

DelDOT MASH Compliance and Updates to the DelDOT Bridge Rails

Mike Nauman, P.E

Objectives of This Training

At the end of this training you will be able to:

- Understand what MASH compliance means.
- Understand the role of the FHWA, AASHTO and the user agency (i.e. DelDOT) in implementing MASH.
- Identify DelDOT standard bridge rail and their appropriate application.
- Understand stiffness transitions and the new DelDOT stiffness transition.



Engineering Code of Ethics

1. **THE ENGINEER SHALL HOLD PARAMOUNT SAFEGUARDING LIFE, HEALTH AND PROPERTY AND PROMOTING THE PUBLIC WELFARE IN THE PERFORMANCE OF HIS PROFESSIONAL DUTIES.**

Roadside Safety Statistic

- In 2016, there were 1,088 fatalities where the most harmful event was either a barrier or barrier end.
- This accounts for 5.6% of the roadway departure fatalities.



BCT Terminal





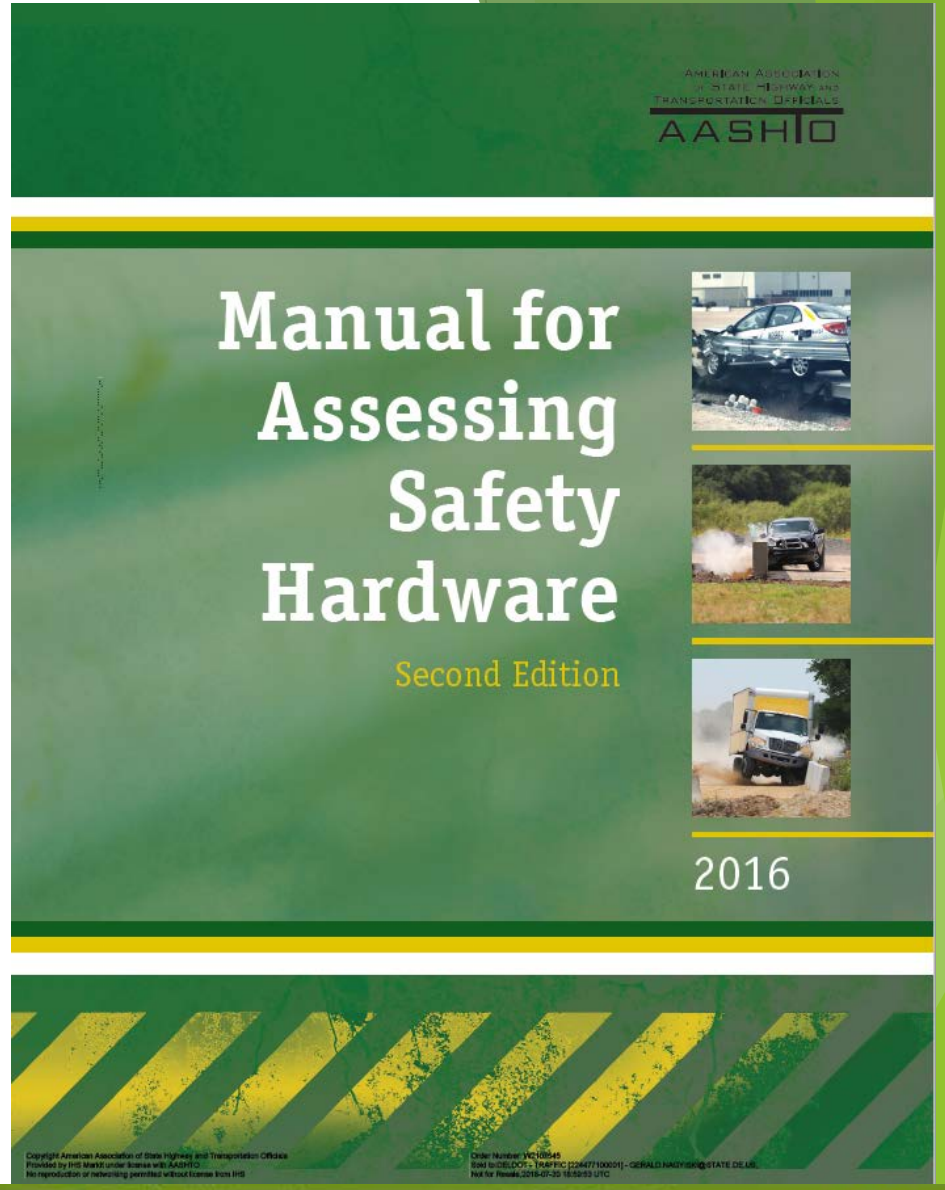


What is MASH?

MASH is the AASHTO Manual for Assessing Safety Hardware.

What is the Purpose of MASH?

"The Purpose of this manual is to present uniform guidelines for the crash testing of both permanent and temporary highway safety features and recommended evaluation criteria to assess test results".





Why is MASH Compliance Important?

- FHWA/ AASHTO signed a joint implementation agreement regarding MASH implementation.

- For contracts on the National Highway System with a letting date after the dates below, only safety hardware evaluated using the 2016 edition of MASH criteria will be allowed for new permanent installations and full replacements:
  - December 31, 2017: w-beam barriers and cast-in-place concrete barriers
  - June 30, 2018: w-beam terminals
  - December 31, 2018: cable barriers, cable barrier terminals, and crash cushions
  - December 31, 2019: bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently), all other terminals, sign supports, and all other breakaway hardware

- Temporary work zone devices, including portable barriers, manufactured after December 31, 2019, must have been successfully tested to the 2016 edition of MASH. Such devices manufactured on or before this date, and successfully tested to NCHRP Report 350 or the 2009 edition of MASH, may continue to be used throughout their normal service lives.

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **INFORMATION:** AASHTO/FHWA Joint Implementation Agreement for Manual for Assessing Safety Hardware (MASH)

Date: JAN – 7 2016

From: Thomas Everett
Director, Office of Program Administration

In Reply Refer To: HSST

Michael S. Griffith
Director, Office of Safety Technologies

To: Division Administrators
Directors of Field Services
Federal Lands Highway Division Directors

Purpose

The purpose of this memorandum is to share information regarding the American Association of State Highway and Transportation Officials (AASHTO)/FHWA Joint Implementation Agreement for the AASHTO Manual for Assessing Safety Hardware (MASH). Recently, the agreement was successfully balloted by AASHTO's Standing Committee on Highways and approved by FHWA.

Information

On November 12th, 2015, FHWA issued a memorandum (http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/policy_memo/memo111215/) indicating that all modifications to NCHRP 350-tested devices will require testing under MASH in order to receive a Federal-aid eligibility letter from FHWA. In addition, a Federal Register Notice (https://www.federalregister.gov/articles/2015/11/13/2015-28753/manual-for-assessing-safety-hardware-mash-transition) was also issued regarding this action. This action provided a significant step forward to the implementation of MASH.

Through the AASHTO/FHWA partnership, the agreement was executed to define actions needed for full implementation of MASH over the course of several years. Per the agreement, the implementation of the forthcoming edition (anticipated Spring 2016) of the AASHTO Manual for Assessing Safety Hardware (MASH) will be as follows:

- The AASHTO Technical Committee on Roadside Safety will continue to be responsible for developing and maintaining the evaluation criteria as adopted by



Who Determines MASH Compliance?

- MASH Compliance is determined by the User Agency.
- Excerpts from an April 9, 2018 FHWA memo to Division Administrators, Federal Lands Division Engineers and Directors of Field Services:
  - The FHWA's longstanding policy is that all roadside safety hardware installed on the NHS be crashworthy.
  - Roadside safety hardware is eligible for Federal funding if it has been determined to be crashworthy by the user agency (i.e. State DOT).
  - It is each State's responsibility to determine crashworthiness and to approve new or modified roadside safety hardware meeting the State's specific needs.
  - The determination of crashworthiness of roadside safety hardware, acceptance for use on highway projects, and installation and maintenance are responsibilities handled at the State and local level.

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **ACTION:** Evaluating a State DOT's Process to Determine Roadside Safety Hardware Crashworthiness on the National Highway System (NHS)

Date: April 9, 2018

From: Michael S. Griffith
Director, Office of Safety Technologies

In Reply Refer To: HSA

To: Division Administrators
Federal Lands Division Engineers
Directors of Field Services

PURPOSE

The purpose of this memorandum is to provide guidance to the FHWA Division Offices to assist in their evaluation that a State DOT has an acceptable process for determining the crashworthiness of roadside safety hardware used on the National Highway System (NHS).

BACKGROUND

The FHWA's longstanding policy is that all roadside safety hardware installed on the NHS be crashworthy. To support this policy, the joint implementation agreement for the American Association of State Highway Transportation Officials (AASHTO) Manual for Assessing Safety Hardware (MASH) was adopted by AASHTO and FHWA. This agreement established dates for implementing AASHTO MASH as the criteria for determining crashworthiness of roadside safety hardware.

The FHWA continues to provide a voluntary service of reviewing crash test results and issues eligibility letters for *new* roadside safety hardware only. The FHWA no longer provides Federal-aid eligibility letters for modifications made to an AASHTO MASH-crash tested device. An eligibility letter is not a requirement for roadside safety hardware to be determined eligible for Federal funding. Roadside safety hardware is eligible for Federal funding if it has been determined to be crashworthy by the user agency (i.e., State DOT).

An FHWA eligibility letter should not be the sole basis for a State's determination of crashworthiness. It is each State's responsibility to determine crashworthiness and to approve new or modified roadside safety hardware meeting the State's specific needs. Each State should consider its own operational issues such as installation and



What Does MASH Compliance Mean?

- MASH establishes the applicable safety evaluation criteria for various roadside applications:
  - Longitudinal barriers;
  - Terminals and crash cushions;
  - Truck and trailer mounted attenuators and variable message boards and arrow board trailers; and
  - Support structures, work zone traffic control devices, breakaway utility poles and longitudinal channelizers.
- MASH categorizes 6 different Test Levels based on impact speed and design vehicle.
- MASH breaks the evaluation criteria into three different factors:
  - Structural adequacy;
  - Occupant risk; and
  - Post-impact vehicular response.



