JVIB

October 2005 • Volume 99 • Number 10

Modern Roundabouts: Access by Pedestrians Who Are Blind

Richard G. Long, David A. Guth, Daniel H. Ashmead, Robert Wall Emerson, and Paul E. Ponchillia

---

Abstract: This article describes the key differences between roundabouts and traditional intersections that have traffic signals or stop signs and discusses how these differences may affect the mobility of pedestrians who are visually impaired. It also provides a brief summary of the authors' research on this topic and suggests strategies for addressing the access issues that roundabouts sometimes create.

All research cited in this article was conducted by the authors and was supported by Grant No. R01 EY12894-04 from the National Eye Institute (NEI), National Institutes of Health. The contents of this paper are solely the responsibility of the authors and do not represent the official views of NEI.

According to *Roundabouts: An Informational Guide* (Federal Highway Administration, 2000, p. 19), "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 (about 25 mph)." Thus, roundabouts are "a subset of a wide range of circular intersection forms" (p. 19), including the "rotaries" or "traffic circles" that have existed for many years in Washington, DC; Boston, Massachusetts; and other cities.

Background

Modern roundabouts are relative newcomers to traffic engineering in the United States, but they have been widely used in Europe, Australia, and elsewhere for many years. From a traffic-engineering perspective, the primary purpose of a roundabout is to promote the efficient, safe movement of traffic without the need for traffic signals and the queuing that signals create. As Figure 1 shows, roundabouts have a circular, raised island in the center of the intersection, and a circulatory roadway surrounds this island. Vehicles enter a roundabout, travel counterclockwise (in the United States) around the circulatory roadway, and then exit the intersection at the desired point. A yield line for vehicles is typically painted at the outside edge of the circulating roadway at each entering street, and yield signs direct entering drivers to yield to vehicles in the circle. Roundabout designs can be used to replace the intersection of two or more single-lane roads, multilane roads, or a combination of single-and multilane roads. Some roundabouts have circulatory roadways that are wide enough for two vehicles abreast, while others have a circulatory roadway that is wide enough for only one vehicle.

Roundabouts have splitter islands on each approach. These islands, shaped like elongated triangles and made of concrete or painted on the roadway, separate the entry and exit lanes of a street. Crosswalks usually cut through splitter islands at street level. Splitter islands help to slow traffic as it enters and exits the roundabout by deflecting it from a straight-line course. They also provide a pedestrian refuge midway through a street crossing. Roundabout designers use a variety of design features to slow vehicles to speeds of 25 miles per hour or less as they approach and negotiate these intersections. Slower speeds increase the likelihood that drivers will yield to pedestrians and enhance the safety of both drivers and passengers in vehicles (Retting, Persaud, Garder, & Lord, 2001).

Retting et al. (2001), who provided a summary of data on vehicle crashes and injuries at U.S. roundabouts, noted that roundabouts dramatically reduce the likelihood of severe injuries from vehicular accidents at intersections. These data are important because the reduction of crash and injury rates relative to other types of intersections is one of the most compelling reasons cited by traffic engineers for the installation of roundabouts. As Retting et al. noted, there are several reasons for this clear safety benefit. First, roundabouts eliminate the risk that left-turning motorists can be struck broadside by approaching vehicles because all turning movements when exiting a roundabout are to the right. Roundabouts also eliminate the often-serious crashes that occur at signalized intersections when vehicles are hit broadside by vehicles on the intersecting street that run a red light. Finally, the relatively slow vehicle speeds also confer safety benefits because the speed of vehicles and the severity of injuries to the occupants of vehicles are correlated.

Pedestrians at roundabouts

Roundabouts are designed to direct pedestrian travel along crosswalks that are located on the entry or exit legs, as shown in Figure 1. Pedestrians are not supposed to enter the circulatory roadway or cross the central island. Crosswalks at roundabouts are usually located about one to three car lengths away from the vehicular yield line. Crosswalks are often painted in a striped "zebra" pattern, and there may or may not be signs that instruct drivers to yield to pedestrians. In most U.S. states, drivers are required by law to yield to pedestrians who have entered the crosswalk, but not to pedestrians who are standing on the sidewalk waiting to cross.

