STAFF REPORT
INFORMATION ONLY

Feasibility and Benefits of Roundabouts in Toronto

Date:	March 25, 2008
To:	Public Works and Infrastructure Committee
From:	General Manager, Transportation Services
Wards:	All Wards
Reference Number:	p:\2008\ClusterB\tra\tim\pw08004tim

SUMMARY

This report discusses roundabouts and their operations and the consideration of their use within the City of Toronto. It is generally acknowledged that roundabouts can improve vehicle operations and safety if properly designed. Some of the benefits gained through their use include:

- reduced vehicle delays and queues;
- lower traffic speeds that reduce collision frequency and severity;
- reduced vehicle emissions through fewer starts and stops and less delay; and
- potentially reduced operation and maintenance costs when compared to signalized intersections.

Roundabouts also have some associated disadvantages when considered in a city that is as well developed as the City of Toronto. Of particular concern is that roundabouts:

- are not friendly to pedestrians and cyclists, particularly children, elderly, the disabled, blind and visually-impaired;
- are likely to require land acquisition; and
- are costly and disruptive to implement.

As a result of the foregoing, there are limited opportunities in the City to convert existing signalized intersections to roundabouts and, consequently, it is not recommended that a roundabout be implemented at a specific location even on a pilot-project basis. However, Transportation Services will continue to consider roundabouts as an option when assessing the reconfiguration of existing intersections and in the design of new intersections.

FINANCIAL IMPACT

There are no financial impacts arising from the receipt of this report.

DECISION HISTORY

City Council, at its meeting on September 26 and 27, 2007, referred Councillor Ootes' motion M135 regarding the feasibility and benefits of roundabouts, to the Public Works and Infrastructure Committee. Subsequently, at its meeting of October 31, 2008, the Public Works and Infrastructure Committee:

"a. referred the following recommendations in the member motion M135 from Councillor Ootes, seconded by Councillor Parker, to the General Manager, Transportation Services with a request that he report on this matter to the Public Works and Infrastructure Committee:

1. That the General Manager, Transportation Services report to the Public Works and Infrastructure Committee meeting in January 2008, regarding the potential benefits of traffic roundabouts for the City of Toronto (including the safety and environmental benefits) to replace traditional, signalized intersections.

2. That the General Manager, Transportation Services report to the Public Works and Infrastructure Committee, regarding the criteria that must be met for a signalized intersection to be considered an appropriate candidate for conversion to a roundabout.

3. That the General Manager, Transportation Services report to the Public Works and Infrastructure Committee, regarding how all road users would utilize roundabouts, including: pedestrians, cyclists, motorcycle operators, personal vehicles, public transit buses and trucks.

4. That the General Manager, Transportation Services, in consultation with local Councillors, report to the Public Works and Infrastructure Committee on potential locations for a limited number of roundabouts, which would be assessed as part of a pilot project, prior to any larger roll-out.

5. That the General Manager, Transportation Services report to the Public Works and Infrastructure Committee on the financial costs associated with the design and implementation of the roundabouts listed in Recommendation 4; and

b. requested the General Manager, Transportation Services to include in his report back to the Public Works and Infrastructure Committee comments on traffic circles, including the differences between roundabouts and traffic circles."

COMMENTS

Defining Roundabouts

Roundabouts are unsignalized circular intersections where traffic flows one-way (counter-clockwise) around a centre island. They are characterized by yield control at all traffic approaches and are channelized, through the use of "splinter islands" separating an approaching roundabout's entrance from its exit. This channelization is used to complement a roundabout's geometric curvature and facilitates a controlled low speed steady movement of traffic into and out from the circulatory roadway. Good roundabout design ensures that speeds on the approaches are reduced and controlled on circulation to about 30 km/hr or less. With this lower speed, drivers are afforded more time to assess intersection operations and determine when an acceptable gap exists for a safe merging movement into the roundabout. In conjunction with their fundamental design of facilitating right-turn movements to access all roadways and eliminating crossing conflicts (i.e., right-angle conflicts), roundabouts have proven to reduce the frequency and severity of collisions.

