

Modern Roundabouts:

a guide for
application



Kentucky

Community Transportation Innovation Academy

2005

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Cover Photograph: Aerial view of modern roundabout in Okemos, MI providing intersection control for a collector and minor arterial.

Introduction

The purpose of this guide is to present general concepts, example applications and some of the design considerations of roundabouts as a form of intersection control that can be considered by communities and transportation professionals. This guide has been organized into six sections to present these concepts. These are:

- What is a Modern Roundabout?
- What is Not a Modern Roundabout?
- Why a Modern Roundabout?
- Where Should We Consider Roundabouts?
- When Should We Consider Roundabouts?
- How are Modern Roundabouts Designed?

This document is not intended to provide detailed information for the planning, design or operation of roundabouts. More detailed information can be found in the FHWA publication, ***“Roundabouts: An informational Guide.”*** Additional resources are also provided at the end of the guide.

A roundabout is simply a form of intersection control. As with any form of intersection control modern roundabouts present tradeoffs between cost, operational efficiency, safety, aesthetics and right of way impacts. As a result roundabouts should be considered, along with other traffic control alternatives, as another tool to be used by the transportation engineer when identifying the best solution for a project.

In terms of cost, roundabouts have comparative construction costs with traffic signals. While roundabouts may require more pavement and right-of-way than traffic signals, they may significantly reduce the number of lanes and widths on the approaches. Special applications of approach reductions are discussed in the section ***Where Should We Consider Roundabouts.*** Roundabouts also present numerous opportunities for aesthetic and community enhancements including landscaping, which may increase project costs, but the safety and operational benefits of roundabouts can be realized with minimal project funds. Additionally, operational and maintenance costs of roundabouts can be significantly lower than traffic signals by eliminating the need for power service.

The following sections of this guide address the operational and safety benefits of the roundabouts and provide a brief introduction to their planning and design. Several case studies are presented demonstrating different applications of modern roundabouts, from major urban arterials, to low volume high-speed rural routes and as intersection treatments at major interchanges. Using the information in this guide and the additional references, it may be possible to see how roundabouts can be used to provide a safe and efficient intersection treatment in your district or community.

What is a Modern Roundabout?

The first modern roundabout was introduced in 1966 in the United Kingdom to resolve issues with the early traffic circles that experienced operational failure and high crash rates at high volumes. Since 1966, the modern roundabout has been used successfully in many countries such as the United Kingdom and Australia and is rapidly gaining greater acceptance in the United States as an intersection control strategy. To date over 1000 modern roundabouts have been installed in this country.



Modern Roundabout in Okemos, MI

Four main characteristics separate modern roundabouts from other traffic circles and rotaries.

- 1. Entering traffic yields right of way to vehicles in the circulating traffic.**
- 2. No other traffic control is present at the modern roundabout beyond the yield control at entry.**
- 3. Horizontal curvature / deflection is present at the entry and exit to the roundabout.**
- 4. No pedestrian activities take place across the circulating roadway or within the central island.**

These features ensure high operating capacity and increased safety of the modern roundabout as they maintain unrestricted circular traffic flow and slower operating speeds. Modern roundabouts are an effective intersection control strategy that can be used to address both operational and safety issues throughout Kentucky.

What is Not a Modern Roundabout?

Circular Intersection treatments have been used in the United States since the early 1900s. While these circles may look like roundabouts, they impose different control strategies and do not operate like a modern roundabout. Many traffic circles:

- Impose control on circulating traffic (i.e. stop, yield or signal control).**
- Provide parking and pedestrian activities within the circulating roadway and the central island.**
- Do not provide curvature / deflection for all or selected movements.**

Introducing conflicting parking and pedestrian activities and removing horizontal deflection within a traffic circle will significantly decrease the safety and capacity of the traffic circle. If a traffic circle has any of the characteristics listed above, it is NOT a modern roundabout.



