MICRO SIMULATION OF PELICAN CROSSING AT THE ROAD SECTION OF COLOMBO STREET, YOGYAKARTA

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ABSTRACT

Yogyakarta has a problem related to pedestrians. The inappropriate implementation of crossing facility and disobedience of pedestrians while crossing the street leads to conflicts between pedestrians and vehicular traffic. Taking the road section of Colombo Street as the case study, this research proposed pelican crossing with independent and coordination time signal operation. Using Aimsun software, the existing traffic signal, geometric design, traffic flow and turning proportion were taken into account to build the initial model. Afterwards, a calibration of queue length and a validation of vehicle speed were carried out to obtain a basic model which represents the existing condition of the system. Comparing the basic model and the alternatives in terms of performances of junctions, road section and pedestrians in the pelican, this research resulted in setting double cycling of pelican as 100 seconds for the independent operation and setting common cycle time 120 seconds for the coordination operation as the best alternatives. In addition, the implementation of pelican crossing brought about the reduction of vehicle speed in the road section so that the safety of pedestrian increased.

Keywords: Pedestrian, pelican crossing, Aimsun, signal time, speed

1 INTRODUCTION

1.1 Background

The mixed traffic causes many problems for both vehicles and pedestrians in terms of delay and safety. Pedestrian behavior of not crossing the road on the appropriate place, nevertheless on anywhere of the road section is very risky and may cause conflicts with the vehicles passing through the road. The discontinuity of pedestrian arrival flow also complicates the determination of time signal of pelican crossing so that most pelican crossings in Yogyakarta, Indonesia have not been operated appropriately. In the road section of Colombo Street in which cars travelling at 45-55 kph brings on long waiting time and crossing time because the precedence vehicles do not give any priority for pedestrians. Whereas, the activities of Yogyakarta State University, sport stadium, and business area during peak hours generate conflicts on pedestrians crossing the street. Pedestrians must wait for a gap of adequate duration in traffic to permit them crossing the road without interference from vehicular traffic. Frequently, when the delay between adequate gaps or spaces becomes excessive, pedestrians may become impatient and endanger themselves by attempting to cross the road during inadequate gaps. Thus, they are potential to be hit by the vehicular traffic.

1.2 Objectives

This research is aimed at:

a) determining the appropriate crossing facility at the road section of Colombo Street;
b) simulating pelican crossing at Colombo Street using Aimsun software;
c) proposing scenario alternatives of independent operation and coordination operation of pelican crossing;
d) comparing performance results based on the alternatives;
e) assessing the influence of vehicle speed towards pedestrian safety.

1.3 Research Scope

Some limitations used to make the research discussion more focused and comprehensive are described as follows:

a) problem assessment is focused on the road section of Colombo Street, started at Gejayan signalized T-junction to Sagan signalized intersection without considering the minor roads and side frictions;
b) traffic flow and pedestrian flow are measured during morning or afternoon peak hour;
c) the types of vehicles in the model of Aimsun consist of passenger car, bus Trans Jogja and motorcycle;
d) calibration and validation procedures in the model use the data of mean queue length and speed respectively;

2 LITERATURE REVIEW

2.1 Pedestrian Crossing Facility

Based on recommendation of UK Department of Transport (IHT, 1987), the criterion to assess the potential conflicts between pedestrians and vehicles is described in Equation (1).

$$P V^2 \quad (1)$$

where P is the pedestrian flow across a 100 m length of road centered on the proposed crossing site (pedestrian/hour) and V is the number of vehicles in both directions (vehicles/hour).

The value of $P V^2$ should be the average of four peak hours in a day. For further details of recommended pedestrian crossing can be seen in Table 1.

