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PERFORMANCE ANALYSIS OF SIMPANG EMPAT ROUNDABOUT IN BANJARBARU CITY

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ABSTRACT

The design of roundabout intersections is one of the vital aspects in the development of road networks, especially in areas with high traffic density from various directions. One of the roundabouts located in Banjarbaru City serves to serve the flow of vehicles from four main directions, namely Banjarbaru, Martapura, Sungai Ulin, and Cempaka. Along with the growth in population and motorized vehicles, traffic problems in the form of conflicts between vehicles and congestion are becoming increasingly complex at this location. The analysis method used refers to the 2023 Indonesian Road Capacity Guidelines (PKJI 2023) and analysis using Excel software. The data analyzed include the geometric aspects of the roundabout, traffic volume for 24 hours, and population data for Banjarbaru City. The results of the study showed that the existing conditions resulted in a degree of saturation (Ds) of 0.861, a delay (T) of 13.690 seconds/pcu, and a queue opportunity (Pa) of 51%, which indicates that the performance of the roundabout has decreased. After conducting repair simulations, there are two alternative solutions proposed, namely changing the roundabout into an intersection with traffic lights (APILL) which is able to reduce Ds to 0.721 and delay (T) to 11.51 seconds/pcu, as well as the option of widening the road geometry which produces Ds of 0.675, delay of 10.117 seconds/pcu, and the opportunity for queues to decrease to 26%.

Keywords: roundabout, degree of saturation, delay, PKJI 2023, APILL intersection.

1. INTRODUCTION

Roundabouts are one of the most important types of intersections in highway planning because in this location there is traffic interaction from various directions with various destinations. Considering that intersections are used jointly by all road users, the design must pay attention to aspects of safety, efficiency, speed, operational costs, and road capacity. The intersection located at the confluence of Jalan A.Yani (Banjarbaru), Jalan A.Yani (Martapura), Jalan Ir. P. M. Noor, and Jalan H. Mistar Cokro Kusumo is currently regulated by a roundabout system. The roundabout serves the flow of vehicles from four main directions: Banjarbaru, Martapura, Sungai Ulin, and Cempaka. Although the geometry of this roundabout has not changed since the last few years, the increase in the number of people in Banjarbaru City has led to a significant growth in vehicle volume.

This results in a high density of vehicles passing through the roundabout, especially during peak hours, both on weekdays and weekends. As a result, there are frequent traffic jams, vehicle delays, and long queues on all roundabout arms coming from various directions of the road.

2. THEORETICAL FOUNDATION

Roundabout

Roundabouts are a type of intersection regulated by traffic regulations in Indonesia, with the main principle of giving priority to vehicles that are already on the main lane of the roundabout. Based on their classification, roundabouts can be divided into two main types: single lanes and roundabout lanes. This type of junction was first developed in the United Kingdom and America, then widely adopted in various countries, including Indonesia. Roundabouts are considered more effective to be used at road intersections with relatively balanced current capacity and volume. Therefore, roundabouts are ideally applied to the intersection of two or four lanes. However, if applied to roads with a larger volume, the risk of congestion and a decrease in the level of safety will increase (Dharmawan & Syahroni, 2016). Traffic conflicts that arise at this roundabout have the potential to cause congestion, so it is necessary to evaluate performance periodically by considering traffic parameters. Therefore, traffic performance analysis needs to be carried out continuously to anticipate the increasing volume of vehicles (Waris, 2018).

Vehicle Classification

Based on PKJI 2023, vehicles that pass through are categorized into five main groups: Motorcycles (SM), Passenger Cars (MP), Medium Vehicles (KS), Large Buses (BB), and Heavy Trucks (TB). Meanwhile, non-motorized vehicles are not taken into account in the main traffic flow because they are considered a side barrier, and their effect has been compensated through the side obstacle capacity correction factor (FCHS). For urban areas, vehicles are grouped into only three main categories, namely SM, MP, and KS. Capacity calculations on urban roads include main road capacity, intersection capacity with signal (APILL), non-signalized intersection capacity, and intersection lane capacity.

