# IMPACT OF ROAD GEOMETRY ON TRAFFIC FLOW: A SIMULATION STUDY USING PTV VISSIM

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## ABSTRACT

Rapid urban growth, unplanned development, continuous rural-to-urban migration and mixed traffic conditions have contributed to severe congestion at major urban intersections in Bangladesh. Chattogram, the country's second-largest city and a key commercial hub, experiences persistent traffic problems due to high vehicle volumes, poor lane discipline, and limited traffic management. Improving traffic flow efficiency is therefore essential to reduce delays, enhance safety, and sustain economic productivity. Traffic modeling and simulation provide effective tools for evaluating geometric and operational performance, supporting data-driven planning and congestion mitigation in complex urban road networks. This study focuses on the Anderkilla intersection, a critical node in Chattogram's central commercial area that connects major urban corridors. The objective is to assess how road geometry and mixed traffic composition influence flow performance and congestion patterns. Geometric features were measured through field surveys, while traffic data collected from CCTV recordings included vehicle classification, turning movements, and flow rates. Using these data, a microscopic simulation model was developed in PTV VISSIM, incorporating both motorized and non-motorized traffic. The model was calibrated using Wiedemann 99 car-following and lane-changing parameters and validated with the GEH statistic, where most links achieved GEH < 5, confirming the model's reliability. Geometric capacity analysis revealed that all approaches operate within traffic capacity; however, localized congestion occurs due to irregular geometry, turning conflicts, and non-lane-based driving behavior, which largely stems from inadequate traffic management and lack of strict lane discipline. Simulation results during the PM peak hour (5:00-7:00 PM) indicated that average vehicle delay ranged from 5.7 to 7.4 seconds, with an 8-10% reduction observed in the later peak period. These findings highlight that the existing intersection geometry is generally adequate; however, operational inefficiencies, illegal parking, street hawker, and pedestrian interference still disrupt overall traffic flow. Overall, the study demonstrates that simulation-based geometric evaluation effectively captures the interaction between road geometry and mixed traffic flow. The outcomes provide practical recommendations for geometric refinement and operational management, offering valuable guidance for improving traffic performance and safety in rapidly developing urban areas like Chattogram.

***Keywords:*** *Road geometry, Traffic congestion, Heterogeneous, Traffic simulation, PTV VISSIM*

## 1. INTRODUCTION

Efficient traffic management at intersections is essential for ensuring smooth urban mobility and minimizing congestion-related delays. Intersections act as critical nodes in transportation networks, where vehicle conflicts and turning movements often create operational challenges. Improving traffic operations at these points is, therefore, crucial for maintaining overall network performance and travel reliability (Xi et al., 2015). Effective vehicle movement control at conflict points ensures smoother mobility and reduces congestion in mixed-traffic environments (Majstorovi´c et al., 2023). To overcome these challenges, systematic planning supported by rigorous research methodologies is indispensable for comprehensively analyzing, assessing, and optimizing urban traffic systems (Zhu et al., 2021). Urban intersections frequently experience heavy congestion, which significantly impacts transportation efficiency, economic productivity, and the overall quality of urban life (Sultana et al., 2017). In the context of developing cities like Chattogram, Bangladesh, the Anderkilla intersection exemplifies such issues, being characterized by irregular road geometry, heterogeneous traffic flow, and limited traffic control measures that collectively reduce operational efficiency. Road geometric features such as lane width, turning radius, and intersection alignment are known to have a direct influence on traffic throughput, stability, and safety (Utami et al., 2020). Moreover, uncontrolled factors such as illegal parking, pedestrian interference, street vending, and aggressive driving behavior further deteriorate flow conditions and reduce intersection capacity (Yousif & Purnawan, 1999; Asman et al., 2019).

Given these complexities, simulation-based traffic analysis has become an indispensable tool for evaluating and improving geometric and operational efficiency in urban road networks. Particularly in developing countries, microscopic traffic simulation software like PTV VISSIM allows for the modeling of heterogeneous, non-lane-based traffic flow conditions with high fidelity (Muniruzzaman et al., 2016). The reliability of such simulations depends on accurate geometric modeling combined with field-based calibration and validation processes, which involve key behavioral parameters such as standstill distance, desired headway time, and lane-changing aggressiveness (Mathew & Radhakrishnan, 2010). To assess the accuracy of simulated traffic volumes against field observations, the GEH statistic has been widely adopted as a robust validation metric (Abdeen et al., 2023). Accurate data collection serves as the foundation for simulation reliability. Input data for microscopic models can be obtained from manual field surveys or video-based monitoring systems such as CCTV, with the latter offering higher accuracy, temporal consistency, and the ability to retrospectively analyze vehicle interactions (Majumder & Wilmot, 2023; Hoxha et al., 2023). Such datasets enhance the calibration of simulation models, ensuring that the modeled network closely replicates real-world driving behavior and flow characteristics.

