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Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks

Michael A. Ritter
Ronald K. Faller
Paula D. Hilbrich Lee
Barry T. Rosson
Sheila Rimal Duwadi



Abstract

In the past decade, bridge railing design criteria have moved away from static-load design and have focused on full-scale crash testing as a more appropriate and reliable means of evaluating bridge railings. The five bridge railing plans presented reflect the results of a cooperative research project between the Midwest Roadside Safety Facility, University of Nebraska–Lincoln; the USDA Forest Service, Forest Products Laboratory; and the Federal Highway Administration. The project objective was to develop and crash test bridge railings and approach railing transitions for longitudinal wood bridge decks. The bridge railings were completed in accordance with AASHTO Performance Level 1, Performance Level 2, and NCHRP Report 350 Test Level 4 (TL–4). Approach railings were tested or adapted from previous testing in accordance with NCHRP Report 230. Full drawing sets are provided in customary U.S. and SI units of measure. The testing procedures, results, and drawings have been approved by the Federal Highway Administration Federal-Aid and Design Office for use on Federal-aid highway projects.

Keywords: Bridge, wood, railing, deck, crash-tested

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Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks

Michael A. Ritter, Research Engineer¹
 Ronald K. Faller, Research Engineer²
 Paula D. Hilbrich Lee, General Engineer¹
 Barry T. Rosson, Assistant Professor²
 Sheila Rimal Duwadi, Research Structural Engineer³

¹USDA Forest Service, Forest Products Laboratory
²Midwest Roadside Safety Facility, University of Nebraska-Lincoln
³Federal Highway Administration, Turner-Fairbank Research Center

Introduction

Bridge railings have historically been designed based on static-load design criteria. In the past decade, design criteria has refocused toward full-scale crash testing as a more appropriate and reliable method of evaluating bridge railings. These plans reflect the results of a cooperative research project between the Midwest Roadside Safety Facility, University of Nebraska-Lincoln; the USDA Forest Service, Forest Products Laboratory; and the Federal Highway Administration. The objective of the project was to develop and crash test bridge railings and approach railing transitions for longitudinal wood bridge decks. The bridge railings were completed in accordance with AASHTO Performance Level 1 (PL-1) and Performance Level 2 (PL-2) requirements and are described in the cited reports. One bridge railing was also tested to the requirements of NCHRP Report 350, Test Level 4 (TL-4). Approach railings were tested or adapted from previous testing in accordance with NCHRP Report 230. For the convenience of the user, full drawing sets have been provided in customary U.S. and SI units. The testing procedures, results, and drawings have been approved by the Federal Highway Administration Federal-Aid and Design Office for use on Federal-aid highway projects.

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Acknowledgments

We express sincere appreciation to Brent Prauner and Keith Robertson of the Midwest Roadside Safety Facility, University of Nebraska-Lincoln and Merv Eriksson of the USDA Forest Service, Northern Region, for their assistance in drawing preparation.

Specifications

AASHTO. 1989. Guide Specifications for Bridge Railings. Washington, DC: American Association of State Highway and Transportation Officials.

AASHTO. 1990. 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

ANSI/AASHTO/AWS D1.5-88. Bridge Welding Code. Washington, DC: American Association of State Highway and Transportation Officials.

ASTM. Annual Book of ASTM Standards. Philadelphia, PA: American Society for Testing and Materials.

ASTM A36-90 Standard Specification for Structural Steel
 ASTM A47-84 Standard Specification for Ferritic Malleable Iron Castings
 ASTM A307-92a Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
 ASTM A325-92a Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
 ASTM A722-90 Standard Specification for Uncoated, High-Strength Steel Bar for Prestressing Concrete

SAE J412. 1989. General Characteristics and Heat Treatment of Steels. Warrendale, PA: Society of Automotive Engineers.

References

Faller, R.K.; Ritter, M.A.; Holloway, J.C.; Pfeifer, B.G.; Rosson, B.T. 1992. Performance level 1 bridge railings for timber decks. In: Transportation Research Record 1419. Washington, DC: Transportation Research Board, National Research Council: 21-34.

NCHRP. 1981. Recommended procedures for the safety performance evaluation of highway appurtenances. NCHRP Rep. 230. Washington, DC: National Research Council, Transportation Research Board, National Cooperative Highway Research Program.

Ritter, M.A.; Post, E.R.; Faller, R.K. 1990. Vehicular railing systems for timber bridges: a program overview. Wood Design Focus. 1(4): 4-7.

Ritter, M.; Faller, R. 1994. Crashworthy bridge railing for longitudinal wood decks. In: PTEC 94 Timber shaping the future: Proceedings of Pacific Timber Engineering conference; 1994 July 11-15; Gold Coast, Australia. Queensland, Australia: Fortitude Valley MAC; 2: 298-307.

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

Rosson, B.T.; Faller, R.K.; Ritter, M.A. [in press]. Performance level 2 and test level 4 bridge railings for timber decks. Paper presented at the 1995 annual meeting of the Transportation Research Board. Washington, DC: National Research Council, Transportation Research Board.

Comments

Comments on these drawings should be addressed to the Timber Bridge Team, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53705-2398.

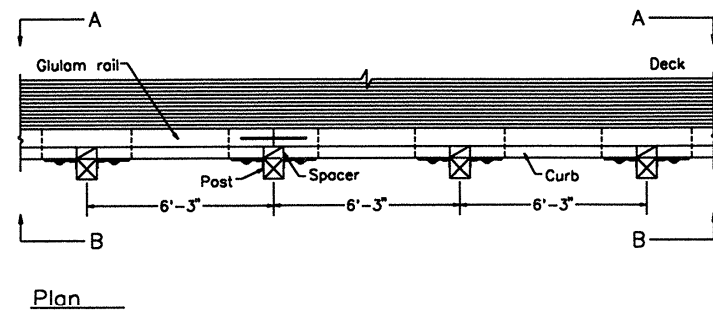
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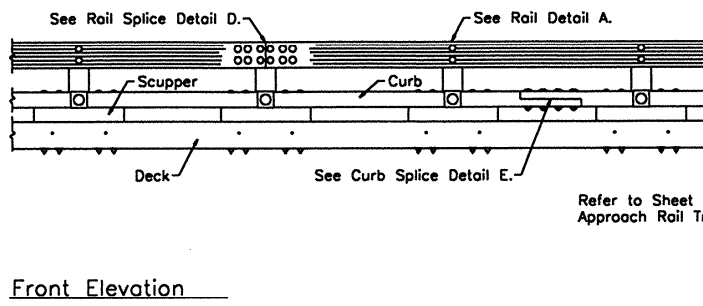
Rail Drawings in Customary U.S. Units



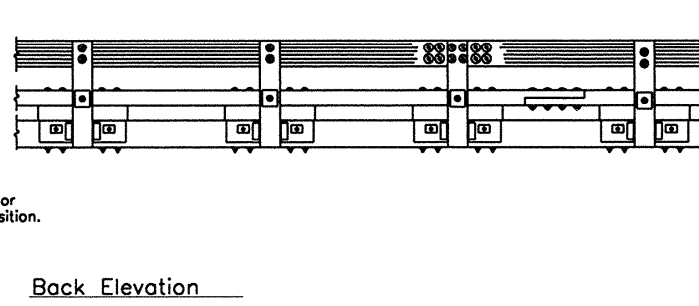
General Configuration



Section A-A



Section B-B



DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 1 (PL-1), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated and glued laminated timber decks which are 8 in. or greater in actual thickness.
2. Dimensions given for glued laminated timber rails are actual dimensions. The depth of the glulam timber rail may be increased to a maximum of 10-3/4 in. to allow for other standard glulam sizes. In such cases, detail dimensions shall be modified accordingly.
3. Dimensions for wood posts, curbs, and scuppers are given as nominal dimensions. Actual dimensions may be a maximum of 1/2 in. less than the stated nominal dimensions depending on material surfacing. Dimensions for spacer block depth are actual dimensions.
4. The steel deck reinforcing bars shown on the drawings are 5/8 in. diameter ASTM A722 bars. Other bar materials and/or diameters may be used provided that each bar, is designed for a maximum applied load of 8,000 lb. If the bar diameter is changed, plate and deck holes must be modified accordingly.
5. Curb and rail splices shall be located so that curb and rail members are continuous over not less than 2 posts. Curb splices shall be located a minimum of 1.5 post spacings away from rail splices. It is recommended that glulam rails be continuous over the bridge length.

MATERIALS

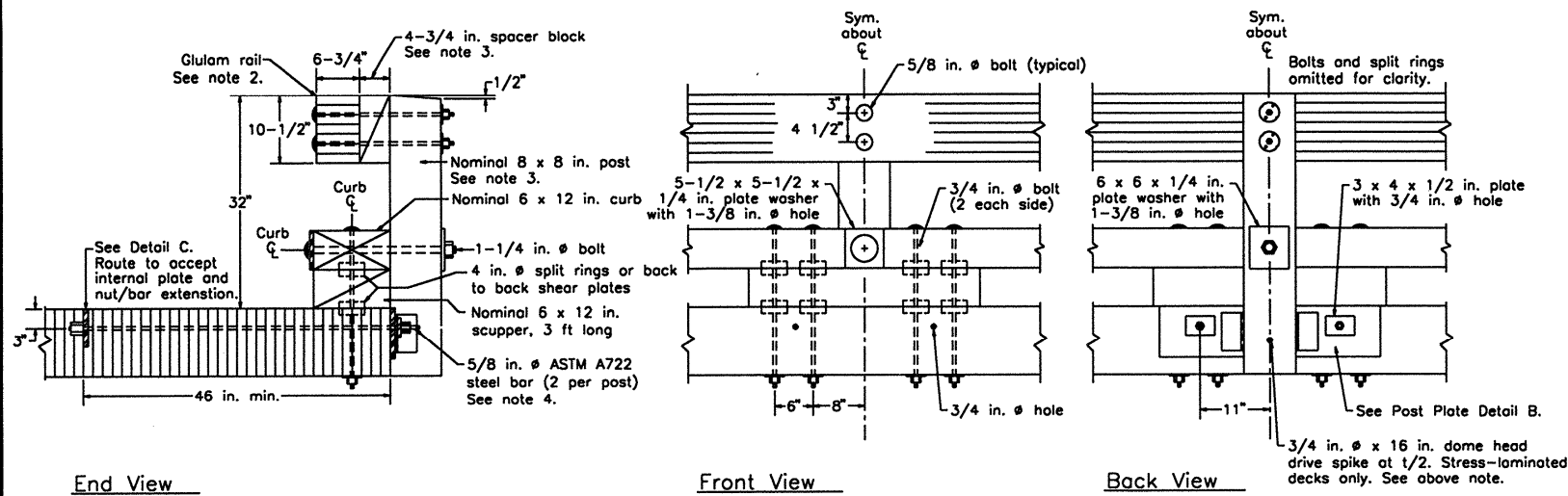
6. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133.
7. The bridge rail shall be horizontally laminated glued laminated timber; visually graded Western Species Combination No. 2 or visually graded Southern Pine Combination No. 48. Other species and grades of glued laminated timber may be used provided that the minimum tabulated values are not less than the following:
 $F_{ty} = 1,800 \text{ lb/in}^2$ $E = 1,800,000 \text{ lb/in}^2$
8. Posts, curbs, scuppers, and spacer blocks may be sawn lumber or glued laminated timber. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or visually graded No. 1 Douglas Fir-Larch. Glued laminated timber and other species and grades of sawn lumber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 1,350 \text{ lb/in}^2$ $E = 1,500,000 \text{ lb/in}^2$
9. Steel plates and shapes shall comply with the requirements of ASTM A36.
10. Bolts shall comply with the requirements ASTM A307, Grade 2 and should preferably be dome head timber bolts. Bolts on traffic face of rail shall be dome head.
11. Split rings shall be manufactured from SAE 1010 hot rolled carbon steel. Shear plates shall be malleable iron manufactured according to ASTM A47, Grade J2510.
12. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

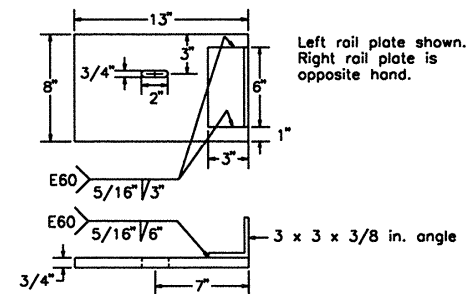
13. To the extent possible, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives. When field fabrication of wood is required or if wood is damaged, all cuts, bore holes, and damage shall be immediately field treated with wood preservative in accordance with AASHTO M133.
14. Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of dome-head timber bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.
15. The tops of rail posts and the top of the rail splice plate kerf shall be sealed with roofing cement or otherwise protected from direct exposure to weather.

A Railing Details

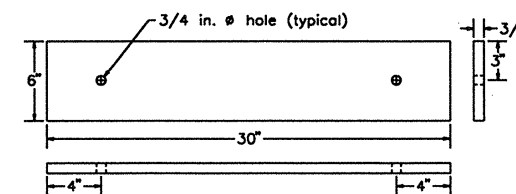
For stress-laminated decks, omit internal plate, post plates, and ASTM A722 steel bars.



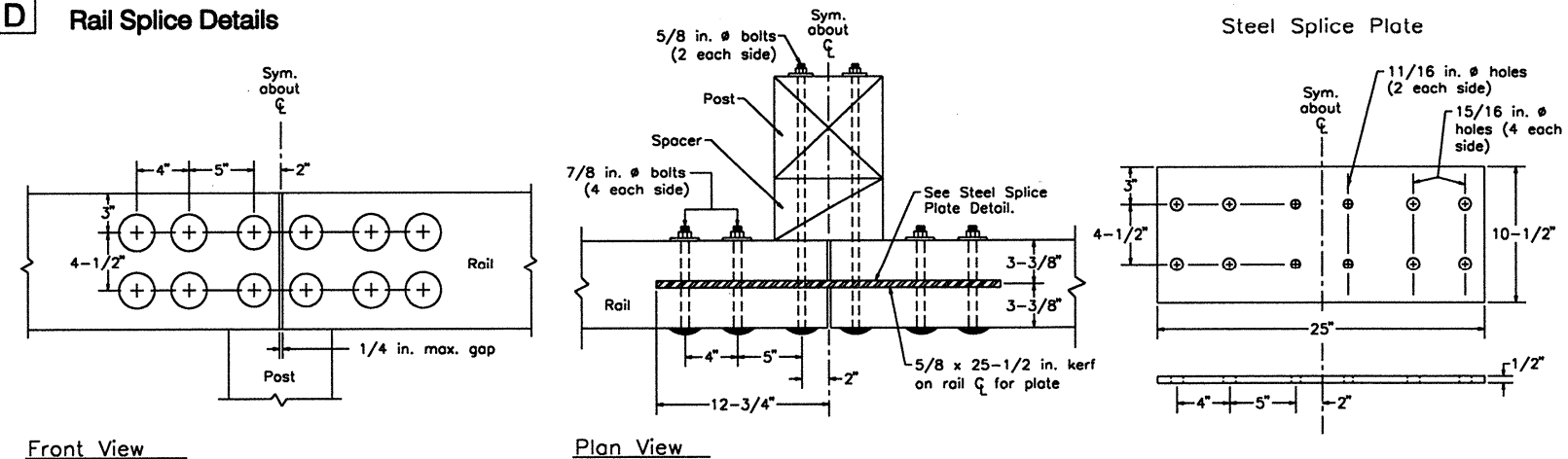
B Steel Post Plate



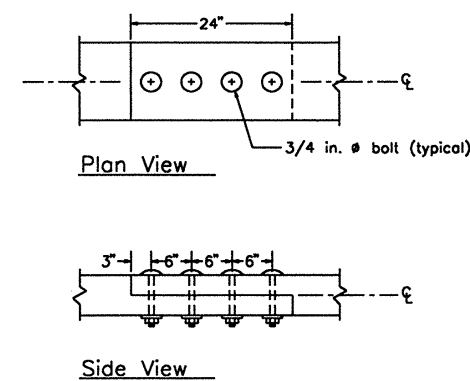
C Internal Steel Plate



D Rail Splice Details



E Curb Splice Detail



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.



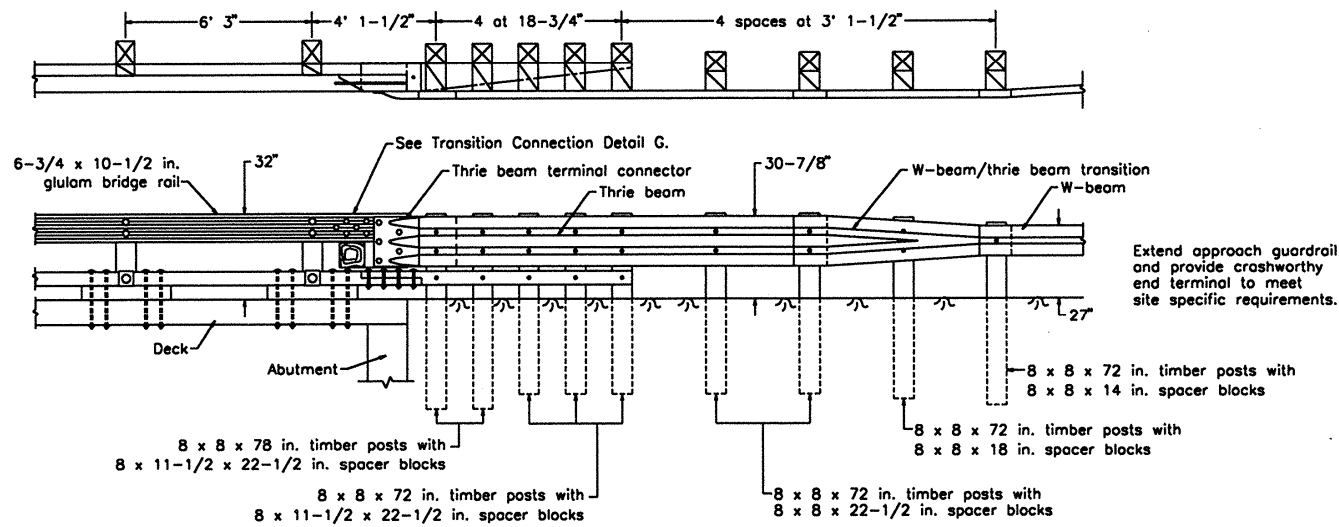
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail with Curb
AASHTO Performance Level 1

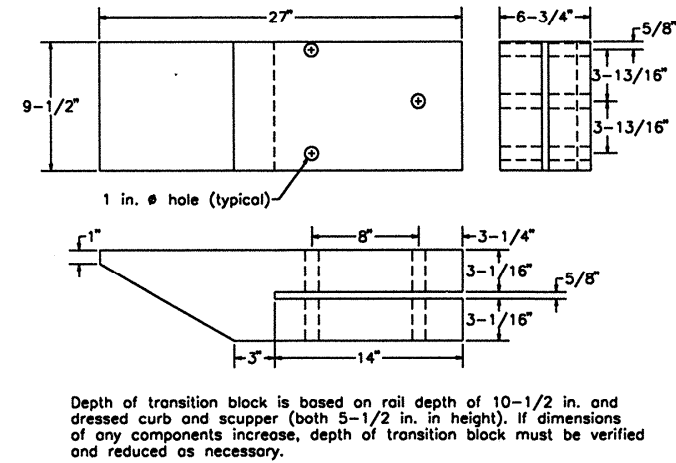
September 1995

Sheet 1 of 2

Approach Rail Transition General Configuration

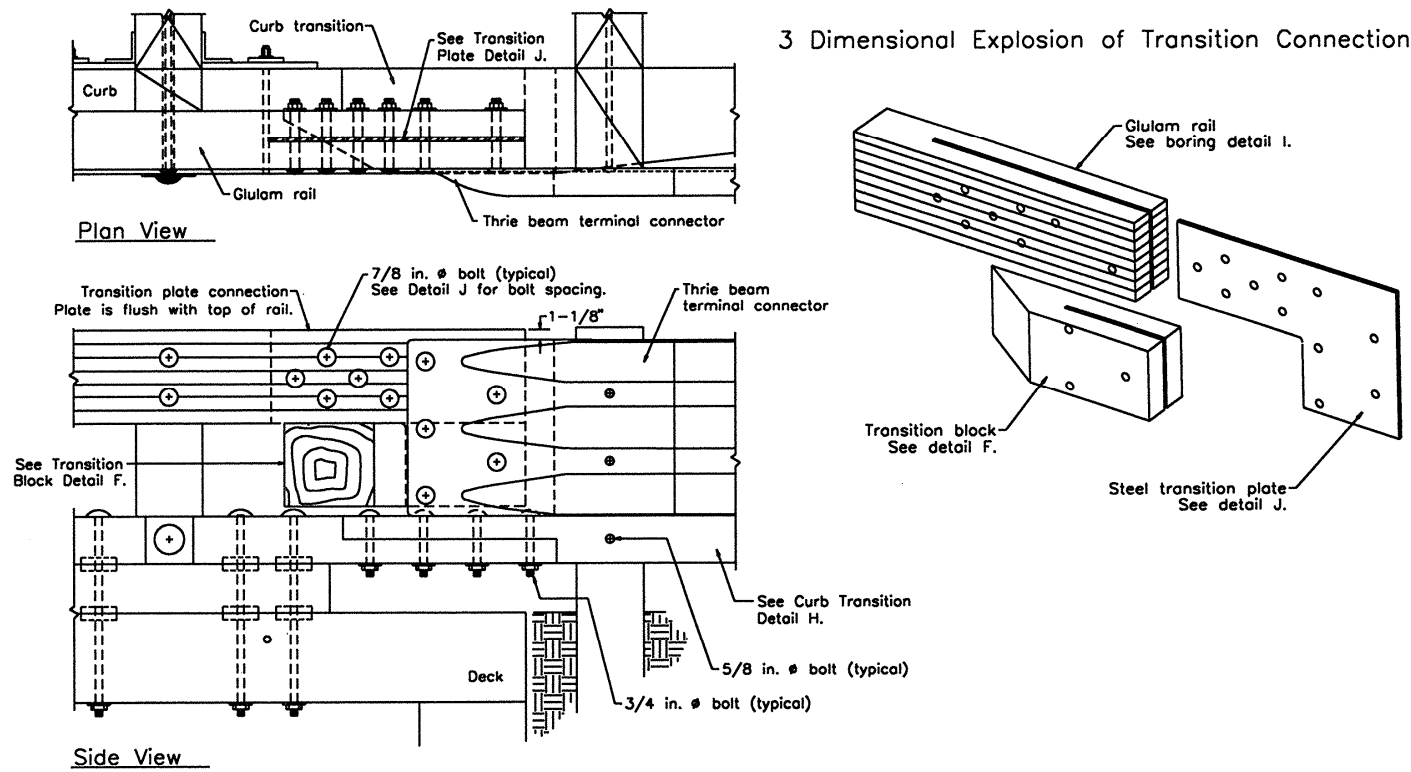


F Transition Block

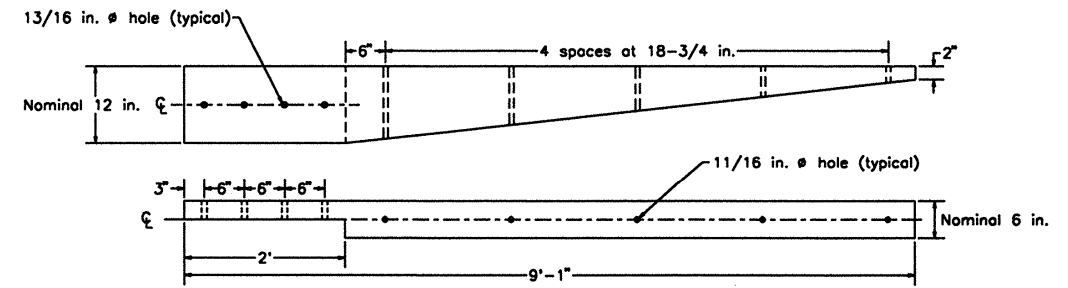


- In addition to the notes on Sheet 1, the following apply to the approach rail transition:
1. The approach rail transition was successfully crash tested to the requirements for Service Level 2 (SL-2), as outlined in NCHRP Report 230.
 2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
 3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

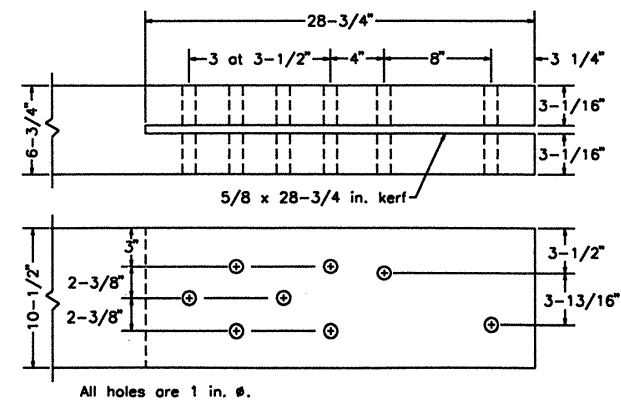
G Transition Connection Details



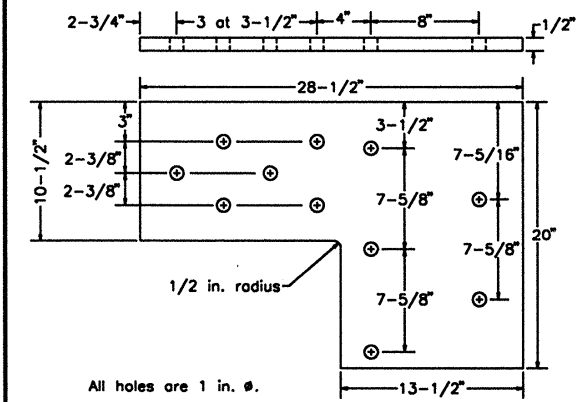
H Curb Transition



I Transition Glulam Rail Boring Detail



J Steel Transition Plate



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.



