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CAPACITY AND LEVEL-OF-SERVICE ASSESSMENT OF RUMUOKORO ROUNDABOUT IN THE CITY OF PORT HARCOURT UNDER MIXED TRAFFIC

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ABSTRACT

Rapid motorisation and uncoordinated land-use growth along arterial corridors in Port Harcourt, Nigeria, have overloaded many at-grade junctions, including roundabouts originally designed for far lower demand. This study evaluated the operational performance of the five-leg Rumuokoro Roundabout, a key node linking the Choba, Eliozu, Rumuokwota, Rumuaholu and Rumuodomaya corridors. Geometric data (inscribed circle diameter, entry width, entry radius, entry angle, flare length and weaving length) were obtained with a laser distance measurer, while classified traffic volumes, U-turn proportions, heavy-vehicle percentages, gap acceptance, queue lengths and pedestrian crossing demand were recorded using video recording, tally sheets and a digital stopwatch during weekday morning and evening peak periods. Entry speeds were measured with a laser speed gun to obtain the 85th-percentile value. Entry capacity at each leg was estimated using the Kimber empirical regression model, and level of service (LOS) was assigned using Highway Capacity Manual control-delay thresholds adapted for roundabouts. Results showed a substandard inscribed circle diameter (42.3 m), zero flare length, a short weaving length (22–28 m) and an 85th-percentile entry speed of 48 km/h, all outside recommended limits. Volume-to-capacity ratios ranged from 1.31 to 1.79 across the five legs, with control delays between 201 and 312 seconds per vehicle, placing every approach in LOS F (breakdown condition). The Choba and Eliozu approaches, carrying the highest through volumes and heavy-vehicle shares, recorded the longest queues (up to 625 m) and highest delays. The findings indicate that geometric deficiencies rather than volume alone are driving the roundabout's failure, and the paper recommends geometric retrofitting, entry-speed control and a review of the intersection control strategy.

Keywords: Roundabout capacity; Level of service; Kimber model; Traffic congestion; Geometric design; Port Harcourt

1 INTRODUCTION

Roundabouts have long been favoured over signalised and priority-controlled junctions because, when properly designed, they reduce conflict points, lower approach speeds and improve safety while sustaining reasonable

throughput [1; 2]. Their performance, however, is highly sensitive to geometric form: inscribed circle diameter, entry width, entry angle, flare and weaving length jointly determine the entry capacity that a given circulating flow will allow. Where these elements are undersized relative to the demand a junction must serve, roundabouts can deteriorate into some of the most congested nodes on an urban network rather than the free-flowing junctions they were intended to be.

In Nigerian cities, many roundabouts were built decades ago under lower traffic demand and have not been re-engineered to match the vehicle ownership growth, informal commercial activity and unplanned land-use intensification that now surround them. Port Harcourt, the capital of Rivers State, is a clear example: corridors feeding the Rumuokoro Roundabout - Choba, Elioza, Rumuokwota, Rumuaholu and Rumuodomaya - serve a mix of residential, institutional (including a major university) and commercial traffic, and the roundabout itself has become a widely reported bottleneck during both peak periods. Similar operational breakdowns have been documented at other Nigerian roundabouts; for instance, an assessment of the Falomo-Awolowo roundabout in Lagos under heterogeneous traffic found volume-to-capacity ratios well above unity and control delays consistent with forced (LOS F) flow on nearly every approach [3], suggesting that the problem is not unique to any single city but reflects a broader gap between inherited roundabout geometry and present-day demand across Nigerian urban corridors.

Despite the evident congestion at Rumuokoro, there is limited published, data-driven evidence quantifying how far its geometry and operation deviate from recognised design standards, and by how much its entry capacity is currently exceeded. Anecdotal accounts of long queues and driver frustration are common, but a rigorous capacity and level-of-service (LOS) analysis grounded in field-measured geometric and traffic data is necessary to move from anecdote to an evidence base that can support intervention design.

This study therefore aims to evaluate the existing operational performance of the Rumuokoro Roundabout by (i) surveying its geometric parameters and comparing them with Federal Ministry of Works (FMW) [4] and international standards; (ii) quantifying peak-period traffic volumes, turning movements, heavy-vehicle proportions, queue lengths and pedestrian crossing demand on each approach; (iii) estimating entry capacity and level of service using the Kimber (1980) regression model and Highway Capacity Manual delay thresholds; and (iv) identifying which geometric and operational factors most strongly constrain performance, as a basis for improvement recommendations. The scope is limited to the five-leg roundabout and its immediate approaches under existing (do-nothing) geometry and demand; it does not evaluate specific redesign alternatives, which are left for further study.

