Roundabouts on Alberta Highways

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Abstract

Roundabouts have become commonplace in numerous locations across the globe; however, they are relatively new in Alberta. Experience has shown marked improvements in safety and efficiency, and thus roundabouts have become an ideal option over signalized intersections or other intersection improvements. Additionally, their operation and maintenance costs are typically lower than for signalized intersections. However, in Alberta, there are concerns that current roundabout construction costs are high in comparison to alternate options. Numerous commercial loads, including oversize and overweight (OSOW) vehicles, use Alberta's highway corridors on a daily basis. The department's intent is to maintain a highway system that will have no blockages for high loads or oversized loads. Roundabouts may present a bottleneck if OSOW loads are not considered. This problem can be addressed by constructing wider approaches and/or using wide aprons; yet this comes at a cost for construction and may adversely affect operations by regular traffic due to higher speed entries. Another strategy is to make the centre island completely traversable with removable signs. However, situations such as these may present higher costs than anticipated. The department has identified potential high cost factors, including: traffic accommodation during construction, size of inner circle and overrun areas and the required amount of concrete, design life, etc. There is a general consensus that the cost will decrease once roundabouts become less unknown to contractors, as presently they are not accustomed to roundabout construction. The department aims to determine best design practices for roundabouts with the most cost-effective solution. For example, one good design practice is to build a roundabout that works for current volumes plus a reasonable time period (i.e. 10 years), and then be prepared to add additional lanes if required. Aside from saving cost, this practice is safer and allows drivers to adjust to a simpler roundabout. Cost-sharing formulas have also been proposed to finance the roundabout. For the purposes of this paper, a comparison of construction practice and resulting costs of existing roundabouts will be presented. Information on roundabout practices in other jurisdictions, with a focus on the accommodation of OSOW loads, will be obtained through comprehensive literature review and communication with professionals. The main intent of this paper is to identify potential improvements to current roundabout design and construction and to provide recommendations on the most efficient solution that maximizes safety while being fiscally acceptable.

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1.0 Review of Roundabouts in Other Jurisdictions

Roundabout designs and implementation of roundabouts in other jurisdictions have been investigated both by literature review and through communication with design professionals.

1.1 Literature Review

Roundabouts have been proven to be feasible and advantageous at many locations. According to the Transportation Research Board, a single lane roundabout is likely to operate effectively for intersection daily entering volumes of 0-18,000, with a general rule of thumb that the sum of entering and circulating volumes for each approach is less than 1,000 vehicles per hour. It has also been found that while initial construction costs may be higher for a roundabout, the ongoing maintenance is less costly than for signalized intersections. The three key considerations for horizontal design of a roundabout are design speed, path alignment and design vehicle. The design speed is defined by the theoretical speed that drivers could achieve if taking the fastest path through the roundabout without regard to lane line striping according to predefined criteria for offset from the curb, etc. For single lane roundabouts, maximum theoretical entry speeds of 20-25 mph (32-40 km/h) are recommended. [1]

A feasibility study should be completed on any intersection being considered for a potential roundabout location. Contents of a roundabout feasibility study report may include: current status of traffic operations and safety, a conceptual roundabout configuration, a demonstration that the proposed configuration can be implemented feasibly and will provide adequate capacity, potential complicating factors, evidence of community consultation, and an economic analysis. The first roundabout in any geographic area requires an implementing agency to perform beyond regular due diligence. The full range of design and analysis alternatives should be explored in consultation with other operating agencies in the region. Designers must ensure that the roundabout accommodates the design vehicles, achieves capacity, provides slow and consistent speeds and smooth channelization and is overall safe. If the roundabout accommodates pedestrians then it must be designed to provide safe passage. The slope of the truck apron should generally be no more than 2% as greater slopes may increase the likelihood of loss-of-load or tipping incidents. Generally, it is not desirable to place roundabouts on steep grades. It is also beneficial to stage the construction of a multilane roundabout to allow road users to become familiar with a relatively simple roundabout before adding extra lanes or turning roadways that may be needed when the volume increases. As future traffic volumes and patterns are difficult to predict, the need for a more complex layout may never materialize. Generally, diverting or detouring as much traffic from the intersection as possible is the most desirable option for efficient construction. [2]

A roundabout can offer operational improvements over other intersection types, such as higher capacity and lower delays. In addition, roundabouts offer significant benefits for improving safety and can often be justified solely on the basis of crash reductions and severity, particularly for reducing serious injury and fatal crashes. Recent research of roundabouts in the United States identified crash reductions of approximately 35.4% for all crashes and 75.8% for injury crashes when an intersection was converted from a signal or stop control to a roundabout.[2] However, roundabouts may come with a high capital cost. Factors contributing to costs may include: maintaining traffic during construction, large amounts of landscaping in the central and splitter islands, higher than typical pavement design life, extensive signage and lighting, and the provision of curbs on all outside pavement edges.[2]

Public acceptance of roundabouts has often been found to be one of the biggest challenges facing a jurisdiction that is planning to install its first roundabout. A public involvement process should be initiated as soon as practical, preferably early in the planning stages of a project while other intersection forms are also being considered. A successfully implemented roundabout, especially one that solves a perceived problem, can be an important factor in gaining support for future roundabouts at locations that could take advantage of the benefits that roundabouts may offer.[2]