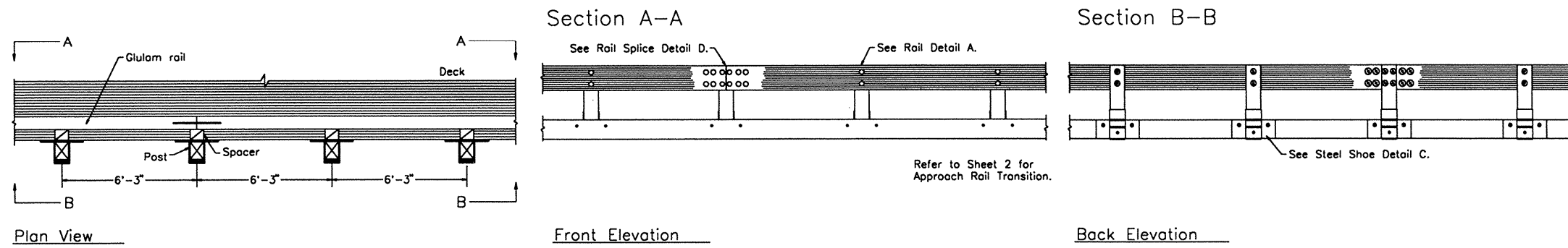
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail with Curb
AASHTO Performance Level 1

September 1995

Sheet 2 of 2

General Configuration



DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 1 (PL-1), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks which are 10-1/2 in. or greater in actual thickness.
2. Dimensions for the wood rail, post, and spacer are actual dimensions. Post dimensions correspond to the standard dressed dimensions for a nominal 8 x 10 in. member that is surfaced on 4 sides (S4S).
3. The depth of the glulam timber rail may be increased to a maximum of 13-3/4 in. to allow for standard glulam timber sizes. In such cases, detail dimensions shall be verified and modified accordingly.
4. The steel deck reinforcing bars shown on the drawings are 1 in. diameter ASTM A722 bars. Other bar materials and/or diameters may be used provided that each bar is designed for a maximum applied load of 40,000 lb. If the bar diameter is changed, plate and deck holes must be modified accordingly.
5. Rail splices shall be located so rail members are continuous over not less than 4 posts. It is recommended that the rail be continuous over the bridge length.

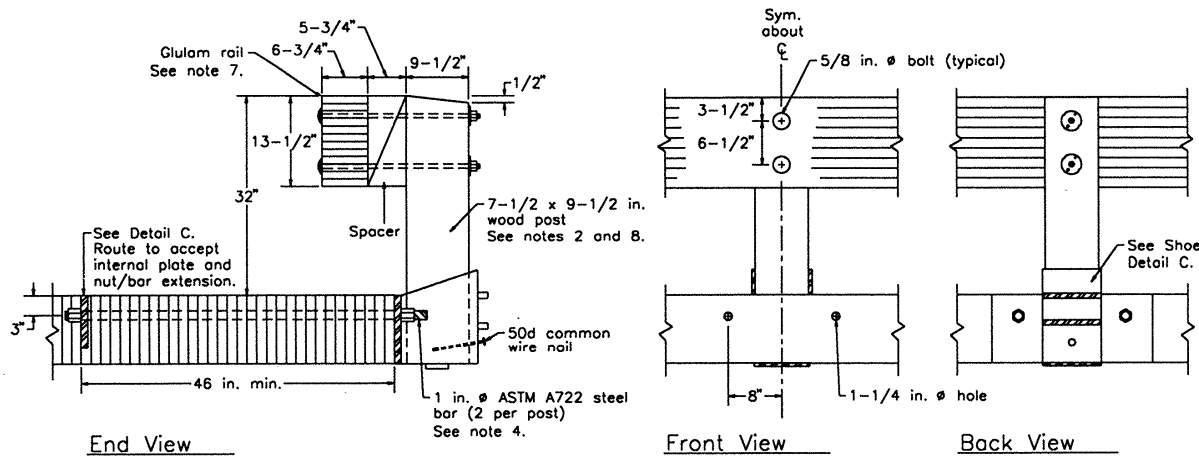
MATERIALS

6. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133.
7. The bridge rail shall be horizontally laminated glued laminated timber; visually graded Western Species Combination No. 2 or visually graded Southern Pine Combination No. 4B. Other species and grades of glued laminated timber may be used provided that the minimum tabulated values are not less than the following:
 $F_{bT} = 1,800 \text{ lb/in}^2$
 $E = 1,800,000 \text{ lb/in}^2$
8. Posts and spacer blocks may be sawn lumber or glued laminated timber. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or visually graded No. 1 Douglas Fir-Larch. Glued laminated timber and other species and grades of sawn lumber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 1,350 \text{ lb/in}^2$
 $E = 1,500,000 \text{ lb/in}^2$
9. Steel plates and shapes shall comply with the requirements of ASTM A36.
10. Bolts shall comply with the requirements ASTM A307, Grade 2 and should preferably be dome head timber bolts. Bolts on traffic face of rail shall be dome head.
11. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

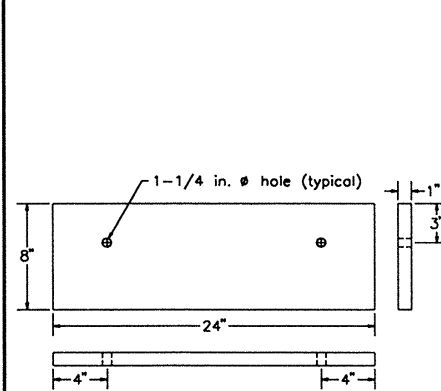
FABRICATION AND CONSTRUCTION

12. Welding shall be completed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code.
13. 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 field treated with wood preservative in accordance with AASHTO M133.
14. Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of dome-head timber bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.
15. The tops of rail posts and the top of the rail splice plate kerf shall be sealed with roofing cement or otherwise protected from direct exposure to weather.

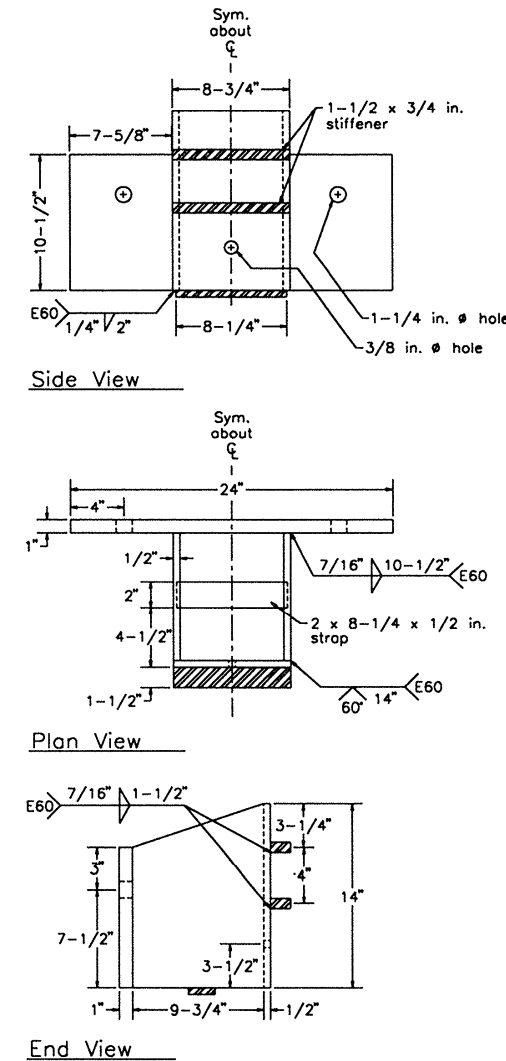
A Railing Details



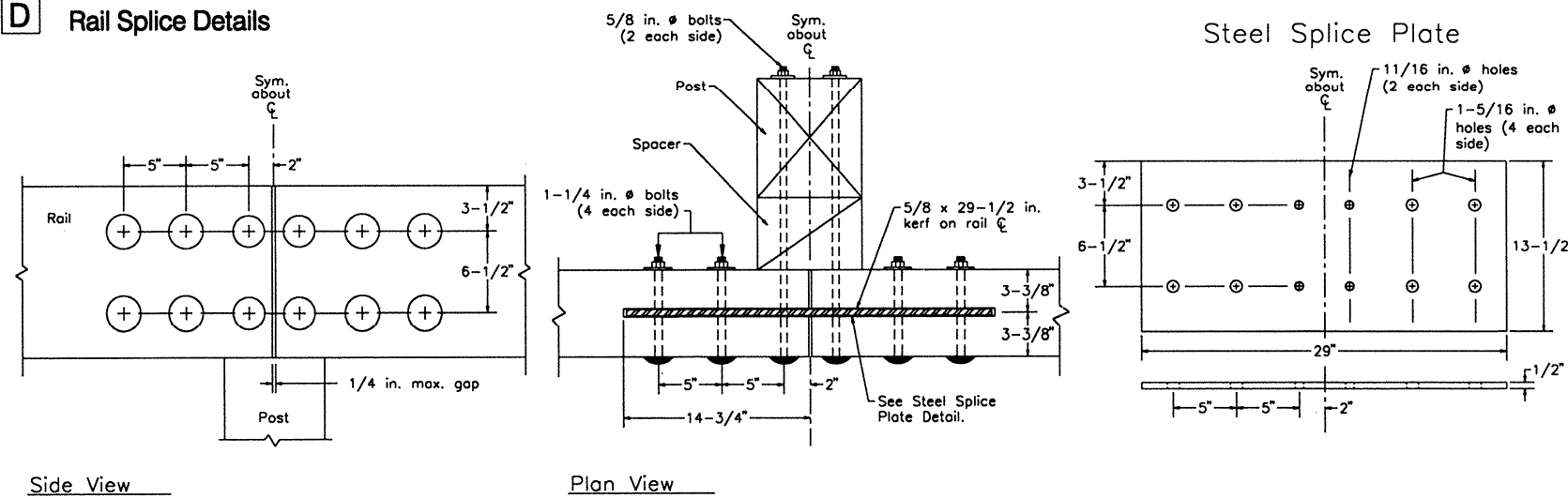
B Internal Steel Plate



C Steel Shoe Details



D Rail Splice Details



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.



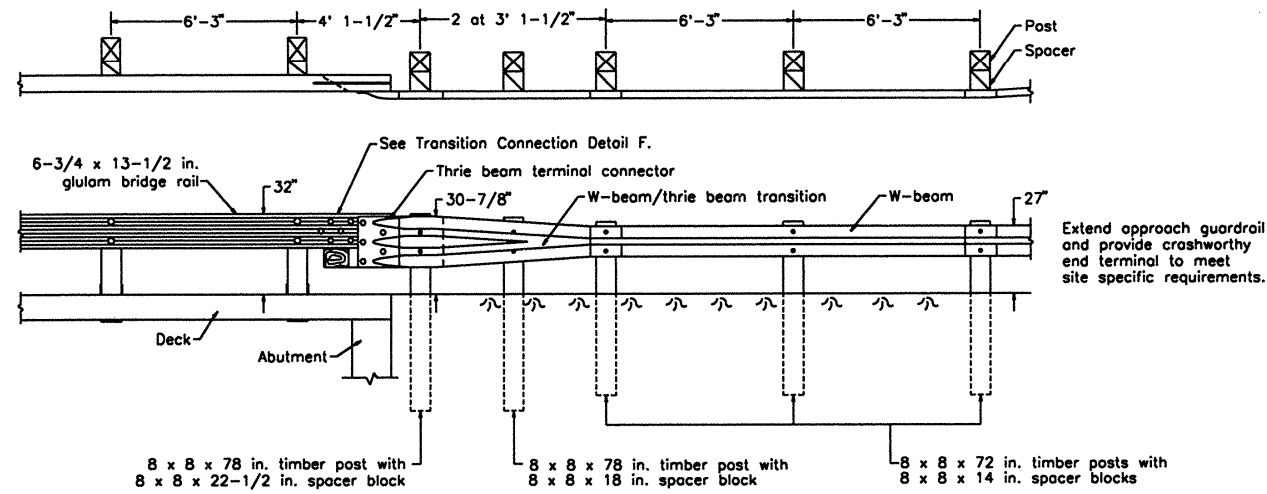
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail without Curb
AASHTO Performance Level 1

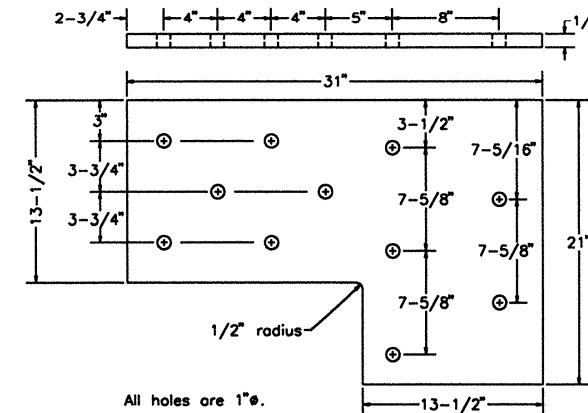
September 1995

Sheet 1 of 2

Approach Rail Transition General Configuration



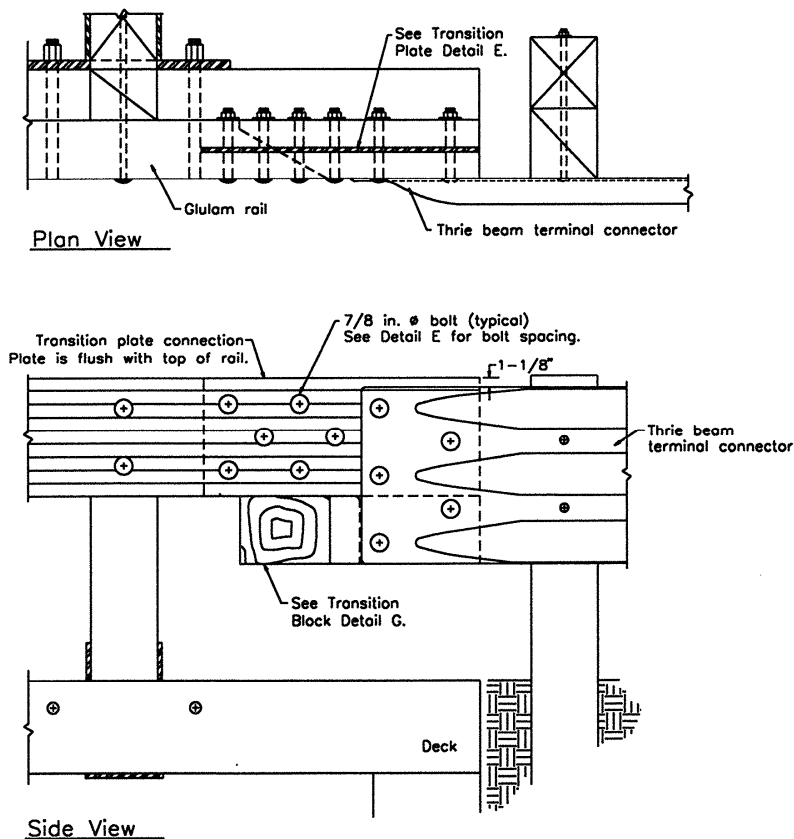
E Steel Transition Plate



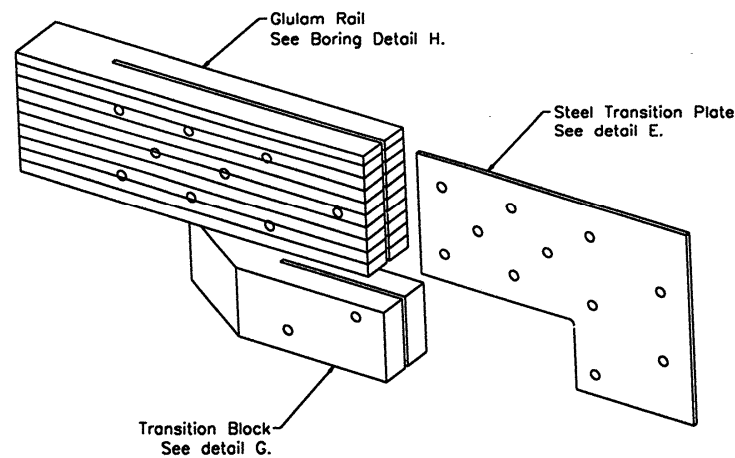
In addition to the notes on Sheet 1, the following apply to the approach rail transition:

1. The approach rail transition was successfully crash tested to the requirements for Service Level 1 (SL-1), as outlined in NCHRP Report 230.
2. Thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements AASHTO M180.
3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

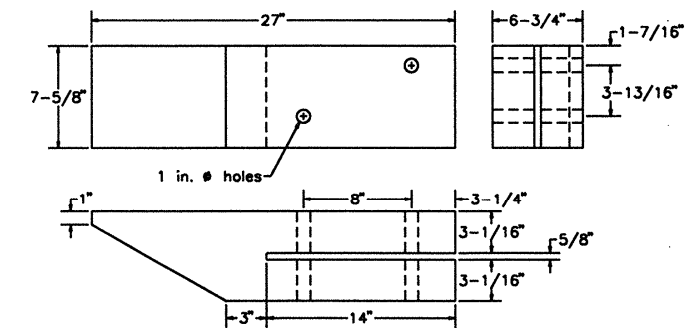
F Transition Connection Details



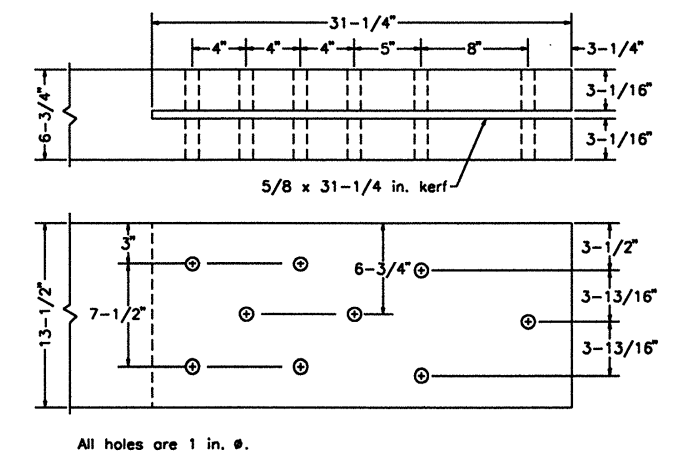
3 Dimensional Explosion of Transition Connection



G Transition Block



H Transition Glulam Rail Boring Detail



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.



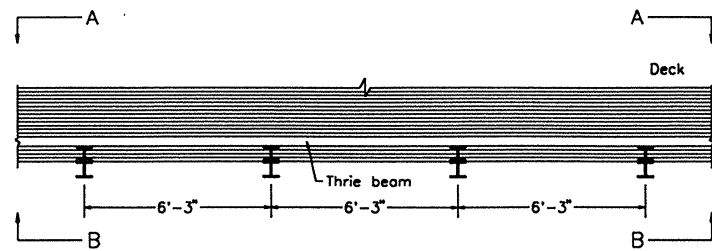
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail without Curb
AASHTO Performance Level 1

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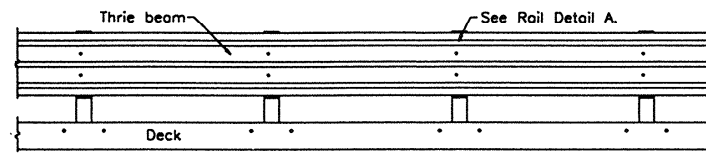
Sheet 2 of 2

General Configuration



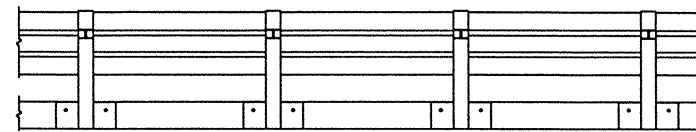
Plan View

Section A-A



Front Elevation

Section B-B



Back Elevation

Refer to Sheet 2 for Approach Rail Transition.

DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 1 (PL-1), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks which are 10-1/2 in. or greater in actual thickness.
2. The steel deck reinforcing bars shown on the drawings are 1 in. diameter ASTM A722 bars. Other bar materials and/or diameters may be used provided that each bar is designed for a maximum applied load of 44,000 lb. If the bar diameter is changed, plate and deck holes must be modified accordingly.

MATERIALS

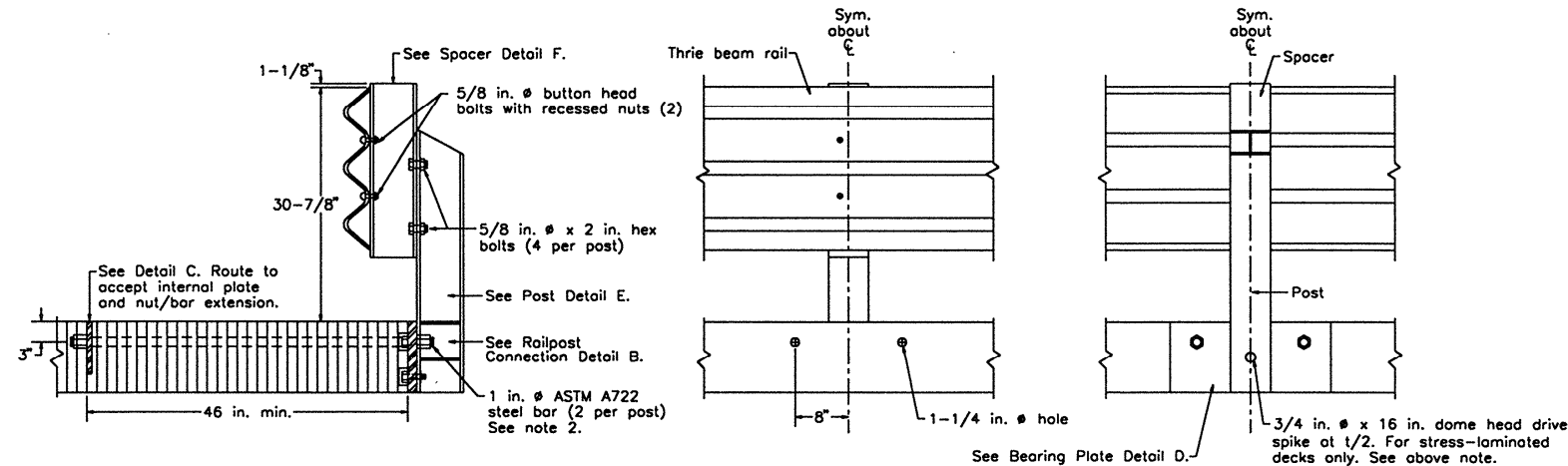
3. The bridge rail shall be 10 gage thrie beam. Unless noted, all rail, rail splice and post bolts shall comply with the requirements of AASHTO M180.
4. Steel plates and shapes shall comply with the requirements of ASTM A36.
5. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

6. Welding shall be completed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code.
7. 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 field treated with wood preservative in accordance with AASHTO M133.
8. Washers shall be provided under hex bolt nuts.