Circular traffic yielding right of way at Town Square Circle in Bardstown, KY

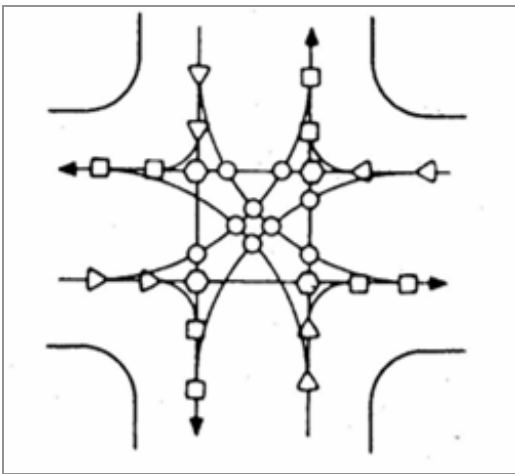
Why a Modern Roundabout?

A modern roundabout should be considered as a viable intersection control as roundabouts often provide two primary benefits when compared to traffic signal and stop controlled alternatives. These are: 1) **improved intersection safety** and 2) **increased intersection capacity**.

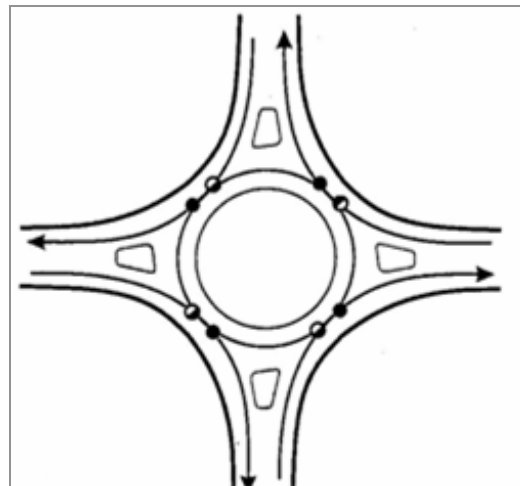
Intersection Safety

Roundabout applications in the United States have shown an overall crash reduction of **37 percent** and a **51 percent** reduction in injury and fatality crashes. Improved safety at modern roundabouts is primarily due to a decrease in the number of conflict points and lower operating speeds.

Conflict points occur where one vehicle path crosses, merges or diverges with, or queues behind the path of another vehicle, pedestrian, or bicycle. Conflict points can occur from legal or illegal maneuvers. Research has shown a direct correlation between the number of conflict points at an intersection and crash rates.



A typical four-leg intersection has 32 conflict points. Signalization can reduce conflict points by 50% (16 points).



Modern roundabouts reduce intersection conflict points by 75% (8 total). Roundabouts also eliminate cross-traffic conflict points reducing crash severity.

Lower Operating speeds resulting from the horizontal curvature and deflection at the entry of the modern roundabout aid in reducing the severity of crashes at roundabouts.

Pedestrian crashes have also been shown to be reduced with the implementation of roundabouts. This is primarily due to: 1) slower operating speeds, 2) reduction in pedestrian conflict points, and 3) separation of entry and exit lanes by the splitter islands.

