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PERFORMANCE ANALYSIS TUGU KETUPAT KANDANGAN II ROUNDABOUT

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ABSTRACT

A roundabout is a type of intersection in which there is a circular island in the middle where the movement of the intersection is replaced by a weaving, distracting vehicles from straight traffic and slowing it down. Roundabouts have the advantage of slowing all passing vehicles and warning of the danger of collisions with other vehicles. There is a transition where special vehicles must use the by-pass road, resulting in traffic on Jl. Al-Falah – Brigjen H.M. Yusi increased . Based on these conditions, an analysis of the performance of the Tugu Ketupat Kandangan II roundabout was carried out to determine the performance of the roundabout in current and future conditions. In this study, roundabout geometric data and a traffic volume survey were collected which was carried out 1 day from 06:00 - 20:00 WITA. In addition, the analysis was carried out using the calculation method of the Manual Kapasitas Jalan, 1997 to determine the degree of saturation, queuing opportunities, delays, and capacity values found at the Tugu Ketupat Kandangan II roundabout. The current roundabout performance analysis reveals that the roundabout saturation value is 0.653. The capacity values for AB = 4310 pcu/hour, BC = 3781 pcu/hour, CA = 3440 pcu/hour. The value of the degree of saturation for AB = 0.471, BC = 0.653, and CA = 0.495. The average delay value is 4 sec /pcu. The queue probability value is 17%. For the next year's roundabout performance, the specified parameters are not fulfilled and the existing traffic flow can not be served. The research shows that several alternative solutions are needed and evaluated every few years to support the smooth, safe, and orderly traffic at the Tugu Ketupat Kandangan II roundabout.

***Keywords**:* Degree of saturation, queue probability, delay, roundabout performance analysis

1. INTRODUCTION

Compared to other transportation systems, road transportation is the most dominant means of transportation. Building a good land transportation network requires various facilities and infrastructure that can accommodate the development of emerging traffic flows. The roundabout at the intersection of Jalan Melati - Jalan Al-Falah - Jalan Brigjen H.M. Yusi was built following the enactment of regulations requiring special transport vehicles to cross the by-pass road which was originally an unsignaled 3 intersection so that the number of traffic accidents between vehicles was due to an increase in passing vehicles. reduce. Based on this, it is necessary to analyze the performance of the

roundabout to improve driver comfort and safety. Limitations of the problem to clarify the problem and facilitate the analysis are as follows:

a. The survey location is at the Tugu Ketupat Kandangan II roundabout which connects Jalan Melati, Jalan Al-Falah, and Jalan Brigjen H.M. Yusi.
b. The collection of traffic surveys, namely primary data, is carried out on weekdays during peak hours.
c. The analysis of the performance of the roundabout refers to the Manual Kapasitas Jalan Indonesia, 1997 and Pedoman Perancangan Bundaran untuk Persimpangan Sebidang, 2004.

2. THEORITICAL STUDY

2.1 Theoritical Foundation

Based on research states that roundabouts are a type of intersection control commonly used in urban and suburban areas. The transition of signaled / unsignaled intersections to roundabouts is carried out to reduce the number of traffic accidents between passing vehicles for safety. The advantages of roundabouts are that they slow down passing vehicles and warn of the danger of collisions with other vehicles.

Table 1. Definition of Roundabout Type

Type of Roundabout	Roundabout Radius (m)	Number of Entry Lines	Entry Lane Width W1 (m)	Weaving Length Lw (m)	Weaving Width Ww (m)
R10-11	10	1	3.5	23	7
R10-22	10	2	7.0	27	9
R14-22	14	2	7.0	31	9
R20-22	20	2	7.0	43	9

(Source: MKJI, 1997)

2.2 Input Data

2.2.1 Geometric Conditions

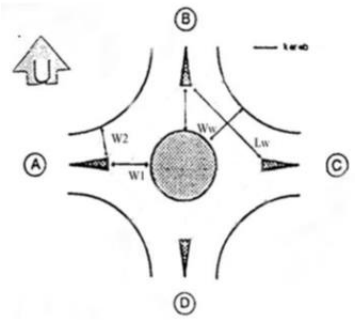

Figure 1. Roundabout Weaving *(Source: MKJI, 1997*)

2.2.2 Traffic Condition

The traffic condition input data is divided into the following three sections:

a. Sketch of the various movements and traffic flows.

b. Light vehicles (LV), heavy vehicles (HV), and motorcycles (MC) constitute the composition of traffic.

