

## PRECONSTRUCTION DESIGN MEMORANDUM

**MEMO:** PCDM-14

**SUBJECT:** Design Guidance for MASH and PreMASH Safety Hardware

**DATE:** June 7, 2018

**RE:** Standard Drawings 805-xxx-xx and 805P-xxx-xx

This memo provides guidance for the selection of appropriate guardrail details during implementation of MASH tested safety hardware. The SCDOT MASH-2016 Transition Plan and the AASHTO/FHWA Joint Implementation Agreement establish a timeline for implementation of new MASH hardware for use in SCDOT right of way. This document provides guidance for designers on use of new drawings as they are made available.

Please note that the procedures for calculating guardrail length of need have not changed. The only changes are with the design lengths for MASH hardware and the associated pay items.

Crash Cushions are covered under PCDM-02 and may be used as leading end treatments for rigid barrier where appropriate. Note that crash cushions are also subject to MASH criteria and will be updated in a later phase and supplemented with additional information.

Drawings meeting MASH criteria or related items not subject to crash testing are located in the 805 section of the SCDOT Standard Drawings. Previous versions (2016 edition) of guardrail drawings are available by searching 805P\* drawing numbers, and are shown with a cover sheet and their old drawing number. All old drawings/pay items are available for conditions described in section 3.0 and may be used until further guidance is provided. The new drawings/pay items should be used for all new installations (except as noted) beginning with the July 2018 letting.

Examples have been provided at the end of this memorandum to assist designers with scenarios to calculate length of need (LON) and identify the appropriate pay items.



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Use the new items below starting with the July 2018 Letting. Old items are shown for reference only.

Table 1- MASH Phase I Implementation								
NEW ITEMS (JULY 2018 LETTING)					OLD ITEMS (RESTRICTED USE AFTER JUNE 2018)			
	Abbreviation	NEW Pay Item	Test Level (MASH)	Length	Abbreviation	Old Pay Item	Test Level (NCHRP350)	Old Length
Leading End Treatment (805-1xx-xx)	MT3	8051151	TL3	72' [45' LON]	Type T TL3	8057100	TL3	50' [25' LON]
	MT2	8051155	TL2	42' [20' LON]	Type T TL2	8057050	TL2	25' [12.5' LON]
Longitudinal Barriers (805-2xx-xx)	MGS3	8052100	TL3	Increments of 12.5'	W-Beam	8051050	TL3	Increments of 12.5'
	MGS3CS	8052150	TL3	Increments of 12.5'	W-Beam & Add. Length Posts	8051050 & 8055050	TL3	Increments of 12.5'
	MGS2C	8052200	TL2	Increments of 12.5'	W-Beam w/ Curb	8051050	TL2	Increments of 12.5'
Stiffness Transitions (805-3xx-xx)	MTBBC3	8053253	TL3	37' [37' LON]	TBBC Thrie Beam Bridge Conn	8053250	TL3	31.25' [31.25' LON]
	MTBBC2	8053255	TL2	21.25' [21.25' LON]	W-Beam Bridge Conn.	8051210	TL2	12.5' [12.5' LON]
Trailing End Treatment (805-1xx-xx)	MB	8051710	Trailing Tests only	40' [0' LON]	Type B	8057500	Trailing Tests only	12.5' [0' LON]

Tangent Leading End Treatments, Longitudinal Barrier, Stiffness Transitions, and Trailing End Treatments are available. Use the NEW Standard Drawings and pay items for all new guardrail installations that follow tangent alignment or horizontal curves.

The new guardrail shoulder break is minimum 45” from face of rail (3” more than previous). Adjust cross sections and earthwork quantities to reflect this change.

A Standard Drawing and pay items for “compressed shoulder” applications have been developed to assist designers in locations where it is not practical to utilize the standard shoulder breaks. The compressed shoulder break is 19” from face of rail.

Definitions for “Safety Hardware”:

Component – Individual parts that make up a device. (Ex: Post, Rail, Offset Blocks).

Device – Individual installed sections of barrier. (Ex: Leading End Treatment, Bridge Transition, Longitudinal Barrier, Trailing End Treatment).

System/Run – A group of connected devices that are designed to function together in order to accomplish a desired level of protection. (For the purposes of this document, each guardrail installation attached to a bridge parapet is a separate system, so 4 possible systems on a typical bridge).

Reference General Notes Section 99 on SCDOT Standard Drawings 805-001-02 and 805-001-03 for definitions of acronyms.

