Performance Analysis of Round about Under heterogeneous traffic Condition

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Abstract – This research paper examines the performance of a roundabout in a busy area of Lucknow city. The city has a population of around 3.1 million people, and this roundabout is located near commercial areas and schools. The roundabout is un-signalized. The main objective of this study is to analyze how well this Roundabout are functioning and provide insights for future improvements in the Lucknow District region.

To gather data, traffic observations were conducted on weekdays during peak periods from 5:30 pm to 6:30 pm. Video recordings were used for this purpose, and the traffic was classified into three categories: light vehicles, heavy vehicles, and bicycles. The analysis of the operational performance of both intersections was carried out using the SIDRA INTERSECTION software.

The results indicate that the roundabout is operating near their maximum capacities. However, the Level of Service (LOS) provided by this Roundabout is not sufficient for the high volume of traffic they receive. The volume to capacity (v/c) ratio analysis shows that the Dr. Tandon Road in an unstable state

In conclusion, the findings suggest that improvements are needed the roundabout

***Key Words*:** SIDRA INTERSECTION, Capacity, Level of service, Roundabout

1.INTRODUCTION

For my research work on designing and analyzing the performance of a roundabout, I used the SIDRA INTERSECTION software. The main focus of my study is to understand how roundabouts can be effectively designed and how they perform in terms of traffic flow and efficiency. By utilizing the SIDRA INTERSECTION software, I will be able to simulate and evaluate different design configurations of roundabouts, considering factors such as traffic volume, vehicle types, and geometric measurements. This research aims to provide valuable insights into the design principles and performance indicators of roundabouts, which can contribute to improving transportation planning and traffic management strategies.

Roundabouts are specialized forms of at-grade intersections where vehicles from converging arms are directed to move in a single direction around a central island in an orderly and organized manner, before exiting towards their desired direction [1]. While roundabouts are prevalent in Europe and Australia, they have also gained acceptance in countries like India and others. Roundabouts serve as efficient alternatives to traffic lights at intersections with low traffic volume, offering reduced delays, improved handling of heavy left turns, decreased casualties, and slower traffic speeds. Additionally, roundabouts present advantages such as lower maintenance costs and landscaping opportunities within their central islands [2].

However, it is worth noting that the design of roundabouts often neglects crucial elements like swept path analysis, which is critical for intersection design in general, including roundabouts. Unfortunately, due to improper intersection and roundabout design, India has recorded an alarming average of 415 deaths per day according to the Ministry of Road Transport and Highways [3]. To achieve sustainable infrastructure goals that protect the environment and conserve resources, roundabouts can play a significant role by eliminating the need for energy and reducing accidents, ultimately leading to more efficient traffic flow compared to other intersection solutions such as traffic lights and all-way stop controls [4].

Previous studies have shown that both roundabouts and 3-4 leg intersections experience unstable operational performance at their maximum capacity, mainly due to heavy traffic volume influx into the roundabout [5]. Therefore, analyzing and calculating the junction capacity of roundabouts and conducting swept path analysis are crucial factors to consider. Various factors come into play, including traffic delays, operational costs, level of service, accident rates, and environmental impact [6]. As a result, roundabouts have increasingly replaced traditional intersections, and considerations such as alignment, swept path analysis, and sight distance play vital roles in the geometric design of roundabouts [7].

In a study by Abdul Awwal and Aarish Khan (2020), the performance of a roundabout and a 3-leg intersection in Aligarh city was analyzed using SIDRA INTERSECTION software. The findings revealed that both the maximum capacity and level of service (LOS) were not satisfactory for the high volume of traffic.

Additionally, the volume to capacity (V/C) ratio of both the intersection and roundabout was found to be unstable. Young-Joo Lee, Wonho Suh, et al. (2018) conducted an analysis of roundabout capacity using mathematical modeling and microscopic simulation with VISSIM. They found that the capacity of roundabouts is dependent on the gap acceptance model. The results based on simulation data and mathematical models indicated that the Highway Capacity Manual 2010 (HCM2010) underestimates the approach capacity for turnaround rates below 500 veh/hr to 800 veh/hr, depending on the minimum gap time. On the other hand, it overvalues the approach capacity for flow volumes greater than 700 to over 900 veh/hr, depending on the minimum allowable gap selected. The research team also overestimated the approach capacity for turnaround time.

Md Sameer Sohail et al. (2020) conducted an analysis on a 4-legged roundabout intersection in Hyderabad using the SIDRA INTERSECTION software. They found that the roundabout experiences high traffic volume during peak and off-peak hours, resulting in an unstable level of service (LOS) ranging from C to F at the arrival legs. Based on these findings, they suggested redesigning the roundabout, emphasizing the importance of considering geometric design and capacity in the process.

