Oregon Department of Transportation

SECTION 1.13
Rails, Impact Attenuators and Protective Screening

Revisions for the current edition are highlighted yellow. Deleted text is not marked.

Past editions of the Bridge Design Manual are available through our website.

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1.13 Rails, Impact Attenuators and Protective Screening

1.13.1 Bridge Rail, General C1.13.1

The current roadside safety crash test standard is the *Manual for Assessing Safety Hardware (MASH) 2016*.

After Dec. 31, 2019, all bridge rails on the National Highway System (NHS) must meet MASH, per AASHTO/FHWA Joint Implementation Agreement for Manual for Assessing Safety Hardware (MASH). When no MASH alternative exists, states can approve lesser standards, but should aim for MASH whenever possible.

Local agency projects off the NHS may use NCHRP 350, at the request of the local agency. Use *LRFD Chapter 13*, rather than this chapter, when local agency projects use NCHRP 350.

Bridge rails are roadway safety features. In most cases, the primary goal is keeping vehicles, bicycles and pedestrians on the road safely. Due to the dynamic nature of impacts, crash testing of all roadway safety features is performed to assure that critical failure modes such as vehicular stability and occupant compartment deformation are satisfied. MASH establishes the vehicles, speeds, and angles for the collisions required to achieve a passing crash test.

Prior to MASH, the controlling crash test standard was NCHRP 350, which itself replaced NCHRP 230. MASH crash test vehicles are taller than previous standards, requiring higher railings to maintain stability.

MASH requirements are directed at new construction. Thus far, AASHTO has not set acceptance criteria for retrofitting existing non-standard bridge rails, leaving it to the owner to establish warrants.

Due to the change to MASH, where this section is in conflict with *LRFD Section 13*, the *BDM* controls for all state-owned bridges and bridges on the NHS.

Under MASH, roadside safety features are evaluated based on six different Test Levels (TL), each including different vehicles and crash speeds and angles. The levels are intended to correlate to different levels of traffic.

In Oregon, bridges on or over all interstate routes and National Highway System (NHS) routes require a **minimum** crash test rating of TL-4 for all bridge rails. ODOT promotes highway planning that replaces or upgrades railing on existing bridges on these routes to TL-4.

FHWA allows existing bridge rails that are compliant with NCHRP 350 to remain in place under certain circumstances. All undamaged rails constructed after 1994 are assumed to be compliant. Contact the BDM Technical Resource for rails for pre-1994 rails when compliance cannot be established.

To determine the appropriate TL for a bridge, follow the procedure of NCHRP Report 22-12(03), which uses a risk-based methodology. When this method does not correlate well with a specific bridge site, contact the BDM Technical Resource for alternatives.

In addition to the safety requirements of MASH, bridge rails should also meet OSHA requirements for the safety of maintenance and inspection personnel. *OSHA "Fall Protection – Walking-Working Surfaces"* requires a 42-inch high railing or other fall protection accommodations.

AASHTO is currently preparing to update *LRFD Section 13* to better accommodate MASH testing.

More information on the different test levels is available in *LRFD 13.7.2*.

TL-3 is the lowest level FHWA permits on NHS routes.

See the *Other Structures Design Manual* for discussion on rail over buried structures.

See *BDM 1.13.6* and *1.13.7* for more information on when NCHRP 350 compliant rails must be replaced.

In some situations, the test level reached through *NCHRP Report 22-12(03)* may not be appropriate due to other design features or conditions, such as wide sidewalks or very low speeds. In these cases, prepare a Design Exception to use a different test level.

On state highways, 42-inch high bridge rails are preferred. *BR200* has transverse holes to enable workers to tie off for fall protection. Rail height is measured vertically from a 10-foot straight edge placed perpendicular to the lanes on the bridge deck to the top of the highest load resisting rail member.

1.13.1.1 Design Exception Process

Submit Design Exceptions per *BDM 1.2.2*.

Include in the Design Exception:

- Discussion of why an ODOT standard is not appropriate.
- Evaluation of appropriate test level.
- Crash test data documentation for alternate rail or one similar to the proposed design and conclusions that the rail performed acceptably in all three categories (structural adequacy, vehicle stability and occupant compartment deformation).

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1.13.2 ODOT Standard Vehicular Railings

Table 1.13.2-1 lists the ODOT standard bridge railings with current MASH test levels. Transitions are presented in *BDM 1.13.9*.

C1.13.2

More information about these rails are available in the standard drawing reports and on Projectwise.

While the rail itself may not be OSHA compliant, a personal fall arrest system can be used to comply with OSHA (e.g. tie-off, anchorages, etc). See *BDM 1.15.5.1* for additional information on fall protection.