A Railing Details

For stress-laminated decks, omit internal plate and ASTM A722 steel bars.



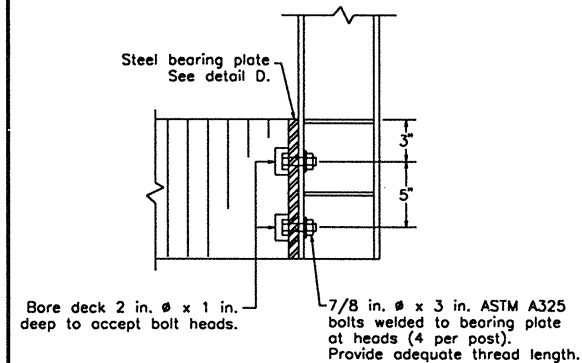
End View

Front View

Back View

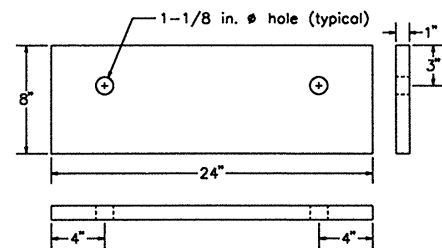
B Rail Post Connection

Note: 1 in. # steel bars omitted for clarity.

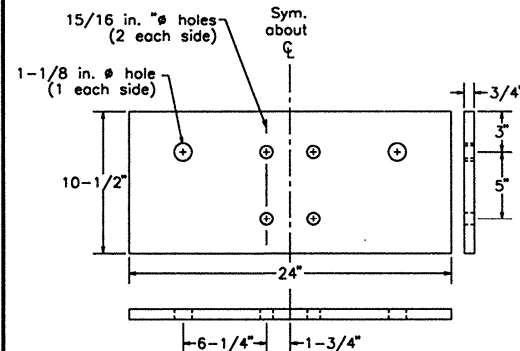


End View

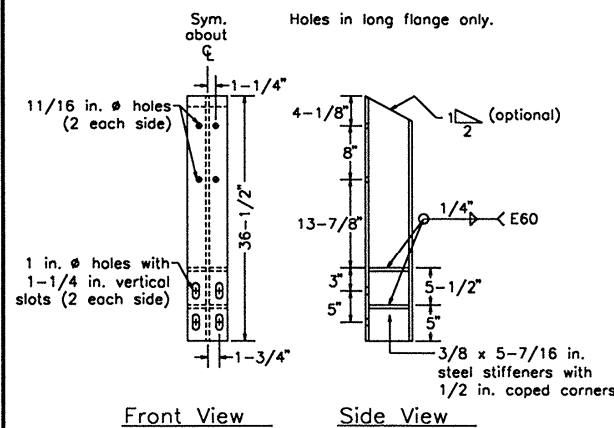
C Internal Steel Plate



D Steel Bearing Plate



E W6 x 15 Steel Post

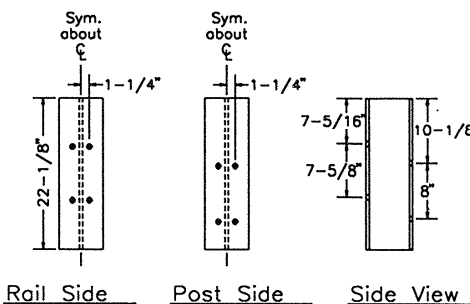


Front View

Side View

F W6 x 15 Steel Spacer

All holes are 11/16 in. #.



Rail Side

Post Side

Side View

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.



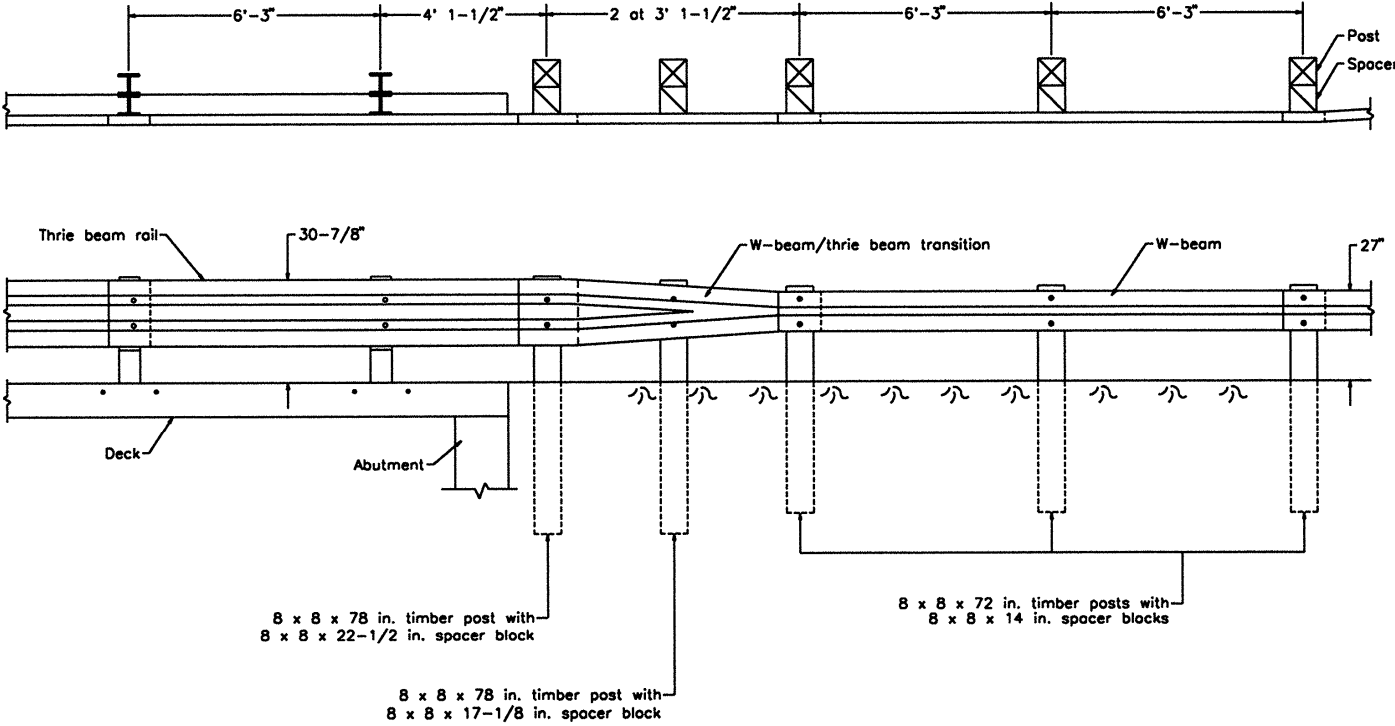
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Steel Rail
AASHTO Performance Level 1

September 1995

Sheet 1 of 2

Approach Rail Transition General Configuration



Extend approach guardrail and provide crashworthy end terminal to meet site specific requirements.

- In addition to the notes on Sheet 1, the following apply to the approach rail transition:
1. The approach rail transition was successfully crash tested to the requirements for Service Level 1 (SL-1), as outlined in NCHRP Report 230.
 2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
 3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

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.



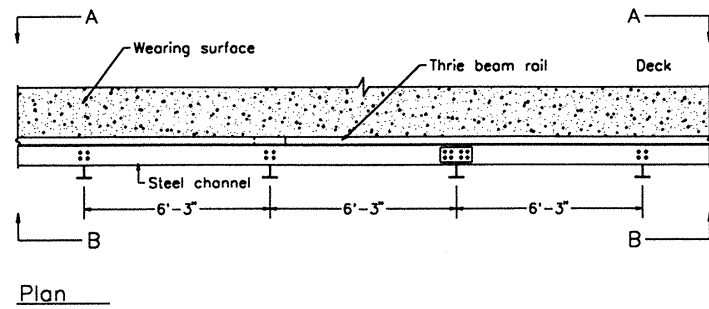
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Steel Rail
AASHTO Performance Level 1

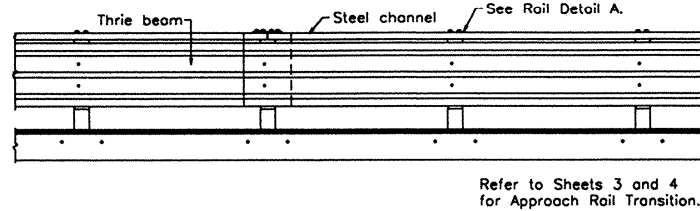
September 1995

Sheet 2 of 2

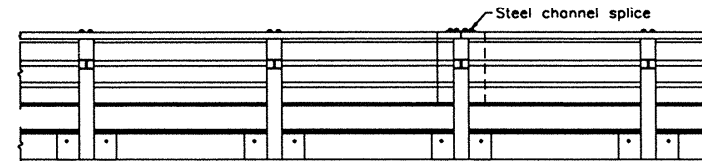
General Configuration



Section A-A



Section B-B



DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 2 (PL-2), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks which are 10-1/2 in. or greater in actual thickness.

2. Steel deck reinforcing bars shall be 1 in. diameter ASTM A722 bars.

MATERIALS

3. The bridge rail shall be 10 gage thrie beam. Unless noted, all rail, rail splice and post bolts shall comply with the requirements of AASHTO M180.

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

5. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

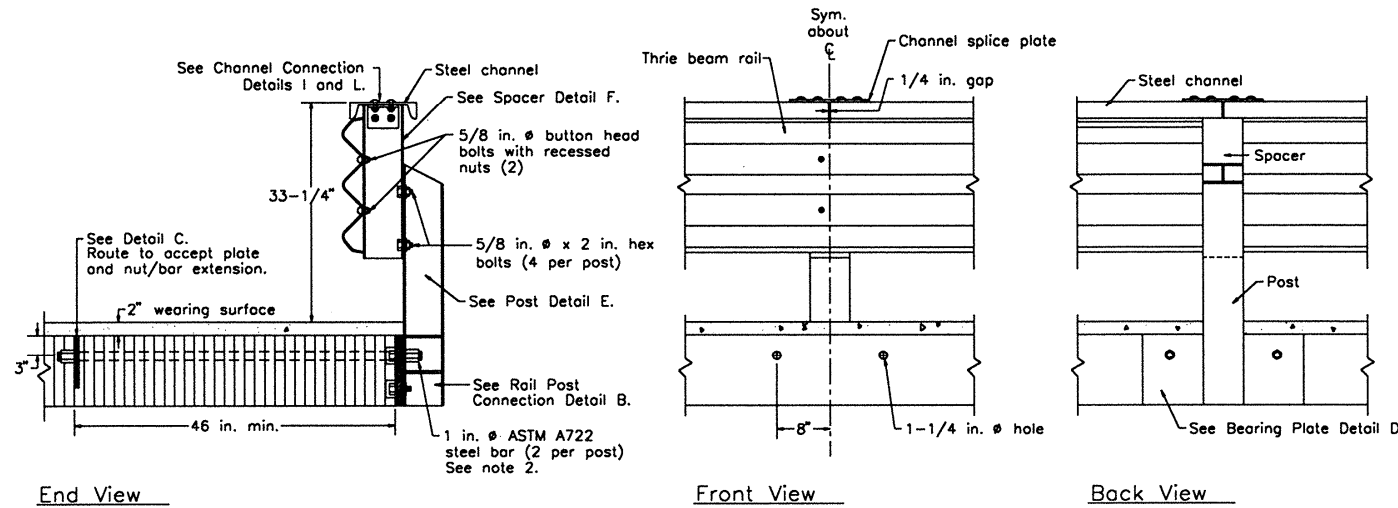
6. Welding shall be completed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code.

7. 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 field treated with wood preservative in accordance with AASHTO M133.

8. Washers shall be used in combination with hex head nuts.

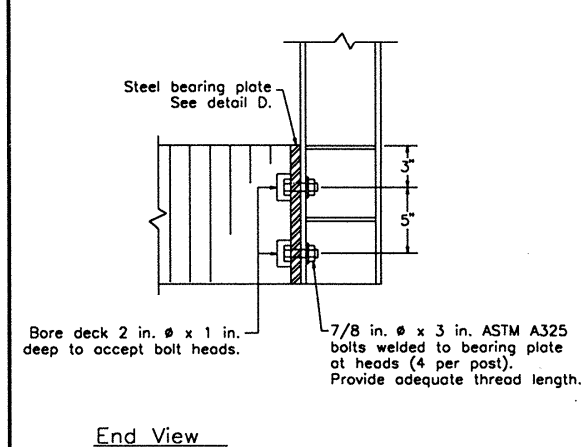
A Railing Details

For stress-laminated decks, omit internal plate and ASTM A722 steel bars.

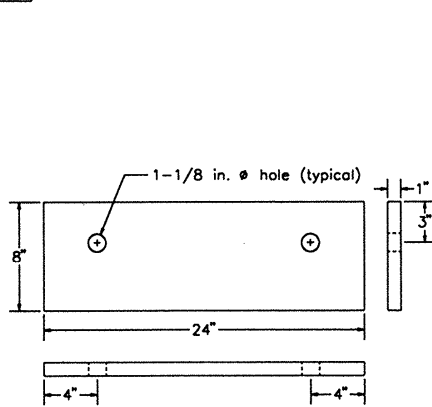


B Rail Post Connection Detail

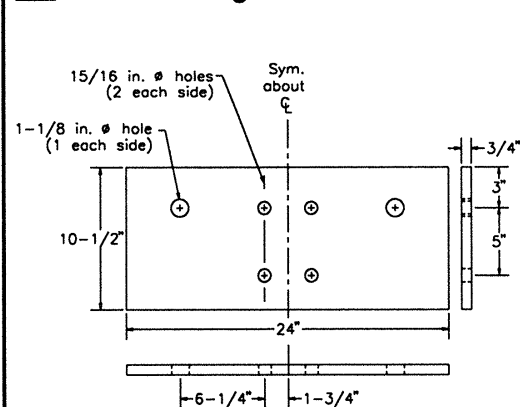
Note: 1 in. ϕ steel bars omitted for clarity.



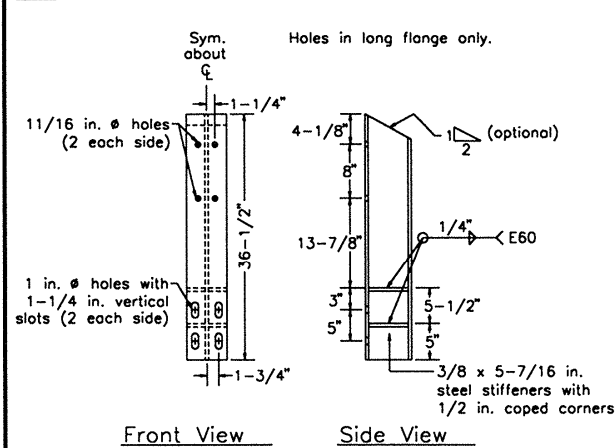
C Internal Steel Plate



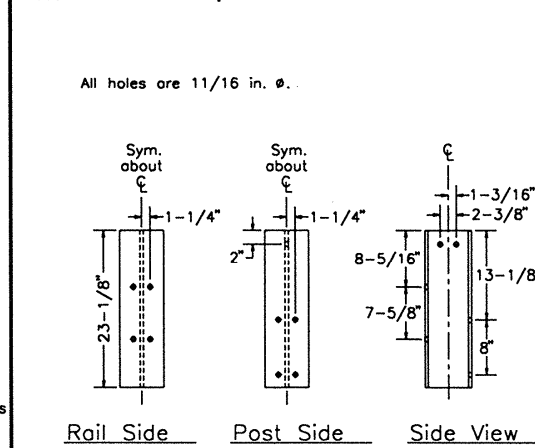
D Steel Bearing Plate



E W6 x 15 Post



F W6 x 15 Spacer



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

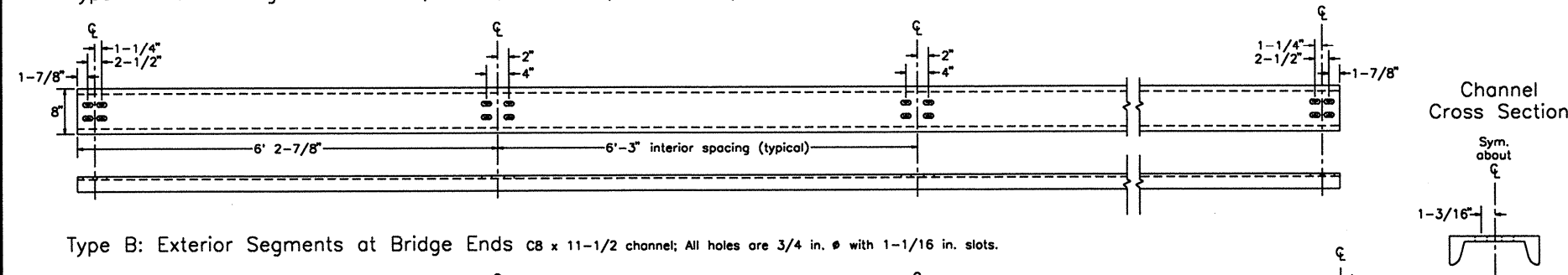
Steel Rail
AASHTO Performance Level 2

September 1995

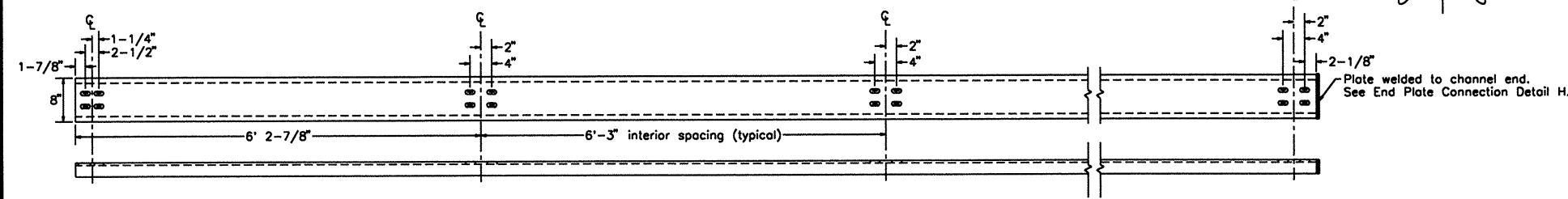
Sheet 1 of 4

G Steel Channel Details

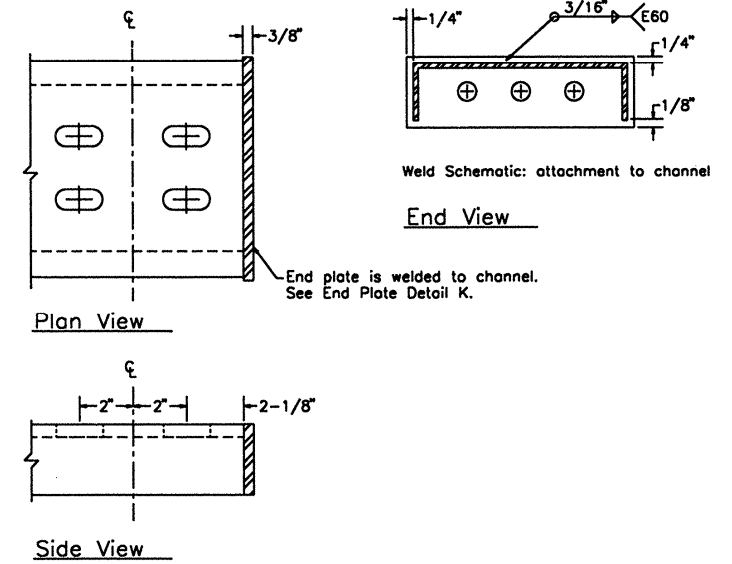
Type A: Interior Segments C8 x 11-1/2 channel; All holes are 3/4 in. ϕ with 1-1/16 in. slots.



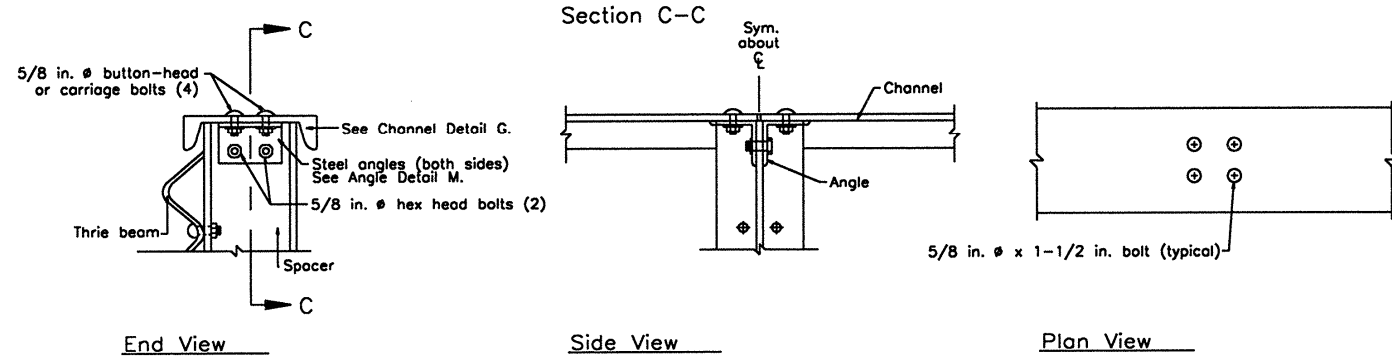
Type B: Exterior Segments at Bridge Ends C8 x 11-1/2 channel; All holes are 3/4 in. ϕ with 1-1/16 in. slots.



