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(Research Article)

Evaluation of traffic management at Futa Northgate, Akure Ondo state, Nigeria

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Abstract

Due to increasing usage of automobiles, traffic congestion in most cities is becoming an issue and slowing down the day-to-day activities of human and also deteriorating the quality of the road due to the constant congestion. The movement of products and services between locations has become essential and integral to both global and metropolitan economic existence, and modern enterprises, industries, trades, and general activities are dependent on transportation and transportation infrastructure, hence this project is to evaluate the traffic management on the FUTA North Gate Road and propose recommendations to improve traffic flow and reduce congestion. The research identified the causes of traffic congestion, proffered a solution to traffic congestion for the single carriageway under study and analyzed the implications of the proffered traffic management strategy. Data collection on the road was done during peak days of the week (Tuesday – Friday) and also during peak hours of the day i.e. early hours of the morning and in the evening using the traffic count method. The study revealed that the existing single carriageway has a dimension of 3.75-meter width per each side, with a 2.7-meter shoulder, showed 2,585 as the maximum number of vehicles that ply the road causing traffic congestion as a result of poor road conditions, lack of proper traffic management systems, increased population and vehicle ownership, inadequate road infrastructure, and poor driving habits exceeding the capacity.

The study concludes that implementing traffic management strategies which includes promoting the use of public transportation, improving the design of intersections and roundabouts, investing in road infrastructure, and educating drivers on safe and responsible driving habits can help improve the traffic flow and reduce congestion on busy roads. While some recommendations may require significant investment, the benefits of a more efficient and sustainable transportation system will far outweigh the costs in the long run. It is important that all stakeholders work together to implement these recommendations and create a transportation system that benefits everyone.

Overall, this project highlights the importance of having an efficient and effective traffic management system, and the need to consider all possible impacts before implementing road expansion projects. By adopting a holistic approach to traffic management and implementing the recommended measures, we can create a more efficient and sustainable transportation system that benefits both motorists and the environment giving a long-term solution going ahead.

Keywords: Traffic management; Traffic congestion; Transportation system; Traffic management systems

1. Introduction

Road transport have demonstrated worldwide to be the most effective and preferred mode for the movement of people and transportation of goods and services all over the world (1). Rapid mobility is one of the most essential necessities

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in contemporary culture. As a result, residents can use a variety of transit options, including automobiles, subways, and bicycles. Automobiles, however, remain the most popular form of transportation among all of these because of their convenience and usefulness (2). In this respect, assuming ongoing population growth, the number of automobiles in major cities will increase as well, but much more quickly than transportation infrastructure; as a result, traffic congestion will become a serious problem.

Transportation itself is a social progress because it has been, throughout history, the way in which not only goods and services moved around but ideas are exchanged among people (3,4).

It raises a number of issues that are detrimental to the environment and society, including an increase in the number of traffic accidents, negative effects on the economy, and excessive levels of greenhouse gas emissions (5). Three main causes of traffic congestion may exist, according to the US Department of Transportation (DoT) (US-DoT, 2015). The first one has to do with factors that influence how much traffic moves, like accidents, construction zones, and bad weather. The second one is associated with traffic demand, which entails changes in both routine traffic and unique events and the last is the transportation system, which consists of the physical bottlenecks and traffic-control equipment.

Road networks are scrutinized based on their accessibility, connection, and traffic density components as well as their level of service, compactness, and density of specific roadways. With the movement of products and services from one location to another becoming essential and integral parts of global and urban economic survival, modern enterprises, industries, trades, and general activities are dependent on transportation and transportation infrastructure. Developments in many types of transportation are now essential to both physical and economic progress. These transportation methods include highways, pipelines, inland waterways, railroads, ropeways, and cableways, as well as human porterage.

Traffic management is a critical issue in many urban areas around the world, affecting not only the daily routines of individuals but also having a significant impact on the economy and the environment. The problem is complex and multi-faceted, involving various stakeholders such as drivers, public transportation operators, and government agencies. Effective solutions must take into account the demands and needs of all parties involved, as well as the resources and infrastructure available. Traffic Management System is made up of a variety of management tools and applications that integrate communication, sensor, and processing technologies (2).

In response, many cities have implemented a variety of traffic management strategies aimed at improving traffic flow, enhancing safety and reducing congestion which is a widespread problem that has a significant impact on traffic management and can cause a range of negative effects, including increased journey times, reduced road capacity, increased fuel consumption, increased emissions and increased road safety risks.

Another important development in the field of traffic management was the widespread adoption of public transportation. In many cities, the use of buses, trains, and other forms of public transportation has played a key role in reducing the number of cars on the roads and improving the efficiency of the transportation system. This, in turn, has led to reductions in congestion, improved air quality, and decreased travel times for passengers.

More recently, there has been a growing recognition of the importance of sustainable transportation and the role that traffic management can play in supporting this objective. Many cities are now investing in initiatives that encourage the use of alternative modes of transportation, such as cycling and walking, as well as the development of more sustainable public transportation systems. This has led to a renewed focus on the design and operation of transportation infrastructure, as well as the development of new technologies and data-driven approaches to traffic management.

The background and context of a study on traffic management is rooted in the need to address the challenges posed by rapidly growing urban populations and the associated increase in traffic volumes. Over the years, various strategies and approaches have been developed and implemented to improve the efficiency and sustainability of the transportation system. Today, there is a growing recognition of the need for a holistic and data-driven approach to traffic management, which takes into account the needs and demands of all stakeholders and the available resources and infrastructure.

1.1. Historical Overview of Traffic Management

Traffic management refers to the set of measures and strategies aimed at improving the flow of vehicles, pedestrians, and other modes of transportation in urban areas (6,7). The history of traffic management can be traced back to ancient times when cities were first established, and the need for regulations to manage the movement of people and goods became apparent.

1.1.1. Key milestones and innovations

In the Middle Ages, city planning focused mainly on fortification and defense, but as cities grew and commerce developed, the need for more sophisticated systems of roadways and traffic regulation emerged. During the Industrial Revolution, the growing use of horse-drawn carts and later, automobiles, resulted in increased congestion and the need for traffic management solutions.

In the early 20th century, traffic management was still in its infancy, with little attention paid to issues such as road design and traffic signals. However, the growing number of cars on the road and the increasing frequency of accidents led to the formation of the first traffic departments, which were responsible for the regulation of traffic.

