



# VIRGINIA MASH IMPLEMENTATION UPDATE

2019 VIRGINIA CONCRETE CONFERENCE

 Andrew M. Zickler, PE

March 1, 2019

# ~~VIRGINIA MASH IMPLEMENTATION UPDATE~~ WHY DO MODIFICATIONS TO RAILINGS NEED A DESIGN EXCEPTION? OR CRASH TESTING INSIGHTS FOR DESIGNERS.

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# MASH

## Why is VDOT adopting MASH?

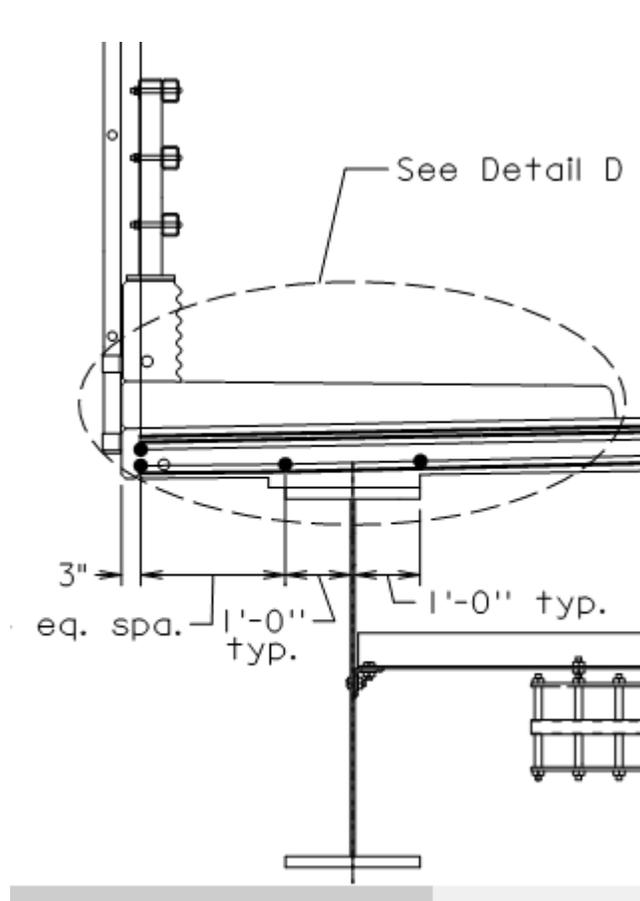
- **Safety.**
  - MASH represents a significant improvement over NCHRP 350
  - Test Vehicles more closely match in-service vehicle population
  - Practical Worst Case Philosophy
  - Limits are more evidence based
- **FHWA and AASHTO Joint Implementation Agreement:**
- **Funding**



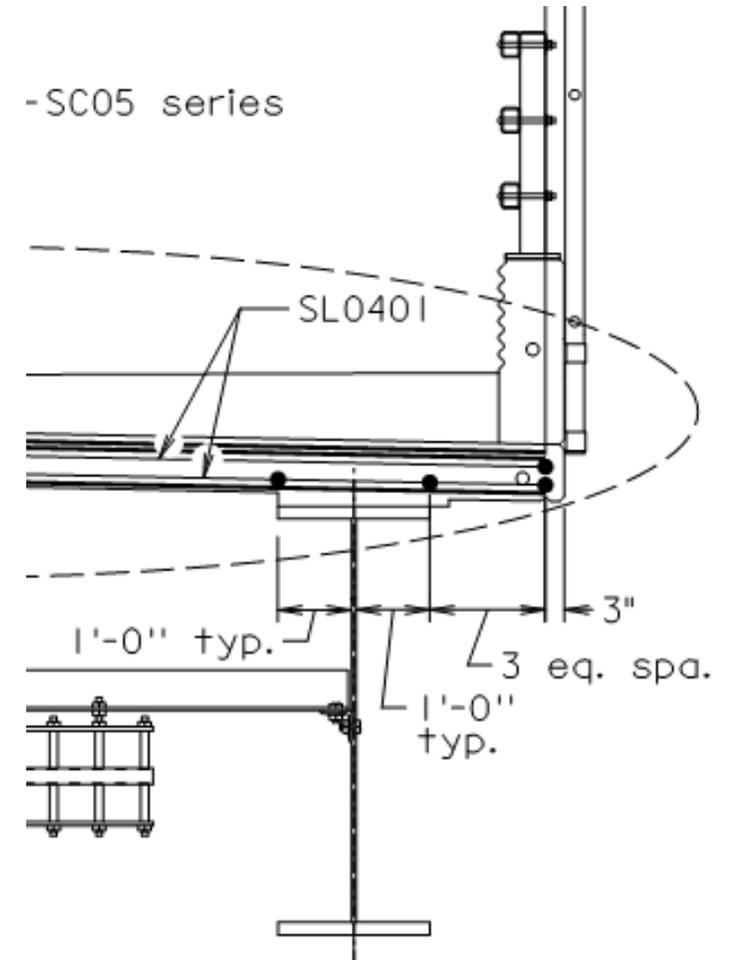
<https://design.transportation.org/wp-content/uploads/sites/21/2018/06/MASH-Implementation-Agreement-Final.pdf>