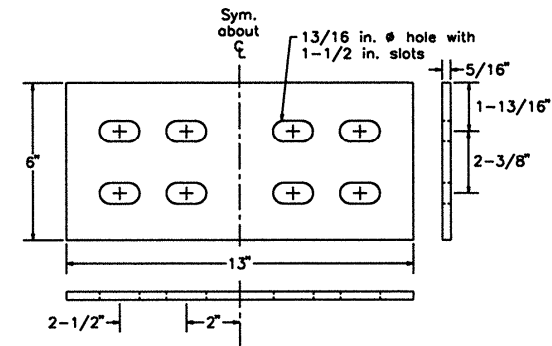
H End Plate Connection Detail



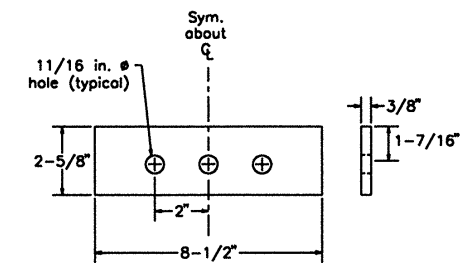
I Channel Connection Details



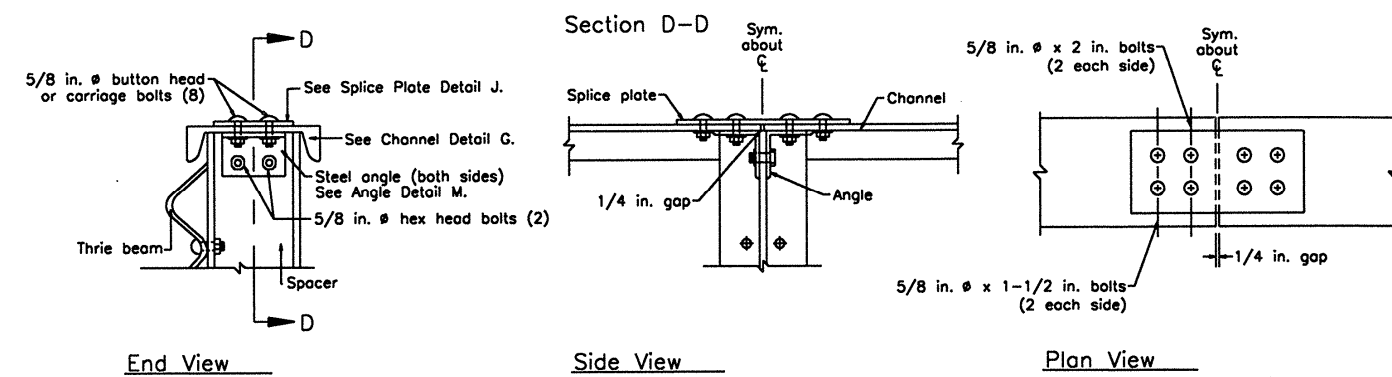
J Steel Splice Plate



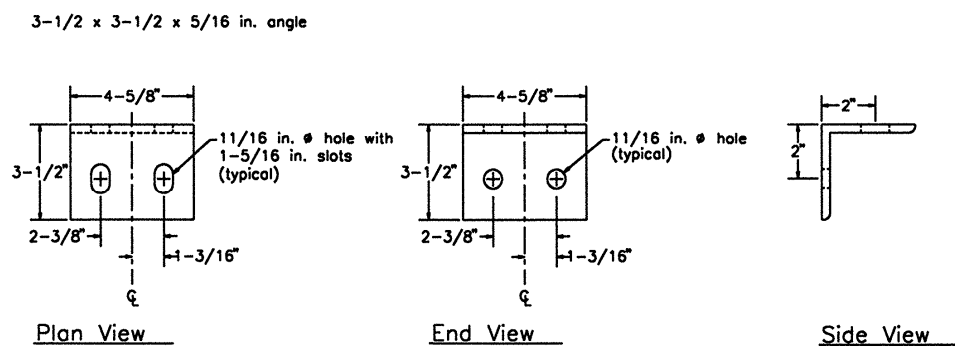
K Steel End Plate



L Channel Splice Connection Details



M Steel Angle



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



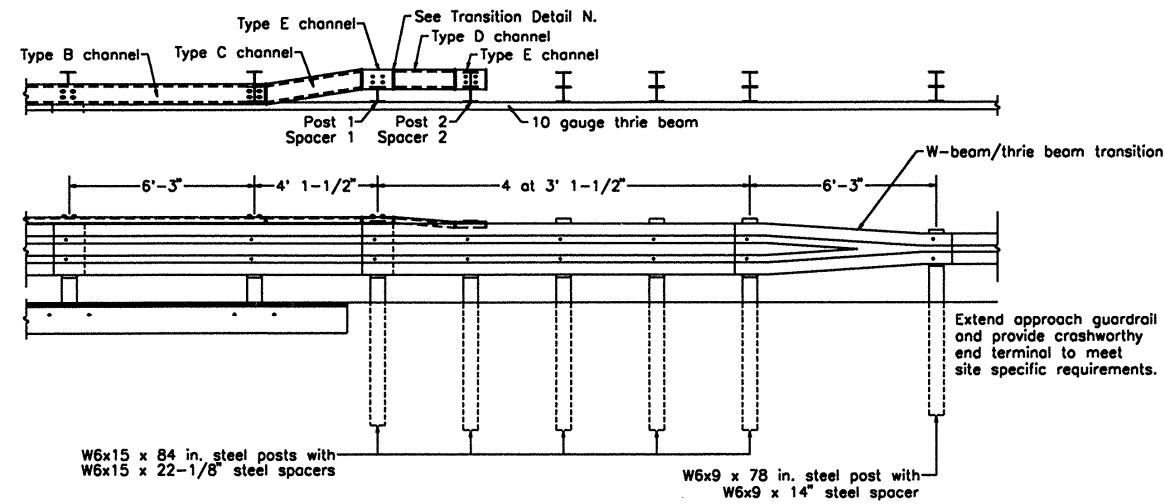
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Steel Rail
AASHTO Performance Level 2

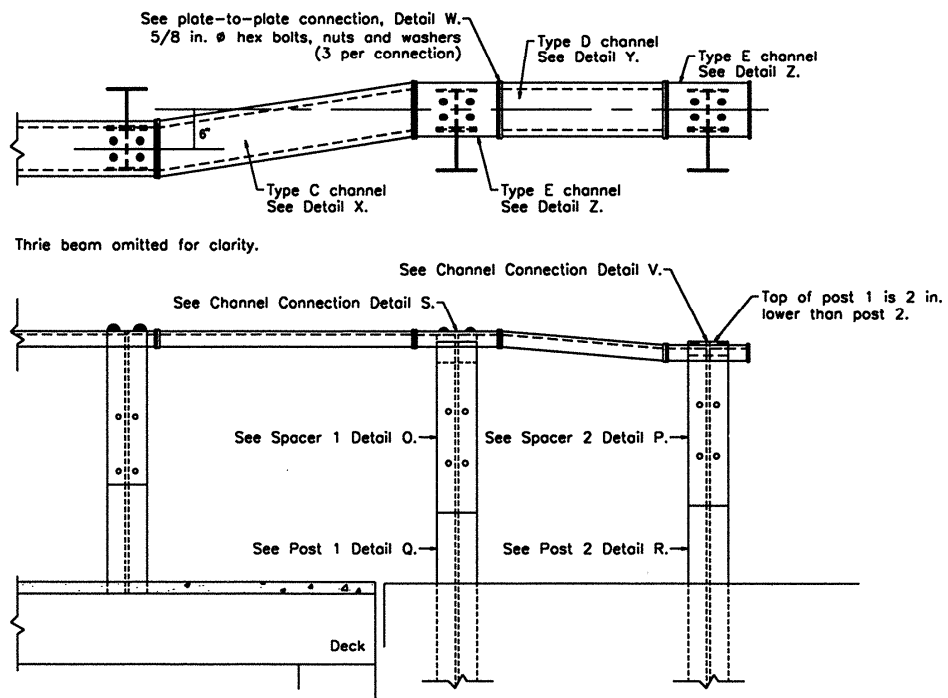
September 1995

Sheet 2 of 4

Approach Rail Transition General Configuration

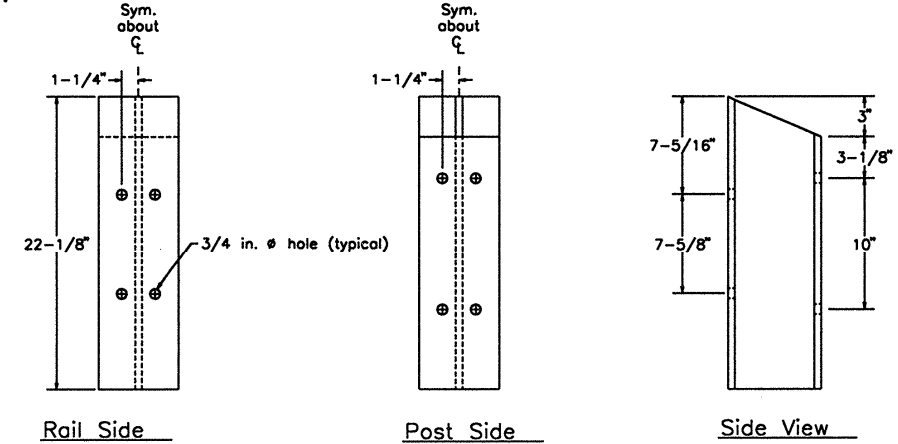


N Transition Detail

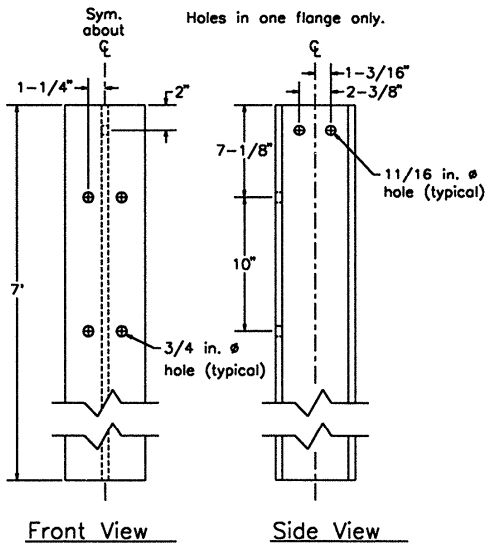


- In addition to the notes on Sheet 1, the following apply to the approach rail transition:
1. The approach rail transition was successfully crash tested to the requirements for Service Level 1 (SL-1), as outlined in NCHRP Report 230.
 2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
 3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

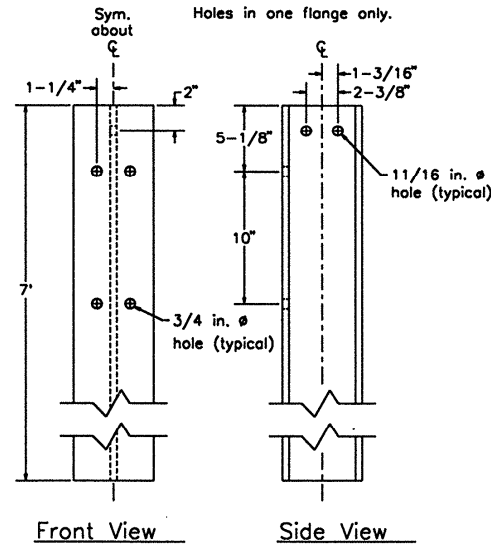
O W6 x 15 Spacer 1



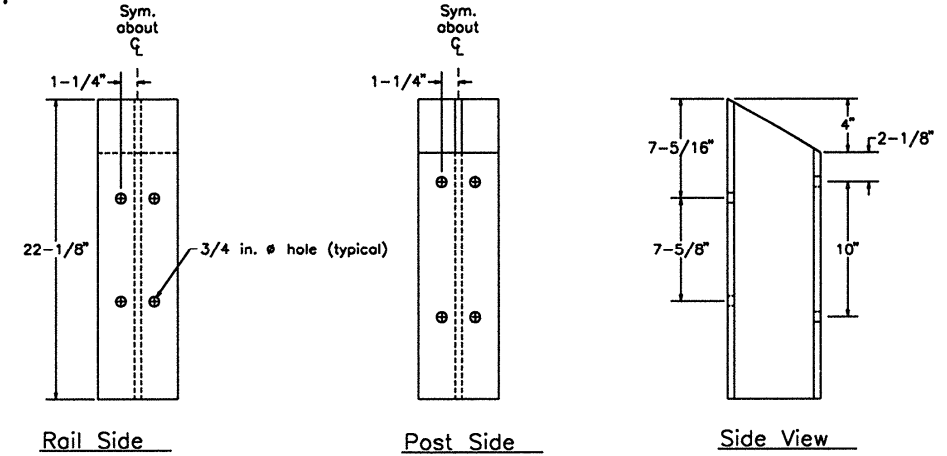
Q W6 x 15 Post 1



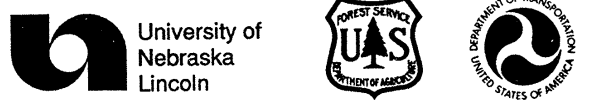
R W6 x 15 Post 2



P W6 x 15 Spacer 2



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



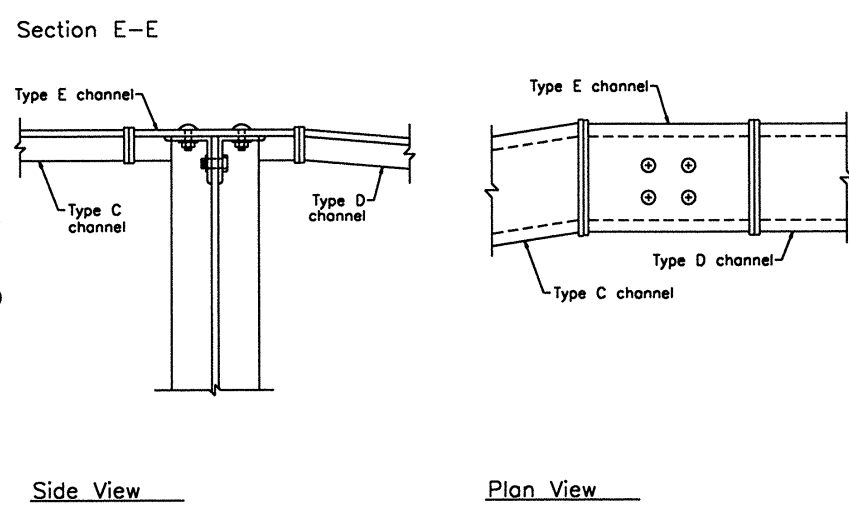
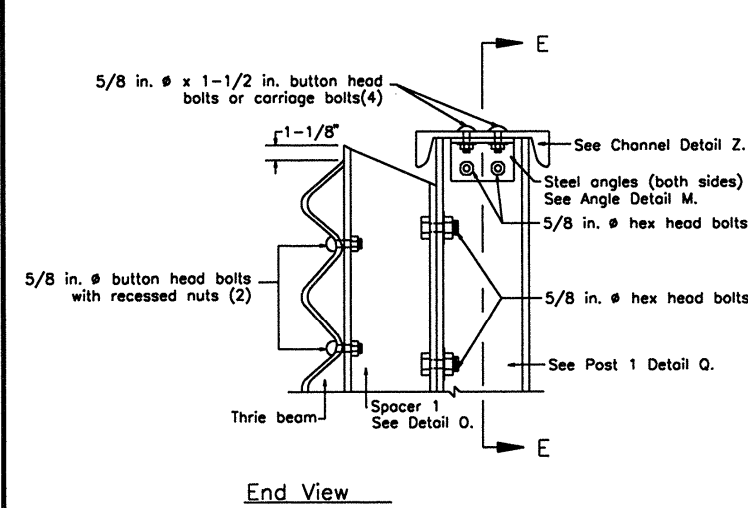
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Steel Rail
AASHTO Performance Level 2

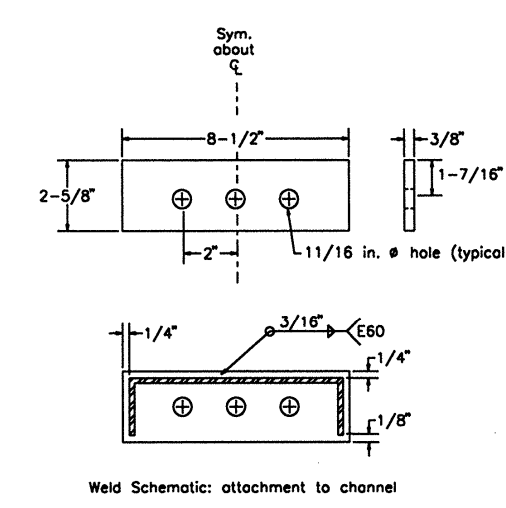
September 1995

Sheet 3 of 4

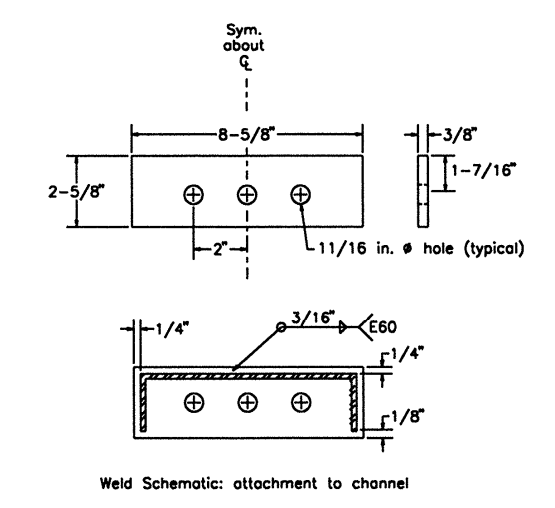
S Channel Connection at Post 1



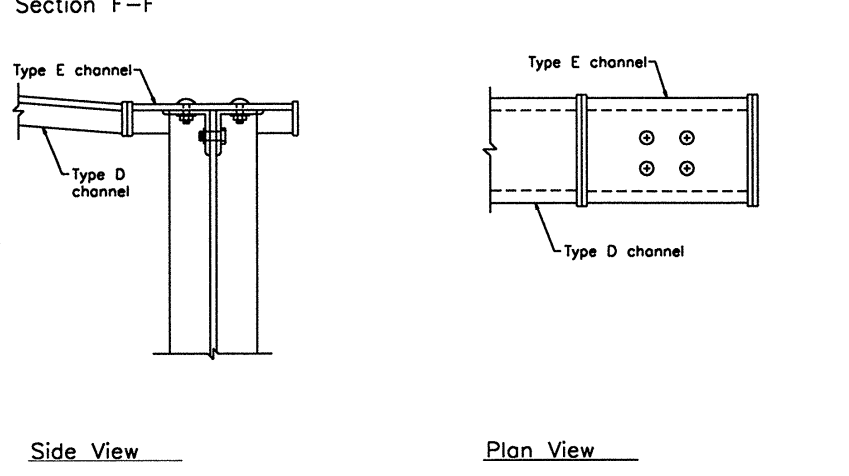
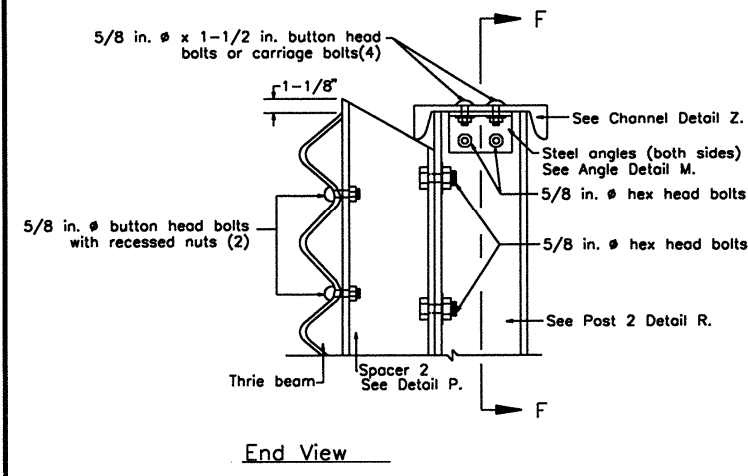
T 8-1/2 in. Steel End Plate



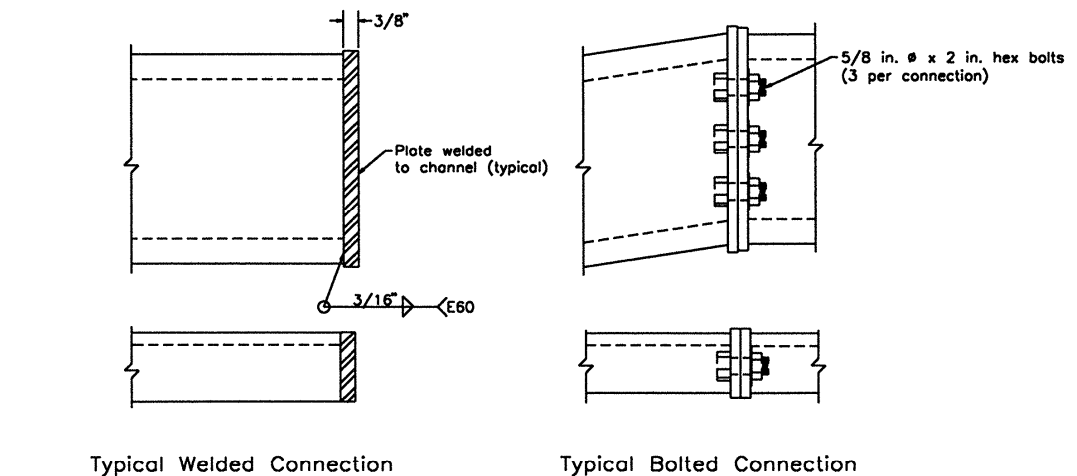
U 8-5/8 in. Steel End Plate



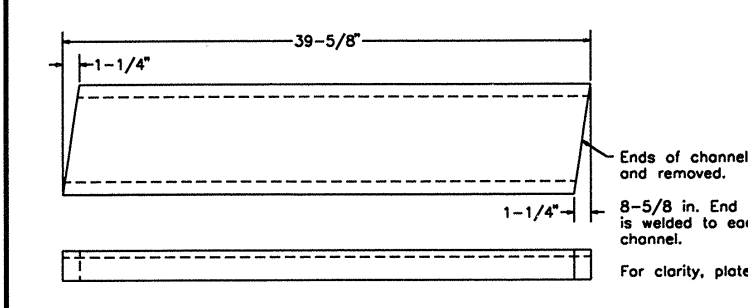
V Channel Connection at Post 2



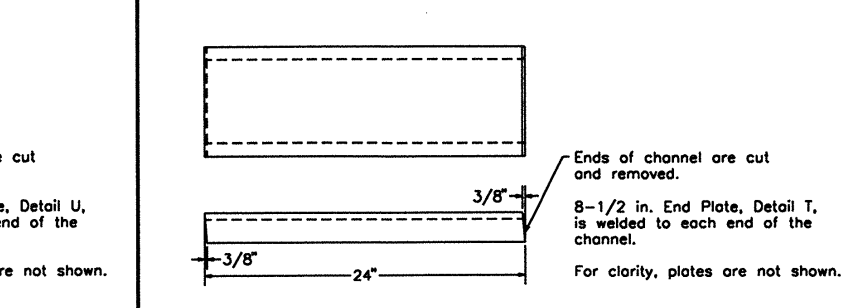
W Plate Connection Details



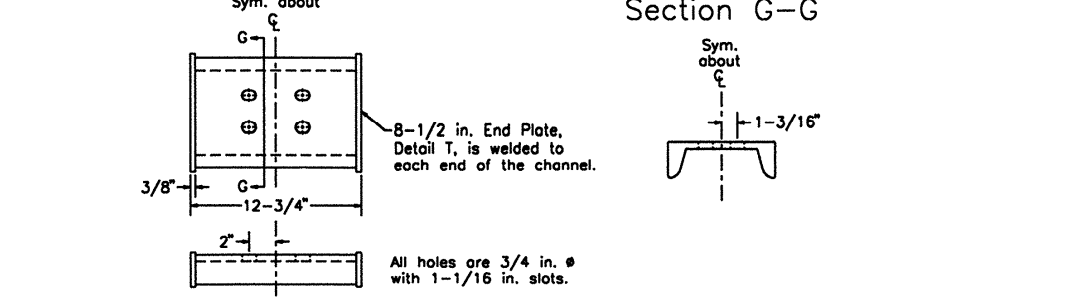
X Type C - C8 x 11-1/2 in. Steel Channel



Y Type D - C8 x 11-1/2 in. Steel Channel



Z Type E - C8 x 11-1/2 in. Steel Channel

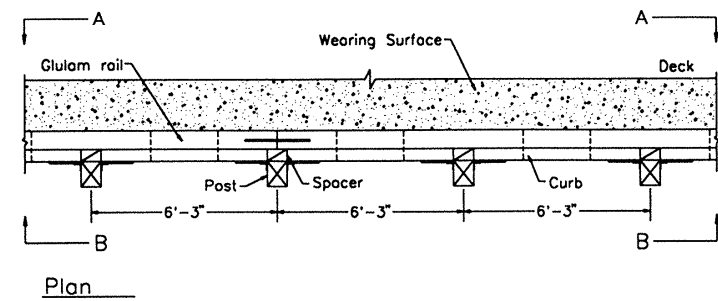


The bridge railings depicted on these drawings were developed and crash tested under a cooperative research agreement between the Midwest Roadside Safety Facility of the University of Nebraska-Lincoln, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.