Table 2. Vehicle emp Value

Vehicle Type	emp
Motorcycles (MC)	0.5
Light Vehicles (LV)	1.0
Heavy Vehicles (HV)	1.3

(Source: MKJI, 1997)

c. The ratio of non-motorized vehicles is determined by the recorded flow of non-motorized vehicles.

2.2.3 Roundabout Weaving Ratio

a. Calculation of the ratio of motorized vehicles using:

$P_W = Q_W / Q_{TOT}$

b. Calculation of non-motorized vehicles using:

$P_{UM} = Q_{UM} / Q_{VEH}$

2.2.4 Environmental Conditions

a. City Size

Table 3. City Size Class

City Size (CS)	Total Population (millions)
Very Small	<0.1
Small	0.1-0.5
Medium	0.5-1.0
Large	1.0-3.0
Very Large	>3.0

(Source: MKJI, 1997)

b. Road Environment Type

Table 4. Environment Type

Commercial	Commercial land use (eg shops, restaurants, offices) with direct access for pedestrians and vehicles.
Settlements	Residential land use with direct access for pedestrians and vehicles.
Limited Access	No access or limited direct access (eg due to physical barriers, side roads, etc.)

(Source: MKJI, 1997)

c. Side Barrier Class

Side resistance is defined as high, medium, and low.

2.3 Capacity

a. Calculation of basic capacity using:

$$Co = 135 \times W_W^{1.3} \times (1+ W_E/W_W)^{1.5} \times (1 - P_W/3)^{0.5} \times (1+ W_W/L_W)^{-1.8}$$

Table 5. City Size Adjustment Factor

Size City (CS)	Population (Million)	Factor Adjustment Size City (F_{CS})
Very small	< 0.1	0.82
Small	0.1 - 0.5	0.88
Medium	0.5 - 1.0	0.94
Big	1.0 - 3.0	1.00
Very big	> 3.0	1.05

(Source: MKJI, 1997)

Table 6. Adjustment Factors for Type of Road Environment, Side Barriers, and Non-Motorized Vehicles

Class Type Environment Street (RE)	Class Obstacle Side (SF)	Ratio Vehicle Non-Motorized (P_{UM})					
		0.00	0.05	0.10	0.15	0.20	0.25
Commercial	High	0.93	0.88	0.84	0.79	0.74	0.70
	Medium	0.94	0.89	0.85	0.80	0.75	0.70
	Low	0.95	0.90	0.86	0.81	0.76	0.71
Settlement	High	0.96	0.91	0.86	0.82	0.77	0.72
	Medium	0.97	0.92	0.87	0.82	0.77	0.73
	Low	0.98	0.93	0.88	0.83	0.78	0.74
Access Limited	High/Medium/Low	1.00	0.95	0.90	0.85	0.80	0.75

(Source: MKJI, 1997)

b. Capacity calculation using:

$$C = C_O \times F_{CS} \times F_{RSU}$$

2.4 Traffic Behavior

2.4.1 Degree of Saturation

$$DS = Q/C$$

2.4.2 Delay

a. Traffic delay calculation using:

DT = 2 + 2.68982 x DS - (1 - DS) x 2 for DS < 0.6

DT = 1/(0.59186 - 0.52525 x DS) - (1 - DS) x 2 for DS > 0.6

b. Calculation of roundabout traffic delays using:

$DT_R = DT_{TOT}/Qenter$

c. Calculation of the roundabout delay using:

$D_R = DT_R + 4$ (sec/pcu)

2.4.3 Opportunity Queue

a. Upper limit; $QP\% = 26.65DS - 55.55^2 + 108.57^3$

b. Lower limit; $QP\% = 9.41DS + 29.967^{4.619}$

2.4.4 Calculation of Average Daily Traffic Projection

$$LHR\ n = LHR\ o\ (1 + i)^n$$

2.4.5 Weaving and Roundabout

Roundabout performance indicator parameter values are:

a. The value of the degree of saturation roundabout (DSr) < 0.80 (HCM, 1985)
b. The value of the degree of saturation of the weaving (DS) < 0.75 during peak hours (MKJI, 1997).
c. Average delay traffic (DT_R) < 10 sec/pcu (HCM, 1985).

