

# AASHTO Manual for Assessing Safety Hardware, 2015

AASHTO/FHWA Joint Implementation Plan  
Standing Committee on Highways  
September 24, 2015

# Full Scale *MASH* Crash Tests

## (*NCHRP 22-14(02)*)

- Conducted several full-scale crash tests of existing hardware, including:
  - Strong Post W-Beam System
  - Midwest Guardrail System
  - New Jersey Shaped Concrete Barrier
  - F-Shape temp. concrete barrier with 3-loop connection
  - Iowa Transition
  - Tangent Guardrail terminal
  - New Jersey Shaped Concrete Barrier (32 inches), failed TL-4 under *MASH*

# MASH TL-3

## 27 in. W-Beam Strong Post (Wood)



# MASH TL-3, 31 in. MGS



# RECENT *MASH* TL-4 CRASH TESTS

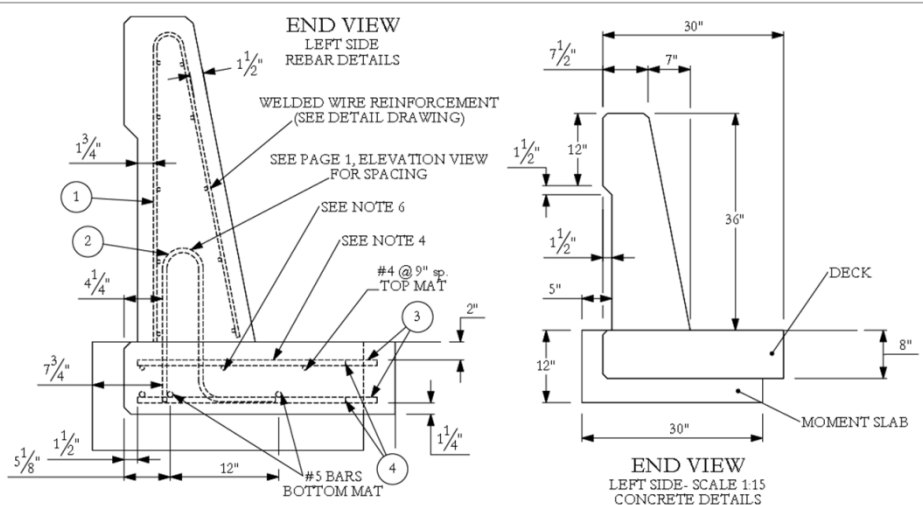
Test No. (Funding Agency)	Impact Conditions Vehicle Weight (lb) Speed (mph) Angle (deg)	Barrier Height (in.)	Barrier Type	Result
476460-1 (NCHRP)	22,090 57.4 14.4	32	NJ Safety Shape	Vehicle rolled over
420020-9B (TxDOT)	22,000 57.2 16.1	36	Single Slope Barrier	Test Pass

Based on crash testing and finite element impact simulations, a height of 36 in. has been selected as the minimum barrier height required for vehicle stability for *MASH* TL-4

# MASH TL-4 TEST ON 32-INCH JERSEY BARRIER



# MASH TL-4 TEST ON 36-INCH SINGLE SLOPE BARRIER



1. Concrete is Class S (4000 psi) for the deck, and Class C (3600 psi) for the parapet.
2. Transverse bars in deck weld to existing rebar (not shown) protruding from runway.
3. Deck is canti-levered from runway. Moment slab is back-filled with compacted crushed limestone.
4. Transverse bars at 6" spacing in top mat, 18" at bottom.
5. Rebar lap splices are 17" for #4's and 21" for #5's.
6. This bar may be adjusted laterally +/- 3" to allow tying to stirrup.

The Texas A&M University System						
Texas Transportation Institute College Station, Texas 77843						
Revisions:		Date	Drawn By	Scale	Sheet No.	
1.						2 of 3
2.		2010-07-22	GES	1:10	2 of 3	
3.				Project No.	End Views	
4.				420020-9		
5.				Single Slope Barrier (SSTR)		

T:\A\_2009-2010\420020\_T&E\DOT-9\_Single Slope Barrier\SolidWorks Drawings\420020-9\_Drawing

