Guardrail/Bridgerail Recommendations for Very Low-Volume Local Roads in Kansas

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The Problem
The Local Road System in Kansas is Very Large.

- Over 19,000 bridges
  - Over 8,600 are over 50 yrs. old

- About 3,600 local bridges are deficient.
  - 2,300 +/- are under 50 feet in length
  - 750 +/- are between 50 feet and 100 feet
  - 2,600 +/- are on roads with 50 vpd or less

- Not enough dollars available to make real progress in addressing the problems.
What can we do to increase the number of bridges that are improved?

• Increase the funds available for bridges
  – Additional dollars not likely
  – Shifting funds from other programs will only short-change important needs in other areas

• Use the limited dollars we currently have available in a more efficient way.
Construct bridges that are appropriate for the application.

- Cost of typical Federal-Aid bridge is hard to justify on very low-volume road.

- Low-cost alternatives should be considered
  - Structurally and functionally adequate bridge
  - Many details are lower cost
Examples Low-Cost Bridge
Concerns with the Low-Cost Options
(Roadside Safety Issue)

• Bridge rail is lightweight and untested.
  – W-beam section mounted on either W6X9 guardrail post or other lightweight steel member, welded or bolted to structure.
  – Rail terminates in a blunt end.

• No approach guardrail
Objective of Research

Establish practical risk-based guidelines for design of bridge rails and use of bridge approach guardrails on very low-volume locally-owned roads in Kansas.
Investigation
Tasks Included in the Study

- Review AASHTO policies and guidelines
- Review of relevant research studies
- Research policies of other state highway agencies
- Perform crash analysis of bridge/approach guardrail crashes on low-volume roads in Kansas
- Perform benefit/cost analyses based on typical traffic and location features
AASHTO Criteria

Greenbook

– Emphasizes cost-effective design: results “may need to be modified to meet the needs-versus-funds challenges”.

– Dollars should be spent where they provide the greatest benefit to the system as a whole, rather than individual project sites.
AASHTO Criteria

Very Low-Volume Guide

– Supplement to Greenbook to address unique characteristics of very low-volume local roads.

– Risk assessment approach that, when applied systemwide, provides similar safety benefit as Greenbook criteria.

– Recommends rational approach to safety and discourages expenditure of safety funds at sites where little safety benefit will occur.

– Generally, provision of clear zone or installation of safety barriers on very low-volume local roads is not cost effective.
AASHTO Criteria

Roadside Design Guide

– Recognizes the need to allow flexibility in application of roadside safety principles.

– Recommends economic evaluation of alternative safety treatments.

– “Low Volume” chapter recommends smaller improvements across the entire system, rather than bringing individual sites up to the highest level of safety.
AASHTO Criteria

Roadside Design Guide

- “. . . bridges in urban or low-volume roads that carry low traffic volumes, reduced speeds, or both may not need bridge railings designed to the same standard as bridge railings on high-speed, high-volume facilities”. (p. 7-9)

- “. . . under some circumstances (e.g., extremely low traffic volumes or approach speeds, good sight distance, and low probability of a severe crash), a decision to use no approach guardrail may be appropriate”. (p. 12-7)
Relevant Research

• **Schrum, Lechtenberg, Stolle, Faller, & Sicking, 2012**
  - Cost effective roadside safety treatments for low-volume roads in Kansas and Nebraska.

• **Bigelow, Hans, & Phares, 2010**
  - Analyzed crashes on bridge rails and approach guardrails on low-volume road bridges in Iowa.

• **Gates and Noyce, 2005**
  - Analyzed bridge approach guardrails on low-volume roads in Minnesota.

• **All 3 studies concluded that it is not cost-effective to upgrade bridge rails or approach guardrails on very low-volume roads.**
Policies of Other State Transportation Agencies in the Region

Iowa
- Approach guardrail not required if all of the following conditions are met:
  - Current ADT < 400 vpd
  - Width of new structure > 24 feet
  - Tangent alignment
  - B/C ratio < 0.80
  - Bridge width greater than roadway width

Illinois
- Bridge approach guardrail is not required if any one of the following is met:
  - Posted speed < 25 mph and no curb
  - ADT < 150 vpd, bridge width same as approach roadway, and bridge is on tangent alignment
  - Township or road district bridge wider than approach roadway and bridge is on tangent alignment

