Washington State Department of Transportation
Bridge and Structures Office

Design Memorandum

TO: All Design Section Staff
FROM: Amy Leland
DATE: December 20th, 2023
SUBJECT: WSDOT roadside safety hardware and barrier update
NUMBER: 2023-05

This design memorandum provides revisions to the Bridge Design Manual M 23-50.22 and shall be considered active after the date of this memorandum. This memorandum provides revisions to align with construction clearances in the Design Manual, to provide clarity on minimum height requirements per test level of rigid barriers, to update and incorporate revised metrics for concrete barrier at the TL-4 level, as well as to update related elements such as moment slab design for TL-4 test levels in relation to the other changes.

Bridge Design Manual Revisions

The following sections of the WSDOT Bridge Design Manual are revised as follows:

Revise Section 2.3.9 with:

2.3.9 Construction Clearances

The third paragraph of this section shall be modified with the following:

The horizontal dimension of the falsework or construction opening shall be measured normal to the alignment of the road which the falsework spans. The horizontal dimension of the falsework or construction opening shall be the sum of the temporary traffic lane widths and shoulder distances, plus two 2′ widths for the temporary unanchored concrete barriers, plus additional 3′ deflection distances behind the temporary barriers. For multi-span falsework openings, a minimum of 2′, and preferably 4′, shall be used for the interior support width. This interior support shall also have a 2′ lateral distance to the traffic side and 3′ on the back side of the two 2-foot-wide temporary concrete barriers that will flank the interior support.

Replace Section 7.6.1 with:

7.6.1 Traffic Barrier Loads

This section shall be replaced with the following:

Traffic barriers shall be rigidly attached to a bridge approach slab or moment slab that is cantilevered over the top of a wing/curtain wall or Structural Earth wall. The barrier

collision load is applied directly to the bridge barrier with load path through the bridge approach or moment slab. ~~The yield line theory as specified in AASHTO LRFD Appendix A13.3 is primarily for traffic barrier on bridge deck slabs and may not be applicable to traffic barrier on less rigid supports, such as retaining walls.~~

Revise Section 8.1.4.B.3 with:

8.1.4.B.3 Application of Collision Loads

The second paragraph of this section shall be revised with the following:

As shown in Figures 8.1.4-3 and 8.1.4-4, the collision force (CT, F_t) is assumed to be distributed over the longitudinal length (L_t) at the top of the traffic barrier and is assumed to distribute downward to the top of the footing at a 45 degree angle. See LRFD-BDS Table A13.2-1 for L_t and F_t values, except the TL-4 design metrics for concrete traffic barriers provided in LRFD-BDS Table A13.2-1 shall be replaced with the TL-4 design metrics provided in Table 10.2.4-1. The distribution of the collision force in the footing shall be the distance between expansion joints.

Revise Section 8.2.2 with:

8.2.2 Loads

This section shall be supplemented with the following:

Vehicular collision forces shall be in accordance with LRFD-BDS Article 15.8.4 except the TL-4 design metrics for concrete traffic barriers provided in LRFD-BDS Table A13.2-1 shall be replaced with the TL-4 design metrics provided in Table 10.2.4-1.

Revise Section 8.3.3B with:

8.3.3.B Application of Loads

This section shall be supplemented with the following:

Where applicable, vehicular collision forces shall be in accordance with LRFD-BDS Section 13 and Appendix A13 except the TL-4 design metrics for concrete traffic barriers provided in LRFD-BDS Table A13.2-1 shall be replaced with the TL-4 design metrics provided in Table 10.2.4-1.

Revise Section Appendix8.1-A1 with:

Appendix 8.1-A1 Summary of Design Specification Requirements for Walls

Wall Type "Soldier Pile Walls With and Without Tiebacks" subsection "traffic barrier" shall be revised with following:

WSDOT BDM and the AASHTO LRFD-BDS ~~Bridge Design Specifications~~ Section A13.3 for Concrete Railings considering a minimum TL-4 impact load. Ft is distributed over Lt at the top of barrier. Load from top of barrier is distributed downward into the wall spreading at a 45 degree angle.

Revise Section 10.1.1.H with:

10.1.1.H Impact Loads General Guidelines

The first paragraph of this section shall be revised with the following:

Vehicle impact loads shall be applied to sign, luminaire and traffic signal foundations that are integrated into roadside traffic barriers. The vehicle impact loads shall be applied at the height specified for intended test levels in accordance with the AASHTO LRFD-BDS Section 13 Table A13.2-1 "Design Forces For Traffic Railing (32-inch for TL-4 and 42-inch for TL-5)" as modified by BDM Section 10.2.4.

