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FPL-GTR-107

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

Michael A. Ritter
Ronald K. Faller
Steve Bunnell
Paula D. Hilbrich Lee
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

Ritter, Michael A.; Faller, Ronald K.; Bunnell, Steve; Lee, Paula D. Hilbrich; Rosson, Barry T. 1998. Plans for crash-tested bridge railings for longitudinal wood decks on low-volume roads. Gen. Tech. Rep. FPL–GTR–107. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 12 p.

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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

Michael A. Ritter, Research Engineer[1]
Ronald K. Faller, Research Engineer[2]
Steve Bunnell, Civil Engineer (retired)[3]
Paula D. Hilbrich Lee, General Engineer[1]
Barry T. Rosson, Associate Professor[2]

[1]USDA Forest Service, Forest Products Laboratory
[2]Midwest Roadside Safety Facility, University of Nebraska-Lincoln
[3]USDA Forest Service, National Forest System, Engineering

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.

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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

University of Nebraska Lincoln

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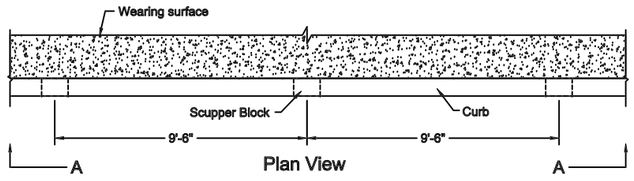

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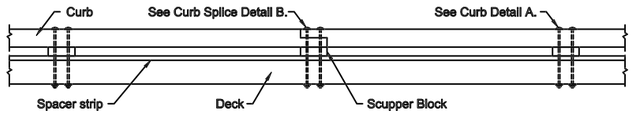

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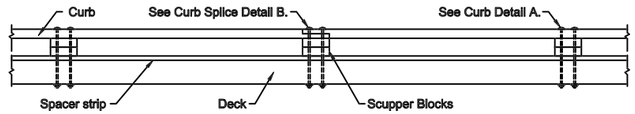

A Curb Details

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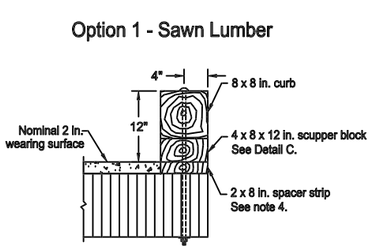

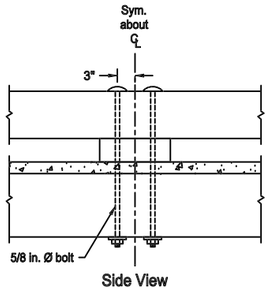

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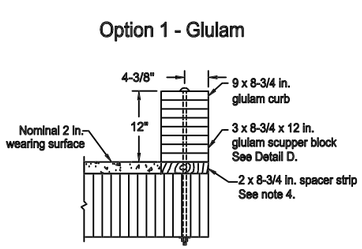

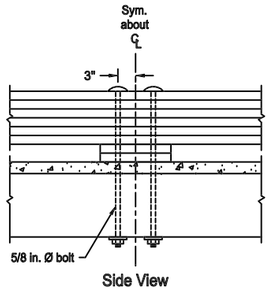

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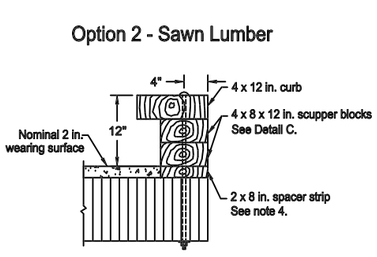

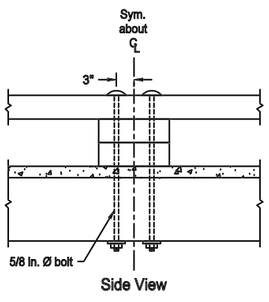

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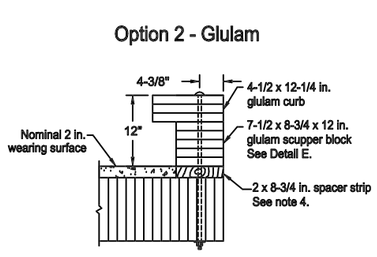
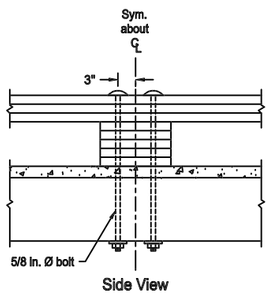
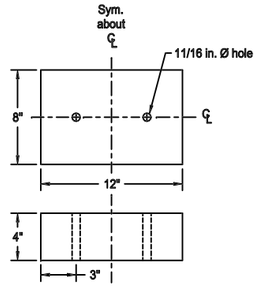




