Minnesota Department of Transportation
MS 610
3485 Hadley Avenue North
Oakdale, MN 55128

Office Tel: (651) 366-4506
Office Fax: (651) 366-4497

Memo

TO: Bridge Design Engineers

FROM: Arielle Ehrlich
State Bridge Design Engineer

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MEMO TO DESIGNERS (2016-01): Single Slope Barrier (Type S) Bridge Standards

New bridge barrier standards have been developed for use that incorporate a single slope shape on the front face. The single slope shape has been shown to impart less climb and instability to passenger vehicles during a crash. The new MnDOT Type S bridge barriers were developed based on the Texas Type SSTR barrier. The Texas Type SSTR barrier was developed to meet the crash testing requirements found in the AASHTO Manual for Assessing Safety Hardware 2009 (MASH) Test Level 4 (TL-4) and was successfully crash tested to that level. AASHTO has not yet published a table of MASH test level design forces that can be used for deck overhang design or other components of the bridge. Therefore, although the barriers as developed meet the MASH criteria for geometry and are expected to meet the MASH criteria for strength, the new Minnesota Type S barrier standards have been published as meeting the crash testing requirements of NCHRP 350 Test Level 4.

Available Type S Bridge Standards

Standards are available for three barrier heights: 36", 42", and 54". Variations are included for:

- bridges with integral, semi-integral, and parapet type abutments
- bridges with and without a wearing course
- bridges with and without a sidewalk
- bridges with split median barriers
- bridges with solid median barriers

Detailing Requirements

A single slope TL-5 barrier has not been developed at this time. For bridges where a TL-5 barrier would currently be recommended due to high design speeds, curvature, truck traffic, or other site considerations (see LRFD Bridge Design Manual (BDM) Article 13.2.1), use a TL-4 42" tall Type S barrier or TL-4 54" tall Type S barrier where a glare screen is needed.

For bridges with wingwall orientation parallel to the roadway that have the barrier located on top of the wingwalls, detail the wingwalls to be the same thickness as the barrier (1'-4") for the top 1'-6" and then transition to the full standard thickness. See Figure 1.

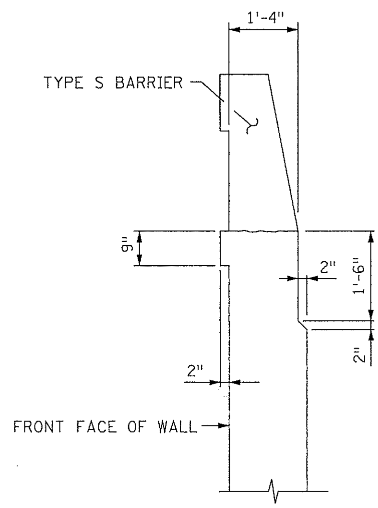


Figure 1

The Midwest Roadside Safety Facility (MwRSF) has provided recommendations for barrier placement on bridges that are dependent on the cross slope. MwRSF recommends limiting the angle between the roadway surface and the vertical axis of the barrier to a maximum of 90 degrees. Use the following guidance to meet these recommendations. Note that this guidance is similar to what was found in the Memo to Designers (2011-02), which is now rescinded:

- For driving surfaces with a normal crown section, detail the barriers as plumb. See Figure 2 below.

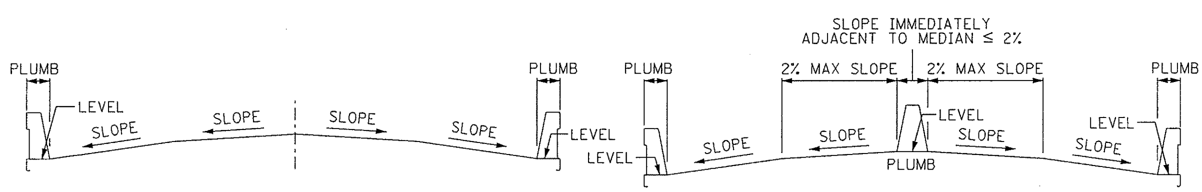


Figure 2

- For driving surfaces with a <u>constant</u> cross slope (superelevated roadway) <u>exceeding</u> 2%, detail the angle between the bridge deck/roadway and the vertical axis of the barrier so it does not exceed 90 degrees. See Figure 3 below.

