

Analysis of Traffic Flow Patterns and Movement Distributions at Selected Urban Roundabouts in Ilorin Metropolis, Nigeria

(A Case Study of Oja-Oba, Pakata, Adeta and Mandate Roundabout)

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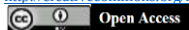
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ABSTRACT

Understanding traffic flow patterns and movement distributions at urban roundabouts is essential for effective traffic management and intersection planning. This study examined the traffic flow patterns and movement characteristics of four selected roundabouts: Oja-Oba, Pakata, Adeta and Mandate in Ilorin Metropolis, Nigeria. The study aimed to identify variations in traffic demand across the approaches and determine the distribution of vehicles according to their directions of movement. Data were collected through field surveys and video recordings of vehicular traffic during peak periods. Existing geometric characteristics, including entry width, radius, circumference and inscribed diameter, were also documented to describe the physical characteristics of the selected roundabouts. Traffic flow patterns were analysed across the approaches, while traffic movements were classified into left-turn, through traffic, right-turn and circulating movements. The results provided a comparative understanding of traffic distribution and directional movement at the four roundabouts, highlighting differences in traffic demand among approaches and the movement characteristics of each intersection. The study establishes a basis for understanding traffic distribution at urban roundabouts and provides relevant information for traffic management, intersection planning and future transportation studies in Ilorin Metropolis. The findings may also support evidence-based decisions concerning the management of traffic at roundabouts in other rapidly urbanising cities with similar traffic conditions.

Introduction

Roundabout is a type of circular intersection designed to improve traffic flow and enhance safety by requiring vehicles to yield upon entry and circulate counter clockwise around a central island (Radu et al. 2024). This design reduces conflict points, particularly those associated with head-on and high-speed collisions, and encourages a smoother and more predictable traffic movement. (Radu et al. 2024).

Roundabouts are critical traffic control measures designed to enhance vehicular movement and minimize conflicts at intersections. Their efficiency is highly dependent on various geometric features, such as entry width, exit width, inscribed circle diameter, lane width, and approach angles. Studies have shown that geometric design significantly impacts roundabout capacity, queue length, and safety (Brilon et al 2025).

The first use of the word 'roundabout' appeared in the UK Ministry of Transport and Planning Institute Circular No.302 in 1929 as cited by (Neda k 2013). Roundabouts are common form of traffic intersection control in many urban areas. They are known to bring about certain desirable operations and safety returns. Roundabouts have distinctive operational and safety features that make them the choice for traffic control. When multiple roadways meet and form a junction, especially when volumes are moderate and distribution of traffic among the approach roads is about even, roundabouts can function efficiently and safely (Vinayraj, V., & Perulmal, V. 2023). When demand is high and / or not evenly distributed among entry approaches, excessive delay and aggressive driving behaviour may emerge thus compromising both operation characteristic of roundabouts (Zhang et al, 2022).

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 (Hoang, V. et al 2025).

Evaluation of junction capacity is very important since it is directly related to delay, level of service, accident, operational cost and environmental issues. For more than three decades modern roundabouts have been used successfully through the world as an intersection control device (Dere, I., et al 2025).

Capacity represents the service rate (queue clearance rate) in the performance (delay, queue length, stop rate) functions, and therefore is relevant to both under saturated and over saturated conditions, (Feng, Z., 2005). Level of service is a qualitative measure used to relate the quality of traffic service. Level of service is used to analyse highways by categorizing traffic flow and assigning quality levels of traffic based on performance measure like speed, density. (Kuhne, R., 2021).

Roundabouts are special form of at-grade intersections laid out for the movement of traffic in one direction around a central traffic island (Prassas, E. S., & Poess, P. R., 2020).

Traffic simulation models are divided into different classes depending on the level of detail describing the traffic (Olstam, j.j., 2019). Generally, the three classes are Macroscopic, Mesoscopic and Microscopic. The macroscopic models use a low level of detail, both when describing the traffic stream and the interactions between road users and their surroundings. Aggregated variables are used to describe flow, speed and density instead of modelling individual vehicles (Algherbal, E., & Ratrout, N.T., 2025). The microscopic models use a high level of detail in the description of the traffic stream, and every vehicle is modelled individually as well as the interactions between road users and their surroundings (Heymann, M., & Degani, A., 2019). The movements and interactions of the road users are modelled with the help of sub-models for lane-changing, acceleration and gap acceptance, the mesoscopic models are somewhere in between the macroscopic and microscopic models where the traffic streams are modelled with a high level of detail as individual vehicles or packets of vehicles, the vehicles' interactions are modelled with lower detail than in the microscopic models and are more like the macroscopic models where aggregated values are used (Karafyllis, I., 2022).

