HIGHWAY GROUP CHAIRMAN'S FACTUAL REPORT

RAILROAD INTERSECTION AT GRADE COLLISION INVOLVING UNION PACIFIC RAILROAD TRAIN (UPRR) 2ASMAR-2 AND BURLINGTON NORTHERN SANTA FE TRAIN (BNSF) UKCKHKMO-05T FOLLOWED BY DERAILMENT AND IMPACT INTO AND PARTIAL COLLAPSE OF THE MISSOURI HIGHWAY BRIDGE A4376 SPANNING MISSOURI STATE ROUTE M

NEAR CHAFFEE, MISSOURI

MAY 25, 2013 ABOUT 2:30 A.M.

DCA-13-MR-004

ATTACHMENT 2

EXCERPTS FROM AASHTO LRFD, AREA, AND AREMA MANUALS

(8) PAGES

AASHTO LRFD BRIDGE

DESIGN SPECIFICATIONS

Customary U.S. Units • 2012

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AASHTO
The Voice of Transportation

cases where substructures are found to be inadequate to resist the increased longitudinal forces, consideration should be given to design and detailing strategies which distribute the braking force to additional substructure units during a braking event.

3.6.5—Vehicular Collision Force: *CT*

3.6.5.1—Protection of Structures

Unless the Owner determines that site conditions indicate otherwise, abutments and piers located within a distance of 30.0 ft to the edge of roadway shall be investigated for collision. Collision shall be addressed by either providing structural resistance or by redirecting or absorbing the collision load. The provisions of Article 2.3.2.2.1 shall apply as appropriate.

Where the design choice is to provide structural resistance, the pier or abutment shall be designed for an equivalent static force of 600 kip, which is assumed to act in a direction of zero to 15 degrees with the edge of the pavement in a horizontal plane, at a distance of 5.0 ft above ground.

Where the design choice is to redirect or absorb the collision load, protection shall consist of one of the following:

- An embankment;
- A structurally independent, crashworthy ground-mounted 54.0-in. high barrier, located within 10.0 ft from the component being protected; or
- A 42.0-in. high barrier located at more than 10.0 ft from the component being protected.

Such barrier shall be structurally and geometrically capable of surviving the crash test for Test Level 5, as specified in Section 13.

C3.6.5.1

Where an Owner chooses to make an assessment of site conditions for the purpose of implementing this provision, input from highway or safety engineers and structural engineers should be part of that assessment.

The equivalent static force of 600 kip is based on the information from full-scale crash tests of rigid columns impacted by 80.0-kip tractor trailers at 50 mph. For individual column shafts, the 600-kip load should be considered a point load. Field observations indicate shear failures are the primary mode of failure for individual columns and columns that are 30.0 in. in diameter and smaller are the most vulnerable. For wall piers, the load may be considered to be a point load or may be distributed over and area deemed suitable for the size of the structure and the anticipated impacting vehicle, but not greater than 5.0 ft wide by 2.0 ft high. These dimensions were determined by considering the size of a truck frame.

Requirements for train collision load found in previous editions have been removed. Designers are encouraged to consult the AREMA Manual for Railway Engineering or local railroad company guidelines for train collision requirements.

For the purpose of this Article, a barrier may be considered structurally independent if it does not transmit loads to the bridge.

Full-scale crash tests have shown that some vehicles have a greater tendency to lean over or partially cross over a 42.0-in. high barrier than a 54.0-in. high barrier. This behavior would allow a significant collision of the vehicle with the component being protected if the component is located within a few ft of the barrier. If the component is more than about 10.0 ft behind the barrier, the difference between the two barrier heights is no longer important.

One way to determine whether site conditions qualify for exemption from protection is to evaluate the annual frequency of impact from heavy vehicles. With the approval of the Owner, the annual frequency for a bridge pier to be hit by a heavy vehicle, AF_{HPB}, can be calculated by:

$$AF_{HBP} = 2(\text{ADTT})\,(P_{HBP})365 \qquad \text{(C3.6.5.1-1)}$$

where:

ADTT = the number of trucks per day in one direction

P_{HBP} = the annual probability for a bridge pier to be hit by a heavy vehicle

Table C3.6.1.4.2-1 may be used to determine ADTT from available ADT data.

P_{HBP} = 3.457 x 10^{-9} for undivided roadways in tangent and horizontally curved sections

1.090 x 10^{-9} for divided roadways in tangent sections
2.184 x 10^{-9} for divided roadways in horizontally curved sections

Design for vehicular collision force is not required if AF_{HBP} is less than 0.0001 for critical or essential bridges or 0.001 for typical bridges.