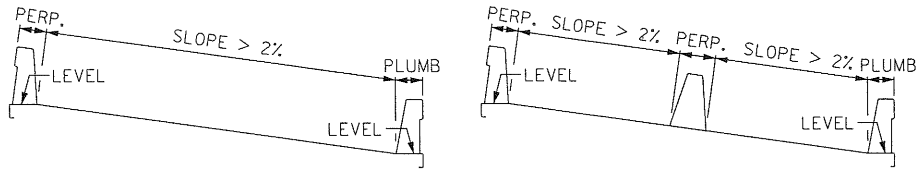
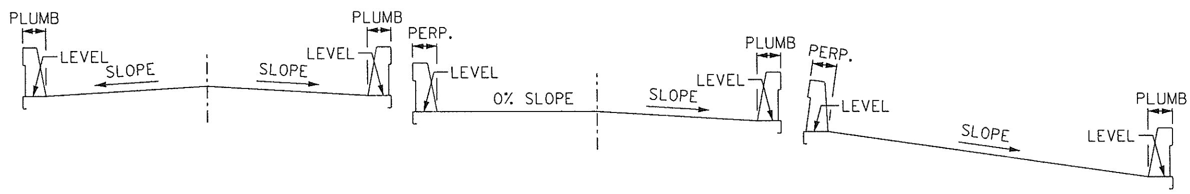


Figure 3

- For bridge decks with a variable or changing cross slope or superelevation, detail the angle between the bridge deck/roadway and the vertical axis of the barrier to transition from plumb to perpendicular (or vice versa) as shown in Figure 4. In this example, the cross section changes from a "normal" cross slope to a superelevated cross slope, so the left barrier transitions from plumb at the "normal" cross slope to perpendicular at 0% slope.



Normal Cross Slope | Changing Cross Slope | Full Superelevation

Figure 4

- As indicated by the examples above, the vertical position of the barrier axis varies depending on the adjacent driving surface slope; therefore, it is imperative that the bridge and roadway designer work together to ensure that design plans are coordinated and that the detailing on the bridge plan matches the roadway plan and vice versa. Consideration of the barrier axis must also be taken into account when the barrier is mounted on top of a wall or approach panel.

- Regardless of whether the barrier is mounted plumb or perpendicular to the roadway surface, the portion of the deck immediately under the barrier should remain level as is shown in the sketches above. An exception to this is solid median barriers on superelevated cross-slopes.

- Where the cross slope exceeds 2%, include barrier height dimensions for both the front and back face of barriers located at the top of the slope. In addition, revise the R501E, R502E, and R503E bars to provide a minimum front leg projection of 10 inches.

Deck Overhang Design

Deck overhang requirements are dependent on the overhang length and overhang location along the bridge.

