Evaluation of Service at the 4-Way Intersection on Soekarno Hatta Street Palembang City

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Abstract. The four-arm intersection that connects Jalan Macan Lindungan, Parameswara, Soekarno Hatta and Jalan Prawiranegara, is an intersection that requires an evaluation of traffic management, especially in regulating flow and traffic lights. The purpose of this research is to find out whether the current regulation of traffic and traffic lights can still be used or not. This type of research is in the form of quantitative descriptive with data collection methods with direct data collection in the field for 7 days, especially during peak hours. The data needed are road geometry, traffic volume for each vehicle composition based on its direction (straight, turn left, and turn right), side barriers, speed and queue length. The implementation procedure refers to the 1997 HCM and other supporting references. From the results of data processing obtained, it can be concluded that there is a need for a traffic light arrangement design and flow diversion. This is because the number of vehicles passing through the intersection exceeds the capacity, causing congestion and long delays, especially during peak hours.

Keywords: Crossroads · Flow · Traffic Lights

1 Introduction

An intersection can be interpreted where a traffic flow from various directions meets or crosses [1]. Broadly speaking, intersections are divided into two types, namely level (meet) and non-plot (separate) intersections. At the intersection of a plane there are many points conflict points caused by vehicle manoeuvers, namely diverging, merging, crossing [2]. The conflicts that most often causes traffic accidents is crossing [3, 4].

In big cities conflicts at intersections will often occur. Conflict can be interpreted as a condition in which road users (people and vehicles) approach each other at the same time and space, causing a risk of collision if the movement cannot be changed [1]. The cause is the number of vehicles passing through the intersection and each other wanting to pass the intersection first so that there will be a buildup of vehicles at the point of conflict which can result in congestion, long delays and accidents. The speed of the vehicle also looks not well controlled. Therefore, a solution to this problem is needed, one of which is the presence of traffic lights. Traffic lights are used to avoid congestion at intersections, provide opportunities for vehicles/pedestrians at each intersection to pass through intersections, reduce traffic conflicts/accidents [5, 6].

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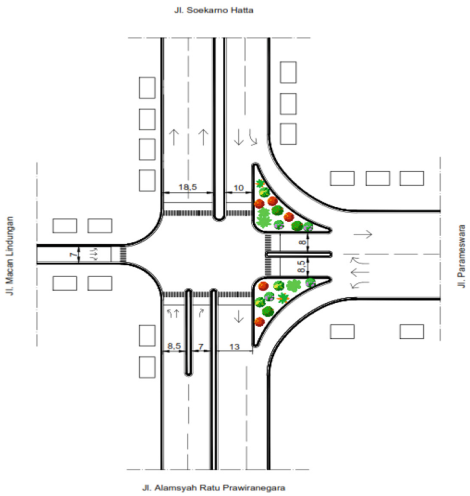

Fig. 1. 4.way intersection on Soekarno Hatta Street

As one of the big cities on the island of Sumatera, especially South Sumatra, Palembang City has many intersections that require management for smooth traffic. PJunction of Inspector Marzuki-Way Hitam-Sei Rambang, Tanjung Api-Api, and the Intersection of Force 66 have evaluated and re-analyzed the performance of the intersection. The result of this analysis is that there is a need to reset the cycle time [7–9]. The intersection at batch 66 has been diverted but cannot solve the problem with service level D [8]. One solution is the planning of a non-level intersection (flyover).

Of the three intersections, solutions to the problem have been found, but there are still many intersections that require re-evaluation of the performance of the intersection, one of which is the Soekarno-Hatta intersection. This intersection is very crowded and there are frequent delays. In addition, Soekarno-Hatta Road is a Sumatran cross road filled with heavy vehicles between provisions and a connecting road to the toll gate.

In the applicable regulations, arterial road access should be connected to the collector and the collector road connected to the local [10, 11]. This is due to differences in vehicle types, speed and width and functions of the road [4]. However, this does not apply to the Soekarno-Hatta intersection which connects the arterial-local road directly at the intersection. Based on the results of the initial survey that has been carried out, the road on the Macan Lindungan route is a local road category with a width of 7 m for two lanes connected directly to Soekarno-Hatta and Alamsyah Ratu Prawiranegara road with a width of 28.5 m^2 lanes which are categorized as arterial roads, and Parameswara road has 18.5 m wide for 2 lanes which are included in the Collector Road category (Fig. 1).

