INTERSECTION DESIGN AS A ROUNDABOUT

Towhidul Islam*[1], S. M. R. Rahman[2] and Md Saiful Amin[3]

[1]*Lecturer, Port City International University, Bangladesh, e-mail: islam.towhidul.021@gmail.com*
[2]*Lecturer, Port City International University, Bangladesh, e-mail: rahat.austce@gmail.com*
[3]*Lecturer, Port City International University, Bangladesh, e-mail: saifulamin.buet@gmail.com*

***Corresponding Author**

ABSTRACT

The vehicle ownership is increasing daily with the population boom of Bangladesh. The traffic scenario is also moving along with this alternation. In the swiftly evolving global of transportation engineering, the roundabout is quickly gaining recognition as an alternative to a signalized intersection. The number of roundabouts in the U.S. has risen to kind of 3,700 during the last 20 years. Due to common use, there has been a need for detailed study to better apprehend the characteristics of roundabouts and its performance on transportation networks. Sustainability-related benifits of roundabouts are of particular interest. Most of the countries widely adopted roundabouts as an alternative of signalized intersection wherein applicable due to its convenience for operation with lesser conflict points. Roundabouts are designed to control traffic flow smartly at the intersections without using the stop signs or traffic signals. Roundabouts are received more attention increasingly due to the advantages of accident-decreasing and efficiency-increasing. The capacity of a roundabout is the key parameter to check the performance of the roundabout. The capacity of the roadway roundabout depends on the flow at different legs approaching the roundabout. The performance of roundabouts in terms of delays, queues and saturation index typically depends on entry capacity. We surveyed several peak hours at Tiger-Pass intersection (which is one of the busiest intersections of Chittagong city) to design this signalized intersection as roundabout. This paper evaluates a signalized intersection as an alternative geometric design to a multi-lane roundabout. This paper also discusses briefly the possible benefits after the conversion of an intersection into a roundabout. This study will give us the benefit to find the intersections where authority should build more roundabouts.

Keywords: *Intersection, Roundabout, Entry capacity.*

1. INTRODUCTION

According to the Bangladesh Bureau of Statistics (2014), Chittagong has a population of more than 2.5 million and it is developing gradually over time. Rapid urbanization increases the number of vehicles on the road section extensively in our country. The road traffic in the Tiger-pass intersection is solely heterogeneous containing vehicles. In the road transport network, the traffic junctions is considered to be the most complex and the most challenging points where several traffic streams intersect. If traffic junctions with circular flow of traffic (the so-called roundabouts) are compared with traditional at-grade urban road junctions with or without traffic lights, it may easily be decided that properly dimensioned and designed roundabouts greatly increase the level of efficiency. Moreover, during their total lifespan, they reduce the vehicle waiting time at road junctions, the total time of travel, fuel consumption and the length of travel, while also lightening harmful impacts on the environment due to the release of exhausted gases. In addition from an economic standpoint, such intersections bring plentiful benefits such as lower cost of construction, lower land purchase costs and installation of equipment (illuminated traffic signs in particular), less costly maintenance, and lower losses generated by congestions due to excessive traffic load. Besides, the level of traffic safety grows significantly when roundabout-type intersections are used.

"A roundabout is a type of circular intersection or junction in which road traffic is permitted to flow in one direction around a central island, and priority is typically given to traffic already in junction" (Robinson, 2000). The main types of roundabouts are Grade Separated, Mini, Normal, Compact, Signalized, and Double Roundabouts (the last being a combination of Mini, Compactor Normal Roundabouts).

The traffic capacity of the roundabout depends on several factors which include the geometry of the roundabout, the diversity of vehicles, and driver behavior. Usually, the priority of movement at roundabouts is for the circulating flows; therefore the approaching traffic must wait and look for a gap in the circulating flow. There is a need to evaluate roundabouts with different characteristics, such as intersection demand level, traffic demand patterns (e.g., turning movement ratios), and geometric characteristics (e.g., entrance angle, exit angle), and pedestrian volumes.

The aim of this study is to improve the existing condition of the "Tigerpass intersection" of Chittagong city and to find out the dimensions to convert this rotary intersection to a roundabout. The study tends to find out the solution for all busiest intersections like Tigerpass intersections. Researchers, Planners, Policymakers will get ideas about the congestions and solutions along with one of the most important intersections of Bangladesh. The study will also help transport engineers as there will be explanations of possible all benefits.

