Transportation Engineering & Safety Conference

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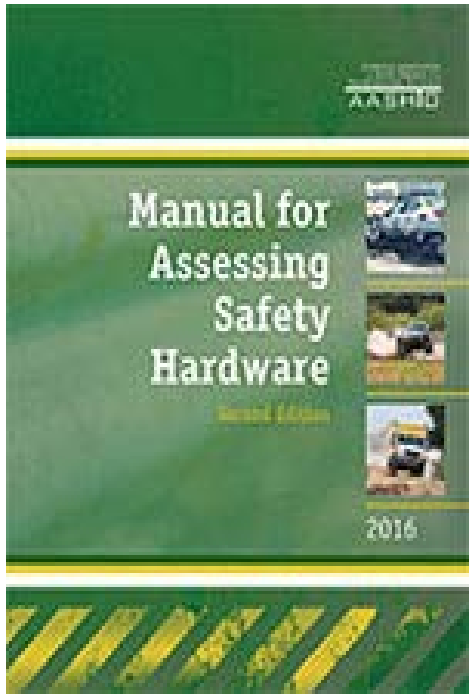
Today's presentation

- MASH Background & Implementation Schedule
- PA MASH Implementation Status

  - What's Completed
  - Ongoing/Needs to be done

- New Policies and Program Initiatives to upgrade guiderail and end treatments



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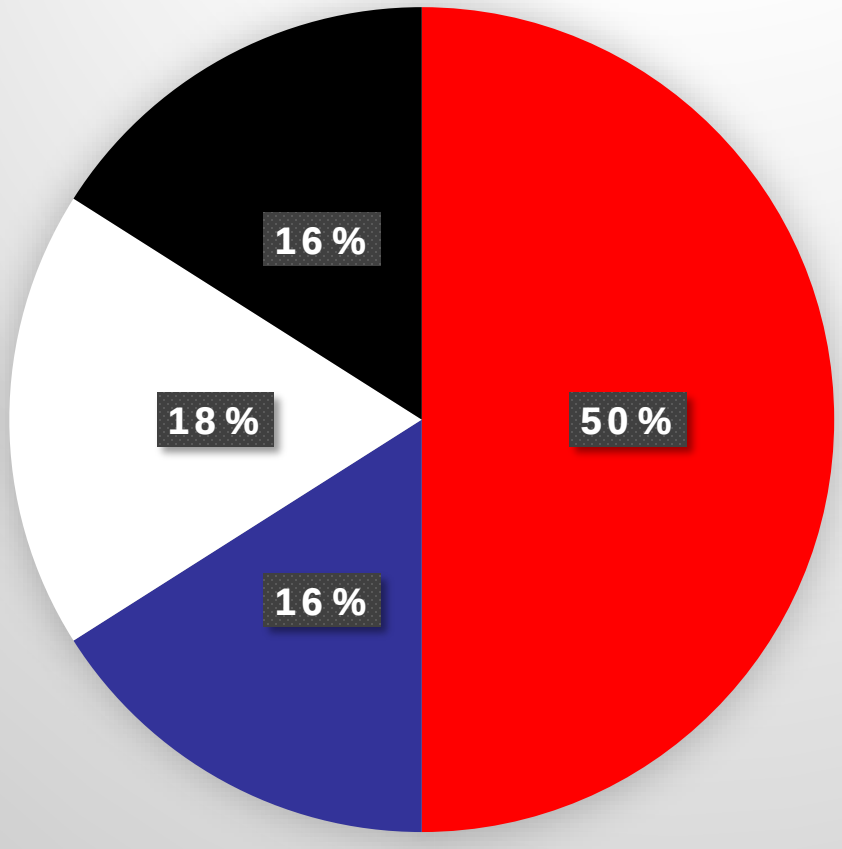
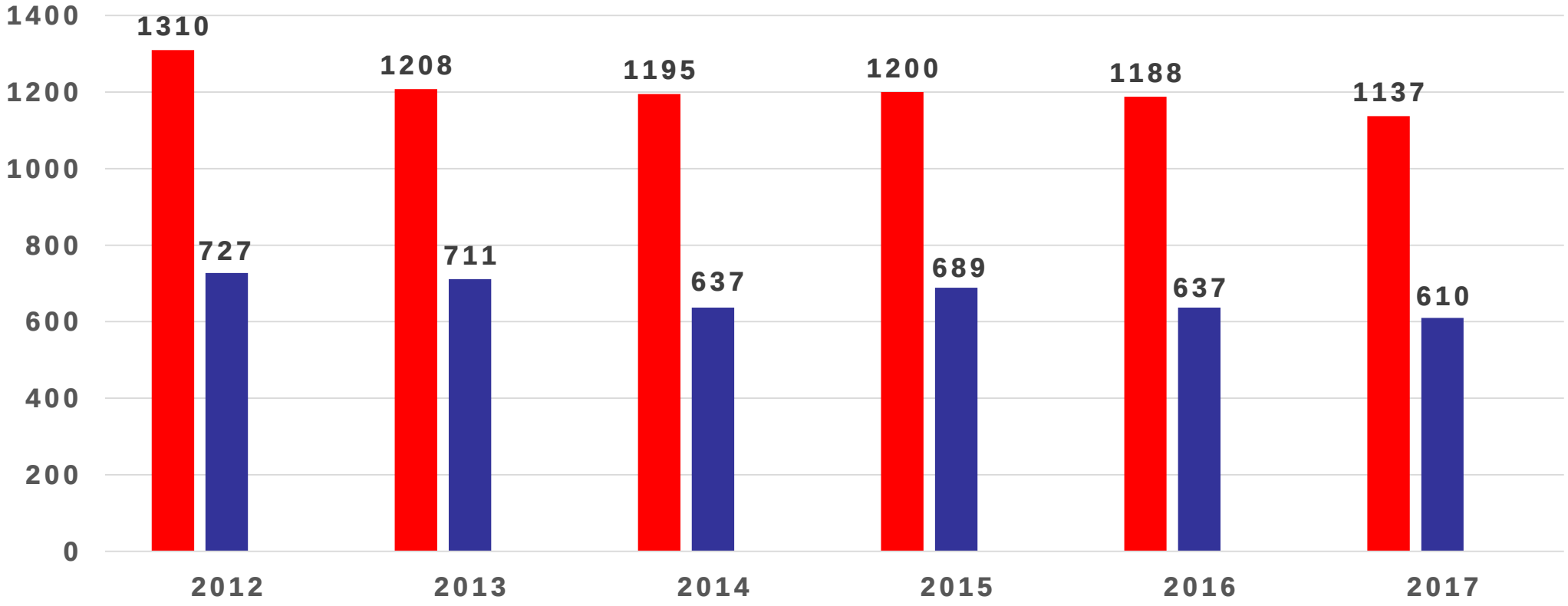
Why worry about Safety - US Fatalities