Brugmann, J., (2013) indicated in their report the potential of using microscopic simulation for traffic safety assessment, in order to perform safety analyses in microscopic simulation models, accurate representations of the interaction behaviour between different road users as well as their interactions with the environment are required, also, the variation in road user behaviour and vehicle performance are highly important. There are some classes of sub-models, used in microscopic simulation, describing driving behaviours and some of them are related to safety performance (Reid, J.M., 2019).

Ptv VISSIM uses two basic principles, priority rules and conflict areas, when dealing with the movement conflict between modes of transport at non-signalized intersections (e.g., roundabouts and T-intersections) (Bai, Y., 2021). Generally, it is recommended that conflict areas are used for modelling such intersections, however, if the model does not return expected results in the interaction between modes of transport, priority rules can be used (Anderson, J.C., 2025).

2. Method

2.1 Data Collection

2.1.1 Geometric Characteristics of the Selected

Geometric characteristics of Oja-Oba, Pakata, Adeta and Mandate Roundabouts were obtained through field measurements and verified using Google Earth Pro. Parameters measured included entry and exit widths, approach width, central and inscribed circle diameters, entry radius, circulatory roadway width and weaving length. The data were used to assess geometric adequacy and its influence on roundabout capacity and operational performance.

2.2 Operational Performance of the Selected Roundabouts

2.2.1 Peak-Hour Traffic Volume

Traffic data were collected through video recordings over seven consecutive days at the four selected roundabouts. Drones were used at Oja-Oba, Pakata and Adeta, while a high-resolution video

camera was used at Mandate because of airport-related restrictions on drone operations. The recordings covered morning, afternoon and evening periods and were analysed to determine traffic volume, vehicle classification, directional movements and peak-hour demand. The same data extraction and analysis procedures were applied at all locations to ensure consistency.

2.2.2 Traffic Pattern

Traffic pattern describes how traffic behaves and distributes itself around a roundabout. It includes: Traffic volume and distribution across approaches, Peak-hour and off-peak traffic variations, Dominant vehicle types and turning movements, Directional distribution of traffic entering and leaving the roundabout, Relationship with operational performance: Traffic patterns help identify approaches experiencing high traffic demand, congestion and potential capacity problems.

2.2.3 Traffic Movement

Traffic movement describes the direction and manner in which vehicles travel through the roundabout. It includes: Left-turn (LT) movements, Through (TT) movements, Right-turn (RT) movements, Circulating movements (CM).

3. Result and Discussion

3.1 Geometry Analysis of the Selected Roundabout

The table 1 presents the existing geometric characteristics of Oja-Oba, Pakata, Adeta and Mandate roundabouts. The entry widths range from 2.0 m to 3.2 m, indicating relatively narrow entry sections that may restrict traffic flow under high-demand conditions. Adeta has the largest inscribed diameter (51.40 m), while Mandate has the smallest reported diameter (13.39 m). These geometric differences may influence vehicle circulation and operational performance, particularly capacity, delay and degree of saturation.

Table 1 Existing Geometry Characteristic of the Roundabout

Roundabout	Entry width M	Radius (M)	Circumference	Inscribed Diameter
Oja-Oba	2.-2.3	7.83	49.52	15.66
Pakata	2.0-2.4	7.14	42.50	14.28
Adeta	2.0-3.2	25.70	161.45	51.40
Mandate	2.0-3.2	6.75	42.41	13.50

Table 1 presents the existing geometric characteristics of the four selected roundabouts in Ilorin Metropolis. The entry widths range from 2.0 m to 3.2 m. Adeta has the largest inscribed diameter (51.40 m) and radius (25.70 m), while Mandate has the smallest inscribed diameter (13.50 m). Oja-Oba and Pakata have inscribed diameters of 15.66 m and 14.28 m, respectively. These measurements describe the physical characteristics of the roundabouts and provide background for examining traffic flow patterns and movement distributions at the selected sites.

3.2 Traffic volume Analysis of the Selected Roundabout

3.2.1 Traffic Pattern Result Analysis on Oja Oba, Pakata, Adeta, and Mandate Roundabout

Figures 1-4 illustrate the traffic flow patterns at Oja-Oba, Pakata, Adeta and Mandate roundabouts, respectively. The figures present the distribution of traffic flow across the approaches, highlighting variations in traffic demand and the dominant flow patterns at each roundabout. These patterns provide insight into the distribution of traffic demand and support the assessment of operational performance in terms of capacity, degree of saturation, delay and level of service.

