INDOT Bridge Design Conference 2013

Bridge Railing & Deck Design Example

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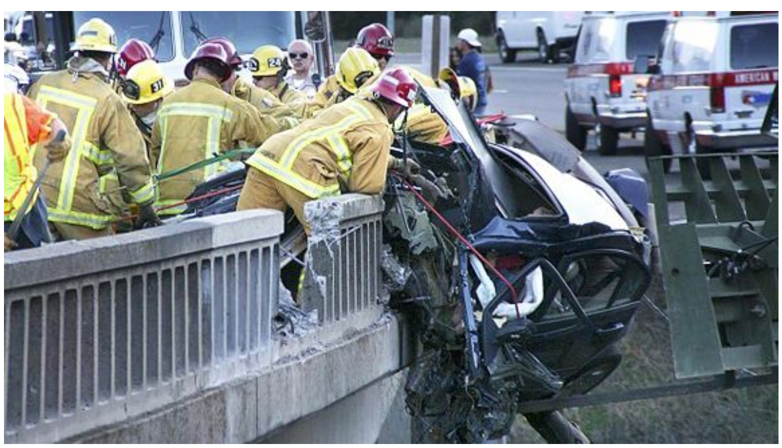
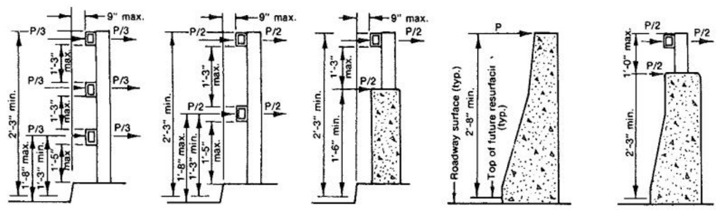
Engineering Resources, Inc.

Bridge Railing Design



Bridge Railing Design

- AASHTO 17th Edition and prior
  - 10k Load distributed over 5’
  - Applied perpendicular at top of rail



(To be used where there is no curb or curb projects 9" or less from traffic face of railing.)

TRAFFIC RAILING

FIGURE 2.7.4B Traffic Railing

Bridge Railing Design

NCHRP Report published in 1993

All Railing Systems must be crash tested.

National Cooperative Highway Research Program

NCHRP Report 350

Recommended Procedures for the Safety Performance Evaluation of Highway Features

Transportation Research Board
National Research Council

Bridge Railing Design

Rail selection defined in IDM 404-4.01(05) Making Test-Level Determination

Based on:

- Construction year AADT
    - Curvature
    - Grade
    - Deck Height
- % Trucks
- Design Speed
- Barrier Offset

Site Characteristics		Adjusted Construction-Year Average Annual Daily Traffic, T, (1000s) for Traffic-Barrier Test Levels								
		Highway Type								
% Trk.	Edge of Travel Lane to Front Face Barrier, L_2 (ft)	Divided, or Undivided With 5 or More Lanes			Undivided With 4 Lanes or Fewer			One-Way		
		Test Level			Test Level			Test Level		
		TL-2	TL-4	TL-5	TL-2	TL-4	TL-5	TL-2	TL-4	TL-5
0≤ % <5	≤ 3	< 5.5	5.5 ≤ T < 162.2	≥ 162.2	< 3.7	3.7 ≤ T < 107.0	≥ 107.0	< 2.8	2.8 ≤ T < 81.1	≥ 81.1
	$3 < L_2 \le 7$	< 6.3	6.3 ≤ T < 188.6	≥ 188.6	< 4.4	4.4 ≤ T < 134.1	≥ 134.1	< 3.2	3.2 ≤ T < 94.3	≥ 94.3
	$7 < L_2 \le 12$	< 8.4	8.4 ≤ T < 247.3	≥ 247.3	< 6.1	6.1 ≤ T < 171.9	≥ 171.9	< 4.2	4.2 ≤ T < 123.7	≥ 123.7
	> 12	< 11.2	11.2 ≤ T < 314.7	≥ 314.7	< 8.2	8.2 ≤ T < 245.4	≥ 245.4	< 5.6	5.6 ≤ T < 157.4	≥ 157.4
5≤ % <10	≤ 3	< 4.7	4.7 ≤ T < 50.0	≥ 50.0	< 3.2	3.2 ≤ T < 32.0	≥ 32.0	< 2.4	2.4 ≤ T < 25.0	≥ 25.0
	$3 < L_2 \le 7$	< 5.4	5.4 ≤ T < 61.4	≥ 61.4	< 3.7	3.7 ≤ T < 41.8	≥ 41.8	< 2.7	2.7 ≤ T < 30.7	≥ 30.7
	$7 < L_2 \le 12$	< 7.2	7.2 ≤ T < 70.6	≥ 70.6	< 5.1	5.1 ≤ T < 49.3	≥ 49.3	< 3.6	3.6 ≤ T < 35.3	≥ 35.3
	> 12	< 9.6	9.6 ≤ T < 88.5	≥ 88.5	< 6.9	6.9 ≤ T < 67.8	≥ 67.8	< 4.8	4.8 ≤ T < 44.3	≥ 44.3
10≤ % <15	≤ 3	< 4.1	4.1 ≤ T < 29.6	≥ 29.6	< 2.8	2.8 ≤ T < 18.8	≥ 18.8	< 2.1	2.1 ≤ T < 14.8	≥ 14.8
	$3 < L_2 \le 7$	< 4.8	4.8 ≤ T < 36.7	≥ 36.7	< 3.3	3.3 ≤ T < 24.8	≥ 24.8	< 2.4	2.4 ≤ T < 18.4	≥ 18.4
	$7 < L_2 \le 12$	< 6.3	6.3 ≤ T < 41.2	≥ 41.2	< 4.4	4.4 ≤ T < 28.8	≥ 28.8	< 3.2	3.2 ≤ T < 20.6	≥ 20.6
	> 12	< 8.4	8.4 ≤ T < 51.5	≥ 51.5	< 5.9	5.9 ≤ T < 39.4	≥ 39.4	< 4.2	4.2 ≤ T < 25.8	≥ 25.8
15≤ % <20	≤ 3	< 3.7	3.7 ≤ T < 21.0	≥ 21.0	< 2.5	2.5 ≤ T < 13.3	≥ 13.3	< 1.9	1.9 ≤ T < 10.5	≥ 10.5
	$3 < L_2 \le 7$	< 4.3	4.3 ≤ T < 26.1	≥ 26.1	< 2.9	2.9 ≤ T < 17.6	≥ 17.6	< 2.2	2.2 ≤ T < 13.1	≥ 13.1
	$7 < L_2 \le 12$	< 5.6	5.6 ≤ T < 29.1	≥ 29.1	< 3.9	3.9 ≤ T < 20.3	≥ 20.3	< 2.8	2.8 ≤ T < 14.6	≥ 14.6
	> 12	< 7.5	7.5 ≤ T < 36.3	≥ 36.3	< 5.2	5.2 ≤ T < 27.7	≥ 27.7	< 3.8	3.8 ≤ T < 18.2	≥ 18.2
20≤ % <25	≤ 3	< 3.3	3.3 ≤ T < 16.3	≥ 16.3	< 2.2	2.2 ≤ T < 10.3	≥ 10.3	< 1.7	1.7 ≤ T < 8.2	≥ 8.2
	$3 < L_2 \le 7$	< 3.9	3.9 ≤ T < 20.3	≥ 20.3	< 2.6	2.6 ≤ T < 13.7	≥ 13.7	< 2.0	2.0 ≤ T < 10.2	≥ 10.2
	$7 < L_2 \le 12$	< 5.0	5.0 ≤ T < 22.5	≥ 22.5	< 3.5	3.5 ≤ T < 15.7	≥ 15.7	< 2.5	2.5 ≤ T < 11.3	≥ 11.3
	> 12	< 6.7	6.7 ≤ T < 28.1	≥ 28.1	< 4.7	4.7 ≤ T < 21.4	≥ 21.4	< 3.4	3.4 ≤ T < 14.1	≥ 14.1

MEDIAN-BARRIER OR BRIDGE-RAILING TEST-LEVEL SELECTION, DESIGN SPEED 50 mph

Figure 49-6D(50)

Back

Bridge Railing Design

AASHTO Manual for Assessing Safety Hardware (MASH)

Introduced in 2009

Acceptable railings located at http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/bridgerailings/

NCHRP 350 Railings do not have to be replaced.

Bridge Railing Design

FHWA BRIDGE RAIL MEMORANDUM, MAY 30, 1997: PART 1, 2 & 3 COMBINED AND SORTED BY TYPE

FIGURE NUMBER	BRIDGE RAILING	RAILING HEIGHT (IN.)	TEST VEHICLE	IMPACT SPEED (MPH)	IMPACT ANGLE DEGREES	Meets NCHRP 230	PERFORMANCE LEVEL	NCHRP 350 EQUIVALENT TEST LEVEL FROM FHWA MEMO 3	REFERENCES	FHWA Bridge Rail Memo #1	FHWA Bridge Rail Memo #2	FHWA Bridge Rail Memo #3
W-BEAM BRIDGE RAIL												
1	Texas Type T6 (Tubular W-beam)	27	2,280 lb. Car 4,500 lb. Car 2,000P Pickup	58 61.8 100 kph	14 27.5 25	Yes		TL-2	1,2 1,2 3	3		1-3
2	West Virginia W-beam Retrofit Railing for Concrete Baluster designs, curb mounted	28.5	817 kg Car 2452 kg Pickup	80 kph 72 kph	20 20		Originally tested to PL-1	TL-2	4			3-11
THRIE-BEAM BRIDGE RAIL												
3	NCHRP SL1 Thrie Beam, Wood Posts	32	2,250 lb. Car 2,350 lb. Car 4,500 lb. Car	63 60.1 61.9	18.7 15.9 14.5	Yes		TL-2	2,5	1		1-1
4	NCHRP SL1 Thrie Beam, Steel Posts	32	1,987 lb. Car 2,250 lb. Car 2,250 lb. Car 20,000 lb. Bus	61.4 58.6 60 44.7	14.1 16 16 7.7	Yes		TL-2	2,5	2		1-2
5	Nebraska Tubular Thrie Beam	32	1,970 lb. Car 4,700 lb. Car	61.4 58.4	20 24.3	Yes		TL-3	6,7	11		1-12
6	Oregon Side-Mounted Thrie Beam	27	1,970 lb Car 5,737 lb Pickup	52.2 46.1	19.7 20.8	Yes	PL-1	TL-2	8,9,10		1-1	2-1
7	Washington 10 gage Thrie Beam Retrofit for Balusters Curb/Sidewalk	30	1,840 lb Car 4,725 lb Car 5,400 lb Pickup	58.6 60.7 66.3	19.5 15.6 19.4	Yes	PL-1	TL-2	11		1-6	2-7
8	California Thrie Beam	32	1,935 lb Car 5,565 lb Pickup	48.7 44.9	18.3 21	Yes	PL-1	TL-2	12,13		1-9	2-8
9	Missouri Thrie Beam and Channel (top mounted)	30-5/8", 30.625"	1,984 lb Car 4,495 lb Car	59.6 60.9	16 24	Yes		TL-3	14,15		1-10	2-13
10	Michigan 10 gage retrofit on Curb/Sidewalk (Michigan R4 Retrofit Bridge Rail)	34	1,972 lb Car 5,724 lb Pickup 18,000 lb Truck	61.5 60.6 49	20 20 15	Yes	PL-2	TL-4	16		1-15	2-15
11	Delaware Thrie-beam Retrofit Railing (curb-mounted)	32	8,000 kg Single-Unit Truck	80 kph	15		Tested to NCHRP 350	TL-4	4			3-24
METAL TUBE BRIDGE RAIL												
Aluminum Tube Bridge Rail												
12	Aluminum Tru-Beam (Modified AASHTO BR5)	32	2,150 lb. Car 4,500 lb. Car	61.3 58.9	21.5 27.2	Yes		TL-2	17,18	4		1-4
13	Foothills Parkway Aluminum Bridge Rail	33	2,069 lb Car 5,465 lb Pickup 5,565 lb Pickup	52 46.6 45.7	22 20.7 22.7		passed PL-1, NCHRP 230 failed, anchorage not long enough passed, corrected anchorage, PL-1	TL-2	19,20		2-22	3-12
Steel Tube Bridge Rail, Attached to Bottom of Deck												
14	Texas Energy Absorbing Bridge Rail	27	1,972 lb. Car 4,500 lb. Car	62.6 61	16 25	Yes		NCHRP 230	21,22,23	6		
Steel Tube Bridge Rail, Attached to Side of Deck												
