Performance of Right-Turn Lane Designs at Intersections

Introduction

Intersection-related crashes are one of the main contributors to total crashes. In 2014, intersection-related crashes contributed to 47% of all crashes and 28% of fatal crashes in the US, as reported by the National Highway Traffic Safety Administration (NHTSA, 2014). Within Indiana, intersection-related crashes contributed to 31% of total crashes and 24% of fatal crashes (INDOT, 2014). In addition, the Federal Highway Administration (FHWA) estimated the annual economic and societal cost of intersection-related crashes was close to $50 billion (FHWA, 2015). Therefore, engineers and researchers have been looking for alternative ways to improve the safety and operation of intersections. Researchers commonly focus on examining the relationships of the intersections’ geometry designs and the types of crashes, but a recent concern is safety impacts at intersections with right-turn lanes (RTLs). RTLs provide space for deceleration and storage for right-turning vehicles. Since RTLs separate turning movements from through traffic, they have been known to improve safety and operations at intersections. Depending on the traffic control methods and design elements used, RTLs can be designed in different forms; however, each form has advantages and disadvantages. Constructing appropriate RTLs will improve traffic safety, increase travel speed, reduce delay, and reduce congestion. Therefore, to figure out the design configurations that result in higher crash rates, there is a need to evaluate the safety and operation of RTLs.

Findings

• A high design speed limit increases the number of crashes compared to a low design speed limit. The effects of the design speed limit are different for roadway class and county class.
• Exclusive RTLs reduce crashes, and the effects of the exclusive RTL depend on the AADT of roadway class and county class.
• A 1% increase in the RTL turn radius leads to a 0.22% increase in crash frequency. The effects of the RTL turn radius are different for roadway class and county class.
• RTLs with “yield/stop” signs have 0.785 times more crashes on average than RTLs with traffic signal control. RTLs with “nothing for control” have 0.647 times more crashes on average than RTLs with traffic signal control.
• When RTLs are on local roads and US roads, RTLs with signal control have fewer crashes, and RTLs with “yield/stop” signs have more crashes than RTLs with no traffic control. The effects of traffic control are different for RTLs on local and US roads.
• RTLs with signal control have fewer crashes than RTLs without signal control design. RTLs with “yield/stop” signs have more crashes than RTLs with no traffic control for roads in Marion County, Madison County, Tippecanoe County, Clark County, Harrison County, Allen County, and Laporte County. However, the effect of traffic control is insignificant for roads in Hamilton County and Hancock County.
• The presence of bicycle lanes increases the crash cost by 0.57% ($10,445), and a 1% increase in the RTL turn radius leads to a 0.14% increase in crash cost.
• A 1% increase in RTLs turn radius increases crash frequency by 0.56% and increases the crash cost by 0.21%.
• A 1% increase in the RTL turn radius leads to a 0.17% reduction of crash cost in Madison County, Tippecanoe County, Clark County, Harrison County, Vanderburgh County, Allen County, and Laporte County. A 1% increase in the RTL turn radius results in a 0.59%–0.28% increase in crash frequency for all counties.
• A 1% increase in the RTL turn radius increases the crash cost by 1.78% on interstate roads and increases the crash cost by 0.19% on the local/city road.
• The exclusive RTLs decrease crash cost by 0.07% ($4,229) compared to shared RTLs.
• The effect of the RTL type is different for county class and roadway class. Exclusive RTLs increase crash costs by 0.48%, relative to shared RTLs in Marion County; however, they decrease crash costs by 0.12% in Madison County, Tippecanoe County, Clark County, Harrison County, Vanderburgh County, Allen County, and Laporte County. Exclusive RTLs decrease crash costs by 0.36% in Hamilton County and Hancock County. The exclusive RTLs increase crash cost by 2.69% on the interstate road, but they decrease crash costs by 0.74% on the US road, relative to the shared RTLs.
• The effects of traffic control at RTLs are different for roadway class and county class. Traffic signs decrease crash costs from 0.38%–1.64% for RTLs in different roadways. Traffic signals decrease crash costs from 0.82%–0.51% on different roadways. RTLs with traffic signals increase the crash cost by 0.36%, and RTLs with traffic signs increase the crash cost by 0.20%, relative to RTLs with nothing for control.

Implementation

There were six tasks for estimating the effects of influencing factors on RTL safety performance.

Task 1 was conducting a literature review on previous research, determining the best practices for RTL designs that reduce crashes, and identifying methodology and data sources for analysis.

Task 2 was collecting and processing candidate intersection data. Data collection involved three parts.
1. The population of RTLs was collected from the INDOT geodatabase, US census, and Google Maps.
2. The intersection-related characteristic of RTLs was manually collected from Google Maps, Google Street View, and the INDOT traffic count database.
3. The crash data was obtained from the Automated Reporting Information Exchange System (ARIES). A road name comparison-based method for the multi-source datasets were employed in the data processing.

Task 3 was data description. A correlation analysis was conducted for the explanatory variables, including RTL geometric factors, intersection characteristics, environmental-related factors, and location factors. To understand the traffic management background of different counties, we conducted a clustering method to divided ten counties into three groups according to population, percent of educated people, yearly household income, and the number of individuals below the county poverty level. Finally, the preliminary data description summarized the statistical analysis for RTLs at the roadway and county level.

Task 4 was conducting statistical modeling for both the crash frequency and crash severity. We applied the negative binomial random effect model to estimate the crash frequency and applied the log-linear model to estimate the crash severity. To get detailed estimates, we estimated the crash on the overall county level, on the county level, and on the roadway class level. To ensure the reliability of the estimates, we conducted the robustness test for both models. The interpretations of the estimated results were based on the marginal effect and the elasticity estimates.

Task 5 was providing recommendations for RTL safety improvements. We combined the crash frequency and severity analysis results, provided the key geometric design factors that influenced the safety performance, and ranked recommendations for the RTLs geometric design by their effectiveness.

Task 6 was summarizing the recommendation of the RTL geometric design based on the analysis of crash frequency and severity.

Recommended Citation for Report


View the full text of this technical report here: https://doi.org/10.5703/1288284317277

Published reports of the Joint Transportation Research Program are available at http://docs.lib.purdue.edu/jtrp/.