Performance Evaluation of Haliru Abdu Rotary Intersection

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Abstract— *The aim of this research is to fill the gap by assessing the existing capacity of Haliru Abdu rotary intersection with a view to suggesting a feasible solution in order to develop its performance on the ground of sustainability. Therefore, the data were collected at a suitable location along each of the approach legs for the three days three hours (rush or peak hours) in the morning session (7:00 to 10:00 am), and three hours (rush or peak hours) in the evening session (3:00 to 6:00 pm) of the rotary. Thus, the data collected were analyzed using standard method of performance analysis (manual) and sidra solution software version 5.0 (HCM 2010 Model). Therefore, for manual calculation, the entry capacity and entry flow values of each arm are (532,709,676, and 729veh/hr.) and (2196, 2566, 2378, and 2083veh/hr.) respectively. On the other hand, sidra solution software outputs are (1930, 1558, 1375 and 638veh/hr.) and (2312, 2701, 2503 and 2193veh/hr.) respectively. Therefore, the ratio of volume to capacity for both manual and sidra solution software output are > 1 for all the approaches to the intersection. This implies that, all the approaches at the intersection operate under poor operating system (LOS F). The study highlights the positive solutions to the approaches of the intersection. Therefore, it can be concluded that the road in a constant traffic jam would be at LOS F, which is a poor operating performance.*

Index Terms— Intersection; performance evaluation; rotary; volume; capacity; level of service

1 Introduction

Birnin Kebbi is a city located at Northern part of the country. It is called the land of equity created on 27th August, 1991. Existence of education, commercial and residential in the state make traffic flow high in a lot of areas with road intersections. In this study, a highly sensitive roundabout intersection will be evaluated due to the problems of delay encountered by motorists [1]. A rotary intersection is one in which all traffic merges into from one way round a central island (TRB, 2011). It allows a continuous traffic movement from all the legs at reduced speed when operating at low volume [2]. Rotary intersections are normally conflicting points between vehicles, cyclists and pedestrians [3]. Although, pedestrians crossing facilities must be properly included to avoid conflict. Intersections are normally classified as "at grade separated" and "grade separated", and under each type are various forms [4]. Closely at grade intersections generally from the major determinants to free traffic flows. Haliru Abdu rotary intersection encounters a lot of congestion especially during working and business hours which lead to low traffic and high increase in density, travel time and number of stops in the traffic stream [1]. On the other hand, a roundabout can be defined as a central island or inscribed circle that allows traffic movement in either clockwise or anticlockwise directions depending on the country driving (i.e. left or right hand driving), example of a roundabout is channelized intersection [5].
Therefore, the following geometric modifications of a roundabout may be needed in order to:

i. Adaptation of queues at internal stop lines on the ring carriageway [5].
ii. Improve the capacity on external arms and on the ring carriageway [5].
iii. Establish alignment enhancements and lane control measures on the ring carriageway [5].
iv. Increase forward visibility and inter-visibility zones in the junction [5].
v. Establish specific measures for the pedestrians, cyclists, street buses, taxi transport, and supply traffic.

Additionally, these geometric modifications may be in the category of:

i. Increase nearside or off-side directional lanes [5].
ii. Add extra internal directional lanes within the ring carriageway [5].
iii. Improving the size of splitter islands in order to obtain longer internal arms [5].
iv. Isolated facilities or signaled intersecting facilities [5].

However, rotary intersection also encounters a high number of accidents due to the non-compliance of traffic regulations that lead to the taking of others "right of way" [3]. A roundabout is the British word for a road in which traffic moves in one direction around a central island [4]. It is a circular structure in a road at a place where several roads met in order to control merging and conflicting traffic flows [4]. It causes diversion of traffic from its preferred straight line path, requiring drivers to slow down as they enter the junction [2]. Roundabout significantly reduce potential points of conflict between pedestrians and motor vehicles and are considered to be safer for them [1]. Therefore, the aim of this research is to fill the gap by assessing the existing capacity of Haliru Abdu rotary intersection with a view to suggesting a feasible solution in order to develop its performance on the ground of sustainability. In order to achieve this aim, the following objectives are forwarded below:

i. To identify the possible causes of congestion at the intersection.
ii. To minimize the rate of congestions at the intersection.
iii. To provide a better critical solutions to the possible causes affecting the intersection for future humanity.

