Congestion And Performance Evaluation Of Roundabouts: Case Study At Indore City; India

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Abstract- *When there is a greater demand for space than the road can provide due to an inflow of vehicles, traffic jams arise. Statistical computer models and numerical field data about vehicle counts are essential instruments for assessing the traffic volume and serviceability of a route. In this investigation, both have been employed. This study's main goals are to assess the Level of Service (LOS), travel time, degree of saturation, wait time, and perform a thorough analysis of the traffic flow to develop a plan to lessen roundabout traffic congestion. During peak hours, from 12:00 to 1:30 p.m., the number of vehicles passing through the roundabout at Redisson Square's eastern entrance, located at MR 10, was counted. In order to make the mixed traffic stream uniformly equal, it was subsequently changed to passenger car units (PCU). The roundabout at Redisson Square at the city entry needs more development to improve the terrible traffic conditions, according to the findings of the systematic study of the data collected. The current road layout was measured using surveying equipment to perform an accurate simulation, and the findings were utilised to create a model. Lanes for acceleration and deceleration were suggested to enhance roundabout efficiency and ease traffic. Following road safety, the roundabout extension idea was then incorporated into the geometric design in order to assess its efficacy in easing traffic congestion. From 2015 to 2024, the roundabout's lanes' level of service improved significantly in terms of traffic flow, road safety, and accident records.*

Keywords: Roundabout; Traffic Congestion, Intersection Safety; Level of Service; Urban Road Infrastructures

I. INTRODUCTION

The road system cannot be created separately because it is an essential component of the community's land usage. The system's nodes, which are an essential component of any road network and influence how well the network functions, are intriguing. Due to the rising rate of automobile ownership, the traffic problems in emerging cities are never-ending. A major obstacle to creating a network that can meet traffic demands is the emergence of road traffic in medium-sized and large cities. An essential part of this network is intersections, which need to be thoughtfully planned in order to efficiently handle traffic.

Due to urbanisation and industrialisation, large cities have seen considerable expansion in recent decades. Manually controlling traffic at the intersection is nearly impossible due to the increasing volume of vehicles. Despite the presence of lights at junctions, there hasn't been much of a reduction in traffic. Roundabouts are gaining popularity as a way to reduce traffic congestion while maintaining high traffic volume and improving both the intersection's aesthetics and traffic conditions.

Nowadays, the growing number of cars in urban areas is directly responsible for traffic problems. Due to the rising number of cars, roundabouts and intersections must have adequate space for safe movement; therefore, a capacity assessment of the roundabout is necessary for effective traffic flow. Intersections have an impact on urban traffic capacity and safety. One sort of intersection is a signalised intersection, where signals regulate the flow's length and arrangement at the intersection. This type of intersection is typically used on roads with heavy traffic.

Rotaries are appropriate for a variety of intersections, including those that improve performance, lessen traffic jams, and maintain a balanced flow of traffic. A variety of traffic flow issues can be resolved by a rotary. One road has more traffic than another, which prevents cars from entering the roundabout from entering from other roads. Delays, service quality, accidents, operating expenses, and other problems depend on the rotary's maximum capacity. There are three, four, five, and six approaches in the majority of rotaries. The majority of them have been in India for over 15 years. In India, mixed traffic is particularly prevalent in cities. The primary cause of traffic congestion on urban roadways and at intersections is increased traffic volume. The performance of urban roadways and crossings will deteriorate as traffic volume increases. Effective traffic regulation is necessary to address these issues and improve road user services. Before they may weave out of the traffic flow into their respective directions, all vehicles from various routes are transported around a big central island in a clockwise pattern at a massive road crossroads called Rotary. When there is roughly equal traffic coming from three or more approaches, rotaries are more efficient. According to IRC, rotary can effectively handle up to 3000 vehicles per hour entering from all sides of the intersection, with a lower limit of 500 vehicles per hour. Traffic rotaries should be installed in areas where fast traffic turning right accounts for at least 30% of all traffic or when intersecting traffic accounts for at least 50% of all traffic on all intersecting roads. Traffic congestion is a result of the rise in privately owned vehicles brought on by population growth.

ROTARY OR INTERSECTION

A rotary intersection, sometimes referred to as a roundabout, is a type of at-grade road junction specifically designed to control traffic flow by guiding every vehicle in a single, continuous, and usually clockwise motion around a central island. A rotary intersection's primary goal is to enhance operational safety and efficiency by transforming potentially serious crossing and turning conflicts into less severe merging and diverging actions. Geometric concerns, including entry and exit widths, central island diameter, weaving length, and entry angle,s are important design elements that are intended to promote a decrease in vehicle speeds and orderly traffic circulation. Because they minimise the need for signal management, reduce delay, and lessen the frequency and severity of traffic accidents, rotaries are especially useful at crossroads with significant amounts of right-turn traffic or complex geometry. However, because they usually require more space than other intersection types and are less appropriate in restricted urban areas or when pedestrian traffic is substantial, their efficacy depends on balanced approach volumes and enough land availability.