Table 1. Preliminary Recommendation of Pedestrian Crossing

$P V^2$	P	V^2	Preliminary recommendation
Over 10^8	50 to 1100	300 to 500	Zebra
Over $2x10^8$	50 to 1100	400 to 750	Divided zebra
Over 10^8	50 to 1100	Over 500	Pelican
Over 10^8	Over 1100	Over 300	Pelican
Over $2x10^8$	50 to 1100	Over 750	Divided pelican
Over $2x10^8$	Over 1100	Over 400	Divided pelican

2.2 Traffic Signal Control

According to IHT (1987), traffic signal, also called as traffic light, could be adjusted and coordinated by involving the strategy on the circumstance, extending individual signal timings and leading into a system linking all signals together electronically to impose the strategy. The use of traffic signal control can result in the reduction of congestion, an improvement of road safety and introduction to particular strategies regulating the road network. The installation of traffic signal is aimed at maximizing the traffic capacity (the throughput of vehicles, vehicle occupants and pedestrians) whilst reducing vehicular delay and waiting time for pedestrians and maintaining the safety level of pedestrian.

2.3 Pelican Crossing

Pedestrian crossing facility on the road section equipped with traffic signal *(APILL)* is commonly called Pelican Crossing (Pedestrian Light Controlled), following the standard applied in UK (Malkhamah, 2004). In its operational, pelican crossing used far-side pedestrian signal heads and the crossing period of a flashing amber/flashing green of a fixed duration. It could be demanded solely by pedestrians by pushing the button (DoT et al, 1995).

In Indonesia, the operational of pelican crossing referred to the standard of *Direktorat Jenderal Perhubungan Darat Tahun 1997* (DJPD, 1997) by using 6 periods as described in Table 2.

Table 2. Operation Standard of Pelican Crossing in Indonesia

Period	Signal for pedestrian	Signal for driver	Duration (seconds)
1	Red	Green	Not determined
2	Red	Amber	3
3	Red	Red	3
4	Green	Red	Equation 2
5	Flashing green	Red	3
6	Red	Red	3

Source: DJPD (1997)

$$PT = \frac{L}{Vt} + 1{,}7\left(\frac{N}{W} - 1\right) \quad (2)$$

Where PT is minimum green time for pedestrian (second), Vt is pedestrian speed (1.2 m/second), L is the length of crossing (meter), N is pedestrian flow per cycle time (person), and W is the width of crossing (meter)

2.4 Microscopic Simulation

This research utilized a microscopic simulation to simulate the pelican crossing performance in Colombo Street by using Aimsun software. Microscopic simulation represents a circumstance that behaviour of each vehicle in the network was continuously modeled throughout the simulation time period while it occupied the traffic network in accordance with some vehicle behaviour models for instance car-following and lane changing (TSS, 2010). Some input data required in micro simulation models (Dowling, 2004) includes:

a) geometry design, i.e. lengths, lanes and curvature;
b) controls, i.e. signal timing, signs;
c) existing demands, i.e. turning volumes, origin-destination (O-D) table;
d) calibration data, i.e. capacities, travel times, queues;
e) transit, bicycle, and pedestrian data.

3 RESEARCH METHODOLOGY

3.1 Research Location

This research was conducted mainly at the road section of Colombo Street started at Sagan signalized intersection to Gejayan signalized T-junction.