Test Level Selection:



2,420 lb small car



5,000 lb pickup truck

TL-1 to TL-3



TL-4 22,000 lb box truck



TL-5 80,000 lb Tractor-Van Trailer



TL-6 80,000 lb Tractor-Tank Trailer

TL-4 to TL-6



Test Level	MASH Test No.	Test Vehicle	Impact Speed (mph)	Impact Angle (degrees)	Acceptable Impact Severity (kip-ft)
1	1-10	Passenger Car 2420-lb	31	25	≥13
	1-11	Pickup Truck 5000-lb	31	25	≥27
2	2-10	Passenger Car 2420-lb	44	25	≥25
	2-11	Pickup Truck 5000-lb	44	25	≥52
3	3-10	Passenger Car 2420-lb	62	25	≥51
	3-11	Pickup Truck 5000-lb	62	25	≥106
4	4-10	Passenger Car 2420-lb	62	25	≥51
	4-11	Pickup Truck 5000-lb	62	25	≥106
	4-12	Single-Unit Truck 22,000-lb	56	15	≥142
5	5-10	Passenger Car 2420-lb	62	25	≥51
	5-11	Pickup Truck 5000-lb	62	25	≥106
	5-12	Tractor-Van Trailer 79,300-lb	50	15	≥404
6	6-10	Passenger Car 2420-lb	62	25	≥51
	6-11	Pickup Truck 5000-lb	62	25	≥106
	6-12	Tractor-Tank Trailer 79,300-lb	50	15	≥404



Test Level	Barrier Section[c]	Test No.	Vehic.	Impact Speed,[a] mph (km/h)	Impact Angle,[a] θ, deg.	Im-pact Point	Acceptable IS Range,[a] kip-ft (kJ)	Evaluation Criteria[b]
1	Length-of-Need	1-10 1-11	1100C 2270P	31 (50.0) 31 (50.0)	25 25	(c) (c)	≥13 (17.4) ≥27 (36.0)	A,D,F,H,I A,D,F,H,I
	Transition	1-20[d] 1-21	1100C 2270P	31 (50.0) 31 (50.0)	25 25	(c) (c)	≥13 (17.4) ≥27 (36.0)	A,D,F,H,I A,D,F,H,I
2	Length-of-Need	2-10 2-11	1100C 2270P	44 (70.0) 44 (70.0)	25 25	(c) (c)	≥25 (34.2) ≥52 (70.5)	A,D,F,H,I A,D,F,H,I
	Transition	2-20[d] 2-21	1100C 2270P	44 (70.0) 44 (70.0)	25 25	(c) (c)	≥25 (34.2) ≥52 (70.5)	A,D,F,H,I A,D,F,H,I
3	Length-of-Need	3-10 3-11	1100C 2270P	62 (100.0) 62 (100.0)	25 25	(c) (c)	≥51 (69.7) ≥106 (144)	A,D,F,H,I A,D,F,H,I
	Transition	3-20[d] 3-21	1100C 2270P	62 (100.0) 62 (100.0)	25 25	(c) (c)	≥51 (69.7) ≥106 (144)	A,D,F,H,I A,D,F,H,I
4	Length-of-Need	4-10 4-11 4-12	1100C 2270P 10000S	62 (100.0) 62 (100.0) 56 (90.0)	25 25 15	(c) (c) (c)	≥51 (69.7) ≥106 (144) ≥142 (193)	A,D,F,H,I A,D,F,H,I A,D,G
	Transition	4-20[d] 4-21 4-22	1100C 2270P 10000S	62 (100.0) 62 (100.0) 56 (90.0)	25 25 15	(c) (c) (c)	≥51 (69.7) ≥106 (144) ≥142 (193)	A,D,F,H,I A,D,F,H,I A,D,G
5	Length-of-Need	5-10 5-11 5-12	1100C 2270P 36000V	62 (100.0) 62 (100.0) 50 (80.0)	25 25 15	(c) (c) (c)	≥51 (69.7) ≥106 (144) ≥404 (548)	A,D,F,H,I A,D,F,H,I A,D,G
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6	Length-of-Need	6-10 6-11 6-12	1100C 2270P 36000T	62 (100.0) 62 (100.0) 50 (80.0)	25 25 15	(c) (c) (c)	≥51 (69.7) ≥106 (144) ≥404 (548)	A,D,F,H,I A,D,F,H,I A,D,G
	Transition	6-20[d] 6-21 6-22	1100C 2270P 36000T	62 (100.0) 62 (100.0) 50 (80.0)	25 25 15	(c) (c) (c)	≥51 (69.7) ≥106 (144) ≥404 (548)	A,D,F,H,I A,D,F,H,I A,D,G

Structural Adequacy	A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	10, 11, 12, 20, 21, 22, 30[a],31[a],32[a],33[a], 34[a], 35, 36, 37[a], 38[a]
	D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E.	All
	F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	All except those listed in Criterion G



<table>
<tr><td rowspan="4">Occupant Risk (see Section 5.2.2)</td><td colspan="3">G. It is preferable, although not essential, that the vehicle remain upright during and after collision.</td><td>12, 22</td></tr>
<tr><td colspan="3">H. Occupant impact velocities (OIV) (see Appendix A, Section A5.2.2 for calculation procedure) should satisfy the following limits:
<table><tr><th colspan="3">Occupant Impact Velocity Limits, ft/s (m/s)</th></tr><tr><th>Component</th><th>Preferred</th><th>Maximum</th></tr><tr><td>Longitudinal and Lateral</td><td>30 ft/s (9.1 m/s)</td><td>40 ft/s (12.2 m/s)</td></tr><tr><td>Longitudinal</td><td>10 ft/s (3.0 m/s)</td><td>16 ft/s (4.9 m/s)</td></tr></table></td><td></td></tr>
<tr><td>10, 11, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 50, 51, 52, 53, 80, 81, 82, 90, 91</td></tr>
<tr><td>60, 61, 62, 70, 71, 72</td></tr>
<tr><td colspan="3">I. The occupant ridedown acceleration (see Appendix A, Section A5.2.2 for calculation procedure) should satisfy the following limits:
<table><tr><th colspan="3">Occupant Ridedown Acceleration Limits (G)</th></tr><tr><th>Component</th><th>Preferred</th><th>Maximum</th></tr><tr><td>Longitudinal and Lateral</td><td>15.0 G</td><td>20.49 G</td></tr></table></td><td>10, 11, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 50, 51, 52, 53, 54, 60, 61, 62, 70, 71, 72, 80, 81, 90, 91</td></tr>
</table>



Evaluation Factors	Evaluation Criteria	Applicable Tests
Post-Impact Vehicular Response (see Section 5.2.3)	J. through M. Reserved.	
	N. Vehicle trajectory behind the test article is acceptable.	30[b], 31[b], 32[b], 33[b], 34[b], 37[b], 38[b], 40, 41, 42, 43, 44, 45, 60, 61, 70, 71, 72, 80, 81, 82, 90, 91



What is Different Under MASH?

- MASH updated test vehicles to reflect the 85th Percentile of the United States passenger vehicle fleet.



- Updated inconsistencies in previous test matrices. Reviewed run-off the road reconstruction information to test for real world crash conditions.
- Updated evaluation criteria to be inherently less subjective. See next slide.

TABLE 2-2A. Recommended Test Matrices for Longitudinal Barriers

Test Level	Barrier Section[c]	Test No.	Vehic.	Impact Speed,[a] mph (km/h)	Impact Angle,[a] θ, deg.	Im-pact Point	Acceptable IS Range,[a] kip-ft (kJ)	Evaluation Criteria[b]
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NCHRP Report 350

These criteria require that the test article not penetrate the occupant compartment and that there be no deformations of or intrusions into the occupant compartment that could cause a disabling injury. In the absence of an acceptable measure of such deformations or intrusions, it is essential that adequate documentation in the form of photographs of occupant compartment damage be made and reported. Photographs of the interior prior to the test should also be made to permit direct comparisons of before and after conditions. Until an acceptable methodology is developed, it is recommended that the procedure given in Appendix E be used to compute and document an Occupant Compartment Deformation Index (OCDI).

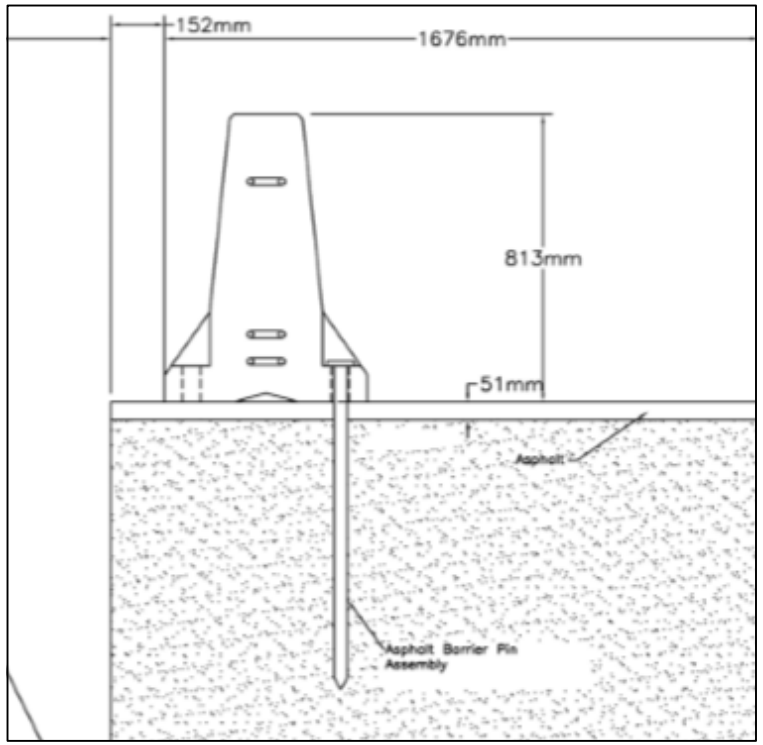
MASH

As for deformation or intrusion, the extent of deformation varies by area of the vehicle damaged and should be limited as follows:

- Roof ≤ 4.0 in.
- Windshield—no tear of plastic liner and maximum deformation of 3 in.
- Window—no shattering of a side window resulting from direct contact with a structural member of the test article, except for special considerations pertaining to tall, continuous barrier elements discussed below (Note: evaluation of this criteria requires the side windows to be in the up position for testing). In cases where side windows are laminated, the guidelines for windshields will apply.
- A- and B-pillars—no complete severing of support member and maximum resultant deformation of 5 in. Lateral deformation should be limited to 3 in.
- Wheel/foot well and toe pan areas ≤ 9 in.
- Side front panel (forward of A-pillar) ≤ 12 in.
- Front side door area (above seat) ≤ 9 in.
- Front side door area (below seat) ≤ 12 in.
- Floor pan and transmission tunnel areas ≤ 12 in.

