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Geometric Improvement and Traffic Signal Design at Angadippuram Intersection

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Abstract: ***Rapid urbanization and the increasing number of vehicles have led to severe traffic congestion at urban intersections, affecting traffic efficiency and road safety. This study presents a traffic analysis and improvement proposal for the Angadipuram intersection, which experiences heavy congestion during peak hours. Traffic volume studies and field observations were conducted to evaluate the existing traffic conditions, geometric characteristics, and operational performance of the intersection. The collected data were analyzed to identify the major causes of delays, queue formation, and traffic conflicts.***

Based on the analysis, suitable geometric improvements and an optimized traffic signal design were proposed to improve intersection performance. The proposed measures include roadway widening, channelization, improved turning movements, and effective signal phasing. The effectiveness of the proposed modifications was evaluated in terms of traffic flow efficiency, delay reduction, and safety enhancement. The results indicate that the recommended improvements significantly reduce congestion, improve vehicle movement, and enhance overall operational efficiency and road safety at the intersection. This study highlights the importance of proper traffic engineering and intersection design in addressing urban traffic problems and supporting sustainable transportation development.

Keywords: ***Traffic Engineering, Intersection Design, Signal Timing, Geometric Improvement, Traffic Flow***

I. INTRODUCTION

Traffic congestion at road intersections has become a serious problem in rapidly developing urban and semi-urban areas due to the continuous increase in vehicle population. Improper road geometry, mixed traffic conditions, roadside activities, and the absence of proper traffic control systems often lead to delays, traffic conflicts, and accidents. Efficient traffic management at intersections is therefore essential to ensure smooth vehicular movement and road safety.

Angadippuram intersection, located in Malappuram district along NH 966, is an important junction connecting major nearby towns such as Kozhikode, Perinthalmanna, and Valanchery. The intersection experiences heavy traffic flow during peak hours because of commercial activities, pedestrian movement, and mixed vehicle composition including two-wheelers, cars, buses, and heavy vehicles. The existing geometric condition and lack of proper signal control contribute to congestion and unsafe traffic movement at the junction.

This study focuses on the analysis of the existing traffic conditions at Angadippuram intersection and the development of suitable geometric improvements and traffic signal design. Traffic volume studies, field observations, and geometric surveys were conducted to identify the operational problems and traffic characteristics of the intersection. Based on the analysis, appropriate improvement measures were proposed to reduce congestion, improve traffic flow efficiency, and enhance safety for both vehicles and pedestrians.

II. STUDY AREA AND DATA COLLECTION

A. Study Area

The study was carried out at Angadippuram intersection located in Malappuram district, Kerala, along NH 966. The junction is an important connecting point between Kozhikode, Perinthalmanna, and Valanchery. Due to commercial activities, pedestrian movement, and increasing vehicle population, the intersection experiences heavy traffic congestion during peak hours. Mixed traffic conditions and the absence of proper traffic control measures create delays, traffic conflicts, and safety issues at the junction.

B. Data Collection

Traffic volume data were collected at the intersection through field surveys during peak and off-peak hours. Video recording and manual counting methods were used to observe and record traffic movement. The collected data were classified according to vehicle type for accurate traffic analysis and Passenger Car Unit (PCU) calculation.

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The vehicles were classified into the following categories:
* Two-wheelers
* Cars and Jeeps
* Auto-rickshaws
* Buses
* Trucks and Heavy Vehicles

The collected traffic data were later analyzed to identify traffic flow characteristics, congestion levels, and operational problems at the intersection.

III. TRAFFIC ANALYSIS

A. *Traffic Volume Study*

Traffic volume study was conducted at Angadippuram intersection to evaluate the existing traffic conditions and identify peak hour traffic flow. Traffic data were collected using video recording and manual counting methods during different time intervals. Vehicles passing through the intersection were classified into categories such as two-wheelers, cars, auto-rickshaws, buses, and heavy vehicles. The collected data were converted into Passenger Car Units (PCU) using IRC standards for detailed traffic analysis.

B. *Traffic Flow Analysis*

Traffic flow analysis was carried out using the collected traffic volume data to determine traffic intensity, directional distribution, and congestion level at the intersection. The analysis revealed heavy traffic movement during morning and evening peak hours due to mixed traffic conditions, roadside commercial activities, and pedestrian movement. Irregular turning movements and inadequate road geometry were also identified as major causes of delay and traffic conflicts.

