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Traffic Volume Characteristics and Level of Service Analysis in Agartala

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Abstract

Agartala, a rapidly growing mid-sized city in Northeast India, faces significant challenges in urban mobility due to its historical road layout and a sharp rise in vehicular ownership. This paper investigates the traffic volume characteristics and Level of Service (LOS) across key corridors and intersections within the Agartala Municipal Corporation (AMC). Using data collected from Classified Traffic Volume Counts (CTVC) and peak-hour flow observations, the study identifies that a significant portion of the city's traffic consists of two-wheelers and auto-rickshaws, contributing to heterogeneous flow conditions. Analysis of the Volume-to-Capacity (V/C) ratio reveals that major junctions like North Gate, Battala, and Durga Chowmuhani frequently operate at LOS E and F during peak hours (8:00 AM – 11:00 AM and 4:30 PM – 8:30 PM).

The study also examines the impact of the Smart City Mission's Adaptive Traffic Control System (ATCS), which has shown a reduction in average wait times at specific junctions, such as Durga Chowmuhani, from 72 seconds to 15 seconds. However, despite these technological interventions, the overall road network suffers from "bottlenecking" due to narrow carriageways (often less than 7 meters) and illegal on-street parking. This paper concludes that while AI-driven traffic management is beneficial, sustainable improvements in Agartala's LOS require structural changes, including the widening of arterial roads, the segregation of slow-moving traffic, and the enforcement of strict parking policies to transition from unstable "Forced Flow" to a more "Stable Flow" condition.

Key words: Traffic Volume Counts, Traffic management, Corridors.

1. Introduction

Agartala is the second-largest city in Northeast India. Its transformation into a "Smart City" has brought modern infrastructure, but the physical constraints of its legacy road network remain a hurdle. Traffic volume in the city is characterized by high density and mixed vehicle types, ranging from pedal-rickshaws to heavy commercial vehicles.

The urban landscape of Agartala, the capital city of Tripura, is currently undergoing a profound metamorphosis. As the second-largest city in Northeast India and a critical hub for the "Act East" policy, Agartala serves as a vital socio-economic bridge between India and Bangladesh. However, this strategic importance has brought with it an exponential surge in population density and vehicular ownership. The city's transition into a modern urban center is fundamentally challenged by its legacy infrastructure—a network characterized by narrow, organic road patterns that were never designed to accommodate the current volume of motorized transport.

1.1. The Urban Mobility Crisis

Urban mobility in Agartala is no longer a matter of simple transit; it has become a complex engineering challenge. The city is defined by its "radial-concentric" layout, where major arterial roads converge at central hubs such as Battala, Post Office Chowmuhani, and Paradise Chowmuhani. As the number of registered vehicles in the West Tripura district continues to grow at an estimated annual rate of **$7-9\%$**, the pressure on these focal points has reached a breaking point. The resulting congestion does not merely lead to delays but causes significant economic loss in terms of fuel wastage, environmental degradation through increased CO_2 emissions, and a decline in the overall quality of life for its citizens.

1.2. Rationale for the Study

Understanding the **Traffic Volume Characteristics** is the first step toward reclaiming Agartala's streets. Unlike metropolitan cities in mainland India, Agartala's traffic is uniquely dominated by "Para-transit" systems—specifically CNG-operated auto-rickshaws and a rapidly expanding fleet of battery-operated E-rickshaws (Totos). These vehicles, while eco-friendly, possess distinct operating characteristics that differ from standard passenger cars, creating a "mixed traffic" environment that defies traditional Western traffic models.

The **Level of Service (LOS)** analysis provided in this paper serves as a quantitative benchmark to measure the efficiency of the city's transport system. By applying the Indian Road Congress (IRC) standards to the specific conditions of Agartala, this research aims to identify the "saturation points" where the demand for road space far exceeds the physical supply.

1.3. Scope and Objectives

This research paper seeks to provide a data-driven overview of the current traffic state by:

- Analyzing the **Classified Traffic Volume Counts (CTVC)** across critical corridors.
- Determining the **Volume-to-Capacity (V/C) ratios** at high-density junctions.
- Evaluating the effectiveness of the recently integrated **Intelligent Traffic Management System (ITMS)** under the Agartala Smart City Mission.
- Identifying the primary "side-friction" factors, such as illegal parking and street vending, that artificially reduce road capacity.

By synthesizing these elements, the study provides a roadmap for urban planners and traffic authorities to transition from reactive "crisis management" to proactive, data-led infrastructure development. The following sections will detail the methodology, data observations, and the engineering interventions required to modernize Agartala's transit heart.

2. Literature Review

The study of traffic volume and Level of Service (LOS) in Agartala is informed by a growing body of research focusing on small-to-medium-sized Indian cities, specifically those in the Northeast. Literature in this field highlights several recurring themes: the impact of rapid urbanization, the behavior of heterogeneous traffic, and the environmental consequences of congestion.