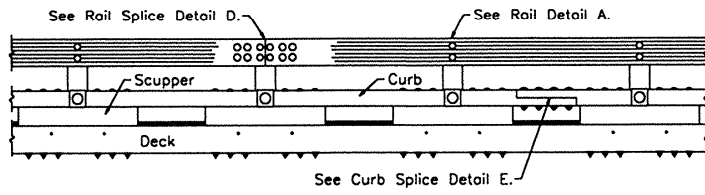
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Steel Rail AASHTO Performance Level 2	September 1995	Sheet 4 of 4
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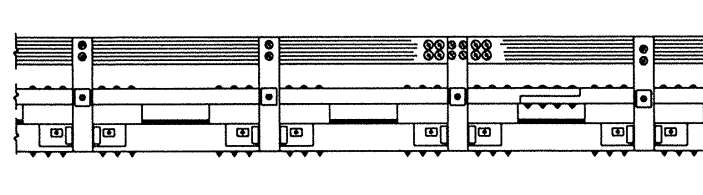
General Configuration



Section A-A



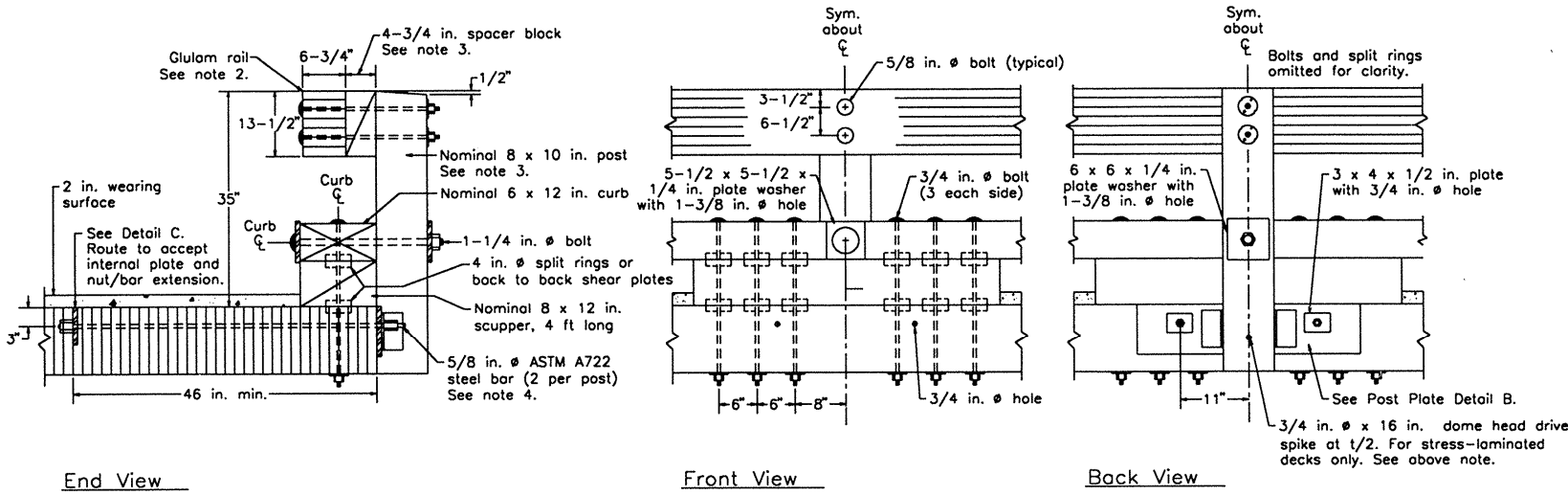
Section B-B



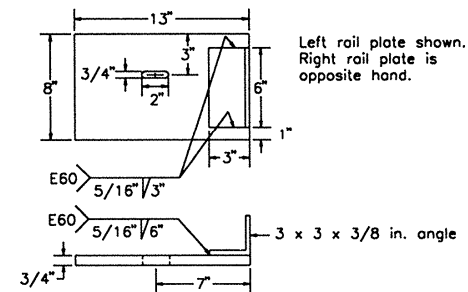
Refer to Sheet 2 for Approach Rail Transition.

A Railing Details

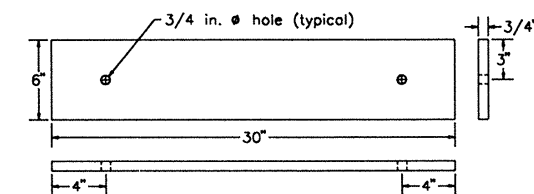
For stress-laminated decks, omit internal plate, post plates, and ASTM A722 steel bars.



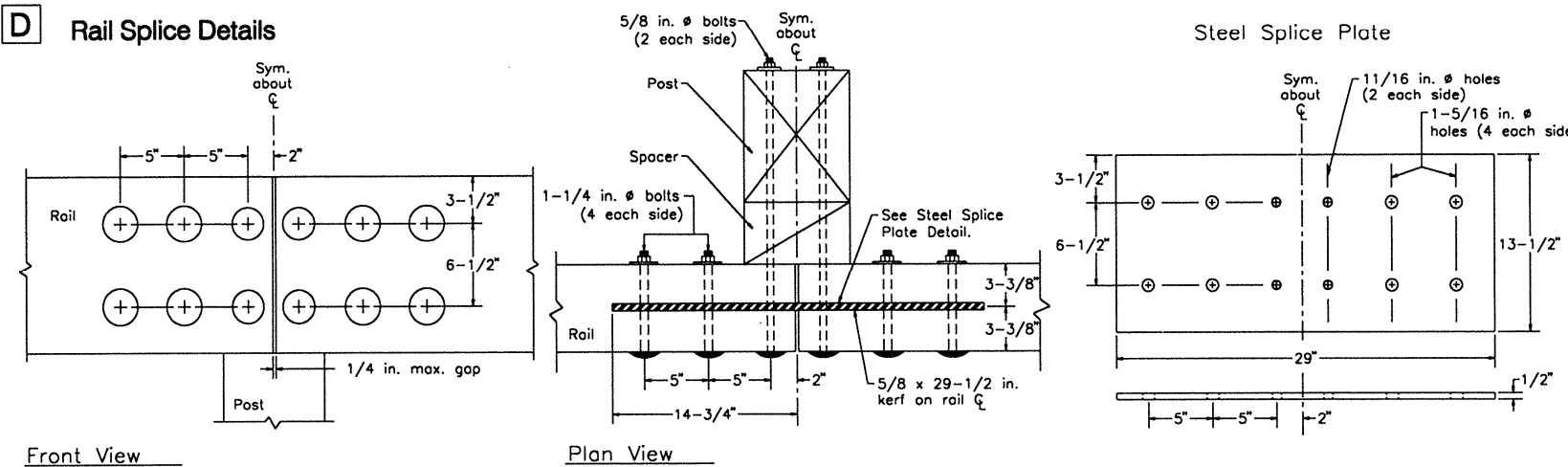
B Steel Post Plate



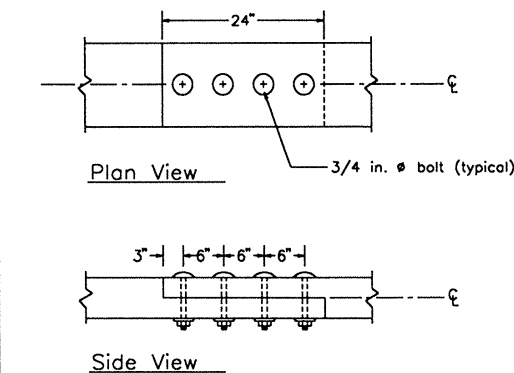
C Internal Steel Plate



D Rail Splice Details



E Curb Splice Detail



DESIGN

- This bridge rail was successfully crash tested to the requirements for Test Level 4 (TL-4), as outlined in NCHRP Report 350. In addition, the rail meets crash test requirements for Performance Level 2 (PL-2), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks which are 10-1/2 in. or greater in actual thickness.
- Dimensions given for glued laminated timber rails are actual dimensions. The depth of the glulam timber rail may be increased to a maximum of 13-3/4 in. to allow for other standard glulam timber sizes. In such cases detail dimensions shall be verified and modified accordingly.
- Dimensions for wood posts, curbs, and scuppers are given as nominal dimensions. Actual dimensions may be a maximum of 1/2 in. less than the stated nominal dimensions depending on material surfacing. Dimensions for spacer block depth are actual dimensions.
- Steel deck reinforcing bars shall be 5/8 in. diameter ASTM A722 bars.
- Curb and rail splices shall be located so that curb and rail members are continuous over not less than 2 posts. Curb splices shall be located a minimum of 1.5 post spacings away from rail splices. It is recommended that glulam rails be continuous over the bridge length.

MATERIALS

- Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133.
- The bridge rail shall be horizontally laminated glued laminated timber; visually graded Western Species Combination No. 2 or visually graded Southern Pine Combination No. 4B. Other species and grades of glued laminated timber may be used provided that the minimum tabulated values are not less than the following:
 $F_{br} = 1,800 \text{ lb/in}^2$ $E = 1,800,000 \text{ lb/in}^2$
- Posts, curbs, scuppers, and spacer blocks may be sawn lumber or glued laminated timber. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or visually graded No. 1 Douglas Fir-Larch. Glued laminated timber and other species and grades of sawn lumber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 1,350 \text{ lb/in}^2$ $E = 1,500,000 \text{ lb/in}^2$
- Steel plates and shapes shall comply with the requirements of ASTM A36.
- Bolts shall comply with the requirements ASTM A307, Grade 2 and should preferably be dome head timber bolts. Bolts on traffic face of rail shall be dome head.
- Split rings shall be manufactured from SAE 1010 hot rolled carbon steel. Shear plates shall be malleable iron manufactured according to ASTM A47, Grade 32510.
- All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

- 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 field treated with wood preservative in accordance with AASHTO M133.
- Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of dome-head timber bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.
- The tops of rail posts and the top of the rail splice plate kerf 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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



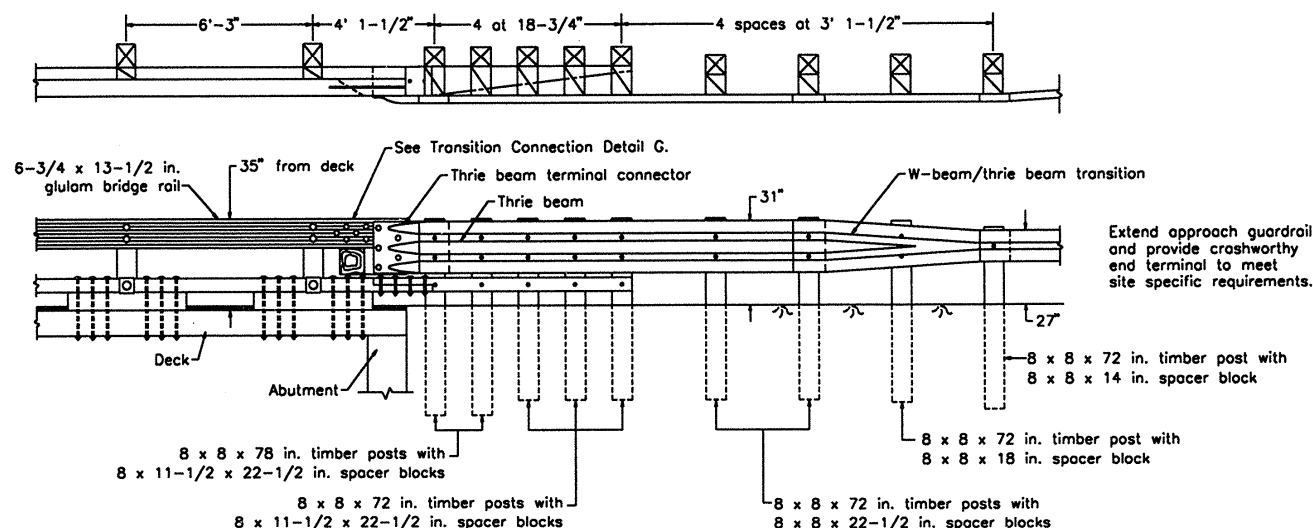
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail with Curb
NCHRP 350 Test Level 4

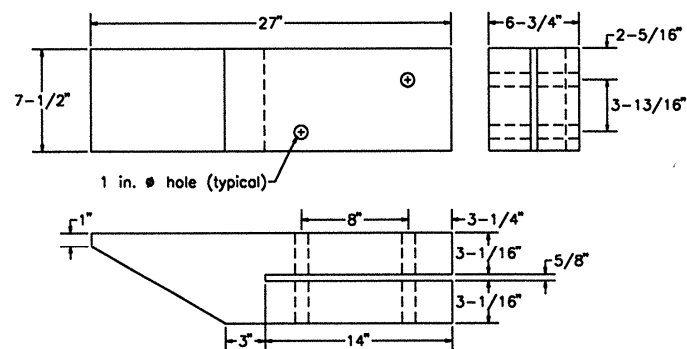
September 1995

Sheet 1 of 2

Approach Rail Transition General Configuration



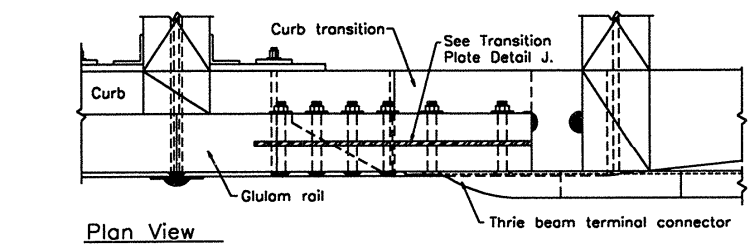
F Curb Transition Block



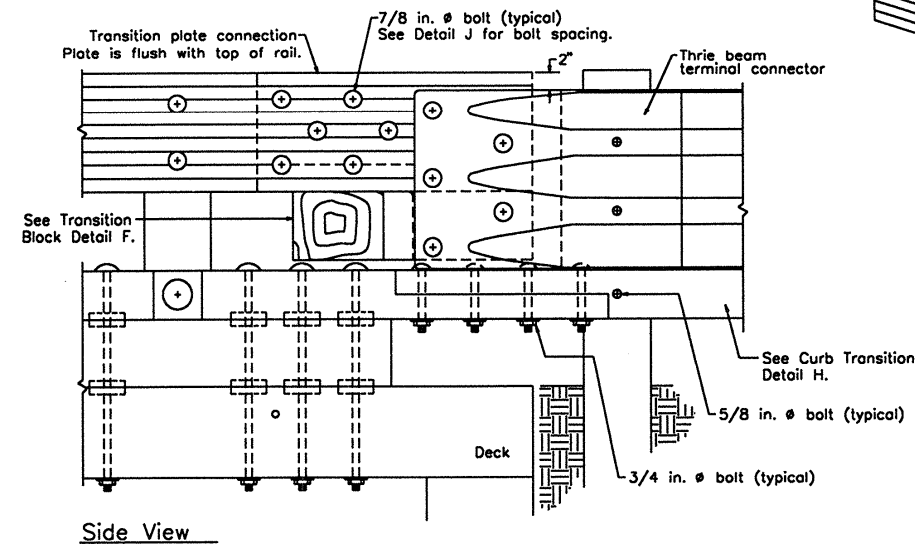
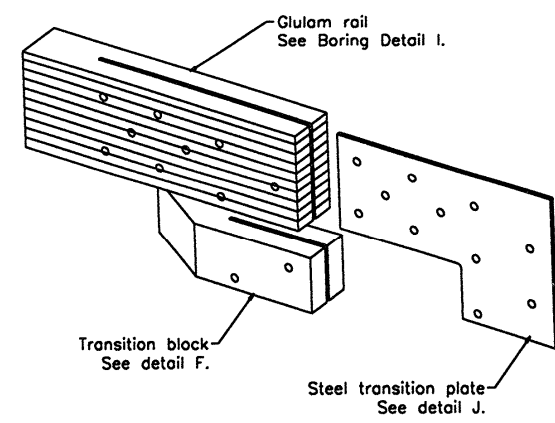
Depth of transition block is based on rail depth of 13-1/2 in. and dressed curb and scupper (5-1/2 and 7-1/2 in. in height, respectively). If dimensions of any components increase, depth of transition block must be verified and reduced as necessary.

- In addition to the notes on Sheet 1, the following apply to the approach rail transition:
1. The approach rail transition was successfully crash tested to the requirements for Service Level 2 (SL-2), as outlined in NCHRP Report 230.
 2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
 3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

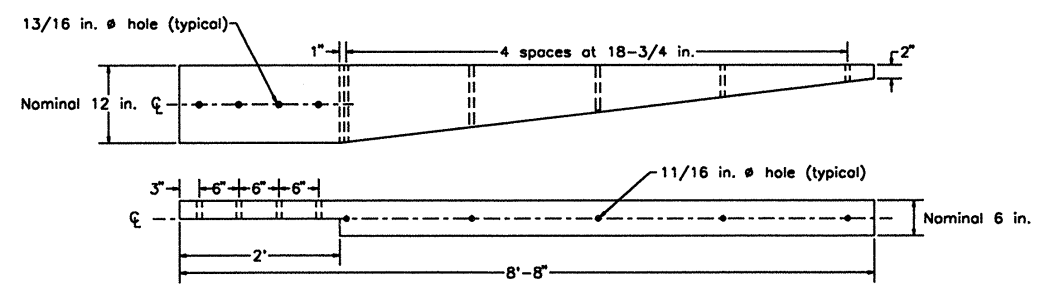
G Transition Connection Details



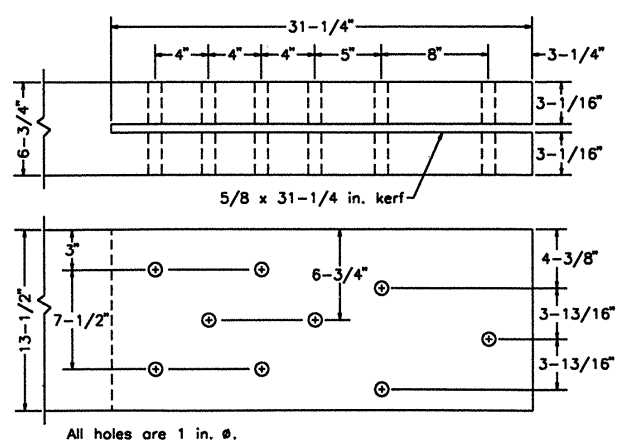
3 Dimensional Explosion of Transition Connection



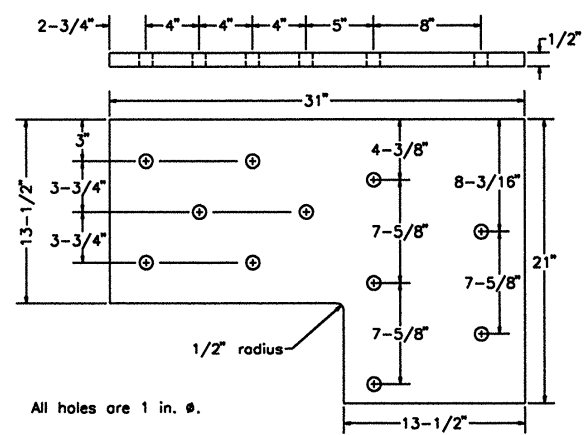
H Curb Transition



I Transition Glulam Rail Boring Detail



J Transition Plate



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail with Curb
NCHRP 350 Test Level 4

September 1995

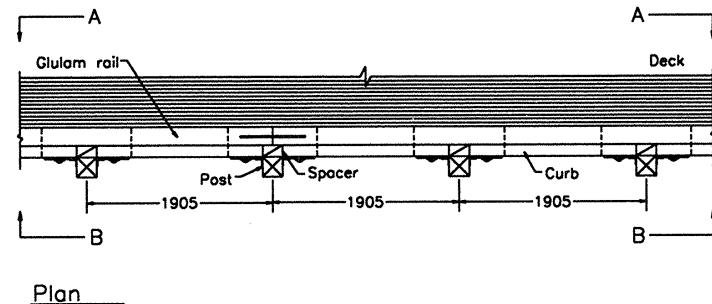
Sheet 2 of 2

Rail Drawings in S.I. Units

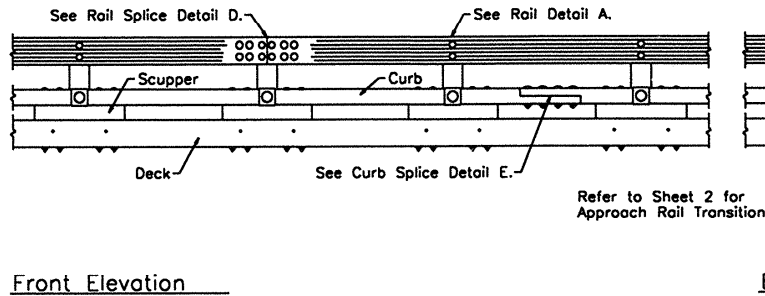


General Configuration

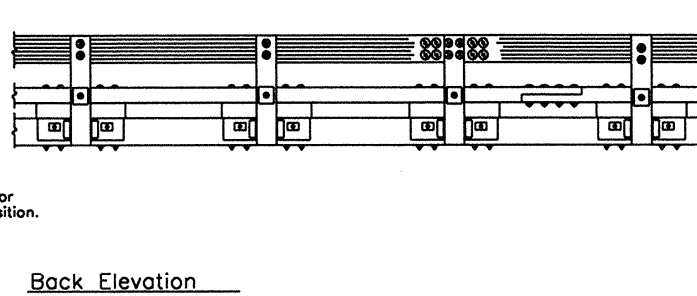
All units are in millimeters based on a soft conversion from customary U.S. units.



Section A-A

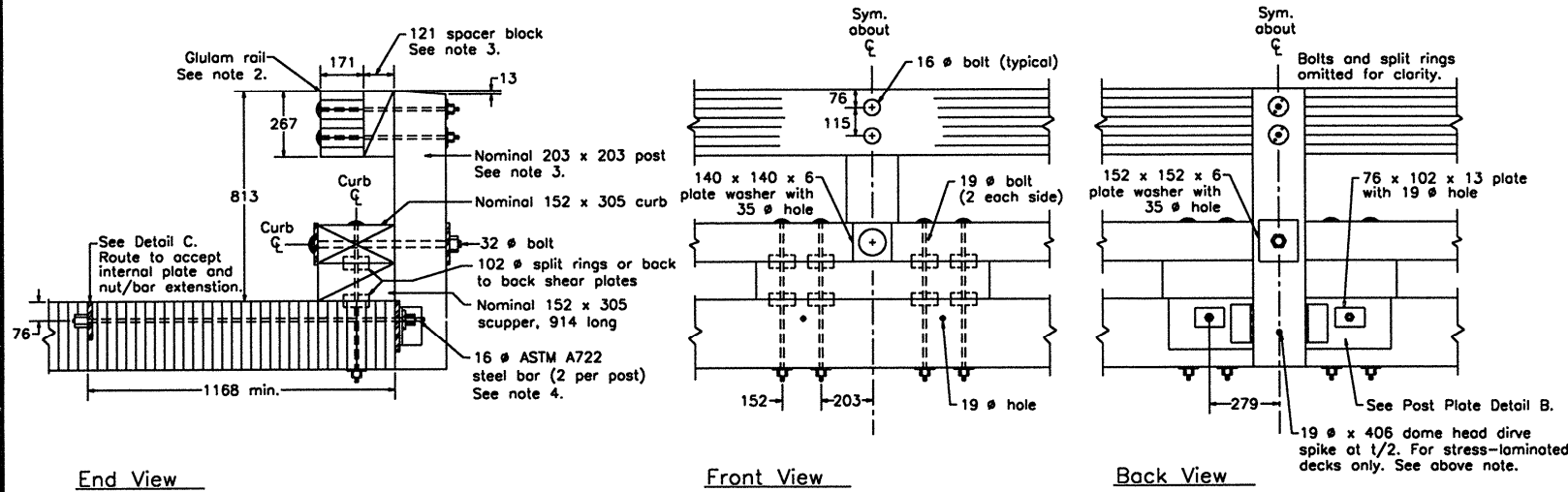


Section B-B

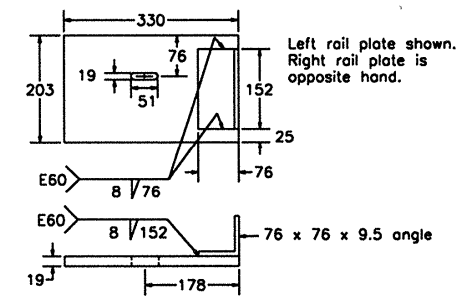


A Railing Details

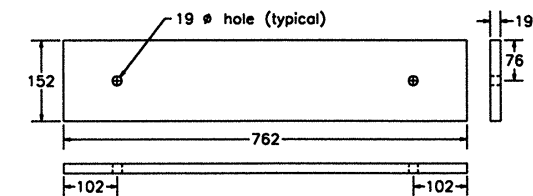
For stress-laminated decks, omit internal plate, post plates, and ASTM A722 steel bars.



