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A Study of Collision Risk Estimation and Users Evaluation at Merging Section of Urban Expressway in Japan

Koji Suzuki[1*], Kazuki Imada[1] and Yuki Matsumura[2]

[1]*Nagoya Institute of Technology, JAPAN.*

[2]*JR-Central Consultants Company, JAPAN.*

suzuki.koji@nitech.ac.jp, cko13511@stn.nitech.ac.jp, y-matsumura@jrcc.co.jp

Abstract

This study aims to estimate collision risk by using a surrogate safety measure and discusses the quality of service perceived by drivers at merging sections of an urban expressway in Japan. First, to elucidate collision risk occurrences at merging sections, we analyzed the collision risk between a merging vehicle and a main lane vehicle by using the Possibility Index for Collision with Urgent Deceleration (PICUD). Second, we performed discriminant analyses of the PICUD estimation results to reveal the factors influencing collision risk at each merging section for several conflict patterns. The discriminant analyses revealed that the merging position, traffic volume of the main lane, and direction of merging section have a significant effect on the collision risk for merging movements.

Keywords: Collision risk, User evaluation, Merging section, Urban expressway

1 Introduction

Spatial constraints at urban expressways in Japan cause several problems. Because of spatial constraints, the lengths of some merging sections are insufficient and these sections comprise a right-hand-side entrance ramp that is directly connected to the main lane. This causes stress to unfamiliar and elderly drivers and they perceive collision risks while merging onto the expressway. Therefore, these situations must be quantitatively evaluated from the viewpoints of traffic conflict risk and the quality of service perceived by drivers.

Makigami and Matsuo (1988) analyzed the critical gap for a left-hand-side merging section (hereinafter side-ramp) and a right-hand-side merging section (hereinafter center-ramp) on an urban expressway; however, they did not evaluate the quality of service (hereinafter QOS) at the merging sections. In addition, Ohsawa et al. (2010) analyzed the characteristics of vehicle movements in the

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acceleration lane at a center-ramp, and Ogino et al.(2003) evaluated the effects of reducing traffic congestion by analyzing the vehicle movements at a center-ramp; however, they also did not discuss the QOS at the merging sections. Using a simulation model, Makigami et al. (1984) evaluated traffic safety at merging sections on an expressway by using traffic conflict data such as braking and lane-changing behaviors. Kita and Hirai (1993) developed a merging behavior model considering merging timing coordination and evaluated the potential risk at merging sections by using the time to collision (TTC) index. In addition, Watanabe and Nakamura (2005) or Chu et al. (2013) developed the gap choice behavior model and acceleration movement model for merging sections. Moreover, Akutsu and Iwasaki (2005) analyzed the QOS at merging sections by using detector data from the point of applicability of the evaluation index at a basic section.

As stated above, many studies have evaluated the gap choice behavior and acceleration behavior of coordinating vehicles at merging sections on urban expressways. However, the potential risk after gap choice behavior at a merging section has not been evaluated using a surrogate safety measure (hereinafter SSM). Moreover, the relationship among traffic situation, road structures of merging sections, and certain conflict patterns has not been analyzed from multiple viewpoints.

Therefore, this study aims to estimate collision risk by using an SSM and discusses the QOS perceived by drivers at merging sections of an urban expressway in Japan. Using image processing technology, we observed vehicle merging movements and traffic conflicts at three ramps with different geometries.

2 Characteristics of Survey Site

We evaluated vehicle movements at three ramps (merging sections) on Nagoya Expressway in Nagoya city, Japan. Figure 1 shows the merging section geometries

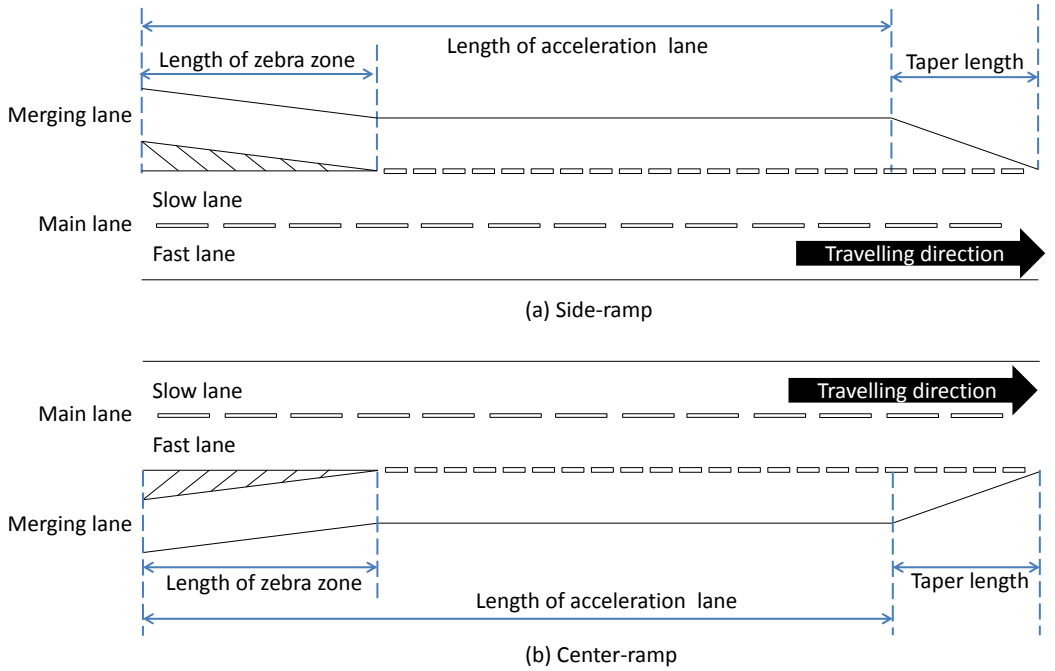

Figure 1 Merging section geometries