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INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

EVALUATION OF PAKATA ROUNDABOUT CAPACITY, A MAJOR JUNCTION ARTERIAL ROAD IN ILLORIN

BY

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BEING IN RESEARCH WORK SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING, INSTITUTE OF TECHNOLOGY, KWARA STATE POLYTECHNIC, ILORIN

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF HIGHER NATIONAL DIPLOMA (HND) IN CIVIL ENGINEERING

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CERTIFICATION

This is to certify that this research study was conducted by **SOLIU MUJEEB OLAYIWOLA (HND/23/CEC/FT/0166)** and had been read and approved as meeting the requirement for the award of Higher National Diploma (HND) in Civil Engineering of the Department Civil Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

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DECLARATION

I hereby declare that this project work titled OPTIMIZATION OF HYBRID FOAM EVALUATION OF PAKATA ROUNDABOUT CAPACITY, A MAJOR JUNCTION ARTERIAL ROAD IN ILLORIN is a work done by me, SOLIU MUJEEB OLAYIWOLA with matric number, HND/23/CEC/FT/0166 of the Department of Civil Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

……………………… ………………….

Signature Date

DEDICATION

This project is dedicated solemnly to God Almighty, who is the sole inspiration of all things, without whom there would not be, and neither would this project.

Appreciation goes to my loving parents for their support in the fulfillment of my Higher National Diploma (HND) both orally and financially. May God allow them to eat the fruit of their labor (Amen)

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ABSTRACT

Pakata Roundabout, a critical five-arm junction on Ilorin's main arterial road, faces escalating congestion and safety challenges due to rising traffic volumes and mixed vehicle composition. This study evaluates its capacity by combining field traffic surveys (7 AM–6 PM, seven days) with geometric measurements and analytical modeling based on the Highway Capacity Manual (2021) and gap-acceptance theory. Traffic volume counts converted to passenger-car units (PCU) revealed peak flows exceeding 1,300 PCU/hour on major approaches, yielding flow–capacity ratios (F/C) of 1.17–1.38 and average stopped delays of 23–32 s per vehicle, corresponding to Level of Service (LOS) C–D. Geometric assessment identified insufficient entry flare widths, narrow splitter-island deflection, encroachments within sight triangles, and undersized auxiliary weaving lanes as primary constraints. Capacity calculations for weaving sections indicated a minimum practical throughput of 3,735 PCU/hour versus a demand of 4,479 PCU/hour, confirming oversaturation. Based on these findings, a phased improvement strategy is proposed: widen North and South entries to two lanes, extend weaving lanes to at least four times their width, enhance splitter-island deflection, and clear sightline obstructions to achieve LOS C or better. If residual congestion persists, implement reversible, peak-period signal-assist at major entries. These interventions are projected to increase capacity by 10–15% and reduce average

delays below 35 s per vehicle, thereby restoring stable operation and enhancing safety at this vital intersection

CHAPTER ONE

1.1 INTRODUCTION

Roundabouts have become a popular alternative to traditional intersections in recent years due to their ability to reduce congestion, improve safety, and enhance traffic flow (FHWA, 2020). Roundabouts are designed to manage traffic flow by allowing vehicles to continuously circulate through the intersection, reducing the need for traffic signals and stop signs (Akçelik, 2017). However, as traffic volumes continue to increase, roundabouts are facing new challenges, particularly in terms of capacity (HCM, 2010).

The capacity of a roundabout is defined as the maximum number of vehicles that can pass through the roundabout in a given time period (Rakha & Zhang, 2015). Evaluating the capacity of a roundabout is crucial to ensure that it can handle the projected traffic volumes and to identify potential bottlenecks (Tian & Wu, 2017). A well-designed roundabout can handle high traffic volumes efficiently, reducing congestion and improving air quality (Zhang & Prevedouros, 2018).

In recent years, several studies have investigated the capacity of roundabouts using various methods, including analytical models (Tian & Wu, 2017), simulation models (Zhang & Prevedouros, 2018), and field observations (Bared et al., 2017). These studies have shown that the capacity of a roundabout is influenced by various factors, including the number of lanes, the diameter of the roundabout, the speed limit, and the volume of traffic (Akçelik, 2017).

However, most of these studies focused on roundabouts in low-to-medium traffic volume environments. There is a need for research on the capacity evaluation of roundabouts in high-traffic volume environments, particularly in main arterial roads (Rakha & Zhang, 2015). This study aims to address this knowledge gap by evaluating the capacity of Pakata roundabout, a major junction on the main arterial road in Ilorin

There are primarily two methods of analyzing the operational performance of roundabouts. These are the gap acceptance method and empirical regression technique method. The former uses the geometric features which impact driver behavior. At a priority intersection, the driver on the minor road will wait for an acceptable gap in the major road traffic stream before entering or crossing the intersection. In the case of the roundabout, the entering driver must yield to circulating traffic before entering the roundabout.

The empirical regression technique is based on the theory that geometric features of a roundabout greatly impact its operational level of performance. For example Figure 1 describes the key geometric features that affect the performance of a roundabout, (Kimber, 2019).

The geometric data are obtained through physical measurements of geometric features that make up the roundabout using linen tape. These include the inscribed circle diameter, approach half width, entry width, flare length, entry radius and entry angle. Figure 1.shows the key geometric features that affect the performance of a roundabout (Highway Capacity Manual, 2020).

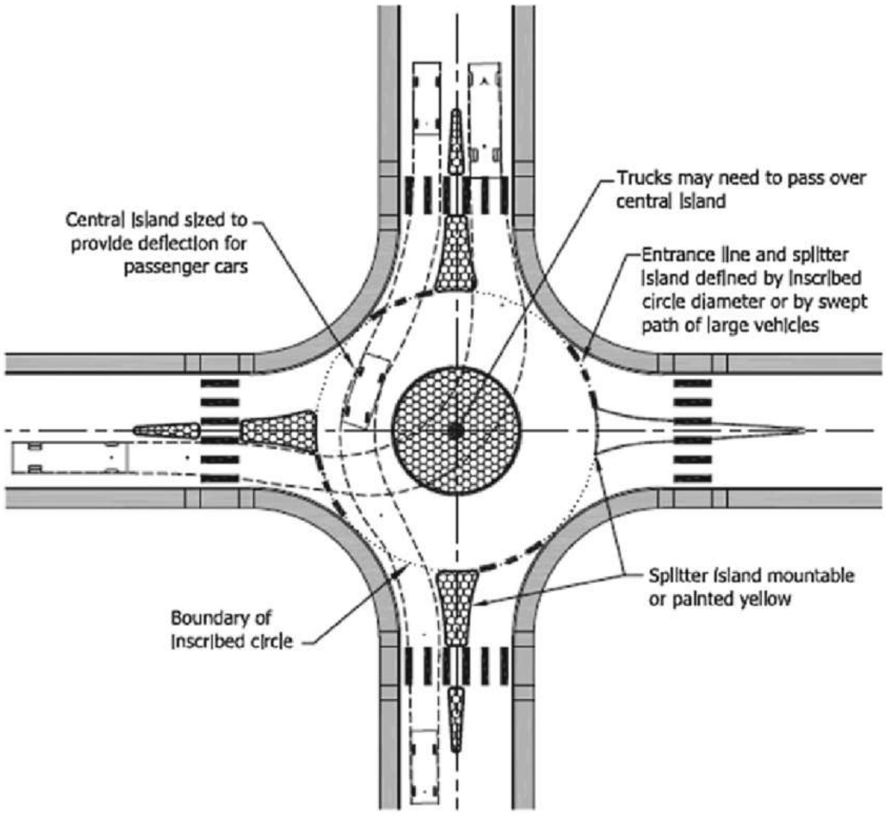

Figure 1. Geometric Features for Capacity Formula (Salter and Hounsell, 2017).