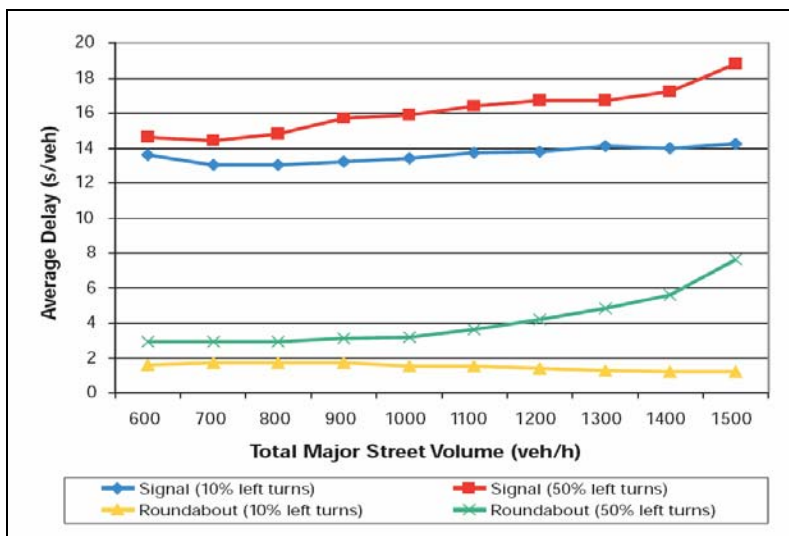
Intersection Capacity and Operations

In addition to safety improvements, roundabouts have been widely used as a means to increase intersection capacity and reduce delays. Past research has shown that single lane roundabouts will perform better than two-way stop control (TWSC), all-way stop control (AWSC) and signals for volumes up to 25,000 entering vehicles per day. Two-lane roundabouts will demonstrate similar improvements for volumes up to 34,000 entering vehicles per day.

The increased capacity of modern roundabouts is generally attributed to:

- **Continuous flow of traffic**, reduces start and stop delay
- **All right-turn movements**, are more efficient and require shorter gaps in traffic
- **Lower operating speeds**, further reduce gap requirements

In addition, the following has been established by past research:



1. A roundabout will always provide a higher capacity and lower delay than AWSC intersections.

2. Roundabout approach delay is relatively insensitive to major street approach volumes.

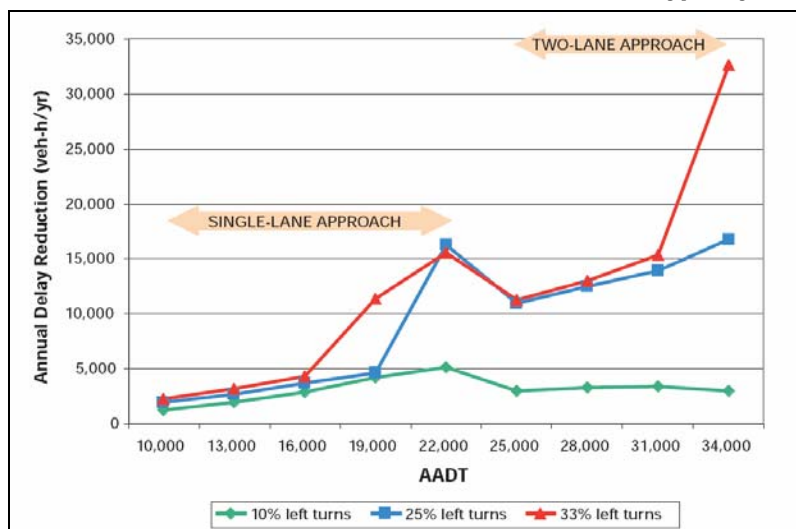
3. Modern roundabouts show increased delay reductions compared to other intersection treatments as the percentage of left turns increases.

4. Modern roundabouts typically

show superior performance when volumes are balanced between the major and minor street volumes. Roundabout capacity decreases and minor street volume decreases.

5. Modern roundabouts provide the most significant savings when operating at the upper threshold of their design capacity (typically 85 percent of the intersection capacity)

6. A substantial part of the total delay reduction benefit of roundabouts is realized during off-peak periods.



As with all potential intersection treatments, detailed capacity and operational analysis should be conducted to ensure that the proposed configuration provides the most beneficial operating conditions.

Where Should We Consider Roundabouts?

As with any type of intersection control, modern roundabouts can be adapted to fit a wide range of conditions, including varying speeds, alignments and traffic volumes. Variability of applications can be achieved by varying the design speed or the roundabout, placing advanced signing and changing other operational elements, similar to the adjustment of phasing and timing at traffic signal installations to meet varying conditions.