C. *Peak Hour Analysis*

Peak hour analysis was performed to identify the maximum traffic demand at the intersection. Peak Hour Factor (PHF) was calculated to study traffic flow variation and intensity during peak periods. The analysis indicated high traffic volume and uneven traffic distribution at critical approaches of the intersection, resulting in congestion and queue formation. The obtained results were used for further geometric improvement and traffic signal design.

D. *PCU Analysis*

Passenger Car Unit (PCU) analysis was conducted to convert different vehicle categories into equivalent passenger car units for uniform traffic evaluation.

Standard PCU values recommended by IRC were used for the conversion process. The PCU analysis helped in identifying the critical traffic approaches and determining the design traffic volume required for signal design and intersection improvement proposals.

IV. GEOMETRIC IMPROVEMENT

A. *Existing Geometric Condition*

The existing geometric condition of Angadippuram intersection was studied through field observations and geometric surveys. The intersection was found to have inadequate road width, improper turning radius, lack of channelization, and insufficient pedestrian facilities. Mixed traffic conditions and roadside encroachments further reduced the operational efficiency of the junction. These deficiencies resulted in traffic congestion, irregular vehicle movements, delays, and safety issues for both vehicles and pedestrians.

B. *Proposed Geometric Improvements*

Based on the traffic analysis and site observations, suitable geometric improvements were proposed to improve traffic flow and road safety at the intersection. The proposed improvements include widening of approach roads, provision of proper turning lanes, improved turning radii, and channelization using traffic islands. Pedestrian movement facilities and better road markings were also suggested to reduce traffic conflicts and improve safety. Figure 1 shows the proposed layout of Angadippuram intersection.

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C. Benefits of Geometric Improvement

The proposed geometric improvements help in reducing traffic congestion, minimizing delays, and improving the overall operational efficiency of the intersection. Proper channelization and turning facilities improve vehicle movement and reduce traffic conflicts. The improvements also enhance pedestrian safety and provide smoother traffic flow during peak hours.

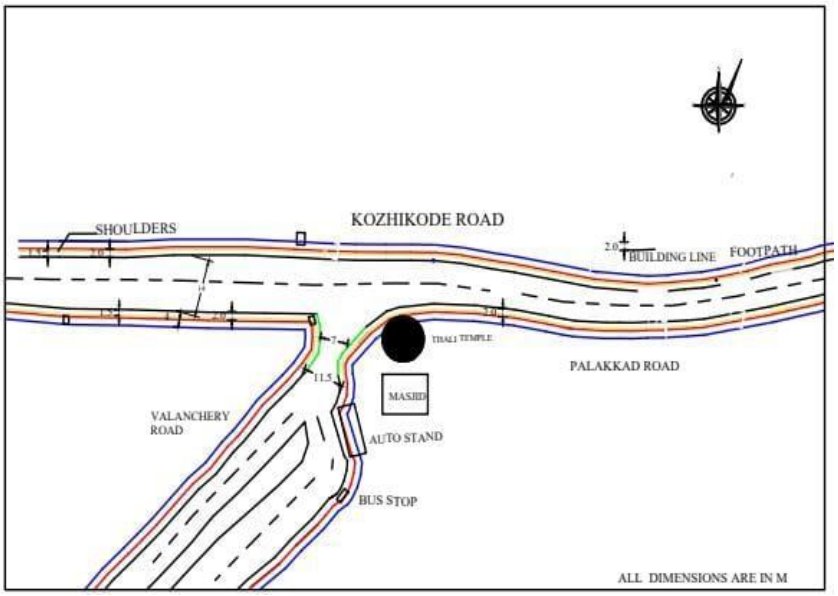


Fig. 1 Proposed layout of Angadippuram intersection

V. TRAFFIC SIGNAL DESIGN

A. Signal Design Method

Traffic signal design was carried out at Angadippuram intersection based on the traffic volume analysis and IRC guidelines. Webster's method was adopted to determine the optimum signal cycle length, green time allocation, and phase design. The design was aimed at reducing traffic delay and improving the overall efficiency of traffic movement at the intersection.

B. Phase Design

The intersection movements were divided into suitable phases to regulate conflicting traffic streams safely and efficiently. The critical traffic approach for each phase was identified based on the highest Passenger Car Unit (PCU) values obtained from the traffic survey. Proper phase arrangements were provided to ensure smooth vehicular movement and pedestrian safety.

C. Cycle Length Calculation

The optimum signal cycle length was calculated using Webster's formula by considering saturation flow, flow ratio, and total lost time. Saturation flow values were estimated according to IRC standards based on the effective road width of each approach. The calculated cycle length helped in minimizing traffic delay and queue formation at the intersection.