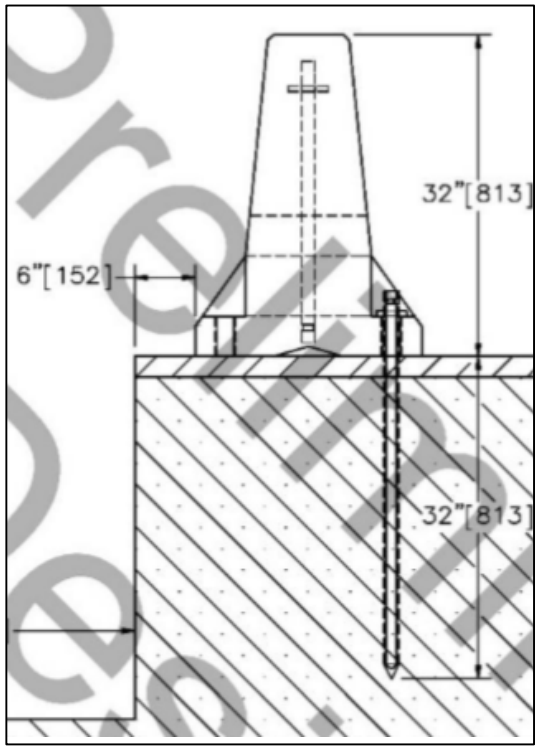


Case in Point: Pinned to Asphalt Barrier



NCHRP Report 350

Research Report 03-180-06



MASH

Research Report 03-386-19











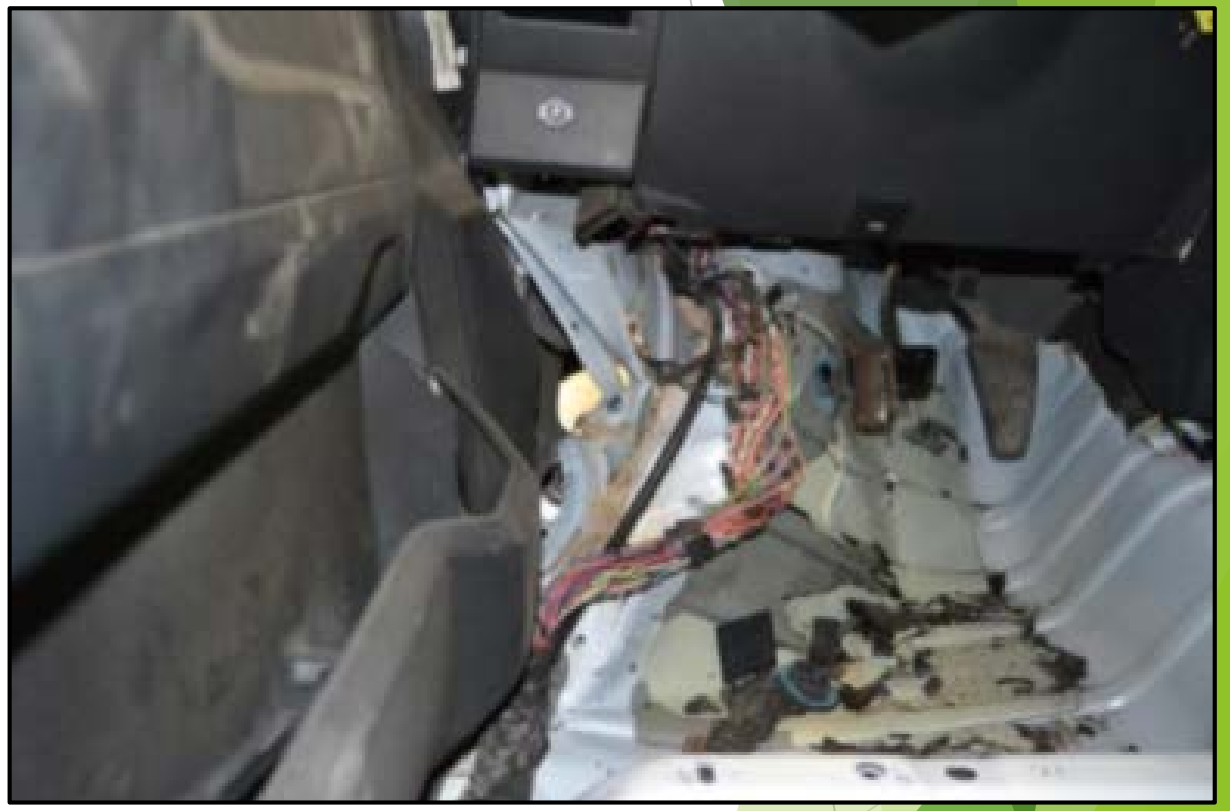




DelDOT

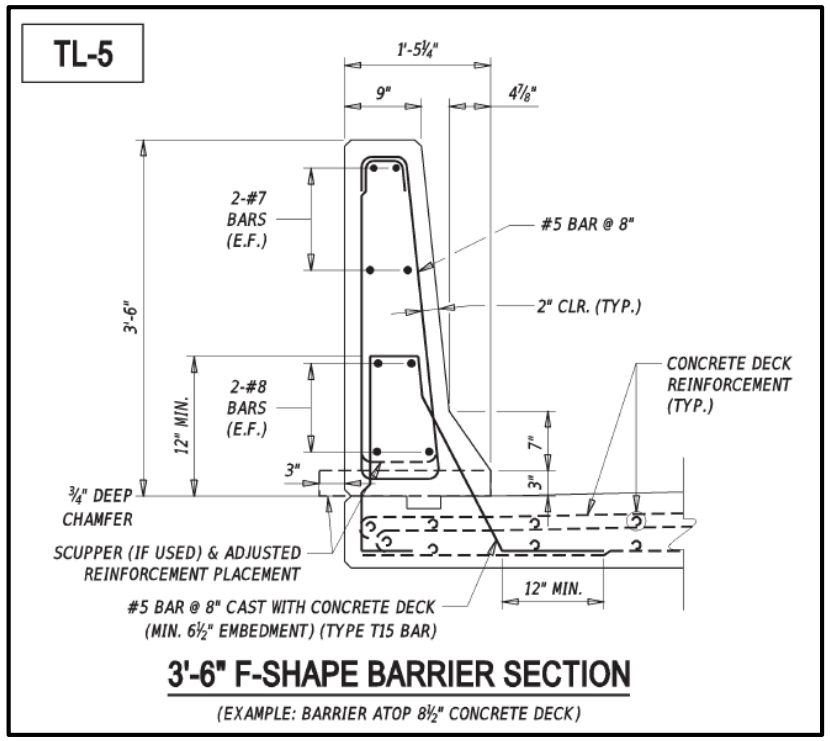
Case in Point: Pinned to Asphalt Barrier