This is of course an unbalanced intersection in handling traffic flow. There will be a fairly long queue especially on the collector and local lanes when entering or leaving the intersection. This condition will be seen during peak hours, both morning and evening.

Based on preminary survey conducted in the field, it can be seen that the number of vehicles passing through the intersection looks very crowded, especially in the morning and evening. In the morning there is a crowd from the west, and south to the east/Parameswara direction. Vehicles entering the east are very many and queued so that there is a decrease in vehicle speed. In addition, the lack of public awareness of the orderly traffic also affects the smooth flow of traffic and is at risk for accidents.

Therefore, it is necessary to evaluate the performance of the Soekarno-Hatta Road intersection which aims to determine the performance of the intersection, resolve the problems that occur and obtain the best solution in smooth traffic, especially at the intersection.

2 Methodology

2.1 Based on Data

In this study refers to the guidelines Highway Manual Capacity. Analyzing the signalized intersection, several data are needed:

2.1.1 Geometric Data

Is the overall data about the condition of the intersection to be studied. The data needed is in the form of geometric condition data such as (road width, road length and images).

2.1.2 Traffic Volume

Calculation of traffic volume is smp/hour multiplied by the equivalent of each vehicle, which is the overall data about the condition of the intersection to be studied (Table 1).

2.1.3 Side Resistance Adjustment Factor (FSF)

SFS value is based on the number of side resistance compare to the total volume (Table 2).

2.1.4 Factor Grade

This value based on the road's grade condition which refers to the slope/grade graph at HCM.

2.1.5 City Size Adjustment Factor (FCS)

See Table 3.

Table 1. Passenger Car Equivalent (emp)

Vehicle Type	emp	
	protected	unprotected
LV	1	1
HV	1.3	1.3
MC	0.2	0.2

Table 2. FSF Value

Street environment	Side Resistance	Phase Type	Non-Vehicle Ratio			
			0.00	0.05	0.10	0.15
Settlement (RES)	High	Unprotected	0.96	0.91	0.86	0.81
		Protected	0.96	0.94	0.92	0.99
	Middle	Unprotected	0.97	0.92	0.87	0.82
		Protected	0.97	0.95	0.93	0.90
	Low	Unprotected	0.98	0.93	0.88	0.83
		Protected	0.98	0.96	0.94	0.91

Table 3. 1 FCS value

City dwellers (Millions)	City size adjustment factor
>3.0	1.05
1.0–3.0	1.00
0.5–1.0	0.94
0.1–0.5	0.83
0.1	0.82

2.1.6 Determination of Left Turn Factor Value (PLT)

$$PLT = \frac{QLT(smp/jam)}{Qtot(smp/jam)} \tag{1}$$

Left Turn Adjustment Factor (FLT)

$$\mathrm{FLT} = 1.0 - \mathrm{PLT} \times 0.16 \tag{2}$$

2.1.7 Determination of Right Turning Factor (PLT)

$$PRT = \frac{QRT(smp/jam)}{Qtot(smp/jam)} \tag{3}$$

Right Turn Adjustment Factor (FRT)

$$\mathrm{FRT} = 1.0 + \mathrm{PRT} \times 0.26 \tag{4}$$

2.1.8 Determination of the value of the Parking Adjustment Factor (FP)

$$\mathrm{FP} = \left\{ \left[(\mathrm{LP}/3 - (\mathrm{WA} - 2)) \times (\mathrm{LP}/3 - \mathrm{g})/\mathrm{WA} \right] / \mathrm{g} \right\} \tag{5}$$

Normal Value of Green time on foot (g) is 26 s.

Table 4. Normal Value of Inter.Green Time

Intersection size	Average road width	Normal Value of inter-green time
Small	6–9 m	4 s/phase
Currently	10–14 m	5 s/phase
Big	15 m	6 s/phase

2.1.9 Intersection Flow Ratio (IFR)

Represents the sum of the highest critical current ratios for all successive signal phases in a cycle.

