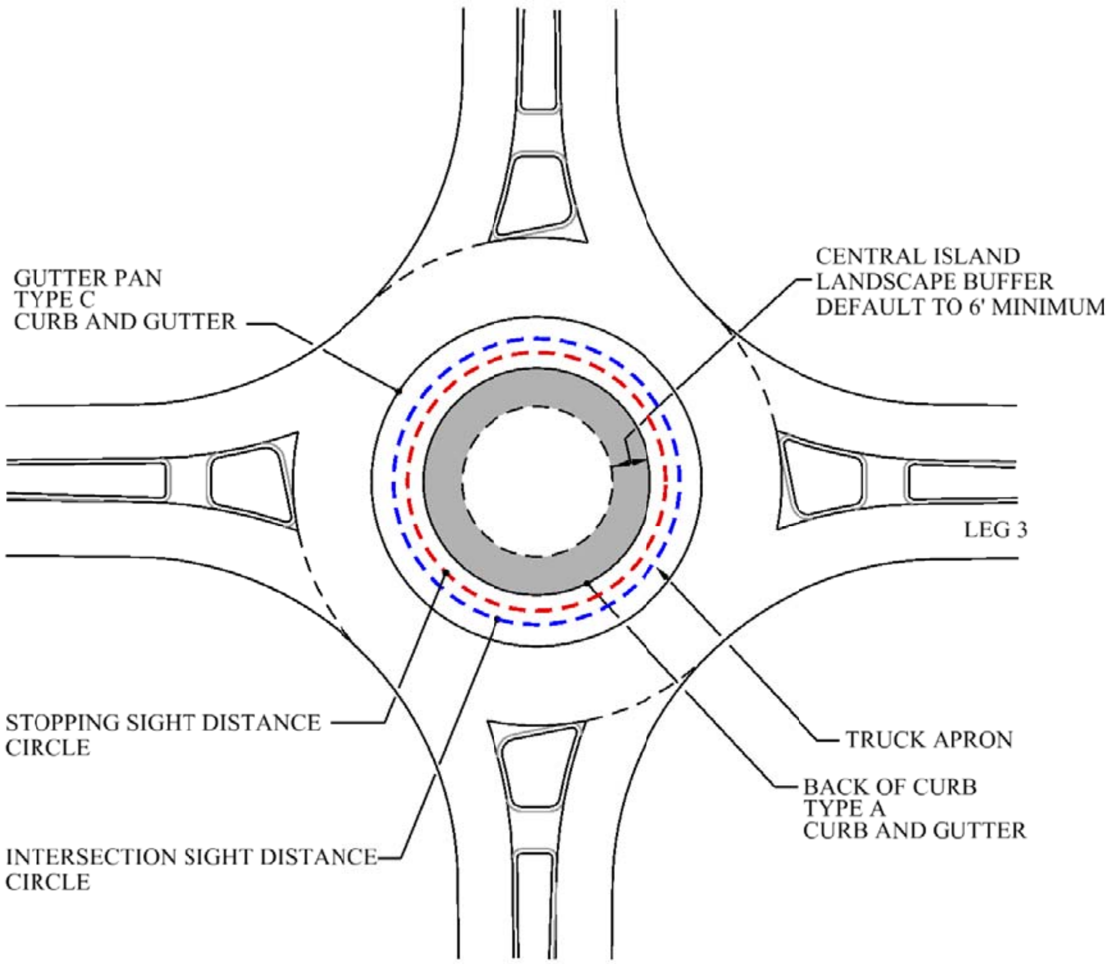


FIGURE 6.7.5.1-1

6.7.5.2 SIGHT DISTANCE TO CROSSWALK FOR SKEWED INTERSECTIONS

At skewed intersections, the right turn movement path is similar to a through movement path. Therefore, a single R5 value cannot be drawn. Instead the right turn path will consist of three R values: R5a, R5b, and R5c as shown in Figure 6.7.5.2-1.