Vertical ground clearance and curbs in particular are a major problem for large trucks and loads that are oversize and/or overweight (OSOW) vehicles. Using a larger design vehicle such as a WB-67 (comparable to a WB-20 in Canada), particularly on state highways, would make it easier to accommodate OSOW vehicles. It is possible to have a road through a roundabout for OSOW vehicles with an offset entrance if the OSOW vehicle moves to the opposite lane prior to entering. National Network Commercial Vehicle Size Standards in the United States regulate the length, width, height, and weight of commercial vehicles traveling throughout the country. Some jurisdictions (e.g. European countries) do not have issues with OSOW vehicles simply because they strictly regulate truck size; however this is not desirable in Alberta (according to government policy) due to the necessity to facilitate the various industries that wish to move large loads on the public provincial highway network. Truck aprons should be designed so that they are traversable for trucks but discourage passenger vehicles from using them. They should be of a different material than the traveled way. In the United Kingdom for example, ‘grasscrete’ is used, which is a stabilized turf system that allows OSOW vehicles to travel straight through the roundabout. Another option popular in some European countries is the use of low, mountable cobblestone instead of concrete. However, these practices may not always be feasible in Alberta as the turf or cobblestone could deteriorate quickly due to the volume of OSOW vehicles using the roundabout. Another jurisdiction with a unique practice in accommodating OSOW vehicles is Minnesota, where “superload corridors” accommodate sizes that reportedly cover 80% of OSOW vehicles, and “expanded envelope corridors” can accommodate even larger and heavier permitted loads; however, policy prohibits construction of roundabouts on these corridors.[3]

The British Columbia (B.C.) Ministry of Transportation (MoT) uses the 2003 Kansas Roundabout guide as a primary resource. Their policy considers roundabouts as the first option for intersection designs where four–way stop control or traffic signals are supported by traffic analysis. The design vehicle for roundabouts is a WB-20 unless otherwise agreed upon by the Ministry.[4]

University of Texas and Kittleson & Associates state that during construction of a roundabout, it is best to detour all legs. They also provide a possible staged construction sequence: Install signing and lighting, construct widening, reconstruct or resurface approaches, construct splitter islands, delineate the central island and construct the central island.[5]

The Florida Department of Transportation (DoT) requires a formal “justification report” to document the selection of a roundabout as the most appropriate traffic control mode at any intersection on their State highway system. Conversely, the Maryland Department of Transportation requires consideration of a roundabout as an alternative at all intersections proposed for signalization.[6]

In 2000, state-built roundabouts on state highways in the Unites States ranged in cost from $350,000 - $500,000. There are many appropriate locations for roundabouts, such as high accident locations, locations with high delays, four-way stop intersections, etc. Common reasons behind the success of roundabouts include high capacity and fluidity, safety, shorter delays and reduced environmental impacts, and aesthetics and urban design. However, some problems have also been encountered; these include delays to high-volume approaches in the case of unequal control volumes, lack of clear right-of-way control for pedestrians, maintenance, and complicated and costly construction. Some methods identified by the Maryland DoT to reduce costs of the roundabouts include: detouring traffic during construction, limiting resurfacing to the roundabout, simplistic landscaping, reducing size of signs, and the possibility of area-wide contractors to bid on larger quantities.[7]

1.2 Correspondence

According to a representative from the Connecticut DoT, if a roundabout cannot accommodate an OSOW vehicle then the OSOW vehicle is directed to an alternate route; however, this has not yet been an issue that they are aware of. Their biggest issue to date is low-boy truck trailers due to their limited vertical clearance. In general, they have found that if the truck apron has the same cross-slope as the circulatory roadway, the extra height (usually 1-2 in. (2.5-5 cm)) does not cause a problem. For a very large load, they would most likely shut down all approaches and then allow the truck through, using the other side if necessary. They recommended building a roundabout based on current volumes, possibly with some growth, and leaving room for expansion to whatever future design year is being considered. They stated that aside from saving cost, this practice also helps maximize safety and allows drivers to get used to a simpler roundabout before getting into multiple lanes.

A representative with the B.C. MoT mentioned that the ministry has a policy to consider roundabouts as the first option for intersection designs where a degree of traffic control greater than a two-way stop is required. Roundabouts are considered on all roads including corridors of speed 70 km/h and higher. They stated that 25 roundabouts have been completed within B.C., and an additional 10 roundabouts are currently under review. According to the spokesperson, the design requirements for all B.C. highways including intersections and roundabouts is premised on meeting the legal vehicle size of a tractor trailer truck classified by the Transportation Association of Canada (TAC) as a WB-20. The total paved circulatory width should, at a minimum, accommodate the largest frequent design vehicle, which is typically a WB-20 side by side with a passenger car. In addition, the highway legs through the roundabout shall be a minimum of two lanes per direction where these lanes may be any combination of left, through and right turn lanes. There has been a case where the Ministry has modified the design of a roundabout on corridors being used to move loads as wide as 7.32 m on a fairly regular basis. Since these loads essentially cover the surface area of a two-lane highway they can only be moved at night. In this circumstance the redesign did not impact the central part of the roundabout; rather, it involved raised channelization on the approaches.

A spokesperson with Washington State Department of Transportation (WSDoT) stated that in 2006, WSDoT and the Washington Trucking Association (WTA) created a significantly different “curb detail” (friendly towards sidewalls of tires) and also made a commitment to install removable signs (where the base is detachable, but still crashworthy and stable in wind) in order to make sure that there are numerous ways to deal with the arrival of OSOW vehicles. In addition, WSDoT altered the height of truck aprons to 3” (7.6 cm) and are considering lowering it further to 2” (2.5 cm) based on their experiments.

1.2.1 Summary of Correspondence

- A good design practice is to build a roundabout that works for current volumes plus a reasonable time period (i.e. 10 years), and be prepared to add additional lanes in the future.
- Traffic control/accommodation is a high cost factor.
- A big issue is designing to accommodate low-boy vehicles due to their limited vertical clearance. Therefore, the apron slope should be similar to that of the circulatory road.
- For a very large load, it may be possible to shut down the roundabout completely, using the wrong way (counter flow) if necessary.
- One jurisdiction has made a commitment to install removable signs and have a curb supportive of sidewalls of tires to accommodate OSOW vehicles.
- Research of vehicle type and how often it will use the intersection is crucial to design.
- Public input process may be lengthy but is worthwhile.
- The general consensus is that roundabouts are much safer than signalized intersections.