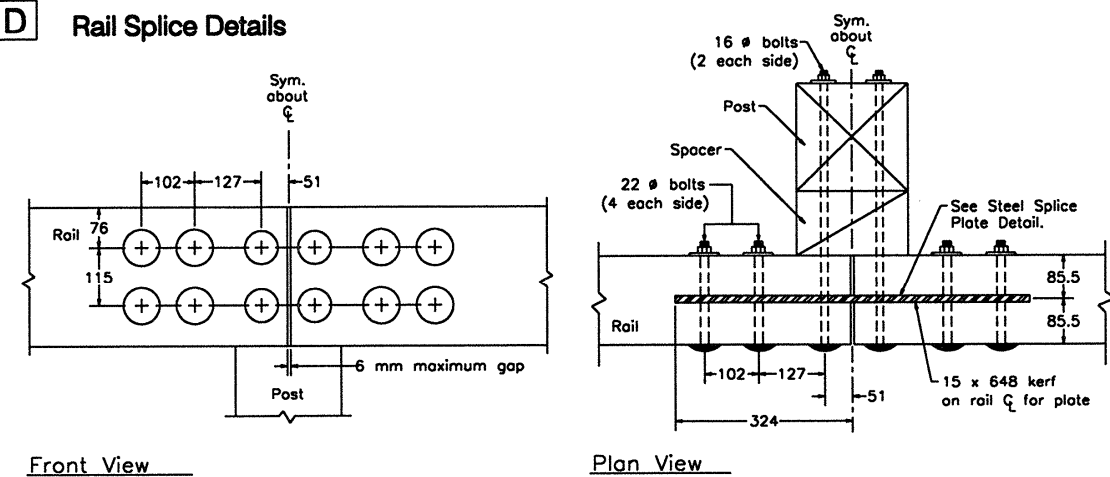
B Steel Post Plate



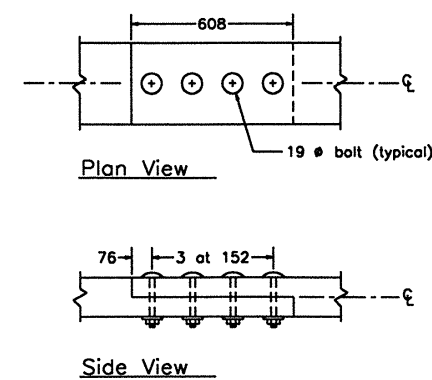
C Internal Steel Plate



D Rail Splice Details



E Curb Splice Detail



DESIGN

- This bridge rail was successfully crash tested to the requirements for Performance Level 1 (PL-1), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated and glued laminated timber decks which are 203 mm or greater in actual thickness.
- Dimensions given for glued laminated timber rails are actual dimensions. The depth of the glulam timber rail may be increased to a maximum of 273 mm to allow for other standard glulam sizes. In such cases, detail dimensions shall be modified accordingly.
- Dimensions for wood posts, curbs, and scuppers are given as nominal dimensions. Actual dimensions may be a maximum of 13 mm less than the stated nominal dimensions depending on material surfacing. Dimensions for spacer block depth are actual dimensions.
- The steel deck reinforcing bars shown on the drawings are 16 mm diameter ASTM A722 bars. Other bar materials and/or diameters may be used provided that each bar is designed for a maximum applied load of 35.6 kN. If the bar diameter is changed, plate and deck holes must be modified accordingly.
- Curb and rail splices shall be located so that curb and rail members are continuous over not less than 2 posts. Curb splices shall be located a minimum of 1.5 post spacings away from rail splices. It is recommended that glulam rails be continuous over the bridge length.

MATERIALS

- Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133.
 - The bridge rail shall be horizontally laminated glued laminated timber; visually graded Western Species Combination No. 2 or visually graded Southern Pine Combination No. 48. Other species and grades of glued laminated timber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 12.4 \text{ MPa}$ $E = 12410 \text{ MPa}$
 - Posts, curbs, scuppers, and spacer blocks may be sawn lumber or glued laminated timber. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or visually graded No. 1 Douglas Fir-Larch. Glued laminated timber and other species and grades of sawn lumber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 9.3 \text{ MPa}$ $E = 10342 \text{ MPa}$
 - Steel plates and shapes shall comply with the requirements of ASTM A36.
 - Bolts shall comply with the requirements ASTM A307, Grade 2 and should preferably be dome head timber bolts. Bolts on traffic face of rail shall be dome head.
 - Split rings shall be manufactured from SAE 1010 hot rolled carbon steel. Shear plates shall be malleable iron manufactured according to ASTM A47, Grade 32510.
 - All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.
- ### FABRICATION AND CONSTRUCTION
- 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, bare holes, and damage shall be immediately field treated with wood preservative in accordance with AASHTO M133.
 - Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of dome-head timber bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.
 - The tops of rail posts and the top of the rail splice kerf 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.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

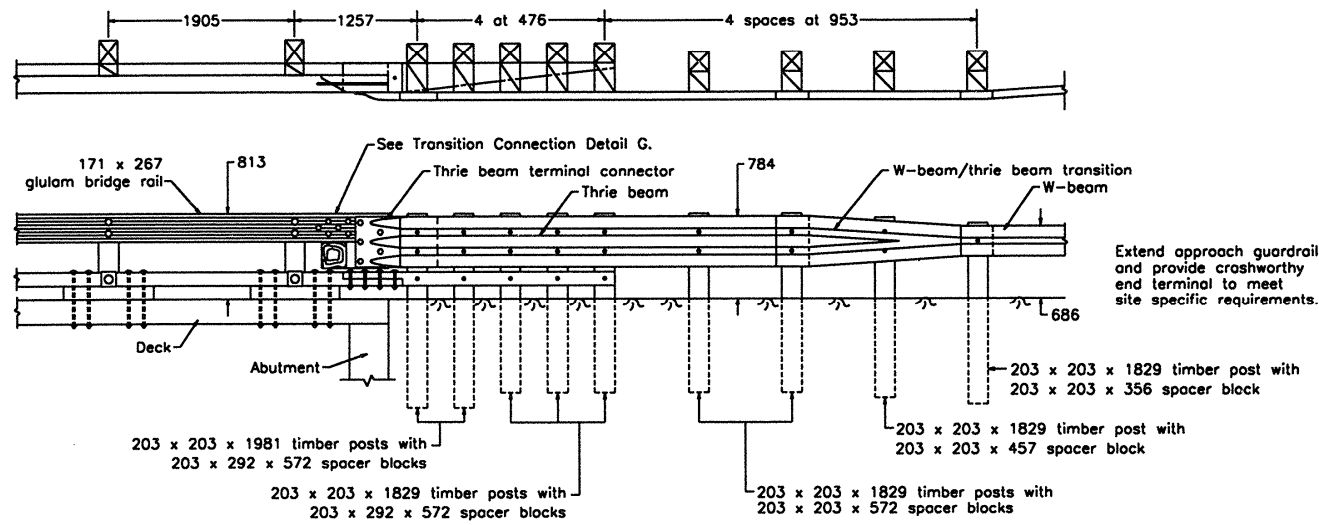
Glulam Timber Rail with Curb
AASHTO Performance Level 1

September 1995

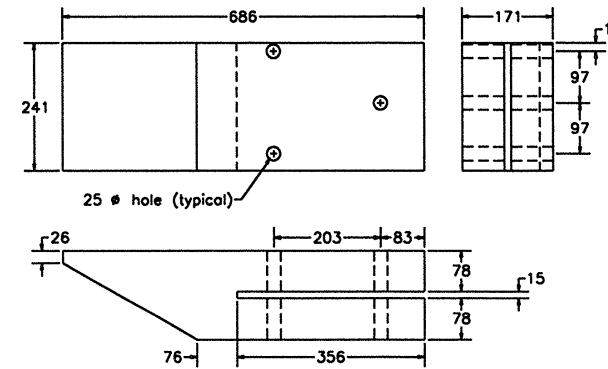
Sheet 1 of 2

Approach Rail Transition General Configuration

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



F Transition Block

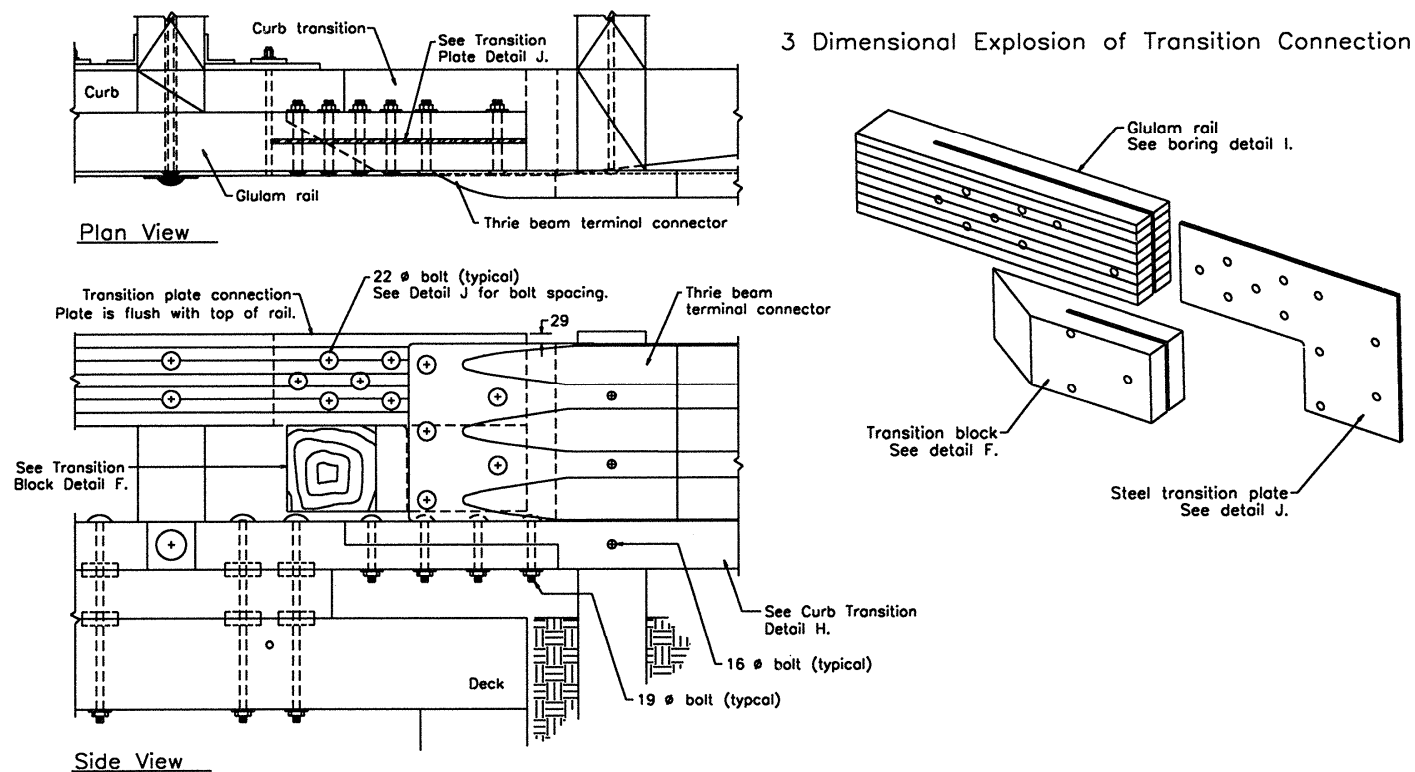


Depth of transition block is based on rail depth of 267 mm and dressed curb and scupper (both 140 mm in height). If dimensions of any components increase, depth of transition block must be verified and reduced as necessary.

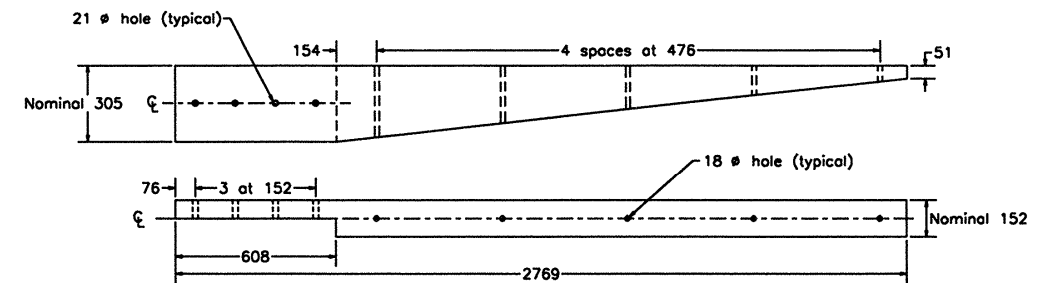
In addition to the notes on Sheet 1, the following apply to the approach rail transition:

1. The approach rail transition was successfully crash tested to the requirements for Service Level 2 (SL-2), as outlined in NCHRP Report 230.
2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

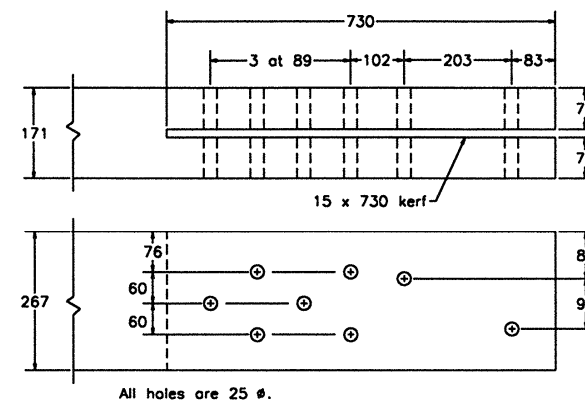
G Transition Connection Details



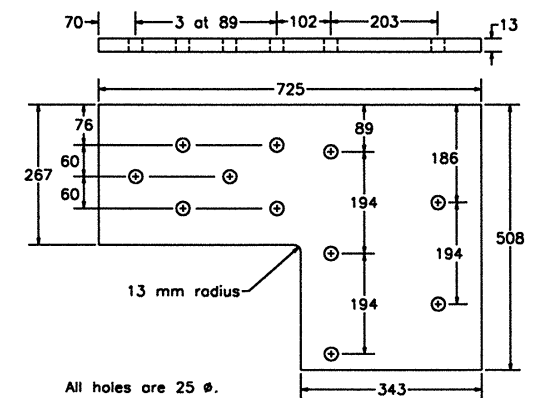
H Curb Transition



I Transition Glulam Rail Boring Detail



J Steel Transition Plate



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.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

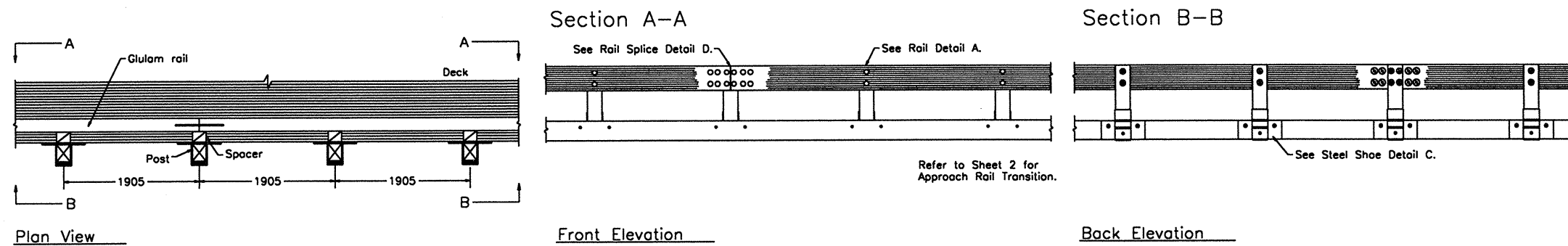
Glulam Timber Rail with Curb
AASHTO Performance Level 1

September 1995

Sheet 2 of 2

General Configuration

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



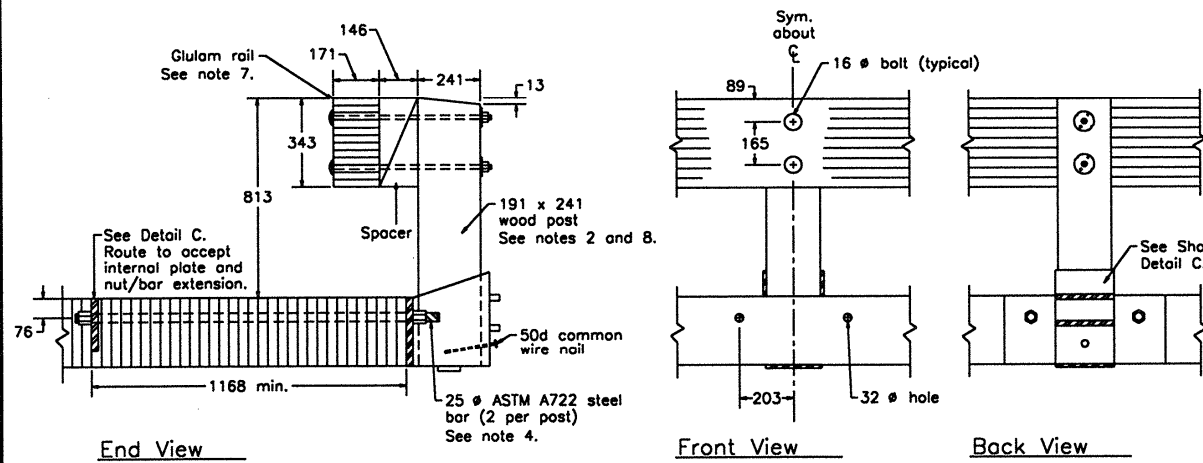
DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 1 (PL-1), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks which are 267 mm or greater in actual thickness.
2. Dimensions for the wood rail, post, and spacer are actual dimensions. Post dimensions correspond to the standard dressed dimensions for a nominal 203 x 254 mm member that is surfaced on 4 sides (S4S).
3. The depth of the glulam timber rail may be increased to a maximum of 349 mm to allow for standard glulam timber sizes. In such cases, detail dimensions shall be verified and modified accordingly.
4. The steel deck reinforcing bars shown on the drawings are 25 mm diameter ASTM A722 bars. Other bar materials and/or diameters may be used provided that each bar is designed for a maximum applied load of 177.9 kN. If the bar diameter is changed, plate and deck holes must be modified accordingly.
5. Rail splices shall be located so rail members are continuous over not less than 4 posts. It is recommended that the rail be continuous over the bridge length.

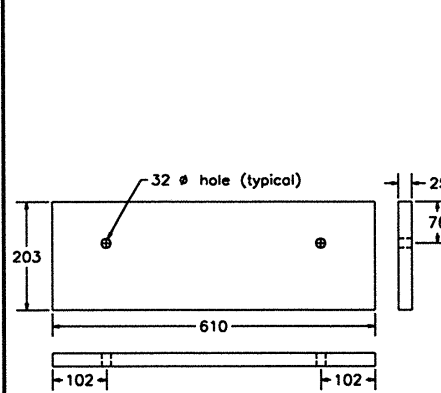
MATERIALS

6. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133.
 7. The bridge rail shall be horizontally laminated glued laminated timber; visually graded Western Species Combination No. 2 or visually graded Southern Pine Combination No. 48. Other species and grades of glued laminated timber may be used provided that the minimum tabulated values are not less than the following:
 $F_{bw} = 12.4 \text{ MPa}$
 $E = 12410 \text{ MPa}$
 8. Posts and spacer blocks may be sawn lumber or glued laminated timber. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or visually graded No. 1 Douglas Fir-Larch. Glued laminated timber and other species and grades of sawn lumber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 9.3 \text{ MPa}$
 $E = 10342 \text{ MPa}$
 9. Steel plates and shapes shall comply with the requirements of ASTM A36.
 10. Bolts shall comply with the requirements ASTM A307, Grade 2 and should preferably be dome head timber bolts. Bolts on traffic face of rail shall be dome head.
 11. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.
- ### FABRICATION AND CONSTRUCTION
12. Welding shall be completed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code.
 13. 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 field treated with wood preservative in accordance with AASHTO M133.
 14. Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of dome-head timber bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.
 15. The tops of rail posts and the top of the rail splice plate kerf shall be sealed with roofing cement or otherwise protected from direct exposure to weather.

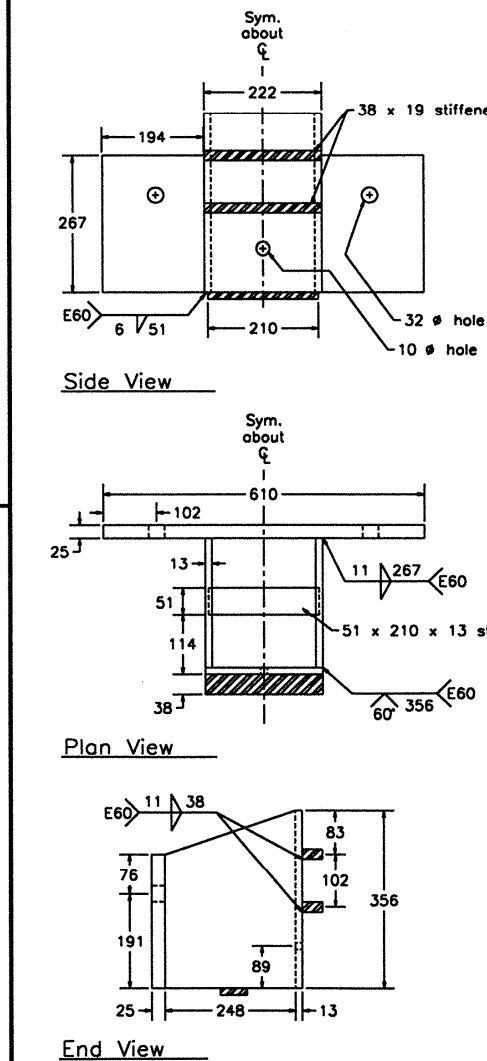
A Railing Details



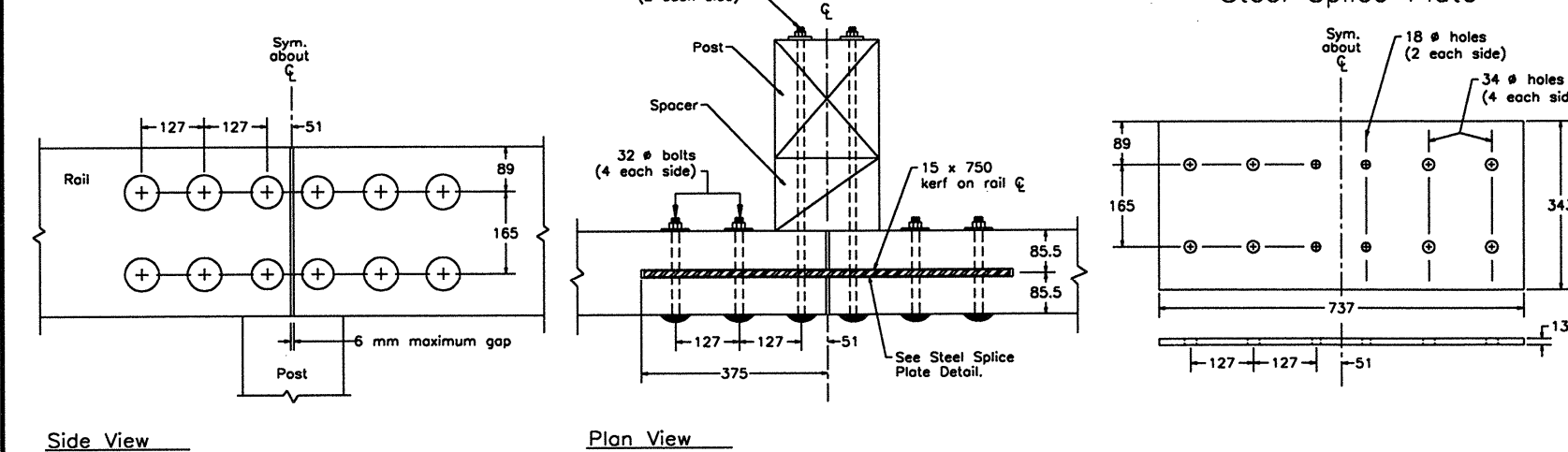
B Internal Steel Plate



C Steel Shoe Details



D Rail Splice Details



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.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

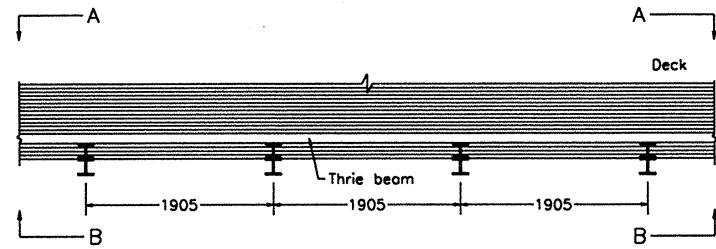
Glulam Timber Rail without Curb
AASHTO Performance Level 1

September 1995

Sheet 1 of 2

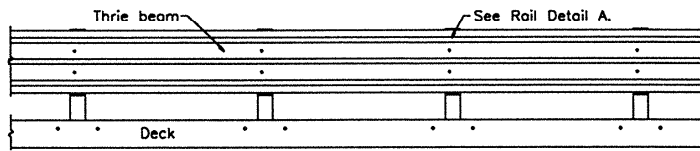
General Configuration

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



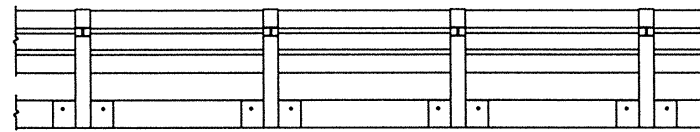
Plan View

Section A-A



Front Elevation

Section B-B



Back Elevation

Refer to Sheet 2 for Approach Rail Transition.

DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 1 (PL-1), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated and glued laminated timber decks which are 267 mm or greater in actual thickness.
2. The steel deck reinforcing bars shown on the drawings are 25 mm diameter ASTM A722 bars. Other bar materials and/or diameters may be used provided that each bar is designed for a maximum applied load of 195.7 kN. If the bar diameter is changed, plate and deck holes must be modified accordingly.

MATERIALS

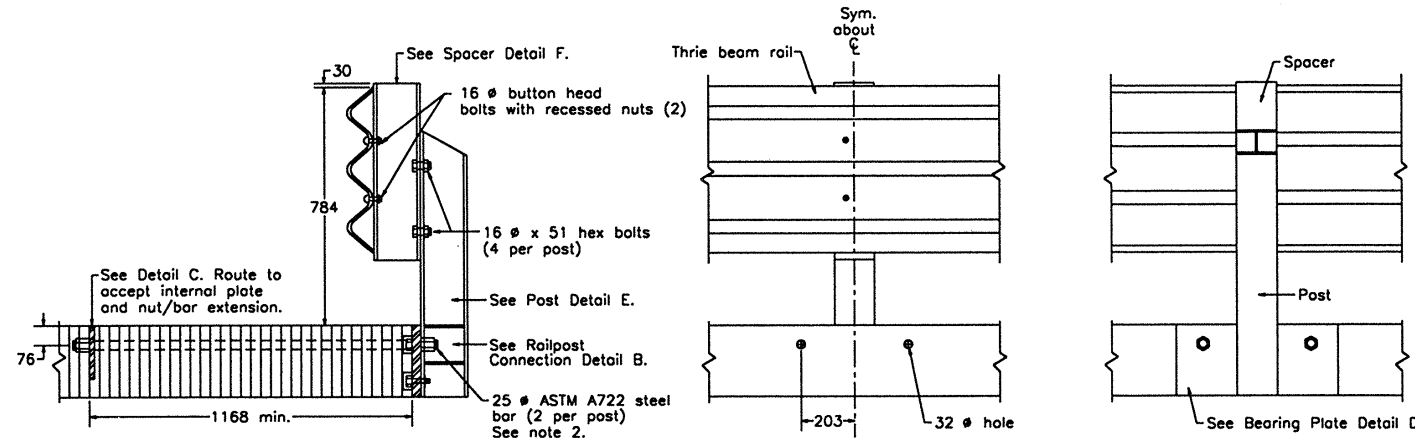
3. The bridge rail shall be 10 gage thrie beam. Unless noted, all rail, rail splice and post bolts shall comply with the requirements of AASHTO M180.
4. Steel plates and shapes shall comply with the requirements of ASTM A36.
5. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

6. Welding shall be completed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code.
7. 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 field treated with wood preservative in accordance with AASHTO M133.
8. Washers shall be provided under hex bolt nuts.

A Railing Details

For stress-laminated decks, omit internal plate and ASTM A722 steel bars.



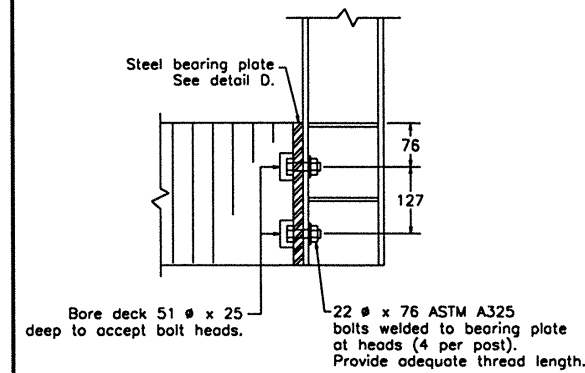
End View

Front View

Back View

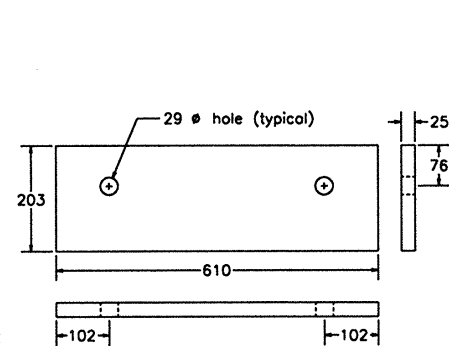
B Rail Post Connection

Note: 25 # steel bars omitted for clarity.

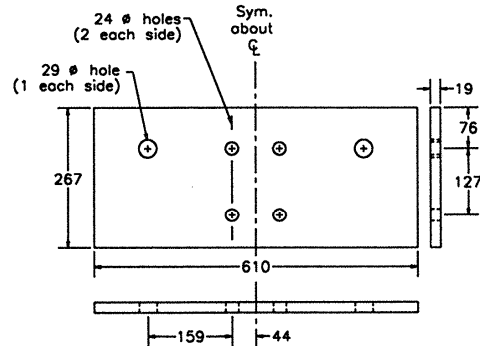


End View

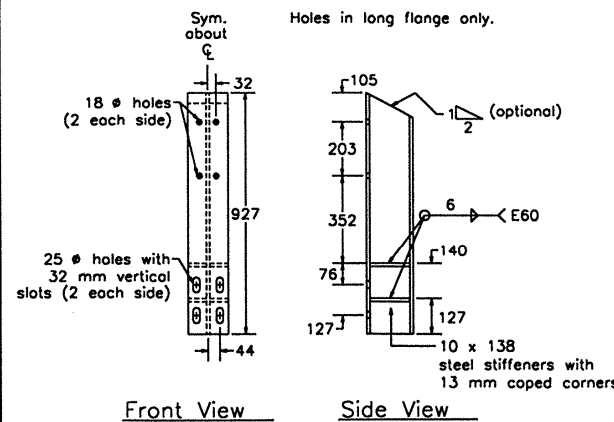
C Internal Steel Plate



D Steel Bearing Plate



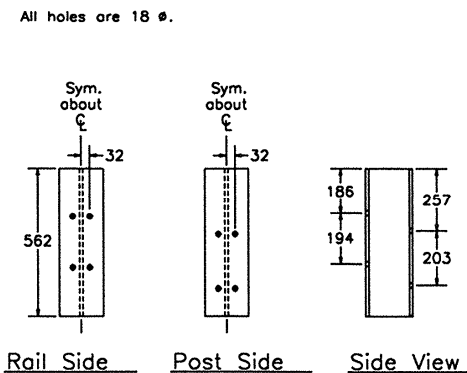
E W150 x 22 Steel Post



Front View

Side View

F W150 x 22 Steel Spacer



Rail Side

Post Side

Side View

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.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

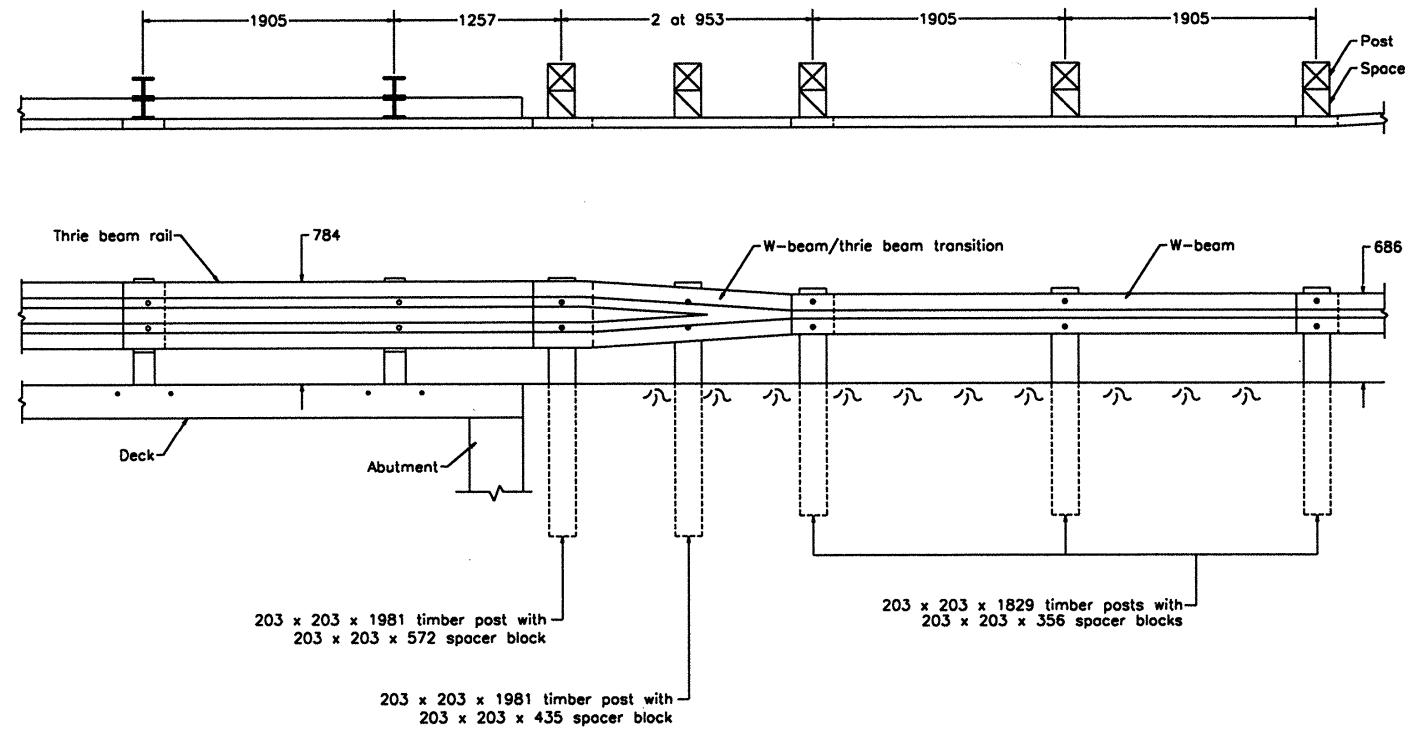
Steel Rail
AASHTO Performance Level 1

September 1995

Sheet 1 of 2

Approach Rail Transition General Configuration

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



- In addition to the notes on Sheet 1, the following apply to the approach rail transition:
1. The approach rail transition was successfully crash tested to the requirements for Service Level 1 (SL-1), as outlined in NCHRP Report 230.
 2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
 3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

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.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

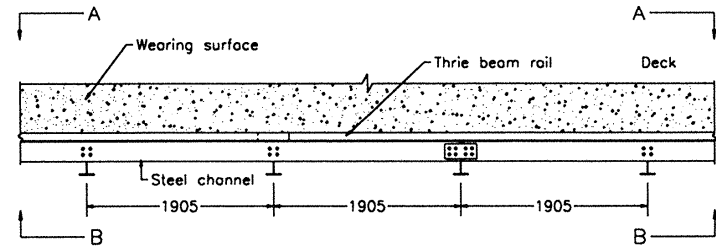
Steel Rail
AASHTO Performance Level 1

September 1995

Sheet 2 of 2

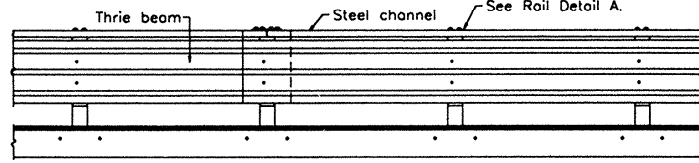
General Configuration

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



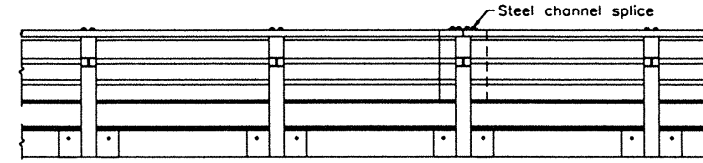
Plan

Section A-A



Front Elevation

Section B-B



Back Elevation

Refer to Sheets 3 and 4 for Approach Rail Transition.

DESIGN

1. This bridge rail was successfully crash tested to the requirements for Performance Level 2 (PL-2), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated, and glued laminated timber decks which are 267 mm or greater in actual thickness.

2. Steel deck reinforcing bars shall be 25 mm diameter ASTM A722 bars.

MATERIALS

3. The bridge rail shall be 10 gage thrie beam. Unless noted, all rail, rail splice and post bolts shall comply with the requirements of AASHTO M180.

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

5. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

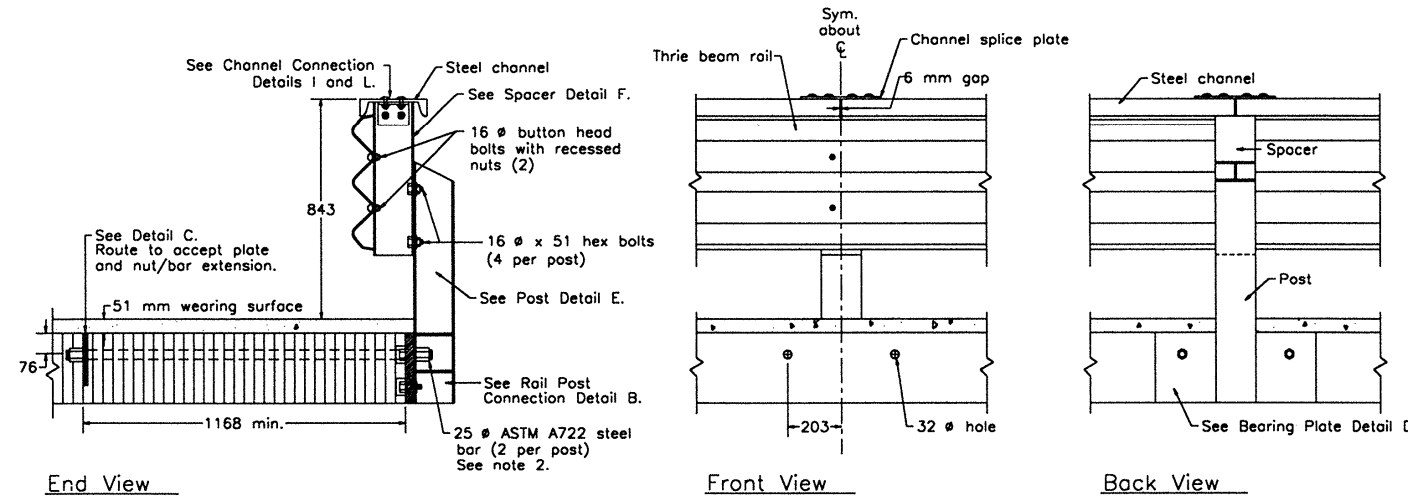
6. Welding shall be completed in accordance with the requirements of the ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code.

7. 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 field treated with wood preservative in accordance with AASHTO M133.

8. Washers shall be used in combination with hex head nuts.

A Railing Details

For stress-laminated decks, omit internal plate and ASTM A722 steel bars.



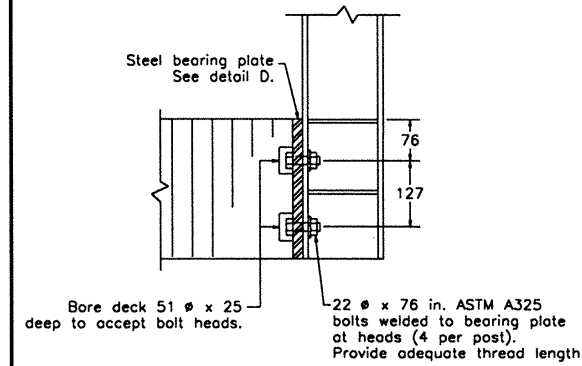
End View

Front View

Back View

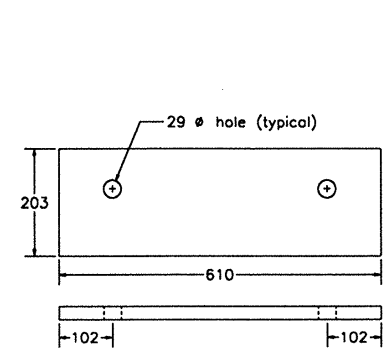
B Rail Post Connection Detail

Note: 25 # steel bars omitted for clarity.

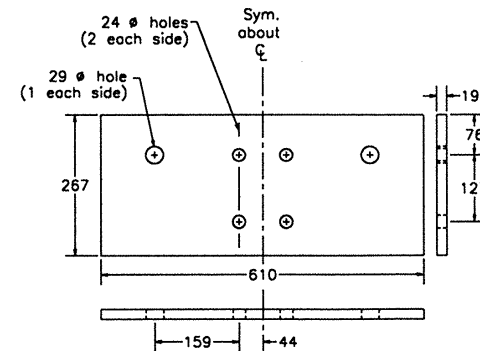


End View

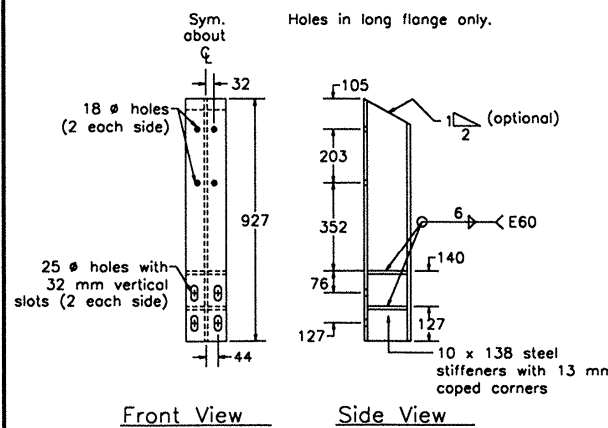
C Internal Steel Plate



D Steel Bearing Plate



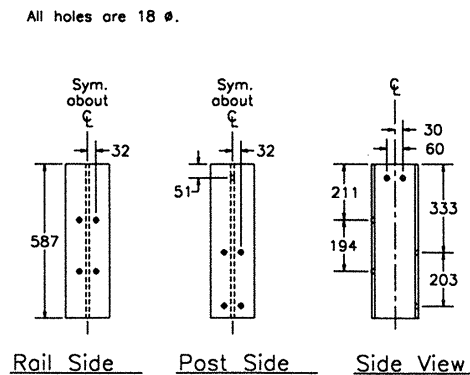
E W150 x 22 Post



Front View

Side View

F W150 x 22 Spacer



Rail Side

Post Side

Side View

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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



Crash Tested Bridge Rails for Longitudinal Wood Decks

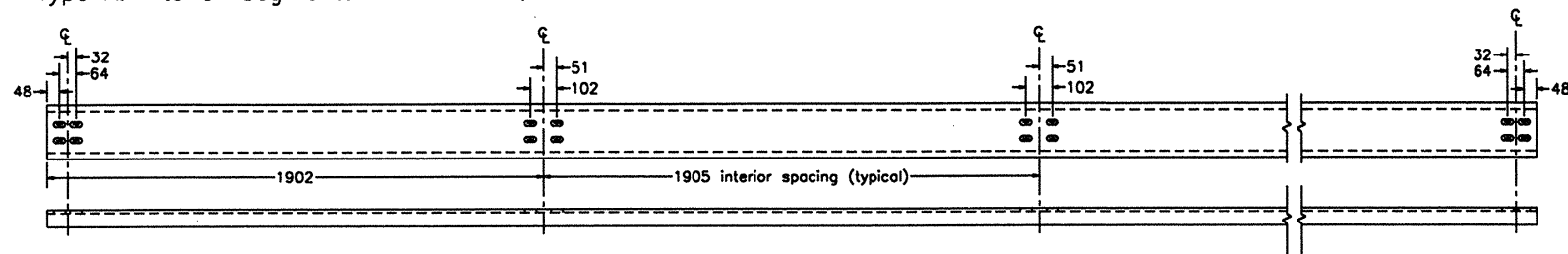
Steel Rail
AASHTO Performance Level 2

September 1995

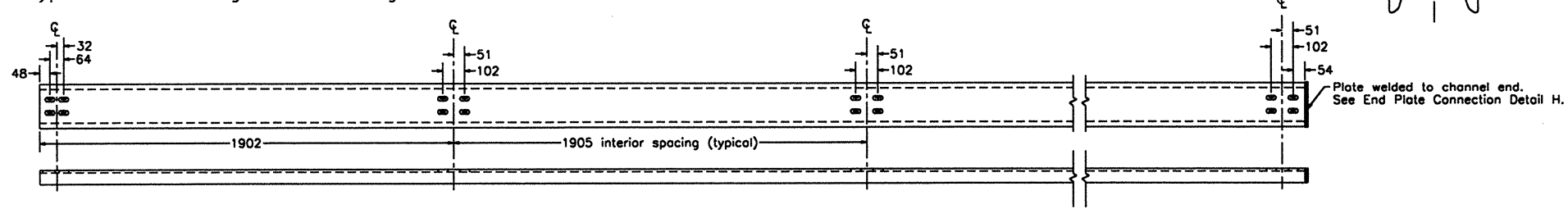
Sheet 1 of 4

G Steel Channel Details All units are in millimeters based on a soft conversion from customary U.S. units.

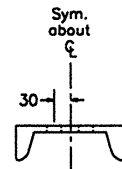
Type A: Interior Segments c200 x 17 channel; All holes are 19 # with 27 slots.



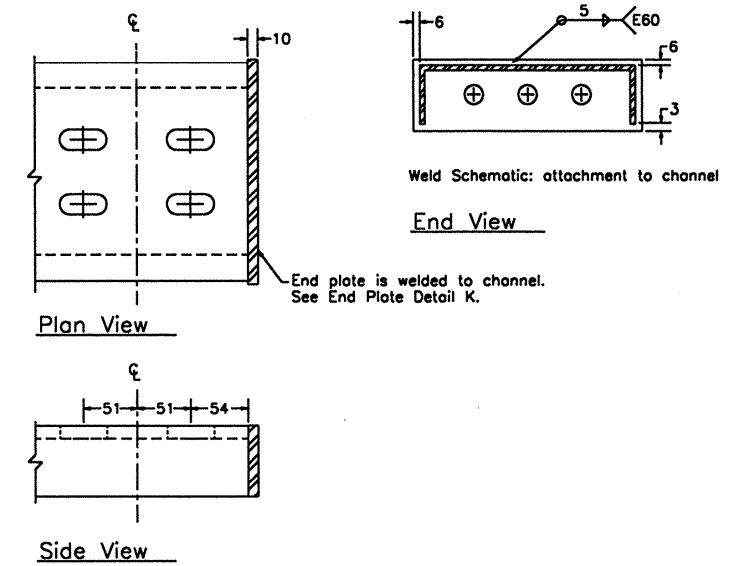
Type B: Exterior Segments at Bridge Ends c200 x 17 channel; All holes are 19 # with 27 slots.