The history of roundabout and in particular its evolution from the old traffic circles and rotaries built in the first half of the 20th century. Dahl et al. (2012) found that the rate of decreasing in the observed capacity with an increase in the circulating flow was lower at the roundabouts.

One study showed that non-signalized roundabouts aresafer than traditional intersections (Turner, 2011). Perdomo et al. (2014) scrutinized factors affecting pedestrian crossing behavior and found that the existance of pedestrian crossings, crossings location, vehicular speed, pedestrian islands, signage, number of traffic lanes and traffic volumes all affect the pedestrians' willingness to cross at roundabouts. Hels et al. (2007) investigated roundabouts are familier to result in fewer traffic accidents than traditional intersections. However, this is to a lesser degree true for bicycles than for vehicles. One of the first studies on vehicle safety at roundabouts in North America was performed by Montonen, who conducted a crash study using data from roundabouts both on national and municipal roads. The results showed that on national and municipal roads with roundabouts the accident rate was 26% and 23% while the injury accident rate was 4% and 4% respectively (Montonen, 2008). Many studies mainly focused on vehicle safety at roundabouts which all conclude that when intersections are converted to roundabouts the safety benefits are tangible (Jensen, 2013). One simulation study in 2001 modeled 25 signalized intersections in Burlington, Vermont as roundabouts using the software SIDRA (Redington, 2001). The author estimated a 250,000 yearly reduction in fuel use, when signalized intersections were converted to roundabouts; which amounts to 61,000 tons of CO_2 saved per year. Roundabout features such as signage and advance warning play an important role in determining driver performance when navigating the roundabout. It has been observed that single-lane roundabouts perform better safety-wise compared to multilane roundabouts (Wankogere, 2014). Roundabouts are linked with a 30% to 50% reduction in the number of injury accidents. Fatal accidents are reduced by 50% to 70%. Effects on property damage accidents are highly uncertain, but in three-leg intersections, an increase often will occur (Elvik, 2003).

2. METHODOLOGY

2.1 Overview

The first phase of this study involved the selection of a suitable location. We selected the Tigerpass intersection for its convenience in collecting geographic data and the intersection plays a significant role in Chittagong city. Throughout the second phase, geographic and vehicular data of the intersection were collected. In the third phase, after data collection the data will be analyzed to determine the capacity of each entry lane, entry flow rate, circulating and existing flow rate to calculate central island, splitter island, and sight distance. As a final product of this study, we will convert the existing intersection to roundabout and will present its possible benefits for sustainable transportation.

2.2 Survey & Data Collection

2.2.1 Geographic Data Collection

As per our selected area, we collected its geographic data or features by a total station. The dimensions of existing roadway width, splitter islands, footpaths, and current land-use patterns are considered while conducting the survey Finally, we made an Existing Dimension Drawing of Tigerpass Intersection (selected study area) to make all of its features visible which will help to a workforce of the whole procedure. The Dimension Drawing is given below.

