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FPL-GTR-107

Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks on Low-Volume Roads

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Steve Bunnell
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Barry T. Rosson

Abstract

The plans for crashworthy bridge railings for low-volume roads were developed through a cooperative research program involving the USDA Forest Service, Forest Products Laboratory (FPL); the Midwest Roadside Safety Facility, University of Nebraska-Lincoln (MwRSF); and the Forest Service, National Forest System, Engineering. Three railings were developed and successfully tested in accordance with National Cooperative Highway Research Program (NCHRP) Report 350 Test Level-1 requirements. The fourth system was developed for a lower test level based on criteria developed by the Forest Service for single-lane bridges on very low-volume roads. For the convenience of the user, full drawing sets are provided in customary U.S. and S.I. units.

August 1998

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The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin.

Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks on Low-Volume Roads

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Introduction

Since 1989, the USDA Forest Service, Forest Products Laboratory (FPL), and the Midwest Roadside Safety Facility, University of Nebraska-Lincoln (MwRSF) have worked in cooperation to develop crash-tested bridge railings for timber bridge decks. This research originally focused on Performance Level 1 (PL-1) and Performance Level 2 (PL-2) railings as outlined in the *AASHTO Guide Specifications for Bridge Railings* (AASHTO 1989), but was expanded as a cooperative effort with the Federal Highway Administration (FHWA) to include Test Level 2 (TL-2) and Test Level 4 (TL-4) railings in accordance with *Recommended Procedures for the Safety Performance Evaluation of Highway Features* (NCHRP Report 350) (Ross and others 1993). Although this research resulted in numerous railing systems for bridges on primary or secondary highways, there were no railings developed specifically for low-volume roads (Ritter and others 1995). Since most timber bridges are located on low-volume roads, the Forest Service, National Forest System, Engineering, identified a need to develop crashworthy timber bridge railings designed specifically for low-volume applications.

These plans reflect the results of a cooperative research project between FPL, MwRSF, and the Forest Service, National Forest System, Engineering, to develop four crashworthy bridge railing designs for low-volume applications. Three of the railings were developed and successfully tested in accordance with NCHRP 350 TL-1 requirements (Ross and others 1993). The fourth system was developed for a lower test level based on criteria developed by the Forest Service for single-lane bridges on very low-volume roads. For the convenience of the user, full drawing sets are provided in customary U.S. and S.I. units.

Acknowledgments

We express sincere appreciation to Brent Prauner, Keith Robertson, and Eric Keller of the Midwest Roadside Safety Facility, University of Nebraska-Lincoln, and the FPL Information Services Team for assistance in preparing this publication.

Specifications

AASHTO. 1989. Guide specifications for bridge railings. Washington, DC: American Association of State Highway and Transportation Officials.

AASHTO. 1995. Standard specifications for transportation materials and methods of sampling and testing. vol. 1: specifications. Washington, DC: American Association of State Highway and Transportation Officials.

- M111 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- M133 Preservatives and Pressure Treatment Process for Timber
- M168 Wood Products
- M180 Corrugated Sheet Steel Beams for Highway Guardrail
- M232 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

AASHTO-AGC-ARTBA.1995. A guide to standardized highway barrier hardware. Washington, DC: American Association of State Highway and Transportation Officials.

ASTM. 1998. Annual book of ASTM standards. Philadelphia, PA: American Society for Testing and Materials.

- A36 Standard Specification for Structural Steel
- A47 Standard Specification for Ferritic Malleable Iron Castings
- A307 Standard Specification for Carbon Steel Bolts and Studs, 60,000 lbs/in^2 Tensile Strength
- A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 kips/in^2 Minimum Tensile Strength
- A722 Standard Specification for Uncoated, High-Strength Steel Bar for Prestressing Concrete

SAE. 1985. J429. Mechanical and material requirements for externally threaded fasteners. Warrendale, PA. Society of Automotive Engineers.

SAE. 1989. J412. General characteristics and heat treatment of steels. Warrendale, PA. Society of Automotive Engineers.

References

Faller, R.K.; Rosson, B.T. 1997. Development of a flexible bridge railing for longitudinal timber decks. Res. Rep. TRP-03-62-96. Lincoln, NE: University of Nebraska-Lincoln, Midwest Roadside Safety Facility.