Revise Section 10.2.1 with:

10.2.1 General Guidelines

The fifth paragraph of this section shall be revised and the section supplemented with the following:

The WSDOT Bridge and Structures' standard for traffic barriers on new bridges, bridge approach slabs, Buried Structures, retaining walls, and ~~Geosynthetic wall~~ Moment Slab Traffic Barrier and differential grade median traffic barriers shall be a 42-inch Single Slope concrete barrier for all Interstate, United States Numbered Highway System, and State highway routes unless special conditions apply. The 42-inch height is for worker fall protection in accordance with WAC 296-880 and as described in the Design Manual Chapter 1060.

Class 1 Buried Structures may use a barrier or railing system in accordance with the Design Manual M 22-01 Chapter 1610. Buried Structures which employ a barrier or railing which is not on an approach slab, moment slab, bearing directly on the Buried Structure lid, or structurally integral with the Buried Structure or other structures may use a barrier or railing system in accordance with Design Manual M 22-01 Chapter 1610.

All rigid barriers (such as a concrete barrier) shall meet the following requirements in relation to test level.

1. Adequate height to contain the crash test vehicle(s).
2. Has a crashworthy shape.
3. Barrier is determined to be structurally rigid by crash testing or structural analysis.

Adequate height is defined as a minimum of 42", 36", and 32" for TL-5, TL-4, and TL-3 respectively. The heights for TL-5 and TL-4 are from the November 2017 Project No 20-07/Task 395 TTI Project 607141 "Mash Equivalency of NCHRP Report 350-Approved Bridge Railings" Table 4.1, the height for TL-3 is informed by guidance and recommendations from Texas Transportation Institute (TTI) through Pooled Fund correspondence. Placement of hot mix asphalt (HMA) or other material reducing the reveal height below these values downgrades the barriers test level.
For the 32" barrier height, a vertical faced concrete barrier, similar to WSDOT pedestrian barrier, may be used as TL-3 with a minimum height of 29" when competing interests exist (such as site distance).

Revise Section 10.2.3.A with:

10.2.3.A Service Level 1 (SL-1) Weak Post Guardrail (TL-2)

The following additions shall be made.

This system is limited to WSDOT internal use only.

Revise Section 10.2.3.F with:

10.2.3.F Traffic Barrier – 42" and 45" F-Shape (TL-4 and TL-5)

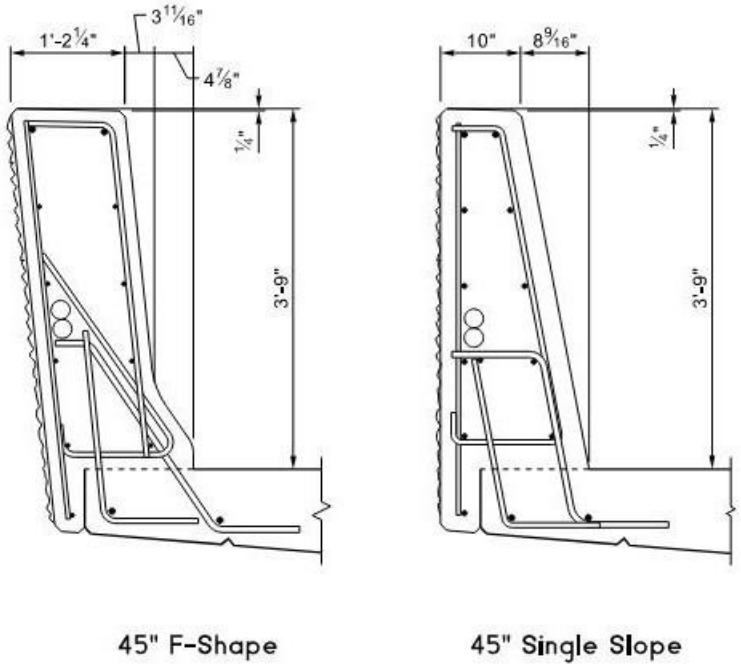
Revise Section 10.2.3.G with:

10.2.3.F Traffic Barrier – 42" and 45" Single Slope (TL-4 and TL-5)

The following revisions and additions shall be made.

This option offers a simple to build alternative to the Shape F configuration. For complete details see Bridge Standard Drawing 10.2-A6 and Standard Plan C81.10 ~~10.2-A7~~.

Figure 10.2.3-4



Revise Section 10.2.4 with:

10.2.4 Design Criteria

10.2.4.A Design Values

The following modifications and additions shall be made.

AASHTO LRFD-BDS Appendix A13, as modified by the BDM, shall be used to design bridge traffic barriers and their supporting elements (i.e. the deck).

All concrete TL-4 barriers and their supporting structures shall employ design metrics from the following table 10.2.4-1 which governs over AASHTOLRFD-BDS table A13.2-1.

Table 10.2.4-1

TL-4 Concrete Barrier Design Parameters				
Design Parameters	Barrier Reveal Height (in.)			
	36	39	42	>45
Impact Force, F_t (kips)	67.2	72.3	79.1	93.3
Friction Force, F_L (kips)	21.6	23.6	26.8	27.5
Vertical Force, F_v (kips)	37.8	32.7	22.0	N/A
Length of Force, L_t and L_L (ft)	4.0	5.0	5.0	14.0
Effective Load Height, H_e (in.)	25.1	28.7	30.2	45.5

N/A – Not Applicable

Values for intermediate heights between 36" and 42" may interpolate between the values in the table. The 42" height values may be used for reveal heights up to 45".