1.2 AIM AND OBJECTIVES

Aim:

The aim of this study is to evaluate the capacity of Pakata roundabout, a major junction on the main arterial road in Ilorin,

Objectives:

i. To conduct a traffic survey of Pakata roundabout, in order to determine its current traffic volumes and patterns.
ii. To evaluate the capacity of Pakata roundabout using analytical models and simulation software.
iii. To identify the factors that affect the performance of Pakata roundabout, including geometric design, traffic volume, and driver behavior.
iv. To develop a framework for evaluating the capacity of roundabout junctions on main arterial roads, which can be used by traffic engineers and planners to design and operate roundabouts more efficiently.

1.3 PROBLEM STATEMENT

Pakata roundabout, a major junction on the main arterial road in Ilorin, is experiencing increasing traffic volumes, leading to congestion, delays, and safety concerns. The capacity of the roundabout is unknown, and there is a need for a comprehensive evaluation of its performance in order to identify the factors that affect its capacity and provide recommendations for improving its capacity.

1.4 SCOPE OF STUDY

The study will focus on Pakata roundabout, a major junction on the main arterial road in Ilorin. The study will involve a traffic survey of the roundabout, The scope of this work will be limited to reconnaissance survey by visiting the study area to observed the traffic situations, field work to collect the necessary traffic data at the junction or intersections such as volume and delay, analysis of the collected data in accordance with highway capacity manual (2021) with the aid of statistical procedure and proposal of improvement strategies.

1.5 JUSTIFICATION

This study is justified because Pakata roundabout is a critical junction on the main arterial road in Ilorin, and its capacity has a significant impact on the overall traffic flow and safety in the area. With increasing traffic volumes, the roundabout is experiencing congestion, delays, and safety concerns, making it essential to evaluate its capacity and identify factors that affect its performance. By conducting this study, recommendations can be provided to improve the capacity of Pakata roundabout, leading to reduced congestion, improved traffic flow, and enhanced safety. Furthermore, the study will contribute to the knowledge of capacity evaluation of roundabout junctions on main arterial roads, which can be used by traffic engineers and planners to design and operate roundabouts more efficiently 1.6 Scope of the study This project work is to evaluate the traffic operations on main roundabout junction in Ilorin so as to propose necessary remedial measure that could assure the reasonable and sustained traffic operation for effective working of urban city for social and economic safety. It is therefore imperative that the necessary studies be carried out during the week days and weekend.

CHAPTER TWO

LITERATURE REVIEW

2.1 JUNCTION

Roundabouts have emerged as a vital traffic management solution for controlling vehicular flow and improving safety at intersections. Defined as channelized intersections where traffic circulates counterclockwise around a central island, roundabouts are designed to minimize conflict points and optimize vehicle movement (Austroads, 2020). They differ from traditional traffic circles by requiring incoming vehicles to yield to circulating traffic, thereby reducing the frequency and severity of accidents (FHWA, 2019).

The evaluation of a roundabout's capacity is a critical aspect of traffic engineering, as it determines the intersection's ability to handle current and projected traffic volumes. Factors such as geometric design, traffic composition, and driver behavior significantly influence a roundabout's performance (Siddharthan et al., 2017). Basic Concepts of Roundabouts and Definition of A roundabout is a channelized intersection at which all traffic moves anticlockwise around a central traffic island. (AACRA Geometric Design Manual, 2003). This definition can be used for traffic circles also because it doesn't mention priority. Roundabouts are intersections of two or more roads that are made up of a one way-circulating roadway that has priority over approaching traffic. Yield signs control the approaching traffic and the driver can only make a right turn onto the circulating roadway. The only decision the entering motorist needs to make once they reach the yield line is whether or not a gap in the circulating traffic is large enough for them to enter. The vehicles then exit the circulating roadway by making a right turn toward their destination (FHWA-RD-00-067, 2000). Roundabouts are often confused with traffic circles or rotaries and it is important to be able to distinguish between them. According to FHWA-2000 information guide, roundabouts have five main characteristics that identify them when compared to traffic circles:

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i. Traffic control: Yield control is used on all entries at roundabouts. The circulatory roadway has no control.

ii. Priority to circulating vehicles: Circulating vehicles have the right of way in roundabouts. Some traffic circles require circulating traffic to yield to entering traffic.

iii. Pedestrian access: Pedestrian access is allowed only across the legs of the roundabout, behind the yield line. Some traffic circles allow pedestrian access to the central island.

iv. Parking: No parking is allowed within the circulatory roadway or at the entries. Some traffic circles allow parking within the circulating roadway.

v. Direction of Circulation: All vehicles circulate counter-clockwise and pass to the right of the central island of the roundabout. Some neighborhood traffic circles allow left-turning vehicles to pass to the left of the central island. Besides to those five mentioned above, Thaweesak (1998) included additional features of roundabout, which distinguish them from other traffic circles.

vi. Approach Flare: Most roundabout approaches flare out at the entries and allow more vehicles to enter the circulating roadway at a more obtuse angle. This improves capacity, and allows entering vehicles to enter at similar speeds as the circulating vehicles unless a queue has developed at the entry. The size and angle of the flare is generally controlled by a raised traffic island that separates the entering and exiting traffic at an approach. This island also gives pedestrians a safe location to cross the approach in two stages. This is the old English principle and gives high capacity, but low safety due to high speed in some countries.

Deflection: This characteristic is the geometry of the facility that requires vehicles to slow down as they maneuver through the roundabout. The size of the Center Island and angle of approach determine the deflection and potential speeds of entering and circulating vehicles. Generally, the effect of the roundabout is that traffic is required to slow down to negotiate the curve around the central island, but unlike full stop and signal controlled intersections, vehicles entering a roundabout are not required to stop completely. This makes the facility more efficient under a wide range of traffic volumes, as motorists only need to find an acceptable gap for entrance.

2.1.1 DESIGN PRINCIPAL OF A GOOD JUNCTION OR INTERSECTION

Design of junction is an important task. They need to be designed carefully after considering a number of factors. Some of the main design principles are mentioned below

1. Uniformity and simplicity- junction must be designed and operated for simplicity and uniformity. The design must keep the capabilities and limitation of drivers, pedestrians and vehicles using intersection. It should be based on knowledge of what a driver will do rather than what he should do. All the intersection or junctions movements should be obvious to the drivers, even if

he is a stranger to the area thus maintaining uniformity.

2. Minimize conflict points- any location having merging, diverging or crossing maneuvers of two vehicles is a potential conflict point the main objective of the intersection design is a minimize the number and severity of potential conflicts between cars, buses, trucks, bicycles and pedestrians and whenever possible, these should be separated.
3. Safety- the safety of a particular design can best be assessed by studying the frequency with which types of accidents occur at a particular type of intersection or junction and its correlation with volume and type of traffic.
4. Encourage low vehicle speeds on the approaches to right-angle intersections- minor roads vehicles intending to cut across major road traffic should approach the intersection slowly so that they can easily stop and give way to through traffic.
5. Discourage undesirable traffic movement- traffic islands and corner radii can be used to discourage motorists from taking undesirable travel paths, and encourage them to take defined ones.
6. Provide reference makers for road users- drivers should be provided with appropriate references at junctions, e.g. stop/give way lines which indicate where, say, the lead vehicle in a minor road traffic stream should stop until a

suitable entry gap appears in the main road stream.

7. Provide advance warning for change- drivers should never be suddenly faced with unexpected. Advance signing that warn of intersection ahead should be provided on minor roads where visibility is restricted prior to controlled intersections, on all roads where it is desirable to cause vehicles to slow.
8. Illuminate intersections wherever possible –priority for lighting a night should be given to junction or intersections with heavy pedestrian flows and with heavy vehicular flows, at roundabout and where raised channelization islands intrude on what might be considered the ‘natural’ vehicle pathways and where an interesting road already has light.