37461 in 2016
35485 in 2015
32744 in 2014



Why worry about Safety? PA Fatalities



2017 Roadway Departure Fatalities: 54% of total

Overturned: 36%; Trees: 25%; Poles: 10%; Guiderail/ET: 5%; barriers: 3%; embankment: 3%; Others:18%

Why so many fatalities and what can we do?

Driver fault is a contributing factor in over 90% of the crashes (infrastructure and equipment failure responsible for rest). Speeding and Alcohol contributing to over 50% of the fatalities

- Need multiple strategies (e.g., 4E) to improve safety
  - Engineering; Enforcement; Education; Emergency medical services + Legislation, Marketing, Technology

Countermeasure

- Keep vehicles on the roadway [better pavements, markings, signs, lighting, rumble strips, safety edge and…Autonomous vehicles?]
- Provide for Safe Recovery (flat slopes, clear ROW, etc.)
- Reduce Crash Severity by installing crashworthy devices

MASH – Manual for Assessing Safety Hardware

- MASH 2016 contains the new testing and evaluation criteria for assessing safety performance of safety hardware. MASH 2016 is updated version of MASH 2009 and includes some new requirements, particularly involving cable barriers.

- MASH replaced NCHRP Report 350 testing and evaluation criteria (used since 1993 and which replaced NCHRP 230 used since early 1980)

- MASH evaluation criteria include:
  - Structural adequacy of the tested hardware
  - Occupant risk
  - Post-impact vehicle stability/trajectory

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Why MASH?

4400 lb

NCHRP 350

5000 lb

MASH

1800 lb

2420 lb

Because of the recognition that vehicle fleet on our highways has changed and include larger heavier vehicles

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Why MASH?

