Modern roundabouts have gained acceptance in much of the world but skepticism remains for construction of roundabouts on rural roadways with high speed approaches. Some agencies and the public believe that drivers will not be able to recognize the roundabout and slow down to safely navigate the roundabout at slow speeds. However, drivers face similar driving situations every day on existing roadways when they encounter curves in the road, stop signs or signals. This paper provides a summary of the safety data at rural roundabouts with high speed approaches, the approach speed data findings on 10 roundabout approaches and three two-way stop controlled intersections as well as case studies including design best practices for rural roundabouts.

The INTERSECTIONS

Nineteen conventional rural intersections with problematic crash histories were converted to modern roundabouts. The table below shows the locations of the intersections, year intersection was converted, posted speeds limits and average daily traffic.

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Location</th>
<th>Posted Speed</th>
<th>ADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection 1</td>
<td>Location 1</td>
<td>Speed 1</td>
<td>ADT 1</td>
</tr>
<tr>
<td>Intersection 2</td>
<td>Location 2</td>
<td>Speed 2</td>
<td>ADT 2</td>
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<tr>
<td>...</td>
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CRASH DATA - BEFORE & AFTER STUDY

Over 98 data years, the stop controlled intersections experienced 511 total crashes and 12 fatalities. Once these same intersections were converted to modern roundabouts, and over 98 data years after the conversion, 168 total crashes, 44 injury crashes and no fatalities occurred. This is a 65% reduction in total crashes and 85% reduction in injury crashes.

One of the largest benefits of the modern roundabout on rural, high-speed roadways is the significant reduction in injury producing crash types – namely the angle or T-bone crash. An 88% and 78% reduction was realized for angle crashes and turning crashes, respectively. Side-impact crashes increased by 100% (14 before and 28 after) and fixed object crashes increased by 258% (19 before and 68 after). Interestingly, the increase in fixed object crashes was not associated with an increase in resulting injury crashes. A majority of the fixed object crashes were contributed to hitting curbing within the roundabout or sign posts.

To account for Regression to the Mean associated with simple before and after studies, as shown above, the Empirical Bayes method was used and confirmed the results with estimations of the percentage reduction in total crashes between 62 to 67% and reduction in injury crashes between 85 to 87%. Agencies can rely on both descriptive statistics and statistical analyses to help them make timely decisions about safety improvements.

RURAL ROUNDAWAY CRASH PREDICTION MODEL

NCHRP Report 572 Roundabouts in the United States provides general crash prediction models used for estimating the expected number of crashes at an existing or planned roundabout as a function of the number of approach legs and number of circulat- ing lanes. Interaction-level safety prediction models for total crashes and injury crashes for rural intersections with high speed approaches were not available. New models, specifically for rural intersections, were developed and compared to the general model in NCHRP Report 572. Both fatal and injury crashes were determined using an injury crash prediction model for rural roundabouts. The total crash and injury crash prediction models, developed with negative binomial models, are shown.

Comparing the new model to the general model shows discrepancies which is expected as the new model is site specific – rural, high-speed roadways. On average the NCHRP Report 572 total crash model slightly over predicted crashes (by 0.37 crashes/year) compared to the new model where crashes are on average slightly under predicted (by 0.07 crashes/year). Below the total crash model is shown on the left and the injury crash model is shown on the right. (Note: Nine common intersections were used in both models).

For the injury crash models, the NCHRP Report 572 general model and the new model are very similar in that they both slightly under predict crashes (0.17 and 0.1, respectively).

SPEED STUDY

Speed can increase the risk of injury producing crashes, especially at intersections where vehicles may be approaching an intersection with high speed differentials. It is known that roundabouts force all drivers to reduce their speed in the intersection; however, no advanced approaches speed data was available for roundabouts with high speed approaches to verify this phenomenon. A comparative evaluation of the difference in the average approach speeds between rural roundabouts and rural two-way stop control intersections and between rural roundabouts with and without rumble strips on the approach approaches was conducted.

The four roundabouts included rural New Prague, MN and Paola, Florence and Garnett, KS. Additionally, two rural two-way stop controlled intersections – rural Story County and rural Polk County – utilized the same criteria as the roundabouts were selected. Approach speed data proved that drivers are able to slow down in advance of roundabouts on rural roadways and the mean speeds at 100 ft from the yield line were 2.5 mph lower than mean speeds at 0 ft from the stop bar at stop controlled ap- proaches. Additionally, a comparison between roundabout approaches with and without rumble strips showed mean speeds 4.3 mph and 3.3 mph lower at 100 ft and 250 ft from the yield line, respectively, for the approaches with rumble strips; how- ever, the variations in speeds increased with the introduction of rumble strips.

SUMMARY AND CONCLUSIONS

With nearly 3,000 fatalities and tens of thousands more injury crashes at rural inter- sections annually, safer inter- sections in these environ- ments are a necessity. The research presented here provides evidence that rural roundabouts on high speed roadways are reducing intersection injury crash experiences unlike any other intersection countermeasure. Roundabouts are a proven safety countermeasure.

Crash prediction models, like those found in the AASHTO Highway Safety Manual and shown here can help agencies assess the potential safety benefits (reduced crashes) gained by safety countermeasures to advance the preferred safety alternative.

Rural Roundabouts...

- Significantly reduce the risk of injury crashes
- Prevent high speed angle crashes that result from drivers running stop lights and red lights.
- Slow down all drivers
- Reduce vehicle speed within the critical decision area of the intersection (within 100 ft)
- Are prime candidates for intersections with poor crash histories
- Save lives