Expressways are of great importance and serve as the backbone of a roadway system. One of the reasons why expressways provide high level of services is that limited access is provided to permit vehicles to enter or exit expressways. Entering and exiting of vehicles are accomplished through interchanges, which consist of several ramps. A weaving segment might form when an on-ramp is closely followed by an off-ramp. The geometric design of ramps and the traffic behavior of weaving segments are different from other expressway segments. These differences result in distinct crash mechanisms of these two expressway special facilities. Hence, the safety of these two facilities needs to be explored.

The majority of previous traffic safety studies on expressway special facilities are based on highly aggregated traffic data, e.g., Annual Average Daily Traffic (AADT). The highly aggregated traffic data cannot represent traffic and weather conditions at the time of crashes. One way to solve this problem is microscopic safety study through hourly crash prediction and real-time safety analysis. Hourly crash prediction determines the relationship between crashes and hourly traffic flow characteristics. Real-time safety analysis enables us to predict crash risk in the next few minutes using the current traffic, weather, and other conditions.

There are four types of crash contributing factors: traffic, geometry, weather, and driver. Among these, the geometric factors' influence on safety are generally excluded because the majority of previous microscopic safety studies are on mainlines, where the geometric design of a segment does not change much. Not enough microscopic safety studies have adopted weather factors because of the limited availability of weather data. The impact of drivers on safety has also not been widely considered since driver information is hard to be obtained. This study explores the relationship between crashes and the four contributing factors. Weather data are from airport weather stations and crash reports. Meanwhile, land-use and trip generation parameters serve as surrogates for drivers' behavior.

Several methods are used to explore the impact of these factors. Random forests are used in discovering important and significant explanatory variables. Then, the selected variables are put in logistic regression models and Poisson-lognormal models to respectively estimate crash risk and crash frequency. Meanwhile, in case of correlation among observations in the same segment, a multilevel modeling structure has been implemented. Furthermore, a data mining technique—Support Vector Machine (SVM)—is used to distinguish crash from non-crash observations.

Once the crash mechanisms for special expressway facilities are found, we are able to provide valuable information on how to manage roadway facilities to improve the traffic safety of special facilities. This study adopts Active Traffic Management (ATM) strategies, including Ramp Metering (RM) and Variable Speed Limit (VSL), in order to enhance the safety of a congested weaving segment. The results shows that the crash risk and conflict count of the studies weaving segment have been significantly reduced because of ATM.

Finally, potential relevant applications beyond the scope of this research but worth investigation in the future are also discussed in this dissertation.

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