Table 1.13.2-1 MASH Bridge Rails

Drawing No.	Description	Tested or Evaluated	MASH Test Level	OSHA Compliant
BR200	Concrete Bridge Rail Type **F**	Evaluated	3	With Anchorages
BR206	2-Tube Curb Mount Rail	Evaluated	3	
BR208	3-Tube Curb Mount Rail	Tested	4	Yes
BR214	Concrete Parapet with Steel Post	Evaluated	4	No
BR216	Sidewalk Mounted Combination Bridge Rail	Evaluated	4	Yes
BR222	Vertical Concrete Parapet, 42-Inch	Evaluated	4	Yes
BR226	2-Tube Side Mount Rail	Evaluated	3	
BR273	Thrie Beam Rail Retrofit for Curb and Parapet Rail	Evaluated	3	No
BR277-BR280	Historic Look Rail	Evaluated	4	Yes
BR285-BR287	Type **F** Concrete Rail Tube Retrofit	Evaluated	4	Depending on existing
BR290	3 foot 6 inch Type **F** Rail	Evaluated	5	Yes
BR295 & 296	Minimum Deflection Bridge Temporary Barrier	Tested	3	No
DET3220-3224	Weak Post Guardrail Attachment to Culvert	Tested	3	No

Table 1.13.2-2 lists other ODOT standard bridge railings that have not yet been evaluated or tested under MASH. Use of these rails on a state highway requires a Design Exception.

More information about the specific rails is available in the standard drawing reports.

Table 1.13.2-2 ODOT Standard Bridge Rails without a MASH Crash Test Equivalency

Drawing No.	Description	Crash Test Standard	Evaluated NCHRP 350 Test Level
BR212	Concrete Post and Beam Bridge Rail	Unknown	-
BR220	Flush Mounted Combination Bridge Rail	NCHRP 230	4*
BR221	32 inch Vertical Concrete Parapet	NCHRP 230	4*
BR233	Thrie-Beam Rail and Transition	NCHRP 230	2*
BR250	Pedestrian Rail on Sidewalk Mounted Concrete Parapet	None	2*
BR253	Sdwk. Mounted Conc. Parapet with Chain Link Fencing	None	2*
BR256	Pedestrian Railing on Type **F** Concrete Bridge Rail	NCHRP 350	4
BR260	Chain Link Fencing on Type **F** Concrete Bridge Rail	NCHRP 350	4

*These values are based on an equivalent test level evaluation.

1.13.2.1 Rail Orientation

Orient bridge rail posts and joints normal to grade in the longitudinal direction and vertical in the transverse direction for ease of construction and aesthetics.

C1.13.2.1

When deck superelevations exceed 8 percent, consideration can be given to orienting posts normal to grade in both directions to be more aesthetically pleasing. Apply modifications to all rail components so they are all oriented the same (i.e. concrete parapet and attachments).

1.13.2.2 Rail Aesthetics

Maintain the minimum concrete cover requirements when using architectural treatments on concrete bridge rails. Cover can be increased to accommodate formliner patterns. Architectural treatment on the traffic face of a traffic barrier is only permitted within the limits of NCHRP Report 554. When that standard is met, no design exception is required.

1.13.2.3 Other Crash Tested Rails

Bridge rail designs from any state or local agencies that have been crash tested to MASH may be used with a Design Exception. Submit requests to the BDM Technical Resource for frequently used rails to be added to ODOT's Bridge Rail standard drawings.

1.13.2.4 Non-Standard Rails

On a case-by-case basis, rails that have not been crash tested may be permitted on state-funded projects with the submission of a Design Exception. The rails must be designed according to *LRFD Section 13*, and usage must be limited to TL-2 locations. Contact the BDM Technical Resource early in the project when this option is considered for a state-owned bridge.

1.13.3 Bicycles and Pedestrians

C1.13.3

Use bicycle and pedestrian railing or combination railing on the outside of structures that are specifically designed to carry bicycle and pedestrian traffic.

Modify *AASHTO 13.4* as follows:

Separate a pedestrian walkway from an adjacent roadway by a barrier curb or combination railing where vehicular design speeds are less than 40 mph. Where speeds exceed 40 mph and a pedestrian walkway is provided, separate the walkway from the adjacent roadway by a traffic railing or combination rail and provide a pedestrian railing on the exterior of the walkway.

LOCAL AGENCY

For Local Agency projects, follow *AASHTO 13.4*

Bicycle and pedestrian rails must meet or exceed 42 inches in height. Opening sizes on bicycle, pedestrian and combination rails are defined by *LRFD 13.8.1*.

Use curbs above the level of the sidewalk under all pedestrian railings where there will be significant pedestrian, vehicular or boat

At locations with high bicyclist traffic, rail height can be increased to 48 inches and up to 54 inches.

traffic under the structure. Runoff from sidewalks does not need to be carried off a structure, see *BDM 1.9.5* for additional guidance.

This requirement is intended to keep debris from being kicked under the railing onto traffic below.

Objects that are placed in the range of 27 inches to 80 inches may become protruding objects for pedestrians in the walkway, and shall not extend more than 4 inches into the adjacent walkway from the nearest vertical face or detectable edge.

Parapets, railings and fencing adjacent to the walkway can have impacts to the pedestrian access route. ADA requirements need to be reviewed carefully to ensure these items do not create protruding objects or restrictions in the clear width available to pedestrians.

1.13.4 Joints in Concrete Bridge Rail

SCORING JOINTS

Place scoring joints at 15 foot maximum centers, equally spaced between Type 'B' joints and expansion joints. Show the location of each joint on the deck plan without dimensions. Do not consider these joints to be end segments for the purpose of overhang calculations.

The joint spacing must equal or exceed the critical length, L_C, of the yield line failure pattern (see *LRFD A13.3.1*) for a vehicle impact within a wall segment. The bottom two longitudinal bars are continuous through scoring joints but terminate two inches before all other joint types.

TYPE 'B' JOINTS (AT INTERIOR BENTS WITH CONTINUOUS DECK)

To reduce shrinkage cracks in the rail, form a joint using ¼ inch preformed expansion joint filler through the rail. These joints also reduce the tendency of the rail to act compositely with the superstructure. Do not consider these joints to be end segments for the purpose of overhang calculations.

AT BRIDGE DECK EXPANSION JOINTS

Provide rail joints at every bridge deck expansion joint to prevent cracking or spalling of the rail or structure. Show rail details at expansion joints on the drawings. Skew rail joints to match the deck joint for skew angles up to 20 degrees. For skew angles in excess of 20 degrees, orient the rail joint normal to the rail.

C1.13.4

For typical ODOT standard concrete rails, space joints in the range of 10 to 15 feet.

See *BDM 1.9.2.2.2* for overhang reinforcement design information.

For ODOT Standard Rails, L_C is listed on the ODOT Bridge Engineering website – Software Tools for Design. It is typically in the range of 8.5 to 12.5 feet.

Detail concrete bridge rail open joints as follows to prevent vehicle snagging:

- 4 inches or less are acceptable as open joints.
- Greater than 4 inches, use a steel cover plate. See standard drawings *BR200* for expansion joint cover plate details.

When a custom steel cover plate is needed, design as follows:

- Minimum thickness of 3/8 inch.
- Bolts or screws which do not protrude beyond the traffic face of the barrier.
- Recess plate into concrete barrier.
- Other details of the cover plate may be designed based on site and project needs.

It is a potential problem when water passes through the joint and erodes the embankment. Railroad overcrossings may have additional requirements for joints in rails, depending on the railroad.

For joints between the bridge end and bridge approach slab, see expansion joint standard drawings for the rail joint material and arrangement. See Standard Drawings *BR139, BR140, BR141, BR145, BR157, DET3138 and DET3150* for joint details.

Joint protection requirements are based on TRNo. 619651-01 from December 2023.

1.13.5 Bridge Modernization Projects

On Bridge Modernization projects, replace bridge rails to meet the required MASH TL criteria at the bridge site. The structural designer works with the project team to select the best rail for a given site. Considerations include:

- Roadway geometry.
- Traffic volume.
- Speed.
- Truck traffic.
- Accident history.
- Pedestrian needs.
- Sight distance.
- Occupant risk.
- Aesthetics.
- Corridor context.
- Maintenance.
- Inspection.
- Cost/benefit and related factors.

For new bridges, design the overhang to resist the test level of the rail or TL-4, whichever is greater.

Standard deck overhang design is provided on *DET3170* and *DET3171*. When designing deck overhangs per LRFD, rail design capacities are available for ODOT standard rails on the ODOT Bridge Engineering website – Software Tools for Design. Using the calculated parapet resistance, M_c and T, of the parapet at its base per *LRFD A13.4.2*. LRFD rail design capacities will give overly conservative results in most cases.

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The intent is to reduce the risk of future strengthening over the life of the bridge.

LRFD A13.4.2 describes the design approach for deck overhangs supporting concrete parapet railings. The design approach does not specify vehicular-collision loads. Overhangs are designed for the maximum inelastic force effects generated and transmitted by the railing resisting a vehicular impact. This results in an extremely conservative deck overhang that is not in accordance with observed field behaviors.

