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ASSESSMENT OF PENNDOT STRUCTURE MOUNTED GUIDE RAIL (SMGR) FOR COMPLIANCE WITH MASH TEST LEVEL 2

Prepared by

Nauman M. Sheikh, P.E.
Senior Research Engineer
and
William F. Williams, P.E.
Associate Research Engineer

Texas A&M Transportation Institute
n-sheikh@tti.tamu.edu

Texas A&M Transportation Institute
Texas A&M University System
College Station, Texas

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Objectives

This document provides an assessment of Pennsylvania Department of Transportation's (PennDOT) Structure Mounted Guide Rail (SMGR) to determine its compliance with American Association of State Highway Transportation Officials' (AASHTO) Manual for Assessing Safety Hardware (MASH) for Test Level 2 (TL2).

System Overview and Scope Limitations

The PennDOT SMGR consists of a steel reinforced concrete deck and curb, with steel rails supported by steel posts anchored to the top of the curb. Two rectangular HSS rails are attached to the steel posts using bolts that pass through a timber block placed between the HSS rails and the steel posts. The HSS rails are covered by 12-guage W-beam guardrail sections. Below the W-beam guardrail, a C6x8.2 rub rail is attached to the steel posts. The steel posts are welded on steel baseplates, which are bolted to the concrete curb using threaded anchor rods that are cast into the concrete curb. The concrete curb is 18 inches wide and 10.5 inches tall. On the traffic side of the rail, a 2.5-inch-thick asphalt overlay is constructed in front of the curb, resulting in an effective 8-inch height of the curb on the traffic side. Figure 1 shows a cross-section of the SMGR system. Further details are available in PennDOT standard BC-706M, January 31, 2019. The SMGR system was crash tested for MASH Test Level 3 (TL3) by Bullard et al.[1] and Figure 2 shows some photos of the SMGR test installation prior to the test. The SMGR installation crash tested by Bullard et al. had an 8-ft 4-inch post spacing, whereas the SMGR system in PennDOT's standard BC-706M has a 6-ft 3-inch post spacing.

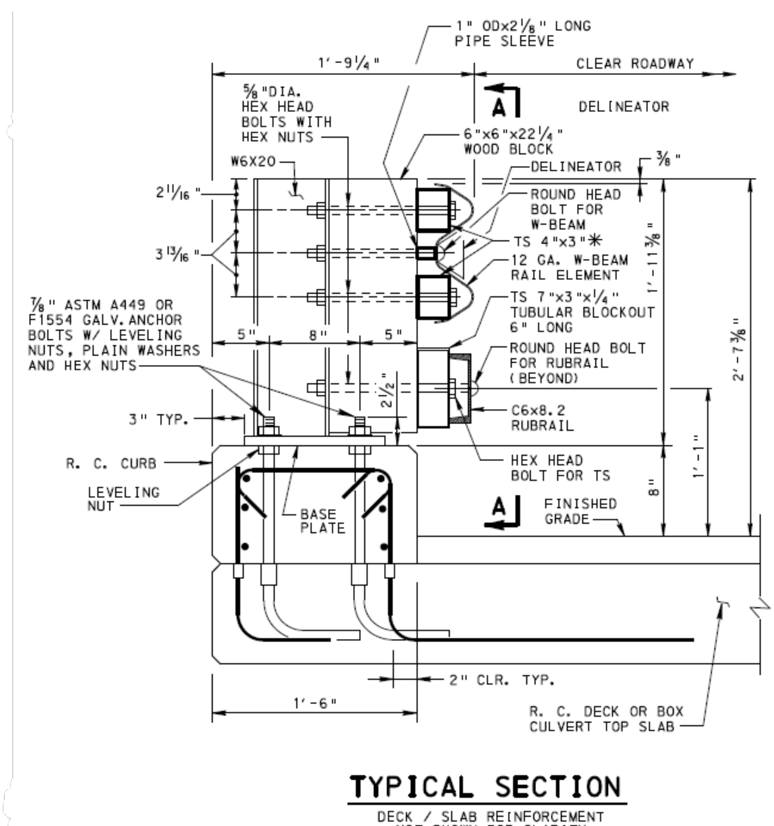

Figure 1. Key SMGR design details (PennDOT standard BC-706M, January 31, 2019.)

