Evaluation of Bridge Guardrails for Potential Safety Improvement on Low-Volume Rural Roads in Kansas Using Roadside Safety Analysis Program (RSAP)

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Extended Abstract

This research project aimed to reduce rural bridge-related crashes in Kansas. Roadside Safety Analysis Program Version 3 (RSAPv3), an Excel-based simulation program originally developed under National Cooperative Highway Research Program (NHCRP) report 22-9(1) and later refined under other NCHRP contracts, is an encroachment-based software tool for cost-effective evaluation of roadway safety improvements using independent probabilities representing roadside encroachment events. RSAPv3 was used to carry out simulations in this research study, because it utilizes real crash data for predictions and could be easily updated with local data. Fatal, injury and property damage only (PDO) crash costs of 2017 were provided by KDOT as inputs into RSAPv3. The value of human life was found to vary state-to-state is an important input for the simulation.

In order to reduce roadside obstacles, the Roadside Design Guide (RDG) suggests six ways including: removal of the obstacle, redesigning the obstacle for safe navigation, relocation of the obstacle, reducing collision severity via proper breakaway devices, shielding the obstacle with a roadside barrier or collision cushion, and delineating the obstacle if other measures are not applicable (AASHTO, 2011). Benefit-cost analysis was introduced in RDG (AASHTO, 2011) to prioritize resources among safety implementations in terms of economic comparisons. The benefit was the expected reduction in crash costs and was associated with improvements of projects. Meanwhile, costs included expenses of construction, maintenance, and repair. Benefits and costs were annualized to compare treatments with different project lifespans.

The Roadside Safety Analysis Program (RSAP) was designed to explore whether it was rational to implement bridge rails or bridge-approach guardrails to protect errant vehicles, in terms of benefit-cost analysis. Bridge width varied on different roadways — 20 ft. and 24 ft. on two-wheel-track gravel roads; and 20 ft., 24 ft., 26 ft., and 28 ft. on three- or four-wheel-track gravel or paved roads. The width of a local bridge could be even wider than the road. For example, the widest local bridge on three- or four-wheel-track gravel or paved roads was 28 ft. Given the shoulder width of roadway as 0 ft., roadway width would be (12 ft. * 2 + 0) = 24 ft. According to a common practice of KDOT, the guardrail should be implemented on the edge of the road for optimal performance. Since the bridge-approach guardrail was attached to the bridge rail, it would be located on the slope beside the road, given the bridge was wider than the road, which is unacceptable from an engineering perspective. Two transition sections

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were set up to enlarge the width of roadway to match the bridge on both sides. Only the shoulder width was enlarged in the transition part for simplification.

Length of the transition sections was 100 ft. on each side of bridge, and the length of the bridge was 120 ft. On the other hand, the bridge-approach guardrail would narrow the road given the roadway was wider than bridge. This was deemed accceptable by KDOT. Therefore, no transition section was needed under this circumstance.

As for the shoulder on the bridge, the paved lane was commonly striped across the bridge according to KDOT. Therefore, it was assumed in this project that the lane was carried across the bridge for whatever the surface of the roadway. The extra space beyond the lane would be considered as shoulder on a rural bridge. According to KDOT, the average height of bridge surface to water is 12 ft. Four sections of bridge-approach guardrail were attached to the bridge rail, with an 87.5-ft. length for each, all equipped with crashworthy end-treatment. This project assumed fatal crash costs as $4,733,650 in fiscal year 2017 as provided by KDOT.

This research study investigated two safety scenarios on rural bridges in Kansas to evalaute whether it was recommended to implement bridge rails or bridge-approach guardrails based on a bene-fit cost analysis. For scenario one, a medium bridge edge was set as a base condition. After replacing the medium bridge edge with a w-beam bridge rail, the benefit-cost ratio was greater than 2.00, given and ADT exceeding 400 vpd on three- or four-wheel-track gravel or paved roads. Under certain conditions, the ratios were even greater than 10.00, which was a significant threshold. Additionally, these ratios declined with increasing shoulder width on the bridge, which was consistent with previous traffic safety research on forgiving roadsides. This was the highest ratio from the permutation of all three alternatives. Therefore, it was recommended to replace medium bridge edges with w-beam bridge rails on three- or four-wheel-track gravel or paved roads, given a certain threshold according to field conditions. Meanwhile, it was not recommended to implement bridge-approach guardrails on three- or four-wheel-track gravel or paved roads. For the second scenario, a bridge with TL-2 bridge rail was set as a base condition. It was found that even the largest benefit-cost ratio was not significant. Thus, it was not recommended to implement bridge-approach guardrails on two-wheel-track gravel roads in terms of benefit-cost analysis for this scenario.

The guidance developed in this research study involved whether implementing guardrails, considering rural bridges, could help KDOT efficiently prioritize safety improvements on low-volume rural roads in Kansa. Additionally, the calibrated RSAPv3 model allowed for KDOT to continue to refine and conduct simulations with updated crash data, crash costs, and unusual guardrail situations found in the field in sometime very rural areas of Kansas.

The authors are aware that several assumptions of roadway and bridge structure geometries, as well as plan comparisons, were made in the simulation to simplify the procedure, which might affect the accuracy of the predictions. Moreover, the prediction of RSAPv3 relied heavily on a similarity between its own crash dataset and simulation conditions. If engineering details of the simulations were significantly different from the crash dataset in RSAPv3, accuracy of the results might be affected. However, the local crash dataset can be updated with RSAPv3 to solve this issue.

AASHTO. (2011). *Roadside Design Guide*. AASHTO