- For deck overhangs that carry a Type S barrier (measured from centerline of beam to edge of deck) of up to 40% of the beam spacing, the BDM deck reinforcement tables 9.2.1.1 and 9.2.1.2 may be used for the interior overhang regions. For the exterior overhang regions (applies to regions where the longitudinal barrier reinforcement is discontinuous, such as end of bridge joints and expansion joints), the following modifications to the overhang reinforcement are necessary to meet NCHRP 350:
    - For the 36" Type S, provide #5 bars at 5" spacing or A_s = 0.74 in^2/ft for the top transverse bars over a distance of 8 feet from the joint. Include 180 degree standard hooks on the edge-of-deck ends of these bars. This can be accomplished either by providing hooked overhang bars that splice to the main transverse deck bars or by providing hooked transverse bars that run from edge to edge of the deck. Note that this only applies when the gutter line is located outside the edge of the fascia beam flange. For cases where the gutter line is located inside the edge of the fascia beam flange, provide reinforcement per the BDM deck reinforcement tables 9.2.1.1 and 9.2.1.2 with no modification.
    - For the 42" Type S where the deck consists of a 9" slab without a wearing course, include 180 degree standard hooks on the edge-of-deck ends of the top transverse bars over a distance of 9 feet from the joint. This can be accomplished either by providing hooked overhang bars that splice to the main transverse deck bars or by providing hooked transverse bars that run from edge to edge of the deck. For all other cases, provide reinforcement per the BDM deck reinforcement tables 9.2.1.1 and 9.2.1.2 with no modification. Also, note that for all cases where the gutter line is located inside the edge of the fascia beam flange, no modification is needed and reinforcement per the BDM deck reinforcement tables 9.2.1.1 and 9.2.1.2 can be provided.
    - For the 54" Type S, no modification is needed. Provide reinforcement per the BDM deck reinforcement tables 9.2.1.1 and 9.2.1.2.
    - BDM Figure 9.2.1 specifies an 8" minimum edge-of-deck thickness when the deck includes a wearing course, and a 9" minimum edge-of-deck thickness when there is not a wearing course. Where the "Deck Thickness" column in the BDM deck reinforcement tables 9.2.1.1 and 9.2.1.2 specifies a thickness greater than 9", increase the edge-of-deck thickness by the difference between the specified deck thickness and 9". For example, for a steel beam bridge with a 12'-0" beam spacing, BDM table 9.2.1.2 specifies a 9.75" deck thickness. If the bridge has a wearing course, use an edge-of-deck thickness of 8.75". If the bridge does not have a wearing course, use an edge-of-deck thickness of 9.75". Also note that for bridges with wingwalls oriented parallel to the roadway or that tie into a retaining wall, adjust the wingwall/retaining wall coping height as needed to match the edge-of-deck thickness. Consult

with the Bridge Office Architectural Specialist for guidance.

- For deck overhangs that require a special design, use the following guidance for checking the extreme event limit state.

  Design collision loads F_{cdes} and M_{cdes} will be needed to complete the deck overhang design. For each barrier height H, values for L_c, M_c, and R_w have been determined using the yield line method found in AASHTO LRFD Spec. Article A13.3.1. The TL-4 value of 54 kips for F_t was adjusted for the difference between the barrier height and height of F_t application. Then $4/3 \cdot F_t$ was compared to R_w, and the smaller value distributed over L_c + H for end regions and L_c + 2H for interior regions. Also, M_c was adjusted when $4/3 \cdot F_t$ governed. The results are the moments M_{cadj} and tension forces F_{cadj} given in Table 1 below.

	36" Type S		42" Type S		54" Type S	
	Exterior	Interior	Exterior	Interior	Exterior	Interior
M_{cadj} (k-ft/ft)	20.5	9.4	18.8	7.8	17.4	6.7
F_{cadj} (k/ft)	7.9	3.7	6.1	2.7	4.1	1.8

Table 1

In order to use these values, translate the moment M_{cadj} at the top of the deck to a moment M_{cdes} located at the center of the deck using the following method (refer to Figure 5):