# Are these railings the same?

BR 27 on a sidewalk

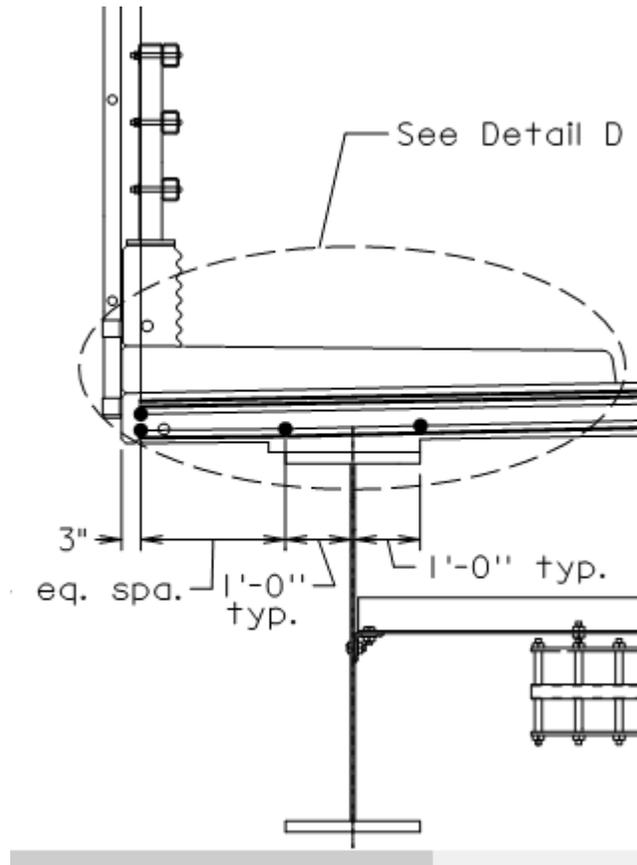


BR27 behind a sidewalk

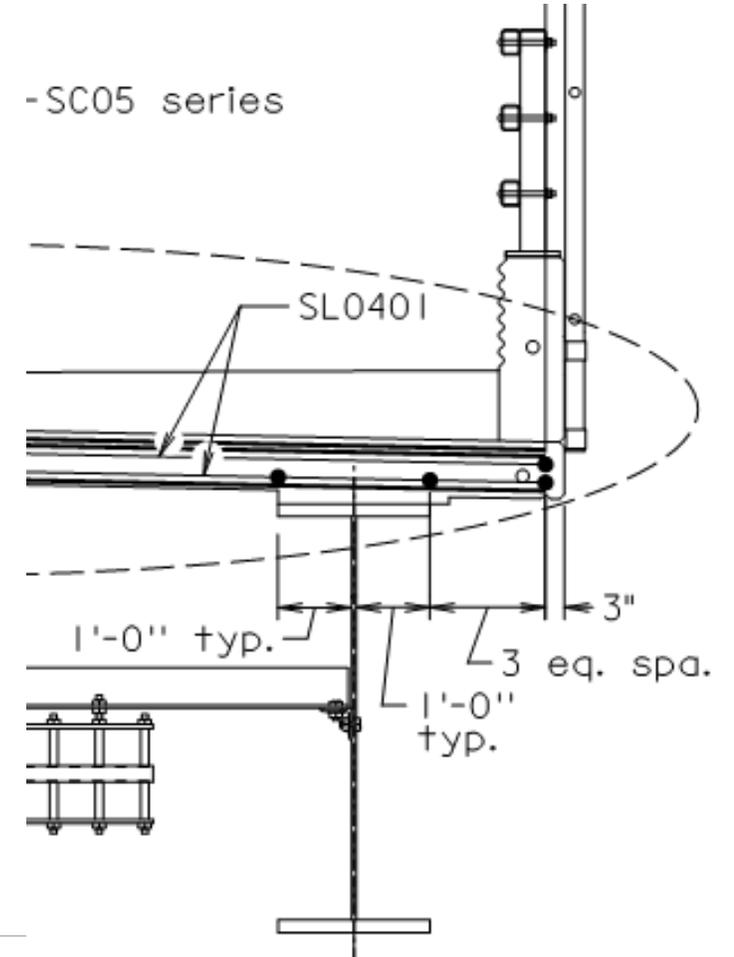


# Better question, will they perform the same way?

## BR 27 on a sidewalk

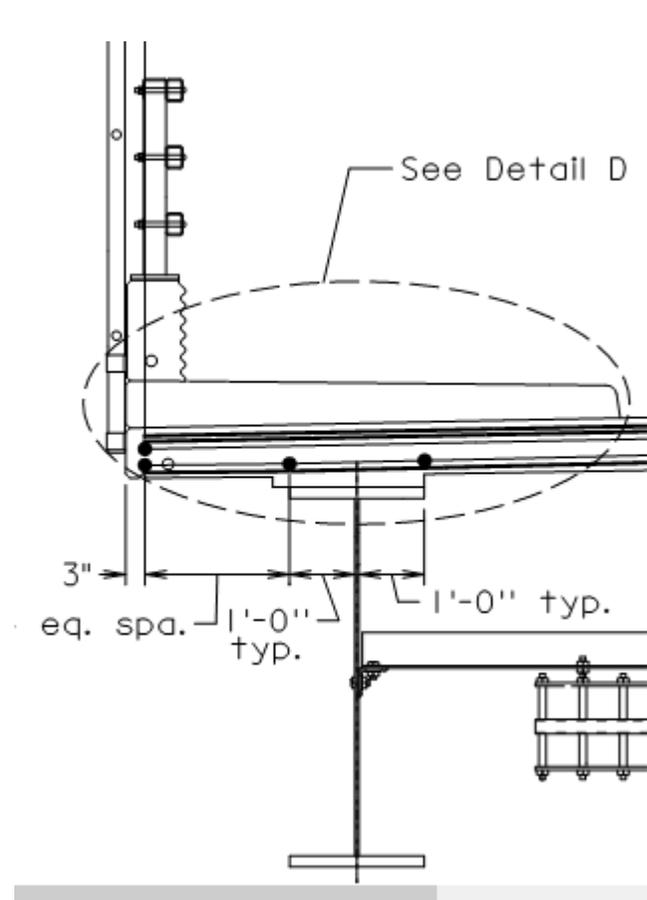