Hence, no any study available to fill this gap, whereas, this research has filled the gap by assessing the existing capacity of Haliru Abdu rotary intersection in order to develop its performance for the benefit of the present and future generations.

2 Literature Review

2.1 The Concept of Capacity

The traffic managing capability of a highway system is generally determined based of level of service and capacity [6].Therefore, the capacity of a transportation system can be defined as the maximum number of vehicles or pedestrians that can reasonably be anticipated to use the road facility in a particular given period of time under prevailing traffic movements, roadways, and control conditions [6].

2.2 The Concept of Level of service

The concept of level of service (LOS) is usually used to describe the operating conditions for each type of traffic flow system [6]. Therefore, the maximum number of traffic that can be adapted while maintaining the absolute operating conditions is known as the service volume for that level of service[6]. The level of service could be classified based on the operating conditions as shown in the Table 1 [6].

3 METHODOLOGY

Manual counting method was adopted in this research. Manual counts are made when the desired data cannot be obtained by mechanical or automatic counting devices. This method requires the use of field observers who recorded the gathered data on previously prepared tally sheets. Data were collected at a suitable location along each of the approach legs for the three days three hours in the morning session (7:00 to 8:00 am) and three hours in the evening session (3:00 to 6:00 pm) of the rotary. At each of the locations, traffic count for various classes of vehicles were taken. The observed traffic volumes were reduced from different number of vehicles to their equivalent passenger car units (pcu) based on the above conversation factors stated in Transport and Research Laboratory, TRL (1993).

The geometric features such as the entry width, approach half width, flare sharpness, average flare length, inscribe circle diameter and entry radius were also measured. All the four approach legs were observed separately by an observer assigned to count vehicles turning either left, right or moving straight ahead with their classification according to their various types. This enables the actual number of vehicles passing each approach leg to be properly identified and the capacity at each approach leg to be calculated. Similarly, the geometric parameters of the intersection were measures too.

3.1 Circulatory Flow (Q_c)

North Arm (Arm A)

Q_c = 972+819+952 = 2743

South Arm (Arm B)

Q_c = 744+758+865 = 2367

East Arm (Arm C)

Q_c = 908+952+744 = 2604

West Arm (Arm D)

Q_c = 790+865+972 = 2627

The ratio of volume to capacity (V/C) of each arm is determined as follows:

Arm A

V/C = 2196/532 = 4.1

Arm B

V/C = 2566/709 = 3.6

Arm C

V/C = 2378/676 = 3.5

Arm D

V/C = 2083/729 = 2.9

4 RESULTS

From Table 2, it can be seen that the volume to capacity is > 1 for all approaches to the intersection. Hence; all the approaches are operated at forced flow (poor operating system).

From Table 3, the values of V/C were increased and nature of flow varied depending on the level of services. Note that, LOS means Level of Services, V/C means Volume to Capacity ratio, and NOF means Nature of Flow.

From Table 4, the volume to capacity ratio is > 1 for all approaches to the intersection. Hence; all the approaches are operated at forced flow (poor operating system).

5. DISCUSSION

From the above results so far, the results indicated that the ratio of volume to capacity is > 1 compare to all other approaches to the intersection. Therefore, all the approaches at the rotary intersection operate in a poor performance. The level of service of all the approaches fell within the range of level of service F (LOS F), which described a breakdown in vehicular flow or forced flow. Similarly, the intersection in a constant traffic jam would be at LOS F. This is because LOS does not describe an instant state, but, rather an average or typical service. Therefore, road facilities operating at LOS F generally have more demand than capacity. Hence; LOS F describes a road for which the travel time cannot be predicted.

