EVALUATION OF THE CAPACITY OF A ROUNDABOUT IN JESSORE MUNICIPALITY BY USING SIDRA

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ABSTRACT

The aim of this study is to evalute the capacity, degree of saturation, Level of Service (LOS) of the roundabout and identifying the causes behind accident as well as congestion in the Jessore Municipality, Bangladesh. Now a days, the population growth is increasing rapidly. As a result number of vehicles are also increased. So, to ensure safety, it is very necessary to evalute the capacity of roundabout. In this study, the name of the roundabout is Monihaar. The capacity analysis is conducted by using SIDRA. In this software, two types of data (geometric data and traffic volume data) were collected from the roundabout named Monihaar for evaluation of capacity. The geometric data was collected by using tape and the traffic data (vehicle characteristic and pedestrain volume) was collected at peak periods for one hour with their movement of direction on a working day of sunny weather by using a video camera. The results from the analysis indicate that the degree of saturation (v/c) of the roundabout is greater than 0.85. This 0.85 value is recommended by analysis procedure of some model countries such as Australia, Germany, United Kingdom and U.S.A whose roundabouts are designed to operate at no more than 85 percent of their estimated capacity. The LOS is found 'F' for the roundabout. Effective capacity verses geometric parameter relationship have been developed in order to find out the causes of their over saturation (v/c ration greater than 0.85). The result indicates that number of entry lane, high traffic flow and disobeying the traffic rules are the major causes of their over- saturation.

Keywords: *Roundabout, degree of saturation, capacity, level of service, SIDRA.*

1. INTRODUCTION

The concept of a circular intersection dates back to 1903, when a "gyratory" operation for traffic control was adopted by the French at Place de l'Etoile (now Place Charles de Gaulle). During the early half of the 20th century, numerous gyratory systems (traffic circles or rotaries) were built throughout the United States. Unfortunately, both the design and traffic conditions at that time led to severe problems with gyratory systems. The first traffic circle concept was inroduced in 1877 by French architect Eugene Henard (De Argo, 1992). In 1960's British adopted a mandatory yield at entry rule was a very dramatic and important change in the success and use of modern roundabouts. The concept of modern roundabouts was introduced in 1963 when the British government employed the off-side rule based on which the priority was given to the circulating vehicles on the traffic circles (Sisiopiku & Oh, 2001). For more than three decades modern roundabouts have been used successfully throughout the world as a junction control device (Akcelik, 1997). Roundabout capacity evaluation is very important as it is related to delay, level of service, accident, operation cost and environmental issues.

SIDRA is a software package used for intersection (junction) and network capacity, level of service and performance analysis by traffic design, operations and planning professionals. Sidra Intersection is a micro-analytical traffic evaluation tool that employs lane-by-lane and vehicle drive cycle models. It can be used to compare alternative treatments of individual intersections and networks of intersections involving signalized intersections (fixed-time and actuated), roundabouts (unsignalized), roundabouts with metering signals, fully signalized roundabouts, two-way stop and give-way (yield) sign control, all-way (4-way and 3-way) stop sign control, merging, single-point urban interchanges, traditional diamond and diverging diamond interchanges, basic freeway segments, signalized and unsignalized midblock crossings for pedestrians, and merging analysis.

Now a days, increasing traffic volume and congestion are two major problems in developing countries like Bangladesh severely seen at junctions at peak hours in the morning and evening. But, it is very difficult to control these traffic problems by traffic police specially at peak periods. These problems occur due to huge

population and current infrastructure of the roads. Poor road planning and non –standard geometric conditions have significant effect on roundabout capacity and traffic condition (May, 1990).

The roundabout named Monihaar in Jessore municipality has served more than thirty-five years. A little attention has been paid to the design and capacity evaluation of the roundabouts. Therefore, road authorities and other concerned bodies need to conduct a comprehensive capacity and delay study of every roundabout so that they can come up the solutions for the traffic congestions, traffic delay, level of services, accident and operating costs.

2. METHODOLOGY

To achieve the aim of this study, roundabout's geometry and traffic data (peak hour) were required. The geometric data should be measured as both capacity and safety improvement depends on geometric design. It is the major concern for road design. The roundabout was chosen based on the target population of it in terms of size and vehicle numbers. As much as possible, the traffic data should indicate the existing peak hour traffic conditions.

2.1 Geometric Data Collection

For capacity and delay analysis the geometric data collected include: island diameter, number of circulatory lane, circulatory roadway width, inscribed circular diameter, average lane width at entry, entry lane number, and entry angle and entry radius. These data were measured with a tape and by using the concept of geometry.

2.2 Traffic Data Collection

According to SIDRA software, traffic movements of vehicles and their volume classification are important parameters for capacity analysis. High pedestrian volume also has a significant effect on capacity. Thus traffic and pedestrian volume data were collected at peak periods for a period of one hour on working day of sunny weather with their direction of movements. For each separated lane, traffic volume was collected. It was done by using a video camera.