Studies of crashes involving pedestrians and vehicles at roundabouts that have been conducted in Europe (Schoon & van Minnen, 1993, 1994; Tumber, 1997) have found no significant change in pedestrian-vehicle crash rates after signalized and stop-controlled intersections are converted to roundabout intersections, and, overall, pedestrian-vehicle crashes at roundabouts occur relatively infrequently. However, what is less clear is whether fewer accidents occur because fewer pedestrians cross at an intersection after it is converted to a modern roundabout. Decisions by pedestrians to avoid intersections that they used to cross could be an indication of concerns about crossing at a particular location. This issue needs to be studied further.

The legal context

Roundabouts, like all intersections that have pedestrian facilities, should be accessible to all users. The Americans with Disabilities Act requires access to roadways, and its implementing guidelines, known as the Americans with Disabilities Act Accessibility Guidelines (ADAAG), describes the features of accessible intersections. The ADAAG does not address access to roundabouts, but such access is addressed in the Draft Public Rights-of-Way Accessibility Guidelines that have been proposed by the U.S. Access Board as an amendment to ADAAG (see U.S. Access Board, 2002). The draft guidelines, if implemented, would require some type of accessible pedestrian-activated crossing signals at each crosswalk of a multilane roundabout, including those at splitter islands.

Components of crossing at roundabouts

Determining the features of an unfamiliar intersection

Pedestrians must recognize that an intersection is just ahead and determine its characteristics as they prepare to cross. Many pedestrians who are blind are experienced in determining the characteristics of unfamiliar "traditional" intersections from the sounds of vehicles that are negotiating the intersection and from other cues. A roundabout has different acoustic "signatures" than does a traditional intersection. Because vehicles on the parallel street are deflected away from the center of the intersection by the central island and do not stop at the circulatory roadway unless there is a vehicle in the roadway, it may appear that there is a rightward curve in the road, rather than an intersection (if no perpendicular traffic is heard). Since roundabouts are not yet common in the United States, many pedestrians who are blind have probably not yet heard the auditory patterns that are created by the movement of vehicles at roundabouts. With experience and training, it is likely that many will be able readily to distinguish roundabouts from other types of intersections, just as they currently differentiate various types of signal- and stopsign-controlled intersections. Research is needed to determine the type and degree of exposure and training that pedestrians who are blind need to distinguish the characteristics of various types of unfamiliar intersections, including roundabouts.

Locating the desired crosswalk and place to stand

One important distinction between roundabouts and other intersections is that the two crosswalks at a particular "corner" of a roundabout are typically farther apart and farther from the intersection than they are at more traditional intersections (see Figure 1). Features that have been suggested to assist travelers in locating roundabout crosswalks include the use of landscaping or low brick or concrete edging leading to the curb ramps (Whipple, 2004). Such features can be detected by following them with a long cane. Pedestrians who use dog guides and who use suggestive turn commands as they approach a turn will need to become accustomed to the placement of curb ramps at roundabouts.

In addition, as of July 2001, all newly constructed curb ramps at roundabouts, as at other intersections, were required by the ADAAG to include a 24-inch strip of detectable warning material installed across the full width of the ramp at the edge of the street. As at traditional intersections with blended curbs or other designs that make locating the street-sidewalk boundary challenging, detectable warning material may reduce the likelihood that pedestrians will enter the street without being aware that they are doing so. Detectable warning material would also provide information on the boundaries of the splitter island.

Establishing alignment and maintaining heading

At typical intersections, the sounds of vehicles on the parallel and perpendicular streets are often an important source of information for establishing alignment (Guth, Hill, & Rieser, 1989) and for maintaining heading (a desired line of travel) while crossing (Guth & Rieser, 1997). Both tasks may be difficult using traffic sounds alone because vehicles at roundabouts are traveling on curvilinear paths. If research on alignment and the experience of pedestrians who are blind reveal that alignment is challenging at some roundabouts, additional cues for accomplishing these tasks may be necessary.

