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Abstract. The high level of population growth can have an impact on increasing traffic growth, especially at intersection points. One of the intersections in Palembang is the Patal-Pusri intersection which has been equipped with an underpass to overcome the level of congestion that occurs at the intersection. The purpose of this study was to analyze the performance of the Patal-Pusri intersection after the underpass was operation. The analyze was conducted by calculating the cycle time, capacity and level of service the existing traffic flow and do an evaluation the comparison of the level of service at the beginning of the underpass operation in 2015 with current conditions. the traffic survey was conducted at 3 busy times, namely 06.00 - 08.00 WIB, 11.00 - 13.00 WIB and 16.00 - 18.00 WIB. Data were analyzed using the guidelines for the Indonesian Signalized Intersection Road Capacity Manual (1997). The results of the calculation of the cycle time obtained by 141 seconds, the intersection capacity of 3390 pcu/hour and the largest volume of traffic flow is 3142 pcu/hour. Analysis level of service of 0.909 (Level E) which means very bad. Whereas level of service at the beginning of the underpass operation was at level A which means very good, this shows that occurrence the decline in level of service from level A to level E within 4 years.

1. Introduction

Roads are land transportation infrastructures that have an effect on improving people's lives. Land transportation problems include traffic jams, accidents, queues and delays that often occur in cities that have a traffic volume that exceeds the capacity of a road. Intersections are a node in the transportation network where two or more roads meet and here the traffic flow experiences conflict [1]. Traffic rules are set to control this conflict so that it can be determined who has the first right to use the intersection. The choice of intersections for an area should be based on economic, traffic safety and environmental considerations [2]. If the road and intersection cannot accommodate the large number of vehicles, then what happens is a decrease in the performance of a road and intersection.

Types of intersections based on how the arrangement is divided into 2, namely signalised Intersection and unsignalised Intersection, while based on the type of intersection divided by 2, namely intersection and interchange [3]. Several studies have been carried out on the intersection including research that analyzes the performance of the Boru intersection in Serang city which shows the level of service at the Boru intersection is D (Budiman, et al, 2016), the study states that the crossing performance at the Tanjung Api-Api intersection in Palembang is E to F [4,5] and another study is a performance analysis at the intersection of Teuku Umar Barat street - Gunung Salak street is E to F [6], while [7] states that the performance of the RE Martadinata street intersection is E to F, research on the evaluation of the

performance of the four arm signals at the Inpres intersection Lhokseumawe city [8], and research on the analysis of traffic performance of the three arm intersection in Manado city [9].

The Patal – Pusri Intersection is one of the four signal intersections in Palembang City that is equipped with an underpass in the direction of R.Soekamto - Abdul Rozak. Patal - Pusri intersection has the potential to cause accidents, queues, traffic jams and delays due to fairly dense traffic flow especially during peak hours with various types of vehicles inside. Traffic current that through the intersection Patal - Pusri is the current in R. Soekamto street - MP. Mangkunegara street - Abdul Rozak street and AKBP Cek Agus street. The type of environment around the Patal – Pusri intersection is a commercial area, this can be seen by the presence of offices, hotels, housing, shopping centers and others. The existence of the underpass at the intersection will certainly have an impact on the performance of the intersection, so it is necessary to do an analysis of the Patal - Pusri intersection after operating the underpass for a span of 4 years. The purpose of this study was to analyze the performance of the Patal-Pusri intersection after the underpass was operation. The results of research conducted can be used in solving problems that occur at the intersection under review.

2. Methodology

2.1. Study area

This research was conducted in the city of Palembang at the intersection of the Patal-Pusri Underpass. This underpass intersection consists of R. Soekamto street (south), MP. Mangkunegara street (west), R. Abdul Rozak street (north), and AKBP. Cek Agus street (east). The location map survey can be seen in Figure 1.

Figure 1. Study Area

. Framework analysis

Activities in this study consist of several stage, namely: the first stage of secondary data collection, obtained through intermediary media, books, notes, evidence that already exists or archives that are either published or not publicly published; the second step was to carry out a preliminary survey to determine the location of the observation by measure the distance from the point to point needed in the survey, then determine the method to be used and preparation before direct observation on the road

section; the third stage was the collection of primary data, that is: measurement of the width of the traffic lanes (geometric data), traffic volume surveys of each type of vehicle (traffic counting), side barriers, traffict lights; and the fourth step is to compile the data and analyze the crossing performance that was reviewed.