Missouri
- Delineate end of bridge in lieu of shielding when all of the following conditions are met:
  - Functional classification of Local Road or Collector
  - Operating speed < 60 mph
  - ADT ≤ 400 vpd
- Elimination of approach barriers is not recommended where there are geometric or sight distance concerns or where there is a history of crashes exceeding the statewide average for similar roads.
Bridge/Approach Guardrail Crash Review

• 5-year period, 2008-2012
  – 306,056 total reported crashes
  – 10,276 fatal or serious injury crashes
Bridge/Approach Guardrail Crash Review

• Query filters:
  – Functional class=Rural Minor Collector or Rural Local
  – Surface type=Gravel or Dirt
  – Crash type= Fixed Object
  – Object type = Bridge structure, bridge rail, guard rail, culvert, embankment, curb, or barricade.

• Resulting Dataset:
  – 1,433 total crashes
  – 30 fatal and 65 serious injury crashes.
Bridge/Approach Guardrail Crash Review

• Approach
  – All fatal and serious injury crashes were reviewed
  – All minor injury and PDO crashes involving bridge structure (167), bridge rail (200), or guardrail (90) were reviewed.
  – Remaining minor injury and PDO crashes spot-checked
    • Culvert – 358 crashes/74 reviewed
    • Embankment – 485 crashes/48 reviewed
    • Curb – 31 crashes/3 reviewed
    • Barricade – 7 crashes/1 reviewed
  – Total = 678 candidate crashes in detail
Bridge/Approach Guardrail Crash Review

- Determined applicability of each crash reviewed using Google Maps, K-Gate (KDOT Geo-reference system), and SI&A info.

- Criteria was ADT ≤ 50 vpd and bridge length ≤ 50 feet.

- Overall Results
  - 74 total crashes
  - 3 fatal crashes
  - 2 serious injury crashes
Bridge/Approach Guardrail Crash Review

• Findings
  – Crashes involving short bridges on very low-volume local roads are extremely rare events.
    • These crashes represent 0.02% of all crashes
    • Applicable fatal and serious injury crashes represent 0.0016% of all crashes and 0.05% of all fatal/serious injury crashes
  – Vast majority of crashes involving shorter bridges on very low-volume local roads did not involve a fatality or serious injury (93.2%)
Bridge/Approach Guardrail Crash Review

• Findings
  – Although numbers were low, percentage of fatal crashes vs. all applicable crashes was higher than statewide average (4.05% vs. 0.65%).
  – Percentage of serious injury crashes vs. all applicable crashes was equal to statewide average (2.7% for both).
Bridge/Approach Guardrail Crash Review

• Findings

  – During the review it was observed that there were a large number of crashes with non-applicable features on or immediately adjacent to a horizontal curve or intersection. This indicates these geometric features need to be considered in the final recommendation.

  – All of the fatal crashes and one of the two serious injury crashes occurred on narrow bridges between 15 and 21 feet wide.
RSAP Analysis

• Performed analysis using both versions 2.0.3 and 3.0.1

• Alternative treatment options
  – Bridge structure with no bridge rail
  – Bridge structure with w-beam rail and blunt ends
  – Bridge structure with w-beam rail and crashworthy end terminals

  – Note: due to cost and based on judgment that it would not be cost effective, it was determined that crashworthy bridge rail with crashworthy approach guardrail would only be evaluated if B/C of one of these alternatives was greater than 1.0.
RSAP Analysis

• Assumptions
  – New bridge will be at least 24-feet wide
  – The roadway being investigated is a two-wheelpath road (10 ft. lane in center with two 7 ft. wide “shoulders”.)
  – Construction cost used for all alternatives did not include grading, right of way acquisition, or utility adjustments.
  – Height of structure above the stream or ground underneath is 13 ft. (Med. Hazard in RSAP 3)
  – “Bracketing” bridge lengths and using highest ADT being considered will yield results applicable to the full ranges.
## RSAP Analysis

### RSAP 2 Results

<table>
<thead>
<tr>
<th>20 Ft. Bridge</th>
<th>RSAP 2.0.3</th>
<th>Incremental b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20 Ft Bridge, no rail</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20 ft. bridge with w-beam rail, no end terminals</td>
<td>0.18</td>
</tr>
<tr>
<td>3</td>
<td>20 ft. bridge with w-beam rail and end terminals</td>
<td>0.20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>50 Ft. Bridge</th>
<th>RSAP 2.0.3</th>
<th>Incremental b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td></td>
</tr>
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<td>1</td>
<td>50 Ft Bridge, no rail</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50 ft. bridge with w-beam rail, no end terminals</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>50 ft. bridge with w-beam rail and end terminals</td>
<td>0.16</td>
</tr>
</tbody>
</table>