Instead, for *LRFD A13.4.2* design case 1 for concrete parapet railings in TL-4 locations, design the deck overhang to resist the lesser of a vehicular impact moment, M_{CT}, and coincidental axial tension force, T_{CT}, calculated as follows, for the end and wall conditions:

$$M_{CT,end} = \frac{1.25 \times F_t \times H_e}{L_{c,end} + H_e + X}, \text{ and}$$

$$T_{CT,end} = \frac{1.25 \times F_t}{L_{c,end} + H_e + X}.$$

$$M_{CT,wall} = \frac{1.25 \times F_t \times H_e}{L_c + 2H_e + 2X}, \text{ and}$$

$$T_{CT,wall} = \frac{1.25 \times F_t}{L_c + 2H_e + 2X}$$

Where:

H_e = Effective height of the vehicle rollover force (ft).

L_c = Critical length of yield line failure pattern (ft).

X = Lateral distance from toe of barrier to deck design section (ft).

F_t = Transverse force specified in Table 1.13.5 for MASH TL-4 impact load for different barrier heights (kips).

Based on observations of impacted bridge railings from crash testing, an overhang designed with typical deck reinforcing of #5 at six inches does not fail when a railing failure occurs due to a collision. See *TTI Test Report No. 9-1002-5*, *Figures 3.1-3.3, 6.3* and *6.4*. In the absence of a more rigorous method for designing overhangs, many states use the loads shown here, based on finite element impact simulations from NCHRP funded research.

The end condition, at bridge ends and expansion joints, controls design due to the limited distribution length.

Table 1.13.5-1 Design Forces and Designations for Standard Barrier Heights (in)

Standard Barrier Heights	**36 inch**	**39 inch**	**42 inch**
F_t Transverse (kip)	67.2	72.3	79.1
F_L Longitudinal (kip)	21.6	23.6	26.8
F_v Vertical (kip)	37.8	32.7	22
L_t and L_L (ft)	4	5	5
H_e (in)	25.1	28.7	30.2

When designing or checking overhangs, do not reduce capacity due to development length of the deck bars.

Impact loading is different in effect from sustained loading. Testing shows that typical development length calculations do not apply.

1.13.6 Bridge Retrofit Projects

C1.13.6

1.13.6.1 Process

C1.13.6.1

Establish required test level for the site. Upgrade the rail when any of the safety warrants exist (*BDM 1.13.6.3*), regardless of project scope. Otherwise, when project scope impacts the rail, assess the existing bridge rail for structural adequacy, vehicle stability, and occupant compartment deformation, in the post-project configuration (*BDM 1.13.6.2*).

When a deck overlay will reduce the relative height of the rail, this negatively impacts the structural adequacy of the rail.

See *BDM 1.9.2.2.2* for bridge deck overhang strengthening requirements.

Based on the deficiencies and required test level, select a retrofit or replacement option. When an appropriate standard drawing or detail is not available, it is permissible to design one for a specific project. A Design Exception is required in these cases.

Research is on-going into the behavior of resin bonded anchors under impact loading. Anticipate new standard rail attachment details upon completion of this research.

1.13.6.2 Assessment of Existing Bridge Rails

STRUCTURAL ADEQUACY

Structural adequacy is a function of a barrier's ability (including deck overhang) to effectively contain and redirect a vehicle. Vehicles may not penetrate, underride, or override the barrier. It is possible to use engineering analyses, based on yield line theory or plastic design procedures, to compute the load capacity of rigid or semi-rigid barriers. Then compare that with known design forces for the desired test level. All aluminum tube rails are structurally inadequate.

Since structural adequacy also requires the vehicle not override the barrier, barrier height is critical. For required height based on test levels, see *Table 1.13.6.2-1*.

Table 1.13.6.2-1 Minimum Bridge Rail Heights

Test Level	Minimum Height (inches)
TL-2	27
TL-3	29
TL-4	36
TL-5	42

VEHICLE STABILITY

In order to ensure the safety of vehicle occupants, a vehicle must remain upright during and after a collision with the barrier. MASH evaluates this based on a maximum pitch and roll of the vehicle during testing. This is a common failure mode for bridge rails.

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For more information on the assessment of existing bridge rails, see NCHRP 22-14(03).

These heights are not the same as *LRFD Table A13.2.1* due to MASH testing.

Whenever possible, assess this through comparison with previously crash tested rails.

Curbs and sidewalks that project in front of the face of rail negatively impact vehicle stability. Comply with *LRFD 13.7.1.1* for sidewalk height.

Many states only permit unprotected curbs and sidewalks, where design speeds are 45 mph or less.

OCCUPANT COMPARTMENT DEFORMATION

Occupant compartment deformation is commonly associated with snagging of the vehicle on the rail. Consider extensions or recessions beyond two inches as potential snag points; rails comprised of separate unconnected elements.

Evaluate snag hazard of post setback distance, ratio of contact width to height, and vertical clear opening based on *LRFD Section 13*.

Improved vehicle design has reduced occupant compartment deformation, making this a less critical factor for evaluating barriers under MASH. Rails that satisfied this criteria under NCHRP 350 should be expected to meet MASH testing as well.

