Roundabout Design: Safety and Capacity
Background Paper
July 25, 2004

Introduction

According to the May 13, 2000 Insurance Institute for Highway Safety (IIHS) Status Report, roundabouts have been shown to reduce crashes at intersections. Research cited in the IIHS June 28, 2001 Status Report found that by reducing the number of motorists required to stop before entering an intersection, roundabouts also decreased delays. Public opinion surveys cited in the 2001 Status Report found that in three U.S. cities, initial public opposition to roundabouts under consideration diminished and support for roundabouts grew within a few months after the installation of the roundabouts.

> At first, communities say, "We don't want roundabouts here. We don't need them just because England or France has them." But after the roundabouts are in, communities like them because they work (Eugene Russell, Status Report, July 28, 2001).

Background

Circular intersections were common throughout Europe and America in the early 1900's, but they fell out of favor when traffic congestion and intersection crashes increased in the 1950's. Most roundabouts were replaced by traffic signals (Taekratok 1998). Americans' affinity for technical solutions may explain the shift to signalized intersections; however, many American highway engineers are now coming "full circle," and are beginning to use roundabouts to reduce crashes and increase capacity (Ourston and Hall 1995). The construction of the first roundabouts of the type discussed in the remainder of this paper began in the United Kingdom in 1956. The first such modern roundabout in the United States was constructed in 1990 (Ourston and Hall 1997), and today, there are more than 800 such roundabouts in the U.S (Roundabouts USA).

Roundabouts, like rotaries and traffic circles, can serve to replace standard signalized or unsignalized intersections with circular intersections; however, modern roundabouts are designed differently and operate differently from older circular intersections, and as such, are associated with different advantages and disadvantages than are other types of circular intersections. For this reason, it is important to understand the differences between roundabouts and other types of circular intersections, which will be referred to hereafter as "traffic circles."

Important design characteristics differentiating roundabouts from traffic circles are discussed in detail in the Federal Highway Administration's *Roundabouts: An Informational Guide*. In order for a circular intersection to be considered a modern roundabout, it must have the following features, which differentiate modern roundabouts from other traffic circles:

Traffic Control

- In roundabouts, traffic entering the roundabout yields to traffic in the roundabout, and there is no control of vehicles in the roundabout. Vehicles circulating the roundabout have right-of-way.
- In contrast, traffic circles may use stop control, or even no control, at some or all entries, and may require traffic inside of the circle to yield to traffic entering the circle.

Pedestrian Access

- In roundabouts, pedestrian access is limited to crossing the legs of the roundabout, behind the yield line.
- In contrast, in traffic circles, pedestrians may be allowed to cross the circle and access the central island.

Parking

- No parking is allowed within the roundabout or at its entries.
- Some traffic circles allow parking within the circle or at the entries.

Direction of Circulation

- In roundabouts, vehicles necessarily circulate counterclockwise and pass to the right of the center island.
- Some traffic circles allow left-turning vehicles to pass to the left of the center island.

The design characteristics of roundabouts afford them several advantages over both standard intersections and other types of traffic circles. The Federal Highway Administration considers the following to be elements of good roundabout design, which afford well-designed roundabouts several advantages over poorly designed roundabouts, traffic circles, and other types of intersections:

Speeds

- Properly designed roundabouts achieve speed reduction, generally below 20 – 30 mph, by requiring drivers to circulate in paths of sufficiently small radius.
- Deflection of the paths of entering vehicles, achieved through roadway alignment and the use of raised splitter islands, physically prohibits entry tangential to the circular roadway, which forces drivers to slow down in order to enter, and promotes consistency between the speeds of vehicles in the roundabout and the vehicles entering the roundabout.
- Some traffic circles are designed to allow much higher speed entry and driving, especially by means of tangential entries (i.e., entries with no roadway deflection). Older rotaries, in particular, tended to allow tangential entry, and also have larger diameters, allowing higher speeds.

Capacity

- Vehicles entering a circular intersection require larger gaps in order to enter higher speed traffic. Thus, traffic may enter roundabouts, which emphasize speed reduction, sooner, whereas a longer queue may develop as drivers await sufficiently large gaps to enter higher speed traffic in other types of traffic circles.
- Entering traffic at traffic circles with *stop* control, rather than *yield* control, must await even larger gaps, to allow adequate time to accelerate from the stop line to the speed of the circulating traffic.