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MASH Test for 26 3/4” Strong Post Guide Rail

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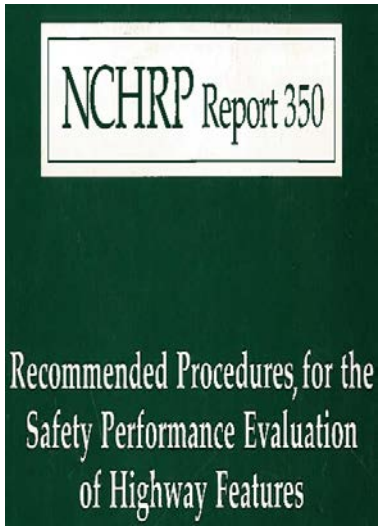
MASH Test levels, Test Criteria & Key Changes

TEST LEVEL	Test VEHICLE Type – (weight Lb.)	SPEED mph	ANGLE OF IMPACT
1	**PASSENGER CAR – (1809 to 2,420) ←** **PICKUP TRUCK – (4409 to 5,000) ←**	31 31	**25** (20) ← 25
2	**PASSENGER CAR – (2,420)** **PICKUP TRUCK – (5,000)**	44 44	25 25
3	**PASSENGER CAR – 2420** **PICKUP TRUCK – 5000**	62 62	25 25
4	**PASSENGER CAR – (2,420)** **PICKUP TRUCK – (5,000)** **SINGLE UNIT TRUCK – (17636 to 22,000) ←**	62 62 **56 (50)←**	25 25 15
5	**PASSENGER CAR – (2,420)** **PICKUP TRUCK – (5,000)** **TRACTOR VAN TRAILER – (79,300)**	62 62 50	25 25 15
6	**PASSENGER CAR – (2,420)** **PICKUP TRUCK – (5,000)** **TRACTOR TANK TRAILER – (79,300)**	62 62 50	25 25 15

MASH 2016 Implementation Milestones



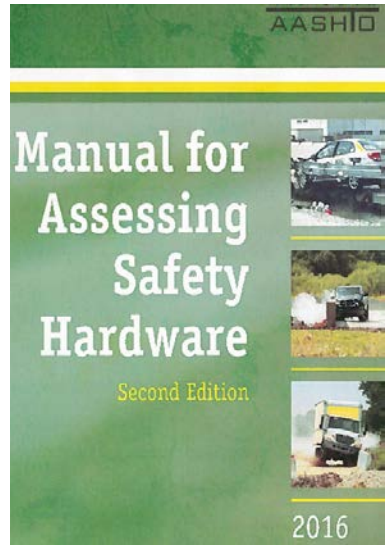
REPORT 350 SUNSET

Dec. 31, 2017
W-Beam & Cast-in-Place Concrete Barriers

Jun. 30, 2018
W-Beam Terminals Tangent

Dec. 31, 2018
Crash Cushions ???

Dec. 31, 2019
Bridge Rails, Transitions, All Other Longitudinal Barriers Including Portable Barriers Installed Permanently All Other Terminals, Sign Supports & Other Breakaway Hardware. Cable Barriers & Their Terminals. W-Beam Terminals flared



MASH SUNRISE

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PennDOT Compliance with MASH Implementation Schedule

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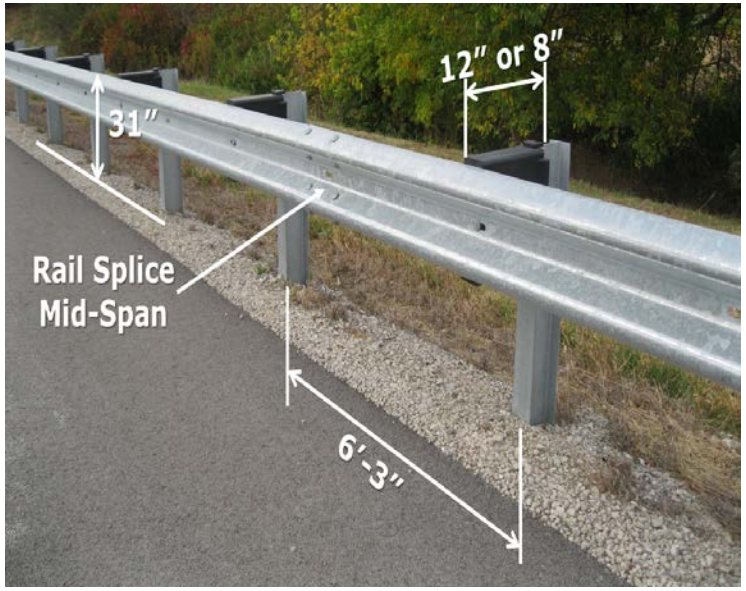
PennDOT MASH Implementation Status

Strong Post W-Beam

MASH compliance was required by 12/31/2017

Implemented in Aug. 2017

Replaced Type 2-S Guide Rail with Type 31-S Guide Rail.



