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MEASURE EFFECTIVENESS OF ROUNDABOUTS IN URBAN AREAS AND THEIR COMPARISON WITH SIGNALISED INTERSECTIONS

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Abstract – *Nowadays, traffic congestion has become one of the main societal and economic issues in metropolitan cities of both developed and developing countries. Traffic congestion is mainly observed at road intersections in urban areas, and particularly, it becomes severe during peak hours. Roundabouts are popular in urban areas as intersection controls and, as such, used widely irrespective of their effectiveness in terms of safety and capacity. Given that roundabouts have been used widely in urban areas, it is important to measure their effectiveness such as average delay, maximum queue length, the level of service (LOS) and compare them with signalised intersections and signalised roundabouts to gauge the intersection safety, traffic efficiency, and resulting congestion.*

Key Words: **Roundabouts, Signalised intersections, Signalised roundabout, Delay, SIDRA software, Saturation flow, Cycle Length.**

1.INTRODUCTION

The road network is an integral part of the community land use and cannot be developed independently. Interesting are nodes of the system and so a fundamental part of any road network, which determines how effectively the network operates. The developing cities face never-ending traffic issues with the increasing rate of vehicle ownership. Emerging road traffic in medium and large cities is a significant challenge in terms of developing a network that would be able to satisfy the needs of traffic. Intersections are a critical component of this network and must be carefully designed to manage traffic effectively.

During the past decades, major cities have experienced tremendous growth due to industrialization and urbanization. Traffic is expanding day by day, so it is almost impractical to control the traffic manually at the intersection. Although the signals have been provided on intersections the traffic congestion has not reduced effectively. To improve traffic conditions as well as the aesthetic of the intersection, roundabouts are becoming popular to alleviate traffic congestion while keeping in view high traffic volume.

In the present time, traffic issues can be directly attributed to the increasing vehicle ownership in the urban areas, these increased rates of vehicles require space for movement with safety having enough capacity of roundabouts, intersections so capacity evaluation needs to be done on the roundabout for efficient operation of traffic. Intersections influence the safety and capacity of urban traffic. Signalised intersections are one of the intersection types in which the arrangement and length of the flow at the intersection are controlled by the signals. For the most part, this kind of intersection is utilized on roads with high traffic volume. [1]

1.1 Need for the study

Nowadays road traffic congestion has become a vital societal and economic problem in urban areas both in developed and developing countries. In the last five decades, a wide scope of traffic flow theories and models have been developed to minimise the issue of traffic congestion. [2] Traffic congestion is primarily observed at road intersections in urban areas, and especially, it becomes severe during peak hours. Roundabouts are currently considered as an alternative traffic control device that can improve safety and operational efficiency at intersections when compared to other intersection controls, usually for traffic flow management or to improve safety. Roundabouts play a key role in the improvement of the environmental impact of traffic compared to other forms of at-grade intersections. It is commonly seen nowadays in the urban area that roundabouts have gained popularity and are being used as intersection control at many major urban intersections. However, it is pivotal to measure the effectiveness of roundabouts in urban areas and compare them with signalised intersections. [3]

1.2 Justification of the study

Firstly, this research applied knowledge to measure the effectiveness of roundabouts, as well as the comparison with signalised intersections, since the congested streets and intersections need capacity analysis to give the premise to evaluating traffic lanes. The main advantages are traffic safety, operational performance, environmental factors, pedestrian safety, more efficiency, and aesthetics. The roundabouts are implemented based on geometric and operational aspects. A signalized roundabout with a circular island and signalized intersections were studied in terms of capacity, delay, and emissions located in Ahmedabad, Gujarat. This research included three types of comparisons: Roundabouts, Signalised roundabouts, and Signalised

intersections using a manual method of PCU count, queue length, saturation flow, delay, as well as compared using SIDRA Intersection 8.0 analysis software.