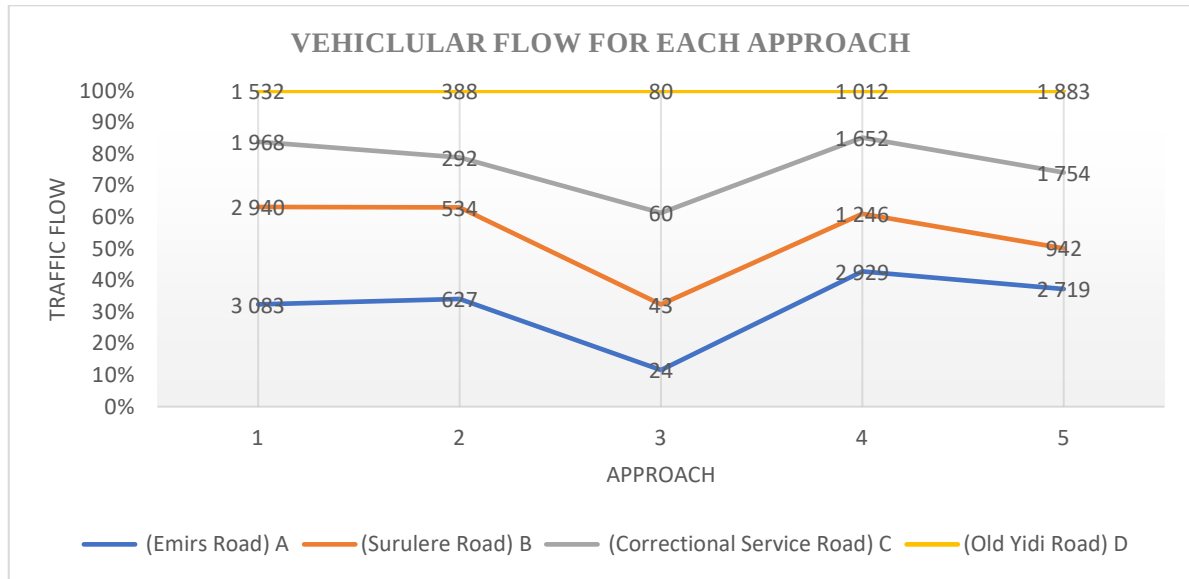


Figure 1: Vehicular flow pattern for Oja Oba Roundabout

The figure 1 explain the distribution of traffic movements at Oja-Oba Roundabout, which connects Emirs Road (Approach A), Surulere Road (Approach B), Correctional Service Road (Approach C) and Old Yidi Road (Approach D).

The traffic pattern indicates variation in traffic flow across the approaches, suggesting that traffic demand is not evenly distributed around the roundabout. This variation may be associated with differences in land use, travel demand and the importance of the connecting roads. Approaches experiencing higher traffic demand are more likely to experience congestion, increased delays and higher degrees of saturation, particularly where entry widths are inadequate.

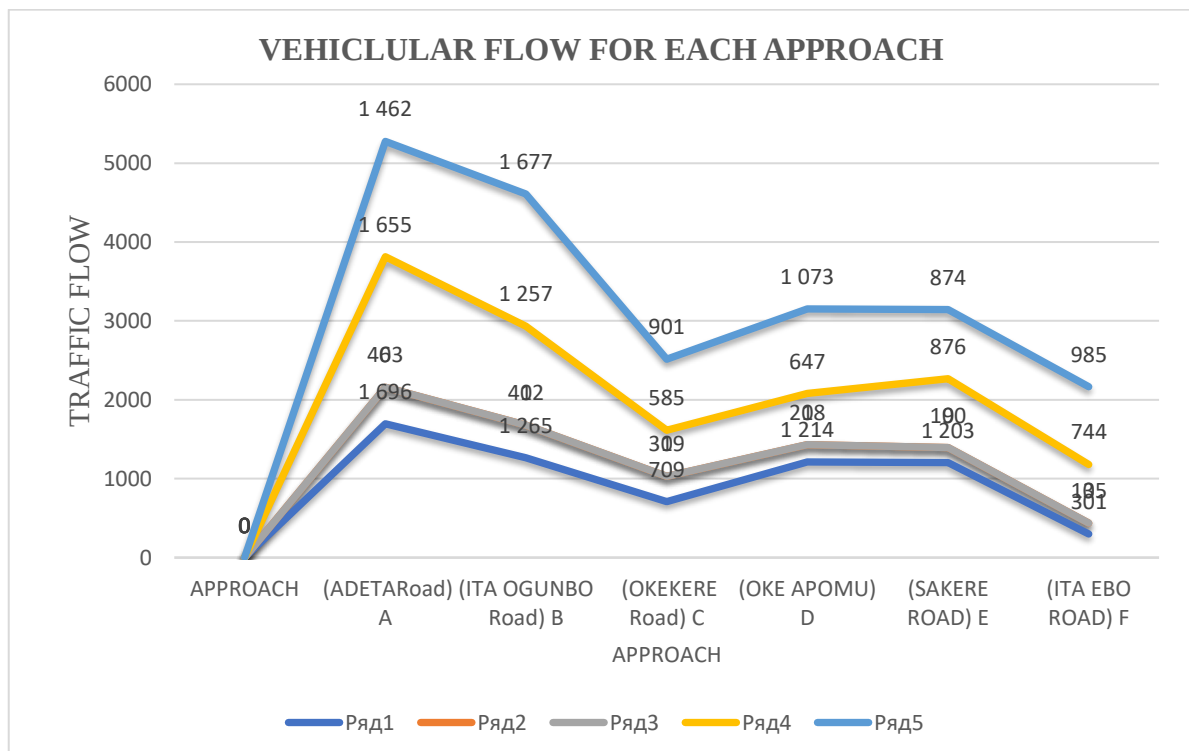


Figure 2: Vehicular flow pattern for Pakata Roundabout

The figure 2 presents the vehicular flow distribution across six approaches: Adeta Road (A), Ita Ogumbo Road (B), Okekere Road (C), Oke Apomu Road (D), Sakere Road (E) and Ita Ebo Road (F).