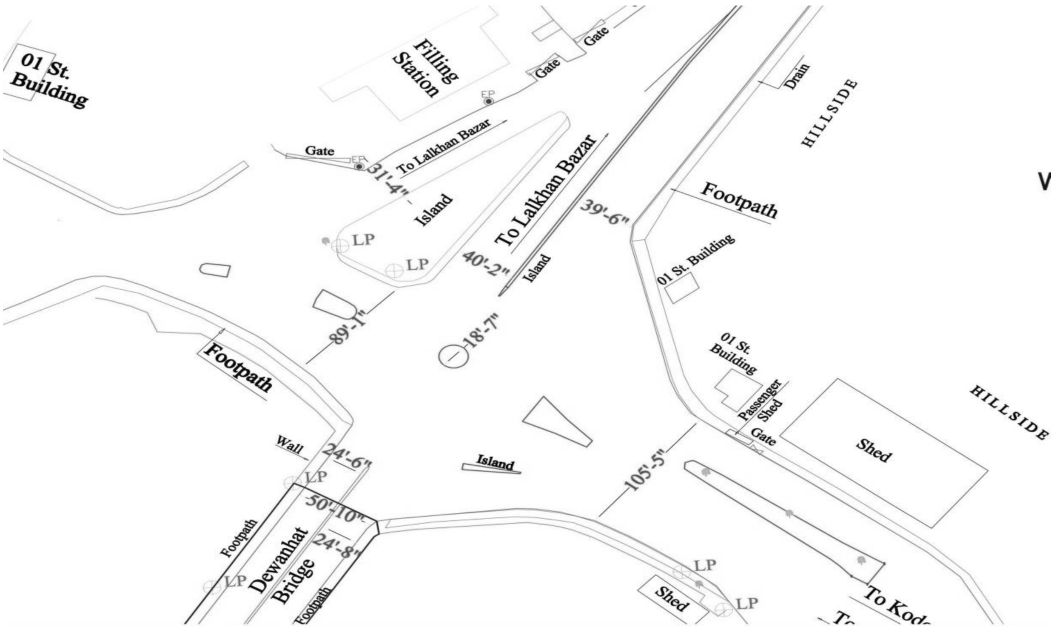

Figure 1: Dimension Drawing of Tigerpass Intersection

2.2.2 Vehicular Data Collection

The vehicular data has been collected using a video camera. For a particular amount of time, a video has been captured and data is later collected by rewinding. In addition to traffic volume, it is possible to obtain other traffic parameters from the captured video. It is possible to cross-check data and ensures quality. In this study, traffic volume was calculated by manual counting for the one-hour duration on a typical peak day. Peak 1-hour traffic data was collected along all directions for every hour at that time. Finally, add them together to show the volume with percentage details in the result and analysis section.

The date of data collection was 12th June 2018 and the time was from 5.00 pm to 6.00 pm. We set several sets of cameras at suitable points of the intersection. After filming one hour, we had found the overall composition of different vehicle categories, showed in Table 1. From the video clip, we had also determined flows in veh/hr. Table-1 also reveals that there are 81% of motorized and 9% of nonmotorized vehicles.

Table 1**-** Overall Composition of different vehicle categories

Serial No.	**Vehicle Category**	**Flow (veh/hr)**	**Composition (%)**
1	Cycle	121	3
2	Rickshaw	242	6
3	Motor Bike	616	16
4	CNG	826	22
5	Tempu	134	4
6	Human Howler	259	7
7	Car	1003	26
8	Mini Bus	102	3
9	Bus	287	8
10	Mini Truck	86	2
11	Large Truck	73	2
12	Pick up	40	1
Total		3790	

InTable-2, distribution from each entry lane to other lanes as well as shown. It has been ovserbed that there is no flow from Ambagan to Kodomtoli and Ambagan to Dewanhat due to the restriction in entry. From Figure-1 it can be seen that there is no restriction from Ambagan to Lalkhan Bazar as there is a connecting lane.

Table 2**-** Vehicle per hour Distribution from Four Entry Lane to Other Lanes

From	**To**	**Flow (Veh./hr)**	**Total Flow (Veh./hr)**
Lalkhan Bazar	Dewanhat	534	1275
	Kodomtoli	395	
	Ambagan	346	
Kodomtoli	Ambagan	346	976
	Dewanhat	316	
	Lalkhan Bazar	314	
Dewanhat	Lalkhan Bazar	585	1265
	Ambagan	226	
	Kodomtoli	454	
Ambagan	Lalkhan Bazar	274	274
	Kodomtoli	0	
	Dewanhat	0	

3. DATA ANALYSIS AND INTERPRETATION

3.1 Assembling Traffic Data

This includes obtaining the data relating to periods that are relevant for analysis and which may vary depending on the nature of the side, converting typical crossroad turning movements into roundabout entry and circulating flows and converting heavy commercial vehicle flows to passenger car units. Figure-3 shows a typical turning movement diagram by collected survey data, and Figure-4 shows the typical turning movement diagram converted to roundabout flows. And maximum circulating capacity of 1353 veh/hr has been found at the Ambagan approach and estimated by adding the entry flows which were contributing to the circulating flow (New Market to Lalkhan Bazar= 314 veh/hr, Dewanhat to Lalkhan Bazar= 585 veh/hr, and Dewanhat to New Market= 454 veh/hr).

