Justification and Feasibility of Roundabout

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Abstract

Each year, cities receive numerous requests to reduce the traffic congestion on their streets. To reduce traffic congestion and improve safety, many cities start considering the use of "roundabouts." Roundabouts are used throughout the world, to reduce accidents, traffic delays, fuel consumption, air pollution and construction costs, while increasing capacity and enhancing intersection beauty and used to control traffic speeds in residential neighbourhoods, also accepted as safe type of intersection design. This paper explains the benefits of roundabout over signalised intersection. Also explains the procedures required to justify roundabout as the most appropriate form of control for a given situation.

Keywords- Roundabouts, Traffic signals, conflict points, Intersection, AWSC, TWSC, Traffic circles

I INTRODUCTION

A modern roundabout has three major characteristics compared to its predecessors, traffic circles and rotaries. First, the roundabout gives vehicles in the circular travel way the right-of-way. Second, roundabouts are small, generally from 21 to 50 meter in diameter compared to 100 meter. Third, roundabouts have a raised entry "splitter" island that slows down speed just before entry. [1] Roundabouts have three main characteristics that identify them when compared to traffic circles [3].

♦ Offside priority or yield-at-entry – Roundabouts give vehicles in the circulating roadway the right of way. In addition to giving priority to vehicles already in the facility, roundabouts control the entering vehicles with a yield sign, not stop signs or traffic signals.

♦ Approach flare – Most roundabout approaches flare out at the entries and allow more vehicles to enter the circulating roadway at a more obtuse angle. This improves capacity, and allows entering vehicles to enter at similar speeds as the circulating vehicles unless a cue has developed at the entry This island also gives pedestrians a safe location to cross the approach in two stages.

♦ Deflection – This characteristic is the geometry of the facility that requires vehicles to slow down as they manoeuvre through the roundabout. The size of the centre island and angle of approach determine the deflection and potential speeds of entering and circulating vehicles. [2]

Parking is not allowed within the circulating roadway or at the entries of the approach legs, and all entering traffic is required to proceed around the roundabout in a clockwise direction. The effect of the roundabout is that traffic is required to slow down to negotiate the curve around the centre island, but unlike stop and signal controlled intersections, vehicles entering roundabout are not required to stop. This makes the facility more efficient under a broad range of traffic volumes, as motorists need only to find an acceptable gap for entrance.

Figure 1 shows vehicle movement circulating path at roundabout intersection.
II WHY USE A ROUNDABOUT

A. Safety: Roundabouts have been shown to reduce fatal and injury accidents as much as 76% in the USA, 75% in Australia and 86% in Great Britain. The reduction in accidents is attributed to slower speeds and reduced number of conflict points. According to Indian survey it decreases accident rate by 40%.

B. Pedestrian Safety: All research suggests that modern roundabouts are safer than signalized intersections for pedestrians. In each stage the pedestrian has to look in only one direction to cross a one-way traffic stream. Pedestrian refuges are provided in the areas within the splitter islands.

C. Low Maintenance: Eliminates maintenance costs associated with traffic signals also electricity costs are reduced.

D. Reduced Delay: By yielding at the entry rather than stopping and waiting for a green light, delay is significantly reduced.

E. Capacity: Intersections with a high volume of right turns are better handled by a roundabout than a multi-phased traffic signal.

F. Aesthetics: A reduction in delay corresponds to a decrease in fuel consumption and air pollution. In addition, the central island provides an opportunity to provide landscaping.

III VEHICLE CONFLICTS

Conflicts can be divided into three basic categories, in which the degree of severity varies, as follows:

• Queuing conflicts: These conflicts are caused by a vehicle running into the back of a vehicle queue on an approach. These types of conflicts can occur at the back of a through-movement queue or where left-turning vehicles are queued waiting for gaps. These conflicts are typically the least severe of all conflicts because the collisions involve the most protected parts of the vehicle and the relative speed difference between vehicles is less than in other conflicts.

• Merge and diverge conflicts: These conflicts are caused by the joining or separating of two traffic streams. The most common types of crashes due to merge conflicts are sideswipes and rear-end crashes. Merge conflicts can be more severe than diverge conflicts due to the more likely possibility of collisions to the side of the vehicle, which is typically less protected than the front and rear of the vehicle.