D. Green Time Allocation

Green time was allocated for each traffic phase according to the traffic demand and flow ratio of each approach road. The effective green time distribution ensured efficient utilization of intersection capacity and reduced waiting time for vehicles. Proper amber and red time intervals were also provided to improve traffic safety and operational efficiency.

E. Proposed Traffic Signal System

A multi-phase traffic signal system was proposed for the Angadippuram intersection to control traffic movement systematically. The proposed signal design improves traffic flow, reduces congestion and delays, and enhances safety for both vehicles and pedestrians at the junction.

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VI. CALCULATION OF CYCLE LENGTH

The geometric features of the intersection were improved according to the guidelines recommended by the Indian Roads Congress (IRC). The road width and other geometric parameters were modified based on IRC standards to ensure proper traffic movement and safety. The improved geometric data obtained from these IRC recommendations were then used for calculating the flow ratios and determining the optimum signal cycle length using the Webster method.

Hence, we tried to designed using IRC proposed values;

From	To	Width in metres	Q		S		Y	
Valancheri	Perinthalmanna	6.5	Q1	691.7	S1	3412.5	Y1	0.202696
Perinthalmanna	Malappuram	5.075	Q2	2104.9	S2	2550	Y2	0.825451
Malappuram	Valancheri	6.89	Q3	545.5	S3	3617.25	Y3	0.150805
							Y	1.178952

Co= (1.5*25+5)/(1-0.909415)

=469.17

- Lost Time (L)
- Assume 4 s per phase (2 s amber + 2 s start delay)
- Number of phases = 3
- $L=3\times4=12s$.
- Effective Green Time, $Co-L=120-12=108s$
- Green Time Allocation g = y1/Y(Co-L)
- Phase 1

  G1 =(0.18822/0.90941)108 =22.35=24s
- Phase 2

  G2= (0.52476/0.90941)108= 62.31=64s
- Phase 3

  G3=(0.14844/0.90941)108 =17.62s

But pedestrian time = 19 s, so minimum green must be 19 s.

VII. RESULTS AND DISCUSSION

The project titled “Geometric Improvement and Traffic Signal Design at Angadippuram Intersection” was carried out to analyses the existing traffic conditions and propose suitable traffic management measures for improving the operational efficiency and safety of the intersection. The study involved detailed traffic volume surveys, geometric measurements, PCU analysis, and traffic signal design using Webster’s method.

The traffic volume survey conducted at Angadippuram intersection revealed that the junction experiences heavy and mixed traffic flow throughout the day, especially during morning and evening peak hours. The intersection carries a significant proportion of two-wheelers, cars, buses, auto-rickshaws, and heavy vehicles due to its location on NH 966 and its connection to important nearby towns such as Perinthalmanna and Valanchery. The survey data collected over four days showed continuous traffic congestion and high traffic demand on all approaches.

From the classified traffic volume count, all vehicle categories were converted into Passenger Car Units (PCU) using IRC recommended conversion factors. The analysis indicated that the Malappuram–Perinthalmanna approach recorded the highest traffic volume among all approaches, making it the critical traffic movement at the intersection. Peak hour traffic conditions showed excessive vehicular accumulation, long queues, and delay during turning movements.

The geometric survey conducted at the site identified several deficiencies in the existing intersection layout. The major problems observed were inadequate carriageway width, absence of proper channelization, insufficient turning radius, poor pedestrian crossing facilities, and roadside encroachments caused by commercial activities. These deficiencies reduced the operational efficiency of the junction and increased the probability of traffic conflicts and accidents.

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Based on the traffic analysis, suitable geometric improvement measures were proposed. The proposed improvements included lane widening, provision of channelizing islands, improvement in turning radii, and better organization of traffic movements. These modifications were intended to reduce conflicts between vehicles, improve traffic flow continuity, and enhance pedestrian safety at the intersection.

Traffic signal design was carried out using Webster's method in accordance with IRC guidelines. The saturation flow values, flow ratios, total lost time, optimum cycle length, and green time allocation for each phase were calculated. The analysis showed that the optimum cycle length obtained for the intersection was comparatively high due to the heavy traffic demand and mixed traffic conditions. A higher cycle length indicates increased waiting time and delay for road users.

The signal timing analysis also revealed that signalization alone may not provide the most efficient solution for the Angadippuram intersection. Due to the heavy turning movements and irregular traffic pattern, alternative traffic control measures such as a properly designed roundabout or channelized intersection may perform more effectively when combined with geometric improvements.