## 1.0 New Guardrail Installations - Ditch Sections

Use the MT2 leading end treatments on sites with design speeds of 45MPH or less, and use the MT3 leading end treatments on all other sites. MT3 leading end treatments may also be used for lower design speeds if the designer determines conditions are present to warrant a

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higher test level end treatment. A portion of the end treatment may be considered to cover length of need. This redirective length is shown in Table 1 in brackets [xx' LON].

Use the MGS3 longitudinal barrier detail wherever standard guardrail shoulder break (now 45" from face of rail) can be provided. The entire pay length of this device can be used to cover length of need.

Use the MGS3CS longitudinal barrier where a compressed guardrail shoulder break (now 19" from face of rail) is required. Be aware that the minimum shoulder widths at the end treatment, as specified in the Standard Drawing, are always required regardless of the use of compressed shoulder. "Additional length post" pay items are no longer required on these locations. The entire pay length of this device can be used to cover length of need.

Use the MTBBC2 stiffness transition/bridge approach on sites with design speeds of 45MPH or less, and use the MTBBC3 stiffness transition/bridge approach on all other sites. MTBBC3 stiffness transition may also be used for lower design speeds if the designer determines conditions are present to warrant a higher test level end treatment. The length of this device can be used to cover length of need, shown in Table 1 in brackets [xx' LON].

Both the MTBBC3 and MTBBC2 devices use the same bolt-hole pattern. The MTBBC2 device may be used on trailing ends located outside of the clear zone for opposing traffic.

The Type MB trailing end treatment may be used on trailing ends when the guardrail is outside of the clear zone for opposing traffic. This device is fully gating, so none of it should be considered in the required length of need as shown in Table 1 in brackets [0' LON].

### **2.0 New Guardrail Installations – Curb Sections (Design Speed = 45 MPH or Less)**

Use MT3 leading end treatments when leading end treatments are required behind a curb. Use MGS2C longitudinal barrier to complete the length of need requirement on the site.

Use the MTBBC3 on all 4 parapet corners whenever there is curb present between the guardrail and the edge of travel lane and trailing ends are within the clear zone for opposing traffic. This is a common condition on 2 and 3 lane roads. The trailing end of the bridge parapet can terminate when the parapet is outside the clear zone for opposing traffic. If there is no additional need for barrier, a blunt or tapered rigid end may be considered or can be extended. If extended, the designer can utilize rigid roadside barrier or utilize either the MTBBC2 or MTBBC3 devices.

The Type MB trailing end treatment may be used on trailing ends when the guardrail is outside the clear zone for opposing traffic. This device is a fully gating device and there should be a safe/clear roadside beyond the barrier. As with ditch installations, this device is limited to trailing end conditions and sites where the barrier is outside the clear zone for opposing traffic.

### **3.0 New Guardrail Installations – Curb Sections (Design Speed Greater Than 45 MPH)**

Currently, there are no devices available under MASH or any previous tests that meet a higher design speed when installed behind the curb. Designers should consider alternatives to eliminate hazards when design speeds greater than 45 MPH and curbs are present on a specific site. Where higher speeds, curbs, and guardrail are required at the same location, designer should consider resources such as the Roadside Design Guide and the FHWA Safety Website for additional guidance.

### **4.0 Use of Pre-MASH Standards after Implementation**

The designer can specify the run using devices from the 2016 Standard Drawings and pay items only at specific locations within a project where conditions require the use of a device that does not yet have a MASH option. If the following devices are required at a specific site on a project, use the 2016 Standard Drawings and pay items for all the devices within that guardrail system/run on the project. Old pay items will include MO (for Maintenance Only) at the beginning of the pay item description.

#### **805P-510-00 Guardrail with Moment Slab (Base Plated) -**

#### **805P-655-xx Bridge Retrofit Options (Base Plated) –**

Base plated MGS options are projected to be available for January 2019 Letting. Until then, use the 2016 Standard Drawings for all parts within this system/run when these MO items are needed.

#### **805P-565-00 Long Span (12'-6") single post omitted**

Long Span MGS options are projected to be available for January 2019 Letting. Until then, use the 2016 Standard Drawings for all parts within this system/run when these MO items are needed.

#### **805P-580-xx Curved Guardrail at Intersections/Drives**

Use the 2016 Standard Drawings for all parts within this system/run when this MO item is needed until further guidance is provided.

#### **805P-675-xx Bridge Retrofit Options (Connector Bracket)**

It does not appear that research will be devoted to MASH test this type of connection. Guardrail manufacturers are providing resistance to fabricate these types of items without site specific measurements. These details may be removed from the Standard Drawings and would need to be included in project plans or special provisions with appropriate field measurements before specifying the item.