In this study, PTV VISSIM is employed to simulate and analyze the effects of existing road geometry on traffic flow performance at the unsignalized Anderkilla intersection in Chattogram. The research aims to evaluate how geometric characteristics and mixed traffic composition collectively influence operational performance, measured through geometric capacity analysis and delay evaluation. Geometric capacity analysis helps identify how physical design constraints affect maximum flow and vehicle interaction in mixed-traffic environments (Shepelev et al., 2022), while delay analysis provides a direct measure of user experience and intersection efficiency (Sofokidis et al., 1973). More specifically, the key objectives of this study are-

- To identify the road geometry and traffic issues that influence flow efficiency at the selected intersection.
- To develop a calibrated and validated PTV VISSIM simulation model that accurately represents existing geometric and traffic conditions.
- To evaluate the intersection's performance through manual geometric capacity analysis using field data and delay analysis based on simulation results.

## 2. METHODOLOGY

This study analyzed the impact of road geometry on traffic flow efficiency and safety at the Anderkilla intersection using PTV VISSIM through data collection, model development, calibration, validation, and performance evaluation, as summarized in the workflow diagram of the study shown in Figure 1.

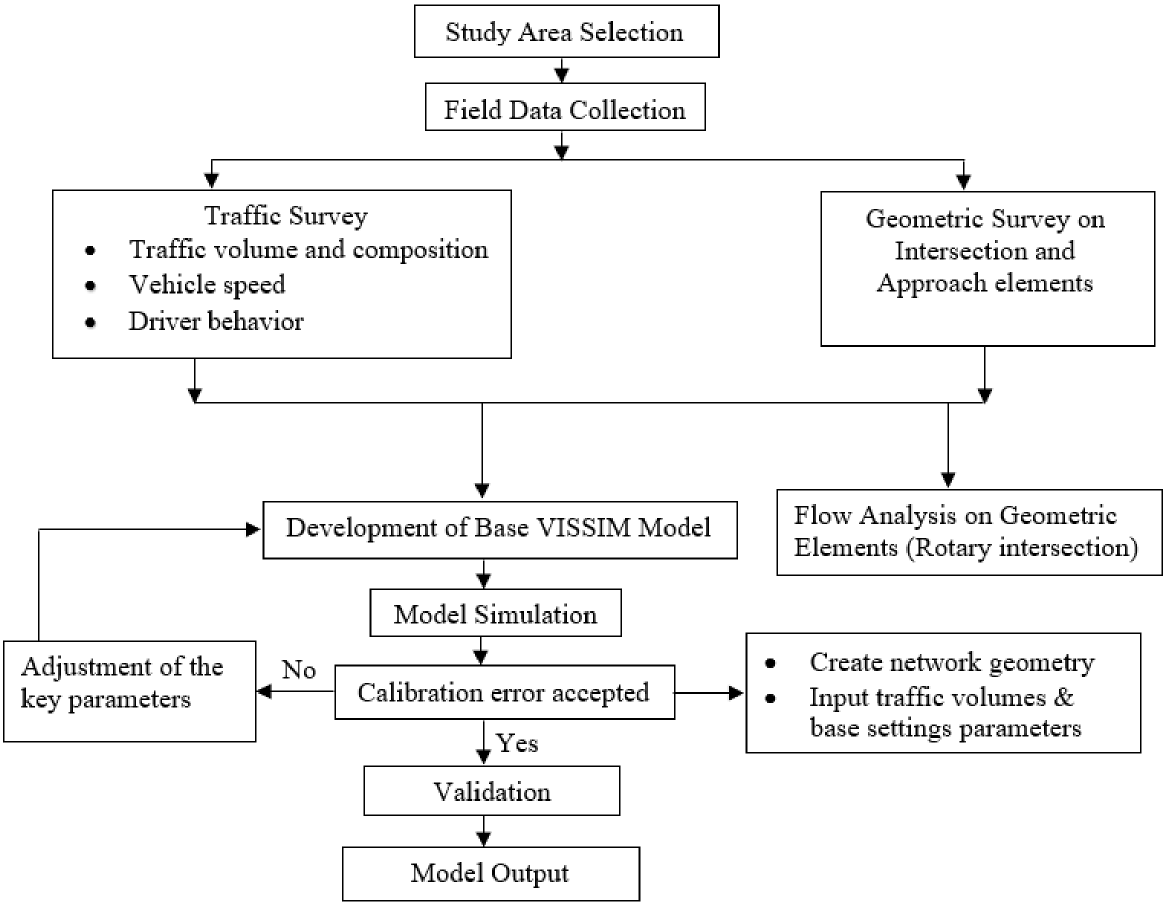


Figure 1: Work Flow Diagram of the Present Study

### 2.1 Study Area

The study area selected for this research is the Anderkilla Intersection. This is a conventional unsignalized rotary intersection, located in the central commercial zone of Chattogram City, Bangladesh. It connects three major roads: Nawab Sirajuddaula Road, Momin Road, and Anderkilla Road and serves as a key junction for mixed traffic flow consisting of cars, buses, trucks, motorcycles, and rickshaws. The intersection operates under an unsignalized condition with irregular geometry and uneven lane distribution. Nawab Sirajuddaula Road on the north approach consists of two lanes carrying traffic from Chawkbazar, Momin Road on the west approach has two lanes connecting to Cheragi Pahar, while Anderkilla Road on the southwest approach has a single narrow lane used for two-way movement toward the Laldighi. Overall, the intersection allows six directional vehicle movements, with through, left-turn, and right-turn flows from each approach. Due to the absence of proper channelization, lane discipline, and pedestrian facilities, this intersection frequently experiences congestion and conflicts, making it suitable for analyzing the impact of road geometry on traffic flow efficiency and safety through PTV Vissim simulation. The geometric layout and modeled network of the Anderkilla intersection are presented in Figure 2(a) and Figure 2(b), showing both the map view and the VISSIM layout.