### All b/c ratios well below 1.
## RSAP Analysis

### RSAP 3 Results

<table>
<thead>
<tr>
<th>20 Ft. Bridge</th>
<th>RSAP 3.0.1</th>
<th>Incremental b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20 Ft Bridge, no rail</td>
<td></td>
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<tr>
<td>2</td>
<td>20 ft. bridge with w-beam rail, no end terminals</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>20 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>50 Ft. Bridge</th>
<th>RSAP 3.0.1</th>
<th>Incremental b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>50 Ft Bridge, no rail</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50 ft. bridge with w-beam rail, no end terminals</td>
<td>0.17</td>
</tr>
<tr>
<td>3</td>
<td>50 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
</tr>
</tbody>
</table>

- All b/c ratios are well below 1 and are very similar to the results using RSAP 2.
RSAP Analysis

• Regardless of the results of this analysis, engineering judgment would lead one to consider the installation of the w-beam guardrail on the bridge. This railing will provide delineation of the edge of the bridge deck, helping to “funnel” the traffic across the bridge, and it provides some redirection capability for lower speed traffic that might drift toward the edge at a low angle.
RSAP Analysis

• To determine if there would be support for installing a w-beam bridge rail, an analysis was performed using RSAP 3.0.1 using the feature, Bridge Edge, High Hazard. This hazard is of the most severe type and assumes there is a fatality each time a vehicle crosses it. Although this is for extreme conditions that don’t exist in Kansas, it should be considered to establish an upper limit for decision-making.
RSAP Analysis

• RSAP 3 High Hazard Results

<table>
<thead>
<tr>
<th>20 Ft. Bridge</th>
<th>RSAP 3.0.1 – High Hazard Bridge Edge</th>
<th>Incremental b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20 Ft Bridge, no rail</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20 ft. bridge with w-beam rail, no end terminals</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>20 ft. bridge with w-beam rail and end terminals</td>
<td>0.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>50 Ft. Bridge</th>
<th>RSAP 3.0.1 – High Hazard Bridge Edge</th>
<th>Incremental b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>50 Ft Bridge, no rail</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50 ft. bridge with w-beam rail, no end terminals</td>
<td>1.22</td>
</tr>
<tr>
<td>3</td>
<td>50 ft. bridge with w-beam rail and end terminals</td>
<td>0.02</td>
</tr>
</tbody>
</table>

• Results are still well below the threshold for economic justification but show some benefit for a w-beam rail.
Conclusions

• Risk of fatal or serious injury crash at shorter, low-volume bridges is very low. This has been shown by both the crash study and RSAP analysis.

• On a system-wide basis the cost of crash-tested bridge rail and properly installed guardrail cannot be justified based on the expected safety benefit.

• Use of untested bridge rail (or none at all) and no approach guardrail is consistent with AASHTO guidance that recognizes the need for lower design criteria on low-volume roads.

• Previous studies in other states have reached similar conclusions.
Recommendations

• Bridge rails on new or rehabilitated bridges may be of non-tested design, and approach guardrails are not required if all of the following are met:
  – Functional classification of Local Road
  – ADT $\leq$ 50 vpd
  – Road surface is gravel, sand or dirt (unpaved)
  – Two Wheel path Road
  – Bridge length $\leq$ 50 ft.
  – Bridge not on or adjacent to horizontal curve or intersection
  – Type 3 object marker installed at all ends of bridge rails
What does this mean moving ahead?

• These designs are being promoted in the Kansas Local Bridge Improvement Program (KLBIP).

• FHWA Kansas Division has approved designs of this type for Federal-Aid Off-System Bridge funding.