Average queue probability (QP) < 35% (HCM, 1985).

3. METHOD

3.1 Research Location and Time

The research location is on Jalan Melati, Jalan Al-Falah, and Jalan Brigjen H.M. Yusi planned to take place for one day on weekdays during peak hours from 06.00 - 20.00.

3.2 Research Stage

3.2.1 Preparation

a. Consolidation of research methods, determination of methods, and analysis used in the study.
b. Study the literature to maximize the possibility to improve the discussion of research carried out using data and models that have been developed at the research site.
c. Survey preparation to facilitate on-site implementation.

3.2.2 Data Collection

a. The stage of preparing survey forms, survey resources, and making a schedule for survey implementation according to the survey method used.
b. The need for secondary data in the form of a collection of theories, provisions, and supporting regulations. Meanwhile, the field survey helped validate the data obtained through secondary data collection.
c. Data was collected through a secondary survey, namely collecting the necessary data from relevant agencies and direct observation in the field for primary data collection.
d. In carrying out the traffic volume survey, the surveyor will survey by observing directly at the location.
e. Using survey data, a roundabout performance analysis process was carried out based on the Indonesian Road Capacity Manual, 1997.

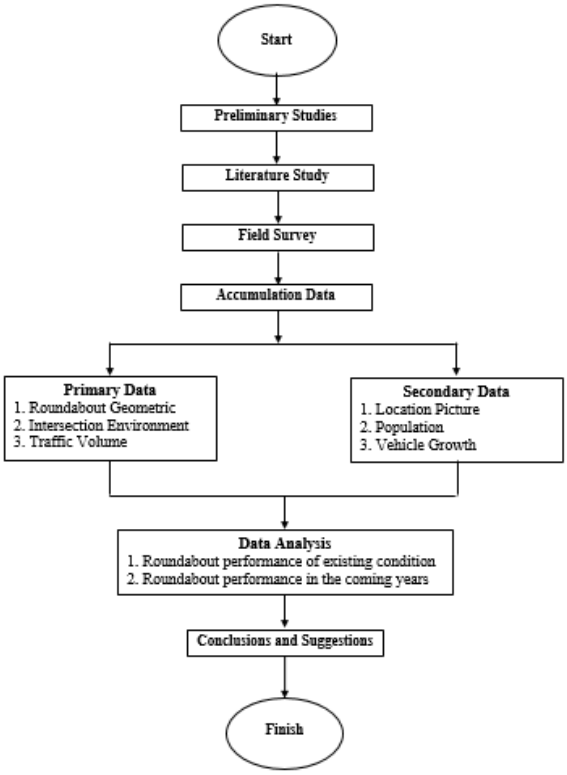

Figure 2. Research Flowchart

4. RESULTS AND DISCUSSION

4.1 Research Data

4.1.1 Roundabout Geometric Data

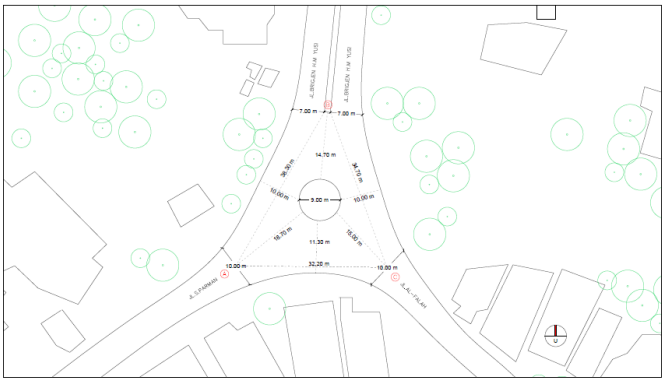

Figure 3. Geometric Roundabout

4.1.2 Traffic Flow Data

Table 7. Traffic Flow Data

Approach	Time	Direction Movement			Amount (pcu/hour)
		LT (pcu/hour)	RT (pcu/hour)	UT (pcu/hour)	
A (West)	Morning	731	598	0	1329
	Noon	520	952	0	1471
	Afternoon	298	680	0	977
	Evening	168	342	0	510
B (North)	Morning	840	1031	1	1872
	Noon	816	555	4	1375
	Afternoon	492	273	1	766
	Evening	293	172	0	465
C (East)	Morning	512	701	0	1213
	Noon	768	641	0	1409
	Afternoon	547	496	0	1042
	Evening	290	253	0	543

Peak hours occur in the morning = 4414 smp/hour

4.2 Performance Analysis of the Existing Roundabout