The outcomes of this study would focus on saturation flow, time taken by vehicles to clear the junction, queue formation, priority for BRTS, Safety, Pedestrian, and cyclists, estimating the delay under heterogeneous conditions in the Ahmedabad city and may be useful to the urban local bodies (such as municipalities, urban development authorities, etc.) in making decisions.

1.3 Objective

- To measure the effectiveness of roundabouts in Ahmedabad city.
- To make a comparison of roundabouts with signalised intersections for operational capacity.

2. METHODOLOGY

2.1 Traffic volume count

A survey had to be done on weekdays. Classified volume count was carried out at each of the intersections during Peak hours (Morning & Evening) and Off-Peak hours (Afternoon). The method adopted for the survey was manual counting of traffic for 6 intervals of 2 hours. each intersection in morning peak: 09:00 AM -11:00 AM and in evening peak: 06:30 PM -08:30 PM and off-peak: 02:00 PM - 4:00 PM. The Volume in units of numbers was then later converted into one common unit PCU. Traffic counts a Monday morning rush hour, and a Friday evening rush hour may indicate high volumes and are not included in the analysis; therefore, counts are conducted on a Tuesday, Wednesday, or Thursday. These PCU values were used for analysis. [4]

2.2 Selections of study area

- Roundabouts: Ujala
- Signalised Roundabout: Nirma, ONGC, Visat
- Signalised Intersections: C.G. Road, Vijay Road

2.2.1 Ujala Roundabouts

- Longitude: 72.4928° E
- Latitude: 22.9801° N
- Leg 1: Towards the Sarkhej-Bavla road
- Leg 2: Towards the S.G. Highway
- Leg 3: Towards the Ujala bridge

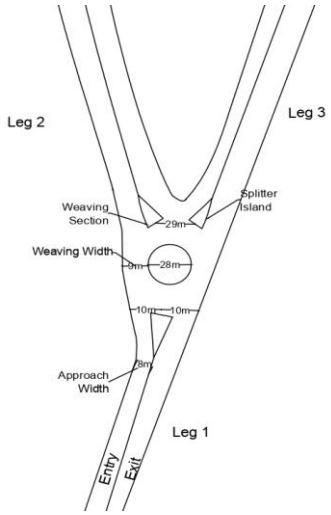

Fig -1: Ujala Roundabout

Parameters:

- Diameter of the Roundabout = 28 m
- Entry Width = 10 m
- Exit Width = 10 m
- Approach Width = 8 m
- Weaving Length = 29 m
- Weaving Width = 9 m
- Splitter Island = 9 m
- Number of Circulating Lanes = 3

2.2.2 Nirma Signalised Roundabout

- Longitude: 72.540682° E
- Latitude: 23.020744° N
- Leg 1: Towards the Shivajrani road
- Leg 2: Towards the Sahajanand College
- Leg 3: Towards the Dharnidhar
- Leg 4: Towards the Ambawadi

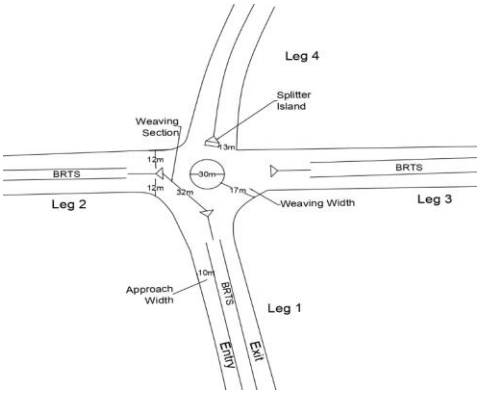

Fig -2: Nirma Signalised Roundabout

Parameters:

- Diameter of the Roundabout = 30 m
- Entry Width = 12 m
- Exit Width = 12 m
- Approach Width = 10 m
- Weaving Length = 32 m
- Weaving Width = 17 m
- Splitter Island = 13 m
- Number of Circulating Lanes = 3

2.2.3 ONGC Signalised Roundabout

- Longitude: 72.5975° E
- Latitude: 23.1056° N
- Leg 1: Towards the Vishwakarma college
- Leg 2: Towards the new C.G. Road
- Leg 3: Towards the UGVCL Motera office
- Leg 4: Towards the Motera stadium road

