JOURNAL OF TRANSPORTATION SYSTEMS ENGINEERING AND INFORMATION TECHNOLOGY
Volume 7, Issue 5, October 2007
Online English edition of the Chinese language journal

Available online at www.sciencedirect.com
ScienceDirect

Cite this article as: J Transpn Sys Eng & IT, 2007, 7(5), 96−101.

RESEARCH PAPER

Calculating the Lengths of Auxiliary Lane and its Channelization of Urban Expressway Exit Using Simulation

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Abstract: The rational lengths of auxiliary lane and its channelization of urban expressway exit play an important role in increasing the exit capacity and decrease the influence to expressway traffic flow from exit. The entrance-exit style exit of diamond interchange was surveyed, and traffic flow data was collected. VISSIM microcosmic simulation model was calibrated and validated using survey data, and the exit of diamond interchange simulation model was built. Using simulation, the authors analyzed the survey data and worked out the recommendation values of auxiliary lane and its channelization length of urban expressway exits.

Key Words: urban expressway; traffic simulation; auxiliary lane; channelization

Introduction

Urban expressway system is playing a more and more important role in the urban road network and its entrances and exits are vertical to its capacity, where the so-called "static bottleneck" often occurs. The urban expressway system in China began to be built in 1980s, which is much later than that in developed countries, and there is a lack of deep study on alignment and traffic characteristics. There is no definite item for urban expressway exits and waving sections in the current Urban Road Design Standards (CJJ37-90). According to the operation of urban expressway, many problems occur at entrances and exits. Vehicles queue on main roads and local roads near the exit and cause congestion, and crashes happen frequently in the waving section before an exit or at the intersection of an exit and a local road. Analysis on urban expressway exits will help to decrease or eliminate the "static bottleneck" and improve the capacity and level of service of the whole system. Meanwhile, a lot of field data will be necessary under different scenarios if using traditional statistical methods. It is difficult to obtain so much data because of the limit of money and technical methods. However, traffic simulation may be an effective method to do the analysis. In this study, the authors calibrated and verified the VISSIM microscopic simulation software based on field data and set up a model of exits on diamond interchange, and the recommended values of the lengths of auxiliary land and its channelization on diamond interchange were obtained using simulation with the model.

1 Traffic flow characteristics of exits

Vehicles use an exit to drive to a ramp or a local road from the main road. It can be classified into two categories according to the features: one is an exit to a ramp, such as exits on cloverleaf interchange or directional interchange; the other is exits on diamond interchange. The former can be classified into with auxiliary lane or without auxiliary lane. According to the relative locations and different combinations of entrances and exits, it can also be classified into all-entrance, all-exit, entrance-exit, and exit-entrance. In this study, the authors analyzed the type of entrance-exit exits with auxiliary lane on diamond interchange.

Vehicle speed on the expressway is much higher than that on the local road. Although the exiting vehicles will decrease their speed on the auxiliary lane on main road, there is still speed difference with vehicles on local road. Moreover, when the exiting vehicles merge into the flow on local road, they need to look for gaps to change lanes, so an auxiliary lane is needed. A badly designed auxiliary lane easily tends to be a bottleneck to a whole expressway system. If there is no auxiliary lane, a yield sign should be set up on the local road

Received date: 2007-05-10
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and vehicles on local road must yield to those from main road. If the vision condition is bad or the exiting vehicles are too fast, crashes will tend to happen. So the yield sign will only be recommended when there is a low traffic flow on the local road. When the auxiliary lane is not long enough for drivers to increase or decrease their speed or to look for enough gaps to merge, the exiting vehicles will run slowly or even queue on the auxiliary lane. However, in urban expressway system, distances between interchanges are rather short and it is hard or even impossible to set up an exit auxiliary lane with a rational length.

When the auxiliary lane is long, vehicles will merge into local road at different spots and the exiting vehicles in and out of the auxiliary lane will become diverging. If there are more than one diverging point, vehicles on local road will be disturbed. Moreover, vehicles on local road will use the auxiliary lane to overtake. When exiting traffic demand is high, as there is too few diverging points, the diverging vehicles will unable to merge into the local road and will wait or queue in the auxiliary lane, which will affect the operation of main road. So the rational lengths of the auxiliary lane and its channelization are significant to improve the exit's capacity and decrease the effect to the main road.

2 Model calibration and verification

Simulation has been applied for traffic engineering comprehensively. Compared to other traffic analysis method, traffic simulation has many advantages and does not need the real facilities to be involved, so it can be applied for in-planning traffic system behaviors analysis. Simulation can be used to determine the important factors in the system operation and the interaction among them as well. In this study, a northbound exit on Jingguang Bridge (diamond interchange, see Fig. 1) on the Third Ring Road, a typical expressway in Beijing, was chosen to study. Field data of traffic flow was collected and analyzed, and the results were used to calibrate and verify the traffic simulation model.

2.1 Data collection

Data of the studied exit should include geometric data, traffic flow data and background data. The geometry characteristics of observed exits are: three lanes on main road, two lanes on local road, one auxiliary lane in waving section, one auxiliary lane at exit, and upstream road gradient is <2%; the traffic flow data includes traffic flow on main road, local road and the exit, and traffic composition and speed. (See Table 1); the background data includes the on site road conditions and weather conditions, and traffic management, and so on.

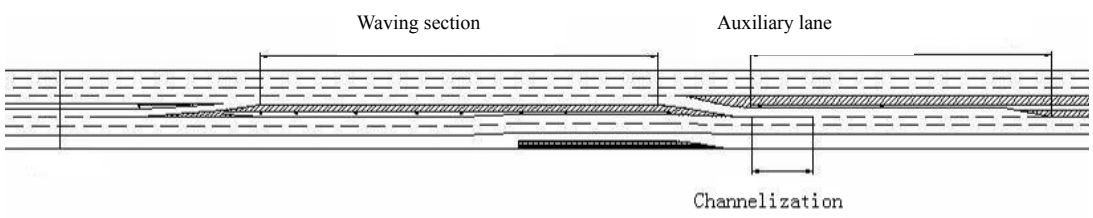

Fig. 1 Study area

Table 1 Result of traffic flow survey

Time of period	Volume on main road	Large vehicle percentage	Volume on local road	Large vehicle percentage	Exit	Large vehicle percentage
07:00–08:00	3451	0.08	868	0.22	1104	0.12
08:00–09:00	3550	0.05	1205	0.21	1226	0.06
09:00–10:00	4583	0.03	1028	0.20	815	0.02
10:00–11:00	3825	0.02	1101	0.16	1002	0.01
11:00–12:00	3915	0.02	1401	0.13	772	0.01
14:00–15:00	3779	0.02	1113	0.13	820	0.02
15:00–16:00	4327	0.03	1279	0.13	914	0.02
16:00–17:00	3465	0.05	1776	0.10	744	0.04
Average	3862	0.04	1221	0.16	925	0.04

2.2 Model calibration

VISSIM is a simulation software developed according the traffic characteristics in foreign countries and the traffic difference between China and other countries should be considered when using this software to solve problems in China. The following are parameters in VISSIM model: