MwRSF Research on Bridge Railings & Transitions

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Research Project Overview

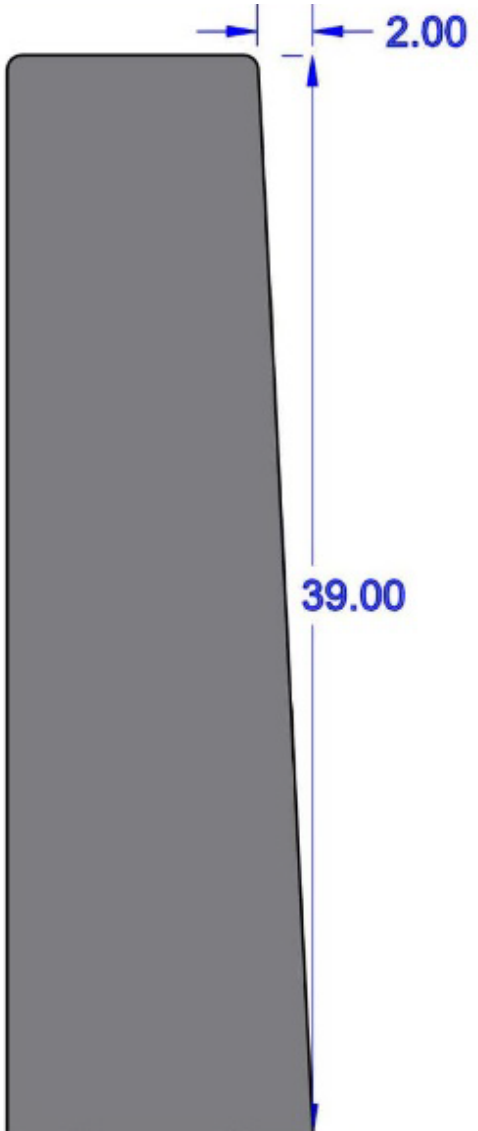
- Development of an Optimized MASH TL-4 Concrete Bridge Rail
- Nebraska: Cost-Efficient, TL-2 Bridge Rail for Low Volume Roads
- Ohio/Illinois: MASH TL-4 Steel-Tube Bridge Rail and Guardrail Transition
- Iowa: DOT Combination Bridge Separation Barrier with Bicycle Railing
- TL-3 Development of a Standardized Concrete Buttress for MGS Thrie Beam Transitions
- Nebraska: 34-In. Tall Thrie-Beam Approach Guardrail Transition
- Wisconsin: Evaluation of a Culvert-Mounted, Strong-Post MGS to MASH TL-3
- NCHRP 22-34: Determination of Zone of Intrusion Envelopes under MASH Impact Conditions for Rigid Barrier

Optimized TL-4 Concrete Bridge Rail

- Objective
  - Develop an optimized, concrete bridge rail to MASH TL-4 safety performance standards
- MASH TL-4
  - Increased rail height
  - Increased impact loads

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

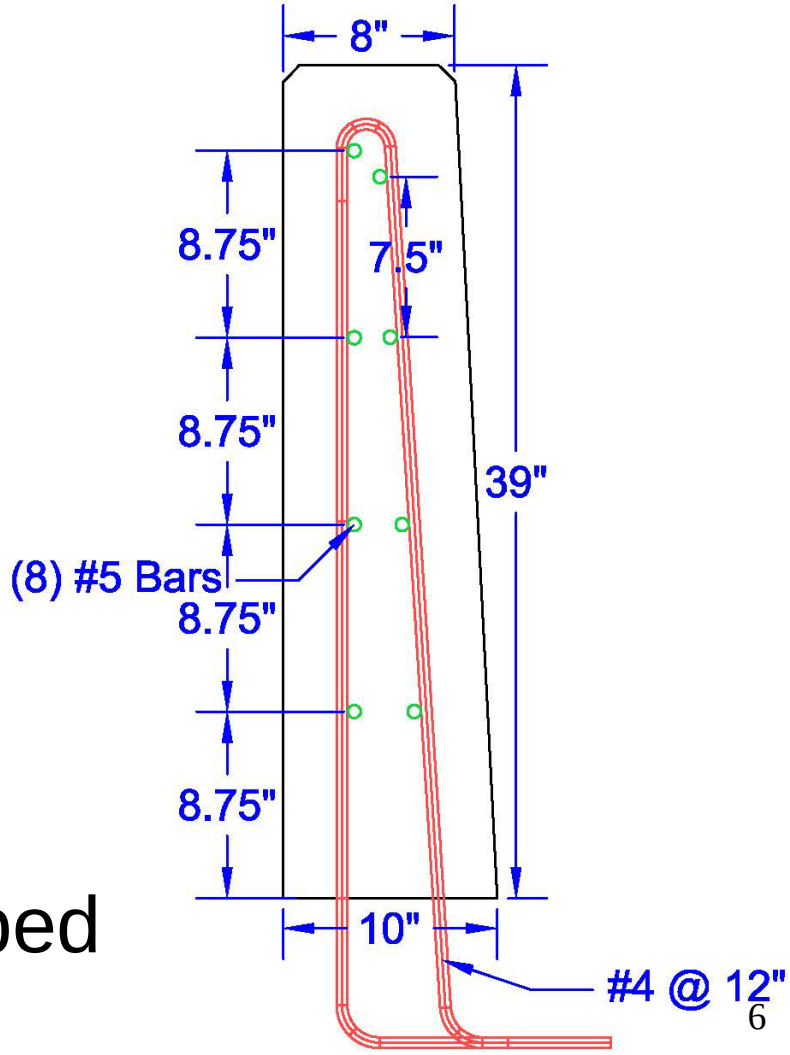


Bridge Rail Optimization

- Design loads – NCHRP 22-20(2)
  - 80 kip lateral load applied over 48” length
  - 33” load height (30” + 3” overlay)
  - Analysis with Yield Line Theory
- Design variables
  - Barrier width
  - Longitudinal bar size and quantity
  - Stirrup size and spacing
- Estimated costs for materials and installation labor
- Optimize based on strength, cost, weight, and deck loading