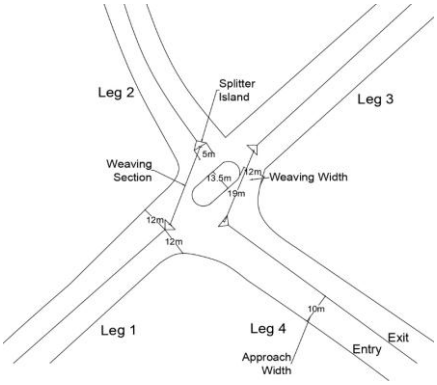

Fig -3: ONGC Signalised Roundabout

2.2.4 Visat Signalised Roundabout

- Longitude: 72.5892° E
- Latitude: 23.0986° N
- Leg 1: Towards an Eklavya English school
- Leg 2: Towards the Mehsana bypass road
- Leg 3: Towards the Ahmedabad-Patan Highway Road

Parameters:

- Diameter of the Roundabout = 20 m
- Entry Width = 10 m
- Exit Width = 10 m
- Approach Width = 9 m
- Weaving Length = 40 m
- Weaving Width = 10 m
- Splitter Island = 10 m
- Number of Circulating Lanes = 2

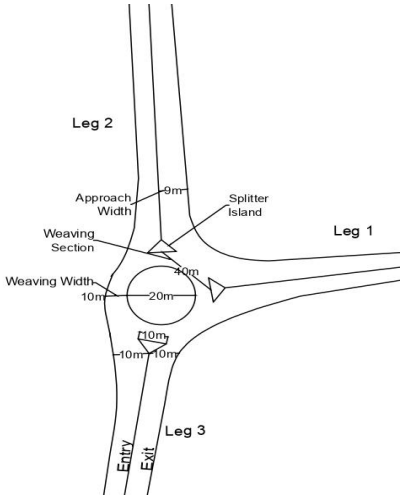

Fig -4: Visat Signalised Roundabout

2.2.5 C.G. Road Signalised Intersection

- Longitude: 72.5575° E
- Latitude: 23.0284° N
- Number of legs = 4
- Leg 1: Towards the Swastik crossroad
- Leg 2: Towards the Mithakhali circle
- Leg 3: Towards the Panchwati crossroad
- Leg 4: Towards the St. Xavier's college
- Approach Width = 10 m
- Number of Lanes = 3

2.2.6 Vijay Road Signalised Intersection

- Longitude: 72.5491° E
- Latitude: 23.0427° N
- Number of legs = 4
- Leg 1: Towards the Darpan circle
- Leg 2: Towards the Commerce six road
- Leg 3: Towards the University road
- Leg 4: Towards the Drive-in road
- Approach Width = 10 m
- Number of Circulating Lanes = 3