3.2 Data Analysis

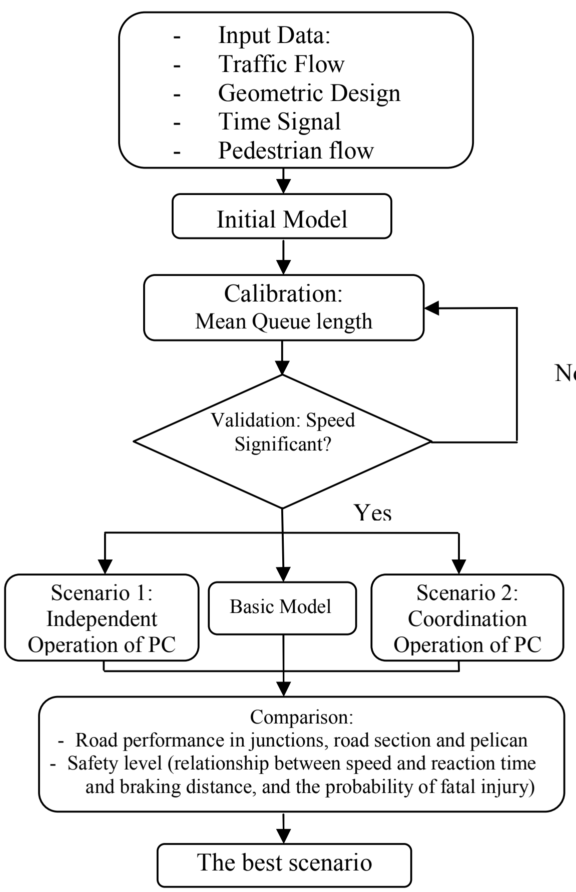

Figure 1. Research simulation flowchart.

After obtaining the data using traffic counting and field observation, some procedures were conducted to complete the research. Firstly, an initial model as the input of primary and secondary data was created. This initial model later would be calibrated by using data of mean queue length and validated by using data of vehicle speed. If the initial model was insignificant by using 95% of confidence level, it must be recalibrated until the validation was significant. Calibration and validation procedures would result in a basic model representing the real condition on the field. Secondly, the basic model to propose pelican crossing alternative by using two scenarios of different fixed times was developed. Furthermore, the scenarios would be compared to the basic model in terms of mean queue length, delay and the relationship between speed and risk of road crash so that the best scenario would be obtained. The simulation planning is shown in the flowchart in Figure 1.

4 RESULT AND DISCUSSION

4.1 Determination of Crossing Facility

By using Equation (1), the calculation to determine the crossing facility is described as the follows:

$$PV^2 = 287 \times 1831^2$$

$$= 9.622 \times 10^8$$

The value of PV^2 is categorized into the specification in Table 3 so that the type of crossing facility would be obtained. The value of 9.622×10^8 is in specification of $> 2 \times 10^8$ with $P = 50 – 1100$ and $V > 750$, since it was in accordance with the specification of road section to propose pelican crossing to facilitate pedestrian crossing the street.

The position of pelican crossing was determined by taking the most demand of pedestrian crossing and the accepted walking distance to the crossing into considerations. From the observation, it was obtained that most pedestrians cross the street around UNY and the business area so that the location of pelican would be closed to the generation and attraction of pedestrian crossing the street. Whilst, the accepted walking distance to the crossing obtained from the mini interview towards the pedestrians was that 50 m far. Based on those findings, the location of pelican determines as shown in Figure 2.

Figure 2. Location of pelican crossing at colombo street.

4.2 Simulation of Pelican Crossing at Colombo Street

4.2.1 Traffic Volume

The types of vehicles considered in this research were car, motorcycle, and bus Trans Jogja. As the input of Aimsun model, the flow of motorcycle had to be converted into pcu by multiplying it with the convert factor i.e. 0.15 (Munawar, 2006). It was because the software was not likely to model the motorcycle. Further, traffic demand as the input in Aimsun uses traffic state so that it was necessary to determine the turning proportion in each approach at either Gejayan intersection or Sagan junction.

4.2.2 Traffic Signal

The existing traffic signal in Sagan intersection and Gejayan junction were the fixed signal. This study simulated the fixed time control plan signals towards both signalized junctions and the proposed pelican crossing. The observation had revealed that the cycle time of Gejayan junction is 90 seconds with 3 phases, while the Sagan intersection has cycle time of 105 seconds with 4 phases.

4.2.3 Initial Model

The initial model was resulted by considering traffic signal, traffic flow, turning proportion, and geometric design in Aimsun.

4.2.4 Calibration and Validation

The first calibration was carried out by changing the global parameter, i.e. reaction time at stop, from the default value 1.35 to 1.5. The calculation revealed that the mean queue length of the model and measured data resulted from the first calibration were not similar at the 95% of confidence level.