1.13.6.3 Safety Warrants

C1.13.6.3

Rails are considered candidates for retrofit or replacement as part of a bridge retrofit category project when any of the following are true:

- Three or more accidents or a fatality has occurred in the past five years at the bridge site.
- The rail is in a condition state four.

- The rail height is less than 27 inches.

Existing rails may be raised to meet height requirements, provided the existing strength capacities are not reduced by the revised configuration.

- The rail has aluminum components.

Aluminum rails are structurally inadequate under most impact conditions. In some cases it is possible to simply replace aluminum tubes with steel tubes without significant cost.

- The bridge is located on an interstate or high-speed, high-volume facility (for this purpose high volume is considered AADT of 30,000 or higher and has shoulder widths of less than three feet).

- A safety assessment by the Region Traffic Engineer included in the *1R/3R Record of Decision Document* recommends an upgrade.

The Region Traffic Engineer provides a safety assessment to analyze existing safety hazards, crash history, site geometry, identify high risk sites, and determine when the implementation includes the appropriate solution. See *HDM 119.1* for additional information. Document the concurrence in the DCSA.

1.13.6.4 Deck Anchorage

Options for anchoring a replacement bridge rail to an existing deck include through bolting and resin bonded anchors. When through bolting, oversize the drilled holes to create a ¼ inch annular space, seal the bottom of the bolt hole and grout the annular space around the bolt with high strength grout.

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This is required to ensure shear loads from impact transmit evenly to the deck.

See *BDM 1.9.2.2.2* for deck overhang capacity information.

1.13.7 Bridge Preservation Projects

Bridge preservation projects only require bridge rail modifications when:

- The relative height of the existing bridge rail is reduced below 29 inches (32 inches on interstates and other divided highways), or
- The project is part of a 3R or 4R project on an NHS route and the existing bridge rail is not NCHRP 350 compliant.

In either of these cases, correct the deficiency or obtain an approved Design Exception.

Correct unprotected bridge rail ends and unconnected rail transitions per *BDM 1.13.9*.

C1.13.7

The 29 inch rail height is based on the minimum bridge rail height for TL-3 rail. FHWA requires all rail to be TL-3, minimum.

Where projects negatively impact bridge rail height, *BR285* is a reasonable, cost-effective repair.

Where the existing rail is aluminum, assess the site risks and consider retrofitting the rail.

1.13.8 Bridge Maintenance Projects

C1.13.8

Refer to TSB22-01(B) for requirements when MBM work affects bridge rails. A design exception is needed in the case of *TSB22-01(B)*: 2.a.

Address unprotected bridge rail ends and unconnected rail transitions per *BDM 1.13.9*.

Contact the Bridge Maintenance Engineer or refer to the *BMDM* for additional information.

1.13.9 Bridge Rail Transitions

C1.13.9

Rail transitions are required on rail installations. They provide a controlled variation in stiffness from the approach guardrail to the more rigid bridge rail. The current transitions are crash-tested and have very close post spacing.

Research indicates transitions that past *NCHRP 350* testing will continue to meet MASH criteria *(NCHRP Project 22-14(03)*).

It is common to add concrete blocking to a rail transition to accommodate a taller guardrail transition. Adding blocking to non-standard transitions above the TL-4 impact height (H_e as defined in *AASHTO A13.2-1*) does not require a design exception. Review by the BDM Technical Resource is still needed.

Select a transition, in conjunction with the roadway designer, appropriate for the speed.

In low speed locations (45 mph or less) where approach rail is not used, slope the bridge rail end down (end must be outside of the clear zone) or shield it using a crash cushion. See *HDM 405.4,* for additional guidance.

Upgrade transitions when unprotected ends or unconnected rail transitions are present or obtain an approved Design Exception, except in the following situations:

Both Bridge and Roadway sections have programs to fund these specific safety improvements. Contact the Bridge Program Engineer for funding support from the Bridge Rail Safety Program. Contact the Senior Roadside Design Engineer for funding support from the Barrier Upgrade Program.

• Addressing transitions is not required and a DE is not needed on Bridge Preservation projects where all scope elements are outside the edge of pavement. When the only scope within the edge of pavement is a non-structural overlay (as defined in *BDM 1.9.3.1)* seek funding from the 1R Roadside Safety Feature Upgrade Program by contacting the Senior Roadside Design Engineer to address these safety features.	These types of deck treatments are defined as a maintenance activity and are not considered resurfacing as defined by *BDM 1.2.10.2.2* and *FHWA* and thus do not rise to a higher standard of care.
• Addressing transitions is not required, but a DE is needed on MBM funded projects. Seek funding from the 1R Roadside Safety Feature Upgrade Program by contacting the Senior Roadside Design Engineer to address these safety features.	The limited scope and resources of the MBM program do not accommodate addressing blunt ends or rail transitions. Refer to TSB22-01B for additional information.