## BR27 behind a sidewalk

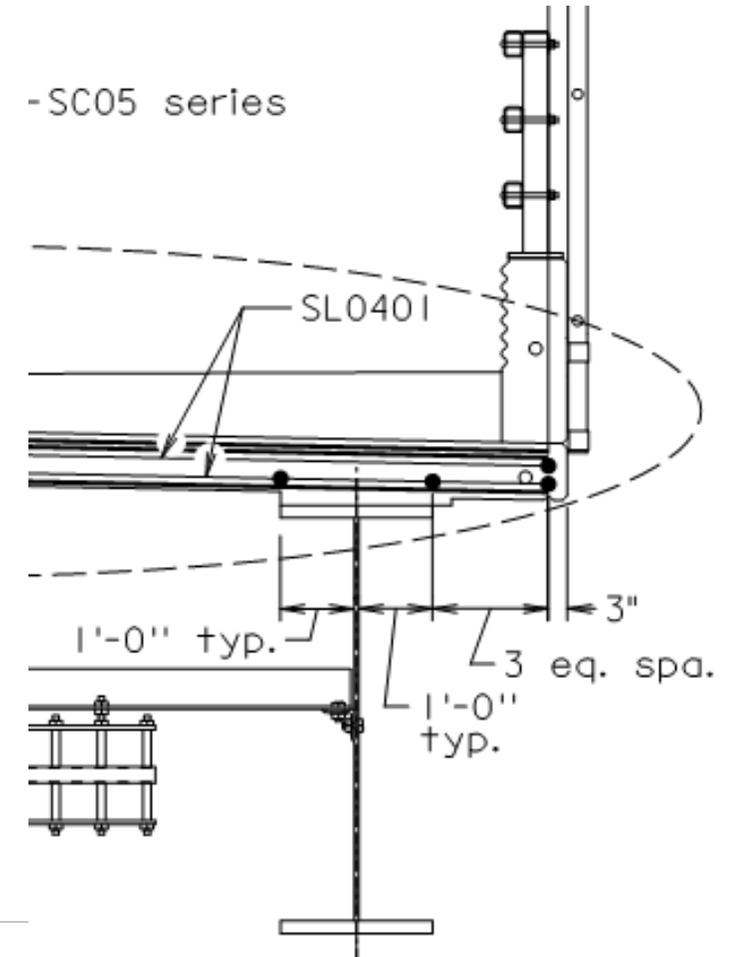


# New Crash test? Or Yield Line Evaluation?

## BR 27 on a sidewalk



## BR27 behind a sidewalk

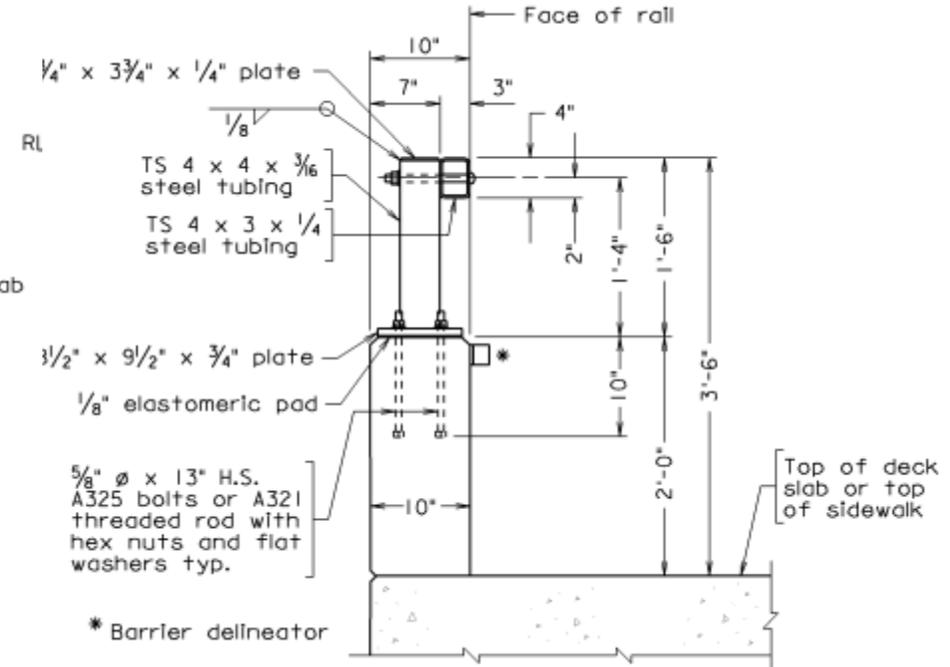
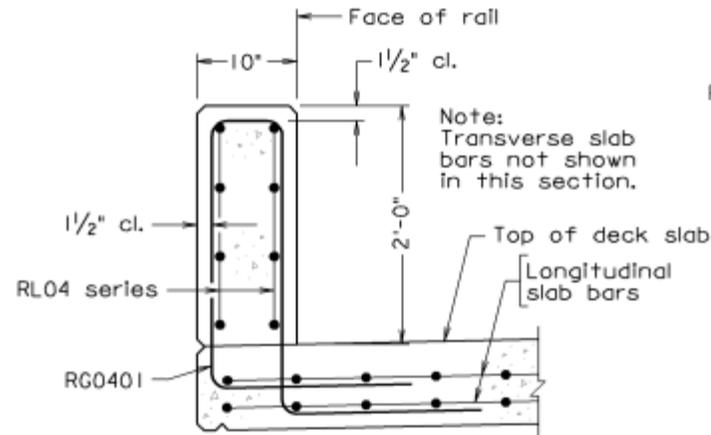
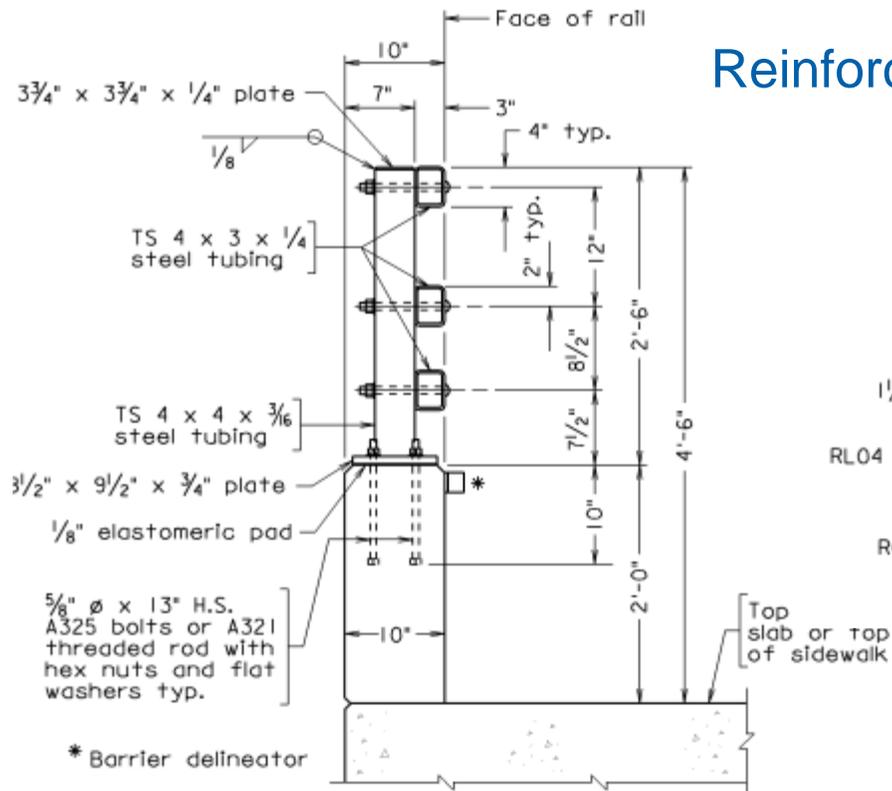


