# CROSS-INTERSECTION TRAFFIC ANALYSIS: A CASE STUDY OF KYALIWAJJALA NAMUGONGO


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**A FINAL YEAR RESEARCH AND DESIGN PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF BACHELOR OF SCIENCE IN CIVIL AND ENVIRONMENTAL ENGINEERING OF UGANDA CHRISTIAN UNIVERSITY**

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## ABSTRACT

This research was conducted as part of a project whose objective was to enhance the geometry of the Kyaliwajjala-Namugongo cross-intersection in Kyaliwajala, Wakiso. The geometric designs of the current road networks were to be improved in order to handle the rise due to the rising number of road users and the limited resources available.

Traffic congestion interferes with business activities, lowers productivity, costs lives, and pollutes the environment on a global scale. According to research, it can also be a sign of the economy's expansion. The population of vehicles also grows as the economy expands and household real income rises, which adds to traffic congestion in cities. Given the essential role that productivity plays in (GDP) growth, the high costs associated with treating accident victims and paying out compensation, the yearly cost of travel time due to traffic delays, and ultimately the societal cost of environmental pollution, these factors hinder the nation's economic progress. Therefore, the main focus of this study was on the efforts to evaluate traffic congestion's detrimental impacts, causes, and finally, effects. Therefore, the study's emphasis was on developing the Kyaliwajjala-Namugongo intersection and improving it in order to control traffic congestion and its impacts at the junction. The interchange of a roundabout with an overpass to be implemented at the Kyaliwajjala Intersection will be the most cost-effective solution in safety, aesthetics and space requirement. The cross-intersection is designed to serve a future design traffic of 70037 veh/day and a design hourly volume of 8405veh/h.

**DECLARATION**

I, KAIRANIA IVAN, do declare that this report is my own work, and a true presentation of my work.

…………………………

KAIRANIA IVAN DATE:

## APPROVAL

This proposal has been submitted for examination with my approval as the University supervisor.

…………………………….

MR. ANDREW KASUMBA DATE:

## ACKNOWLEDGEMENT

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# CHAPTER 1: INTRODUCTION

## 1.1 BACKGROUND

In both established and developing nations across the world, traffic congestion has been on the rise. It is mostly worst at intersections where there are frequent collisions as cars move to get to distant areas. Everything points to the congestion getting worse, which poses a clear threat to the quality of urban living (Bull, 2003). (The central business district (CBD) of Uganda has experienced heavy traffic congestion over the years, and it continues to be a problem today. Most routes are severely congested in the morning, at lunchtime, and in the evening, but some routes are congested all day long into the wee hours of the night (Kwikiriza, 2016). The number of automobiles in the central business area has significantly grown, according to Uganda Motor Vehicle Sales, from 770,000 in December 2018 to 832,000 in December 2019 (Naddumba E, 2019). Congestion is the outcome of poorly designed road networks, including small roads and limited lanes on some of the other highways. According to Sheila Maria Belgis Putri Affiza (2022) traffic congestion is pretty common and is worse during peak hours when travel speeds are at or below 15 km/h. oftentimes, the situation gets worse during rush hour.

The Kyaliwajjala-Namugongo cross-intersection, which has four arms and is not signalized, receives traffic from both Namugongo Road and Kyaliwajjala-Naalya Road. Due to the cross-intersection's advantageous position, traffic users mostly utilize it to access the capital and the commercial areas in and around Namugongo, Kireka, Kyaliwajjala, Naalya, and other locations. According to research, it also represents economic expansion. When an economy expands and real household income rises, the number of vehicles likewise rises in proportion, which adds to traffic congestion in cities (Kwikiriza, 2016). According to the Uganda Bureau of Statistics, based on the population census conducted in 2014, Uganda's population growth rate is 3.1%. This means that although more people are traveling to the capital city of Kampala for a variety of reasons, including work, via this junction, the road has not been significantly altered to accommodate this growth.

According to a site study, there is poor traffic control near this cross-intersection, and to make matters worse, there are no traffic signalized controls at the cross-intersection to govern the direction of traffic. Unwanted outcomes are being impacted, including slowed vehicle flow, lengthened travel times, accidents, and financial losses. Developing nations are using Adaptive Traffic Control Systems (ATCS) and, where practical, hiring traffic cops to control traffic flow in order to eliminate or significantly minimize this issue. Therefore, developing nations should focus on improving the traffic management and control system as well as expanding the transportation infrastructure to enhance the city's transportation system. This will result in fewer fatal accidents, lower government spending, more productivity (GDP), and clean, smart mobility (less traffic congestion) in the towns.

### 1.2 PROBLEM STATEMENT

Kyaliwajjala-Namugongo is a four-legged cross-intersection without signals, traffic congestion mostly worsens during rush hours as drivers hurry to and from the biggest cities in the country. According to a site study, there is severe traffic congestion at this cross-intersection and inadequate traffic management since traffic officers occasionally control the flow of traffic, who are unable to function at the same level as a geometric design. The cross-intersections' strategic location, which offers quicker access to the capital, the Namugongo Shrine, educational facilities, and important routes like the northern by-pass, contributes to the cross-intersection's heavy utilization. Traffic jams have been linked to a number of factors, including narrow roads, poor urban planning, a lack of parking, and the concentration of the majority of social and economic activity in city centers (Kwikiriza, 2016). Unwanted effects for junction users include; impeded vehicle flow, lengthened travel times, financial losses, increased fuel consumption as a result of the sluggish speeds during vehicle queues, and others. The high expenditures of accident-related medical care and compensation, the yearly cost of travel time due to traffic delays, and lastly the societal cost of environmental pollution all have an impact on the economy's GDP. In addition to causing environmental damage due to pollution, traffic congestion interferes with business operations, lowers productivity levels, and costs human lives.

According to Kwikiriza (2016), this occurs not only at the Namugongo-Kyaliwajjala cross-intersection but also all throughout the nation. This study's main objective was to upgrade the cross-intersection into an effective, optimal traffic regulation system that can control both traffic flow within the cross-intersection arms and traffic congestion in order to address this issue instead of using traffic officers to manage traffic flow.

## 1.3 OBJECTIVES

### 1.3.1 MAIN OBJECTIVE

To optimize traffic flow at the Kyaliwajjala-Namugongo intersection using a data-driven geometric design.

### 1.3.2 SPECIFIC OBJECTIVES

1. To determine the topography of the intersection.
2. To assess the performance of the cross-intersection in its current state
3. To develop an optimal traffic regulation system for the cross-intersection.

## 1.4 GEOGRAPHICAL SCOPE

The study is exclusively focused on the Kyaliwajjala-Namugongo junction and will span a minimum of 500 meters along each of the cross-intersection arms.

## 1.5 OUTLINED METHODOLOGY

- Gathering topographical information through surveying
- Using the manual traffic count method to conduct traffic counts
- Choosing a control intersection design from the 2010 Uganda Road Design Manual
- To determine the capacity of the intersection

## 1.6 JUSTIFICATION

Despite the fact that traffic officers regulate traffic at the Kyaliwajjala-Namugongo cross-intersection at the moment, they are unable to operate as well as a geometric design. This study's development of a traffic regulation system will ensure optimal traffic flow and lessen traffic congestion and its impacts at the intersection.

## 1.7 SIGNIFICANCE

The Kyaliwajjala-Namugongo road users will be able to use the cross-intersection with fewer discomforts, annoyance, and time loss owing to shorter waits and queue lengths after the cross-intersection geometric design and capacity are enhanced.

# 2 CHAPTER TWO: LITERATURE REVIEW

## 2.1 INTRODUCTION

A cross-intersection is a crucial part of road and transportation networks where two or more roads meet or cross one other. It is also known as a crossroads or cross-intersection. The passage of automobiles, pedestrians, and occasionally bikes is facilitated at these crossroads, making them important locations in both urban and rural settings. There are many different types of cross-sections, such as roundabouts, four-way junctions, T-intersections, and more, each having its own traffic flow dynamics and safety considerations. For smooth traffic flow, safety, and effective mobility within an area, proper cross-section management and design are crucial. In order to maximize their functionality, cross-sections frequently require careful design, engineering, and traffic management because to the potential for traffic congestion, accidents, and other issues.

## 2.2 TYPES OF CROSS-INTERSECTIONS

The three-leg or T-intersection, the four-leg intersection or cross-intersection, and the multi-leg intersection are their three primary types of intersections. Cross-intersections are grouped according to a number of criteria, such as their geometric layout, regulatory methods, and purpose. Road authorities, urban planners, and transportation engineers may better comprehend and manage crossings with the aid of these categories. Since the study is going to mainly on coming up with an optimal traffic regulation system. We shall focus the study mainly on categorization by geometric design, and the three common types of cross-intersections under this include At-Grade intersections, Grade-Separated Intersection and Roundabouts.

### 2.2.1 AT-GRADE INTERSECTION.

At-grade intersections are those in which two or more roadways come together or pass one another at ground level without the use of a bridge, tunnel, or grade separation. These crossroads can appear in a number of different ways and are frequently encountered on road networks. The following models can be used for at-grade intersections:

#### *2.2.1.1 Four-way intersections (All-Way Stop).*

In a four-way junction (sometimes known as an all-way stop), four roads come together at grade, usually at a right angle to form a crossroads. In this kind of intersection, stop signs regulate traffic in all directions and demand that all cars stop completely before crossing the intersection. By granting the right-of-way to one direction at a time, all-way stops are intended to enable the safe and orderly passage of traffic. In crossroads where there is a need to assure safety and lower the possibility of accidents, the use of a four-way intersection with all-way stop signs is particularly useful in controlling traffic. However, it might not be appropriate at crossroads where there is a considerable imbalance in the volume of traffic since it might cause unneeded pauses and delays for cars on the road with more traffic. A more effective control method in these circumstances may be traffic lights. For traffic to move smoothly and safely at four-way intersections with all-way stop signals, proper signage, road markings, and driver education are necessary.

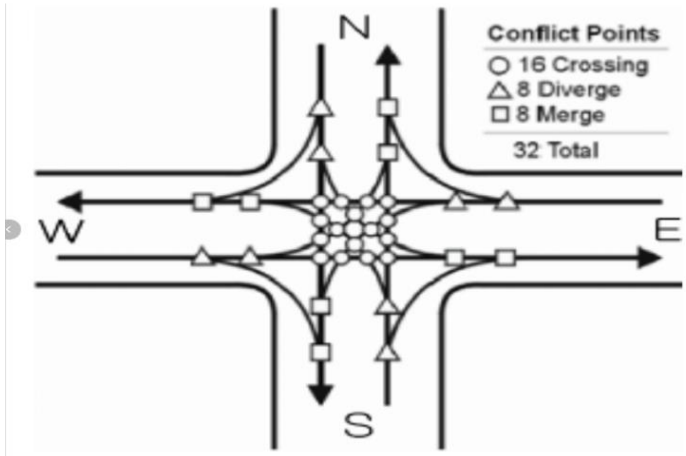



*Figure 1: four way cross-intersection and the conflict points (Source: Nasima F Bhuiyan)*

*2.2.1.2 T-Intersections.*

A T-intersection is a particular kind of at-grade intersection where two roads cross, forming a "T" shape. The road that forms the top of the "T" at a T-intersection comes to a stop, while the road that intersects it, which forms the stem of the "T," continues through the intersection. The "T" in this pattern refers to how it looks like the letter T In both urban and rural regions. T-intersections are frequently encountered and are utilized to join smaller roads to main ones. They are frequently employed when one route has less traffic than the other or when the terrain and architecture of the road make it difficult to build more complicated intersections. T-intersections must be operated safely and effectively, which calls for appropriate signage, road markings, and respect to right-of-way regulations.

*Figure 2: A T-intersection (Source: Adams Smith)*

### *2.2.1.3 Roundabout (Traffic Circle).*

A roundabout, usually referred to as a traffic circle, is a style of at-grade intersection with numerous lanes that is shaped in a circular pattern. Roundabouts work on the premise of yielding rather than stopping, in contrast to conventional crossings managed by traffic lights or stop signs. Within the roundabout, traffic circulates counterclockwise around a central island. Roundabouts are intended to lessen congestion, increase safety, and improve traffic flow.

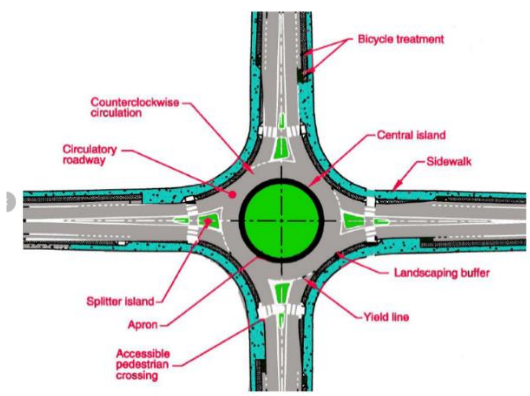



*Figure 3: A roundabout showing traffic flow (Source: Semu Mitiku Kassa)*

### 2.2.2 GRADE-SEPARATED INTERSECTION

Grade-separated crossings are a form of intersection design in which intersecting roadways or transit corridors are physically separated at various heights. These junctions are meant to prevent direct collisions between cars, hence enhancing traffic flow and safety. Highways and large roads frequently have grade-separated junctions. Grade-separated crossings come in a number of important varieties, such as;

#### *2.2.2.1 Overpass (Bridge).*

Grade-separated junctions are a crucial part of the contemporary transportation infrastructure, and an overpass, sometimes referred to as a bridge, is an essential part of these intersections. One road crosses over another in this layout, resulting in a clear division at various heights. The smooth flow of traffic is made possible by overpasses, which also greatly increase safety. Overpasses are essential to highway and road networks. They are a basic remedy for removing possible conflicts and congestion that might develop at conventional at-grade junctions. Overpasses provide a clear way for cars to travel without hindering or colliding with the traffic below by allowing one road to soar above another. As a consequence, traffic moves more smoothly and continuously because upper road traffic may pass through the crossroads unhindered. In urban, suburban, and highway contexts where traffic volume and efficiency are crucial, overpasses are a major component. They are extremely important for guaranteeing the quick and safe circulation of cars, especially on highways with high speeds. By lowering traffic congestion and travel times, overpasses not only improve the flow of traffic as a whole, but they also significantly increase road safety by removing the possibility of collisions at crossings. Additionally, these buildings frequently have aesthetically pleasing architectural styles that blend in with the surroundings, enhancing the visual appeal of the transit infrastructure.