• Crossing conflicts: These conflicts are caused by the intersection of two traffic streams. These are the most severe of all conflicts and the most likely to involve injuries or fatalities. Typical crash types are right-angle crashes and head-on crashes.

As per figure 2, a roundabout reduces vehicular crossing conflicts for both three- and four-leg intersections by converting all movements to right turns. Again, separate turn lanes and traffic control (stop signs or signalization) can often reduce but not eliminate the number of crossing conflicts at a traditional intersection by separating conflicts in space and/or time. However, the most severe crashes at signalized intersections occur when there is violation, i.e. breaking of rules.

Figure 2. Conflict Points on a Regular 4-way Intersection Compared to a Modern Roundabout Intersection.(source: Planning Level Guidelines for Modern Roundabouts)

Figure 2 shows the reduction in vehicle-vehicle conflict points between a traditional four-approach intersection and a roundabout. Roundabout reduces vehicle-vehicle conflict points from 32 to 8 also reduces vehicle to pedestrian conflicts points from 24 to 8.

IV SPACE REQUIREMENTS

Roundabouts that are designed to accommodate vehicles larger than passenger cars or small trucks typically require more space than conventional intersections. However, this may be more than offset by the space saved compared with turning lane requirements at alternative intersection forms. The key indicator of the required space is the inscribed circle diameter. A detailed design is required to determine the space requirements at a specific site. [4]

However, as capacity needs increase the size of the roundabout and comparable conventional (signalized) intersection, the increase in space requirements are increasingly offset by a reduction in space requirements on the approaches. This is because the widening or flaring required for a roundabout can be accomplished in a shorter distance than is typically required to develop left turn lanes and transition tapers at conventional intersections. This effect of providing capacity at the intersections while reducing lane requirements between intersections, known as “wide nodes and narrow roads,”

Figure 3. Area comparison : Urban flared roundabout vs. comparable signalized intersection.

(source: FHWA Roundabout Guide)
V ROUNDBOATS VS. SIGNALS AND STOP SIGNS

Three general questions must be answered to justify a roundabout as the most appropriate form of control at any intersection:

Will a roundabout be expected to perform better than other alternative control modes? Are there factors present to suggest that a roundabout would be a more appropriate control, even if delays with a roundabout are slightly higher?

If any contraindicating factors exist, can they be resolved satisfactorily?

If these questions may be answered favourably, then a roundabout should be considered as a logical intersection choice.

VI INTERSECTION CONTROL ALTERNATIVES

Traffic signals and stop signs are alternative to roundabouts for intersection control. It has significant operational limitations in comparison with a roundabout[5].

A. Traffic Signals - Roundabouts can efficiently handle particular intersections with decreased delay and greater efficiency than traffic signals. It is true where traffic volumes entering the roundabout are roughly similar and where there are a high number of right turning vehicles [6].

Traffic signals cause unnecessary delay for many reasons:

a. The need to provide a minimum green time to each movement in every cycle creates time intervals in which no vehicles are entering the intersection.

b. The need to provide for the most critical of two or more movements that proceed simultaneously results in an ineffective use of green time by non-critical movements.

c. The "lost time" associated with start up and termination of a green phase detracts further from the amount of time that is available for moving traffic.

d. Right turns that take place from shared lanes impede other movements in the shared lanes unnecessarily. This results in a very inefficient utilization of the available roadway space.

e. Heavy left turns from exclusive lanes, require dedicated phases that rob time from major movements and increase the total time lost due to start up and termination of traffic movements.

f. Signals are mechanical devices that not only require maintenance but also periodically malfunction. They are also dependent upon electrical power and do not, therefore, provide any control during power failures.

Unsignalised and signalised intersections have their own limitations. Mostly unsignalised intersection can accommodate low traffic volumes with much less delay than traffic signals, but this control mode favours the major street (unstopped) movements at the expense of the minor street movement. When the major street traffic volumes are heavy (typically 1400 vph or more) there is little or no opportunity for cross street access.

Two phase, three phase or four phase signalised intersections treat the cross street movements more favourably. However, the rate at which vehicles may enter an intersection (i.e. headway) is relatively low and, therefore, the total intersection capacity is somewhat limited.

B. Roundabouts

A roundabout overcomes all of these disadvantages. There is no sequential assignment of right-of-way and therefore no wasted time. [6]

a.) An orderly and regimented traffic flow is provided.