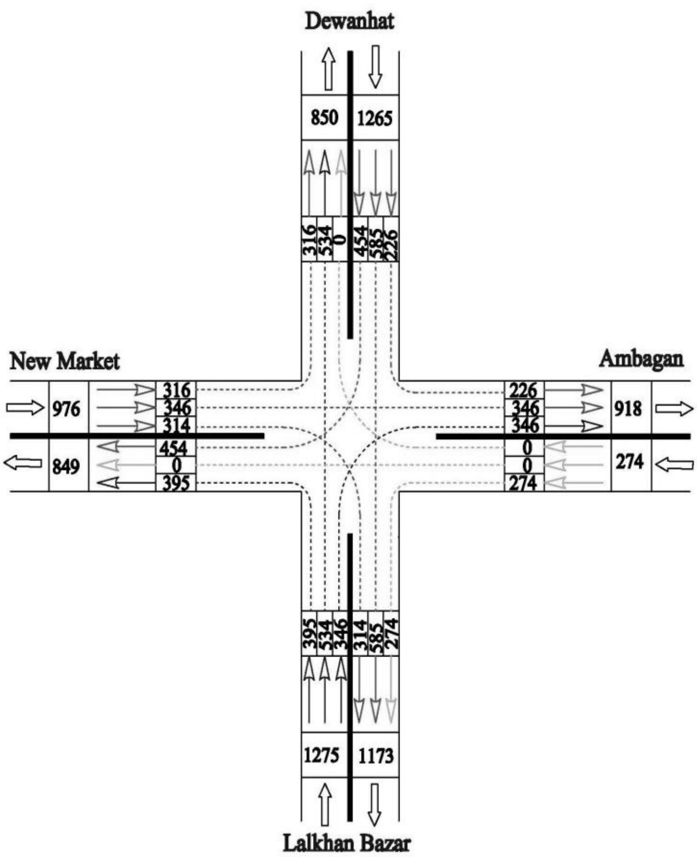

Figure 3: Typical turning movement diagram.

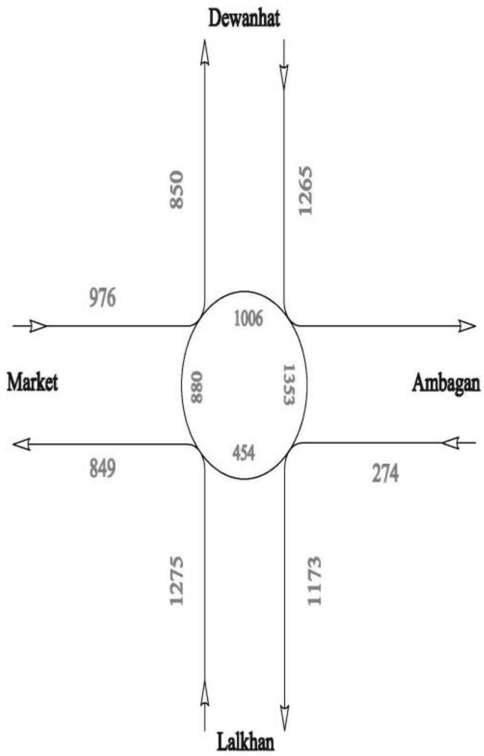

Figure 4: Typical turning movement diagram showing entry and circulating flow.

3.2 Determination of the Number of Entry and Circulating Lanes

The number of entry lanes will generally be determined from the number of lanes on the approach carriageway. However, an entry may be widened to provide additional lanes, particularly where turning movements are heavy. It is usually assumed that the number of circulating lanes will equal the number of entry lanes at any approach. However, a single lane approach may be provided at a multi-lane roundabout. According to the roundabout design guideline: state of maryland department of transportatbn state highway administration, Figure-5(a) is a plot of entry flows against circulating flows and provides a quick means of assessing the acceptability of a single or multi-lane roundabout. From that figure, we get the required number of two entries and circulating lanes for the Tigerpass intersection. Figure-5(b) is a plot of entry flows against circulating flows it has been found that the value of the inscribed diameter of the roundabout is a minimum 40 m.

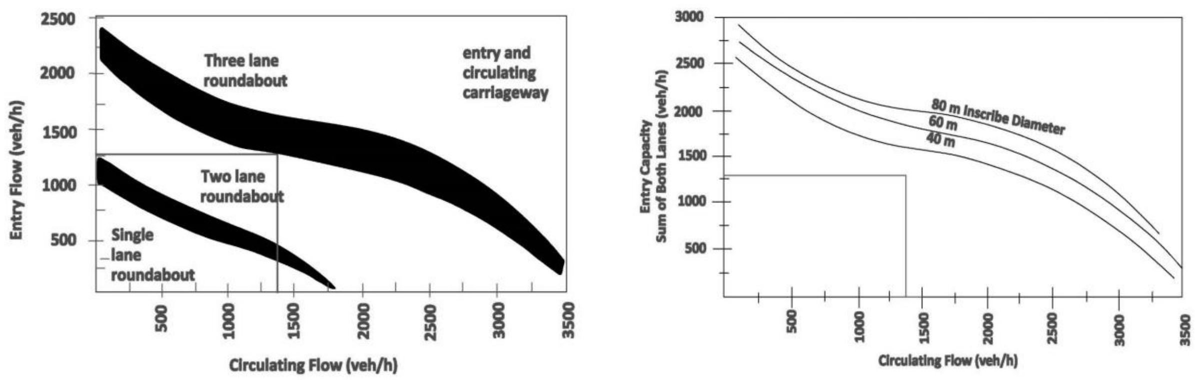

Figure 5: Diagram of Entry flow vs Circulating flow: (a) to determine the number of entry and circulating lane; (b) to determine the inscribed diameter of the roundabout.

