Roundabouts & Bicycle Facility Design: Selected Resources

May 15, 2017

Background

What is a roundabout? (from FHWA's Roundabouts: An Informational Guide)

"Roundabouts are circular intersections with specific design and traffic control features. These features include yield control of all entering traffic, channelized approaches, and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than 50 km/h (30 mph)." (page 5)
https://www.fhwa.dot.gov/publications/research/safety/00067/00067.pdf

Design Involves Tradeoffs

"Roundabout design involves trade-offs among safety, operations, and accommodating large vehicles." (page 130)
https://www.fhwa.dot.gov/publications/research/safety/00067/000676.pdf

Network Considerations Affect Roundabout Design Alternatives

"Roundabouts have been considered as isolated intersections in most other international roundabout guides and publications. However, roundabouts may need to fit into a network of intersections, with the traffic control functions of a roundabout supporting the function of nearby intersections and vice versa. (page 213)
https://www.fhwa.dot.gov/publications/research/safety/00067/000678.pdf

"Roundabouts operate effectively only when there are sufficient longer and acceptable gaps between vehicles in the circulatory lanes. If there is a heavy movement of circulating drivers, then entering drivers at the next downstream entry may not be able to enter. This situation occurs most commonly during the peak periods, and the performance of the roundabout can be greatly improved with entrance metering. [But, r]oundabouts should not be planned for metering or signalization unless unexpected demand dictates this need after installation." (page 214)
https://www.fhwa.dot.gov/publications/research/safety/00067/000678.pdf

Benefits of Roundabouts

"According to the Insurance Institute of Highway Safety (IIHS), there are many safety benefits associated with the modern roundabout:

- 90 percent reduction in fatal crashes
- 75 percent reduction in injury crashes
- 30-40 percent reduction in pedestrian crashes
- 10 percent reduction in bicycle crashes
- 30-50 percent increase in traffic capacity

"There other benefits to roundabouts, including

- reduction in fuel use and pollution.
- no signal equipment to install and repair.
- quieter neighborhoods."

https://azdot.gov/about/transportation-safety/roundabouts/overview

Safety, Health and Public Welfare are Paramount Considerations Among Civil Engineers

"Most are familiar with the Hippocratic Oath taken by physicians swearing to practice medicine honestly and without harm. Professional engineers also are bound by a code of ethics, the American Society of Civil Engineers Code of Ethics, which states: *Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.* (page 2)
http://c.ymcdn.com/sites/www.acecwi.org/resource/resmgr/imported/Roundabouts_White_Paper_vFinal.pdf

Safety Related Considerations

Safety is better at small and medium capacity roundabouts -- FWHA

"In particular, single-lane roundabouts have been found to perform better than two-way stop-controlled (TWSC) intersections in the U.S. (5). Although the frequency of reported crashes is not always lower at roundabouts, the reduced injury rates are usually reported (6). Safety is better at small and medium capacity roundabouts than at large or multilane roundabouts (1, 7). While overall crash frequencies have been reduced, the crash reductions are most pronounced for motor vehicles, less pronounced for pedestrians, and equivocal for bicyclists, depending on the study and bicycle design treatments (4, 6, 7). (page 103)
https://www.fhwa.dot.gov/publications/research/safety/00067/000675.pdf

Safety Increases When Conflicts, Speed Differentials and Speed Changes Are Reduced

"For optimum roundabout safety and operational performance the following should be noted:

- Minimizing the number of potential conflicts at any geometric feature should reduce the multiple vehicle crash rate and severity.
- Minimizing the potential relative speed between two vehicles at the point of conflict will minimize the multiple vehicle crash rate and severity (it may also optimize capacity). To reduce the potential relative speed between vehicles, either the absolute speeds of both vehicles need to be reduced or the angle between the vehicle paths needs to be reduced. Commuter bicyclist speeds can range from 20 to 25 km/h (12 to 15 mph) and designs that constrain the speeds of motor vehicles to similar values will minimize the relative speeds and improve safety. Lower absolute speeds will also assist pedestrian safety.
- Limiting the maximum change in speed between successive horizontal geometric elements will minimize the single vehicle crash rate and severity." (page 104)

https://www.fhwa.dot.gov/publications/research/safety/00067/000675.pdf

Single Lane Roundabouts Introduce Fewer Conflicts -- FWHA

"In general, double-lane roundabouts have some of the same safety performance characteristics as their simpler single-lane counterparts. However, due to the presence of additional entry lanes and the accompanying need to provide wider circulatory and exit roadways, double lane roundabouts introduce additional conflicts not present in single-lane roundabouts. This makes it important to use the minimum required number of entry, circulating and exit lanes, subject to capacity considerations. For example, according to United Kingdom roundabout crash models, for a 10,000 entering Average Daily Traffic (ADT), flaring the entry width from one to two lanes is likely to increase injury crashes by 25 percent (8).

