Roundabouts in Edmonton -
A Comparison to the State-of-the-Art

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ABSTRACT

In the 1950s Edmonton constructed 12 two-lane roundabouts on major roadways in the City. Subsequently, 7 of these roundabouts were replaced with 5 of them being replaced in the 1979 to 1993 period primarily for capacity reasons.

Since the early 1990s a number of planning and design guidelines for roundabouts have been prepared by various jurisdictions to provide state-of-the-art guidance on designing roundabouts that accommodate traffic flows in a safer manner. While these guidelines vary somewhat in the details of their guidance, this study concluded that the Edmonton roundabouts had geometry that would currently be at or beyond the range suggested by these guidelines for key elements such as Inscribed Circle Diameter, Circulatory Lane Width, Entry and Exit Radii and Entry Angle. This geometry likely contributed to the ability of the Edmonton roundabouts to accommodate traffic volumes at the upper end of the expected capacity despite having significant unbalanced peak directional flows and pedestrian crossing volumes, in some cases. It also possible that this geometry had an impact on the collision records for the Edmonton roundabouts, which tend to represent some of the higher collision locations in the City.

1.0 BACKGROUND

Since the 1990s there has been renewed interest in constructing roundabouts. To address this interest, a number of agencies have developed planning and design guidelines based primarily on European and Australian practices with some local biases on specific geometric elements.

In the 1950s, 12 two-lane roundabouts were constructed on the arterial roadway network in Edmonton. The design principles utilized in developing these roundabouts is undocumented and long forgotten and how it compares to current guidelines is of interest given their long service record in a North American driving environment.

Two of the 12 roundabouts were replaced with grade-separated interchanges; one in the late 1960s and the other in the early 1980s. However, between 1979 and 1993, 5 of the 12 original roundabouts were removed and replaced with signalized intersections. The issue of roundabouts being removed in Edmonton and replaced with traffic signals is often cited as a concern by stakeholders in considering the adoption of roundabouts as an acceptable form of intersection control. Often this concern is raised without any of the parties having a good understanding of the reasons for the removal of these roundabouts.

2.0 STUDY OBJECTIVES

The objectives of this study were to:

- Document the history, operation and safety record of roundabouts in Edmonton.
- Summarize the range of recommended geometric design elements presented in a cross-section of state-of-the-art design guidelines.
- Compare the geometric design elements of roundabouts in Edmonton with those in the state-of-the-art design guidelines and identify any differences.

3.0 STATE–OF-THE-ART GUIDELINES

3.1 PHILOSOPHIES

Since the early 1990s a number of new or updated roundabout planning and design guides have been produced by various jurisdictions. In general terms, they can be grouped by the planning and design philosophies of the following countries:

- United Kingdom
- Continental Europe
- Australia
- United States

Each of these countries has slightly different philosophies regarding planning and design of roundabouts, but they all provide guidance on a number of points related to capacity, safety and design parameters. It should also be noted that the guidance is presented in different forms and to different levels of detail in the various guidelines and direct comparisons between the guidelines typically requires some interpolation.

3.2 GEOMETRIC DESIGN ELEMENTS

The following geometric elements are typically considered in the design of roundabouts with respect to capacity and safety:

- Inscribed Circle Diameter
- Approach Lane and Entry Width
- Flare Length
- Entry Angle
- Entry Radius
- Entry Path Deflection and Curvature
- Circulatory Width
- Exit Width

Figure 3.1 illustrates these elements.

Not all of the elements are discussed in each guideline and where they are the information is often presented using different descriptive approaches. Table 3.1 summarizes the recommended design guidelines for each philosophy for two-lane roundabouts. It should be noted that many of the elements are interrelated and simple comparisons are difficult to make. However, in general, the Continental European guidelines espouse lower design vehicle speeds through roundabout areas and thus recommend more constrained geometric elements than the other philosophies.

Table 3.1 Comparison of Recommended Geometric Design Elements

Geometric Element	United Kingdom (1)	Continental Europe (2,5)	Australia (3)	United States (4)
Inscribed Circle Diameter	28m to 100+m	25m to 35m	---	45m to 60m
Maximum Entry Width	8m	7m	8m	---
Flare Length	25+m	5m to 25m	---	25+m
Entry Angle	20 to 60 degrees	30 to 45 degrees	---	---
Entry Radius	6m to 20m	15m to 30m	---	30m to 60m
Maximum Entry Path Deflection and Curvature	100m	60 to 100m	100m	83m
Maximum Circulatory Width	9m	9m	8.4m to 8.8m	9.1m to 9.8m
Exit Width	Same as entry width	Same as entry width	Same as entry width	Same as entry width
Exit Radius	20m to 40m	10m	10m to 25m	Minimum of one-half of ICD (20m to 30+m)

3.3 CAPACITY

Roundabout capacity is a function of the traffic volumes and the roundabout geometry. In general, the various guidelines agree that roundabout capacity is maximized when the entry leg traffic volumes are relatively balanced and pedestrian volumes are low. They also agree that a two-lane roundabout has nearly twice the capacity of a single lane roundabout. However, although the various guidelines agree that roundabout geometry can affect capacity, there is some variation in the impact on capacity that the guidelines attribute to the various geometric features of a roundabout. These variations are reflected in the individual detailed capacity analyses that are outlined in the various guidelines.