3. RESULTS AND DISCUSSIONS

According to the methodology, the geometric data collected include: number of circulatory lane, island diameter, circulatory roadway width, inscribed circle diameter, entry lane number and average lane width at entry. These data were measured with tape. The collected geometric data are summarized in Table 1.

Table 1 : Summary of Intersection Geometry

SI No.	Roundabount name	No. of Legs	Number of Circulatory Lane	Island diameter (m)	Circulatory Road width (m)	Inscribed Circle Diameter (m)
01.	Monihaar	3	2	4	15	34

From the summarized geometric data it is seen that the island diameter of the roundabout is 4 m. When circulatory width is added, the range becomes 34 m, which can be categorized from mini-roundabouts to urban multilane roundabouts according to Roundabout Information Guide (FHWA, 2000).

When the central island diameter increases the circulatory lane numbers also increases. The roundabout has 2 circulatory lanes. So it is possible to use the data for the analysis using SIDRA software. The island diameter linearity increases with the approaches leg numbers.

Number of entry lanes and average lane width are the two important parameters for the analysis. The above parameters are measured from the roundabout approach site very carefully.

In Table 2, it is found that the approach legs have 2 lanes and the average lane width ranges between 5 m to 8 m. Entry angle and entry radius are measured by using the concept of geometry.

Table 2: Summary of Legs or Approaches Geometry

SI No.	Roundabout name	Leg name	Number of Entry Lane	Average Lane Width (m)	Entry Angle	Entry Radius (m)
01.	Monihaar	Muruli	2	7.5	180	-------
		Khajura	2	7.0	60	2
		R.N.Road	2	5.1	33	2

The movement of traffic vehicle and their volume are important parameters in capacity analysis according to SIDRA software. Traffic volume was collected for each separated lanes. The volume of each type of vehicles is summarized in Table 3.

Table 3: Vehicle Volume at Intersections at Peak Hour

Roundabout Name	Heavy Vehicles			Light Vehicles									Total Traffic (PCU)	% of Heavy Vehicle
	Bus	Truck	Total	Car	Pick Up	Micro Bus	Jeep	Easy Bike	Van & Rickshaw	Motor Cycle	Bicycle	Total		
Monihaar	19	128	147	50	33	26	37	1619	1491	1122	988	5366	6119	7

The percentage of heavy vehicles at the intersection is 7% as shown in Table 3.3. Light vehicle travels in higher amount than heavy vehicles at the intersection.
Figure 1 and 2 represents the maximum and the minimum numbers of vehicle and pedestrian traffic at surveyed junction.

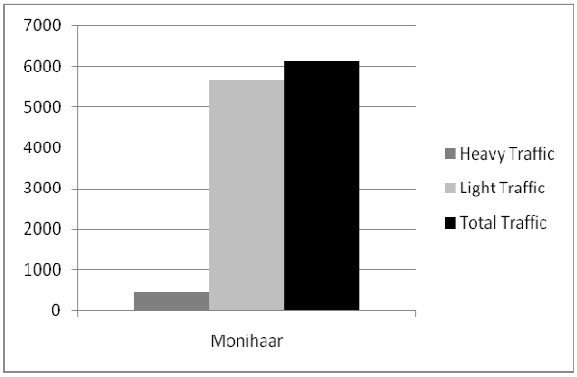

Figure 1: Maximum Peak Hour Vehicles Volume Distribution on Intersection

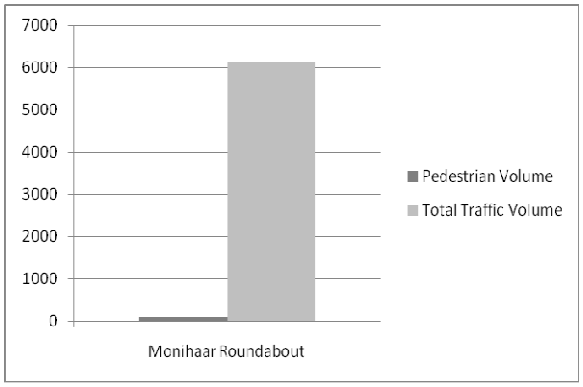

Figure 2: Pedestrian Vs Vehicles Volume at Junctions

The traffic movement on the approaches or legs and the traffic volume in passenger car unit are also necessary for the analysis. The passenger car equivalent factors are used to convert the number of vehicles in passenger car unit. The PCU values suggested in the Geometric design of Highways (MoC, 2001) are given in Table 4.