C Scupper Block Detail



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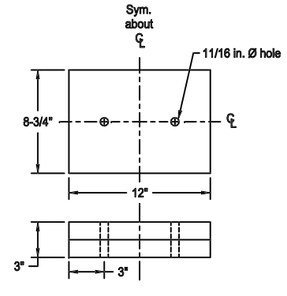

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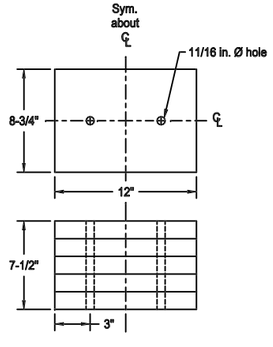
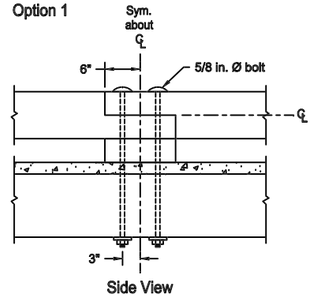


B Curb Splice Details

Option 1



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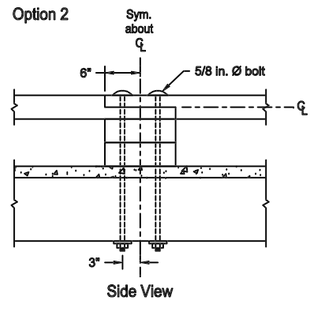

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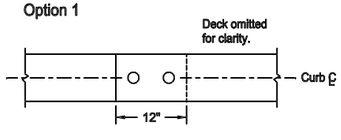

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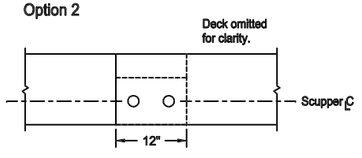


Design

1. These curb railings were successfully crash tested for low-volume road applications using a 4,409 lb pickup truck test vehicle with an impact velocity of 15 mph and impact angle of 15 degrees. These railings are adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued-laminated (glulam) timber decks that are 10 in. or greater in actual thickness. For additional information, refer to Development of Low-Volume Curb-Type Bridge Railings for Timber Bridge Decks (Ritter and others 1993).

2. Drawings include crash-tested designs for two curb railing options with details for both sawn lumber and glulam configurations. In all cases, the actual height of the curb railing shall be 12 in. above the traveled way (top of wearing surface or top of bridge deck if a wearing surface is omitted), but not greater than 14 in. above the bridge deck.

3. Scupper blocks are included in the curb railing designs to provide the required curb height and allow openings for deck drainage. Scupper blocks for either option may be sawn lumber or glulam and may require adjustment in the height dimension to achieve the actual curb height specified in Note 2 based on actual dimensions of the curb and scupper block members. In the case of the sawn lumber option 2, the two scupper blocks may be replaced with a single block of the required dimensions.

4. Each curb railing is shown with a 2-in.-thick continuous spacer strip intended to serve also as a retainer for an asphalt pavement wearing surface. If a lumber or gravel wearing surface is used, the strip should be under the scupper blocks only (not continuous) to allow for free deck drainage, or the strip may be eliminated and the scupper block height adjusted accordingly. If no wearing surface is used, the strip may be eliminated.

5. Dimensions for sawn lumber are nominal dimensions. Actual dimensions will vary depending on surfacing but shall not be less than 1/2 in. less than the stated nominal dimensions.

6. Dimensions for glulam are actual dimensions. The 8-3/4 in. standard glulam width may be decreased to a minimum 8-1/2 in. to allow for other standard glulam sizes. In such cases, detail dimensions shall be modified accordingly.

Materials

7. Sawn lumber and glulam shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133. Glulam shall be manufactured using wet use adhesives to an industrial appearance grade.