2.0 Existing Roundabouts within Alberta

2.1 General Information

The department currently provides Design Bulletin 68 as its standard for roundabout design in the province. [9] To date, seven roundabouts have been constructed on the provincial highway network. They are located as follows and are listed in the order in which they were constructed:

1. Highway 63:12 Interchange in Fort McMurray (King Street and Tolen Drive)
2. Junction of Highway 22 and Highway 8, northeast of the Hamlet of Bragg Creek
3. Junction of Highway 744, 100 Street and 96 Avenue in the Town of Peace River
4. Junction of Highway 20 and Highway 11A in the Town of Sylvan Lake
5. Junction of Highway 6, Highway 507 and Hewetson Avenue in the Town of Pincher Creek
6. Junction of Highway 55 and Highway 892, west of the City of Cold Lake
7. Junction of Highways 44 and 633 near Villeneuve (opened to traffic in December 2013)

There has been another roundabout constructed at Leva Avenue and Lantern Street in Gasoline Alley, Red Deer County, which opened to the public in August 2013. It was designed and reviewed by Red Deer County. The Government of Alberta provided partial funding to the County of Red Deer for the Leva Avenue improvement project; this funding was used for linking Leva Avenue to an existing range road.

Alberta Transportation has also constructed a roundabout along Valley Ridge Boulevard, north of the Trans-Canada Highway 1 crossing through Calgary as 16th Avenue. This roundabout is within the City of Calgary's jurisdiction.

In addition to communicating with various experts across the country and in the United States, Alberta Transportation personnel have been approached to solicit their opinions on the implementation of roundabouts within the province. All of the feedback is included in the respective roundabout section with the exception of the following: one general opinion was provided by a representative for the Central Region. He mentioned that the high cost of roundabouts is linked to the fact that they are quite new to the province, and believes that the cost will decrease once they become more commonplace and less of an unknown entity for contractors. In addition, he stated that more consideration should be given to the frequency of OSOW loads that would utilize the roundabout; he is of the opinion that some roundabouts are overdesigned in terms of structural thickness, which implies that the cost of concrete and surfacing materials for the project is higher than necessary.

2.1.1 Traffic Volumes

Turning Movement Diagrams (TMD's) provide information regarding the types of vehicles that utilize a particular intersection. The available highest and lowest average daily traffic volumes for Bragg Creek, Cold Lake, Pincher Creek, Sylvan Lake and Villeneuve roundabouts for the past decade are summarized in Table I, located at the end of the report.

2.1.2 Geometric Data

Geometric data for the existing roundabouts was gathered and compiled for easy comparison. The data is presented in Table II. Notable observations on the data are as follows:

- None of the roundabouts were designed by the same consultant, with the exception of Fort McMurray interchange and Bragg Creek.
- Cold Lake has a significantly wider apron than the rest.
- Bragg Creek has the largest inscribed circle diameter and central island diameter.
- Cold Lake and Bragg Creek roundabouts are higher speed roundabouts because they are located in a rural setting, whereas Sylvan Lake, Peace River, and Pincher Creek roundabouts are designed for lower speed because they are located in an urban setting.
- All roundabouts have four legs, with the exception of Peace River which has five legs.

2.2 Location-Specific Information

2.2.1 Roundabout at Junction of Hwy. 8 and Hwy.22 near Bragg Creek

A design report completed by the consultant (EarthTech Canada Inc.) contained information on planning, the results of which are summarized below.

- Average Annual Daily Traffic volumes (at time of design) were: 8300 at north leg, 7000 at south leg, 6900 at east leg, and very low volume on west leg.
- The intersection was analyzed for the 2023 traffic horizon – multi-way (four-way) stop control vs. signalized intersection vs. roundabout.
- Two alternatives were forecasted to be effective: a signalized intersection with a north/south left turn and a roundabout with single lane approaches on all legs.

- Preliminary cost estimate of the roundabout was almost half of that of signalization.
- It was sized to accommodate off-tracking of large trucks up to WB-36 sized vehicles and to include the future option of a second lane on the "circle."

Construction on the roundabout commenced on July 19, 2007. A Northbound (NB) / Southbound (SB) detour for Hwy 22 was constructed and opened along the west side of Hwy 22. New lanes and the circle were open to traffic on November 1, 2007. The project was completed and construction was shut down on August 18, 2008. Some problems encountered during construction included the following:

- Many rain days hampered progress.
- There were a few minor deficiencies for pavement segregation and smoothness.
- When the roundabout opened there was initial public confusion, but they soon adjusted.
- General opinion after the roundabout was opened is that it effectively dealt with the volume and type of traffic at this intersection.
- Paving in the roundabout proved to be quite challenging especially when doing the final lift with traffic following through and so production was limited.
- There were some discrepancies with contractor and traffic accommodation, including not using standard retro-reflective signs, using non-standard barriers and small, flimsy, portable sign stands.
- There were some suggestions that the diameter of the circle should have been smaller, as the diameter is in the upper range for modern roundabouts.
- The roundabout approaches required reconstruction in a curvilinear fashion to provide for traffic calming (slowing) and proper entry geometry.
- Meanders in the approaches conflicted directly with overhead power on one side, requiring pole line relocation which in turn affected grade construction.
- The contractor asserted that the timing of the removal of the power utility was the largest single impact on the project completion.

Input from the Program Management Branch included the following: While the consultant has underestimated the project cost, the difference is more likely related to the very heavily committed state of the industry and tight construction timelines. It is not particularly desirable work as it is low production piecemeal at numerous locations and with the volume of work available the contractors have the luxury of setting their own prices. While the tender price for this project is very high, three bids were received with the second bidder being only $100,000 higher than the low bid. It is unlikely that re-tendering would provide any lower prices. This project provides major safety improvements; because of the importance of the work and available funding, the Region recommends awarding to the low bidder.

The consultant's opinion of the contributing factors affecting the increase in cost included:

- The Alberta economy pushes construction price up at a fast pace.
- Most contractors are at or near capacity to have projects finished within this season.
- A June tender schedule for this October completion date requires bidders to reschedule their already tight availability, which resulted in a premium price deferential.
- Small, slow production jobs were tagged on to this project, and bidders put in a higher than normal mobilization to allow for a minimum of mobilizing three times.
- Traffic accommodation is not a separate bid item. All works are intersection treatments therefore bidders anticipated full traffic accommodation setup at each of the 5 locations (instead of the normal one or two construction zone setups on lineal projects).
- Specific bid items of significant variance include: mobilization, common excavation, Granular Base Course (GBC), Asphalt Concrete Pavement (ACP), and concrete surfacing.