6. CONCLUSION

The aim of this research is to fill the gap by assessing the existing capacity of Haliru Abdu rotary intersection with a view to suggesting a feasible solution in order to develop its performance on the ground of sustainability. Therefore, the ratio of volume to capacity (V/C) were determined as 4.1, 3.6, 3.5, and 2.9 respectively in a manual calculation. The sidra solution software outputs were also obtained as 1.2,1 .7, 1.8, and 3.4 respectively. Therefore, based on the results output, it can be concluded that, the ratio of volume to capacity is > 1 for all the approaches to the intersection. This implies that, all the approaches toward intersection operate in a poor operating system. The Level of Service (LOS) of all the four arms fell within the range of F (forced flow or a breakdown in vehicular flow).

7. FIGURES AND TABLES

Table 1: Classifications of levels of service (LOS) for Highways.

LOS	Typical operation condition
A	V/C (volume to capacity ratio) ≤ 0.15, Free flowing traffic.
B	0.15 < V/C ≤ 0.27, Still free flowing traffic.
C	0.27 < V/C ≤ 0.43, Traffic flow is still under stable condition.
D	0.43 < V/C ≤ 0.64, Approaching unstable flow and vehicle movements are constrained by high volume of traffic.
E	0.64 < V/C ≤ 1.00, Unstable flow
F	V/C >1.00, Congested flow.

Source: [6].

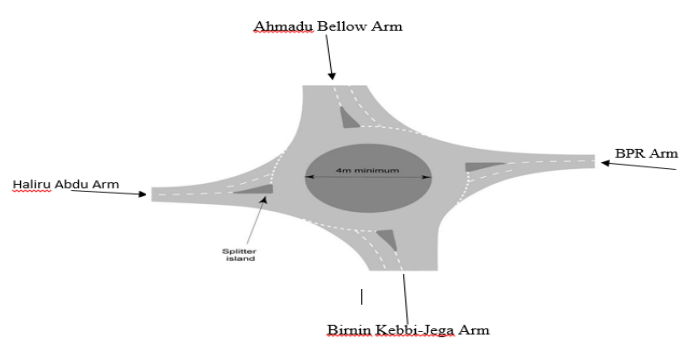

Figure 1: A typical roundabout with four arms [5].

Table 2: Manual calculation outputs.

Stream	Volume (veh/hr)	Capacity (veh/hr)	V/C	Circulatory flow (veh/hr)	LOS
Arm A	2196	532	4.1	2743	F
Arm B	2566	709	3.6	2367	F
Arm C	2378	676	3.5	2604	F
Arm D	2083	729	2.9	2627	F

From the table above, it can be seen that the volume to capacity is > 1 for all approaches to the intersection. Hence; all the approaches are operated at forced flow (poor operating system).

Table 3: The ratio of volume to capacity for different level of services.

LOS	V/C	NOF
A	0.36	Free flow
B	0.54	Reasonably free flow
C	0.71	Stable flow
D	0.87	Approaching unstable flow
E	1.0	Unstable flow
F	>1	Forced or breakdown flow

From the above table, the values of V/C were increased and nature of flow varied depending on the level of services. Note that, LOS means Level of Services, V/C means Volume to Capacity ratio, and NOF means Nature of Flow.

Table 4: Sidra Solution Software Outputs (SSSO).

Stream	Volume (veh/hr)	Capacity (veh/hr)	V/C	LOS
Arm A	2312	1930	1.2	F
Arm B	2701	1558	1.7	F
Arm C	2503	1375	1.8	F
Arm D	2193	638	3.4	F

From the table above, the volume to capacity ratio is > 1 for all approaches to the intersection. Hence; all the approaches are operated at forced flow (poor operating system).

8. APPENDICES

Table 5: Conversion Factors for Car Equivalent.

Vehicle Types	PCU
Passenger car/pickup P/P_u	1.2
Truck/Lorry/Trailer T_r	2.7
Motor Cycle M_c	0.8
Mini Bus M	1.9
Bus B	2.8
Tricycle T_c	1.0

Source: [4].

Table 6: Flow from Ahmadu Bello Way approaching the Intersection (5:00 to 6:00 pm).