The second calibration was conducted by changing the section parameter, i.e. visibility distance, and the vehicle parameter, i.e. minimum distance between vehicles. The calculation revealed that the mean queue length of the model and measured data resulted from the second calibration were similar at the 95% of confidence level due to $|T| < t_{n_x+n_y-2}(\alpha/2)$. Therefore, the second calibration was continued to the validation the data of speed.

The speed data were obtained by measuring the vehicles speed in each section travelling towards Gejayan and Sagan junction using SMS (Space Mean Speed) method. There were 12 sets of speed data obtained during one-hour observation and 12 sets of simulation data obtained from speed data in second calibration. After conducting validation, it resulted in a basic model which has represented the real condition of the network.

4.2.5 Basic Model

In this research, basic model which was built after conducting calibration and validation had several conditions that must be considered to do further analysis about pedestrian crossing. In the real condition, pedestrians cross the Colombo Street anywhere. Due to the vehicular traffic, pedestrians need to wait for the adequate gap to cross the street. In the basic model, this research did not include this condition but directly include pedestrian flows in the location of the proposed pelican while developing the basic model. If the existing condition of pedestrians were applied in the simulation, it would show a higher delay of pedestrians in the basic model. The pedestrian flows in the simulation always existed in every 5 minutes during an hour and registered as the demand of pedestrians to cross the street.

4.3 Scenario Alternatives

4.3.1 Independent Operation of Pelican Crossing

a) Alternative 1 : Pelican Crossing using Cycle Time 50 Seconds
Alternative 1 was setting the existing cycle time in Sagan intersection and Gejayan junction, i.e. 105 seconds and 90 seconds respectively, and combined with the single cycling of proposed pelican crossing, i.e. 50 seconds. This research also took 2 seconds into account as the time of forced change due to the limitation of fixed time signal setting in the software.

b) Pelican Crossing using Double Cycling 100 Seconds
This alternative was about to set the existing cycle time in Sagan intersection and Gejayan junction, i.e. 105 seconds and 90 seconds respectively, and combined with the double cycling of proposed pelican crossing, i.e. 100 seconds. The operational of pelican with cycle time 100 seconds were similar to the operation of pelican with cycle time 50 seconds, but it was operated twice with the same time composition.

4.3.2 Coordination Operation of Pelican Crossing

a) Signal Coordination using Cycle Time 120 Seconds
Alternative 3 set the cycle time in Sagan intersection, Gejayan junction and pelican crossing using 120 seconds with respect to double cycling and double windows of pelican. Window time as 2 seconds was also used. Window time was the time it took in a cycle time which was determined in a few seconds to regulate the stop of period 1 when pedestrians press the push-button (Malkhamah, 2004). In addition, the phase at Sagan was set to unclockwise operation.

b) Alternative 4 : signal Coordination using Cycle Time 130 Seconds
This alternative was about to set the cycle time in Sagan intersection, Gejayan junction and pelican crossing using 130 seconds. As alternative 3, this research attempts to implement double cycling and double windows of pelican crossing in this alternative. Yet, the phase at Sagan was set to clockwise operation.

4.4 Comparison of Performance Results

The comparisons between alternative 1 and 2 as well as alternative 3 and 4 were described as follows.

Table 3. Comparison of alternative 1 and 2 in the junction

Intersection/ Junction	Section	Delay (sec/km)			Queue (veh)		
		Basic	Alt 1	Alt 2	Basic	Alt 1	Alt 2
Sagan	337	137,1	135	126,7	8	8	8
	341	129,6	114,7	120,9	8	7	7
	429	160,7	152,7	146,5	13	12	12
	457	133,6	173,1	162,4	8	10	10
	Average	140,3	143,9	**139,1**	10	10	10
Gejayan	276	58,4	43,3	45,5	6	4	5
	292	95	86,8	80	11	10	9
	460	72,9	49,8	55,1	8	5	6
	Average	75,4	**59,9**	60,2	9	7	7

