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Multi- Leg Intersection Analysis and Optimization using VISSIM

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Abstract: *PTV VISSIM is a microscopic traffic simulation tool, use to analyse urban traffic congestion at multi-leg intersections and optimize traffic flow. Panchavati Square at Amravati is one of the complex multi-leg intersection. The research involves traffic data collection, including vehicle volumes, turning movements, signal timings at peak hours. The study evaluates the existing intersection performance by assessing key parameters such as average vehicle delay, vehicle travel time, queue lengths, queue counters, level of service (LOS), and emissions. Various optimization strategies are tested, including signal timing adjustments, lane reconfigurations, and adaptive traffic control systems. Simulation results indicate that optimized signal phasing and geometric improvements significantly reduce delays and improve intersection efficiency. The findings highlight the effectiveness of VISSIM-based simulation in enhancing intersection performance, reducing congestion, and improving urban mobility. The study provides recommendations for implementing optimized traffic control strategies to ensure safer, more efficient, and environmentally sustainable urban transportation.*

Keywords: Multi-leg intersection, signal optimization, traffic simulation, urban mobility, VISSIM

I. INTRODUCTION

Multi-leg intersections, where three or more roads converge, present unique challenges in traffic management due to the complexity of vehicle movements and the potential for increased conflicts. Efficiently managing these intersections is critical to minimizing delays, reducing congestion, and ensuring safety for all road users. VISSIM, a microscopic traffic simulation software developed by PTV Group, is an essential tool for analysing and optimizing traffic flow at complex junctions such as Panchavati Square, Amravati. VISSIM provides a detailed, simulation-based approach to understanding the intricacies of multi-leg intersections. By modelling the behaviour of individual vehicles, it allows engineers and planners to assess the impact of various traffic control measures, such as signal timing adjustments, lane configurations, and the implementation of roundabouts or other traffic calming strategies.

One of VISSIM's key strengths is its ability to simulate various traffic scenarios under different conditions, including peak hour congestion, incidents, and the introduction of new traffic control devices. The software's robust traffic signal modelling capabilities are particularly valuable for multi-leg intersections, where efficient signal phasing and timing are crucial to managing the complex movements and minimizing delays. Urbanization and rapid population growth have significantly increased traffic congestion, especially at busy intersections. Multileg intersections, characterized by three or more roadways converging at a single junction, pose unique challenges in terms of traffic flow, safety, and management. Panchavati Square in Amravati is one such critical intersection requiring detailed traffic analysis and optimization for efficient operation. This study employs VISSIM, a microscopic traffic simulation software, to analyse and optimize traffic flow at Panchavati Square with vehicle input, vehicle routes, conflict area, links etc.

II. REVIEW OF LITERATURE

VISSIM, developed by PTV Group, is widely recognized in transportation engineering for its detailed, microscopic simulation of traffic behaviour. It has been employed extensively to model intersections of varying complexity, including multi-leg configurations where three or more roads converge. VISSIM's ability to simulate individual driver

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behaviours, vehicle interactions, and traffic signal operations makes it a valuable tool for analysing the performance of multi-leg intersections under different traffic conditions with the result.

VISSIM in traffic simulation:

Fellendorf and Vortisch (2010) provided an extensive overview of VISSIM's modelling framework, discussing its applicability to various traffic scenarios with intersections. Their work highlights VISSIM's strengths in handling complex traffic dynamics at intersections, particularly in urban environments where multi-leg intersections are common. The work by Fellendorf and Vortisch (2010), titled "Microscopic Traffic Flow Simulator VISSIM", provides an authoritative discussion on the development, functionality, and application of VISSIM, one of the leading microscopic traffic simulation tools. This paper is included in the book Fundamentals of Traffic Simulation (edited by Barcelo), which serves as a comprehensive reference on simulation methodologies in traffic engineering.

Modelling multi- leg intersections:

Zhou and Taylor (2011) applied VISSIM to simulate a five-leg intersection in an urban area. Their study focused on optimizing signal timing to reduce delays and improve traffic flow. The results demonstrated the software's effectiveness in identifying critical issues related to congestion and the potential benefits of signal optimization. Zhou and Taylor's study provides a detailed examination of VISSIM, a microscopic traffic simulation software widely used for modelling and analysing traffic flow. Their work highlights the strengths and limitations of the software, focusing on its application to urban and freeway traffic scenarios. Below is a review of their key contributions and insights Microscopic Simulation: VISSIM operates at the individual vehicle level, providing detailed modelling of driver behaviour, lane-changing, and car-following dynamics. The software's flexibility allows customization of traffic conditions and local driving behaviour of the traffic.

Signal Optimization & Traffic Control at Multi-Leg Intersections:

Courage et al. (2002) provided an early application of VISSIM for signal optimization at multi-leg intersections, highlighting the software's utility in evaluating different phasing plans and the potential for reducing vehicle delays and improving safety. Provide a comprehensive examination of PTV VISSIM as a traffic microsimulation tool, focusing on its calibration parameters and their impact on simulation accuracy. The study explores the role of key calibration parameters like CC (car-following) parameters, desired headway time, sensitivity to preceding vehicles, and stopped condition acceleration. These influence vehicle interactions such as following distances, accelerations, and decelerations. They emphasize calibrating the model to reflect real-world traffic accurately, using techniques that involve varying and testing parameter combinations across scenarios.

