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Transportation Research Procedia 6 (2015) 198 – 212

Transportation Research Procedia

www.elsevier.com/locate/procedia

4th International Symposium of Transport Simulation-ISTS'14, 1-4 June 2014, Corsica, France

Microscopic Simulation on the Design and Operational Performance of Diverging Diamond Interchange

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Abstract

A proper traffic impact study needs to be conducted in order to estimate the extra traffic volume generated from new development to mitigate the negative impact on existing roads. Generally, results from traffic impact studies indicated that most of the existing intersections in urban areas have already exceeded the capacity. The problem becomes even more complicated when the peak hour flow rates are reaching capacity at the signalized intersections of a diamond interchange. Therefore, this study attempts to search for alternative interchange design to address the problem by means of simulation. This paper elaborates the microscopic simulation models developed using the VISSIM software to investigate the design and operational performance of a diverging diamond interchange for different traffic scenarios and signal plans.

Selection and/or peer-review under responsibility of the Organizing Committee of ISTS'14

Keywords: Traffic impact, diamond interchange, capacity, simulation, diverging diamond interchange

1. Introduction

New developments will generate additional vehicular trips which will cause impact to the existing roads in the surrounding area. Therefore, proper traffic impact study needs to be conducted to estimate the extra traffic volume in order to mitigate the negative impact of the new development on the existing roads. Based on results obtained from traffic impact studies, more often than not, most of the existing intersections in urban areas have already exceeded the capacity. Many of intersections now need to have additional lanes in order to cope with the increasing demand and some of them even need to be upgraded into grade-separated interchanges, which can be very costly.

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Selection and/or peer-review under responsibility of the Organizing Committee of ISTS'14
doi:10.1016/j.trpro.2015.03.016

The problem becomes even more complicated if it is the expressway overpass or underpass of a grade-separated interchange which has peak hour flow rates reaching the capacity. Therefore, this study attempts to search for alternative interchange design to address the problem by means of microscopic simulation using the VISSIM software.

The case study is the Autocity, Juru area which is located in the state of Penang and approximately 3.5 km from the Juru Toll Plaza of the North-South Expressway. In the heart of Autocity, Juru, there are three critical traffic hot spots; two signalized local intersections and one signalized diamond interchange. Currently, all intersections are operating at level-of-service F even after many attempts had been made to adjust and optimize the cycle time. At present, the cycle time is set at approximately two minutes for both of the signalized intersections and 3 minutes for the signalized diamond interchange. It is therefore envisaged that further extension of cycle time will only cause higher delay and longer queue length. This clearly showed that the capacity of the intersections has been exceeded. The improvement of the diamond interchange is very critical in this case as this interchange is a traffic bottleneck in the Autocity area. Once traffic is cleared from the interchange, traffic from the other signalized intersections in the vicinity can then be dispersed quickly and smoothly.

One innovative way to improve the capacity and operational performance of the interchange is by converting it into a diverging diamond interchange. A diverging diamond interchange is a unique type of diamond interchange as it applied the unusual concept of traffic rule in which it requires traffic on the expressway overpass (or underpass) to briefly drive on the opposite side of the road. Generally, a diverging diamond interchange only needs two-phase operation for six-signalized movements and therefore can improve the efficiency of a signalized interchange. Also, a diverging diamond interchange has less conflict points than a conventional diamond interchange. In Penang where traffic keeps to the left side of the road, the ability to make right-turns without crossing over the road to make the turns produces less conflict points. However, driver confusion may cause safety problems in the design of a diverging diamond interchange and so proper signage must be provided to guide the drivers to manoeuvre through the interchange in a safe manner. This paper describes microscopic simulation models developed to investigate the design and operational performance of a diverging diamond interchange for different traffic scenarios and signal plans; i.e. different signal phases and timing using microscopic simulation approach.

2. Road network in study area

There are five existing junctions in the study area. Junction A and Junction B are the at-grade four-legged signalized intersections of the diamond interchange on the North-South Expressway. Junction A and Junction B connect Jalan Kebun Nenas with the North-South Expressway. Junction C is a signalized T-junction located at about 160 meters away from Junction B. Junction C connects Jalan Kebun Nenas with Jalan Perusahaan. Junction D is a four-legged signalized intersection located about 280 meters away from Junction C and connects Jalan Perusahaan with Jalan Perusahaan Maju 8. Junction E is a stop-controlled T-junction that connects Jalan Perusahaan Maju 8 with Jalan Perusahaan Maju 9.

In the near future, a new development is proposed to be constructed on a 39-acre site in the Autocity, Juru area. Currently it can be accessed from Jalan Perusahaan 8. The proposed development consists of a mixed development of apartments and hotel. The building is designed with four blocks of apartment in which each block has 302 units and 1 block of hotel. In order to provide access in and out of the development area, a new road, which is connected with Junction E will be constructed and thus making Junction E a four-legged junction. Fig. 1 shows the road network and junction designation in the study area. Fig. 2 and 3 show the morning and evening peak hour flow rates in the existing situation and that upon completion of proposed development respectively. Fig. 4 to Fig. 6 show the configuration and signal phasing for Junction A and B, C and D respectively, while Fig.7 shows the configuration of Junction E before and after the completion of the proposed development.