2.2.2 Roundabout at Junction of Hwy.744, 100 Street and 96 Avenue in Peace River

Details obtained from the contract package for the Peace River roundabout are outlined below.

- Major work on the project was delayed by three major causes: extension of the contaminated waste reclamation, re-design of the roundabout due to the installation of the retaining wall, and inclement weather conditions.
- The extension of the roundabout into the main street delayed the project for 15 days.
- The re-design of the roundabout due to the installation of the retaining wall delayed the project for approximately 18 days.
- As per AT's instructions to open the roundabout with concrete medians, the contractor completed work during inclement weather conditions. Specifically, the contractor was delayed or unable to complete work days from October 31, 2009 to November 12, 2009 when the roundabout was due to be opened for the winter.

The AT project administrator who worked on the roundabout in Peace River mentioned that this particular roundabout was completed over two construction seasons, with winter concreting (with heating and hoarding). In addition, a unique feature of this roundabout is that it has semi-mountable curbs inside a concrete apron, with brick work inside the semi-mountable curb in the centre. He mentioned that it has the same effect but looks different from other roundabouts and therefore has raised some questions. Overall, he has observed that the roundabout has been a huge improvement in this location as the difference in user costs outweighed the difference in construction costs.

2.2.3 Roundabout at Junction of Hwy. 20 and Hwy. 11A in Sylvan Lake

A summary report completed by the consultant (Al-Terra Engineering) on the Sylvan Lake roundabout was reviewed and is summarized below.

- Construction included base work, paving, pouring curb and gutter, pouring medians, and upgrading lighting, occurring for around four months.
- After grade widening was complete in each quadrant, it was either graded or paved to tie into the existing pavement so that traffic could partially move over onto the new surface to allow construction to start in the original travel lanes.
- Some base and grading work was completed concurrently in two separate quadrants to minimize site occupancy.
- Most utility adjustments were carried out in 2007, before construction started; this was a great benefit to the project since the construction site was small.

Some problems encountered during construction involved the following:

- Scheduling was difficult due to the piecemeal nature of the project.
- Building alignment was tedious since part of each quadrant encroached into the existing travel lanes while the other part involved widening the existing grade.
- Heavy rains and construction scheduling to constantly accommodate traffic delayed progress.
- Due to the wet ground conditions, the Contractor was instructed to place a geotextile under all granular material.

The modified construction price came in at 3.2% above the modified tender price. Traffic accommodation increased costs; the contractor stated that future intersection construction of this type would benefit from a full intersection closure and major detours which would significantly decrease costs and site occupancy. Areas of unexpected high costs included: common excavation, borrow excavation, GBC and ACP.

In conclusion, the consultant mentioned that future rural roundabouts will benefit from good design, consideration of urban design standards as to how they can apply to low speed roundabouts, efficient coordination of sub-contractors, and continued emphasis on safety and proper traffic accommodation.

An AT construction engineer who was involved in the Sylvan Lake roundabout pointed out a few things unique to it that should be taken into consideration when examining costs. Firstly, the final pave for the roundabout occurred approximately three years after the initial construction to reduce traffic delays, save on costs due to scale of quantity, and because it also fit in better with the curb and gutter at time of construction rather than trying to match it later. In contrast, the final pave is being done at time of construction on current roundabout projects. In addition, there were minimal right of way requirements for the roundabout. Finally, the Sylvan Lake roundabout design did not consider OSOW vehicles.

2.3.4 Roundabout at Junction Hwy. 6, Hwy. 507, and Hewetson Avenue in Pincher Creek

An AT Engineer who was involved in the Pincher Creek roundabout mentioned that the roundabout was not triggered by any Traffic Impact Assessment (TIA); rather, a series of developments in the area led to concerns voiced by the Town of Pincher Creek that the existing intersection was unsafe, needed upgrades (preferably signalization) and pointed to a number of TIA's and studies by the Town. The engineer believes that these studies were unrealistic as they were based on high estimates of growth/development without any calibration with field data or analysis of growth rate/demographics. He stated that this is typical of most TIA's and therefore they are not a good basis for programming capital projects.

Construction commenced on July 19, 2011 and was completed on September 22, 2011. The successful bidder was 6.2% above the design estimate. Cost overrun from estimated to actual construction quantities were as follows:

- Channel excavation, common excavation, granular fill, hand-laid riprap and erosion control soil covering underran, removal of existing painted lines and extra work for ditch regrading was not required as estimated.
- GBC overran due to more overbuilding than expected.
- Extra work included: filter fabric for widening and rock check dams, culvert extension, enlarged breakaway bases, and steel post base and breakaway assembly.
- The contractor was awarded a bonus for density, gradation, segregation, traffic signing compliance, and site occupancy.

According to the consultant (ISL Engineering and Land Services), the operation was well organized and productivity was high. The consultant concluded that stakeholders were satisfied with the final product and the overall project was considered satisfactory.

2.3.5 Roundabout at Junction of Hwy. 55 and Hwy.892, west of Cold Lake

The consultant on the Cold Lake roundabout, Clifton Associates, confirmed that the cost of construction was approximately four times the amount of a signalization system. However, to provide signalization additional Right-of-Way (ROW) would have been required, as well as widening at the approaches to provide right turn lanes and general intersection improvement. The consultant mentioned that construction of this type of roundabout, where the legs meet the roundabout at a tangent, requires a substantial amount of civil works to be carried out to "offset" the legs in the lead up to where they join the roundabout. Less civil works are required when the approach legs are "perpendicular" to the circumference of the roundabout; road users in this type of roundabout have to slow down otherwise they will collide with the roundabout structure.

Significant traffic accommodation occurred to properly operate the detour and to ensure the work zone was free of vehicles. Local issues included heavy traffic using minor roads as short cuts which caused disturbance to the residents. However, there were very few public complaints. The consultant also mentioned that OSOW loads had been permitted to use Highway 55, approaching the roundabout from the west and exiting heading north on Highway 892 as these two highway sections are part of the high load corridor. Modifications were recommended and all OSOW vehicles that arrived at the construction site were sufficiently accommodated.