Direction	Vehicle Types	Flow	PCU Values	PCU/ HR	Total Flow (veh/hr)
Left Turn	P	344	1.0	344	865
	M	148	1.1	163	
	B	32	2.25	72	
	T_r	-	2.5	-	
	T_c	192	0.6	115	
	M_c	428	0.4	171	
Straight Ahead	P	300	1.0	300	790
	M	148	1.1	163	
	B	24	2.25	54	
	T_r	-	2.5	-	
	T_c	208	0.6	125	
	M_c	372	0.4	149	
Right Turn	P	168	1.0	168	541
	M	88	1.1	97	
	B	8	2.25	18	
	T_r	-	2.5	-	
	T_c	172	0.6	103	
	M_c	388	0.4	155	

Table 7: Flow from Jega Road approaching the Intersection (5:00 to 6:00 pm).

Direction	Vehicle Types	Flow	PCU Values	PCU/ HR	Total Flow (veh/hr)
Left Turn	P	380	1.0	380	952
	M	132	1.1	145	
	B	48	2.25	108	
	T_r	8	2.5	20	
	T_c	224	0.6	134	
	M_c	412	0.4	165	
Straight Ahead	P	384	1.0	384	908
	M	140	1.1	154	
	B	24	2.25	54	
	T_r	8	2.5	20	
	T_c	236	0.6	142	
	M_c	388	0.4	155	
Right Turn	P	196	1.0	196	706
	M	136	1.1	150	
	B	4	2.25	9	
	T_r	32	2.5	80	
	T_c	204	0.6	122	
	M_c	372	0.4	149	

Table 8: Flow from Badariya Road approaching the Intersection (5:00 to 6:00 pm).

Direction	Vehicle Types	Flow	PCU Values	PCU/ HR	Total Flow (veh/hr)
Left Turn	P	300	1.0	300	972
	M	142	1.1	156	
	B	84	2.25	189	
	T_r	23	2.5	58	
	T_c	224	0.6	146	
	M_c	308	0.4	123	
Straight Ahead	P	232	1.0	232	819
	M	124	1.1	136	
	B	44	2.25	99	
	T_r	12	2.5	30	
	T_c	288	0.6	173	
	M_c	372	0.4	149	
	P	200	1.0	200	

Right Turn	M	84	1.1	92	587
	B	12	2.25	27	
	T_r	-	2.5	-	
	T_c	144	0.6	86	
	M_c	452	0.4	182	

Table 9: Flow from Old Garage Road approaching the Intersection (5:00 to 6:00 pm).

Direction	Vehicle Types	Flow	PCU Values	PCU/ HR	Total Flow (veh/hr)
Left Turn	P	344	1.0	344	744
	M	124	1.1	136	
	B	-	2.25	-	
	T_r	8	2.5	20	
	T_c	208	0.6	125	
	M_c	296	0.4	118	
Straight Ahead	P	336	1.0	336	758
	M	112	1.1	123	
	B	-	2.25	-	
	T_r	24	2.5	60	
	T_c	192	0.6	115	
	M_c	308	0.4	123	
Right Turn	P	228	1.0	228	581
	M	92	1.1	101	
	B	-	2.25	-	
	T_r	12	2.5	30	
	T_c	188	0.6	113	
	M_c	272	0.4	109	

Table 10: The Geometric Parameters measured for each entry arm at the intersection.

Parameters	Arm A (mm)	Arm B (mm)	Arm C (mm)	Arm D (mm)
Entry width (e)	9600	9300	9600	8910
Appr. half width (v)	8600	7500	8700	8820
Aveg. Flare Length (l)	40,000	40,000	42,000	41,000
Flare Sharpness (s)	-	-	-	-
Inscribe Circle Dia. (D)	52,000	52,000	52,000	52,0000
Entry Angle (Q)	32º	24º	28º	17º
Entry radius (r)	30,000	27,000	23,000	23,000

Note that, PCU= Passenger Car Unit, P=Passenger car, M=Medium car, T_x =Taxi transport, T_G=Truck, M_G =Medium truck

ACKNOWLEDGMENTS

The authors had like to thank the Ministry of Higher Education and Kebbi State University of Science and Technology, Aliero (KSUS-TA) in the form of research grant, otherwise, this research would not have been possible. We shall remain indebted to all of them for their kind and generosity.

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