CTS Research Brief

Safety and Risk in Modern Urban Roundabouts

Studies investigate bike and pedestrian risks and the effects of signing and striping

**Fast Facts**

- Friction exists between pedestrians/bicyclists and drivers at roundabout crossings; drivers do not always yield to pedestrians and bicyclists as required by Minnesota law.

- Roundabouts save pedestrians and bicyclists time: average pedestrian delay was less than 3 seconds, compared with about 30 seconds for a similar signalized intersection.

- A number of factors affect drivers’ yielding behavior at roundabouts, including direction of travel, size of pedestrian group, presence of other vehicles, and location of pedestrians in relation to the vehicle.

- Visually impaired pedestrians at roundabout crossings have problems that are similar to those at uncontrolled intersections with similar volumes.

- Clarifying roundabout signing and striping can help minimize collisions caused by drivers misunderstanding roundabout rules.

- Extending the solid line at the approach to a two-lane roundabout helps drivers select the correct lane before entering the roundabout, reducing improper left turns from the outer lane and resulting crashes.

**Research Background**

Roundabouts are a fairly recent addition to the road system in the United States, and their relative newness has made them a topic of much discussion and debate. Two studies from researchers at the University of Minnesota aim to shed light on two key issues surrounding roundabouts.

<table>
<thead>
<tr>
<th><strong>Roundabouts provide proven benefits to vehicle traffic in terms of safety and efficiency. They create higher vehicle flows in all directions with virtually no impediments and dramatically reduce the incidence of fatal and severe-injury crashes compared to traditional signalized intersections.</strong></th>
<th><strong>Roundabouts have generated a significant number of complaints from pedestrians and bicyclists, suggesting difficulties and safety concerns. In addition, drivers throughout the country continue to misunderstand the rules of the roundabout, resulting in improper use and avoidable collisions.</strong></th>
</tr>
</thead>
</table>

---
The general public and the pedestrian and biking communities often have concerns about roundabouts, but this study shows that the experience of the pedestrian in a roundabout is actually a positive one. We can use this research to help overcome the disconnect between public perception and the facts.

— Klayton Eckles, Engineering and Public Works Director, City of Woodbury

Pedestrian/Bicyclist Safety and Risk
The first study focused on the experience of bicyclists and pedestrians using roundabout crossings and examined the conditions that affect the yielding behavior of drivers. To collect data for this study, researchers from the Minnesota Traffic Observatory (MTO) positioned specialized video surveillance equipment at two carefully selected Twin Cities-area roundabouts, one in Minneapolis and another in Richfield. Over the course of 32 days (16 days at each of the sites), surveillance equipment captured nearly 14,000 pedestrian crossing events and more than 17,000 bicycle crossing events.

Once the data were collected, researchers reviewed, coded, and analyzed each of the crossing events according to a number of factors, including who yielded, the location of the crossing, and the number of subjects involved. Researchers then looked deeper into a random sample of these crossing events to consider the conditions inside the roundabout before the vehicle proceeded to the crossing and met with the pedestrian or bicyclist. The data were then analyzed as a whole to shed light on the issue of pedestrian and cyclist safety and risk at modern urban roundabout crossings.

Effects of Signing and Striping
A second study conducted by MTO researchers examined the before-and-after effects of signing and striping on a modern two-lane roundabout in Richfield. After its completion, this roundabout exhibited an abnormal number of crashes. In response, local engineers experimented with changes in the roundabout’s signs and striping. MTO researchers analyzed crash records and examined hundreds of hours of video to compare the crash rates and number of violations committed by drivers before and after the changes.

Research Findings

Pedestrian/Bicyclist Safety and Risk
The results of this study highlight the existence of friction between pedestrians and drivers at roundabout crossings. Minnesota law requires that all vehicles yield for pedestrians at crossings, yet they did not always do so. In Richfield, drivers yielded about 42% of the time, while in Minneapolis drivers yielded approximately 83% of the time.

Where the pedestrian or bicycle crossing starts, and the direction the vehicle is driving, are important determinants of drivers’ yielding behavior:

- If a bike or pedestrian crossing starts in the roundabout island, a driver is more likely to yield.
- If a vehicle is exiting the roundabout, the driver is much less likely to yield.
- Drivers tend to yield more frequently to larger groups of bicyclists and pedestrians.
- Vehicles exiting the roundabout that have entered at the immediate upstream entrance (right-turning movement) have an increased probability of yielding.
- The more vehicles in the roundabout, the less likely drivers are to yield to pedestrians.

Despite the delays pedestrians and bicyclists experienced when drivers failed to yield, researchers found that the average delays were much shorter than delays at signalized intersections. For example, if the Richfield intersection were signalized, the average delay for a pedestrian or bicyclist would be 30 seconds; pedestrians and bicyclists at the Richfield roundabout experienced an average delay of less than 3 seconds.
Effects of Signing and Striping

The findings for this study indicate that the changes in signing and striping have made the Richfield roundabout safer. In particular, extending the solid line leading up to the intersection approach from 50 feet to 250 feet seems to have reinforced the message to drivers that they must select the correct lane before approaching the roundabout entrance—reducing the occurrence of drivers making an improper turn and the need for a driver to change lanes within the roundabout.