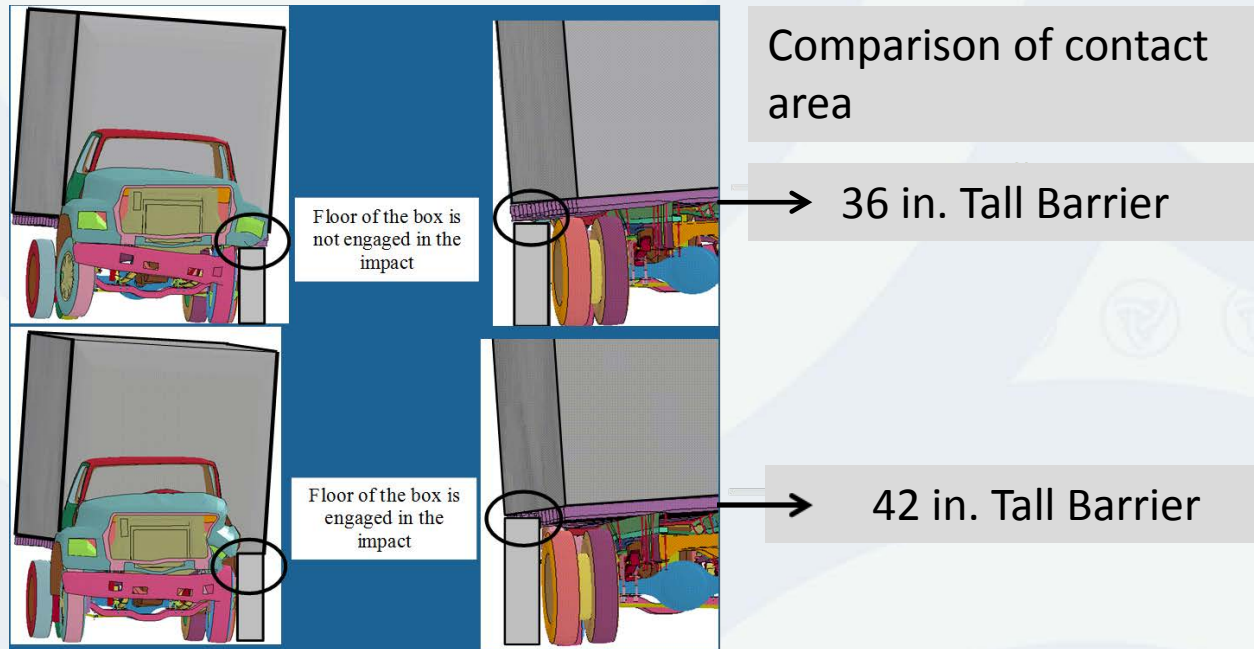


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TRIG ■  
TMP(°C):29  
PLAYING  
FRAME 166

Kodak HG2000 Imager COLOR - REV 1.3 - [100.0.0.1 - U] [9600 Baud]

# CONCLUSIONS FOR *MASH* TL-4 LOADS

Lateral force increases as barrier height increases  
Vehicle contact area changes (box structure engaged)  
Less vehicle roll (more mass engaged)





# CONCLUSIONS FOR *MASH* TL-4 LOADS

Minimum barrier height for truck stability = 36 inches.

Magnitude and resultant height of lateral impact force ( $F_t$ ) varies with barrier height.

For 36-inch tall barrier:  $F_t = 67.2$  kips and  $H_e = 25.1$  in.

For 42-inch tall barrier:  $F_t = 79.1$  kips and  $H_e = 30.2$  in.

Although  $F_t$  has 24% increase for 36-inch tall *MASH* TL-4 barrier compared to Table A13.2-1 *Design Forces for Traffic Railings*, associated moment for deck cantilever design does not change.

Table A13.2-1  $\rightarrow$  54 kips x 32 in. = **1,728 in-kips**

*MASH* 36-inch barrier  $\rightarrow$  67.2 kips x 25.1 in. = **1,687 in-kips**

# MASH 2009 to MASH 2015

Parameter	MASH 2009	MASH 2015
Hood Height Measurement Reference Point	N/A	Clarification for rounded hoods on new vehicle models
Tractor Trailer <ul style="list-style-type: none"><li>• Maximum Overall Length</li><li>• Cargo Bed Height</li></ul>	<ul style="list-style-type: none"><li>• 50 ft</li><li>• 52 in. (+/- 2 in.)</li></ul>	<ul style="list-style-type: none"><li>• 53 ft *</li><li>• 50 in. (+/- 2 in.)*</li></ul>

\* Proposed to match current fleet based on testing experience and manufacturers survey  
(1) Allows 1° tolerance on impact angle at target impact speed