# New Crash test? Or Yield Line Evaluation and DE?

54"BR 27 on a sidewalk

42"BR27 on a sidewalk

Reinforcing in the parapet is the same

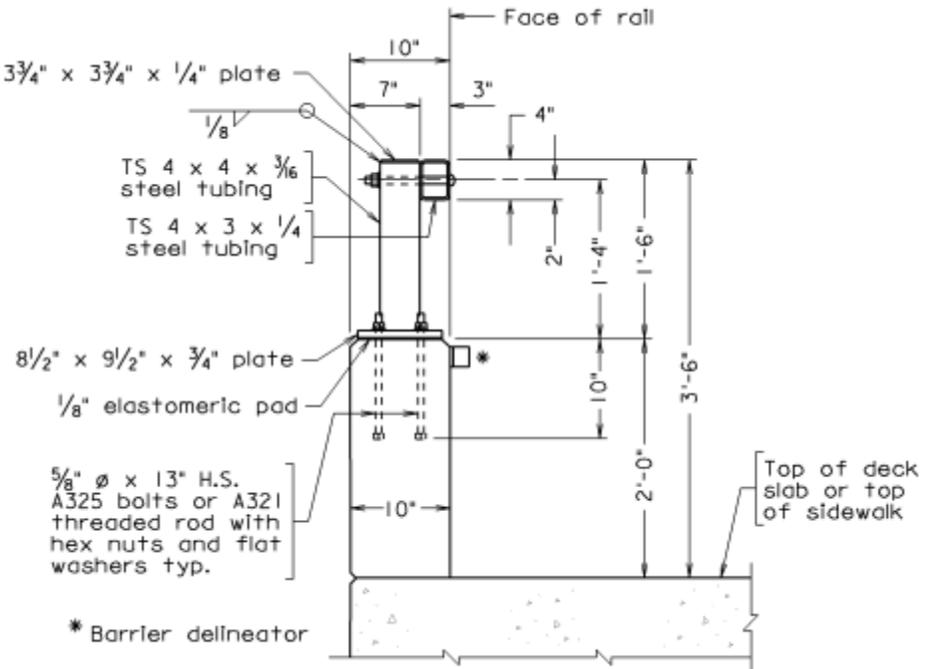
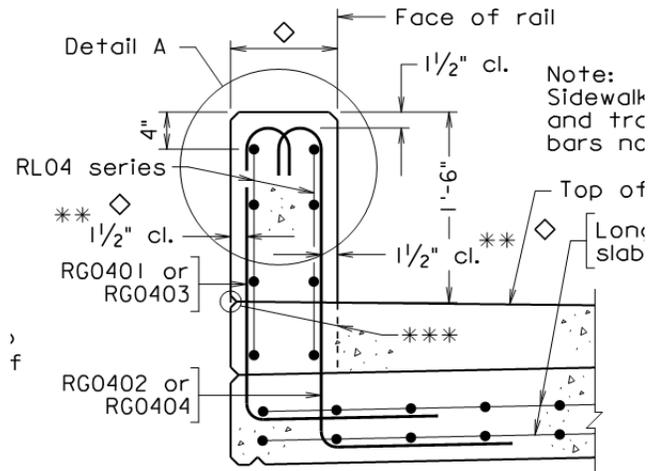
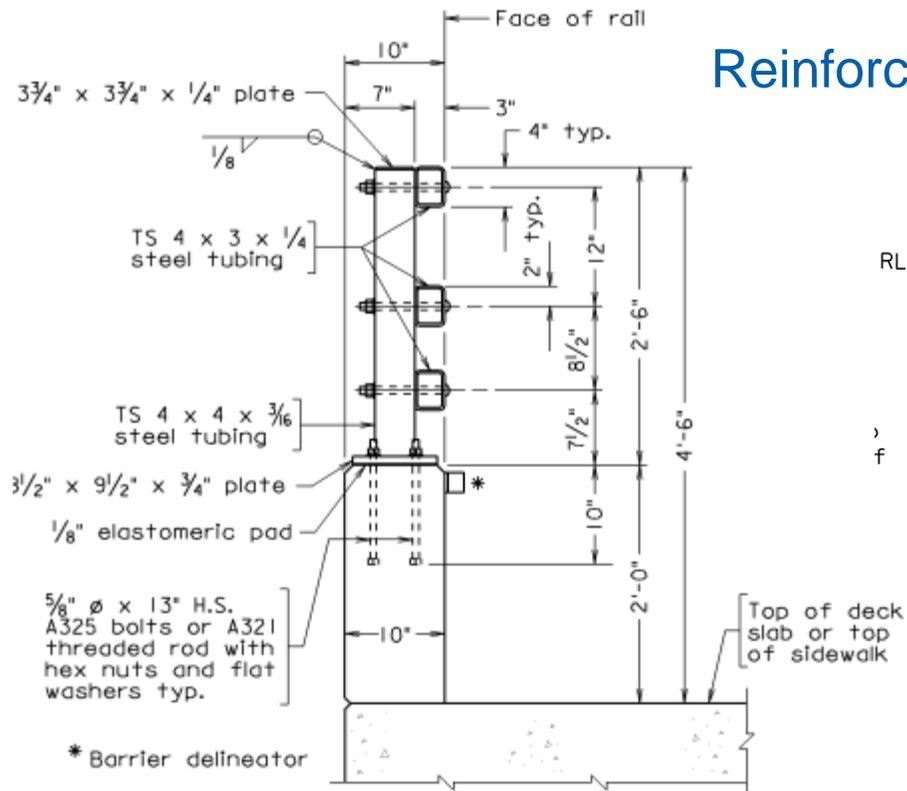


# New Crash test? Or Yield Line Evaluation and DE?

54"BR 27 on a sidewalk

42"BR27 on a sidewalk

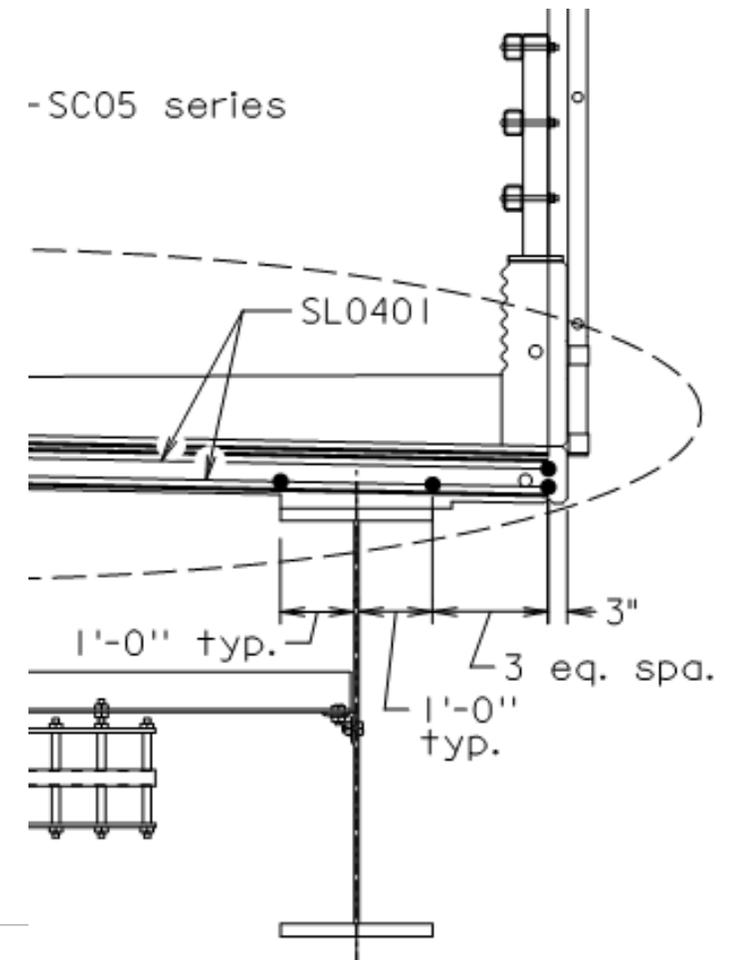
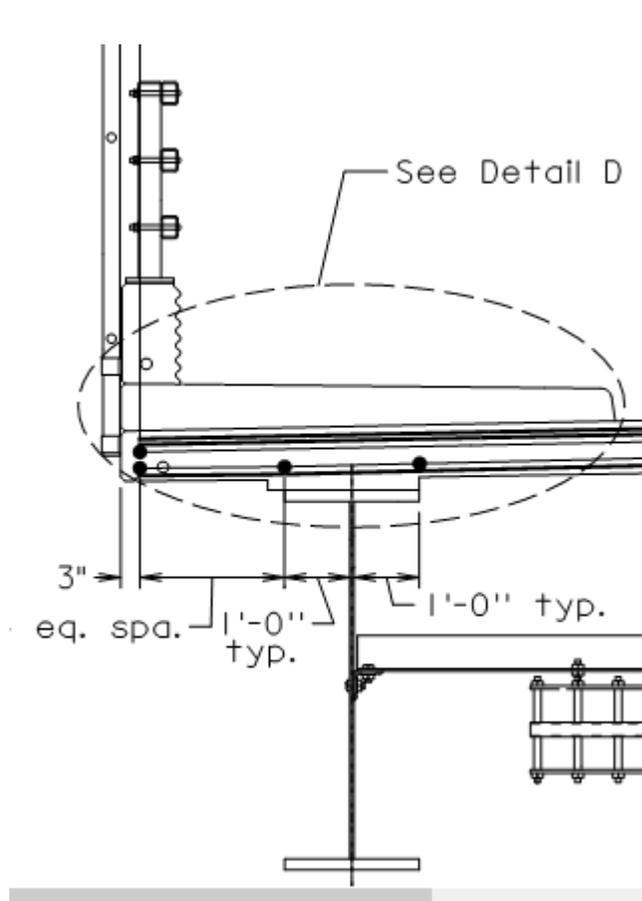
Reinforcing in the parapet is the same



