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主 論 文 の 要 旨

論文題目 A Study on Crash Risk at Expressway Basic Segments and Its Influencing Factors（高速道路単路部における交通事故リスクとその影響要因に関する研究）

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論 文 内 容 の 要 旨

In modern society, expressway serves as the main arteries for daily commuting/business trips and its performance is critical to quality of service (QOS) of the whole transportation network. Traffic safety, as one crucial aspect affecting QOS, its evaluation methodology remains absent at the stages of road planning and design. Without necessary performance check, improper road design and management may give rise to less safe operation.

For safer road design and traffic operation, it is required to identify crash characteristics and their influencing factors. With the realization of data immediately before crashes, proactive traffic management strategies seem available based on predicting the probability of crash occurrence in advance. However, most existing models are not perfect regarding their predictive powers. Despite the insufficiency of modeling methods, few studies have incorporated geometry, traffic flow and ambient conditions in a single model. Meanwhile, previous studies paid little attention to the varied impact of traffic flow on crashes with the change of traffic conditions. Besides, crashes are characterized in facility and expressway type-specific, while existing models are focused on the whole network of expressway.

This study aims to develop a crash risk estimation model (CREM) to identify the affecting mechanisms of crash influencing factors at basic segments, considering the interaction of geometry, traffic flow and ambient conditions. CREM is developed separately for urban and intercity expressways and then is further compared between the two types of expressways, with the purpose to more comprehensively understand the cause of crash occurrence. The final objective of this study is to apply the measure of crash risk for traffic safety evaluation of geometric design and for proactive traffic management strategies.

In Chapter 1, background statements about the losses to society induced by expressway crashes, the importance of explanatory factor identification for geometric design/traffic management, and several significant characteristics of crashes on expressway are discussed. The related problems of existing studies are analyzed and the objectives of this study are

hereby provided. Finally, the research outline is graphically illustrated.

Chapter 2 shows the state-of-the-art review on crash analysis. Fundamental characteristics of crash data and explanatory factors involved in existing studies are introduced. The strengths and weaknesses of popular crash analysis methods are discussed. Considering the nature of crash event as well as the objectives of this study, the matched case-control logistic regression is proposed as an appropriate method to measure the effects of various independent variables on crash occurrence, which is a binary outcome event in essence.

Chapter 3 describes the study sites including the section from Mikkabi interchange (I.C) to Yokaichi I.C of Tomei-Meishin Expressway referring to intercity expressway and Nagoya Urban Expressway corresponding to urban expressway. Five datasets over the year from 2007 to 2009 that consist of crash records, detector data, geometric design, traffic regulation records and daily sunrise/sunset time records, are utilized. Preliminary analyses on the different geometric design and traffic characteristics between urban and intercity expressways are conducted, and the findings are prepared for the following analysis.

Following, Chapter 4 explains the development of CREM for urban expressway. Crash rate (CR) model and principal component analysis (PCA), as two proactive analyses, may identify the significant and independent variables through focusing on traffic conditions. Based on those variables, a matched case-control study is designed and then conditional logistic regression is applied for quantifying the effects of those variables on crash risk. The model demonstrates that 1) horizontal alignment is the most significant factor related to crashes, while its significance is on the decrease with the increase in traffic density; 2) in contrast, the effect of vertical alignment on crashes gets more important; and 3) owing to the more powerful inter-vehicle interaction, speed becomes more sensitive to crash risk as traffic density increases. Ambient conditions are not negligible exposure, since nighttime and holiday may increase crash risk relative to daytime and weekday, respectively.

By the similar process, CREM for intercity expressway is established in Chapter 5, and its crash characteristics including CR statistics and the sensitivities of variables to crash risk different from urban expressway are analyzed. By expressway type, geometric design is a major cause leading to higher CR and crash risk on urban expressway in low-density uncongested flow, such as poor geometric consistency induced by small curves and heavy driver workload caused by narrower cross section compared to intercity expressway. When traffic density increases, the inter-vehicle interaction gets more intensive, and thus traffic conditions on intercity expressway get less safe for its vehicle composition characterized by higher percentage of heavy vehicle (HV). In congested flow, the variation in speed is quite sensitive to crash risk, and intercity expressway still has worse safety situation due to the interruption of HV to other traffic, especially driving on steep vertical slopes.

An extended analysis on the applications of CREM is executed in Chapter 6 regarding 1) the evolving process of crash risk along with traffic conditions and 2) the quality of geometric design, e.g., assessing safety benefit and identifying crash-prone locations. It indicates that crash risk is convex downward to traffic density in uncongested flow, and

following a decreasing trend in congested flow. The safety benefit of horizontal alignment can be more reliably measured through crash risk prediction in low-density uncongested flow. Comparatively, the safety benefit of vertical alignment seems highly related to the prediction of crash risk in congested flow. Meanwhile, the potential crash-prone locations would be identified and they are further found out to be traffic condition dependent.
Finally, Chapter 7 summarizes research conclusions and provides some recommendations for future works. For proactive traffic management strategies, the model in present study may provide leverage to predict hazardous conditions and avoid an impending crash. Crash risk estimation can be applied for assessing safety benefit of geometric design and the results of geometric variables related to crash risk may supply a benchmark for the improvement of performance-check expressway design. Besides, the concept of identifying crash-prone location based on crash risk estimation is considered more applicable for operational applications at the view point of traffic management. Concerning the better application for proactive traffic management and geometric design, directions for future works are addressed regarding the applicability to other facility types, the improvement of the model validity and the implementation of traffic control measures.