1 - General

The modern roundabout is a subset of many types of circular intersections. The term modern roundabout and roundabout are used interchangeably throughout this document. The roundabout is a one-way circular intersection with specific design control features. The term “modern roundabout” is used in the United States to differentiate roundabouts from the older and often large diameter non-conforming traffic circles, rotaries or very small traffic calming circles used on residential streets.

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

Roundabouts may be considered for a wide range of intersection types including but not limited to freeway interchange ramp terminals, state route intersections, and state route/local route intersections. Roundabouts generally process high volume left turns more efficiently than all-way stop control or traffic signals, and will process a wide range of side road volumes. Roundabouts can improve safety by simplifying traffic movements, reducing vehicle speeds, and providing a clearer indication of the driver’s right of way compared to other forms of intersection control. The required intersection sight distance is approximately half what is required for a signalized intersection because of reduced intersection speeds.

The following is a list of locations where a roundabout has high potential.

1. Intersections with a high-crash rate or a higher severity of crashes.
2. Where an existing intersection is failing, for any reason.
3. Where other alternatives are expensive.
4. Where aesthetics are an objective.
5. Transitions in functional class or desired speed change (including rural to urban transitions).
6. Where a random/continuous arrival pattern exists.
7. Where a random/continuous traffic pattern is desired or platoons are especially expensive and inefficient (on-ramps, bridges)
8. Freeway ramp terminals
9. High-speed rural intersections.
10. Intersections of dissimilar functional class (arterial-arterial, arterial-collector, arterial-local, collector-collector, collector-access).
11. 4-leg intersections with entering volumes are less than 8,000 vph or approximately 80,000 ADT
12. 3-leg intersections of any volume
13. 2-way stop control intersections with a high-crash rate or a higher severity of crashes
14. Intersection of two signalized progressive corridors where turn proportions are heavy (random arrival is better than off-cycle arrival).
15. Closely spaced intersections where signal progression cannot be achieved.
16. Locations where future access will be added to the intersection.
17. Replacement of 4-way stops
18. Intersections near schools
19. Other intersections where safety is a major concern, such as HSIP Funds.

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

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

2 - Modern Roundabout vs. Other Circular Intersections

The modern roundabout is defined by three basic principles that distinguish it from a traffic circle.

1. Yield-at-Entry - Vehicles approaching the circular intersection must wait for a gap in the circulating flow, or yield, before entering the circle.
2. Traffic Deflection - Traffic entering the roundabout is directed or channeled to the right with an appropriate curved path into the circulating roadway that avoids the central island.
3. Geometric Curvature - The radius of the circular road and the angles of entry can be designed to slow the speed of vehicles. Key geometric design parameters and the fastest speed path are critical to achieve proper design.

On the surface, modern roundabouts, old traffic circles and rotaries look similar; however, there are subtle differences that distinguish the two intersection concepts. The fundamental difference is their differing design philosophies. Modern roundabouts control and maintain low speeds for entering and circulating traffic. This is achieved by small diameters and low-speed entry geometry. By contrast, traffic circle geometry encourages high-speed merging and weaving, made possible by larger diameters and large high-speed entry radii. Modern roundabouts control vehicle speed by geometric design elements that allow only slow speeds therefore creating safer driving conditions. The common characteristics distinguishing a modern roundabout from a traffic circle or a rotary type intersection are summarized in Table 1.

Table 1. Distinguishing Characteristics of Modern Roundabouts

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

3 - Advantages and Disadvantages

Table 2 lists the advantages and disadvantages of roundabouts versus other intersection alternatives.

Table 2. Advantages and Disadvantages of Roundabouts vs. Other Alternatives

Category	Advantages	Disadvantages
Safety	Reduced number of conflict points compared to other non-circular intersections. Elimination of high angles of conflict and lower operational speeds; fewer and less severe accidents. Reduction in conflicting speeds passing through the intersection. Reduced decision making at point of entry. Long splitter islands and other geometric features provide good advanced warning of the intersection. Raised level of consciousness for drivers.	Crashes may temporarily increase due to improper driver education. During emergencies, signalized intersections can preempt control.
Capacity	Traffic yields, nonstop, continuous traffic flow. Generally higher capacities experienced.	Coordinated signal systems can increase capacity of the network.
Delay	Generally reduced delay as compared with an equivalent volume for signalized intersection. During off-peak hours, signal timing can create undue delay at signalized intersections.	As queues develop, drivers accept smaller gaps, which may increase crashes.
Cost	Maintenance of signals (heads, loop detectors, controllers). Lower accident rate and severity; reduced accident costs.	Central island landscaping maintenance. Illumination cost.
Pedestrians & Bicyclists	Splitter islands provide pedestrian refuge and shorter one-directional traffic crossing. Low speed conditions improve bicycle and pedestrian safety.	Pedestrians, especially handicapped may experience increased delay in securing acceptable gaps to cross. Longer travel path.
Environmental	Reduced starts and stops; reduced air pollution.	

3.1 -

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

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

By constructing a pair of roundabouts at the ramp intersections, capacity improvements to the interchange can be accomplished without the costly requirements of widening the structure to carry additional lanes over or

under a freeway, or expressway (see FDM 11-30-1 for more information on interchanges).

