A Framework for Assessing Roundabout near a School Zone

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Abstract

Roundabouts are circular intersections with specific design and control features on entry and circulate around a central island. The concept was developed and has been widely used in many European countries such as Great Britain, Spain and France. Signalized roundabout is "the most effective and economical solution for sharing out balancing the entry flows between the approaches" (Yang, et al, 2004). Roundabouts are considered safe. Accident studies have shown that conversion of a stop-controlled intersection into a roundabout reduces the number of injury collisions, and more importantly fatal collisions (Persaud, et.al, 2001; Elvik, 2003). In the United States, roundabouts, specifically, modern roundabouts are slowly being adopted as one form of intersection control.

This paper provides a framework for identifying the viability of a mini-roundabout near a school zone using the guidelines published by the National Cooperative Highway Research Project and the AASHTO standards. Additional decision criteria for roundabouts are also explored in this paper.

Introduction

Driving through an intersection is one of the most difficult traffic situations. Motorists at an intersection have to constantly yield to vehicular traffic, crossing pedestrians, and bicyclists. While most intersections have some forms of controls such as yield signs, stop signs, signal lights, or traffic circle or roundabout, it is crucial that the traffic control suits the condition of a particular intersection to maximize its capacity without sacrificing safety.

Roundabouts were developed in Europe and have been used widely around the world. However, roundabouts are not very popular to drivers in the United States which could be attributed to lack of understanding of how a roundabout really works. As a result, observations and experience to further researches in roundabouts in the United States are limited, and their design and application are still perfecting.

This paper illustrates the procedure for identifying the viability of a mini-roundabout near a school zone using the guidelines published by the National Cooperative Highway Research Project and explores additional decision criteria for roundabouts.

Methodology

The methodology used in this study involves using the existing design guidelines to assess the viability of a roundabout and identifying additional factors to assess the viability of a roundabout near a school zone. An intersection near a school zone was selected as a case study. Traffic data such as peak hour volumes and vehicle speeds were collected.

What is a Roundabout?

The American Association of State Highway and Transportation Officials (AASHTO) defines a roundabout, often referred to as a modern roundabout, as an “intersection with a central island around which traffic must travel counterclockwise and in which entering traffic must yield to circulating traffic. “ Roundabouts are considered safe and efficient because traffic flows in one direction only. Unlike in a traffic circle where vehicles freely merge with traffic, entering vehicle in a roundabout has to yield to traffic inside the roundabout. Modern roundabouts have curved and narrow entries which force drivers to slow down resulting in an overall reduction in speed. A roundabout has eight conflict points, which is seventy-five percent less than that of a typical intersection which has thirty-two conflict points as shown in Figure 1.

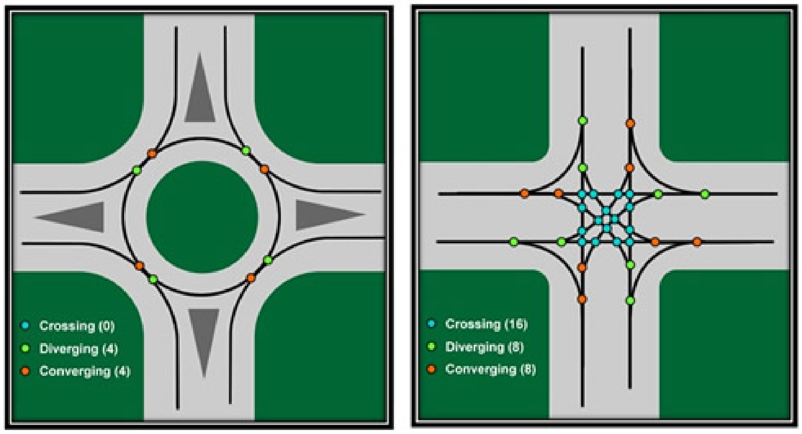

Figure 1. Conflict Points at Roundabout vs. Intersection (Source: FHWA)

Accident studies have shown that conversionof astop-controlled intersection into a roundabout reduces the number of injury collisions, and more importantly fatal collisions (Persaud, et.al, 2001; Elvik, 2003).

There are three types of roundabout: the mini-roundabout which is ideal for low-speed area with minimal right-of-way, single-lane roundabout with single lane at entry and a single circulatory lane, and the multilane roundabout with more than one entry lane on one of the approaches, and more than one circulatory lane. Table 1provides a summary of the design elements for each type of roundabout according to AASHTOstandards.

Table 1. AASHTO Comparison of Roundabout Types (Source: AASHTO, 2011)

Design Element	**Mini-Roundabout**	**Single-Lane Roundabout**	**Multilane Roundabout**
Recommended maximum entry design speed	25 to 30 km/h [15 to 20 mph]	30 to 40 km/h [20 to 25 mph]	40 to 50 km/h [25 to 30 mph]
Maximum number of entering lanes per approach	1	1	2+
Typical inscribed circle diameter	13 to 27 m [45 to 90 ft]	27 to 46 m [90 to 150 ft]	40 to 76 m [140 to 250 ft]
Central island treatment	Mountable	Raised	Raised
Typical daily volumes on 4-leg roundabout	0 to 15,000	0 to 20,000	20,000+

The USDOT FHWA has less stringent design elements of typical inscribed circle of 45 feet to 80 feet and daily service volumes on 4-leg roundabout of 10,000 vehicles per day, and a maximum entry design speed of 15 mph.