According to the consultant, the construction process was slow, although in the consultant's opinion that was more of a reflection on the contractor's inexperience with this type of construction than was due to the roundabout or its design. There were no major problems that occurred during construction. Some minor issues encountered were as follows:

- The design did not deal with all surface water and two swales had to be incorporated.
- The design had "free end" extruded curbing with nothing to back them so if it was mounted by a large vehicle the curb would fail.
- The design was originally not for a 50 year life-span so the pavement had to be redesigned after the project had started to ensure compliance.
- The method for holding up sign posts was not well defined in the documents and as a result led to misunderstandings by the contractor.

In closing, the consultant stated that the roundabout has been excellent at managing the flow of traffic over time and believes roundabouts will prove to be a great success as more people become accustomed with their use.

2.3.6 Roundabout at Junction of Hwy. 44 and Hwy. 633 near Villeneuve

The roundabout at the intersection of Highways 44 and 633 has recently (Nov/Dec 2013) opened to the public. The consultant, CIMA+, shared some knowledge based on their experience. Firstly, the item with the largest implication on costs was the requirement for accommodating OSOW vehicles. The design vehicles accommodated were a Heavy Hauler (Low Boy) Vehicle (46.8 m), a Platform Trailer Vehicle (54.3 m) and a Superload-Reactor Vehicle (97.8 m), all of which have very large tracking paths. This caused the roundabout footprint to be considerably larger than if the design vehicle was a WB-36. As a result, there were requirements for a greater paved surface area, additional curb and gutter and more ROW. Highway 44 is designated as a Long Combination Vehicle (LCV) corridor. The need to accommodate OSOW vehicles was mandated as part of Design Bulletin 68 [9]. In the consultant's design they assumed that OSOW vehicles would travel counter flow on the approach to the roundabout circulatory roadway and cross over the splitter islands. While this reduced the overall footprint, it also resulted in the need for semi-mountable curbs throughout the roundabout along with making any sign within the splitter islands removable.

In addition, the consultant mentioned that the perpetual pavement design utilized at the roundabout also led to increased projected costs. This design, which has a nominal design life of 50 years, consists of 170–300 mm ACP over 400-600 mm GBC which is significantly thicker than a pavement with a more typical 20 year pavement design life. The rationale behind using the perpetual design is that there is less risk of overlaying the curb and gutter in the future. A second option would be to use a more traditional 20 year design life, with the risk that selective reconstruction of the surfacing within the roundabout may be required at rehabilitation. In the consultant's past experience with City of Edmonton, a 20 year pavement design life is typically utilized on all roadways, most of which have an urban style cross-section. Another option would be to utilize a 20 year design life but to increase the rehabilitation cycles (i.e. 10 years), which would repair any distresses before they permanently affect the pavement structure. Finally, the consultant stated that some additional guidance may be necessary in determining more realistic unit pricing. For example, a specific mark-up on unit pricing to consider a roundabout scenario may be beneficial.

3.0 Roundabout Costs

Factors to consider with roundabout costs include, but are not limited to, the following:

- Traffic Accommodation: Cost of maintaining traffic during construction may be relatively high for retrofitting roundabouts. It can be very costly to accommodate traffic if an entire new detour is constructed. Many individuals have mentioned that traffic accommodation is one of the biggest factors contributing to the overall cost in roundabout construction.
- ROW Acquisition: ROW costs are normally not a significant additional cost, but are worth considering as roundabouts typically take up more space than conventional intersections. With the exception of the Pincher Creek roundabout, which fit into the existing intersection, the cost of acquiring ROW for the other existing AT roundabouts ranged from $81,000 - $380,000 (3.8-4.8% of bidding price).
- Diameter and Overrun Areas: The diameter of the roundabout has a direct influence on cost as increased size leads to higher quantities of materials required. Both the diameter and overrun areas should be designed as modestly as possible to accommodate the maximum capacity without compromising safety.

- Surfacing: Based on the data collected on the existing roundabouts, the amount of GBC and ACP utilized in construction has a direct correlation with the overall cost. Additionally, the relative locations of the roundabouts within the province may increase hauling costs. Directly related to the amount of ACP required is the roundabout design life. Personnel involved in previous roundabout projects have stated that more consideration should be given to the frequency of OSOW loads that would utilize the roundabout as some roundabouts are overdesigned, which implies that the cost of pavement is more excessive than necessary. More study is required in surfacing strategies to find ways to reduce the quantity required, as surfacing can become very expensive with increasing pavement thickness. Currently pavements for roundabouts are designed for 50 years. Two suggestions are made based on observations of practices elsewhere: 1) use a 10 or 20 year design period for the travel lanes and be aware that resurfacing may be needed in the shorter term due to the need to re-allocate lane usage (with fresh pavement markings and lines) and 2) reduce the pavement thickness on the over-run areas and central apron as the loading on these areas is very infrequent. Pavement designers should visit some existing roundabouts to get a better understanding of the very low usage of all areas that are off the main travel lanes.
- Accommodating OSOW vehicles: Designing the roundabout to accommodate OSOW vehicles will certainly lead to increased costs over a roundabout that does not have to accommodate any OSOW vehicles. Indeed, in AT's newest roundabout at the junction of Highway 44 and Highway 633 (Villeneuve), the consultant confirmed that the item with the largest implication on cost was the requirement of accommodating OSOW vehicles.
- Contractors / Tendering Schedule: If a project is tendered later in the year, the price will increase as the contractor has less time to complete the project. At the Bragg Creek roundabout, a June tender schedule for an October completion date required bidders to reschedule their already tight availability resulting at a premium price deferential. There were not many contractors available to bid on the project for completion in the same year. Many are of the opinion that one highly likely source of high cost is linked to the fact that roundabouts are quite new to the province; this cost will decrease once they become more commonplace and less of an unknown for contractors.