Similarly, little is known about the information that is needed to maintain a heading while crossing at a roundabout intersection. Depending on whether a pedestrian who is blind is crossing from the splitter island or the curb, veering from this heading while crossing is likely to lead to contact with the curb or with the curbed edge of the splitter island. Given the location of roundabout crosswalks and what is known about the nature and extent of veering (see, for example, Cratty, 1971; Guth & LaDuke, 1995), blind pedestrians are unlikely to veer enough to enter the circulatory roadway. The use of some of the veer-recovery techniques that are used at signalized intersections may prove to be effective at some roundabout intersections. Additional sources of information to direct pedestrians along the crosswalk (such as tactile markings along the edges of a crosswalk) may also prove to be necessary, but no research has been conducted in this area. Return curbs, which are curb ramps with vertical sides that are parallel to the desired line of travel, may also prove to be useful for alignment.

Crossing at a "low-risk" time

Perhaps the most important task in reducing risk during street crossing is to begin to cross at an appropriate time. At a roundabout, this typically means one of the following: (1) crossing when no approaching vehicle can reach the crosswalk before the crossing is completed, (2) crossing with the expectation that approaching vehicles that can reach the crosswalk before the crossing is completed will be able to yield and then monitoring these vehicles to ensure that they yield, or (3) crossing when vehicles are stopped or stopping just upstream of the crosswalk. Because of the potential consequences of failing to cross at an appropriate time, we chose to focus our initial program of research about nonvisual street crossings at roundabouts on this step of the street-crossing process. Our initial experimental work was intended to describe the performance of street-crossing judgments and, later, actual street crossings, by blind and sighted individuals at roundabouts that varied in their geometric characteristics and traffic volumes. Our empirical studies were preceded by several focus-group discussions that we conducted with blind pedestrians in England and France, where roundabouts are common. We concluded from these discussions that some roundabouts are difficult or risky to cross and that empirical research is needed to gain a better understanding of the challenges that roundabouts pose. One French individual who is visually impaired reported that she had to "be quite bold" while crossing at roundabouts, and, roughly translated, she said, "Sometimes I use the pray-and-go technique when entering the crosswalk."

The initial studies

In our initial empirical studies, we asked pedestrians who were blind and those who were sighted to indicate when they could cross from the curb to the splitter island before the next approaching vehicle reached the crosswalk. The participants in these studies did not actually cross the street. Instead, they pushed a button that was linked to a computer when they believed that they could cross safely. The arrival of vehicles at the crosswalk after a participant pushed the button was also recorded. By subtracting the time needed to cross from the time of arrival of the closest vehicle after the participant pushed the crossing button, we determined whether the participant would actually have been able to complete the crossing before a vehicle reached the crosswalk. These relatively simple initial studies about traffic judgments using hearing were motivated not only by the outcomes of our focus groups, but by the fact that several U. S. traffic engineers and civic planners had indicated to us that they did not believe that roundabouts would pose a problem for pedestrians who are blind. These engineers believed that roundabouts would not be difficult to cross without vision because of the two-stage nature of roundabout crossings (exit then entry lanes, or vice versa), because vehicles move relatively slowly in roundabouts, and because drivers would stop for pedestrians who were blind.

Our first study was conducted at three roundabouts in the Baltimore, Maryland, area with six adults who were blind and six who were sighted (Guth, Ashmead, Long, Wall, & Ponchillia, 2005; Guth, Ashmead, Long, Ponchillia, & Wall, 2003). Each participant made judgments about whether he or she could cross from the curb to the splitter island before the arrival of the next vehicle at the crosswalk. The participants completed this task at both the entry and exit lanes. The sites were a single-lane roundabout carrying about 12,000 vehicles per day, a multilane roundabout carrying about 24,000 vehicles per day, and a multilane roundabout carrying more than 40,000 vehicles per day. One of our measures was the "safety margin" of judgments when the participants indicated that it was safe to cross, that is, the difference between the arrival time of the next vehicle at the crosswalk and the time it would have taken the participant to cross; if he or she actually initiated a crossing. The safety margins were significantly shorter for the blind participants than for the sighted participants at the two higher-volume roundabouts, but not at the low-volume roundabout. Overall, the blind participants were about 2.5 times more likely than were the sighted participants to report that they would initiate a crossing when there was not adequate time to cross. The blind participants at all three roundabouts tended to detect the onset of a crossable gap about three seconds after the sighted participants did. A major factor that influenced this finding was that the blind participants had to wait for the sound of receding traffic to decrease before they could hear approaching vehicles. Exit-lane judgments were more difficult than were entry-lane judgments, perhaps because of the challenge of determining whether vehicles were exiting or continuing in the circulatory roadway.