In the 1920s and 1930s, traffic engineers began to study the science of traffic flow and develop new technologies such as traffic lights and roundabouts to improve the flow of vehicles. The first computerized traffic management system was introduced in the 1950s, which allowed for real-time monitoring and control of traffic flow.

The 1960s and 1970s saw the introduction of new technologies such as ramp meters, which regulated the flow of vehicles onto freeways, and advanced traffic management systems (ATMS), which allowed for real-time monitoring and control of traffic conditions. The development of Intelligent Transportation Systems (ITS) in the 1990s represented a major step forward in traffic management, incorporating advanced technologies such as GPS and real-time traffic information to improve the flow of traffic.

In recent years, traffic management has become an increasingly important issue due to the rapid growth of urban populations and the increasing number of vehicles on the road. As a result, many cities have implemented comprehensive traffic management systems, which incorporate a range of measures, including traffic signals, roundabouts, speed cameras, and real-time traffic information systems (8,9,10).

1.2. Theoretical Frameworks of Traffic Management

1.2.1. Overview of traffic flow theory

Traffic flow theory is a branch of transportation engineering that deals with the study of the movement of vehicles on roads. The main objective of traffic flow theory is to understand the behavior of vehicles on roads and to develop models that can be used to analyze and optimize traffic congestion (11,12). The theory is based on several key concepts, including the relationship between vehicle flow, density, and speed, the impact of different types of roadways and traffic control systems, and the role of driver behavior in traffic flow.

1.2.2. Importance of capacity analysis

Capacity analysis plays a crucial role in traffic management as it helps to evaluate the ability of a transportation system to handle the demands placed upon it. By understanding the capacity of a system, traffic managers can make informed decisions on how to best allocate resources and improve the flow of traffic.

Capacity analysis considers several factors, including the number of lanes, the design of intersections, the speed of vehicles, and the behavior of drivers. By taking these factors into account, capacity analysis can provide a quantitative measure of the maximum number of vehicles that can be accommodated by a transportation system during a given period of time.

This information is critical for traffic managers who must balance the needs of different road users, including motorists, cyclists, and pedestrians and also plan for future growth.

1.3. Traffic Management Techniques

Traffic management refers to the coordination and regulation of vehicles and pedestrians on roads, highways, and other transportation networks to ensure the efficient and safe flow of traffic. The goals of Traffic management strategies according to Ajala (13) are majorly four: ensure free flow of traffic, reduce congestion and delay, increased road capacity, and reduced road traffic crashes (accident).

- Signal Control: This is the most common form of traffic management and involves the use of traffic signals at intersections to regulate the flow of vehicles. The timing of the signals can be adjusted based on the volume of traffic, weather conditions, and other factors to ensure the safe and efficient movement of vehicles.
- Variable Message Signs: These are electronic signs that can display real-time information about traffic conditions, road closures, and other important information to help drivers make informed decisions about their routes.
- Intelligent Transportation Systems (ITS): Intelligent Transportation Systems is an integration of information and communication technologies with transportation systems to improve safety, efficiency, and sustainability. It includes technologies such as GPS, real-time traffic monitoring, and traffic simulation models to help manage traffic flow and reduce congestion (14,15).
- Road Pricing: This is a congestion management technique that involves charging drivers a fee to use roads during peak hours. The fees are usually based on the time of day, the distance traveled, and the level of congestion on the roads.
- Roundabouts: Roundabouts are circular intersections that are designed to reduce congestion and improve safety by slowing down traffic and reducing the number of conflict points between vehicles (16).
- High-Occupancy Vehicle (HOV) Lanes: HOV lanes are dedicated lanes for vehicles with multiple occupants, such as carpools and buses, to encourage carpooling and reduce congestion (17).
- Ramp Metering: Ramp metering is a technique used to control the flow of vehicles entering freeways from on-ramps. Meters regulate the flow of vehicles onto the freeway to avoid congestion and improve safety.
- viii. Work Zone Management: Work zone management involves the implementation of strategies to manage traffic and ensure the safety of workers and drivers during construction and maintenance activities on roads and highways

Emerging technologies are playing a crucial role in traffic management by providing new and efficient ways to monitor, control, and optimize the flow of vehicles. Here are some of the key emerging technologies in traffic management:

- Connected and Autonomous Vehicles: They are vehicles that are equipped with advanced sensors, cameras, and communication systems that allow them to interact with each other and with the surrounding infrastructure. They have the potential to revolutionize traffic management by improving the safety and efficiency of transportation. With the help of these vehicles, traffic managers can gather real-time information about traffic conditions, reduce congestion, and improve road safety (18).
- Advanced Traffic Management Systems: This is a system that uses advanced technologies such as computerized traffic control, sensors, and cameras to monitor and control traffic flows. It can also integrate real-time information from various sources such as GPS, weather, and road conditions to provide a comprehensive view of traffic conditions. With the advanced traffic management systems, traffic managers can make informed decisions about traffic management and respond quickly to traffic incidents (19).
- Real-Time Traffic Information: This is a system that provides real-time information about traffic conditions to drivers and traffic managers. It utilizes various sources of information such as GPS, cameras, and sensors to provide real-time updates about traffic flow, congestion, and road conditions. The information enables traffic managers to respond quickly to traffic incidents and make informed decisions about traffic management.
- Smart Parking Systems: Smart parking systems are an innovative solution that enables drivers to find available parking spots in real-time. These systems use sensors and cameras to monitor the availability of parking spots and provide real-time information to drivers through a mobile app or a web interface. Smart parking systems can help reduce congestion and improve the overall efficiency of transportation.
- Smart Traffic Lights: Smart traffic lights are an innovative solution that can optimize the flow of traffic by adjusting the timing of traffic lights based on real-time traffic conditions. Smart traffic lights can also communicate with vehicles and other traffic management systems to improve road safety and reduce congestion.
- Advanced Public transport system (APTS): Public transport system is a part and parcel of life for almost all citizens of city or country. It is a proven fact that the Intelligent Transport Systems (ITS) tools increase the efficiency, ticket sale and clientage manifold times. The passenger information system at terminals, bus stations (metro stations, railway stations, airport) and on board has proven its importance in almost all types of modes. Almost every type and form of passenger information system has shown its importance in the overall transport system.
- Emergency management system (EMS): The emergency management system is the need of every city. If any accident occurs on road network, then there are two priorities for network managers. The first one is to save the life of victim (take out victim from the accidental vehicle) and second is to clear the network for other road users. The first one of top priority is only possible if the network manager is having the full support of

emergency management system. The basic EMS is having life supporting system and capacity to assist victims at road side.