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

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

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

4 - Roundabout Categories

Roundabouts are categorized by size and environment. The following is a list of basic categories explained in FHWA, Roundabouts: An Informational Guide [2]. (FHWA Roundabout Guide) There will be situations where categories are not applicable. The planning process and final design methodologies for roundabouts are to be based on “principles” versus strict rules or one-size fits all standards. For example there are no categories for transitional areas and the final design will depend on various factors.

4.1 - Mini-roundabouts

Mini-roundabouts are small roundabouts used in low-speed urban environments and will not be addressed in this manual.

4.2 - Urban Compact Roundabout

Urban compact roundabouts are small roundabouts used in low-speed urban environments and will not be addressed in this manual.

4.3 - Urban Single-Lane Roundabout

This type of roundabout is characterized as having a single-lane entry at all legs and one circulatory lane. The roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a non-traversable central island, and may include an apron surrounding the non-traversable part of the central island to accommodate long trucks. The smaller inscribed diameter roundabouts shown in FDM 11-26-20, Table 4 may accommodate the WB-65. The minimum inscribed diameter to accommodate a WB-65 is 120 feet. Where long trucks are anticipated, verify that the circulating roadway width and the truck apron can accommodate off-tracking of a WB-65 design vehicle.

4.4 - Urban Multilane Roundabout

Urban multilane roundabouts are roundabouts in urban areas that have at least one approach leg with two or more entry lanes. They include roundabouts with entries on one or more approaches that flare from one to more lanes or the approach is a multilane facility. These require wider circulatory roadways to accommodate more than one vehicle traveling side by side. The speeds at the entry, on the circulatory roadway, and at the exit are similar to those for the urban single-lane roundabouts. Again, it is important that the vehicular speeds be consistent throughout the roundabout. The geometric design includes raised splitter islands, a non-traversable central island, and appropriate horizontal deflection, and may include an apron surrounding the non-traversable part of the central island to accommodate long trucks. A truck apron should be included to allow the semi tractor to stay in the inner lane and the trailer to off-track onto the apron. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65.

4.5 - Rural Single-Lane Roundabout

Rural single-lane roundabouts generally have high speeds on the approach roadway in the range of 45 to 55 mph. They require supplementary geometric and traffic control device treatments on the approach roadway to encourage drivers to slow to an appropriate speed before entering the roundabout. Rural roundabouts may have larger diameters than urban roundabouts to allow slightly higher speeds at the entries, on the circulatory roadway, and at the exits. This is permissible if few pedestrians are expected at these intersections, currently and in the future. A truck apron should be included to allow the semi tractor to stay in the lane and the trailer to off-track onto the apron. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65. Other geometric design elements include raised and extended splitter

islands, a non-traversable central island, and adequate horizontal deflection.

Rural roundabouts that may one day become part of an urbanized area should be designed as urban roundabouts, with slower speeds and pedestrian treatments. In the interim, design them with supplementary approach and entry features to achieve safe speed reduction.

4.6 - Rural Multilane Roundabout

Rural multilane roundabouts have speed characteristics similar to rural single-lane roundabouts with approach speeds in the range of 45 to 55 mph. They differ in having two or more entry lanes, or entries flared from one or more lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural multi-lane roundabouts mirror those of their urban counterparts. The main design differences are designs with higher entry speeds and larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that may one day become part of an urbanized area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. In the interim, design them with approach and entry features to achieve safe speed reduction. A truck apron should be included to allow the semi tractor to stay in the inner lane and the trailer to off-track onto the apron. Where long trucks are anticipated, verify that the circulating roadway width and off-tracking can accommodate a WB-65.

5 - Defining Physical Features

The defining features of a roundabout are shown in Figure 1 and described in Table 3.