Šime Bezina et al. (2019) conducted a study to determine the impact of arrival axis rotation on roundabout design. By considering theoretical examples with different radii (Rv = 15, 17.5, and 20 m), they found that the maximum rotation angle value depends on the size of the radius. As the radius increases, the possible angle of rotation for the approach axis also increases.

Shivam Shukla (2017) evaluated roundabout capacity using three different roundabout models: the Tanner model, NCHRP model, and German model. The capacity analysis was based on the gap acceptance method, adopted by Tanner based on the HCM 2010. The study found that roundabouts in urban and suburban areas in India are highly crowded during peak hours, highlighting the need for redesigning and analyzing the geometry of roundabouts.

The Highway Capacity Manual (HCM) 2016 model is a widely recognized and authoritative resource for analyzing the capacity and level of service (LOS) of transportation facilities, including roundabouts. Developed by the Transportation Research Board (TRB), the HCM provides a comprehensive framework and methodology for evaluating the performance of various roadway elements.

In the context of roundabouts, the HCM 2016 model offers a systematic approach to assess their operational characteristics, traffic flow efficiency, and overall effectiveness. It provides guidelines and procedures for estimating the capacity, delay, queuing, and LOS of roundabouts based on their geometric design, traffic volume, and other relevant factors.

In summary, the HCM 2016 model serves as a valuable tool for analyzing the capacity and LOS of roundabouts, providing a standardized and reliable methodology for evaluating their performance. Its application aids in the design and planning of roundabouts that effectively accommodate traffic demands, contributing to safer and more efficient transportation systems.

Therefore, it is crucial for road authorities and other concerned bodies to conduct comprehensive capacity and delay studies for every roundabout. By doing so, they can gather valuable data and insights into the performance of these intersections, enabling them to identify any issues or areas of improvement. Through a thorough analysis of capacity and delay, appropriate solutions can be developed to address traffic congestion and enhance the overall efficiency of roundabouts.

By investing in capacity and delay studies, road authorities can make informed decisions on allocating resources, implementing appropriate design modifications, and prioritizing future infrastructure projects. This proactive approach enables them to optimize the performance of roundabouts, reducing travel times, improving safety, and enhancing the overall quality of transportation networks.

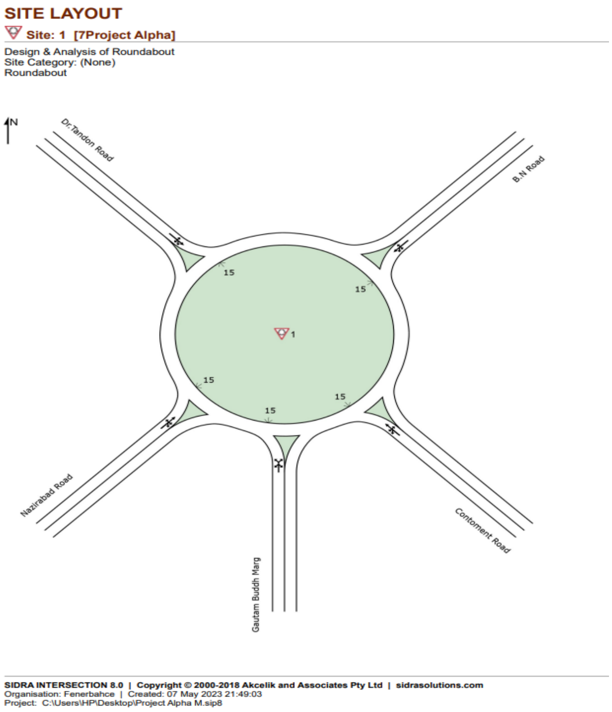


Figure 1 Roundabout layout

Roundabout Geometry

Approach	S(m)	SE(m)	NE(m)	NW(m)	SW
Circulating Width	20	20	20	20	20
Island diameter	15	15	15	15	15
Inscribed diameter	50	50	50	50	50
No. of circ lane	1	1	1	1	1

Table -1

2. DATA COLLECTION & METHODOLGY

For the research, we chose a roundabout located at a busy spot where there is a lot of traffic, including heavy vehicles. This roundabout connects different areas of Lucknow city and has five legs without traffic signals (known as Give Way Control). We recorded traffic volume during the busiest time in the evenings from Monday to Saturday and averaged the values for each leg of the roundabout. The roundabout has two-way traffic with two lanes (without a median). We chose these locations based on certain assumptions:

A) Roundabout are unsignalized

B) The roads should be flat without any slopes

C) The pedestrian activity should be minimal.