3. METHOD

This study uses a field observation method that aims to obtain primary data directly at the study location, namely the intersection roundabout in Banjarbaru City, South Kalimantan. Observations were carried out directly in the field for a full 24 hours to get a real picture of the traffic conditions that occurred. The data collected consisted of primary data in the form of geometric surveys and traffic volumes, as well as secondary data in the form of data on the population of Banjarbaru City.

4. RESULTS AND DISCUSSION

Roundabout Geometric Data

Based on the results of a field survey conducted from June 24 to 25, 2024, it shows a geometric picture of the intersection of Banjarbaru City. Traffic data calculations were taken for a full 24 hours, starting at 24.00 to 23.59 WITA with time recording intervals every 10 minutes. This geometric data is then processed in accordance with the provisions of PKJI 2023.

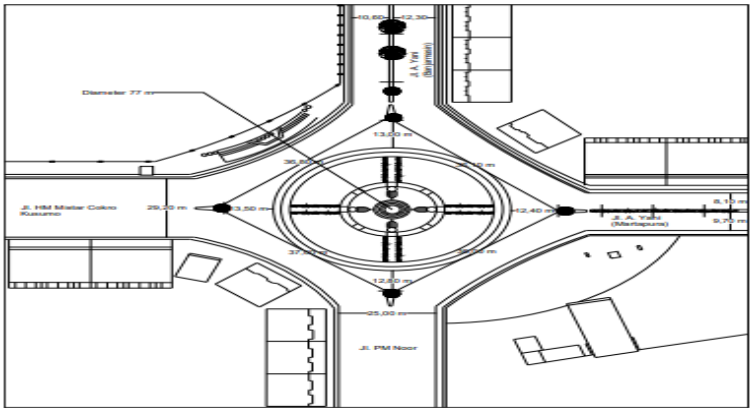

Figure 4. 1 Geometric Roundabout Simpang Empat Banjarbaru City

Population Data

Data on the population of Banjarbaru District was obtained from the Central Statistics Agency (BPS) of Banjarbaru City, South Kalimantan Table 4.1.

Table 4. 1 Number of Population of Banjarbaru District (BPS Banjarbaru City)

Yes	Year	Sum Inhabitant	Growth Rate (%)
1	2020	253.442	1.34
2	2021	258.753	1.57
3	2022	265.575	1.67
4	2023	272.763	1.71
5	2024	285.546	1.77

Based on Table 4.1 data from the Central Statistics Agency (BPS) of Banjarbaru City, the number of people in the period 2020 to 2024 has increased by an average of 1.61% per year. The average population in that period was around 267,215 people, which classifies Banjarbaru City as a small city according to PKJI 2023.

Traffic Conditions

From the observation results, the highest traffic flow occurred in the afternoon between 16.20 - 17.20 WITA with a total flow of 4917 smp/hour. The volume of vehicles is calculated based on conversion to passenger car units (SMP) using equivalent values according to PKJI 2023. Other peak traffic movements occur in the morning, afternoon, and evening with varying volumes.

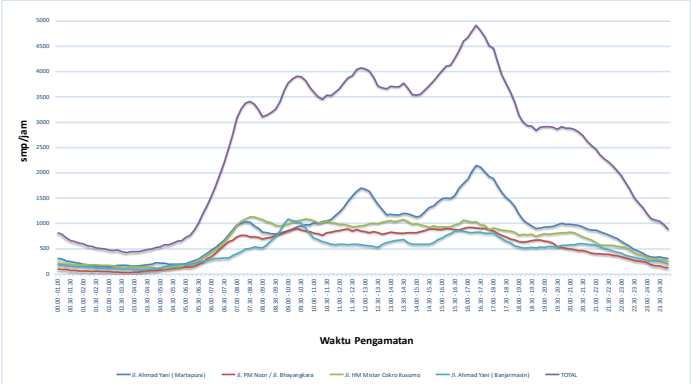

Figure 4. 2 Traffic Flow Graph

Based on Figure 4.2, it is found that the peak of the flow in the morning movement (day trip) occurs in the morning period at 08.50 to 09.50 WITA with a total movement of 3624 junior high schools/hour, during the day from 11.50 to 12.50 WITA as many as 4078 junior high schools/hour, and in the afternoon from 16.20 to 17.20 WITA as many as 4917 junior high schools/hour. The peak of the flow for night trips occurs at 19.40 to