Due to the flexibility of their design, modern roundabouts can be used to meet the unique demands of high-volume urban arterials, low-volume rural roads, grade-separated interchanges. Other applications in Kentucky include implementation on high-speed urban by-pass routes.



Urban Arterial Example

The picture to the left shows a series of four roundabouts on an urban arterial serving Golden, Colorado's primary commercial arterial corridor. The previous five-lane design accommodated through traffic, but access to business and side streets presented a significant problem. In planning improvements for the corridor, the City chose to implement a series of modern roundabouts to slow traffic, improve access, increase safety and provide an aesthetically pleasing project along the

arterial. Construction began in 1998 and all four roundabouts were fully operational by fall of 1999. The series of urban roundabouts resulted in a corridor where traffic moves slowly, vehicles experience little delay at major intersections, and pedestrians can readily access the many businesses in the area. The net result is a vibrant commercial corridor.

Rural Intersection Example

A roundabout was installed at the intersection of Marion Center Road/Adam Center Road in Allen County, IN at a six legged offset intersection. The roundabout was chosen to address high-speed crashes at the intersection that were expected to increase due to the construction of a new interchange to the south and industrial development to the north. Since the construction of the roundabout in 1998, only 1 crash has occurred at the intersection, which was in the first 6 months of operation. The roundabout



reduced the amount of right-of-way required for construction, eliminated the need for stop signs, and reduced the traveling speed at the intersection to lead to a successful project.

Interchange Example

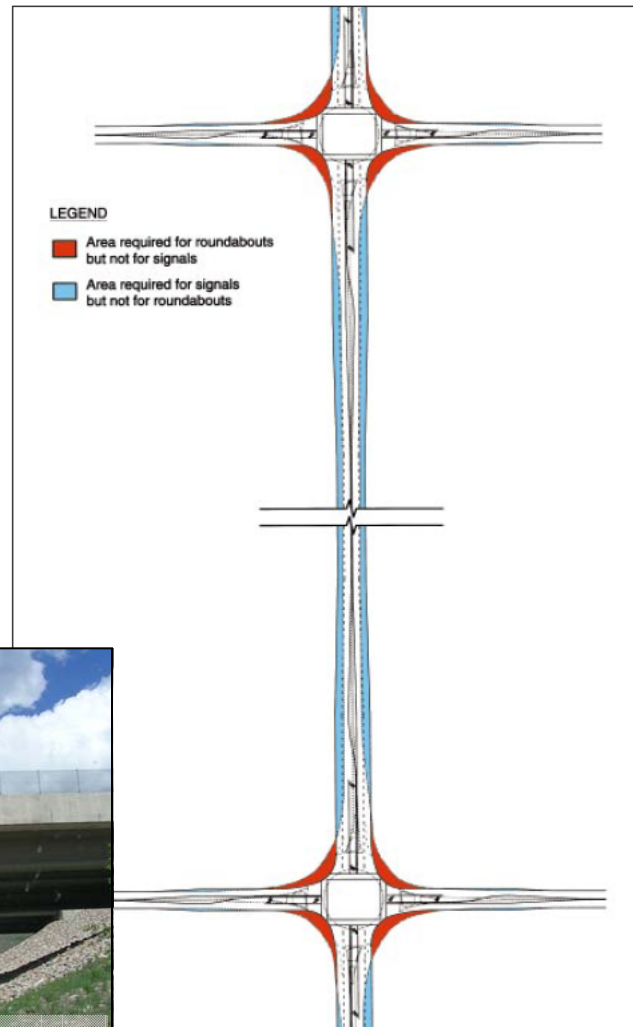


The roundabout to the left was installed in 2002 and serves as the US 421 SB exit ramp in Winston-Salem, NC. This installation solved a significant left turn problem where over 900 vehicles make a left turn in the AM peak hour. Delay and queuing at the intersection was also significantly reduced.