The determination of the annual frequency for a bridge pier to be hit by a heavy vehicle, AF_{HPB}, is derived from limited statistical studies performed by the Texas Transportation Institute. Due to limited data, no distinction has been made between tangent sections and horizontally curved sections for undivided roadways. The target values for AF_{HBP} mirror those for vessel collision force found in Article 3.14.5.

Table C3.6.5.1-1 provides typical resulting values for AF_{HBP}.

Table C3.6.5.1-1—Typical Values of AF_{HBP}

		Undivided	Divided Curved	Divided Tangent
ADT (Both Directions)	ADTT* (One Way)	P_{HBP}=3.457E-09	P_{HBP}=2.184E-09	P_{HBP}=1.09E-09
		$AF_{HPB} = 2 \times ADTT \times 365 \times P_{HBP}$		
1000	50	0.0001	0.0001	0.0000
2000	100	0.0003	0.0002	0.0001
3000	150	0.0004	0.0002	0.0001
4000	200	0.0005	0.0003	0.0002
6000	300	0.0008	0.0005	0.0002
8000	400	0.0010	0.0006	0.0003
12000	600	0.0015	0.0010	0.0005
14000	700	0.0018	0.0011	0.0006
16000	800	0.0020	0.0013	0.0006
18000	900	0.0023	0.0014	0.0007
20000	1000	0.0025	0.0016	0.0008
22000	1100	0.0028	0.0018	0.0009
24000	1200	0.0030	0.0019	0.0010
26000	1300	0.0033	0.0021	0.0010
28000	1400	0.0035	0.0022	0.0011

*Assumes ten percent of ADT is truck traffic.

3.6.5.2—Vehicle Collision with Barriers

The provisions of Section 13 shall apply.

2.1.5 Pier Protection

Piers supporting bridges over railways and located within 25 ft of the centerline of a railroad track shall be of heavy construction or shall be protected by a reinforced concrete crash wall extending to not less than 6 ft above top of rail. When two or more light columns compose a pier, a wall at least 2 ft thick shall connect the columns. When a pier consists of a single column, it shall be protected by a crash wall parallel to track. The wall shall be at least 2 ft 6 in. thick and extend for a distance of at least 6 ft from both sides of the column. The face of crash walls shall extend a distance of at least 6 in. beyond the face of column on the side adjacent to the track and shall be anchored to the columns and footings with adequate steel reinforcement.

2.2 NOTATIONS, DEFINITIONS AND DESIGN LOADS

2.2.1 Notations

a = depth of equivalent rectangular stress block, inches. See Article 2.31.1 (f)

a_b = depth of equivalent rectangular stress block for balanced strain conditions, inches. See Article 2.33.2(c)

A = effective tension area of concrete surrounding the main tension reinforcing bars and having the same centroid as that reinforcement, divided by the number of bars, square inches. When the main reinforcement consists of several bar sizes the number of bars shall be computed as the total steel area divided by the area of the largest bar used—Article 2.39

A_b = area of an individual bar, square inches—Article 2.14

A_c = area of core spirally reinforced compression member measured to the outside diameter of the spiral, square inches—Article 2.11.2

A_g = gross area of section, square inches

A_s = area of tension reinforcement, square inches

A'_s = area of compression reinforcement, square inches

A_{sf} = area of reinforcement to develop compressive strength of overhanging flanges of I- and T-sections, square inches—Article 2.32.3

A_{st} = total area of longitudinal reinforcement, square inches—Article 2.33.1 (c) and 2.33.2(a)

A_v = area of shear reinforcement within a distance s, square inches

A_{vf} = area of shear friction reinforcement, square inches—Article 2.29.4 and 2.35.4

A_w = area of individual wire to be developed or spliced, square inches

A_1 = loaded area—Articles 2.28 and 2.36

A_2 = maximum area of the portion of the supporting surface that is geometrically similar to and concentric with the loaded area—Articles 2.28 and 2.36

b = width of compression face of member, inches

b_o = periphery of critical section for slabs and footings, inches—Articles 2.29.6 and 2.35.6

American Railway Engineering and Maintenance-of-Way Association

Part 2

Reinforced Concrete Design[1]