8. Curbs and scupper blocks may be sawn lumber or glulam. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or Douglas Fir-Larch. Glulam and other species and grades of sawn lumber may be used provided that the minimum tabulated values for the species and grade are not less than the following:

F_b = 1,350 lb/in^2 ; E = 1,500,000 lb/in^2

9. Bolts shall comply with the ASTM A307 requirements, Grade 2, and should preferably be dome head timber bolts. Bolts on the top of the curb rail shall be dome head.

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.

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.

University of Nebraska Lincoln

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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

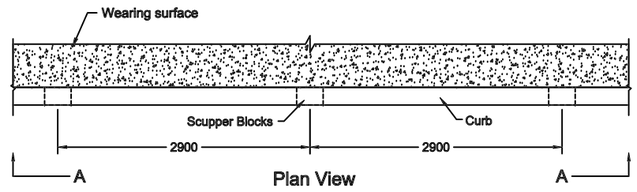
Low Volume Curb Railing	August 1998	Sheet 1 of 1

Rail Drawings in S.I. Units

University of Nebraska Lincoln

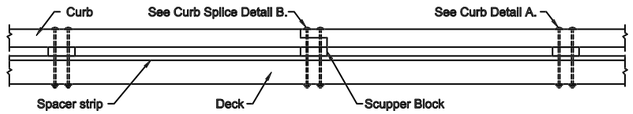
General Configuration

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



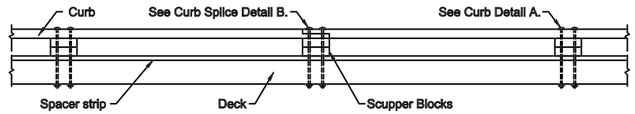
Plan View

Option 1; Section A-A



Front Elevation

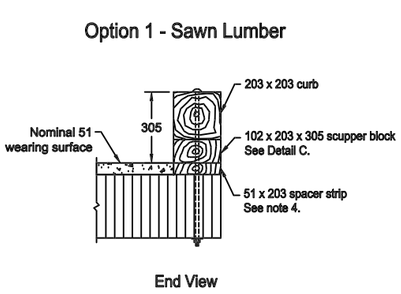
Option 2; Section A-A



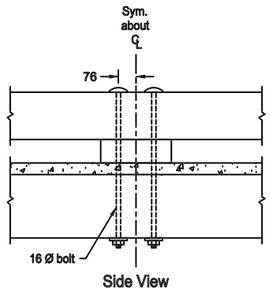
Front Elevation

A Curb Details

Option 1 - Sawn Lumber

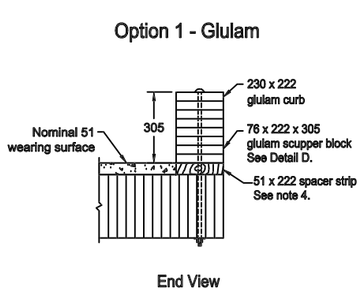


End View

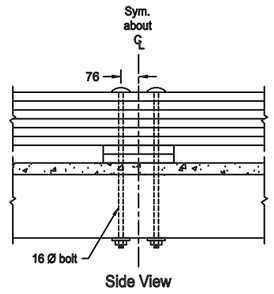


Side View

Option 1 - Glulam

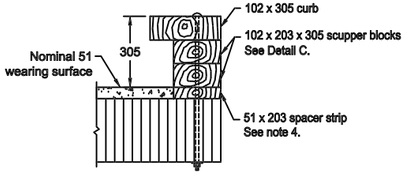


End View



Side View

Option 2 - Sawn Lumber



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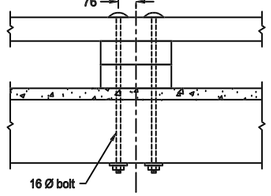
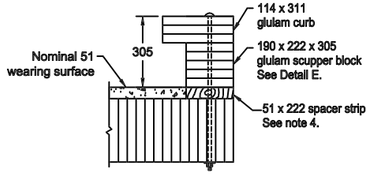


Side View

Option 2 - Glulam



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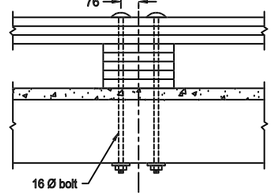
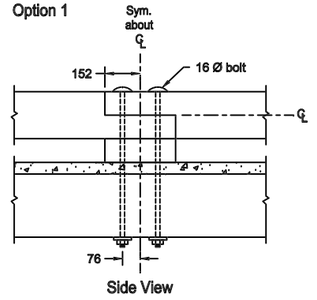


