IaDOT Roadside Safety Research

- Roadway departures are a major factor in fatalities $\Rightarrow$ approximately $\frac{1}{2}$ of fatalities
- Iowa DOT active in roadside safety research
Combination Bicycle Railing

- Existing IaDOT design
- Develop MASH TL-2 low-height, vertical-face traffic barrier with attached bicycle railing
  - Determine minimum TL-2 vertical parapet height
  - Combination rail must meet AASHTO LRFD guidance
    - 42” above sidewalk
    - ZOI concern

Figure 1: Iowa DOT Standard Separation Barrier (in service)
Minimum TL-2 Parapet Height

- Combination of simulation and previous crashing utilized
- Selected 24 in. tall parapet for design and testing
(IA) Combination Bicycle Railing

- Top-mounted posts
  - Offset to reduce vehicle interaction
- Single horizontal rail
- 48-in. total height for all installations
  - 24-in. tall parapet and 24-in. tall bicycle rail
- Welded, pre-fabricated rail and post sections
  - 20-ft long
Simulation of Proposed Design

- Selected CIP to maximize potential for vehicle snag
- Similar snag observed to be acceptable in previous testing of MASH TL-3 parapet mounted signs

<table>
<thead>
<tr>
<th>Simulation Run Impact Point</th>
<th>Vehicle Extent Beyond Face of Parapet at Post Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 ft US of post</td>
<td>8.43 in.</td>
</tr>
<tr>
<td>3.8 ft US of post</td>
<td>8.52 in.</td>
</tr>
<tr>
<td>3.3 ft US of post</td>
<td>7.47 in.</td>
</tr>
<tr>
<td>1.7 ft US of post</td>
<td>3.60 in.</td>
</tr>
</tbody>
</table>
Test No. IBBR-1

Test no. 2-11 ➔ 2270P, 44 mph and 25 degrees
Test No. IBBR-1

- Test met all MASH TL-2 criteria
  - 24 in. parapet redirected without assistance of pedestrian rail
Optimized MASH TL-4 Bridge Rail

- Existing NCHRP Report
  - 350 TL-4 bridge rails
    - 32” height
    - 54-70 kip capacity
    - NJ and F-shape vehicle stability issues (roll and climb)

- MASH TL-4
  - Increased rail height
    - 36” minimum height (vehicle override)
  - Increased impact loads
    - 50% increase in impact severity
Optimized MASH TL-4 Bridge Rail

- Objective
  - Develop an optimized, concrete bridge rail to MASH TL-4
- Optimize for performance and cost
- Compatible with future 3-in. roadway overlay
- 5-ft deck overhang
General Barrier Geometry

- **39” Tall**
  - 36” to satisfy MASH TL-4
  - 3” future overlay

- **Single Slope Front Face**
  - Vehicle stability
  - Near vertical 1:19.5

- **Vertical Back**
  - Sloped back acceptable
  - Reduced width more critical

- **Top Barrier Width**
  - 8” minimum for rebar bends
Bridge Rail Optimization

- Satisfy design loads – NCHRP 22-20(2)
  - Yield Line Theory
  - 80-kip lateral load applied over 5 ft
- Design variables
  - Barrier width
  - Longitudinal bar size and quantity
  - Stirrup size and spacing
- Optimize based on strength, cost, weight, and deck loading
- Deck design
Test Installation

- 150-ft long barrier
- 75-ft simulated bridge deck
  - 5-ft overhang
  - 3” overlay
Test 4CBR-1 (MASH 4-12)
Optimized MASH TL-4 Bridge Rail

- Satisfied all criteria for MASH 4-12
  - Minor cracking of rail
  - No visible damage to deck

- MASH passenger vehicle tests (4-10 and 4-11) deemed non-critical
  - Near-vertical shape → vehicle stability
  - Previous MASH 1100C and 2270P impacts into single-slope and vertical shaped barriers

- Bridge rail considered MASH TL-4 crashworthy
TL-4 Open Concrete Rail

- Development of a MASH TL-4 open concrete bridge rail
  - Optimize opening for aesthetics, drainage, and snag potential
  - Limit deck damage
  - Accommodate pavement overlays
Bridge Rail Design

- 39” height
  - 36” for TL-4 + 3” future overlay
- Beam
  - (8) #6 longitudinal bars
  - #4 stirrups @ 12”
- Post
  - 36” long, 10” wide, 12” tall
  - 4” post setback
  - 2” offset from deck edge
  - (12) #5 vertical bars
- 9 ft post spacing
  - 6 ft openings
2270P and 1100C Testing
10000S Test
MGS Adjacent to Slope

- Guidance and recommendations for Midwest Guardrail System installed adjacent to fill slopes
  - Level terrain to 1V:2H
  - Barrier offsets between 2 ft in front of the slope breakpoint to beyond the slope breakpoint
Existing MGS on Slope Tests

9’ long posts at SBP  6’ long posts at SBP
<table>
<thead>
<tr>
<th>Fill Slope</th>
<th>Post Offset from Slope $^{1,2}$ (ft)</th>
<th>Post Type</th>
<th>Post Length, (L) (ft)</th>
<th>Post Spacing (in.)</th>
<th>Blockout Depth (in.)</th>
<th>Working Width (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1V:2H</td>
<td>0 (at SBP$^3$)</td>
<td>W6x8.5 or W6x9</td>
<td>$6 \leq L \leq 9$</td>
<td>75</td>
<td>0 - 12</td>
<td>See Figure 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-in. x 8-in. Southern Yellow Pine (SYP)</td>
<td>$6 \leq L \leq 7.5$</td>
<td>75</td>
<td>8 - 12</td>
<td>See Figure 1</td>
</tr>
<tr>
<td>$\leq$ 1V:2H</td>
<td>0 (at SBP$^3$)</td>
<td>W6x8.5 or W6x9</td>
<td>6</td>
<td>75</td>
<td>0 - 12</td>
<td>See Figure 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-in. x 8-in. Southern Yellow Pine (SYP)</td>
<td>6</td>
<td>75</td>
<td>8 - 12</td>
<td>See Figure 2</td>
</tr>
<tr>
<td>$\leq$ 1V:2H</td>
<td>0 &lt; Offset &lt; 2</td>
<td>W6x8.5 or W6x9</td>
<td>6</td>
<td>75</td>
<td>0 - 12</td>
<td>See Figure 2 and Figure 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-in. x 8-in. Southern Yellow Pine (SYP)</td>
<td>6</td>
<td>75</td>
<td>8 - 12</td>
<td>See Figure 2 and Figure 3</td>
</tr>
<tr>
<td>1V:2H</td>
<td>-1.25 (down slope)</td>
<td>W6x8.5 or W6x9</td>
<td>8</td>
<td>75</td>
<td>8 - 12</td>
<td>55.2</td>
</tr>
</tbody>
</table>

1 – Slope offset is measured from slope break point to center of post  
2 – Slope offset is positive (+) in front of the slope break point and negative (-) down the slope  
3 – SBP = Slope Break Point
Dynamic Deflection and Working Width

MGS (Standard Post Spacing) Deflection and Working Width Estimation for Various Post Lengths Installed at Slope Break Point of 1V:2H Slope

MGS (6' Post, Standard Spacing) Deflection and Working Width Estimation Installed at Slope Break Point of Slopes between 1V:2H and Level Terrain

Dynamic Deflection and Working Width for MGS (6' Post, Standard Spacing) Installed Adjacent to a 1V:2H Slope with Variable Offsets
Acknowledgements

- Iowa DOT
- Midwest Pooled Fund Program