*Figure 4: An Overpass (Source: Dave Creek)*

#### *2.2.2.2 Underpass*

A key element of grade-separated crossings is an underpass, which is defined by its design as allowing one route to pass beneath another, frequently at a different elevation. To reduce traffic congestion and assure safe and effective road travel, this architectural solution is frequently used in metropolitan settings. Underpasses efficiently minimize direct confrontations at crossings by allowing one route to travel beneath another, ensuring a continuous flow of traffic and improving overall safety. This infrastructure is especially helpful where there are considerable road connection constraints caused by natural features like railways, rivers, or heavily populated metropolitan areas. Roads are seamlessly connected by underpasses, which improve connectivity and traffic flow while avoiding the need for stop signs or traffic signals, reducing travel times and reducing the danger of accidents. Utilizing underpasses allows for the unhindered passage of cars and people while smoothly integrating highways into the existing urban environment, considerably improving the overall urban traffic infrastructure.


*Figure 5: An Underpass (Source: Jodi Belcher)*

*2.2.2.3 Interchange*

An interchange is a sophisticated and carefully planned transportation hub that enables the smooth movement of cars between two or more crossing roads or highways. Interchanges are a subset of grade-separated junctions. Interchanges, which are made up of a network of overpasses, underpasses, and designated ramps, are the foundation of effective transportation networks. They come in a variety of shapes, and the decision depends on things like local infrastructure requirements, traffic volume, and geographical limitations. Common interchange types include the diamond interchange, which is renowned for its simplicity and affordability and connects exit and entrance ramps to a crossroad via traffic signals or stop signs; the cloverleaf interchange, which is distinguished by its distinctive looping design and allows for the continuous flow of vehicles as they navigate on and off the highway; and the stack interchange, an intricate system of elevated roads that frequently resembles a multi-level puzzle and was designed to accommodate large vehicle volumes.

*Figure 6: An interchange (Source: Michael Chase)*

*2.2.2.4 Flyover*

A high, elevated roadway or bridge construction called a flyover, a common element of grade separated intersections, is created to help the free flow of traffic by enabling cars to avoid ground-level intersections or other barriers. A flyover, which often forms an arch over an existing road or crossroads, offers a designated channel for cars to turn or transition without obstructing the main flow of traffic. Flyovers improve traffic efficiency and minimize congestion by dividing traffic levels, especially in highly populated metropolitan regions where space is constrained and traffic volumes are high. They are essential components of urban transportation networks, providing a tactical response to the problems presented by intersecting roads and the demand for efficient traffic flow. With graded approaches, guardrails, and adequate lighting to improve visibility, flyovers are carefully constructed to ensure safe and effective navigation. They have developed into crucial elements of intricate highway interchanges, changing conventional crossroads into more nimble and useful transportation networks.

#### *2.2.2.5 Tunnel*

Tunnels are specialized engineering wonders that provide a subterranean solution for controlling crossing roadways or transit lines in the context of grade-separated intersections. These buildings give highways a way to go over or below inaccessible natural features like mountains, rivers, or highly populated metropolitan areas. The purpose of tunnels is to prevent intersecting roadways from crossing one another directly at ground level. This reduces the risk of accidents and keeps traffic moving. The subterranean corridor that allows cars to pass without interfering with the main surface road network is the most prominent feature of tunnels in grade-separated crossings. Usually, tunnels have designated entrances and exits that smoothly direct traffic into and out of the underground corridor. They may also have ventilation and emergency systems to deal with unanticipated scenarios. They are also frequently illuminated for visibility, guaranteeing safe and effective navigation. When space is at a premium and conventional at-grade intersections would be impracticable or would disturb the surrounding natural landscape, tunnels are very helpful. These situations include heavily populated metropolitan areas and areas with difficult topography

### 2.2.3 ROUNDABOUTS

A roundabout, also known as a traffic circle, is a particular kind of intersection with a circular layout where several routes converge and intersect at one central location. Roundabouts, which work on the concept of yielding, allow for a continuous flow of traffic in a circular manner around a central island, unlike conventional intersections regulated by traffic lights or stop signs. This creative layout promotes safety while simultaneously improving traffic flow. To ensure a smooth and orderly flow of traffic, vehicles approaching the roundabout must surrender to those already circulating within it. Roundabouts are distinguished by the lack of stop signs or traffic signals; instead, they rely on drivers' adherence to the yielding guidelines, which considerably lowers the risk of accidents. Congestion and travel delays are reduced, especially during peak traffic hours, by not stopping and starting at traffic signals or stop signs. It is also a top concern to ensure the safety of pedestrians. Marked crosswalks and pedestrian islands provide safe passageways for individuals walking, and motorists are obligated to give way to pedestrians in these areas. These cross-intersections serve as efficient traffic calming devices, promoting slower moving vehicles and reducing accident severity, improving road user safety for everyone. Their rising popularity is due to their benefits, which have been demonstrated to make them a sustainable solution for a variety of junction difficulties.

## 2.3 SIGNALISED CROSS-INTERSECTIONS

Signaled cross-intersections, also known as signalized intersections or traffic signal intersections, are intersections where traffic flow is controlled by traffic signals. Traffic signal theory is primarily concerned with estimating the delays and queue lengths that arise from implementing a signal control method at a cross-intersection. When a cross-intersection is appropriately planned, signal control may improve traffic efficiency and safety by minimizing traffic jams and conflicts caused by differing vehicle movements.

<u>Advantages of signalized cross-intersections</u>

- There is a fair distribution of the available capacity.
- If capacity is not achieved, there is a set and known maximum waiting time.
- It is not necessary for the driver on the minor road to determine when it is safe to continue.

When a signal from green to red, most rear-end crashes and drivers passing the signal at that time are the main causes of safety issues at signalized cross-intersections. This has significant effects on timings and visibility of signals

## 2.4 ROAD DESIGN

Highway design criteria for traffic include cross-section components, lateral and vertical clearances, and horizontal and vertical alignments. This part of the design process deals with the visible dimensions of a roadway. The objective of geometric design is to preserve high traffic flow while minimizing vehicle delay; the level of skill used in the development of the geometric design dictates the efficiency of a roadway. This can only occur if the design components are properly thought out (Weerasekera, 2016). The Uganda Road Design Manual Vol. 1 (2010) and the AASHTO standards, which provide the current British practice, are two examples of the geometric standards used in Uganda (Robert, 2016). These standards were developed by the Ministry of Works and Transport.

### 2.4.1 ALIGNEMENT AND PROFILE

This involves placing tangents and curves to produce a directional transition, which makes up the road's profile. It consists of two transition curves, curves, and horizontal arcs joining a sequence of straight-line gradients (Latif, 2020). These are used to make sure that drivers are shown a continually unfolding section of the road so that they can anticipate directional changes and respond appropriately and instantly. When feasible, the alignment is changed to ensure that the earth dug balances with the embankments that need to be constructed, hence minimizing the quantity of earth that needs to be transported (Glennon, 2010).

### 2.4.2 VERTICAL ALIGNMENT

Design speed, topography, traffic numbers, highway functional categorization, sight distance, horizontal alignment, vertical clearances, and drainage all affect a roadway's vertical alignment. At the point of rotation, the roadway's vertical alignment, also known as its profile, is normally determined. Because it is unaffected by superelevation, this point is utilized. To provide a seamless transition between road grades, vertical curves are utilized (Taylor, 2013). A parabolic curve that has a steady rate of grade change makes up a vertical curve. To increase the driver's seeing distance, a parabolic curve "flattens" the curve at the peak or bottom of a hill. Crest and sag are the two fundamental forms of vertical curves. As the name suggests, a slope's top and bottom have vertical curves that are called crest and sag, respectively. At the vertical point of junction, the grade lines cross over one another (Adel, 2021).

### 2.4.3 HORIZONTAL ALIGNMENT

A roadway's alignment directly affects its operating characteristics. In consequence, sight distances, highway capacity, and vehicle operating speeds are all impacted by alignment. With limited financial resources, the horizontal alignment must offer a safe, useful highway infrastructure with sufficient sight distances. According to (Kolita 2016), there are several design requirements that the alignment needs to follow, such sight distance, superelevation rates, and minimum radii. In addition to improving the facility's overall safety, these standards will improve the highway's visual appeal. It is comparatively uncommon to build roads following new alignments. Highway reconstruction usually involves making horizontal and/or vertical alterations to the existing alignments in order to comply with modern design guidelines. In terms of straight-line tangents and horizontal curves, a roadway's horizontal alignment is specified. Horizontal curves and straight-line tangents are used to define a highway. The tangent parts can transition smoothly amongst each other thanks to the curves. Two forms of horizontal curves that are used to satisfy different design requirements are spirals and circular curves (Latif, 2020).

### 2.4.4 SUPERELEVATION

The outward pull on a vehicle navigating a horizontal curve is known as centrifugal force. Centrifugal force has little influence when moving slowly or on bends with wide radii. However, the effects of centrifugal force grow while traveling faster or around bends with smaller radius. Many factors affect the transitional pace at which superelevation is applied into and out of curves. These variables include curve radius and design speed. For a given radius, higher design speeds require greater superelevation than lower design speeds. Furthermore, for a given design speed, sharper bends require greater superelevation than flatter curves. Rotating the pavement cross-section around a rotation point progressively introduces superelevation. The center line serves as the point of rotation for undivided roadways. The inside edge of the travelled path is normally where the point of rotation is found on split roads. Typically, the usual parts of the roadway show the position of the point of rotation. Allopi (2012)

### 2.4.5 THEORETICAL REVIEW

According to the Organization for Economic Co-operation and Development [OECD], study (2007) on managing urban traffic congestion, traffic congestion is both a physical and a relative phenomenon, thus there isn't a single, widely accepted definition of it. Traffic congestion is a real-world occurrence that manifests as slower speeds, longer travel times, and more motor vehicle waiting when there is an excess demand for road space. Its definition as a relative phenomenon is the discrepancy between the performance of the road and the expectations of road users (OECD, 2007).

The Organization for Economic Co-operation and Development (OECD) has carried out in-depth theoretical assessments of traffic congestion, emphasizing its complexity and effects on economies, urban development, and social well-being in general. According to the OECD, traffic congestion is a complicated problem caused by an imbalance in the supply and demand for transportation. Numerous reasons contribute to it, including population increase, urbanization, economic expansion, and a lack of suitable transportation infrastructure. According to OECD studies, congestion has negative effects on national economies, public health, and travel times, fuel consumption, and carbon emissions in addition to being bad for the environment. Furthermore, because low-income households are disproportionately affected, traffic congestion makes it difficult for people to obtain essential services, reduces productivity, and worsens income inequality. According to OECD analysis, they stress that practical solutions need a complex strategy that combines investments in transportation infrastructure, traffic control plans, and environmentally friendly urban design. To reduce the negative consequences of congestion, OECD research supports creative policy ideas such congestion pricing, improved public transit, and the use of intelligent transportation systems.

## 2.5 CAUSES OF TRAFFIC CONGESTION

- Lack of Infrastructure: Poor road infrastructure is one of the main reasons for traffic congestion in Uganda. Numerous roadways are poorly constructed, narrow, congested, and badly maintained. Congestion occurs often as a result of the current road networks' struggles to handle the expanding number of cars in metropolitan areas.
- Urbanization and Population Growth: Both of these factors are present in Uganda, where the population has been gradually increasing. The need for transportation services is growing as more people relocate to cities. Rapid urbanization has caused unplanned settlements to sprout up and increased traffic in cities, which has worsened congestion.
- Inadequate Public Transportation. Limited and ineffective public transit options might result in a significant reliance on private automobiles, which exacerbates traffic congestion. More individuals are using personal automobiles for transportation since the public transportation choices in many areas of Uganda are insufficient, unreliable, and sometimes hazardous.
- Lack of Traffic Management and Enforcement: Chaotic road conditions can result from inadequate traffic management combined with slack enforcement of traffic laws. Congestion and safety difficulties on the road can be further exacerbated by reckless driving, disobedience to traffic signals and signs, and a lack of law enforcement.
- Illegal Parking on streets. Illegal parking on public property is a major cause of traffic congestion. In Uganda, taxis are mostly responsible for doing this; some just park

for a little period of time, while others do so for an extended period, narrowing the road and contributing to traffic congestion in that region.