1.4. Problem Statement

One of the primary issues facing modern cities is traffic congestion and this does not exclude city with a considerable development due to the wide usage of vehicles. In this case the North Gate axis of the Federal University of Technology, Akure (FUTA) is also facing a daily increasing traffic congestion due to the movement of vehicles coming from Ilesha and other places entering into Akure or going towards Owo and vice versa, as well as the ones entering the Federal Institution from the two opposite lanes of the road leading to gradual movement of vehicle caused by the existing bumps that situated a few meters before the school entrance in both directions, the single carriageway road capacity and the trading activity (buying and selling) on the road side. Hence, the need to proffered traffic management strategy to control traffic congestion.

2. Research methodology

2.1. Study Area

The study was conducted at the Federal University of Technology, Akure (FUTA), a federal institution in Akure, Ondo State, Nigeria (Latitude 7.30707°N, Longitude 5.13978°E). FUTA has three main entrances: North Gate, South Gate, and West Gate. This research focuses on the North Gate axis, situated along the Ilesha-Akure road, just after Ibule-Soro when approaching from Ilesha.

The Ilesha-Akure road, constructed in 1978, serves as a vital connection between southwestern Nigeria and the northern and eastern regions of the country (20). This single carriageway leads to Owo on the right and Ibadan on the left. The road, originally built by the British administration in the late 1960s, is surfaced with asphalt. Due to the dense student population in the area, the region attracts numerous traders. The opposite side of the road is characterized by a mix of trading activities and residential buildings.

Figure 1 Aerial Map of FUTA North Gate showing Akure Owo road

Figure 2 Satellite view of FUTA North Gate

2.2. Data Collection Method

To evaluate traffic management along the major highway at the Federal University of Technology, Akure (FUTA) North Gate axis, the traffic count method was employed. This method involved manually counting vehicles passing through specific points on the highway at various times during peak hours, providing accurate data on traffic volume and patterns.

2.2.1. Traffic Counts

Traffic counts were conducted manually to determine the number and type of vehicles passing through designated points on the highway at different times of the day. These counts were performed during peak periods, morning (8:00–9:00 AM) and evening (4:00–5:00 PM) from Tuesday to Friday. The following vehicle categories were recorded: motorcycles, tricycles, passenger cars, buses, 2-axle, and 3-axle vehicles.

The data collected from the traffic count was used to:

- Analyze peak traffic periods.
- Identify areas of congestion.
- Inform the development of traffic management strategies, such as congestion pricing or carpool lanes.

The traffic count method was chosen due to its accuracy in capturing real-time vehicle flow, allowing for effective evaluation of current traffic conditions. Additionally, it provides valuable insights for monitoring changes in traffic patterns over time, facilitating ongoing improvements.

2.2.2. Primary and Secondary Data Sources

Primary Data: Oral interviews, observations, and on-site data collection (including vehicle counts and traffic delays) were conducted. Photographs were also taken to document the research area, road network, and traffic flow.

Secondary Data: The geometric characteristics of the road were gathered from secondary sources, such as Google Earth, to complement the field data. These data helped provide a comprehensive understanding of the road's layout and its impact on traffic flow.

2.2.3. Apparatus for data collection

To determine the total number of vehicles that passes through the section of the road for a particular duration and time, the apparatus used are:

- Stop watch: This is used to measure the duration for which the test was carried out.
- Recording sheets: They are used for recording the observed traffic volume
- Reflective jackets: These were worn by observers for safety purpose
- Speaker: The speaker was used to communicate between observers to ensure uniformity of starting and ending time for each time interval

2.2.4. Procedures for Data Collection

The data collection for the road was done during peak days of the week (Tuesday – Friday) and also during peak hours of the day i.e. times where expected vehicular volume is high. The peak hours are the early hour of the morning (8am-9am) and in the evening (4pm-5pm). The following are the steps:

- The road section to be used for the traffic count was identified
- The best observation point for the data collection was selected at either side of the road for safety and accuracy
- Observers and recorders were stationed at the selected points and the passing vehicles were classified
- The traffic count was done for one hour splitted into four parts of 15 minutes per duration
- For the first 15 minutes, the class of vehicle passing were counted and recorded. The observation and recording were done at the selected points in the same duration
- The above step was repeated for the next 3 fifteen minutes intervals totaling one hour
- After one hour of collection, the observers and recorders gathered the data for analysis.

2.2.5. Techniques of Data analysis

Several analytical techniques were employed to evaluate traffic management along the major highway at the Federal University of Technology, Akure (FUTA) North Gate axis. These techniques helped identify areas of congestion, inefficiencies, and potential solutions to improve traffic flow.

- Traffic Flow Analysis: Traffic flow data, collected from manual counts and other monitoring methods, were analyzed to identify areas where congestion occurred. Factors such as bottlenecks and accidents were examined to determine their impact on traffic flow. This analysis provided critical information for developing strategies to reduce congestion and improve road performance.
- Simulation Analysis: Computer simulation models were used to simulate different traffic scenarios. By inputting variables such as traffic volume and vehicle speed, the simulations predicted traffic behavior under various conditions. This approach helped identify potential problems and test solutions before actual implementation, improving decision-making in traffic management.
- Geospatial Analysis: Geographic Information Systems (GIS) were employed to analyze the spatial distribution of traffic patterns. By mapping key locations such as interchanges, traffic signals, and bottlenecks, geospatial analysis helped identify areas where traffic management improvements were needed. This approach provided a clear visual representation of the traffic network, facilitating better planning.
- Public Perception Analysis: Surveys and interviews were conducted to gather public opinions on traffic conditions, road safety, and transportation services. The data obtained helped assess the impact of driver behaviour, and public transport usage and highlighted areas where public education or awareness campaigns could enhance traffic management strategies.

2.2.6. Traffic Delay Studies

Travel time and delay characteristics are critical indicators of the level of service and traffic flow efficiency on a highway. A delay study was conducted to assess the amount, causes, location, duration, and frequency of delays, as well as overall travel and running speeds.

2.2.7. Application of Delay Data

The delay data were applied to:

- To evaluate the congestion
- To carry out the Before-and-After study
- To assign traffic to certain networks and new or improved facility.
- To carry out the economic studies.
- To make trend study, i.e., the evaluation of level of service as it changes with the passage of time.

