A MASH Compliant Sign Mounting Designs for Placement on Concrete Median Barrier

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Abstract

There is a growing need to place signs on median barrier as a way to relay information to the traveling public. However, with the lack of MASH compliant sign mounting designs, state DOT’s are limited to the Zone Of Intrusion (ZOI) guidelines to place such signs. The ZOI is derived from NCHRP Report 350 tests and does not address the placement symmetry encountered in concrete median barriers (CMB) installation. In this paper, four different sign mounting designs are successfully crash tested according to MASH TL 3-11 that can be placed on top of a 32-inch or taller CMB.

Keywords: Signs on medians, MASH, Median Barrier
INTRODUCTION

Concrete median barriers have been used throughout the nation as permanent and temporary barriers for providing separation of traffic. Typically, these barriers are tested and considered crashworthy through crash testing according to National Cooperative Highway Research Program (NCHRP) Report 350 or American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessment of Safety Hardware (MASH) (1,2). Due to space restrictions, a sign or a light pole is placed on top of such barriers. However, when signs or light poles are mounted on top of barriers, the crashworthiness of the system is not necessarily guaranteed. There is very limited research on how a combination of device and barrier would perform if impacted by an errant vehicle. Therefore, there is a need to identify existing practices of placing hardware on top of median barriers, as well as defining the crashworthiness of such combinations.

BACKGROUND

Researchers at Midwest Roadside Safety Facility (MwRSF) developed the concept of Zone of Intrusions (ZOIs) as a guideline for the placement of attachments on top of or behind a barrier (3). They conducted a comprehensive review of full scale crash testing of bridge rail and median barriers to establish ZOIs for traffic barriers. A wide variety of traffic barrier classes including sloped-faced and vertical-faced concrete barriers were reviewed. ZOIs were identified for different NCHRP Report 350 test levels (1). Extent that a pick-up or single truck intrudes over the top of barrier during an impact was the basis for establishing the ZOI. The maximum intrusions of any portion of a test vehicle beyond the top-front corner of the barrier were first considered as the definition of intrusion. For TL-3, barrier classes were combined into three groups based on the size of intrusion extent: (1) sloped face concrete barrier and steel tube rail on 6 inch curb or greater; (2) vertical face concrete barrier, combination of concrete and steel rail, all timber rail; and (3) steel tube rails not on a curb or on less than a 6 inch curb. ZOIs for TL-3 identified by Keller et al. are shown in Figure 1. Keller et al. recommended the placements of attachments outside the ZOI identified for each barrier class. Moreover, they recommended that the impact performance of an attachment and its placement that does not follow these suggested criteria can only be verified through the use of full-scale crash testing. More on the ZOI concept is presented in references (4) and (5).

Recently, a crash was performed on a TxDOT Type 2 portable concrete traffic barrier (PCTB) with a sign support assembly as per MASH test 3-11 (6). A crash test performed in 2001 on the modified TxDOT Type 2 PCTB with grid-slot connection and 1/4 inch thick steel straps... Sign support and sign mount connection was anchored on top of this modified concrete barrier in conjunction with the steel strap connections to three barrier joints A 2270P (5000 lb) Dodge Ram 1500 pickup impacted the test article at a speed and angle of 63.4 mi/h and 24.6 degrees, respectively. The test successfully passed the safety evaluation criteria set forth in MASH test 3 11.
Researchers at TTI recently investigated the performance of a temporary concrete barrier with sign attachments mounted on top (11). The objective of the research was to develop a TxDOT standard for mounting traffic control signs and devices on concrete barrier. A crash test...
RESEARCH APPROACH

The outcome of finite element simulations and engineering analyses of eight conceptual designs was that four concepts have the likelihood of passing MASH evaluation criteria. The simulation effort is not documented in this paper due to space restriction. The analyses were performed using up to 6 ft × 4 ft sign panel size. The concepts are:

- Schedule 80 post mounted rigidly on a spread tube.
- Hinge and sacrificial pin design.
- Sliding base and chute design.
- Slotted 10 BWG post (with 2-inch or 3-inch long slots).