Side View

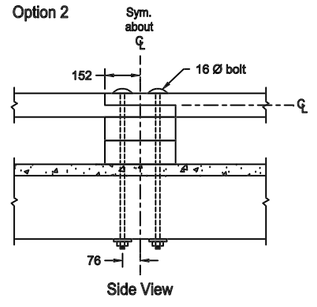
B Curb Splice Details

Option 1



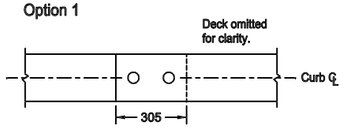
Side View

Option 2



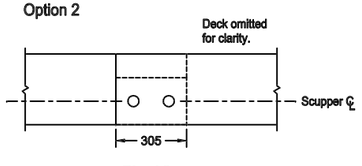
Side View

Option 1



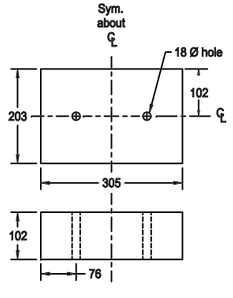
Plan View

Option 2



Plan View

C Scupper Block Detail



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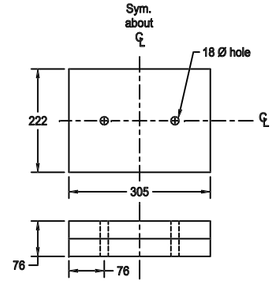

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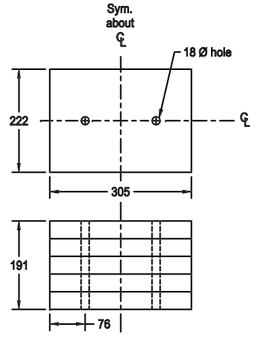

Design

1. These curb railings were successfully crash tested for low-volume road applications using a 19.6 kN pickup truck test vehicle with an impact velocity of 24 kph and impact angle of 15 degrees. These railings are adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued- laminated (glulam) timber decks that are 254 mm or greater in actual thickness. For additional information, refer to Development of Low-Volume Curb-Type Bridge Railings for Timber Bridge Decks (Ritter and others 1993).

2. Drawings include crash-tested designs for two curb railing options with details for both sawn lumber and glulam configurations. In all cases, the actual height of the curb railing shall be 305 mm above the traveled way (top of wearing surface or top of bridge deck if a wearing surface is omitted), but not greater than 356 mm above the bridge deck.

3. Scupper blocks are included in the curb railing designs to provide the required curb height and allow openings for deck drainage. Scupper blocks for either option may be sawn lumber or glulam and may require adjustment in the height dimension to achieve the actual curb height specified in Note 2 based on actual dimensions of the curb and scupper block members. In the case of the sawn lumber option 2, the two scupper blocks may be replaced with a single block of the required dimensions.

4. Each curb railing is shown with a 51-mm-thick continuous spacer strip intended to serve also as a retainer for an asphalt pavement wearing surface. If a lumber or gravel wearing surface is used, the strip should be under the scupper blocks only (not continuous) to allow for free deck drainage, or the strip may be eliminated and the scupper block height adjusted accordingly. If no wearing surface is used, the strip may be eliminated.

5. Dimensions for sawn lumber are nominal dimensions. Actual dimensions will vary depending on surfacing but shall not be less than 13 mm less than the stated nominal dimensions.

6. Dimensions for glulam are actual dimensions. The 222 mm standard glulam width may be decreased to a minimum 216 mm to allow for other standard glulam sizes. In such cases, detail dimensions shall be modified accordingly.

Materials

7. Sawn lumber and glulam shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133. Glulam shall be manufactured using wet use adhesives to an industrial appearance grade.

8. Curbs and scupper blocks may be sawn lumber or glulam. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or Douglas Fir-Larch. Glulam and other species and grades of sawn lumber may be used provided that the minimum tabulated values for the species and grade are not less than the following:

F_b = 9.3 MPa; E = 10,342 MPa

9. Bolts shall comply with the ASTM A307 requirements, Grade 2, and should preferably be dome head timber bolts. Bolts on the top of the curb rail shall be dome head.

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.

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.

University of Nebraska Lincoln

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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

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