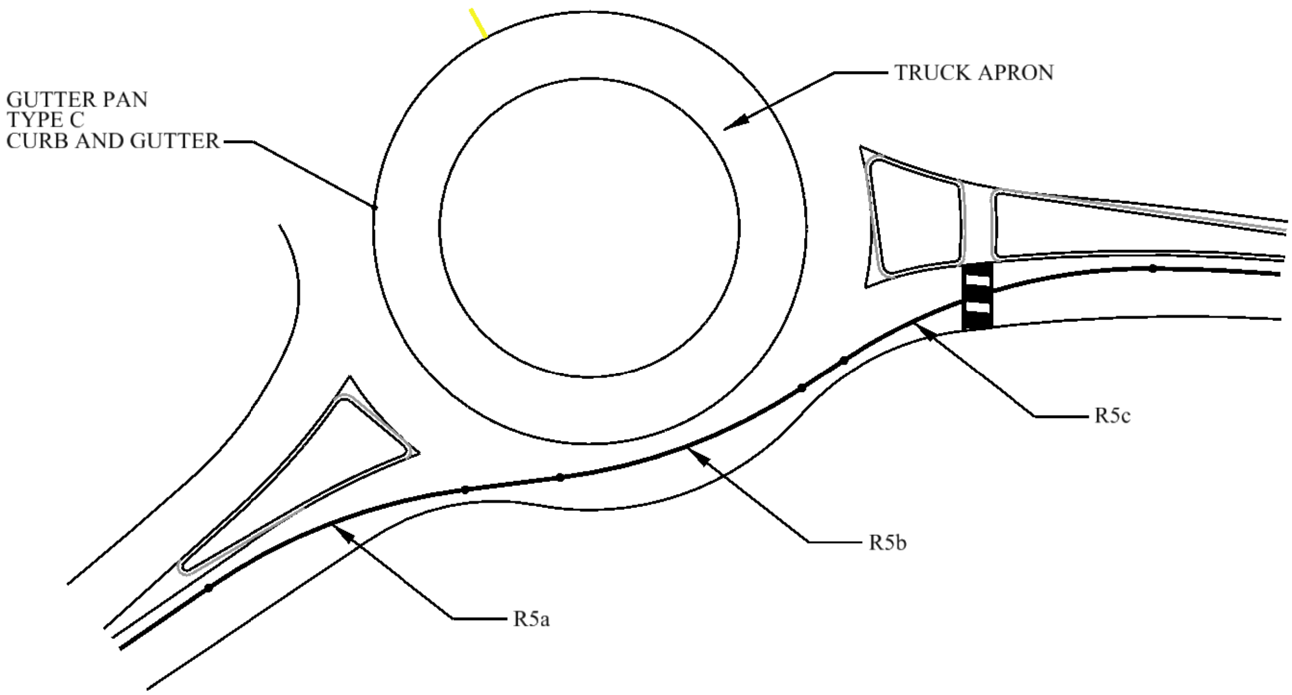


FIGURE 6.7.5.2-1

The speed, V, associated with the R5b value should be used to calculate the stopping sight distance, d, needed to the crosswalk. The stopping sight distance to the crosswalk should then be drawn according to Exhibit C in this report.

If the distance, d, from the crosswalk falls along the curve R5b, then the sight lines can be drawn from that point. If the distance, d, falls along the curve R5a, then the speed V must be recalculated using the average of the R5a and R5b values.

6.8 DESIGN DETAILS

6.8.1 PEDESTRIAN DESIGN CONSIDERATIONS

6.8.1.1 SIDEWALKS

The minimum sidewalk width on SHA projects is 5 ft. This width should be as wide as 10 ft in high pedestrian areas. The preferred landscape buffer width between the curb and the sidewalk is 5 ft or greater although where right-of-way is restricted it may be less. When the buffer is 3 ft or greater, it should be turfgrass as other landscape plantings will likely block the required sight distance. Sidewalk buffer areas less than 3 ft. wide should be hardscaped.

On projects that have extra right-of-way at the roundabout corners and where sidewalk is part of the scope of work, the sidewalk design shown in Exhibit 6-64 should be taken into consideration.

Use SHA Standard No. MD 655.11 for the sidewalk ramps and place detectable warning surfaces on each ramp.

6.8.1.2 CROSSWALKS

Crosswalks at roundabouts should be marked and treatments provided according to Chapter 10 of the *SHA Pedestrian and Bicycle Design Guidelines*. Typically at roundabouts, the location of the crosswalk is 20 ft. from the edge of the circulatory roadway or yield line. If it is determined that the crosswalk should be placed further back, place it in even vehicle lengths of 20 ft. plus assume a 5 ft. gap between queued vehicles (20 ft., 45 ft., 70 ft.).

The minimum cut through for the splitter island should be no less than the dimensions shown in Exhibit 6-12. The cut through should not be ramped; however it should contain detectable warning surfaces along each side.