Pedestrian and Non-Motorized Traffic in Multi-Leg Intersections:

Sisiopiku and Akin (2003): examined pedestrian behaviour at multi-leg intersections using VISSIM, focusing on the safety and efficiency of pedestrian crossings. Their findings highlighted the importance of considering pedestrian traffic in the design and management of multi-leg intersections. The study by Sisiopiku and Akin (2003) utilized the VISSIM simulation software to evaluate traffic signal performance and address the challenges of oversaturated arterial networks. Their research focused on optimizing signal timings and examining strategies to mitigate congestion, emphasizing the importance of dynamic traffic assignment (DTA) in such scenarios.

Case Studies and Real-World Applications:

Several case studies have demonstrated the practical application of VISSIM in the analysis and improvement of multi-leg intersections. These studies typically involve the simulation of existing intersections to identify issues and test potential improvements before implementation.

Milam and Stanek (2001):documented a case study involving a multi-leg intersection in California, where VISSIM was used to evaluate the impact of proposed changes in lane configuration and signal timing. The study showed how VISSIM could provide detailed insights that informed decision-making processes. Milam and Stanek (2001) conducted a study comparing macroscopic and microscopic traffic modelling tools, particularly focusing on applications for

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roundabouts. Their research highlighted the advantages and challenges of using VISSIM, a microscopic simulation software, for evaluating traffic performance, especially in cases involving complex geometries and oversaturated conditions.

Congestion Management, Public Transport and Traffic Simulation:

VISSIM's capability to model individual vehicle behaviour under various traffic scenarios. Demonstrated the integration of VISSIM with external platforms like MATLAB to test advanced traffic signal algorithms. Insights into improving signal timings and flow management using simulated scenarios. Highlighted urban intersections with congestion challenges and how optimization through VISSIM could reduce delays and emissions.

Yang, H., & Xu, J. (2015):The study by Yang and Xu (2015) explores the application of VISSIM software in simulating and analysing urban traffic scenarios, focusing on the evaluation and optimization of traffic flow under various conditions.

Limitations and Challenges:

Ma and Li (2014): discussed the challenges of calibrating VISSIM models for complex intersections, emphasizing the importance of using real-world data to ensure accurate simulations. The 2014 paper by Ma and Li, titled "Application of VISSIM in Traffic Simulation and Analysis", focuses on the use of VISSIM (a microscopic traffic simulation software) to model and analyse traffic flow and transportation systems. The paper highlights the advantages, challenges, and effectiveness of using VISSIM in urban planning, traffic management, and transportation studies.

III. METHODOLOGY

1) Data Collection

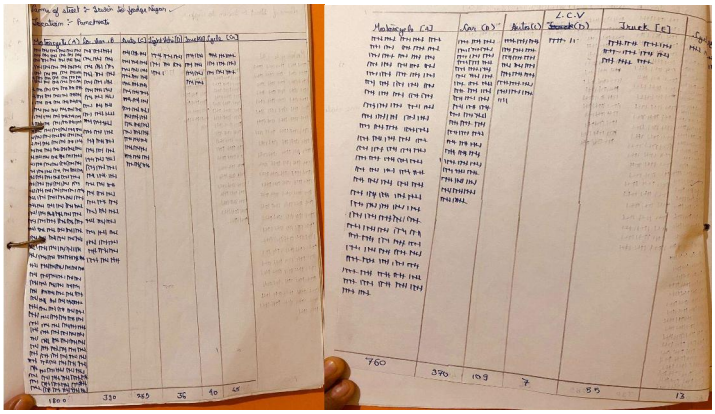

Fig. 1. Data collected at Panchavati square, Amravati

2) Traffic Volume Data: Manual or automated vehicle counts during peak and off-peak hours.
3) Geometric Data: Intersection layout, number of lanes (total 26 links)
4) Signal Timings: Existing signal phases and cycle lengths.
5) Model Development in VISSIM
6) Input traffic volume, vehicle route and signal timing data.
7) Calibrate the model using real-world observations to ensure accuracy
8) Simulation and Analysis
9) Run baseline simulations to evaluate current performance metrics such as queue lengths, delays, and Level of Service (LOS).
10) Identify problem areas (e.g., high delays, congestion hotspots.
11) Optimization Scenarios.

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12) Signal timing adjustments.
13) Evaluate the performance of each scenario based on key metrics like average delay, queue length and emissions.
14) Result Interpretation

IV. CONCLUSION

It is a powerful tool for analysing traffic flow, optimizing signal timings, and improving overall intersection performance by simulating different traffic scenarios VISSIM helps identify conflict points, no. of links, vehicle input, vehicle routes which gives queue length, density, delay result, vehicle travel time etc. for particularly Panchavati square Ultimately, VISSIM supports informed decision-making for infrastructure planning, offering insights into improving traffic management, reducing emissions, and enhancing safety at complex intersections like Panchavati Square.

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