3.3 Determination of the Dimension of Central Island

As the inscribed diameter has been selected 45m (150ft), from Table: 3 (Robinson, 2000, p. 150), Minimum Circulatory Lane Width is 9.8m (32ft) and Central Island standard diameter is 25.4m (86ft).

Table 3: Minimum circulatory lane widths for two-lane roundabouts (Robinson, 2000, p. 150)

Inscribed Circle Diameter	Minimum Circulatory Lane Width*	Central Island Diameter
45 m (150 ft)	9.8 m (32 ft)	25.4 m (86 ft)
50 m (160 ft)	9.3 m (31 ft)	31.4 m (103 ft)
55 m (180 ft)	9.1 m (30 ft)	36.8 m (120 ft)
60 m (200 ft)	9.1 m (30 ft)	41.8 m (140 ft)
65 m (215 ft)	8.7 m (29 ft)	47.6 m (157 ft)
70 m (230 ft)	8.7 m (29 ft)	52. 6 m (172 ft)

*Based on 1994 AASHTO Table III-20, Case III(A) (4). Assumes infrequent semi-trailer use (typically less than 5% of total traffic). Refer to AASHTOfor case with higher truck percentage.

3.4 Splitter islands

Splitter islands have been provided on all roundabouts, except those with very small diameters at which the splitter island would obstruct the visibility of the central island. Their purpose is to provide shelter for pedestrians (including wheelchairs, bicycles, and baby strollers), assist in controlling speeds, guide traffic into the roundabout, physically separate entering and exiting traffic streams, and deter wrong-way movements. Additionally, splitter islands can be used as a place for mounting signs. Figure 6 (Robinson, 2000, p. 157) shows the minimum dimensions for a splitter island at a multi-lane roundabout.

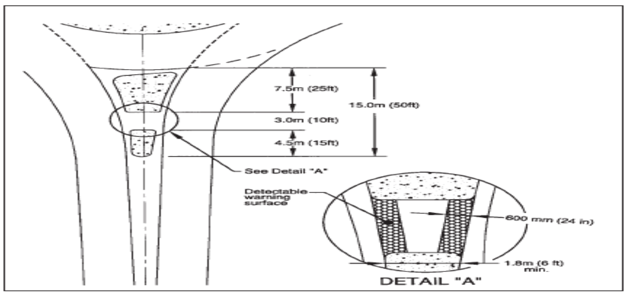

Figure 6: Standard dimensions of minimum splitter island (Robinson, 2000, p. 157).

3.5 Final Layout

After following all of the standards, we have converted Tigerpass intersection into the roundabout as the following figure by keeping the connecting lane from Ambagan to Lalkhn Bazar. And It has been computed that there is no need for land acquisition.