Concrete traffic barriers shall be designed using yield line analysis as described in AASHTO LRFD-BDS A13.3.1. The impact loads on traffic barriers shall be applied at the height specified for intended Test Levels in accordance ~~to~~ with the AASHTO LRFD-BDS Table A13.2-1 "Design Forces for Traffic Railing", as modified in this section. WSDOT Standard F Shape, Single Slope, and Pedestrian barriers meet these requirements.

Deck overhangs supporting traffic barriers shall be designed in accordance with AASHTO LRFD-BDS A13.4 as modified in this section. For concrete traffic barriers in Design Case 1, AASHTO requires MS, the deck overhang flexural resistance, to be greater than Mc of the concrete traffic barrier base. This requirement is consistent with yield line analysis (see AASHTO LRFD-BDS CA13.3.1), but results in over conservative deck overhang designs.

In order to prevent this unnecessary overdesign of the deck overhang, the nominal traffic barrier resistance to transverse load RW (AASHTO LRFD-BDS A13.3.1) transferred from the traffic barrier to deck overhang shall not exceed 120 percent of the design force Ft (AASHTO LFRD-BDS Table A13.2-1 & BDM Table 10.2.4-1) required for a traffic barrier. The deck overhang shall be designed in accordance with the requirements of AASHTO LRFD-BDS A13.4.2 to provide a flexural resistance Ms, acting coincident with the tensile force T. At the inside face of the barrier Ms may be taken as:

The remainder of this section, not reproduced here, remains unchanged except as noted.

When an HMA overlay is required for initial construction, increase the ~~weight~~ height for ~~Shape F~~ traffic barrier. See Section 10.2.4.C for details.

Replace Section 10.2.4.B with:

10.2.4.B Geometry

The following replaces 10.2.4.B.

The traffic face geometry is part of the crash test and shall not be modified. A single slope face is the WSDOT standard, see section 10.2.1. Contact the WSDOT Bridge and Structure Office Bridge Rail Specialist for further guidance.

Thickening of the traffic barrier is permissible for architectural reasons. Architectural modifications to continuous runs of barrier should not significantly increase the stiffness of the barrier. Thickening which does significantly increase the stiffness should be limited to localized areas associated with the architectural feature. All unique features, modifications, or barriers require design inclusive of load path to connected element. Concrete clear cover must meet minimum concrete cover requirements but can be increased to accommodate rustication grooves or patterns.

Thickening of the traffic barrier is permissible to accommodate roadside features such as sign bridges, luminaires, or similar elements. See section 10.2.1 for process for acceptance for use within the state of Washington.

Revise Section 10.2.4.C with:

10.2.4.C Standard Detail Sheet Modifications

The following modifications and additions shall be made.

When designing and detailing a bridge traffic barrier on a superelevated bridge deck the following guidelines shall be used:

- For bridge decks with a superelevation of 8 percent or less, the traffic barriers (and the median barrier, if any) shall be oriented perpendicular to the bridge deck.
- For bridge decks with a superelevation of more than 8 percent, the traffic barrier on the low side of the bridge (and median barrier, if any) shall be oriented perpendicular to an 8 percent superelevated bridge deck. For this situation, the traffic barrier on the high side of the bridge shall be oriented perpendicular to the bridge deck.

Type F safety shape notes:

- The toe of the barrier, defined as the vertical portion of the traffic facing side of the barrier, shall be a maximum of 3" when exposed to traffic.
- Overlays shall not rise higher than the barrier toe, the toe of the barrier may be covered by a future overlay.
- Use of barrier toes >3" to account for an overlay present from day 1 open to traffic require unique design for the barrier and deck connection.

The standard detail sheets are generic and may need to be modified for each project. See section 10.2.1 for the process for unique modifications. The permissible modifications are:

- Removal of the electrical conduit, junction box, and deflection fitting details.
- Removal of design notes.
- ~~If the traffic barrier does not continue on to a wall, remove W1 and W2 rebar references.~~ Removal of non-applicable elements such as

transitions not used or barrier on wall or other supporting structure not present in the project.

- ~~Removal of the non-applicable guardrail end connection details and verbiage.~~
- ~~If guardrail is attached to the traffic barrier, use either the thrie beam end section "Design F" detail or the w-beam end section "Design F" detail. If the traffic barrier continues off the bridge, approach slab, or wall, remove the following:~~
- ~~Guardrail details from all sheets.~~
- ~~Conduit end flare detail.~~
- ~~Modified end section detail and R1A or R2A rebar details from all sheets.~~
- ~~End section bevel.~~
- Increase the 3" toe dimension of the Shape F traffic barriers up to 6" to accommodate HMA overlays present on day 1 open to traffic.