Fig 1: Rotary or Roundabouts

OBJECTIVES OF THE RESEARCH

- Mapping of Route using Arch GIS and Google Maps.
- Evaluate hourly report of traffic for a period of one month to identify the peak hours traffic flow
- Design a new roundabout for better traffic flow.
- Identify the reasons for traffic congestion considering case study MR10 Indore.
- To make a comparison of roundabouts with signalised intersections for operational capacity.
- To assess the present performance of the intersection from traffic flow efficiency and safety perspectives by considering all road users

LITERATURE REVIEW

As a type of at-grade intersection, roundabouts have drawn interest from all around the world due to their potential to improve operational effectiveness and traffic safety. Particularly in heterogeneous traffic situations like those found in Indian cities, roundabout study has recently broadened to include congestion management, capacity evaluation, geometric design concerns, and safety performance. In order to provide the theoretical and empirical framework for evaluating roundabout performance in Indore, this chapter reviews recent scholarly and technical research.

II. REVIEW OF LITERATURE SURVEY

Abhijnan Maji and Indrajit Ghosh (2025) has undertaken a thorough evaluation of user safety perceptions at roundabouts in two Indian cities, concentrating on the impact of sociodemographic characteristics on perceived dangers in mixed traffic situations. The study found unique trends in safety perceptions among various user groups using multivariate statistical techniques such as Multiple Correspondence Analysis (MCA), Cluster Analysis, Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Multiple Linear Regression (MLR). Even though roundabouts are typically thought to be safer than traditional intersections, the results showed that characteristics like age, driving experience, vehicle type, and frequency of roundabout use substantially affected how users perceived safety. The study highlighted the intricacy of safety perceptions in non-lane-based, diverse traffic that is typical in low- and middle-income nations like India, offering insights that can guide better roundabout design and safety tactics.

According to the study, single-lane roundabouts were thought to be safer, especially when entering and moving around, whereas double- and multi-lane roundabouts were thought to be riskier, especially when exiting. While younger and inexperienced users reported more hazards overall, experienced drivers felt more assured. Cyclists and motorcyclists, among other vulnerable road users, cited higher dangers when there was inadequate lighting. It was suggested that roundabout safety perceptions be improved through better illumination, focused infrastructure, and consideration of driver experience.

Durga Paudyal et.al (2025) examined the Lakhan Thapa Chowk roundabout's operational performance in Butwal, Nepal, focusing on factors including average speed, queue length, delay, and Level of Service (LOS). Four improvement options were assessed using the VISSIM microsimulation model: a grade-separated intersection along Siddhartha Highway (Alternative III), an improved roundabout geometry (Alternative I), widened lanes and additional lanes at the Bardaghat leg (Alternative II), and a combination of a grade-separated intersection with an at-grade roundabout (Alternative IV). To determine the best layout for increasing traffic efficiency, each option was evaluated over a 5-year and 10-year period under both present and anticipated traffic conditions.

The analysis revealed that the most effective way to improve traffic performance at the Lakhan Thapa Chowk roundabout was to use Alternative IV, which combines an at-grade roundabout with a grade-separated intersection. It attained Level of Service (LOS) B for the base year with an operational speed of 37.19 km/h, a queue length of 18.06 meters, and a delay of 12.06 seconds. With LOS C, a delay of 24.4 seconds, a queue length of 36.95 meters, and an average speed of 33.03 km/h, it maintained good efficiency during the five-year prediction. It achieved LOS E with a delay of 47.68 seconds, a queue length of 37.72 meters, and an operational speed of 26.95 km/h after ten years, still outperforming other options. These findings demonstrate that Alternative IV is the best long-term course of action for enhancing traffic flow and easing intersection congestion.