"The number of vehicular and pedestrian conflicts points in both conventional intersections and roundabouts increases considerably when they have additional approach lanes. The designer is encouraged to graphically determine conflicts for a particular location, as this information can raise awareness of design issues and may be useful in public presentations.

"The types of conflicts present in multilane roundabouts that do not exist in singlelane roundabouts occur when drivers use the incorrect lane or make an improper turn. These types of conflicts are depicted in Exhibit 5-3 and Exhibit 5-4, respectively. While these types of conflicts can also be present in other intersection forms, they can be prevalent with drivers who are unfamiliar with roundabout operation. The conflicts depicted in Exhibit 5-4, in particular, can be created by not providing a proper design geometry that allows vehicles to travel side-by-side throughout the entire roundabout (see Chapter 6). Crashes resulting from both types of conflicts can also be reduced through proper driver education." (page 107)
https://www.fhwa.dot.gov/publications/research/safety/00067/000675.pdf

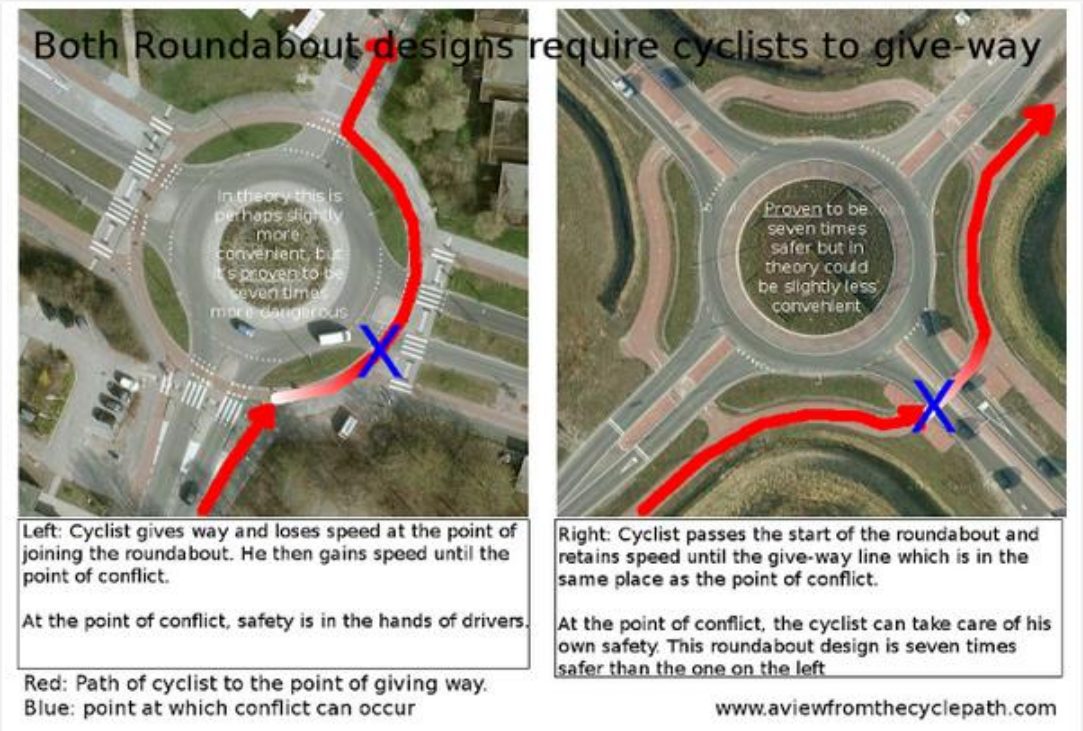
Bicycle Entrance and Exit Ramps

"Bicyclists should be provided similar options to negotiate roundabouts as they have at conventional intersections, where they navigate either as motor vehicles or pedestrians depending on the size of the intersection, traffic volumes, their experience level, and other factors. Bicyclists are often comfortable riding through single lane roundabouts in low-volume environments in the travel lane with motor vehicles, as speeds are comparable and potential conflicts are low. At larger or busier roundabouts, many cyclists may be more comfortable and safer using ramps connecting to a sidewalk or multi-use path around the perimeter of the roundabout as a pedestrian."
https://safety.fhwa.dot.gov/intersection/innovative/roundabouts/fhwasa10006/#s33

"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." (page 7)
http://wisconsindot.gov/rdwy/fdm/fd-11-26.pdf

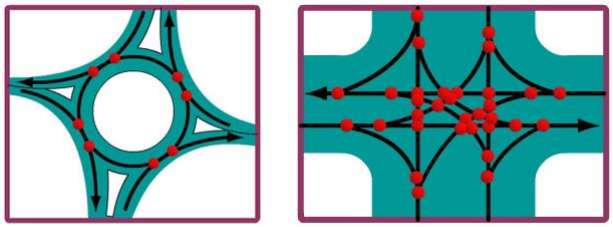
[Note: More than one roadway exit ramp may be provided on longer approach stretches.]