Revise Section 10.2.4.D with:

10.2.4.D Miscellaneous Design Information

The following modifications and additions shall be made.

- Show the back of pavement seat in the "Plan – Traffic Barrier" detail.
- At roadway expansion joints, show traffic barrier joints normal to centerline except as shown on sheets Appendix 9.1-A1-1 and 9.1-A2-1.
- When an overlay is required or intended, the adequate height to contain the test vehicle from BDM section 10.2.1 shall be provided in the post overlay condition, or the barrier does not qualify for the given test level. ~~, the 2'-8" minimum dimension shown in the "Typical Section – Traffic Barrier" shall be referenced to the top of the overlay.~~
- When bridge lighting, sign bridges, or other appurtenances are a ~~is~~ part of the contract, include the associated details and connection sheets. ~~The lighting bracket anchorage detail sheet.~~
- Approximate quantities for the traffic barrier sheets on an 8" thick deck including the tail and a representative ½" of concrete for the fractured fin finish are:

~~Barrier Type~~	~~Concrete Weight (lb/ft)~~	~~Steel Weight (lb/ft)~~
~~32" F-shape (3" toe)~~	~~460~~	~~18.6~~
~~32" F-shape (6" toe)~~	~~510~~	~~19.1~~
~~34" Single Slope~~	~~490~~	~~16.1~~
~~42" F-shape (3" toe)~~	~~710~~	~~25.8~~
~~42" F-shape (6" toe)~~	~~765~~	~~28.4~~
~~42" Single Slope~~	~~670~~	~~22.9~~
~~32" Pedestrian~~	~~640*~~	~~14.7~~

Barrier Type	Weight (lb/ft)	$\bar{x}$ (in)*
32″ F-shape (3″ toe)	481	4.12
34″ Single Slope	517	5.80
42″ F-shape (3″ toe)	734	4.91
42″ Single Slope	703	6.61
45″ F-shape (3″ toe)	782	4.75
45″ Single Slope	764	6.80
32″ Pedestrian	640**	

Using concrete class 4000 with a unit weight of 155 lb/ft^3

* $\bar{x}$ is measured from the back face of barrier or for type f the back face of barrier at deck level.

**with 6″ sidewalk, will vary with sidewalk thickness, legacy numbers from prior calc.

- Steel Reinforcement Bars:

  S_1 & S_2 or S_3 & S_4 and W_1 & W_2 bars (if used) shall be included in the Bar List. S_1, S_3, and W_1 bars shall be epoxy coated.

The following table is renamed from 10.2.4-1 to 10.2.4-2 and replaced in its entirety. (note, old redacted table not listed, yet removed from the BDM)

Table 10.2.4-2

Barrier Impact Design Forces on Traffic Barrier & Deck Overhang													
Parameters		Type F 32 in. (TL-3)[1]		Single Slope 34 in. (TL-3)[1]		Type F 42 in.[3] (TL-4)		Single Slope 42 in.[3] (TL-4)		Type F 45 in. (TL-5)		Single Slope 45 in. (TL-5)	
		Interior	End[2]	Interior	End[2]	Interior	End[2]	Interior	End[2]	Interior	End[2]	Interior	End[2]
Standard Reference		10.2-A1-1 to 3		10.2-A3-1 to 3		10.2-A5-1A to 3		C-81.10		10.2-A5-1 to 3		10.2-A6-1B to 3	
Traffic Barrier Design	Average M_c (ft-kips/ft)	20.62	20.62	19.39	19.39	26.02	26.02	22.49	22.49	25.95	25.95	23.08	37.12
	M_c at Base (ft-kips/ft)	27.24	27.24	26.11	26.11	32.97	32.97	30.76	30.76	32.97	32.97	31.94	51.61
	M_w (ft-kips)	42.61	46.23	46.29	43.42	72.96	72.14	54.77	53.02	98.41	97.11	83.97	81.34
	L_c (ft)	8.62	4.76	9.62	5.22	11.71	6.49	11.13	6.31	15.39	9.48	15.19	8.92
	R_w (kips)	133.24	73.56	131.72	71.41	174.05	96.55	143.02	81.08	213.04	131.22	186.96	176.61
	F_t (kips)	54.00	54.00	54.00	54.00	79.10	79.10	79.10	79.10	124.00	124.00	124.00	124.00
	H_e (in)	[5]	[5]	[5]	[5]	30.20	30.20	30.20	30.20	[5]	[5]	[5]	[5]
	L_t and L_L (ft)	[5]	[5]	[5]	[5]	5.00	5.00	5.00	5.00	[5]	[5]	[5]	[5]
Deck Overhang Design	1.2*F_t (kips)	64.80	64.80	64.80	64.80	94.92	94.92	94.92	94.92	148.80	148.80	148.80	148.80
	Design R_w (kips)	64.80	64.80	64.80	64.80	94.92	94.92	94.92	81.08	148.80	131.22	148.80	148.80
	R_w*H_e/(L_c+aH) (ft-kips/ft)[4]	12.39	23.28	11.30	21.47	12.77	23.90	18.33	28.93	22.75	34.71	22.96	41.10
	Design M_s (ft-kips/ft)	12.39	23.28	11.30	21.47	12.77	23.90	13.19	20.79	22.75	32.97	22.96	41.10
	Design T (kips/ft)	4.65	8.73	4.24	8.05	5.07	9.50	5.24	8.26	6.50	9.92	6.56	11.74
Deck to Barrier Reinf.	A_s required (in^2/ft)	0.29	0.57	0.27	0.53	0.23	0.43	0.27	0.43	0.41	0.61	0.45	0.83
	A_s provided (in^2/ft)[6]	0.41	0.62	0.41	0.62	0.41	0.62	0.28	0.53	0.59	0.88	0.66	0.96
	S_1 Bars[6]	#5 @ 9 in	#5 @ 6 in	#5 @ 9 in	#5 @ 6 in	#5 @ 9 in	#5 @ 6 in	#5 @ 13.5 in	#5 @ 7 in	#6 @ 9 in	#6 @ 6 in	#6 @ 8 in	#6 @ 5.5 in

