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Transformation and Development of Level of Service (LOS) in Mixed Traffic Situations

[1]K. Smitha Suguna Leela, [2]D. Rajashekar Reddy

[1]Assistant Professor, Civil Engineering Department, Matrusri Engineering College, Saidabad, Hyderabad, TS, India

[2]Professor, Civil Engineering Department, University College of Engineering (UCE), Osmania University (OU), Hyderabad, TS, India.

Abstract - Level of Service (LOS) is a qualitative metric used to evaluate the quality of vehicular traffic service, focusing on roadways and intersections from the traveler's perspective. While the Highway Capacity Manual (HCM) provides LOS criteria established for developed nations, these criteria carriage significant challenges when applied in developing countries like India. The Asia-Pacific region, including India, is characterized by heterogeneous traffic conditions, where diverse vehicle types and unpredictable traffic behaviors create complexities that existing models cannot adequately address. This study examines LOS in the context of mixed traffic conditions prevalent in Indian urban areas by analyzing findings from various researchers. The analysis aims to offer insights into refining LOS criteria to better suit the unique traffic dynamics of developing nations, ultimately contributing to more accurate and practical assessments of traffic service quality.

Keywords- Level of Service (LOS), Highway Capacity Manual (HCM), vehicular traffic service, mixed traffic conditionsTransactions, User Authentication Shopping Cart, Order Tracking

I. INTRODUCTION

The concept of Level of Service (LOS) is fundamental in transportation engineering, serving as a qualitative measure to evaluate the quality of vehicular traffic service. Introduced by the Highway Capacity Manual (HCM) in 1965, LOS categorizes traffic conditions into six levels, from A (free-flowing) to F (congested), based on Measures of Effectiveness (MoE) such as speed, travel time, and density. While these criteria provide valuable benchmarks in developed nations, their direct application in developing countries like India presents significant challenges.

India, along with other nations in the Asia-Pacific region, experiences unique traffic dynamics characterized by a high degree of heterogeneity. The traffic mix includes a wide variety of vehicles—ranging from bicycles and motorcycles to cars, buses, and trucks often sharing the same road space. This diversity, combined with varying driver behaviors and road conditions, results in complex traffic flows that existing LOS models struggle to accurately predict and assess.

In the Indian context, traditional LOS frameworks, as outlined by the HCM, fall short of addressing the specific challenges posed by mixed traffic conditions. These conditions are marked by irregularities that affect traffic movement and safety, necessitating a more tailored approach to accurately gauge traffic service quality. This study seeks to bridge this gap by evaluating and adapting LOS criteria to better

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reflect the realities of mixed traffic scenarios in India. Drawing insights from various researchers and practitioners, this research aims to develop a more effective and contextually relevant framework for assessing LOS in heterogeneous traffic environments.

II. PROBLEM STATEMENT

The application of Level of Service (LOS) criteria, as outlined by the Highway Capacity Manual (HCM), is primarily designed for developed nations with relatively homogeneous traffic conditions. In contrast, developing countries like India face significant challenges due to the prevalence of heterogeneous or mixed traffic conditions. The diverse mix of vehicle types including bicycles, motorcycles, cars, buses, and trucks combined with varying traffic behaviors and infrastructure constraints, creates complex traffic flows that existing LOS models fail to accurately predict or assess. This discrepancy results in an inadequate evaluation of traffic service quality, leading to potential inefficiencies in traffic management and infrastructure planning. The absence of a tailored LOS framework for mixed traffic conditions in India underscores the need for a comprehensive study that redefines LOS criteria to reflect the unique traffic dynamics of developing nations. This study aims to address this gap by analyzing current findings and proposing an adapted LOS framework suitable for heterogeneous traffic environments.

III. OBJECTIVES OF THE PRESENT STUDY

- To conduct a comprehensive literature review for a detailed understanding of Level of Service in the context of mixed traffic.
- To analyze the findings of various authors to understand the challenges and limitations of implementing LOS in heterogeneous traffic conditions.
- To study and document the traffic patterns and characteristics specific to mixed traffic situations in India
- To develop and propose modifications or new approaches to the LOS criteria that are better suited for the Indian context, ensuring accurate and practical assessment of traffic service quality.