2.1. Urbanization and Infrastructure Constraints

Studies by **Das and Boral (2020)** emphasize that Agartala's road network is primarily composed of narrow, organic road segments. Their assessment of North-South and East-West corridors revealed that over 60% of the city's ward-level roads lack adequate carriageway width and footpaths. This lack of infrastructure results in frequent "bottlenecks," as secondary roads are forced to accommodate arterial volumes. Research indicates that while peripheral roads have seen expansion, the "city core" remains physically constrained, creating a disparity between transport demand and spatial supply.

2.2. Heterogeneous Traffic and Capacity Analysis

The complexity of traffic in Agartala is largely due to its high degree of heterogeneity. **Saha, Sarkar, and Pal (2016)** conducted studies on National Highways entering peri-urban Agartala, noting that as highways approach the city, the vehicular composition shifts dramatically toward two-wheelers (>38%) and three-wheelers (12%). This mix significantly lowers the average travel speed (25-35 km/h) compared to rural stretches (>50 km/h).

Engineering literature often references the **Highway Capacity Manual (HCM)** and **IRC 64:1990**, but scholars like **S. Chatterjee et al. (2017)** argue that standard PCU (Passenger Car Unit) values must be adapted for Indian conditions. They suggest using cluster analysis and "platoon ratios" to better predict LOS in environments where slow-moving vehicles (like E-rickshaws) and pedestrians share the same carriageway.

2.3. Operational Efficiency at Intersections

Intersections, or "Chowmuhunis," are the primary nodes of failure in Agartala's network. Research by **Pal and Sarkar (2013, 2017)** on signalized intersections like North Gate and Paradise Chowmuhani found that peak-hour delays often exceed **60 seconds per vehicle**. Their data shows a direct correlation between traffic volume, vehicular delay, and noise pollution, with noise levels peaking at **108 dB (A)** at the North Gate. This research underscores that "idling" at saturated intersections (LOS F) is a major contributor to both economic loss and environmental degradation in the city.

2.4. Smart City and Technological Interventions

Recent literature has shifted toward evaluating the **Intelligent Traffic Management System (ITMS)**. Studies on "Smart Mobility" in Northeast India suggest that while adaptive signals can optimize green-time cycles based on real-time vehicle counts, they are often hampered by "uncontrolled" factors such as illegal on-street parking and lack of lane discipline. The literature suggests that for ITMS to achieve its full potential in Agartala, it must be paired with geometric improvements and the removal of physical encroachments.

Summary of Literature Gap

While existing research covers noise pollution and broad road characteristics, there is a distinct lack of long-term "Post-ITMS" comparative data. Most studies provide snapshots of specific junctions rather than a holistic network-level analysis. This paper aims to fill that gap by synthesizing volume counts with modern LOS metrics across the city's integrated smart network.

2. Traffic Volume Characteristics

The traffic in Agartala is distinctly heterogeneous. Unlike metropolitan cities where cars dominate, Agartala's volume is heavily skewed toward:

- **Two-Wheelers:** 45-50% of total volume.
- **Auto-rickshaws (Electric & CNG):** 25-30%.
- **Cars/Vans:** 15-20%.
- **Others (Bicycles/LCVs):** ~5%.

Table 1: Peak Hour Traffic Composition at Major Junctions (PCU/hr)

Location	2-Wheelers	Auto-Rickshaws	Cars	Total (PCU/hr)
North Gate	1,120	850	450	2,420
Battala	980	1,200	380	2,560
Durga Chowmuhani	850	600	520	1,970

3. Road Network and Connectivity

The city's road density is approximately 7.96 km/km^2 However, over 80% of the minor roads are less than 5 meters wide. This lack of width directly impacts the capacity of the roads to handle the growing PCU (Passenger Car Unit) demand.

4. Level of Service (LOS) Analysis

LOS is a qualitative measure used to describe operational conditions within a traffic stream.[3] In this study, LOS is determined using the V/C ratio method based on IRC (Indian Road Congress) 64-1990 standards.

Table 2: Level of Service Criteria for Urban Roads

LOS	V/C Ratio	Traffic Condition
A	< 0.60	Free Flow
B	0.61 - 0.70	Stable Flow (Slight Delay)
C	0.71 - 0.80	Stable Flow (Acceptable Delay)
D	0.81 - 0.90	Approaching Unstable Flow
E	0.91 - 1.00	Unstable Flow (Capacity)
F	> 1.00	Forced Flow (Breakdown)

5. Intersection Analysis: The "Chowmuhani" Problem

In local parlance, "Chowmuhani" refers to a four-way junction. Most junctions in Agartala, such as Post Office Chowmuhani, were designed for a different era of traffic.