Table 4. Comparison of alternative 1 and 2 in the road section

Section	Travel time (sec/km)			Delay (sec/km)			Veh speed (kph)		
	Basic	Alt 1	Alt 2	Basic	Alt 1	Alt 2	Basic	Alt 1	Alt 2
393+457	202,6	254,1	243,2	136,3	187,8	177	53,7	47,4	43,9
421+460	141	131,2	136,2	74,9	65	70,2	54,1	51,6	47,9
Average	171,8	192,7	**189,7**	105,6	126,4	**123,6**	53,9	49,5	**45,9**

Table 5. Comparison of alternative 1 and 2 in the pelican crossing

Direction	Crossing time (sec/km)			Waiting time (sec)		
	Measured	Alt 1	Alt 2	Measured	Alt 1	Alt 2
South-North	15,8	16,8	16,7	17	15,4	15,3
North-South	19,5	17,5	17,1	24,9	16	15,7
Average	17,6	17,1	**16,9**	20,9	15,7	**15,5**

Table 6. comparison of alternative 3 and 4 in the junction

Intersection/ Junction	Section	Delay (sec/km)			Queue (veh)		
		Basic	Alt 3	Alt 4	Basic	Alt 3	Alt 4
Sagan	337	137,1	258,9	56,2	8	17	3
	341	129,6	104	199,4	8	6	12
	429	160,7	147,9	231,2	13	12	20
	457	133,6	35,2	39,2	8	1	1
	Average	140,3	136,5	**131,5**	10	9	9
Gejayan	276	58,4	52,3	73,8	6	6	8
	292	95	221	272	11	24	27
	460	72,9	24,6	17,7	8	2	1
	Average	75,4	**99,3**	121,2	9	**11**	12

Table 7. comparison of alternative 3 and 4 in the road section

Section	Travel time (sec/km)			Delay (sec/km)			Veh speed (kph)		
	Basic	Alt 3	Alt 4	Basic	Alt 3	Alt 4	Basic	Alt 3	Alt 4
393+457	202,6	112,6	116,7	136,3	46,4	50,5	53,7	50,2	52,7
421+460	141	108,9	93,1	74,9	42,9	27	54,1	53,7	53,7
Average	171,8	110,8	**104,9**	105,6	44,6	**38,7**	53,9	**51,9**	53,2

Table 8. comparison of alternative 3 and 4 in the pelican crossing

Direction	Crossing time (sec/km)			Waiting time (sec)		
	Measured	Alt 3	Alt 4	Measured	Alt 3	Alt 4
South-North	15,8	17,1	18,2	17	15,2	16,6
North-South	19,5	17,8	18,5	24,9	15,8	16,9
Average	17,6	**17,4**	18,3	20,9	**15,5**	16,7

To obtain the best alternative, the grey shade was put in the smallest average value of each parameter change and then counts which alternative that has the most number of grey shades. The most number of grey shades revealed the best alternative to choose. It was obtained that alternative 2 was the best for independent operation and alternative 3 was the best for coordination operation.

4.5 Influence of Speed towards Pedestrian Safety

4.5.1 Distance of 25 m before Pelican

Using SPSS, the 85 percentile vehicle speeds were 48 kph, 36 kph and 45 kph for basic model, alternative 2 and alternative 3 respectively. The analysis revealed that the 36 kph and 45 kph speed-travelling cars would stop before hitting a pedestrian due to reaction and braking distance less than 25 m. Yet, the 48 kph speed-travelling car would hit the pedestrian since it needs the distance of reaction time and braking more than 25 m. From the assessment of the probability of fatal injury, only the 48 kph speed-travelling car would hit pedestrian crossing the street at a point 25 m in front of them.

