The Effect of Traffic Movement Design Study at The Manahan Flyover to the Road Network Performance Using Traffic Micro-Simulation VISSIM

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Abstract. Level crossings between railway and highway causes transportation problems in the form of traffic jams and accidents. The Manahan Flyover development in the Surakarta city is an effort to minimize transportation problems in the Manahan and Kota Barat areas. Field condition shows that traffic congestion in the Manahan Flyover can be minimized, but traffic accident rate is increasing. Within nine months an accident occurred with two dead victims. The potential of traffic accident is inseparable with the design of the Manahan Flyover with the design of three-way intersection. The aim of study is to redesign traffic movement in the Manahan Flyover and surrounding Manahan area. Traffic micro-simulation VISSIM model is used to evaluate the performance of road networks at peak traffic conditions with different simulation models. The scenario simulation model is developed based on the calibrated base simulation model. In order to avoid potential accidents, therefore, the direction of traffic movement at the Manahan Flyover is made with a one-way system. The modelling scenario results indicate that the diversion of traffic movement at the Manahan Flyover must be followed by various traffic management and engineering efforts in the Manahan area including road widening, parking management, application of a one-way system.

Keywords: Manahan flyover, road network performance, traffic movement, traffic Micro-Simulation VISSIM

1. Introduction

The high rate of population growth in the Surakarta city and surrounding areas, causing various problems, especially in the field of transportation. As the population grows, the mobility of the population travel movements will increase, which will eventually burden the existing road network infrastructure. Transportation is the economic pulse of a city, so the existence of transportation is very important. Therefore, the effectiveness of the performance of urban transportation system needs to be endeavoured to support the economic growth of a city or region.

Railway level crossing is a meeting point between the movement of traffic between the trains and vehicles. When a train crosses a railway level crossing, it causes delays and queues of vehicles and even accidents if there is a violation of the provisions of the applicable law. Traffic jams often occur in the Manahan railway level crossing area in the Surakarta city due to the high intensity of passing trains and the vehicles volume passing through Dr. Moewardi road. The Central Government's program in improving railway-based mass public transportation services in Java was realized in the construction of the double track railway. This development has the potential to increase the intensity of traffic congestion in the Manahan railway level crossing area. In order to realize smooth, orderly and safe
traffic, the Manahan railway level crossing was changed to a non-level crossing by facilitating the vehicles movement with flyover infrastructure.

The Manahan Flyover began operation at the end of December 2018. The results of traffic performance evaluation in the Manahan and Kota Barat areas around the railway level crossing indicate that traffic congestion can be minimized by the operating of the Manahan Flyover. However, on the contrary, the rate of traffic accidents is increasing. In the nine months since the operation of Manahan Flyover, there has been a traffic accident with two dead and several victims with low and moderate severity [1-2]. The accidents occurred at the Manahan Flyover intersection. This makes Manahan Flyover to become an acute accident blackspot area. The potential of traffic accident cannot be separated from the Manahan Flyover design that does not follow the traffic engineering criteria [3]. The Manahan flyover design is in the form of a three-way intersection with a conflicting point at the traffic flow from Adi Sucipto road and MT Haryono road heading to Dr. Moewardi road. This point of conflict should have been avoided since the design of the Manahan Flyover because the traffic volume on both roads was relatively high during peak hours, which could lead to potential traffic accidents. Moreover, from year to year the amount of traffic volume will increase in accordance with the annual growth rate of traffic. Figure 1 shows the Manahan Flyover infrastructure with design of three-way intersection [4].

![Figure 1. Design engineering details of the Manahan Flyover and Manahan Flyover infrastructure.](image)

In connection with the operational of the Manahan Flyover with existing designs, it is necessary to make efforts in traffic management and engineering, in order to minimize the occurrence of traffic accidents and traffic congestion in the Manahan and Kota Barat areas. The purpose of this study is to redesign the movement of traffic on the Manahan Flyover and the surrounding Manahan area in order to provide traffic safety and smoothness.

2. Research Method

2.1. Study Area and Data Collection

This study is conducted in area covering the Manahan area located to the north of the railway and the Kota Barat area to the south of the railway. The main roads that are analysed included Dr. Muwardi road, Adi Sucipto road, MT Haryono road, meanwhile feeder roads including Menteri Supeno road, KS Tubun road. Detailed map of the study area can be seen in Figure 2. Data modelling is required to carry out traffic modeling and analysis of road network performance. Primary data needed includes traffic volume, composition and proportion of turns, desired vehicle speed, road geometry. Secondary data related to traffic signal timings is obtained from the Department of Transport Surakarta City and Design Engineering Details of the Manahan Flyover is obtained from the Ministry of Public Works, the National Research and Development PUSJATAN [4].
2.2. Research Stages
The study work begins with the preparation stage to formulate the problem, set aims and prepare study methods. Then, data collection stage for input data simulation model of the road network. The following stage is the analysis includes the development of simulation models and evaluating the effectiveness of simulation models using traffic micro-simulation VISSIM. The analysis results of the simulation model are discussed in relation to the performance of the road network under study. The last stage is the conclusion of the analysis results and further research recommendations.