Faller, R.K.; Rosson, B.T.; Sicking, D.L.; [and others]. 1995. Design and evaluation of two bridge railings for low-volume roads. In: Proceedings of 6th International conference on low-volume roads; 1995 June 25-29; Minneapolis, MN. Washington, DC: National Academy Press; Vol. 2: 357-372.

Faller, R.K.; Rosson, B.T.; Fowler, M.D.; Ritter, M.A. 1996a. Top-mounted W-beam bridge railing for longitudinal timber decks located on low-volume roads. Res. Rep. TRP-03-61-96. Lincoln, NE: University of Nebraska-Lincoln, Midwest Roadside Safety Facility.

Faller, R.K.; Rosson, B.T.; Ritter, M.A.; [and others]. 1996b. Railing systems for longitudinal timber deck bridges. In: Ritter, M.A.; Duwadi, S.R.; Lee, P.D.H., ed(s). National conference on wood transportation structures; 1996 October 23-25; Madison, WI. Gen. Tech. Rep. FPL-GTR-94. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 145-157.

Faller, R.K.; Rosson, B.T.; Soyland, K.; [and others]. 1996c. TL-1 curb-type bridge railing for longitudinal timber decks located on low-volume roads. Res. Rep. TRP-03-54-96. Lincoln, NE: University of Nebraska-Lincoln, Midwest Roadside Safety Facility.

Ritter, M.A.; Faller, R.K.; Sicking, D.L.; Bunnell, S. 1993. Development of low-volume curb-type bridge railings for timber bridge decks. Res. Rep. TRP-03-31-93. Lincoln, NE: University of Nebraska-Lincoln, Midwest Raodside Safety Facility.

Ritter, M.A.; Faller, R.K.; Lee, P.D.H.; [and others]. 1995. Plans for crash-tested bridge railings for longitudinal wood decks. Gen. Tech. Rep. FPL-GTR-87. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 27p.

Ross, H.E., Jr.; Sicking, D.L.; Zimmer, R.A.; Michie, J.D. 1993. Recommended procedures for the safety performance evaluation of highway features, National Cooperative Highway Research Program (NCHRP) Rep. 350. Washington, DC: National Research Council, Transportation Research Board.

Comments

Address comments on these drawings to the Wood Transportation Structures Team, USDA Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53705-2398. http://www.fpl.fs.fed.us/wit/

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Rail Drawings in Customary U.S. Units

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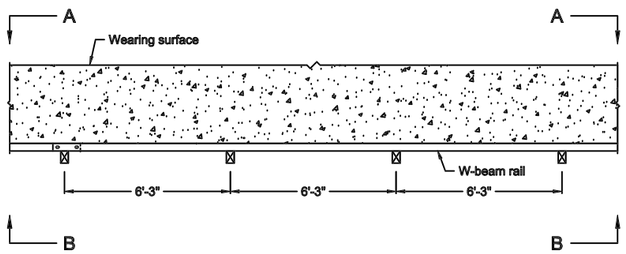

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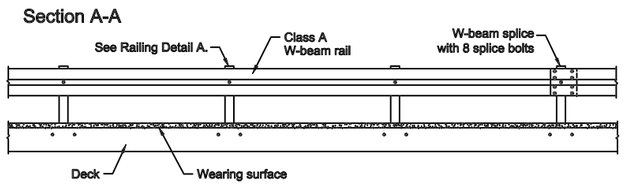

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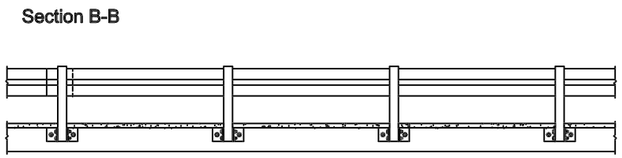

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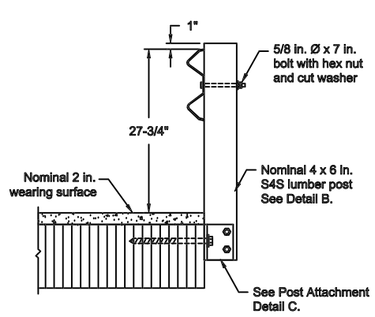