Changes

- Height changed from 27 ¾" to 31"
- Mid-span splice instead of splices at post

Post spacing (6' 3") and bracket size (8" or 12") remained the same

MASH Test 3-11on 31-S Guide Rail

Type 2 Weak Post Guide Rail (RC-53M)

MASH compliance was required by 12/31/2017. Our Weak post beam was crash tested by TTI in 2017 and it passed. [We applied and received FHWA eligibility letter on 5/17/2018 (B-305)]

<u>Weak Beam Characteristics</u>

- Post spacing = 12’-6”
- Height = 32” Splices: mid span
- 9’ deflection for 12.5’ post spacing
- Backup plate between rail and post

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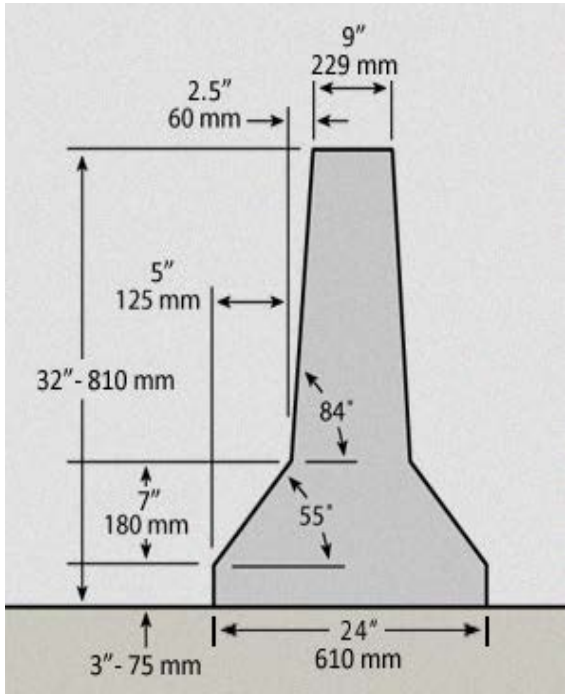
Crash Test Weak Post Guide Rail – at full speed

Cast-in-Place Concrete Barrier (RC-57M)

- MASH compliance was required by 12/31/2017
- We used engineering analysis to determine that our cast-in-place barriers 32” and 50” met MASH TL-3 requirements
- FHWA concurred in our findings in 12/2017



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MASH TYPE II & III W-beam Tangent Terminals

- Only MASH 2016 W-beam terminals can be used for projects let after June 30, 2018. We have met this requirement.

- Currently Bulletin 15 includes three MASH 2016 **Type II TL-3** Tangent terminals which include:
  - Road Systems MSKT
  - Trinity SoftStop
  - Lindsay MAX-Tension

We currently don't have any Type II flared or Type III Terminals in our Bulletin 15

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MASH TYPE IV, V, VI Crash Cushions

- Only MASH 2016 crash cushions can be used for projects let after December 31, 2018.

- At this time we have only one MASH 2016 terminal for each category in Bulletin 15:

  IV (gating system where two-way traffic is present)
  V (non-gating crash cushion where two-way traffic is present)
  VI (gating non-directive where two-way traffic is present)

We are hoping that more will become available

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Non-Crashworthy End Terminals for Guide Rail

Currently 3 types of non-crashworthy guide rail end terminals are included in our standards. These include:

- Turndowns [divided roads: trailing ends;
  non-divided roads: posted speed <45mph, ADT<2000, not a high crash location]

- Terminal section single (TSS)
  Driveways and intersections for local/minor collector with ADT<2000

- Type 31-S strong post anchor terminal

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End Treatments/terminals in PA