Optimized Rail Configuration

- Strength
  - Rw = 80.8 kips
- Cost
  - $39.00 per linear ft
- Weight
  - 380 lb/ft
- Deck loading
  - ϕMc = 8.6 (k-ft)/ft
- Head ejection envelope configuration also developed



Deck Design

- DOT bridge deck survey responses
  - 8” thick
  - Up to 5’ overhang
  - Clear cover: top-2.5”, bottom-1”
- Design per AASHTO LRFD Section 13.4
  - Critical design for impact load and barrier capacity
  - Longitudinal distribution of F_t
  - Evaluation should provide insight on future bridge deck design

Future Work

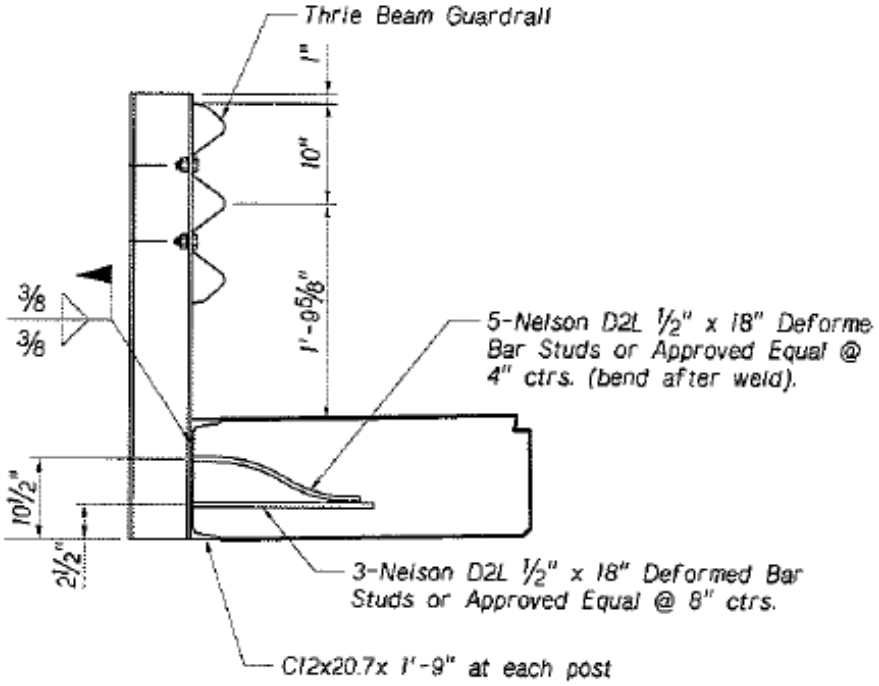
- Optimized TL-4 bridge rail planned for testing in July 2018
  - Test no. 4-12 (10000S)
  - 39” tall rail with 3” overlay ➔ 36” rail height
- Summary report
  - Design methodology
  - Full-scale testing
  - Exterior and end section details

TL-2 Bridge Rail for Rural Roads (NE)

- Objective
  - Develop low cost, MASH TL-2, bridge rail for use on low-volume roads
  - Side-mounted posts
    - Limit deck encroachment
    - Avoid damage during snow removal
    - Deck edges must be flat for formwork

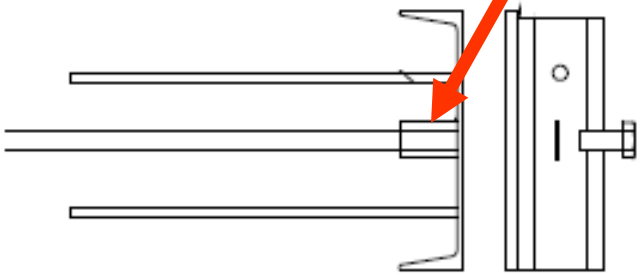
Bridge Deck Options

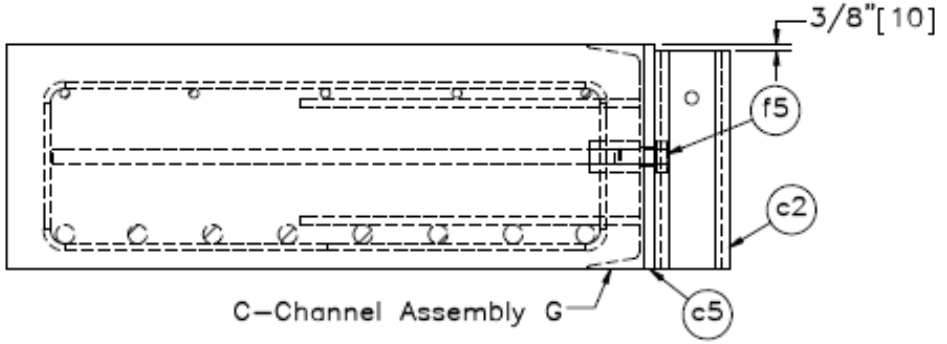
- Precast Slab Deck
  - 12” minimum thickness
- Cast-in-Place Slab
  - 7” minimum thickness
- Both utilize channel along deck edge



Bolted Socket Attachment

- Coupling nuts & threaded rods cast into deck
- A325 bolts attach to channel (nuts)





Test No. N2BR-1

- 7” CIP Deck
- Ø7/8” rods, coupling nuts, and bolts
- C7x9.8 Channel
- S3x5.7 posts @ 75” spacing

Test No. N2BR-1

Test No. N2BR-1

TL-2 Bridge Rail for Rural Roads (NE)