Each guideline provides some indication, for planning purposes only, of the maximum Average Annual Daily Traffic (AADT) volume that single and double lane roundabouts can be expected to accommodate. Table 3.2 summarizes the AADT values provided or inferred from the hourly volume capacities.

Table 3.2 Comparison of Maximum Two-Lane Roundabout Capacities

Guideline Philosophy	Maximum Two-Lane Roundabout Capacity (AADT)
United Kingdom	40,000 to 60,000
Continental Europe	35,000 to 40,000
Australia	35,000 to 50,000
United States	40,000 to 60,000

It should be noted that the American guidelines are based on capacity calculations developed in the United Kingdom and would be expected to be similar. Conversely, the generally more constrained geometrics recommended in the Continental European guidelines would be expected to produce somewhat lower capacities.

3.4 SAFETY

Literature and practitioners generally conclude that single-lane roundabouts provide improved safety through both reduced total collisions and the severity of collisions as compared to other forms of intersections. Published collision rates also suggest that the Continental European roundabouts, with their more constrained geometry and subsequently lower design speeds, have lower collision rates. For two-lane roundabouts there is less data available on collision reduction potential. What data is available suggests that there is some collision reduction potential in the 10 to 20% or possibly more range as compared to other forms of intersections.

4.0 EDMONTON'S ROUNDABOUTS

4.1 HISTORY

Figure 4.1 illustrates the location of the original 12 arterial road two-lane roundabouts developed in Edmonton in the 1950s. All the roundabouts are located at the intersection of major roadways, typically four-lane arterial roads. In one case the roundabout has 5 legs.

The roundabouts on Groat Road at 107 Avenue and on St. Albert Trail at 125 Avenue were replaced with grade-separated interchanges. The roundabout on St. Albert Trail at 125 Avenue was replaced as part of the development of the east-west Yellowhead Trail corridor. At the Groat Road / 107 Avenue intersection, the topography lent itself very well to having Groat Road underpass 107 Avenue when Groat Road was upgraded.

Of the other 10 roundabouts, which are the focus of this study, 5 are still in operation as roundabouts some 40 to 50 years after they were first constructed. A sixth roundabout is also still operational, but was converted to a signalized roundabout approximately 25 years ago. The location and status of these 10 roundabouts is summarized in Table 4.1.

It should be noted that besides converting existing roundabouts to other forms of intersection control, in recent years Edmonton has constructed 2 new roundabouts and is planning other roundabouts. However, these roundabouts, designed based on the guidelines outlined in the FHWA's Roundabouts: An Informational Guide, are single lane, "neighbourhood" type roundabouts. The entering traffic volumes and role of these roundabouts is quite different than the original roundabouts constructed in the 1950s and are not part of this review.

Table 4.1 Summary of Study Locations

Location	Status – 2002	Comments
87 Avenue / 142 Street	Roundabout	
107 Avenue / 142 Street	Roundabout	
111 Avenue / Groat Road	Traffic signal	Converted 1989
118 Avenue / St. Albert Trail	Traffic signal	Converted 1979 to a signalized roundabout
Belgravia Road / 114 Street	Traffic signal	Converted 1993
University Avenue / 114 Street	Traffic signal	Converted 1993
River Road / 105 Street	Traffic signal	Converted 1981 as part of conversion to one-way system
118 Avenue / 101 Street	Roundabout	
Connors Road / 85 Street	Roundabout	
98 Avenue / 84 Street	Roundabout	

4.2 GEOMETRIC ELEMENTS

Figure 4.2 illustrates the four roundabouts that were converted to typical signalized intersections. The size of the original roundabout is shown on the current intersection geometry. All of the Inscribed Circle Diameters for these roundabouts were in excess of 60 metres, with the one at River Valley Road and 105 Street having an Inscribed Circle Diameter in excess of 100 metres.