20.40 WITA with a total movement of 2913 smp/hour. Data on the amount of traffic flow during peak hours can be seen in Table 4.2.

Table 4. 2 Number of Traffic Flows at peak hours at Banjarbaru Roundabout

PERIOD	LARGEST CURRENT	PEAK HOUR	SM	MV	KS	TOTAL
Morning (duration 9 hours)	Jl. Ahmad Yani (Martapura)	08.50 - 09.50	206	573	44	839
	Jl. Ir.P.M.Noor		196	406	216	818
	Jl. H.Mistar Cokro Kusumo		306	478	188	972
	Jl. Ahmad Yani (Banjarbaru)		249	665	62	996
	Total					**3624**
Afternoon (duration 5 hours)	Jl. Ahmad Yani (Martapura)	11.50 - 12.50	329	1254	105	1697
	Jl. Ir.P.M.Noor		197	470	182	849
	Jl. H.Mistar Cokro Kusumo		260	482	207	954
	Jl. Ahmad Yani (Banjarbaru)		134	382	39	579
	Total					**4078**
Afternoon (duration 5 hours)	Jl. Ahmad Yani (Martapura)	16.20 - 17.20	446	1623	59	2140
	Jl. Ir.P.M.Noor		203	541	170	913
	Jl. H.Mistar Cokro Kusumo		331	517	185	1034
	Jl. Ahmad Yani (Banjarbaru)		240	522	38	831
	Total					**4917**
Night (duration 5 hours)	Jl. Ahmad Yani (Martapura)	19.40 - 20.40	285	673	39	1000
	Jl. Ir.P.M.Noor		137	315	77	529
	Jl. H.Mistar Cokro Kusumo		299	416	101	815
	Jl. Ahmad Yani (Banjarbaru)		144	384	24	569
	Total					**2913**

A. Roundabout Performance Analysis

1. Basic capacity (Co)
   = Ww Factor × We/Ww Factor × Pw Factor × Ww/Lw Factor = 3751 × 2538 × 0.855 × 0.575 = 4.685 smp/hour
2. City Size Correction Factor (FUK)

   The number of people taken from data on the number of people according to age groups (souls) in Banjarbaru City was obtained at ±267,715 people. So the FUK at the Simpang Empat Roundabout in Banjarbaru City is included in the size of the city is very small = 0.88.

3. Road Environmental Factors (FRSU)

   The type of road environment includes the commercial category with high side resistance, FRSU value = 0.93.

4. Total Capacity (C)

   C = Co × FCS × FRSU = 4675 × 0.88 × 0.93 = 3.870 smp/hour

B. Traffic Behavior

1. Total Traffic Flow (q)

   Q = 3,250 smp/hour

2. Degree of saturation (DS)

   DS = q/c = 3250/3870 = 0.861

3. Traffic Delay in the Strut (Tr) section

   $= \frac{1}{(0{,}96815 - 0{,}52525 \times DS)} - (1 - Ds) \times 2$

   $= \frac{1}{0{,}96815 - 0{,}52525 \times 0{,}861)} - (1 - 0{,}861) \times 2 = 6.89$ sec/smp

4. Total traffic delays (DTOT)

   = q × TR = 3250 × 689 = 22,389

5. Roundabout traffic delay (TLL)

   $= \frac{\sum DTOT}{MVTOT} = \frac{22{,}389}{2{,}215} = 9{,}690$ sec/smp

6. Roundabout delay (T)

   = TLL + 4 = 9.690 + 4 = 13.690 sec/smp

7. Opportunities for Success (Pa)

   The upper limit percentage of the odds can be calculated as follows:

   Pa = 26.65 × 0.861 – 55.55 × 0.8612 + 108.87 × 0.8403 = 51%

   The lower limit percentage of opportunities can be calculated as follows:

   Pa = 9.41 × 0.861 + 29.967 × 0.8614.619 = 23%

   So the average chance of queue = (51% + 23%)/2 = 37%

8. Indicators Work

   Based on the results of the current analysis, the performance of the Simpang Empat Roundabout in Banjarbaru City is no longer optimal because it does not meet the work indicators that show the Degree of Saturation (DS) > 0.85, the T Roundabout Delay > 10 sec/smp, and the Queue Opportunity > 35%. Then alternative improvements will be made to overcome the problem.

9. Roundabout Handling Alternatives

   Based on the results of the analysis of the performance of the intersection roundabout, which shows that the value of Ds ≥ 0.861 exceeds the roundabout performance limit

set in PKJI 2023, which is Ds ≤ 0.85, efforts are needed to handle the alternative intersection. The recommended treatment alternatives are as follows:

1. Changes with the Traffic Signaling Device (APILL) at the intersection roundabout.
2. Geometric widening of the road.

Table 4. 3 Recapitulation of Comparative Values of Roundabout Conditions

No.	Management of Simpang Empat Banjarbaru Roundabout	Degree of Saturation (Ds)	Traffic Delays det/smp	Delay (T) det/smp	Queue Opportunities (Pa %)
1.	Existing	0,861	6,89	13,690	51%
2.	APILL 4 Phase Junction Changes	0,896	37,8	30,8	-
3.	APILL 3 Phase Junction Changes	0,874	35,4	28,24	-
4.	Changes to APILL 2 Phase Junction	0,721	13,2	11,51	-
5.	Geometric Widening of the Road	0,675	3,56	10,117	26%

From the results of the calculation analysis carried out at the Simpang Empat Roundabout in Banjarbaru City, it was found that in the existing condition the roundabout no longer has optimal performance. Then two alternative handling options were carried out, namely the first by widening the road with optimal performance results and the alternative handling of the installation of traffic signaling devices (APILL) with optimal results. From all the analyses carried out, it was found that the results of the analysis with road widening and 2-phase APILL were better for the Simpang Empat Roundabout compared to the 4-phase APILL and 3-phase APILL alternatives.

5. CONCLUSIONS AND SUGGESTIONS

Conclusion

From the problems and discussions in this study, it can be concluded that:

1. In the existing condition, the roundabout showed less than optimal performance with the results of the analysis of the degree of saturation (Ds) value of 0.861, delay (T) of 13.690 sec/junior high, and the chance of queue (Pa) of 51%.
2. Because the performance of the roundabout in existing conditions is not optimal, alternative handling planning is carried out. Two alternatives were obtained, namely by changing the intersection to an APILL intersection with the results of the analysis

obtained a Degree of Saturation (Ds) of 0.721 and Delay of the intersection (T) of 11.51 seconds/junior high and a geometric widening of the road with the result of a Degree of Saturation (Ds) of 0.675, Delay (T) of 10.117 seconds/junior high, and Chance of Queue (Pa) of 26%. Alternative improvements in the form of two-phase APILL intersections and road geometry widening have proven to be able to improve traffic performance.

Suggestion

The suggestions that have been given related to this Final Project include:

1. Further studies are needed on other handling alternatives considering the limited land around the roundabout which is filled with shops and residential areas.
2. Installation of traffic signs such as parking prohibitions and stops in the area around roundabouts to reduce side obstacles.
3. Increasing awareness of traffic order among road users to create safe and comfortable traffic conditions.
4. The implementation of the proposed improvement alternatives needs to be prioritized to improve the performance of the roundabout in the coming years.

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