3. Result and Discussion

3.1. Simulation Model
Road network modelling for Manahan and Kota Barat areas is carried out by using traffic micro-simulation VISSIM (Version 10.6). It is a microscopic, time step (1-second) and behaviour-based simulation model, which is developed to model urban traffic and public transportation operation and to evaluate various alternatives according to planning of traffic management and engineering [5]. Road network modelling stage includes network coding and calibration of the existing base model, developing simulation model scenarios and comparison of road network performance measure for all models.

3.1.1. Development of Base Simulation Model. The base simulation model is made to replicate the condition of the existing road network and traffic movement in accordance with the conditions in the field. Traffic micro-simulation VISSIM has the ability to model mixed traffic conditions where vehicles do not follow lane-based operations, which is vehicle can move into any position across available lane space and squeeze between two vehicles moving side-by-side or two successive vehicles moving in the same lane. In order to make output of the simulation model relatively similar to the conditions in the field statistically, therefore, the model needs to be calibrated. The calibration process is carried out by setting the car following, lane change, desired speed distribution, reduced speed area and priority rules parameters [6-9]. Figure 3 shows the base simulation model of the Manahan Flyover.
3.1.2. Development of Scenario Simulation Model. A number of traffic management and engineering efforts are carried out in the scenario simulation model to obtain optimal performance of the road network in the study area. Based on traffic behaviour observations at the Manahan Flyover shows that the potential for traffic accidents is relatively high between traffic from the west (Adi Sucipto Road) and north (MT Haryono road) that meets at the Manahan Flyover. In order to avoid potential accidents, therefore, the direction of traffic movement at the Manahan Flyover is made with a one-way system in Adi Sucipto road approach. Traffic flow from West (Adi Sucipto road) to South (Dr. Moewardi road), which passes through Manahan Flyover is directed towards to MT Haryono road approach in the North, see Figure 4. Road widening and vehicle parking management are carried out at KS Tubun road and Menteri Supeno road in order to increase their road capacity. This were done so that traffic movement from zone B to zone C using the Adi Sucipto road moved to the KS Tubun Road and the Minister of Supeno road, see Figure 2.

Figure 3. Manahan Flyover base simulation model.

Figure 4. One-way system with new traffic flow direction in the scenario simulation model.

3.2. Simulation Results and Discussions
In these studies, identical simulation models are run for approximately one-hour periods with five random seed on both the base and scenario simulation models to produce the output value of measure of performance, namely an average vehicle delay, travel time and speed. The output values of both models are then compared. Comparison of the average vehicle delay at KFC and Manahan Flyover Intersections for all simulation models can be seen in Figure 5. The simulation results show that the
average vehicle delay at intersections of the scenario simulation model lower than the base simulation model. Similarly, for the average travel time of various segments, where scenario simulation model produces lower travel time compared to the base simulation model, see Figure 6.

![Average Delay Comparison](image1)

**Figure 5.** Comparison of average delay at KFC and Manahan Flyover intersections.

![Average Travel Time Comparison](image2)

**Figure 6.** Comparison of average travel time.

Comparison of the road network average vehicle delay and speed for all simulation models can be seen on Figure 7. The simulation results show that the road network average vehicle delay of the scenario simulation model lower than the base simulation model. Vehicle delays on the road network are low due to high vehicle speeds. Scenario simulation model produces the higher vehicle speed in the network compare to the base simulation model.

![Network Performance - Average Delay Comparison](image3)

![Network Performance - Average Speed Comparison](image4)

**Figure 7.** Comparison of network average delay and speed.

Simulation results show that in general the scenario simulation model produces better road network performance than the base simulation model. In addition, in the absence of conflicting point between traffic flows from Adi Sucipto road and MT Haryono road heading to Dr. Moewardi road, the potential for traffic accidents is reduced.

Traffic management and engineering efforts undertaken in the Manahan area includes road widening and management parking at KS Tubun road and Menteri Supeno road in order to increase road capacity.
and break down the road side obstacles, diverting vehicle travel route from zone B to C by passing KS Tubun road and Menteri Supeno road. Figure 8 shows traffic condition before and after traffic management and engineering efforts.

![Traffic conditions before and after management efforts](image_url)

**Figure 8.** Traffic condition before and after traffic management and engineering efforts.

4. Conclusion

Imperfect and immature various traffic management and engineering studies on the Manahan Flyover design have caused a negative impact on traffic accident at the Manahan Flyover intersection. Based on traffic behaviour observations at the Manahan Flyover shows that the potential for traffic accidents is relatively high between traffic from the West and North that meets at the Manahan Flyover intersection. In order to avoid potential accidents, therefore, the direction of traffic movement at the Manahan Flyover is made with a one-way system. The simulation results indicate that the diversion of traffic movement at the Manahan flyover on the scenario simulation model produces better performance than the base simulation model in terms of road network performance and traffic accident. This scenario must be followed by various traffic management and engineering efforts in the Manahan area including road widening and parking management in the KS Tubun road and Menteri Supeno road.

5. References

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