The Performance of Demand Responsive Pelican Crossing at Midblock Pedestrian Crossing Facility

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Abstract. Pedestrians are travellers who are the most vulnerable to traffic accidents. In general, pedestrian safety in urban areas tends to be neglected. Lack of adequate pedestrian facilities, especially midblock pedestrian crossing facilities, has an impact on pedestrian safety. In order to improve pedestrian safety, therefore the Surakarta city government provides a pedestrian crossing facility, namely Pelican crossing. The existence of a Pelican crossing has an impact on road performance where the traffic and pedestrian flow is regulated by signal timing. The existing Pelican crossing is a type of pedestrian-actuated control logic with fixed-time operation. This study aims to design demand responsive Pelican crossing based on Vehicle Actuated Control Extension Principle (VAC EP) logic, where signal timing is based on real time traffic conditions. The performance of Pelican crossings at midblock pedestrian crossing facility is analysed by using a calibrated and validated VISSIM simulation model. The performance of the proposed Pelican crossing (VAC EP) is compared to the existing Pelican crossing. The simulation analysis results show that the proposed Pelican crossing (VAC EP) performance is better than the existing Pelican crossing, in terms of average pedestrian delay.

1. Introduction

The progress of a city economic has an impact on the growth of people movement in carrying out activities. The growth of people movement is marked by the increasing use of both motorized and non-motorized modes of transportation. Uncontrolled use of private motorized vehicles can lead to an increase in traffic density in urban areas, which results in congestion and traffic accidents. In this connection, the Surakarta city government is obliged to provide public transportation facilities that are able to meet the needs of the community so that people are willing to switch from using private motorized vehicles to using public transportation. This can be done by building infrastructure and public transportation facilities that are integrated with cycling and pedestrian facilities.

Pedestrians are the travellers who are most vulnerable to traffic accidents. Lack of adequate pedestrian facilities, especially midblock pedestrian crossing facilities, greatly impacts the safety of pedestrians. The tendency of motorized vehicle drivers who are reluctant to grant pedestrians the right to cross can increase the potential for traffic accidents [1]. Pedestrian crossing facilities consist of Zebra cross and Pelican crossing [2]. Pelican crossing is a pedestrian crossing facility that uses traffic signal control settings. Pelican crossings were first introduced in the United Kingdom in 1969, and were designed to improve upon the existing signal controlled pedestrian crossings and to replace Zebra crossings where pedestrian flows were heavy [3]. The operation of Pelican crossing in Indonesia is based on the standard issued by the Directorate General of Land Transportation in 1997 [2] which uses 6 signal control periods, see Table 1. The duration of period 4 is calculated by using equation 1.
Table 1. Standard operation of Pelican crossing

| Period | Pedestrian Signal for | Vehicle Signal for | Duration |
|--------|-----------------------|--------------------|----------|
| 1      | Red                   | Green              | Not specified |
| 2      | Red                   | Amber              | 3        |
| 3      | Red                   | Red                | 3        |
| 4      | Green                 | Red                | Calculated by equation |
| 5      | Flashing green        | Red                | 3        |
| 6      | Red                   | Red                | 3        |

\[ PT = \frac{L}{1.2} + 1.7\left(\frac{N}{W-1}\right) \]  

(1)

where \( PT \) is minimum green time for pedestrians (seconds), \( L \) is the length of crossing (meter), \( N \) is the pedestrian volume (pedestrian/cycle), and \( W \) is width of crossing (meter).

Midblock pedestrian crossings in Indonesia mostly are pedestrian-actuated control with fixed-time operation. It is a stand-alone pedestrian actuated signal control. Pedestrians can call green phase by pushing the pedestrian button. Pedestrian signal phase on the far side of roadway shows pedestrians when to cross. The vehicle signal phase will turn red after reach the total length of green time. The signal timing for pedestrian green time is pre-set depending upon the length of crossing and pedestrian volume, see Equation 1. This type of Pelican crossing is ineffective because the signal timing settings do not consider traffic conditions [4]. Pelican crossing based pedestrian-actuated control is designed such that vehicular movements are omitted, thus, vehicular movements experience unexpected stops and excess travel delay, which may result in road accident and traffic congestion problems, respectively. Such signal controls are somewhat not mobility-friendly [5].