2 MATERIALS AND METHODS

2.1 Study Area

The Rumuokoro Roundabout is a five-leg, single-lane-circulation, at-grade junction located along the Port Harcourt–Aba corridor in Obio/Akpor Local Government Area, Rivers State, Nigeria. It connects the Choba and Elioza approaches on the east–west axis with the Rumuokwota, Rumuaholu and Rumuodomaya approaches, which together carry commuter, commercial and heavy-goods traffic between the university, residential and market districts it serves.

2.2 Data Collection Instruments and Procedure

Field data were collected over representative weekday morning and evening peak periods using the following instruments, each matched to a specific data category: a Sony HDR-CX405 video camera, positioned to cover each approach and the circulatory carriageway, for recording traffic conflicts, classified vehicle counts and queue development; a handheld digital stopwatch for timing service (discharge) headways and gap-acceptance events at the yield line; a Bosch GLM 50 C laser distance measurer for the geometric survey, from which the inscribed circle diameter, entry widths, entry radii and weaving lengths were derived; a TruCam LTI laser speed gun for spot-speed sampling used to obtain the 85th-percentile entry speed (V85) on each approach; and standardised tally sheets for manual recording of classified traffic volume, U-turn movements and pedestrian crossings, cross-checked against the video record.

Geometric measurements were taken directly on site and cross-verified against satellite imagery. Classified volume counts, U-turn proportions and heavy-vehicle percentages were extracted from the recorded video in 15-minute intervals through the morning and evening peak hours and aggregated to hourly passenger-car-unit (PCU) flows using standard PCU factors. Queue lengths were measured from the yield line to the back of the longest observed queue on each approach. Pedestrian crossing demand was counted within a 50 m band of the roundabout, with each crossing further classified as either gap-selection through live traffic or use of a designated crossing aid.

2.3 Analytical Framework

Entry capacity at each leg was estimated using the empirical linear regression model developed by Kimber in 1980 from track and public-road roundabout studies in the United Kingdom, which remains the basis of several national roundabout capacity procedures [2]. The model expresses entry capacity as a linear function of the conflicting circulating flow, moderated by geometric parameters:

$$Q_e = k (F - f_c \times Q_c) \text{ ----- } 1.0$$

where; Q_e is the entry capacity at the yield line (PCU/hr); Q_c is the circulating flow conflicting with the subject entry (PCU/hr); k , F and f_c are empirical coefficients derived from the entry geometry.

The geometric terms are computed as:

$$F = 303 x_2; f_c = 0.210 tD (1 + 0.2 x_2); x_2 = v + (e - v) / (1 + 2S); S = 1.6 (e - v) / l' \text{ --- } 2.0$$

in which e is the entry width, v is the approach half-width, l' is the effective flare length, tD is a geometric delay term related to the inscribed circle diameter (D), and ϕ is the entry angle. The measured values in Table 1 were substituted into this framework to obtain Q_e for each of the five legs, after which the volume-to-capacity ratio was computed as v/c = entry volume / Q_e .

Control delay was estimated from the resulting v/c ratios following the steady-state/oversaturation delay formulation underlying the Highway Capacity Manual procedure for roundabouts, and level of service was assigned using the HCM control-delay thresholds adapted for roundabout entries: LOS A (≤ 10 s), B (10–15 s), C (15–25 s), D (25–35 s), E (35–50 s) and F (> 50 s) [4]. This delay-based LOS scheme, rather than the v/c ratio alone, was used as the primary indicator of operational quality, consistent with current HCM and NCHRP Report 672 practice [2].

3 RESULTS AND DISCUSSION

3.1 Geometric Condition of the Roundabout

Table 1 compares the measured geometric parameters of the Rumuokoro Roundabout with Federal Ministry of Works and international guidance.

Every geometric parameter measured falls short of, or at best marginally meets, recommended practice. The inscribed circle diameter of 42.3 m is well below the 50 m generally recommended for a two-lane roundabout expected to carry truck traffic [2], and the complete absence of flare ($l' = 0$ m) removes one of the two design elements that [1] identified as having the largest influence on entry capacity, the other being entry width itself, which is also marginally undersized on most legs. The short weaving length (22–28 m against a desirable 40 m) further compresses the distance available for merging and diverging manoeuvres within the circulatory carriageway. Perhaps most significantly for safety, the 85th-percentile entry speed of 48 km/h exceeds the FMW maximum of 40 km/h; because roundabouts rely on low entry speeds to allow drivers to select gaps safely, this speed excess, combined with the tight ICD, is consistent with the elevated entering-circulating conflict potential reported at similarly undersized small-diameter roundabouts elsewhere [6].