3.1 Cost of Existing Roundabouts

The total cost of each existing roundabout is summarized along with its geometric data in Table II, which can be viewed at the end of the report. The bid items used in construction which have had the most significant impact on cost are summarized below:

- Common excavation and concrete curb cost significantly more in the Bragg Creek and Villeneuve roundabouts.
- The quantity of asphalt concrete pavement used increases concurrently with total cost.
- GBC surpassed $1.2 million in the Villeneuve roundabout.
- Concrete sidewalk cost significantly more at Sylvan Lake than at other locations.
- Site occupancy cost was significantly higher at Cold Lake and Villeneuve locations.
- Mobilization cost surpassed $1.2 million at the Bragg Creek roundabout. However, the mobilization for only the roundabout was lumped together with the mobilization for other intersectional improvements.
- Granular fill cost significantly more at Cold Lake than at the other locations.
- Borrow and subgrade excavation was quite costly at Villeneuve, and either very low or non-existent at all other locations.

3.2 Financing the Roundabout

3.2.1 Alberta's Funding Practice

The current policy requires that developers be responsible for upgrades to highway intersections. At times, this policy may conflict with the department's business goal of connecting communities and supporting economic and social growth. A single development with a private means of access to the highway is to be responsible for all costs for highway improvements attributed to their developments. The current policy allows for department funding for developments accessing the highway if there is a highway construction project at that location identified in the department's three year business plan. The current recommendation is that upon receipt of development applications where highway improvements are anticipated, a TIA should be requested to identify what improvements, if any, are required for existing traffic, and what improvements are required to accommodate the development.

3.2.2 Funding in Other Jurisdictions

With respect to the idea of cost-sharing, a spokesperson from Connecticut DoT states that this is not an issue for the Connecticut DoT as all of their roundabouts are completely federally funded, with the exception of decorative features such as illumination posts and signage.

A representative from B.C. MoT has identified that the British Columbia MoT has a cost-sharing agreement with the Insurance Corporation of B.C. (ICBC) for safety projects. This is a $3-5 million per year partnership and the ICBC project funding is based on their investment criteria which are dependent on safety performance of the location. Since roundabouts are considered a safer form of traffic control they qualify for ICBC funding. Typically, the cost-sharing agreement with ICBC is for ministry driven projects and not development driven. Thus, the developer will have to fund the intersection improvements that are triggered by the development.

According to a spokesperson from WSDoT, cost-sharing is very site-specific and precise to the stakeholders involved who share jurisdiction or who can benefit from the "more efficient/safer" intersection. If a development comes forward that requires mitigation (there is a threshold for the number of trips it will add to the roadway), then the development is responsible for funding the improvement, per the WSDOT standards for a roundabout design or other fix. In the past the traditional solution has been left or right turn channelization or a signal; however roundabouts are increasingly becoming the preferred choice of improvement or resolution. If a development is proposed for an area that is already funded, for example at an intersection, costs can be shared with the development and potentially get quicker approval.

4.0 Discussion

There are many advantages and disadvantages to the modern roundabout. These factors are taken into consideration during highway planning and assist in the decision of whether the implementation of a roundabout is warranted.

4.1 Advantages

- Less Serious Collisions: Head-on and angle collisions are virtually non-existent because of the circular rather than opposing flow of traffic. In fact, roundabouts in the USA and other countries have achieved a 50-90% reduction in collisions compared to intersections using two or four-way stop control or traffic signals.[8]
- Low Operation and Maintenance Costs: The only maintenance costs for a roundabout are for landscape maintenance and occasional sign replacement. Even if the construction cost of a roundabout is higher than for traffic signals, an economic analysis including construction, operation, maintenance and collision cost reduction associated with each type of control will usually show that a roundabout has a higher benefit/cost ratio than a signalized intersection.
- Self-Regulating: Generally, a well-designed roundabout closely matching approach and mid-block capacity rarely needs altering, except where the road is widened and the number of approach lanes is increased.
- Environmental Benefits: Roundabouts account for a reduction in noise levels, and can be expected to result in a lower pollutant output as the result of reduced delay and fewer vehicle stops and starts.
- Traffic Calming: Roundabouts can accommodate traffic at locations where there is a need for traffic calming, such as at the boundary between rural and urban environments.
- Operational Improvement: A roundabout will always provide a higher capacity and lower delays than All-Way Stop Control (AWSC) operating with the same traffic volumes and right-of-way limitations. A single-lane roundabout may be assumed to operate within its capacity at any intersection that does not exceed the peak-hour volume warrant for signals. Roundabouts are also associated with better utilization of connected roads and greater capacity. During a power outage, roundabouts will continue to allow traffic movement.

4.2 Disadvantages

- Heavy Flows vs. Minor Flows: In the case of unequal approach volumes, the modern roundabout gives the advantage to the minor flow, adding delay to the heavy flow. This can be addressed by metering of certain approaches when queuing occurs on the heavier traffic legs.
- Pedestrian and Bicycle Right-of-Way: Additional assessment is warranted prior to constructing roundabouts in areas where heavy pedestrian or bicycle activity is expected. Pedestrian and bicycle flows can be an issue, depending on the volume. However, this is more of an issue for multi-lane roundabouts.
- Snow removal: Snow clearing may become an issue with modern roundabouts in winter conditions. Although some have the advantage of allowing snow removal vehicles to turn around in the modern roundabout, the added pavement that requires clearing can increase time for snow removal.
- Raised Splitter Islands: In single-lane roundabouts, splitter islands limit circulation flexibility during construction and in cases of collisions. This can be addressed by using mountable curbs.
- Construction: Construction becomes more costly and complicated because of the need to grade a larger surface and the maintenance of traffic during construction.
- Topography: Roundabouts should only be considered in areas that can accommodate an acceptable inscribed diameter and other appropriate geometric design elements. To provide adequate sight distance for approaching drivers to perceive the intersection layout, it is good to locate the roundabout either on level terrain or at the bottom of a sag vertical curve. Sight distance demands are minimized through the use of low operating speeds.