The Baltimore study clearly established that two of the roundabouts posed challenges to access for the sample of blind participants, while one did not appear to do so, at least under our low traffic-volume experimental conditions. Our findings led us to conclude that some moderate- and high-volume roundabouts that are similar to those we studied in the Baltimore area may pose an unacceptable level of risk for blind pedestrians, while low-volume roundabouts may not. One difficulty in interpreting these findings of differences in judgments across the roundabouts we studied is that the differences could be due to variables other than the amount of traffic flow. The roundabouts, for example, differed in the number of lanes, number of intersecting streets, terrain, and other characteristics.

To determine the effect of the volume of vehicles on judgments of safety margins while controlling for variables like the ones just mentioned, we conducted a second study at a single-lane roundabout in Tampa, Florida, that had a widely varying volume of traffic over the course of the day. As in the Baltimore study, the blind participants made more high-risk judgments than did the sighted participants. And, as expected, they did so more often during periods of peak traffic volume (rush hours) than during periods of low-traffic volume. In one experimental condition, we asked the participants to make judgments at simulated crosswalks that were 20 meters (about 66 feet) away from the actual crosswalks (that is, upstream from the entry-lane crosswalk and downstream from the exit-lane crosswalk). In this condition, their judgments improved during the rush-hour tests. Moving crosswalks away from the circulatory roadway is one strategy that has been proposed for improving crossings, presumably because it moves pedestrians farther from the noise of vehicles in the circulatory roadway and reduces the ambiguity about whether vehicles that are approaching the exit lane are exiting across the crosswalk or continuing in the roundabout. However, these gains may be partially offset by the increased speed that exiting vehicles can gain before they reach a crosswalk that has been moved away from the circulatory roadway.

The work in Baltimore and Tampa involved making judgments about crossing without actually crossing the street. It left open the possibility that participants were using different criteria than they would have had they actually crossed. To address this possibility, as well as to follow up on several differences that we found in the earlier studies, we conducted a third study at a high-volume, two-lane roundabout in Nashville, Tennessee (Ashmead, Guth, Wall, Long, & Ponchillia, 2005). In that study, blind and sighted participants made judgments without actually crossing during half the trials and crossed during the other half. The participants who were blind performed similarly on the two types of trials. This finding supported the validity of using the judgment-only experimental method as a means of investigating access to roundabouts. As at the two higher-volume roundabouts in Baltimore and the Tampa roundabout at periods with higher volume, the blind pedestrians had greater difficulty than did the sighted pedestrians distinguishing gaps in approaching traffic that were long enough to cross from those that were not.

A performance measure that we used for the first time in the Nashville study was the frequency of interventions by an orientation and mobility (O&M) instructor, who closely followed the participants as they crossed the street during the trials. An intervention was recorded any time the O&M instructor physically stopped the pedestrian from continuing to cross because of safety concerns. Although interventions occurred in only 6% of the trials, there was a 99% cumulative probability of a serious pedestrian-vehicle conflict at this intersection if a person who was blind crossed it daily for three months. (A conflict is a situation in which a crash is likely unless the driver or pedestrian takes immediate evasive action.) This is a key finding of our work, in that it is perhaps the most compelling evidence of the challenges that roundabout intersections pose for individuals who are blind or have low vision. Many participants who were blind told us that they would not cross at this intersection if they had any other option. Drivers on the entry lanes but not on the exit lanes frequently yielded to pedestrians. The sighted participants always took advantage of this yielding, but the blind participants rarely did so, particularly because of the difficulty in auditorily detecting that drivers had yielded in two lanes simultaneously.