Although small enough to be considered in some urban contexts, roundabouts can be large enough to accommodate the turning radius of large vehicles like buses and semi-tractor trailers. They typically have an inscribed circular diameter of approximately 40 metres for single-lane roundabouts, and up to 60 metres for double-lane roundabouts. The centre island has a typical diameter of approximately 25 and 40 metres for single and double-lane roundabouts, respectively (see Appendix 1: Basic Geometric Elements of a Roundabout). There have been thousands of roundabouts installed in Europe, hundreds in the United States and countless others in many parts of Canada, with a growing renewed interest to build more. Currently, the City of Toronto operates four single-lane "neighbourhood" type roundabouts. They are located at Windermere Avenue and Coe Hill Drive (Ward 13; built in 2001), Highland Avenue and Roxborough Drive (Ward 27; built in 2007), Rosewell and Cheritan Avenues (Ward 16, built in 2007), and Kingsgrove Boulevard at Brentwood Road North (Ward 5; built in the 1940s). There is also one proposed at the base of Port Union Road where it meets Bridgend and Duthie Streets. This project currently requires a last piece of land acquisition before implementation.

Other Circulatory Intersection Types

In addition to roundabouts, rotaries and traffic circles, including those used for traffic calming, are other types of intersection geometrics that have been used to accommodate the circular movement of traffic. Rotaries, the original form of a circulating traffic intersection, are distinguished from roundabouts primarily by their scale and right-of-way rule. They tend to be rather large (diameter up to 100 m) allowing high-speed entries and significant volume of traffic to enter and weave amongst the numerous circulatory lanes. In addition to being hazardous at times, the rotary fell out of favour because of its operating rule which requires circulatory traffic to yield to entering traffic. Furthermore, significant congestion often occurred during busy periods to the point of gridlock, eventually leading to the demise of this intersection type. The City of Toronto does not operate any rotaries.

The traffic circle improves upon the rotary by reversing the right-of-way rule requiring intersection approach traffic to yield to the circulating traffic, or in some cases 'stop' before entering the circle. The traffic circle is typically smaller than the rotary, resulting in slower entry and circulatory speeds as well as reduced or eliminated weaving conditions, providing for a generally safer intersection type. However, design features and operating efficiencies among traffic circles vary considerably. In many cases, the centre island in many low volume residential neighbourhood intersections serve as a park. There are a few of these types of traffic circles presently in the City. One example of this type of traffic circle (approximately 40 m in diameter) exists where Connaught Circle and Claxton Boulevard meet (Ward 21). Another example (approximately 90 m in diameter) with a park in the middle is Elm Ridge Circle (Ward 21). Both of these operate with 'stop' control on all approach legs.

The most common form of traffic circle that currently exists within the City of Toronto, of which there are approximately eleven, is the type that were inserted in the centre of an existing residential neighbourhood intersection. The primary objective of implementing these small-scale intersection islands is to calm traffic flow and enhance the safety of the traffic through the intersection. This intersection centre island enhancement typically has a small diameter (a few metres) with limited landscaping. Because of its small scale, this type of traffic circle cannot accommodate large left-turning vehicles. As a result, large vehicles must pass in front of the island, travelling in a clockwise direction, to conduct these movements. Two examples of the eleven such circles that exist in the City are along Broadway Avenue (Ward 22): one at Banff Road and another at Rowley Avenue.

Utilizing a Roundabout

On the approach to a single-lane roundabout, a motorist or cyclist would signal their intention to enter the roundabout and watch for pedestrians and cyclists, yielding to circulating traffic on the left. If there is a conflict on the approach, the motorist or cyclist must stop. When the way is clear, the motorist or cyclist can proceed one-way counter-clockwise in the roundabout always keeping to the right of the centre island. On the approach to the desired exit street, the motorist or cyclist must signal their intention to exit the roundabout (i.e., right turn indication), again watching for pedestrians and cyclists on the approach to the exit street and proceeding when the way is clear.

In roundabouts with two lanes, the motorist or cyclist must get in the appropriate lane on the approach to the roundabout, obeying the lane markings and posted signage. The right-most lane is used for both exits on the first right or continuing straight. The left-most approach lane is used to go straight, exit the roadway on the left (i.e., the third right-turn on the roundabout), or make a U-turn. As with single-lane roundabouts, the users must yield to circulating traffic in the roundabout, proceeding only when there is a safe gap to enter. For those in the right-most approach lane, roundabout entry is made into the right-most circulatory lane. The motion to exit to the desired street is the same as in a single-lane roundabout. For those in the left-most approach lane, roundabout entry is made into the left-most circulatory lane. These lane users stay in this lane until their exit approaches. When the way is clear, they are required to signal their intention to turn, moving across to the outside lane and then exiting the roundabout. Examples of some of the various traffic movements in a roundabout are illustrated in the figures contained in Appendix 2 of this report.