Figure 2(a): Map view of Anderkilla Intersection

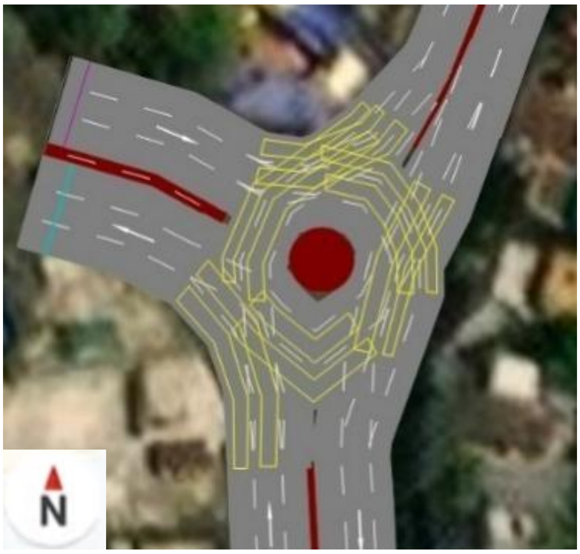


Figure 2(b): Simulated network layout in PTV Vissim

## 2.2 Investigation Survey

An investigation survey was carried out at the Anderkilla intersection, a three-legged junction comprising six distinct links. The survey aimed to collect geometric and traffic data required for the simulation study. A preliminary field inspection was conducted to assess site characteristics and identify suitable data collection points. The collected information formed the basis for developing and validating the PTV VISSIM model.

### 2.2.1 Geometric Survey

The existing geometric characteristics of the Anderkilla intersection were obtained through detailed field measurements physically. Parameters such as lane widths, approach lengths, circle radius, number of lanes, and overall intersection layout were carefully documented. These parameters are essential for evaluating the influence of road geometry on traffic flow and driver behavior under mixed traffic conditions.

### 2.2.2 Traffic Survey

Traffic data were gathered from CCTV recordings over seven consecutive days. Vehicle counts were manually extracted using the tally method to determine traffic volume, composition, turning movements, and flow characteristics across different time periods. The processed data were later used for model calibration and validation.

## 2.3 Geometric Capacity Analysis

The geometric capacity analysis of a rotary intersection is to be verified by a computational or analytical method and by network modeling analysis. This analysis is performed to evaluate traffic flow efficiency and ensure the intersection can accommodate the expected traffic under various conditions.

### 2.3.1 Computational Method

In this method, the capacity of a rotary intersection depends on the entry and exit widths, weaving length, and the proportion of weaving traffic. For the Anderkilla intersection, geometric elements were evaluated based on field-measured traffic volumes and a design speed of 30 km/h obtained from the site. The Transport and Road Research Laboratory (TRRL) recommends a modified Wardrop formula, presented in Equation (1) and Equation (2), to estimate practical capacity (Wardrop, 1957). Figure 3 illustrates the geometric elements of the three-leg intersection used in capacity estimation, including the distribution of weaving traffic streams.

$$\text{Ratio}, P = \frac{b+c}{a+b+c} \quad (1)$$

$$\text{Capacity}, Qp = \frac{280 * W * \left(1+\frac{e}{W}\right) * (1-\frac{P}{3})}{(1+\frac{W}{L})} \quad (2)$$

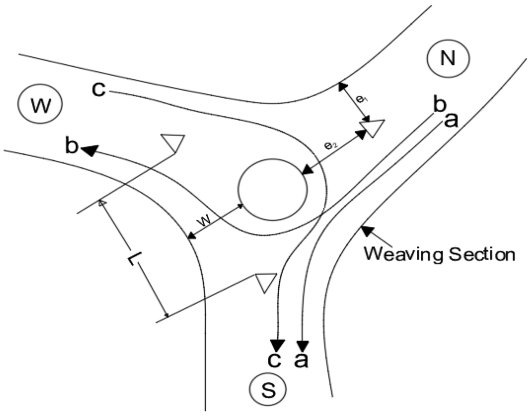


Figure 3: Dimensions and weaving traffic proportion used in the rotary capacity formula.