15	California Type 18 (See-Through, Collapsing Ring)	36	1,850 lb. Car 4,530 lb. Car	59.7 60.7	12 23	Yes		NCHRP 230	24,13	17		
16	Collapsing Ring Bridge Railing	59	2,090 lb. Car 4,400 lb. Car 40,000 lb. Bus 40,000 lb. Tractor-Trailer 70,000 lb. Tractor-Trailer	55.7 62 53.9 57 44.4	23.5 22.7 15.1 15.6 10	Yes		NCHRP 230	25,26,27,28	21		
17	Ohio Box Beam Rail (W-beam backed up with box beam)	27	1,980 lb. Car 4,790 lb. Car	60.6 60	19.6 25	Yes		TL-2	6	8		1-6
18	California Type 115	30	1,965 lb Car 5,635 lb Pickup	59 64.2	19 21	Yes	PL-1	TL-2	29,13		1-7	2-6
19	Illinois Side Mounted Bridge Rail	32	1,970 lb Car 5,565 lb Pickup 18,000 lb Truck	59.9 60.4 51.4	20.1 20.4 14.7		tested to PL-2	TL-4	8,30		2-6	3-22
Steel Tube Bridge Rail, Attached to Top of Deck												
20	Texas T101 Bridge Rail	27	2780 lb. Car, 4,660 lb. Car 4,630 lb. Car 6,900 lb. Bus 19,940 lb. Bus 20,010 lb. Bus 31,880 lb. Bus	57.3 60.2 59.8 53.4 55.3 52 58.4	15 15 25.8 15 15.2 13.2 16	Yes		TL-3	18,31,32,33,2	7		1-11
21	Texas 421 Aesthetic Steel Pipe Bridge Rail	32	1,800 lb Car 4,500 lb Car	59.7 62.4	21.4 26.8	Yes		TL-2	34,35		1-12	2-11

Bridge Railing Design

Railing Design per AASHTO LRFD Bridge Design Specifications – Chapter 13

Intended for design of rails to be crash tested.

Table A13.2-1—Design Forces for Traffic Railings

Design Forces and Designations	Railing Test Levels					
	TL-1	TL-2	TL-3	TL-4	TL-5	TL-6
F_t Transverse (kips)	13.5	27.0	54.0	54.0	124.0	175.0
F_L Longitudinal (kips)	4.5	9.0	18.0	18.0	41.0	58.0
F_v Vertical (kips) Down	4.5	4.5	4.5	18.0	80.0	80.0
L_t and L_L (ft)	4.0	4.0	4.0	3.5	8.0	8.0
L_v (ft)	18.0	18.0	18.0	18.0	40.0	40.0
H_e (min) (in.)	18.0	20.0	24.0	32.0	42.0	56.0
Minimum H Height of Rail (in.)	27.0	27.0	27.0	32.0	42.0	90.0

Bridge Railing Design

AASHTO CA13.3.1

In this analysis it is assumed that the yield line failure pattern occurs within the parapet only and does not extend into the deck. This means that the deck must have sufficient resistance to force the yield line failure pattern to remain within the parapet.

Bridge Railing Design

IDM 404-3.02(02) Deck Overhang

Based on observations of impacted bridge railings, an overhang designed according to previous AASHTO bridge-design specifications shows the desired behavior that the overhang does not fail if a railing failure occurs due to a collision. Accordingly, the overhang shall be designed for a collision force of 25% greater than the required capacity, which results in a design approximating present satisfactory practice.

Bridge Railing Design

IDM 404-4.01(05)

For a minor bridge rehabilitation project which ***does not include bridge-deck replacement or deck widening*** and the bridge currently has a ***crashworthy TL-4 bridge railing***, the existing railing ***need not be upgraded to a TL-5 railing***, though the warrants for the TL-5 railing are satisfied. If there is no significant history of truck accidents, the installation of the TL-5 bridge railing shall be deferred until the time of the deck replacement or deck widening.