III. METHDOLOGY

Step 1- Site Selection
Step 2- Literature Review and Preliminary Survey
Step 3- Data Collection Components

- **I. Traffic Volume Count Survey**
- **II. Spot Speed Survey**
- **III. Headway and Gap Acceptance Survey**
- **IV. Level of Survey (LOS)**
- **V. Accident Data Compilation**

Step 4- Geometrical Survey
Step 5- Data Processing and Analysis

IV. PROBLEM IDENTIFICATION

CASE STUDY

The traffic flow in Indore is characterized by significant complexity and congestion, largely influenced by the city’s rapid population growth and expanding vehicular density. The road infrastructure, including many of the city's roundabouts, has struggled to keep pace with these increases, leading to frequent bottlenecks and operational inefficiencies. Many roundabouts, originally designed to accommodate moderate traffic volumes, now experience oversaturation during peak hours, contributing to prolonged delays, uneven traffic dispersion, and widespread congestion across feeder roads.

Traffic safety presents a major concern, as mixed-traffic behavior involving a diverse fleet of vehicles—including two-wheelers, three-wheelers, cars, buses, and heavy vehicles—complicates flow dynamics at roundabouts. The heterogeneity of traffic combined with inadequate lane discipline and insufficient traffic regulatory measures has been linked to higher crash rates at roundabout locations. Contributing factors to accidents include improper merging, inadequate signage, narrow lane widths, and substandard geometric design of several roundabouts, which often fail to meet IRC guidelines.

Existing infrastructure challenges compound these issues. Many roundabouts suffer from geometric constraints such as undersized inscribed circle diameters, lack of well-defined splitter islands, and insufficient pedestrian crossing provisions. Although ongoing urban development has prompted infrastructure augmentation efforts under Indore’s Smart City initiatives, the pace of road expansions and intersection upgrades has been insufficient relative to traffic growth. Consequently, traffic congestion remains a critical impediment to mobility, affecting travel times, economic productivity, and environmental quality within the city.

Overall, the condition of traffic flow, safety, and infrastructure in Indore highlights the need for comprehensive, data-driven strategies focused on improving roundabout design, enforcing traffic regulations, and adopting real-time traffic management solutions. Addressing these challenges is vital to enhancing urban mobility and achieving sustainable transportation goals in the face of Indore's dynamic socio-economic landscape.

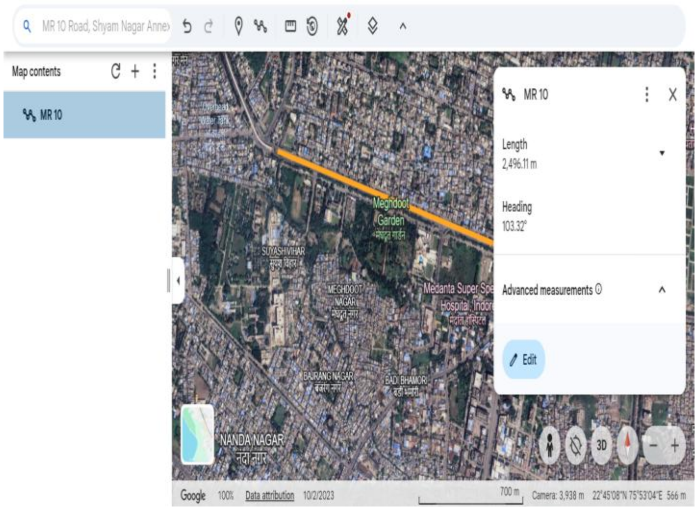


Fig 2: MP 10

Fig 5: Proposed Point of Intersection

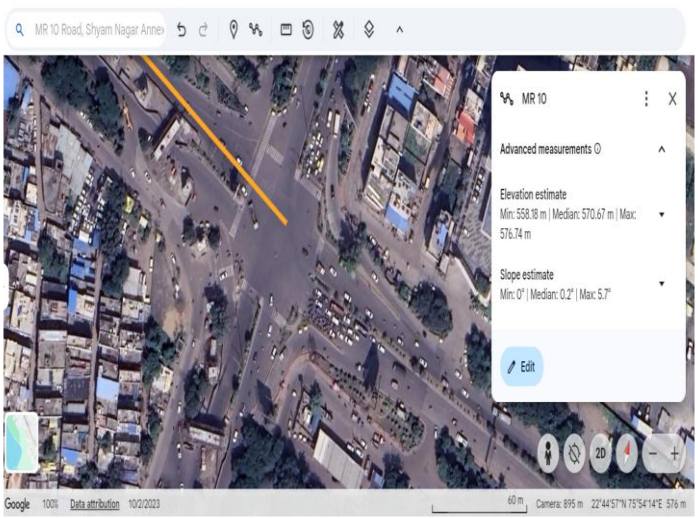


Fig 3: MR 10 (median estimation)

