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Assessment of Urban Roadway Performance through Traffic Volume, PCU, and LOS Analysis Using IRC Standards

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1. ABSTRACT :

Rapid urbanization and continuous growth in vehicular population have created serious operational challenges on urban roads in India. Heterogeneous traffic conditions, roadside activities, inadequate roadway infrastructure, and lack of lane discipline frequently reduce traffic efficiency and increase congestion levels. The present study focuses on assessing urban roadway performance through traffic volume analysis, Passenger Car Unit (PCU) estimation, and Level of Service (LOS) evaluation using IRC standards.

Traffic data was collected from selected urban road sections through manual traffic counting and video recording surveys during peak and off-peak hours. Vehicles were classified into different categories and converted into equivalent PCU values for effective analysis under mixed traffic conditions. Roadway capacity was estimated using IRC methodology, and Volume-to-Capacity (V/C) ratios were calculated to determine operational conditions and LOS categories.

The results revealed that major urban roads operate under moderate to congested conditions, with higher V/C ratios observed on arterial corridors. The study highlights the influence of roadway geometry, traffic composition, and roadside friction on traffic performance. Appropriate traffic management strategies and infrastructure improvements were recommended for enhancing roadway efficiency and reducing congestion.

2. KEYWORDS: Roadway Performance, Traffic Volume, Passenger Car Unit (PCU), Level of Service (LOS), Urban Traffic, IRC Standards, Traffic Congestion, V/C Ratio, Mixed Traffic Flow, Urban Transportation.

3. INTRODUCTION

Urban transportation systems have become increasingly important due to rapid population growth, economic expansion, and continuous urban development. In recent years, Indian cities have experienced a substantial rise in travel demand because of increasing industrial activities, commercial development, and improved living standards. The number of private vehicles, particularly two-wheelers and passenger cars, has increased rapidly, placing additional pressure on existing road infrastructure. However, roadway expansion and transportation planning have not progressed at the same pace as vehicular growth, resulting in severe congestion and operational inefficiencies on urban roads.

Traffic congestion has emerged as a major challenge in many Indian cities, especially during peak travel periods. Increased delays, low travel speeds, higher fuel consumption, and environmental pollution are common consequences of overloaded urban road networks. In addition, roadside activities, irregular parking, pedestrian movement, and lack of traffic discipline further affect traffic flow conditions and reduce roadway efficiency. Such problems highlight the necessity of evaluating roadway performance through systematic traffic analysis.

Roadway performance evaluation is essential for understanding the operational condition of urban roads and identifying sections operating under excessive traffic pressure. Traffic volume studies provide valuable information regarding the magnitude and variation of traffic flow during different time periods. These studies help in identifying congestion-prone areas and understanding traffic demand patterns. Under heterogeneous traffic conditions, the concept of Passenger Car Unit (PCU) becomes important because it converts different vehicle categories into a common equivalent unit for effective analysis. Similarly, Level of Service (LOS) analysis helps in assessing roadway performance in terms of speed, comfort, convenience, and traffic flow quality.

The present research aims to assess urban roadway performance using traffic volume analysis, PCU estimation, and LOS evaluation based on IRC standards. The study focuses on understanding traffic behavior, evaluating roadway operational efficiency, and suggesting suitable measures for improving traffic conditions on urban roads.

4. TRAFFIC CHARACTERISTICS OF URBAN ROADS

Urban roads in India exhibit highly complex traffic conditions due to the presence of heterogeneous traffic streams and mixed vehicle behavior. A wide variety of vehicles, including two-wheelers, auto-rickshaws, passenger cars, buses, trucks, bicycles, and other slow-moving vehicles, share the same roadway space simultaneously. Since these vehicles differ significantly in size, speed, acceleration, and maneuverability, traffic flow becomes irregular and difficult to predict.