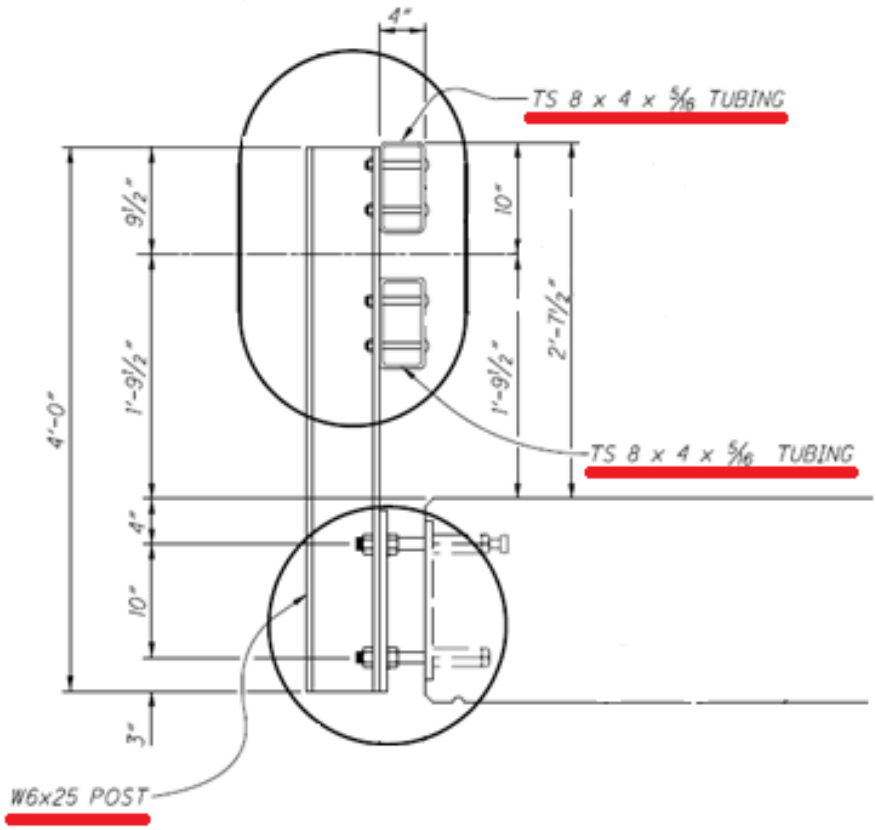
- MASH TL-2 crashworthy, low-cost bridge rail option for low-volume roads
  - Available for both CIP and precast decks
  - No deck damage
  - Easily repaired
- Welded socket version developed as well
- Future Work
  - Analyze connection to MGS
  - Guidelines for MGS lengths adjacent to bridge
  - Summary report

TL-4 Steel Tube Bridge Rail (OH/IL)

- Objectives:
  - Development of a MASH TL-4, side-mounted, steel tube bridge rail
  - Development of an adjacent approach guardrail transition to MASH TL-3
- Recent Developments:
  - Railing design and optimization
  - Post-to-deck attachment design

Existing Steel Tube Bridge Rail

- Twin-Tube Bridge Rail
  - NCHRP Report 350 TL-4
  - Post offset 4” from deck
  - 31.5” total height
  - W6x25 posts
  - Shear stud anchorage

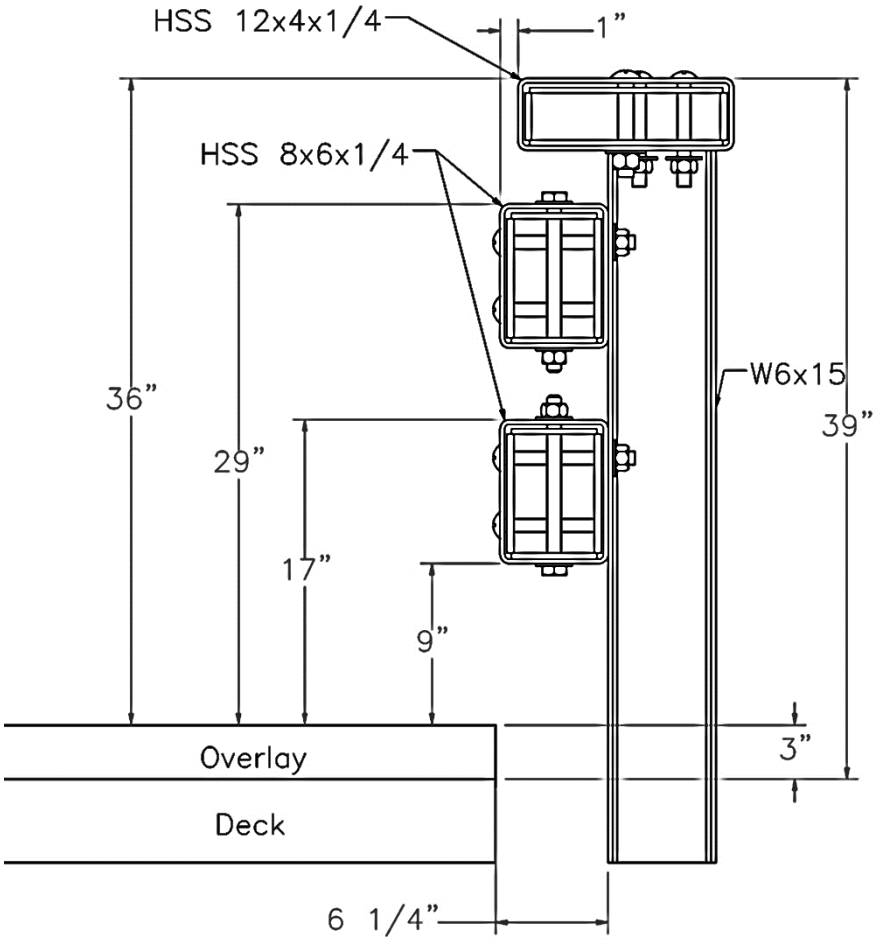


Design Criteria

- MASH TL-4
- Three tube rails
- Future 3” overlay
- Optimize system (weight/cost)
- Side-mounted posts
- Face of barrier flush with edge of deck
- Minimize potential for deck damage
- Compatible with CIP slab decks and pre-stressed box beams