End Treatment Type	Total	BPN1	BPN2	BPN3	BPN4
Type 1 Buried in Cut Slope	16,537	2,732	3,666	4,269	5,870
Type 2 Energy Absorbing	**32,961**	3,926	7,656	11,684	9,695
Type 3 Non-Energy Absorbing	7,242	1,155	2,174	2,526	1,387
Type 4 Gating System - Median	783	181	541	53	8
Type 5 Non-Gating - Median	1,163	128	901	117	17
Type 6 Gating, Non-Redirective	18	4	9	5	0
Strong Post Anchor	3,964	1,542	1,007	545	870
Bridge Connection	41,451	5,059	8,445	12,066	15,881
TSS Terminal Section, Single	82,102	2,371	13,110	27,868	38,753
Other	2,296	342	579	638	737
Turndowns Concrete End Anchor	50,618	1,134	6,182	16,398	26,904
Total	239,135	18,574	44,270	76,169	100,122

PennDOT Initiatives to Meet MASH Compliance in Remaining Areas

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Precast Concrete Barrier

- MASH compliance for precast barrier is equired by 12/31/2019

- Currently we use 32” and 50” (glare screen) F-shape precast barrier with slotted plate connection which is a weak connection and barely passed NCHRP 350 TL-3 crash test, in freestanding condition).

- Considering heavy truck traffic on our highways and MASH requirements (32” for TL-3; 36” for TL-4; and 42” for TL-5) we decided to reevaluate our current barrier standards.

- Conducted survey of our Districts and adjacent States
  - NJ: 32” (NJ shape) & 42” F shape cast-in-place
  - MD: 34” (NJ shape) & 42” F shape cast-in-place/slip form
  - NY: 42” single slope cast-in-place/slip formed
  - OH: 42” and 57” single slope cast-in-place/slip formed

Eventually we decided to use 42” tall barrier as our standard barrier moving forward. 32” and 50” barriers will be retained and used as needed

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Precast Concrete Barrier (cont.)

- TTI has evaluated 32” 42” and 50” F shape and determined that 50” height is most critical for crash testing.
- Barrier was designed with pin & loop connection, 2” embedment, and required nearly 3 times more reinforcement than our current barrier due to increased impact force.
- Barrier is now being constructed for crash testing. If test is successful TTI is expected to issue their professional opinion on MASH compliance for other barrier heights.
- Crash testing/Report is due by 3/2019. We expect to issue CT in May and new standards in summer.

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MASH TL-4 Cast-in-Place Concrete Barrier

- We are also in process of designing TL-4 cast-in-place concrete barrier for MASH compliance. Contractors will be able to select either precast or CIP.

- As another option, we are also considering adding Texas 42” Single Slope concrete barrier to our standards. This barrier was crash tested with X-bolt connection.

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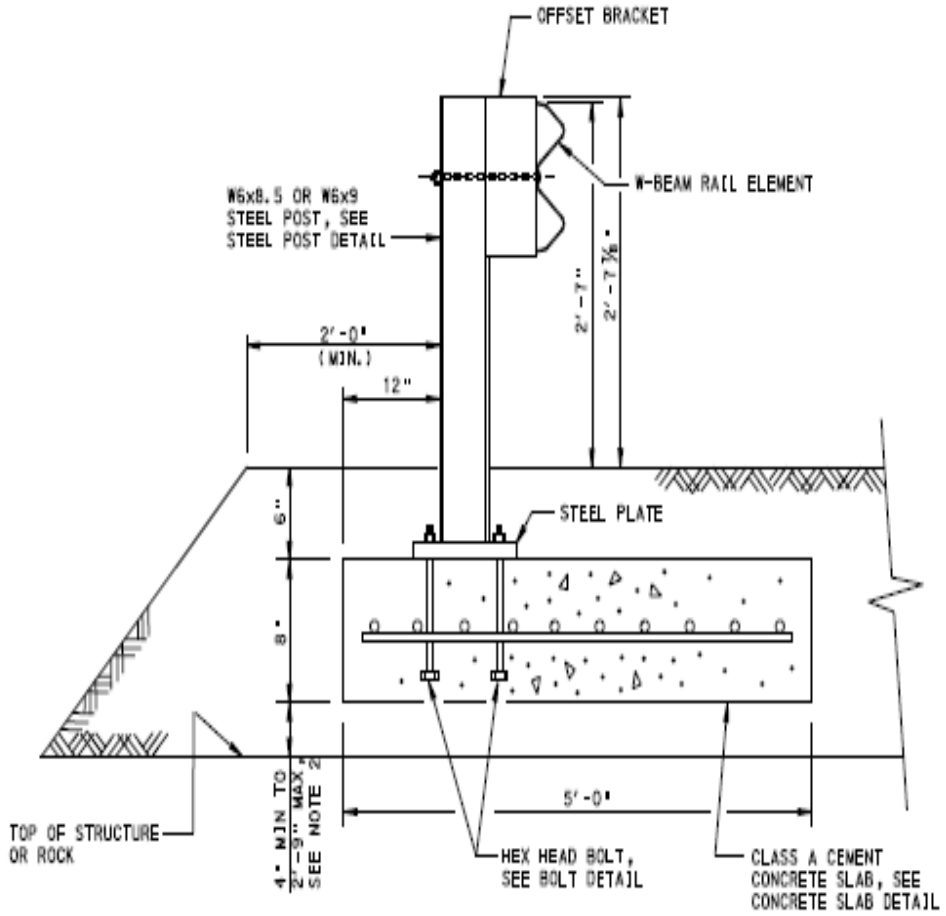
Type 31-S Guide Rail Over Underground Structures