Overall the North Carolina DOT has 40 roundabouts completed or under design. A majority of these are planned for major US and state routes including 5 interchanges that will be upgraded with roundabouts.

As stated above this roundabout was designed to handle over 900 left turning vehicles per hour. In addition to the operational improvements realized by the project, the installation of a roundabout at this location eliminated the need for the bridge widening to install multiple left turn lanes providing significant cost savings to the NCDOT.

The figure to the right compares the pavement area of adjacent roundabouts and traffic signals. Significant savings can be realized with roundabouts in areas with constrained ROW or near narrow structures such as underpasses or overpasses.



When Should We Consider Roundabouts?

Roundabouts provide a form of intersection control that should be considered along with stop controlled and signalized intersection concepts to address unacceptable delays and potential safety problems. However, in addition to the operational and safety benefits of the modern roundabout, they are often considered in situations to meet the unique needs of the community and the existing transportation system.

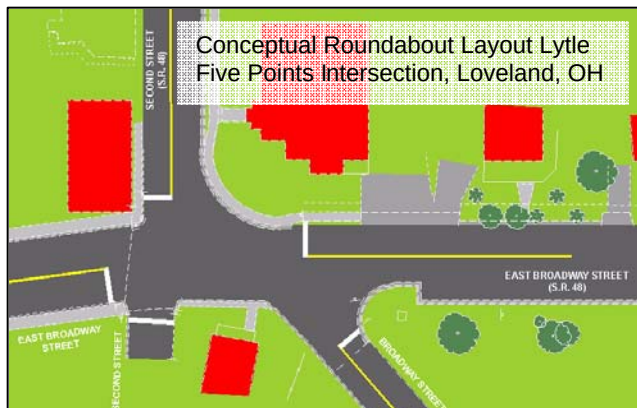
Community Enhancement

The raised splitter islands and central island of the modern roundabout provides for the opportunity to place landscaping and other visual treatments to provide improved aesthetics at the intersection when compared to stop controlled and signalized intersection. Roundabouts can often serve as “gateways” into commercial and residential districts.