The plotted values indicate differences in traffic demand among the approaches. The vehicle counts also suggest that the composition of traffic varies from one approach to another. Such variations are important because the operational performance of a roundabout depends not only on the total traffic volume but also on the distribution of traffic movements and the types of vehicles using each approach.

Approaches carrying relatively high traffic volumes may experience greater pressure on their entry capacity, potentially resulting in queuing and delays during peak periods.

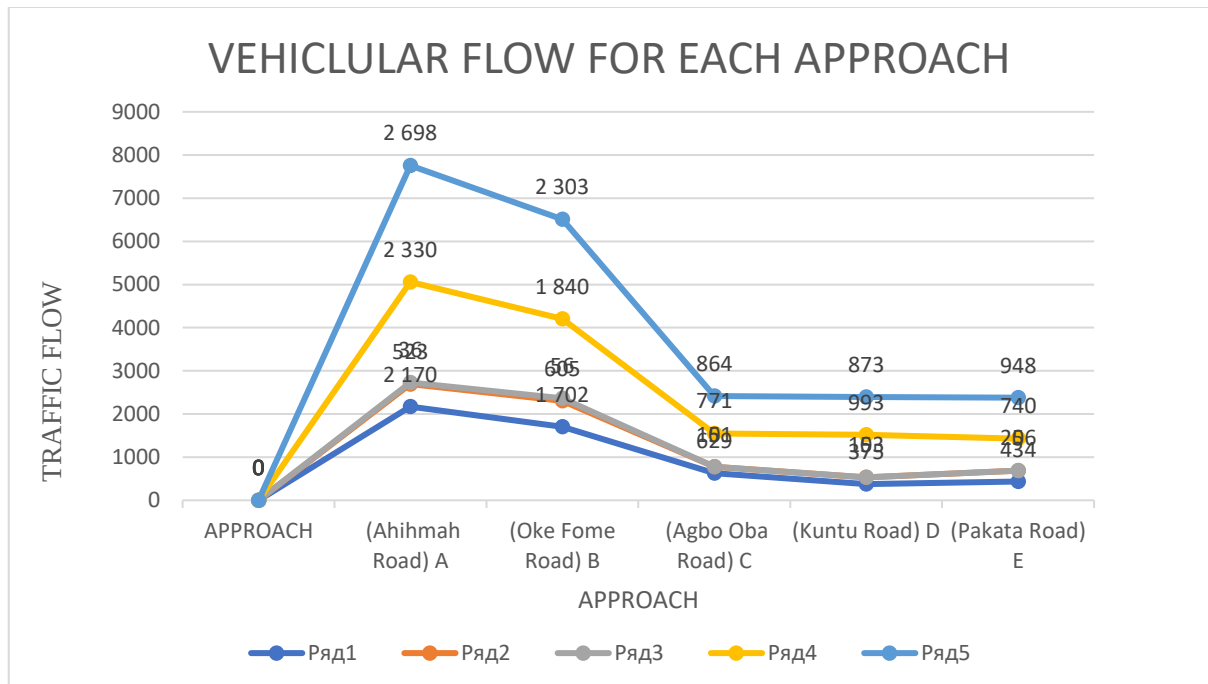


Figure 3: Vehicular flow pattern for Adeta Roundabout

The figure 3 illustrates traffic distribution across five approaches: Al-Hikmah University Road (A), Oke Foma Road (B), Agbo Oba Road (C), Kuntu Road (D) and Pakata Road (E).

The plotted values show that traffic demand varies considerably between the approaches. Al-Hikmah University Road and Oke Foma Road have substantially higher displayed traffic values than the other approaches, indicating that these two approaches carry a comparatively large share of the traffic represented in the figure.

This uneven distribution may place greater operational pressure on the busier approaches, especially during peak periods. Where traffic demand exceeds the available entry capacity, congestion, increased delay and poor levels of service may occur.