Vehicle-Vehicle Conflict

- Roundabouts have fewer conflict points than intersections. As illustrated in the figure below, a standard four-legged intersection of two two-lane roads has 32 potential conflict points, whereas a roundabout constructed at the same intersection would only have 8 conflict points.
- Collisions tend to be less severe between vehicles traveling at low relative speeds (i.e. traveling in the same direction at similar speeds) than at high relative speeds (i.e. head-on or right angle crashes at intersections, or crashes between vehicles traveling in the same direction at greatly differing speeds in traffic circles). The roundabout eliminates the possibility of head-on and right angle crashes, and also decreases the relative speeds between vehicles.

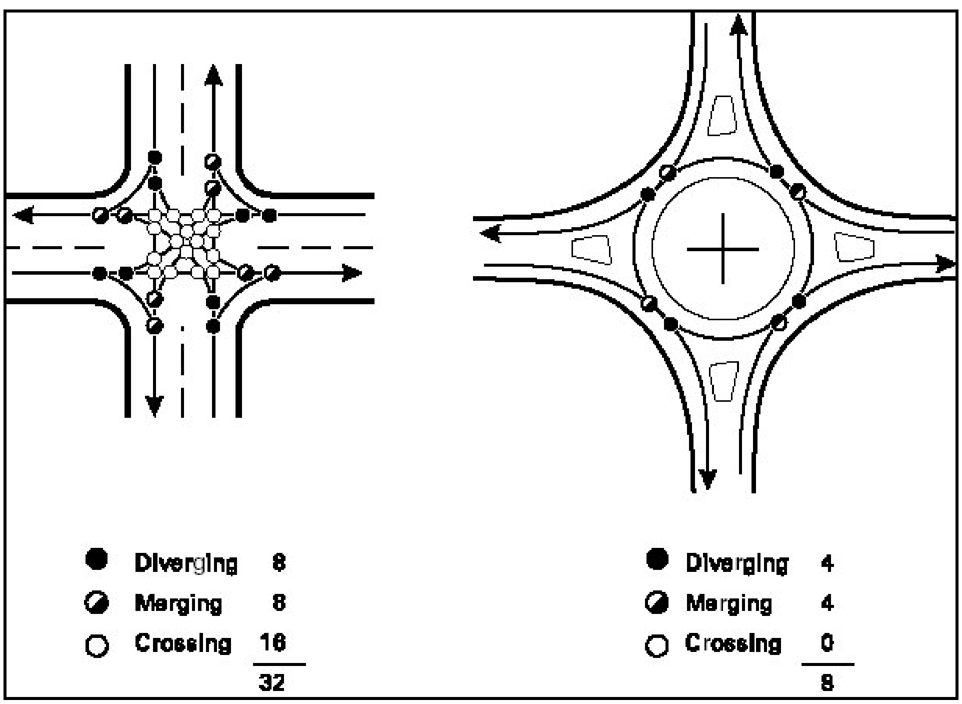

Figure 1. Comparison of vehicle-vehicle conflict points for four-legged intersection and roundabout (Robinson, Rodegerdts, Scarborough et al. 2000).

Pedestrian-Vehicle Conflict

- All but the smallest, lowest speed roundabouts (called "mini-roundabouts") provide a raised splitter island separating traffic entering and exiting a given leg of the roundabout. This enables pedestrians to cross only one direction of traffic at a time, by stopping on the splitter island if necessary. (hmm…the FHWA manually really does cite this as an advantage of roundabouts with splitter islands, but after having seen that video, I'm not sure if this is such a bright idea).
- At standard intersections, pedestrians must cross traffic coming from multiple directions, increasing their exposure to motorists violating red lights or turning left and crossing their paths.

Calming Effects

- Roundabouts can serve to decrease aggressive driving, in that roundabouts provide no red light to try to "beat," or opportunity to race away from the stop line after the signal finally turns green.

Studies of Safety

Several studies to date have examined the safety implications of replacing standard intersections with roundabouts in the United States, Europe, and Australia. No studies were found claiming that roundabouts are more dangerous than signalized intersections, and most claimed that constructing roundabouts carried at least some safety benefits for at least some road users.