2.2 Intersection Analysis

2.2.1 Calculation of Basic Saturated Current (So)

$$So = 600 \times We \tag{6}$$

2.2.2 Calculation of Actual Saturated Current (S)

$$S = So \times FCS \times FSF \times FG \times FP \times FRT \times FLT \tag{7}$$

2.3 Use of Signal Phase

2.3.1 Determination of Phase Signal

The signal phase plan should be selected as a starting alternative for evaluation purposes. Phase settings affect capacity and delay. 2 phase produces greater capacity and lower average delay than 3 phase or 4 phase.

2.3.2 Inter-green Time and Lost Time

In the analysis carried out for design purposes, the following inter-green time (yellow + all red) can be considered as normal values, the normal value of inter-green time is seen based on the size of the intersection or the average road width [5] (Table 4).

2.4 Signal Timing

2.4.1 Approach Type

Identifying each approach if two traffic movements on one approach are dispatched at different phases. Specifies the type of approach protected (P) or countered (0). Shielded is the condition if the right-turning current is dispatched when traffic from the opposite direction is facing red. While the countercurrent is a right-turning current from an approach from the opposite direction that occurs in the same phase as a straight-forward and left-turning current from that approach [5].

Table 5. Recommended Cycle time [5]

Phase	Cyletime Recommendation
2	40–80
3	50–100
4	80–130

2.4.2 Effective Wide (We)

This width is obtained based on information about the width of the approach (WA), the width of the entry (WIN) and the width of the exit (WOUT). Effective width (We) can be calculated for approaches with traffic islands, determination of entry width (WIN).

2.4.3 Cycle Time and Green Time

$$C, \min = \frac{L}{1 - IFR}(det\ i\,k) \tag{8}$$

Optimal cycle time (Co):

$$Co = \frac{1,5L + 5}{1 - IFR}(det\ i\,k) \tag{9}$$

Effective green time (Hi)

$$Hi = \frac{\sum yi, mak}{IFR}(Co - L)\ det\ i\,k \tag{10}$$

Actual green time (Hia)

$$\mathrm{Hia = Gi + k - li} \tag{11}$$

The minimum cycle length is 40 s and the maximum is 130 s, depending on the control method as shown in Table 5. But it can be operated for up to 180 s at very large intersections,

2.5 Capacity (C)

The capacity of the signalized intersection approach can be expressed as follows

$$\mathrm{C = S \times g/c} \tag{12}$$

The junction capacity is related to the IFR value. Theoretically the intersection can be operated up to 100%. The value of the practical capacity used is 90%. Thus, the practical capacity is:

$$\mathrm{IFR, prak = 0.9(1 - L/Cmak)} \tag{13}$$

3 Result and Discussion

3.1 Geometric Data

See Fig. 2 and Table 6.

3.2 Volume and Side Resistance

Based on BPS 2022, the population in the city of palembang is 1.7 million people, so FCS value is 1.0 (See Fig. 3 and Table 7).

Fig. 2. Geometric Intersection Design on Soekarno. Hatta Road

Table 6. Geometric Data

Direction	Name Road	W	infm
N	Soekarno-Hatta	32	protected
E	Parameswara	20	protected
S	Alamsyah Ratu Prawiranegara	32	protected
W	Macan Lindungan	7	protected

Table 7. Volume and side resistance

Direction	Volume (pcu/hour)	Side Resistance	FSF	Category
North	1083	200	0.96	Low
East	1296	234	0.95	Currently
South	1006	147	0.96	Low
West	350	270	0.93	Currently

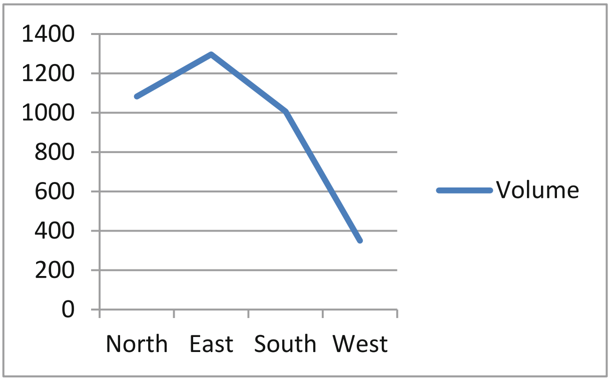

Fig. 3. Traffic volume (pcu/hour)

Table 8. Fg Value

Direction	Name Road	Grade	FG value
N	Soekarno-Hatta	0	1
E	Parameswara	0	1
S	Alamsyah Ratu Prawiranegara	0	1
W	Macan Lindungan	0	1

3.3 Factor Grade (FG)

See Table 8.