2.2. Performance analysis of signalized intersections [10]

Several equations are used to calculate the performance of the Patal-Pusri intersection, namely:

1) Basic Saturated Current

Basic saturated current (S0) is the amount of queue departure in the approach during ideal conditions (pcu/ green hour).

$$S_0 = 600 \text{ x } We \text{ pcu/green hours} \quad (1)$$

2) Saturated Current

A saturated current (S) is the queue magnitude departures in the approach during certain conditions after adjusted to the intersection conditions (pcu/green hour).

$$S = S_0 \times F_{CS} \times F_{SF} \times F_G \times F_P \times F_{RT} \times F_{LT} \quad (2)$$

3) Cycle Time

Cycle time is the complete sequence of signal indications (between two consecutive green starts at the same approach).

Cycle time before adjustment:

$$Cua = 1{,}5 \text{ x } LTI + 5 / 1 - IFR \quad (3)$$

Green time:

$$g_i = (Cua - LTI) \text{ x } PRi \quad (4)$$

Adjustable cycle time:

$$c = \Sigma g + LTI \quad (5)$$

4) Capacity and Degree of Saturation

Capacity (C) is the maximum amount of traffic that can be accommodated by an approach in a certain time. The capacity for each approach is:

$$C = S \text{ x } g / c \quad (6)$$

The capacity value is used to calculate the degree of saturation (DS) of each approach.

$$DS = Q / C \quad (7)$$

5) Traffic Behavior

Number of queues (NQ1) remaining from the previous green phase.
For DS > 0,5 :

$$NQ_1 = 0{,}25 \text{ x C x } [(DS-1) + \sqrt{(DS-1)^2 + (Sx(DS-0{,}5)/C]} \quad (8)$$

Calculate the number of queues that arrive during the red phase (NQ2) with the following equation:

$$NQ_2 = C \text{ x } [(1-GR)/(1-GRxDS)] \text{ x } (Q-3600) \quad (9)$$

Number of vehicles waiting in line:

$$NQ = NQ_1 + NQ_2 \quad (10)$$

Queue length calculation is as follows:

$$QL = (NQ_{MAX} \text{ x } 20) / (W_{ENTER}) \quad (11)$$

Stop number (NS) for each approach which is defined as the average number of stops per unit of a passenger car (including repeated stops in the queue) whose value can be calculated by the equation:

$$NS = 0{,}9 \text{ x } (NQ/QxC) \text{ x } 3600 \quad (12)$$

Calculation of the number of vehicles stopped from each crossing arm is calculated by the equation:

$$N_{SV} = Q \times NS \quad (13)$$

Average stop number for all intersections (NSTOT) are calculated by the equation:

$$NSOT = (\sum NSV) / QTOT \quad (14)$$

The average traffic delay of each approach (DT) is calculated by the equation:

$$DT = c \times A + [(NQ_1 \text{ x } 3600)/C] \quad (15)$$

$$A = \text{constanta} = [0{,}5x(1\text{-}GR)^2]/[(1\text{-}GRxDS)] \quad (16)$$

The value of the ratio of vehicles stopped at the approach (Psv) is calculated by the equation:

$$Psv = Nsv / \Sigma Q \text{ Total} \quad (17)$$

The average geometric delay of each approach can be calculated with the following equation:

$$DG_j = (1 - Psv) \times PT \times 6 + (Psv \times 4) \quad (18)$$

Of all the delays, the results are added to the equation as follows:

$$D = DT + DG \quad (19)$$

Hereafter is to determine the total amount of delay, with the following equation:

$$\Sigma D = D \times Q \quad (20)$$

The average delay is calculated by the following equation:

$$D_I = \sum(D \text{ x } Q) / Q \text{ total} \quad (21)$$

3. Data and analysis

3.1. Peak days and hours

Accumulation of vehicle density on peak hours can be seen in Table 1.

Table 1. Accumulation of vehicle density on peak hours

Days	Times	Volume (pcu)*
Monday	06.35 – 07.35	10076
Tuesday	06.30 – 07.30	9594
Wednesday	06.10 – 07.10	9391
Thursday	06.45 – 07.45	9334

Friday	06.25 – 07.25	8684
Saturday	17.00 – 18.00	8657

*The result show peak hours were on Monday.