Our fourth study involved evaluating an intervention to improve access to a relatively high-volume, single-lane roundabout in Raleigh, North Carolina. This study was a follow-up to our formal (Geruschat & Hassan, 2005; Guth et al., 2005) and informal observations that at many roundabouts, few drivers yielded to pedestrians who were waiting to cross, even those who used mobility devices. In those previous studies, we also found that when a vehicle yielded, blind pedestrians often failed to detect it, which sometimes appeared to be due to ambient noise levels that made it impossible to hear the idling vehicle, sometimes because vehicles yielded so far back from the crosswalk that they could not be heard, sometimes because the vehicles themselves were quiet as they yielded, and sometimes because of a combination of these factors. In October 2004, our team built and evaluated a prototype system that used a series of in-roadway sensors to detect the presence of vehicles approaching a crosswalk and a set of decision rules to determine when a vehicle had yielded. When the system detected a vehicle that had yielded, this information was conveyed via speech messages that were presented by speakers at the crosswalk. The participants crossed with and without the system, and all trials were filmed. Although the prototype system requires more development and testing, it is clear that the information presented by the system is a useful adjunct to the "naturally" available acoustic information.

Issues in access to roundabouts

Roundabouts are likely to become more common in the United States as more transportation engineers and planners take advantage of the clear and substantial safety benefit that they create for the occupants of vehicles. Pedestrians who are blind and the O&M instructors who serve them will be faced with the challenges involved in navigating these intersections safely. The research we have conducted thus far suggests that some roundabouts will pose challenges to access by pedestrians who are blind. Our research has focused on the task of determining when to begin crossing, although research is also needed on how roundabouts, particularly those that are unfamiliar to pedestrians, influence the ability of pedestrians who are blind to locate the desired crosswalk, to align for the crossing, to stay in the crosswalk during crossing, and to locate the splitter island.

Roundabouts with moderate or high volumes of vehicles may be of particular concern to pedestrians who are blind. Also, situations in which pedestrians must cross more than one lane of traffic often appear to be more challenging than situations in which only one lane must be crossed to reach a splitter island or curb. The number of lanes to be crossed is important because when crossing two lanes of traffic that are headed in the same direction, it is necessary to determine that vehicles have yielded in both lanes or that there is an adequate gap to afford crossing both lanes. Crossing when there is an adequate gap only in the near lane or when a vehicle has stopped only in the near lane may result in a situation in which the pedestrian reaches the middle of the two lanes and cannot complete the crossing because there are neither crossable gaps nor drivers who have yielded in the second of the two lanes. This "multiple-threat" challenge is perhaps one of the most significant access issues that blind pedestrians will face at multilane roundabouts.

Another emerging issue that will likely affect access to roundabouts is the type and amount of sounds that vehicles make. As quieter vehicles become more common, hearing-based judgments of appropriate times to begin crossing seem likely to become less accurate or reliable. We suggest that quiet vehicles make it more difficult to detect gaps in traffic that are crossable and more difficult to detect vehicles that have yielded upstream of the crosswalk. Research is needed to determine the impact of quiet vehicles on detecting gaps in traffic and in detecting vehicles that have yielded for pedestrians at a variety of "uncontrolled" crossings, including roundabouts, channelized right-turn lanes, and uncontrolled intersections.

In regard to the issue of signalizing roundabouts, the U.S. Access Board (n.d.) recommends that roundabouts should be signalized to ensure that they are accessible for pedestrians who are blind. It appears that some roundabouts will probably require some sort of signals to ensure access, while others may not. Which intersections require signals, and what type of signals should they be? How may pedestrian signals be operated so that they support access but do not significantly restrict the movement of vehicles in and out of the roundabout? Researchers at the University of North Carolina's Highway Safety Research Center and North Carolina State University's Institute for Transportation Research and Education are investigating this problem by modeling roundabout operations under various pedestrian and vehicle conditions to explore signals options that meet the needs of all roundabout users (Rouphail, Hughes, & Chae, 2005).