2.2.8. Operational or Congestion Delay

Operational delays are caused by interference within the traffic stream. Two types of delays were observed:

- **External Interference (Side Friction)**: These delays were caused by vehicles parking or unparking, pedestrian crossings, stalled vehicles, double parking, and cross traffic, which interrupted the flow of vehicles.
- **Internal Interference (Congestion)**: These delays occurred due to high traffic volumes, insufficient roadway capacity, and merging or weaving maneuvers, which hindered smooth traffic movement.

For the analysis:

- **In case of main streets:** The average running speed was measured during free-flowing traffic conditions, with the speed limit taken as the maximum running speed.
- **In case of city center streets:** The average spot speed was measured at points where traffic flow was unimpeded, providing a clear indication of normal operating speeds away from intersections.

2.3. Software Used

- Revit: For 3D modelling of the road infrastructure to evaluate traffic management.
- AutoCAD: To analyze traffic patterns and simulate various road management scenarios.
- Lumion: For 3D rendering and visualizing traffic scenarios under different conditions.

3. Results and discussion

3.1. Assessment of the road and traffic conditions

A feasibility study was carried out to assess the road and traffic conditions on the existing single carriage way. The study revealed that the existing carriage way has dimensions of 3.75-meter width per each side, with a 2.7-meter shoulder, it has no median and also the drainage is not functioning. Also, there were several causes of traffic congestion, including:

- High volume of vehicles.
- Poor road conditions
- Lack of proper traffic management systems.

The study recommended several solutions to address these issues, including the construction of additional lanes, improvements to the road surface, and the installation of traffic lights and other traffic management systems. The study also emphasized the importance of proper driver education and training to help reduce the incidence of accidents and improve overall road safety. By implementing these recommendations, it is hoped that traffic conditions can be improved and road safety can be enhanced for all road users.

3.2. Proposed Dual Carriageway and Modifications

The solution proffered in this study is a dual carriageway road; this carriageway construction project underwent several revisions to mitigate potential environmental and social impacts. The initial design was adjusted to avoid ecologically sensitive areas, reduce the project's footprint, and minimize the number of displacements of people and businesses. These adjustments were made after consulting with local stakeholders, including community members, environmental groups, and government agencies.

The current state of the single carriageway road is as depicted from Figures 4.1 to 4.8, while the proposed dual carriageway road is depicted from Figures 4.11 to 4.16, with all of the proposed structures and lighting included. The proposed dual carriage road will provide a smoother flow of traffic at the North Gate of the Federal University of Technology, Akure, it will connect two major cities, Owo and Akure, providing a direct route for commuters, freight transport, and tourists. The road will feature modern infrastructure, including solar powered lighting panels, culverts, and drainage systems, improving road safety and reducing travel times. Furthermore, the proposed dual carriage road construction project will create jobs and stimulate economic development in the region, creating new business opportunities and facilitating regional growth.

3.3. Traffic delay and causes

A study of traffic at the FUTA North Gate revealed that the current single-carriageway is insufficient to accommodate the volume of vehicles, particularly during peak traffic hours. The following are the key factors contributing to traffic delays and congestion:

- Capacity Density

The capacity density exceeds the designed capacity of the road network and as such a 'dead weight' or traffic congestion sets in and the intensity increases with more vehicles getting to the spot than leaving the point. As this happens, traffic speed of vehicles is reduced and thereby increasing personal commuting time.

- Increased Motorization.

Increased motorization refers to the trend of more people owning and using cars. As more people own cars, there are more vehicle on the road, which in turn leads to more traffic and congestion.

- Frequent Breakdown of Vehicles and Road Traffic Crashes

Most of the vehicles on the roads are aging or poor maintenance which leads to breakdown on the road and builds up traffic. The maintenance culture is very poor. Broken down vehicles, and those involved in crashes that are not immediately cleared away from the road often cause traffic to build up and hence the inevitable resultant traffic congestion.

- Fewer/Narrow Lanes:

The lanes are few and thereby making the capacity of the road small or reduced and the inability of the carriage way to adequately accommodate the vehicular volume results in congestion. This happens to be the major cause in which solution on this basis will be proffered.

- Cars exiting and entering the FUTA north-gate also contribute to the delay on the road.
- The bumps on the road are close to each other and as such vehicles have to slow down to avoid damages and causing congestion.
- Heavy duty vehicles plying the road causing impedance to other vehicles.
- Lack of traffic sign and even traffic wardens.
- Wrong and unrestricted parking on the road.
- Indiscipline from drivers.
- People hawking on the road and those selling by the road side.

Figure 3 Image 1 from the North Gate

Figure 4 Image 2 from the North Gate

Figure 5 Image 3 from the North Gate

Figure 6 Image 4 from the North Gate

Figure 7 Image 5 from the North Gate

Figure 8 Image 6 from the North Gate

Overall, the proposed road construction project has undergone necessary adjustments to address environmental and social concerns while meeting the region's transportation needs. The proposed road construction project is expected to bring numerous benefits, including reduced travel times, improved road safety, increased economic development, and enhanced access to public transportation. The project's success will depend on the careful planning and execution, ensuring that the road is constructed to the highest safety and environmental standards.

3.4. Results

The following are the data collected for different days and times, the data was observed and all observers took the data appropriately.

3.5. Traffic count for DAY 1 (Tuesday 8pm-9pm)

Table 1 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	Total
Motorcycle	66	46	63	52	227
Tricycle	5	6	12	4	27
Passenger car	126	120	106	127	479
Bus	32	37	35	39	143
2-axle	9	8	7	13	37
3-axle	6	10	8	6	30
					943

Table 2 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	
Motorcycle	66	79	74	78	231
Tricycle	2	8	6	10	24
Passenger car	107	78	109	90	277
Bus	22	36	36	39	111
2-axle	8	9	13	6	28
3-axle	8	17	12	9	38
					709

Table 3 The Volume of Vehicles Exiting the FUTA North

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	Total
Motorcycle	29	35	38	30	132
Tricycle	9	14	16	8	47
Passenger car	66	69	78	67	280
Bus	7	9	14	16	46
2-axle	1	3	0	1	5
3-axle	0	0	0	0	0
					510

3.6. Traffic count for DAY 1(Tuesday 4pm-5pm)

Table 4 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	35	46	42	60	183
Tricycle	0	0	0	1	1