# What if they are lightweight concrete?? New Crash test? Or Yield Line Evaluation?

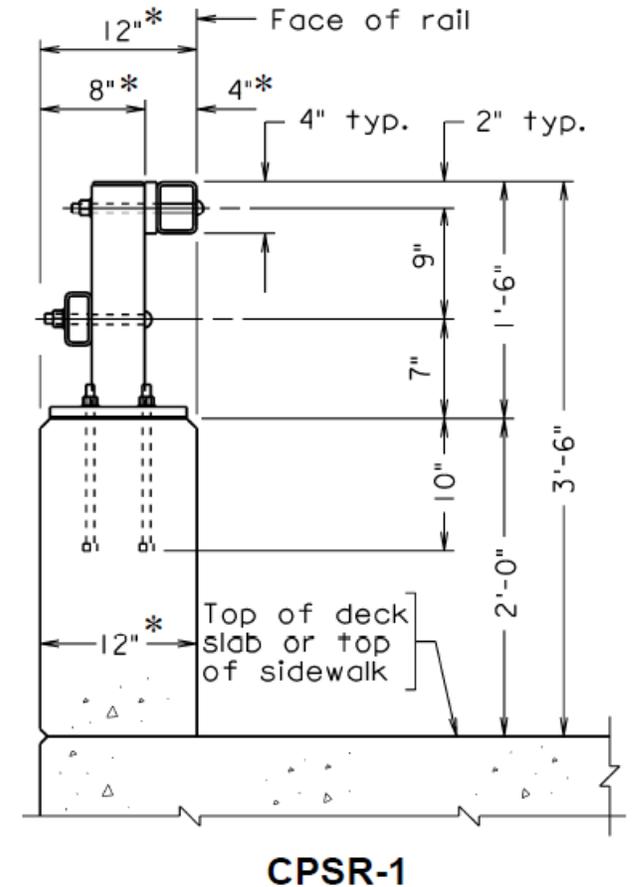
BR 27 on a sidewalk

BR27 behind a sidewalk



# New CPSR railing

- **Barrier replaces the BR27 Standard rail**
- **Only has 42" version**
- **Parapet base is now 12" instead of 10"**
  - Increase anchorage capacity
  - Increased yield line capacity
- **Has been evaluated to meet MASH TL-4**
  - BR27 was evaluated to only meet TL-3



# MASH changes that affect this railing

- **TL-4 vehicle gets much bigger**
  - Increased weight (25%)
  - Increased velocity (12.5%)
  - Increased height of the impact c.g.
  - Increased energy of vehicle at impact, over 50%
- **TL-2 and TL-3 vehicles increase in weight and height too.**
- **What's next?**



<https://design.transportation.org/wp-content/uploads/sites/21/2018/06/MASH-Implementation-Agreement-Final.pdf>