See *HDM 405.2.1* for rail transition treatment based on roadway project type.

Problems have arisen when the first post off the structure conflicts with the bridge end. Consider any post conflicts and detail a solution in the contract plans. Prepare a design exception when adjusting the post spacing.

Possible remedies include the following. When a remedy requires a structural evaluation, a DE is required.

- Remove concrete to allow room for the normal post to fit.
- Add a concrete pad (with anchor bolts) to the existing concrete, and add a base plate to the first post.
- Mount a structural steel spacer block to a vertical face of a rail end block, in place of a post.

1.13.10 Rails over Railroads

Use cast-in-place concrete rail without openings on structures over railroads. Use rail with a minimum height of 42 inches for structures in snow and ice areas, and rails with a minimum height of 30 inches elsewhere.

Extend rail to the limits of the railroad right-of-way or a minimum of 25 feet beyond the centerline of the outermost existing track, future track or access road, whichever is greater.

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Snow and ice zones are defined in *BDM 1.2.4.3*.

Existing locations with insufficient height or non-solid barrier (e.g., 3-tube rail) may require in-filling gaps over facilities below. Possible solutions are use of splashboards or providing tubes between primary rail tubes equal to the thickness of the spacers used for primary rail tubes. See discontinued drawing *BR245* for splash board details or BR 09515.

Refer to *UPRR-BNSF Guidelines for Railroad Grade Separation Projects* for additional information on requirements at railroad crossings.

1.13.11 Temporary Barriers

FHWA requires that temporary bridge rails meet TL-3 performance criteria using successfully crash tested systems. Temporary bridge rail is constructed from pin and loop median barrier (RD500) secured against sliding and overturning as shown in BR*295* and *BR296*.

C1.13.11

See the *SDR* for the validated crash test results used to develop *BR295 and BR296*.

Contact the technical resource when proposing to use this rail in non-standard situations. Examples include but are not limited to:

- Bridge deck thickness less than 6 inches.
- Traffic on both sides of barrier.
- ACP deck overlay.
- Less than 6 inches behind pinned barrier.
- Bridge deck is not concrete.

- Inadequate room to provide space behind the barrier.

Restraints are not required when the barrier can be displaced 5.5 feet or more away from the traffic side(s) without infringing on a traffic lane, a work area, or beyond the edge of the deck.

There is a balance of the risk to bridge deck life (pinning barrier) vs worker and traveling public safety (slide distance). The risk to life safety has been deemed greater than the risk to the bridge deck life due to damaged rebar. Lateral displacement control is critical in most situations (narrow shoulders, work zones, etc.) Because there is no recovery area for traffic or workers, the barrier must be prevented from "walking" or deflecting during impact. Simultaneously, avoiding damage to the primary deck reinforcement to prevent long-term spalling and capacity issues is a priority. Since the anchor holes in the precast segments are at fixed locations, longitudinal flexibility is limited.

Contact the technical resource to discuss mitigation measures to balance displacement control with deck protection.

Other temporary rail options:

- At least one crash tested proprietary steel safety shape rail system exists, which could be a contractor option for temporary rail use. Example: see *FHWA Acceptance Letter B-165*.
- Minnesota DOT b919-v3 has a MASH TL-3 detail to attach minimum defection temporary barrier to a glulam timber deck.

There is no formal Design Exception process for components of Temporary Traffic Control Plan design (i.e. Temporary Bridge Rail). Instead, obtain an approved Bridge Design Deviation per *BDM 1.2.2* and document decisions in the DCSA and Transportation Management Plan when deviating from standard.

See Traffic Control Plans (TCP) Design Manual *3.4.2* for additional information on Design Exceptions for temporary barrier conditions. Filing a Design Exception is an option when temporary conditions become part of a permanent traffic control condition, or the temporary condition is in place for two years or more.

Coordinate with the Traffic Control Plans (TCP) designer to confirm the assumed layout of temporary barrier on the bridge agrees with the final layout shown in traffic control plans, and to determine when the detail plans must note the reflectorized barrier. Modify *BR295* accordingly.

Install anchor bolts as shown on *BR295* and *BR296*. Do not drill into or otherwise damage the tops of supporting beams or girders, bridge deck expansion joints or drains. Install anchor bolts and nuts so that the maximum extension beyond the face of the barrier units is ½ inch. Snug tighten the nuts on the anchor bolts. For through bolted installations, snug tighten the double nuts on the underside of the deck against each other to minimize the potential for loosening.

For more information regarding temporary barriers, see *Section 2.6.1* and *3.4.25* of *TCP Design Manual*.