Passenger car	92	93	86	80	351
Bus	15	12	12	14	53
2-axle	0	2	3	2	7
3-axle	5	4	13	10	32
					627

Table 5 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	41	53	46	42	182
Tricycle	0	0	0	0	0
Passenger car	90	81	66	72	309
Bus	26	18	14	14	72
2-axle	0	1	0	0	1
3-axle	3	3	0	4	10
					574

Table 6 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	10	10	22	13	55
Tricycle	0	1	0	0	1
Passenger car	54	65	43	55	217
Bus	1	2	2	0	5
2-axle	0	0	0	0	0
3-axle	0	0	0	0	0
					278

Table 7 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	3	6	10	10	29
Tricycle	0	0	0	0	0
Passenger car	33	37	40	43	153
Bus	1	1	0	1	3
2-axle	0	2	0	0	2
3-axle	0	0	0	0	0
					187

3.7. Traffic count for DAY 2(Wednesday 8am-9am)

Table 8 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	Total
Motorcycle	55	29	48	35	167
Tricycle	0	2	3	1	6
Passenger car	100	100	83	108	391
Bus	16	20	10	20	66
2-axle	7	6	5	10	28
3-axle	0	8	5	2	15
					673

Table 9 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	Total
Motorcycle	56	60	55	57	228
Tricycle	0	2	3	5	10
Passenger car	86	57	89	68	300
Bus	15	20	21	23	79
2-axle	4	3	3	5	15
3-axle	4	12	8	5	29
					661

Table 10 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	Total
Motorcycle	15	20	24	15	74
Tricycle	2	4	2	5	13
Passenger car	50	52	59	49	210
Bus	0	0	3	4	7
2-axle	0	0	0	2	2
3-axle	0	0	0	0	0
					306

Table 11 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	Total
Motorcycle	19	16	13	19	67
Tricycle	1	2	1	2	6
Passenger car	65	46	47	49	207
Bus	2	3	2	2	9
2-axle	0	2	0	2	4
3-axle	0	0	0	0	0
					293

3.8. Traffic count for DAY 2(Wednesday 4pm-5pm)

Table 12 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	53	45	41	45	184
Tricycle	0	1	0	0	1
Passenger car	98	69	81	83	331
Bus	13	12	36	13	74
2-axle	3	5	3	5	16
3-axle	3	4	4	4	15
					621

Table 13 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	36	26	20	27	109
Tricycle	0	0	1	0	1
Passenger car	47	52	60	50	209
Bus	5	14	5	6	30
2-axle	0	3	4	0	7
3-axle	6	1	1	3	11
					367

Table 14 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	5	9	8	15	37
Tricycle	1	2	1	1	5
Passenger car	86	64	58	68	276

Bus	1	1	0	1	3
2-axle	0	0	0	0	0
3-axle	0	0	0	0	0
					321

Table 15 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	13	7	12	7	39
Tricycle	1	0	1	1	3
Passenger car	49	28	31	34	142
Bus	0	2	1	0	3
2-axle	0	0	0	0	0
3-axle	0	0	0	0	0
					187

3.9. Traffic count for DAY 3 (Thursday 8am-9am)

Table 16 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	45	25	38	25	133
Tricycle	0	1	2	0	3
Passenger car	95	95	78	103	371
Bus	11	15	15	15	56
2-axle	6	6	4	8	24
3-axle	0	7	4	1	12
					599

Table 17 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	51	56	50	52	209
Tricycle	0	0	1	4	5
Passenger car	81	52	82	63	278
Bus	8	16	15	15	54
2-axle	2	2	2	1	7
3-axle	3	11	7	5	26
					579

Table 18 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	10	15	19	10	54
Tricycle	1	3	3	1	8
Passenger car	44	45	54	43	186
Bus	0	0	1	1	2
2-axle	0	1	0	0	1
3-axle	0	0	0	0	0
					251

Table 19 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	14	11	8	14	47
Tricycle	0	1	1	1	3
Passenger car	60	41	42	46	189
Bus	0	0	2	2	4
2-axle	0	0	0	1	1
3-axle	0	0	0	0	0
					244

3.10. Traffic count for DAY 3(Thursday 4pm-5pm)

Table 20 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	43	35	31	35	144
Tricycle	0	1	2	0	3
Passenger car	92	61	73	81	307
Bus	10	11	31	9	61
2-axle	2	1	1	2	6
3-axle	2	0	2	1	5
					526

Table 21 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	31	21	15	21	88
Tricycle	2	0	1	0	3
Passenger car	41	45	55	45	186

Bus	1	11	2	3	17
2-axle	1	2	2	0	5
3-axle	3	2	2	2	9
					308

Table 22 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	21	5	3	11	40
Tricycle	2	3	4	1	10
Passenger car	87	65	43	48	243
Bus	0	1	1	1	3
2-axle	0	0	0	0	0
3-axle	0	0	0	0	0
					296

Table 23 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	11	12	10	2	35
Tricycle	1	0	1	1	3
Passenger car	41	21	24	24	110
Bus	1	2	1	1	5
2-axle	0	1	0	0	1
3-axle	0	0	0	0	0
					154

3.11. Traffic count for DAY 4(Friday 8am-9am)

Table 24 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	57	34	51	41	183
Tricycle	1	3	5	1	10
Passenger car	103	107	82	108	400
Bus	20	25	15	22	82
2-axle	10	3	7	12	32
3-axle	9	0	5	2	16
					723

Table 25 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	60	65	60	66	251
Tricycle	3	5	2	4	14
Passenger car	90	60	93	73	316
Bus	18	23	25	28	94
2-axle	3	5	0	9	17
3-axle	6	18	10	9	43
					735

Table 25 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	19	25	29	19	92
Tricycle	3	7	4	9	23
Passenger car	68	68	65	49	250
Bus	2	3	5	8	18
2-axle	1	0	1	1	3
3-axle	0	0	0	0	0
					386

Table 26 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	26	25	25	26	102
Tricycle	2	3	5	3	13
Passenger car	69	50	54	54	227
Bus	3	4	4	3	14
2-axle	1	2	2	0	5
3-axle	0	0	0	0	0
					361

3.12. Traffic count for DAY 4(Friday 4pm-5pm)

Table 27 The Volume of Vehicles from Road-Block Akure to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	42	49	48	71	210
Tricycle	0	2	0	1	3