6.8.2 BICYCLE DESIGN CONSIDERATIONS

Since maximum entry speeds for roundabouts are between 25 and 30 mph, bicyclists should be able to navigate the roadway of a roundabout safely. If the engineer determines a roundabout to be unsafe for bicyclists such as in a large multilane roundabout, then a shared use path should take the place of a sidewalk. See Exhibit 6-67 and 6-68 for guidance.

6.8.3 PARKING CONSIDERATIONS

In urban conditions, parking lanes near roundabouts may be present. Special consideration should be taken to locate them far enough from the roundabout that drivers exiting the roundabout can come to a controlled stop. Considering the maximum roundabout entry speed is 30 mph and R2 is less than R1, the parking lane should be located at least 200 ft. from the midpoint of R2 on approach leg B. AASHTO Exhibit 10-73 was used to derive this distance. Also verify that the appropriate sight distance for leg A exists to the parking lane for R5 similar to the method used for crosswalks as discussed in Section 6.7.3.1. Lastly, a parking lane should not be located within a crosswalk. See the diagram below for more information.

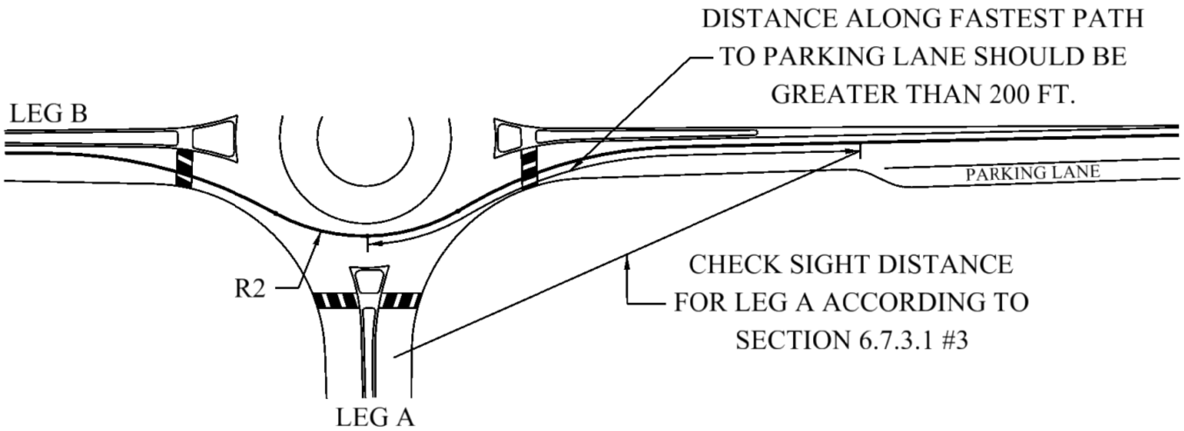


FIGURE 6.8.3-1

6.8.5 TREATMENTS FOR HIGH-SPEED APPROACHES

This section describes design elements that should be utilized on high speed approaches to increase visibility and driver awareness of a roundabout. Treatments for high speed approaches may also apply to low speed roadways as well.

6.8.5.1 VISIBILITY

Landscape the central island according to Section 6.4.4 and Chapter 9 to increase its visibility from the approach roadways. In addition to landscaping, advanced warning signs, pavement markings, and rumble strips may also be necessary to enhance visibility and driver awareness of the roundabout.

6.8.5.2 CURBING

Introducing curbing on otherwise open sections is desirable to reduce the approach speeds of vehicles on high speed rural roadways. Use the chart below to determine the suggested minimum length of curbing.

Design Speed of Approach (mph)	**Minimum Length of Curbing on Approach (ft) Based on Entry Speed R1 (mph)**			
	15	**20**	**25**	**30**
30	200	170	140	100
35	250	210	185	150
40	295	265	235	185
45	350	325	295	250
50	405	385	355	315

This chart is based on AASHTO Exhibit 10-73 for deceleration lengths on grades of 2% or less.

For approach speeds greater than or equal to 45 mph use Type C Curb and Gutter along the outside edge of roadway and transition it to Type A as the approach speed decreases below 45 mph.

6.8.5.3 SPLITTER ISLANDS

For approach design speeds from 30 to 50 mph, the splitter islands should be a minimum of 100 to 200 ft. respectively. Additionally, the splitter islands should extend beyond the end of the exit curve to prevent exiting traffic from crossing into the path of approaching traffic (pg 6-22). The splitter islands should be constructed as described in Section 6.4.1.