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Interim Questions?

Thank You!

Bridge Railing & Deck Design

The remainder of the presentation will discuss:

INDOT LRFD bridge railing & deck design practice.

Sidewalk railing applications.

Barrier railing on bridge rehabilitation projects.

LRFD Bridge Deck Design

Deck design seems simple, but several LRFD design sections are involved:

- Section 3: Loads & Load Factors
- Section 4: Distribution
- Section 5: Reinforced Concrete Design
- Section 9: Deck & Deck Systems
- Section 13: Railings

LRFD Bridge Deck Design

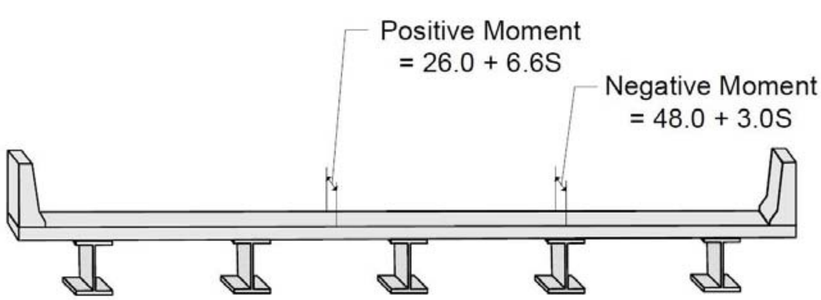
Bridge deck design requirements are covered under IDM Chapter 404.

For longitudinal beam bridges, two conditions are checked in the transverse direction to design the deck reinforcing steel:

- The interior condition between beams.
- The exterior deck overhang condition.

LRFD Bridge Deck Design - Interior

- Interior design uses an equivalent strip method, where wheel loads are distributed over the strip width.



Equivalent Strip Equations

LRFD Bridge Deck Design – Deck Overhang

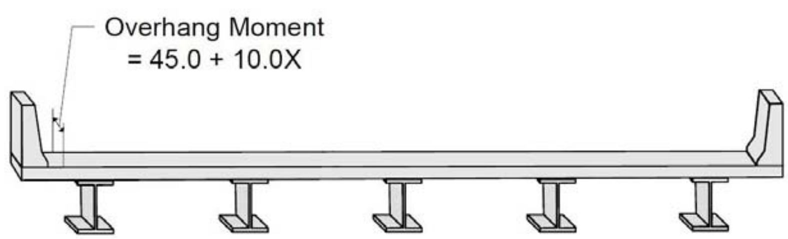
The deck overhang design requires checking three cases (LRFD A13.4, in reverse order for the presentation):

- Design Case 3: The loads specified in Article 3.6.1 that occupy the overhang for the Load Combination Strength I limit state;
- Design Case 2: Vertical forces specified in Article A13.2 for the Extreme Event Load Combination II limit state;
- Design Case 1: Transverse and longitudinal forces specified in Article A13.2 for the Extreme Event Load Combination II limit state.

LRFD Bridge Deck Design – Deck Overhang

Design Case 3: Strength I limit state

- This is effectively the same design process as the interior strip using dead and live loads applied to the cantilever. (Only governs with large overhang)



Equivalent Strip Equation

LRFD Bridge Deck Design – Deck Overhang

Design Case 2: *Extreme Event II limit state (Vertical Barrier Force)*

- This case involves a vertical load applied to the top of the railing. For concrete barrier railing, this condition does not control.
- The barrier railing longitudinally distributes the force if it is constructed monolithically and continuous. (IDM 404-3.02 & 3.04)
- This case is applicable to post type railing.

LRFD Bridge Deck Design – Deck Overhang

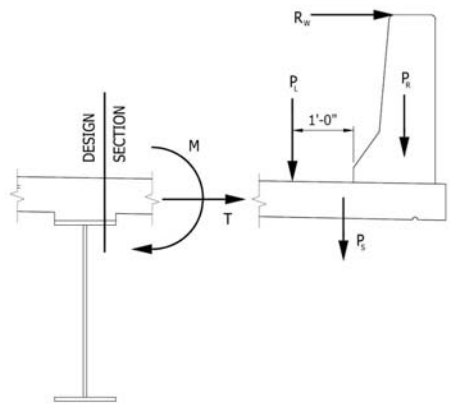
Design Case 1: *Extreme Event II limit state (Horizontal Barrier Force)*

- Design procedures are in LRFD Section A13.4.
- This presentation will focus only on Section A13.4.2 – *Decks Supporting Concrete Parapet Railings*

Overhang Design Loading

Design Case 1: Extreme Event II limit state (Horizontal Barrier Force)

- The deck reinforcing steel must be designed to accommodate the combined moment and tension force.



Overhang Design Loading

If certain conditions are met, AASHTO allows an easy solution to determine the live loading.

3.6.1.3.4—Deck Overhang Load

For the design of deck overhangs with a cantilever, not exceeding 6.0 ft from the centerline of the exterior girder to the face of a structurally continuous concrete railing, the outside row of wheel loads may be replaced with a uniformly distributed line load of 1.0 klf intensity, located 1.0 ft from the face of the railing.

Horizontal loads on the overhang resulting from vehicle collision with barriers shall be in accordance with the provisions of Section 13.