Passenger car	99	97	92	89	377
Bus	17	17	15	18	67
2-axle	7	2	3	3	15
3-axle	6	5	11	14	36
					708

Table 28 The Volume of Vehicles from Ilesha Road to FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes		31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	47	57		48	47	199
Tricycle	0	0		0	0	0
Passenger car	87	78		61	67	293
Bus	21	13		12	11	57
2-axle	1	0		0	0	1
3-axle	1	2		1	4	8
						558

Table 29 The Volume of Vehicles Exiting the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	9	7	20	10	46
Tricycle	1	0	0	0	1
Passenger car	51	61	33	45	190
Bus	1	1	1	0	3
2-axle	0	0	0	0	0
3-axle	0	0	0	0	0
					240

Table 30 The Volume of Vehicles Entering the FUTA North Gate

Vehicles classes	0-15 Minutes	16-30 Minutes	31-45 Minutes	46-60 Minutes	TOTAL
Motorcycle	2	4	9	9	24
Tricycle	0	0	0	1	1
Passenger car	30	32	40	40	142
Bus	1	1	1	1	4
2-axle	0	2	1	0	3
3-axle	0	0	0	0	0
					174

3.13. Proposed Road Construction

A proposed solution to the issue of incessant traffic backups at FUTA North Gate is the construction of a new double carriage road and an expansion of the existing one. For this project, what is proposed is a road construction plan that will be designed to ease traffic on a major highway.

The current dimensions of the road are 2.7 meters for the shoulder, 7.4 meters for the width of the road, and 3.7 meters for the road per section. The proposed dimensions of the new road will be a 7.5-meter width per each side, with a 2.7-meter shoulder and a 2.2-meter median.

The expansion of the road will help alleviate traffic congestion by increasing the number of lanes for vehicles to travel. By adding an extra lane, drivers will have more space to manoeuvre, which will reduce the likelihood of accidents and increase the overall safety of the road.

The addition of a median will also help reduce accidents by separating traffic in opposite directions. This feature will also allow for additional safety features to be added, such as barrier walls or safety cables. The 2.7-meter shoulder will provide additional space for vehicles that may have issues with their tires or engines, reducing the likelihood of breakdowns that could cause traffic backups.

Furthermore, the proposed road construction plan includes an emphasis on sustainability. The new road will be built using environmentally friendly materials that are designed to last longer and require less maintenance. This will reduce the amount of carbon emissions released during construction and decrease the overall environmental impact of the project.

3.14. Traffic Characteristics and Delay Study Measurement for the Road

From the above data collected the dominance of low-capacity vehicle i.e. motorcycle and passengers' cars. At every period where traffic count data is collected, passenger cars have the highest counts followed by motorcycle, bus etc. the study revealed uniform characteristics along the road with passenger cars and motorcycles leading the record. However, the implication is that per a transit dominates the traffic. Hence, congestion is inevitable especially during the peak periods.

$$\text{Hourly capacity} = 40{,}000/12 = 3{,}333 \text{ vehicles per hour}$$

This is close to 50% excess of the observed maximum traffic volume recorded during peak hours of the day and as such this clearly curbs the present traffic congestion on the road and also can cater for future demands due to urbanization or increased motorization. In addition to the design of the road, there are other factors that can contribute to traffic congestion. These include high volumes of vehicles, poor traffic management, and accidents.

3.14.1. Delay Study Measurement for the Road

The methodology includes the counting of the number of vehicles stopped in the intersection approach at successive intervals (such as 10, 15, 20) seconds. In addition, a volume count during the same time. This sampling permits estimating the vehicle-seconds of stopped time delay. An example of 5-min. of data is shown and analyzed in the table below.

Table 31 Delay Study data for Monday(4pm-5pm)

Time	Total number of vehicles stopped in the approach at time					Approach volume	
	1min	2min	3min	4min	5min	Number Stopping	Number not stopping
4:00 p.m.	0	2	7	9	5	11	6
4:05	4	0	0	3	9	6	14
4:10	9	16	14	6	10	18	0

4:15	1	4	9	13	6	17	0
Subtotal	22	27	38	40	30	56	37
Total	127					93	

Total delay= $(total\ number\ observed) \times (observation\ interval)$

= 127 × 1 = 127

Average delay per stopped vehicle $= \frac{total\ delay}{no.of\ stopping\ vehicles}$

127/56 = 2.2 minutes/vehicle = 132 seconds/vehicle

Table 32 Delay Study data II

Time	Total number of vehicles stopped in the approach at time					Approach volume	
	1min	2min	3min	4min	5min	Number Stopping	Number not stopping
4:20 p.m.	5	4	6	10	7	13	5
4:25	2	1	3	7	6	8	10
4:30	12	16	14	8	12	16	2
4:35	5	4	10	11	6	13	1
Subtotal	24	25	33	36	31	50	18
Total	149					68	

Total delay= $(total\ number\ observed) \times (observation\ interval)$

= 149 × 1 = 149

Average delay per stopped vehicle $= \frac{total\ delay}{no.of\ stopping\ vehicles}$

149/50 = 2.98 minutes/vehicle = 178.8 seconds/vehicle

Table 33 Delay Study data III

Time	Total number of vehicles stopped in the approach at time					Approach volume	
	1min	2min	3min	4min	5min	Number Stopping	Number not stopping
4:40 p.m.	5	8	4	5	8	15	3
4:45	0	6	3	5	7	3	16
4:50	7	12	18	8	13	13	3
4:55	5	3	7	16	8	20	1
Subtotal	17	31	32	32	36	51	23

Total	148	74

Total delay= $(total\ number\ observed) \times (observation\ interval)$

$$= 148 \times 1 = 148$$

$$\text{Average delay per stopped vehicle} = \frac{total\ delay}{no.of\ stopping\ vehicles}$$

148/51 = 2.9 minutes/vehicle = 174 seconds/vehicle

The average delay per vehicle is 2.9 minutes/vehicle (174 secs/vehicle) and the delay for the road under case study has a delay of 168 seconds/vehicle which is over a 100% excess of the standard average delay per vehicle for any roadway which clearly signifies traffic congestion and also from careful observation and analysis, the 85^{th} percentile speed which is the speed most vehicles move with is 28km/hour and the speed that signifies free flowing traffic should be above 72km/hour.