- Our current standards (RC-51) allow GR post on only <u>one concrete slab</u> over underground structures such as low fill culverts.
- TTI will be crash testing our current design using 6 posts to allow more flexibility
- RCs will be updated as tests are successfully completed.

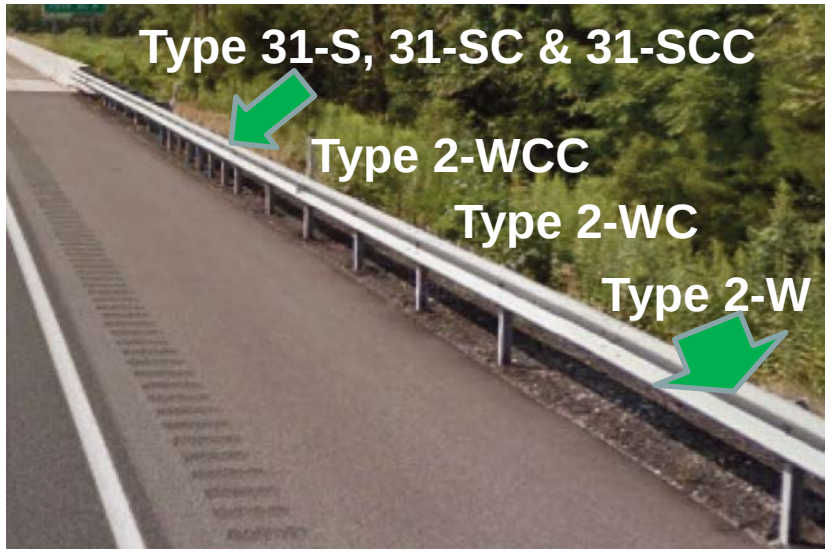


STEEL POST OVER UNDERGROUND STRUCTURE

Transitions Due by 12/31/2019

- When a softer barrier precedes a stiffer barrier, a gradual stiffening must occur to prevent pocketing. We also need transitioning between different height and types of barriers

- Pooled Fund Groups and other States are conducting several of these tests. For example, Connecticut DOT is testing weak w-beam to strong W-beam transition. We will update our standards as information becomes available.



What happens if Transitions are not Adequately Stiffened

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Buried-in-Backslope (BIB) Terminal – TYPE I

- Compliance is required by 12/31/2019 for **flared** terminals
- Type I BIB with double rail was recently crash tested by TTI for MASH
- RC-54M has been updated with new details and will be included in upcoming Change #4 to RCs.
- We plan to keep the Single Rail Option as well based on engineering opinion provided by TTI

High Tension Cable Barriers

- MASH compliance is required for projects let after Dec 31, 2019
- Currently there are no 2016 MASH tested cable barriers.
- DM-2, Chapter 12 is currently being updated with additional guidance on: posts, spacing, deflection, cable splices, lateral placements, end anchor placement, placement on horizontal and vertical curves
- DM-2 will be updated again when MASH cable rails become available.