3.2. Analysis

3.2.1. Calculation of capacity and level of service

Calculation of traffic current (Q) on the direction of the R. Soekamto street is 332 PCU/hour, the direction of the MP. Mangkunegara street is 1605 PCU/hour, the direction of the R. Abdul Rozak street is 167 pcu/hour, and the direction of the AKBP Cek Agus street is 1038 pcu/hour. Calculation of the traffic current ratio (Q/S) on the R. Soekamto street direction is 0.13, the direction of the MP. Mangkunegara street is 0.38, the direction of R. Abdul Rozak street is 0.07, and the direction of the AKBP Cek Agus street is 0.27.

Calculation of phase ratio (PR) on the direction of R. Soekamto street is 0.16, the direction of MP. Mangkunegara street is 0.46, the direction of R. Abdul Rozak street is 0.08, and the direction of the AKBP Cek Agus street is 0.33. Calculation of green traffic light time (g) on the direction of the R. Soekamto street is 20, the direction of the MP. Mangkunegara street is 57, the direction of R. Abdul Rozak street is 11, and the direction of AKBP Cek Agus street is 41.

Calculation of capacity (C) on the direction of R. Soekamto street is 369, the direction of MP. Mangkunegara street is 1701, the direction of R. Abdul Rozak street is 189, and the direction of the AKBP Cek Agus street is 1131. Degree of saturation calculation (Q/C) on the direction of R. Soekamto street is 0.899, the direction of MP. Mangkunegara street is 0.943, the direction of R. Abdul Rozak street is 0.883, and the direction of the AKBP Cek Agus street is 0.914.

Calculation of level of service (LoS) on the direction of R. Soekamto street is E, the direction of MP. Mangkunegara street is E, the direction of R. Abdul Rozak street is E, and the direction of AKBP Cek Agus street is E. The level of service at level E can be characterized as different current speeds even sometime stop, volume approaches capacity standard.

3.2.2. Intersection performance analysis

The results of calculating the volume, capacity and queue length in 2019 can be seen in Table 2, while the average delay of level of service can be seen in Table 3.

Table 2. Volume, Capacity, Queue Length on Patal - Pusri Intersection in 2019

Approach Name	Volume (pcu/hour)	Capacity (pcu/hour)	Queue Length (m)
R.Soekamto	332	369	115.56
MP.Mangkunegara	1605	1701	197.14
R. Abdul.Rozak	167	189	71.11
AKBP.Cek Agus	1038	1131	177.14

Table 3. The Average Delay of Level of Service in 2019

Approach Name	The Average Delay (seconds/pcu)	Level of Service	Annotation

R. Soekamto MP. Mangkunegara R. Abdul Rozak AKBP Cek Agus	86,36	F	Very Bad

From the calculation of the average delay the performance level of service obtained at the intersection of Patal - Pusri is at level F, which is very bad. From these results, of course there must be efforts to improve the performance of the intersections on Patal - Pusri.

3.2.3. Comparison evaluation of level of service

Reptyalyani (2015) has conducted research on level of service performance on Patal - Pusri intersection at the beginning of the undepass operation at the Patal - Pusri Intersection. The results of the research on the performance of the Patal - Pusri Intersection can be seen in Table 4 and Table 5.

Table 4. Volume, Capacity, Queue Length on Patal - Pusri Intersection in 2015

Approach Name	Volume (pcu/hour)	Capacity (pcu/hour)	Queue Length (m)
R.Soekamto	252,3	1258	151.30
MP.Mangkunegara	2186	755	237.98
R. Abdul.Rozak	171.3	755,18	167.18
AKBP.Cek Agus	800	587	240.76

Table 5. The Average Delay of Level of Service in 2015

Approach Name	The Average Delay (seconds/pcu)	Level of Service
R.Soekamto MP. Mangkunegara R. Abdul.Rozak AKBP.Cek Agus	110	A

When compared with the results of research on the Patal - Pusri intersection in 2015 at the beginning of the underpass operation with the current research results in 2019, it was found that the performance of the Patal - Pusri intersection in 2015 as a whole was at level A which means that the crossing performance was very good while the level of service in 2019 is at level F which means very bad. this shows that after 4 years since underpass infrastructure was completed until now, level of service Patal - Pusri intersection has decrease from level A to level F. This decrease in service level can be caused by many things, such as the level of traffic growth at the Patal - Pusri intersection is very high, the increasing number of vehicles in the city of Palembang and population increase. For that the government must be pay more attention with problems that will arise at the Patal - Pusri intersection.

4. Conclusions

The conclustion from this analysis is the level of service obtained at each phase of the intersection is E (very bad) whereas level of service at the beginning of the underpass operation was at level A which means very good, this shows that occurrence the decline in level of service from level A to level E within 4 years.

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