3. Data Analysis

3.1 Traffic volume count

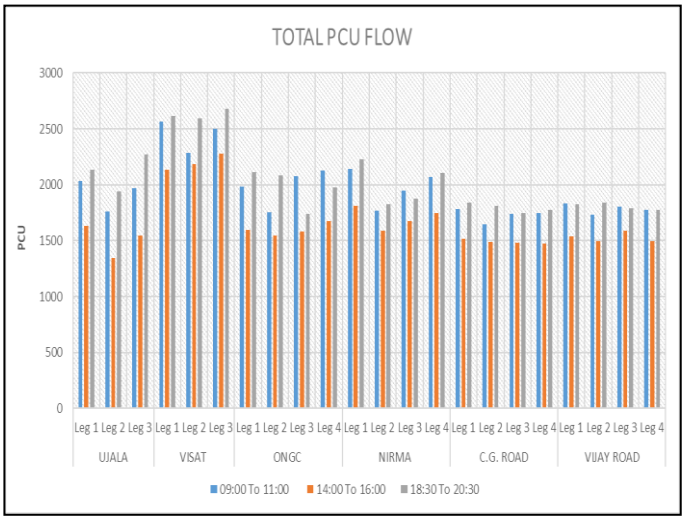

Chart -1: Total PCU Flow

The total vehicle counts were taken at each intersection during peak hours (Morning & Evening) and off-peak hours (Afternoon). A peak in the morning followed by a lean flow until another peak in the middle of the afternoon, after which there may be a new peak in the late evening. The peak in the morning is often more sharp by reaching the peak over a short duration and immediately dropping to its lowest point. The afternoon peak on the other hand is characterized by a generally wider peak. The peak is reached and dispersed over a longer period than the morning peak. However, in urban satellite towns, the morning peak may be too early and the evening peak may be too late in comparison to the principal towns without significant midday peaks. Chart-1 shows the Time vs no. of vehicle flow for the same intersections and reflects the variant in the flow.

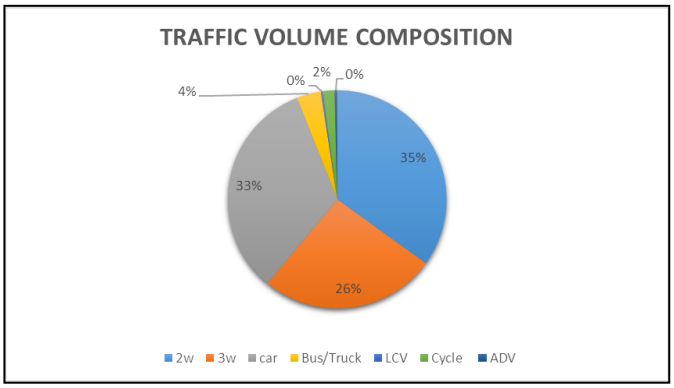

Chart -2: Total Percentage of Vehicle

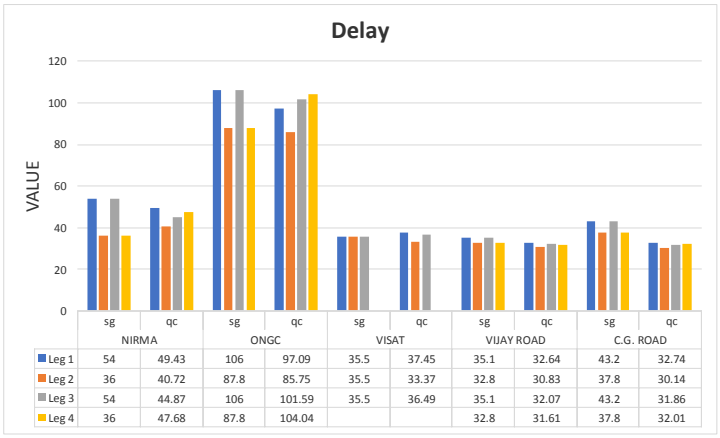

Chart -3: Delay at Intersections and Roundabouts

Chart-3 shows a correlation with the observed delay.

It is observed that delay is more due to longer cycle time. Also if the proportion of green allotted to a particular approach is less, vehicles have to stand in a queue for a longer period as the Red time increases. It considers the effect of the Green Ratio (g/c) ratio, Road width, and traffic composition to determine the stopped delay.

For the same cycle length, delay decreases with the increase in the g/c ratio on a particular leg of the intersection. Similarly, for the same green time in different cycle lengths, delay decreases with an increase in the g/c ratio.

If, sg>qc indicates that there is no delay in that approach.
If, sg<qc this indicates a delay in the approach.