These four concepts are shown in figure 2. Three concepts, the spread tube, the hinge with sacrificial pin and the sliding base mounting were simulated using a 2.5-inch nominal size Schedule 80 post. The fourth concept, the slotted post, was simulated using a 2.5-inch nominal size 10 BWG post. The results of all detailed simulations indicated that these four concepts would pass MASH 3-11 test conditions within the accepted evaluation criteria.

Figure 2 The four recommend sign mounting concepts
CRASH TESTS RESULTS

Crash Test No. 466462-1 on the Spread Tube Sign Support System Mounted on CMB

The barrier on which the spread tube sign support system was mounted contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. The sign support did not interfere with the ability of the barrier to contain and redirect the vehicle. No movement in the barrier was observed. The sign post and the spread tube had insignificant damage as shown in Figure 3.

Figure 3 Spread tube concept before and after MASH TL 3-11 test

Crash Test No. 466462-2a on the Bracket and Sacrificial Pin Sign Support Mounted on CMB

The barrier on which the bracket and sacrificial pin sign support was mounted contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. The sign support did not interfere with the ability of the barrier to contain and redirect the vehicle. No movement of the barrier was observed. The sign post and the mounting bracket had insignificant damage as shown in Figure 4.

Figure 4 Hinge and sacrificial pin concept before and after MASH TL 3-11 test
Crash Test No. 466462-3 on the Chute Channel Sign Support Mounted on CMB

The barrier on which the sliding base and chute channel sign support was mounted contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. The sign support did not interfere with the ability of the barrier to contain and redirect the vehicle. No movement of the barrier was noted but the post and the sliding base displaced along the chute as intended. The sign post and the mounting detailed had permanent deformation as shown in Figure 5.

Figure 5 The Sliding base and chute concept before and after MASH TL 3-11 test
Crash Test No. 466462-4 on the Slotted 10 BWG Sign Support on CMB

The barrier on which the slotted 10 BWG sign support was mounted contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. The sign support did not interfere with the ability of the barrier to contain and redirect the vehicle. No movement of the barrier was noted. However, the post deformed and developed a plastic hinge around the slotted region as intended and the sign panel remained attached to the post but rested on the other side of the CMB as shown in Figure 6.

Figure 6 The slotted 10BWG sign concept after the test

Tests Summaries

Figure 7 through figure 10 present the test summary sheet for each test indicating that all of the four tests successfully passed the MASH evaluation criteria.
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General Information
Test Agency .................... Texas A&M Transportation Institute (TTI)
Test Standard Test No. .... MASH Test 3-11
TTI Test No. ................. 466462-1
Test Date .................... 2012-06-11

Test Article
Type ....................... Sign Support on CMB
Name ..................... Spread Tube Sign Support System
Installation Length/Height .. Barrier 90 ft long × 32 inches high
Material or Key Elements . 6-inch long, 3-inch diameter schedule 40 pipe inside a 6 inch wide × 2-inch deep × ¼-inch thick steel tubing
Soil Type and Condition..... Barrier placed on concrete surface, dry

Test Vehicle
Type/Designation ............. 2270P
Make and Model ............. 2006 Dodge Ram 1500 Pickup
Curb ......................... 4969 lb
Test Inertial .................. 5050 lb
Dummy ........................ No dummy
Gross Static .................. 5050 lb

Impact Conditions
Speed .......................... 61.6 mi/h
Angle .......................... 25.0 degrees
Impact Severity ............... 114.4 kip*ft
Location/Orientation ........... upstrm of support

Exit Conditions
Speed .......................... 46.2 mi/h
Angle .......................... 0.8 degrees