4.2.1 Calculation of the Roundabout Weaving

Table 8. Calculation of Roundabout Inflow

Approach	Roundabout Inflow (pcu/hour)	Q_{Enter} (pcu/hour)
A	$A-_{LT} + A-_{RT} + A-_{UT}$	1329
	731 + 599 + 0	
B	$B-_{LT} + B-_{RT} + B-_{UT}$	1872
	840+ 1031 + 1	
C	$C-_{LT} + C-_{RT} + C-_{UT}$	1213
	512 + 701 + 0	
Total		4414

Table 9. Calculation of the Roundabout Weaving

Weaving Section	Qw (pcu/hour)	Q_{TOT} (pcu/hour)	Pw (pcu/hour)
AB	598	2030	0.295
BC	1033	2470	0.418
CA	701	1703	0.412

Non-motorized vehicle ratio

$P_{UM} = Q_{UM} / Q_{MV}$

$= 293/7481$

$= 0.039$

4.2.2 Environmental Conditions

a. According to the Central Statistics Agency (BPS), in Hulu Sungai Selatan Regency there were 237,702 people in 2019, so the adjustment factor for the city size class classified as amounted to a small population.
b. Based on observations, the type of road environment is commercial.
c. Based on observations, the side resistance is classified as medium.

4.3 Capacity

Table 10. Geometric Weaving Parameters

Weaving Section	Wide Enter		Entry Width Average (W_E) ((W1+W2)/2)	Weaving Width (W)	Weaving Length (Lw)	Weaving Ratio (Pw)
	Approach 1 (W1)	Approach 2 (W2)				
AB	5	18.7	11.85	10	38.2	0.295
BC	7	14.7	10.85	10	34.7	0.418
CA	5	15	10	11.3	32.2	0.412

Table 11. Capacity Value

Weaving Section	Factor Adjustment		Capacity Base (Co) (pcu/hour)	Capacity Total(C) (pcu/hour) ($Co \times F_{CS} \times F_{RSU}$)
	Size City (F_{CS})	Environment Street (F_{RSU})		
AB	0.88	0.901	5436	4310
BC			4769	3781
CA			4339	3440

4.4 Traffic Behavior

Table 12. Roundabout Weaving Section Traffic Behavior of Existing Conditions

Weaving Section	Inflow Section Weaving (Q_{TOT}) (pcu/hour)	Degree of Saturation (DS)	Traffic Delay Section Weaving (DT) (sec/hour)	Total Traffic Delay (DT_{TOT}) (sec/hour) ($Q_{TOT} \times DT$)	Queue Chance (QP%)	Average Queue Chance (QP%)
AB	2030	0.471	2,208	4482	5 - 12	8.5
BC	2470	0.653	3,326	8216	10 - 24	17
CA	1703	0.495	2,321	3953	6 - 13	9.5
DS from DS_R weaving		0.653	Total	16651		
Average roundabout traffic delay DT_R (sec/pcu)				4		
Average roundabout delay D_R (DT_R + 4) (sec/pcu)				8		
QPR roundabout queue odds%					10 - 24	17