LRFD Bridge Deck Design – Deck Overhang

A13.4.2—Decks Supporting Concrete Parapet Railings

For Design Case 1, the deck overhang may be designed to provide a flexural resistance, M_s in kip-ft/ft which, acting coincident with the tensile force T in kip/ft, specified herein, exceeds M_c of the parapet at its base. The axial tensile force, T, may be taken as:

$$T = \frac{R_w}{L_c + 2H} \quad \text{(A13.4.2-1)}$$

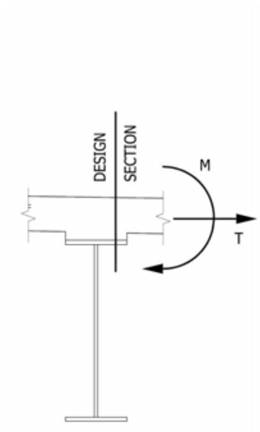
where:

R_w = parapet resistance specified in Article A13.3.1 (kips)

L_c = critical length of yield line failure pattern (ft)

H = height of wall (ft)

T = tensile force per unit of deck length (kip/ft)



LRFD Bridge Deck Design – Deck Overhang

A yield line analysis produces the nominal railing resistance.

A13.3.1—Concrete Railings

Yield line analysis and strength design for reinforced concrete and prestressed concrete barriers or parapets may be used.

The nominal railing resistance to transverse load, R_w, may be determined using a yield line approach as:

- For impacts within a wall segment:

$$R_w = \left(\frac{2}{2L_c - L_t}\right)\left(8M_b + 8M_w + \frac{M_c L_c^2}{H}\right) \quad \text{(A13.3.1-1)}$$

LRFD Bridge Deck Design – Deck Overhang

H = height of wall (ft)

L_c = critical length of yield line failure pattern (ft)

L_t = longitudinal length of distribution of impact force F_t (ft)

R_w = total transverse resistance of the railing (kips)

M_b = additional flexural resistance of beam in addition to M_w, if any, at top of wall (kip-ft)

M_c = flexural resistance of cantilevered walls about an axis parallel to the longitudinal axis of the bridge (kip-ft/ft)

M_w = flexural resistance of the wall about its vertical axis (kip-ft)

For use in the above equations, M_c and M_w should not vary significantly over the height of the wall. For other cases, a rigorous yield line analysis should be used.

LRFD Bridge Deck Design – Deck Overhang

The critical wall length over which the yield line mechanism occurs, L_c, shall be taken as:

$$L_c = \frac{L_t}{2} + \sqrt{\left(\frac{L_t}{2}\right)^2 + \frac{8H(M_b + M_w)}{M_c}} \qquad \text{(A13.3.1-2)}$$

- For impacts at end of wall or at joint:

$$R_w = \left(\frac{2}{2L_c - L_t}\right)\left(M_b + M_w + \frac{M_c L_c^2}{H}\right) \qquad \text{(A13.3.1-3)}$$

$$L_c = \frac{L_t}{2} + \sqrt{\left(\frac{L_t}{2}\right)^2 + H\left(\frac{M_b + M_w}{M_c}\right)} \qquad \text{(A13.3.1-4)}$$

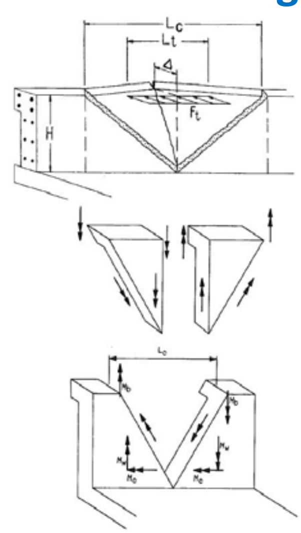


Figure CA13.3.1-1—Yield Line Analysis of Concrete Parapet Walls for Impact within Wall Segment

LRFD Bridge Deck Design – Deck Overhang

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.

How Much Force???

Using the railing capacity to design the deck overhang reinforcing can be overly conservative.

The IDM now allows the use of 1.25 x F_t as a maximum.

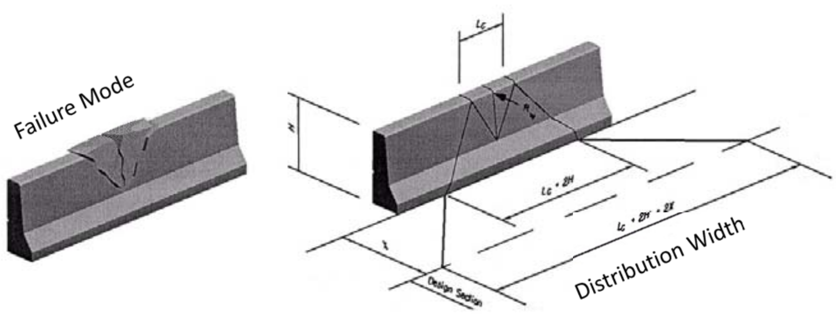
LRFD Railing Design Forces

The F_t value comes from LRFD Table A13.2-1 using the appropriate railing test level.

Table A13.2-1—Design Forces for Traffic Railings

Design Forces and Designations	Railing Test Levels					
	TL-1	TL-2	TL-3	TL-4	TL-5	TL-6
F_t Transverse (kips)	13.5	27.0	54.0	54.0	124.0	175.0
F_L Longitudinal (kips)	4.5	9.0	18.0	18.0	41.0	58.0
F_v Vertical (kips) Down	4.5	4.5	4.5	18.0	80.0	80.0
L_t and L_L (ft)	4.0	4.0	4.0	3.5	8.0	8.0
L_v (ft)	18.0	18.0	18.0	18.0	40.0	40.0
H_e (min) (in.)	18.0	20.0	24.0	32.0	42.0	56.0
Minimum H Height of Rail (in.)	27.0	27.0	27.0	32.0	42.0	90.0

Load Application & Distribution



The collision forces are distributed over a distance L_c for moment and L_c + 2H for axial force. The distribution length increases at a 30 - 45 degree angle from the barrier face to the design section.