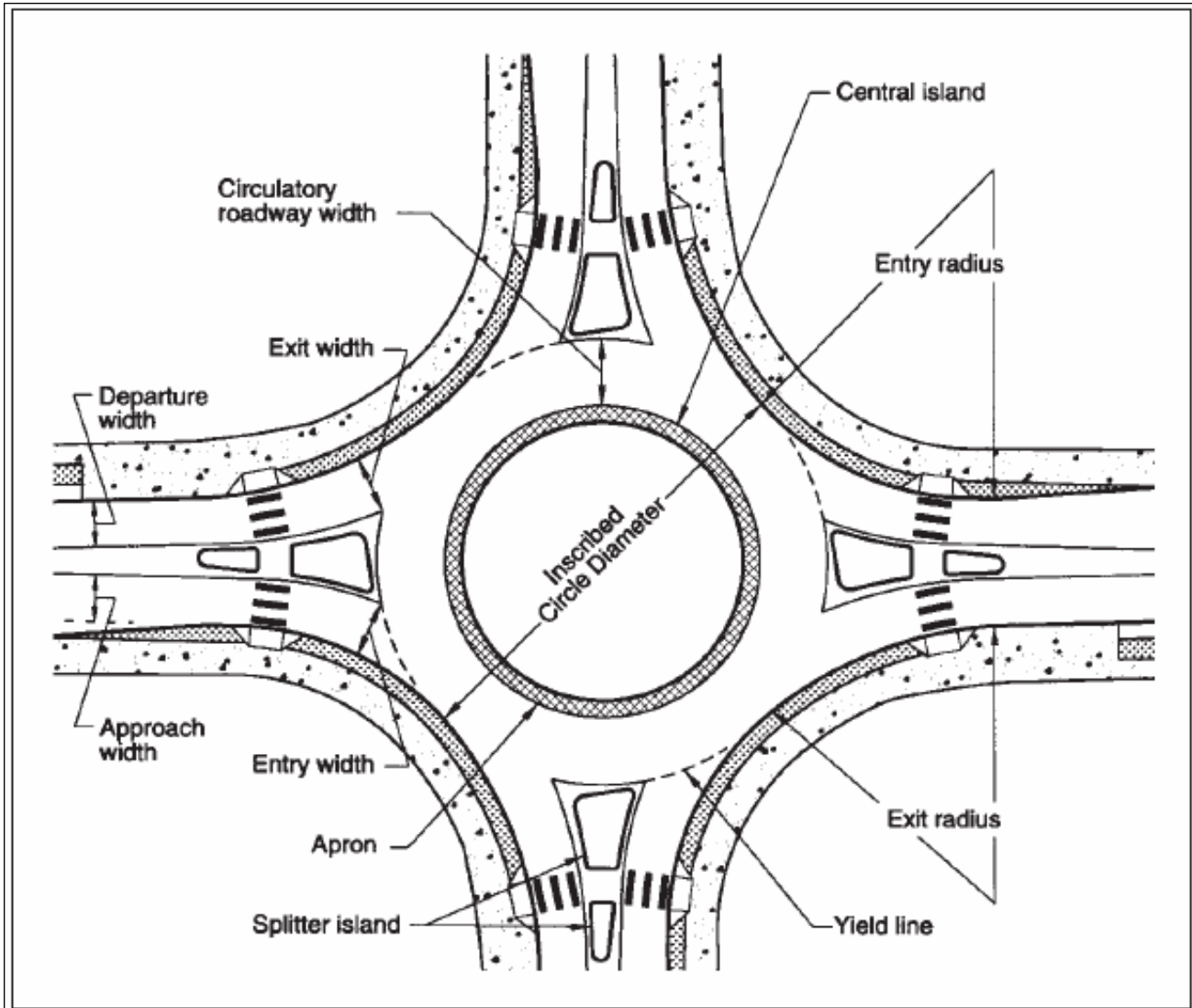


Traffic Calming The slower operating speeds of the roundabout provide a good tool for lowering the operating speeds along roadways especially when roundabouts are used in succession. Roundabouts are typically used to calm traffic on residential and local streets, however, they may be used along state routes when there is a documented discrepancy between speed limits and operating speeds.

Special Conditions Due to the unique operating characteristics of modern roundabouts they can often be used to address site specific problems that may not be efficiently solved by signal or stop controlled alternatives. These special conditions include unusual and offset geometric alignments, 5 or more approaches at an intersection and high volumes or high left turning volumes.



How are Modern Roundabouts Designed



There are five key elements that are incorporated in the design of roundabouts:

- Central island
- Splitter island
- Circulatory roadway
- Apron
- Yield line

All of the design elements of the modern roundabout must be designed to achieve a balance of safety and capacity. Typical ranges of these values are shown in the following table for different roundabout applications.

Design Element	Urban Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
Recommended entry design speed (mph)	15	20	25	25	30
Typical inscribed circle diameter	80 to 100 ft	100 to 130 ft	150 to 180ft	115 to 130 ft	180 to 200 ft
Splitter island Treatment	Raised, with crosswalk cut	Raised, with crosswalk cut	Raised, with crosswalk cut	Raised and extended	Raised and extended
Typical daily service volumes (veh/day)*	15,000	20,000	34,000	20,000	34,000

*Assumes 4-leg roundabout

As with the design of all roadways elements, design values for roundabouts should be carefully chosen to fit the traffic and environmental characteristics of the proposed context. The values given above are provided as examples of typical values and should not be used in place of detailed operational and geometric analysis.

The following sections provide a brief discussion of some of the design factors that will influence the ultimate design of a modern roundabout. Additional information on roundabout design can be found in the FHWA publication, ***Roundabouts: An informational Guide***, and the other resources listed at the end of this document.