Implementation of midblock Pelican crossing affects vehicle and pedestrian delays at Pelican crossing facilities. For this reason, it is necessary to do a study to improve the effectiveness of Pelican crossing performance. This study aims to design demand responsive Pelican crossing based on Vehicle Actuated Control Extension Principle (VAC EP) logic, where signal timing is based on real time traffic conditions. The performance of the proposed Pelican crossing (VAC EP) at midblock pedestrian crossing facility is analysed by using a calibrated and validated VISSIM simulation model. The performance of the proposed Pelican crossing (VAC EP) is compared to the existing Pelican crossing.

2. Research Method

2.1. Study Area and Data Collection

The study was conducted at the Pelican crossing facility on Kolonel Sutarto road in front of Moewardi Hospital, Surakarta city. Kolonel Sutarto road is an arterial road with a 4/2 D (four-lane divided) road type with an average road width of 14.0 meters, see Figure 1. Data required for simulation model includes geometry, traffic and pedestrian volume, vehicle speed and signal timing data. Secondary data in the form of signal timing data were obtained from the Department of Transportation Surakarta city, while the primary data for pelican crossing geometry, traffic and pedestrian volume were obtained from field surveys. Primary data related to traffic and pedestrian volume in the study area were taken two hours at the morning and evening peak hours, consecutively. Traffic count survey at Pelican crossing area was conducted to obtain pedestrian volume, traffic volume and its vehicle type composition. It is done separately for each direction of traffic and pedestrian. The Pelican crossing inventory survey are conducted to obtain Pelican crossing geometry. Table 2 shows the traffic and pedestrian volume in the study area.
Figure 1. Pelican crossing on Kolonel Sutarto road

Table 2. Traffic and pedestrian volume in the study area

| No. | Time Interval | Traffic (East) | Pedestrian (South) |
|-----|---------------|----------------|--------------------|
|     |               | Motorcycle | Light Vehicle | Heavy Vehicle | Total | Pedestrian |
| 1   | 06.00-07.00   | 2.358     | 673           | 83           | 3.114 | 50        |
| 2   | 07.00-08.00   | 2.952     | 629           | 110          | 3.691 | 82        |
| 3   | 14.00-15.00   | 2.065     | 834           | 140          | 3.039 | 14        |
| 4   | 15.00-16.00   | 2.510     | 779           | 149          | 3.438 | 31        |

| No. | Time Interval | Traffic (West) | Pedestrian (North) |
|-----|---------------|----------------|--------------------|
|     |               | Motorcycle | Light Vehicle | Heavy Vehicle | Total | Pedestrian |
| 1   | 06.00-07.00   | 1.511     | 222           | 61           | 1.794 | 9         |
| 2   | 07.00-08.00   | 1.665     | 495           | 51           | 2.211 | 21        |
| 3   | 14.00-15.00   | 1.736     | 546           | 67           | 2.349 | 90        |
| 4   | 15.00-16.00   | 1.881     | 481           | 77           | 2.439 | 64        |

2.2. Stages of Study
The study work begins with the preparatory stage, which includes the literature study, problem formulation, goal setting and prepares study methods. The next stage is the secondary and primary data collection stage. This data is used as an input data for road network simulation model development by using VISSIM traffic micro-simulation. The next step is the modeling analysis stage, which includes modeling the Pelican crossing, designing and evaluating the effectiveness of different type of Pelican crossing. The modeling analysis results are discussed in relation to the performance of different types of Pelican crossing. The final stage is the conclusion of the modeling analysis results and subsequent research recommendations.

3. Result and Discussion

3.1. Simulation Model
Simulation model stage consists of Pelican crossing simulation model development, signal controller logic coding and comparison of the performance of different type of Pelican crossing. Pelican crossing simulation models are built by using VISSIM traffic micro-simulation Version 2020 – SP 09. It is a microscopic, time step (1-second) and behaviour based simulation model, which is developed to model urban traffic and public transportation operations. It can be used as a tool for evaluating various alternatives in accordance with transportation engineering and planning measures of performance [6].
The existing Pelican crossing simulation model is calibrated and validated by comparing the simulation results with field data [7]. Figure 2 shows the existing Pelican crossing simulation model. The signal controller logic of the existing Pelican crossing based on the pedestrian-actuated control with fixed-time operation. It was developed by using Vehicle Actuated Program language in VISSIM traffic micro-simulation. By this way, the signal controller logic could interact directly with VISSIM traffic micro-simulation via internal signal state generator [8]. This controller use green time of vehicle and pedestrian phases are 60 and 18 seconds, respectively.

