

Considerations for Accommodating Visually Impaired Pedestrians at Roundabouts

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Abstract

As roundabouts become more popular in North America, issues arise that require a designer to accommodate all people and modes safely in a roundabout. Roundabouts generally, have significant safety benefits over other traffic control devices for vehicles and therefore are considered useful to improve safety primarily as drivers must make complex decisions at traffic signals where in a roundabout the decision making is simplified in a slower environment. However this traffic control measure has some drawbacks including the accommodation of visually impaired pedestrians and the perceived need by some to have audible cues.

Applications such as the “Hawk” system (a series of signal phases), actuated flashing beacons with audible cues, and tactile devices are discussed in the report.

A case study is presented that addresses visually impaired pedestrian considerations at a one-lane roundabout. Finally, an overview of future design and education considerations is given, which is of particular importance for jurisdictions where roundabouts are being introduced.

Introduction

As roundabouts become more popular in North America, issues arise that require a designer to accommodate all people and modes safely in a roundabout. Roundabouts generally have significant safety benefits over other traffic control devices for vehicles and therefore are considered useful to improve safety, primarily as drivers must make complex decisions at traffic signals, whereas in a roundabout the decision-making is simplified in a slower environment. However this traffic control measure has a drawback, the accommodation of Visually Impaired (VI) pedestrians and the need to have sensory cues.

In particular, roundabouts create different circumstances for VI pedestrians, compared to other typical intersections. Behaviour of VI pedestrians largely depends on the sources of various sounds. The circulating travel system of roundabouts may produce a unique sound environment which causes VI pedestrians more difficulty in discerning vehicles' approach, speed and destinations.

This paper discusses issues in accommodating VI pedestrians at roundabouts, with a discussion of mitigation alternatives and considerations between single and multi-lane roundabouts. Much of the documentation is taken from a study completed by Boulevard Transportation Group Ltd for the City of Surrey, BC.

Background Information

Benefits of Roundabouts

A roundabout is a type of traffic control device. The device is unique in that all approaching or entering vehicles must yield the right-of-way to circulating traffic in the roundabout. The vehicles circulating in the roundabout (centre circulating lanes) all travel in a counter clockwise rotation. The benefits of a roundabout are that the driver wishing to enter the roundabout is dealing with a pedestrian crosswalk prior to negotiating the roundabout and when negotiating a roundabout only has vehicles approaching from the left and therefore only needs to see an acceptable gap in the one-way traffic.

At appropriate locations roundabouts can improve safety and traffic operation over unsignalized and signalized intersections. Drivers deal firstly with pedestrians in a crosswalk prior to dealing with other decisions of when to enter a roundabout. Slower speeds and having all vehicles travelling in the same direction eliminate right angle and head-on collisions. The third benefit is achieved by eliminating or reducing the number of stops or traffic delays experienced as drivers are approaching a yield condition through which they may proceed without stopping, if traffic conditions permit. For these reasons of improved safety and operation, roundabouts have become a good solution to traffic conflicts and congestion.

Roundabout geometry is specifically designed to allow drivers to approach a crosswalk prior to making decisions at the roundabout. The crosswalks at a roundabout are set back from the roundabout a minimum of one car length. The driver looks for pedestrians at a crosswalk before crossing the pedestrian area and entering the roundabout. When drivers are in the roundabout and

exiting, they must yield to pedestrians in the crosswalk. The set-back allows for vehicles not to be in the roundabout when they are yielding to a pedestrian.

Roundabouts facilitate pedestrian crossings by providing a two-staged crossing where the pedestrian crosses to the centre refuge median. In this way pedestrians can judge the approaching vehicles in one direction and make a decision as to when an acceptable gap is available to cross. Once at the median the pedestrian can judge the opposite direction and complete their crossing when safe.