Figure 4.3 illustrates the existing geometry for the 118 Avenue / St. Albert Trail roundabout and the 118 Avenue / 101 Street roundabout. As illustrated in the figure, the geometrics for the 118 Avenue / St. Albert Trail roundabout were altered somewhat when it was converted to a signalized roundabout. The 118 Avenue / 101 Street roundabout is considered rather unique in its geometry and differs substantially from the other roundabouts in the City.

Figure 4.4 illustrates the 4 existing roundabouts, while Table 4.2 summarizes the geometric design elements for the 4 typical roundabouts as well as for the 118 Avenue / 101 Street roundabout.

Table 4.2 Summary of Roundabout Geometrics

Geometric Element	87 Avenue / 142 Street	107 Avenue / 142 Street	Connors Road / 85 Street	98 Avenue / 84 Street	118 Avenue / 101 Street
Inscribed Circle Diameter	83m	97m	100 x 123m oval	79 x 96m oval	82 x 122m oval
Maximum Entry / Exit Width	8.5m / 8.5m	8.5m / 8.5m	8.5m / 8.5m	8.5m / 9.5m	7.3m / 7.3m
Entry Angle	60 degrees	40 to 45 degrees	30 to 40 degrees	20 to 40 degrees	0 to 40 degrees
Entry Radius	25 to 35m	30 to 40m	30 to 70m	30 to 80m	25m to tangent
Maximum Entry Path Deflection and Curvature	60m	65m	100+m	100m	N/A (long tangent)
Maximum Circulatory Width	11m	11m	11m	10.5m	11.5m
Exit Radius	40 to 50m	40 to 45m	40 to 55m	35 to 75m	25m to tangent

4.3 TRAFFIC VOLUMES

Entering daily traffic volumes at the 10 locations are summarized in Table 4.3. The entering legs are typically arterial roadways leading in and out of major employment areas, such as the downtown and university areas. Accordingly, the peak directional flows on all the roadways are very significant during the AM and PM peak hours. This results in unbalanced traffic volume flows at most of the intersections, which are not reflected in the AADT volumes presented in Table 4.3.

Table 4.3 Summary of Average Annual Daily Traffic Volumes

Location	Year	Entering Volume	North Leg	South Leg	East Leg	West Leg
87 Avenue / 142 Street	2002	23,000	8,600	2,500	2,500	9,200
107 Avenue / 142 Street	2002	45,000	7,600	7,650	15,900	13,950
111 Avenue / Groat Road	1989	55,000 *	12,500	15,000	14,200	13,000
118 Avenue / St. Albert Trail	1979	57,800	16,550	15,500	14,750	13,000
Belgravia Road / 114 Street	1993	55,000	12,150	20,350	4,750	18,150
University Avenue / 114 Street	1993	47,000 *	8,600	18,900	8,300	11,450
River Road / 105 Street	1981	41,000	0	25,900	7,000	8,300
118 Avenue / 101 Street	2002	35,000	9,250	6,300	14,450	5,250
Connors Road / 85 Street	2002	38,000 *	4,600	12,500 / 5,100	5,800	10,000
98 Avenue / 84 Street	2002	33,000	3,400	4,750	12,400	12,500

* - High pedestrian volume crossing location

4.4 COLLISION RATES

Collision rate data for the period 1997 to 2002 was averaged along with available collision rate data for the 5 years prior to conversion of the 5 roundabouts to signalized intersections. Table 4.4 summarizes that data.

Table 4.4 Summary of Collision Rates (Collisions per Million Entering Vehicles per Year)

Location	Current Status	1997 to 2002 Average	5 Year Average Prior to Conversion
87 Avenue / 142 Street	Roundabout	1.22	---
107 Avenue / 142 Street	Roundabout	3.88	---
111 Avenue / Groat Road	Traffic signal	1.45	3.38
118 Avenue / St. Albert Trail	Signalized roundabout	3.25	N/A
Belgravia Road / 114 Street	Traffic signal	1.46	2.44
University Avenue / 114 Street	Traffic signal	2.39	2.64
River Road / 105 Street	Traffic signal	0.48	4.59*
118 Avenue / 101 Street	Roundabout	2.38	---
Connors Road / 85 Street	Roundabout – 5 legs	3.75	---
98 Avenue / 84 Street	Roundabout	1.57	---

* - Only 1 year of collision data available
N/A - not available

In general, a review of the data presented in Table 4.4 suggests that the collision rates for those roundabouts that were converted to typical signalized intersections have declined from when they operated as roundabouts.