Equation (1) and Equation (2) were applied to assess the capacity and traffic flow for the three main approaches, with Qp representing capacity (PCU/hr), W the weaving width (m), e the average entry width (m), L the weaving length (m), and P the proportion of weaving traffic streams (a, b & c).

### 2.3.2 Network Modeling Analysis in PTV VISSIM

The Anderkilla intersection was modeled in PTV VISSIM to simulate mixed traffic and evaluate road geometry impacts. Field-measured geometric and traffic data defined links, lanes, vehicle types, and traffic composition, while turning movements were assigned through routing decisions. Vehicle behaviors were configured to reflect local driving patterns. The network layout is shown in Figure 2(b). The model was calibrated and validated against observed data to ensure reliable simulation results.

#### 2.3.2.1 Base Setting Parameters

The accuracy of a traffic simulation in PTV VISSIM depends on properly defining the base setting parameters, which govern overall driving behavior and network operations. These parameters include vehicle types, speed distributions, acceleration and deceleration patterns, and lane-changing behavior. Together, they ensure that traffic movements within the model reflect realistic driving conditions. A critical component of these base settings is the car-following behavior, which determines how one vehicle responds to the movement of another. The Wiedemann 99 model, suitable for urban mixed traffic, was used to represent driver responses to distance and speed variations.

#### 2.3.2.2 Model Calibration and Validation

Using essential parameters, including car-following and lane-changing behavior, the model was calibrated to reflect real traffic conditions. It was then simulated to analyze flow and geometric performance, and the results were compared with a separate set of observed traffic volumes for validation. The model accuracy was assessed using the GEH Statistic, developed by Geoffrey E. Havers (GEH), which is widely recognized in traffic engineering for evaluating the agreement between simulated and observed flows. According to Fernandes (2017), the GEH statistic is one of the most effective indicators for assessing the goodness of fit of model results (Zisan et al., 2024).

The GEH value is calculated using the Equation (3):

$$GEH = \sqrt{\frac{2(O_v - S_v)^2}{(O_v + S_v)}} \quad (3)$$

Where, $O_V$ represents the observed traffic volume (vehicles/hour), and $S_V$ represents the simulated traffic volume (vehicles/hour). The interpretation of GEH values is as follows:

- GEH < 5.0: Good match between observed and simulated volumes
- 5.0 ≤ GEH ≤ 10.0: Moderate match
- GEH > 10.0: Poor match, indicating the model is not acceptable

When the majority of GEH values are below 5, the model is considered valid and sufficiently reliable for further analysis.

## 3. RESULTS & DISCUSSIONS

Following traffic and geometric surveys, the intersection's geometric elements and peak-period traffic flows were collected by field measurements. Geometric capacity analysis was conducted using two approaches: an analytical method to evaluate capacity limits, and a model-based approach to assess delays and the impact of intersection geometry on traffic performance.

### 3.1 Collection of Geometric Data

The intersection is a three-legged rotary with approach roads, as shown in Figure 4, numbered from A1 to A6 as indicated. The corresponding entry and exit widths are presented in Table 1. Additional geometric elements, including weaving length, weaving width, non-weaving section width, and entry width, were measured to replicate the existing geometry and are highlighted in Table 2. These geometric data will be used for VISSIM model development.

Table 1: Approach Road Width

| Link Name | Width (ft) |
|---|---|
| Chawkbazar to Anderkilla (A1) | 22.83 |
| Anderkilla to Chawkbazar (A2) | 19.83 |
| Cheragi Pahar to Anderkilla (A3) | 28.5 |
| Anderkilla to Cheragi Pahar (A4) | 29.5 |
| Laldighi to Anderkilla (A5) | 27 |
| Anderkilla to Laldighi (A6) | 27 |

Table 2: Geometric Parameters of the Weaving Section

| Parameters | | Distance (ft) |
|---|---|---|
| Weaving width | W11 | 32.75 |
| | W12 | 40 |
| | W13 | 21.83 |
| Weaving Length | W21 | 95.7 |
| | W22 | 64 |
| | W23 | 160 |
| Width of non-weaving section | e11 | 60.5 |
| | e12 | 37.83 |
| | e13 | 45 |
| Width at entry | e21 | 22.5 |
| | e22 | 23.3 |
| | e23 | 31.15 |
| | e24 | 34.25 |
| | e25 | 29 |
| | e26 | 29.66 |