3.2 SIDRA

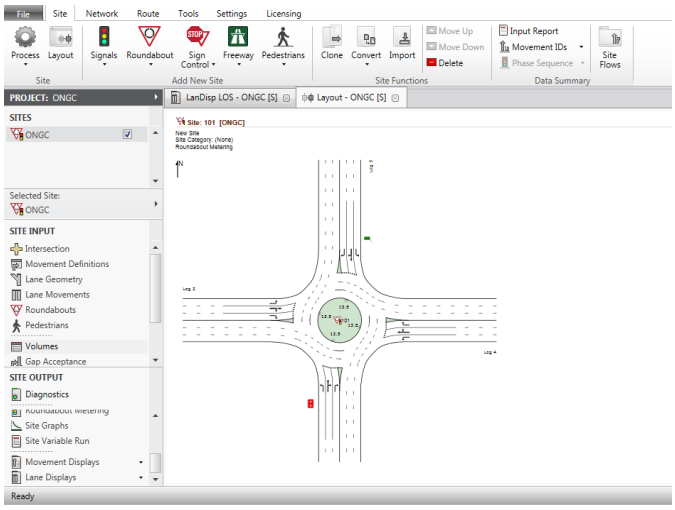

Fig -5: ONGC Signalised Roundabout

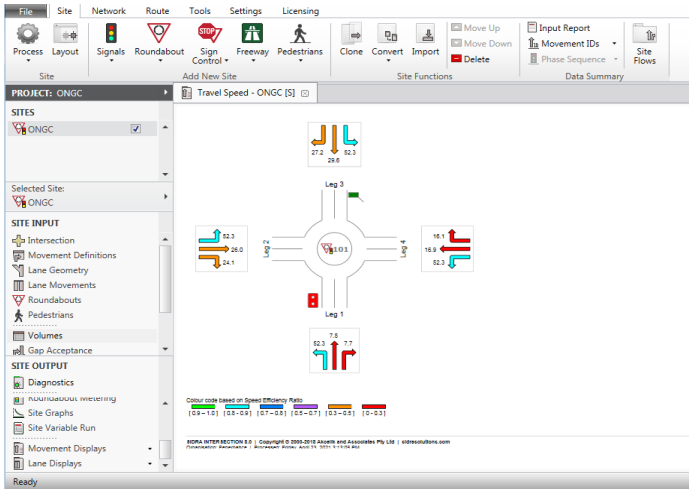

Fig -6: Travel Speed at ONGC Signalised Roundabout

Figure 6 depicts the layout of intersections and roundabouts. SIDRA software is used to calculate the travel speed efficiency, Delay control, and Level of services (LOS) at intersections and roundabouts and compare it to manual data to provide a more accurate image. In the Level of services, A denotes free flow, B denotes reasonably free flow, C denotes stable flow, D denotes Approaching unstable flow, E denotes unstable flow, and F denotes forced or breakdown flow. Los F denotes high congestion at intersections or roundabouts, as well as a lack of comfort and convenience for commuting using this route. To improve the LOS while providing a pleasant driving experience for all road users.

4. CONCLUSIONS

Signalisation enhances the operational efficiency of roundabouts. It is particularly effective when unacceptable vehicle delays occur due to high traffic volumes from one; causing unacceptable queues. Due to the pandemic, traffic flow and PCU count may be affected. No evidence was identified to suggest that a signalization would degrade roundabout traffic operations. When traffic signals are installed that stop both entry and exit traffic at the same time, allowing pedestrians to cross from both directions, queues back up into the circulating roadway, and disrupt traffic operations. Since saturation flow is low so green time should be increased to reduce traffic congestion at signalised intersections and roundabouts.

The performance of both signalised and unsignalised roundabouts, signalised intersections was evaluated based on, such delays, maximum queue length, and the level of service (LOS). It was also concluded that the average delay of the signalized roundabouts was improved by (9% to 35%) and the LOS improved by two levels.

During this study the observations that have been recorded in the field of study areas are as follows:

I. The LOS in the morning period was better than the evening period, which means that the volume of traffic flows in the evening more than in the morning period.

II. The capacity of an intersection and roundabout was unable to absorb the huge volume of traffic flow at rush hours.

III. Some intersections and roundabouts need new lanes to be added to reduce the congestion and improve system speed.

IV. Some intersections couldn't have new lanes added to them. Therefore, alternative routes must be opened to reduce traffic jams at these intersections.

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