3.15. Result of the Proposed Dual Carriage Way

After getting the data on the single carriage way a dual carriage way was proposed, a single dual carriage way will significantly ease the flow of traffic. By providing an additional lane for vehicles, more cars can be accommodated on the road at once, reducing the risk of traffic congestion. With a dual carriage road, vehicles can travel at a faster speed, allowing for more efficient travel times, especially during peak traffic hours.

Another benefit of the dual carriage road is that it can reduce the number of accidents that occur on the road. With two lanes, drivers have more options for passing slower-moving vehicles or avoiding obstacles on the road. This can reduce the risk of rear-end collisions and other types of accidents that can contribute to traffic congestion.

There is a very little available information indicating the capacity of the four-lane highway. It is known to be much more than twice the capacity of the two lanes. Reports indicates that a flow of 40,000 vehicles per day on certain peak days. With two lanes available for the different direction, it allows for the two lanes to flow at approximately their maximum capacity.

Assuming capacity of the proposed dual carriage way is 40,000 vehicles per day and also assuming 12-hour peak hours for a day which is nearly impossible and can be termed the worst-case scenario. The proposed dimensions of the new road (Dual carriage way) are 7.5-meter width per each side, with a 2.7-meter shoulder and a 2.2-meter median.

A close look at the images below shows two lanes for each direction which can be the service lane and the speed lane. The service lane or the shoulder will cater for vehicles that would want to park especially passenger cars, taxi etc. possibly for the alighting of passengers so as not to impede the speed of other vehicles coming behind. The speed lane will be for vehicles that wouldn't park and will continue in the journey without stopping. With the two lanes provided, easy flow and movement of traffic is very much ascertained.

The road expansion as an effective measure to alleviate traffic congestion on the road will give rise to the following:

- Increased Capacity: Road expansion will increase the overall capacity of the transportation network, allowing for a greater number of vehicles to travel simultaneously. By adding extra lanes or constructing new roads, traffic flow can be improved and congestion reduced. Increased capacity helps to accommodate the growing number of vehicles on the road.
- Improved Traffic Flow: Expanding the road under study can enhance the efficiency of traffic flow by minimizing bottlenecks and congestion-prone areas. A wider road with additional lanes facilitates smoother movement of vehicles, reducing the chances of traffic jams and gridlock. This leads to reduced travel times, increased average speeds, and improved overall traffic operations.
- Enhanced Safety: The road expansion which will involve the implementation of safety measures such as wider lanes, improved signage, and better road markings. These enhancements contribute to increased safety for motorists, cyclists, and pedestrians. With wider roads, there is more space for vehicles to maneuver, reducing the likelihood of collisions and accidents. Moreover, a well-designed expansion of the road will include dedicated cycling lanes and pedestrian-friendly infrastructure, promoting safer active transportation options.

- Support for Public Transportation: Expansion of the road can also benefit public transportation systems. Dedicated bus lanes, transitways, or exclusive lanes for high-occupancy vehicles can be incorporated into road expansion projects. This prioritization of public transportation encourages commuters to shift from private cars to buses or trains, reducing the number of vehicles on the road and mitigating traffic congestion. It also enhances the reliability and efficiency of public transport services, making them more attractive alternatives for commuters.
- Economic Impact: Reducing traffic congestion through road expansion has positive economic implications. Efficient transportation networks lead to improved productivity, as people and goods can move more swiftly and reliably. Reduced travel times and improved accessibility can boost economic activity by facilitating the movement of goods and services, supporting local businesses, and attracting investments.
- Accommodating Future Growth: Road expansion takes into account the anticipated growth of urban areas and prepares the infrastructure for the future. By constructing larger roads or adding lanes in advance, cities can proactively address potential congestion issues as populations increase. This approach minimizes the need for costly retroactive measures and ensures that transportation systems can handle higher volumes of traffic efficiently.

