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W-BEAM GUARDRAIL MOUNTED ON CONTINUOUS UNDERGROUND CONCRETE SLAB

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Objectives

This document provides an assessment of a roadway safety barrier system to determine its compliance with American Association of State Highway Transportation Officials' (AASHTO) Manual for Assessing Safety Hardware (MASH) as requested by Wisconsin Department of Transportation (WisDOT) (*1*).

System Overview

In 2019, TTI evaluated the W-beam guardrail system with steel posts bolted on top of buried concrete slabs with a baseplate and epoxy anchor bolt connection (Figure 1) *(2)*. Several guardrail posts in the impact region were bolted on individual 60-inch x 60-inch x 8-inch concrete slabs that were buried 6 inches underneath compacted road base material. TTI performed MASH Test 3-10 and Test 3-11 with MASH small car (1100C) and pickup truck (2270P) vehicles, respectively. Both tests were successful and the guardrail system with the posts attached to the unconnected and buried concrete slabs was determined to be MASH Test Level 3 (TL-3) compliant.

In the field applications, site restrictions sometimes require attaching the posts to a continuous concrete slab or culvert instead of the unconnected 60-inch x 60-inch slabs used in TTI's design. This report assesses the MASH TL-3 compliance of the above-referenced W-beam guardrail design with posts attached to a buried but continuous concrete slab or culvert. This guardrail system is here after referred to as the Continuous Slab Guardrail System. This report also provides guidance on developing alternate footing designs if needed.

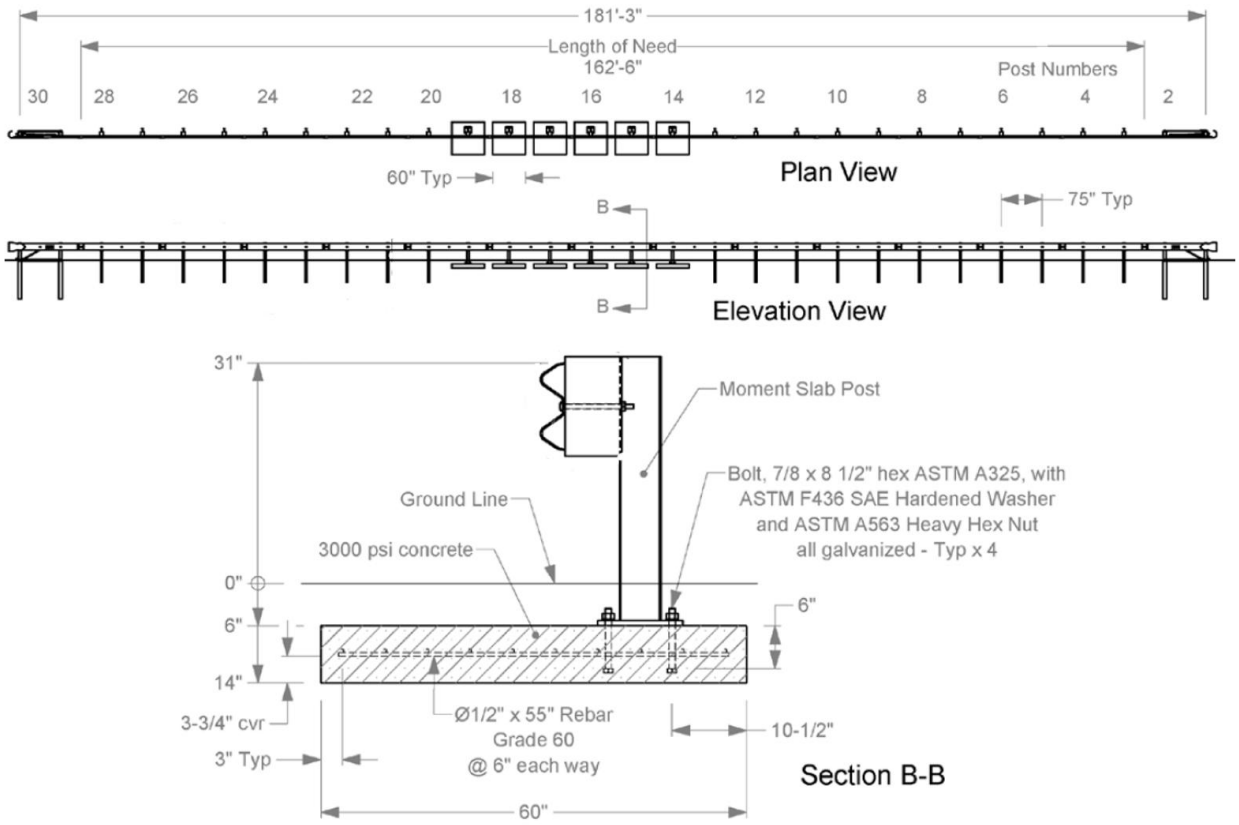

Figure 1. TTI Guardrail System with Posts Attached to Unconnected Concrete Slabs *(2)*.