Individual traffic movements are subordinated in favour of traffic as a whole.

b.) All traffic proceeds, at a fairly uniform speed. Frequent stopping and starting are avoided.

c.) Weaving replaces the usual crossing movement at typical at-grade intersections. Direct conflict is eliminated, all traffic streams merging or diverging at small angles.

Accidents occurring from such movements are usually of a minor nature.

d.) Vehicles enter under yield control instead of stop control and therefore have lower headways and higher capacities.

e.) There are no electrical components to malfunction.

Roundabouts, on the other hand, have their own limitations:

For very low-volume applications, TWSC and AWSC are easier and less expensive to implement.

Since roundabout operation is not periodic, it is not possible to coordinate the operation of roundabouts on an arterial route to provide smooth progression for arterial flows.

A roundabout requires a comparatively larger area and may not be feasible in many built-up locations.

Roundabouts offer the least positive form of control.

Where the angle of intersection between two roads is too acute, it becomes difficult to provide adequate weaving length.

VII ROUNDBOAT JUSTIFICATION CATEGORIES

To provide an organized approach to the justification process, a series of categories has been developed, each of which represents a good reason to install a roundabout. A brief description of the justification categories is as under: [1], [4]

A. Community Enhancement: Roundabouts proposed for community enhancement require minimal analysis as a traffic control device. The main focus of the planning procedure should be to demonstrate:

That they would not introduce traffic problems that do not exist currently.

Projects qualifying for roundabout treatment should demonstrate that a roundabout is an essential part of the community’s development plan for a given area, and not just an arbitrary idea.

i. They are often located in commercial and civic districts.

ii. Traffic volumes would typically be low.

iii. Aesthetics are an important factor in this category.
B. Traffic Calming
Projects qualifying for roundabout treatment in this category should demonstrate that there is a need for traffic calming along the intersecting roadways. Examples of conditions that might suggest a need for traffic calming include:
Documented observations by state and/or local agencies of speeding, high traffic volumes and/or careless driving activities.

C. Safety Improvement
Projects qualifying for roundabout treatment in this category should demonstrate that there is a safety problem at the intersection. In addition, it should be documented how the roundabout treatment will improve safety at the intersection. A special review of accident reports and the type of accidents occurring is usually necessary. Examples of safety problems include:
High rates of crashes involving conflicts that would be readily resolved by a roundabout (right angle, head-on, left/through, U turns, etc); High crash severity that should be reduced by the slower speeds associated with roundabouts.

D. Operational Performance
A roundabout may be considered as a logical choice if its estimated performance is better than alternative control modes, usually either stop or signal control. Projects qualifying for roundabout treatment in this category should demonstrate that an all-way stop control (AWSC) delay should be compare with roundabout delay. A roundabout will always provide a higher capacity and lower delays than AWSC operating with the same traffic volumes and right-of-way limitations. Delay from the roundabout treatment would compare favourably with the signal treatment. This category will normally be limited to single lanes on the approaches and on the circulating roadway.

E. Special Conditions
Projects qualifying for roundabout treatment in this category should demonstrate that site specific conditions make a roundabout the appropriate intersection treatment. These conditions include unusual geometrics, high traffic volumes, right-of-way limitations, 5 or more legs in the intersection, etc[6].

VIII CONSIDERATIONS AND FEASIBILITY
As with any intersection design, safety, operational, economic, and environmental concerns need to be considered when evaluating alternatives. Balancing competing needs is important and essential. Every intersection should be evaluated based on site-specific issues as well as the intersection’s relationship to the adjacent roadway network to assure the most efficient and safe intersection alternative. Feasibility check can be made by guidelines given as per Annexure 1.[1],[4].

IX CONCLUSION
Roundabouts are not the solution to all traffic problems at all locations. Careful study is required to identify the most appropriate control method at any given location. The studies required to justify the installation of traffic signal control and all-way stop control are based on the warrants and requirements set forth in the Indian Road Congress. A modern Roundabout should be considered as an alternative traffic control to traffic signals and stop sign control. There are of course good roundabouts and bad roundabouts; no amount of clever software can ever get away from the need to have good traffic engineers responsible for the achievement of successful and safe operation. Only the human touch can take into account all the factors involved in the design of an individual roundabout.