• This study provides documentation to support Kansas counties using bridges with untested bridgerails and no approach guardrails.
Expanded Study

• Expanded study to incrementally include longer bridges and higher traffic volumes.
  – First step to 100’ bridges and 100 vpd
    • Analysis of bridge rail/guardrail crashes on bridges with length between 50 feet and 100 feet and located on a local road with ADT between 50 and 100 vehicles per day.
    • Benefit-cost analyses based on these parameters and typical location features.
## Expanded Study

### Table 2. Traffic Volume and Bridge Length by Category

<table>
<thead>
<tr>
<th></th>
<th>Category</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td><strong>Bridge Length (L)</strong></td>
<td>L ≤ 50'</td>
<td>L ≤ 50'</td>
<td>51' ≤ L ≤ 100'</td>
<td>51' ≤ L ≤ 100'</td>
</tr>
<tr>
<td><strong>Traffic Volume (V)</strong></td>
<td>V ≤ 50 vpd</td>
<td>51 vpd ≤ V ≤ 100 vpd</td>
<td>V ≤ 50 vpd</td>
<td>51 vpd ≤ V ≤ 100 vpd</td>
</tr>
</tbody>
</table>
**Expanded Study**

**SUMMARY OF CRASH REVIEW 2008 – 2014**

**LOW-VOLUME ROAD BRIDGE CRASHES**

<table>
<thead>
<tr>
<th>CRASH SEVERITY</th>
<th>ADT ≤ 50</th>
<th></th>
<th></th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L ≤ 50</td>
<td>50 &lt; L ≤ 100</td>
<td>L ≤ 50</td>
<td>50 &lt; L ≤ 100</td>
</tr>
<tr>
<td>FATAL CRASHES</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>SERIOUS INJURY CRASHES</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>NON-FATAL/NON-SER. INJ. CRASHES</td>
<td>56</td>
<td>29</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL CRASHES IN STUDY (7 YEARS)</td>
<td>57</td>
<td>30</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>
Expanded Study

\[
P_C = \frac{N_C}{N_B} \times \frac{100}{7}
\]

\( P_C \) = Annual Probability (percent chance) of a crash on a bridge in a volume/length category;

\( N_C \) = Number of crashes on bridges in the volume/length category; and

\( N_B \) = Number of bridges in the NBI inventory for the volume/length category.
# Expanded Study

## TABLE 5. RSAP 2.0.3 B/C RESULTS FOR 20-FOOT LONG BRIDGE

<table>
<thead>
<tr>
<th>20 Ft. Bridge</th>
<th>RSAP 2.0.3</th>
<th>b/c</th>
<th>b/c</th>
<th>b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>20 Ft Bridge, no rail</td>
<td>1.00</td>
<td>0.58</td>
<td>0.26</td>
</tr>
<tr>
<td>2</td>
<td>20 ft. bridge with w-beam rail, no end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.20</td>
</tr>
<tr>
<td>3</td>
<td>20 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

## TABLE 6. RSAP 2.0.3 B/C RESULTS FOR A 50-FOOT LONG BRIDGE

<table>
<thead>
<tr>
<th>50 Ft. Bridge</th>
<th>RSAP 2.0.3</th>
<th>b/c</th>
<th>b/c</th>
<th>b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>50 Ft Bridge, no rail</td>
<td>1.00</td>
<td>0.59</td>
<td>0.30</td>
</tr>
<tr>
<td>2</td>
<td>50 ft. bridge with w-beam rail, no end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.16</td>
</tr>
<tr>
<td>3</td>
<td>50 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

## TABLE 7. RSAP 2.0.3 B/C RESULTS FOR A 100-FOOT LONG BRIDGE

<table>
<thead>
<tr>
<th>100 Ft. Bridge</th>
<th>RSAP 2.0.3</th>
<th>b/c</th>
<th>b/c</th>
<th>b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternates</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>100 Ft Bridge, no rail</td>
<td>1.00</td>
<td>0.57</td>
<td>0.41</td>
</tr>
<tr>
<td>2</td>
<td>100 ft. bridge with w-beam rail, no end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>100 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
# Expanded Study

## Table 8. RSAP 3.0.1 B/C Results for a 20-Foot Long Bridge

<table>
<thead>
<tr>
<th>Alternates</th>
<th>RSAP 3.0.1</th>
<th>b/c</th>
<th>b/c</th>
<th>b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 Ft Bridge, no rail</td>
<td>1.00</td>
<td>0.55</td>
<td>0.18</td>
</tr>
<tr>
<td>2</td>
<td>20 ft. bridge with w-beam rail, no end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>20 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

## Table 9. RSAP 3.0.1 B/C Results for a 50-Foot Long Bridge

<table>
<thead>
<tr>
<th>Alternates</th>
<th>RSAP 3.0.1</th>
<th>b/c</th>
<th>b/c</th>
<th>b/c</th>
</tr>
</thead>
<tbody>
<tr>
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<td>50 Ft Bridge, no rail</td>
<td>1.00</td>
<td>0.55</td>
<td>0.18</td>
</tr>
<tr>
<td>2</td>
<td>50 ft. bridge with w-beam rail, no end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>50 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