4.5.2 Distance of 50 m before Pelican

The 85 percentile vehicle speeds were 55 kph, 48 kph and 54 kph for basic model, alternative 2 and alternative 3 respectively. Assessment revealed that all vehicles with 48 kph, 54 kph and 55 kph would stop before hitting a pedestrian due to reaction and braking distance less than 50 m. Furthermore, pedestrian in the crossing at a point 50 m in front of the 48 kph, 54 kph and 55 kph speed-travelling cars would be avoided from being hit due to the adequate distance of reaction time and braking.

5 CONCLUSION

5.1 Conclusion

a) pelican crossing proposed in the research was appropriate based on the analysis of PV2 in which P = 287 pedestrian/h and V = 1831 pcu/h so that PV2 = 9.622 x 108 was in accordance with the specification of >2 x 108 with P = 50 – 1100 and V > 750;
b) traffic flow, turning proportion, traffic signal and geometric design ware taken into account to build initial model in Aimsun software. Then, calibration and validation using statistical method towards queue length and vehicle speed respectively were carried out to obtain basic model which represents the existing condition of the network. Basic model resulted of calibration and validation had the confidence level as much as 95%;
c) the proposed pelican crossing was set as the fixed time signal plan with two kinds of scenario, i.e. independent operation and coordination operation of pelican crossing. Further, the independent operation of pelican embraced setting the existing time signals of Sagan and Gejayan junction with the single cycling of pelican as 50 seconds and double cycling of pelican as 100 seconds. While, the coordination operation included coordination the time signals of Gejayan junction, Sagan intersection and the pelican crossing with the common cycle time of 120 seconds and 130 seconds;
d) the comparison of performance results revealed that the best alternative of independent operation was setting double cycling of pelican as 100 seconds, while setting common cycle time 120 seconds was the best alternative of coordination operation;
e) at a point of pelican crossing site of 25 m in front of 36 kph and 45 kph speed-travelling car, the safety of pedestrian would increase due to the decreasing of vehicle speed and the adequate distance of reaction time and braking. As well as the pedestrian in the crossing at a point 50 m in front of 48 kph, 54 kph and 55 kph speed-travelling car would be avoided from getting hit due to the adequate distance of reaction time and braking.

5.2 Suggestion

a) for the implementation, it would be better if the installation of pelican imitates pelican design in Singapore since it provided the countdown of flashing green signal for pedestrians as what has been discussed in this research. Besides, the fences should be put due to the attraction and necessity;
b) the pedestrians should be encouraged to use the crossing facility appropriately;
c) the law enforcement towards disobedience of pedestrians and drivers in the crossing site should be maintained;
d) for the future research, Aimsun software installation would be more useful if it is more properly completed with the license of Legion software which provides more support in pedestrian modelling.

REFERENCES

Department of Transport (DoT). The Scottish Office, The Department of Environment for Nothern Ireland. (1995). *Local Transport Note 2/95: The Design of Pedestrian Crossings*, The Stationery Office, London.

Direktorat Jenderal Perhubungan Darat. (1997). *Keputusan Direktur Jenderal Perhubungan Darat, No. : SK.43/AJ 007/DRJD/97, Perekayasaan Fasilitas Pejalan Kaki di Wilayah Kota*, Direktorat Jenderal Perhubungan Darat, Kementerian Perhubungan, Jakarta.

Dowling R., Skabardonis A., Alexiadis V. (FHWA). (2004). *Traffic Analysis Toolbox Volume III: Guidlines for Applying Traffic Microsimulation Modelling Software*, Federal Highway Administration, Washington.

Institution of Highways and Transportation (IHT), and The Department of Transport. (1987). *Roads and Traffic in Urban Areas*, IHT, London.

Malkhamah, S. (2004). "Evaluasi Penetapan Periode pada Pelican di Indonesia." *Media Teknik No. 4 Tahun XXVI Edisi November 2004*, Yogyakarta.

Munawar, A. (2006). "Queues and Delays at Signalized Intersections, Indonesian Experience." *5th International Symposium on Highway Capacity and Quality of Service*, Yokohama.

Transport Simulation System (TSS). (2010). *Microsimulator and Mesosimulator Aimsun 6.1*, Barcelona.