Graphical illustration of the traffic flow at mandate roundabout

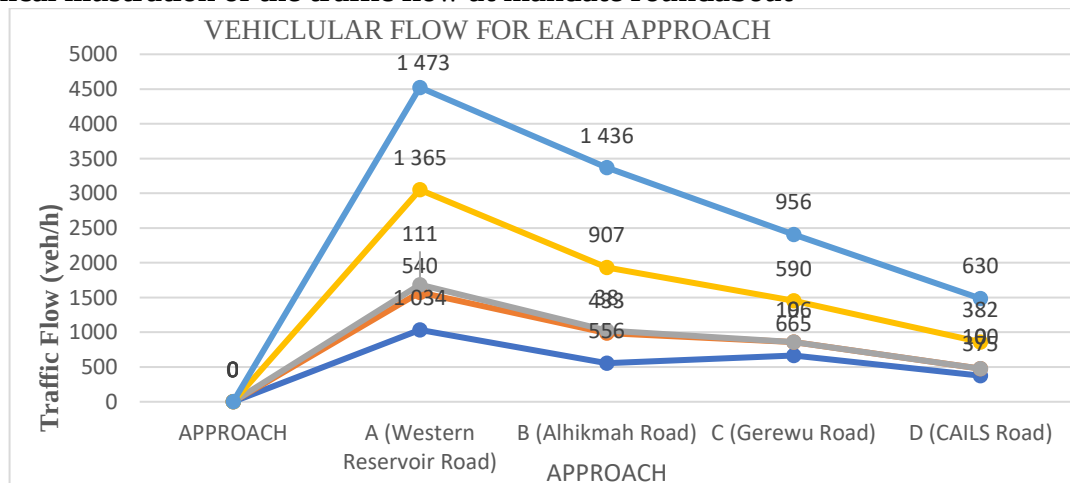


Figure 4: Traffic Pattern for Mandate Roundabout

The figure 4 presents the traffic flow distribution across four approaches: Western Reservoir Road (A), Al-Hikmah Road (B), Gerewu Road (C) and CAILS Road (D).

The displayed values indicate that Western Reservoir Road carries the highest traffic volume, followed by Al-Hikmah Road. Gerewu Road carries a lower volume, while CAILS Road has the lowest displayed traffic values.

This pattern suggests that traffic demand is concentrated on the Western Reservoir Road and Al-Hikmah Road approaches. Consequently, these approaches may experience greater operational pressure than the others, particularly during peak traffic periods.

3.2.1 Traffic Movement Result Analysis on Oja Oba, Pakata, Adeta, and Mandate Roundabout

Figures 5-8 traffic movement analysis was conducted at Oja-Oba, Pakata, Adeta and Mandate roundabouts to determine the distribution of vehicles according to their directions of movement. The movements were classified into left-turn (LT), through (TT), right-turn (RT) and circulating movement (CM). The analysis provides an understanding of traffic demand across the approaches and serves as a basis for evaluating the operational performance of the selected roundabouts in terms of capacity, degree of saturation, delay and level of service.