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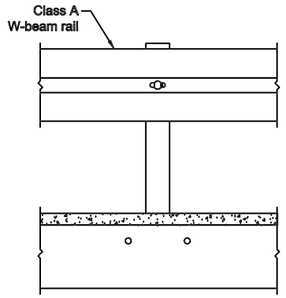

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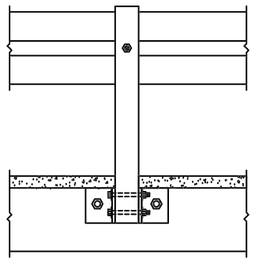
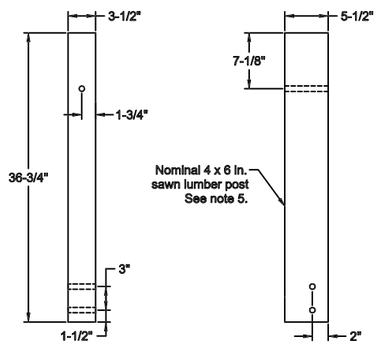


Back View

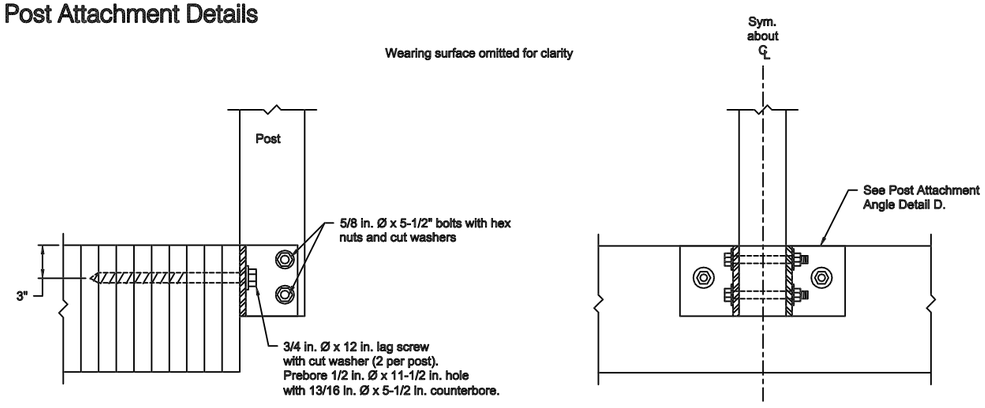
B Post Detail



Front View

Side View

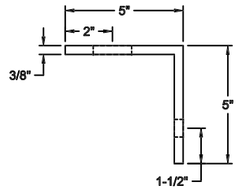
C Post Attachment Details



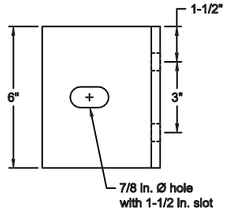
End View

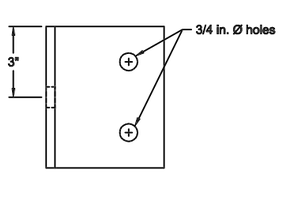
Back View

D Post Attachment Angle



5 x 5 x 3/8 in. A36 steel angle





Design

1. This bridge rail was successfully crash tested to the requirements for Test Level 1 (TL-1), as outlined in NCHRP Report 350 (Ross and others 1993). This rail is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued-laminated (glulam) timber decks that are 6 in. or greater in actual thickness and are less than 100 ft in length. For additional information, refer to Development of a Flexible Bridge Railing for Longitudinal Timber Decks (Faller and Rosson 1997).

2. This railing is a breakaway system where the wood posts are designed to separate from the deck attachment at vehicle impact. Vehicle containment is by tension developed in the steel bridge railing and approach railing systems.

3. Bridge railing shall be provided with a strong-post W-beam approach guardrail (SGR04a-b) and an appropriate end terminal as outlined in the AASHTO-AGC-ARTBA Guide to Standardized Highway Barrier Hardware.

4. Actual height of the bridge rail shall be 27-3/4 in. above the traveled way (top of wearing surface or top of bridge deck if a wearing surface is omitted), but not greater than 29-3/4 in. above the bridge deck.

Materials

5. Sawn lumber posts shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133. Post dimensions shall be 3-1/2 by 5-1/2 in., which are the actual dimensions for a nominal 4-by 6-in. post that is surfaced on four sides (S4S).