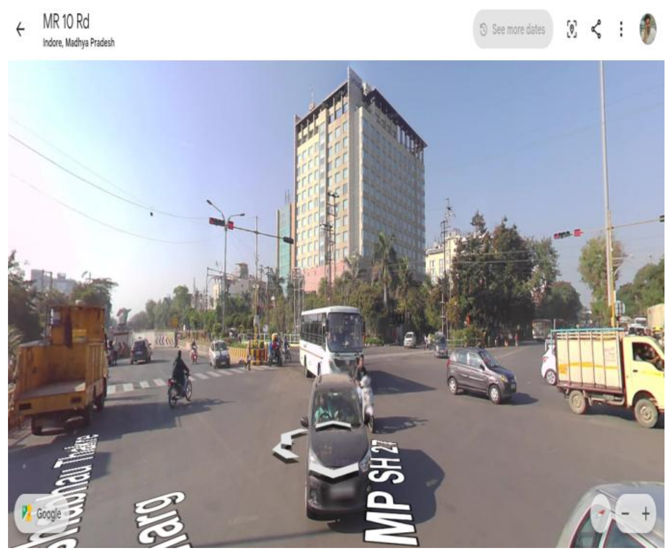


Fig 6: Fig Street View of Intersection

Fig 4: Redesigning of Intersection

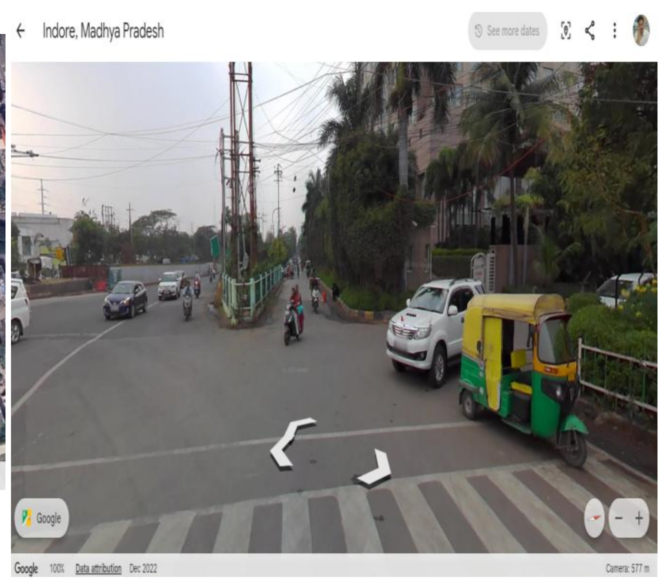
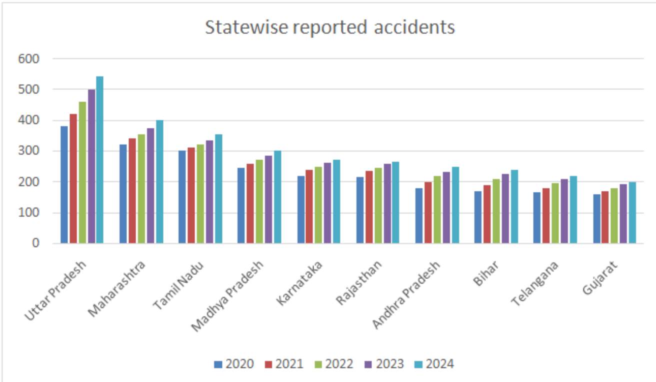


Fig 7: **Fig Street View of Service Road**

V. RESULTS AND DISCUSSION



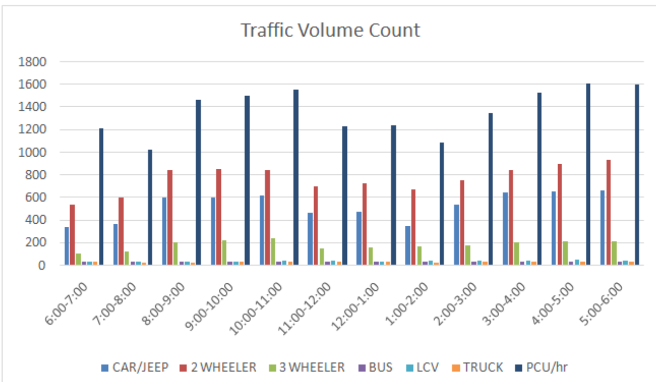
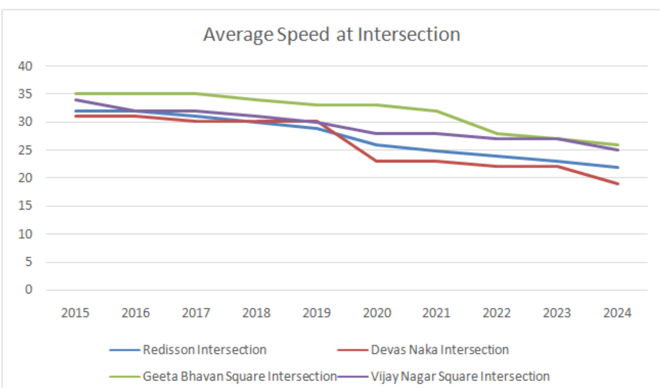