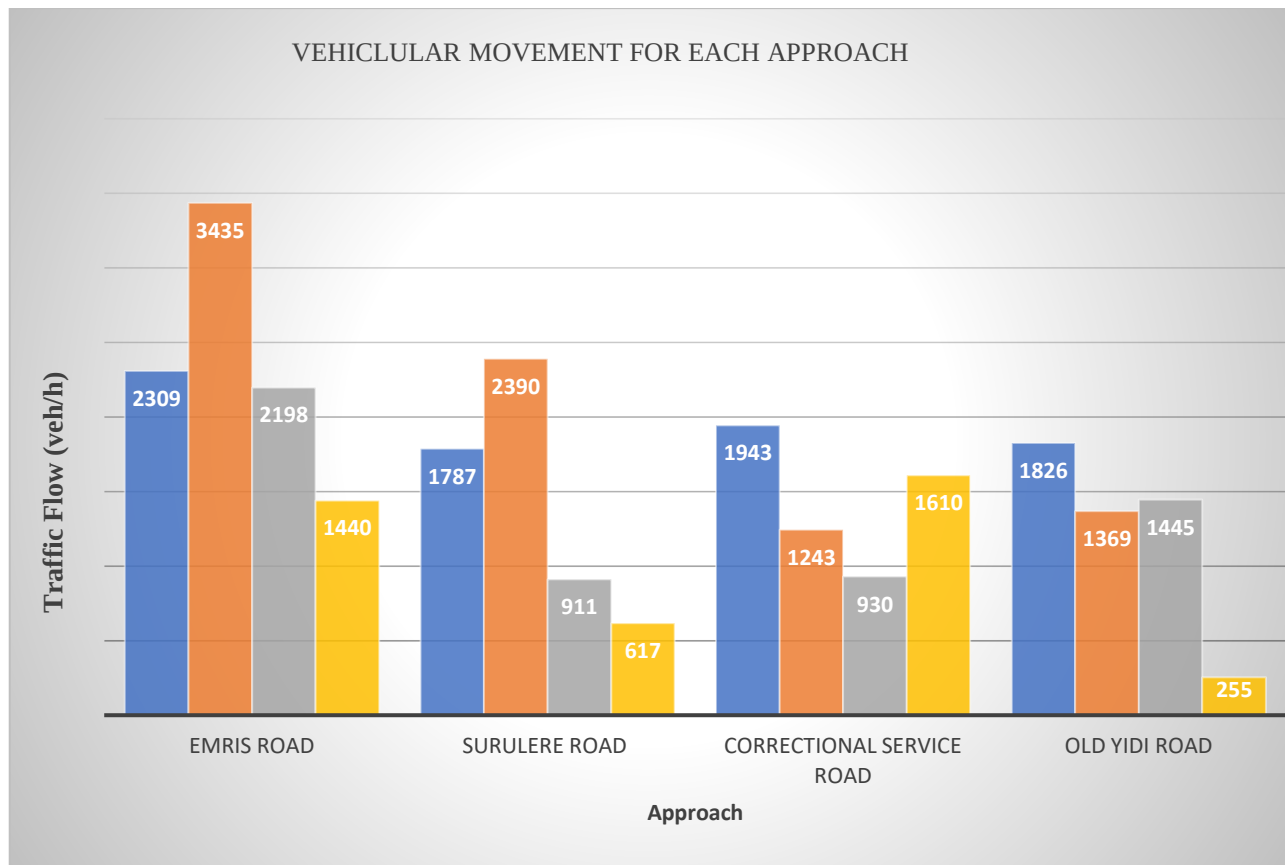


Figure 5: Traffic Movement for each Approach at Oja Oba Roundabout

The figure 5 presents the distribution of left-turn, through traffic, right-turn and circular movements across Emirs Road, Surulere Road, Correctional Service Road and Old Yidi Road.

The displayed values indicate that through traffic is a major movement at Oja-Oba Roundabout, particularly on Emirs Road, where the highest labelled movement value is 3,435 veh/h. Substantial traffic movements are also observed on Surulere Road and Correctional Service Road. Old Yidi Road records a left-turn volume of 1,826 veh/h, through traffic of 1,369 veh/h and right-turn traffic of 1,445 veh/h, while circular movement is comparatively low at 255 veh/h.

The relatively high movement volumes indicate considerable traffic demand on several approaches. This may increase competition for entry and circulating space, particularly where the available entry widths are inadequate for the prevailing demand.

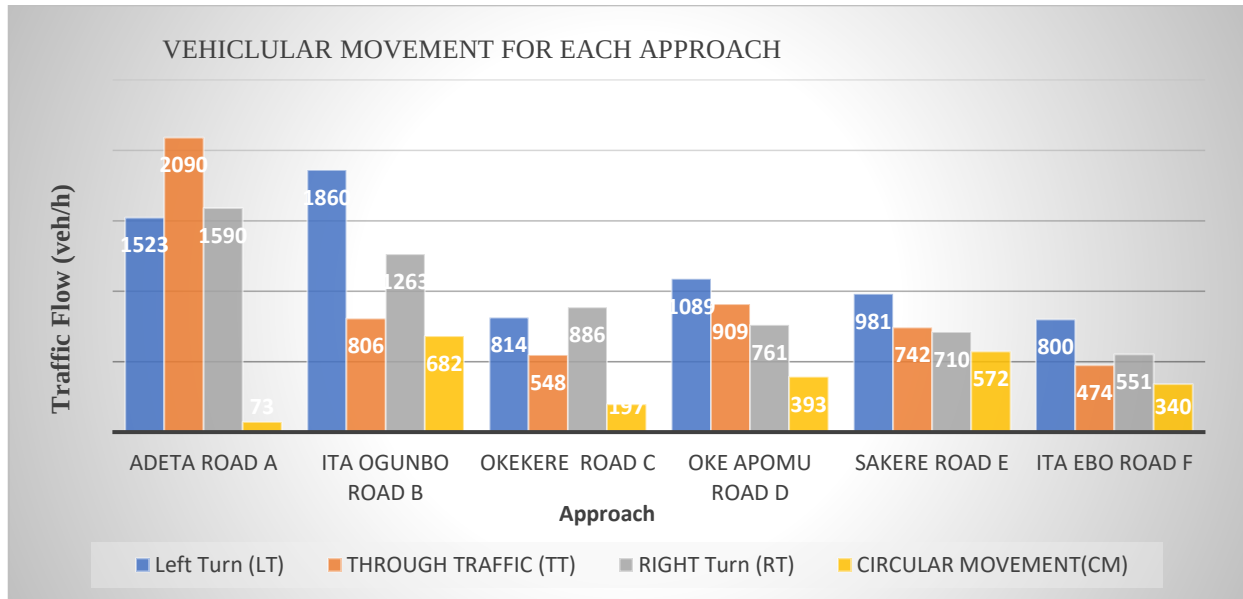


Figure 6: Traffic Movement for each Approach at Pakata Roundabout

The figure 6 illustrates the traffic movement patterns across six approaches: Adeta Road, Ita Ogumbo Road, Okekere Road, Oke Apomu Road, Sakere Road and Ita Ebo Road.