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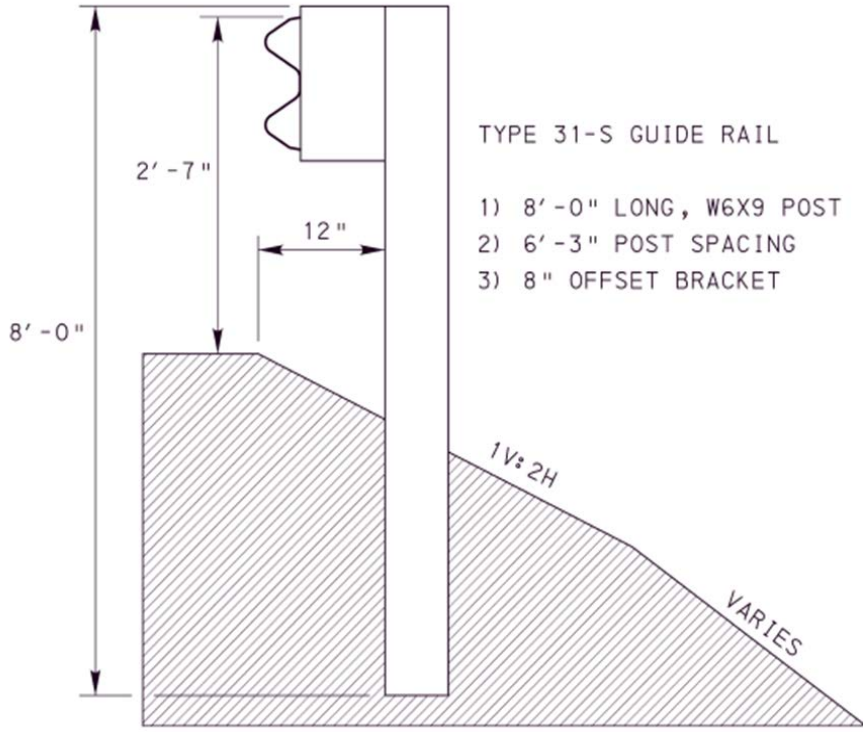
Example of Changes to DM-2

- It is clarified that 2’ soil back-up is needed behind weak posts due to lack of crash tests to support otherwise

- Provides updated guidance for when extra length strong posts are required, i.e. 6’ posts can be used where only 1’ back-up is present. (This is supported with crash tests)



An exception is shown in the figure where 8’ Post is used I’ away from slope breakpoint

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Looking Forward to 12/2019 – Other Hardware

Temporary concrete barriers

- Temporary barriers manufactured after 12/31/2019 must comply with 2016 MASH. Barriers manufactured before that date, and successfully crash tested to NCHRP 350 or MASH 2009, may continue to be used throughout their normal service lives*

- We are currently surveying neighboring States to learn about their plans?

- We may establishing a “sunset” date for pre-2020 temporary barriers.

- We are also considering requiring use of a stamp, sticker, or decal to identify when a barrier was manufactured

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New Policy Initiatives to Upgrade/Maintain Safety Devices

- Policy on systematic upgrading end treatments and guiderail
- Policy on repair, maintenance, and installation of guiderail and end treatments (for maintenance work and on demand contracts)
- Policy on Training Requirements for Department inspection personnel and installers
- Policy on documenting non-standard installation

Statewide Plan
Systematically Upgrade Guide Rail and End Treatments
3 Parts/Pieces

- Programmed Project Upgrades
  - Upgrades as part of planned/programmed projects.
- Systematic Upgrades
  - New projects to upgrade guide rail and end treatments to “acceptable” standards. Upgrade will be prioritized by network.
- Interstate End Treatments
  - Replacement of end treatments on the Interstate System to current standards over the next three years.

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Acceptable and Current Standards in Policy

“Acceptable” Standard = Generally roadside safety hardware meeting NCHRP 350

- NCHRP 350 End Treatments
- NCHRP 350 guiderail
- NCHRP 350 Weak Post Guide Rail with mid-span splice locations
- NCHRP 350 high tension cable
- Not damaged
- Type 2S Guide Rail not less than 26.5” height (exception)

Current Standards = MASH 2016 (per implementation dates)

How Do We Know Strong Post Guide Rail is Pre-NCHRP 350?