[1]These barriers are downgraded to TL-3 due to insufficient height to contain the test vehicle. Their design is based on TL-4 metrics from AASHTO chapter 13 and A13.
[2]Traffic barrier dimensions and reinforcement used for calculation reflect WSDOT standard drawings or standard plans. Modifications shall be calculated per AASHTO-LRFD Chapter 13, A13, and the WSDOT BDM.

[3]TL-4 barriers are designed to the updated forces from WSDOT BDM Chapter 10, which governs over AASHTO Chapter 13 for these barriers.

[4]a = 1 for an end segment and 2 for an interior segment.

[5]AASHTO Table A13.2-1 with H_e taken as H_e (min).
[6]S1 bar spacing and As provided are presented for fully developed bars.
Loads are based on vehicle impact only. For deck overhang design, the designer must incorporate dead load as well as check other limit states per LRFD A13.4.1.

f_y = 60 ksi; f'c = 4 ksi

Revise Section 10.3.1A with:

10.3.1A Differential Grade Concrete Barriers

The following modifications and additions shall be made, content not reproduced here remains unchanged.

3. Vehicle impact loads shall be applied on the side of the concrete barrier retaining soil if there is traffic on both sides. The vehicle impact loads shall be applied at the height specified for intended Test Levels in accordance to the AASHTO LRFD-BDS Section 13, Table A13.2-1 "Design Forces for Traffic Railing (32-inch for TL-4, and 42-inch for TL-5)" as modified by section 10.2.4.

4. For soil loads with vehicle impact loads, the AASHTO LRFD-BDS Extreme Event loading for vehicular collision shall also be analyzed. Equivalent Static Load (ESL) per NCHRP Report 663 may be applied as the transverse vehicle impact load for evaluating sliding, bearing, and overturning only. For TL-3 barrier systems, the ESL shall be 10 kips, for TL-4 barrier systems, the ESL shall be 15 kips, and for TL-5, the ESL shall be 23 kips. The point of rotation for overturning shall be taken at the toe of barrier. Sliding resistance factor shall be 0.8 and overturning resistance factor shall be 0.5 (supersedes AASHTO 10.5.5.3.3).

Traffic barriers supporting a soil height greater than 4'-0" shall be designed as reinforced concrete retaining walls with a traffic barrier at the top and a barrier shape at the cut face. For external stability, the full loadings for the Extreme Event Limit State from AASHTO LRFD-BDS, Section 13 are applicable as modified by BDM section 10.2. When using these AASHTO loadings the associative phi factors from AASHTO are applicable. These provisions do not waive any requirements for walls or barriers from other codes, manuals, or sources.

Revise Section 10.3.2 heading as follows:

~~**10.3.2. Traffic Barrier Moment Slab**~~

10.3.2. Moment Slab Traffic Barrier

Revise Section 10.3.2.A with:

10.3.2.A General

The following modifications and additions shall be made, content not reproduced here remains unchanged.