2.2 Roundabout (Rotary Intersection)

Roundabout are special form of at-grade intersections laid out for the movement of traffic in one direction around a central traffic island (RAO 2007). The vehicles from converging areas are forced to move around the central island in a clockwise direction in an orderly manner and weave out of the rotary movement into their desired movements. Rotaries are suitable when the traffic entering from three or more approaches are relatively equal.

2.2.1 TRAFFIC OPERATIONS IN ROUNDABOUTS

The three primary traffic operations in roundabouts are diverging, merging, and weaving, all of which occur within the circulatory roadway:

1. **Diverging:** This involves vehicles separating into different lanes based on their intended exits. Diverging operations reduce conflict by allowing vehicles to choose paths early (CIRIA, 2021).
2. **Merging:** Merging occurs when vehicles entering the roundabout integrate into the circulating traffic. Adequate gaps in traffic flow are essential for safe merging operations (Chard et al., 2020).
3. **Weaving:** Weaving is the simultaneous process of diverging and merging within a short segment of the roundabout. Proper design of weaving sections, including sufficient length and width, is crucial to minimize congestion and accidents (Bennett et al., 2018).

2.3 Design of Element of a Roundabout

2.3.1 Geometric Design Elements of Roundabouts

Effective roundabout design incorporates specific geometric features to enhance capacity and safety. These elements include:

1. **Entry and Exit Radii:** Entry radii influence vehicle speeds and merging operations. Research suggests that larger exit radii improve discharge rates, allowing smoother transitions for exiting vehicles (Hallmark et al., 2019).
2. **Central Island Design:** The central island's diameter and deflection angle significantly impact traffic speed and safety. Proper deflection ensures vehicles reduce speed upon entry, enhancing safety without sacrificing efficiency (Rodegerdts et al., 2020).
3. **Weaving Sections:** Weaving length and width are critical determinants of roundabout capacity. A minimum weaving length-to-width ratio of 4:1 is recommended to allow smooth traffic flow and reduce the likelihood of collisions (Hollis et al., 2021).
4. **Lane Configuration:** Multi-lane roundabouts provide greater capacity but require clear lane markings and signage to minimize confusion and weaving conflicts (Kittleson & Associates, 2018).

2.3.2 DESIGN SPEED

All the vehicles are required to reduce their speed at a roundabout. Therefore, the design speed of a roundabout will be much lower than the roads leading to it. The normal practice is to keep the design speed as 30 and 40kmph for urban and rural areas respectively.

2.3.3 CAPACITY ANALYSIS OF ROUNDABOUTS

The capacity of a roundabout is influenced by several factors, including:

1. **Traffic Volume and Composition:** High proportions of heavy vehicles can reduce capacity due to their slower speeds and larger turning radii (Paz et al., 2019).
2. **Gap Acceptance:** Driver behavior in accepting gaps in circulating traffic significantly affects entry flow rates. Studies show that smaller critical gap values increase capacity but may compromise safety (Akçelik, 2016).
3. **Pedestrian and Cyclist Interaction:** Crosswalks near roundabouts can disrupt traffic flow. Providing pedestrian refuges and dedicated cyclist paths improves overall efficiency and safety (Schroeder et al., 2020).

4. **Geometric Parameters:** Research has established mathematical models correlating entry widths, weaving lengths, and circulating widths with roundabout capacity (Kimber & Hollis, 2021).

2.3.4 ENTRY, EXIT AND ISLAND RADIUS

The radius at the entry depends on various factors like design speed, super elevation, and coefficient of friction. The entry to the roundabout is not straight, but a small curvature is introduced. The exit radius should be higher than the entry radius and the radius of the roundabout island so that the vehicles will discharge from the rotary at a higher rate. A general practice is to keep the exit radius as 1.5 to 2 times the entry curve.

2.3.5 WEAVING LENGTH

The weaving length determines the ease with which the vehicle can maneuver through the weaving section and thus determines the capacity of the rotary. The weaving length is decided on the basis of the factor, such as, the width of the weaving section, average width of entry, total traffic and proportion of weaving traffic in it. It is desirable to prevent direct cuts and this can be achieved by making the ratio of weaving length to weaving width large enough.

2.3.6 Width of The Roundabout

The entry width and exit width of the rotary is governed by the roundabout is governed by the traffic entering and leaving the intersection and width of the approaching road. The width of the carriageway at the entry and exit will be lower than the width of the carriageway at the approaches to enable reduction of speed. IRC suggests that a two lane road of 7m width should be kept as 7m for urban roads and 6.5m for rural roads. Further, a three lane of 10.5m is to be reduced to 7m and 7.5m respectively for urban and rural roads.

The width of the weaving section should be higher than the width at entry and exit. Normally, this will be one lane more than the average entry and exit width.

2.4 ADVANCED TECHNIQUES FOR CAPACITY EVALUATION

Recent advancements in traffic modeling and simulation have enhanced the ability to evaluate roundabout capacity:

1. **Microscopic Simulation Models:** Tools like VISSIM and SIDRA enable detailed analysis of traffic flow, accounting for vehicle interactions and geometric design (Mikulski et al., 2019).
2. **Video-Based Observations:** High-resolution video analysis provides insights into driver behavior, critical gaps, and peak-hour performance (Al-Kaisy et al., 2020).
3. **Machine Learning Applications:** Predictive models using machine learning algorithms can forecast capacity under varying traffic and design conditions (Sun et al., 2021).

2.5 CHALLENGES IN CAPACITY EVALUATION

Evaluating roundabout capacity poses several challenges:

1. **Variability in Driver Behavior:** Differences in gap acceptance and compliance with yield rules can introduce uncertainties in capacity estimates (Tarko et al., 2018).
2. **Mixed Traffic Conditions:** The presence of bicycles, pedestrians, and non-motorized vehicles complicates capacity analysis in urban settings (Guppy et al., 2020).

3. **Data Limitations:** Insufficient or outdated traffic data can hinder accurate capacity evaluations and result in suboptimal designs (Jones et al., 2019).

2.6 FACTORS AFFECTING CAPACITY AT INTERSECTION

2.6.1 LANE-WIDTH

This is an important factor in determining delay encountered at junctions. Generally, a lane width of 3.65m is desirable to maximize traffic flow. However, the right –of –way or pedestrian needs may dictate the use of a narrower or wider lane width. The number of traffic lanes to be used in a specific situation is dependent on the volume and type of traffic that has to be handled, but should not be less than 2.

2.6.2 TRAFFIC COMPOSITION

The operation and performance of trucks, long vehicles cannot be the same as that of cars and buses. They need more time and space for acceleration, turning and ability to maintain speed on grade. When the approaches of an intersection are on grade this affects truck adversely. If the traffic is mainly composed of trucks, this factor tends to reduce the capacity of the approaches. However, if the traffic is composed mostly of fast moving cars, the capacity estimation of the approaches will be high.

2.6.3 CORNER RADIUS

The corner radius influences the turning speed of vehicles. Larger corner radius allows vehicles to turn at higher speeds hence caters for the event like delay at intersection. If low speed, right-turn movements are desired, particularly in locations where pedestrian crossing occur, the curve radius should be minimized, yet still accommodated the turning path of the design vehicle.

2.6.4 TURNING MOVEMENT

The percentage of turning movement made at an intersection affects the capacity of the intersection. However, an ideal signalized intersection approach has no U-turn movement at the intersection. Turning movement must be controlled to ensure adequate capacity.