We measured the dimensions of the roundabout and the legged using a measuring tape. Additionally, we captured video footage during the peak hour of 5:30 pm to 6:30 pm when people are returning home, especially those who commute for work. We categorized the traffic into light vehicles (such as cars, three-wheelers, and E-rickshaw), heavy vehicles (including buses and some tractors), and bicycles. To ensure smooth traffic flow, we assumed no pedestrian interference. Figure 2 illustrate the traffic movements at the roundabout.

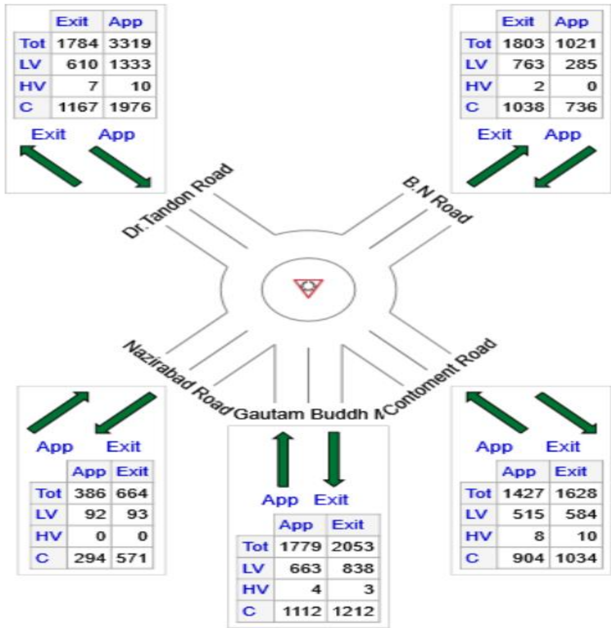


Figure 2 Traffic Movement

Many studies have previously considered various traffic flow parameters, such as capacity, level of service (LOS), delay, travel speed, and geometric and control factors, to assess the operational performance and efficiency of Roundabout. To ensure our study is effective and consistent with previous research, we have also used these traffic flow parameters as performance measures for analyzing the roundabout in this study. We aim to simulate and analyze these parameters to gain insights into the performance and efficiency of the Roundabout.

3. RESULT & DISCUSSION

A. TRAFFIC VOLUME

Table 2 presents the traffic volume entering the roundabout, From Table 2A, it can be observed that light vehicles (LV) dominate the vehicle inflow into the roundabout. Heavy vehicles, such as buses and trucks, account for approximately 1% of the total traffic. Non-motorized vehicles, specifically bicycles, contribute significantly, representing about 55% of the total traffic inflow into the roundabout. Among the legs of the roundabout, DR. Tandon Road carries the highest traffic volume, accounting for approximately 55% of the total inflow. This can be attributed to People returning from Shops and people going own desire location by buses around this time (5:30 pm onwards). Nazirabad Road also has the highest volume of bicycles, representing about 86% of the total bicycle traffic. Whereas total volume influx onto other legs respectively 1447, 1021,3175, 1725, 380

Gautam buddh marg

	NW	NE	SE	S
Total vehicle	178	76	80	46
LV	54	13	15	10
HV	0	0	0	0
Bicycle	124	63	71	36

Table 2A

Dr. Tandon Road

	NE	SE	S	SW
Total vehicle	819	851	1233	272
LV	350	366	591	36
HV	0	8	2	6
Bicycle	469	487	784	236

Table 2D

Contoment Road

	SE	S	SW	NW
Total vehicle	240	266	84	431
LV	68	100	11	106
HV	0	0	0	0
Bicycle	172	166	73	325

Table 2B

B.N Road

	SW	NW	NE	SE
Total vehicle	160	639	475	451
LV	18	300	200	145
HV	0	1	1	2
Bicycle	142	392	274	304

Table 2

Nazirabad Road

	S	SW	NW	NE
Total vehicle	364	148	482	453
LV	137	28	150	200
HV	1	0	6	1
Bicycle	226	120	326	232