6.8.5.4 APPROACH CURVES

The maximum entry speed, R1, is 25 mph for single lane roundabouts and 30 mph for multilane roundabouts. NCHRP recommends limiting the approach speeds to 35 mph prior to the entry curve closest to the roundabout (pg 6-78). In order to accomplish this, successive curves can be used as shown in Exhibit 6-70. The change in speed on successive geometric curves should be limited to 12 mph.

It may be beneficial when designing a high speed approach using successive curves to work from the roundabout outward. For example, if the greatest entry speed is 25 mph and the change in speed on successive geometric curves should be limited to 12 mph, then the moderate radius curve should be designed for a speed of 35 mph. If the moderate radius is designed for 35 mph, then the broad radius should be designed for 45 mph. (Additional guidance for the successive curve treatment is being developed)

Additionally, it is necessary to reduce the approach speed prior to the broad radius from the approach design speed to the broad radius speed. This can be accomplished using rumble strips and warning signs and even warning beacons.

6.8.5.5 ADJUSTMENT STRATEGIES FOR HIGH-SPEED APPROACHES

Below is a list of strategies that may be used to help address high-speed approaches (speeds greater than 30 mph) observed in an existing condition or during a post construction survey, when geometric modifications may not be possible or feasible. Before implementing the strategies listed or if the strategies are not sufficient for your needs, please coordinate with the District Traffic Office and the Office of Traffic and Safety. Potential strategies for speed control include:

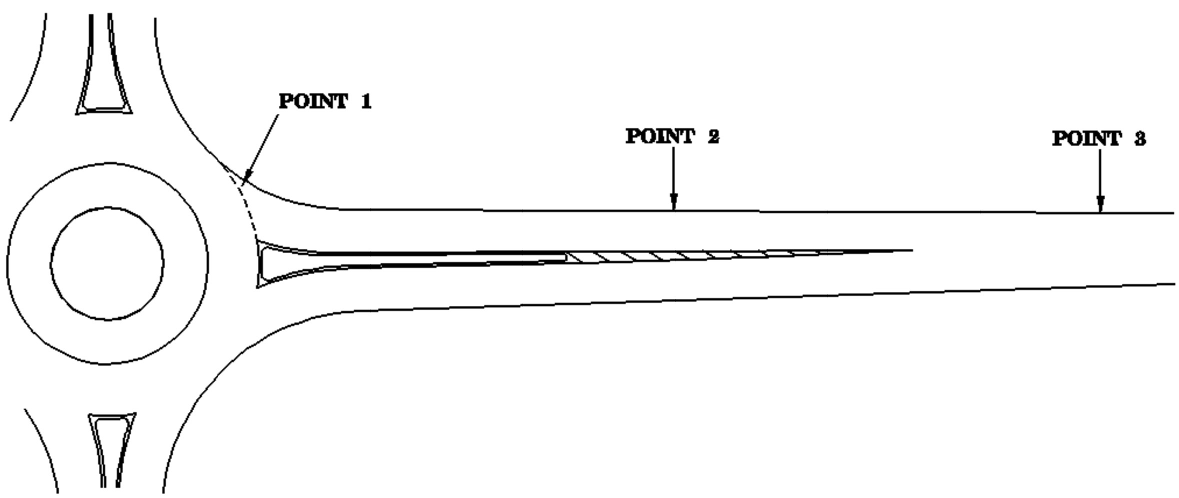
- Provide larger advance warning signs (RAB ahead)
- Provide larger yield signs
- Provide larger chevron signs in the central island
- Increase the length of the splitter island by installing a longer, hatched splitter island adjacent to the existing island
- Reduce width of approach lane
- Place rumble strips at the centerline and edgeline
- Provide flashing yellow beacons along high speed approaches
- Use transverse ‘bar’ markings on the high speed approaches
- Enhance lighting
- Provide a graduated or transition speed zone
- Provide 10 in. edgelines and center line/gore lines
- Place delineators at edgeline (D6)
- Place traverse rumbles in areas with high crash rate or significant safety issue