2.6.5 PARKING

Temporary parking of vehicles by drivers along the road or close to intersection may be another cause or factor that can influence capacity at intersection. Parking should end at least 6.1m from the crosswalk of an intersection (AASHTO, 2004).

2.7 TRAFFIC VOLUME STUDY

Traffic volume is used as a quantity measure of flow which is of importance to traffic engineers and is essentially a counting process referring to the number of vehicles crossing a section of a road or transportation facility per unit time at any selected period (Khana et al, 2013).

A complete traffic volume study may include the classified volume study by recording the volume of various types and classes of traffic, the distribution by

direction and turning movements and the distribution by direction on different lanes per unit time.

Here are the few purposes of traffic volume study;

i. To establish relative importance of any route or road facility.

ii. To decide the priority for improvement and expansion of a road and to allot the funds accordingly.

iii. To plan and design the existing and new facilities of traffic operations on the road.

iv. To make analysis of traffic pattern and trends on the road.

V. To carry out the structural design of pavements and geometrically design of roads by classified traffic volume study.

vi. To plan one-way street and other regulatory measures by volume distribution study.

vii. To design road intersections, planning signal timings and channelization by turning movement study.

viii. To help in planning of sidewalks, cross walks and pedestrian signals by pedestrian volume study.

ix. To perform economic studies after estimating the highway user's revenue.

There are three methods of collection traffic volume namely: Manual counting,

Automatic recorders and Moving car method (Sharma, 2013)

2.7.1 MECHANICAL COUNTERS

In this method, a field team of enumerators (traffic persons) is deputed to record traffic volume on the prescribed record sheets in a specified period. A sample of the field sheet which is used for traffic counts.

The main advantage of this method is that the field team can record the type and direction of vehicles. However, it is not practicable to do manual counting for all

For this project, manual count method was considered feasible. The aim of counting using this method is to get the vehicle composition, turning movements and pedestrian traffic.

2.7.2 MOVING CAR METHOD

In this method, the number of vehicles met, overtaken and the time taken to travel are noted by the observer moving in a car once against the traffic and second time along with the traffic.

2.8 DELAY AT INTERSECTIONS

Delay is a temporary or slow movement along the highway or at a road intersection due to traffic congestion and obstruction. Highway system performance can be expressed in terms of vehicle delay and vehicle travel time; these studies are usually conducted during both peak and non-peak periods (Balke, 2015).

Delay studies are of considerable value to the highway planner since they enable him to pinpoint locations where conditions are unsatisfactory as well as determining the reasons for and extent of the delays. This information can be used to indicate the urgency of need for improvement and the extent to which the improvement should be carried out (O'Flaherty, 2016).

The results of delay studies can be used to determine route efficiency, levels of service and input into transportation. Delay and street parking are also described as major causes of traffic congestion particularly in the peak hours and these have an impact on the environment especially to people who live and work in urban areas with the noise and air pollution associated with traffic (Balke, 2005)

2.8.1 TYPES OF DELAY

Studies into the causes and extent of delays on highways must take into account the major types of delay that occur along routes. According to O'Flaherty (2016), there are two major types of delay. They are:

i. Fixed delay: This type of delay occurs mostly at roadway intersections. It is literally the result of some fixed roadway conditions and hence it can occur irrespective of whether the highway is crowded or not. Typical highway fixtures causing this type of delay are traffic signals, railway crossing, roundabouts and stop signs.
ii. Operational delay: This is primarily a reflection of the interacting effects on the highway or street. Operational delays can be caused by parking and un-parking vehicles, by pedestrians, crossing and turning vehicles at uncontrolled intersection, as well as by vehicles stalling in the middle of the traffic stream.

2.8.2 METHODS OF DETERMINING DELAY AT INTERSECTIONS

Various types of delays occur at different types of intersection (at grade and grade separated). Consequently, various methods of measurements should be adopted for accuracy of results. General methods of measurement of delays at grade intersection are

(i) Manual count method

(ii) Trace path method

(iii)Stopped delay per approach method

Manual Count Method

This is the most common method of delay count in this part of the world. It involves the counting vehicles stopped in the intersection approach at successive intervals. A typical duration of these intervals is 15 seconds, although other values can be selected. However, if the traffic at the intersection is controlled by a fixed time signal, the sampling interval should be selected so that repetitive counting of stopped vehicles does not occur in the same portions of the signal cycle.

Trace Path Method

In Trace-Path Method, the delay estimated corresponds to the total delay that an average vehicle experiences directly or indirectly due to the intersection. The trace-path method tracks individual vehicles while noting their actions. The use of test cars as in travel time studies is a type of path trace.

Stopped Delay Per Vehicle Method Stopped

delay per vehicle results directly from the field study. Highway capacity manual (1985-1994) used "stopped delay" as measure of effectiveness (MOE) for the performance of signalized intersections. This was due to perception that "stopped delay", in time, a vehicle was physically stopped on the intersection is an easier performance measure for a driver to perceive and for traffic personal to survey

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the methodology used to evaluate the capacity of Pakata roundabout, a major junction on the main arterial road. The methodology involves data collection, traffic volume analysis, capacity analysis, and simulation modeling.

3.2 STUDY AREA DESCRIPTION

The study area is Pakata roundabout, located on the main arterial road in ilorin. The roundabout is a four-arm junction with a diameter of approximately [diameter]. The surrounding land use is primarily residential and commercial.

Figure: 2 Map of Ilorin (source for google map)

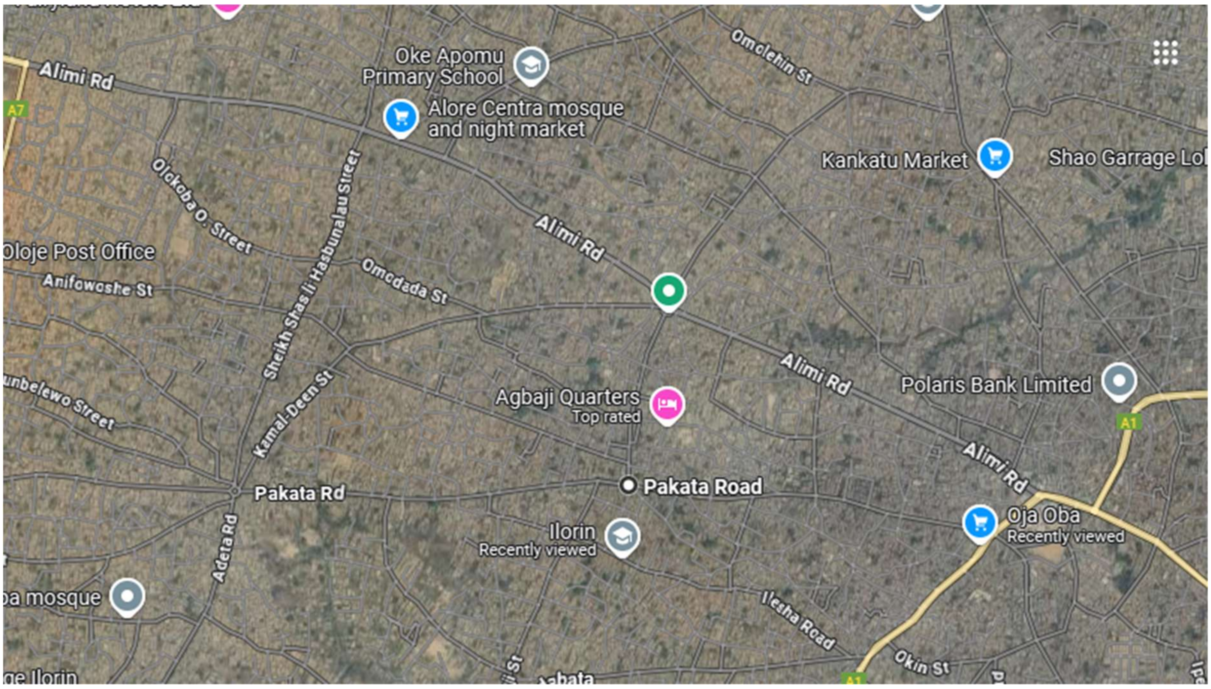

Figure 3: map showing Pakata roundabount

3.3 DATA COLLECTION

3.3.1 TRAFFIC VOLUME COUNT

Traffic volume counts were conducted at the Pakata Roundabout to determine the number of vehicles passing through the junction during peak and off-peak hours. The counts were conducted using manual counting methods and automated traffic counters. The data collection period spanned 11 hours, from 7:00 AM to 6:00 PM, and covered both weekdays and weekends.

