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TRAFFIC FLOW ANALYSIS AND CONGESTION MITIGATION STRATEGIES FOR HESARAGHATTA ROAD

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Abstract*— Rapid urbanization in Bengaluru has led to severe congestion across arterial corridors. This paper presents a detailed traffic flow analysis of Hesaraghatta Road near Chikkabanavara, a critical connector between residential, educational, and industrial zones. Using Classified Volume Counts (CVC), Passenger Car Unit (PCU) conversion (IRC:106-1990), and Level of Service (LOS) evaluation, the study quantifies operational efficiency and identifies bottlenecks. Results show a peak-hour flow of 1841 PCU/hr, PHF of 0.95, and LOS between D–E, indicating unstable flow conditions. Recommendations include short-term interventions (bus bays, pedestrian crossings, encroachment removal) and long-term strategies (road widening, signal optimization, AI-based traffic management).

***Keywords*— Traffic Flow Analysis, Passenger Car Unit, Peak Hour Factor, Level of Service, Urban Congestion**

I. INTRODUCTION

Rapid urbanization and increasing vehicle ownership have significantly impacted traffic conditions in metropolitan cities. Bengaluru, known for its rapid growth in IT and industrial sectors, faces severe congestion problems due to inadequate infrastructure and increasing demand.

Hesaraghatta Road is a vital urban corridor connecting residential areas, educational institutions, and commercial zones. The stretch near Chikkabanavara experiences high traffic volumes throughout the day, particularly during peak hours.

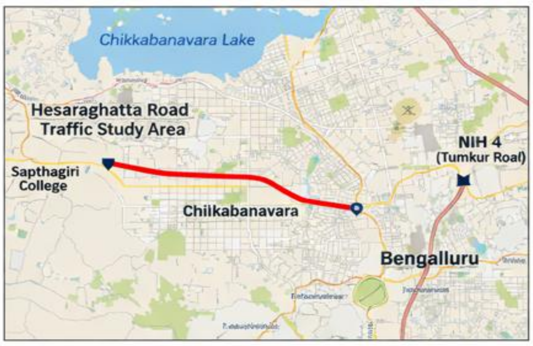

Fig. 1: Study Area Location

The presence of heterogeneous traffic, including two-wheelers, cars, auto-rickshaws, buses, and heavy vehicles, creates complex traffic flow conditions. Additionally, roadside encroachments, lack of pedestrian infrastructure, and poor traffic management contribute to congestion.

Traffic flow analysis is essential for evaluating roadway performance and identifying measures to improve traffic conditions. This study focuses on analysing traffic characteristics and proposing suitable solutions.

II. LITERATURE REVIEW

Traffic flow modeling in developing countries is significantly different from that in developed nations due to heterogeneous traffic conditions.

Reddy and Srivastava (2020) emphasized that conventional traffic models are not suitable for Indian roads due to mixed traffic composition. Gap acceptance theory explains how smaller vehicles utilize available space aggressively, leading to unstable flow.

Tsuboi (2021) highlighted the importance of traffic optimization for reducing emissions and improving sustainability. Gong et al. (2022) introduced data-driven approaches for traffic equilibrium analysis.

Recent studies have explored AI and IoT integration in traffic systems for real-time monitoring and predictive analysis. However, there is a lack of localized studies focusing on suburban corridors like Hesaraghatta Road.

III. PROBLEM STATEMENT

Hesaraghatta Road experiences severe congestion due to high traffic demand and inadequate infrastructure. The limited carriageway width, lack of traffic control, and roadside encroachments reduce effective road capacity.

Unregulated pedestrian movement and absence of bus bays further disrupt traffic flow. During peak hours, traffic becomes highly unstable, resulting in delays and reduced speeds. There is a need for detailed traffic analysis to evaluate performance and propose effective solutions.

IV. OBJECTIVES OF THE STUDY

The primary objective of this study was to evaluate the traffic characteristics along Hesaraghatta Road in order to understand congestion patterns and roadway performance. This required a systematic approach to quantify traffic demand, analyze flow conditions, and identify operational inefficiencies. Specifically, the study sought to:

- Conduct classified volume counts for different vehicle categories during peak and non-peak hours, thereby capturing the heterogeneity of traffic.
- Convert raw traffic counts into Passenger Car Units (PCU) using IRC:106-1990 standards, ensuring comparability across vehicle types.
- Compute essential traffic parameters such as flow rate, density, speed, and Peak Hour Factor (PHF) to establish the corridor's operational profile.
- Determine the Level of Service (LOS), a widely accepted measure of roadway performance, to assess user experience under varying demand conditions.