The Highway Capacity Manual (HCM 2010) indicated that the level of service criteria for roundabouts is “based solely on control delay,” and volume-capacity ratio of a lane. Due to limited research at the time of HCM 2010 publication, “roundabouts share the same basic control delay formulation with two-way and all-way STOP-controlled intersections". On-site situations show that traffic flow on a roundabout has different characteristics than that of a stop-controlled intersection. HCM 2010 stated that additional research on pedestrian operations and bicycles behavior and operations at roundabouts are needed to be developed and refined.

According to *NCHRP Synthesis of Highway Practice 264 - Modern Roundabout Practice in the United States* (NCHRP 264), practitioners currently are using design guidelines that have been developed by a state department of transportation, a consulting firm, or a foreign agency. Most state department of transportation follow the Austrian design guide or British standards which address the following issues:site of roundabouts; performance of roundabouts, such as improvement and safety; bicycle and pedestrian requirements; geometric design; and landscaping(NCHRP 264, 23). In recent years, more research on roundabout design has emerged and design standards formulated. The 2011 version of the *AASHTO Geometric Design of Highways and Streets* provides some standards for each type of roundabout.

Is a Roundabout Viable near a School Zone?

Roundabout near a school zone may be a form of traffic calming measure since vehicles are forced to slow down and yield to traffic. With proper design, a roundabout could be a focal point where school buses, passenger cars, pedestrians such as school children, and bicycles are able to share the road safely. In the United States, roundabouts near school zones are slowly increasing in number.

The framework for assessing the viability of a roundabout near a school zone is illustrated in an intersection in a residential neighborhood. The intersection of Fanwood Avenue (NS) and MaritaStreet (EW) is a near Gant Elementary School. The streets are two lanes and the intersection is controlled by 4-way stop. The intersectionhas an approach width of 34 feet and 36 feet on Fanwood Avenue and Marita Street, respectively. Observations done on this location show an 85th percentile speed of 27 mph which is 2 mph above the posted speed limit of 25 mph.Vehicular traffic flow is light with around 1500 to 2000 vehicles per day. School buses, pedestrians, and bicyclists were also observed in this intersection. Using the Austrian design guide and AASHTO standards, the intersection is evaluated to determine the viability of a roundabout in this location. The results are presented in Table 2.

Table 2 shows that only two out of the nine appropriate locations' guidelines are met. The first deals with the four-way stop control and the second, the high number of left turn movements in this intersection. The number of accidents is an important consideration which does not seem to meet the guideline.

Three of the four inappropriate locations' guidelines show that the intersection is not an inappropriate location. However, the condition that makes it inappropriate deals with one of the most important considerations, which is space. The potential problematic characteristics identified in the remaining four items require additional observations. The presence of numerous pedestrians and bikes, and presence of numerous disabled and blind users require special attention and detailed observations.

Table 2.Location Evaluations for a Roundabout

Appropriate Locations		
Item #	**Guidelines(NCHRP 264, 42)**	**Study Site**
1	High accident, especially related to left-turn or right-turn movements	No reported accident in this intersection
2	Four-way stop intersections	Four way stop intersection
3	Locations with traffic signal is not warranted	Traffic signal is not warranted based on observed traffic flow
4	Intersections with high delays	Intersection currently operates at LOS A
5	Intersections with more than 4 legs	4-leg intersection
6	Intersections with high left-turn flows	AM peak hour: NB left is 16% and WB left is 24% of total approach volume and PM peak hour: NB left is 51% , SB left 28% and EB left is 21% of total approach volume
7	Intersections with changing traffic patterns	No changing traffic patterns
8	Signalized intersections with restricted storage capacity	Not signalized
9	To replace a pair of closely spaced intersections	Will not replace closely spaced intersections
Inappropriate Locations		
Item #	**Guidelines (NCHRP 264, 42)**	**Study Site**
1	Locations with insufficient space	Approach width is 34 ft on Fanwood Ave. and 36 ft on Marita St.
2	Locations with high grades/slope	Flat location (Grade ~ 0)
3	Locations with heavy flows on the major-road and low flows on the minor-road	Low flows on both roads
4	Locations within a coordinated signal network	Not within a coordinated signal network
5*	Presence of numerous bicycles or pedestrians	Substantialvolumes of pedestrians and bicyclists were observed (needs additional observation);
6*	Presence of numerous disabled and blind users	None observed (may need additional observations for an extended period)
7*	Large proportion of heavy vehicles	Low volume of school buses was observed
8*	Presence of fire station	No fire station nearby
9*	Rail crossing	No rail crossing
Note: *These conditions can be appropriated with special attention regarding design and operational aspects.		