6. Posts shall be visually graded No. 2 or better with a maximum tabulated bending stress (F_b) of 1,250 lb/in^2 and a maximum tabulated modulus of elasticity (E) of 1,600,000 lb/in^2.

7. W-beam rail and rail splice bolts shall comply with the requirements of AASHTO M180. Railing shall be Class A (0.105-in. nominal base metal thickness).

8. Steel plates and shapes shall comply with the requirements of ASTM A36.

9. Unless otherwise noted, bolts and lag screws shall comply with the requirements of ASTM A307.

10. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or M232 or shall otherwise be provided with adequate corrosion protection.

Fabrication and Construction

11. To the extent possible, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives. When field fabrication of wood is required or if wood is damaged, all cuts, bore holes, and damage shall be immediately treated with wood preservative in accordance with AASHTO M133.

12. Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. When the size and strength of the head are sufficient to develop connection strength without wood crushing, washers may be omitted under heads of dome-head timber bolts.

13. Top of rail posts shall be sealed with roofing cement or otherwise protected from direct exposure to weather.

The bridge railings depicted on these drawings were developed and crash tested under a cooperative research agreement between the Midwest Roadside Safety Facility of the University of Nebraska-Lincoln and the USDA Forest Service, Forest Products Laboratory.

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FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Crash-Tested Bridge Rails for Longitudinal Wood Decks on Low-Volume Roads

Side Mounted Breakaway Railing
NCHRP 350 Test Level 1 (TL-1)

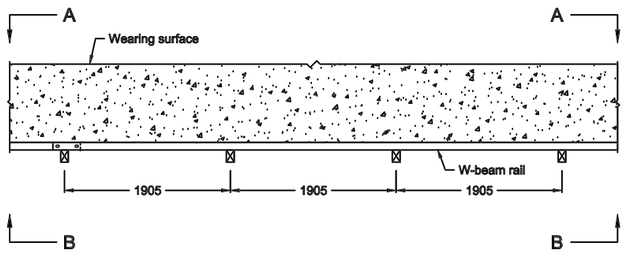
August 1998

Rail Drawings in S.I. Units

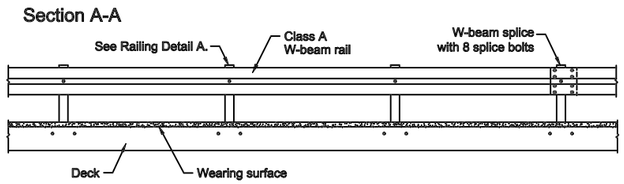
University of Nebraska Lincoln

General Configuration

All units are in millimeters based on a soft conversion from customary U.S. units.



Plan View



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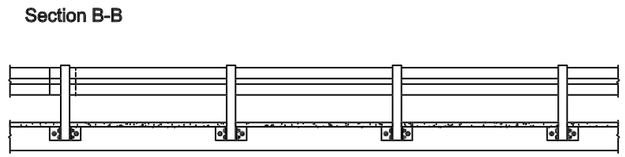
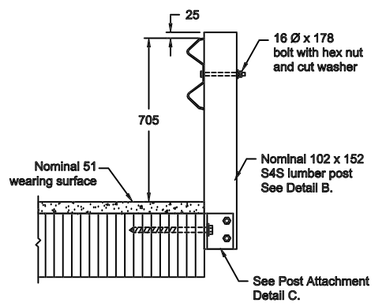


Back Elevation

A Railing Details



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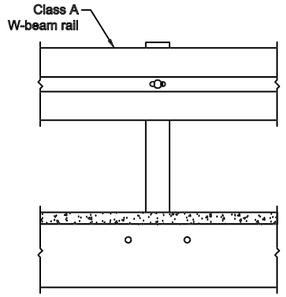
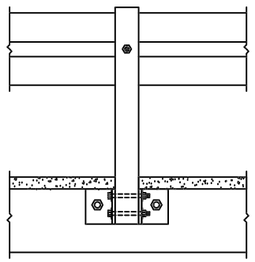
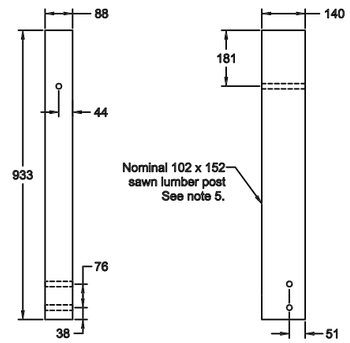