Multi-lane roundabouts with three or more lanes are complex in their operation, require substantial right-of way, and as such would not be considered practical in a built up urban context like the City of Toronto.

Pedestrians

Pedestrians crossing the roadway(s) at a roundabout must do so at the marked crossings on the approaches (see Appendix 1). These areas provide for crossing a single direction of traffic at a time, accessing the approach/splinter island and then crossing the opposing direction of traffic. In these areas, although vehicles are slowing on their approach to the roundabout, pedestrians must yield to all vehicles by law. At these crossings, pedestrians might be joined by cyclists, particularly those who are inexperienced or intimidated and, as a result, walk their bicycles across the pedestrian crosswalks rather than exercise their right to utilize the roundabout. Pedestrians are also prohibited from crossing to and utilizing the central island of the roundabout. Given that roundabouts can get fairly busy with vehicles, conditions are often unsafe for pedestrians and therefore crossing is often discouraged. Further discussion on the impact of roundabouts on pedestrians, particularly vulnerable pedestrians, is provided later in this report.

Large Vehicles

Given their large scale and turning radius, over-sized vehicles like tractor-trailers and buses will need to utilize the available space on the approach, circulation and exit from the roundabout. The circulation space required for the manoeuvring of these vehicles includes the marked inside flattened island area on the inside of a single-lane roundabout (truck apron), and both lanes of a two-lane roundabout. This is a key space limiting factor for all other roundabout users. Also, this is a primary reason that lane changing or passing other vehicles in the roundabout, is not permitted.

Emergency Vehicles

When operating on an approach to a roundabout, all motorists and cyclists are required to pull over to the right and stop to allow approaching police, fire or ambulance vehicles, with their flashing lights and/or sirens on, to pass by. If operating within the roundabout, or if there is a need to make room for emergency vehicles on the roundabout approach, one can continue through the roundabout and exit as one normally would and then pull over at the first available opportunity.

Considering the use of Roundabouts

Well-designed roundabouts have proven to be a safe and efficient form of intersection control for vehicular traffic to replace both un-signalized (i.e., stop-controlled) and signalized intersection control. For the purpose of this report, the appropriateness of roundabouts for the replacement of signalized intersection control is the sole consideration.

Roundabouts can be considered as a replacement for a signalized intersection control in those situations when the reduction in delays to traffic is a primary objective, where intersecting roads have approach volumes that are similar and the left-turning traffic volumes are high, where pedestrian crossing volumes are minimal, and at those intersections where there is a meeting of more than two roadways. They can also be considered as a measure to control speed and improve traffic safety.

The most common form of high volume intersection control, the signalized intersection, is designed to facilitate the efficient and safe movement of traffic through an intersection by their fundamental control of the opposing streams of traffic. Also, traffic control signals, particularly coordinated series along an arterial road, can facilitate a very high volume of free-flow of traffic through a corridor. One key trade-off for this traffic travelling at an unreduced speed through these types of controlled intersections is that when a conflict occurs, there is an increased potential for a more sever event.

Capacity

Although an alternative to signalization, roundabouts have an upper limit on the volume of traffic that can be accommodated through its intersection. According to the U.S. Federal Highway Administration's "Roundabouts: An informational Guide, June (2000)", single-lane roundabouts can generally be considered when average annual daily traffic (AADT) flow is less than 25,000 vehicles and circulating flow at any point on the roundabout is less than 1,800 vehicles/hour. In the case of double-lane roundabouts, AADT up to 34,000 vehicles and circulating flows at any point on the roundabout less than approximately 3,000 vehicles/hour can generally be accommodated before detailed operational analysis is required to consider slightly higher traffic volumes. In Toronto, most of the major arterial roads that have signalized intersections exceed the traffic capacity requirements of either a single- or double-lane roundabout.

As an example, at the intersection of Don Mills Road and Eglinton Avenue East, which has been cited as a candidate location for a roundabout, the AADT approach volumes are approximately 90,000, far exceeding the capacity of a two-lane roundabout. In addition, this location is also the intersection of two of the seven corridors comprising the Transit City Plan. The consideration of roundabouts along any of the Transit City's planned corridors is not practical. This network of electric light-rail lines, each on their own right-of-way, presents a significant challenge and cannot be accommodated through a roundabout without the consideration of a grade-separation.