IV. LITERATURE REVIEW

Bidkar et al. (2023) investigated the impact of construction work zones on rear-end conflicts under heterogeneous traffic conditions. Their study highlighted the increased risk of collisions due to the diverse mix of vehicles and the varying speeds at which they operate. Singh et al. (2024) conducted a study on the safety performance of divided multilane highways in India, focusing on the effects of access points, geometric design, and heterogeneous traffic. Their findings underscored the need for context-specific LOS criteria that consider the unique traffic dynamics of Indian roads. Rao and Kumar (2022) developed a travel time congestion index (TTCI) tailored for urban roads in India. This index accounts for the differences between actual and desired travel times, providing a more accurate assessment of congestion levels in mixed traffic conditions.

V. METHOD & ANALYSIS

The study aimed to evaluate the Level of Service (LOS) under heterogeneous traffic conditions on urban roads. Data collection was performed using video recordings of traffic flow at selected road sections. LOS evaluation was based on key parameters: road characteristics, average speed, and volume-to-capacity (V/C) ratio. The LOS was categorized using standard definitions, where LOS A represents the best quality of service and LOS F the worst.

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- Data Collection: Traffic data was collected through video analysis, capturing vehicle types, speeds, and traffic volumes during peak hours (9 AM to 10 AM IST).
- LOS Classification: Vehicles were categorized according to average speed (Table 1) and volume-to-capacity ratio (Table 4). The speed-based classification used specific thresholds for each LOS category.
- PCU Calculation: Passenger Car Unit (PCU) values for different vehicle types were used to calculate the volume-to-capacity ratio, based on Indian Highway Capacity Manual (Indo-HCM, 2017) standards.
- Speed-Based LOS: The average speed of vehicles was compared against predefined thresholds to assign LOS categories for each road section. Table 1 provided the specific speed ranges corresponding to LOS A to F.

Volume-to-Capacity Ratio: The PCU values were multiplied by vehicle counts to calculate the PCU/hr for each vehicle type, allowing for the determination of the V/C ratio (Table 4). Traffic Composition: Pie charts were used to represent the distribution of vehicle types in the traffic flow. It was noted that motorcycles constituted over 50% of the traffic, while heavy vehicles made up only about 1%.
Table 1 classifies the Level of Service (LOS) for roads based on the average speed of vehicles. LOS is a qualitative measure indicating the operational conditions within a traffic stream. The classifications are as follows:

LOS A: Represents free-flow conditions with very high speeds and minimal restrictions. Vehicles can travel at or near the desired speed.
LOS B: Indicates stable flow with slight restrictions on maneuverability. Vehicles travel at relatively high speeds.
LOS C: Represents a stable flow with more restrictions on vehicle maneuverability. Speeds are moderate.
LOS D: Denotes a high-density flow with significant restrictions. Speeds are lower, and maneuverability is restricted.
LOS E: Represents a very high-density flow with limited speed and maneuverability. Conditions are near or at capacity.
LOS F: Indicates forced flow with extremely low speeds and severe congestion.
The average speed of vehicles is measured using video analysis, and based on predefined speed ranges, roads are classified into one of the LOS categories.

Table 1: Level of Service Based on Average Speed of Vehicles

Sr. No	LOS	Street Class 1 (km/h)	Street Class 2 (km/h)
1	A	>30	>40
2	B	26-30	28-40
3	C	20-25	18-27
4	D	15-19	13-17
5	E	10-14	12-16
6	F	<10	<12

PCU Calculation

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Where:
Veh/hr is the number of vehicles per hour.
PCU is the Passenger Car Unit value assigned to each vehicle type.
For example, for 2-wheelers:

Table 2: PCU and PCU/hr for Street 1

Sr. No	Vehicle	Veh/hr	PCU	PCU/hr
1	2-WHEELER	250	0.20	50
2	CARS	75	1.00	75
3	LCV	10	2.00	20
4	TRUCK	2	3.50	7
5	BUS	4	3.50	14
6	3-WHEELER	60	0.70	42