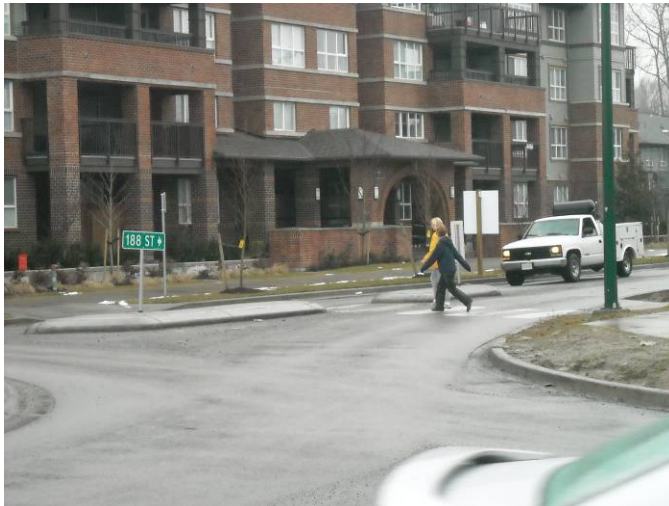


Figure 1: Pedestrians Crossing at 188th & 68th Roundabout, Surrey BC

Pedestrian Crossing and Control System

In the Province of British Columbia there is a hierarchical system of pedestrian crossing. The system includes signing, markings and signal control for crossing locations. The hierarchical system, arranged from lowest level of control to highest level of control is:

- pedestrian crosswalk (unmarked),
- pedestrian crosswalks (signed and marked crossings),
- special crosswalks,
- pedestrian activated signals, and
- grade separation.

The Ministry of Transportation and Infrastructure (MOT) and the Transportation Association of Canada (TAC) provide guidelines for road authorities to place these various crossing controls. These guidelines are based on available gap calculations and therefore take into consideration physical limitations, volumes, and pedestrian age.

Roundabouts and the Visually Impaired

Issues with the Visually Impaired

Pedestrians crossing at a roundabout are generally recognized as safer than crossing at other types of intersections due to roundabout characteristics of geometrics and operation. On the other hand, a roundabout can be a new experience to VI pedestrians crossing. When VI pedestrians wish to use crosswalks at a roundabout the circumstances can be more challenging due to having to resort to hearing rather than seeing.

At a roundabout, a crosswalk is typically located close to the circulatory lane (7.5m clearance). VI pedestrians crossing at a roundabout can find it difficult to determine a proper crossing opportunity due to indistinguishable vehicle noise sources, where it is unclear whether a vehicle circulating in the roundabout is exiting or not. For this reason VI pedestrians may feel more unsafe at roundabouts than at other conventional intersections.

Visually Impaired Pedestrian Crossing Requirements

An accessible street crossing is one that is usable by pedestrians who have mobility, cognitive, and/or sensory impairments. The VI pedestrian planning on manoeuvring through a roundabout needs information and guidance that utilizes the senses that pedestrian has whereas most people use vision to discern and make decisions VI do not. The VI pedestrian uses tactile and audio clues for discerning and making decisions.

Determining safe crossing gap and deciding when to initiate the crossing, needs more than just geometric design elements to help assist the VI pedestrian determine safe crossing times. Appropriately placed tactile surfaces or audible guidance can assist VI pedestrians to locate sidewalks, ramps, crosswalks and splitter islands. Providing perpendicular alignment of the crosswalk to the roadway will assist VI pedestrians with directional guidance.

Determining a time for safe crossing can be accomplished through sensory clues or through active control devices. Sensory clues leaves the responsibility to the pedestrian and is subject to the skills of the pedestrian's other senses in detecting their surroundings. Active control indicates to the pedestrians when they have the right of way and indicates to drivers when they must stop. However in both cases, an amount of human error can be expected, particularly, drivers may intentionally or unintentionally disobey active controls.

The key issues with regards to determining when to initiate the crossing with safe crossing gap:

- The availability of acceptable crossable gaps in traffic.
- The pedestrian's ability to reliably detect crossable gaps when present.
- The pedestrian's ability to reject 'risky' gaps.
- The likelihood of drivers yielding or if required stopping for pedestrian in the crosswalk.
- The ability of VI pedestrians to detect the presence of drivers who yield.
- Treatments that reduce or minimize delay to both the pedestrian and to motorized traffic.

Although there is a requirement for vehicles to yield to pedestrians, it has been noted in some research, that some VI pedestrians do not wish to cross in front of stopped vehicles or will practice behaviour of yielding to vehicles. A safety guideline for pedestrians has been to make eye contact with drivers. VI pedestrians may not be able to follow this good practice.