Table 4: PCU of Different Types of Vehicles in Bangladesh (MoC, 2001)

Vehicle Categories	PCU
Passenger Car	1.00
Light Goods Vehicle	1.00
Bus	3.00
Truck	3.00
Rickshaw/Van	2.00
Bicycle	0.50
Auto Rickshaw/Motorcycle	0.75

Table 5 represents entry traffic flow on roundabout approach legs. It is observed in the table that there is unbalanced traffic flow at legs or approaches at the roundabout. However, it is not recommended to design roundabout as traffic control devices when the traffic flow is unbalanced at different legs (FHWA, 2000).

Table 5: Summarized Entry Traffic Flow on Roundabout Approach Legs

SI No.	Roundabout Name	Leg Name	Entry Traffic On Legs (PCU)	Percentage of Traffic Share
01.	Monihaar	Muruli	1954	32
		Khajura	1869	31
		R.N.Road	2296	38

As mentioned earlier that SIDRA software is used to get the ultimate result of this study. By using SIDRA software, following results are obtained. Table 6 indicates the summarized capacity analysis results for the intersection. The performance is measured with v/c ratio or degree of saturation and the level of service also applied according to US HCM.

Table 6: Summarized Capacity Analysis Results on the Intersections

SI No.	Roundabout Name	Total Vehicle Flow (PCU)	Effective Capacity (Vehicle/h)	Degree of Saturation (V/C)	Average Delay (Sec)	LOS
01.	Monihaar	6119	3625	1.784	276.5	F

From Table 6, it is seen that the roundabout at Monihaar junction has very low effective capacity compared to the entry flow. Total vehicle flow is almost twice of effective capacity. The level of service is F.
Actually the intersection performance or capacity depends on the approaches or legs performance and always their v/c ratio is taken from the maximum v/c ratio of the legs. Figure 3 shows the peak flow or entry flow verses effective capacity.

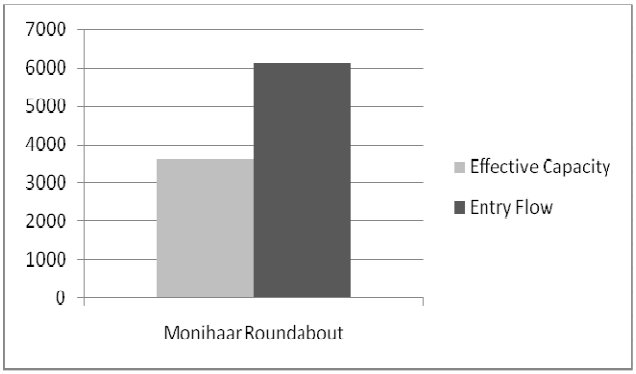

Figure 3: Graphical Representation of Peak Entry Flow Verses Effective Capacity

For the roundabout named Monihaar, lane by lane capacity has been carried out and capacity at legs, degree of saturation and opposing flow has been summarized as shown in Table 7.

Table 7: Summarized Capacity Analysis Results on the Approaches or Legs

SI No.	Roundabout Name	Leg Name	Entry Traffic On Legs (PCU)	Opposing Circulatory Flow	Degree of Saturation (v/c)	Capacity at Legs	v/c> 0.85
01.	Monihaar	Muruli	1954	566	1.784	893	0.934
		Khajura	1869	1026	1.729	592	0.879
		R.N.Road	2296	632	1.356	810	0.506

Based on US HCM, it is easy to identify the legs which are in critical condition. It states that degree of saturation of legs greater than 0.85 are in critical condition. By observing the column, v/c >0.85 of Table 7 it is seen that two legs named Muruli and Khajura of the roundabout are in critical condition.

By observing entry traffic at legs, traffic volume of circulatory flow, circulatory lane numbers and degree of saturation, it is possible to identify the problems of the approaches. It is concluded that the entry lane number is not adequate of the above mentioned two critical legs of the roundabout.

4. CONCLUSIONS

The result of the capacity analysis of the roundabout at Monihaar indicates that the roundabout is in serious condition and over saturated. Traffic police are failing to perform their duty specially at peak period. From the

field observation it is seen that drivers are not maintaining traffic rules and regulations. Overtaking tendency is the main cause behind accident and congestion. Besides, sometimes driver stop their vehicle at any place of the road without giving signal. That is the most dangerous cause behind accident. The study showed that the major problems are related to the number of entry lanes, high traffic flow and unbalanced traffic on the approaches which in fact, not recommended on the roundabout. Again roundabout is built when the traffic flow was lower and future traffic volume extension was not considered. Even if modern roundabout driving rules are to be applied to Monihaar roundabout, some of the important geometric elements such as deflection, proper island splitters etc. don't exist. Deflection is the most important geometric element, which forces drivers to reduce their speed and to avoid collision between neighboring leg entering vehicles. The splitter islands on the roundabout approaches provide important cues to the driver as to the angle and radius of approach on entry to the roundabout. Also there is no divider to separate the lane. So the drivers frequently change the lane which is one of the causes of accident.

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