One important factor of installing a roundabout is space. From the existing conditions of the study site, a mini-roundabout would be the type of roundabout that would be viable in this location. Since AASHTO standards requires a minimum diameter of 45 feet on a mini-roundabout the minimum diameter could not be attained without encroaching on the right of way for pedestrian walkways as shown on Figure 2. Another consideration is the design vehicle. A conventional school bus with 65 passengers has a turning radius of 38.6 feet while a large school bus with 84 passengers has a turning radius of 39.1 feet. Conventional buses were noted during the data collection which has a turning radius of almost the size of a min-roundabout. Implementing roundabouts at inappropriate locations, such as the study site, can increase unnecessary delays, costs, and accidents.

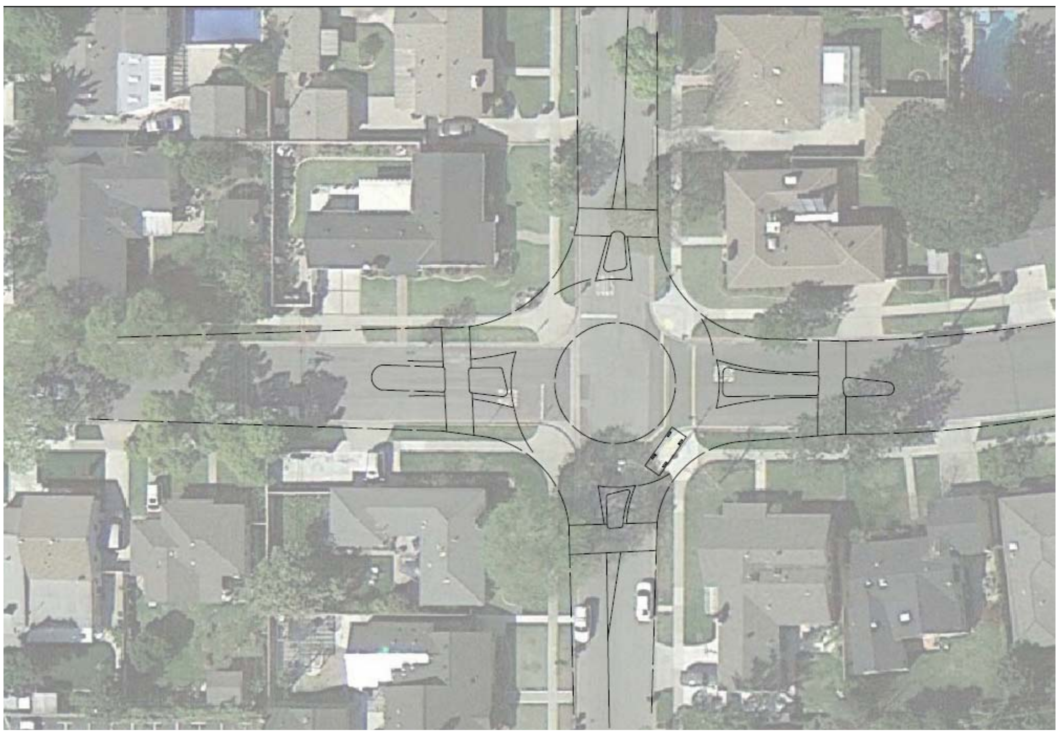

Figure 2.Schematic diagram of a roundabout in the study site.

Speed seems to be a factor missing in the design guideline and may be considered an important decision criterion for the viability assessment of a roundabout near a school zone. As previously mentioned, the 85th percentile speed is 27 mph which is 2 mph more than the speed limit of 25 mph. In a zone with significant presence of school children and young bicyclists, a slight increase in the posted speed limit may create problems in the future. A roundabout in this intersection would force vehicles to slow down because of its curved and narrow entry lane. In this location, a mini-roundabout may be a suitable traffic calming measure.

The degree of conflicting interactions between passenger vehicles, buses, pedestrians, and bicyclists may also be a decision criterion. A roundabout directs traffic in one direction only thus eliminating vehicle to vehicle conflicts on left turning movements which are high in the study site. A pedestrian refuge makes it less complex for a pedestrian to cross and minimizes conflicts between pedestrians and vehicles.

One of the issues that could potentially affect implementation of roundabouts near a school zone is the public's unfamiliarity with roundabout which often leads to misperception. Educating the public and involving the community, especially the affected school, early in the process are imperative for a successful implementation of a roundabout.

Conclusion

This paper provides a framework and introduces additional factors for assessing the viability of a roundabout as an intersection control near a school zone. Key factors include the volumes of left and right turn movements, the number accidents related to left and right turn movements, the size of the intersection, and the operational characteristics of the intersection. Speed of vehicles in the study site is an important factor to consider as well as the degree and complexity of vehicle-pedestrian-bicycle interactions.

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