At other instances, the make-up and capacity of the road are taken into consideration as elements that do impact traffic congestion on a highway or at a specific location. In comparison to lighter passenger car units (pcu), heavier vehicles, such as trailers and trucks, have a greater impact on traffic congestion because they may not move at the highway's intended design speed, and these gradual delays eventually result in longer queues (Saharkar, 2014).

### 2.6 EFFECTS OF TRAFFIC CONJESTION

- Economic impact. Traffic congestion has a significant negative impact on the economy. Productivity losses occur from the time that people and organizations spend delayed in traffic. The financial strain is also exacerbated by the increased fuel usage and wear and tear on the vehicles. Congestion can obstruct the movement of products and service and raise operating costs, which would be detrimental to Uganda's economic expansion.
- Reduced Road Safety. Road congestion is linked to an increased probability of accidents, which results in decreased road safety. Collisions can happen more frequently in stop and-go traffic and when drivers are driving erratically in dense traffic. An important public health issue is created as a result of the increase in traffic-related injuries and fatalities.
- Wasted Time and Reduced Quality of life. Time Spent in Congestion Leads to Personal annoyance, Stress, and Time Waste: Time spent in traffic congestion leads to personal annoyance, stress, and time squandered. Commuters frequently spend hours

traveling, which affects their ability to combine work and life and their general quality of life. Additionally, it may discourage people from walking, biking, or taking public transportation, which would worsen traffic.

- Air Pollution and Environmental Damage. Traffic congestion, mostly through automobile emissions, causes air pollution and environmental harm. In addition to degrading air quality, the discharge of dangerous pollutants such carbon monoxide, nitrogen oxides, and particulate matter has a negative impact on people's health. This pollution can worsen respiratory conditions and have long-term negative effects on the ecosystem.
- Infrastructure Stress and Maintenance Costs: Over time, heavy traffic and congestion can cause road infrastructure to deteriorate. The financial strain on government budgets may increase as a result of the potential need for more regular maintenance and repairs on roads, bridges, and junctions. The burden on the current infrastructure also makes it difficult to develop and enhance transportation systems.

In Uganda, metropolitan areas like Kampala, where population expansion and urbanization have contributed to increasing motor traffic, are particularly pertinent to these consequences of traffic congestion. Comprehensive approaches, such as the promotion of public transportation, urban design that supports sustainable mobility, and the deployment of traffic management systems are needed to address traffic congestion in Uganda.

## 2.7 TRAFFIC MANAGEMENT

Traffic management is the organization, arrangement, guiding, and control of both stationary and moving traffic, including pedestrians, bikers, and other types of vehicles, according to the Transportation Research Board (1992). In order to decrease traffic congestion and its associated issues, it primarily attempts to provide safe, orderly, and efficient flow of people and commodities. Wherever feasible, it also seeks to improve the quality of the local environment on and next to traffic infrastructure. In order to do this, traffic management systems are built from a collection of management tools and applications that integrate communication, sensor, and processing technology. They gather information on traffic from a variety of sources, including automobiles, traffic signals, in-road sensors, and roadside sensors.

Additionally, a number of traffic dangers may be detected and then mitigated, increasing overall traffic efficiency and ensuring a smooth traffic flow, by conceptualizing and utilizing such traffic-related data in a cooperative manner (Souza, 2018).

### 2.7.1 GOALS OF TRAFFIC MANAGEMENT

The objectives for traffic management are as follows, although they may be changed based on the circumstances;

- To guarantee a smooth flow of traffic. Therefore, maintaining traffic flow is a key objective of any traffic management system. Numerous variables, including road form and function, adjacent land uses, and traffic volume characteristics, affect how traffic moves. The daily, monthly, and yearly fluctuations in traffic volume must be recognized, and the direction of flow at any given site is crucial. It displays the focal point for traffic generating. A solid traffic volume analysis aids in managing the flow of traffic to a point where the higher volume streams are given precedence. (Ajata, 2017)

- To lessen traffic accidents: Today's globe is seeing a serious increase in traffic accidents. Road accidents are the fifth largest cause of mortality worldwide, according to a UN report from 2011. The goal of any traffic management system should be to reduce the loss of lives and property since the efficiency and effectiveness of the road transportation system are linked to safety.
- To lessen traffic congestion and delays: When a road system is unable to handle the volume of traffic at a suitable pace, there is often conflict between vehicles, including cars, trucks, buses, as well as pedestrians and other road users. These areas, often known as choke spots or bottlenecks, can be found at intersections or on specific stretches of road. They are typically brought on by street trade, poor roads, on-street parking, and damaged or abandoned automobiles.
- To enhance road capacity: Depending on its intended use, every road intersection or junction has a design capacity. If traffic management systems are not built, a road may not be able to handle the level of traffic for which it was designed. The facility can handle a large amount of traffic in a timely manner thanks to traffic management features including road markings and traffic control signals.

### 2.7.2 WAYS THROUGH WHICH TRAFFIC MANAGEMENT CAN BE DONE

In order to ensure the effective and safe flow of automobiles and people on highways, traffic management is an essential component of urban and transportation planning. To control traffic successfully, a variety of tactics and techniques can be used. The following are some essential techniques for managing traffic:

- Traffic lights: At junctions, traffic lights regulate the flow of traffic. They control the right-of-way and aid in controlling the flow of automobiles. Signals can be controlled to minimize delays and maximize traffic flow during peak hours.
- Stop signs and yield signs: At junctions, stop signs are used to signal that all moving vehicles must stop completely before continuing. Drivers are instructed by yield signs to allow other cars the right-of-way. For safe traffic management, proper signs and junction design are essential.
- Roundabouts: By removing the requirement for intersection halting, roundabouts, as previously said, enhance continuous traffic flow and safety. They ease traffic and are particularly good at controlling it in cities.
- Traffic Lanes and Lane Management: Dedicated lanes, such bus lanes, carpool lanes, or bike lanes, can be used to control traffic and relieve congestion. In order to favor certain types of cars or carpools during peak hours, lane management may involve limits.
- Intelligent Transportation Systems (ITS): To monitor and control traffic in real time, ITs includes a variety of technology such traffic cameras, sensors, and data analytics. These systems are capable of modifying signal timings, offering real-time traffic data, and streamlining traffic.

- Public Transportation Improvements. Enhancing public transportation choices, such as buses, trams, and commuter train, might persuade individuals to forgo driving their own cars, which eases traffic congestion. Combinations of these tactics, catered to the unique requirements and circumstances of a location, are frequently needed for traffic control. A safer, less congested transportation system may be created with effective traffic management, which can also help make it more sustainable.

### 2.7.3 DIVISION OF ROADS INTO FUNCTIONAL CLASS

Planning and managing transportation sometimes involves categorizing roadways into functional groupings. According to their intended usage, design features, and service function within the larger transportation network, roads can be categorized functionally. Although the specific classification scheme might differ from one nation to another, it often comprises the following essential functional classes;

- Motorways or Interstate Highways. These are restricted-access, high-capacity roads built for swift, long-distance traffic. They frequently cover considerable distances since they link important cities and areas. Interstate highways are exclusively accessible by motor vehicles, with on-ramps and off-ramps commonly used to regulate access.
- Arterial Roads. Within urban and suburban regions, arterial roads act as important thoroughfares, offering important pathways for the movement of traffic. They frequently feature a number of lanes, traffic lights, or gated entrances. Compared to local streets, arterial roads are built for heavier traffic loads and quicker speeds.

- Collector Highways. Between arterial highways and neighborhood streets, collector roads serve as a bridge. They gather traffic from neighborhood streets and direct it onto the system of arterial roads. A stop sign or a yield sign may be present at junctions on collector routes, which frequently have reduced speed restrictions.
- Rural Roads. Rural arterial, rural collector, and rural local roads are only a few examples of the various road classifications used in rural regions. These categories take into account aspects including traffic volume, accessibility requirements, and speed limitations in rural areas.
- High-occupancy vehicles (HOV) Lanes. HOV lanes are special lanes set aside on some roadways for multi-passenger vehicles including buses, vanpools, and carpoolers. These lanes promote the usage of public transit and ridesharing.

Functional classification helps transportation planners, engineers, and policymakers make informed decisions about road design, maintenance, and investment. It guides the allocation of resources and the development of transportation policies based on the specific needs of each road type and it aids in the coordination and management of transportation networks, promoting safe and efficient movement of people and goods.

### 2.7.4 GEOMETRIC DESIGN OF HIGHWAYS

A key component of highway engineering is geometric design, which deals with the alignment, cross-section, and dimensions of roads as well as their physical layout. These design features are necessary to guarantee the functioning, effectiveness, and safety of roadways. The following are some of the crucial elements of the geometric layout of highways:

- Alignment. Highway alignment describes the location of the road both horizontally and vertically. The arrangement of the road's course in plain view, including its bends and straight stretches, is known as horizontal alignment. The profile of the road, including grades (slopes), crests, and dips, is the emphasis of vertical alignment. The objective is to maintain natural topography while offering safe and enjoyable driving conditions.
- Cross-Section. A highway's width, including the number of lanes, shoulders, medians, and other roadside features, is determined by its cross-section. Design considerations include things like traffic volume, vehicle kinds, and safety standards. The cross-intersection also accommodates other roadside infrastructure, such as signs and drainage features.
- Shoulder and Lane Widths. For highway safety and traffic movement, determining the optimum lane and shoulder widths is essential. Wider lanes provide cars greater room to move, while the shoulders are used for halting and recovering in case of emergencies. The design must take into account lane and shoulder widths that adhere to safety regulations and can handle diverse vehicle types.

- Medians. The center barriers that split opposing traffic flows are known as medians.

They can be either narrow or broad, and in addition to acting as safety barriers and room for obstructions, they also lessen the possibility of head-on crashes. The kind and breadth of medians are part of the geometric design.

Highway geometric design is based on engineering standards and guidelines, which vary by jurisdiction. It requires careful consideration of factors such as traffic volumes, safety, environmental impacts, and the specific purpose of the highway (e.g., urban, rural, or expressway). The goal is to create roadways that are safe, efficient, and compatible with the surrounding environment.

## 2.8 SIGHT DISTANCE

Sight distance is a crucial element in designing safe intersections. It refers to the length of roadway a driver can see ahead. At intersections, it is especially important for drivers approaching or leaving an intersection to have a clear view of the entire intersection area, including any traffic control devices (like signs and signals) and along the intersecting roads. This unobstructed view is essential to allow drivers to see potential hazards and avoid collisions. The clear area that provides this sight distance is called a sight triangle.

## 2.9 DESIGN VEHICLE

A design vehicle is a theoretical vehicle that represents the critical design features of a specific class of real vehicles. It is used to ensure that roads can accommodate the most common vehicles in that class. The design vehicle is based on a weighted average of the features of many real vehicles. This means that the size and other features of the design vehicle take into account the number of vehicles of each size that are on the road. Even though the design vehicle represents the most common vehicle sizes, it is still important to make sure that roads can accommodate larger vehicles. This is especially important if more than 10% of the traffic on a road is made up of large vehicles.

*Table 1: Dimensions of design vehicle*

| Design Vehicle type | Symbol | Overall (m) | | | Overhang (m) | | Wheel base (m) | Minimum design turning radius (m) | Minimum inside radius (m) |
|---|---|---|---|---|---|---|---|---|---|
| | | Height | width | Length | Front | Rear | | | |
| 4 x 4 passenger car | DV-1 | 1.3 | 2.1 | 5.8 | 0.9 | 1.5 | 3.4 | 7.3 | 4.2 |
| Single unit truck | DV-2 | 4.1 | 2.6 | 9.1 | 1.2 | 1.8 | 6.1 | 12.8 | 8.5 |
| Single unit bus | DV-3 | 4.1 | 2.6 | 12.1 | 2.1 | 2.4 | 7.6 | 12.8 | 7.4 |
| Semitrailer combination large | DV-4 | 4.1 | 2.6 | 16.7 | 0.9 | 0.6 | 6.1 & 9.1 | 13.7 | 5.8 |
| Interstate Semitrailer | DV-5 | 4.1 | 2.6 | 21.0 | 1.2 | 0.9 | 6.1 & 12.8 | 13.7 | 2.9 |

## 2.10 DESIGN SPEED

Design speed is a planning tool used to determine the geometric features of a road. It is not a specific speed limit. Instead, it is a selected speed that is used to design the various elements of a road, such as curves, hills, and sight distances. These elements all work together to influence how safely vehicles can operate on the road. When designing a road, engineers consider the design speed along with other factors, such as the type of road, the expected traffic volume, and the surrounding environment. By considering these factors, they can create a road that is safe and efficient for drivers.

## 2.11 METHODS USED TO LESSEN TRAFFIC AT THE KYALIWAJJALA CROSS-INTERSECTION

### 2.11.1 Roundabout

Roundabouts are circular intersections that are designed to keep traffic flowing continuously. They typically have yield signs instead of traffic signals. Drivers entering the roundabout must yield to traffic already circulating in the roundabout. Roundabouts are becoming increasingly common because they offer several advantages over traditional intersections with traffic signals.

### 2.11.2 Traffic lights

Traffic signals are a type of traffic control device used at intersections to regulate traffic flow and improve safety. They work by assigning right of way to different traffic movements through time sharing. When timed correctly, traffic signals can increase the capacity of an intersection and improve traffic flow for both vehicles and pedestrians.