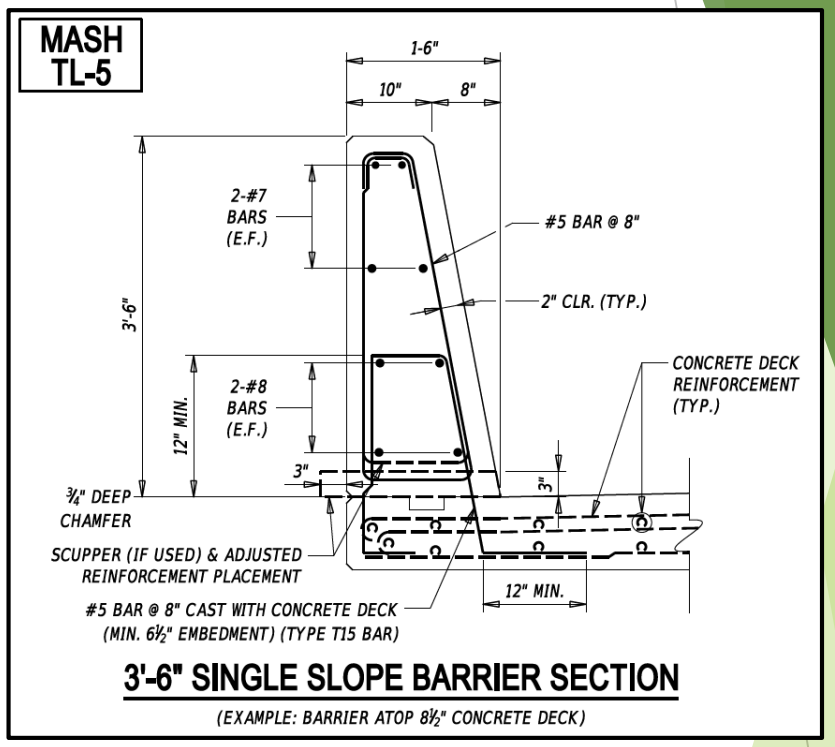




Changes to DelDOT Bridge Rails



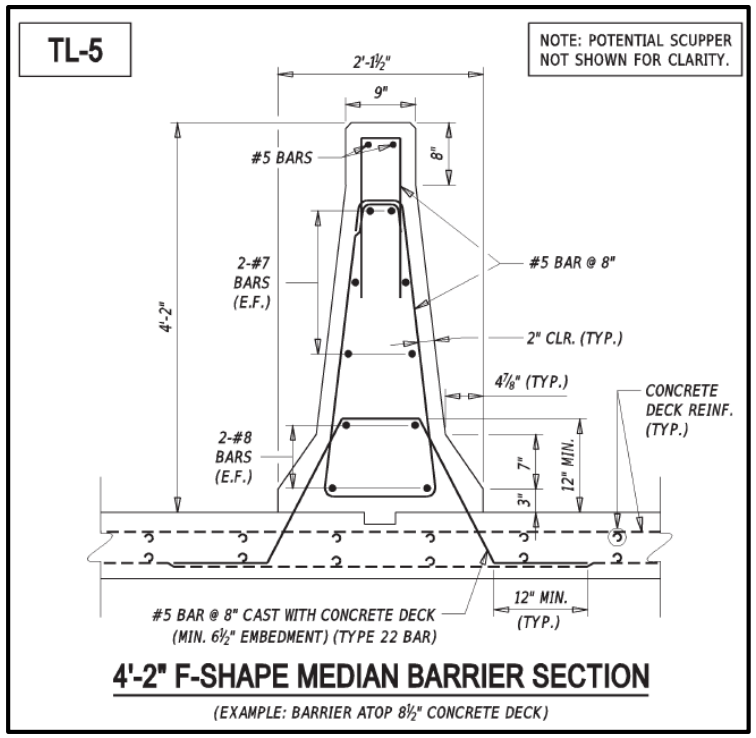
Old TL-5



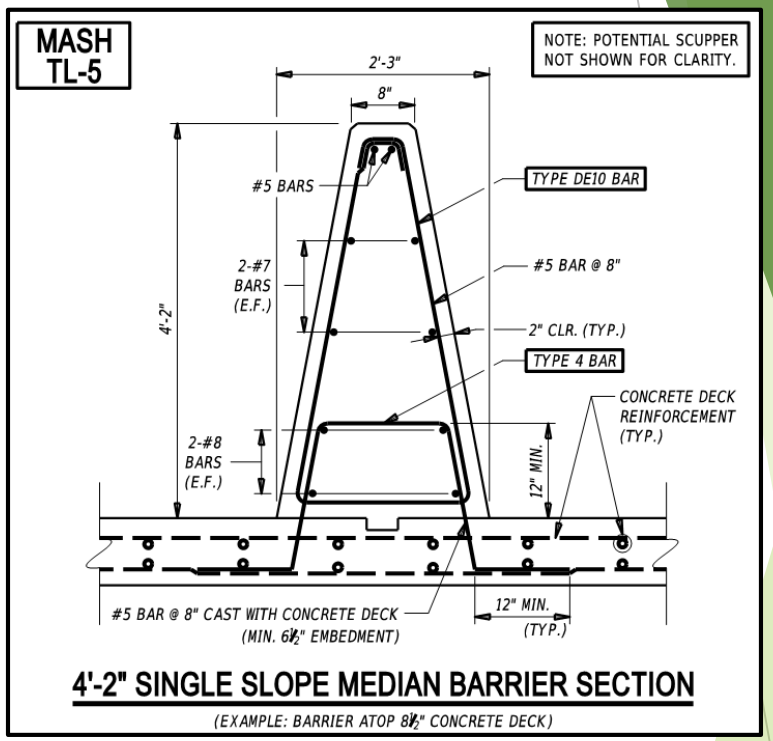
New TL-5



Changes to DelDOT Bridge Rails



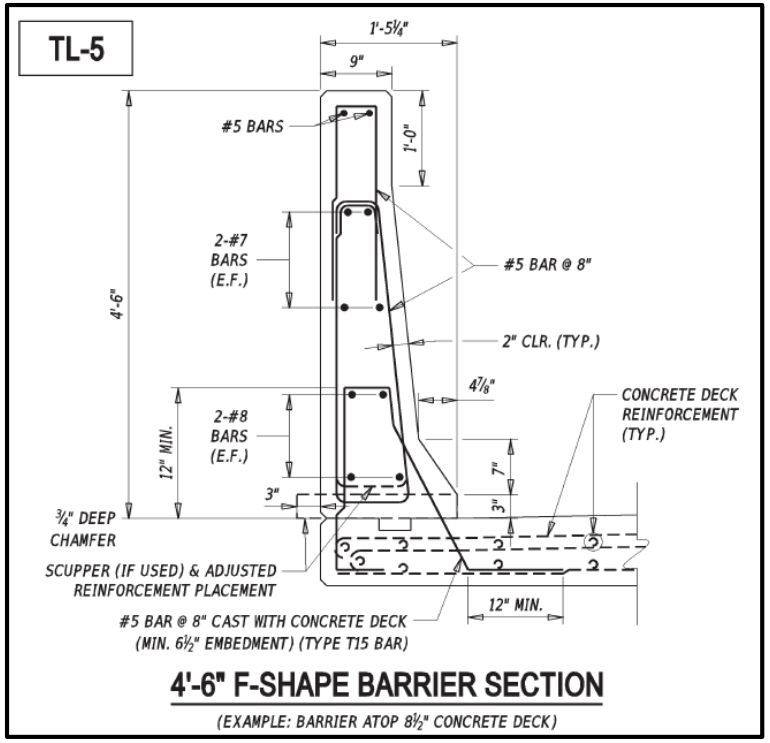
Old Median Barrier



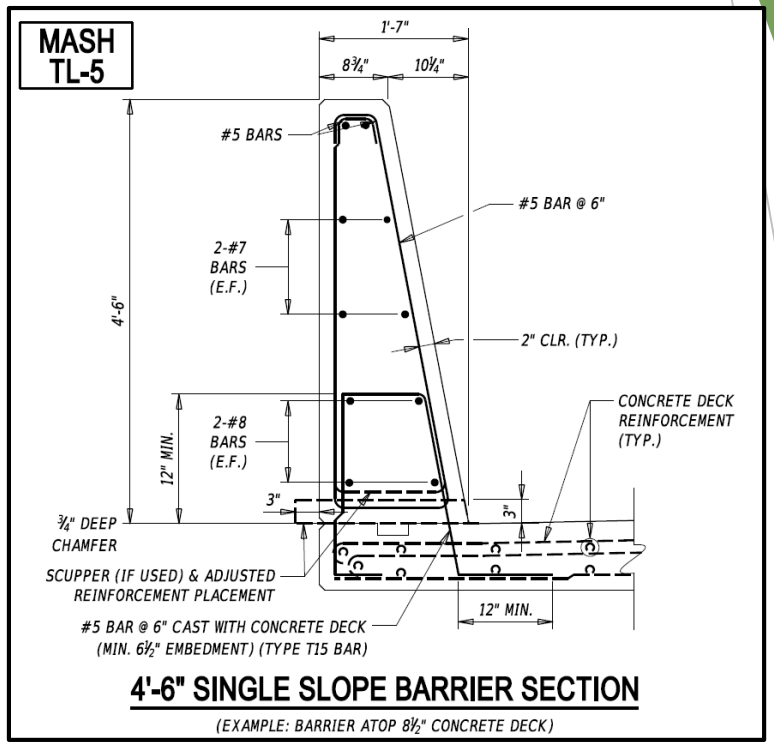
New Median Barrier



Changes to DelDOT Bridge Rails



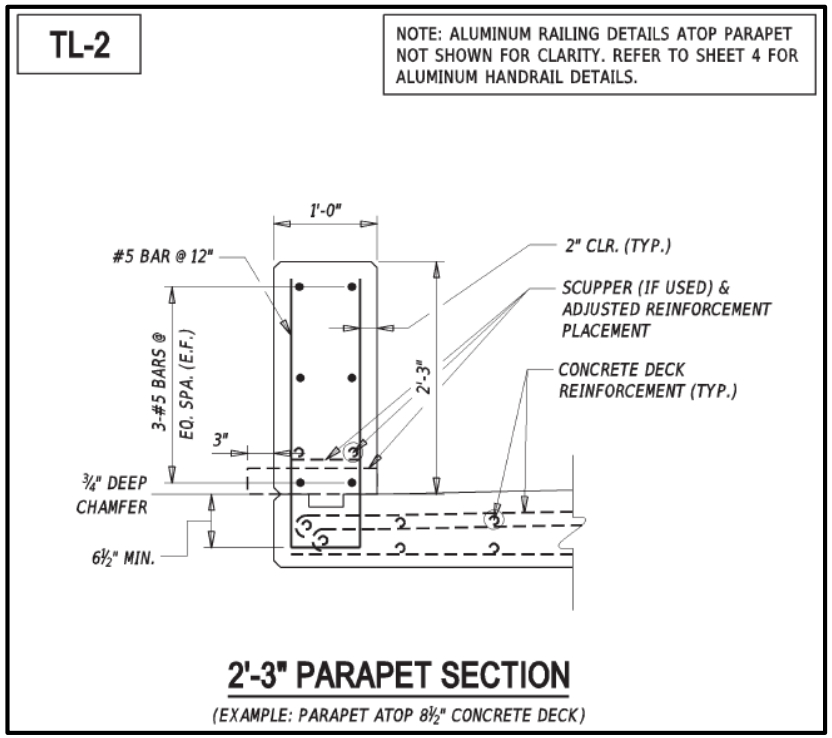
Old 54” Barrier



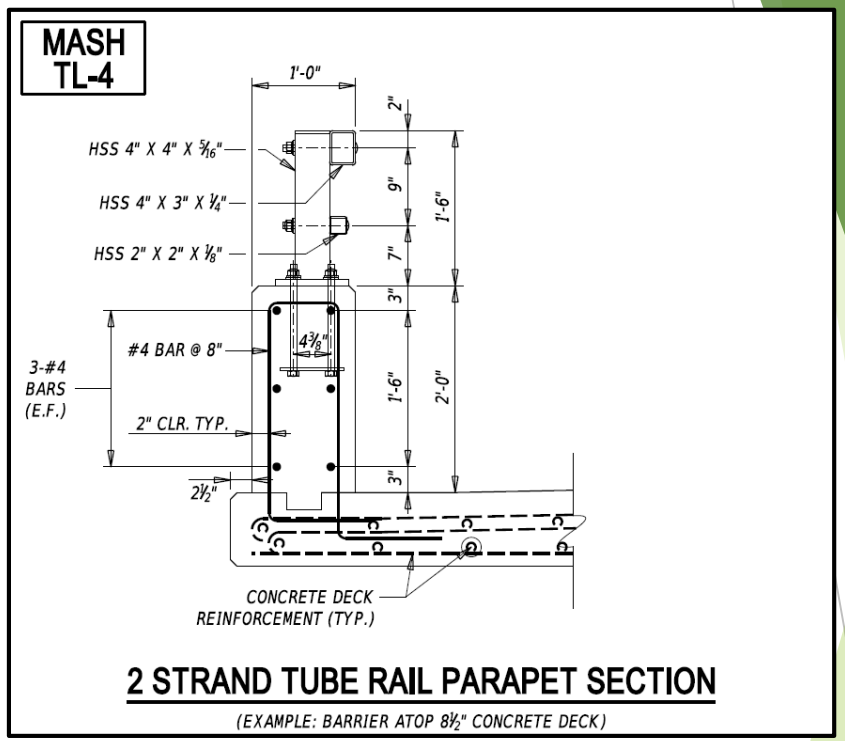
New 54” Barrier



Changes to DelDOT Bridge Rails



Old Pedestrian Rail Barrier



New Pedestrian Rail Barrier



NEW DelDOT Single Slope Detail

- Single Slope barriers have become popular nationwide in recent years.
- Two primary benefits:
  - The system is not affected by future pavement overlays and
  - Safety.
- An FHWA memo issued on May 17th, 2010 contained a Frequently Asked Questions Section with the following question: "Which concrete barrier shape should we use – Jersey Barrier, "F-Shape", Constant Slope, Single Slope or Vertical?"
- Answer:

In general, for high speed highways the single slope barrier is most appropriate to limit rollovers, since much of the fleet now has side airbags to absorb the impact to the occupants. The side impact airbags will improve the safety of the occupants. For lower speed roads, the F shape would be better for the majority of impacts it would be expected to handle.












DelDOT





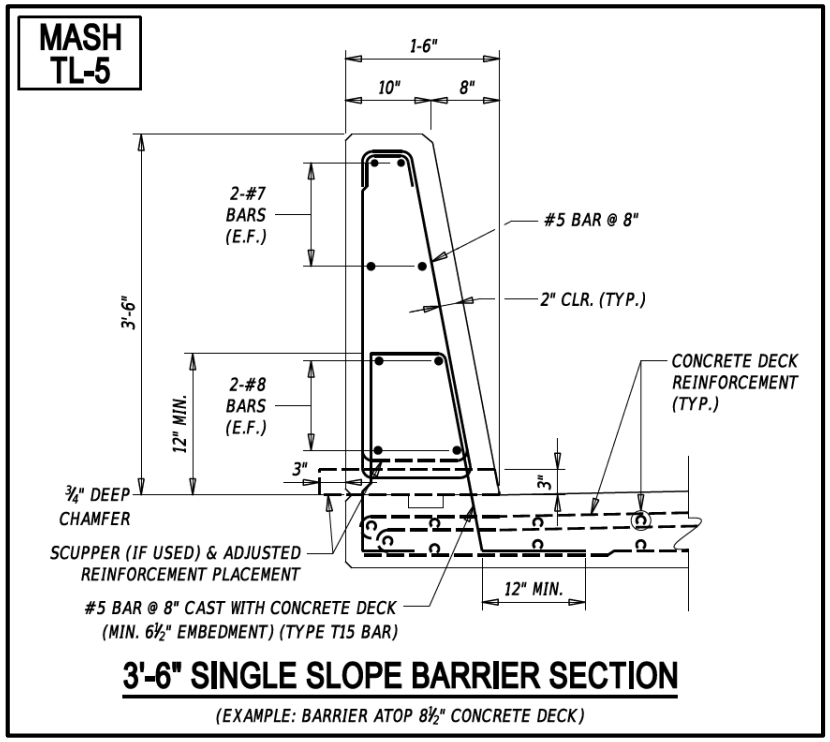






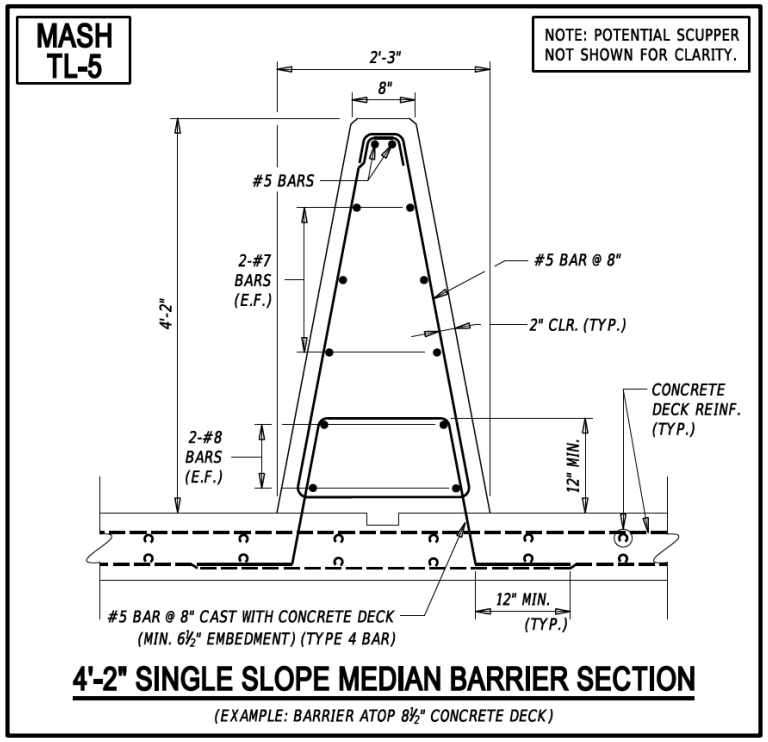


DelDOT



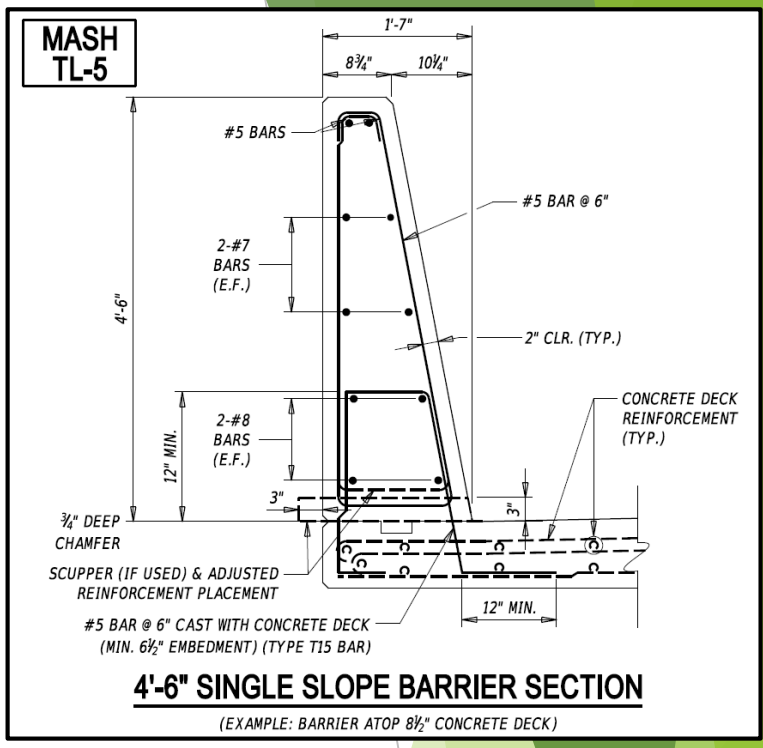
3'-6" SINGLE SLOPE BARRIER SECTION

(EXAMPLE: BARRIER ATOP 8½" CONCRETE DECK)