— 2012

2.1.5 PIER PROTECTION (2005)

2.1.5.1 Adjacent to Railroad Tracks1

a. To limit damage by the redirection and deflection of railroad equipment, piers supporting bridges over railways and
with a clear distance of 25 feet (7600 mm) or less from the centerline of a railroad track shall be of heavy construction
(defined below) or shall be protected by a reinforced concrete crash wall. Crash walls for piers from 12 to 25 feet (3600
to 7600 mm) clear from the centerline of track shall have a minimum height of 6 feet (1800 mm) above the top of rail.
Piers less than 12 feet (3600 mm) clear from the centerline of track shall have a minimum crash wall height of 12 feet
(3600 mm) above the top of rail.
b. The crash wall shall be at least 2′ -6″ (760 mm) thick and at least 12 feet (3600 mm) long. When two or more columns
compose a pier, the crash wall shall connect the columns and extend at least 1 foot (300 mm) beyond the outermost columns parallel to the track. The crash wall shall be anchored to the footings and columns, if applicable, with adequate reinforcing steel and shall extend to at least 4 feet (1200 mm) below the lowest surrounding grade.
c. Piers shall be considered of heavy construction if they have a cross-sectional area equal to or greater than that required
for the crash wall and the larger of its dimensions is parallel to the track.
d. Consideration may be given to providing protection for bridge piers over 25 feet (7600 mm) from the centerline of

track as conditions warrant. In making this determination, account shall be taken of such factors as horizontal and vertical alignment of the track, embankment height, and an assessment of the consequences of serious damage in the case of a collision.

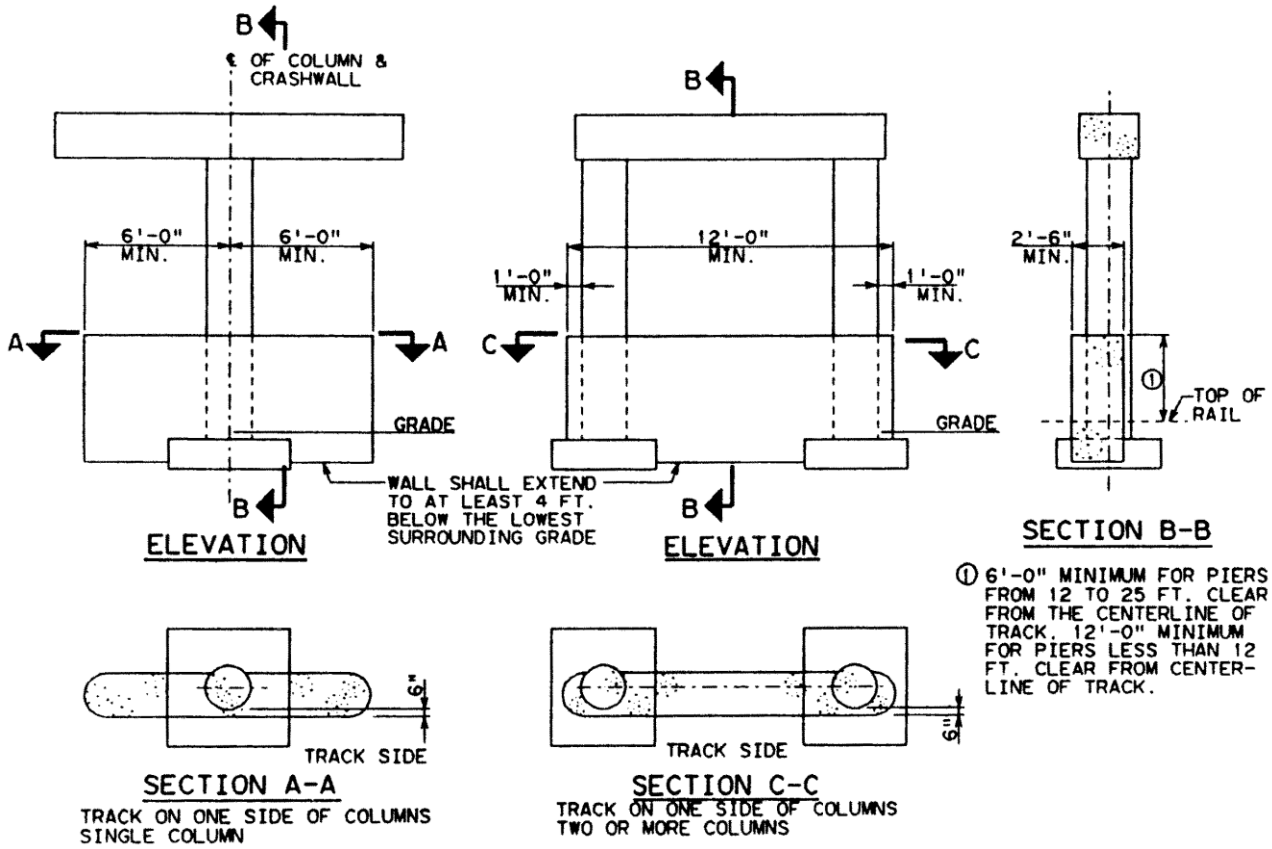

Figure C-8-2-1. Pier Protection: Minimum Crash Wall Requirements (Not To Scale)