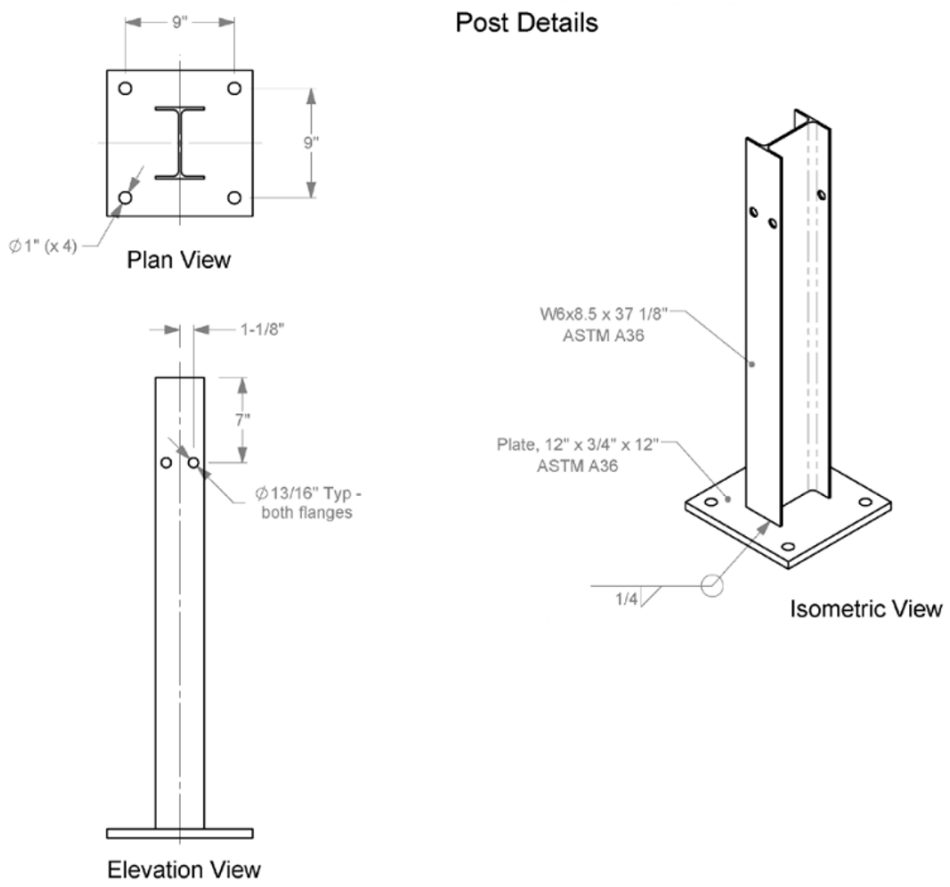

Figure 2. Post and Baseplate Details of the TTI Guardrail System *(2)*.

MASH Compliance Assessment

The MASH TL-3 compliance assessment of the Continuous Slab Guardrail System was performed based on the 2019 TTI test of the W-beam guardrail system described earlier *(2)*. In both Test 3-10 and Test 3-11, the unconnected 60-inch x 60-inch x 8-inch buried slabs did not show any signs of movement. In Test 3-11, the steel posts in the impact region deformed plastically near the grade level. The epoxy anchor bolt connection of the post baseplates to the unconnected concrete slabs remained intact and undamaged.

From the results of this test, it can be concluded that the attachment of the posts to the unconnected concrete slabs provided adequate restraint to the posts. The attachment of the posts to the unconnected slabs via the baseplate and epoxy anchor bolts was adequate to allow the posts to deform plastically without damaging the baseplate-to-concrete slab connection.

If the buried concrete slab is made continuous, as desired in the Continuous Slab Guardrail System, the increased mass of the concrete slab is expected to provide higher constraint to the attached guardrail posts. This is not expected to deteriorate the MASH performance of the guardrail system, and the Continuous Slab Guardrail System would be considered MASH compliant based on TTI testing.

If the adhesive anchor bolts are replaced with through-the-slab bolting, or mechanical anchors, etc., the performance of the system is expected to meet the MASH TL-3 criteria as long as the following conditions are met:

- The alternate anchor design should exceed the plastic moment capacity of the guardrail post. An anchor design exceeding the plastic moment capacity of the post ensures that the post will plastically deform prior to the failure of the concrete anchor. A typical ASTM A36 guardrail post has a minimum specified yield strength of 36 psi. In practice, however, ASTM A36 steel available from most steel manufacturers far exceeds the minimum specification. It is not uncommon for the specified minimum 36-psi A36 steel to have a yield strength closer to 50 ksi. For this reason, in determining the plastic moment capacity of the guardrail post, it is recommended to use 50 ksi yield strength for a conservative design of the alternate anchor.
- The alternate anchor design should retain the post baseplate dimensions and material strength used in the TTI design (Figure 2).
- Guardrail posts should be buried 6 inches deep or more in the compacted road base like the TTI design. Additional evaluation through testing or analysis may be needed for depths less than 6 inches.

Conclusions

Based on the results of the past testing presented and discussed above, it can be concluded that Continuous Slab Guardrail System is compliant for MASH TL-3 criteria. If changes in post anchorage to the concrete slab are made, they should meet the requirements listed herein.

References

[1] AASHTO. Manual for Assessing Roadside Safety Hardware, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.

[2] Federal Highway Administration (FHWA), Federal Aid Eligibility Letter HSST-1/B-332. Washington, D.C., February 27, 2020.