4'-2" SINGLE SLOPE MEDIAN BARRIER SECTION

(EXAMPLE: BARRIER ATOP 8½" CONCRETE DECK)



4'-6" SINGLE SLOPE BARRIER SECTION

(EXAMPLE: BARRIER ATOP 8½" CONCRETE DECK)

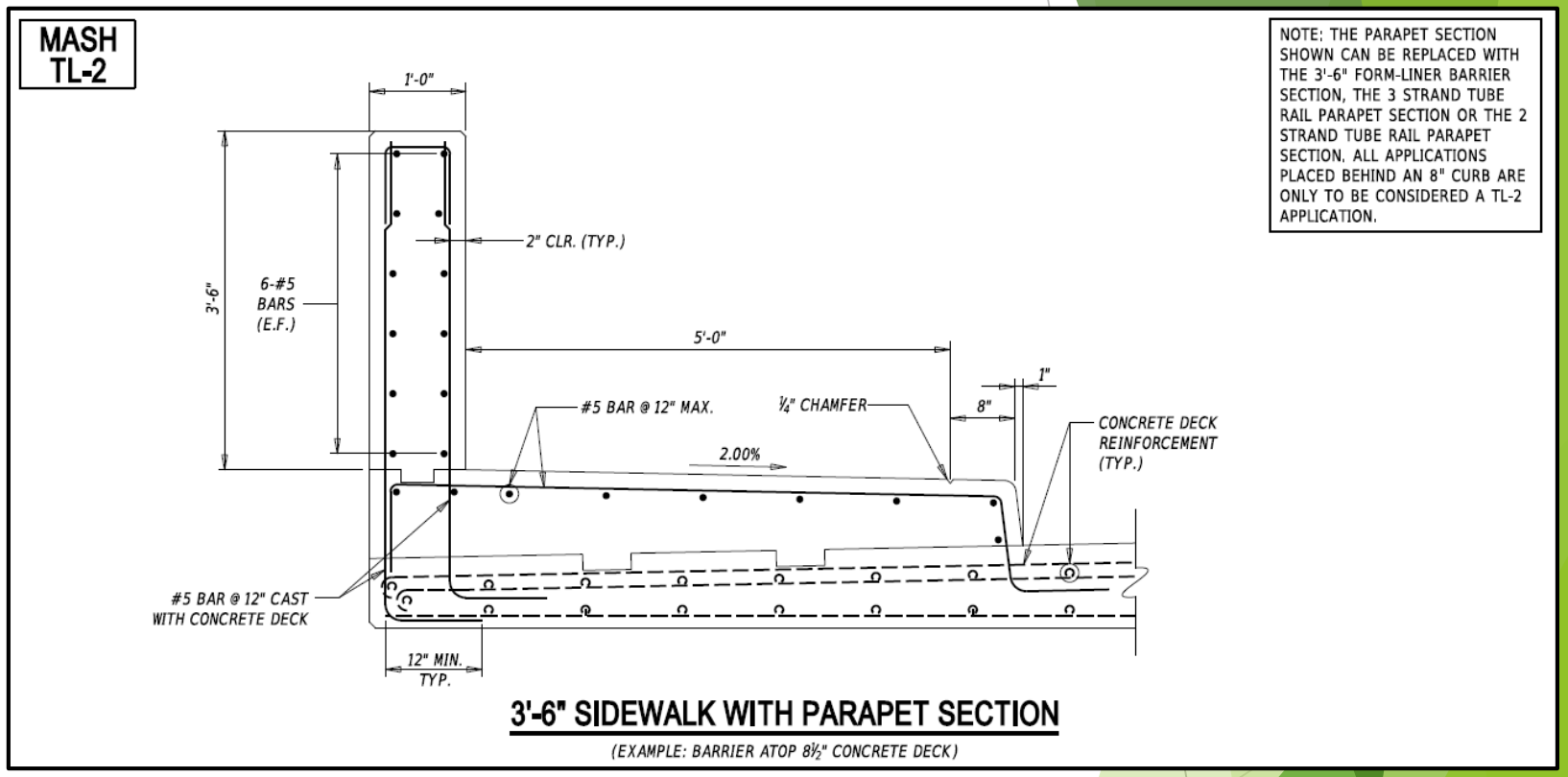
Single Slope Barrier - The 3 feet 6 inches single slope barrier is the preferred barrier for highway vehicular use on freeways and expressways and is considered a TL-5 application. The 4 feet 2 inches tall single slope median barrier is a TL-5 application and is to be used at median locations as a glare screen and where gap protection is not required. Similarly, the 4 feet 6 inches tall single slope barrier is a TL-5 application to be used adjacent to median gaps ranging from 6 inches to 12 feet wide. Refer to *Section 103.3.3 - Protection for Median Gap of Parallel Structures* for further description and background information regarding median gap protection.



New DelDOT Bridge Rails

- Caltrans crash-tested application.
- Vertical wall can be replaced.



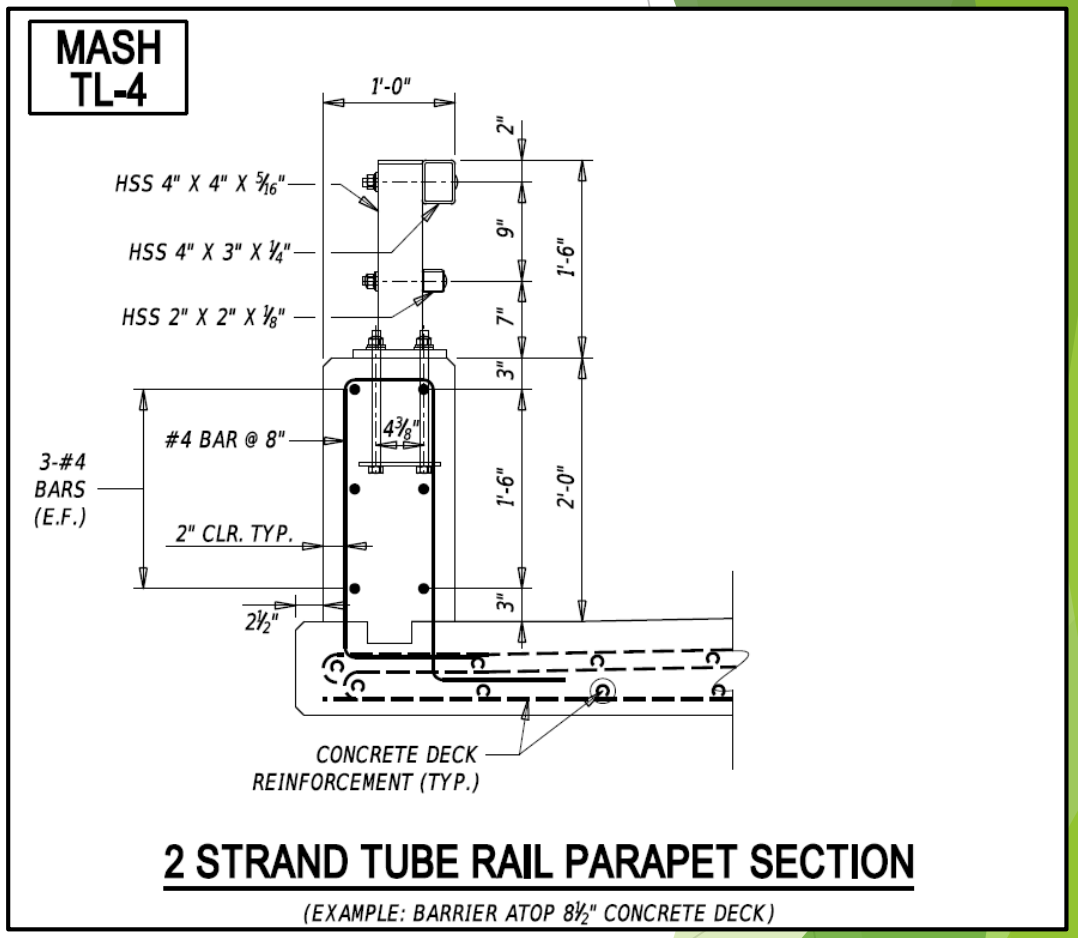





DelDOT

New DelDOT Bridge Rails (The Mike Gettings Rail)