## Table 10. RSAP 3.0.1 B/C Results for a 100-Foot Long Bridge

<table>
<thead>
<tr>
<th>Alternates</th>
<th>RSAP 3.0.1</th>
<th>b/c</th>
<th>b/c</th>
<th>b/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100 Ft Bridge, no rail</td>
<td>1.00</td>
<td>0.58</td>
<td>0.29</td>
</tr>
<tr>
<td>2</td>
<td>100 ft. bridge with w-beam rail, no end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>100 ft. bridge with w-beam rail and end terminals</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Conclusion

The analyses show that, although the crash risk is greater than the baseline risk found for bridges investigated in Report No. KS-14-16, the risk under any of these scenarios is very low. In addition, the costs of installing a crash-tested bridge rail and properly installed approach guardrail section on these bridges cannot be justified because the return on the investment, measured in reduced crash costs, is very low.
Based on the results of this study, it is recommended that the recommendations of Report No. KS-14-16 be expanded to include bridge rails installed on new or rehabilitated bridges up to 100 feet long with traffic volume up to 100 vpd. These recommendations allow installation of a non-tested bridge rail design with no approach guardrail if the structure meets all of the conditions outlined below.

1. The bridge is located on a road functionally classified as a Local Road.
2. Traffic volume is less than or equal to 100 vpd.
3. The approach roadway is a two-wheel path road.
4. Roadway surface on the approaches is gravel, sand or dirt.
5. Maximum length of bridge is 100 feet.
6. The new structure shall be no less than 24 feet wide.
7. The bridge is not located on or adjacent to a curve or intersection.
8. A Type 3 object marker shall be installed at each end of the bridge rails.
Full reports are available through KDOT’s Library

https://kdotapp.ksdot.org/kdotlib/kdotlib2.aspx

In the search box, type in:

**KS-14-16** *(original study)*

*or*

**KS-17-03** *(expanded study addendum)*
Questions/Comments

Contact Information

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Kansas Dept. of Transportation
Tel: (785) 296-3861
Email: Tod.Salfrank@ks.gov
I.M. No. 3.213 “Traffic Barriers (Guardrail and Bridge Barrier Rails)”

NICOLE FOX, P.E.
DEPUTY DIRECTOR
IOWA DOT, OFFICE OF LOCAL SYSTEMS
Presentation Overview

- Background
  - NCHRP, MASH, requirements, FHWA

- Guardrail
  - Bridge projects, upgrades, roadway projects

- Bridge Barrier Rail
  - Use, new construction, updates
TL-1: A successful test of a 1800 pound car impacting a barrier at 20 degrees, and a 4400 pound pickup truck impacting a barrier at 25 degrees, both at a speed of 31 miles per hour (mph)

TL-2: A successful test of a 1800 pound car impacting a barrier at 20 degrees, and a 4400 pound pickup truck impacting a barrier at 25 degrees, both at a speed of 44 mph

TL-3: A successful test of a 1800 pound car impacting a barrier at 20 degrees, and a 4400 pound pickup truck impacting a barrier at 25 degrees, both at a speed of 62 mph

TL-4: TL-3 car and truck, and a 17,650 pound single-unit truck impacting the barrier at an angle of 15 degrees and a speed of 50 mph

TL-5: TL-3 car and truck, and a 79,400 pound tractor trailer impacting the barrier at an angle of 15 degrees and a speed of 50 mph

TL-6: TL-3 car and truck, and a 79,400 pound tanker trailer impacting the barrier at an angle of 15 degrees and a speed of 50 mph
MASH

- TL-1: A successful test of a 2420 pound car impacting a barrier at 25 degrees, and a 5000 pound pickup truck impacting a barrier at 25 degrees, both at a speed of 31 miles per hour (mph)
- TL-2: A successful test of a 2420 pound car impacting a barrier at 25 degrees, and a 5000 pound pickup truck impacting a barrier at 25 degrees, both at a speed of 44 mph
- TL-3: A successful test of a 2420 pound car impacting a barrier at 25 degrees, and a 5000 pound pickup truck impacting a barrier at 25 degrees, both at a speed of 62 mph
- TL-4: TL-3 car and truck, and a 22,000 pound single-unit truck impacting the barrier at an angle of 15 degrees and a speed of 56 mph
- TL-5: TL-3 car and truck, and a 79,400 pound tractor trailer impacting the barrier at an angle of 15 degrees and a speed of 50 mph
- TL-6: TL-3 car and truck, and a 79,400 pound tanker trailer impacting the barrier at an angle of 15 degrees and a speed of 50 mph
Requirements