Occupant Risk Values
Impact Velocity
Longitudinal ............... 21.6 ft/s
Lateral ........................ 25.3 ft/s
Ridedown Accelerations
Longitudinal ............... 5.2 G
Lateral ....................... 6.6 G
THIV .......................... 37.1 km/h
PHD ........................... 7.8 G
ASI ............................. 1.70
Max. 0.050-s Average
Longitudinal ............... 9.6 G
Lateral ........................ 14.1 G
Vertical ....................... 4.8 G

Post-Impact Trajectory
Stopping Distance ........... 198 ft downstrm
Vehicle Stability
Maximum Yaw Angle .......... 27 degrees
Maximum Pitch Angle .......... 9 degrees
Maximum Roll Angle .......... 12 degrees
Vehicle Snagging............... No
Vehicle Pocketing............... No

Test Article Deflections
Dynamic .................. None measurable
Permanent .................. None measurable
Working Width .............. None measurable
Vehicle Penetration .......... 20.4 inches

Vehicle Damage
VDS .......................... 01RFQ5
CDC .......................... 01FREW4
Max. Exterior Deformation .... 18.0 inches
OCDI ........................ RF0000000
Max. Occupant Compartment Deformation .......... 1.5 inches

Figure 7 Summary of Results for MASH Test 3-11 on the Spread Tube Sign Support System on CMB
Figure 8 Summary of Results for MASH Test 3-11 on the Bracket and Sacrificial Pin Sign Support on CMB.
### General Information

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<thead>
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<td>466462-3</td>
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### Test Article

**Type**  | Sign Support on CMB  
**Name**  | Chute Channel Sign Support  
**Installation Length/Height**  | Barrier 90 ft long × 32 inches high/ Sign mounting height at 85.5 inches  
**Material or Key Elements**  | xxx  

### Soil Type and Condition

Barrier placed on concrete surface, dry

### Test Vehicle

**Type/Designation**  | 2270P  
**Make and Model**  | 2006 Dodge Ram 1500 Pickup  
**Curb**  | 5118 lb  
**Test Inertial**  | 5029 lb  
**Dummy**  | No dummy  
**Gross Static**  | 5029 lb  

### Impact Conditions

| Speed | 62.9 mi/h  
| Angle | 24.4 degrees  
| Impact Severity | 118.8 kip*ft  
| Location/Orientation | 34.7 inches upstrm support  

### Exit Conditions

| Speed | 51.5 mi/h  
| Angle | 5.1 degrees  

### Occupant Risk Values

| Impact Velocity | Longitudinal | 16.4 ft/s  
| Lateral | 28.5 ft/s  
| Ridedown Accelerations | Longitudinal | 4.5 G  
| Lateral | 9.0 G  
| THIV | 36.8 km/h  
| PHD | 9.0 G  
| ASI | 1.94  
| Max. 0.050-s Average | Longitudinal | -8.5 G  
| Lateral | -16.4 G  
| Vertical | -4.2 G  

### Post-Impact Trajectory

| Stopping Distance | 220 ft dwnstrm  

### Vehicle Stability

| Maximum Yaw Angle | 31 degrees  
| Maximum Pitch Angle | 10 degrees  
| Maximum Roll Angle | 11 degrees  
| Vehicle Snagging | No  
| Vehicle Pocketing | No  

### Test Article Deflections

| Dynamic | None measureable  
| Permanent | None measureable  
| Working Width | None measureable  
| Vehicle Penetration | 25.9 inches  

### Vehicle Damage

| VDS | 01RFQ4  
| CDC | 01FREW3  
| Max. Exterior Deformation | 14.0 inches  
| OCDI | RF0010000  
| Max. Occupant Compartment Deformation | 1.75 inches  

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**Figure 9 Summary of Results for MASH Test 3-11 on the Chute Channel Sign Support on CMB.**
General Information
Test Agency........................ Texas A&M Transportation Institute (TTI)
Test Standard Test No. .......... MASH Test 3-11
TTI Test No. ................. 466462-4
Test Date ...................... 2012-08-28