Front View



Back View

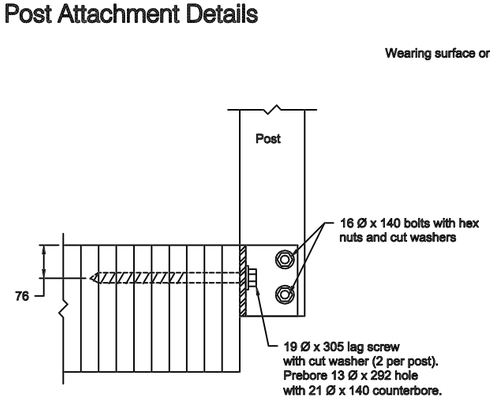
B Post Detail



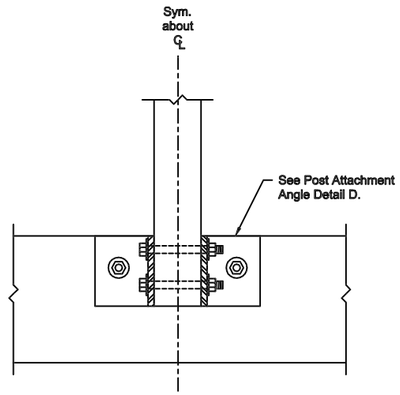
Front View

Side View

C Post Attachment Details

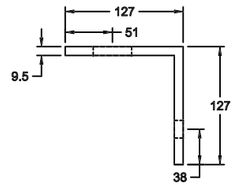


End View

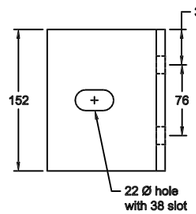


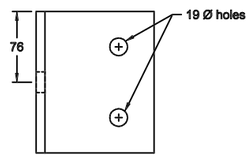
Back View

D Post Attachment Angle



127 x 127 x 9.5 A36 steel angle





Design

1. This bridge rail was successfully crash tested to the requirements for Test Level 1 (TL-1), as outlined in NCHRP Report 350 (Ross and others 1993). This rail is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued-laminated (glulam) timber decks that are 152 mm or greater in actual thickness and are less than 30.5 m in length. For additional information, refer to Development of a Flexible Bridge Railing for Longitudinal Timber Decks (Faller and Rosson 1997).

2. This railing is a breakaway system where the wood posts are designed to separate from the deck attachment at vehicle impact. Vehicle containment is by tension developed in the steel bridge railing and approach railing systems.

3. Bridge railing shall be provided with a strong-post W-beam approach guardrail (SGR04a-b) and an appropriate end terminal as outlined in the AASHTO-AGC-ARTBA Guide to Standardized Highway Barrier Hardware.

4. Actual height of the bridge rail shall be 705 mm above the traveled way (top of wearing surface or top of bridge deck if a wearing surface is omitted), but not greater than 756 mm above the bridge deck.

Materials

5. Sawn lumber posts shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133. Post dimensions shall be 89- by 140-mm, which are the actual dimensions for a nominal 102- by 152-mm post that is surfaced on four sides (S4S).

6. Posts shall be visually graded No. 2 or better with a maximum tabulated bending stress (Fb) of 8.6 MPa and a maximum tabulated modulus of elasticity (E) of 11,032 MPa.

7. W-beam rail and rail splice bolts shall comply with the requirements of AASHTO M180. Railing shall be Class A (2.66-mm nominal base metal thickness).

8. Steel plates and shapes shall comply with the requirements of ASTM A36.

9. Unless otherwise noted, bolts and lag screws shall comply with the requirements of ASTM A307.

10. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or M232 or shall otherwise be provided with adequate corrosion protection.

Fabrication and Construction

11. To the extent possible, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives. When field fabrication of wood is required or if wood is damaged, all cuts, bore holes, and damage shall be immediately treated with wood preservative in accordance with AASHTO M133.

12. Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. When the size and strength of the head are sufficient to develop connection strength without wood crushing, washers may be omitted under heads of dome-head timber bolts.

13. Top of rail posts shall be sealed with roofing cement or otherwise protected from direct exposure to weather.

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Side Mounted Breakaway Railing
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