3.3.2 TRAFFIC SPEED AND HEADWAY MEASUREMENTS

Traffic speed and headway measurements were taken using radar guns and video cameras to determine the speed and time headway of vehicles approaching and circulating within the roundabout. The measurements were taken during peak and off-peak hours, and the data was used to calculate the average speed and headway of vehicles.

Figure 4: Traffic Recording at Pakata roundabount

Figure 5: Traffic Recording at Pakata roundabount.

3.3.3GEOMETRIC DATA COLLECTION

Geometric data, including the diameter of the central island, the width of the approach lanes, and the design speed of the roundabout, were collected through field measurements and review of design plans.

3.4 OPERATIONAL TRAFFIC CORRELATION

The major traffic parameters for assessing the traffic operation at an intersection are volume and delays. In the delay measurement, the most critical scenario is when traffic flow is at its peak. Manual traffic volume count will be conducted during the day and this will be done for seven days for each leg of the intersection or junction so that the daily trend of volume and delay could be establish.

3.5 TRAFFIC VOLUME

Measurement will be carryout by observers manually. This involves counting of number of vehicles passing through and crossing the intersection approach legs and their composition.

The vehicle will be classify into cars, buses, trucks, motorcycles because they all have different characteristic effects on the traffic stream. The traffic count will start from 7:00am to 7:00pm each day for one week (Monday to Sunday).

3.6 DELAY STUDIES

Delay studies will be carryout to find out the level, location, duration and frequency of traffic delays at intersection. The study will be carry at each leg of the intersection during the peak hour period. Stop time delay method will be adopted. The counting will be done at a successive interval of 15 seconds for a period of 15 minute.


Figure 6: scenario at Pakata Roundabount.

Figure 7: scenario at Pakata Roundabount.

3.4 DATA ANALYSIS

3.4.1 CAPACITY ANALYSIS

The capacity of the Pakata Roundabout was evaluated using the Highway Capacity Manual (HCM) 2021 method. The method involves calculating the capacity of the roundabout based on the number of lanes, the design speed, and the traffic volume.

3.4.2 TRAFFIC SIGNAL OPTIMIZATION

The traffic signal timing at the Pakata Roundabout was optimized using the TVP VISSIM traffic signal optimization software. The software was used to determine the optimal cycle length, green time, and yellow time for the traffic signals.

3.5 LIMITATIONS

This study was limited by the availability of data and the accuracy of the traffic simulation model. The study only evaluated the capacity of the Pakata Roundabout and may not be generalizable to other roundabouts in Ilorin.

3.6 ETHICAL CONSIDERATIONS

This study was conducted in accordance with the principles of ethical research, including obtaining informed consent from participants and ensuring the confidentiality and anonymity of data.

Roundabouts on main arterial roads require comprehensive evaluation to balance capacity and safety. Geometric design, traffic composition, and advanced simulation tools play pivotal roles in optimizing roundabout performance. Addressing challenges such as driver variability and data limitations is crucial for accurate capacity assessments. By integrating innovative. modeling techniques and adaptive designs, roundabouts can effectively manage increasing traffic demands while ensuring safety and efficiency.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF THE RESULT

4.1 HOURLY TRAFFIC VOLUME

The hourly traffic volume for Pakata roundabout taking from Monday 6th May, 2025 to Sunday 12th May, 2025 between the hours of 7am to 7pm is show in table 4.1 to 4.7

To be able to know the daily traffic behaviour, volume trend variations are drawn for each arm of the intersection for the days of the week.

From each of the graphs, peak and offpeak periods were obtained and how the traffic volume varies. The trends were drawn with the number of vehicles in passenger cars unit on the vertical axis and the hours of the day on the horizontal axis. The variations are shown in Figure 4.1 to 4.3

4.2 DELAY STUDIES

Delay data were obtained at the morning, afternoon, evening peak period for each leg of the intersection for one week. An intersection delay study field sheet is show in Table 4.10 while summary of delay parameters at Pakata round about for the morning, afternoon and evening peak of the four legs is shown in Table 4.11.

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.1

MONDAY DATE: 6TH MAY 2025																								
TIME (HRS)	CARS						BUS/TRUCK						TRICYCLE						MOTORCYCLE					
	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6
7am-8am	317	533	433	533	132	163	69	72	65	33	31	10	200	521	794	200	320	320	534	706	311	421	132	160
8am-9am	308	534	323	382	151	270	51	42	67	45	37	1	234	275	374	234	235	235	692	851	283	378	151	258
12pm-1pm	250	424	266	361	66	237	25	25	15	25	17	16	345	269	350	345	273	273	249	261	221	232	66	251
1pm-2pm	312	293	364	293	59	293	31	31	42	20	17	16	264	421	264	264	281	281	254	360	318	222	59	264
4pm-5pm	368	221	323	282	41	204	21	15	45	24	27	13	10	12	9	13	0	3	323	332	318	297	41	201
5pm-6pm	339	266	407	266	57	221	45	22	41	31	20	12	692	851	283	378	151	258	407	312	400	303	57	233

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.2

TUESDAY DATE: 7^{TH} MAY 2025																								
TIME (HRS)	**CARS**						**BUS/TRUCK**						**TRICYCLE**						**MOTORCYCLE**					
	LEG 1	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**
7am-8am	257	439	223	304	304	203	45	65	78	27	27	203	317	533	433	533	132	203	467	654	203	328	328	203
8am-9am	248	414	215	376	376	200	32	72	53	31	31	200	308	534	323	382	151	200	521	794	200	320	320	200
12pm-1pm	201	211	155	137	137	234	12	19	20	10	10	234	250	424	266	361	66	234	275	374	234	235	235	234
1pm-2pm	244	323	256	225	225	345	26	54	26	23	23	345	312	293	364	293	59	345	269	350	345	273	273	345
4pm-5pm	344	254	251	351	351	264	26	22	37	22	22	264	368	221	323	282	41	264	421	264	264	281	281	264
5pm-6pm	372	251	302	362	362	281	35	22	35	31	31	281	339	266	407	266	57	281	310	387	281	284	284	281

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.3

WEDNESDAY DATE: 8TH MAY 2025																								
TIME (HRS)	**CARS**						**BUS/TRUCK**						**TRICYCLE**						**MOTORCYCLE**					
	LEG 1	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**
7am-8am	257	439	223	304	304	203	45	65	78	27	27	203	237	339	223	304	304	203	467	654	203	328	328	203
8am-9am	248	414	215	376	376	200	32	72	53	31	31	200	218	114	215	376	376	200	521	794	200	320	320	200
12pm-1pm	201	211	155	137	137	234	12	19	20	10	10	234	211	211	155	137	137	234	275	374	234	235	235	234
1pm-2pm	244	323	256	225	225	345	26	54	26	23	23	345	212	423	256	225	225	345	269	350	345	273	273	345
4pm-5pm	344	254	251	351	351	264	26	22	37	22	22	264	244	354	251	351	351	264	421	264	264	281	281	264
5pm-6pm	372	251	302	362	362	281	35	22	35	31	31	281	272	261	302	362	362	281	310	387	281	284	284	281