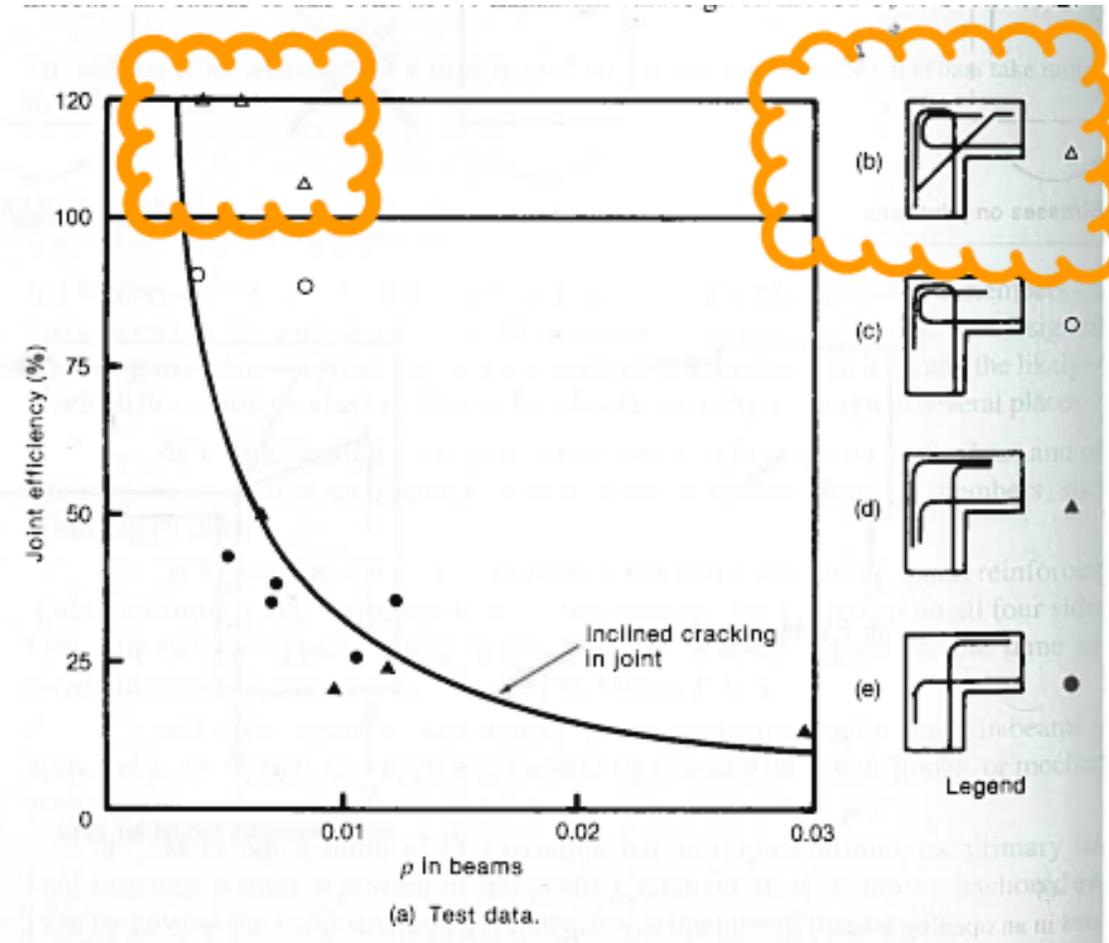
# Recent Research

- Railings which are taller than the minimum MASH height
- In the past there was no guidance related to increasing heights of railings above the minimum height



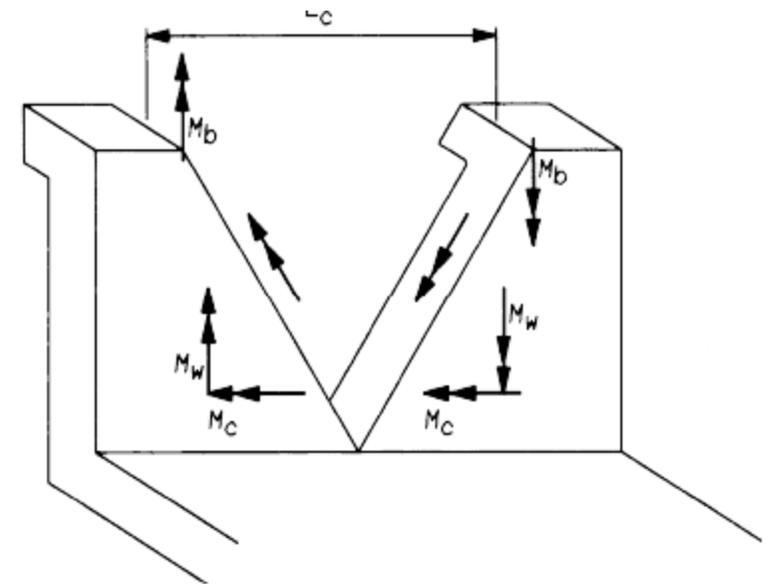
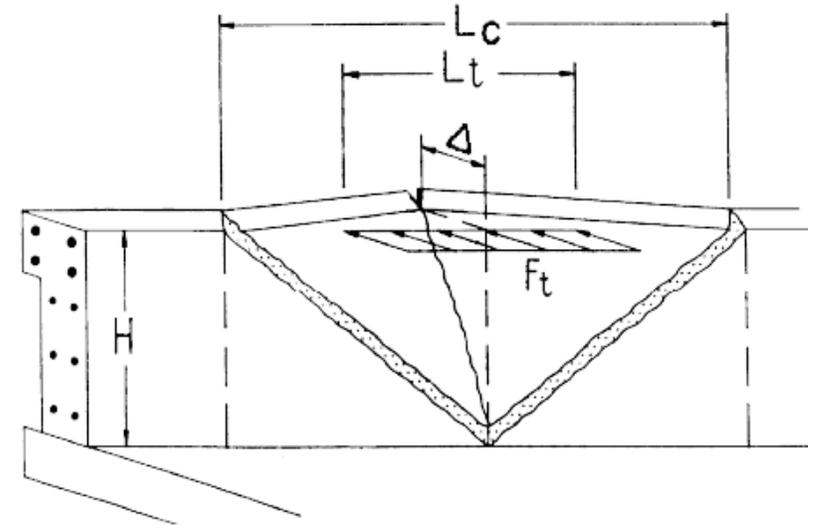
# Parapets and railings are opening corners

- Impact during a collision wants to increase the angle between the parapet and the deck.
- Opening corner strength is highly dependent on the configuration of the reinforcing.
- Adapting crash tested details requires creating details that will reach anticipated capacity



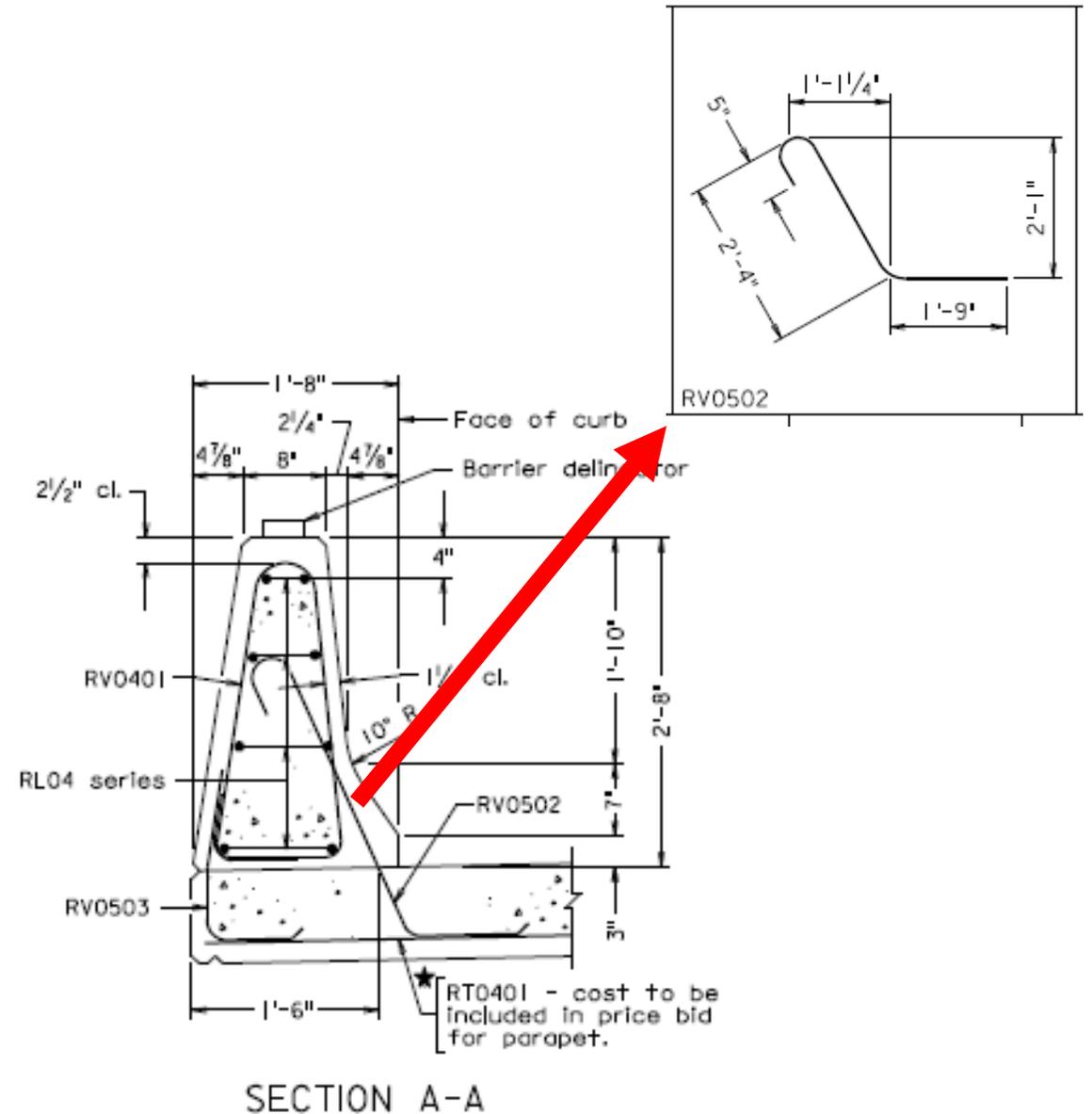
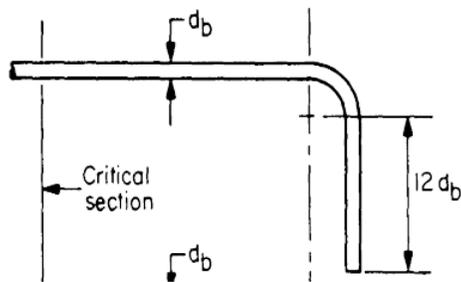
# Rebar Detailing