1.13.12 Protective Screening or Protective Fencing

Oregon law mandates the installation of protective screening. *ORS 366.462* states:

1. The DOT shall construct fences on all freeway overpasses that are built on and after Nov. 4, 1993. The fences shall be designed to deter persons from throwing objects from the overpasses onto the freeways.
2. The DOT shall construct fences on existing freeway overpasses that involve the greatest risk factors.

1.13.12.1 General

Provide protective screening at the following locations on projects that modify the rail or when required by the facility owner:

- All structures crossing freeways (interstates and similar controlled access highways with at least four lanes) that carry vehicles or pedestrians.
- Pedestrian structures which cross high-speed facilities (posted speed equal to or greater than 55 mph) and are located within half mile of a school, playground, park, athletic field, shopping center, or other facility likely to generate pedestrian traffic.
- Structures with sidewalks which cross high-speed facilities (posted speed equal to or greater than 55 mph) and are located within half mile of a school, playground, park, athletic field, shopping center, or other facility likely to generate pedestrian traffic.
- All other structures (with or without sidewalks) crossing high-speed facilities (posted speed equal to or greater than 55 mph) with regular pedestrian traffic.
- All other structures where the fall

C1.13.12.1

Contact the Bridge Standards and Program Manager for a list of applicable freeways.

height is 50 feet or greater.

- On both sides of all overhead structures crossing railroad right-of-way.

Portland and Western Railroad (PNWR) and Central Oregon and Pacific Railroad (CORP) do not require any fencing.

- In front of ITS elements attached to bridge structures.
- When the opening between parallel bridges is 10 feet wide or less. Required only on the interior railings of each structure.

Increasing the bridge rail height to a minimum of 54 inches is also acceptable.

Protective screening need not be provided at freeway ramp structures that typically do not have any provisions for pedestrians.

When a project impacts the bridge rail, install protective screening when any of the situations above apply.

1.13.12.2 Protective Screening Design Criteria

Design protective screening to deter persons from throwing objects from the overpasses onto freeways. Design protective screening using the following criteria:

- Use design loads per *AASHTO 13.8.2* and dead load per standard drawings.
- Able to carry pedestrian rail loading when pedestrians are not separated.
- Openings three inch square or less. For screening over railroads, openings two inch square or less in chain link fencing. Minimize projected area to less than 30 percent of total area.

  - Screening to be no more than one quarter inch above top of concrete surface when less than ten inches from roadway surface. When a curb is present, and screening is ten inches or higher above the roadway surface, opening requirements in bullet three apply.

- Minimum eight feet high from top of walk surface. Minimum 10 feet high at railroad overcrossings from top of walk surface. When ornamental screening has a variable height, maintain minimum height at all locations crossing over travel lanes. Minimum 54 inches high when the opening between parallel bridges is 10 feet wide or less.

C1.13.12.2

The design criteria in this section also applies to exclusionary fencing.

See BNSF/UPRR guidelines, Section 4.7. A one inch mesh being used for special cases.

Use details that are difficult to climb (e.g. no handrail).

The one quarter inch dimension is based on toeboard requirements in *OSHA 1926.451 (h)(4)(ii)* and may not apply in all situations. Ensure the bottom of screening has sufficient stiffness to prevent permanent large deflections.

Protective screening limits and extents:

- Provide protective screening over all travel lanes plus a minimum of 10 feet beyond the travel lanes on each side.

  Coordinate with roadway to consider future widening when determining screening limits.

- Where on or off ramps also cross under a structure, ensure screening extends a minimum of 10 feet beyond the end of any ramp travel lanes.

  In areas where aesthetics is a consideration and when screening does not extend to the end of the structure, provide a transition panel (sloped panel or partial height panel) at the end of each run of screening as an aesthetic termination.

- For divided highways, continue protective screening uninterrupted through the median.

  For unusually wide medians and divided highways with a significant elevation difference for each direction, protective screening may be interrupted through the median with the use of transition panels.

- Provide protective screening on both sides of a structure, even when a sidewalk is provided on only one side. Where twin structures cross a high-speed facility, provide protective screening for the center opening between structures.

- Provide protective screening to the greater of the following on structures over railroads:
  - Railroad right-of-way or
  - 25 feet minimum from centerline of nearest existing or future track or railroad access road.

1.13.12.3 Design Deviations

Submit a design deviation:

- When protective screening is not provided for structures specified in *BDM 1.13.12.1.*
- When protective screening details deviate from standard drawings, e.g. retrofit installation.
- To exclude screening at locations that present a sight distance hazard.

Provide the following with a design deviation request:

- Basis for the design deviation.
- A description of pedestrian activity including width of sidewalks and proximity to pedestrian sources such as schools, playgrounds, parks, shopping center or athletic fields.
- The history of incidents and signs of graffiti at the site or sites in the area.
- The distance to adjacent bridges also crossing the facility and whether they have screening.