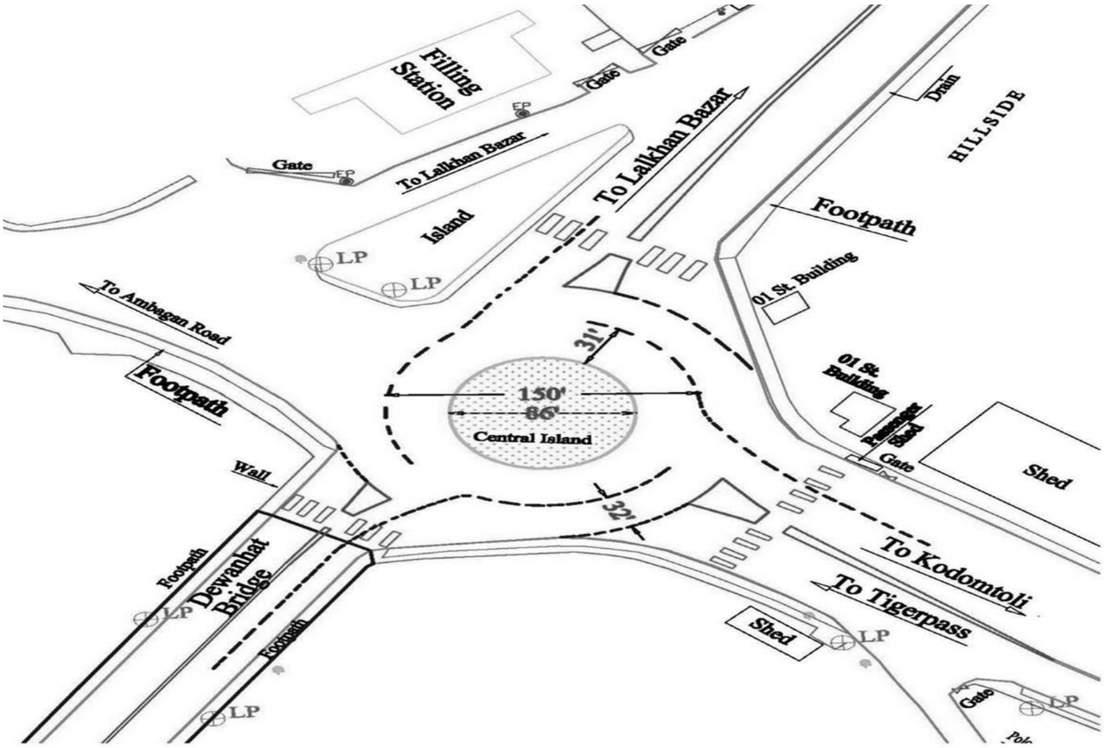

Figure 7: Final dimensional layout of Tigerpass roundabout as per standard design.

4. CONCLUSIONS

Roundabout is an efficient feature in the roadway system for vehicles crossing the intersections smoothly without making any congestion and without halting vehicles for a quite amount of time. Many intersections are now adopting to have a roundabout for traffic management and control. This study was intended to design a roundabout in Tigerpass intersection based on current entry flow. Before design, all existing geometric and vehicular data has been collected with precision and perfection. For the highest of the four entry flow (1275 Veh. /hr), the roundabout has been designed to have two-lane with a minimum inscribed circle of 40m. For the final design, a two-lane roundabout having an inscribed circle of 45m (150ft) diameter has been selected. Thus the circulatory lane width and central island diameter have been found 9.8m (32ft) and 25.4m (86ft) respectively.

ACKNOWLEDGMENTS

Undergrad students of Port City International University Md Shami-Ul-Alam Shamim, Saykat Chowdhury, Md Saimon, Md. Shariful Islam, Utpola Chakma, and Md Nur Alam helped in this research during the survey.

REFERENCES

Bangladesh Bureau of Statistics. (2014). Bangladesh population and housing census 2011. National Report Volume 2. Union Statistics March 2014.

Dahl, J., & Lee, C. (2012). Empirical estimation of capacity for roundabouts using adjusted gap-acceptance parameters for trucks. *Transportation research record*, *2312*(1), 34-45.

Elvik, R. (2003). Effects on road safety of converting intersections to roundabouts: review of evidence from non-US studies. *Transportation Research Record*, *1847*(1), 1-10.

Hels, T., & Orozova-Bekkevold, I. (2007). The effect of roundabout design features on cyclist accident rate. *Accident Analysis & Prevention*, *39*(2), 300-307.

Jensen, S. U. (2013). Safety effects of converting intersections to roundabouts. *Transportation research record*, *2389*(1), 22-29.

Montonen, S. (2008). The safety of roundabouts. *Tehallinnon Selvityksia, Finnra Reports*, *3201089*(8/2008).

Perdomo, M., Rezaei, A., Patterson, Z., Saunier, N., & Miranda-Moreno, L. F. (2014). Pedestrian preferences with respect to roundabouts—A video-based stated preference survey. *Accident Analysis & Prevention*, *70*, 84-91.

Redington, T. (2001). Modern Roundabouts, Global Warming, And Emissions Reductions: Status of Research, and Opportunities for North America. In *Publication of: Canadian Transportation Research Forum* (No. Volume 2).

Robinson, B. W. (2000). *Roundabouts: an informational guide. US Department of Transportation, Federal Highway Administration*. Report FWHA-RD-00-067, Washington.

Turner, D. (2011). Roundabouts: a literature review.

Wankogere, E. J. (2014). Virtual Analysis and Evaluation of Roundabout Safety and Operational Features.