There was disagreement regarding which group of road users enjoyed the greatest safety benefits of converting intersections to roundabouts. Hyden and Varhelyi (2000) found that replacing intersections with roundabouts carried a "very significant risk reduction" for bicyclists and pedestrians, but not for cars, whereas studies cited by Robinson et al. (2000) claimed that crash reductions were most pronounced for motor vehicles, and smaller for pedestrians.

Ourston and Hall (1997) reported slightly fewer crashes after converting intersections to roundabouts; however, the results were not found to be statistically significant (perhaps due to the size of the sample, not necessarily the magnitude of the effect). In a study by the Insurance Institute for Highway Safety, roundabouts were associated with large reductions in crashes and injuries (Persaud et al. 2000, Status Report, May 13, 2000).

Studies cited by Robinson, Rodegerdts, Scarborough et al. (2000) found roundabouts to be associated with mean crash reductions of:

- 41 – 61 percent in Australia,
- 36 percent in Germany,
- 47 percent in the Netherlands,
- 37 percent in the U.S.,

and reductions in injury crashes of:

- 45 – 87 percent in Australia,
- 57 – 78 percent in France,
- 25 – 39 percent in the United Kingdom,
- 51 percent in the U.S.

In interpreting these data, the authors note that the crash reductions cited were generally for sites where roundabouts were deliberately installed for the purpose of replacing intersections known to be problematic, and thus may be higher than the benefits that would be expected if all intersections were to be replaced by roundabouts.

Discussion

Roundabouts can be installed to replace standard signalized or unsignalized intersections. They offer the important advantage of eliminating head-on and right angle crashes that can occur at ordinary intersections, and when they are installed to replace problem intersections, several studies from the U.S., Europe, and Australia confirm that roundabouts tend to decrease overall crashes in general and injury crashes in particular. When discussing the impact of roundabouts on safety and on traffic flow, it is important to acknowledge the differences between modern roundabouts and other types of circular intersections that do not possess the same design characteristics and do not operate in the same way.

In addition to safety benefits, roundabouts are generally thought to improve traffic flow, especially at non-peak hours. However, design is critically important (Brilon and Vandehey 1998; Myers 1994), and there are entire books devoted to the topic. Human behavior is also an important consideration. Traffic flow in roundabouts is more variable than for signalized intersections (Brilon and Vandehey 1998), because there is more room for driver discretion. For instance, drivers can wreak havoc if they don’t all play by the same rules, such as yield-at-entry. Indeed, Brilon and Vandehey (1998) discuss “roundabout culture.” They claim that there are shared rules for roundabout behavior, and that the rules are different in different countries.

One potential drawback of roundabouts is the lack of cues afforded to visually impaired pedestrians at intersections. At signalized intersections, visually impaired pedestrians can hear traffic stopping and starting, know that eventually there will be a red traffic signal phase that will allow them to cross, and in some cases, may have access to pedestrian push-buttons for further assistance. At roundabouts, entries are yield controlled, so there will not be audible starting and stopping of traffic, and there will not be any traffic signal to require all traffic to stop for a prolonged period of time. To make the situation even more challenging for the visually impaired, cars exiting the roundabout are not required to yield to pedestrians, and cars exiting the roundabout sound much like cars circulating the roundabout (Kirschbaum et al. 2001). Furthermore, the large turning radii at the corners might make it difficult for pedestrians to identify the roundabout at all. The U.S. Access Board recommended to the Federal Highway Administration that pedestrian signals be added to roundabouts; however, both the cost of installing signals and the loss of mobility for motorists if traditionally yield controlled roundabouts become signalized are concerns (Safe Pedestrians and a Walkable America 2002).

In conclusion, existing studies on modern roundabouts imply that there may be some benefits to be realized by replacing intersections, especially intersections known for crashes and/or congestion, with roundabouts, and furthermore, that these benefits may increase once American drivers gain experience driving in roundabouts. The difficulties that roundabouts pose for visually impaired pedestrians need to be considered when planning to replace a specific intersection with a roundabout, and possible improvements to roundabout design that could aid visually impaired pedestrians without paralyzing motorists warrant additional research.

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