Mixed traffic behavior is one of the most significant characteristics of Indian urban roads. Smaller vehicles frequently move through available gaps between larger vehicles, creating continuous lateral movement within the traffic stream. This flexible use of roadway space reduces the effectiveness of lane-based traffic flow assumptions commonly applied in homogeneous traffic systems. The absence of strict lane discipline further intensifies traffic complexity, as drivers often utilize any available portion of the roadway to advance during congested conditions.

Vehicle interaction patterns also influence roadway performance significantly. Fast-moving vehicles interact continuously with slower vehicles, leading to overtaking maneuvers, sudden braking, and inconsistent vehicle spacing. Heavy vehicles occupy greater road space and affect the movement of surrounding vehicles, while two-wheelers and auto-rickshaws exhibit highly maneuverable movement patterns. Such interactions reduce traffic stability and influence roadway capacity.

Urban roadway operations are additionally affected by roadside friction factors such as on-street parking, commercial activities, bus stoppages, and pedestrian movement. These activities reduce the effective width of the roadway and create localized bottlenecks. As a result, traffic speeds decrease and congestion levels increase, especially during peak periods. The combined effect of heterogeneous traffic, poor lane discipline, and roadside disturbances creates operational challenges that require detailed traffic analysis and effective management strategies.

5. STUDY AREA AND ROAD NETWORK DETAILS

The present study was conducted in Rohtak, an important urban center of Haryana that has experienced considerable growth in population, commercial development, and transportation demand over recent years. The city serves as a major educational, administrative, and commercial hub, resulting in continuous traffic movement throughout the day. Rapid urbanization and increasing vehicle ownership have significantly affected roadway performance and traffic conditions within the city.

For the purpose of analysis, selected urban road sections representing different roadway categories were identified. The selected roads include arterial roads, sub-arterial roads, and collector roads to ensure representation of varying traffic conditions and roadway functions. Delhi Road was selected as an arterial corridor carrying high traffic volume and serving major traffic movement across the city. Hisar Road was selected as a sub-arterial road connecting important urban zones, while Model Town Road was considered as a collector road serving local traffic movement within residential and commercial areas.

The road network in the study area experiences heterogeneous traffic conditions characterized by mixed vehicle movement, variable speeds, and frequent roadside activities. Two-wheelers constitute a major share of the traffic stream, followed by passenger cars, auto-rickshaws, buses, and trucks. Peak hour congestion is commonly observed on major corridors where traffic demand approaches roadway capacity. Factors such as roadside parking, pedestrian movement, commercial encroachments, and irregular lane usage further influence roadway operational conditions.

The selected road sections provide a suitable basis for evaluating urban roadway performance through traffic volume studies, PCU analysis, and LOS assessment using IRC standards.

7. METHODOLOGY FOR TRAFFIC ANALYSIS

The collected traffic and roadway data were analyzed systematically to evaluate urban roadway performance under heterogeneous traffic conditions. The methodology involved traffic volume analysis, vehicle classification, Passenger Car Unit conversion, capacity estimation, Volume-to-Capacity ratio analysis, and Level of Service evaluation using IRC standards.

7.1 Traffic Volume Analysis

Traffic volume analysis was carried out to determine the number of vehicles using the selected road sections during different periods of the day. Vehicle count data obtained from field surveys was analyzed to identify peak traffic conditions and traffic demand characteristics.

Hourly traffic variation was also examined to understand fluctuations in roadway usage throughout the survey period. The analysis helped in identifying peak congestion periods and operational conditions of the selected roads.

7.2 Vehicle Classification

The observed traffic stream was classified into different categories based on vehicle type. Major vehicle categories included two-wheelers (2W), three-wheelers (3W), passenger cars, buses, and trucks. Classification was necessary because each vehicle category influences traffic flow differently due to variations in size, speed, and maneuverability.

The classification analysis also helped in understanding the traffic composition of each road section and its effect on roadway performance.

7.3 Road Capacity Estimation

Road capacity estimation was performed using IRC standard methodology. The capacity of selected road sections was determined by considering factors such as traffic composition, roadway geometry, lane width, roadside friction, and operational conditions.
The methodology adopted from IRC standards provided realistic estimates of roadway capacity under Indian traffic conditions. Capacity values obtained from the analysis indicate the maximum traffic flow that can be accommodated efficiently under prevailing conditions.