- **Yield Line Theory**
  - Addresses the railing
  - Completely misses the connection.
- **What about the connection??**
  - Yield line theory assumes that all vertical rebar yield with in the length
  - Crash testing verifies that the detail crash tested detail works, but it does not demonstrate that bars reach yield.



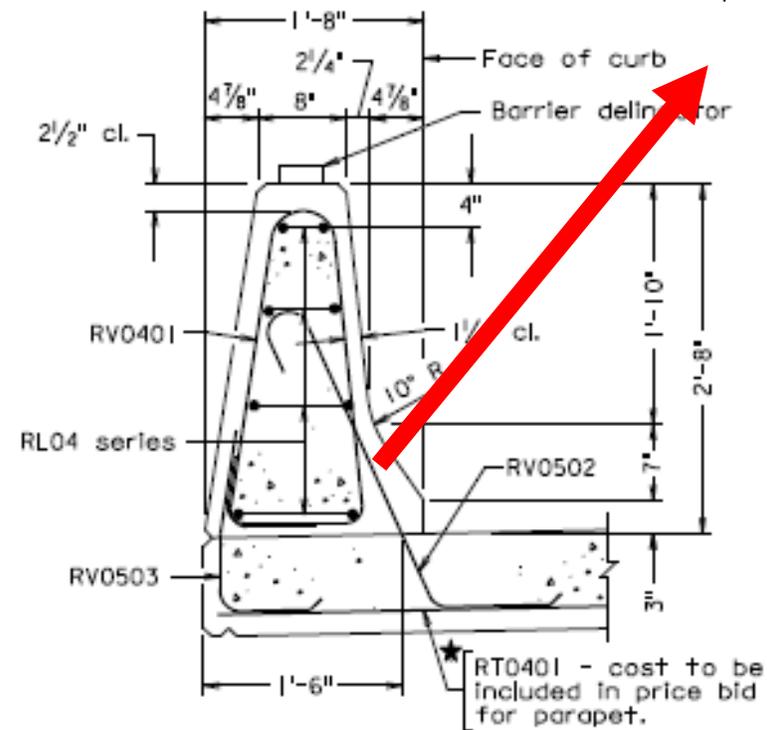
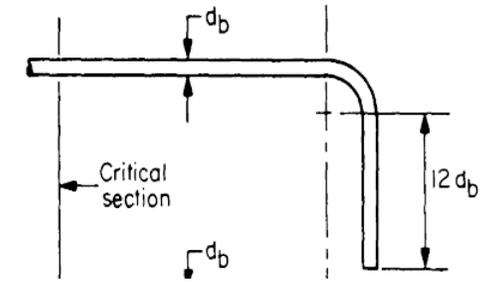
# Rebar Detailing

- **What about modifying the railing to deck connection??**
- **What is the minimum embedment of an angled #5 that will ensure yield?**
- **Mc in the yield line equation does not account for the angle?**
- **AASHTO embedment**



# Rebar Detailing

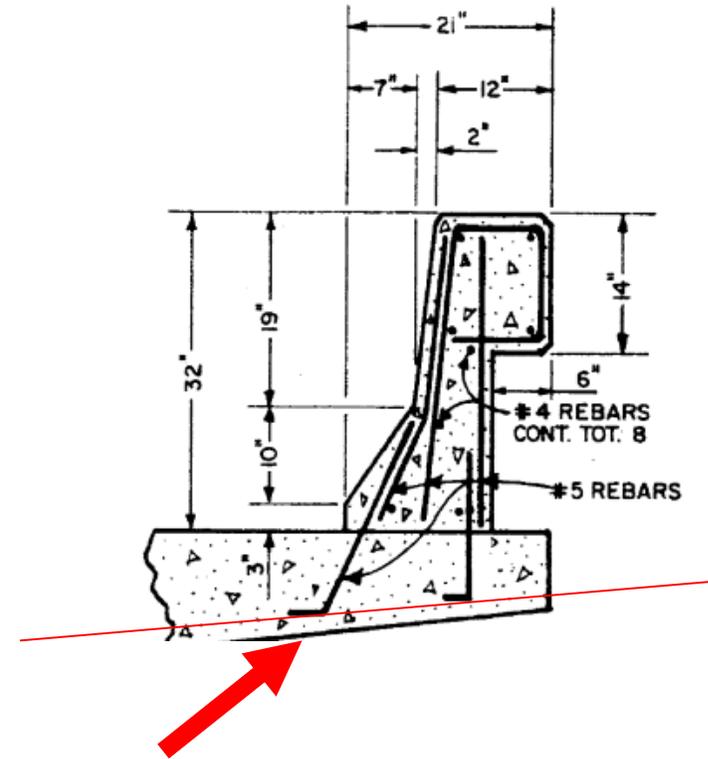
- **Basic development for a hooked #5 is 12 inches for 4ksi concrete (VDOT tables)**
- **Minimum embedment is NLT than 6" (do enough standard modifiers apply?)**
- **Hook is clearly contemplated as normal to surface (what is the modifier for slope?)**
- **Conclusion, bar shape is validated by crash testing.**