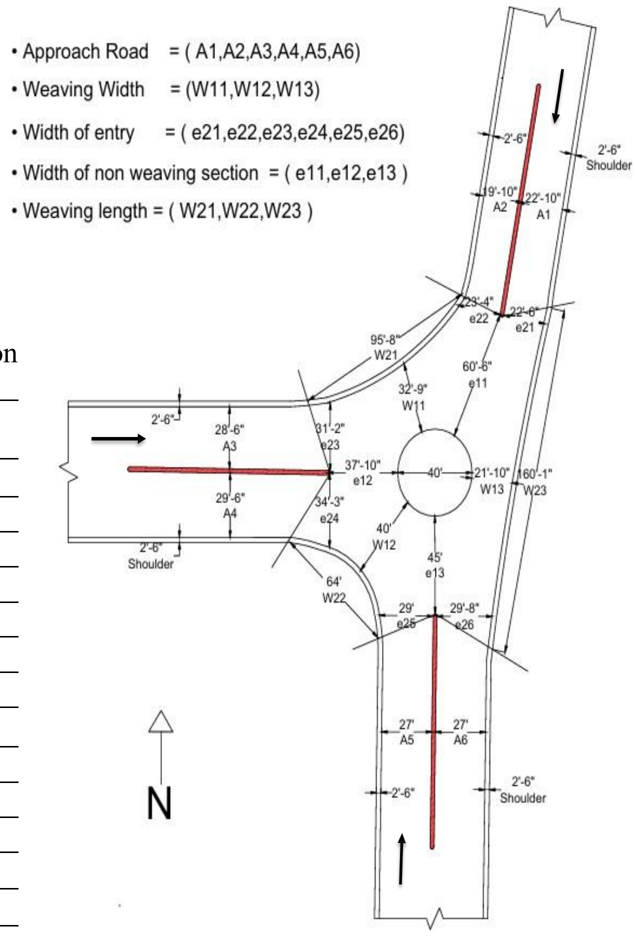


Figure 4: Geometric Elements of Rotary intersection at Anderkilla

### 3.2 Traffic Volume & Composition

The observed volumes were converted into Passenger Car Unit (PCU) values using standard conversion factors: 1.0 for cars, 0.75 for bikes, and 2.8 for other vehicles (RHD Manual, 2000). The converted traffic volumes were then used to analyze the flow capacity in relation to the geometric characteristics of the rotary intersection. Table 3 presents the traffic flow at the Anderkilla intersection during the design (peak) hour.

Table 3: Traffic flow in Anderkilla intersection at PM peak hour

| Approach | Left Turning | | | | Through Traffic | | | | Right Turning | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Car | Bike | Other Vehicles | PCU | Car | Bike | Other Vehicles | PCU | Car | Bike | Other Vehicles | PCU |
| Nawab Sirajuddaula Road (N) | x | x | x | x | 450 | 195 | 20 | 653 | 56 | 25 | 3 | 84 |
| Anderkilla Road (S) | 399 | 177 | 17 | 580 | 384 | 170 | 17 | 560 | x | x | x | x |
| Momin Road (W) | 328 | 143 | 15 | 478 | x | x | x | x | 413 | 183 | 19 | 604 |

### 3.3 Analysis of Geometric Capacity

The geometric capacity of the selected intersection using both analytical and simulation-based approaches are included in this article. The analytical assessment applies the Wardrop method to estimate practical capacity based on field-measured geometric elements and existing traffic distribution. The simulation analysis, developed in PTV VISSIM, replicates actual conditions to examine traffic flow behavior and identify congestion causes.

#### 3.3.1 Analytical Method

Equation (1) and Equation (2) were used to determine the capacity and existing traffic flow for the three main directions at the intersection. The geometric dimensions required for these calculations were obtained from field measurements, as listed in Table 1 and Table 2**.** Table 4 summarizes the traffic streams, geometric parameters, and calculated capacities for each direction.

Table 4: Capacity Analysis of the Anderkilla Intersection

| Direction | Traffic streams | | | Weaving width, W (ft) | Weaving length, L (ft) | Width at entry, e (ft) | P | Capacity, Qp (PCU/hr) | Total Traffic (PCU/hr) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | | | | | | | |
| S-W | 580 | 560 | 84 | 40 | 64 | 37.33 | 0.53 | 3344 | >1224 | Acceptable |
| W-N | 478 | 604 | 560 | 32.75 | 95.7 | 36.04 | 0.71 | 3339 | >1642 | Acceptable |
| N-S | 653 | 84 | 604 | 21.83 | 160 | 41.9 | 0.51 | 3972 | >1341 | Acceptable |

The analytical results in Table 4 indicate that all three approaches of the Anderkilla intersection operate within capacity according to the Wardrop formula, suggesting that the existing geometry is generally adequate.