Rail Load Design for Test Level

- Calculate R_w & L_c from a yield line analysis. Use the lower force value between R_w or 1.25 x F_t.
- Calculate T & M at the Design Section.
- A linear interaction equation is typically used to design the reinforcing steel for the combined loading.

$$\frac{P_u}{P_n} + \frac{M_u}{M_n} = 1.0$$

Solving for M_u:

$$M_u = M_n\left(1.0 - \frac{P_u}{P_n}\right)$$

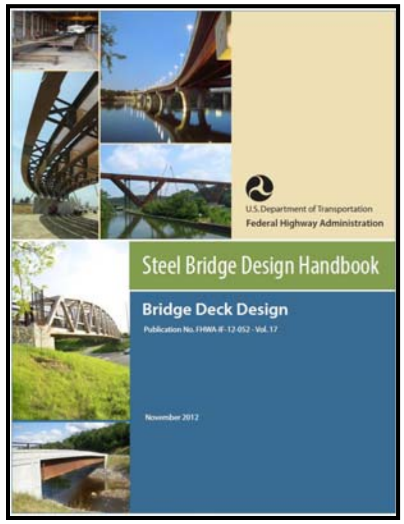
Cutoff Location & Bar Development

- After the reinforcing steel is designed, any required cut-off locations must be determined, and the development length must be verified.
- There are numerous design guides available.
- FHWA is a good resource.

FHWA Guide

Federal Highway has many design guides available for download at:

http://www.fhwa.dot.gov/bridge/steel/pubs/if12052/



www.fhwa.dot.gov/bridge/steel/pubs/if12052/volume17.pdf

Minnesota Design Tables

Since the design values are specific to a rail type and test level, Minnesota tabulated them:

TABLE 13.2.4.1: Resistance Values for Standard Concrete Barriers

Description	End Panel		Interior Panel	
	L_c (ft)	R_w (kips)	L_c (ft)	R_w (kips)
Concrete Barrier (Type F, TL-4) 5-397.114: Separate End Post w/o W.C. 5-397.115: Integral End Post w/o W.C.	4.6	59.2	9.9	124.1
Concrete Barrier (Type F, TL-4) 5-397.116: Separate End Post w/ W.C. 5-397.117: Integral End Post w/ W.C.	4.6	57.2	10.2	122.9
Concrete Barrier (Type F, TL-5) 5-397.122: Integral End Post w/ W.C.	9.3	128.5	14.3	128.8
Concrete Barrier (Type F, TL-5) 5-397.124: Integral End Post w/o W.C.	9.2	133.6	14.0	131.4
Concrete Barrier (Type F, TL-5) w/ Sidewalk 5-397.125: Integral End Post w/ W.C.	9.3	128.5	14.3	128.8
Concrete Barrier (Type F, TL-5) w/Sidewalk 5-397.126: Integral End Post w/o W.C.	9.2	133.6	14.0	131.4
Concrete Barrier and Glare Screen (Type F, TL-5) 5-397.128: Integral End Post w/W.C.	9.3	128.5	14.3	128.8
Concrete Barrier and Glare Screen (Type F, TL-5) 5-397.129: Integral End Post w/o W.C.	9.2	133.6	14.0	131.4
Split Median Barrier (Type F, TL-4) 5-397.131: w/ W.C.	4.5	54.0	12.1	91.1
Split Median Barrier and Glare Screen (Type F, TL-4) 5-397.135: w/o W.C.	4.1	55.8	9.0	106.6
Split Median Barrier and Glare Screen (Type F, TL-4) 5-397.136: w/ W.C.	4.2	61.1	9.2	107.5

Caltrans Overhang Design

Caltrans amended LRFD A13.4.2 as follows:

A13.4.2 Decks Supporting Concrete Parapet Railings

Revise as follows:

For Design Case 1, the deck overhang shall ~~may~~ be designed to resist ~~provide a flexural resistance, M_S in kip-ft./ft. which, acting coincident with~~ the combined effects of tensile force T in kip/ft.~~,~~ and moment M_{ct} as specified herein, ~~exceeds M_C of the parapet at its base. The axial tensile force, T, may be taken as:~~

~~$T = \frac{R_w}{L_c + 2H}$~~

$$T = 1.2\left(\frac{F_t}{L_c}\right) \quad \text{(A13.4.2-1)}$$

$$M_{ct} = 1.2\left(\frac{F_t H}{L_c}\right) \quad \text{(A13.4.2-2)}$$

where:

~~R_w = parapet resistance specified in Article A13.3.1 (kips)~~

L_c = critical length of yield line failure pattern (ft.). In the absence of more accurate calculations, L_c, may be taken as 10 ft for Caltrans Standard Barriers Type 25, Type 732, Type 736, and Type 742; this value of L_c is valid for design forces TL-1 through TL-4 shown in Table A13.2-1. At the location of expansion joints, the value of L_c shall be half that specified above.

H = height of wall (ft.)

T = tensile force per unit of deck length (kip/ft.)

M_{ct} = moment in the deck overhang due to F_t (kip/ft.-ft.)