Similar to Table 2, this table presents the PCU and PCU/hr calculations for Street 2. The same formula is applied:

PCU Calculation
For example, for cars on Street 2:

Table 3: PCU and PCU/hr for Street 2

Sr. No	Vehicle	Veh/hr	PCU	PCU/hr
1	2-WHEELER	280	0.20	56
2	CARS	140	1.00	140
3	LCV	25	2.00	50
4	TRUCK	3	3.50	10.5
5	BUS	15	3.50	52.5
6	3-WHEELER	70	0.70	49

Table 4 classifies LOS based on the Volume-to-Capacity (V/C) ratio, which is a measure of the demand placed on the transportation facility relative to its capacity.

V/C Ratio Calculation
Where:
Volume (PCU/hr) is the total PCU per hour (calculated from Table 2 and Table 3).
Capacity (PCU/hr) is the maximum PCU that can be accommodated on the road without congestion.

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Based on the V/C ratio:
LOS A: Indicates a V/C ratio of less than 0.12 (free-flow).
LOS B: V/C ratio between 0.12 and 0.23.
LOS C: V/C ratio between 0.23 and 0.65.
LOS D: V/C ratio between 0.65 and 0.95.
LOS E: V/C ratio between 0.95 and 4.50 (near capacity).
LOS F: V/C ratio greater than 4.50 (congested)

Table 4: Level of Service Based on Volume-to-Capacity Ratio

Sr. No	Category	Street Class 1	Street Class 2
1	A	<0.12	<0.25
2	B	0.12-0.23	0.25-0.40
3	C	0.23-0.65	0.40-0.95
4	D	0.65-0.95	0.95-1.20
5	E	0.95-4.50	1.20-4.50
6	F	>4.50	>4.50

VI. RESULT AND DISCUSSION

The combined analysis of average speed and volume-to-capacity (V/C) ratios across different Levels of Service (LOS) categories reveals critical insights into traffic conditions under mixed traffic scenarios. The bar chart depicting average speeds shows a clear decline from LOS A to F, highlighting how traffic flow quality deteriorates with increasing congestion. Concurrently, the line graphs for Street 1 and Street 2 illustrate rising V/C ratios, indicating a growing strain on road capacity as traffic demand increases. Notably, Street 2 exhibits higher V/C ratios than Street 1 across all LOS categories, pointing to more severe congestion issues. These findings underscore the necessity for targeted traffic management interventions and infrastructure improvements, particularly in areas with high V/C ratios and lower average speeds, to enhance traffic flow and reduce congestion. Overall, the study emphasizes the importance of adapting Level of Service criteria to better reflect the complexities of heterogeneous traffic conditions, ultimately contributing to more effective urban traffic planning and management.

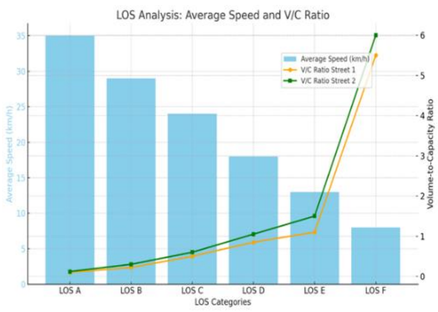

Figure 1: Analysis of average speed and volume-to-capacity (V/C) ratios across different Levels of Service (LOS)

VII. CONCLUSION

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In conclusion, this study has demonstrated the challenges of applying traditional Level of Service (LOS) criteria to heterogeneous traffic conditions commonly found in urban areas. By analyzing both average speed and volume-to-capacity ratios, we identified that while some road sections maintain relatively good service quality (LOS B), others experience significant congestion (LOS E and F), particularly during peak hours. The data highlights the limitations of current LOS methodologies in accurately reflecting the complexities of mixed traffic environments, emphasizing the need for more context-specific approaches. The findings advocate for targeted traffic management strategies and infrastructure enhancements to improve overall traffic flow and reduce congestion. Ultimately, adapting LOS frameworks to account for the unique dynamics of developing countries can lead to more efficient and sustainable urban transportation systems.

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