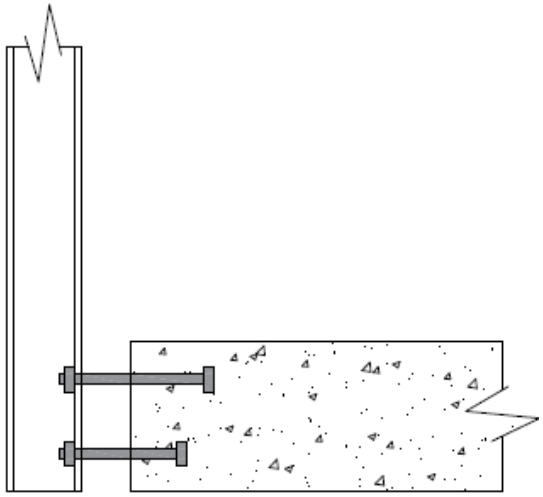
Rail Design

- NCHRP Report 22-20(2) design loads
- Variables
  - Post spacing
  - Tube sections
  - Tube spacing
- W6x15 Posts
  - Limit loading to deck
  - More efficient rail system
- Selected Rail Configuration
  - Post Spacing = 8 ft
  - Weight: 90.7 lb/ft
  - Lateral Capacity: 80.1 kips

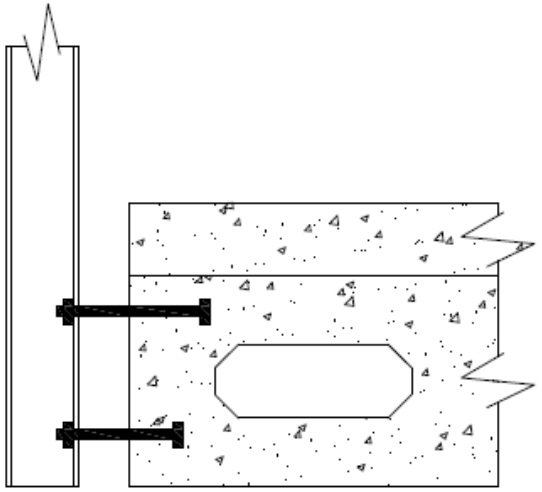


Deck Configurations

- Configuration #1
  - Slab deck
  - Anchor to slab edge
  - Limited deck depth
  - Critical for anchorage loads

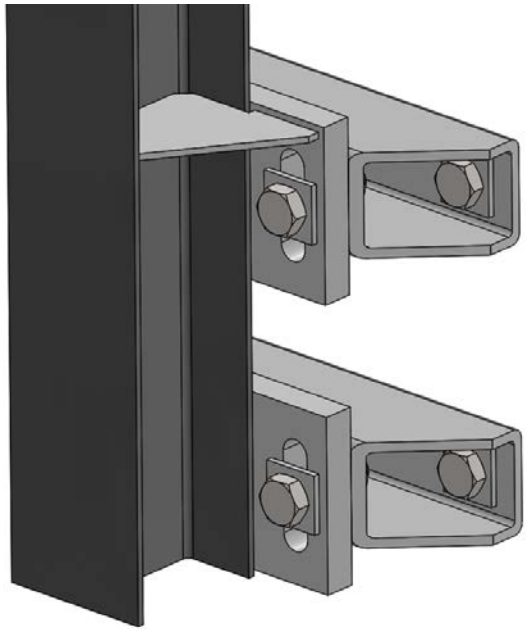


- Configuration #2
  - Pre-stressed box
  - Wearing surface
  - Anchor to box
  - Critical post/system strength



Post-To-Deck Attachment

- Prototype design
  - Coupling nut and threaded rod attachment
  - Welded post and plate assembly
  - HSS5x4x3/8 spacer
  - A325 bolts
- Design benefits
  - Limit deck damage
  - Compatible with multiple decks
  - Bolted attachment
  - No external hardware from deck

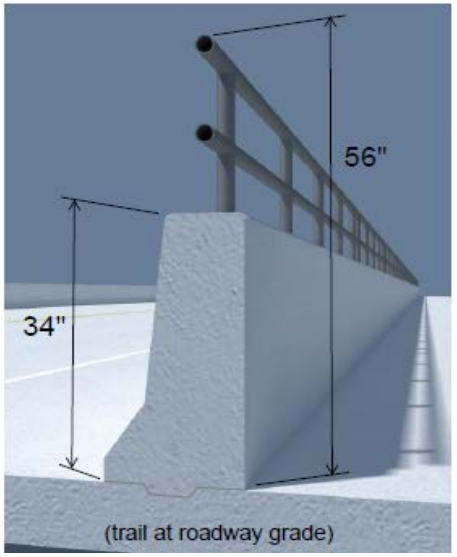


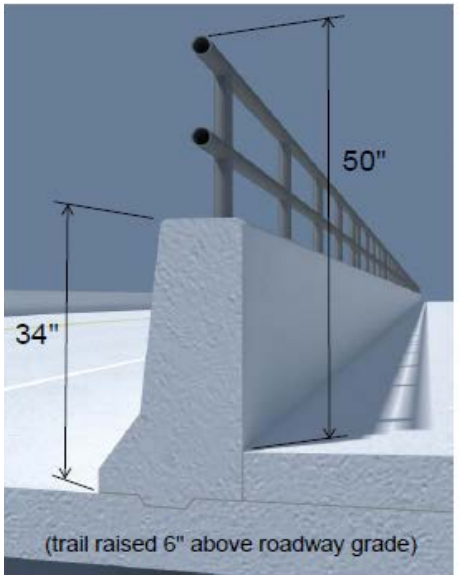
Future Work

- Post-to-deck component testing
  - Optimize attachment hardware
    - Anchor diameter and embedment
    - Plate thickness
    - Tube thickness
- Full-scale testing of bridge rail
  - MASH 4-12
  - MASH 4-11
  - MASH 4-10
- Design of approach transition
- Full-scale testing of transition
  - MASH 3-20 & 3-21