### 2.11.3 Interchange

An interchange is a type of junction where roads cross on different levels. This design separates traffic moving in different directions, which eliminates the need for traffic signals or stop signs. Interchanges are typically used at locations where two or more high-speed roads meet. They can be more expensive to build than traditional at-grade intersections, but they can improve traffic flow and safety.

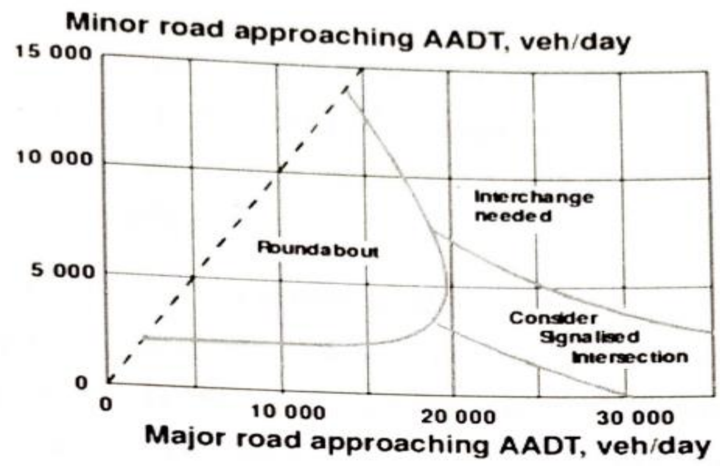



*Figure 7: control intersection type selection (Source: URDM, 2010)*

## 2.12 DESIGN LIFE SELECTION

The designer must specify the design life based on all available information, taking into account a variety of considerations and uncertainties. Generally, the design life should be between 15 and 20 years (Uganda Road Design Manual, 2010).

*Table 2: Design Life parameters (Source: URDM, 2010)*

| Design Data Reliability | Importance/ level of importance | |
|---|---|---|
| | Low | High |
| Low | 10-15 years | 15 years |
| High | 10-20 years | 15-20 years |

# 3 CHAPTER THREE: METHODOLOGY

## 3.1 INTRODUCTION

The methods and exercises used to enhance the geometric design of the Kyaliwajjala Cross-intersection are described in this chapter. The topographical survey, operating speeds, land use next to the cross-intersection, traffic flow, and traffic volumes approaching the cross-intersection were among the necessary data for this research.

The Uganda Road Design Manual (2010), section 8, recommends using a standard process, which is what was done. The Uganda Roads Manual, 2010 states that this procedure is used for both new and improved cross-intersections, such as the Namugongo-Kyaliwajjala cross-intersection. It primarily consists of data collection, determining the major road and cross-intersection design speed, choosing a control cross-intersection type category,

## 3.2 DATA COLLECTION

### 3.2.1 DETERMINING THE TOPOGRAPHY OF THE CROSS-INTERSECTION AND ITS ARMS.

Determining the topography of a cross-intersection and its arms will involve surveying and assessing the physical characteristics of the cross-intersection, such as elevation changes, slopes, and the natural terrain. In order to help determine the road elevation, lane width, and other factors, surveying tools like the total station, GPS, and others will be used.

### *3.2.1.1 PARAMETERS TO BE INVESTIGATED*

a) Road Elevation. A cross-intersection's elevation is defined as its vertical height or level in relation to a certain reference point or datum. In terms of road engineering and design, a cross-junction's elevation is calculated by comparing the height of the road or road segments within the intersection to a standard benchmark or reference point. In order to maintain safe and effective traffic flow, the elevation might change at various locations inside the junction and its approach roads. This makes it a crucial component in the geometric design of the intersection.

b) Layout. The physical layout of a cross-junction, sometimes referred to as a road intersection, refers to the arrangement of the streets where two or more roads converge. In order to ensure the safe and effective circulation of cars and pedestrians, the layout is a crucial element of traffic engineering and road design. Depending on variables including traffic flow, road hierarchy, safety considerations, and available space, a cross-intersection's precise design can change.

c) The minimal radius of curvature of the curb or pavement at the junction is referred to as the turning radius at a cross-intersection, also known as the curb radius or curb return radius. It is a crucial design component that affects how easily and safely cars may make a turn at a junction.

### *3.2.1.2 REQUIREMENTS*

- Real time Kinematic GPS. It was used to capture the coordinates for different points at the cross-intersection
- Notebook and Pen. These two were used to manually record the coordinates and elevations

*3.2.1.3 PROCEDURE*

1) Establish the survey's scope: Establishing the survey's scope entailed deciding on the region to be surveyed as well as its goal. This was to support the planning of the tools, workers, and supplies needed for the survey.

2) Plan the survey: We made sure our survey is organized according to its goals and scope. This included selecting the necessary staff, tools, and survey methodology. The required level of precision and the topography of the survey region was used to identify the best survey method. We selected the Real Time Kinematic GPS machines depending on the availability of the tools

3) 3. Conduct the survey: After that, the strategy was followed in conducting the survey. This entailed putting survey equipment in place, measuring, and documenting information. The survey crew adhered to the established safety protocols and directives, particularly while operating in hazardous areas or close to major roadways.

4) Process and analyze the data: Following the completion of the survey, the data was processed and examined in order to provide an intricate map of the studied region. This entailed producing 3D models of the land area as well as topographic and contour maps.


*Figure 8: Getting Elevations during Topographic surveys*

*3.2.1.4 RESULTS*

I) Gradient, for example the profile and slope of the cross-intersection.

II) Data from planning, for example the road reserve, and other public facilities in the area.

3.2.2 <u>ASSESSING THE PERFORMANCE OF THE CROSS-INTERSECTION IN IT'S CURRENT STATE</u>

Assessing the performance of the cross-intersection is an essential part of traffic engineering and urban planning. The goal is to understand how vehicles, pedestrians, and cyclists move through the intersection to identify potential issues, optimize traffic flow, and enhance safety

*3.2.2.1 PARAMETERS TO BE INVESTIGATED*

a) Traffic Volume. Traffic volume sometimes referred to as traffic flow or vehicular traffic, is the total number of cars and trucks that pass a certain location on a road in a given amount of time. It is commonly expressed in vehicles per hour (vph) or vehicles per day (vpd). It is crucial for capacity analysis, congestion management, and road planning since it gives important details on how busy a route or intersection is. Data on traffic volume is gathered by traffic counts, which can be done manually by observers, automatically by traffic counters, or by employing video cameras.

b) Traffic Composition. Traffic composition describes the mixture of various vehicle and mode types that make up the traffic on a route or transportation network. It requires classifying and comprehending the several components that contribute to the overall traffic flow. Depending on variables including location, hour of the day, and kind of route, traffic composition can vary dramatically.

c) Average Daily Traffic (ADT) is a measure that is frequently used in transportation engineering and planning to determine how much traffic is present on a certain route or section of a road. ADT stands for the average daily traffic (ADT) at a certain location on a road or highway for a given period of time, usually a year. It is an essential factor in many transportation-related choices, such as those involving road design, upkeep, capacity planning, and traffic control.

d) Annual Average Daily Traffic (AADT). An important indicator in transportation engineering and planning is annual average daily traffic (AADT). Over the course of a year, it indicates the typical number of cars that pass a certain location on a road, highway, or intersection in both directions. For a variety of transportation planning and engineering objectives, AADT is used to measure the volume and demand of traffic on the roads.

#### *3.2.2.2 REQUIREMENTS*

- Traffic tally forms. Tallies were put during the traffic counts
- Stop watch. It was used to get the time spent by vehicles in queues and how long they travelled between one point to another

#### *3.2.2.3 PROCEDURE*

a) The categorization of automobiles and motorcycles, such as saloon cars, motorcycles, buses, and many more, was shown on traffic count data sheets. The direction of traffic flow and the intervals of fifteen minutes were two further examples of the time intervals that were given.

b) Additionally, the cross-intersection's traffic count stations were discovered.

c) After that, the enumerators for the traffic count survey were placed at the designated locations.

d) For seven days, there were traffic counts. With a stopwatch, the peak hours were timed at intervals of 15 minutes, and the remaining 16 and 24 hours were timed at intervals of 60 minutes. There was at least one 24-hour count conducted during the week and one on the weekend.

e) Four workdays with 16 hours, one workday with 24 hours, one weekend with 24 hours, and one weekend day with 16 hours were completed.

f) The traffic was then anticipated to last for 24 hours.


*Figure 9: Conducting Manual traffic counts*

*3.2.2.4 RESULTS*

- The Peak Hour, that is to say, this is the hour with the highest volume of traffic at a road or cross-intersection
- The peak-hour factor (PHF), which is the ratio of the entire hourly volume to the peak flow rate within the hour, is produced by peak flow rates and hourly volumes.

$PHF = \frac{V}{4 \times V_{15}}$ Where V is the Peak Hour Volume

$V_{15}$ is the highest 15-minute volume in the peak hour

- The Average Daily Traffic, It is an essential measure for calculating the average number of cars that pass a certain location on a road throughout the course of a normal day. ADT is commonly calculated by dividing the total number of vehicles that pass a certain site (such as a road segment or intersection) by the number of study days.
- Peak Hour Flow Rate , $v = \frac{V}{PHF}$ Where v, is the hourly flow rate (vehicles/hour)

Traffic flow and capacity ratio, $\left(\frac{V}{C}\right)$

### 3.2.3 DEVELOPING AN OPTIMAL TRAFFIC REGULATION SYSTEM FOR THE CROSSINTERSECTION.

Developing and designing an optimal traffic regulation system for a cross-intersection involves the creation of a set of rules, controls, and infrastructure elements to govern and facilitate the safe and efficient movement of vehicles and pedestrians through the intersection. This comprehensive process aims to minimize traffic conflicts, enhance safety, reduce congestion, and promote the orderly flow of traffic

#### *3.2.3.1 PARAMETERS TO BE FOLLOWED*

a) Carriage Way width. A crucial design component in transportation engineering is the carriage width for cross-intersections, sometimes referred to as the road width. At the intersection, it defines the quantity of lanes, lane widths, and total width of the road. The right carriage width for a cross-intersection relies on a number of variables, including the volume of traffic, the kind of road, safety concerns, and local laws.

b) Approach and Departure Speed. The approach and departure speeds for cross-intersections, sometimes referred to as entry and exit speeds, are important considerations in traffic engineering and intersection design. These speeds are used to ensure safe and efficient traffic flow through an intersection. The specific approach and departure speeds can vary based on several factors, including the type of road, the design of the intersection, and local regulations.

d) Lane Width. A cross-intersection's lane width, or simply the width of the lanes inside it, can vary based on a number of variables, such as the design guidelines and rules established by the local transportation authority or the particular requirements of the intersection. For most vehicle classes, including automobiles and small trucks, the normal lane width at a cross-intersection is typically between 10 and 12 feet (3 and 3.7 meters).

*3.2.3.2 REQUIREMENTS*

- AutoCAD Civil 3D and Simulation of Urban Mobility. Used to come up with a simulation of the proposed design.

*3.2.3.3 RESULTS*

- Drawing plans for geometric system.
- Simulation of optimal traffic regulation system

## 3.3 DETERMINATION OF MAJOR ROAD

The major road was chosen by considering

- The turning movements of the different intersection arms
- The peak hourly traffic volumes
- the regulations pertaining to right of way

## 3.4 INTERSECTION CONTROL SELECTION

This was chosen based on the major road and minor road approach traffic volumes from the Uganda Road Design Manual, 2010.

# 4 CHAPTER 4: RESULTS AND DISCUSSION

## 4.1 INTRODUCTION

This chapter describes a variety of studies that were conducted at the Kyaliwajjala-Namugongo cross-intersection to investigate the reasons behind the traffic jams, delays, and accidents that occur there. These findings provide a foundation for guidelines that may be used to help construct the best traffic management system possible to lessen the issue and improve the intersection.

## 4.2 TOPOGRAPHICAL SURVEYS

The purpose of this survey was to help with the geometric design improvement of the Kyaliwajjala-Namugongo cross-intersection by facilitating the analysis of the current terrain state at the intersection with the corresponding profiles. The remainder of the survey might be carried out while work is underway using controls 1 and 2, presumptive coordinates, and elevations. After that, the survey was conducted, and a Real Time Kinematic GPS was used for the measurements. The RTK GPS was used to take precise measurements that made it possible to map the needed region. Every task was completed with the utmost care to yield a very accurate topographic survey map and profiles. The primary purpose of the work was to determine the current road levels (profiles), and the results were presented in drawings that are recorded in Appendix A. The road section was found to have a minimum slope of 0.77% and a maximum slope of 18.94%, indicating that it lies in a rolling country since it has a transverse terrain slope ≤20% which is characterized by gently rising and falling slopes along two of the arms and occasional steep slopes on the other two arms. Because of the gentle and steep slopes encountered, vehicles approaching from the arms with gentle slopes tend to move at a relatively higher speed than the speed they use when leaving the cross-intersection due to the unfavorable change in slopes, and thus this leads to more congestion and delays.