Secondary objectives included identifying critical bottlenecks such as roadside encroachments, pedestrian conflicts, and unregulated bus/auto stops, documenting geometric features like lane and shoulder widths, and proposing short-term and long-term engineering measures to improve safety and efficiency. Together, these objectives provided a holistic framework for diagnosing congestion and recommending interventions.

V. METHODOLOGY

The methodology was designed to ensure accuracy, reproducibility, and contextual relevance. It unfolded in several stages:

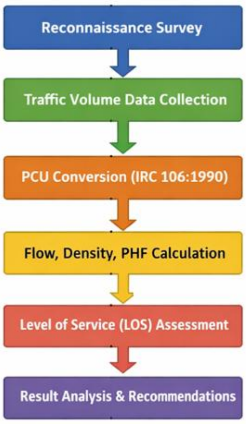

Fig. 2: Methodology Flowchart

1. **Reconnaissance Survey**: A preliminary site visit was conducted to map lane widths, pedestrian desire lines, and informal stopping points. This revealed the corridor's geometric constraints and highlighted areas of conflict between vehicles and pedestrians.
2. **Data Collection**: Classified traffic counts were recorded at 15-minute intervals during both peak (8–10 AM) and non-peak (2–4 PM) hours. The survey was repeated on three separate days to account for variability.
3. **PCU Conversion**: Heterogeneous traffic was standardized using IRC:106-1990 PCU factors. This allowed two-wheelers, cars, autos, buses, and heavy vehicles to be expressed in a common unit, enabling meaningful comparison.
4. **Computation of Parameters**: Flow rate, density, PHF, and LOS were calculated. For example, PHF was derived using the formula

PHF=V/(4×V15), where V is the total hourly volume and V15 is the maximum 15-minute volume.

5. **Result Evaluation**: Field observations were correlated with computed metrics to identify bottlenecks. This ensured that numerical findings were grounded in real-world conditions.

VI. RESULTS AND DISCUSSION

The results revealed a **corridor under severe stress** during peak hours.

- **Traffic Volume**: Peak-hour flow reached **1841 PCU/hr**, while non-peak flow was only **294 PCU/hr**. This stark contrast highlights tidal flow characteristics, with morning demand overwhelming the corridor.

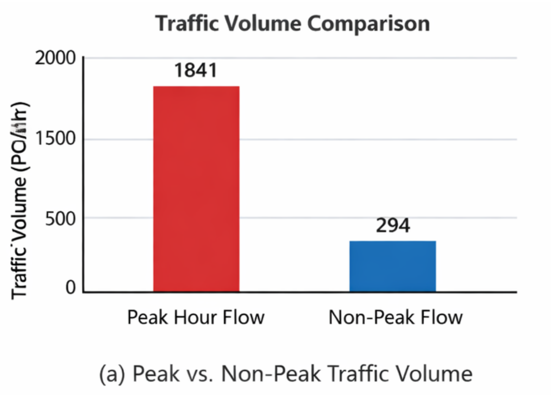

Fig. 3. Traffic Volume Comparison

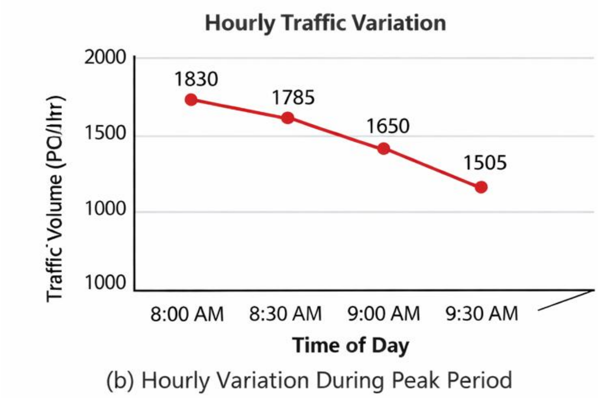

Fig. 4. Hourly Traffic Variation

- **Traffic Composition**: Two-wheelers dominated at **65–70%**, followed by cars (**15–18%**), autos (**10–12%**), and buses/heavy vehicles (**5–8%**). While two-wheelers occupy less space, their frequent lane filtering disrupts larger vehicles. Cars, often single-occupancy, contribute to low person-throughput. Autos add friction due to unregulated stopping, while buses and heavy vehicles, though fewer, exert a disproportionate impact because of their high PCU values.