(IA) Combination Bridge Separation Barrier / Bicycle Railing

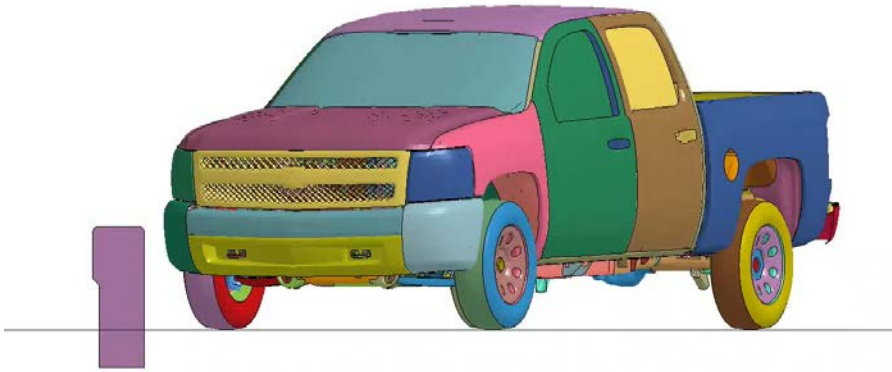
- Objective
  - Develop a MASH TL-2 crashworthy, low-height, vertical-face traffic barrier with an attached crashworthy bicycle railing
  - Determine a minimum TL-2 vertical parapet height
  - Combination railing
    - 42” above sidewalk
    - Prefer top mounted
    - Maximize visibility





TL-2 Parapet Height Selection

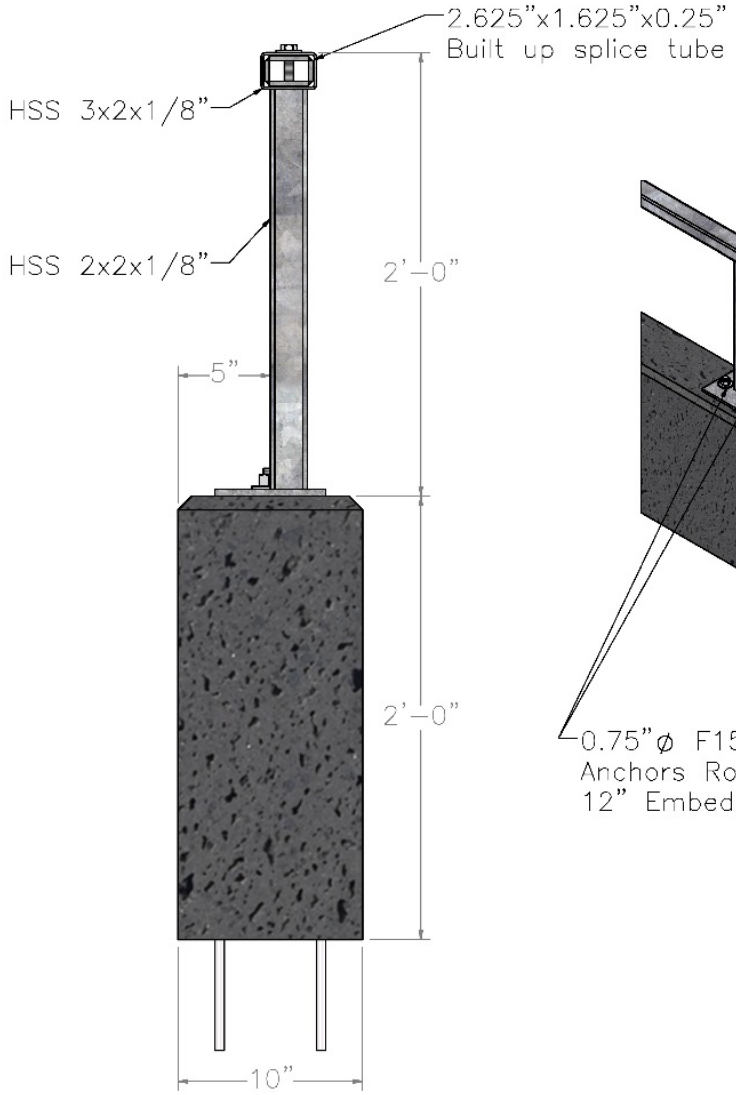
- LS-DYNA simulation of low-height parapet
  - Investigate minimum height
  - Study ZOI
    - Help with placement of rail
    - Determine probability of vehicle/rail interaction
- Review previous testing
  - Vehicle/barrier geometry comparisons
- 24 in. barrier height selected



