SECTION 12
BRIDGE RAILS AND BARRIERS

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12.1 TRAFFIC RAILS *(REV. 12/19)*

12.1.1 General

Traffic or combination rails are required for all structures carrying vehicular traffic. Railings may be solid concrete parapets or an open rail system. All traffic or combination rails shall pass the crash testing requirements specified in **MASH** and shall be approved by the **CTDOT**. Exceptions may be allowed for structures on non-NHS highways and must be approved on a case-by-case basis by the Division Chief of Bridges. See the Guide Sheets for typical details of **MASH**-compliant railings. The Designer is responsible for modifying these sheets as applicable for each project, but no modifications to the details shall be permitted that adversely impact the crash worthiness of the selected rail system unless approved by the Division Chief of Bridges.

For continuous construction, the pouring sequence for all parapets shall be identical to that of the slab.

All new and retrofitted traffic and combination railings on bridges and retaining walls shall have an overall minimum height of 42 inches measured from a roadway or sidewalk surface. MASH Test Levels (TL) shall be shown on the plans.

The single slope barrier is preferred over the F-shape parapet. However, the F-shape parapet may be used where tie-in to adjacent barriers are F-shape. If sidewalks are required on the bridge, they shall be topped with an appropriate pedestrian railing, bicycle railing, or fence system.

Unfavorable geometric or other site conditions where vehicular rollover or barrier penetration could result in severe consequences may warrant a higher MASH TL as determined on a case-by-case basis.

The use of parapet end blocks above the top of the parapet shall be at the discretion of the designer. In areas involving sight distance problems, the parapet end blocks should not be used.

The end height of these blocks shall match the approach railing height. Where parapet end blocks are not provided, exposed rail ends and sharp changes in rail geometry shall be avoided.

12.1.2 Interstate Highways, Freeways, and Expressways

With the exception of the Merritt and Wilbur Cross parkways, a TL-4 shall be used (at a minimum) for all interstate highways, freeways and expressways.

12.1.3 Other Roadways

A TL-3 shall be used (at a minimum) on all other state and local roadways.

The 42-inch high single slope and F-shape parapets may also be used on highways other than Interstate, expressway and freeways.

A concrete parapet with metal handrail adjacent to a sidewalk shall satisfy TL-3 crash test criteria.

12.1.3.1 Scenic Overpass

For bridges on non-limited access highways where there is a strong need to provide a scenic view, an open bridge rail system approved by the **CTDOT** should be used in place of a concrete parapet. The use of this system should be limited to very sensitive areas.

12.1.4 Box Culverts and Short Bridges *(Rev. 04/19)*

On box culverts and very short span bridges, short runs of concrete parapet (less than 30 feet long) are visually disruptive and difficult to provide with an appropriate approach rail anchorage system.

Whenever possible, the first choice should be the use of one of the three nested W-beam rail systems developed to span over short bridges and culverts. These systems span over the structure by leaving out one, two or three of the rail posts. The structure should be extended far enough behind the rail to provide the required deflection distance. A drawing detailing these rail systems is available from the **CTDOT**.

If the structure is beyond the limits of these rail systems, a concrete parapet or open bridge rail system with end blocks shall be used with a continuous approach rail element attached to it.

On very short structures with low drop-off heights, the **CTDOT** on a case-by-case basis may waive the pedestrian and/or bicycle railing requirements. Where pedestrian or bicycle requirements are not waived, the **CTDOT**'s Pedestrian Railing may be used, refer to **BDM** [12.2.1.1].

12.1.5 Retaining Walls

On retaining walls adjacent to traffic, traffic rails shall be solid concrete parapets, 42 inches high and topped with a fence system, as applicable. If the retaining wall is adjacent to a sidewalk, the parapet height above the top of the sidewalk shall be 36 inches and shall be topped with an appropriate pedestrian railing, bicycle railing, or fence system. An open bridge rail system should be used in place of a concrete parapet where the resulting concrete parapet would be less than 30 feet long.

12.1.6 Deck Overhang Design *(Rev. 12/19)*

On new bridge decks, all deck overhangs shall be designed for a minimum of TL-4 load effects.