$$e = M_{cadj} / F_{cadj}$$

$$F_{cdes} = F_{cadj}$$

$$M_{cdes} = F_{cdes} \cdot (e + 0.5 \cdot t_{deck})$$

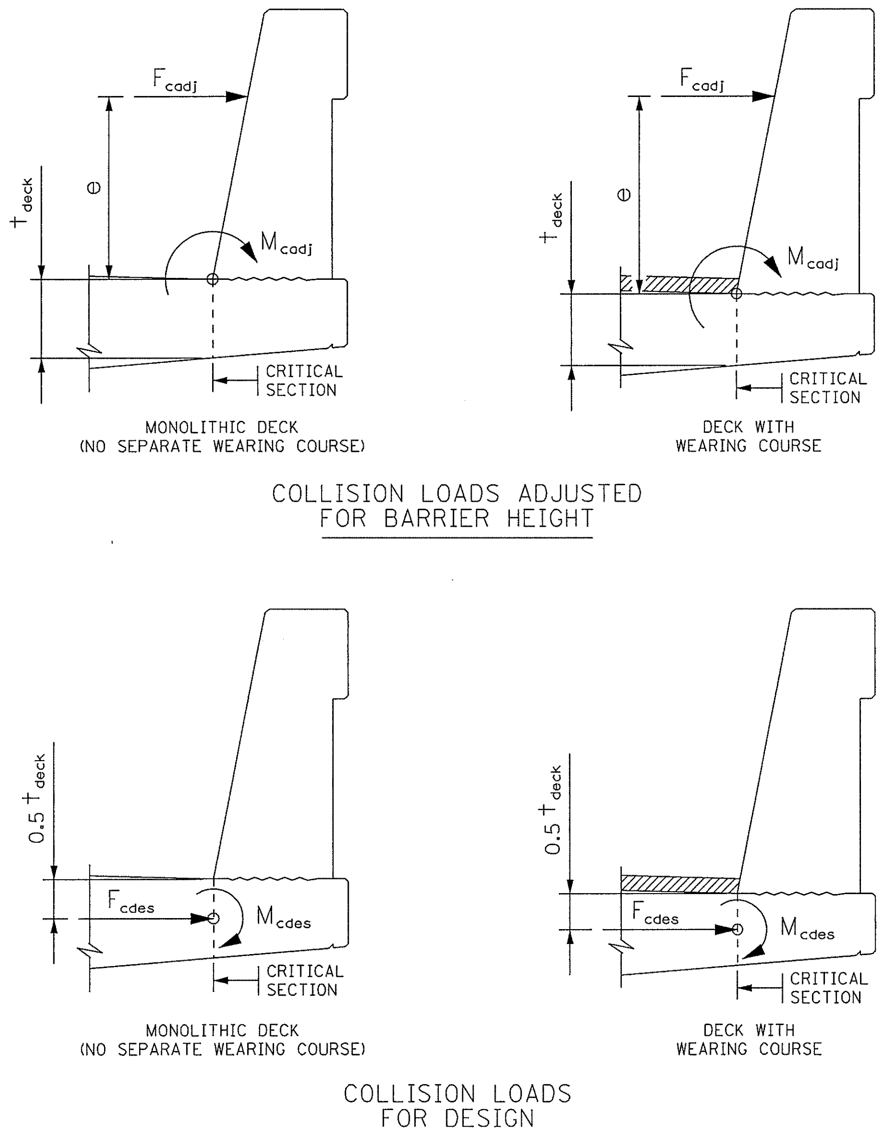


Figure 5

Use the tension force F_{cdes} and moment M_{cdes} as the collision loads for the deck overhang design.

Implementation

When to use the Type S barrier will depend on the project.

Use of the single slope bridge barrier is to begin immediately for the following:

- All new preliminary bridge plans for projects on trunk highways where the Type F barrier normally would be used. (The structural tube railing (T-1) and concrete parapet (P-4) will continue to be used where appropriate.)

- New final design bridge plans for projects on trunk highways where the Type S bridge barrier is shown in the preliminary bridge plan.
- Stand-alone new final design bridge plans for projects on trunk highways where Type F bridge barrier is shown in the preliminary bridge plan, but final design has not been started. An exception to this is bridges that connect to retaining walls, which will require coordination with the road designer on the decision regarding barrier type.
- Non-stand-alone new final design bridge plans for projects on trunk highways where Type F bridge barrier is shown in the preliminary bridge plan, but the roadway designer agrees to the use of Type S bridge barrier instead.

The decision on what type of barrier to use for bridge repair projects will be made on a case-by-case basis.

For local road bridge projects, it is recommended that designers immediately begin use of the single slope barrier in accordance with this memo. For questions, consult with the State Aid Bridge Unit.

Beyond the transition period to single slope barriers, Type F barrier should only be used on bridge repair projects.

Note that the Type F temporary portable precast concrete barrier (Standard Plate 8337) has been successfully crash tested to meet MASH TL-3, so it will not be replaced and can continue to be used where applicable.

If you have any questions, please contact Dave Dahlberg (dave.dahlberg@state.mn.us or (651) 366-4491) or me.

cc: Kevin Western
Dave Dahlberg
Dave Conkel/Local Bridge Design Consultants
Colleen Lichtsinn/Bridge Design Consultants