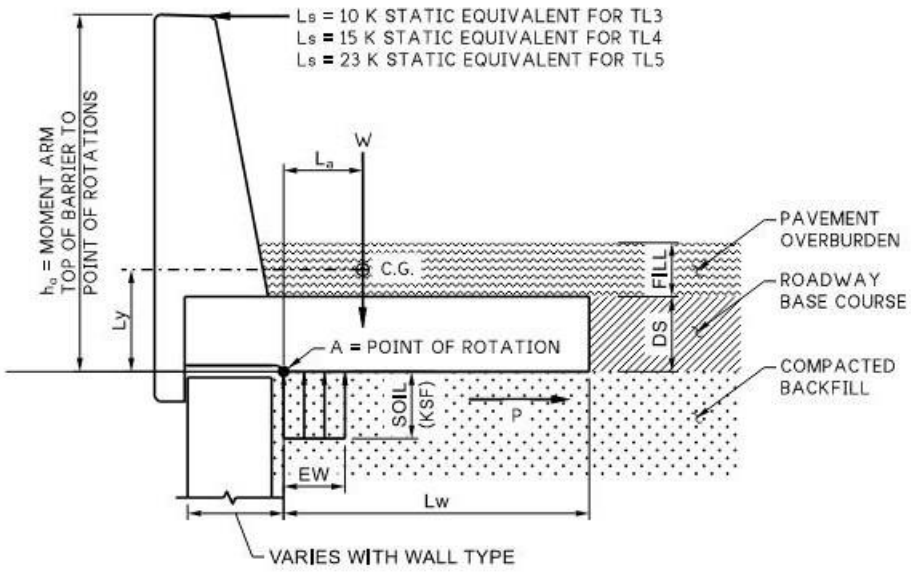
The guidelines provided herein are based on NCHRP Report 663, FHWA/TX-12/9-1002-5, input from Texas Transportation Institute (TTI) on past WSDOT Standards, calculations, and engineering judgement. A resistance factor of 0.5 shall be used to determine rotational resistance. This guideline is applicable for TL-3, TL-4 and TL-5 barrier systems as defined in Section 13 of AASHTO LRFD-BDS ~~*Bridge Design Specifications.* Traffic Barrier~~ Moment Slab~~s~~ Traffic Barriers shall employ a current

concrete traffic barrier from BDM Section 10.2.3.

The options included in standard plan C81.15 are limited to cast in place slab applications.

Figure 10.3.2-1 is replaced with the following:

Figure 10.3.2.-1 Global Stability of Moment Slab Barrier System



GLOBAL STABILITY OF BARRIER - MOMENT SLAB SYSTEM

Replace Section 10.3.2.B.1 with:

10.3.2.B.1 Structural Capacity

The following replaces this section in its entirety.

The structural capacity of the barrier and concrete moment slab shall be designed using impulse loads at appropriate Test Level ~~(TL-4 and TL-5)~~ applied to the top of the barrier, as shown in figure 10.3.2-1 and in accordance with Sections 5 and 13 of AASHTO LRFD-BDS. For strength design the impact force, F_t, is applied at H_e. Any section along the moment slab shall not fail in shear, bending, or torsion when the barrier is subjected to the design impact loads. The torsion capacity of the moment slab must be equal to or greater than the traffic barrier moment generated by the specified TL static equivalent of the vehicle impulse load.

The moment slab shall be designed as a deck supporting barrier in accordance to AASHTO LRFD-BDS A13.4.2 as modified by BDM Section 10.2.4.A. The moment slab reinforcement shall be designed to resist combined forces from the moment M_S (kip-

ft/ ft) and the tensile force T (kip/ft). M_S and T are determined from the lesser of the ultimate transverse resistance of barrier R_W (kip) and 120 percent of transverse vehicle impact force F_T (kip). M_S is not to be exceeded by the ultimate strength of barrier at its base M_C (kip-ft/ft).

Replace Section 10.3.2.B.2 with:

10.3.2.B.2 Global Stability

The following replaces this section in its entirety.

Bearing stress, sliding, and overturning stability of the moment slab shall be based on an Equivalent Static Load (ESL) applied at the top of the barrier as shown in figure 10.3.2-1. ~~Height specified for intended Test Levels in accordance to the AASHTO LRFD Section 13, Table A13.2-1 "*Design Forces for Traffic Railing*".~~ For ~~TL-4~~ TL-3 barrier systems, the ESL shall be 10 kips. For TL-4 barrier systems, the ESL shall be 15 kips. For TL-5 barrier systems, the ESL shall be 23 kips.

The Equivalent Static Load (ESL) is assumed to distribute over the length of continuous moment slab through rigid body behavior. Barrier shall also be continuous or have shear connections between barrier sections if precast throughout this length of moment slab. Any coupling between adjacent moment slabs or friction that may exist between free edges of the moment slab and the surrounding soil ~~should~~ shall be neglected.

Revise Section 10.3.2.B.4 with:

10.3.2.B.4 Sliding of the Barrier

The following modifications and additions shall be made, content not reproduced here remains unchanged.

Ls = Equivalent Static Load (10 kips for TL-3, ~~or~~ 15 kips for TL-4, and 23 kips for TL-5)

Revise Section 10.3.2.B.5 with:

10.3.2.B.5 Overturning of the Barrier

The following modifications and additions shall be made, content not reproduced here remains unchanged.

A = point of rotation, where the toe of the moment slab makes contact with compacted backfill adjacent to the fascia wall, or end of slab neglecting barrier tail for on grade applications.