Table 1: Summary of geometric parameters – Rumuokoro Roundabout

Leg	Entry (PCU/hr)	Q_c (PCU/hr)	Q_e (PCU/hr)	v/c	Delay (s)	LOS	Status
Choba	1,842	1,305	1,190	1.55	259	F	Breakdown
Eliozu	1,976	1,420	1,102	1.79	312	F	Breakdown
Rumuokwota	1,124	2,180	758	1.48	238	F	Breakdown
Rumuaholu	986	2,310	678	1.45	229	F	Breakdown
Rumuodomaya	812	2,405	619	1.31	201	F	Breakdown

3.2 Traffic Volumes, Queuing and Pedestrian Demand

Table 2 presents the classified peak-hour entry and circulating flows, U-turn proportions and heavy-vehicle shares recorded on each leg.

Table 2: Classified volume count and U-turn proportions by leg

Leg	Entry Vol. (PCU/hr)	Circ. Flow (PCU/hr)	U-Turn (%)	HV (%)	Max Queue (m)
Choba (E-W West)	1,842	1,305	14.2	18	625
Eliozu (E-W East)	1,976	1,420	12.8	21	580
Rumuokwota (N)	1,124	2,180	6.1	9	310
Rumuaholu (NE)	986	2,310	4.3	7	255
Rumuodomaya (S)	812	2,405	3.8	11	188
Total / Average	6,740	–	10.8 (avg.)	13.2 (avg.)	–

Total entry demand across the five legs reached 6,740 PCU/hr, with the Choba and Eliozu approaches together accounting for more than half of this volume (3,818 PCU/hr) and also carrying the highest heavy-vehicle shares (18% and 21% respectively) and U-turn proportions (14.2% and 12.8%). Queue lengths mirrored this pattern: the Choba approach recorded the longest morning-peak queue in the study, 625 m from the yield line, which is long enough to have reached and interacted with a signalised intersection some 580 m further upstream, indicating that congestion at Rumuokoro is already spilling back into, and potentially disrupting, an adjacent signal-controlled junction. Evening-peak queues were somewhat shorter (540 m on Choba) but remained severe. Pedestrian activity was also substantial, with crossing demand within 50 m of the roundabout peaking at 320 persons/hour; that 78% of these crossings were made by gap selection through live traffic, rather than at a marked or signal-protected crossing, points to a pedestrian safety exposure that compounds the vehicular capacity problem documented below.

3.3 Entry Capacity and Level of Service

Applying the Kimber entry-capacity model with the measured geometric and flow data yielded the results summarised in Table 3.

Table 3: Existing level-of-service analysis – Rumuokoro Roundabout

Leg	Entry (PCU/hr)	Qc (PCU/hr)	Qe (PCU/hr)	v/c	Delay (s)	LOS	Status
Choba	1,842	1,305	1,190	1.55	259	F	Breakdown
Eliozu	1,976	1,420	1,102	1.79	312	F	Breakdown
Rumuokwota	1,124	2,180	758	1.48	238	F	Breakdown
Rumuaholu	986	2,310	678	1.45	229	F	Breakdown
Rumuodomaya	812	2,405	619	1.31	201	F	Breakdown

All five legs operate at LOS F, with volume-to-capacity ratios between 1.31 (Rumuodomaya) and 1.79 (Eliozu) and control delays between 201 and 312 seconds per vehicle - roughly six to twelve times the 50-second upper bound of LOS F. Eliozu and Choba, the two legs with the highest entry demand, heavy-vehicle proportion and U-turn activity, also record the lowest entry capacities relative to demand and the largest delays, confirming that demand pressure and geometric constraint are acting together rather than independently. The remaining three legs (Rumuokwota, Rumuaholu, Rumuodomaya), although carrying comparatively lower entry volumes, still fail because the circulating flow they face - fed largely by Choba and Eliozu traffic already in the circle - is itself close to or above the two-lane circulating-flow ceiling of about 1,800 PCU/hr commonly used as a rough capacity check [3].