#### **805P-015-00 Critical Offset Nested Thrie-Beam**

This device was utilized to place barrier close to a drop-off hazard, and previously was considered when barrier was needed close to bridge piers or other projected hazards. Zone of Intrusion rigid barriers should be used for new Bridge Pier Protection and considered for other projected hazards. Rigid barriers are recommended for locations

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close to drop-offs such as tops of retaining walls and shallow culverts. Rigid barriers do introduce a drainage issue that needs to be addressed before they are included in all locations. Critical Offset Nested Thrie-Beam should have limited use moving forward, but may be considered in some applications where rigid barrier is not feasible.

## 805P-3xx-xx Thrie-Beam

Do not install new alignments of standard Thrie-Beam.

## 805P-4xx-xx Steel-Backed Timber Guardrail

Do not install new alignments of standard Steel-Backed Timber Guardrail.

Where noted above, use the previous standard (currently available on the Standard Drawing website as 805P drawings) and corresponding pay items for the entire run/system (Leading End Treatment, Longitudinal Barrier, Stiffness Transition & Trailing End Treatment). DO NOT MIX MASH and NCHRP350 devices within a single run of bolted guardrail. Install MASH devices in all other runs/systems throughout the project. Further guidance will be provided as additional MASH devices become available.

## 5.0 Lateral Deflection

The design values for lateral deflection of the new devices are provided in the border of the Standard Drawing and in Table 2. Design Lateral Deflection is the expected amount of lateral movement under common impact conditions. The values of Design Lateral Deflection were increased from the values established in the corresponding crash test reports because higher impact angles or forces will result in additional deflection. These values do not cover all real world impact conditions, so designer is cautioned when using these types of barriers to shield structures that could cause additional damage if impacted (such as some overhead structures) or very severe hazards where containment of the vehicle is of extreme importance (such as on top of retaining walls, bridge parapets, or other extreme drop-off conditions).

Note that gating portions of devices may not be used to cover length of need.

Table 2: Design Lateral Deflection		
Drawing #	Pay Item Description	Design Lateral Deflection
Test Level 3 Conditions		
805-115-11	MT3 LEADING END TREATMENT TL3	Gating (impact head end) , 7' (last 45')
805-210-00	MGS3 GUARDRAIL	7' (TL3)
805-215-00	MGS3CS GUARDRAIL COMPRESSED SHOULDER	7' (TL3)
805-325-30	MTBBC3 (MASH) THRIE-BEAM BARRIER CONNECTOR TL3	5' (at MGS) to 6"(at bridge)
805-170-00	MB TRAILING END TREATMENT	Gating (entire pay length)
Test Level 2 Conditions		
805-115-51	MT2 LEADING END TREATMENT TL2	Gating (impact head end), 5' (last 20')
805-220-00	MGS2C GUARDRAIL BEHIND CURB	5' (TL2)
805-325-50	MTBBC2 (MASH) THRIE-BEAM BARRIER CONNECTOR TL2	4' (TL2)

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## 6.0 Additional Phases of MASH Implementation

Additional phases of MASH qualified devices will include updates for:

- Crash cushions – (PCDM-02 update)
- Cable barriers & cable end anchors
- Median guardrail & impact attenuators – pending usage requirements

## 7.0 Summary of Pay Items

Drawing #	Abbreviation	Pay Item#	Pay Item Description	Unit
805-115-11	MT3	8051151	MT3 LEADING END TREATMENT TL3	EA
805-115-51	MT2	8051155	MT2 LEADING END TREATMENT TL2	EA
805-210-00	MGS3	8052100	MGS3 GUARDRAIL	LF
805-215-00	MGS3CS	8052150	MGS3CS GUARDRAIL COMPRESSED SHOULDER	LF
805-220-00	MGS2C	8052200	MGS2C GUARDRAIL BEHIND CURB	LF
805-325-30	MTBBC3	8053253	MTBBC3 (MASH) THRIE-BEAM BARRIER CONNECTOR TL3	EA
805-325-50	MTBBC2	8053255	MTBBC2 (MASH) THRIE-BEAM BARRIER CONNECTOR TL2	EA
805-170-00	MB	8051710	MB TRAILING END TREATMENT	EA

*July 2018 Letting*

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George R. Bedenbaugh, Jr., P.E.  
Preconstruction Support Engineer

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Effective Date

GRB:hjc

ec:

John Boylston, Director of Preconstruction  
Claude Ipock, Director of Construction  
David Cook, Director of Maintenance  
Rob Perry, Director of Traffic Engineering  
Chris Gaskins, RP Engineer – Design Build  
Dan Hinton, FHWA  
Steve Ikerd, FHWA

Betsy McCall, DM – Lowcountry RPG  
Leah Quattlebaum, RP Engineer - Pee Dee  
Philip Sandel, RP Engineer - Midlands  
Julie Barker, RP Engineer - Upstate  
Ladd Gibson, Program Director - Mega Proj.  
Tad Kitowicz, FHWA

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## Example 1:

- Length of Need was calculated (according to Roadside Design Guide method) to be 265'.
- The culvert headwall is 10' from the guardrail shoulder break.
- Design Speed is 50MPH
- Divided Highway with wide median, so the guardrail is outside the clear zone of the opposing traffic.