## 4.3 ASSESSING PERFORMANCE OF CROSS-INTERSECTION

### 4.3.1 WEEK TRAFFIC VOLUMES

| WEEKLY TRAFFIC COUNTS FOR ALL ARMS COMBINED | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **VEHICLE TYPE** | **Monday** | **Wednesday** | **Thursday** | **Friday** | **Sunday** | **Saturday** | **Tuesday** | **TOTAL** | **TOTAL (PCUs)** |
| **Passenger vehicles** | 7646 | 7488 | 7188 | 6926 | 5207 | 5688 | 8113 | 48256 | 48256 |
| **Motor cycles** | 14711 | 14115 | 11151 | 13285 | 10978 | 12248 | 12724 | 89212 | 89212 |
| **Saloon cars** | 8790 | 8071 | 7916 | 6076 | 5894 | 7682 | 8552 | 52981 | 79472 |
| **Buses** | 29 | 27 | 26 | 21 | 22 | 22 | 32 | 179 | 716 |
| **Coasters** | 70 | 73 | 79 | 66 | 48 | 51 | 102 | 489 | 978 |
| **2- axles** | 1351 | 1284 | 1275 | 1291 | 1074 | 1277 | 1419 | 8971 | 8971 |
| **3- axles** | 670 | 643 | 536 | 507 | 579 | 681 | 558 | 4174 | 20870 |
| **4-axles and more** | 162 | 324 | 346 | 143 | 125 | 122 | 144 | 1366 | 10928 |
| **Small lorry and pick-ups** | 1426 | 1404 | 1195 | 499 | 499 | 1244 | 1449 | 7716 | 11574 |
| **TOTAL** | | | | | | | | | **270977** |

*Table 3: weekly traffic counts*

This was based on a traffic volume field study that was conducted over the course of a week in January 2024 at the cross-crossroads, taking into account traffic arriving and exiting on all four approaches to the intersection. Additionally, it displays the various kinds of cars that utilize the crosswalk on certain weekdays. Five 16-hour counts were also conducted, with four weekdays and one weekend, and two 24-hour counts were conducted, selecting one weekday and one weekend.

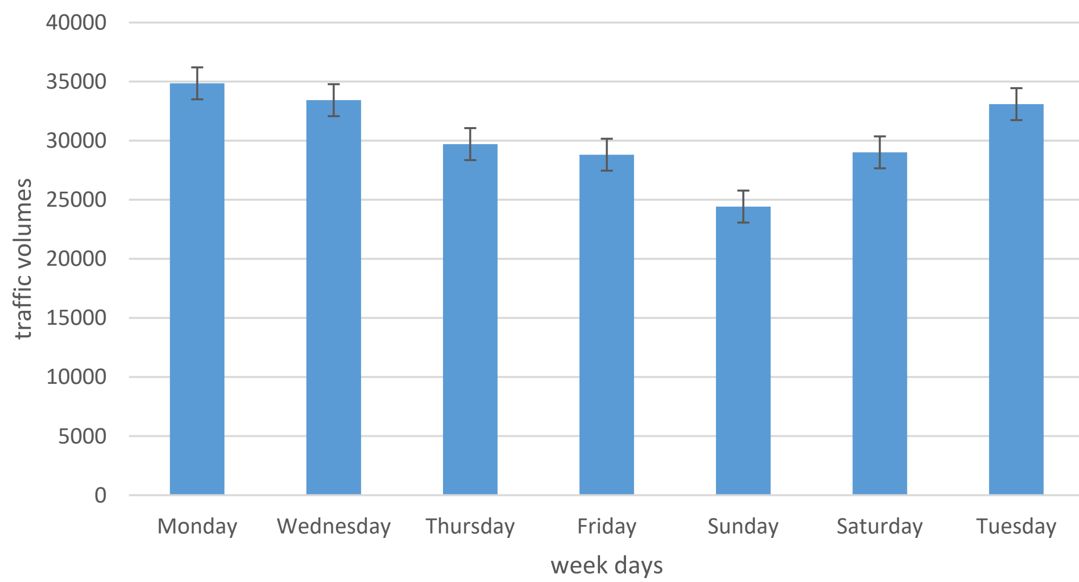



*Figure 10: weekly traffic counts*

### 4.3.2 PEAK TRAFFIC VOLUMES

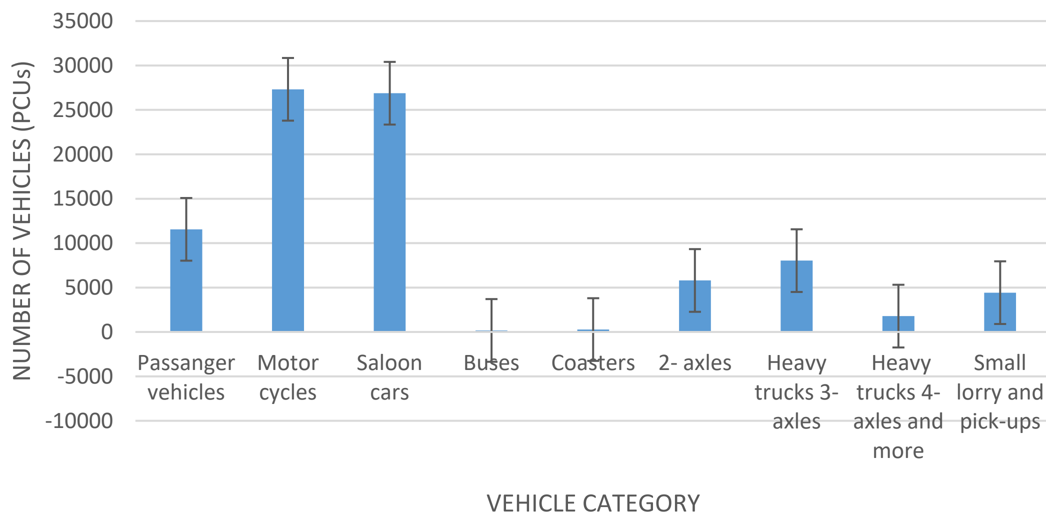
| ARM | TRAFFIC VOLUMES (VEH/HR) |
|---|---|
| NAALYA | 1432 |
| KIREKA | 1112 |
| KIRA | 1136 |
| NAMUGONGO | 1396 |

*Table 4: Peak hourly traffic volumes*

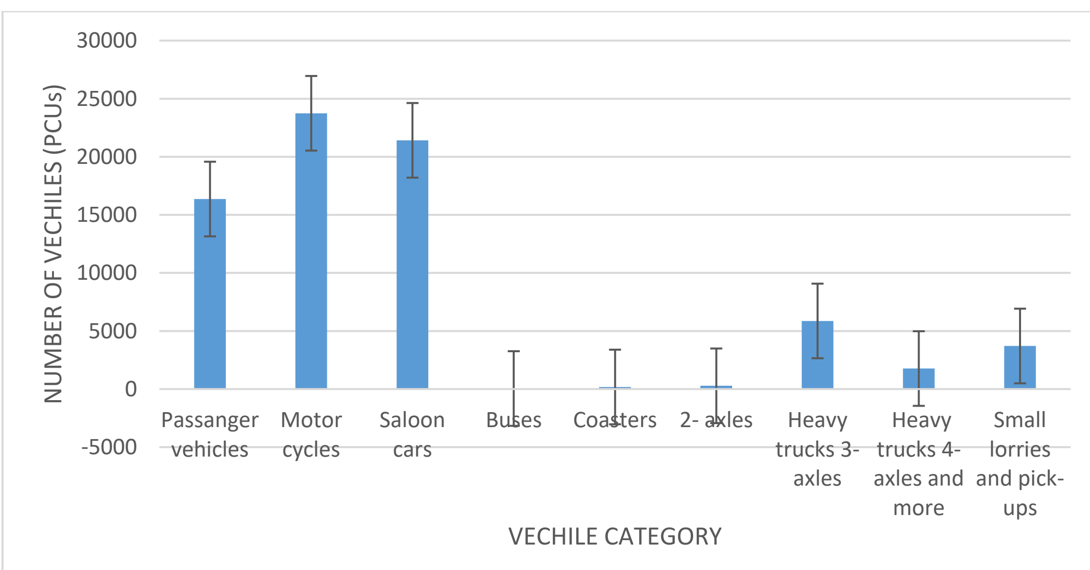
Basing on these daily and peak traffic volumes, Naalya-Namugongo was taken to be the major road. This implies that this road is the most contributor towards the traffic congestion experienced at the intersection, followed by other arms.

### 4.3.3 Traffic composition

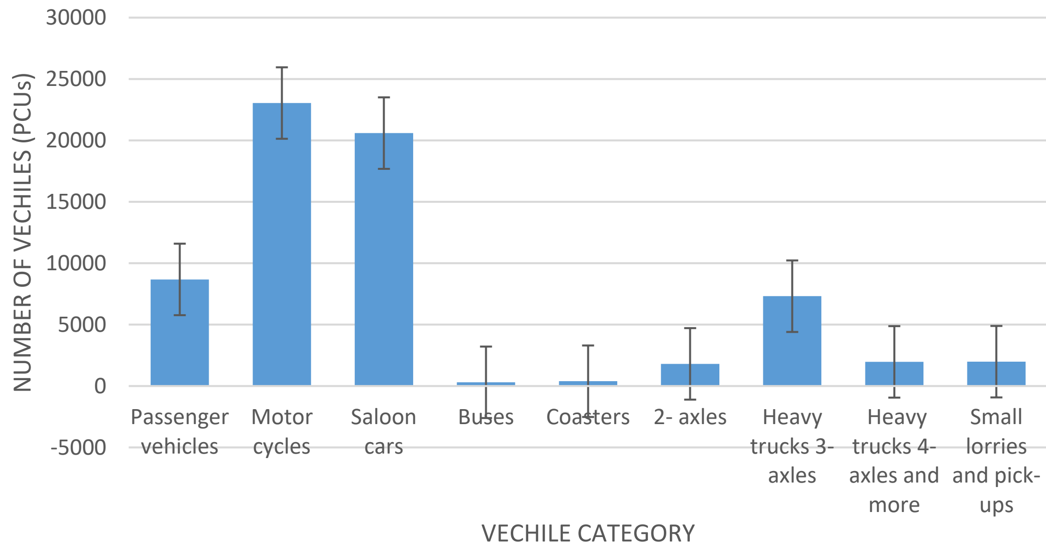
#### *4.3.3.1 Traffic composition For Naalya Arm*



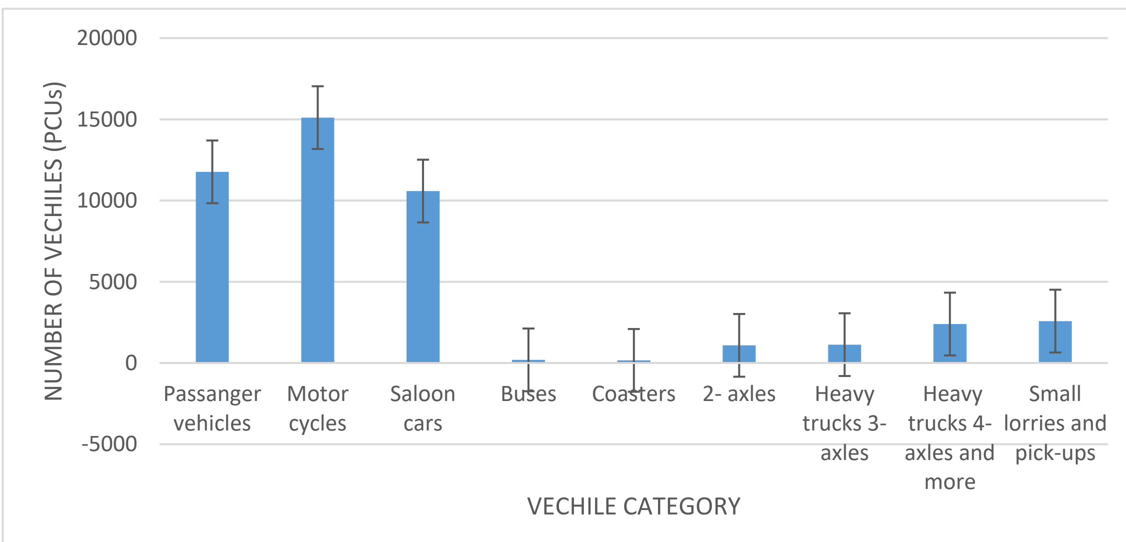

#### *4.3.3.2 Traffic composition For Kireka Arm*



### *4.3.3.3 Traffic composition For Namugongo*




### *4.3.3.4 Traffic composition For Kira Arm*




The above graphs indicate that intersection is mostly used by motor cycles, passenger vehicles, and saloon cars. This is believed to be as a result of the increased land use pattern in terms of residential and commercial land use

### 4.3.4 Turning movements

| TURN | VOLUME (VEH/HR) | | | |
|---|---|---|---|---|
| | KIRA (1) | KIREKA (2) | NAMUGONGO (3) | NAALYA (4) |
| LEFT TURN | 936 | 563 | 812 | 1330 |
| THROUGH | 712 | 1045 | 1339 | 1543 |
| RIGH TURN | 1475 | 1174 | 474 | 447 |