Ls = Equivalent Static Load (10 kips for TL-3, ~~or~~ 15 kips for TL-4, and 23 kips for TL-5)

Revise Section 10.4.1

10.4.1 Policy

The following addition shall be made.

This section is applicable to modifications of structures and structural components in the barrier load path associated with barrier retrofit, rehabilitation, modification, repair, and/or replacements other than complete replacements for structures within the applicable timeframe, those constructed prior to the year 2000.

Revise Section 10.14

10.14 Bridge Standard Drawings

The following modifications and additions shall be made. Note hyperlinks not included herein, not intended for redaction.

Traffic Barriers

10.2-A5-1A Traffic Barrier Shape F 42″~~,~~ (TL-4) 1 of 3
10.2-A5-1B Traffic Barrier Shape F ~~42~~45″~~,~~ (TL-5) 1 of 3
10.2-A5-2 Traffic Barrier Shape F 42″~~,~~ (TL-4 or TL-5) 2 of 3
10.2-A5-3 Traffic Barrier Shape F 42″~~,~~ (TL-4 or TL-5) 3 of 3

~~10.2-A6-1A Traffic Barrier - Single Slope 42 TL4 1 of 3 (PDF 149KB) (DWG 215KB)~~

~~10.2-A6-1B Traffic Barrier - Single Slope 42 TL5 1 of 3 (PDF 89KB) (DWG 75KB)~~

~~10.2-A6-2A Traffic Barrier - Single Slope 42 2 of 3 (PDF 89KB) (DWG 66KB)~~
~~10.2-A6-3 Traffic Barrier - Single Slope 42 3 of 3 (PDF 95KB) (DWG 134KB)~~

10.2-A6-1 Traffic Barrier - Single Slope 45″ TL5 1 of 3
10.2-A6-2 Traffic Barrier - Single Slope 45″ TL5 2 of 3
10.2-A6-3 Traffic Barrier - Single Slope 45″ TL5 3 of 3

The following Section shall be added 10.15

10.15 Bridge Standard Plans

Traffic Barriers

C81.10 42″ Single Slope Barrier on Structure (TL-4)

C81.15 Moment Slab Traffic Barrier 42″ Single Slope (TL-4)

Replace Section 15.10.3.A.1 with:

15.10.3.A.1 Structural Capacity

The following replaces this section in its entirety.

The structural capacity of the traffic barrier moment slab shall be designed for the required TL impact forces in accordance with LRFD-BDS Chapters 5 and 13 as modified by Section 10.2.4.A. The minimum Test Level shall be TL-4.

Any section along the moment slab shall not fail in shear, bending, or torsion when the barrier is subjected to the TL impact forces.

The moment slab reinforcement shall be designed to resist forces developed at the base of the barrier. Moment slab supporting concrete barrier shall be designed in accordance to Deck Overhang Design in accordance with LRFD-BDS Section A13.4 as modified by Section 10.2.4.A.

The torsion capacity of the moment slab shall be equal to or greater than the traffic barrier moment generated by the TL impact forces.

Replace Section 15.10.3.A.2 with:

15.10.3.A.2 Global Stability

The following replaces this section in its entirety.

See Section 10.3.2.B.2 through Section 10.3.2.B.5.

Revise Section 15.10.4.A with:

15.10.4.A General Guidelines and Policy

The following addition shall be made.

This section is applicable to modifications of structures and structural components in the barrier load path associated with barrier retrofit, rehabilitation, modification, repair, and/or replacements other than complete replacements for structures within the applicable timeframe, those constructed prior to the year 2000.

Background

The WSDOT Design Manual updated construction clearances which are reflected in the BDM updates in chapter 2.

WSDOT has an internal procedure to determine the crashworthiness of roadside safety hardware following the AASHTO/FHWA Joint Implementation Agreement for the AASHTO Manual for Assessing Safety Hardware (MASH). As a part of this internal procedure periodic review of literature, crash tests, pooled fund projects, as well as state of practice on roadside safety hardware are conducted with elements considered for adoption or existing requirements or inventory clarified, modified, or expanded upon. The updates concerning the minimum height to contain the tested vehicle are brought to the fore and included explicitly in section 10.2.1.

With the creation of standard plans C81.10 42" Single Slope Traffic Barrier and C81.15 Moment Slab Traffic Barrier 42" Single Slope, WSDOT has adopted revised design metrics for all TL-4 concrete barrier applications. The revised metrics are from FHWA/TX-12/9-1002-5 which references Bligh et. All NCHRP Project 22-20(02).