- Modelling and Simulation: The theory of gap-acceptance leads to complex assumptions regarding driver behaviour. Sophisticated modelling is required to properly simulate reasonable traffic patterns. An acceptable alternative is to use empirical models which are founded on decades of experience and should be calibrated for the local driver experience level.
- Public Acceptance: Often one of the biggest challenges facing a jurisdiction that is planning to install its first roundabout is public acceptance, as the public may initially be wary where it is a new practice. A successfully implemented roundabout, especially one that solves a perceived problem, can be an important factor in gaining support for future roundabouts at locations that could take advantage of the benefits that roundabouts may offer. As they can be a highly effective intersection control method, it is a good idea for agencies to celebrate their successes if they would like roundabouts to be more fully adopted in a timely manner.

4.3 Recommendations / Cost-Reducing Strategies

Recommendations on methods of reducing capital cost for the construction of roundabouts are provided below.

- Low Speed Environment: The design speed for a roundabout should be chosen with consideration of the setting, i.e. rural or urban. However, it is more desirable to provide a low-speed environment as curves can be tighter, leading to a smaller overall size and correspondingly lower cost.
- Central Island: The central island could be traversable with the use of removable, crashworthy objects in centre. All signs can be removed by escorts accompanying any OSOW vehicles. In addition, the central island could have a strong base. The apron can be made less thick than previously constructed roundabouts if the amount of OSOW vehicles is sufficiently less.
- Surfacing: Currently the pavements in roundabouts are designed for 50 years, which certainly contributes to the overall cost as they must be of a much stronger quality than if for a shorter life (e.g. 10 years). Other jurisdictions have found success in designing for a 10 year horizon, and ensuring that there is the possibility to add on another lane if necessary. This is good practice as future traffic predictions may never materialize. In addition, instead of adding resurfacing beyond the limits of the project, the department could limit the resurfacing to that which is actually needed for the roundabout.
- Reduce Diameter: In general, a smaller diameter will lead to a safer roundabout. Safety advantages of a roundabout may begin to diminish when the diameter of the inscribed circle exceeds 75 m [8]; none of the existing roundabouts in Alberta exceed 75 metres. If the roundabout is single-lane, the diameter could be reduced while the apron width could be increased correspondingly. In the case of a multi-lane roundabout, the diameter may be reduced after careful consideration to the type of roundabout (i.e. Case I, Case II, and Case III as per Design Bulletin #68) and accommodation for OSOW vehicle movement.
- Apron and Curbs: The apron should have a cross-slope of 2%, or whatever is required to accommodate low-boy and OSOW vehicles. The height of the curb should be minimized to the best extent possible to save on cost of concrete. Another option is to use rumble strips or other forms of textured pavement, which would be at the same height as the road but would still deter drivers from using the apron. This would also ease maintenance concerns.
- Cost-Sharing: It is unlikely that developers will agree to pay for a roundabout if the estimated cost is significantly higher than for a signalized intersection. Therefore, an option to this would be to have developers cover the cost of a conventional intersection, and the government would cover the incremental cost remaining for the roundabout. It is anticipated that once roundabouts become more familiar to contractors the cost will decrease.

- Analysis: Review of the amount of trucks actually using the apron of existing roundabouts would be useful to ascertain whether the surfacing is overdesigned. This data can be used to improve future design. There have been concerns raised by personnel involved in previous roundabout design that an inadequate or inconsistent amount of analysis is completed before a roundabout is selected. Another option would be to undertake smaller (lower cost) construction of roundabouts in two of the future highway locations; one urban, one rural. The two roundabouts would be built and their operation monitored. If they prove satisfactory, future designs could be based on a smaller prototype.
- Design Exception: Allow design exception if there is an alternate route (as accommodation of large vehicles is very costly or otherwise constrained).
- Detours: During detailed design, constructability should be considered.
- Design Vehicle and Accommodating OSOW vehicles: If a roundabout is designed to accommodate OSOW vehicles or LCV's, it will be more costly to construct. In some jurisdictions there are separate corridors for OSOW vehicles to travel through, and thus they do not have to be accommodated at that particular jurisdiction's roundabouts. Overall this would increase efficiency of flow through the roundabout and would decrease material required at the roundabout. Although it contradicts current policy in Alberta, one option to consider would be to not construct any roundabouts on OSOW vehicle corridors. In some cases OSOW vehicles and LCV's cannot travel on particular corridors as they cannot fit due to structures in the way. In these situations an alternate route must be provided. Careful analysis of current LCV and OSOW vehicle routes should be completed to potentially reduce the amount of corridors that must accommodate OSOW vehicles and LCV's.

5.0 Conclusion

Alberta Transportation's existing roundabouts have been described, and the construction process of each one analyzed. A literature review of practices in other jurisdictions and correspondence with roundabout professionals has been completed. A comparison of each of AT's roundabouts has been provided and high bid items have been identified. Roundabouts remain a relatively new concept in Alberta, and some challenges have arisen in design and construction. These challenges have resulted in construction costs higher than anticipated.

Benefits of roundabouts generally include reduced crash rates and severity, as well as reduced delay, stops, fuel consumption, and emissions. Disadvantages may include higher maintenance costs, complicated construction, and possibly increased delay in the case of extremely disproportionate approach volumes. Costs associated with roundabouts may include construction costs, engineering and design fees, land acquisition, and maintenance costs. Common challenges facing agencies that are planning to install roundabouts include limited public acceptance and designing to accommodate OSOW. A roundabout designed to accommodate significantly more loads than actually present will undoubtedly lead to higher costs. Conversely, a roundabout designed for fewer loads than are actually present will lead to safety concerns and quick deterioration of pavement. Therefore, it is evident that research into traffic patterns and wheel paths is crucial to an efficiently designed roundabout. From observing the construction process of each roundabout, it is also apparent that the efficiency of construction has a direct correlation to cost.