The plotted values show variations in left-turn, through traffic, right-turn and circular movements across the six approaches. The Adeta Road approach records a high displayed movement value of 2,090 veh/h, while Ita Ogumbo Road also carries substantial traffic movements. The remaining approaches show different movement distributions, indicating that traffic demand varies across the roundabout.

These variations are important because high turning and through-traffic volumes can increase the demand for available entry and circulating space. Where the demand exceeds the capacity of an approach, queues and delays may develop.

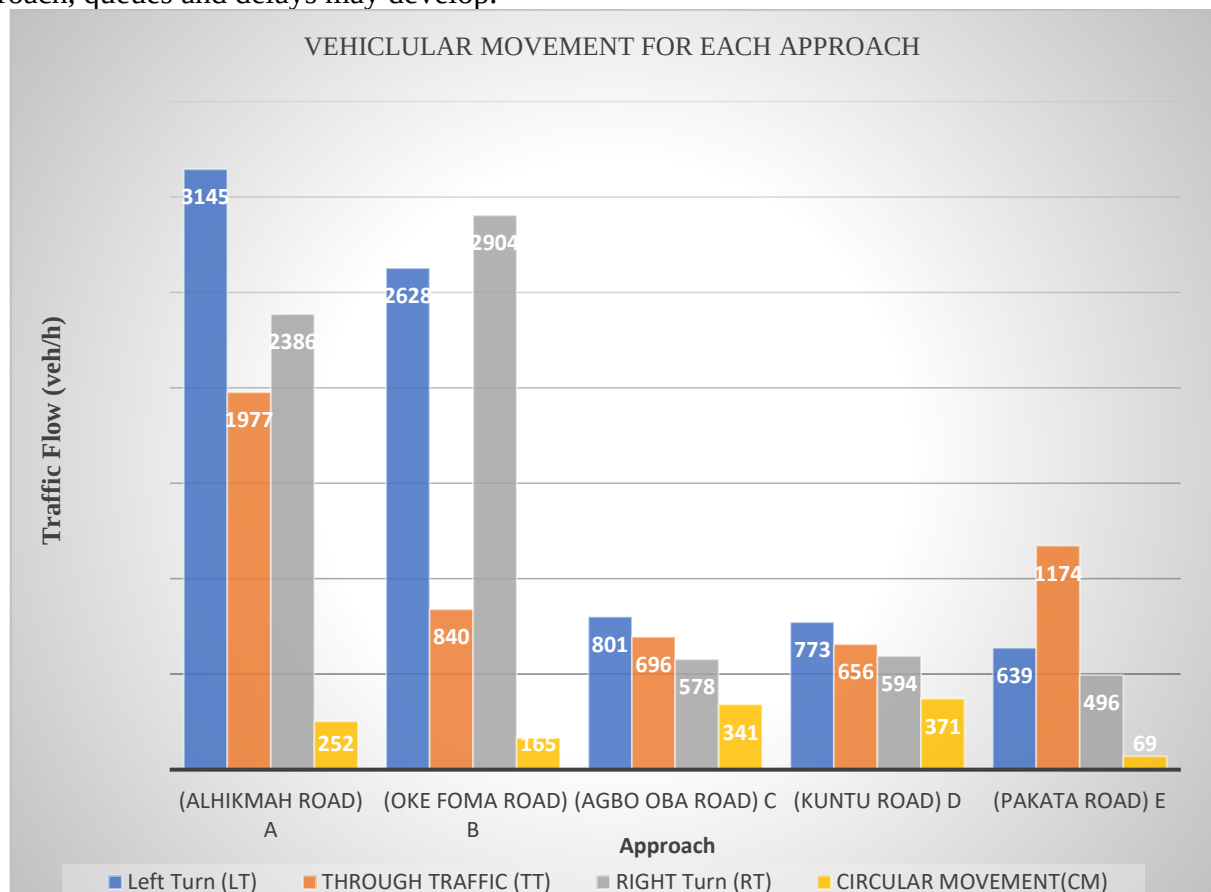


Figure 7: Traffic Movement for each Approach at Adeta Roundabout

The figure 7 presents the traffic movement distribution across Al-Hikmah University Road, Oke Foma Road, Agbo Oba Road, Kuntu Road and Pakata Road.

The highest displayed movement value is 3,145 veh/h on Al-Hikmah University Road. Other substantial movement values include 2,904 veh/h on Agbo Oba Road and 2,628 veh/h on Oke Foma Road. These values indicate that considerable traffic demand is concentrated on some approaches rather than being evenly distributed across the roundabout.

The relatively high movement volumes may increase the pressure on entry capacity and circulating space, potentially resulting in congestion and increased vehicle delays during peak periods.