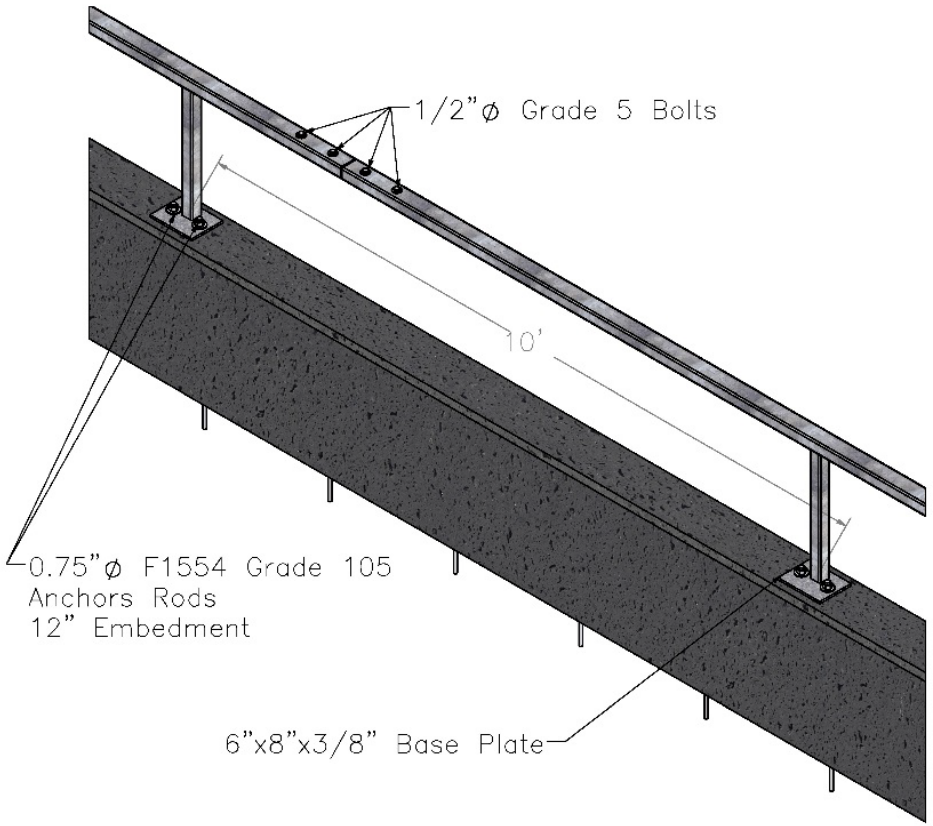
Bicycle Rail Design Parameters

- Top-mounted posts, offset to reduce vehicle interaction
- 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
- Single horizontal rail
- AASHTO pass through opening requirements not applied
  - Iowa defines system as traffic separator