Mitigation Alternatives

Mitigation alternatives for accommodating visually impaired pedestrians fall into three main categories:

1. The location of the crosswalks with respect to the circular portion of the roundabout.
2. Traffic control devices to assist the pedestrian in crossing the roadway.
3. Different types of surface treatments for sidewalk ramps, crosswalks and the roadway approach to the crosswalk.

Various traffic control devices and surface treatments must be practical methods to assist VI pedestrians crossing at a roundabout. Also, relocating crosswalks farther away from a roundabout would give favour to VI pedestrians wishing to cross because the noise from vehicles on a roundabout circle can be significantly reduced. However, at the same time relocating crosswalks could produce down sides to vehicle and other pedestrian operation although it gives benefits to VI pedestrians. Such down sides include additional unwarranted marked crosswalks on a corridor and the impact of these additional unwarranted marked crosswalks.

Crosswalk Locations

Four types of crosswalk can be considered at roundabouts.

- Proximal Crosswalk
- Offset Crosswalk
- Distal Crosswalk
- Mid-block Crosswalk

Proximal Crosswalks

“The terms “proximal” (existing design) and “distal” (exit and approach setback) have been introduced by the NCHRP 3-78 project to refer to the location of the crosswalk relative to the circulatory lane of the roundabout; i.e., whether it is located proximal to (in close proximity to) the circulatory lane – as is the typical placements- or distal (at some distance from) to the circulatory lane.” (1)

Offset Crosswalks

In addition to these two locations a combination of the two, offset crosswalk (exit setback, approach proximal) will also be reviewed. This type of crosswalk has the crosswalk on the exit leg of the roundabout set back 3-4 car lengths from the circulating roadway and the crosswalk on the approach leg of the roundabout set back 1 car length from the circulating roadway.

Distal Crosswalks

The greatest benefits for VI pedestrians are achieved when the crosswalk is moved farther away from the circular portion of the roundabout. The benefits for VI pedestrians regarding the distal crosswalk location compared to the other two choices would be:

- That the approach traffic will be easier and more distinguishable to hear from the circulating traffic noise;
- That there would be more space between the circulating traffic and the crosswalk to allow tactile devices to be put in the approach roadway for a distinguishable audible signal to be made for VI pedestrians;
- The crosswalk is straight across the exit and approach lanes to the roundabout, compared to the offset;
- The VI pedestrian will hear the approaching vehicles to the left for the first lane and to the right for the second lane and not have the confusion of the source of noise that the offset crosswalks have.

Mid-block Crosswalks

A mid-block crosswalk would relocate pedestrian crossings from the area of the roundabout and move them to a location between the adjacent intersections. This practice will result in an increase of walking distance for pedestrians wishing to continue moving along the same street.

The greatest benefit of the mid-block is that it has the highest visibility of the pedestrian by the vehicle driver and the source of vehicle noise is very predictable. The driver is away from the roundabout and has less distraction. This location will have no queuing issues with the roundabout but may be an unexpected location for pedestrian crossing thus resulting in some driver non-compliance to yielding to pedestrians. The midblock application also suggests that there will be a significant diversion required to cross. Also some studies have found that midblock delays actually increase vehicle speeds between the delay points.

Types of Traffic Control

Some jurisdictions have implemented enhanced traffic control at roundabouts to facilitate pedestrian crossings. Three types that have been used at roundabouts are:

- Accessible Pedestrian Signal (APS) device for Vehicle Control
- Hawk System for Vehicle Control
- Vehicles Yield to Pedestrians Legal Requirement

Accessible Pedestrian Signal (APS) Device for Vehicle Control

“Accessible Pedestrian Signal is a system that provides audible cues and vibrotactile signals to convey the same level of pedestrian crossing information that is provided to a person who is sighted. In addition, APS devices also consider the accessibility needs of people with varying degrees of abilities.” (2)

APS devices are devices that can be actuated by a pedestrian to control the movement of vehicle traffic. In this case, it would require the vehicle traffic to stop to make a crossing gap for pedestrian movement. The VI pedestrian can hear the signal and hear and feel the actuation device (pushbutton). These devices omit a distinguishable sound. Many jurisdictions use a combination of bird sounds, such as a cuckoo for north-south crossings and a peep-peep or chirp tone for east-west crossings. The pushbuttons can also emit a tone to signal the location of the device and the surface can be tactile to transmit information to the VI such as the direction of the crossing and the type of crossing.