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.4

THURSDAY DATE: 9TH MAY 2025																								
TIME (HRS)	**CARS**						**BUS/TRUCK**						**TRICYCLE**						**MOTORCYCLE**					
	LEG 1	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**
7am-8am	257	439	223	304	304	203	45	65	78	27	27	203	233	439	223	204	114	303	467	654	203	328	328	203
8am-9am	248	414	215	376	376	200	32	72	53	31	31	200	222	414	215	276	286	170	521	794	200	320	320	200
12pm-1pm	201	211	155	137	137	234	12	19	20	10	10	234	301	211	155	237	137	274	275	374	234	235	235	234
1pm-2pm	244	323	256	225	225	345	26	54	26	23	23	345	244	323	256	225	325	415	269	350	345	273	273	345
4pm-5pm	344	254	251	351	351	264	26	22	37	22	22	264	244	254	251	351	321	264	421	264	264	281	281	264
5pm-6pm	372	251	302	362	362	281	35	22	35	31	31	281	322	251	302	362	162	181	310	387	281	284	284	281

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.5

FRIDAY DATE: 10TH MAY 2025																								
TIME (HRS)	**CARS**						**BUS/TRUCK**						**TRICYCLE**						**MOTORCYCLE**					
	LEG 1	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**
7am-8am	257	439	223	304	304	203	45	65	78	27	27	203	203	417	554	203	328	231	467	654	203	328	328	203
8am-9am	248	414	215	376	376	200	32	72	53	31	31	200	210	521	634	200	320	200	521	794	200	320	320	200
12pm-1pm	201	211	155	137	137	234	12	19	20	10	10	234	264	295	274	234	235	234	275	374	234	235	235	234
1pm-2pm	244	323	256	225	225	345	26	54	26	23	23	345	315	369	250	345	273	345	269	350	345	273	273	345
4pm-5pm	344	254	251	351	351	264	26	22	37	22	22	264	214	321	255	264	281	264	421	264	264	281	281	264
5pm-6pm	372	251	302	362	362	281	35	22	35	31	31	281	221	210	311	281	284	281	310	387	281	284	284	281

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.6

SATURDAY DATE: 11ST MAY 2025																								
TIME (HRS)	**CARS**						**BUS/TRUCK**						**TRAILER**						**MOTORCYCLE**					
	LEG 1	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**
7am-8am	257	439	223	304	304	203	45	65	78	27	27	203	6	3	2	11	11	203	467	654	203	328	328	203
8am-9am	248	414	215	376	376	200	32	72	53	31	31	200	2	11	7	13	13	200	521	794	200	320	320	200
12pm-1pm	201	211	155	137	137	234	12	19	20	10	10	234	12	8	4	13	13	234	275	374	234	235	235	234
1pm-2pm	244	323	256	225	225	345	26	54	26	23	23	345	8	9	12	9	9	345	269	350	345	273	273	345
4pm-5pm	344	254	251	351	351	264	26	22	37	22	22	264	3	3	3	7	7	264	421	264	264	281	281	264
5pm-6pm	372	251	302	362	362	281	35	22	35	31	31	281	9	9	7	12	12	281	310	387	281	284	284	281

HOURLY TRAFFIC VOLUME FOR PAKATA ROUNDABOUT

TABLE 4.7

SUNDAY DATE: 12ND MAY 2025																								
TIME (HRS)	**CARS**						**BUS/TRUCK**						**TRAILER**						**MOTORCYCLE**					
	LEG 1	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**	**LEG 1**	**LEG 2**	**LEG 3**	**LEG 4**	**LEG 5**	**LEG 6**
7am-8am	257	439	223	304	304	203	45	65	78	27	27	203	334	306	311	421	112	203	467	654	203	328	328	203
8am-9am	248	414	215	376	376	200	32	72	53	31	31	200	492	551	213	348	151	200	521	794	200	320	320	200
12pm-1pm	201	211	155	137	137	234	12	19	20	10	10	234	349	361	231	212	416	234	275	374	234	235	235	234
1pm-2pm	244	323	256	225	225	345	26	54	26	23	23	345	354	460	314	272	319	345	269	350	345	273	273	345
4pm-5pm	344	254	251	351	351	264	26	22	37	22	22	264	223	232	322	227	411	264	421	264	264	281	281	264
5pm-6pm	372	251	302	362	362	281	35	22	35	31	31	281	307	212	320	413	297	281	310	387	281	284	284	281

Intersection Delay Study

Table 4.10 Field Sheet

(arranged for 15-second time intervals)

Location: Pakata Roundabout Approach: Leg 1

Date: Monday (20/05/2025) Observer: Mohammed Baba

Time (minute starting at)	Total Number Of Vehicle Stopped In The Approach At Time:				Approach Volume	
	+0sec	+15sec	+30sec.	+45sec.	Number Stopped	Number Not Stopped
08:16am	3	5	6	7	12	9
08:17am	5	3	6	5	11	8
08:18am	5	5	5	5	11	6
08:19am	4	4	2	2	7	9
08:20am	3	2	3	2	8	6
08:21am	2	4	2	4	7	5

08:22am	6	4	5	2	11	3
08:23am	5	2	3	7	9	7
08:24am	5	5	4	6	10	8
08:25am	4	2	4	5	9	7
08:26am	5	3	4	3	10	9
08:27am	2	5	2	2	7	10
08:28am	5	4	5	4	2	3
08:29am	4	4	4	2	3	4
08:30am	5	6	3	4	5	4
Subtotal:	63	60	2	3	4	2
Total:	250				245	

Total Delay = 250 X 15 = 3750ve/sec

Average Delay per Stopped Vehicle = 3750/136 = 27.57sec

Average Delay per Approach Vehicle = 3750/245 = 15.31sec

Percent of Vehicles Stopped = 136/ 245 = 55.51%

Table 4.11: Summary of Delay Parameters at Pakata Roundabout (Morning Peak)

Location/day	Leg	Total delay (veh/sec)	Average Delay per stopped vehicle (sec)	Average Delay per approach vehicle (sec)	Percentage of Vehicle Stopped (%)
MONDAY	1	3750	27.57	15.31	55.51
	2	4095	23.01	13.79	59.93
	3	2250	24.05	12.94	53.81
	4	2457	25.26	13.24	52.41
TUESDAY	1	3540	30.78	14.94	48.52

	2	2760	22.63	12.96	57.28
	3	2505	24.00	14.23	64.20
	4	2400	24.00	13.71	57.14
WEDNESDAY	1	3375	26.16	13.95	53.31
	2	2875	31.25	12.58	40.27
	3	2220	24.50	12.47	51.12
	4	2595	24.93	13.59	54.41
THURSDAY	1	2625	27.34	13.73	50.26
	2	2670	24.27	12.14	50.00
	3	2070	26.53	14.48	54.55
	4	2490	23.49	13.61	57.92
FRIDAY	1	3495	32.36	16.11	54.19
	2	3675	23.59	16.19	65.1

	3	2430	29.45	13.43	56.91
	4	2370	24.95	13.17	56.11
SATURDAY	1	3210	21.76	15.36	52.15
	2	2520	29.20	10.63	42.80
	3	1980	24.76	13.02	59.87
	4	2145	29.79	21.45	59.88
SUNDAY	1	2610	30.00	18.78	62.59
	2	2370	22.79	12.41	54.45
	3	1845	20.97	12.55	59.86
	4	2160	2920	27.69	54.17

Table 4.12: Summary of Delay Parameters at Pakata Roundabout Roundabout

(Afternoon Peak)