When the basis for the design deviation is for sight distance provide the following:

- Concurrence from the Region Roadway Manager.
- A plan showing sight lines obstructed by the proposed screening.
- Cost of widening the structure to avoid a sight distance hazard.

C1.13.12.3

Due to public safety concerns, public or legislative oversight of design deviations for protective screening is likely.

Screening may obscure sight distance on horizontally curved structures; of signage; and the intersection sight distance at ramps, cross-streets, or driveway accesses off the end of the structure. Non-signalized intersections increase this potential hazard. Specialized designs may be considered to address sight distance issues, such as adjusting screening limits.

1.13.12.4 Screening Type Considerations

When placing a barrier between the sidewalk and roadway, use protective screening in place of a pedestrian rail along the outer edge of the structure.

When no separated barrier exists, place screening behind or attached to the combination rail along the outer edge of the structure.

When installing ITS elements on a structure, use Type 'A' fencing.

Use Type 'A' fence *BR240* on pedestrian bridges.

VERTICALLY CURVED SCREENING

Consider curved screening when a sidewalk is present. Curved screening does not require end treatment. Curved screening can be used in combination with Type A, B, C and D fence.

C1.13.12.4

Protective screening affects bridge inspection using under bridge inspection trucks (UBITs). Details should be discussed with the Region Bridge Inspector (RBI) prior to installation over bridges with limited inspection access.

Certain sweepers will not fit through curved fence enclosures. Region 1 sweepers measure 10 foot 5 inches. Standard Drawing *BR240*, Type 'A' Fence has provisions to allow access. Contact the District Bridge Supervisor to determine an acceptable type of fence.

Curved screening is an additional deterrent because it forces the thrower into the roadway in order to clear the screening. Curved screening may cause additional sight obstruction. Curved screening may require additional height to accommodate bicycles and, in some cases, horses with riders. Curved screening is not preferred in the Portland area due to aesthetic concerns.

HORIZONTALLY CURVED STRUCTURES

On structures with tight horizontal curves, consider using straight screening rather than curved. When chorded screening is used on a tight curve, ensure any **gap** between the bottom of screening and the curved edge of the bridge does not exceed three inches. Such **gaps** may be closed using plates attached to concrete surfaces near the bottom of the screening.

It is difficult to construct curved screening on a tight curve and obtain proper fit of the chain link fabric.

1.13.12.5 Screening Aesthetics

C1.13.12.5

AESTHETIC CONSIDERATIONS

Chain link is the most economical screening available and used as the default screening type. However, chain link has very low aesthetic value.

There are proven low-cost methods available for improving the aesthetics of chain link screening:

- End treatment - Providing a special termination section at each end of each screening run is a low-cost and effective aesthetic enhancement. This can be as simple as tapering the ends (for example, see *DWG 65137*) or a reduced-height panel. Any end treatment with a height less than the minimum required must start at least 10 feet beyond any travel lanes or ramps (25 feet from tracks or access road for railroad crossings).
- Color – Use of vinyl-coated chain link can improve the appearance of chain link at a very modest increase in cost. Possible colors are black, navy blue, or dark green, depending on location. Hot-dip galvanize screening before vinyl-coating.

Designers are encouraged to seek input from others (designers, district, and local community) when using aesthetic concepts outside these methods.

ORNAMENTAL SCREENING

ODOT has received requests to install ornamental screening on structures. See Standard Detail *DET3243* and *DET3244*. Address the following before a request can be processed:

- Funding – Ornamental screening can be included in bridge modernization and retrofit projects when deemed an important architectural item by the project team and supported by the environmental study. For retrofit to an existing structure (not associated with an ODOT project), include possible funding sources with the proposal.
- Permits – When an entity outside ODOT proposes to install a feature in ODOT right-of-way, it must obtain a permit from the district office.
- Design – Do not create a distraction for drivers with ornamental protective screening. Review design outside of ODOT's normal standards through a review process with the district maintenance, Region Tech Center and others to assure it is appropriate and meets ODOT clearances and standards.

- Maintenance – Establish maintenance responsibility in case of damage or deterioration. Districts receive funding to maintain ODOT standards. When designed and installed by forces outside of ODOT, resources are required to maintain it, which should include a bond, city or county taking responsibility.

Powder coat ornamental screening. Paint can be used, when requested, for a specific reason and agreed to by maintenance. Also see *BDM 1.2.5.10, Structure Appearance and Aesthetics, Ornamentation*.

1.13.13 Impact Attenuators

Avoid geometry where attenuators will be required on structures.

C 1.13.13

Attenuators are required in areas where hazardous objects cannot be removed from the possible paths of vehicles. Such locations include gore points of diverging roadways and columns in medians.

See *HDM 405.8* for additional information.