Proposed Bicycle Rail Design



- Full-scale crash testing
  - MASH test no. 2-11

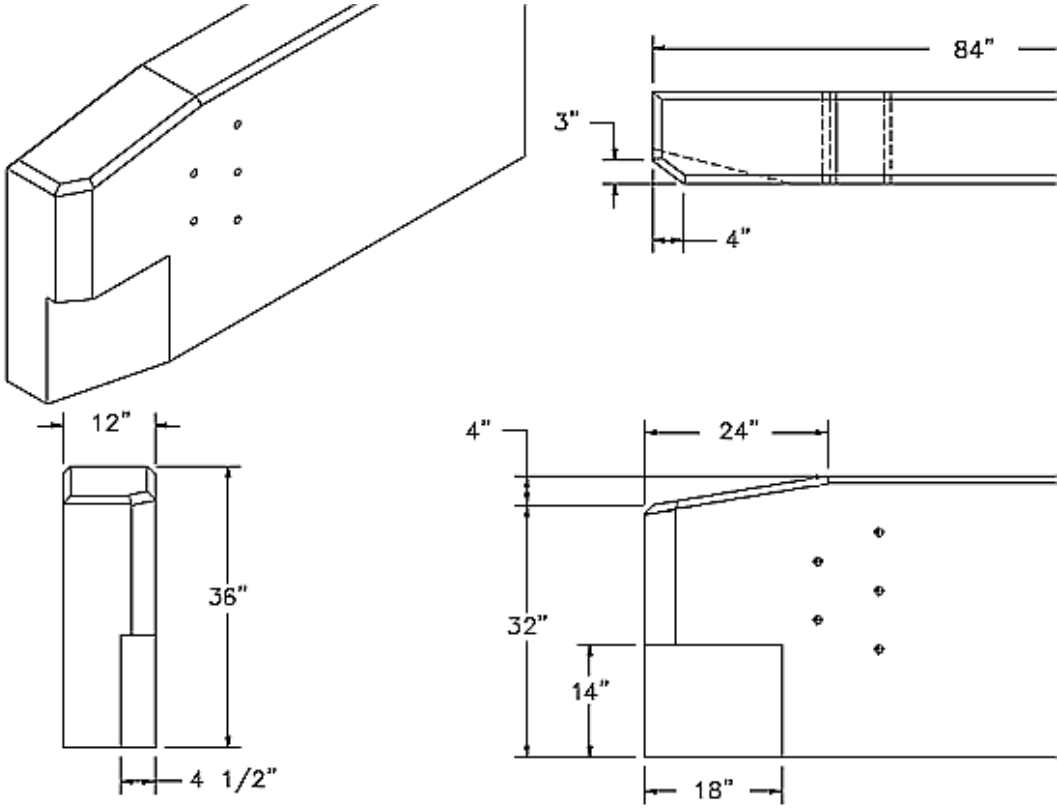


Standardized Concrete Parapet for AGTs

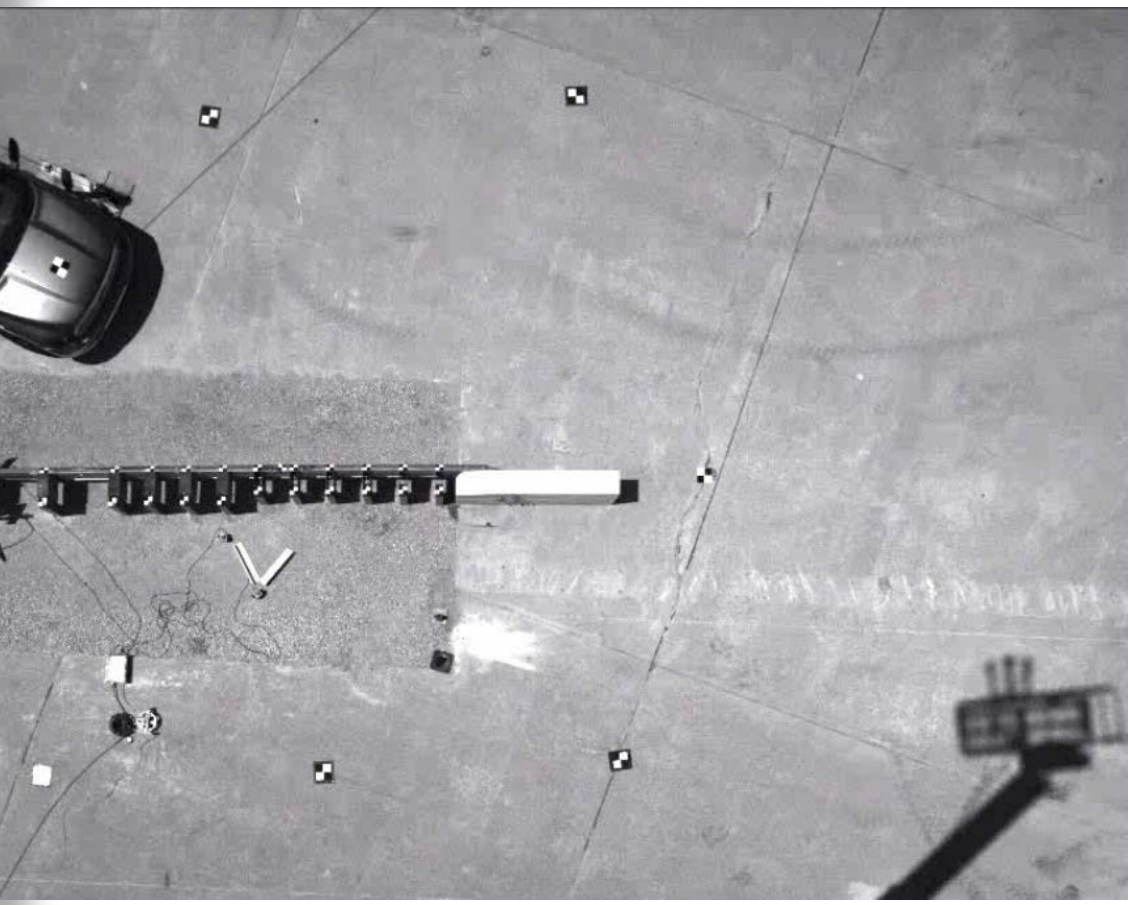
- Objective
  - Develop a concrete end buttress compatible with all NCHRP 350 and MASH approved thrie-beam AGTs(with or without curbs)
- Recent developments
  - Preliminary buttress geometry failed MASH 3-21
  - Revised geometry has been successfully tested at 31” and 34” AGT heights

Buttress Details – 31-in. AGT

Height	36”
Width	12”
Length	7 ft
Vertical Taper	4”x24” 1:6 Slope
Top Chamfer	3”x4”
Bottom Chamfer	4.5”x18” 4:1 Slope
Height of Bottom Chamfer	14” (blockouts)



Test No. AGTB-2 (31-in. AGT)



Full-Scale Testing - 34-in. AGT

- Same geometry as 31-in. buttress with 3-in. height increase

Test No. 3-21

Test No. 3-20

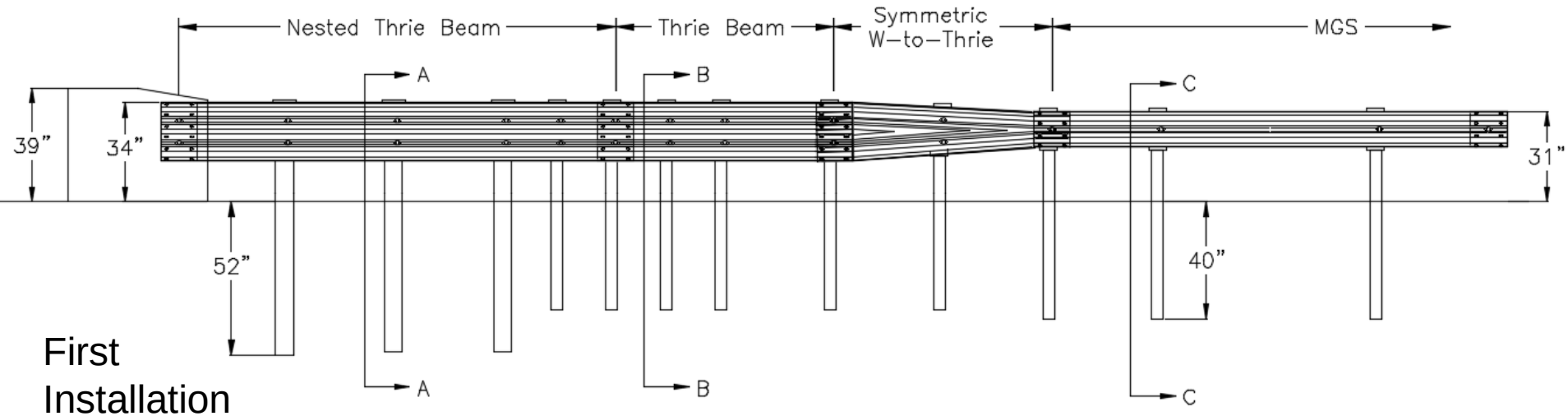
Standardized AGT Buttress Testing

- 31-in. standardized buttress
  - MASH 3-21: Pass
  - MASH 3-20: Non-Critical
    - 1100C small car test was successfully tested on standardized buttress connected to a 34” tall thrie beam AGT
    - 31” rail height has reduced exposure and less likely to snag
- 34-in. standardized buttress
  - MASH 3-20: Pass
  - MASH 3-21: Pass