Table 2. TL-4 Impact Force Variation with Barrier Height [19]

Design Parameter	Barrier Height (in.)			
	36	39	42	Tall
Impact Force, F_t (kips)	67.2	72.3	79.1	93.3
Friction Force, F_L (kips)	21.6	23.6	26.8	27.5
Vertical Force, F_v (kips)	37.8	32.7	22.0	N/A
Length of Forve, L_t and L_L (ft)	4	5	5	14
Effective Load Height, H_e (in.)	25.1	28.7	30.2	45.5

N/A – Not Applicable

Excerpt from FHWA/TX-12/9-1002-5:

https://mwrsf.unl.edu/researchhub/files/Report433/TRP-03-415-21.pdf

Table 3-1 Summary of magnitude, distribution and application of the MASH TL-4 impact loads.

Design Forces and Designations	Barrier Height (in)			
	36	39	42	Tall
F_t Transverse (kip)	67.2	72.3	79.1	93.3
F_L Longitudinal (kip)	21.6	23.6	26.8	27.5
F_v Vertical (kip)	37.8	32.7	22	N/A
L_L (ft)	4	5	5	14
H_e (in)	25.1	28.7	30.2	45.5

N/A= not applicable

Excerpt from NCHRP Project 22-20(02) Web-Only Document 326

https://www.trb.org/Main/Blurbs/182752.aspx

These revised metrics are now employed for all concrete TL-4 applications, however steel barriers (such as OR 3-tube) as well as other test levels remain unchanged. Steel barriers were outside of the scope of the NCHRP Project 22-20(02), TL-5 revised metrics were available. The use of barriers other than concrete TL-4 are not common, and the updated higher metrics are not currently required by AASHTO. By employing the targeted update WSDOT bridge office brings our standard practice for the most commonly used elements into forward compatibility while balancing our limited budgets and bandwidths for updates.

The table is adjusted slightly to allow the 42" reveal height values to be used up to 45" in order to accommodate construction tolerances, architectural tolerances (for pleasing to the eye profile or other), as well as forward compatibility with up to a 3" overlay while still meeting the 42" worker fall protection absent the need for a redesign.

TL-5 barriers, Single Slope and Type F, have been adjusted to be 45" in order to allow for future 3" overlay without downgrading the test level associated with reveal height inadequacies. Use notes for Type F safety shape have been added. Type F TL-4 barrier has been designed to the revised metrics with associated values in the table 10.2.4-2 updated to reflect these changes.

Revisions to the moment slab design were conducted based upon the revised metrics from FHWA/TX-12/9-1002-5, WSDOT past and current practice, NCHRP 663, past Texas Transportation Institute (TTI) input on WSDOT moment slabs (D-3.15-02 since redacted due to height not meeting TL-4 metrics), calculations, and engineering judgement. The Equivalent Static Load (ESL) was scaled up proportionately from 10 kips at Ft=54 kips from NCHRP 663 to 15 kips at Ft=79.1 kips associated with a 42" reveal height which matches the newly created standard plan C81.10 42" Single Slope Traffic Barrier. These are paired with WSDOT currently policy of employing phi=0.8 for sliding and phi=0.5 for overturning. This 15 kip ESL is employed for all TL-4 traffic barriers or associated elements (such as traffic barrier retaining walls) by WSDOT policy and this BDM Memorandum. A crash tested system, TXDOT 0-6968-R7, which was referenced by TTI in WSDOT input, was used as a comparison and corollary. The comparison found WSDOT C81.15 moment slabs of approximately the same dimensions, 20ft long and 12" thick slab, are around twice as massive with close to quadruple the overturning resistance, albeit employ a higher reveal height, 42" compared to 36", and no requirement for soil embedment. A review by Bridge office staff, found the configurations in C81.15 accepted for use within the state of Washington in accordance with WSDOT policy on crashworthiness of roadside safety hardware (CRSH) concerns.

https://static.tti.tamu.edu/tti.tamu.edu/documents/0-6968-R7.pdf

The more recent NCHRP Web-Only Document 326, "Design Guidelines for Test Level 3 through Test Level 5 Roadside Barrier Systems Placed on Mechanically Stabilized Earth Retaining Walls", 2022 which resulted from NCHRP Project 22-20(02) was not used in the formulation of the calculations, policy, or standards reflected herein, however has been reviewed in relation to WSDOT detailing and practice for TL-4 applications, TL-3 and TL-5 test levels are beyond the scope of this update. There are differences in approach from load factor and phi factors, in essence WSDOT ESL=15 kips with phi=0.8 slide and phi=0.5 overturn result in an ESL/phi= 18.75 kips slide and 30 kips overturning. Document 326 recommends load and phi factors of 1 with an ESL of 28 kips for TL-4 applications. The WSDOT design is more conservative from an overturning standpoint, yet less conservative from a sliding standpoint. There are other differences as well. The current updates to the BDM, policy, design, and state of practice go beyond what is required by AASHTO, increase metrics for design, and provide safer infrastructure than currently required by AASHTO, than allowed by past practice prior to this Memorandum, and align with WSDOT goals of providing a reasonably safe transportation system, updating policy for forward compatibility, and balancing multivariate demands on our limited resources, both in design and construction.

Contact Information

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