Another important finding of this study was that the traditional fish-hook style roundabout signs and complex striping patterns often cause confusion among drivers. “Getting rid of the fish-hook signs and simplifying the striping really made a difference,” says Richfield city engineer Kristin Asher. “Our biggest problem before the restripe was left turns from the outside lane causing conflicts and crashes. Once the fish-hook signs were replaced with traditional lane-designation signs and the skips were removed from the circulatory lanes, those crashes essentially disappeared.”

Prior to the changes, left turns from the outer lane accounted for 45% of the recorded crashes. Immediately after the changes, the occurrence of improper turns decreased by 48% and incorrect lane choice was reduced by 53%. One year after the changes, the safety improvements were still significant: the occurrence of improper turns was still down 44% and incorrect lane choice was reduced 50% compared to the “before” scenario.

Traditional fish-hook-style roundabout signs caused confusion among drivers.

Extending solid line striping from 50 to 250 feet before a roundabout helps drivers choose and remain in the correct lane.

Research in Action

Because roundabouts are relatively new to the United States, engineers and project designers are often faced with the challenge of persuading a skeptical public at the start of many new roundabout projects. That’s exactly what happened when a new roundabout was planned on a local thoroughfare in Woodbury, Minnesota. “There was a very engaged neighborhood group near the intersection, and they were concerned that children couldn’t cross the roundabout on foot and that it would cut off their access to local parks,” says Bill Klingbeil, an engineer with the project’s design firm HR Green.

When project designers spoke with the opponents, they learned that very few of them had actually crossed a roundabout. To counter their concerns, Klingbeil shared the results of the MTO’s bike and pedestrian roundabout study and ultimately gained support for the project. “In this study, more than 3,000 people safely crossed a roundabout even busier than the one we were planning, with no close calls or accidents,” says Klingbeil. “The project opponents had a strong opinion on something they had never experienced, and this research helped persuade them that roundabouts are safe for pedestrians.”
Conclusions and Policy Implications

Providing the public with research-based facts to counter objections may help win over roundabout opponents. For example, while this research demonstrates that pedestrian and bicyclist delays at roundabouts are shorter than those at signalized intersections, the numbers taken literally may not describe the perceived delay experienced by the pedestrian. “At a signalized intersection, pedestrians don’t have to interact with traffic, while at a roundabout pedestrians have the right-of-way, and the frustrating, non-yielding behavior of many drivers intensifies the delay experience,” says the study’s lead researcher, MTO director John Hourdos.

These latest roundabout research findings can also be used to improve the safety of modern urban roundabouts for all transportation modes. To improve safety for pedestrians and bicyclists, roundabout exits should be given more attention, as the location of the pedestrian crossing at a roundabout exit has the strongest influence on the driver’s yielding behavior. Therefore, roundabout exits have a greater need for pedestrian warning devices, visible indicators that pedestrians have the right-of-way, and scrutiny regarding the distance of pedestrian crossings from the roundabout.

It’s also important to remember that roundabouts still pose problems for the safety and comfort of visually impaired individuals. “Working only with the fact that at the Richfield roundabout the driver yielding rate was at best 45%, it’s clear that visually impaired individuals cannot assume drivers see them, are willing to stop, or are moving slowly, which are common safe assumptions made at regular signalized intersections,” Hourdos says. “These problems are similar to those that a visually impaired individual would experience at any uncontrolled intersection with comparable volumes.”

To improve safety and decrease driver confusion, it may be necessary to look beyond the current design guidelines for roundabout markings, which are still relatively immature. For example, while numerous details have been added and clarified in the Manual on Uniform Traffic Control Devices guidelines for roundabout markings, there is no specific guideline on the length of the solid line between lanes at the entrances, and most figures show the line turning to dashed shortly upstream of the pedestrian crossing. Researchers found that extending the solid line at the approach to a two-lane roundabout improves safety by helping drivers select the correct lane before entering the roundabout, and believe this is an area where improvements can be made to the current guidelines.

“Both these studies deal with the standards for and perceptions of safety and mobility in roundabouts for both drivers and pedestrians. Through these studies, we can separate the perceptions from the truth and learn about the real strengths and weaknesses of roundabouts in the United States.”

—John Hourdos, Director, Minnesota Traffic Observatory

About the Research

The Investigation of Pedestrian/Bicyclist Risk in Minnesota Roundabout Crossings study was conducted by MTO director John Hourdos and civil engineering professor Gary Davis. The research was sponsored by the Minnesota Department of Transportation. The final research report is available for download at cts.umn.edu/Research/ProjectDetail.html?id=2010099.

The Effects of Signing and Striping on the Safety of a Modern Two-Lane Roundabout study was also conducted by Hourdos and Davis. The research was sponsored by the Minnesota Local Road Research Board. Read more at cts.umn.edu/Research/ProjectDetail.html?id=2012002.