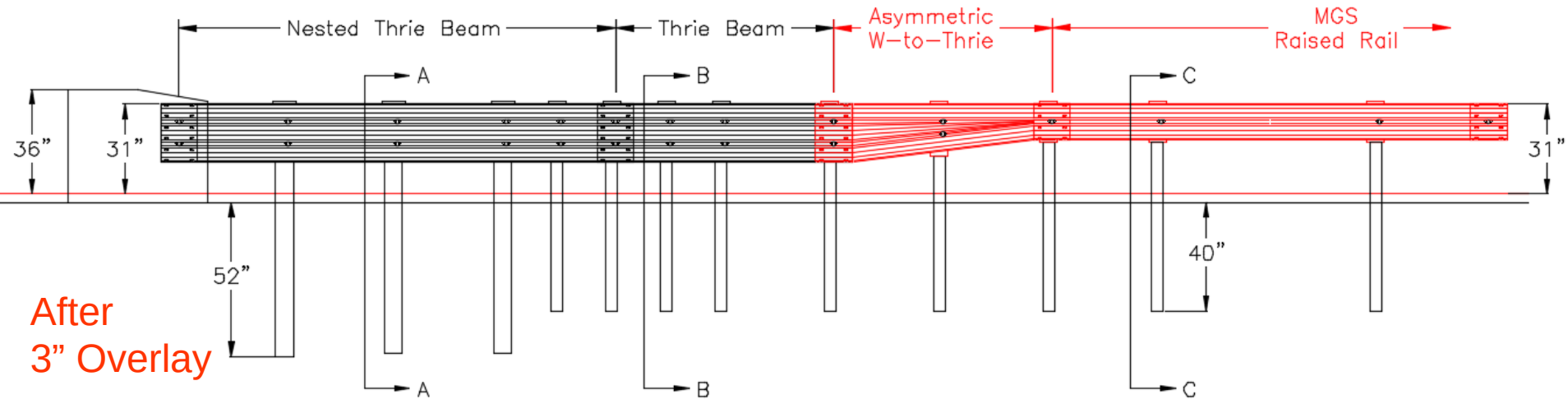
31-in. Standardized AGT Buttress

- System crashworthy to MASH TL-3
- For use with all crashworthy thrie beam AGTs of similar or greater stiffness
  - With or without curbs
- Standardized buttress can be transitioned to various parapet geometries and heights
- Upstream stiffness transition required

34” AGT - Design



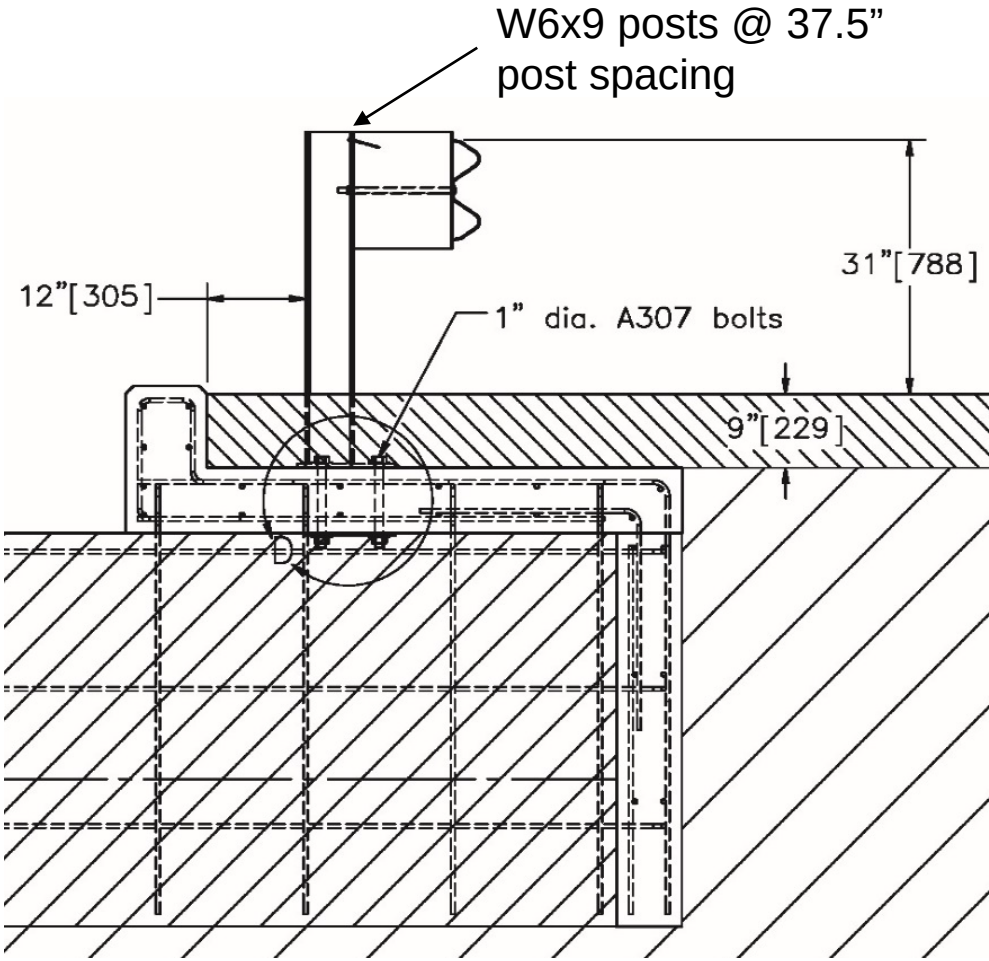
First
Installation



After
3” Overlay

Other Bridge Related Research

- WisDOT Strong Post, Culvert Mounted MGS
  - Two full-scale crash tests
    - Test no. 3-10 - Passed
    - Test no. 3-11 – Passed
- NCHRP 22-34
  - Determination of ZOI Under MASH Impact Conditions



Acknowledgements

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