Test Article
Type.......................... Sign Support on CMB
Name.......................... Slotted 10 BWG Sign Support
Installation Length/Height...... Barrier 90 ft long × 32 inches high/
Material or Key Elements .... Sign mounting height at 84.5 inches

Soil Type and Condition...... Barrier placed on concrete surface, dry

Test Vehicle
Type/Designation.............. 2270P
Make and Model............... 2006 Dodge Ram 1500 Pickup
Curb.......................... 4868 lb
Test Inertial................... 5011 lb
Dummy.......................... No dummy
Gross Static ................... 5011 lb

Impact Conditions
Speed ............... 62.5 mi/h
Angle .............. 25.8 degrees
Impact Severity ....... 124.0 kip*ft
Location/Orientation ... 43.0 inches upstrm of support

Exit Conditions
Speed ............... 49.4 mi/h
Angle .............. 3.5 degrees

Occupant Risk Values
Impact Velocity
Longitudinal ........ 20.0 ft/s
Lateral ............... 28.2 ft/s

Ridedown Accelerations
Longitudinal ............ 5.1 G
Lateral .................. 7.4 G

THIV ...................... 38.4 km/h
PHD ......................... 7.7 G
ASI.......................... 1.91

Max. 0.050-s Average
Longitudinal ............ 9.9 G
Lateral .................. 16.0 G
Vertical .................. 4.1 G

Post-Impact Trajectory
Stopping Distance .......... 200 ft dwnstrm
Aligned w/CMB

Vehicle Stability
Maximum Yaw Angle ....... 30 degrees
Maximum Pitch Angle ...... 9 degrees
Maximum Roll Angle ...... 13 degrees
Vehicle Snagging .......... No
Vehicle Pocketing .......... No

Test Article Deflections
Dynamic ................ None measureable
Permanent ................ None measureable
Working Width (sign panel) ... 89.0 inches
Vehicle Penetration .......... 20.6 inches

Vehicle Damage
VDS ...................... 01RFQ4
CDC ...................... 01FREW30
Max. Exterior Deformation .. 18.0 inches
ODCI ...................... RF0020000
Max. Occupant Compartment Deformation .. 3.0 inches

Figure 10 Summary of Results for MASH Test 3-11 on the Slotted 10 BWG Sign Support on CMB.
CONCLUSIONS

The following sign support designs were crash tested mounted on a concrete median barrier, and were evaluated according to MASH guidelines for longitudinal barriers:

- Spread Tube Sign Support System.
- Hinge and Sacrificial Pin Sign Support System.
- Sliding Base and Chute Channel Sign Support System.
- Slotted 10 BWG Sign Support System.

None of the above sign support systems interfered with the ability of the concrete median barrier to contain and redirect the 2270P vehicles. As indicated earlier, each of the systems performed successfully according to the MASH criteria for longitudinal barriers.

New sign post on median barrier mounting designs have been developed and tested that allow placement of sign systems, with up to 4-ft × 6-ft sign, on permanent median or roadside barriers. These mounting designs were tested on the 32-inch tall NJ barrier because it is considered the most critical barrier profile. Hence, it is expected that these designs are applicable for F-shape and single slope profiles as long as they have a minimum of 32-inch height from the roadway surface.

The sliding base and chute design is the preferred design for implementation among the three listed above. The sign/post assembly would move along the chute once impacted by an errant pick-up. The sign for the slotted 10 BWG post leaned down downstream and had 89.0 inches of maximum permanent deflection on the field side. So, the slotted 10BWG post concept will need enough clearance (i.e., wide shoulder width on each side of a CMB) to reduce potential interference with traffic. Practically, it should be used on roadside barriers or bridge rails. As for the hinge and sacrificial pin design, it did not activate in the crash test. Thus, it is not expected to activate for less severe impacts (nuisance hits). However, if activated, and the sign would lay down on the face of the barrier, then a clearance of 2 ft minimum is needed for the shoulder side on each side of the barrier.

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