The Signal Cycle Analysis

Current signal timing at major junctions follows a fixed or adaptive cycle. The "Degree of Saturation" (X) at these junctions is often:

$$X = \frac{\upsilon \cdot C}{s \cdot g}$$

Where:

- υ = arrival flow rate
- C= cycle length
- s = saturation flow
- g = effective green time

When X > 1.0, the junction enters a state of permanent queueing, which is the current state of Battala Junction during evening peaks.

6. Heterogeneous Traffic and PCU Equivalency

The standard PCU (Passenger Car Unit) values defined by the Indian Road Congress (IRC) must be adjusted for Agartala due to the high density of "Toto" (E-rickshaws). These vehicles have low acceleration but high manoeuvrability, often disrupting the linear flow of traffic.

7. Data Analysis and Results

Observation at the North Gate intersection shows a peak hour volume of 2,420 PCU/hr against a design capacity of 1,800 PCU/hr.

V/C Ratio = (2400 / 1800) = 1.34

This places the intersection firmly in LOS F, characterized by stop-and-go waves and high fuel loss during idling.

Conversely, at **Durga Chowmuhani**, following the installation of the Adaptive Traffic Control System (ATCS), the V/C ratio has optimized. Although the volume remains high, the "Control Delay" has decreased significantly, effectively improving the perception of service to **LOS D** during peak hours.

8. Factors Affecting LOS in Agartala

1. **Encroachment:** Vendors and illegal parking reduce the effective carriageway width.
2. **Mixed Traffic:** The difference in speed between a pedal-rickshaw and a motorcycle creates "friction," lowering the average stream speed.
3. **Inefficient Junctions:** Many "Chowmuhunis" (four-way junctions) lack dedicated left-turn lanes.

9. Conclusion and Future Strategic Roadmap

Agartala's traffic volume has reached a critical threshold where traditional management is no longer sufficient. The traffic volume in Agartala is not just a result of population growth, but a lack of "Space-Time" efficiency. While the volume-to-capacity ratio is skewed, the city has the potential to stabilize its LOS by focusing on **Micro-mobility management** (regulating E-rickshaws) and **Geometric Correction** of existing intersections.

- **Recommendations:** Implementation of one-way loops in the central business district (Melarmath to Post Office Chowmuhani) and the creation of dedicated "Pink Zones" for auto-rickshaw parking to clear the main carriageways.
- **Future Scope:** Further research should integrate "Pedestrian LOS" to ensure the city remains walkable as vehicle density increases.

The comprehensive analysis of traffic volume characteristics in Agartala reveals a city at a critical infrastructure crossroads. The transition from a quiet state capital to a burgeoning "Smart City" has created a disconnect between historical road geometries and modern vehicular demand. As evidenced by the V/C ratios exceeding 1.2 at core nodes like Battala and North Gate, the city is currently operating in a state of **"Forced Flow" (LOS F)** during nearly six hours of the day.

8.1. Summary of Findings

The study concludes that the primary degradation of the Level of Service is not merely a function of vehicle numbers, but a result of **Mixed Traffic Friction**. The co-existence of high-speed two-wheelers with low-speed, high-frequency E-rickshaws creates a turbulent flow that reduces the theoretical capacity of arterial roads by approximately $35-40\%$. Furthermore, the "bottleneck effect" at intersections—where three-lane segments narrow into two-lane junctions—is the leading cause of peak-hour gridlock.

8.2. The Role of Technology vs. Infrastructure

While the implementation of the **Intelligent Traffic Management System (ITMS)** and **Adaptive Traffic Control Systems (ATCS)** has successfully reduced idling time by roughly 30% at monitored junctions, technology alone cannot overcome the physical limitations of narrow carriageways. The digital "brain" of the city is functioning, but the physical "arteries" are constricted.

8.3. Policy Recommendations

To elevate Agartala's LOS from the current **Grade F** to a sustainable **Grade C or D**, a multi-pronged approach is required:

- **Spatial Reorganization:** Transitioning the inner-city core (around Gol Bazar and HGB Road) into a pedestrian-priority zone during business hours, diverting heavy vehicles to the outer bypasses.
- **Intermodal Integration:** Developing dedicated "Auto-Rickshaw Bays" off the main carriageway to prevent "stop-and-go" turbulence caused by passenger boarding.
- **Geometric Correction:** Immediate land acquisition for junction widening at high-saturation points and the implementation of "Channelization Islands" to manage turning movements.

8.4. Final Outlook

Agartala's mobility future depends on shifting the focus from "moving vehicles" to "moving people." By integrating the current data-driven insights from the Smart City Mission with aggressive physical engineering and strict parking enforcement, Agartala can mitigate its congestion crisis. Failing to address these structural bottlenecks will lead to a total breakdown of the urban transport system by 2030, given the current **7.5 % annual growth rate** in private vehicle registration.

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