As an indicator of how the existing roundabouts compare to intersections within the City in general, city-wide collision rates were reviewed. The 25 intersections with highest collision rates have had collision rates higher than 2.4 to 2.7 in the last two years, while the 100 intersections with the highest collision rates have had collision rates higher than 1.6 to 1.7 in the last two years. The collision rates for 3 of the 5 roundabouts (107 Avenue / 142 Street, 118 Avenue / 101 Street and Connors Road / 84 Street) as well as the signalized roundabout at 118 Avenue / St. Albert Trail consistently place them in the top 25 collision rate locations in the City. Often the 3 roundabouts all rank in the top 5 collision rate locations.

A brief review of property damage estimates was done for the existing 5 roundabouts and a cross-section of other high collision rate signalized intersections. In general, the average property damage estimates for collisions at the existing 5 roundabouts were 20 to 40% lower than those at other high collision rate signalized intersections.

5.0 COMPARISON TO STATE-OF-THE-ART GUIDELINES

5.1 GEOMETRY

The geometry of the 2 remaining roundabouts in Edmonton, which are circular in shape, is consistent with guidance provided in the state-of-the-art guidelines with respect to Maximum Entry Path Deflection and Curvature. However, the Inscribed Circle Diameters, Circulatory Lane Width, Entry and Exit Radii are all comparatively large and the Entry Angles are relatively flat or tangential in comparison to all of the state-of-the-art guidelines reviewed. The geometry of the other 3 remaining roundabouts all fall outside the guidance provided in the state-of-the-art guidelines for nearly all parameters. This is primarily due to their oval shape which results in flat entry angles, high Maximum Entry Path Deflection and Curvature radii and Entry and Exit Radii on one or more legs.

5.2 CAPACITY

Current guidelines for larger diameter two-lane roundabouts with geometry favoring higher design speeds suggest that with reasonable balanced traffic flows that a maximum capacity of 50,000 to 60,000 vehicles per day can be accommodated.

The conversion of the River Road / 105 Street roundabout occurred when it had an entering volume of 41,000 vehicles/day. However, this conversion happened primarily due to a major change in traffic patterns in the area rather than due to a lack of capacity specifically at the roundabout.

The other four roundabouts that were converted to traffic signals, were converted due to degenerating capacity conditions. All four roundabouts had significant unbalanced traffic flows during AM and PM peak periods, which contributed to significant delays to vehicles entering from some legs. In addition to the peak hour imbalances, the two roundabouts on 114 Street also had unbalanced flows on a daily basis, which especially exacerbated traffic flows creating significant queues. Nonetheless, conversion of the four roundabouts did not occur until daily traffic volumes reached the 47,000 to 57,800 AADT range. With more balanced flows it is possible that entering traffic volumes might well have reached an AADT of 60,000 before the roundabouts needed to be converted to signalized intersections.

5.3 COLLISIONS

The limited literature information contained in the various guidelines suggests that multi-lane roundabouts should have collision rates 10 to 20% lower than signalized intersections. However, 3 of the

5 remaining roundabouts are amongst the highest collision rate locations in the City. Additionally, comparison of collision rates for those locations where roundabouts were converted to typical signalized intersections suggests that collision rates decreased rather than increased after signalization. As a mitigating factor, average property damage estimates for collisions at the roundabouts were less than those for other high collision rate signalized intersections.

6.0 CONCLUSIONS

The 12 roundabouts constructed in Edmonton in the 1950s were built on major arterial roadways. Accordingly, they appear to have been designed with geometrics intended to maximize traffic flows. The closest comparables in terms of state-of-the-art guidelines appear to be those from the United Kingdom and the United States, although it should be noted that many of the geometric features found in the Edmonton roundabouts are at or beyond the high end of the ranges outlined by these guidelines. Since Average Annual Daily Traffic volumes at the roundabouts were in the higher end of current capacity expectations for roundabouts, despite significant unbalanced directional traffic flows and high pedestrian crossing volumes in some cases, it would appear that the geometrics of the Edmonton roundabouts did positively impact the ability to maximize traffic flows.

Collision rates for the Edmonton roundabouts are relatively high in comparison to other intersections in Edmonton. In instances where roundabouts were converted to typical signalized intersections, the collision rates appear to have decreased rather than increased. This is in conflict with the findings outlined in literature and by practitioners that well designed roundabouts typically have lower collision rates than other forms of at-grade intersections. A possible explanation for this might be that the geometry of Edmonton roundabouts, while conducive to maximizing traffic flows, degraded the superior level of safety typically attributed to roundabouts. Alternatively, another possibility might be that as much of the safety reviews prepared for roundabouts are on lower volume single lane roundabouts, perhaps the safety potential of a roundabout decreases as traffic volumes approach the upper capacity limit. In either case, it would appear to be prudent to avoid trying to accommodate traffic volumes at the higher end of the range recommended in the various design guidelines by using geometry beyond that recommended in the current state-of-the-art guidelines or oval shaped roundabouts.

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