The deck overhang shall be designed to resist the lesser of the resistance, Mc and T, of the parapet at its base calculated in accordance with **LRFD** [A13.4.2] or the vehicular impact moment, M_{CT}, and the coincidental axial tension force, T_{CT}, calculated as follows:

For impacts within a concrete railing segment:

$$M_{CT,int} = (\gamma_r * F_t * H_e)/(L_{c,int} * (2 * X))$$

$$T_{CT,int} = (\gamma_r * F_t)/(\big(L_{c.int} + (2 * x)\big) + (2 * H))$$

For impacts at end of a concrete railing segment or at joint where longitudinal rebar is discontinued:

$$M_{CT,end} = (\gamma_r * F_t * H_e)/(L_{c,end} * X)$$

$$T_{CT,end} = (\gamma_r * F_t)/(\big(L_{c,end} + X\big) + (2 * H))$$

Where:

γ_r = 1.2 for new or modified rails, 1.0 for analysis of existing rails.
F_t = Transverse vehicle impact force, in kips, from **BDM** [Table 12.1.6-1].
H_e = Effective height of vehicle rollover force, in feet.
L_c = Critical length yield line pattern, in feet.
H = Rail height, in feet.
X = distribution length increase at overhang deck section being designed, in feet. The value shall be based on a 30º angle from the traffic face of the barrier.

Table 12.1.6-1 - TL-4 Railing Design Forces and Geometric Criteria

H, Rail height (in.)	36	42	Greater than 42
F_t , Transverse vehicle impact force (kips)	67.2	79.1	93.3
F_L , Longitudinal friction force (kips)	21.6	26.8	27.5
F_v , Vertical force of vehicle (kips)	37.8	22	NA
L_t and L_L (ft.)	4	5	14
H_e , Effective height of vehicle rollover force (in.)	25.1	30.2	45.5

*Commentary: **LRFD** [CA13.4.2] states, "the crash testing program is oriented toward survival and not necessarily the identification of the ultimate strength of the railing system. This could produce a railing system that is significantly over-designed, leading to the possibility that the deck overhang is also over-designed."*

*Therefore, the design of a deck overhang for Design Case 1 is also based on F_t corresponding to the test level as shown in **BDM** [Table 12.1.6-1], not on the capacity of the barrier rail. To account for uncertainties in the load and mechanisms of failure, and to provide an adequate safety margin, the value of F_t has been increased by 20%.*

The value of L_c at end of a concrete railing segment or at joint is typically less than the value within a concrete railing segment. The top reinforcement in the overhang should be designed to accommodate this increased demand in this region.

Caltrans and the ODOT are using a similar approach.

***BDM** [Table 12.1.6-1] - Under TxDOT Research Project 9-1002 'Roadside Safety Device Crash Testing Program," Texas A&M Transportation Institute (TTI) researchers investigated the minimum height and lateral design load for **MASH** TL-4 bridge rails. Researchers used impact simulations to calculate lateral impact loads imparted by the SUT (Single Unit Truck) based on **MASH** TL-4 impact conditions for a rigid single slope barrier with various heights. Results indicated that the lateral loads for **MASH** TL-4 were significantly greater than those specified for NCHRP Report 350 TL-4 impact conditions. Under **MASH**, the severity of TL-4 impacts increased 56% compared to NCHRP Report 350. Consequently, 32 inch tall barriers that met TL-4 requirements under NCHRP Report 350 do not satisfy **MASH**. The minimum rail height for **MASH** TL-4 barriers was determined to be 36 inches. Further, the lateral impact force was found to vary with rail height. For a 36-inch tall barrier, the design impact load was determined to be approximately 68 kips. As the height of the barrier increases, more of the cargo box of the single unit truck is engaged and the lateral load on the barrier increases. For a barrier height of 42 inches, the lateral design impact load increases to approximately 80 kips. The 36-inch single slope bridge rail that was tested had a calculated capacity of approximately 70 kips. The continuous concrete rail performed well without any significant damage to the rail or deck. The values in **BDM** [Table 12.1.6-1] include the design impact loads in the lateral, longitudinal, and vertical direction, and the longitudinal distribution and height of the resultant lateral load were recommended for **MASH** TL-4 impacts.*

12.2 PEDESTRIAN RAILINGS, BICYCLE RAILINGS & FENCES *(REV. 12/19)*

12.2.1 General

When a traffic or combination rail is not required, a railing is required when the vertical drop off is greater than 30 inches, as measured from the top of the adjacent sidewalk, roadway, or ground elevation to the lower elevation. The railing shall be a pedestrian railing, bicycle railing, or fence.

12.2.1.1 Pedestrian Railing

A pedestrian rail is required on parapets less than 42 inches in height, and where a fence is not warranted. If a pedestrian rail is required, it is recommended to use the rail on both parapets, even if the one of the parapets is greater than 42 inches in height. A drawing is available for the **CTDOT**'s standard Metal Bridge Rail - Handrail. Alternative pedestrian railings shall be designed in accordance with **LRFD**. The top of rail members shall be at least 42 inches above the top of the sidewalk or roadway.

12.2.1.2 Bicycle Railing

For bridges on designated bicycle routes, a bicycle railing shall be designed in accordance with the **LRFD**. A map depicting designated bicycle routes in the State of Connecticut is available from the **CTDOT**.

12.2.1.3 Fence

For guidance on the placement of fencing at bridges, refer to **BDM** [Table 12.2.1.3-1].