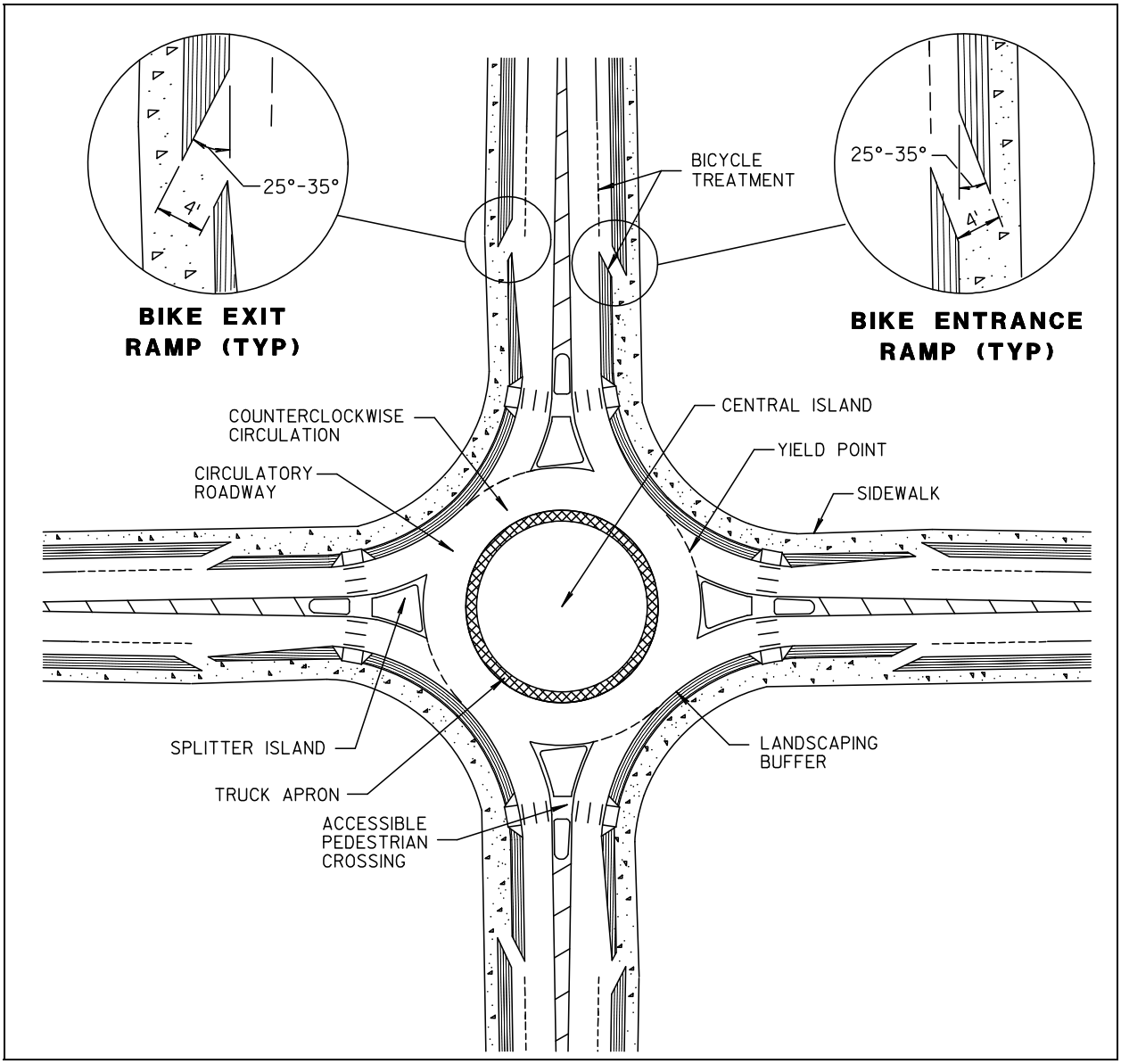

Figure 1. Roundabout Features

Table 3. Roundabout Features

Feature	Description
Central island	The raised area in the center of a roundabout around which traffic circulates.
Splitter island	A raised curb island (special situations may be painted) area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and to provide refuge for pedestrians crossing the road in two stages.
Circulatory roadway (counter clockwise circulation)	The curved path used by vehicles to travel in a counterclockwise fashion around the central island. The width of the circulatory roadway is typically 1.0 to 1.2 times the width of the widest entry width.
Truck Apron	The traversable portion of the central island adjacent to the circulatory roadway. It may be required on smaller roundabouts to accommodate the wheel tracking of long or oversized vehicles.
Yield Point	A point of demarcation separating traffic approaching the roundabout from the traffic already in the circulating roadway. The yield point is usually defined by dotted edge line pavement marking. Entering vehicles must yield to circulating traffic.
Accessible pedestrian crossings	Provide accessible pedestrian crossings at all roundabouts. The crossing location is set back from the yield line, typically one car length. The splitter island is cut to allow pedestrians, wheelchairs, strollers, and bicycles to pass through.
Bicycle treatments	Bicycle treatments at roundabouts provide bicyclists the option of traveling through the roundabout either by riding in the travel lane as a vehicle, or by exiting the roadway and using the crosswalk as a pedestrian, or as a cyclist using the shared-use path, depending on the bicyclist's level of comfort. Bicycle exit ramps should generally leave the roadway within a 25 to 35 degree angle range. Bicycle entrance ramps should generally enter the roadway within a 25 to 35 degree angle range. The entrance and exit ramps should be located approximately 50-150 feet from the circulating traffic to allow the bicyclist an opportunity to transition onto a path away from the circulatory roadway.
Landscaping buffer	Landscaping buffers are provided at most roundabouts to separate vehicular and pedestrian traffic and to encourage pedestrians to cross only at the designated crossing locations. Landscaping buffers can also significantly improve the aesthetics of the intersection as long as they are placed outside the required sight limits.
Sidewalk	Pathway for pedestrians to walk. In the urban environment it is common to provide a multi-use path at the perimeter of the roundabout to accommodate pedestrians and bicyclists.

6 - References

[1] Insurance Institute for Highway Safety publications, May 13, 2000; July 28, 2001; November 19, 2005; www.iihs.org

[2] "Roundabouts: An Informational Guide," Publication No. FHWA-RD-00-067, June 2000 http://www.tfhrc.gov/safety/00068.htm