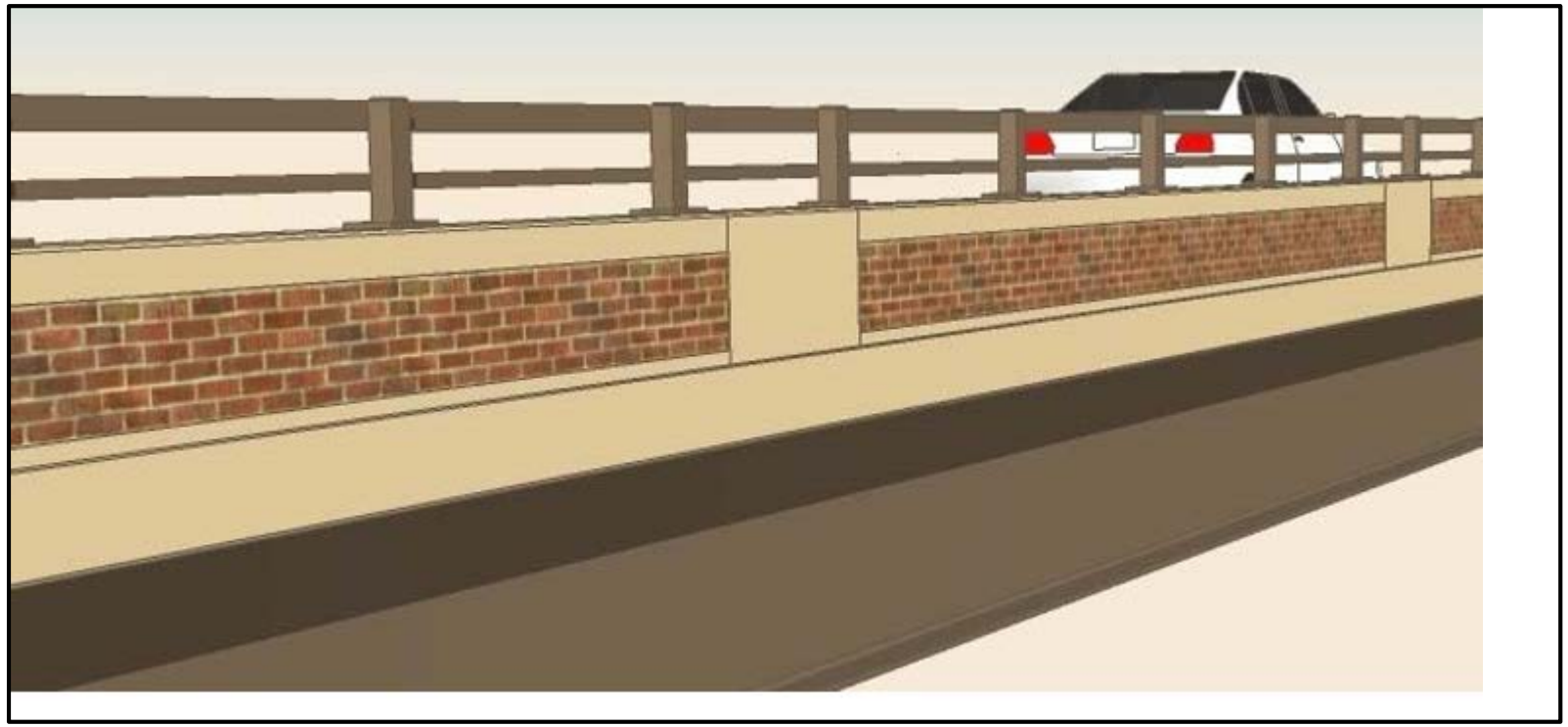




- TL-4 compliant,
- DelDOT Preferred Pedestrian Rail, and
- Can be placed behind Sidewalk (TL-2).



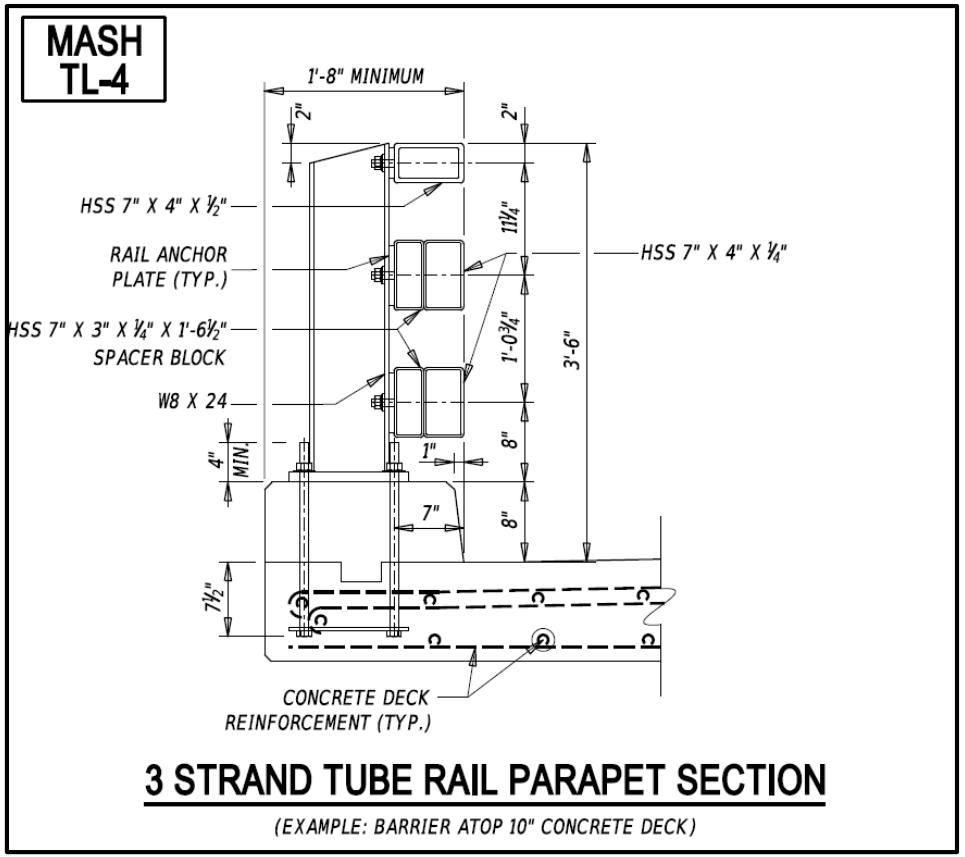
New DelDOT Bridge Rails (The Mike Gettings Rail)



- Two Strand Tube Rail Parapet – the 3 feet 6 inches Two Strand Tube Rail Parapet is the preferred outside railing for bridges with sidewalks or shared-user paths.



New DelDOT Bridge Rails (The Craig Stevens Rail)





- TL-4 compliant,
- Can be used with Accelerated Bridge Construction, and
- Can be placed behind Sidewalk (TL-2)



New DelDOT Bridge Rails (The Craig Stevens Rail)

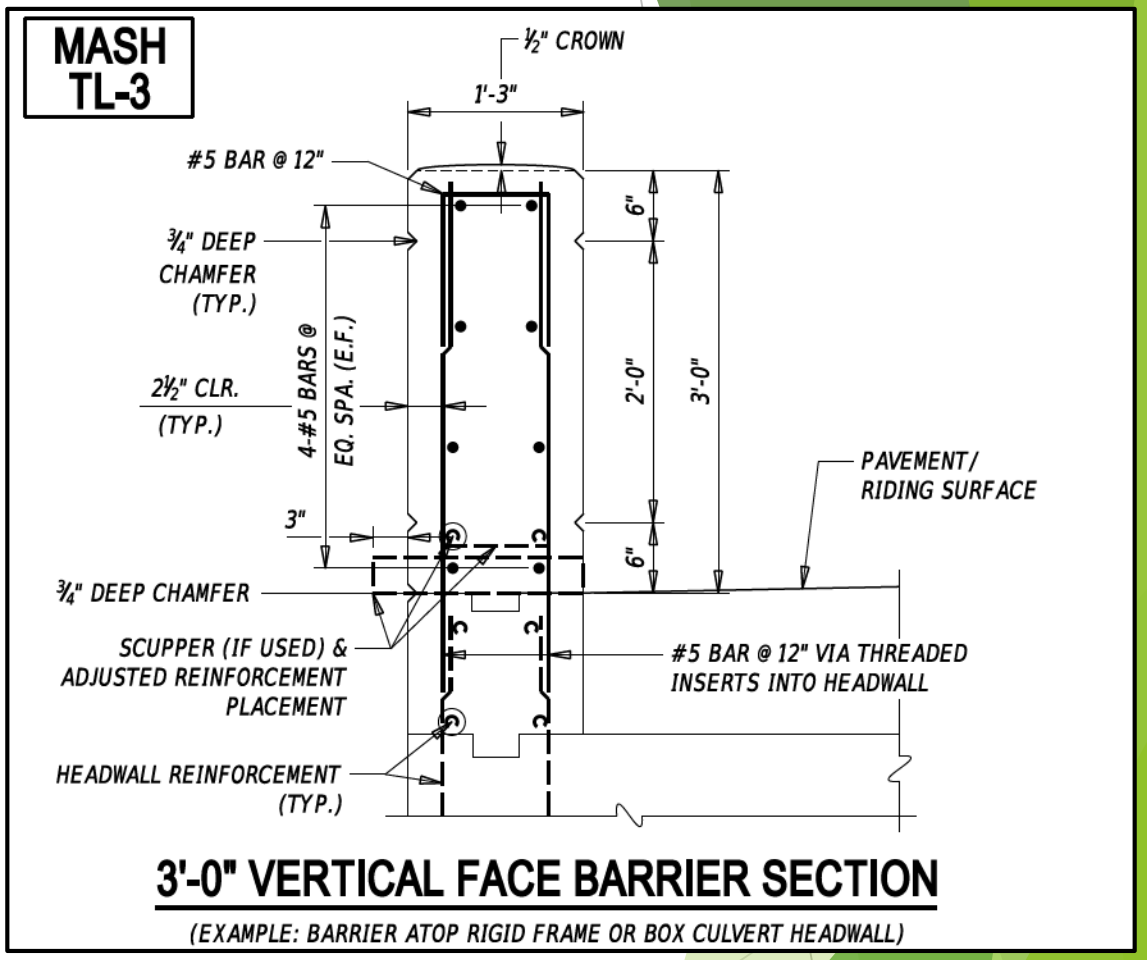


- Three Strand Tube Rail Parapet – The 3 feet 6 inches Three Strand Tube Rail Parapet are utilized on roadways where accelerated bridge techniques preclude the use of a concrete barrier. The bridge rail can also be used at locations where an open rail is desired for aesthetic purposes. The bridge rail is considered a TL-4 application.



DelDOT 36” Vertical Wall

- There have been several MASH crash tests of vertical walls.
- “The 3 feet tall vertical-faced barrier is the preferred bridge barrier for highway vehicular use requiring a minimum of TL-3 on local roads utilizing box culverts, rigid frames, and adjacent box beams.”






YEAR



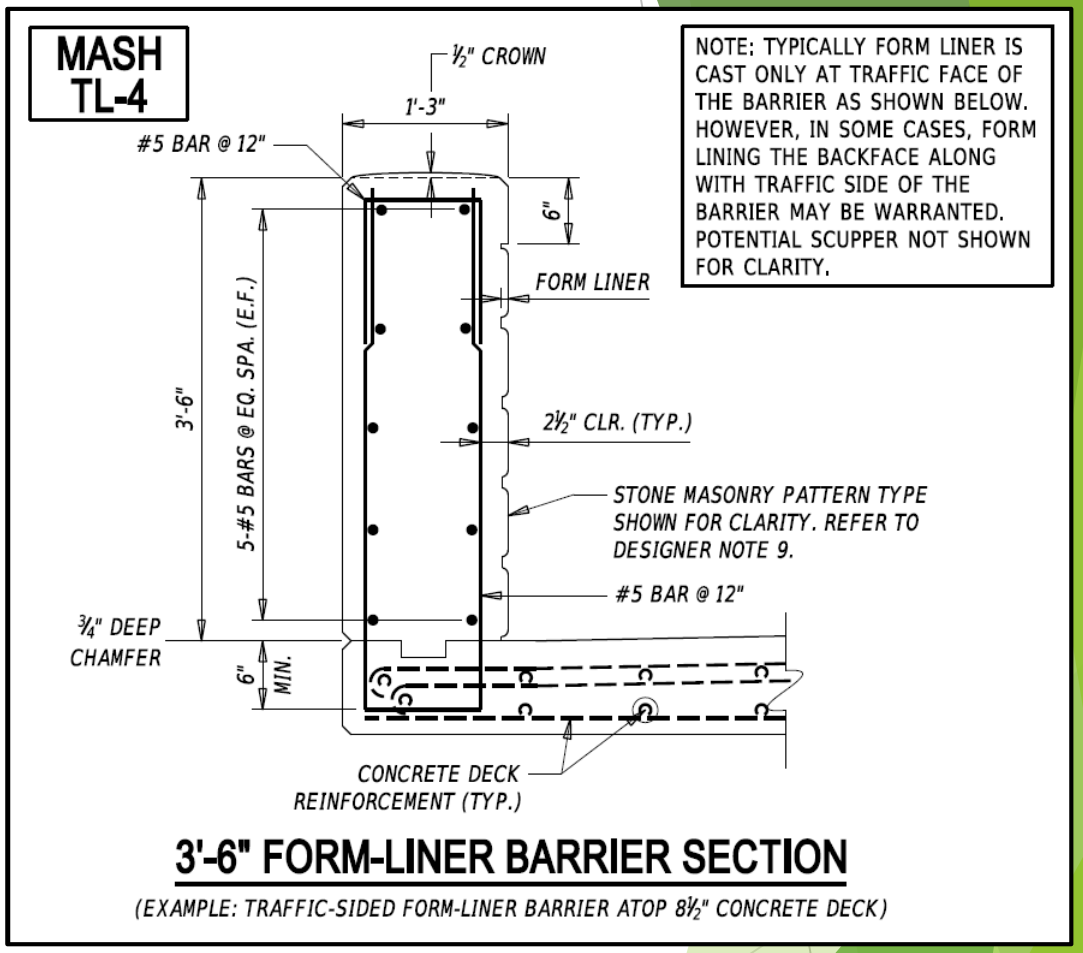




DelDOT

DelDOT 42” Vertical Wall

- There have been several MASH crash tests of vertical walls.
- “The 3 feet 6 inches tall vertical-faced barriers with form-liners may be used as a TL-4 application in lieu of F-shape barriers for aesthetics reasons.”