Several other situations where a roundabout would not be practical are as follows. It would not be practical to consider a roundabout when approach volumes exceed or are anticipated to grow in the future beyond the design capacity of the roundabout. Also, they should not be considered when a major road meets a minor road because of the long delays and queuing that would be experienced by traffic on the major road. This is particularly problematic if sufficient storage for this queuing is not available, resulting in back-ups into adjacent intersections or blockage of upstream driveway entrances. For this reason, they should not be considered to replace a signalized intersection that serves as one in a series of coordinated signalized intersections designed to reduce congestion and facilitate traffic progression. Also, they should not be considered if approach flows are unbalanced and one or more traffic approaches are expected to experience unacceptable delays.

Land Requirements

For a roundabout to operate effectively, space beyond the inside 'square' of a typical intersection is required for placement of the centre island and circulatory roadway. This would have significant impacts on those corner properties where land would need to be acquired for the placement of the roundabout. In addition to the cost of acquiring these lands, roundabouts may also impact access points to these adjacent properties and have other business impacts.

As for the construction of the roundabout, this will require a full base re-grading and reconstruction of the intersection and its approaches to accommodate the centre island and splinter islands. New catchbasin connections to storm sewers will be required with significant pavement and curb modifications to control drainage. Also, water and sewer connections and utilities (gas, phone, telecommunications, hydro, etc.) through the intersection may also have to be relocated. In addition, the supply of parking permitted up to intersections will be impacted. Finally, one other cost that should not be overlooked is that of construction staging during the building of the roundabout in order to accommodate existing traffic. As a result, installing roundabouts as a retrofit for existing signalized intersections may prove to be costly, disruptive and impractical.

Operations, Maintenance and Other Considerations

As for their operations and maintenance costs when compared to a signalized intersection, roundabouts are, generally, a less expensive alternative. Although they might require high landscaping costs to maintain the centre island and splinter islands, traditional signalized intersections incur high energy and equipment maintenance costs that are not required by roundabouts.

There are environmental benefits to roundabouts when compared to a signalized intersection. When operating within their capacity, roundabouts can reduce the delays and idling of motorized vehicles thereby reducing fuel consumption, emissions as well as noise levels.

Manoeuvring through a roundabout intersection will be more challenging for a number of road users, particularly older drivers who might be challenged to react to the new speed-distance merging issues on a curved alignment.

Impacts to Vulnerable Pedestrians

Pedestrians, particularly the elderly, children and disabled may experience difficulty crossing each of the unprotected road crossing legs of the roundabout. When the roundabout becomes busy, the approach entrances and exits lanes could become very intimidating for this population which typically requires longer gaps in the traffic stream to safely cross.

As for the blind and visually-impaired, roundabouts are particularly problematic from the perspective of access to information to the user that would facilitate a safe crossing. These users need to be guided as to where to cross – a challenge for this group at even the simplest and non-congested signalized intersections. This is of particular interest especially considering City Council's deliberations at its March 3 and 4, 2008 meeting in considering a report from Transportation Services addressing the City's Accessible Pedestrian Signals (APS) and new technologies to address the needs of the blind and visually-impaired pedestrians. As a result of Council adopting this report, accessible pedestrian signals are now to be an integral component of the intersection equipment and operation, addressing a significant challenge that exists for this group at signalized intersections. It also follows that where a roundabout could potentially replace a signalized intersection, there would be a requirement to provide crossing conditions for this group that would facilitate and continue to ensure their safe crossing. This would be more challenging to achieve the busier the intersection becomes. Given that roundabouts operate in a free-flowing condition without signals at any of the approaches of pedestrian crossing points, the introduction of enhanced traffic control to further accommodate a difficult pedestrian crossing condition will compromise roundabout operations, introduce new challenges and virtually eliminate any of the benefits identified previously in this report.

Recent City of Toronto Consideration of Roundabouts

While converting existing signalized intersection locations to roundabouts does not appear to be practical, the consideration of roundabouts as an alternative design option to the re-configuration of intersections or the design of new intersections should not be discounted. As an example, as part of the Six Points Interchange Reconfiguration Class Environmental Assessment Study, (i.e., Kipling Avenue, Dundas Street and Bloor Street West) initiated in 2004, a roundabout was one of the thirty-three preliminary intersection design options considered. At the time, it was screened-out from further consideration because the scale of the roundabout required to accommodate the six approach legs did not make good use of the available interchange lands. Additionally, it would have impacted on an active planning application in the area, would have been difficult to implement due to grade differentials, and was not considered to be as pedestrian and cycling friendly as other options.