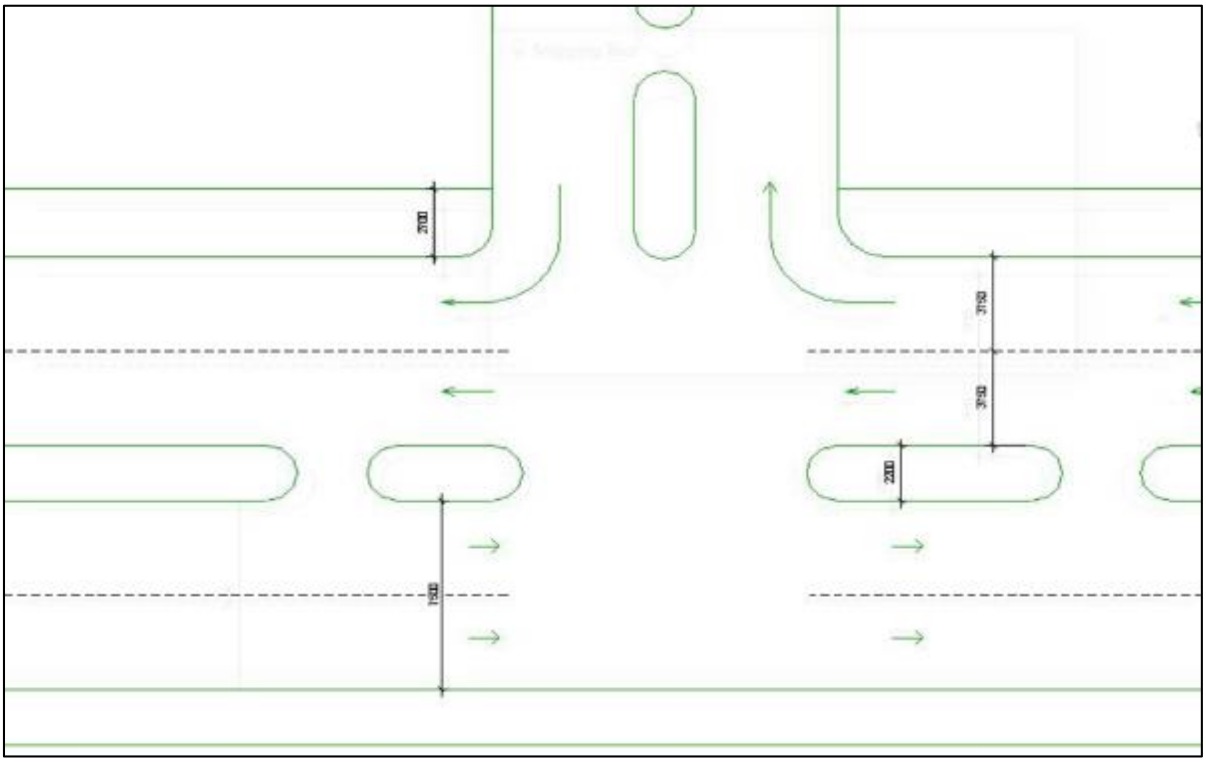

Figure 9 Image 7 from the North Gate showing the plan view

Figure 10 Image 8 from the North Gate

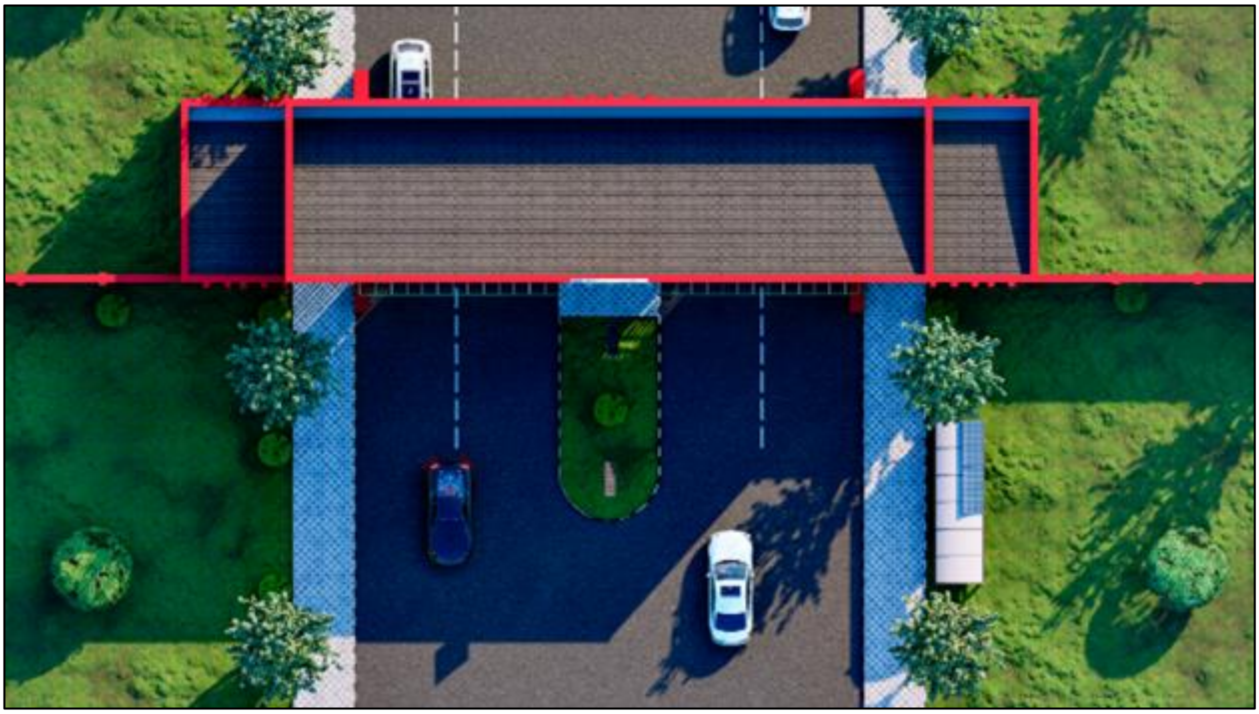

Figure 11 Image 9 from the North Gate

Figure 12 Image 10 from the North Gate

Figure 13 Image 11 from the North Gate

Figure 14 Image 12 from the North Gate

4. Conclusion

The evaluation of traffic management on the FUTA North Gate Road has revealed several causes of the traffic congestion, including increased population and vehicle ownership, inadequate road infrastructure, and poor driving habits. These causes have contributed to the inefficiency of the current traffic management system, resulting in gridlocks and longer commuting times for motorists.

To address these challenges, a road expansion project has been proposed. The proposed road will be wider and will have more lanes than the existing one, which will allow for smoother flow of traffic. The road will also have modern traffic management features, including solar powered lights and roundabouts, which will help to manage the traffic flow and reduce congestion.

However, it is important to note that the proposed road project has some potential drawbacks. For example, it may lead to increased air pollution and noise pollution due to the increased number of vehicles using the road. Additionally, the road expansion project may require the acquisition of private property, which may cause inconvenience and financial loss for affected property owners.

Therefore, it is important that the proposed road project is approached with caution and that all possible measures are taken to minimize its potential negative impact. This includes implementing environmental mitigation measures, such as planting trees and shrubs to absorb pollutants, and ensuring that the design of the road takes into account the needs and concerns of the affected communities.

Overall, the evaluation of traffic management on the FUTA North Gate Road has highlighted the importance of having an efficient and effective traffic management system. While the proposed road expansion project has the potential to ease traffic congestion, it is important to approach the project with caution and to consider all possible impacts before implementing it.

In addition to the proposed road expansion project, there are other measures that can be taken to manage traffic on busy roads. These include promoting the use of public transportation, encouraging carpooling and ride-sharing, and improving the design of intersections and roundabouts.

Recommendations

Based on the evaluation of traffic management on the FUTA North Gate Road, there are several recommendations that can be made to improve the traffic flow and reduce congestion. These recommendations include:

- Expansion of the road: The road should be dualized. Expanding the road can help to reduce travel time and improve the overall traffic flow so as to the reduce congestion of the road.
- Implementing traffic management system: Traffic management should be included such as intelligent traffic lights and variable speed limit, to improve traffic flow and reduce traffic congestion.
- Promoting the use of public transportation: Encouraging the use of public transportation, such as buses and coaster bus, can help to reduce the number of vehicles on the road, thereby easing traffic congestion.
- Educating drivers: Promoting safe and responsible driving habits through education and awareness campaigns can help to reduce accidents and improve traffic flow.
- Reduction of speed breaker: The current speed breaker is too much that it adds to the congestion, by reducing this helps to increase the flow of traffic.
- Parking restraints: Parking restraints that could be implemented includes provision of parking lanes on the shoulders and also implementation of fines on violators of the parking order.

Implementing these recommendations can help to improve the traffic flow and reduce congestion on busy roads. While some of these recommendations may require significant investment, the benefits of a more efficient and sustainable transportation system will far outweigh the costs in the long run. It is important that all stakeholders work together to implement these recommendations and create a transportation system that benefits everyone.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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