Overall, the study concludes that the proposed geometric improvements along with proper traffic control measures can significantly improve the operational performance of the intersection. The recommendations are expected to reduce congestion, minimize delays, improve safety, and provide smoother traffic movement for both vehicles and pedestrians. The study can also serve as a reference for improving similar congested intersections in urban and semi-urban areas of Kerala.

VIII. CONCLUSIONS

The study at Angadippuram intersection revealed severe traffic congestion, inadequate road geometry, and unsafe vehicle movements during peak hours. The traffic signal design using Webster's method resulted in a high cycle length, indicating that a conventional signal system alone may not be effective for this junction. Since a bypass road is proposed in the future, improving the existing intersection through geometric improvements, proper channelization, and traffic management measures is considered more suitable for reducing congestion and improving road safety.

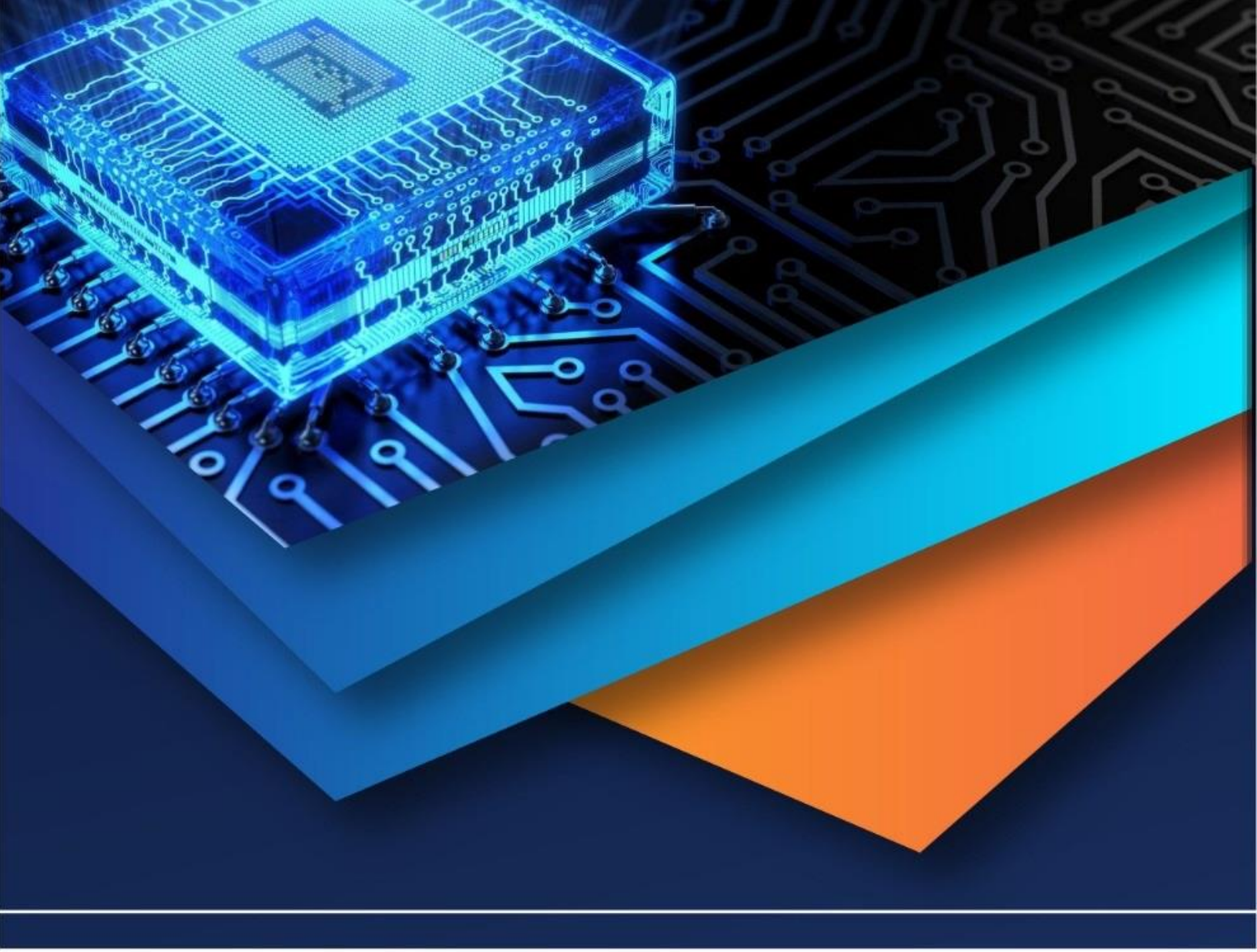
IX. ACKNOWLEDGMENT

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