SECTION A-A

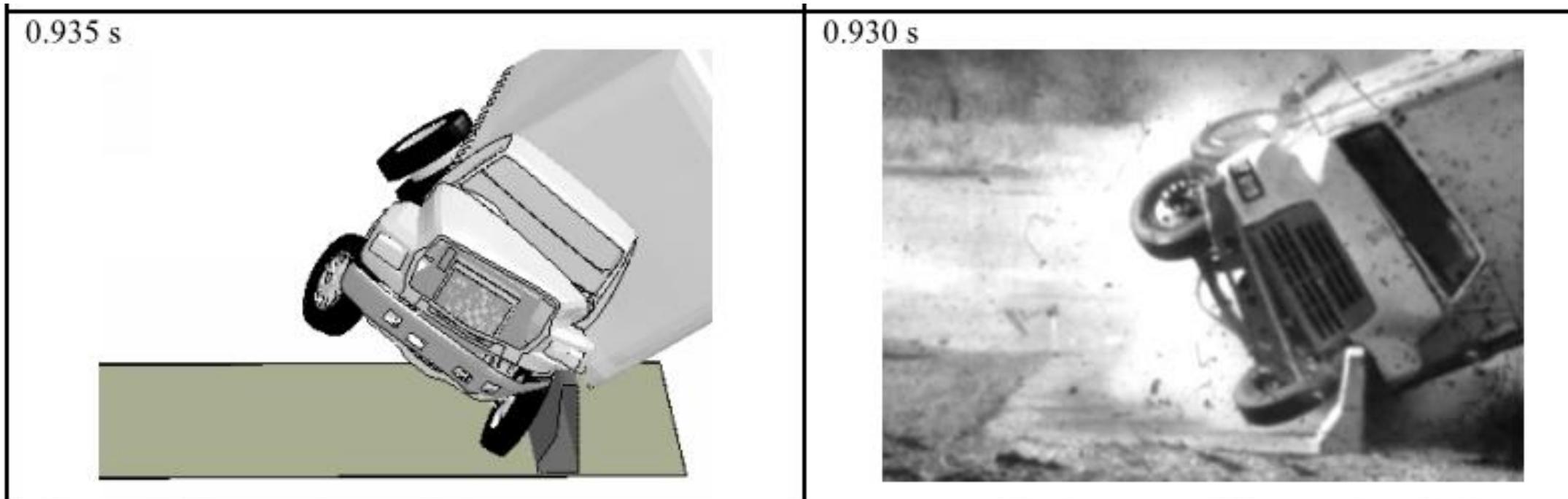
# Deck Overhangs

- Does the overhang shape or length affect the crash testing.
- No definitive testing under MASH.
- Indications are shape of overhang has effects.
- VDOT requires parallel deck overhangs.
- Variable depth overhangs require a design exception.



# Changes you may see resulting from Virginia and national implementation of MASH

## 32" Barrier under MASH TL-4



**Figure 1 Comparison of simulation and crash test results for impact of SUT with 32-inch tall NJ barrier under MASH TL-4 impact conditions.**

# Changes you may see resulting from Virginia and national implementation of MASH

## 36" Barrier under MASH TL-4



# Changes you may see resulting from Virginia and national implementation of MASH

- **Single slope barrier option**
  - TL-4 and TL-5 variants
  - 36” and 42” barrier heights
- **New TL-4 Kansas Corral Railing**
- **Moment slab barrier details**
- **New terminal walls**
- **New transition details**
- **New AASHTO requirements**



# QUESTIONS?



Contact:

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[andy.zickler@vdot.virginia.gov](mailto:andy.zickler@vdot.virginia.gov)

# HARDWARE ELIGIBILITY LETTERS

## Longitudinal Barriers and Bridge Rails

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/listing.cfm?code=long](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=long)

## Barrier Terminals and Crash Cushions

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/listing.cfm?code=cushions](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=cushions)

## Sign Supports, Mailboxes, and Delineator Posts

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/listing.cfm?code=signs](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=signs)

## Luminaire Supports

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/listing.cfm?code=lumin](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=lumin)

## Work Zone Devices

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/listing.cfm?code=workzone](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=workzone)

# GUIDANCE POLICIES

## FHWA Roadside Hardware Memos and Policies

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/policy\\_memo\\_guidance.cfm](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/policy_memo_guidance.cfm)

- Eligibility Process
- NTSB Recommendations
- AASHTO Guidance

## FHWA Federal-aid Eligibility Letter Process

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/elig\\_process.cfm](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/elig_process.cfm)

- For Safety Hardware Devices
- For Highway Flexible Barriers
- Using Finite Element Analysis (FEA)

# GUIDANCE POLICIES

## AASHTO Manuals and Guides

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/aashto\\_guidancecfm.cfm](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/aashto_guidancecfm.cfm)

- **AASHTO Roadside Design Guide**
- **Manual for Assessing Safety Hardware (MASH)**
- **AASHTO/FHWA Joint Implementation Agreement for MASH**
- **FHWA Federal Register Notice – MASH Transition (January 1, 2016)**
- **AASHTO Technology Implementation Group (TIG) Focus Technology**
  - Cable Median Barrier
  - Severe Duty Crash Cushion

# RESOURCES

## Status of AASHTO MASH Implementation

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/aashto\\_mash\\_implementation.cfm](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/aashto_mash_implementation.cfm)

- **Summary of results, by state**

## Guardrail Inspection, Maintenance, and Installation Information

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/guardrail\\_ispe.cfm](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/guardrail_ispe.cfm)

- **Guidance and Memoranda**
- **Device Specific Memoranda and Feedback**
- **Training Opportunities**
- **In-Service Performance Evaluation**
- **Research**

# RESOURCES

## Additional Resources and Partners

[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/resources.cfm](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/resources.cfm)

- **Roadside Hardware Resource Charts**
- **Partners**
  - American Traffic Safety Services Association
  - International Road Federation's Road Safety Matters Blog
  - TRB Roadside Safety Design Committee (AFB20)
  - Turner-Fairbank Highway Research Center
  - Center for Collision Safety and Analysis (CCSA)
- **Pooled Fund Programs**
  - Midwest Roadside Safety Facility (MwRSF)
  - Roadside Safety Pooled Fund Program

# MASH

## AASHTO/FHWA Implementation schedule

- **On the National Highway System (NHS)**

Only safety hardware evaluated using the 2016 edition of MASH criteria will be allowed for new permanent installations and full replacements:

- **December 31, 2017: ...*cast-in-place concrete barriers*...**
- **December 31, 2019: ...*bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently)*...**

<https://design.transportation.org/wp-content/uploads/sites/21/2018/06/MASH-Implementation-Agreement-Final.pdf>

# BRIDGE BARRIERS

**VDOT barrier types can be found in Chapter 25 of Part 2 of the Manual of the S&B Division.**

- <http://www.virginiadot.org/business/resources/bridge/Manuals/Part2/Chapter25.pdf>

**VDOT barrier standards can be found in Part 3 of the Manual of the S&B Division.**

- <http://www.virginiadot.org/business/resources/bridge/Manuals/Part3/Part3.pdf>