Figure 2: Example of an Actuation Device

Hawk System for Vehicle Control

The traffic signal called the Hawk (high-intensity activated crosswalk) System is similar to the APS. Rather than using the red, green, amber signal combination of a typical traffic signal to stop vehicle traffic, it uses a unique blank, flash amber, amber, red, flash red and blank combination to control vehicle movement. The system also requires signing to inform pedestrians on how to cross the street safely.

Vehicles Yield to Pedestrians Legal Requirement

If a pedestrian is at the curb, adjacent to the crosswalk, drivers are required to allow the pedestrian to cross the roadway. The difficulty with this situation is that a vehicle driver is required to recognize, make a judgment about the pedestrian's desire to cross the roadway and then bring the vehicle to a stop before the pedestrian can start crossing the crosswalk. For the VI pedestrians, they must feel confident that the vehicle has yielded to their need to cross the roadway.

Surfaces

Three main types of surface treatments can potentially assist VI pedestrians at roundabouts. They are 1) sidewalk ramp treatment, 2) crosswalk treatments, and 3) approach roadway treatments

Sidewalk and Crosswalk Treatments

The surface of the sidewalk leading to the roadway crosswalk, the crosswalk and the roadway approaches to the crosswalk, can have surface treatments to enhance the ability of the VI pedestrian in locating the walking path and to help determine if there is an acceptable crossable gap in the traffic flow. The following surface treatments are being considered:

- Flush Crosswalk (Crosswalk and Roadway at same grade)
- Flush Crosswalk and Tactile Surface on Roadway Approach (Rumble Strips)
- Flush Crosswalk with Roadway Speed Humps
- Raised Crosswalk
- Raised Crosswalk and Tactile Surface on Roadway Approach (Rumble Strips)

Rumble Strips and Tactile Guidance

The tactile approach or rumble strips is the best for the vehicular and pedestrian traffic. The strips will have the least amount of impact for the drivers and will give an audible clue to VI pedestrians for approaching vehicles. Due to uniform spacing of rumble strips, the VI pedestrian will be able to judge if the vehicle is decelerating to a stop; maintaining a constant speed or accelerating to the crosswalk.

The application of tactile treatments on more than one leg of the roundabout would increase the negative and positive attributes linearly as the audible clues at two different crosswalk locations may become confusing to discern.

Additional Mitigations for the Visually Impaired

Alternate Routes

A potential mitigation is to bypass a roundabout altogether, by identifying alternate routes and educating VI pedestrians of these alternate routes. In this way VI pedestrians can often be accommodated solely at conventional intersections and / or midblock crosswalks.

Training

Introducing training program would be helpful for VI pedestrians to cross safely at roundabouts. In the United States, it was reported that there are some experts who have successfully trained VI pedestrians at using pedestrian crossings at roundabouts.

Considerations at Multi-Lane Roundabouts

Some considerations at multi-lane roundabouts are crossing location, splitter island design, and VI accommodation.

Research on Driver and Pedestrian Behaviour

The research on driver and pedestrian behaviour at crosswalks with multi-lane roundabouts:

- With an increase in the number of crossing lanes, there are lower yield rates by drivers, and possible higher vehicle speeds
- No consistent trends in pedestrian behaviour observed (more pedestrian hesitancy)

Crossing Location at Roundabouts with Multi-Lanes

To reduce crossing distance and provide more vehicle storage, two-vehicle-length storage between the circulatory lane and the crosswalk is preferred. This gives some benefits to VI pedestrians from an increased crosswalk spacing away from the roundabout (crossing alignment can be more perpendicular to the lane and approach simultaneously).

Splitter Island Design for Pedestrian Refuge

The splitter island design should protect pedestrians for two-stage crossing due to the relatively-reduced opportunity to obtain an acceptable gap (more traffic or longer crossing time); wider crosswalk width and more space with protection/detection facility may be needed.