Design Speed

The most critical objective in designing a modern roundabout is achieving appropriate vehicular speed through the roundabout. Typical design speeds range from 15 mph for urban compact roundabouts to 30 mph for rural two-lane roundabouts. Operating speed will be controlled by the entry, circular and exit radii and the entry, circular and exit widths. Proper design should aim to create a consistent speed throughout the roundabout.

Entry and Exit widths are the largest constraint on the capacity of the roundabout. The wider width needed for increased capacity is offset by the increase in crash rate associated with wider entry widths. Therefore, the entry and exit width should be designed with the narrowest width possible to maintain desired capacity.

Circular Roadway widths are determined by the turning path of the design vehicle. For single-lane roundabouts the circulatory roadway width should just accommodate the design vehicle. Truck aprons can be used to reduce the circulating roadway width, while accommodating larger vehicles.



Design Vehicle: School Bus negotiating a roundabout in Little Rock, AR

Delineation, Demarcation and Visibility

Providing adequate visibility of an upcoming roundabout serves to signal to the driver that they are approaching a roundabout and need to adjust their speed accordingly. Several of the design elements of the modern roundabout address this need.

- ***Splitter islands should always be used to indicate the entrance to the roundabout and to direct vehicles to the yield line.***
- ***Central islands should be raised to provide a clear visual indication of the roundabout.***
- ***Proper signing and striping should be used to provide guidance on lane usage and travel direction.***
- ***Additional lighting should be considered at roundabouts to improve night-time visibility.***



Photos: Top; Lane Use and advanced signing for approaching roundabout in Lenexa, KS. and Bottom; Directional sign approaching roundabout in Topeka, KS.

Special Considerations

Roundabouts can be used in a variety of locations under a variety of speed and traffic conditions. Special design features may be employed to ensure that the desired operation of the intersection is maintained within its special context.

Bicycles and Pedestrians. Bicyclist and pedestrian needs should be evaluated and accounted for in the design of all roundabouts. Roundabouts typically provide pedestrian crosswalks about one car length behind the yield bar to provide increased visibility of pedestrians and remove pedestrian traffic from higher speed circulating traffic.

Rural Roundabouts. The key element to installing rural roundabouts is providing adequate visibility and reduction of speeds prior to entering the roundabout. Splitter islands at rural roundabouts should be extended to provide additional deceleration length and combination curves may be added on approaches to assist in speed reduction.

Heavy Turn Movements. The typical roundabout design may be reconfigured to accommodate singular heavy turn movements such as right hand turns by providing exclusive right turn slip lanes.

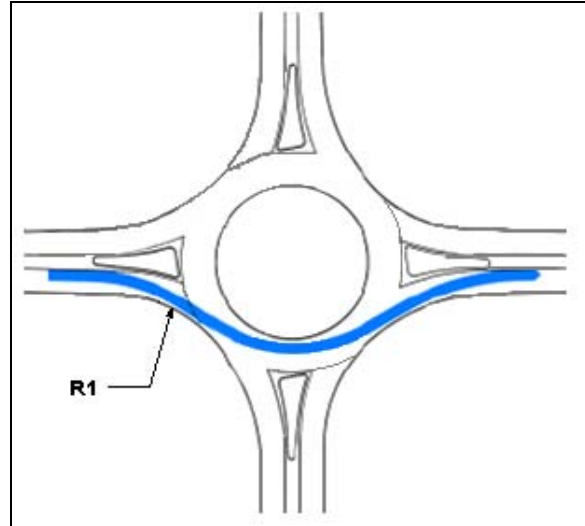
Driver Familiarity and Education. Roundabouts are new in the United States as well as Kentucky and will require an additional period of familiarization with drivers. Brochures and

Putting It All Together

Vehicle operations in a roundabout are not directly controlled by entry, exit or circulatory radii, but instead by the fastest (straightest) path that the vehicle can drive through the roundabout. Therefore, roundabout design requires a holistic approach to ensure that all the pieces work together.