*Table 5: Total turning traffic*

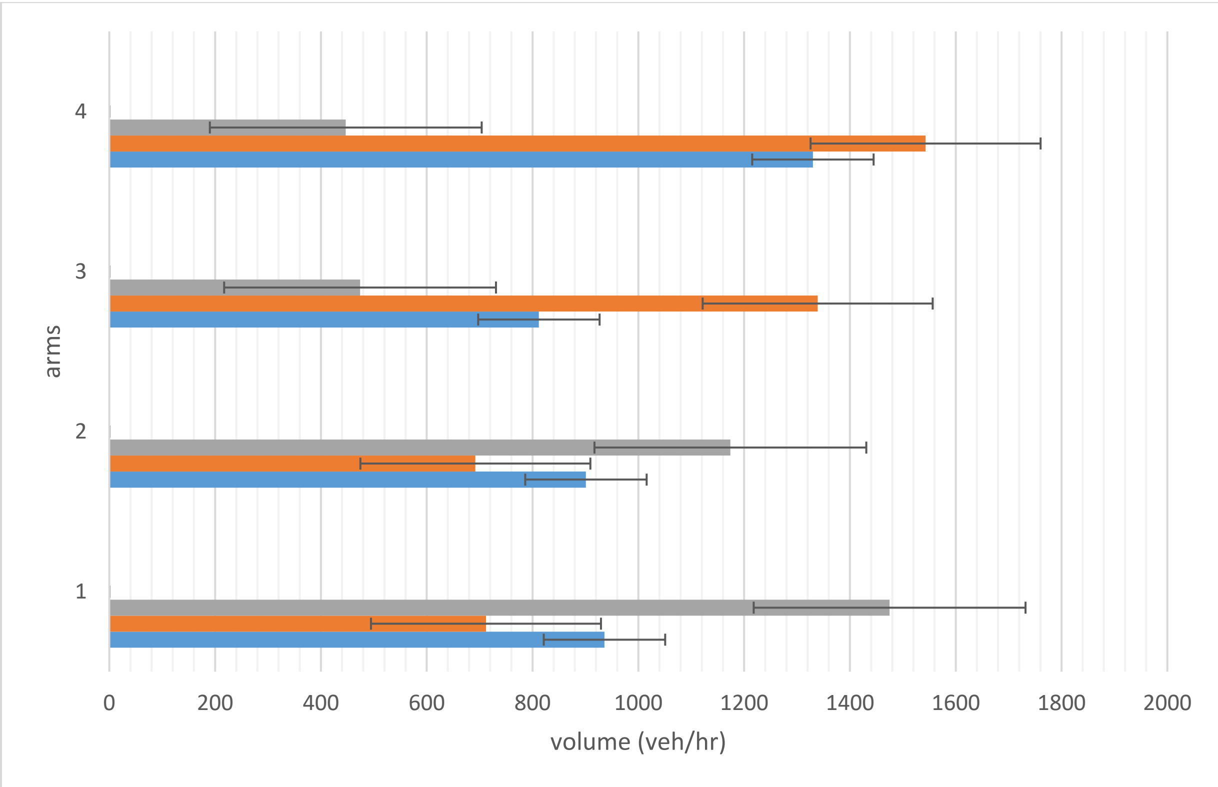



*Figure 11: Total turning traffic for the arms*

The high volumes of right and left turns from the minor arms of Kira and Kireka, and the through traffic from the major arms of Namugongo and Naalya result into high congestion at the intersection.

4.3.5 Existing conditions and parameters

| ARM | DELAY (s) | PHF | V/C | LOS | Queue length (veh/h) | Lane width | Width of the shoulder |
|---|---|---|---|---|---|---|---|
| Namugongo | 480 | 0.92 | 0.92 | E | 55 | 3 | 2 |
| Naalya | 588 | 1.23 | 1.06 | E | 64 | 1.3 | Absent |
| Kireka | 360 | 0.92 | 0.89 | D | 45 | 2.9 | 0.8 |
| Kira | 306 | 0.91 | 0.79 | D | 32 | 2.1 | 1.3 |

*Table 6: Existing parameters at the cross-intersection*

- *Peak Hour factor*$PHF = \frac{V}{4 \times V_{15}}$ where V is the peak hour volume and $V_{15}$ is the highest 15-minute volume in the peak hour
- Flow and Capacity ratio $\left(\frac{V}{C}\right)$

The intersection was determined to have an average v/c of 0.91 hence it is operating at a LOS E which can easily to be functioning LOS E and this can easily turn into LOS F implying that the junction is failing. But Kyaliwajjala being a suburban area, with a high level of importance, according the RDM 2010, roads resituated in this place supposed to have the following characters.

| Standard parameters | units | value |
|---|---|---|
| LOS | - | C |
| Lane width | m | 3.65 |
| Shoulder width | m | 2 – 2.5 |
| Delay | s | Less than 45 |

*Table 7: Required standard parameters*

From the above, the junction experiences long delays and queues. Most of its existing parameters don't comply with the standard road design parameters. This creates a need for the intersection to be upgraded in order to improve its capacity and level of service. From site visits, it was identified that many land uses were situated with in the road reserve, limiting road activities and parking areas

## 4.4 INTERSECTION CONTROL SELECTION

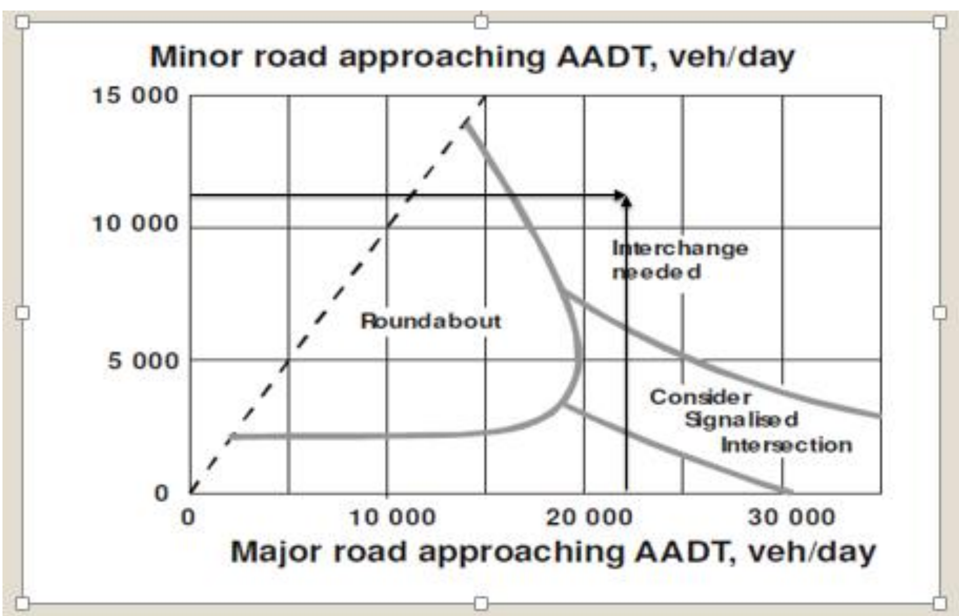



*Figure 12: Intersection control type selection*

Following the procedure in the URDM, section 8.4, an intersection upgrade was selected using the graph above. The intersection was found to have an AADT of 23505 veh/day along the major arm and 11078 veh/day along the minor arm implying that it needed to be improved to an interchange

### 4.5 DEVELOP OPTIMAL TRAFFIC REGULATION SYSTEM

Some of the design parameters to be considered while redesigning. From the different types of interchanges, the following options were selected;

- Diamond interchange
- Grade separated round about (roundabout with an overpass)

An evaluation used to select the final alternative followed this criteria

| **Criteria** | **Alternative one** | **Alternative two** |
|---|---|---|
| Safety | +++ | ++ |
| Space requirement | - | --- |
| Aesthetics | + | ++ |
| Economic | Saves 50-30% (from literature) | Saves 20-30% (from literature) |
| Total | 4 | 2 |

*Table 8: Factors considered to select suitable alternative*

From the above evaluation, the grade separated round about was found to have more benefits compared to the diamond interchange. Therefore a roundabout with an overpass was chosen. In addition, The consulting firm that is going to improve this intersection has a number of geometric design options that it hopes to execute based on the data gathered from the many engineers; nonetheless, it was planning on constructing a half diamond interchange at the cross-intersection. The project is still in the planning stages, however due to the previously mentioned benefits, it is advised that the consulting firm employ this design rather than the originally intended diamond interchange.

### 4.5.1 Roundabout (lower level)

- **Design life.**

This was determined depending on the level of design data reliability and the level of service or importance of the cross-intersection. An a value of 15 years for the design life was to be used (Uganda Roads Design Manual, 2010)

- **Growth rate.**

The growth rate was determined to be 6% according to the Kampala Capital City Authority (KCCA)

- **Design hourly volume**

This was gotten by the formula;

$DHV = ADT \times K$

Where ADT is Average Daily Traffic

And K is the K-value considered depending on the general overview of the cross-intersection, for example the cross-intersection considered in our study was heavily trafficked and was under congested urban conditions and thus a K-value between 0.08 and 0.12 was to be used

- **Number of lanes:**

This refers to the number of traffic lanes in each direction approaching the roundabout. The circulating traffic lanes to accommodate 423veh/hr and the entering to accommodate 580 veh/hr in reference to the standards. (URDM)

- **Entry radius:**

This is the radius of the curve where the approach lane meets the circulating roadway of the roundabout. An entry radius of 18m was considered in reference to the standards (URDM)

- **Turning radius:**

This is the radius of the central island of the roundabout. A turning radius of 14m was selected for the roundabout in reference to the design car which is a semitrailer combination.

- **Lane width:**

This is the width of a single traffic lane within the roundabout. A lane width of 3.65m was selected for the roundabout basing on the standards (URDM, 2010) where a dual carriageway has a lane width of 3.65m

- **Circulatory carriageway width:**

This is the width of the entire roadway within the central island of the roundabout that circulating traffic travels on. 21.6m was selected for the roundabout basing on the standards (URDM, 2010)

- **Approach speed:**

This is the design speed for vehicles approaching the roundabout. An approach speed of 30km/hr was selected basing on the standards (URDM, 2010) which say it has to be less than 40km/hr for a roundabout.

- **Design vehicle:**

This is a hypothetical vehicle that represents the critical design features of a specific class of vehicles (e.g., cars, trucks) and is used to ensure the roundabout can accommodate the most common vehicles. A semitrailer combination was selected as the design vehicle.

- **Entry width:**

This is the width of the opening between the splitter island and the curb where traffic enters the roundabout. An entry width of 6m was selected basing on the design vehicle selected.

- **LOS (Level of Service):**

This is a qualitative measure of traffic operating conditions within the roundabout, designated from a (best) to F (worst) in terms of delay, speed, freedom to maneuver, and driver comfort. A LOS of C was chosen considering in Uganda as a developing country, roads are only upgraded to a maximum level of service C.

- **Delay:**

This is the additional travel time a vehicle experiences due to congestion within the roundabout, measured in seconds per vehicle. A delay of 36 seconds was selected basing on the standards (GRDM) where the delay is supposed to be less than 45 seconds for a roundabout.

- **Design volume:**

This is the total traffic volume that a roundabout is designed to accommodate over a specific period (e.g., hourly, daily). A design of 70037 veh/day was calculated for the roundabout.

- **Central island radius**:

The distance from the center of the roundabout to the edge of the central island. A central island radius of 21m was selected basing on the graphs for 2-lane carriage ways in the standards for (GRDM, 2010)

- **Shoulder and cycle lanes**:

The paved area on the side of the road next to the traffic lanes. They are sometimes used as a breakdown lane for vehicles that have problems. Cycle lanes are designated area on the road for bicycles to ride. Shoulder and cycle lanes of 2m were selected basing on the standards in for (GRDM, 2010)

- **Design year:**

The year for which a road or intersection is designed to handle a certain volume of traffic. A design year of 15 years was selected basing on the standards in the (URDM, 2010)

- **Exit width:**

The width of the lane where traffic exits the road. An exit width of 5.5m was selected basing on the standards of the Uganda Road Design Manual (URDM, 2010)

4.5.2 Overpass (upper level)

The overpass shares many parameters with the roundabout, for example Design speed, Level Of Service, Design vehicle and many other parameters, but some of the differing parameters include;

- **Ramp design speed:**

The speed at which a vehicle can safely travel on a ramp without experiencing excessive lateral forces. The Ramp design speed was selected as 45km/hr basing on the standards range 0r 45-50 km/hr of the Uganda Road Design Manual (2010).

- **Lane width**

The lane width selected for the Overpass was 3.5 basing on the standard range of 3-3.65m of the (URDM, 2010).

- **Average Delay**.

The average delay selected for the overpass is 25seconds basing on the standard that the average delay over an overpass is supposed to be less than 30 seconds

- **Number of Lanes**

The number of lanes was selected as one lane basing on the standards in the Uganda Road Design Manual (2010)

- **Height from ground level:** The vertical distance between the ground and the ramp.

# 5 CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

## 5.1 INTRODUCTION

This chapter provides an overview of the traffic congestion problem at Kyaliwajjala Junction. It explores the causes of the congestion, including the historical background, and proposes solutions based on the findings from field data. The chapter also considers the challenges faced during the study.

## 5.2 CONCLUSION

The study reveals that the traffic congestion problem at Kyaliwajjala Intersection is caused by a combination of factors, including the inability of the intersection to handle the current traffic volume, turning movements of slow-moving heavy trucks, and unrestricted parking at the intersection. Additionally, street vendors and kiosks on the Kira approach to the intersection contribute to the congestion. The cross-intersection has an average (V/C) ratio of 0.91 as seen in the chapter 4, and thus is operating at a Level Of Service of E where there is no constant flow of traffic thus leading to high traffic congestion even in non-peak hours. It is also experiencing an average delay of 7.2 minutes which also contributes to traffic congestion.