Figure 2. SMGR installation photos[1].

MASH TL3 Testing Results

In the MASH Test 3-11 performed by Bullard et al.[1], the 2270P pickup truck impacted the SMGR system upstream of a post located adjacent to a joint in the curb and deck. The impact resulted in significant damage to the curb and deck assembly at the joint location, resulting in high lateral displacement of the steel post and localized damage to the rubrail. Other post locations of the SMGR system remained undamaged. The vehicle became unstable and rolled over while redirecting after the impact. Figure 3 shows the damage to the test installation. The curb and deck damage are also shown in the figure.

Figure 3. Damage to the SMGR test installation after MASH Test 3-11[1].

MASH TL2 Compliance Assessment

Results of the TL3 testing indicated that the concrete curb and deck had inadequate strength adjacent to the joint location, which resulted in excessive post rotation, causing vehicle instability that led to the rollover. To assess MASH TL2 performance of the SMGR system, the researchers determined the nominal lateral resistance of the SMGR system at the target post location using the AASHTO LRFD strength analysis method(2).

The nominal lateral resistance capacity of the SMGR system at the impacted post location, which was situated near the joint in the curb and deck, was determined to be **34.44 kips** at a height of 20 inches above the roadway surface, which is the recommended design load height for MASH TL2.

AASHTO LRFD Bridge Design Specifications (BDS) specify a design force of 54 kips for TL3 bridge rails and 27 kips for TL2 bridge rails (AASHTO LRFD BDS, 9th Edition, Table A13.2-1)(2). Based on this recommendation and the results of the MASH Test 3-11, the SMGR design was determined to be structurally inadequate for TL3 near the joint in the curb and deck. However, the design was determined to be structurally adequate for TL2 impact loading.

Since the pickup truck instability observed in Test 3-11 resulted from extensive damage to the deck and curb at the joint location, as well as damage to the post and rubrail at the impacted post location, the lower impact loads associated with TL2 are not expected to produce similar damage. Therefore, the vehicle is expected to be redirected in a stable manner. This is also supported by successful MASH testing of other similar bridge rail systems that are installed on curb and deck and have passed higher loads of TL3(3,4).

Although the researchers' assessment was based on crash testing of the SMGR system with an 8-ft 4-in post spacing(1), the results and conclusions are also applicable to PennDOT's SMGR system shown in Figure 1, which uses a 6-ft 3-in post spacing. The reduced post spacing in the PennDOT system is expected to slightly decrease rail deflection, resulting in performance that is similar to or marginally better than that of the system with the larger post spacing.

Conclusion

Based on the information presented in this report, the researchers conclude that the PennDOT SMGR system (Figure 1) is expected to perform acceptably for MASH TL2 for post spacings ranging from 6 ft 3 inches to 8 ft 4 inches.

References

[1] D. L. Bullard, Jr., Moran, S., Menges, W. L., Schroeder, G. E., and Kuhn, D. L. "MASH Test 3-11 on PennDOT Structure Mounted Guide Rail (SMGR)." Report 610481-02-1. Texas A&M Transportation Institute, College Station, Texas, 2019.

[2] American Association of State Highway and Transportation Officials (AASHTO) (2020), *AASHTO LRFD Bridge Design Specifications*, 9th Edition, Washington, DC, ISBN: 978-1-56051-738-2.

[3] W. F. Williams, Moran, S., Menges, W. L., Schroeder, W. L., Griffith, B. L., Wegenast, S. W., and Kuhn, D. L. “Development of Thrie-Beam Retrofit for Upgrading Obsolete Bridge Rails.” Report 615131-01. Texas A&M Transportation Institute, College Station, Texas, 2021.

[4] FHWA Letter HSST-1/B-367, Dated September 6, 2022. (MASH TL3 Evaluation of PA 3-Rail Bridge Barrier, Texas A&M Transportation Institute Tests 610481-01-1A and 610481-01-2.