Figure 2. Pelican crossing simulation model

The proposed Pelican crossing simulation model is made based on existing Pelican crossing simulation model that have been calibrated and validated. The proposed Pelican crossing is a demand responsive Pelican crossing based on Vehicle Actuated Control Extension Principle (VAC EP) logic. In this case, the signal timing setting of the Pelican crossing is calculated based on both pedestrians and vehicles conditions. Under this controller, vehicle phase green time is adjusted based on the extension time and time gap between vehicles crossing the detector area at certain distance from the stop line [9]. Parameter that affects the controller performance are the extension time, minimum and maximum green time. [10] suggested that the extension time parameter of the VAC EP Pelican crossing which produces the lowest pedestrian delay in mixed traffic conditions is 2 seconds. Minimum and maximum vehicle phase green time are 7 and 60 seconds, while the pedestrian phase green time is 18 seconds.

The performance of existing and proposed Pelican crossing is compared, to see the advantages and disadvantages of the two types of Pelican crossing, in terms of average vehicle and pedestrian delays. There are four different case studies to evaluate the effectiveness of the Pelican crossing controller with different traffic and pedestrian volume, see Table 1. A simulation run is made approximately one-hour periods to produce the output performance measures. Eight VISSIM simulation runs are undertaken for each model with different random seed values.

3.2. Simulation Results
Comparison of the average vehicle and pedestrian delay at Pelican crossing area between the existing Pelican crossing and the proposed Pelican crossing (VAC EP) for all case studies can be seen in Figure 3. The simulation results show that the proposed Pelican crossing (VAC EP) produced higher average vehicle delay than the existing Pelican crossing for all case studies, see Figure 3a. The difference in the value of the average vehicle delay is relatively small. Comparison of the average pedestrian delay shows that the proposed Pelican crossing (VAC EP) produced lower value than the existing Pelican crossing for all case studies, see Figure 3b.
Figure 3. Comparison of the average vehicle and pedestrian delay at Pelican crossing area

Figure 4 shows the comparison of percentage improvement of the proposed Pelican crossing (VAC EP) in terms of average vehicle and pedestrian delay. The proposed Pelican crossing (VAC EP) yield an improvement compare to the existing Pelican crossing of 9.7% to 14.1% on the average pedestrian delay while in terms of average vehicle delay, the performance of the proposed Pelican crossing (VAC EP) decreases between 1.0% to 4.7%. The performance of the proposed Pelican crossing (VAC EP) is better than the existing Pelican crossing because the vehicle phase green time can be adjusted effectively according to the traffic fluctuation in real conditions. Thus, the waiting time for road crossers is shorter, which results in lower pedestrian delay.

Figure 4. Comparison of percentage improvement of the proposed Pelican crossing (VAC EP) in terms of vehicle and pedestrian delay
4. Conclusions
A demand responsive Pelican crossing based on Vehicle Actuated Control Extension Principal logic at midblock has been developed in VISSIM simulation model. Its performance has been compared to the existing Pelican crossing based on the pedestrian-actuated control logic. The simulation results show that the performance of the proposed Pelican crossing (VAC EP) better than the existing Pelican crossing in terms of average pedestrian delay. It has ability to adjust the vehicle phase green time according to traffic conditions. If the amount of traffic volume is large, the length of vehicle phase green time will be long and vice versa. This effective vehicle phase green time setting affects the efficiency of the waiting time for road crossers so that pedestrian delay is small. The low waiting time for road crossers has an impact on the obedience of road crossers in complying with Pelican crossing rules [4]. Thus, the proposed Pelican crossing (VAC EP) has a high level of safety against road crossers. The performance of the proposed Pelican crossing (VAC EP) can be improved by optimizing the signal timing setting by using artificial intelligent [8].

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