Fig 8: Traffic volume count of Intersection at MR10



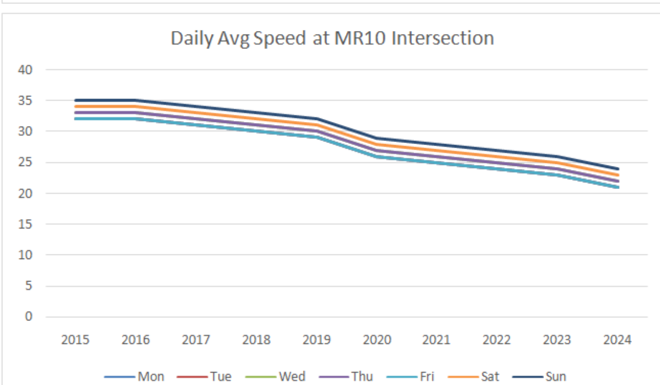


Fig 9: Daily Avg Speed at MR10 Intersection

V. CONCLUSION

From the traffic volume studies conducted at Redison Square situated at MR10 Indore it is seen that the right turning traffic is more at the junction. Hence roundabout can be adopted to control and guide the traffic flow at the intersection. The design of roundabout is done as per IRC 65:2017. The geometric design of roundabout depends on design speed.

The design capacity of roundabout is 2620 PCU/hr, which is greater than the present traffic volume 1883 PCU/hr.

- Intersection accident statistics in India reveal a nationwide increase, with Uttar Pradesh consistently reporting the highest number and rising from 380 incidents in 2020 to 545 in 2024. Similar upward trends are observed in Maharashtra, Tamil Nadu, Madhya Pradesh, and several other states, underscoring a persistent intersection safety challenge across the country. These findings highlight the urgent need for strengthened interventions and policy reforms to address escalating intersection-related accidents and enhance road safety nationwide.
- The traffic composition at MR10 intersection is marked by a dominance of two-wheelers, particularly peaking during the evening rush with 938 vehicles between 5:00–6:00 PM, while car and jeep volumes also reach their highest at 666 in the same time slot. Three-wheelers display increased activity during late mornings and afternoons, emphasizing their growing use for short urban trips. The data indicate distinct congestion peaks, with PCU/hr values surpassing 1,600 at evening peak, underscoring severe rush-hour conditions. By contrast, bus, LCV, and truck counts remain relatively stable, contributing to less variability in flow. These patterns collectively highlight a dynamic and heterogeneous traffic environment, reinforcing the importance of targeted congestion management and infrastructural interventions to enhance operational efficiency and safety at MR10 intersection.
- The dataset reveals a persistent decline in intersection speeds at MR10 from 2015 to 2024, with weekdays consistently exhibiting lower speeds than weekends due to heightened commuter and business activity. While minor speed increases are noted mid-week, overall reductions intensify in recent years as urban congestion and vehicle density rise. Saturdays and Sundays maintain relatively higher speeds, though these too decrease over time, indicating that

congestion now affects the entire week. This trend underscores the urgent need for congestion relief and infrastructure upgrades to sustain urban mobility at major intersections.

- The Passenger Car Unit (PCU) calculation, as per IRC:86-1983 guidelines, involves multiplying the count of each vehicle type by a specified PCU factor that reflects its relative road space occupancy compared to a standard passenger car. This classification includes diverse vehicle categories such as two-wheelers, cars/jeeps, three-wheelers, buses, light commercial vehicles (LCV), and trucks, with car/jeep serving as the reference vehicle type assigned a PCU factor of 1.0. Two-wheelers, which frequently constitute the largest portion of traffic volume, have a factor of 0.5, while larger and less maneuverable vehicles like buses and trucks receive higher factors of 2.0 and 3.0, respectively, despite their lower counts. The resulting PCU/hr values provide a more nuanced understanding of each vehicle class's impact on congestion and flow dynamics, facilitating accurate operational analyses, capacity assessments, and the development of targeted traffic management policies tailored to the heterogeneous traffic composition of urban roadways like the Redisson Square intersection in Indore.

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