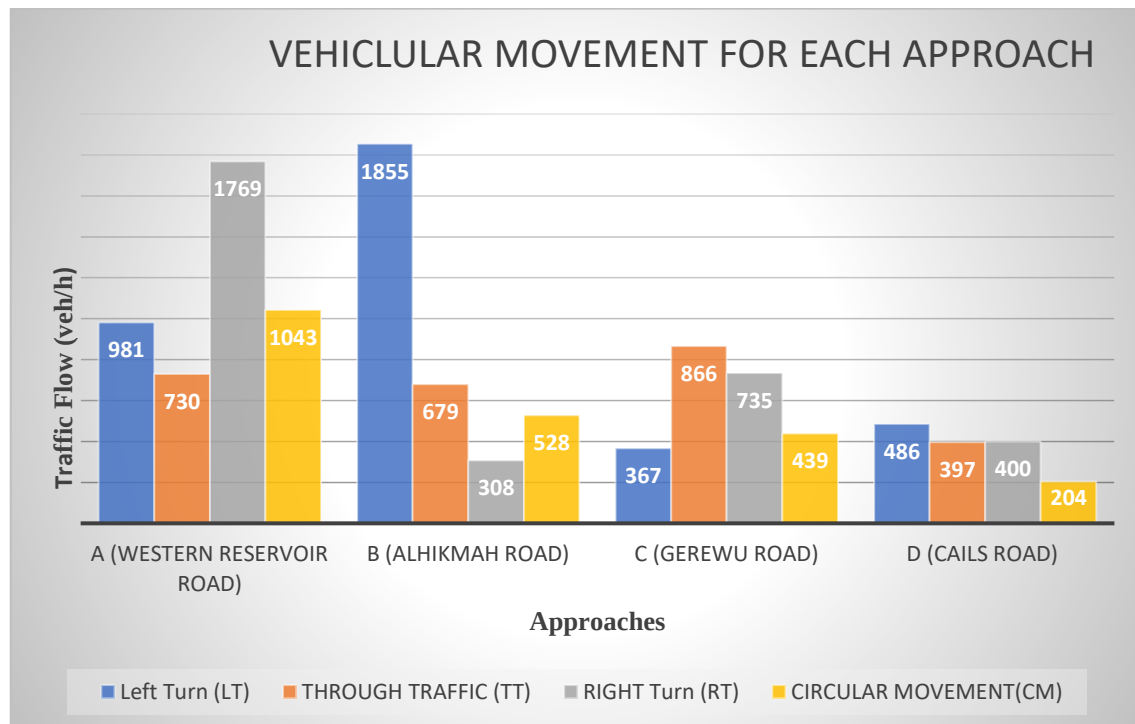


Figure 8: Traffic Movement for each Approach at Mandate Roundabout

The figure 8 illustrates the distribution of traffic movements across Western Reservoir Road, Al-Hikmah Road, Gerewu Road and CAILS Road.

The highest displayed movement value is 1,855 veh/h on Al-Hikmah Road, followed by 1,769 veh/h on Western Reservoir Road. Lower movement values are recorded on Gerewu Road and CAILS Road. This indicates that traffic demand is more concentrated on the Al-Hikmah and Western Reservoir approaches than on the other approaches.

The variation in movement volumes may lead to differences in congestion and delay among the approaches, particularly during periods of high traffic demand. Consequently, the operational assessment should consider both the traffic volume and the capacity available to accommodate each movement.

4. Conclusion

This study examined the geometric characteristics, traffic flow patterns and directional traffic movements at four selected roundabouts Oja-Oba, Pakata, Adeta and Mandate in Ilorin Metropolis, Nigeria. The findings revealed variations in roundabout geometry and traffic demand across the selected sites. The existing entry widths ranged from 2.0 to 3.2 m, while the inscribed circle diameters varied from 13.50 m at Mandate to 51.40 m at Adeta. These differences highlight the need to consider site-specific geometric characteristics when assessing roundabout performance.

The traffic flow and movement analyses further demonstrated that traffic demand was unevenly distributed across the approaches. At Oja-Oba, substantial traffic movements were observed on Emirs Road and other connecting approaches. At Pakata, demand varied across the six approaches, while Al-Hikmah University Road and other approaches at Adeta exhibited comparatively high movement volumes. At Mandate, traffic demand was more concentrated on Al-Hikmah Road and Western

Reservoir Road. These findings indicate that the operational demands of the selected roundabouts differ by location and approach, underscoring the importance of approach-specific traffic assessment.

Therefore, the study establishes that geometric characteristics and the distribution of directional traffic movements are important considerations in evaluating roundabout operation. The findings provide a basis for identifying approaches that warrant further capacity assessment and targeted geometric improvement. Future improvement strategies should be supported by quantitative capacity analysis and traffic simulation to establish their effects on degree of saturation, vehicle delay and level of service. This approach can inform more effective roundabout design and traffic management interventions in Ilorin Metropolis and other urban areas experiencing comparable traffic conditions.

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