OLDEST

NEWEST

Item	Post Spacing	Installed Height (to top of W-beam)	Splices	Offset Brackets?	Steel Backup Plates?*	Rectangular Washers Behind Bolt Heads?
Pre-Modern	12'-6"	?	At Post	No	No	No
Pre-NCHRP 230	6'-3" Steel or wood	33"	At Post	Steel	No	Yes
NCHRP 230	6'-3" Steel or wood	27"	At Post	Steel	Yes	No
NCHRP 350	6'-3" Steel or wood	27 3/4"	At Post	Wood, Plastic, Composite	No	No
MASH 2016	6'-3" Steel or wood	31"	Mid-Span	Wood, Plastic, Composite	No	No

Not "Acceptable" Standard

Acceptable Standard

*At non-splice post locations

PROGRAMMED PROJECT UPGRADES

New construction/reconstruction: Upgrade to current standards

3R and structural overlays

I/freeways/expressway: Upgrade to current standards

NHS & other Routes: Upgrade to acceptable standards

Pavement preservation projects

I/freeways/all NHS routes: Upgrade to acceptable standards

All other routes: Upgrade to acceptable standards if placing >1” of overlay

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Systematically Upgrade Guide Rail and End Treatments

END TREATMENTS ON INTERSTATE SYSTEM

- Systematically upgrade/replace to current standards (MASH 2016) over the next three years, beginning in 2019. (about $100 million)

NEW PROJECTS TO SYSTEMATICALLY UPGRADE

- Systematically upgrade guide rail and end treatments to "acceptable standards" through new projects.
  - Prioritize by network
    - Interstates
    - National Highway System (NHS)
    - Other roadways with > 2000 ADT
    - Other roadways with < 2000 ADT
  - Estimated to cost approximately $600-700 Million. To be spread out over 12 to 15 years.

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Draft Policy for Repair, Replacement, and Maintenance

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Draft Contract Provisions
for
Guide Rail Repair,
Repalcement, and
Maintenance On-Demand
Contracts

7/24/2018

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(Guiderail/End Treatments/Impact Attenuators/Cable Median Barrier)

Policy

On

Repair (Damaged), Replacement, and Maintenance

July 1, 2018

Draft Policy for Repair, Replacement, and Maintenance

- Major objective: Improve the timeliness of repair, replacement, and maintenance of guiderail and end treatments and enhance consistency

- Replace guide rail or Cable barrier in kind if it is a spot damage, damage involves short section such as <than 200’ or less than 40% of a short section, and it meets acceptable standards. Otherwise replace with current standards. Applies to both guiderail and terminals.

- Each District to have one point of contact for on demand contracts.

- Establishes 4 categories of damage: emergency, high, medium, low

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Draft Policy for Repair, Replacement, and Maintenance

- Establishes repair time for each category. Establishes liquidated damages for failure to complete on time, based on amounts paid by commonwealth as a result of law suites.
- Establishes guidelines for improved safety inspection process.
- Improved asset management/inventory processes to improve maintenance and keep it in good state of repair
- Enhanced Inventory Process
  - New application being developed
  - Work on iPads, laptops, and desktops
  - Includes workflow for updating RMS

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Draft Policy - Proposed Training Requirements

- Recognizing that safety devices will perform effectively only if these are designed, installed and maintained properly, we are considering training requirements for Installers and Department Inspectors.

- Training will cover both 1) generic devices and 2) proprietary products Manufacturers will be required to provide training on their proprietary products.

- Department will provide training on generic products. Installers can participate in training provided by the Department or obtain training from ATSSA.

- Draft special provisions will require that a foreman or crew chief will provide a training certificate before installing any device at each location

- We have been coordinating with ATSSA and manufacturers

Policy onDocumentation for Non-Standard Condition

- District: County: Project ECMS:

Project Type

- Reconstruction; 3R; Pavement Preservation; Other:
- ADT: Main Road: Side Road (if applicable):
  :

What is the hazard? _____

- Can hazard be? ☐ Removed ☐Relocated ☐Neither [document reason below]

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Reasons & Justifications for Non-Standard Design

- Topography [steep slopes, no soil support available behind guiderail, etc.]
- Limited ROW [can ROW be acquired? If not, document reasons]
- Drive ways/secondary roads intersecting a main road too close to a bridge or other hazard that a full run of barrier cannot be installed.
- Presence of utilities and/or structures or other reasons
- Alternatives considered/selected, including mitigation and justification [check list and examples]

Questions?

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