Barrier will consist of leading end treatment (MT3), longitudinal barrier (MGS3), and trailing end treatment (MB).

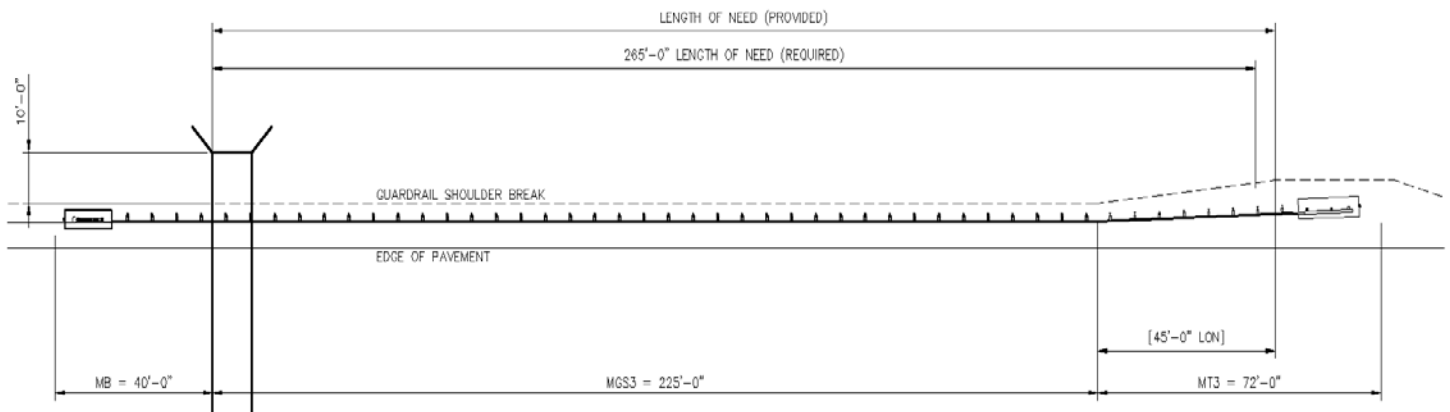
The MT3 device contributes 45' LON. The MB device does not contribute to LON.

The lateral deflection of MGS3 is shown on drawing 805-210-00 as 7', and the culvert headwall is beyond this distance, so MGS3 is an appropriate barrier choice.

The quantity of MGS3 =  $265' - 45' = 220'$ . This value should be increased to an equal increment of 12.5', so 225' of MGS3 should be specified.

Note that the entire length of the MB Trailing End Treatment should be located past the culvert location.

Quantity	Pay Item#	Pay Item Description	Unit
1	8051151	MT3 LEADING END TREATMENT TL3	EA
225	8052100	MGS3 GUARDRAIL	LF
1	8051710	MB TRAILING END TREATMENT	EA



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## Example 2:

- Length of Need was calculated (according to Roadside Design Guide method) to be 152' from the end of a new bridge parapet in a curb section.
- A clear embankment slope is beyond the face of guardrail.
- Design Speed is 45MPH
- The parapet is outside the clear zone for opposing traffic, and there is no hazard at the trailing end of the bridge to warrant barrier.

On the approach side of the bridge, a Leading End Treatment MT3, Longitudinal Barrier MGS2C, and Stiffness Transition MTBB3 are required. Based on recommendations in Section 2.0 of this PCDM, higher test level MT3 and MTBB3 devices are selected because of the presence of a curb.

The MT3 device contributes 45' LON. The MTBB3 device contributes 37' LON.

The quantity of MGS2C =  $152' - 45' - 37' = 70'$ . This value should be increased to an equal increment of 12.5', so 75' of MGS2C should be specified.

Quantity	Pay Item#	Pay Item Description	Unit
1	8051151	MT3 LEADING END TREATMENT TL3	EA
75	8052100	MGS2C GUARDRAIL BEHIND CURB	LF
1	8051710	MTBBC3 (MASH) THRIE-BEAM BARRIER CONNECTOR TL3	EA