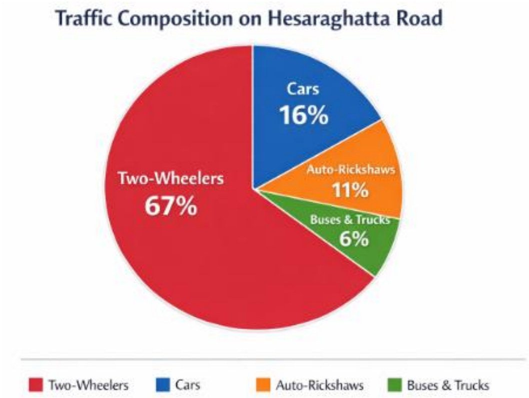

Fig. 5. Traffic composition

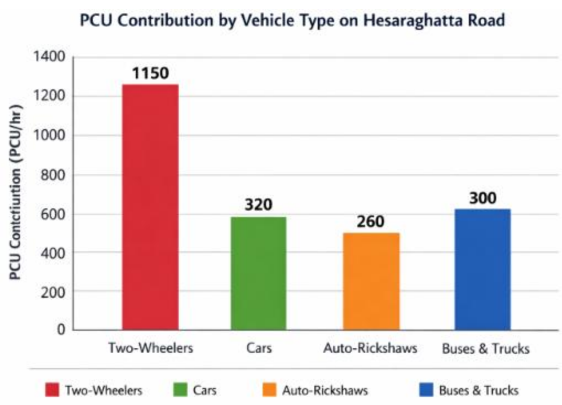

Fig. 6. PCU Contribution by Vehicle type

- **PHF and Density**: The PHF was calculated at **0.95**, indicating sustained high demand throughout the peak hour. Density was approximately **68 vehicles per kilometer**, a level associated with unstable flow, frequent braking, and reduced lane discipline.

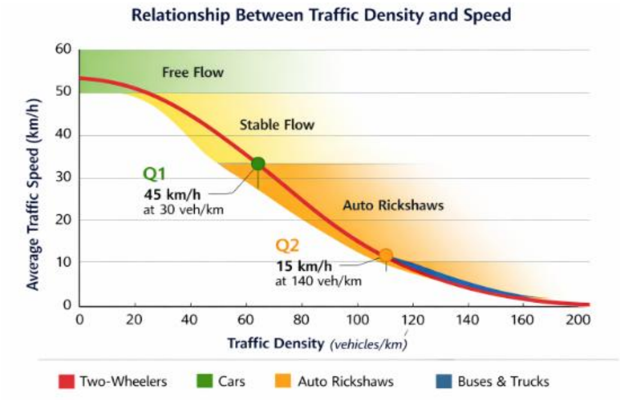

Fig. 7. Relationship between Traffic Density & Speed

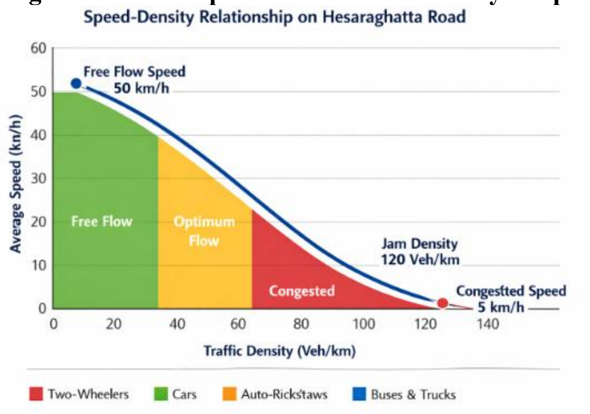

Fig. 8. Speed-Density Relationship

- **Level of Service (LOS)**: Based on these metrics, the corridor's LOS was classified between **D and E**, representing near-capacity conditions with stop-and-go movement and high delays.

Level of Service (LOS) Classification

LOS	Description	Traffic Flow Conditions	V/C Ratio
A	Free Flow	Unrestricted, Excellent	≤ 0.30
B	Stable Flow	Slight Delays	0.31 – 0.50
C	Moderate Flow	Noticeable Congestion	0.51 – 0.70
D	Approaching Capacity	Frequent Delays	0.71 – 0.85
E	Unstable Flow	Severe Congestion	0.86 – 1.00
F	Forced Breakdown	Gridlock, Failing	> 1.00

Two-Wheders   Cars   Auro-Ridshaws   Buses & Trucks

Fig. 9. Level of Service (LOS) Classification

- **Interpretation**: These findings confirm that Hesaraghatta Road operates at or near capacity during peak hours. The lack of designated bus bays, roadside encroachments, and inadequate pedestrian facilities exacerbate congestion.