- **On Interstates and NHS -**
  - TL-3 for Guardrail & Bridge Rail-required by FHWA
  - Iowa DOT Policy
    - TL-3 Guardrail
    - TL-5 Bridge Rail for Interstates
    - TL-4 Bridge Rail on NHS
      - DOT Standards
      - Open Rail, Barrier Rail
  - Off NHS - I.M. 3.213 is the policy for LPA’s
Guardrail: Bridge Projects

- The FHWA will participate in guardrail, including at all 4 corners of a bridge, if desired by the LPA.

- In general, guardrail should, but is not required to, be installed or upgraded under the following circumstances:
  - Farm-to-Market system or on collector streets and roads of a higher classification, guardrail should be installed on all 4 corners except bridges located within an established speed zone of 35 mph or less.
  - Local roadways, guardrail should be installed on the approach corner in both directions (right side in each direction);
On roadway construction projects on the Farm-to-Market System or on collector streets and roads of a higher classification:

- All 4 corners of bridges within the project limits. Existing W-beam installations that are flared and anchored at both ends may be used as constructed without upgrading to current Iowa DOT standards. Some items to consider when deciding on a guardrail upgrade would include rotten posts, un-anchored ends, or ends that are turned down toward the ground.
Guardrail: Upgrades
Guardrail: Lower Volume Roads

- For roadways with less than 400 vehicles per day, or in established speed zones of 45 mph or less, a shorter length guardrail may be used.

- If ALL of the following conditions exist, the LPA may elect to not install guardrail:
  - Current average daily traffic (ADT) at structure is less than 400 vehicles per day.
  - Structure width (curb-to-curb) is 24 feet or greater, and is wider than the approach roadway width.
  - Structure is on tangent alignment.
Use of Iowa DOT Standard Guardrail

- For a roadway with 400 vehicles per day or higher, the following standards should be used:
  - LS-630 This guardrail successfully passed a crash test under MASH TL-3 requirements.
  - BA-250 This guardrail successfully passed a crash test under MASH TL-3 requirements.
For a roadway with less than 400 vehicles per day, the following standards are acceptable:

- **LS-635** This guardrail successfully passed a crash test under the MASH TL-2 requirements.
- **LS-630** This guardrail successfully passed a crash test under MASH TL-3 requirements.
- **BA-250** This guardrail successfully passed a crash test under MASH TL-3 requirements.
FHWA will participate in bridge rail construction or upgrades, if desired by the LPA. In general, bridge barrier rail should, but is not required to, be installed or upgraded under the following circumstances:

- On newly constructed bridges on roadways with **400 vehicles per day or greater**, the bridge barrier rail should be constructed using the Iowa DOT Bridge Standards, which is a **MASH TL-4 design**.

- On roadways with **less than 400 vehicles per day**, Iowa DOT Bridge Standards for bridge barrier rail may be used. However, if the project is not utilizing the Iowa DOT Bridge Standards, a **bridge rail considered to be crashworthy shall be used, meeting a minimum of TL-1 in NCHRP 350 or MASH**.
Bridge Barrier Rail: Upgrades

- Upgrade Guardrail when Bridge Barrier Rail needs to be upgraded.
- A bridge barrier rail upgrade should be considered if all of the following conditions exist:
  - The bridge was designed prior to 1964. According to the Roadside Design Guide 4th Edition 2011, bridge rails designed to AASHTO specifications prior to 1964 may not meet current standards.
  - Current average daily traffic (ADT) at structure is 400 vehicles per day or higher.
  - Structure width (curb-to-curb) is less than 24 feet, or structure width (curb-to-curb) is narrower than the approach roadway width.
In lieu of bridge rail, consideration may be given to extending the guardrail through the bridge on short bridges or bridges which have no end posts. This may be less costly than constructing an end post and attaching the guardrail as per the Iowa DOT Standard Road Plans. The Iowa DOT has developed a standard for the long span system (BA-211), which will work in some of these cases. The long span system has successfully passed TL-3 under MASH.
Questions?