Crash Potential Much Greater With "Annual Ring"/"Bicycle Priority" Design



http://www.aviewfromthecyclepath.com/2014/05/the-best-roundabout-design-for-cyclists.html

Increased "Points Of Conflict" (Opportunities for Collision) Increases Risk -- ADOT



Red dots indicate eight vehicle-to-vehicle conflict points in a modern roundabout.

Red dots indicate 32 vehicle-to-vehicle conflict points in a standard four-way intersection.

https://azdot.gov/about/transportation-safety/roundabouts/overview

Bike Lanes / Riding On the Edge of Roundabouts Not Recommended

"In the U.S., the primary recommendation is not to have bicycle lanes in a roundabout [7]. Bicycle lanes are to be terminated some distance prior to the roundabout [7, 16]. Riding on the edge of a roundabout (as if traversing a roundabout through a bicycle lane) is potentially dangerous for cyclists because it introduces two crash scenarios: 1.) vehicles pass cyclists and crowd them off the lane, and 2.) vehicles exiting the roundabout when a bicycle is riding alongside them introduces the possibility of a right-hook crash [7]."
https://www.researchgate.net/profile/Andrew_Berthaume/publication/261521948_A_New_Methodology_for_Determining_Bicyclist_Safety_at_Single-Lane_Roundabouts/links/00b7d5347d72f1c6b9000000

Wisconsin DOT Bike Lane Design Mandate

"The complexity of vehicle interactions within a roundabout could leave a cyclist vulnerable, and for this reason, designated bike lane markings within the circulatory roadway shall not be used [2009 MUTCD, §9C.04]." (page 14)

Speeds In Roundabouts

Engineers favor slow speeds in roundabouts and their approaches -- FWHA

"The safety and comfort of all users (motorized and non-motorized) is improved when approach and circulating speeds are reduced."
https://safety.fhwa.dot.gov/intersection/innovative/roundabouts/case_studies/rounds4peds.pdf

Speeds of 15mph in Roundabout preferred – PBIC/USDOT

"Modern roundabouts by their design require motorists to slow down typically to less than 25 mph (40 km/h), and preferably 15 mph (25 km/h) to proceed through the intersection."
http://www.pedbikeinfo.org/data/faq_details.cfm?id=3454

Bike Signage For Roundabouts and Approaches

"Bikes May Use Full Lane Signs" Use Approved by Federal Highway Administration

"Section 9B.06 Bicycles May Use Full Lane Sign (R4-11)

"Option:

01 The Bicycles May Use Full Lane (R4-11) sign (see Figure 9B-2) may be used on roadways where no bicycle lanes or adjacent shoulders usable by bicyclists are present and where travel lanes are too narrow for bicyclists and motor vehicles to operate side by side.

02 The Bicycles May Use Full Lane sign may be used in locations where it is important to inform road users that bicyclists might occupy the travel lane.

03 Section 9C.07 describes a Shared Lane Marking that may be used in addition to or instead of the Bicycles May Use Full Lane sign to inform road users that bicyclists might occupy the travel lane.

"Support:

04 The Uniform Vehicle Code (UVC) defines a "substandard width lane" as a "lane that is too narrow for a bicycle and a vehicle to travel safely side by side within the same lane." "
https://mutcd.fhwa.dot.gov/htm/2009/part9/part9b.htm

"Bikes May Use Full Lane Signs" Use At Kansas Roundabouts & Where Too Narrow For Safe Passing

"The "Bikes May Use Full Lane" signs are already installed at roundabouts at the intersections of Wakarusa and Inverness Drive and 19th Street and Barker Avenue.

"'Those are good examples of where the lane is not wide enough for a vehicle to pass a bicyclist, and so the bicyclists are safest if they take the full lane, so that way the cars then queue behind them,' Mortinger said." (page 1)
http://m.ljworld.com/news/2016/nov/07/new-road-signs-provide-bike-friendly-addition-lawr/

"Bikes May Use Full Lane Signs" Integrated Into Maryland's Bicycle Policy & Design Guidelines

"BICYCLES MAY USE FULL LANE sign (R4-11, see Figure 3.6a)

"This Regulatory/Informational sign is intended to be used at locations where it is deemed desirable to remind motorists of the legal right of bicyclists to occupy any space within the travel lane when conditions warrant doing so." (page 3.4)

http://roads.maryland.gov/ohd2/bike_policy_and_design_guide.pdf

"Bicycles May Use Full Lane" Signage Communicates U.S. Roadway Rules and Increases Perception of Safety

"Although limited in scope, our survey results are indicative and suggest that Departments of Transportation consider replacing "Share the Road" with "Bicycles May Use Full Lane" signage, possibly combined with Shared Lane Markings, if the intent is to increase awareness of roadway rights and responsibilities."