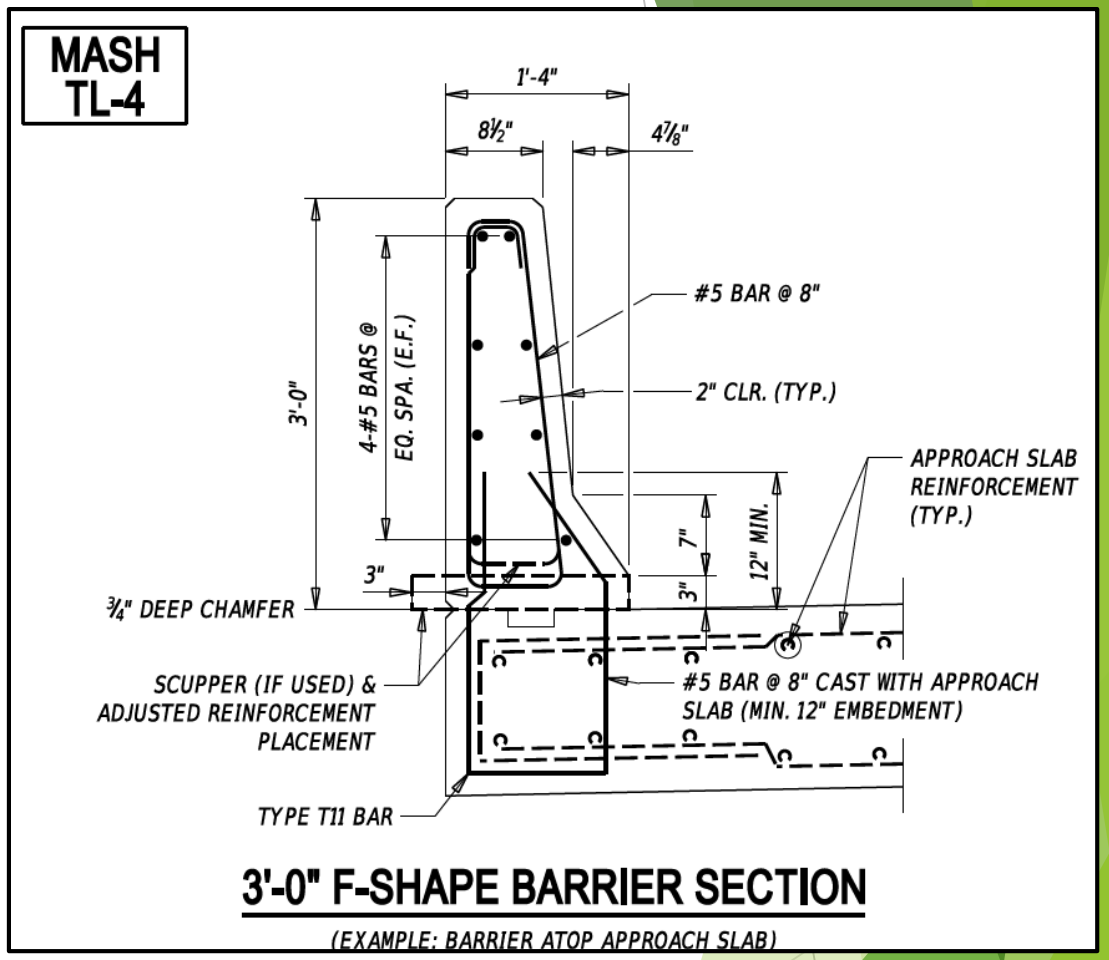






DelDOT 36” F-Shape

- The current generic F-Shape is considered NCHRP Report 350 compliant based upon a letter sent from the FHWA to its Regional Administrators and Federal Lands Highway Program Administrator on May 30th, 1997 which grandfathered in its use.
- “The 3 feet F-shape barrier is the preferred bridge barrier for highway vehicular use on arterial and collector roadways and is considered a TL-4 application.”

















DelDOT

Bridge Rail Ends

- Bridge rail ends present a roadside hazard.
- Must be treated in accordance with AASHTO's Order of Preference












DelDOT


DelDOT

Bridge Rail Ends

- Most common and effective way to make crashworthy is to connect to adjacent w-beam guardrail.
- Must gradually transition the stiffness between the two systems.
  - This prevents pocketing, snagging or penetration.









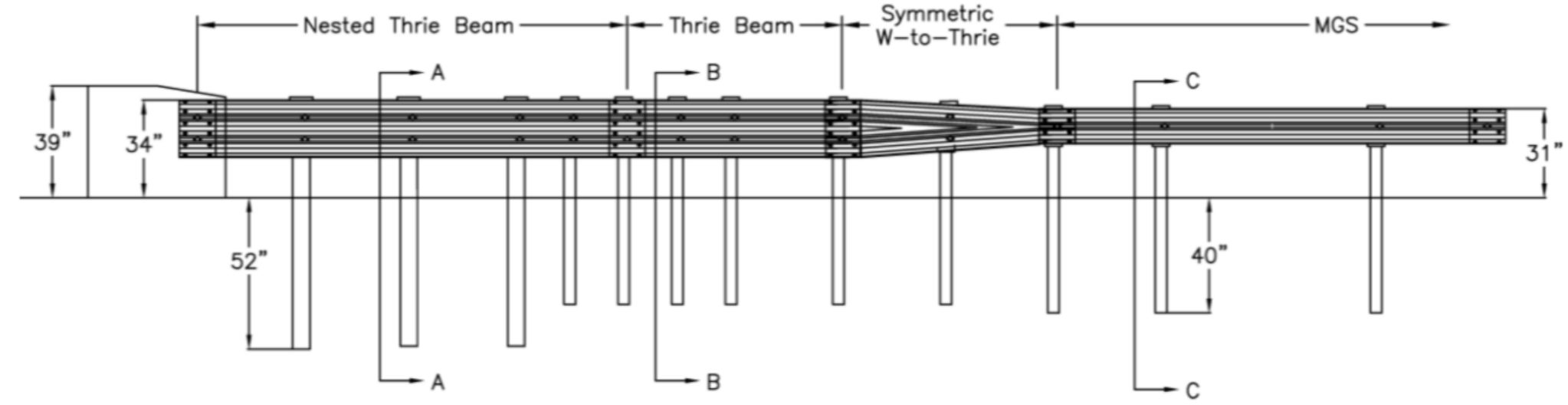


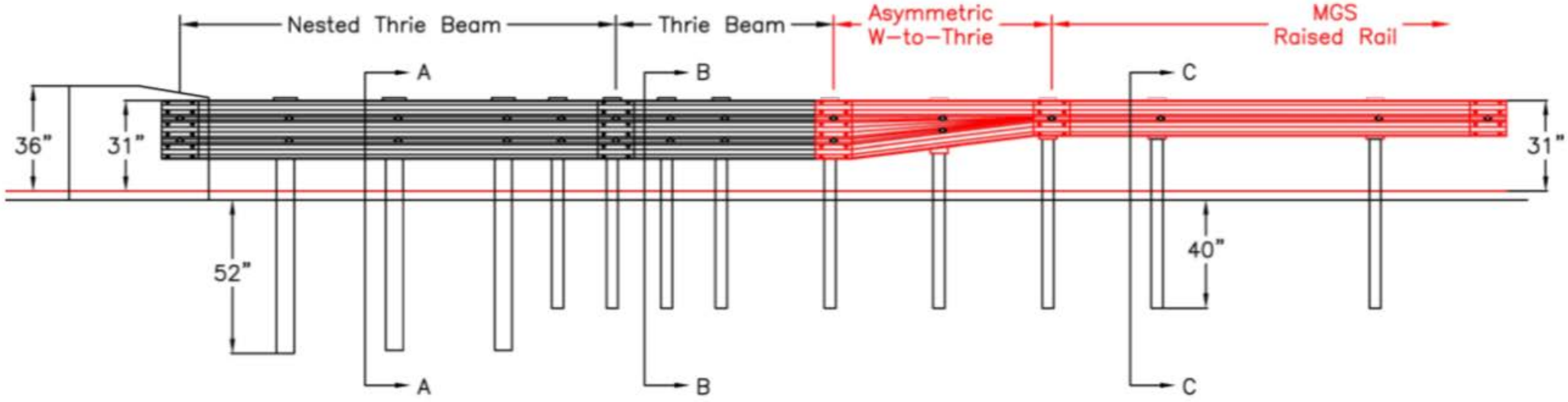

DelDOT

NEW Stiffness Transition

- MASH implementation agreement requires that all transitions let after December 31st, 2019 on the NHS be MASH compliant.
- The Approach Guardrail Transition (AGT) was developed to be crashworthy both before and after a 3" maintenance overlay.
  - Initial configuration:
    - AGT attaches to end post with a thrie beam at a height of 34".
    - Symmetric W-beam to thrie beam used to connect to the Midwest Guardrail System (MGS).
  - After overlay configuration:
    - AGT mount to the end post does not change.
    - Symmetric W-beam to thrie-beam replaced with asymmetric W-beam to thrie beam.
    - Adjacent MGS system raised.




