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Graduation Term:SP 2017
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Degree:MS
Title:SAFETY EVALUATION OF ROUNDABOUTS AT FREEWAY RAMP TERMINALS AND HSM CALIBRATION

The increased usage of roundabouts at intersections in the United States can be attributed to their improved efficiency under certain traffic patterns, reduced maintenance costs, and potential safety benefits in decreasing crashes, especially of more severe crash types. With this wave of popularity, there also has been an increase in roundabouts constructed near freeways as interchange ramp terminals in an attempt to capture similar safety effects at these facilities. However, there has been limited research on the safety impacts that roundabouts possess when utilized in this way, with mixed results. This thesis outlines a detailed safety evaluation using a sample of eight interchanges (13 individual roundabout ramp terminals) recently implemented in Missouri. Before and after crash data was used to perform project-level (entire interchange footprint) and site-specific-level (ramp terminal only) Empirical Bayes (EB) safety evaluations at these locations. Moreover, this evaluation distinguished the specific safety benefits at three different severity levels: fatal and injury (FI) crashes, property damage only (PDO) crashes, and total crashes. In utilizing the EB evaluation method, the observed crash rates associated with the roundabout design was directly compared to what could reasonably be expected had the original ramp terminal configuration remained in place. This method also accounts for regression to the mean bias of observed crash rates and provides the statistical significance of each evaluation. The results for the project-level safety analysis across all interchanges suggested that roundabout implementation could reduce crashes between 13.1-13.8%; however, these collective results do not show the observed trend that the single-lane roundabout interchanges performed much better than those with dual-lanes. The project-level aggregated results of the single-lane roundabout decreased FI crashes by 20.3%, PDO crashes by 26.0% and total crashes by 24.5%. Conversely, the dual-lane roundabouts were shown to only reduce FI crashes by 2.3% while increasing PDO and total crashes by 16.9% and 12.2%, respectively, over the entire interchange. The site-specific safety analysis was also analyzed for the single-lane roundabout sites and dual-lane roundabout sites. The site-specific safety evaluation results for single-lane roundabouts indicated a reduction in FI crashes by 32.8%, PDO crashes by 23.1%, and total crashes by 24.4%. The dual-lane site-specific results showed an increase in FI crashes by 34.7%, PDO crashes by 53.9%, and total crashes by 50.0%. It should be noted that these evaluations do not compare the two roundabout types to each other but rather to their original ramp terminal configurations. From this, there is a clear indication that single-lane roundabouts provide improved safety benefits as ramp terminal configurations while dual-lane roundabouts have been shown to contain less effective safety benefits in certain applications.
The Highway Safety Manual (HSM) is a valuable tool for transportation and traffic engineers that provides an approach to quantify potential safety effects for various roadway characteristics. However, this manual contains national crash prediction models that need to be calibrated to local conditions with the most recent observable crash data to improve accuracy. This thesis also outlines the calibration procedure and performs a recent calibration for four different facility types: rural two-lane, undivided roadway segments, urban five-lane undivided arterial segments (with two-way left-turn lane), urban six-lane freeway segments, and rural two-lane three-leg stop-controlled intersections. Also included is a distribution of the observed crash severity and crash types that can be expected at each facility type.