3.4 Factor Left Turn (FLT)

See Table 9.

$$\mathrm{P_{LT}} = \frac{QLT}{Qtotal} = \frac{324}{1083} = 0.30$$

$$\mathrm{F_{LT}} = (1 - \mathrm{P_{LT}} \times 0.16) = (1{-}0.30 \times 0.16) = 0.95$$

3.5 Factor Right Turn (FRT)

See Table 10.

$$\mathrm{P_{RT}} = \frac{QRT}{Qtotal} = \frac{624}{1296} = 0.48$$

$$\mathrm{F_{RT}} = (1 + \mathrm{P_{RT}} \times 0.26) = (1 + 0.48 \times 0.26) = 1.13$$

Table 9. FLT values

Direction	Left Turn Flow (smp/jam)	Total Flow (pcu/hour)	PLT	FLT
North	324	1083	0.30	0.95
East	480	1296	0.37	0.94
South	34	1006	0.03	0.99
West	28	350	0.08	0.99

Table 10. FRT value

Direction	Right Turn Flow (smp/jam)	Total Flow (smp/jam)	PRT	FRT
North	0	1083	0.00	1.00
East	624	1296	0.48	1.13
South	395	1006	0.39	1.10
West	56	350	0.16	1.16

Table 11. FP value

Direction	Name Road	WA	LP	FP
North	Soekarno-Hatta	13.5	1	0.31
East	Parameswara	12	1	0.26
South	A.S Ratu Prawiranegara	15.5	1	0.17
West	Macan Lindungan	3.5	1	0.14

3.6 FP Value

See Table 11.

3.7 So Value

See Table 12.

3.8 Y Value

See Fig. 4 and Tables 13 and 14.

P = 4 second
11 + 12 = 2 second
a = 3 second
n (phase) = 4

Table 12. So Value (pcu/hour)

Direction	Name Road	We (m)	So
North	Soekarno-Hatta	10	6000
East	Parameswara	8.5	5100
South	A.S Ratu Prawiranegara	15.5	9300
West	Macan Lindungan	3.5	2100

Table 13. Y value

Direction	q/s	y	Y
North	0.18	0.18	0.71
East	0.25	0.25	
South	0.11	0.11	
West	0.17	0.17	

Table 14. gi &ki value

Direction	Name Road	gi (sec)	ki (sec)
North	Soekarno-Hatta	25	24
East	Parameswara	35	35
South	A.S Ratu Prawiranegara	15	14
West	Macan Lindungan	23	22

L = n x (Ip – a) + n (I1+I2) = 4 x (4 – 3) + 4 (2) = 12
Co = $\frac{(1.5L+5)}{(1-Y)} = \frac{(1.5x12+5)}{(1-0.71)} = 79.16$
C = (0.75 – 1.5) Co = 1.4 x 79.16 = 110.83 = 111
Eg = C – L = 111 – 12 = 99
Gi = $\frac{yi}{Y}x(C-L) = \frac{0.18}{0.71}x(111-12) = 25$
ki = gi + l1 + l2 – a = 25 + 2 – 3 = 24 sec

3.9 Capacity (C)

See Tables 15 and 16.

From the results of data processing, it can be seen that the evaluation results of the signalized intersection at the intersection of Jalan Soekarno-Hatta were redesigned to the cycle time with a duration of 111 s. The highest/longest green time value and big capacity is in the east direction, namely Jalan Parameswara with capacity value is 420,44. This