This study confirms that the Hesaraghatta Road corridor is currently operating under strained conditions. The high PHF (0.95) and LOS (D-E) suggest that the current infrastructure is inadequate for the existing traffic demand. While short-term enforcement can offer immediate relief by restoring effective road width, long-term sustainability requires the integration of ITS and grade-separated pedestrian facilities. The data presented here provides a technical baseline for municipal authorities to prioritize investment in this critical urban artery.

VII. PROPOSED SOLUTIONS

The traffic analysis of Hesaraghatta Road indicates that the corridor operates under near-capacity conditions, with unstable flow and frequent delays during peak hours. To address these challenges, a set of engineering, technological, and policy-based interventions are proposed. These solutions aim to enhance operational efficiency, safety, and sustainability while accommodating future traffic growth.

A. Operational and Engineering Interventions (Short-Term)

Geometric Adjustments: Implementation of intersection channelization and the construction of recessed bus bays to isolate boarding activities from the primary through-traffic.

Carriageway Recovery: Strict enforcement of "No-Parking" zones and the removal of roadside encroachments to restore effective lane width.

B. Strategic and Technological Interventions (Long-Term)

Adaptive Signal Control: Transitioning from fixed-time to sensor-based signaling to dynamically manage green-time allocation based on real-time density.

Capacity Expansion: Targeted road widening and the introduction of dedicated turning lanes at the Chikkabanavara bottleneck to enhance the base capacity of the corridor.

VIII. CONCLUSION

The empirical evidence suggests that Hesaraghatta Road is operating at the threshold of its functional capacity. The high PHF and LOS D–E assessment confirm that existing infrastructure cannot support current demand levels without significant intervention. By integrating physical infrastructure improvements with data-driven traffic management, the corridor can achieve a more stable equilibrium, improving both transit efficiency and safety for all road users.

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REFERENCES

[1] B. D. Greenshields, “A Study of Traffic Capacity,” Highway Research Board Proceedings, vol. 14, pp. 448–477, 1935.

[2] H. Greenberg, “An Analysis of Traffic Flow,” Operations Research, vol. 7, no. 1, pp. 79–85, 1959.

[3] R. T. Underwood, “Speed, Volume, and Density Relationships—Quality and Theory of Traffic Flow,” Yale Bureau of Highway Traffic, 1961.

[4] L. A. Pipes, “An Operational Analysis of Traffic Dynamics,” Journal of Applied Physics, vol. 24, no. 3, pp. 274–281, 1953.

[5] Transportation Research Board, Highway Capacity Manual (HCM), Washington, D.C., 2010.

[6] Indian Roads Congress, “Guidelines for Capacity of Urban Roads in Plain Areas,” IRC:106–1990, New Delhi, India.

[7] Indian Roads Congress, “Geometric Design Standards for Urban Roads,” IRC:86–1997, New Delhi, India.

[8] Ministry of Road Transport and Highways (MoRTH), “Specifications for Road and Bridge Works,” Government of India.

[9] K. Reddy and A. Srivastava, “Traffic Capacity Analysis under Mixed Traffic Conditions in Indian Urban Roads,” Journal of Indian Roads Congress, vol. 81, no. 2, pp. 120–130, 2020.

[10] B. Prasad, V. Surisetty, et al., “Gap Acceptance Behavior in Mixed Traffic Conditions at Unsignalized Intersections,” International Journal of Traffic and Transportation Engineering, vol. 9, no. 4, pp. 215–223.

[11] T. Tsuboi, “Traffic Flow Optimization for Low Carbon Transportation Systems,” SATREPS Program Report, 2021.

[12] H. Kaur, S. Mishra, and P. Badhan, “AI and IoT-Based Predictive Traffic Management Systems,” Proceedings of the 8th International Conference on Outcome Based Engineering Education (ICOEI), 2025.

[13] Bengaluru Urban Mobility Study Reports, “Traffic Behavior and Congestion Analysis in Bengaluru,” 2018–2023.

[14] L. R. Kadiyali, Traffic Engineering and Transport Planning, New Delhi: Khanna Publishers.

[15] S. K. Khanna and C. E. G. Justo, Highway Engineering, New Delhi: Nem Chand & Bros