Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Inventory, Operations, and Safety at Free Right-Turn Ramps

Research Objectives

The proposed research has the following objectives.

- Create a statewide inventory of rural free right turn ramp intersections and provide to NDOT in an appropriate format.
- Using NDOT 10-year crash data, conduct statistical safety analyses of rural FRT intersections extending ¼-mile in each direction from the intersection.
- Study vehicular operations at rural intersections with and without FRT ramps. This will include a comparison of recorded vehicular speeds and conflict analysis.
- Develop guidelines for operations and safety tradeoffs to assist with NDOT projects on maintaining similar locations, removing or reconstructing ramps and traffic warning/control signage.

Research Benefits

The research will assist NDOT Traffic Engineering, District staff, and Roadway Design Divisions with making more informed decisions when dealing with rural intersections with free right turn ramps. The research will also lead to improved public safety on Nebraska highways.

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Background

Research on right turns at rural intersections on the state highway system was initiated by the Nebraska Department of Transportation (NDOT) during the 1990's (McCoy et al., 1995) and again during the 2016-2018 period (Khattak and Kang, 2018). In the former study, the authors developed guidelines for the establishment of FRT ramps on rural two-lane highways in Nebraska based on a benefit-cost analysis. They recommended that design-year right-turn AADTs ranging from 440 to 825 vehicles per day (depending on truck percentage) warranted a FRT ramp at unsignalized intersections on rural two-lane highways. Acceleration lanes improved vehicle merge operations and while right-turning traffic moved efficiently, there were no discernable safety improvements from FRT ramps.

In the latter study, the authors looked at safety and economic benefits of rural intersections with offset right-turn lanes (ORTL) compared to rural intersections with no right-turn lanes and those with traditional right-turn lanes. They also investigated drivers' stopping behavior on the minor approaches at ORTLs. Results showed ORTLs had the lowest crash rates; however, the difference was statistically not significant. The cost-benefit analysis indicated that compared to intersections with no right-turn lanes, ORTL intersections had an annual reduction of 0.202 crashes per million entering vehicles, which translated to $22,662 savings in crash costs per year. When compared with intersections having no right-turn lanes, a traditional right-turn lane reduced 0.0758 crashes per million entering vehicles annually or $8,504 savings in crash costs per year. Driver stopping behavior assessment showed that number of through lanes, width of right-turn lane and width of the ORTL offset were statistically associated with driver's stopping position on the minor approach and overall drivers were taking advantage of the ORTLs improved sight distance. In this study, free right-turn (FRT) ramps were excluded due to their uniqueness (compared to traditional right-turn lanes and ORTLs) for a later study. NDOT has several FRT ramps across the state highway system (see Figure 1). The intersection minor approaches stop-controlled and varying driver warning devices may be in place at these locations. There are concerns about the safety and operations of FRT ramps and therefore, there is a need to review the operations and safety of these locations.

Conclusion

This research focused on traffic safety and operational performance of rural, minor approach stop-controlled intersections with free right-turn (FRT) ramps.

As of 2023, 79 FRT ramps exist at 68 rural highway intersections in Nebraska. FRT ramps may be located on three-legged or fourlegged intersections and may be on the minor, the major, or both minor and major approaches of the same intersection. The research compared the 68 rural FRT ramp intersections to 24 similar non-FRT rural intersections to identify differences in crash frequencies, crash rates, and crash severity using 2010-2019 crash data from NDOT. The analysis did not show any statistically significant differences between the two intersection groups. This result is identical to a 1995 Nebraska-based study of rural FRT ramp intersection safety.

The research investigated vehicular conflicts between right-turning vehicles by pairing six non-FRT intersections with six FRT ramp intersections and collecting data using video recording equipment. The comparison was between vehicular conflicts experienced by right turning traffic on the same approach of the FRT ramp and non-FRT intersections. Data analysis showed that non-FRT right-turns on the minor approach, major approach with no exclusive right-turn lane, and major approach with an exclusive right-turn lane experienced statistically significantly higher conflicts per 1,000 entering right-turning vehicles than FRT ramp intersections.

A VISSIM microsimulation model of traffic operations at FRT ramp intersections and non-FRT intersections enabled the creation of 324 scenarios, based on varying traffic and roadway geometry. Assuming a 20-year lifespan, benefit cost (B/C) analysis was conducted for combinations of discount rates (4%, 6%, and 8%), major road AADT (5,000; 10,000; 15,000), minor road AADT (2,500; 5,000; 7,500), percent right turning traffic (10%, 25%, 50%), FRT ramp radius in feet (650; 1,200; 1,800) and speed limit in mph (45, 55, 65). Traffic operational benefits are the basis for considering FRT ramp construction, reconstruction, or removal at rural, minor approach stop controlled intersections in Nebraska. The reason is the absence of any discernable differences in safety at FRT ramp and comparable non-FRT intersections. NDOT can make more informed decisions on FRT ramp intersections based on guidance in this report.

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Interested in finding out more?
Final report is available:
HERE

NDOT Recommendations Based Off Research Project

The Nebraska Department of Transportation (NDOT) is utilizing this research for rural free-right-turn (FRT) ramps in three different ways. First, the NDOT has used some of the data collected with this research to inform decision makers when an aging FRT location was removed with a construction project. Second, the NDOT Traffic Division is currently reviewing the list of FRT ramp intersections for consistent traffic control throughout the state. Lastly, NDOT is still considering further research for these RFT ramp locations prior to any policy changes.

- As provided by Alan Swanson, Lead TAC Member

Research Readiness Level (RRL) Assessment

Level : Applied Research/Proof of Concept/Laboratory Level

RRL 2

Technology Transfer

Transportation Research Board (TRB) papers and Publications

- Haque, M. S., J. Camenzind and A. J. Khattak. 2024. "Safety and Operational Analysis of Free Right-Turn Ramps at Rural Intersections." Accepted for Publication in Transportation Research Record: Journal of Transportation Research Board.

Webinars/Presentations

- Haque, M. S., J. Camenzind, and A. Khattak. 2024. "Safety and Operational Analysis of Free Right-Turn Ramps." Paper number: TRBAM-24-02235. Transportation Research Board 103rd Annual Meeting, January 7-11, 2024, Washington, DC. Link: https://annualmeeting.mytrb.org/OnlineProgram/Details/21262

Awards

- The research article about the Free Right-Turn (FRT) Ramp won the 2024 Best TRB Freeway Operations Committee Paper Award. The research team will be recognized at both the 2024 Mid-Year Meeting and the 2025 TRB Annual Meeting in Washington, DC. The following link is about a news article published on the UNL's College of Engineering website titled "Khattak and CEE Team Awarded 2024 Best TRB Freeway Operations Committee Paper Award". https://engineering.unl.edu/khattak-and-cee-team-awarded-2024-best-trb-freeway-operations-committee-paper-award

This brief summarizes Project SPR-FY22(012)
"Inventory, Operations, and Safety at Free Right-Turn Ramps"
Nebraska Department of Transportation Research Program