However, congestion is still frequently observed at the intersection, primarily due to non-geometric factors. These include vehicles parked along busy roads, street vendors encroaching onto the carriageway, frequent violations of traffic rules such as sudden stops and wrong-lane driving, malfunctioning or absent traffic signals, and the implementation of short-term management measures without long-term planning. Collectively, these issues disrupt traffic flow and reduce operational efficiency, even though the geometric capacity of the intersection is sufficient.

### 3.3.2 VISSIM Model Analysis

This section presents the simulation-based analysis using PTV VISSIM to assess intersection performance under existing conditions. The model, developed from field geometry and traffic data, was calibrated to local driving behavior, validated against observed data, and used to evaluate vehicle delay and congestion. These steps ensure realistic representation and reliable assessment of traffic flow efficiency.

#### 3.3.2.1 Calibration of Driving Behavior Parameters

The calibrated and default Wiedemann 99 parameters are shown in Table 5. Lane-changing parameters are equally important for simulating realistic movements in congested intersections, influencing how drivers merge, overtake, or yield. These parameters are summarized in Table 6. Overall, the base settings were calibrated to match local driving behavior and ensure realistic simulation results.

Table 5: Wiedemann 99 Car-Following Model Parameters

| Parameters Name | Default Value | Car | Leguna | LGV | Large Bus | Medium Truck | Minibus | CNG | Tempo | Bike | NMV (Rickshaw & Bicycle) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CC0 (Standstill Distance) (m) | 1.50 | 1.0 | 0.5 | 1.0 | 1.2 | 1.2 | 0.8 | 0.5 | 0.5 | 0.3 | 0.3 |
| CC1 (Headway Time) (s) | 0.90 | 0.6 | 0.5 | 0.6 | 0.75 | 0.75 | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 |
| CC2 (Following Variation) (m) | 4.00 | 3 | 3 | 3 | 3 | 3 | 3 | 2.50 | 2.50 | 2.50 | 2.00 |
| CC3 (Threshold for Entering Following) | -8 | | | | | | -8 | | | | |
| CC4 (Negative 'Following' Threshold) | -0.35 | | | | | | -0.35 | | | | |
| CC5 (Positive 'Following' Threshold) | 0.35 | | | | | | 0.35 | | | | |
| CC6 (Speed Dependency of Oscillation) | 11.44 | | | | | | 5 | | | | |
| CC7 (Oscillation Acceleration) (m/s²) | 0.25 | | | | | | 0.25 | | | | |
| CC8 (Standstill Acceleration) (m/s²) | 3.5 | 2.00 | 2.00 | 1.30 | 2.10 | 1.50 | 1.90 | 1.80 | 1.70 | 2.20 | 1.50 |
| CC9 (Acceleration with 80 kmph) (m/s²) | 1.50 | 1.15 | 1.15 | 0.90 | 1.15 | 1.00 | 1.10 | 1.10 | 1.10 | 1.25 | 0.25 |

Table 6: Lane-Changing Parameters

| Parameters | Default | Car | Leguna | LGV | Large Bus | Medium Truck | Mini Bus | CNG | Tempo | Bike | NMV (Rickshaw & Bicycle) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| General Behavior | Free lane selection | | | | | | | | | | |
| Waiting time before diffusion (s) | 1 | 0.3 | | | | | | | | | |
| Min headway (Front/rear), (m) | 1 | 0.15 | 0.15 | 0.15 | 0.17 | 0.15 | 0.15 | 0.14 | 0.14 | 0.12 | 0.11 |
| Safety distance reduction factor | 1 | 0.5 | | | | | | | | | |
| Maximum deceleration for cooperative breaking ($m/s^2$) | 3 | 3.0 | | | | | | | | | |
| Overtake reduced speed areas | Selected | | | | | | | | | | |
| Vehicle routing decision look ahead | Selected | | | | | | | | | | |
| Cooperative lane change | Max. speed difference 3.00 km/h and Max. collision time 10 s | | | | | | | | | | |

### 3.3.2.2 Validation of the Calibrated Model

Based on one week of traffic data, two peak hours were identified: 5:00-6:00 PM and 6:00-7:00 PM. The validation was performed for the day that exhibited the highest traffic flow within these periods. Table 7 presents the validation results of traffic volumes for each link during 5:00-6:00 PM, while Table 8 shows the corresponding results for 6:00-7:00 PM.