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0136973

"Bikes May Use Full Lane" Marking and Signage Used in Many States

"I have seen the signs in Austin, Santa Barbara, Seattle, Tuscon, [and] Sedona. I am also aware that they exist in Boston. All of these cities have robust cycling infrastructure, yet they still promote full lane use by bicycles."

Personal communication from David Warwick, chair of Kalamazoo Area Bike Week, May 14, 2017

[Note: The "Bikes May Use Full Lane" (R4-11 & R4-11-1 type variants) type regulatory (rectangular black on white) and warning (W16-1 & variants) (diamond black on yellow) signs may not yet be approved in Michigan's Manual of Uniform Traffic Control Devices and may require individual approval within each jurisdiction with appropriate authority. See http://cyclemoco.com/2012/08/bikes-may-use-full-lane-signs-going-up-in-maryland/ for illustrations.]

Bicyclist Behavior and Use of Roundabouts: Observations and Recommendations

Experienced vs. Less Experienced Bicyclists

Experienced bikers should have little trouble maneuvering through the intersection and mixing with vehicles; however, less experienced bicyclists may encounter more difficulties. The slower speeds within a roundabout allow vehicles and bicycles to travel at compatible speeds. As with pedestrians, the slower speeds reduce accident severity. To ensure the safety of bicyclists, the Federal Highway Administration recommends a side path to allow less experienced bicyclists to exit the roadway and proceed through the intersection safely." (page 5)

http://c.ymcdn.com/sites/www.acecwi.org/resource/resmgr/imported/Roundabouts_White_Paper_vFinal.pdf

"Taking the Lane" Recommended For Bicyclists Wanting to Ride On Roads In Albany, NY

http://www.capitalcoexist.org/tag/bicycle-safety/

Maryland DOT's Advice to Bicyclists Regarding How to Ride in Roundabouts

"Well–designed, low–speed, single–lane roundabouts should not present much difficulty to bicyclists. On the approach to the entry, signal your intentions and merge into traffic. It is generally safest for bicyclists to claim the lane. Keep in mind that drivers should be traveling at about 15 to 20 miles per hour, close to the speed you ride your bicycle.

"Most roundabouts will give you three options:

"Ride like a car: If you are comfortable riding in traffic, ride on the circulatory roadway of the roundabout like a car. Obey all of the same driving instructions as for cars. Watch out for vehicles crossing your path to leave or join the roundabout. Watch out for large vehicles on the roundabout as they need more space to maneuver.

"Walk like a pedestrian: If you are uncomfortable riding in traffic and no special separate facility is provided, dismount and exit the approach lane before the splitter island on the approach, and move to the sidewalk. Once on the sidewalk, walk your bicycle like a pedestrian.

"Use a shared bicycle–pedestrian path: Some roundabouts may have a ramp that leads to a widened sidewalk or a shared bicycle–pedestrian path that runs around the perimeter of the roundabout. Be courteous to pedestrians and yield to them." (page http://www.roads.maryland.gov/Index.aspx?PageId=287#Bicycling

Wisconsin DOT Bicycling Design and Bicyclist Use Considerations

"The complexity of vehicle interactions within a roundabout could leave a cyclist vulnerable, and for this reason, designated bike lane markings within the circulatory roadway shall not be used [2009 MUTCD, §9C.04]." (page 14)

"Bicyclists may have concerns when traveling into, through, or around roundabouts depending on traffic volume, vehicle type composition, experience of the bicyclist, lighting or other factors. Therefore, a bicyclist approaching a roundabout may proceed in a travel lane ("take the lane"), or exit the roadway by way of a ramp and ride on a roundabout sidepath (or a shared use path, if applicable). http://wisconsindot.gov/rdwy/fdm/fd-11-26.pdf

Australian Bicycle Network On Roundabout Approach Bike Lanes and "Taking the Lane"

"Evidence shows that the bicycle lanes on the approach results in decreased cyclist safety. Therefore, some jurisdictions may not favour this treatment and the recent research points to the importance of bicycles taking the lane when there are equitable approach speeds for bicycles and motor vehicles." https://www.bicyclenetwork.com.au/general/for-government-and-business/2947/

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