During the study, we observed that the existing channelization measures have had little effect on reducing traffic congestion and the conflicts that arise from the various traffic movements. The report recommends that an interchange of a roundabout with an overpass be constructed at the intersection to address the identified issues and improve traffic flow. This solution is predicted to reduce traffic delays to 35s, reduce traffic queues, improve traffic flow, and decrease the number of accidents at the intersection.

## 5.3 RECOMMENDATION

The report recommends that an interchange of a roundabout with an overpass be implemented at the Kyaliwajjala Intersection because it is the most cost-effective solution in safety, aesthetics and space requirement. The cross-intersection is designed to serve a future design traffic of 70037 veh/day and a design hourly volume of 8405veh/h

Additionally, the Ministry of Works and Transport can readily take up this proposed design for implementation, as it will effectively eliminate the traffic congestion troubles currently being experienced at the intersection.

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# 7 APPENDICES

## 7.1 APPENDIX A: RESULTS IN TABLES

### 7.1.1 SURVEY DATA

*Table 9: coordinates and elevations*

| **points** | **elevations and coordinates** | | | **reflector points** |
|---|---|---|---|---|
| **1** | 2000 | 5000 | 1200 | pkt1 |
| **2** | 2026.545 | 4995.311 | 1201.393 | pkt2 |
| **3** | 2022.523 | 5001.254 | 1201.415 | Rd |
| **4** | 2025.531 | 5007.283 | 1201.533 | Tr |
| **5** | 2022.192 | 5007.311 | 1201.501 | Rd |
| **6** | 2021.956 | 5020.601 | 1201.623 | Rd |
| **7** | 2024.582 | 5022.508 | 1201.861 | Tr |
| **8** | 2009.255 | 4997.704 | 1200.588 | Rd |
| **9** | 2004.456 | 5000.697 | 1200.353 | Tr |
| **10** | 1987.905 | 5003.313 | 1199.077 | Tr |
| **11** | 1987.383 | 5002.291 | 1199.088 | Rd |
| **12** | 1977.793 | 5006.369 | 1198.429 | Tr |
| **13** | 1977.653 | 5005.529 | 1198.421 | Rd |
| **14** | 1972.43 | 5008.322 | 1198.201 | Tr |

| points | elevations and coordinates | | | reflector points |
|---|---|---|---|---|
| **15** | 1961.999 | 5011.767 | 1197.553 | Tr |
| **16** | 1961.535 | 5010.824 | 1197.527 | Rd |
| **17** | 1944.852 | 5017.398 | 1196.541 | Tr |
| **18** | 1944.492 | 5016.597 | 1196.524 | Rd |
| **19** | 1935.944 | 5020.458 | 1196.013 | Tr |
| **20** | 1935.713 | 5019.759 | 1196.014 | Rd |
| **21** | 1920.924 | 5025.063 | 1195.339 | Rd |
| **22** | 1907.491 | 5029.479 | 1194.522 | Rd |
| **23** | 1893.175 | 5033.539 | 1193.589 | Rd |
| **24** | 1925.44 | 5022.299 | 1195.512 | Rd |
| **25** | 1875.729 | 5029.913 | 1192.561 | Tr |
| **26** | 1875.883 | 5029.914 | 1192.564 | Rd |
| **27** | 1876.485 | 5032.084 | 1192.532 | Rd |
| **28** | 1895.197 | 5024.111 | 1193.546 | Rd |
| **29** | 1896.276 | 5025.064 | 1193.69 | Rd |
| **30** | 1897.021 | 5023.601 | 1193.785 | Rd |
| **31** | 1912.202 | 5017.301 | 1194.571 | Tr |

| points | elevations and coordinates | | | reflector points |
|---|---|---|---|---|
| **32** | 1912.197 | 5018.2 | 1194.574 | Rd |
| **33** | 1929.972 | 5011.979 | 1195.663 | Rd |
| **34** | 1929.619 | 5009.942 | 1195.657 | Tr |
| **35** | 1944.545 | 5005.022 | 1196.567 | Tr |
| **36** | 1945.091 | 5006.042 | 1196.549 | Rd |
| **37** | 1957.178 | 5001.317 | 1197.305 | Rd |
| **38** | 1986.349 | 4995.467 | 1197.745 | Tr |
| **39** | 1970.293 | 4997.324 | 1198.183 | Rd |
| **40** | 1978.487 | 4994.494 | 1198.734 | Rd |
| **41** | 1980.456 | 4992.638 | 1198.762 | Rd |
| **42** | 1980.481 | 4990.596 | 1198.611 | Tr |
| **43** | 1986.034 | 4988.644 | 1199.019 | Tr |
| **44** | 1986.473 | 4989.783 | 1199.148 | Rd |
| **45** | 1996.942 | 4984.945 | 1199.684 | Tr |
| **46** | 1997.229 | 4985.796 | 1199.686 | Rd |
| **47** | 2006.378 | 4983.769 | 1199.943 | Rd |
| **48** | 1999.857 | 4983.013 | 1200.038 | Tr |

| points | elevations and coordinates | | | reflector points |
|---|---|---|---|---|
| **49** | 2005.405 | 4977.234 | 1200.291 | Tr |
| **50** | 2006.213 | 4977.723 | 1200.318 | Rd |
| **51** | 2007.975 | 4970.508 | 1200.585 | Tr |
| **52** | 2009.221 | 4970.743 | 1200.579 | Rd |
| **53** | 2021.612 | 4957.184 | 1201.129 | Rd |
| **54** | 2022.453 | 4966.045 | 1201.274 | Rd |
| **55** | 2023.632 | 4968.468 | 1201.372 | Tr |
| **56** | 2024.562 | 4971.066 | 1201.358 | Rd |
| **57** | 2033.543 | 4968.489 | 1201.637 | Tr |
| **58** | 2033.821 | 4969.522 | 1201.642 | Rd |
| **59** | 2044.05 | 4968.007 | 1202.108 | Rd |
| **60** | 2044.615 | 4966.795 | 1202.031 | Tr |
| **61** | 2086.947 | 4952.508 | 1204.352 | Rd |
| **62** | 2086.41 | 4951.619 | 1204.352 | Tr |
| **63** | 2105.184 | 4943.791 | 1205.452 | Rd |
| **64** | 2106.214 | 4942.141 | 1205.712 | Tr |
| **65** | 2127.461 | 4933.793 | 1206.678 | Rd |

| points | elevations and coordinates | | | reflector points |
|---|---|---|---|---|
| **66** | 2126.641 | 4932.732 | 1206.711 | Tr |
| **67** | 2139.451 | 4927.753 | 1207.297 | Rd |
| **68** | 2140.887 | 4926.081 | 1207.434 | Rd |
| **69** | 2146.148 | 4935.102 | 1207.814 | Rd |
| **70** | 2145.725 | 4936.345 | 1207.982 | Tr |
| **71** | 2170.651 | 4922.983 | 1209.214 | Tr |
| **72** | 2180.644 | 4917.099 | 1209.647 | Rd |
| **73** | 2195.393 | 4905.714 | 1210.517 | Rd |
| **74** | 2179.626 | 4915.895 | 1209.684 | Rd |
| **75** | 2175.162 | 4907.895 | 1209.454 | Rd |
| **76** | 2159.383 | 4916.589 | 1208.547 | Rd |
| **77** | 2144.713 | 4924.162 | 1207.715 | Tr |
| **78** | 2133.982 | 4941.464 | 1206.933 | Rd |
| **79** | 2113.687 | 4950.677 | 1205.958 | Rd |
| **80** | 2113.736 | 4951.239 | 1205.988 | Tr |
| **81** | 2098.388 | 4958.211 | 1205.171 | Tr |
| **82** | 2097.934 | 4957.572 | 1205.026 | Rd |

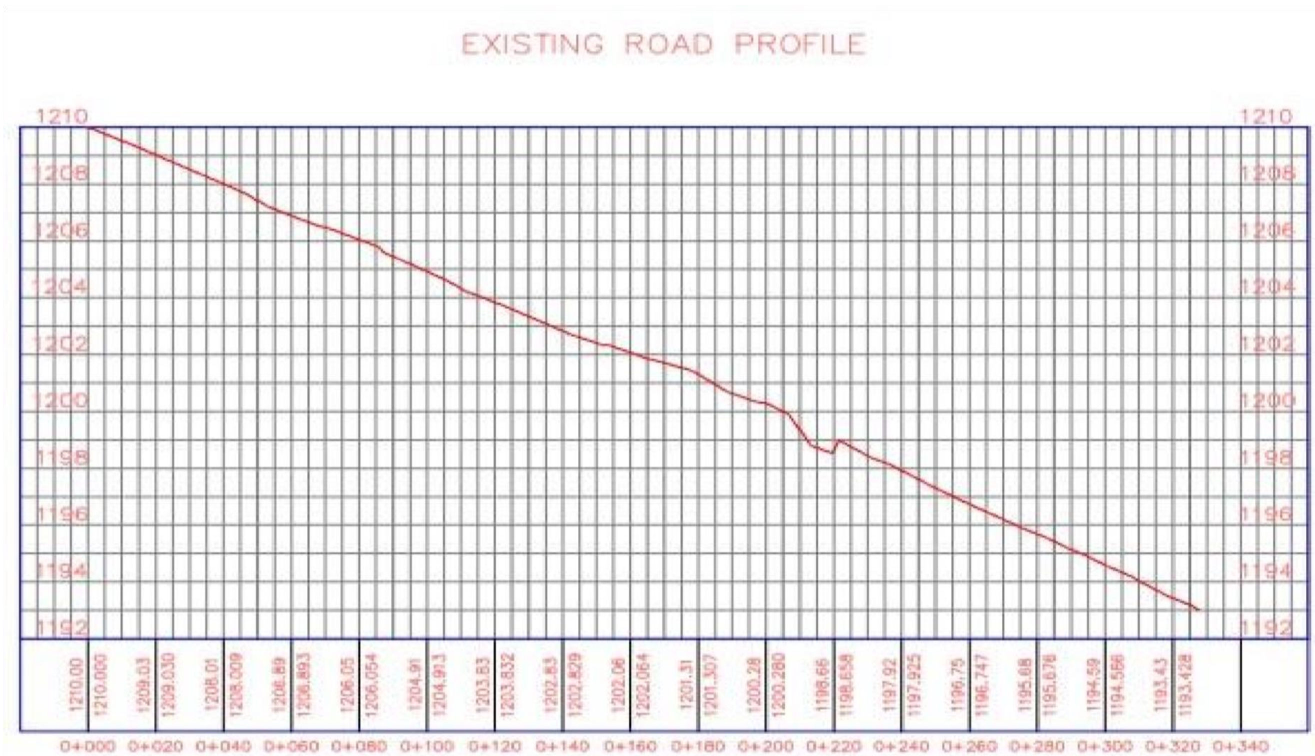
| points | elevations and coordinates | | | reflector points |
|---|---|---|---|---|
| **83** | 2083.648 | 4964.888 | 1203.949 | Rd |
| **84** | 2083.888 | 4966.113 | 1204.177 | Tr |
| **85** | 2065.081 | 4974.046 | 1203.3 | Tr |
| **86** | 2064.671 | 4972.985 | 1203.017 | Rd |
| **87** | 2051.978 | 4978.781 | 1202.458 | Rd |
| **88** | 2051.137 | 4979.544 | 1202.477 | Tr |
| **89** | 2040.441 | 4987.301 | 1201.755 | Tr |
| **90** | 2039.419 | 4985.764 | 1201.942 | Rd |
| **91** | 2026.291 | 4995.065 | 1201.482 | Rd |
| **92** | 2007.795 | 4953.773 | 1200.912 | Rd |
| **93** | 2001.159 | 4914.579 | 1200.641 | Rd |
| **94** | 1999.164 | 4898.549 | 1200734 | Rd |
| **95** | 1995.339 | 4873.393 | 1200.751 | Rd |
| **96** | 1997.046 | 4872.822 | 1200.842 | Rd |
| **97** | 1993.132 | 4842.949 | 1200.744 | Rd |
| **98** | 1991.043 | 4842.81 | 1200.685 | Sp |
| **99** | 1988.082 | 4819.997 | 1200.533 | Rd |