Nested Thrie Beam
Thrie Beam
Symmetric
W–to–Thrie
MGS
A
B
C
39"
34"
31"
52"
40"


Nested Thrie Beam
Thrie Beam
Asymmetric
W–to–Thrie
MGS
Raised Rail
A
B
C
36"
31"
52"
40"


DelDOT









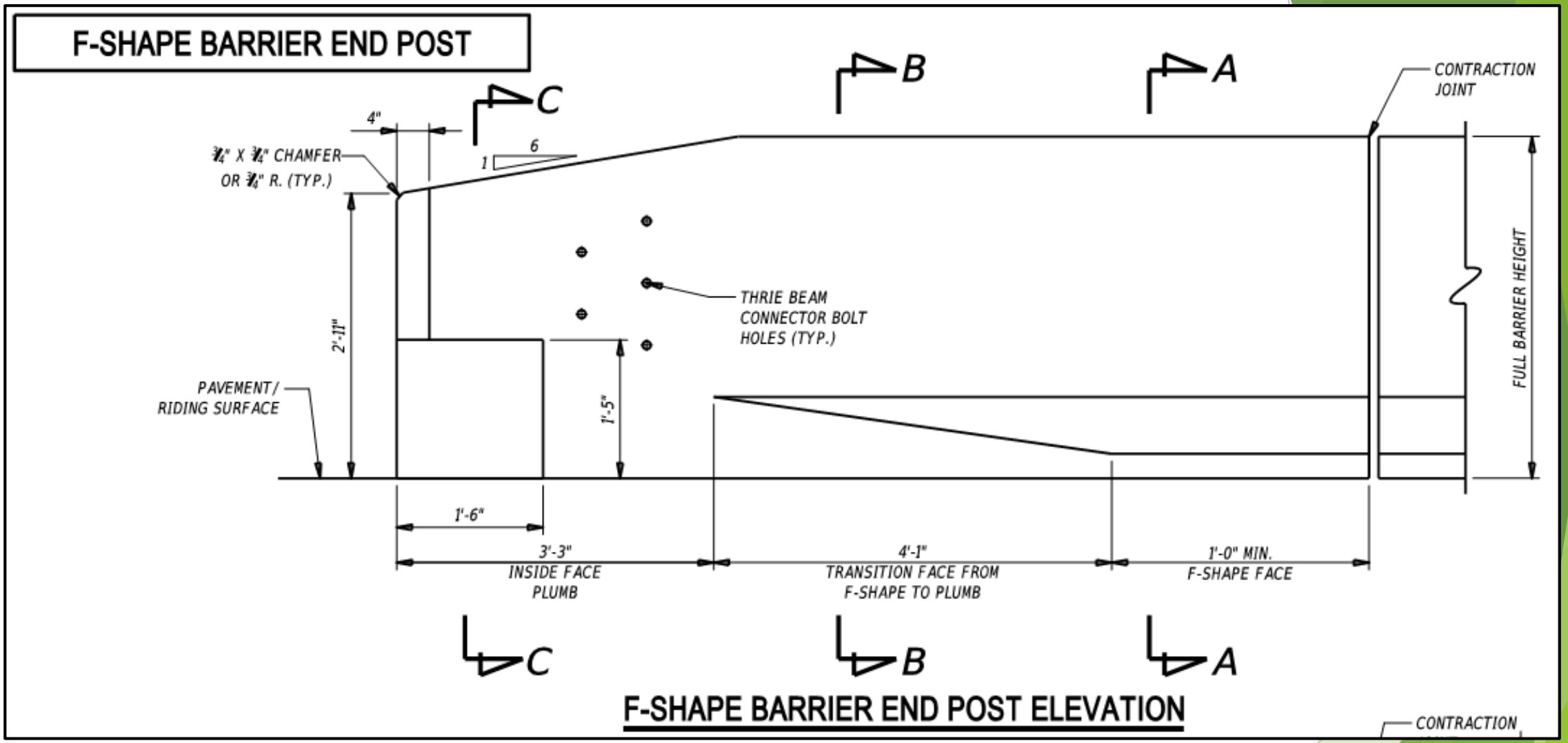
DelDOT

NEW End Post Details

- Transitions are very sensitive applications. Addition or removal of a particular component could lead to a failed test.
- Research Report No. TRP 03-369-19 recommends attaching DelDOT adopted transition to a modified version of the standardized end buttress developed under Research Report No. TRP 03-367-19.
- Standardized end buttress is designed to accommodate multiple AGTs.
- Key Elements:
  - 6:1 barrier height transition.
  - Thrie beam connects to a vertical wall.
  - Transition to safety shape occurs 6” downstream of the thrie beam connector plate.
  - Lateral transition rate of 10:1 is used.
  - Dual approach tapers to reduce vehicle snag.



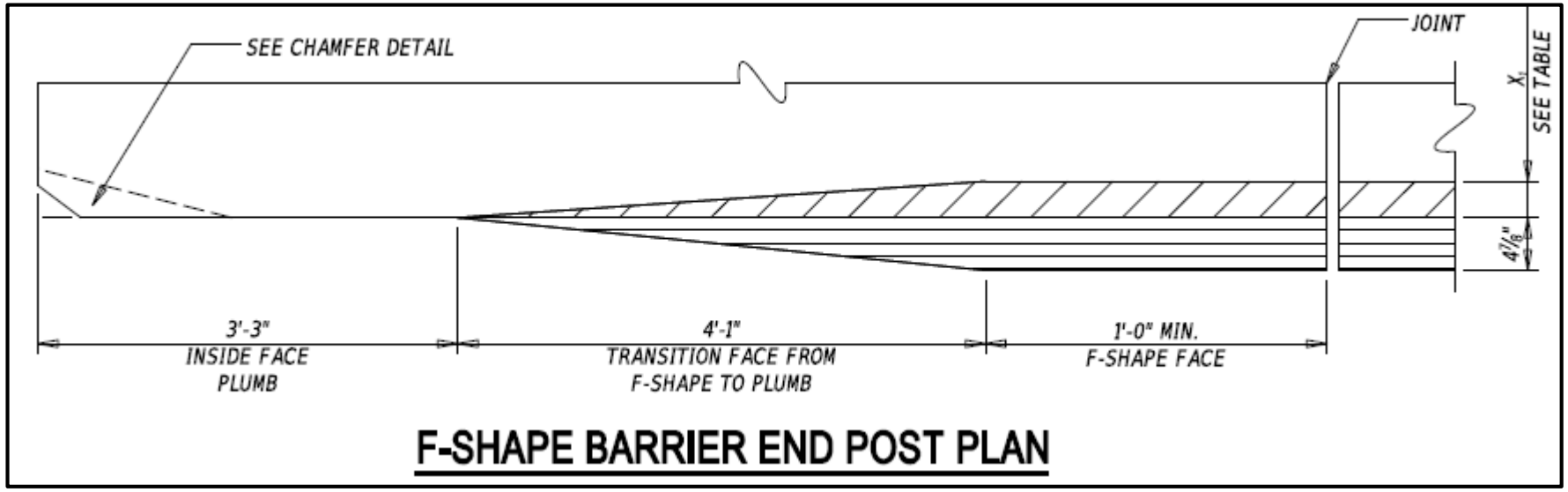
F-SHAPE BARRIER END POST



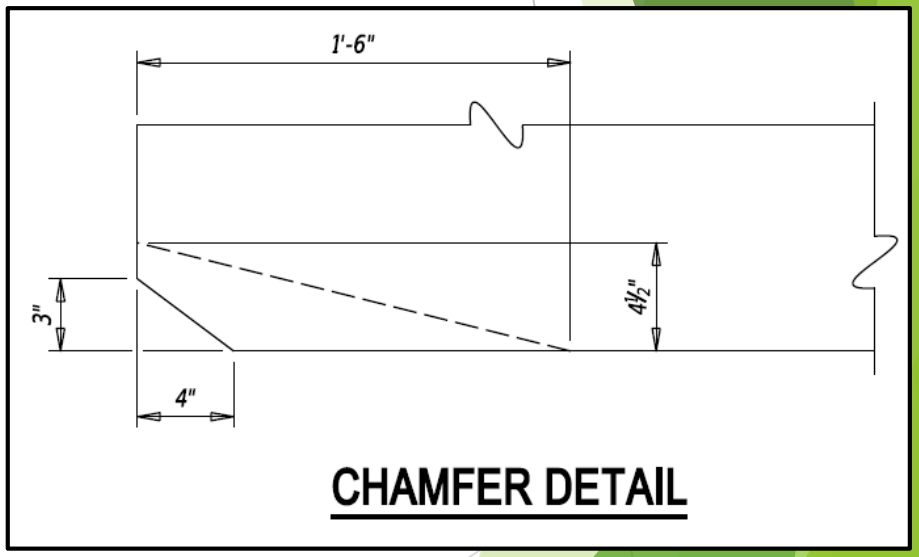
F-SHAPE BARRIER END POST ELEVATION

CONTRACTION



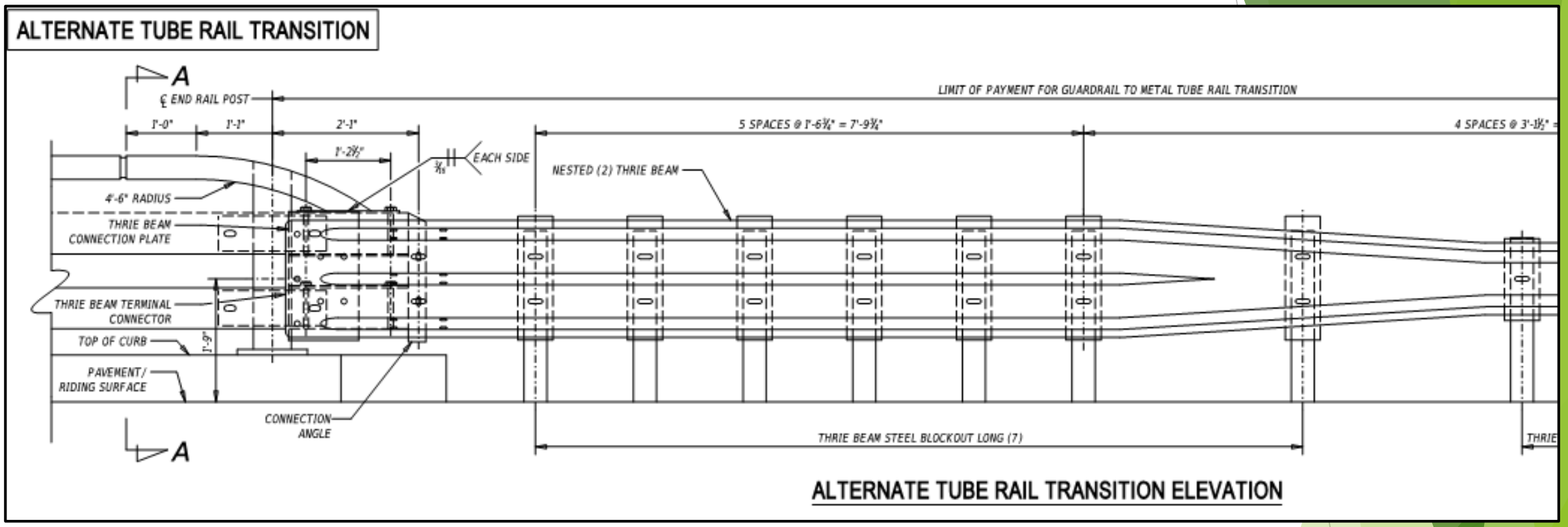


F-SHAPE BARRIER END POST PLAN



CHAMFER DETAIL




ALTERNATE TUBE RAIL TRANSITION
A
℄ END RAIL POST
LIMIT OF PAYMENT FOR GUARDRAIL TO METAL TUBE RAIL TRANSITION
1'-0"
1'-1"
2'-1"
5 SPACES @ 1'-6¾" = 7'-9¾"
4 SPACES @ 3'-1½" =
1'-2½"
EACH SIDE
NESTED (2) THRIE BEAM
4'-6" RADIUS
THRIE BEAM CONNECTION PLATE
THRIE BEAM TERMINAL CONNECTOR
TOP OF CURB
1'-9"
PAVEMENT/ RIDING SURFACE
CONNECTION ANGLE
THRIE BEAM STEEL BLOCKOUT LONG (7)
THRIE
A
ALTERNATE TUBE RAIL TRANSITION ELEVATION







Review Learning Objectives:

- Understand what MASH compliance means.
- Understand the role of the FHWA, AASHTO and the user agency (i.e. DelDOT) in implementing MASH.
- Identify DelDOT standard bridge rail and their appropriate application.
- Understand stiffness transitions and the new DelDOT stiffness transition.