Table 7: Validation Results for Peak Hour (5:00-6:00 PM)

| No | Vehicle Route | Observed Traffic Flow (Veh/hr) | Simulated Traffic Flow (Veh/hr) | Differences (%) | GEH Value | Validation |
|---|---|---|---|---|---|---|
| 1 | Chawkbazar to Cheragi Pahar | 157 | 107 | 31.85 | 4.35 | Good |
| 2 | Chawkbazar to Laldighi | 650 | 523 | 19.54 | 5.24 | Moderate |
| 3 | Cheragi Pahar to Chawkbazar | 530 | 413 | 22.1 | 5.38 | Moderate |
| 4 | Cheragi Pahar to Laldighi | 675 | 535 | 20.74 | 5.69 | Moderate |
| 5 | Laldighi to Chawkbazar | 614 | 507 | 17.43 | 4.52 | Good |
| 6 | Laldighi to Cheragi Pahar | 642 | 524 | 18.38 | 4.88 | Good |

Table 8: Validation Results for Peak Hour (6:00-7:00 PM)

| No | Vehicle Route | Observed Traffic Flow (Veh/hr) | Simulated Traffic Flow (Veh/hr) | Differences (%) | GEH Value | Validation |
|---|---|---|---|---|---|---|
| 1 | Chawkbazar to Cheragi Pahar | 84 | 65 | 22.62 | 2.20 | Good |
| 2 | Chawkbazar to Laldighi | 672 | 557 | 17.11 | 4.64 | Good |
| 3 | Cheragi Pahar to Chawkbazar | 489 | 408 | 16.56 | 3.82 | Good |
| 4 | Cheragi Pahar to Laldighi | 615 | 537 | 12.7 | 3.25 | Good |
| 5 | Laldighi to Chawkbazar | 570 | 489 | 14.21 | 3.52 | Good |
| 6 | Laldighi to Cheragi Pahar | 595 | 492 | 17.31 | 4.42 | Good |

The validation results for the peak hour period from 5:00-6:00 PM (Table 7) indicate that most GEH values ranged between 4.35 and 5.69, with three links showing good agreement and the remaining three links demonstrating a moderate match between observed and simulated traffic volumes. During the 6:00-7:00 PM peak hour (Table 8), all GEH values were found to be below 5.0, indicating a good correspondence across all links. Therefore, as the majority of GEH values in both time periods fall within the acceptable range (GEH < 5), the calibrated model can be considered valid and reliable for further traffic flow analysis and scenario evaluation.

#### 3.3.2.3 Vehicle Delay Time under Existing Traffic Conditions

After calibration and validation, the existing traffic scenario was simulated in PTV VISSIM to assess vehicle delay and congestion levels across the intersection. The delay results for the two peak hours: 5:00-6:00 PM and 6:00-7:00 PM are illustrated graphically in Figure 5 and Figure 6, respectively, showing variations in minimum, average, and maximum delay times for each approach.

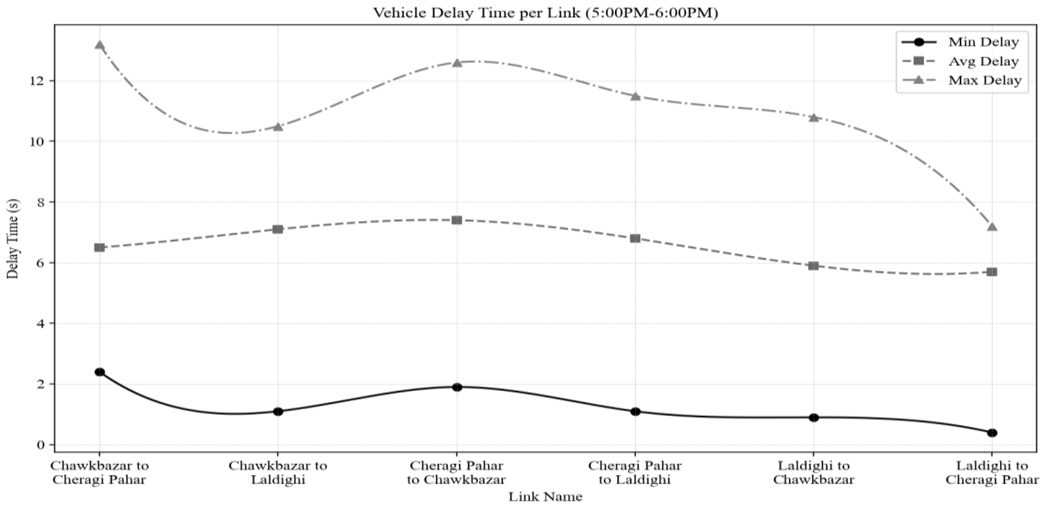


Figure 5: Vehicle Delay Results at Peak Hour (5:00-6:00 PM)

During the 5:00-6:00 PM period, the Cheragi Pahar to Chawkbazar and Chawkbazar to Laldighi links exhibited relatively higher average delays, as shown in figure 5, while the Chawkbazar to Cheragi Pahar movement recorded the maximum delay. The average delay ranged from 5.7 s to 7.4 s, with the most congested approaches showing about 20-25% higher delay, identifying these as the primary bottleneck links due to turning conflicts and geometric constraints.