# MASH 2009 to MASH 2015

Parameter	MASH 2009	MASH 2015
Single Unit Truck • Cargo Bed Height	• 51 in. (+/- 2 in.)	• 49 in. (+/- 2 in.)*
Impact Severity Tolerances	• TL-3: $\pm 8\%$ • TL-4: $\pm 8\%$ • TL-5: $\pm 8\%$	• TL-3: $\pm 8\%$ • TL-4: $\pm 13\%$ <sup>(1)</sup> • TL-5: $\pm 13\%$ <sup>(1)</sup>

\* Proposed to match current fleet based on testing experience and manufacturers survey

<sup>(1)</sup> Allows 1° tolerance on impact angle at target impact speed

# MASH 2009 to MASH 2015

Test No.	Vehicle Type	Barrier Position	Key Evaluation Metrics
3-10	1100C	Level Terrain	Stability & Occ. Crush/Penetration
3-11	2270P	Level Terrain	Working Width & Barrier Strength
3-13	2270P	Front Slope*	Override & Stability
3-14	1100C	Front Slope*	Penetration, Stability, & Occ. Crush
3-15	1100C	Back Slope*	Underride, Stability, & Occ. Risk
3-16	1100C	Back Slope*	Override (Bounce) & Occ. Crush
3-17	1500A	Front Slope <sup>(1)</sup>	Penetration & Occ. Crush
3-18	2270P	Back Slope*	Override (Bounce) & Stability

\* Exact locations within ditch provided based on ditch slope and intended use of barrier

<sup>(1)</sup> Barrier positioned to maximize potential for vehicle penetration

# *MASH* Implementation Plan

# Current Implementation Agreement

- As of January 1, 2011, all newly developed hardware must be tested using *MASH*
- *NCHRP 350*-compliant hardware does not have to be re-tested to *MASH*
- *NCHRP 350*-compliant hardware may remain in-place and continue to be installed
- Non-compliant hardware with no suitable alternatives may be left in place and continue to be installed

# Innovation?

- “Parallel approach” was supposed to allow manufacturers time to develop new products
- Over four years later, very few proprietary *MASH* systems exist
- Additional safety benefits of *MASH* can only be realized if new hardware is developed
- Sunsetting 350 would provide the incentive
- Joint FHWA/AASHTO/TCRS group formed

# Proposed Implementation Agreement

- Applies to National Highway System
- TCRS develops and maintains the evaluation criteria (*MASH*)
- FHWA continues reviewing and determining eligibility of highway safety hardware for federal-aid reimbursement



# Proposed Implementation Agreement

- All *NCHRP 350*- or *MASH 2009*-compliant permanent hardware may remain in place unless damaged beyond repair
- Existing *NCHRP 350*- or *MASH 2009*-compliant temporary devices, including portable concrete barrier, may continue to be used through their normal service lives

# Proposed Implementation Agreement

- Upon adoption of *MASH 2015*, any newly developed hardware must utilize *MASH 2015* for evaluation and testing
- Modifications of eligible hardware shall utilize *MASH 2015* for re-evaluation and/or retesting
- Non-significant modifications of eligible hardware that have a positive or inconsequential effect on performance may continue to be evaluated using Finite Element Analysis
- FHWA will not issue eligibility letters for new or revised hardware tested using *MASH 2009* criteria after December 31, 2016

# Proposed Implementation Agreement

- Utilization of *MASH 2015*-compliant hardware will be required on new permanent installations and full replacements for projects let after the dates below
  - W-beam barrier and cast-in-place concrete barrier: December 31, 2017
  - W-beam terminals: June 30, 2018
  - Cable barrier, cable barrier terminals, and crash cushions: December 31, 2018
  - Bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently), all other terminals, sign supports, and all other breakaway hardware: December 31, 2019

# Proposed Implementation Agreement

- Urges agencies to establish a process to replace existing hardware that has not been successfully tested to *NCHRP Report 350* or later criteria.
- Encourages agencies to upgrade existing hardware to comply with the *MASH 2015* when:
  - Damaged beyond repair, or
  - Agency's policies require an upgrade to the safety hardware

# Anticipated Costs

## Testing of non-proprietary devices

- NCHRP
- Pooled-fund program
- Individual states (unique designs they may use)

## *MASH*-compliant longitudinal barrier systems

- Multiple systems currently available (various types)
- No increase in cost versus previous system

## *MASH*-compliant terminals

- Few systems currently available
- Initial increase in cost (\$200-\$700)

# Questions / Discussion