6.8.5.6 POST CONSTRUCTION

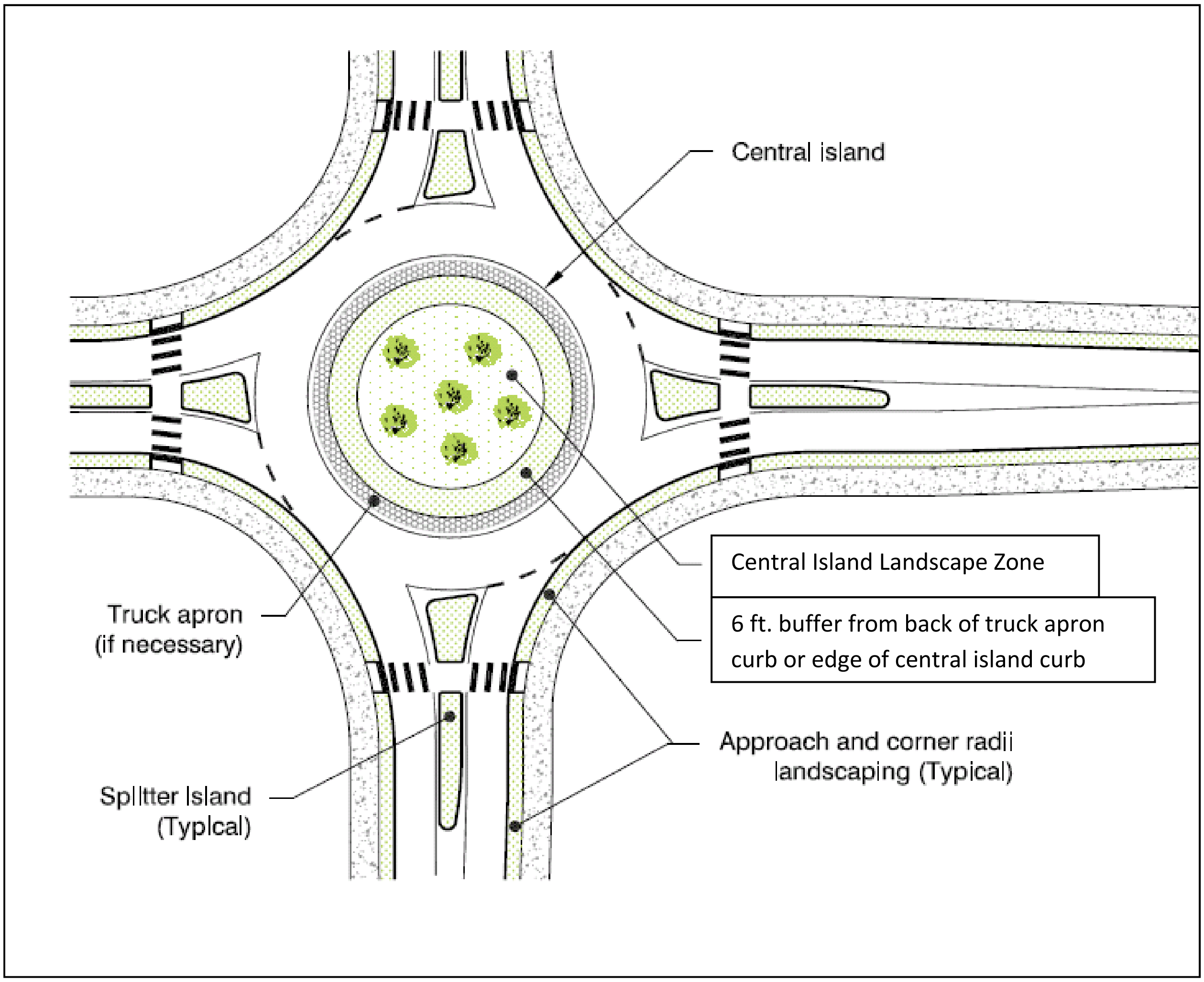
Each new roundabout placed on roadways with approach speed limits of 30 mph or more shall be evaluated for operational characteristics by a traffic engineer after a suitable phase-in period, but no later than the end of the first year of opening. The study shall be conducted according to the ITE Manual of Transportation Engineering Studies, Second Edition (2010) to assess the success of speed reduction strategies on the roundabout approaches. The 85^{th} percentile entry speeds must be at or below 30 mph or further strategies shall be employed to control speed.