Table 2C

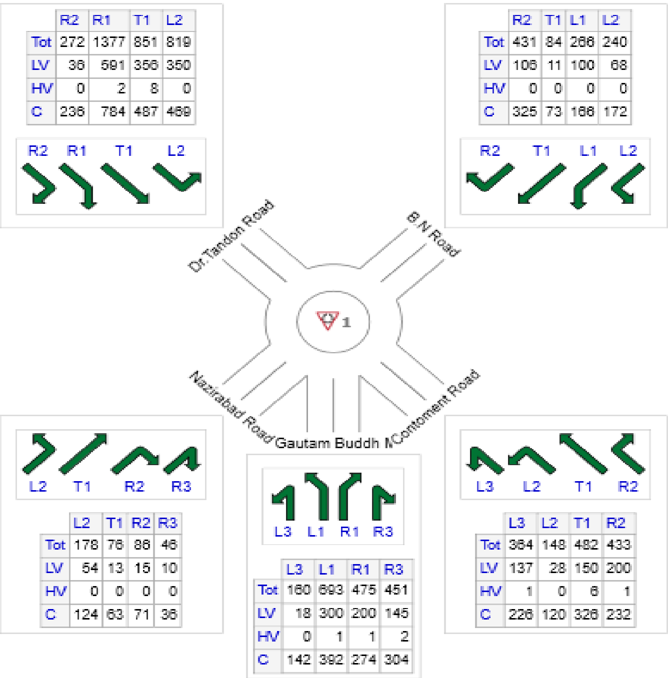
B. CAPACITY & LEVEL OF SERVICE

In the roundabout, the Dr. Tandon Road (TR) leg experiences vehicle influx exceeding its capacity, resulting in the worst Level of Service (LOS) known as LOS F. LOS F signifies heavy traffic congestion where vehicles are stuck and unable to move. This congestion occurs on weekdays during the peak evening hours for Tondon leg. This situation aligns with a study conducted by Kang and Nakmura (2016), which found that the roundabout's capacity decreases with an increase in the proportion of heavy vehicles. Despite trucks not being allowed on tondon leg, a large number of buses still use it, leading to congestion and poor LOS. B.N Road and Contoment road legs have traffic demands nearly equal to their capacity, resulting in LOS A and B, respectively. This could be due to the leg geometry and a lower number of bicycles, which potentially hinder the movement of motorized vehicles. Nazirabad leg has less demand compared to its capacity, possibly due to fewer bicycles and fewer light vehicles like cars and three-wheelers.

Capacity & Demand of Roundabout

Leg	**Capacity**	**Demand**
Gautam buddh marg	3253	1179
Nazirabad	3987	386
Contoment road	3279	1427
B.N Road	3832	1021
Dr. Tandon Road	3288	3319
Total	17639	7326

Table 3



	R2	R1	T1	L2
Tot	272	1377	851	819
LV	36	591	356	350
HV	0	2	8	0
C	236	784	487	469

	R2	T1	L1	L2
Tot	431	84	266	240
LV	106	11	100	68
HV	0	0	0	0
C	325	73	166	172

	L2	T1	R2	R3
Tot	178	76	86	46
LV	54	13	15	10
HV	0	0	0	0
C	124	63	71	36

	L3	L1	R1	R3
Tot	160	693	475	451
LV	18	300	200	145
HV	0	1	1	2
C	142	392	274	304

	L3	L2	T1	R2
Tot	364	148	482	433
LV	137	28	150	200
HV	1	0	6	1
C	226	120	326	232

	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)	Bicycles (C)
S: Gautam Buddh Marg	1779	663	4	1112
SE: Contoment Road	1427	515	8	904
NE: B.N Road	1021	285	0	736
NW: Dr.Tandon Road	3319	1333	10	1976
SW: Nazirabad Road	386	92	0	294
Total	7932	2888	22	5022