Traffic engineers play an important role in the roundabout-access issue. As evidenced by the many recent conference presentations and postings on electronic discussion groups about blind pedestrians' access to roundabouts, U.S. engineers are becoming increasingly aware of access concerns. The National Cooperative Highway Research Program has recently funded a major study of blind individuals' access to roundabouts (Hughes, 2005). This grant is significant because it is, to our knowledge, the first major grant awarded by the transportation community to investigate access issues for persons who are blind. O&M instructors and blind individuals will play an important role in educating engineers about access to roundabouts. They should be prepared to accompany engineers to roundabouts and assist them in experimenting with the task of making judgments about the status of vehicles on the basis of auditory cues. They should discuss with engineers the concerns about single- versus multilane crossings discussed earlier and about the installation of detectable warnings on the splitter island to ensure that the boundaries of the travel lanes and the pedestrian refuge are clearly delineated. O&M instructors and the visually impaired persons they serve may be asked to provide guidance on the installation of accessible pedestrian signals at roundabouts. Information on topics like these can be found on the web sites of Accessible Design for the Blind <www.accessforblind.org> and

Walkinginfo.org <www.walkinginfo.org>.

O&M instructors also need to play a role in helping consumers who are blind become familiar with roundabouts. To do so, they should become familiar with the unique auditory cues made by vehicles as they traverse a roundabout and should cross streets at roundabouts while they are blindfolded. They also should assist consumers in learning about the acoustic and tactile cues that may help them cross safely and efficiently. One tool that may be useful to O&M instructors as they evaluate access to roundabouts with their clients is Sauerburger's (1995) timing method for assessing the detection of vehicles. This method involves measuring the time from the first detection of an approaching vehicle until the vehicle passes the pedestrian and relating this measurement to the time needed to cross. Our research measures were similar to this approach.

How may changes in driver-pedestrian interaction affect access to roundabouts? What role does movement by blind pedestrians that may communicate to drivers their intention to cross play in increasing yielding behavior by drivers? Can blind pedestrians detect yielded vehicles reliably? If drivers yield reliably to pedestrians and pedestrians can readily detect when drivers have yielded, then access to roundabouts will presumably be improved. Research is needed to determine what strategies individuals who are blind can use to increase the likelihood that drivers will yield and that pedestrians will be able to detect yielded vehicles. The enforcement of pedestrian right-of-way laws, along with designs of roundabouts, such as moving the crosswalk away from the circulatory roadway in an effort to increase the likelihood that yielded vehicles will be detected, also appear to be reasonable strategies to pursue at high-volume single-lane roundabouts.

Access to roundabouts by pedestrians who are blind raises important research and practice issues. These issues must be addressed to ensure that pedestrians who are blind can cross streets with a reasonable risk and without undue delay. Researchers, traffic engineers, individuals who are blind, and O&M instructors must continue to work together, as they have during the past five years, to gain a fuller understanding of the issues that roundabouts can create and the strategies that can help to resolve them.

References

Ashmead, D., Guth, D., Wall, R., Long, R., & Ponchillia, P. (2005). Street crossing by sighted and blind pedestrians at a modern roundabout. *ASCE Journal of Transportation Engineering, 131*.

Cratty, B. (1971). *Movement and spatial awareness in blind children and youth*. Springfield, IL: Charles C Thomas.

Federal Highway Administration. (2000). *Roundabouts: An informational guide* (Publication FHWA-RD-00-067). McLean, VA: Author.

Geruschat, D. R., & Hassan, S. E. (2005). Yielding behavior of drivers to sighted and blind pedestrians at roundabouts. *Journal of Visual Impairment & Blindness*, *99*, 286-302.

Guth, D., Ashmead, D., Long, R., Ponchillia, P., & Wall, R. (2003, April). *Blind pedestrians' vehicular gap detection at roundabout intersections*. Paper presented at the 11th International Mobility Conference, Stellenbosch, South Africa.

Guth, D., Ashmead, D., Long, R., Wall, R., & Ponchillia, P. (2005). Blind and sighted pedestrians' judgments of gaps in traffic at roundabouts. *Human Factors*, *47*, 314-331.