7.4 Level of Service Evaluation

Level of Service (LOS) evaluation was carried out to assess roadway performance qualitatively. LOS categories range from LOS A to LOS F, where LOS A indicates free-flow conditions and LOS F represents severe congestion and breakdown flow conditions.
Performance assessment was conducted based on the calculated V/C ratio and roadway operational characteristics. The LOS evaluation helped in identifying road sections operating under stable, moderate, or congested traffic conditions.

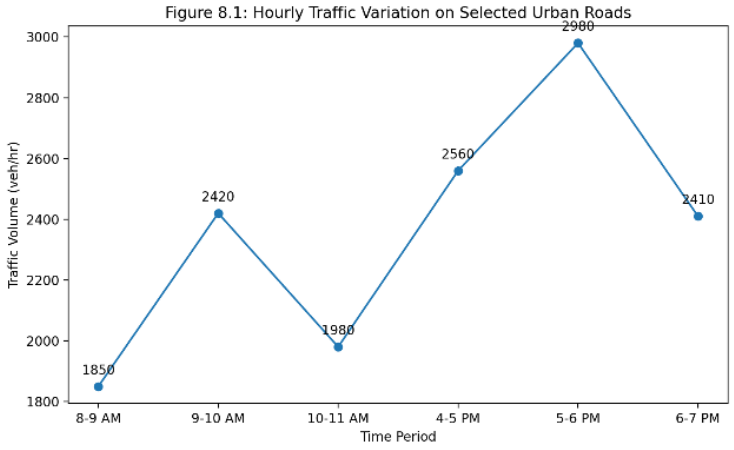
8. RESULTS AND ANALYSIS

Traffic analysis was carried out to evaluate roadway operational conditions under heterogeneous urban traffic environments. The collected field data was examined to understand traffic variation, roadway utilization, and congestion characteristics during different periods of the day. The study revealed considerable fluctuation in traffic movement between peak and non-peak hours, indicating the influence of urban travel demand on roadway performance.
The analysis showed that traffic volume increases significantly during morning and evening peak periods due to office travel, educational activities, and commercial movement. Comparatively lower traffic flow was observed during mid-day hours, where traffic conditions remained relatively stable. The highest traffic demand was recorded during evening peak periods because of simultaneous movement of office commuters, local traffic, and commercial vehicles.
The observed traffic stream consisted of mixed vehicle categories including two-wheelers, three-wheelers, passenger cars, buses, and trucks. Two-wheelers formed the dominant category because of their affordability and convenience in congested urban conditions. Passenger cars also contributed significantly to total traffic flow, while heavy vehicles occupied larger roadway space and affected traffic movement despite their lower numerical share.
The roadway operational condition was further influenced by roadside friction factors such as roadside parking, pedestrian movement, commercial encroachments, and bus stoppages. These activities reduced the effective carriageway width and contributed to localized congestion during high traffic demand periods. Roads with comparatively better geometric conditions and wider carriageways exhibited smoother traffic movement than roads with limited operational space.
The findings indicate that urban roadway performance is strongly dependent on traffic demand variation, mixed traffic behavior, and roadway operating conditions. Proper traffic regulation, parking management, and roadway improvement measures are therefore essential for reducing congestion and enhancing traffic efficiency.

Table 8.1: Hourly Traffic Volume Variation

Time Period	Traffic Volume (veh/hr)	Traffic Condition
8:00 AM – 9:00 AM	1850	Moderate Flow
9:00 AM – 10:00 AM	2420	High Flow
10:00 AM – 11:00 AM	1980	Stable Flow
4:00 PM – 5:00 PM	2560	Heavy Flow
5:00 PM – 6:00 PM	2980	Peak Congestion
6:00 PM – 7:00 PM	2410	High Flow

