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Risk Factor Identification

tech transfer summary

Ultimately, the results of this research will allow for more effective network surveillance and identification of high-risk crash locations at intersections on high-speed, rural, two-lane roadways, as well as along horizontal curves on high-speed, two-lane and multilane roads.

Background

Intersections and horizontal curves present two high-priority areas for engineering countermeasures to improve safety and lower crash severity. The implementation of countermeasure programs is generally focused on high-risk locations, which are identified based on extensive historical traffic safety data (i.e., crash history).

Problem Statement

Unfortunately, the identification of candidate locations for engineering countermeasures is often challenging due to the random and rare nature of traffic crashes, as well as related analytical issues such as regression-to-the-mean (RTM). These challenges are particularly pronounced on rural highways, where many potentially high-risk locations may be difficult to identify given lower traffic volumes.

Project Objectives

The aim of this study was to provide assistance in the identification of risk factors for traffic crashes on two facility types in Iowa: intersections and horizontal curves.

Research Methodology

The researchers identified risk factors through the analysis of a robust database for Iowa roadways, which combined data from various sources that included traffic volumes, roadway geometry, and other characteristics, as well as Iowa crash data.

The researchers used crash trees, regression models, and exploratory visual analytics of Iowa's crash data for the intersection part of this study. They further investigated the effects of skew angle and other factors associated with safety at rural intersections in Iowa using safety performance functions (SPFs). The scope on this part of the study was limited to five years of data (2009–2013) for intersections on high-speed (speed limit of 45 mph or higher), rural, primary, two-lane roadways.

The researchers also used crash trees and conducted a more in-depth investigation into the safety risk factors on primary and secondary horizontal curves (freeway and non-freeway segments) using five years of recent data (2010–2014) for this study. They assessed frequency data for horizontal curves using a negative binomial modeling framework and analyzed crash severity data for horizontal curves using a partial proportional odds model.

December 2016

RESEARCH PROJECT TITLE
Risk Factor Identification

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Iowa Department of Transportation
(InTrans Project 15-551)

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Intersection Study Key Findings

Overall, the five-year intersection crash study results for Iowa's primary roadways reinforce several important geometric design characteristics that affect traffic safety. Looking at a primary factor of interest for intersections, the researchers found crashes to increase with skew angle at both three-leg and four-leg intersections. The researchers found the effect of skew was generally similar to the crash modification factors (CMFs) from the American Association of State Highway and Transportation Officials (AASHTO) *Highway Safety Manual* (HSM).

For broadside and angle crashes, the effects of skew on four-leg intersections were even more pronounced. When comparing broadside and angle crashes to the total number of crashes at four-leg intersections, the through movement on the minor leg was impacted more by skew angle.

The presence of unpaved approach legs was associated with fewer crashes at high-speed, rural intersections, which is likely a reflection of less frequent turning movements from the major road and also fewer crossing movements from the minor road (with the unpaved approach leg).

Crashes were also less frequent at three-leg intersections where lighting was present, as well as at locations with larger heavy-truck volumes were greater. This may be due, in part, to the fact that those highways tend to be of a higher functional class, which would be correlated with other roadway features. These roadways generally have wider lanes and shoulders, larger clear zones, and other higher design standards that may lead to fewer crashes than similar lower functional class facilities.

Horizontal Curve Study Key Findings

The results of the horizontal curve crash analysis showed crashes to increase with traffic volumes on both freeways and non-freeways, as well as in the presence of paved left shoulders on non-freeway segments. Crashes were less frequent on freeway segments with paved outside shoulders and on independent curves on non-freeway segments. Crashes were more frequent on sharper curves (with smaller radii), as well as where curves in opposing directions were present in the immediate vicinity of one another.

The researchers also conducted a crash severity analysis for horizontal curves, with the results showing that injuries tended to be more severe when drivers were unrestrained or ejected from the vehicle, or when the airbags deployed.

Crashes were also more severe when crashes involved a single-vehicle, broadside crash, or two vehicles traveling in opposite directions. Collectively, these findings reflect the greater impact forces that are exerted on motorists in these types of crashes.

Based on the analysis of the freeway segments, males were less likely to be injured than females, and younger drivers were also less likely to experience high-severity crash outcomes, which are findings that may relate to physiological or behavioral differences.

Crashes also tended to be less severe on horizontal curves during dawn and dusk conditions. Additionally, crashes on left curves where concrete barriers or paved inside shoulders were present were associated with decreased crash severity, which likely reflects a lower likelihood of vehicles crossing the median when these features are present.

Implementation Readiness and Benefits

The intersection analysis provides important results that reinforce the extant research literature as to the relationship between intersection skew angle and crash frequency. The Iowa intersection database that was developed contains additional information and site types, which would allow for a detailed investigation into other questions of interest.

This study is one of the first to exploit Iowa's horizontal curve information using the Curve Finder tool. The results of the horizontal curve analyses provide some important preliminary insights into the relationship between traffic crashes and various curve characteristics, which may be used for effective network surveillance and the identification of high-risk horizontal curves. This may include the identification of curves where additional traffic warning signs (e.g., chevrons, advisory speed signs) may be installed.

Moving forward, the extensive databases developed as a part of this study may be supplemented with additional information. As intersections and horizontal curves continue to be emphasis areas for improving safety, the identification of risk factors will allow for the proactive and cost-effective implementation of various engineering countermeasures.

Future Intersection Safety Research

There are several prospective avenues for further intersection safety research and more detailed investigation is warranted into several areas of importance identified in this study. For example, disaggregate-level turning movement counts would provide insights as to the findings related to auxiliary turn lanes and unpaved approach legs. As this study only considered total crashes and broadside/angle crashes, future research could explore various crash types in conjunction with major causes for crashes.

Over the course of a data quality review of the intersection database, concerns arose as to the accuracy of several factors, including offset, rumble strip presence, bicycle lane and crosswalk presence, and other factors. With the continued refinement of the intersection database, additional risk factors could also be investigated.

Future Horizontal Curve Safety Research

As the quality assurance/quality control (QA/QC) process involving information from the Curve Finder tool progresses, the data may be used to conduct further investigations into factors affecting the frequency and severity of crashes along horizontal curves. This database will also provide an opportunity to further investigate curves on other facility types.