The following describes some critical design elements that must be addressed in the design of roundabouts.

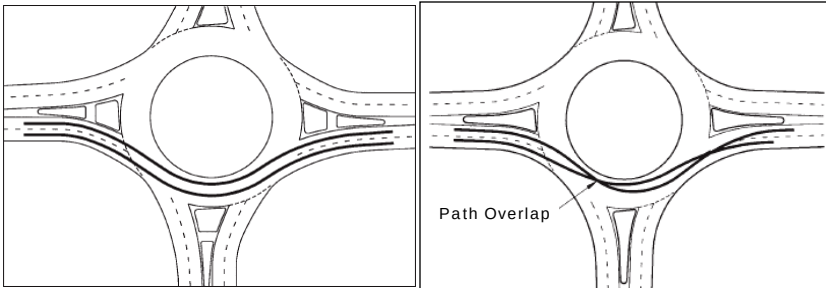
Entry Deflection—Initial deflection entering the roundabout slows the vehicles to the appropriate operating speed and is critical to ensuring safe and efficient operation. Deflection is achieved through the alignment of the entering approach and the size of the central median. Entry deflection is measured using the R_1 radius from the fastest path, which should be selected to operate at the design speed. The FHWA guide provides a methodology for determining the fastest path and provides speed-radii relationships.



Design Vehicles—All turning movements through a roundabout should be checked to ensure that vehicles can be accommodated within the circulatory roadway and truck apron. Selection of the “design vehicle” should also be carefully considered as a larger vehicle can routinely knock down signs and impact landscaping if not accommodated for in the design.

Higher volumes and more complex turning movements at **multilane roundabouts**, present a more complex design challenge than single-lane roundabouts. Below are some of the primary design issues of a multi-lane roundabout.

Entry Path Overlap — One of the most critical safety concerns of multi-lane roundabouts is sideswipe crashes of entering and exiting traffic. These crashes occur when the natural driving paths of the traffic overlap through the roundabout. Proper review of



the roundabout must ensure that the natural travel path of both lanes does not constitute a safety hazard from path overlap. Proper lane delineation can help alleviate path overlap.

Lane Usage — Multi-lane roundabouts are preferred at some locations because they have the ability to carry higher volumes of traffic than single lane roundabouts. However, if the roundabout is poorly designed it will result in unbalanced lane usage on the approach which will significantly reduce the operating capacity of the roundabout. Providing lane use signs on the approaches and striping through the circulatory roadway can significantly improve lane balance and increase the operating capacity of the roundabout. A planned revision of the MUTCD will provide examples of striping for roundabouts. Review of the operational analysis should ensure that lane usage issues are addressed. Approach level analysis will NOT identify deficiencies in lane usage.

Additional Resources

Roundabouts: An Informational Guide

US Department of Transportation

Federal Highway Administration

FHWA-RD-00-067

June 2000

Traffic Calming: State of the Practice

US Department of Transportation

Federal Highway Administration

Institute of Transportation Engineers

FHWA-RD-99-135

August 1999

Geometric Design Practices for European Roads

US Department of Transportation

Federal Highway Administration

FHWA-PL-01-026

June 2001

A Policy in Geometric Design of Highways and Streets, 5th Edition

American Association of State and Highway Transportation Officials

January 2001.

NCHRP Synthesis 264: Modern Roundabout Practice in the United States

Transportation Research Board

National Academy Press

Washington, D.C. 1998

Driving a Roundabout (Video)

City of Lacey Washington

http://www.ci.lacey.wa.us/roundabouts/roundabout_main_page.html

This guide was prepared by Dr. Nikiforos Stamatiadis, P.E., Department of Civil Engineering, and Adam Kirk, P.E., Kentucky Transportation Center, College of Engineering, University of Kentucky.



University of Kentucky
College of Engineering
Kentucky Transportation Center
(859) 257-4513
www.ktc.uky.edu