More recently, the Emery Village Transportation Master Plan Class Environmental Assessment considered the establishment of either a three- or four-legged roundabout at the Finch Avenue and Weston Road intersection to replace the existing traffic control signals. Although evaluated on a number of criteria, roundabouts did not make the short-list of the preferred alternative solutions, primarily due to the amount of land required to construct a roundabout large enough to accommodate the traffic demand through the intersection as well as the impacts of this land acquisition on the existing businesses in the area.

While roundabouts have gained favour in other parts of the world, the consideration of the conversion of existing intersections with traffic control signals to roundabouts can be complex and challenging, not to mention expensive. The City has examined, on many occasions, roundabouts as part of a number of major infrastructure enhancement capital projects. It would therefore be prudent for the City to continue to explore design options for roundabout placement whenever similar large-scale projects are studied. Although, there has been limited opportunity to install roundabouts in the City, they have nevertheless been successful in a number of local neighbourhood settings where they have achieved their desired objectives.

Another area of opportunity for considering roundabouts would be in development scenarios where forecasted future volumes would otherwise warrant the implementation of traffic signals, and sufficient land is available or can be secured to facilitate their implementation. As an example, the roundabout at Rosewell and Cheritan Avenues was implemented primarily as a traffic calming measure to reduce vehicular speeds along Rosewell Avenue, rather than as an alternative to the installation of traffic control signals.

Nevertheless, its recent implementation in 2007, which could only be achieved through the conveyance of land by the adjacent landowners in conjunction with their development application, affords the City an opportunity to assess the benefits of its operations and to identify any problems. Therefore, rather than identifying potential locations for the implementation of any future roundabouts, Transportation Services will monitor and assess the operations of this recent application to determine the appropriateness of any similar facilities.

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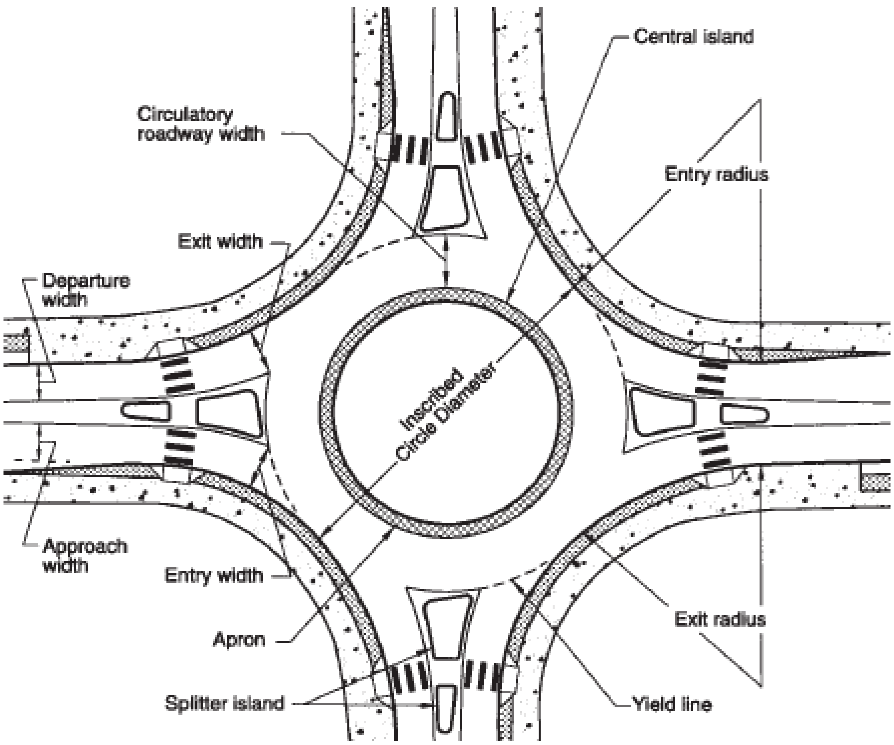
ATTACHMENTS

Appendix 1: Basic Geometric Elements of a Roundabout
Appendix 2: Traffic Movement Through a Two-lane Roundabout

APPENDIX 1

Basic Geometric Elements of a Roundabout
(Source: FHWA, Roundabouts: An Informational Guide, 2000)



APPENDIX 2

Traffic Movement Through a Two-lane Roundabout
(Source: City of Calabasas, California)