4.5 Roundabout Performance Analysis for the Next Year

4.5.1 Average Daily Traffic Projection

Table 13. Number of Vehicles 2013-2017

Type Vehicle	EMP	Amount Vehicle									
		2013		2014		2015		2016		2017	
		Vehicle	smp	Vehicle	smp	Vehicle	smp	Vehicle	smp	Vehicle	smp
Motorcycle (MC)	0.5	1675773	837887	1880110	940055	1906056	837887	2049005	1024503	2256937	1128469
Light Vehicle (LV)	1	192953	192953	199383	199383	215154	192953	249889	249889	278994	278994
Heavy Vehicle (HV)	1.3	274654	357050	355570	462241	358265	357050	403428	524456	419136	544877
Total			1387890		1601679		1387890		1798848		1952339

Table 14. Traffic Growth Rate

Year	LHR	LHRo (pcu/hour)	LHRT (pcu/hour)	N	i (%)
2013	1387890	-	-	-	-
2014	1601679	1387890	1601679	1	15,40
2015	1387890	1601679	1387890	2	-6.91
2016	1798848	1387890	1798848	3	9.03
2017	1952339	1798848	1952339	4	2.07
Growth (i)					4.90

4.5.2 Traffic Behavior in the Next Year

Table 15. Traffic Behavior for the Next Year

Year-	Weaving Section	$DS_R < 0.80$	$DS < 0.75$	$DT_R < 10$ sec/pcu	$QP < 35$ (%)
Existing	AB	0.653	0.471	4	17
			Yes		
	BC		0.653		
		Yes	Yes	Yes	Yes
	CA		0.495		
			Yes		
5	AB	0.830	0.598	6	33
			Yes		
	BC		0.830		
		No	No	Yes	Yes
	CA		0.629		
			Yes		
7.5	AB	0.935	0.674	9	48
			Yes		
	BC		0.935		
		No	No	Yes	No
	CA		0.709		
			Yes		
10	AB	1.054	0.760	19	70.5
			No		
	BC		1.054		
		No	No	No	No
	CA		0.799		
			No		
	CA		0.513		
			Yes		

4.5.3 Alternative Analysis of Roundabout Geometric Change

Table 16. Geometric Parameters of the Roundabout Weaving

Weaving Section	Entry Width		Average Entry Width (W_E)	Weaving Width (Ww)	Weaving Length (Lw)	Weaving Ratio (Pw)
	Approach 1	Approach 2				
AB	10	20	15	15	40	0.295
BC	10	20	15	15	40	0.418
CA	10	20	15	15	40	0.412

Table 17. Alternative Traffic Behavior of Geometric Changes in the Next 10 Years

Year-	Weaving Section	$DS_R < 0.80$	$DS < 0.75$	$DT_R < 10$ sec/pcu	$QP < 35$ (%)
Alternative Geometric Change Next 10 Years	AB	0.745	0.598	5	24.5
			Yes		
	BC		0.745		
		Yes	Yes	Yes	Yes
	CA		0.513		
			Yes		

5. CONCLUSIONS

5.1 Conclusion

a. Performance roundabout on existing condition is still able to serve the traffic flow.

b. Performance roundabout on conditions for the coming years:

1) In the next 5 years, the condition will not be able to serve the traffic flow because the specified DS_R and DS of the BC weaving section parameters are no longer fulfilled.

2) In the next 7,5 years, the condition will no longer be able to serve the traffic flow because DS_R, DS of the BC weaving section, and the average QP% parameters

are no longer fulfilled.

3) In the next 7,5 years, the condition will not be able to serve the traffic flow.

c. Tugu Ketupat Kandangan II roundabout in the next 10 years is already very poor ability to serve traffic flow. Therefore, an alternative geometric change is determined so that performance of the roundabout in the next 10 years is still capable serve traffic flow.

5.2 Suggestions

1. In addition to changing the geometry, other alternative solutions are needed because in the roundabout area, the land is very limited and the area is filled with many shops, offices, community houses, etc. so it will be difficult if the land acquisition has to be carried out.
2. Some other alternatives are to change the traffic management settings, addition of APILL or converting it into a roundabout that has a signal where this must be carried out further research because this Final Project only discusses the performance analysis of the roundabout.
3. Discipline public transport when lifting and unloading passengers.
4. Further research is needed to compare each research of all surveys conducted with higher accuracy.

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