Good design practice is to build a roundabout that works for current volumes plus a reasonable time period (i.e. 10 years), and then be prepared to add additional lanes in the future. Aside from deferring cost, this practice also helps maximize safety and allows drivers to get used to a simpler roundabout before multi-lane roundabouts are introduced. It may be concluded that overall cost will decrease once more roundabouts are built in the province and become more familiar to contractors who will then feel comfortable lowering their prices. The public acceptance process will also become easier as people become more accustomed to using a roundabout and are able to see the benefits that roundabouts provide for themselves. General opinion is in favour of roundabouts; that although the capital cost may be higher, the positive impact they have on society is worthwhile as roundabouts greatly improve safety and decrease congestion, noise and pollution. Many jurisdictions are of the opinion that the overall benefits associated with roundabouts, especially those of increased safety, are great enough that roundabouts should be considered at all intersections.

References

[1]United States Department of Transportation. (2010). *Roundabouts: An Informational Guide, Second Edition.* Washington, D.C.: Transportation Research Board

[2]United States Department of Transportation. (2010). *Roundabouts - A Technical Summary.* Federal Highway Administration.

[3]Russell, E. et al. (2013). *Accommodating Oversize/Overweight (OSOW) Vehicles at Roundabouts.* Manhattan: Kansas Department of Transportation.

[4] Transportation, B. C. (2007). *740_Roundabouts, Supplement to TAC Geometric Design Guide.* BC MoT.

[5] The University of Texas at Austin and Kittleson & Associates, Inc. (2011). *Roundabout Evaluation and Design Workshop.* The Center for Transportation Research.

[6] United States Department of Transportation. (2000). *Roundabouts: An Informational Guide.* Mclean, Virginia: Federal Highway Administration.

[7] Jacquemart, G. (1998). *Modern Roundabout Practice in the United States. A Synthesis of Highway Practice. NCHRP Synthesis 264.* Washington, D.C.: Transportation Research Board, National Research Council.

[8] Aty, M. A. (2001). *State-of-the-Art Report on: Roundabouts Design, Modelling, and Simulation.* Orlando, Florida: University of Central Florida.

[9]Alberta Transportation. (2010 and subsequently revised). *Design Bulletin 68: Roundabout Design Guidelines on Provincial Highways.* Alberta Transportation.

Table I. Available High and Low Average Daily Traffic Volume Counts
Based on AADT

Year	Bragg Creek*		Cold Lake		Pincher Creek		Sylvan Lake		Villeneuve	
	High	Low	High	Low	High	Low	High	Low	High	Low
2002	8190	6870	2750	1250	3450	1280	6180	4550	5020	1330
2003	8280	6930	2000	1140	3680	1280	6060	4930	5400	1180
2004	8280	6830	1980	1100	3700	1280	6360	5020	5640	1200
2005	8170	6690	2090	1180	3720	1280	6800	5440	6120	1300
2006	8330	6610	2250	1400	3880	1330	7430	5950	6710	1420
2007	9350	6550	2610	1450	4060	1380	7250	6350	7300	1460
2008	9070	6350	2910	1530	5500	1470	7200	6200	6600	2080
2009	9110	6370	2910	1530	5500	1470	7330	5640	6560	2080
2010	9440	6600	2890	1530	5500	1470	7440	4780	6920	2120
2011	9300	6540	3010	1530	5500	1470	8040	4780	7160	2120
2012	9300	6480	3290	1550	5400	1460	9900	4930	6760	2120
2013	9480	6430	4010	2220	5440	1460	10610	5300	6550	2110

**Bragg Creek west leg has been excluded from comparison as it is a minor access only and therefore not an accurate representation of traffic volumes*

TABLE II. REQUIRED GEOMETRIC DATA

Parameter	Unit	Hwy 55 Cold Lake	King's St Fort McMurray	Hwy 22 & Hwy 8 Bragg Creek	Highway 11 at Sylvan Lake	Town of Peace River	Town of Pincher Creek
Hwy + Control Section		55:18/892:04(N)/892:	63:11:00	22:14/8:06	11A:06/20:02	744:04	6:04/507:02
Construction Cost		$ 4,750,000.00	N/A	$ 5,620,864.97	$ 3,041,368.84	$ 2,002,527.83	$ 1,421,377.90
AT Regional Office		North Central Region - Athabasca	Fort McMurray Region	Southern Region - Calgary	Central Region - Red Deer	Peace Region - Peace River	Southern Region - Lethbridge
Consultant		Clifton Associates	Reid Crowther	AECOM	Al-Terra	Stantec	ISL Engineering
Inscribed circle dia.	m	49	60-73	60	48.9	50	50
Central island dia. - ex. apron or curb	m	19	18.6	41	29.5	37.4	26
Apron material		100 mm impressed pigmented concrete / 150 mm ACP / 450 mm GBC, 700 mm pit-run gravel, 150 mm topsoil	N/A	200 mm ACP and 450 mm GBC	175 mm concrete coloured and impressed over 150 mm granular	Light red paving stones	Red color, 150 mm fibre reinforced concrete class HPC, GBC average depth 500 mm to match existing structure
Curb type		Semi-mountable curb (110 mm on outside, 75 mm on inside island); 150 mm barrier curb around central island	Semi-mountable curbs on splitter islands, truck apron curbs around central and outside aprons; barrier elsewhere	Semi-mountable curb around apron, barrier around central island	Semi-mountable modified curb around apron, barrier curb around inside circle with landscaping	Semi-mountable curb inside a concrete apron with brick work inside the semi-mountable curb in the centre	Semi-mountable curb and gutter on outside lanes
Apron width in. curb	m	7.5	4.7	4	3	1.5	5
Height of apron above circulatory road		75 mm at 1%	N/A	3% slope	1% slope	100 mm	75 mm sloped at 3%
Roadway material		150 mm ACP / 450 mm GBC / 700 mm granular fill (pit-run)	N/A	200 mm ACP and 450 mm GBC	200 mm ACP Type H1 / 400 mm GBC / 150 mm subgrade	100 mm ACP / 250 mm GBC	60 mm ACP, 170 mm ACP, 200 mm GBC, granular fill
Circulatory road width	m	6.5	5	5	6.4-8.1	4.8	7
Circulatory road slope	%	2%	N/A	2%	1-2%	2%	2%
# of lanes		1	varies from 1-2	1	1	1	1
# of approaches		4	4	4	4	5	4