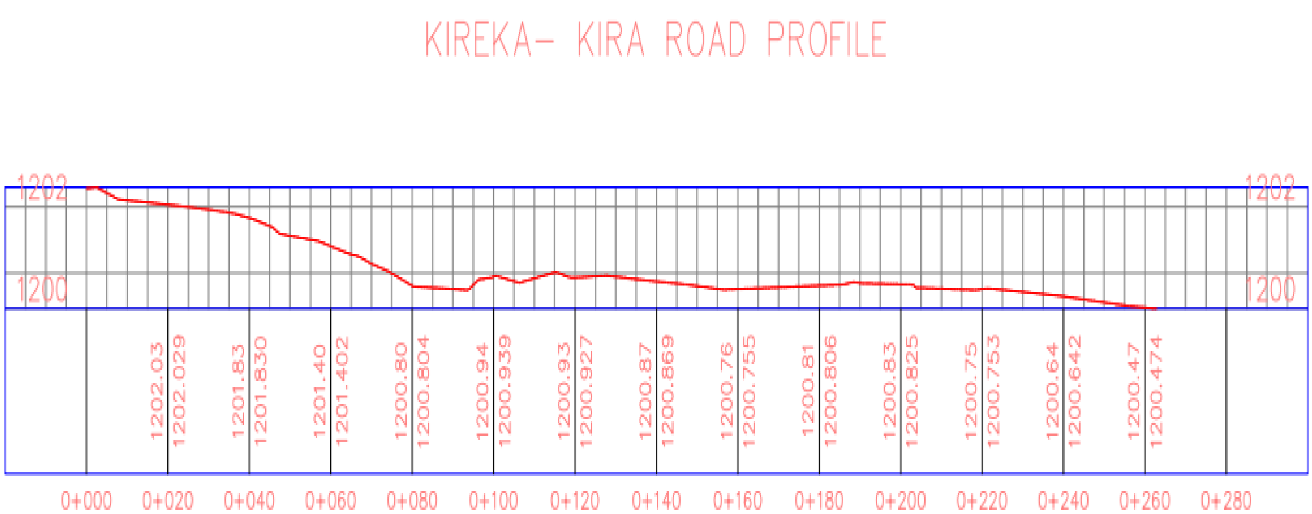
| points | elevations and coordinates | | | reflector points |
|---|---|---|---|---|
| **100** | 2020.391 | 4948.465 | 1200.939 | Rd |
| **101** | 2017.576 | 4932.664 | 1200.917 | Tr |
| **102** | 2015.478 | 4932.694 | 1200.999 | Rd |
| **103** | 2012.292 | 4914.704 | 1200.838 | Rd |
| **104** | 2014.635 | 4914.184 | 1200.838 | Tr |
| **105** | 2008.977 | 4894.949 | 1200.878 | Rd |
| **106** | 2010.941 | 4894.236 | 1200.837 | Tr |
| **107** | 2005.939 | 4863.909 | 1200.791 | Tr |
| **108** | 2004.104 | 4863.703 | 1200.792 | Rd |
| **109** | 2013.675 | 5004.921 | 1201.069 | Rd |
| **110** | 2014.435 | 5020.419 | 1201.456 | Rd |
| **111** | 2023.255 | 5001.694 | 1201.449 | Sh |
| **112** | 2015.457 | 5026.413 | 1201.537 | Rd |
| **113** | 2013.968 | 5026.433 | 1201.563 | Tr |
| **114** | 2014.896 | 5037.476 | 1201.708 | Rd |
| **115** | 2015.626 | 5037.789 | 1201.769 | Tr |
| **116** | 2013.605 | 5051.672 | 1201.759 | Tr |

| **points** | **elevations and coordinates** | | | **reflector points** |
|---|---|---|---|---|
| **117** | 2015.305 | 5052.045 | 1201.948 | Rd |
| **118** | 2013.364 | 5065.024 | 1202.073 | Tr |
| **119** | 2015.305 | 5065.097 | 1202.337 | Rd |
| **120** | 2186.521 | 4890.371 | 1210.621 | Rd |
| **121** | 2022.191 | 5070.161 | 1202.241 | Rd |
| **122** | 2013.271 | 5069.721 | 1202.321 | Rd |
| **123** | 1995.121 | 4809.191 | 1200.421 | Rd |
| **124** | 1981.761 | 4810.751 | 1200.501 | Rd |

### 7.1.2 Topography profiles

*Figure 13: Existing road profiles*



## 7.2 TRAFFIC COMPOSITION

*Table 10: Naalya arm traffic composition*

| NAALYA ARM | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **VEHICLE TYPE** | **Monday** | **Wednesday** | **Thursday** | **Friday** | **Sunday** | **Saturday** | **Tuesday** | **TOTAL** | **TOTAL (PCUs)** |
| **Passenger vehicles** | 2101 | 1981 | 1729 | 1393 | 1067 | 1192 | **2090** | 11553 | 11553 |
| **Motor cycles** | 4451 | 4251 | 4111 | 4212 | 2981 | 3990 | 3321 | 27317 | 27317 |
| **Saloon cars** | 2964 | 2818 | 2702 | 2902 | 1922 | 1712 | **2897** | 17917 | 26876 |
| **Buses** | 8 | 5 | 4 | 6 | 9 | 4 | **7** | 43 | 172 |
| **Coasters** | 20 | 24 | 32 | 22 | 10 | 8 | **19** | 135 | 270 |
| **2- axles** | 882 | 843 | 885 | 881 | 690 | 762 | **855** | 5798 | 5798 |
| **Heavy trucks 3- axles** | 242 | 238 | 234 | 228 | 237 | 200 | **227** | 1606 | 8030 |
| **Heavy trucks 4axles and more** | 35 | 38 | 31 | 37 | 23 | 30 | **29** | 223 | 1784 |
| **Small lorry and pick-ups** | 494 | 488 | 384 | 388 | 357 | 438 | **401** | 2950 | 4425 |
| **TOTAL** | | | | | | | | | 86225 |

*Table 11: Namugongo arm traffic composition*

| NAMUGONGO ARM | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **VEHICLE TYPE** | **Mon day** | **Wednesday** | **Thursday** | **Friday** | **Sunday** | **Saturday** | **Tuesday** | **TOT AL** | **TOTAL (PCUs)** |
| **Passenger vehicles** | 1312 | 1271 | 1291 | 1297 | 1116 | 1101 | **1293** | 8681 | 8681 |
| **Motor cycles** | 3852 | 3651 | 2418 | 3002 | 3998 | 2912 | 3212 | 23045 | 23045 |
| **Saloon cars** | 2220 | 2020 | 2087 | 2172 | 1167 | 1983 | **2082** | 13731 | 20597 |
| **Buses** | 10 | 13 | 11 | 8 | 9 | 9 | **16** | 76 | 304 |
| **Coasters** | 38 | 22 | 27 | 23 | 18 | 19 | **49** | 196 | 392 |
| **2- axles** | 293 | 279 | 228 | 248 | 233 | 233 | **291** | 1805 | 1805 |
| **Heavy trucks 3- axles** | 248 | 239 | 237 | 131 | 130 | 219 | **259** | 1463 | 7315 |
| **Heavy trucks 4 axle and more** | 37 | 34 | 38 | 33 | 39 | 31 | **34** | 246 | 1968 |
| **Small lorries and pick-ups** | 223 | 211 | 192 | 207 | 109 | 169 | **211** | 1322 | 1983 |
| **TOTAL** | | | | | | | | | 66090 |

*Table 12: Kira arm traffic composition*

| KIRA ARM | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **VEHICLE TYPE** | **Monday** | **Wednesday** | **Thursday** | **Friday** | **Sunday** | **Saturday** | **Tuesday** | **TOTAL** | **TOTAL (PCUs)** |
| **Passenger vehicles** | 1992 | 1995 | 1888 | 1911 | 1058 | 1104 | **1820** | 11768 | 11768 |
| **Motor cycles** | 2421 | 2322 | 2001 | 2108 | 1941 | 2112 | 2201 | 15106 | 15106 |
| **Saloon cars** | 1055 | 1007 | 1017 | 1002 | 933 | 998 | **1044** | 7056 | 10584 |
| **Buses** | 8 | 5 | 9 | 6 | 4 | 8 | **8** | 48 | 192 |
| **Coasters** | 9 | 10 | 6 | 11 | 12 | 14 | **18** | 80 | 160 |
| **2- axles** | 129 | 130 | 124 | 127 | 123 | 220 | **233** | 1086 | 1086 |
| **Heavy trucks 3-axles** | 48 | 38 | 27 | 28 | 19 | 33 | **33** | 226 | 1130 |
| **4-axle and more** | 59 | 48 | 49 | 47 | 36 | 26 | **35** | 300 | 2400 |
| **Small lorries and pick-ups** | 245 | 241 | 231 | 233 | 25 | 325 | **420** | 1720 | 2580 |
| **TOTAL** | | | | | | | | | 45006 |

*Table 13: Kireka arm traffic composition*

| VEHICLE TYPE | Monday | Wednesday | Thursday | Friday | Sunday | Saturday | Tuesday | TOTAL | TOTAL (PCUs) |
|---|---|---|---|---|---|---|---|---|---|
| Passenger vehicles | 2348 | 2241 | 2280 | 2325 | 1966 | 2291 | 2910 | 16361 | 16361 |
| Motor cycles | 3987 | 3891 | 2621 | 3963 | 2058 | 3234 | **3990** | 23744 | 23744 |
| Saloon cars | 2551 | 2226 | 2110 | | 1872 | 2989 | **2529** | 14277 | 21415.5 |
| Buses | 3 | 4 | 2 | 1 | 0 | 1 | **1** | 12 | 48 |
| Coasters | 15 | 17 | 14 | 10 | 8 | 10 | **16** | 90 | 180 |
| 2- axles | 47 | 32 | 38 | 35 | 28 | 62 | **40** | 282 | 282 |
| 3- axles | 132 | 128 | 134 | 120 | 193 | 229 | **237** | 1173 | 5865 |
| 4axles and more | 31 | 27 | 29 | 26 | 27 | 35 | **46** | 221 | 1768 |
| Small lorries and pick-ups | 464 | 402 | 388 | 482 | 8 | 312 | **417** | 2473 | 3710 |
| TOTAL | | | | | | | | | 73373 |

## ARTISTIC IMPRESSIONS AND LAYOUTS

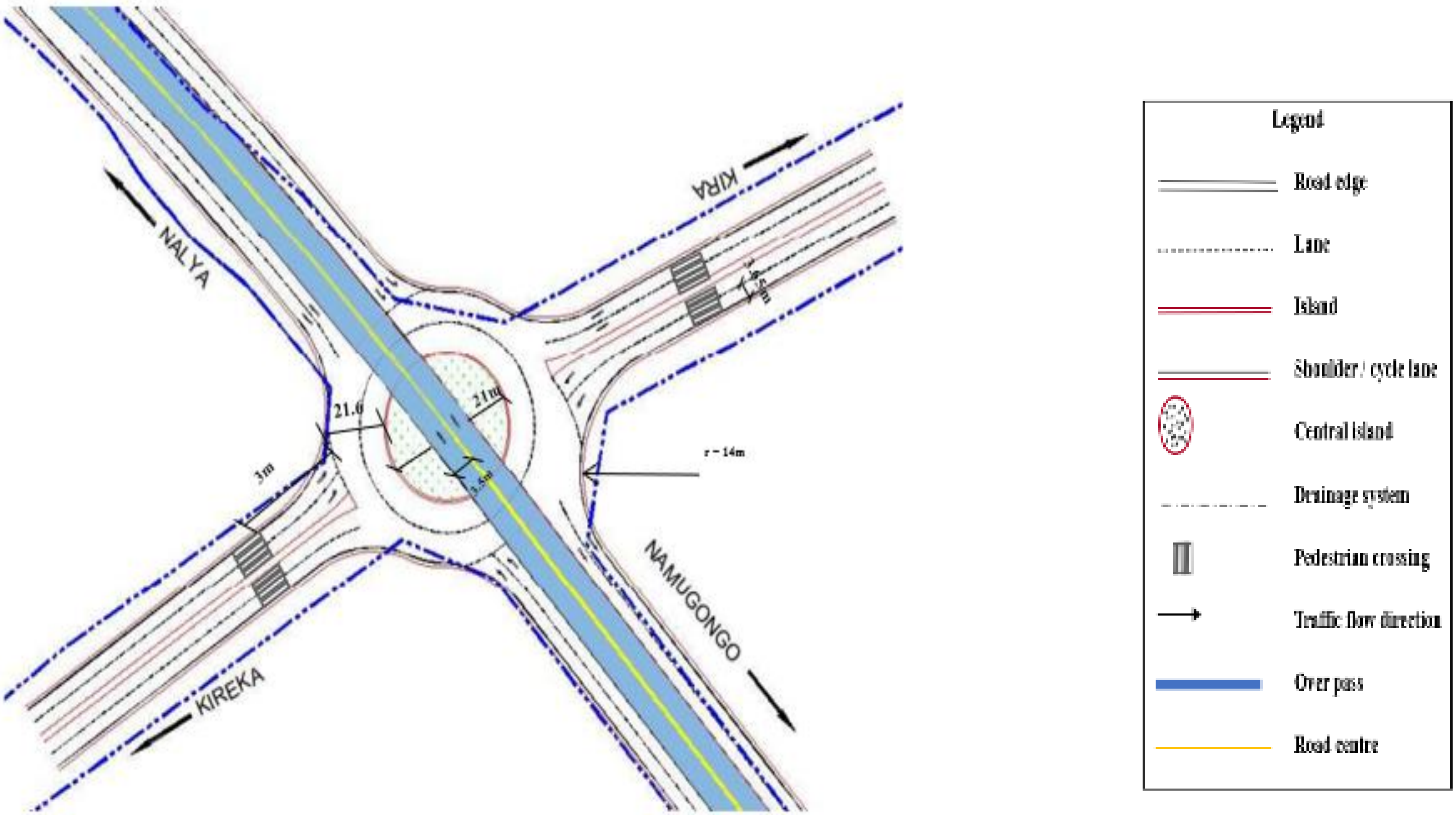



*Figure 14: PROPOSED LAYOUT OF THE GEOMRTRIC DESIGN*

*Figure 15: Plan View of Geometric design*

*Figure 16: Namugongo View of Geometric design*

*Figure 17:Naalya View of Geometric design*

*Figure 18: Clay model of the geometric design*