Overhang Design Recommendations

There are discussion within the Structures Committee regarding the possibility of developing design aids for railing loading on overhangs in one of the following formats:

- Tabulated design forces and critical wall lengths for INDOT Railing for each available test levels, or
- A modified design process similar to Caltrans.

Sidewalk Railing Applications

- LRFD Section 13.4 provides two options for pedestrian walkways railing depending on speed.
- IDM 404-4.02(03) discusses considerations if sidewalks are present, and like LRFD identifies low speed as 45mph or less.

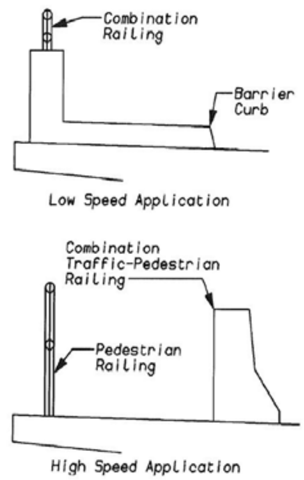


Figure 13.4-1—Pedestrian Walkway

Sidewalk Railing Applications

- If this type is used, a shyline is preferred.
- During a collision, a vehicle can still potentially mount the curb.
- This does not protect pedestrians from falling into traffic.

Sidewalk Railing Applications

- Many municipalities and trail groups are now in favor of providing railing to separate pedestrians from vehicular traffic regardless of the speed.
- There appears to be a trend towards this "High Speed" railing system.
- This system has the benefit of producing a lower structure dead load.

Johnny Appleseed Memorial Bridge

SR 930 over the St. Joseph River, in Fort Wayne

- Widened existing INDOT bridge to extend the river greenway trail
- PF-1 Railing w/ pipe added
- Pedestrian rail at coping
- Great visibility

Johnny Appleseed Memorial Bridge

- The structure could only support an 8 foot trail width
- Provided curved railing to give the illusion of added width and for bicycle pedal protection.

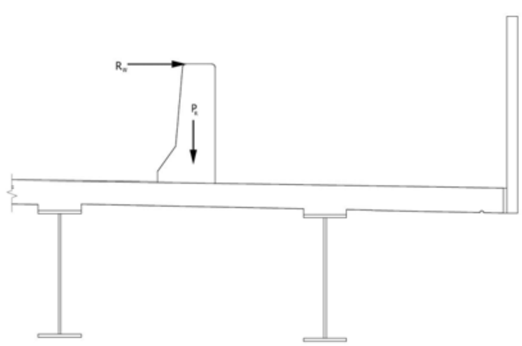
Johnny Appleseed Memorial Bridge

Johnny Appleseed Memorial Bridge

- The system produces a very straight top rail appearance.
- Pedestrians are separated from vehicular traffic and both are protected by appropriate railing systems.

Johnny Appleseed Memorial Bridge

Because there is structure behind the railing to carry the shear force, the tension component can be reduced or eliminated from the design.

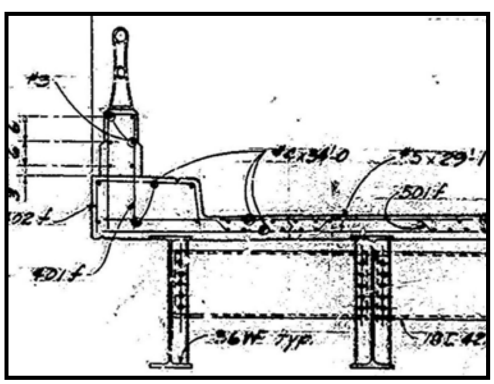


Bridge Rehabilitation Railing

- For an existing bridge having an older safety shape railing with reinforcing that doesn't meet current standards, the first step should be to determine if it can remain.
- Communication with Anne's Rearick's Department should occur early in the process to determine if a level one design exception is appropriate.
- A short form and submittal process to streamline the initial review is under development.
- Utilizing the existing railing will reduce costs, but every situation is unique.

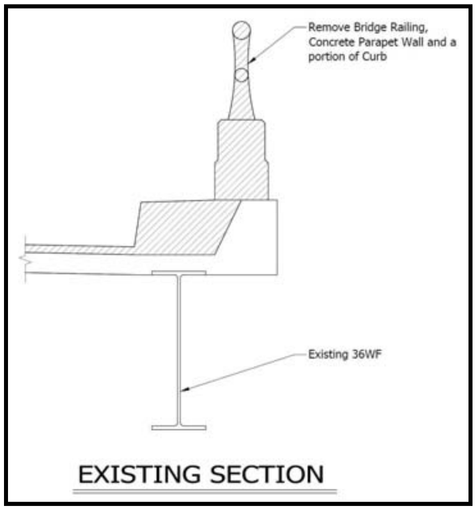
Bridge Rehabilitation Railing

For an existing bridge with unacceptable railing, replacement will be required.



Bridge Rehabilitation Railing

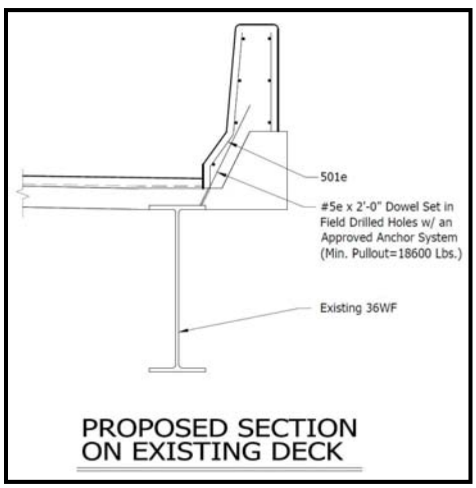
Remove enough of the existing railing & curb to accommodate installation of the new railing.