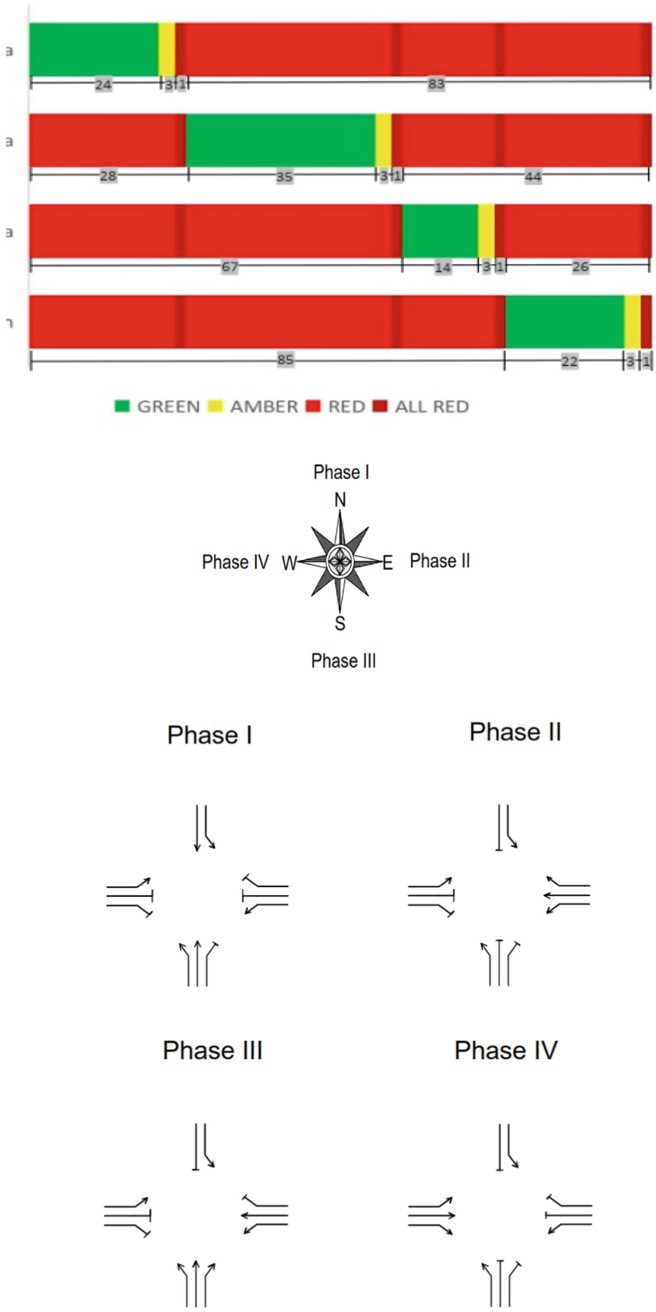

Fig. 4. Cyle time and Phase

Table 15. Resume

	So	FCS	FSF	FG	FP	FRT	FLT	S
North	6000	1	0.96	1	0.31	1.00	0.95	1700,13
East	5100	1	0.95	1	0.26	1.13	0.94	1333,40
South	9300	1	0.96	1	0.17	1.10	0.99	1663,66
West	2100	1	0.93	1	0.14	1.16	0.99	313,11

Table 16. Capacity

	S	Cycle time	Green time	Green Ratio	C
North	1700,13	111	24	0,22	367,60
East	1333,40		35	0,32	420,44
South	1663,66		14	0,13	209,83
West	313,11		22	0,20	62,06

is because the number of vehicles on the road is the highest category compared to other intersections. Furthermore, a large number of vehicles are on Jalan Macan Lindungan. This road is not balanced with the very small effective width of the road which is 3.5 m.

Based on field data, it can also be seen that the most crowded direction of the protected tiger is towards Parameswara or straight, causing the number of vehicles on the road to increase. In the future, it is necessary to regulate the flow so that there is no accumulation of the number of vehicles in one area/intersection, but it is conditioned to be more evenly distributed. It can realize the smooth flow at the junction. In addition, there is also a need for a more effective and appropriate intersection design. This is because the mouth of the west junction is very small compared to the mouths of the other junctions.

4 Conclusion

From the evaluation that has been carried out, it can be concluded that the results of the redesign of traffic light settings by adjusting the cycle time obtained that the green time duration is 24 s, 35, 14 and 22 s, with the longest duration being on Jalan Parameswara. At least this intersection requires a new design, especially the Macan Lindungan section which needs widening/diversion of currents.

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