Guth, D. A., Hill, E. W., & Rieser, J. J. (1989). Tests of blind pedestrians' use of traffic sounds for street-crossing alignment. *Journal of Visual Impairment & Blindness*, *83*, 461-468.

Guth, D., & LaDuke, R. (1995). Veering by blind pedestrians: Individual differences and their implications for instruction. *Journal of Visual Impairment & Blindness*, *89*, 28-37.

Guth, D. A., & Rieser, J. J. (1997). Perception and the control of locomotion by blind and visually impaired pedestrians. In B. B. Blasch, W. R. Wiener, & R. L. Welsh (Eds.), *Foundations of orientation and mobility* (2nd ed., pp. 9-38). New York: American Foundation for the

Blind.

Hughes, R. (2005). *National Cooperative Highway Research Program active project 3-78: Crossing solutions at roundabouts and channelized turn lanes for pedestrians with vision disabilities*. [Online]. Available: http://www4.nas.edu/trb/crp.nsf/e7bcd526f5af4a2c8525672f006245fa/575b1ad6aa4ad3fd85256960006de0cb?OpenDocument

Retting, R., Persaud, B., Garder, P., & Lord, D. (2001). Crash and injury reduction following installation of roundabouts in the United States. *American Journal of Public Health, 91*, 628-631.

Rouphail, N., Hughes, R., & Chae, K. (2005). Exploratory simulation of pedestrian crossings at roundabouts. *Journal of Transportation Engineering, 131*(2), 211-218.

Sauerburger, D. (1995). Safety awareness for crossing streets with no traffic control. *Journal of Visual Impairment & Blindness, 89*, 423-431.

Schoon, C., & van Minnen, J. (1993). *Ongevallen op rotondes II* [Accidents on roundabouts: II. Second study into the road hazard presented by roundabouts, particularly with regard to cyclists and moped riders]. (SWOV report R-93-16). Leidschendam, The Netherlands: SWOV Institute for Road Safety Research.

Schoon, C., & van Minnen, J. (1994). The safety of roundabouts in the Netherlands. *Traffic Engineering and Control, 35*, 142-148.

Tumber, C. (1997). *Review of pedestrian safety at roundabouts*. Victoria, Australia: VicRoads.

U.S. Access Board. (2002). *Draft guidelines for accessible rights-of-way* [Online]. Available: http://www.access-board.gov/rowdraft.htm

U.S. Access Board. (2005, September). *Americans with disabilities accessibility guidelines*. [Online]. Available: http://www.access-board.gov/ada-aba/final.html

U.S. Access Board. (n.d.). *Pedestrian access to modern roundabouts: Design and operational issues for pedestrians who are blind* [Online]. Available: http://www.access-board.gov/research&training/roundabouts/bulletin.htm

Whipple, M. (2004). Curb ramp design by elements and planter strip curb ramp. *Proceedings of the Wayfinding at Intersections Workshop*. Washington DC: Institute of Transportation Engineers, U.S. Access Board.

Richard G. Long, Ph.D., *associate professor, Department of Blindness and Low Vision Studies, Western Michigan University, 1903 West Michigan Avenue, Mailstop 5218, Kalamazoo, MI 49008-5218; e-mail: <Richard.long@wmich.edu>.* ***David A. Guth, Ph.D.,*** *professor, Department of Blindness and Low Vision Studies, Western Michigan University; e-mail: <david.guth@wmich.edu>.* ***Daniel H. Ashmead, Ph. D.,*** *associate professor, Department of Hearing and Speech Sciences, Bill Wilkerson Center, Vanderbilt University, 1114 19th Avenue South, Nashville, TN 37232-8700; e-mail: <daniel.h.ashmead@vanderbilt.edu>.* ***Robert Wall Emerson, Ph.D.,*** *assistant professor, Department of Blindness and Low Vision Studies, Western Michigan University; e-mail: <robert.wall@wmich.edu>.* ***Paul E. Ponchillia, Ph.D.****, chairperson and professor, Department of Blindness and Low Vision Studies, Western Michigan University; e-mail: <paul.ponchillia@wmich.edu>.*

Please direct your comments and suggestions to afbinfo@afb.net