Bridge Rehabilitation Railing

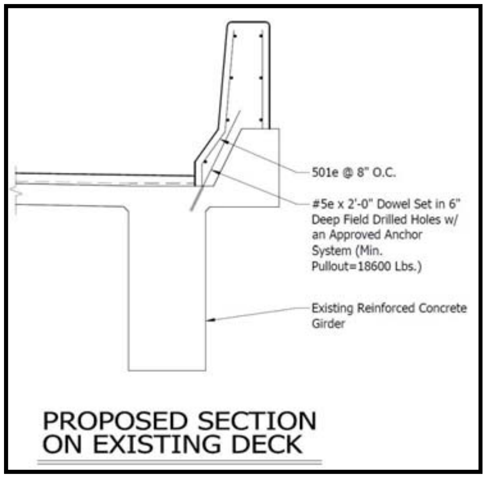
Older decks may only be 6 1/2” thick. This makes it difficult to install the anchor system without drilling through the deck.

On past projects, we have installed a bar at an angle to use the beam flange as a drill stop.



Bridge Rehabilitation Railing

This method can also be used on a reinforced concrete girder section.

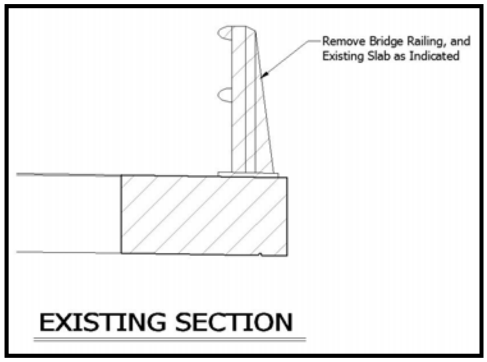


Bridge Rehabilitation Railing

Open railing on old slab bridges allowed salt to corrode the bottom reinforcing steel.

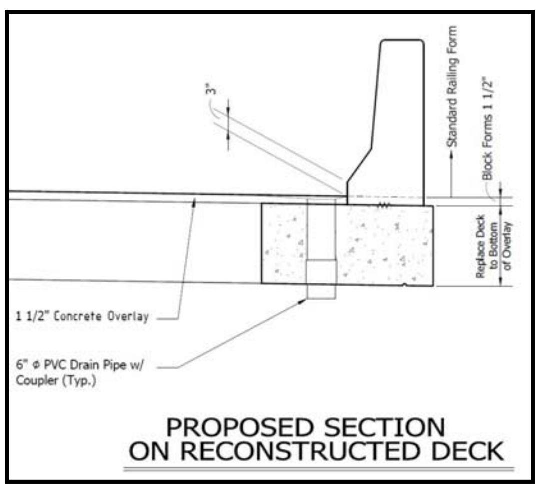
Bridge Rehabilitation Railing

To repair the corroded reinforcing steel and allow for the addition of new barrier railing, a section of the slab must be removed.



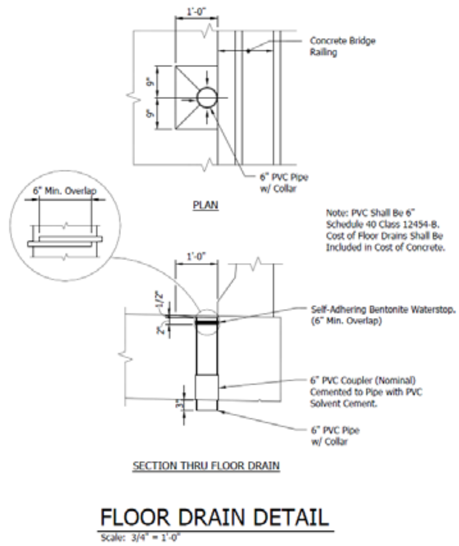
Bridge Rehabilitation Railing

A standard railing concrete form can be blocked 1 1/2" to allow the railing to act as an overlay form and screed rail during construction.



Retrofit Barrier Drainage Detail

- With the new solid barrier railing, water can no longer drain off the slab edge.
- A bentonite waterstop can be installed to ensure water flows through the new drain and not along the edge where salt can migrate into the slab.

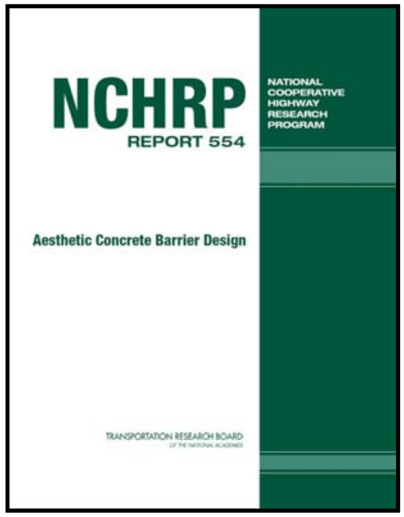


Bentonite Waterstop

- Bentonite waterstop is readily available from multiple suppliers and is self adhering .

Railing Aesthetic Treatments & Safety

This report contains guidelines for aesthetic treatment of concrete safety shape barriers.



http://www.trb.org/main/blurbs/156682.aspx

INDOT Bridge Design Conference 2013

Questions?

INDIANA DEPARTMENT OF TRANSPORTATION INDOT

Thank You!

ASCE INDIANA SECTION