[1] Shauna Hallmark Transportation Engineer Center for Transportation Research and Education, Iowa State University, “Planning-Level Guidelines For Modern Roundabouts Technical Memorandum”, November 2008
[3] Erik Lawrence Seiberlich, “ A Formulation To Evaluate Capacity And Delay Of Multilane Roundabouts In The United States For Implementation Into A Travel Forecasting Model,”
ANNEXURE 1

Before coming to the final selection of roundabout as an intersection following factors should be evaluated.

Table 1 provides guidance and supporting information on factors related to the feasibility of roundabouts.

**Table 1 Important Factor when considering a Roundabout**

<table>
<thead>
<tr>
<th>Category</th>
<th>Conditions</th>
<th>Feasibility check</th>
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<tbody>
<tr>
<td><strong>Safety</strong></td>
<td></td>
<td></td>
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<tr>
<td>Signalized intersections with high proportion of crash types:</td>
<td>Right angle crash and Through crossing crash rate is high</td>
<td>Roundabout is advantageous at intersections where crash rate is high</td>
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<td></td>
<td>High volume of pedestrians and high volume of vehicles</td>
<td>Roundabout can be implemented with further investigations</td>
</tr>
<tr>
<td><strong>Geometry of the Intersection</strong></td>
<td></td>
<td></td>
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<tr>
<td>Physical Parameters</td>
<td>More than four legs, Skewed, Close to another intersection, Within 30 meter of driveway</td>
<td>Roundabout is most suitable choice</td>
</tr>
<tr>
<td>Sight distance</td>
<td>Inadequate stopping sight distance</td>
<td>Where stopping sight distance is inadequate roundabouts are not advisable</td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Traffic Signals</td>
<td>Where queuing may extend into other intersections</td>
<td>Roundabout can be implemented with further investigations</td>
</tr>
<tr>
<td></td>
<td>Within a co-ordinated signal system Where modifications to traffic via signal timing is desired</td>
<td></td>
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<tr>
<td>Signal Delay For</td>
<td>Major movement-peak hours Minor movement-peak hours Major movement-off-peak hours Minor movement-off-peak hours No right-turn lane No protected right-turn phase</td>
<td>For all type of mentioned traffic roundabout is most feasible. Mostly roundabouts give lesser delay compared to signalized delay.</td>
</tr>
<tr>
<td>Turning Movements</td>
<td>High percentage of vehicles turning left Major traffic movement change direction</td>
<td>Roundabout is most suitable choice where right turning movements are more than other turning movements</td>
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<td><strong>Roadway Environment Factors</strong></td>
<td></td>
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<tr>
<td>Near to industrial zone</td>
<td>Large percentage of trucks</td>
<td>Roundabout designing should be done after considering largest vehicle, using roundabout frequently.</td>
</tr>
<tr>
<td>Railroad Crossings</td>
<td>On an approach leg Through the center island</td>
<td>Roundabout is not feasible, though other factors are favorable.</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>On highways access to rural areas</td>
<td>Rural to urban</td>
<td>At the junction of rural road to state highway roundabout is the best choice. On urban arterials at junctions with above mentioned favorable situations roundabout could serve the purpose.</td>
</tr>
<tr>
<td>On urban arterials</td>
<td>Divided roadway to undivided roadway</td>
<td></td>
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<tr>
<td>Aesthetics</td>
<td>Community enhancement</td>
<td>Roundabouts offer the opportunity to provide attractive entries or centerpieces to communities.</td>
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<tr>
<td><strong>Traffic calming</strong></td>
<td></td>
<td></td>
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<tr>
<td>Speed on urban arterials</td>
<td>Speed reduction in residential areas</td>
<td>By reducing speeds, near schools public buildings roundabouts complement other traffic calming measures.</td>
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<tr>
<td><strong>Capacity</strong></td>
<td></td>
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<tr>
<td>Capacity improvement</td>
<td>Need to improvement in capacity due to recent growth in nearby neighbourhood</td>
<td>Roundabouts offer lower circulating speeds which can provide greater capacity.</td>
</tr>
</tbody>
</table>

Any road project qualified for implementation of roundabout must make documentation report for above mentioned categories. After feasibility check implementation of roundabout can be possible.