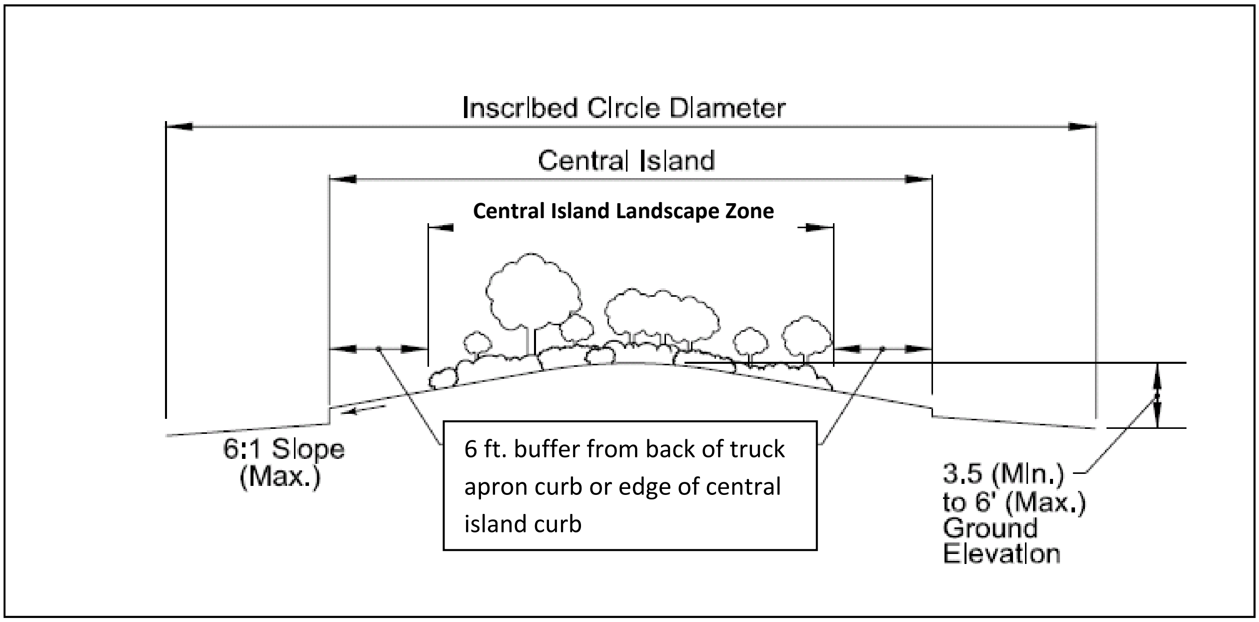
6.8.5.7 EVALUATING THE OPERATING CHARACTERISTICS OF CURRENT AND FUTURE RAB'S

1. Point #1 is at the stopping/yield point – at the RAB
2. Point #2 is x/2
3. Point #3 is a point (x) along the approach to the RAB where the first recognition of the RAB ahead is made, and the 85^{th} %-tile speed of approaching traffic is obtained
4. Using an acceptable rate of deceleration, "spot" speeds are measured at Point #2 (x/2) and, if found to be unacceptable, driver behavior modification strategies/devices are considered
5. A graph of some sort can be prepared for the various approach speeds and values of "x"



9.2 PRINCIPLES





Policy for Placing Fixed Objects in SHA Roundabouts
October 9, 2012

Authority: Under § 8-646, Transportation Article, Md. Code Ann., the State Highway Administration (SHA) is authorized to issue a permit for certain work, which must be performed to the satisfaction and under the supervision of SHA. Such work includes placing any structure on any State highway right of way, changing or renewing any structure placed on any State highway right of way, digging within any State highway right of way for any purpose, planting or removing any vegetation on any State highway right of way, or placing any obstruction or improvement on any State highway right of way.

Background/ Analysis: SHA requires a permit issued by the appropriate District Engineer to place fixed objects in State highway roundabouts, in conformance to existing procedures allowing persons and entities to place objects in State rights-of-way under existing Maryland law. Placing of such objects in roundabouts can present safety and aesthetic benefits, but may also create safety hazards to roadway users. SHA tries to reasonably accommodate community requests to use the SHA right-of-way, but must, first and foremost, work to protect the safety of Maryland travelers.

Proposed Policy: Under certain circumstances provided in the Maryland SHA Roundabout Design Guidelines (2012) an SHA District Office may issue a permit to a governmental or nongovernmental person or entity that applies to the District Engineer to place a fixed object or fixed objects within a State Highway roundabout.

Approved:

Melinda B. Peters SHA Administrator	11-5-12 Date