Figure 8.1: Hourly Traffic Variation on Selected Urban Roads



The figure illustrates hourly variation in traffic volume observed on selected urban road sections. Traffic flow increases gradually during morning hours and reaches peak conditions during evening periods. The highest traffic volume was observed between 5:00 PM and 6:00 PM, indicating severe traffic demand and congestion during evening peak hours

9. DISCUSSION OF RESULTS

The results obtained from the traffic analysis indicate that urban roads experience varying operational conditions depending on traffic demand, roadway characteristics, and roadside activities. Peak hour analysis revealed that traffic congestion increases significantly during morning and evening periods due to office travel, educational activities, and commercial movement. Roads carrying higher traffic demand showed greater operational stress and reduced traffic efficiency.

The study highlights the influence of heterogeneous traffic conditions on roadway performance. The dominance of two-wheelers and the simultaneous movement of vehicles with varying speeds and maneuverability created irregular traffic patterns and frequent vehicle interactions. Such conditions reduced traffic stability and affected roadway operational efficiency. Heavy vehicles, although fewer in number, occupied larger roadway space and contributed significantly to congestion levels.

Roadside friction factors also had a noticeable impact on traffic conditions. On-street parking, roadside commercial activities, bus stoppages, and pedestrian movement reduced the effective carriageway width and disrupted smooth traffic movement. Roads with better geometric conditions and wider carriageways performed relatively better compared to roads with limited operational space.

The calculated operational indicators revealed that major urban corridors operate under moderate to heavy traffic conditions. Higher roadway utilization during peak hours resulted in reduced travel speed and increased delays. The findings are consistent with earlier studies conducted under heterogeneous traffic conditions, which identified traffic composition, roadway geometry, and roadside disturbances as major factors influencing roadway performance.

Overall, the analysis demonstrates that urban roadway performance depends on a combination of traffic demand, mixed traffic behavior, and operational roadway conditions. Proper traffic management and infrastructure improvement measures are therefore essential for reducing congestion and improving transportation efficiency.

10. CONCLUSION

The present study focused on assessing urban roadway performance through traffic volume analysis, Passenger Car Unit estimation, and Level of Service evaluation using IRC standards. The analysis revealed that rapid growth in vehicular population and increasing urban travel demand have significantly affected the operational efficiency of urban roads.

The study found that heterogeneous traffic conditions, lack of lane discipline, and roadside friction factors create complex traffic flow patterns that reduce roadway performance. Peak hour traffic conditions were observed to generate substantial congestion and delays, particularly on major urban corridors carrying high traffic demand.

Traffic volume analysis and roadway performance evaluation indicated that arterial and sub-arterial roads operate under comparatively higher traffic pressure than collector roads. The study also confirmed that roadway geometry, traffic composition, and roadside operational conditions strongly influence traffic flow characteristics and roadway capacity.

The application of IRC standards and PCU analysis proved effective in evaluating urban roadway performance under Indian traffic conditions. The study concludes that systematic traffic analysis is essential for identifying congestion-prone locations and planning suitable traffic management strategies for improving roadway efficiency and urban mobility.

11. RECOMMENDATIONS

Based on the findings of the present study, several measures are recommended for improving the operational performance of urban roads and reducing traffic congestion.

1. Proper traffic management strategies should be implemented to regulate traffic movement during peak hours and minimize congestion.
2. Roadside parking should be controlled through designated parking areas to reduce roadside friction and improve effective roadway width.
3. Traffic signal timing and intersection management should be optimized for smoother traffic flow and reduced delays.
4. Pedestrian facilities such as footpaths and designated crossing areas should be improved to reduce interruptions in vehicle movement.
5. Roadway infrastructure improvements, including widening of carriageways and maintenance of pavement conditions, should be carried out where traffic demand is increasing rapidly.
6. Public transportation systems should be strengthened to reduce excessive dependence on private vehicles and improve overall urban mobility.
7. Advanced traffic monitoring and intelligent transportation systems may be adopted for real-time traffic management and congestion control.
8. Awareness regarding lane discipline and traffic regulations should be promoted among road users to improve roadway operational efficiency.

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