Table 12.2.1.3-1

Feature Crossed (Beneath Bridge)		**Feature Carried (Above Feature Crossed)**				
		Freeway		Non-freeway		Non-motorized user facility
		With Sidewalk	Without Sidewalk	With Sidewalk	Without Sidewalk	
Freeway		Required (A)	Not generally required	Required (A)	Required (A)	Required (A) (B)
Non-freeway		Required (A)	Not generally required	Required (A)	Required (A)	Required (A) (B)
Water		Not generally required	Not generally required	Not generally required	Not generally required	Case by case
Rail	Non-electrified	Required (A) (C)	Required (A) (C)	Required (A) (C)	Required (A) (C)	Required (A) (B) (C)
	Electrified	Required (A) (D)	Required (E)	Required (D)	Required (E)	Required (B) (D)

Legend of Requirements

A. Top of fence 8 feet (96 inches) above surface (i.e., road, sidewalk, trail) including any roadside barrier
B. For rehabilitation of an existing structure with complete enclosure, consider retention of complete enclosure
C. Maximum opening of 0.5 inch within 25 feet of tracks
D. Top of solid barrier 9 feet (108 inches) above sidewalk
E. Top of solid barrier 8 feet (96 inches) above road

For bridges that cross multiple features, the most restrictive requirements (height, material, and configuration) apply to the entire bridge length unless a Department-approved analysis indicates a transition to an adequate and less restrictive design for part of the length is cost effective.

The height of the fencing above the top of the sidewalk or roadway surface shall be a minimum of 8 feet. Curved top fencing is not required. The maximum size of the opening in the fence shall be 2 inches. All fences shall minimize the use of horizontal rails. Fence fabric shall be installed on the pedestrian side of posts. On sidewalk parapets, the face of the fence shall be flush with the parapet face adjacent to the sidewalk. Fence shall be set back as far as practical from the traffic face of the parapets as detailed in **BDM** [Division 3].

Under certain circumstances, fences are required by law as specified in Public Act No. 00-184. No waivers to these requirements that conflict with Public Act No. 00-184 will be granted under any circumstances.

Fencing should satisfy the aesthetic considerations of the structure and be designed in conformance with the **LRFD** for pedestrian railings. Where fencing is provided, it shall consist of black PVC coated fabric with galvanized steel posts and rails. Exceptions will only be allowed for showcase bridges or bridges with historical significance. A fence, if used, satisfies the requirements for either a pedestrian or bicycle railing.

12.2.1.3.1 Railroad Overpasses

Fencing is required on all structures over railroads. It shall be placed on both sides on the span over the railroad tracks. A solid barrier fence is required over electrified railroads.

On long structures over non-electrified railroads, the maximum size of the opening within 25 feet of the tracks shall be 0.5 inches. A larger opening may be used outside of these limits.

The designer shall coordinate with the Railroad on the requirement of curved top fencing.

12.2.2 Drawings for Railings and Fences

The following drawing are available from the **CTDOT**:

1. Pedestrian Railing (Bridge), (angular end for use without end blocks)

These drawings are available from the **CTDOT** in a MicroStation format and will be made available upon request.

12.2.3 Railings and Fences at Lighting and Signing Standards

When lighting or signing standards are located on structures, the railing or fence shall be continuous at these locations. The lighting or signing shall be located outside of the continuous railing or fence (between the railing or fence and the outside face of parapet). Fencing shall be designed with removable panels or other means to provide access to the handhole locations. The parapet details shall accommodate the lighting and signing standard anchorages outside of the railing or fence. The lighting or signing shall not generally be located on a span over a railroad-electrified zone. For details, see **BDM** [Division 3].

12.3 CONCRETE BARRIERS

12.3.1 Permanent Median Barriers on Bridges *(Rev. 04/19)*

Permanent median barriers on bridges shall be concrete and shall match the height and width on the roadway approaches. They may be either cast-in-place or precast concrete.

12.3.2 Temporary Precast

Temporary barriers used to protect the traveling public during the construction of bridges shall be precast concrete and shall conform to the **CTDOT**'s standardized details. In all cases, if the distance from the backside of the barrier to the edge of the deck drop off is less than 6 feet, the barrier shall be rigidly attached to the deck. In cases where this distance is greater than 6 feet, factors such as the type of road; speed, volume and composition of traffic; and the need to protect work areas with limited escape routes shall be taken into account and the barrier rigidly attached if appropriate. Lines of barrier used strictly to separate opposing traffic need not be rigidly attached to the deck and shall be paid for as a roadway item. See the Guide Sheets for typical details of temporary precast barriers.

12.3.3 Concrete Barrier Wall

When required by geometric or roadway design requirements, a concrete barrier wall should be detailed as shown in **BDM** [Division 3].