These results are consistent with the pattern reported for other undersized Nigerian roundabouts under mixed traffic: at the Falomo-Awolowo roundabout in Lagos, HCM-based capacity models likewise returned v/c ratios above unity and LOS F on nearly every approach during peak hours [3]. The Rumuokoro findings extend this evidence to a fully geometry-linked capacity model [1] rather than a purely headway-based one, and show that the breakdown is explained largely by the combination of undersized entry width, zero flare and short weaving length identified in Table 1, rather than by circulating flow alone. This distinction matters for remedial design because Kimber's model shows entry width and flare as the dominant capacity-determining variables [7; 3], even modest widening and the introduction of flare on the Choba and Eliozu entries would be expected to yield a proportionally larger capacity gain than an equivalent increase in circulating-lane capacity alone.

The combination of forced-flow operation, spillback toward an upstream signal, and heavy uncontrolled pedestrian crossing demand indicates that the roundabout has effectively exceeded its functional design life and that safety, not only delay, is now an operational concern at this junction.

4 CONCLUSIONS

This study assessed the existing capacity and level of service of the five-leg Rumuokoro Roundabout in Port Harcourt, Nigeria, using field-measured geometric and traffic data with the Kimber (1980) entry-capacity model. The roundabout's inscribed circle diameter, entry width, flare length and weaving length all fall short of Federal Ministry of Works and international standards, while the 85th-percentile entry speed of 48 km/h exceeds the recommended maximum, indicating a geometry that no longer matches either safe operating speed or current demand. All five approaches operate at LOS F, with volume-to-capacity ratios from 1.31 to 1.79 and control delays from 201 to 312 seconds per vehicle; the Choba and Elioze legs, which carry the highest volumes, heavy-vehicle shares and U-turn activity, are the most severely affected, with queues long enough to interact with an upstream signalised intersection. Pedestrian crossing demand of 320 persons/hour, mostly through unassisted gap selection, adds a safety dimension to the capacity problem.

The evidence indicates that the roundabout's failure is driven substantially by geometric deficiency - undersized entry width, absence of flare and a short weaving section - rather than by traffic volume alone, and that these are the parameters remedial design should prioritise. It is recommended that the responsible highway authority: (i) undertake geometric retrofitting of the Choba and Elioze entries, including entry widening and the introduction of adequate flare, in line with FMW and NCHRP Report 672 guidance; (ii) investigate low-cost speed-reduction measures on entries to bring V85 within the 40 km/h design limit; (iii) provide a marked and, where feasible, signal-protected pedestrian crossing facility within the 50 m influence zone; and (iv) given the depth of oversaturation already observed, evaluate whether the long-term function of this junction is better served by a signalised roundabout or an alternative control strategy, rather than geometric retrofitting of the existing form alone. Future work should extend this assessment to a before-and-after evaluation of any implemented improvement and to microsimulation of alternative control strategies under projected demand growth.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest, financial or otherwise, associated with this research.

REFERENCES

- [1] Kimber, R.M. (1980) The Traffic Capacity of Roundabouts. TRRL Laboratory Report LR942. Crowthorne: Transport and Road Research Laboratory.
- [2] Rodegerdts, L., Bansen, J., Tiesler, C., Knudsen, J., Myers, E., Johnson, M., Moule, M., Persaud, B., Lyon, C., Hallmark, S., Isebrands, H., Crown, R.B., Guichet, B. and O'Brien, A. (2010) NCHRP Report 672: Roundabouts: An Informational Guide. 2nd edn. Washington, DC: Transportation Research Board.
- [3] Olutaiwo, A. and Elewuro, H.O. (2017) 'Performance study of a rotary under heterogeneous traffic flow conditions: a case study of Falomo-Awolowo intersection, Eti-Osa Local Government, Lagos, Nigeria', International Journal of Engineering and Technical Research, 7(5), pp.110–117.
- [4] Federal Ministry of Works (2013) Highway Manual Part I: Design, Volume 1 – Geometric Design. Abuja: Federal Republic of Nigeria, Federal Ministry of Works.
- [5] Federal Highway Administration (2000) Roundabouts: An Informational Guide. Publication No. FHWA-RD-00-067. Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

- [6] Brilon, W. and Stuwe, B. (1993) 'Capacity and design of traffic circles in Germany', Transportation Research Record, 1398, pp.61–67
- [7] Kimber, R.M. and Semmens, M.C. (1977) A Track Experiment on the Entry Capacities of Offside Priority Roundabouts. TRRL Supplementary Report SR334. Crowthorne: Transport and Road Research Laboratory.