Figure-3 DEMAND FLOWS

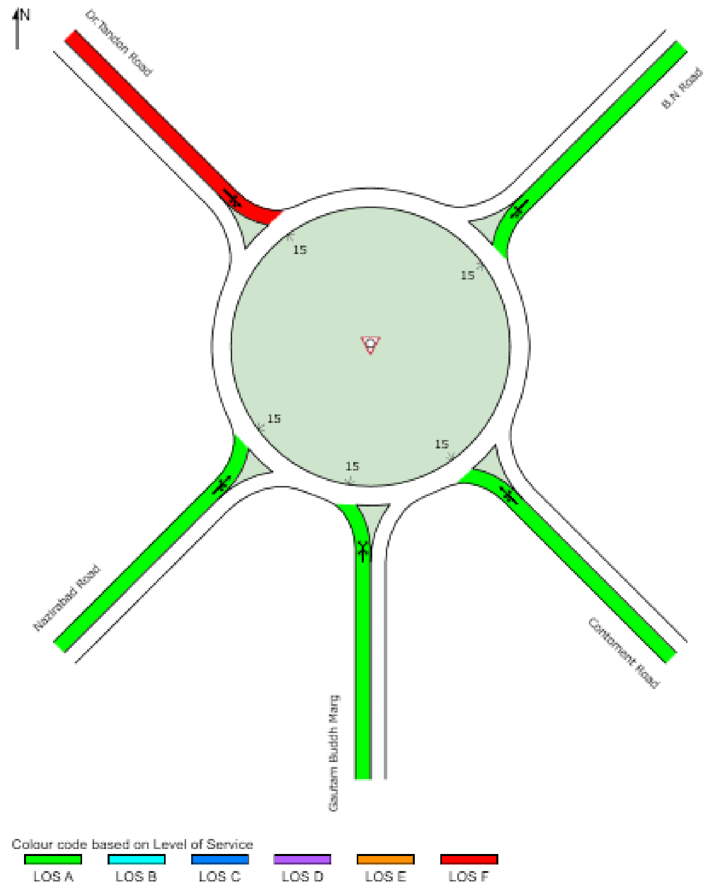


Figure 4 – Level of Service

C. Degree of Saturation V/C

The degree of saturation is a crucial criterion used to assess the operational efficiency of an Roundabout. It measures the ratio of the volume of incoming traffic to the capacity of the intersection during a specific time period. The range of this ratio, denoted as v/c, typically falls between 0 and 1. A v/c ratio greater than 1 indicates that the volume exceeds the capacity, while a high v/c ratio suggests that the intersection is approaching an unstable performance condition.

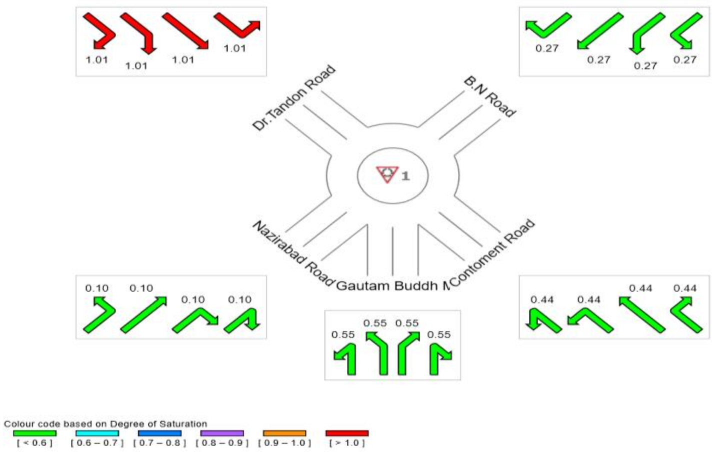


Figure 5 - V/C ratio of Roundabout (per leg per movement)

	Approaches					Intersection
	South	SE	NE	NW	SW	
Degree of Saturation	0.55	0.44	0.27	1.01	0.10	1.01

Table 4 – Degree of Saturation

In Figure 5 and Table 4, the degree of saturation is presented for the roundabout. At the roundabout, the Dr. Tandon Road leg is found to be oversaturated, causing severe congestion. This oversaturation affects all types of movements: left-turn, right-turn, and straight. The Gautam buddh approach has a degree of saturation of 0.55, indicating a impact on operational performance, as the Australian design procedure suggests a limit of v/c = 0.85 for efficient performance. The Contoment approach, with a v/c ratio of 0.44, operates efficiently during peak periods but may become stable if the volume increases further. The Dr. Tandon Approach has a degree of saturation V/C ratio of 1.01 which is more than 0.85, during peak period it may become unstable if the volume increases further. The Nazirabad road has low V/C ratio 0.10 which is operational condition.

4. CONCLUSION

The capacity and demand analysis indicated that some legs of the roundabout operate close to their capacity, while others experience inflow below capacity. The Dr. Tandon Road leg showed the highest demand exceeding its capacity, leading to congestion and poor LOS. The B.N Road and Contoment Road legs operated efficiently, possibly due to leg geometry and lower bicycle traffic.

The degree of saturation (V/C ratio) analysis highlighted the oversaturation and severe congestion at the Dr. Tandon Road leg. This oversaturation affected all movements within the roundabout. The Gautam buddh marg approach showed a moderate impact on operational performance, while the Contoment Road approach operated efficiently during peak periods. The Nazirabad Road leg exhibited a low V/C ratio, indicating an operational condition.

Based on these results, it is evident that proper design, capacity assessment, and geometric considerations are crucial for the efficient performance of roundabouts. Neglecting key factors such as swept path analysis and the proportion of heavy vehicles can lead to congestion and decreased safety.

In conclusion, this research has emphasized the importance of considering factors such as traffic volume, capacity, geometric design, and swept path analysis in the design and analysis of roundabouts. By implementing effective design principles and conducting thorough assessments, roundabouts can contribute to safer and more efficient traffic flow, ultimately improving transportation systems and reducing congestion-related issues.

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