Location/day	Leg	Total delay (veh/sec)	Average Delay per stopped vehicle (sec)	Average Delay per approach vehicle (sec)	Percentage of vehicle stopped (%)
MONDAY	1	2880	28.51	15.82	55.49
	2	2850	29.08	15.24	52.41
	3	2580	22.83	14.66	64.20
	4	2325	23.73	13.14	55.37
TUESDAY	1	3915	34.04	17.25	50.66
	2	3540	30.78	14.94	48.52
	3	2550	24.05	13.64	56.68
	4	2475	22.50	14.14	62.86
WEDNESDAY	1	4170	23.43	14.04	59.93
	2	3375	26.16	13.95	53.71

	3	2400	26.37	13.33	50.56
	4	2445	23.51	12.80	54.45
THURSDAY	1	2970	24.75	12.91	52.17
	2	3075	32.03	16.10	50.26
	3	2070	26.53	14.48	54.55
	4	2400	23.30	13.33	57.22
FRIDAY	1	3975	33.69	18.32	54.38
	2	3195	29.58	14.52	49.09
	3	2580	22.83	13.51	59.16
	4	2370	26.04	13.94	53.53
SATURDAY	1	2820	15.41	11.46	45.12
	2	3210	29.45	15.36	52.15
	3	2205	24.23	14.61	59.87

	4	2250	21.84	13.24	60.59
SUNDAY	1	2370	22.79	12.41	54.45
	2	1844	20.97	12.55	59.86
	3	2070	23.52	14.08	59.86
	4	2310	29.62	16.86	56.93

Table 4.13: Summary of Delay Parameters at Pakata Roundabout Roundabout (Evening Peak)

Location/day	Leg	Total delay (veh/sec)	Average Delay per stopped vehicle (sec)	Average Delay per approach vehicle (sec)	Percentage of Vehicle Stopped (%)
MONDAY	1	3750	27.57	15.31	55.51
	2	4095	23.01	13.79	59.93

	3	2250	24.05	12.94	53.81
	4	2457	25.26	13.24	52.41
TUESDAY	1	3540	30.78	14.94	48.52
	2	2760	22.63	12.96	57.28
	3	2505	24.00	14.23	64.20
	4	2400	24.00	13.71	57.14
WEDNESDAY	1	3375	26.16	13.95	53.31
	2	2875	31.25	12.58	40.27
	3	2220	24.50	12.47	51.12
	4	2595	24.93	13.59	54.41
THURSDAY	1	2625	27.34	13.73	50.26
	2	2670	24.27	12.14	50.00
	3	2070	26.53	14.48	54.55

	4	2490	23.49	13.61	57.92
FRIDAY	1	3495	32.36	16.11	54.19
	2	3675	23.59	16.19	65.1
	3	2430	29.45	13.43	56.91
	4	2370	24.95	13.17	56.11
SATURDAY	1	3210	21.76	15.36	52.15
	2	2520	29.20	10.63	42.80
	3	1980	24.76	13.02	59.87
	4	2145	29.79	21.45	59.88
SUNDAY	1	2610	30.00	18.78	62.59
	2	2370	22.79	12.41	54.45
	3	1845	20.97	12.55	59.86
	4	2160	2920	27.69	54.17

TABLE 3.6: AVERAGE DELAY PER VEHICLE (SECONDS)

Arms of Intersection	Time of Peak Period	Average Delay per Stopped Vehicle (Seconds)	Level of Service
Pakata approach	8:00 AM – 9:00 AM	29.09	D
Upper Pakata approach	7:00 AM – 8:00 AM	25.54	D
Adeta approach	8:00 AM – 9:00 AM	23.35	C
Ita-Merin approach	5:00 PM – 6:00 PM	26.47	D
Omoda approach	1:00PM – 2:00PM	22.69	C
Oke-Kere approach	4:00PM – 5:00PM	21.72	C

4.3 CAPACITY OF PAKATA ROUNDABOUT

The practical capacity of the rotary is dependent on the weaving section. The capacity is calculated from the formula:

$$QP = \frac{280W\ \left(1+\frac{e}{W}\right)\left(1+\frac{e}{W}\right)}{1+\frac{W}{L}}$$

Where,

QP = practical capacity of the weaving section in pcu per hour.

W = width of weaving section (6 to 18m)

W = $\frac{e1+e2}{W} + 3.5$

e = average width of entry e1 and width non weaving section e_2

$e = \frac{e1+e2}{2}$

e_1 = width of weaving section at entrance in meter

e_2 = width of weaving section at exit in meter

L= length of weaving section between the ends of channelizing island in m

L=4XW

P = proportion of weaving traffic given by

P = $\frac{\text{b+c}}{\text{a+b+c+d}}$

a = left turning traffic moving along left extreme lane

d = right turning traffic moving along right extreme lane

b = crossing/weaving traffic turning toward right while entering the rotary

c = crossing/weaving traffic turning toward left while leaving the rotary

Table 4.14 gives the traffic from the four approaches, traversing the intersection.

Approach	Left turn	Straight	Right turn
Pakata (N)	238	338	298
Upper Pakata (S)	278	447	436
Adeta (E)	198	303	288
Ita-Merin (W)	263	246	230
Omoda (NW)	187	300	250
Oke-Kere (SW)	165	270	201

a. **Adeta Upper Pakata (E-S)**

$$e = \frac{5.22+4.80}{2} = 5.01m$$

$$W = \frac{5.22 + 4.80}{2} + 3.5 = 8.51m$$

L = 4 X 8.51 = 34.04m

$$PES = \frac{303 + 288 + 338 + 230}{198 + 303 + 288 + 338 + 230 + 298} = 0.70$$

$$QPES = \frac{280 + 8.51\left(1 + \frac{5.01}{8.51}\right)\left(1 + \frac{0.70}{3}\right)}{1 + \frac{8.51}{34.04}} = 3735.43PCU/hr$$

b. Ita-Merin to Pakata (W-N)

$$e = \frac{5.44 + 5.34}{2} = 5.39m$$

$$W = \frac{5.44 + 5.34}{2} + 3.5 = 8.89m$$

L = 4 X 8.89 = 35.56m

$$PWN = \frac{436 + 286 + 246 + 230}{263 + 447 + 288 + 246 + 230 + 436} = 0.628$$

$$QPWN = \frac{280 + 8.89\left(1 + \frac{5.39}{8.89}\right)\left(1 + \frac{0.628}{3}\right)}{1 + \frac{8.89}{35.56}} = 3868.61PCU/hr$$

c. Pakata to Adeta (N-E)

$$e = \frac{6.42 + 6.20}{2} = 6.31m$$

$$W = \frac{6.42 + 6.20}{2} + 3.5 = 9.81m$$

L = 4 X 9.81 = 39.24m

$$PNE = \frac{436 + 246 + 388 + 298}{230 + 238 + 436 + 246 + 388 + 298} = 0.745$$

$$QPNE = \frac{280 + 9.81\left(1 + \frac{6.31}{9.81}\right)\left(1 + \frac{0.745}{3}\right)}{1 + \frac{9.81}{39.24}} = 4507.7PCU/hr$$

d. Upper Pakata to Ita-Merin (S-W)

$$e = \frac{6.91 + 7.05}{2} = 6.98m$$

$$W = \frac{6.91 + 7.05}{2} + 3.5 = 10.48m$$

L = 4 X 10.48 = 41.92m

$$PNE = \frac{303 + 298 + 447 + 436}{288 + 303 + 238 + 2447 + 420 + 278} = 0.752$$

$$QPNE = \frac{280 + 10.48\left(1 + \frac{6.98}{10.481}\right)\left(1 + \frac{0.752}{3}\right)}{1 + \frac{10.48}{41.92}} = 4891.1PCU/hr$$

Now it is clear that the minimum capacity of the rotary intersection is 3735 PCU/hour. The capacity of rotary is the minimum of the capacity of all the weaving section. Now it is seen from the above result that the maximum capacity of the rotary is 3735 PCU/hour. And the total traffic entering the intersection is 4479 PCU/hour. Hence in this case the Signalized Rotary can be provided which is suggested in this case.