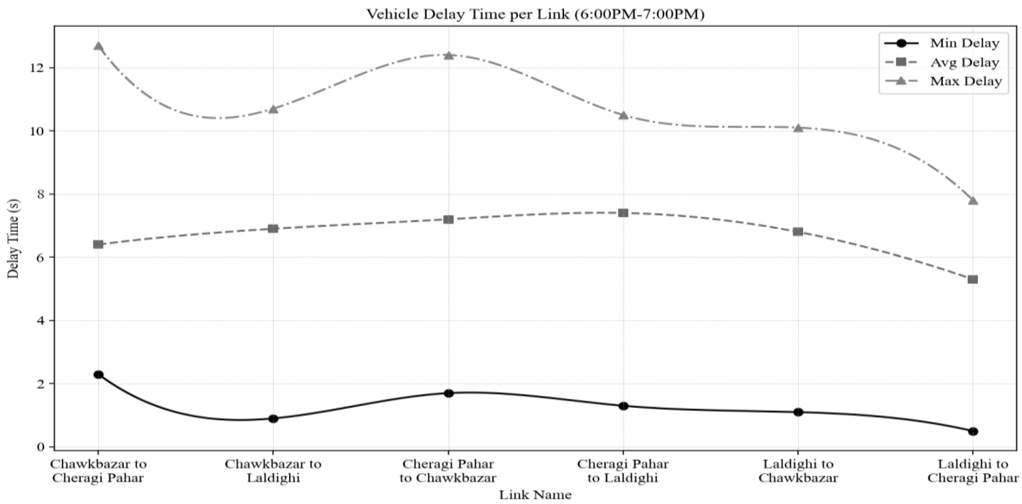


Figure 6: Vehicle Delay Results at Peak Hour (6:00-7:00 PM)

A slight reduction (8–10%) in delay was observed, indicating improved traffic flow toward the end of the PM peak in Figure 6, representing the 6:00-7:00 PM period. The Cheragi Pahar to Laldighi approach experienced the highest delay, while Laldighi to Cheragi Pahar showed the lowest, reflecting smoother operation in that direction. Simulation results indicate that the intersection experiences moderate congestion during peak hours, with certain approaches showing higher vehicle delays. The congestion arises from interactions between mixed traffic types, frequent lane changes, and variability in driver behavior, highlighting that operational inefficiencies can occur even when geometric capacity is sufficient. These findings suggest that targeted measures, such as optimized signal timing or lane management, could improve traffic flow and reduce delays.

## 4. CONCLUSIONS

Traffic congestion is a common challenge in Bangladesh due to high traffic volumes, mixed vehicle types, and frequent violations of traffic rules. The existing scenario was successfully modeled in PTV VISSIM and calibrated using car-following and lane-changing parameters to replicate heterogeneous driving behavior. Validation with observed traffic volumes and GEH statistics confirmed the model's reliability, with moderate matches (GEH 5-6) on three links during 5:00-6:00 PM and all links achieving GEH < 5 during 6:00-7:00 PM. Vehicle delay analysis highlighted primary bottlenecks, with Cheragi Pahar to Chawkbazar and Chawkbazar to Laldighi experiencing higher delays, while slight reductions (8-10%) occurred during the later peak. Despite adequate geometric capacity, traffic congestion persists due to factors such as parked vehicles, vendor encroachments, driver non-compliance, and inconsistent or absent traffic control measures. Overall, the study demonstrates that the intersection geometry is adequate, yet moderate delays and congestion exist, suggesting the need for targeted traffic management or minor geometric improvements. The findings confirm that the study successfully assessed geometric adequacy, represented mixed traffic through a calibrated and validated model, and quantified congestion to illustrate the impact of heterogeneous traffic flow. Future research can extend the model to explore additional traffic performance measures.

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## DECLARATION OF USE OF AI

The authors declare that Artificial Intelligence (AI) tools were used solely for language refinement purposes, including improving grammar, sentence structure, and overall clarity of the manuscript. No AI tools were used for research design, data collection, data processing, analysis, simulation, figure or table preparation, or interpretation of results. All technical and scientific work was conducted entirely by the authors. Sumaya Sadia Toha carried out the data preparation, analysis, writing, and revision of the manuscript. Md. Arif Rayhan and Mahafujar Rahman contributed to data collection and preparation of the introduction, methodology, and results sections, while Swapan Kumar Palit provided academic supervision. The authors confirm that full intellectual responsibility and control over the content were maintained throughout the study.

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