Accommodating Visually Impaired Pedestrians

There is the need to improve or provide more assistive devices at two-lane roundabouts than one-lane roundabouts, such as:

- Way-finding treatments (access surface)
- Facilitating gap detection (amplifying vehicle sounds, slowing approaching vehicles)
- Facilitating yield detection (promoting driver yielding, increasing driver awareness)

An example of enhanced pedestrian crossing measures at a multi-lane roundabout is from the Boulevard des Allumettières in Gatineau, Quebec, where there is a two-lane roundabout with offset (zig-zag) crosswalk and pedestrian signals. This configuration can be beneficial for accommodating both VI and non-VI pedestrians alike.



Figure 3: Two-Lane Roundabout with Offset Pedestrian Crossing and Pedestrian Signals in Gatineau, Que

Source: LeDroit, Sept 21 2009 (<http://www.cyberpresse.ca/le-droit/actualites/gatineau-outaouais/200909/21/01-904116-blondin-voudrait-des-feux-sur-des-allumettieres.php>)

Case Study – Surrey BC

The 188th Street and 68th Avenue roundabout in Surrey BC is located in a suburban area with many new and proposed developments. There is a high school 320m north of the roundabout. At the roundabout, the most significant pedestrian activity takes place during the start time of school, the noon hour and the end time of school. Pedestrians are travelling to a shopping centre on the south west quadrant. On the north west quadrant is a condominium development.

As a result of traffic analysis for the roundabout, it was identified that all movements have excellent to good operation. The west leg with the highest pedestrian volumes was also analyzed as to whether pedestrians are able to have acceptable gaps during the peak hours. The analysis shows that a crosswalk which is set one car length from the circulating roadway will not create queues which spill back into the circulating roadway.

However, there are many variations in non-VI and VI pedestrian behaviour and so no conclusive results can be made based on the research. In most jurisdictions, no specific design guidelines have been prepared to warrant VI pedestrian safety particularly at a roundabout.

The consideration for a distal crosswalk with tactile audible clues was given. However there was concern that a distal crosswalk would not be used by the pedestrians (high school students) as they were more inclined to walk the shortest distance. The observations of pedestrian travel patterns indicated that a high percentage is likely to take the shortest route. In addition to this concern there is a concern that the tactile audible clues could be heard by the condominium development on the north west corner.

For the VI pedestrians in the vicinity of the 188th Street and 68th Avenue roundabout it has been concluded that an alternate route from the north-east quadrant of the roundabout to and from the high school and to and from the shopping area in the south-west quadrant would be beneficial. This route could be accommodated by using the existing marked pedestrian crosswalk north of the roundabout on 188th Street in the vicinity area of the high school or the pedestrian signal one block further north to facilitate crossing 188th Street to the west side. This would provide access to the high school and the west leg of the roundabout. If improvements are made to the crosswalk at the west leg of the roundabout an improved route would be achieved for the VI pedestrians.

Conclusions

Enhancement can be made to improve the safety and operation of VI pedestrians using crosswalks to cross exit and approach roadways at roundabouts. The most beneficial control devices are those that both vehicle drivers and pedestrians will obey. If devices are put into appropriate locations it is the experience of most traffic engineering professionals that the device has a high probability of being obeyed because there is a reasonable need to obey. It is therefore suggested that:

- Because of the number of crosswalks in the Province of British Columbia, and the variations in pedestrian and vehicle driver behaviour, and the variations in pedestrian and vehicle volumes at crosswalk, warrants for traffic control devices to assist VI pedestrians are required.
- Traffic Control Devices to assist VI Pedestrians need to be assessed at different crosswalk locations to prove their suitability.

VI Pedestrians Using Crosswalks Policy

In consideration of the issues of VI pedestrians as well as the increasing implementation of roundabouts the following are recommended:

To develop warrants and guidelines for traffic control device can take years. If the devices have not been legally permitted then tests site and monitoring are required before legislation can be passed to have general implementation of new device. Even when devices are new, the potential costs and the financial constraints all governments experience, devices need to be implemented on a need and fiscal-ability basis. It is recommended that road authorities participate in a program under the umbrella of the Transportation Association of Canada – Traffic Operations and Management Standing Committee, to develop guidelines for traffic control devices for improving the safety of VI pedestrians particularly at roundabouts. This is a long-term recommendation.

References

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