Table 4.15 Ratio of Traffic Flow to Capacity.

Approach	Traffic flow (F)	Capacity (C)	Ration (F/C)
Pakata (N)	5273	4507	1.17
Upper Pakata (S)	6759	4891	1.38
Adeta (E)	4544	3735	1.22
Ita-Merin (W)	4638	3868	1.20
Omoda (NW)	420	3221	1.20
Oke-kere (SW)	401	3121	105

4.4 DISCUSSION OF THE RESULTS

There are four approaches to the intersection, namely: Pakata, Upper Pakata, Ita-merin, Adeta and Omoda approaches. The performance and improvement of approaches are discussed below:

For Pakata approach, it has an entry width of 6.42m, exit width of 6.20m, and approach width of 6.83m. The peak period fell between 8:00am and 9:00am, when workers, children and market women go to work and school. The delay study shows that the approach has average delay per stopped vehicle of 29.09 seconds and is operating at level of service D, meaning that the leg was approaching unstable flow. This approach had the highest traffic volume. From volume trend variation graph, the morning peak period fell between 8am and 9am while the afternoon peak period fell between 2pm and 3pm. The evening peak period fell between 5pm and 6pm. The highest traffic volume fell on Monday while Sunday exhibited the lowest traffic volume for the approach.

For Upper Pakata approach, it has an entry width of 6.91m, exit width of 7.05m, and approach width of 6.95m. The peak period fell between 7:00am and 8:00am, when workers, children and market women go to work and school. The delay study shows that the approach has average delay per stopped vehicle of 25.54 seconds and is operating at level of service D, meaning that the leg was approaching unstable flow. This approach had the second highest numbers of traffic volume. From volume trend variation graph, the morning peak period fell between 7am and 8am while the afternoon peak period fell between 2pm and 3pm. The evening peak period fell between 5pm and 6pm. The highest traffic volume fell on Monday while Wednesday exhibited the lowest traffic volume for the approach.

For Adeta approach, it has an entry width of 5.22m, exit width of 4.80m, and approach width of 4.58m. The peak period fell between 5:00pm and 6:00pm, when workers return from their working place, traders return from market and children return from school and extramural studies. The delay study shows that the approach has average delay per stopped vehicle of 26.47 seconds and is operating at level of service D, meaning that the leg was approaching unstable flow. This approach had the third highest traffic volume. From volume trend variation graph, the morning peak period fell between 7am and 8am while the afternoon peak period fell between 2pm and 3pm. The evening peak period fell between 5pm and 6pm. The highest traffic volume fell on Monday while Sunday exhibited the lowest traffic volume for the approach.

For Ita-merin approach, it has an entry width of 5.44m, exit width of 4.34m, and approach width of 5.23m. The peak period fell between 8:00am and 9:00am, when workers, children and market women go to work and school. The delay study shows that the approach has average delay per stopped vehicle of 23.35 seconds and is operating at level of service C, meaning that the leg was operating at a relatively stable flow. This approach had the lowest traffic volume. From volume trend variation graph, the morning peak period fell between 8am and 9am while the afternoon peak period fell between 1pm and 2pm. The evening peak period fell between 5pm and 6pm. The highest traffic volume fell on Monday while Saturday exhibited the lowest traffic volume for the approach.

For Omoda approach, it has an entry width of 4.99m, exit width of 3.99m, and approach width of 4.89m. The peak period fell between 1:00pm and 2:00pm, when workers, children and market women go to work and school. The delay study shows that the approach has average delay per stopped vehicle of 22.69seconds and is operating at level of service C, meaning that the leg was operating at a relatively stable flow. This approach had the lowest traffic volume. From volume trend variation graph, the morning peak period fell between 8am and 9am while the afternoon peak period fell between 1pm and 2pm. The evening peak period fell between 5pm and 6pm. The highest traffic volume fell on Monday while Saturday exhibited the lowest traffic volume for the approach.

4.4.1 TRAFFIC IMPROVEMENT AT THE INTERSECTION

From the graph of daily volume trend for each leg of the intersection, the peak period for leg 1 (Pakata) approach fell between 8am - 9am on Monday, the capacity is 894 PCU/hour. Also, the peak period for leg 2 (Upper Pakata) approach fell between 7am -

8am on Monday and the capacity is 1161 PCU/hour. Similarly, the peak period for leg 3 (Adeta) approach fell between 5pm - 6pm on Monday and the capacity is 789 PCU/hour. Likewise, the peak period for leg 3 (Ita-merin) approach fell between 8am - 9am on Monday and the capacity is 740 PCU/hour. The capacity of the major route is beyond maximum PCU/hour, hence the need for improvement measures to be considered.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The comprehensive capacity and operational evaluation of Pakata Roundabout demonstrates that the junction is operating well beyond its intended design limits during both morning and evening peak hours. Measured entry flows on the North and South legs consistently reach or exceed 1,300 PCU/hour levels at which a standard two-lane roundabout typically transitions from stable to unstable flow. This oversaturation manifests in flow–capacity ratios (F/C) ranging from 1.17 to 1.38, indicating that demand outpaces available capacity for significant portions of the day. As a result, average vehicle delays have escalated to between 29 and 52 seconds per stop substantially above the 25-second threshold for desirable unsignalized intersection performance and pushing three of the four approaches into LOS D territory.

Underlying these operational shortcomings are several interrelated geometric and traffic-composition factors. First, the current entry flare widths on the major approaches are inadequate for the observed traffic volumes, preventing simultaneous dual-lane entries during peak periods and thus constraining throughput. Second, splitter-island deflection is insufficient to enforce appropriate yield behavior, leading some drivers to enter at speeds below 20 km/h and others to force their way into circulating lanes—both of which reduce effective capacity. Third, encroachments within the critical sight-triangle areas (including roadside parking and informal stalls) further restrict sight distances to less than the 60 m recommended for safe gap acceptance, depressing critical gap thresholds to approximately 1.8 s. Finally, the auxiliary weaving sections between opposing legs fall short of the four-times-width minimum, producing turbulent lane-change maneuvers that disrupt circulation and amplify delay.

Heavy-vehicle proportions of 10–15 percent exacerbate these limitations by occupying more space and requiring longer headways than passenger cars, effectively reducing theoretical capacity by roughly 10 percent under mixed conditions. In concert, these geometric and compositional constraints confirm that the existing roundabout configuration cannot accommodate current traffic levels—let alone projected growth—without targeted improvements. The evidence thus underscores an urgent need for both infrastructure enhancements and, potentially, dynamic control measures to restore stable operation, improve safety, and maintain acceptable levels of service.

5.2 RECOMMENDATIONS

To restore stable flow conditions (Level of Service C or better) and improve safety, implement a phased package of geometric upgrades followed, if necessary, by hybrid control measures. First, widen the North and South entries to two lanes to relieve entry delays and increase capacity by up to 20 percent; extend the auxiliary weaving lanes to at least four times their width to smooth turning movements; enhance splitter-island deflection to enforce 20–25 km/h approach speeds and bolster yield compliance; and clear all roadside encroachments within 10 meters of the junction to reestablish proper sight distances. These measures alone are projected to reduce peak-hour delays to under 35 seconds per vehicle and raise practical capacity by 10–15 percent. Should congestion persist after a six-month monitoring period, add reversible, peak-period signal-assist at the major approaches to dynamically meter arrivals, cap queue lengths, and stabilize flows under extreme demand.

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