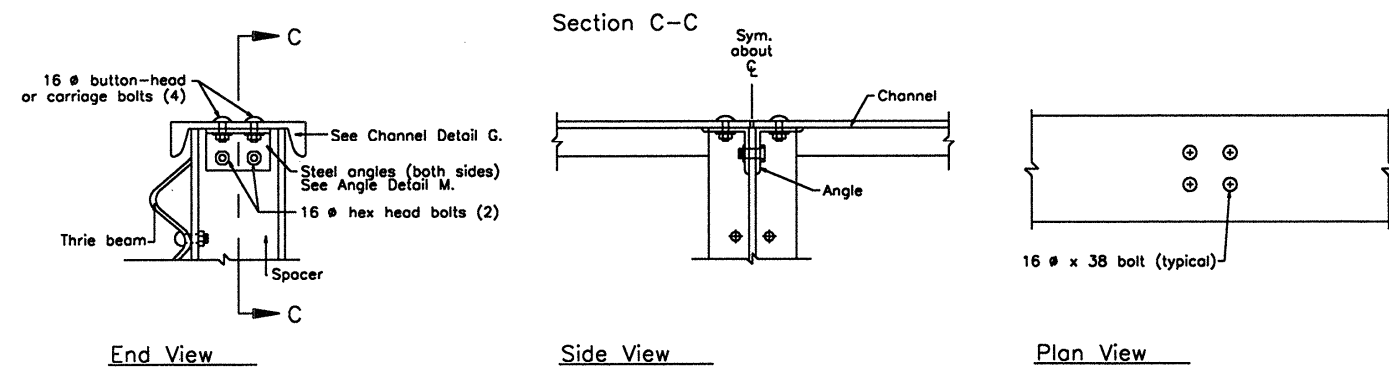
Channel Cross Section



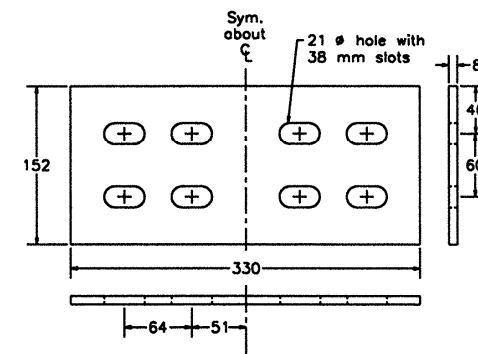
H End Plate Connection Detail



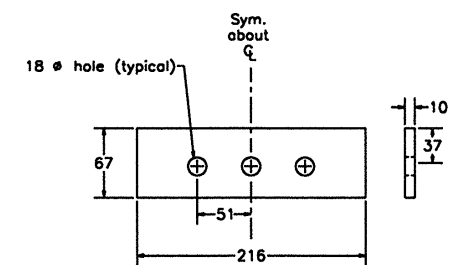
I Channel Connection Details



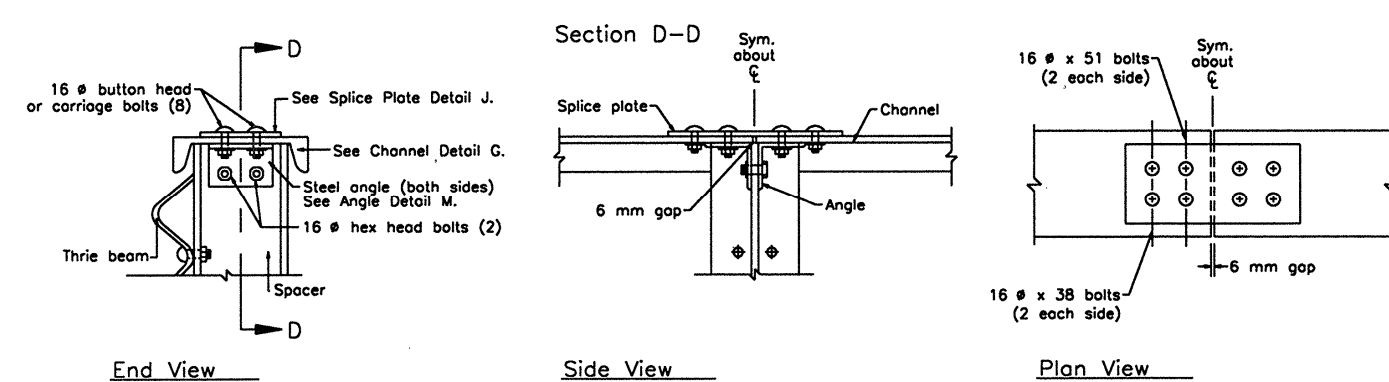
J Steel Splice Plate



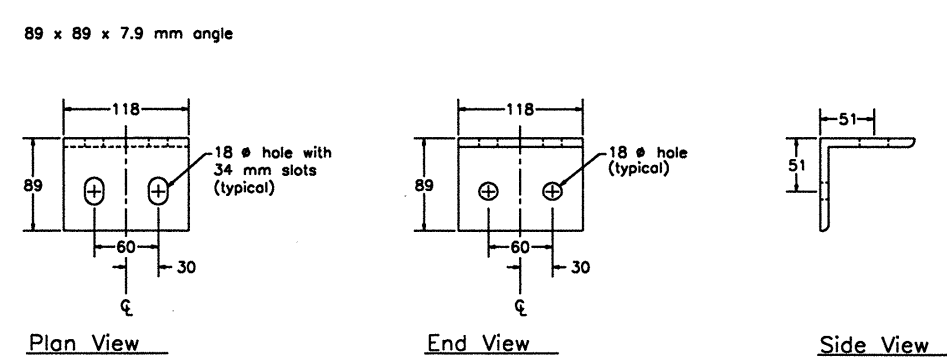
K Steel End Plate



L Channel Splice Connection Details



M Steel Angle



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

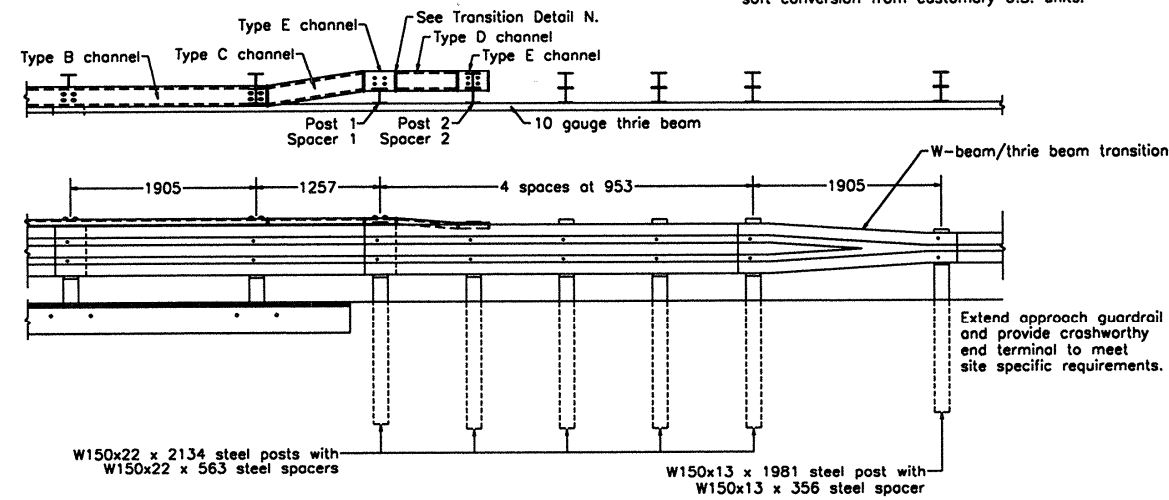
Steel Rail
AASHTO Performance Level 2

September 1995

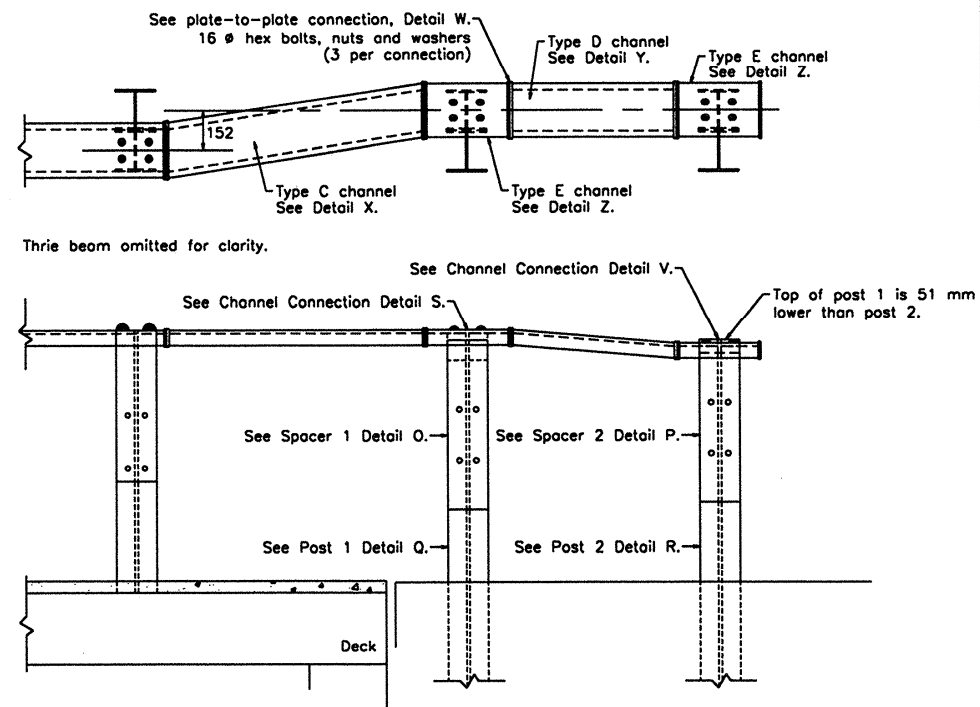
Sheet 2 of 4

Approach Rail Transition General Configuration

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

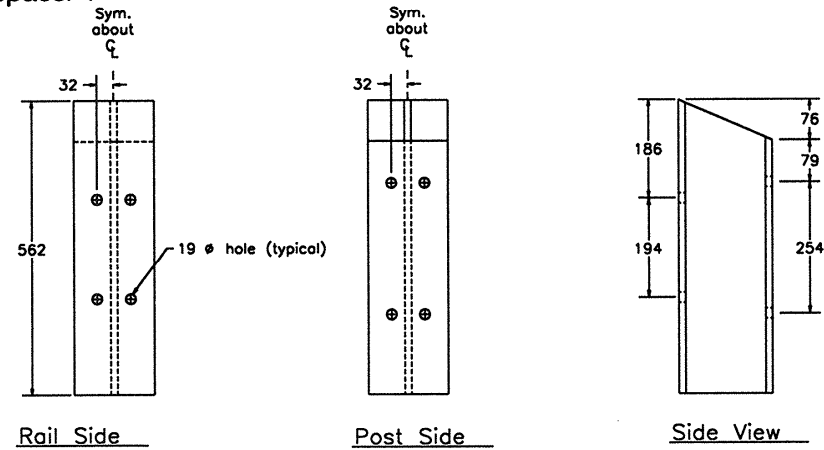


N Transition Detail

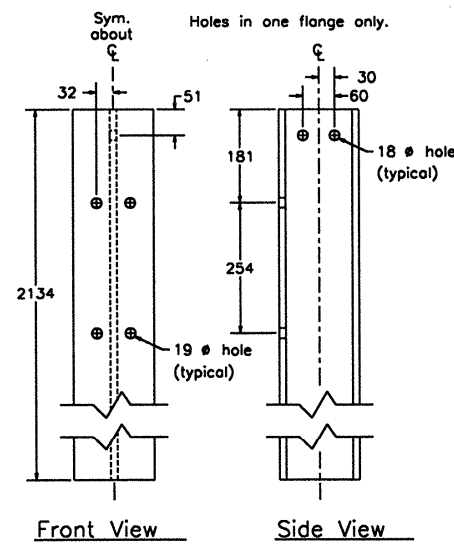


- In addition to the notes on Sheet 1, the following apply to the approach rail transition:
1. The approach rail transition was successfully crash tested to the requirements for Service Level 1 (SL-1), as outlined in NCHRP Report 230.
 2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
 3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

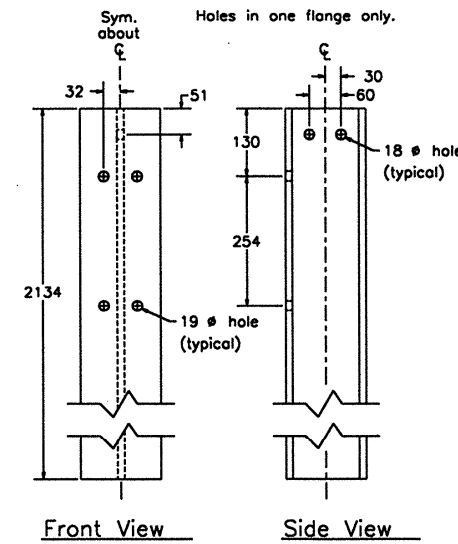
O W150 x 22 Spacer 1



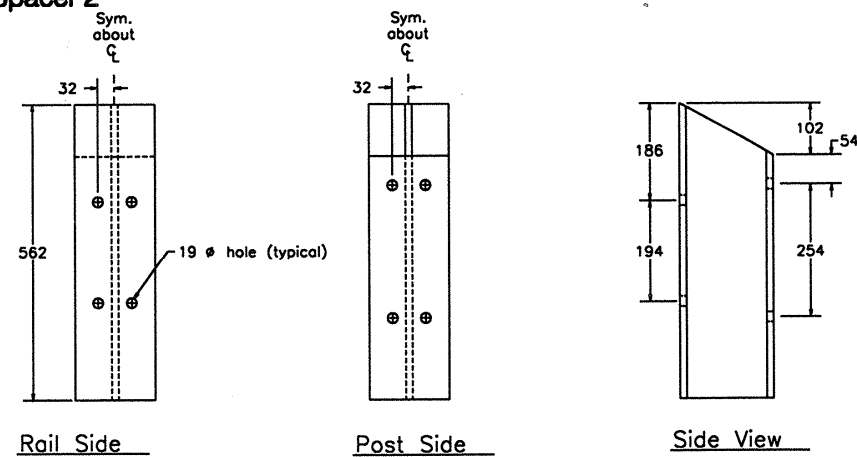
Q W150 x 22 Post 1



R W150 x 22 Post 2



P W150 x 22 Spacer 2



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



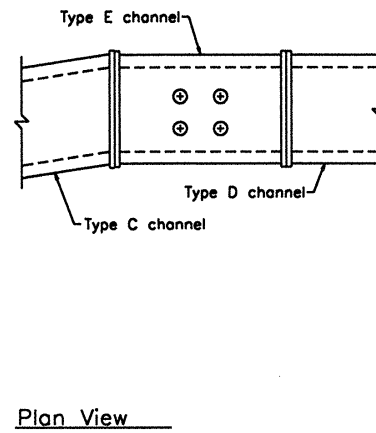
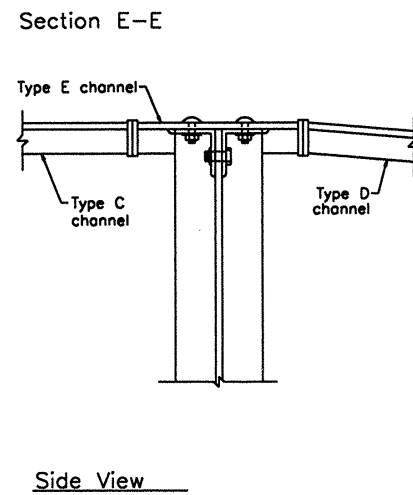
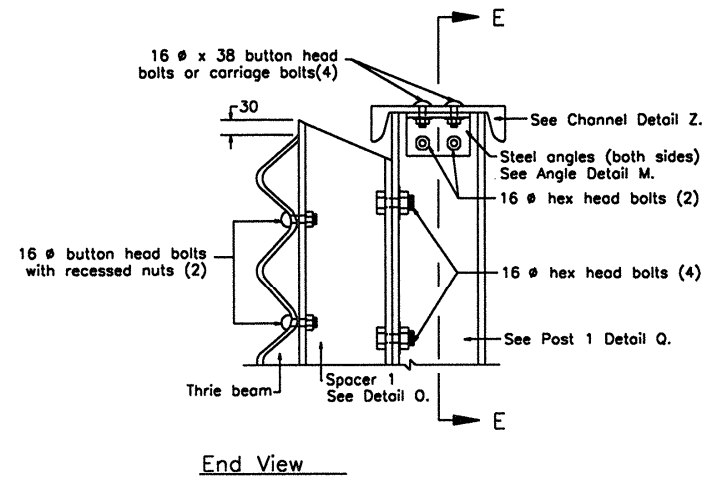
Crash-Tested Bridge Rails for Longitudinal Wood Decks

Steel Rail
AASHTO Performance Level 2

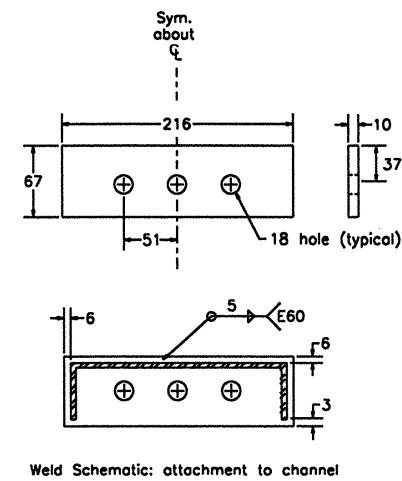
September 1995

Sheet 3 of 4

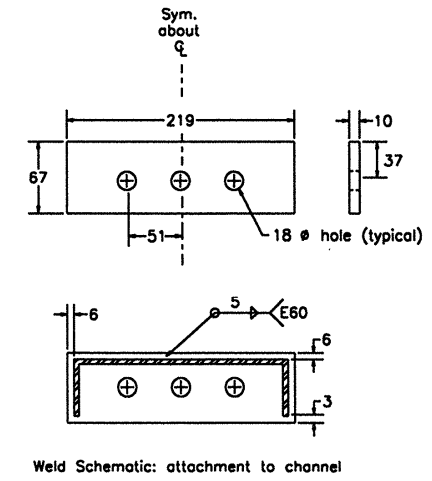
S Channel Connection at Post 1 All units are in millimeters based on a soft conversion from customary U.S. units.



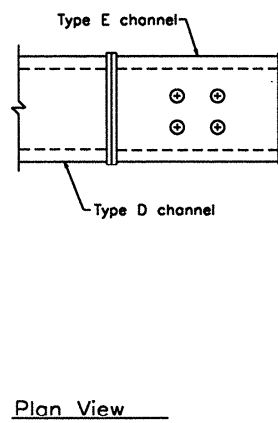
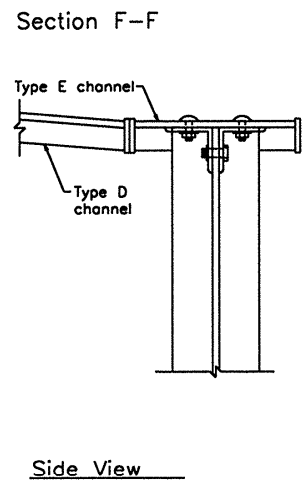
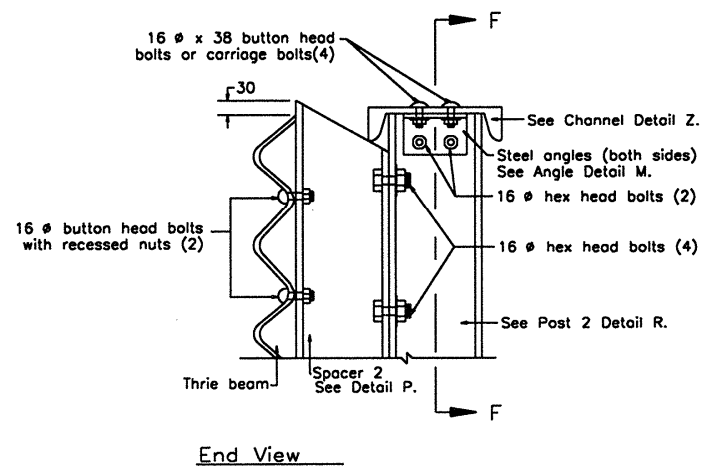
T 216 mm Steel End Plate



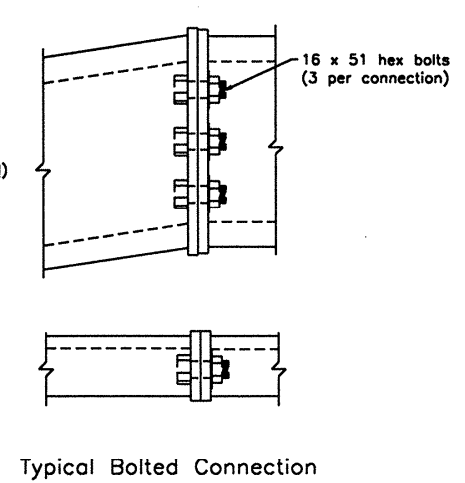
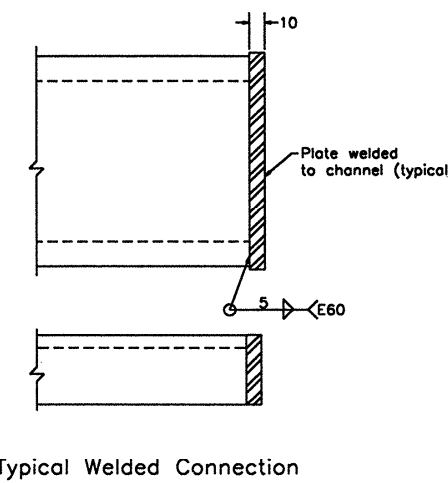
U 219 mm Steel End Plate



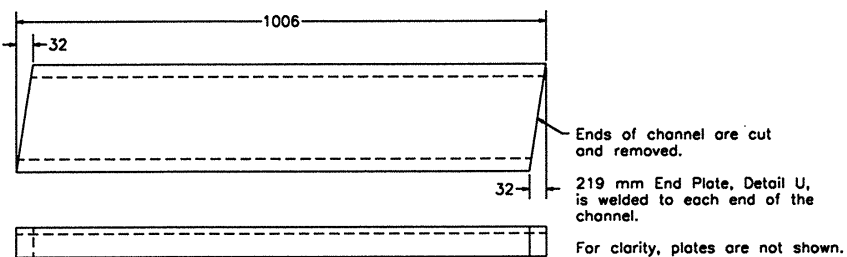
V Channel Connection at Post 2



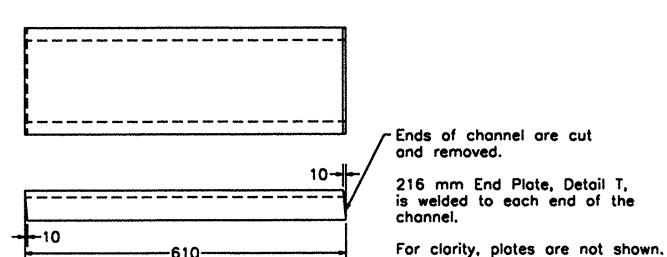
W Plate Connection Details



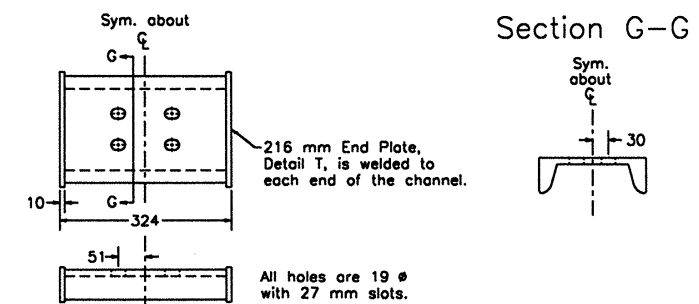
X Type C - C200 x 17 Steel Channel



Y Type D - C200 x 17 Steel Channel



Z Type E - C200 x 17 Steel Channel



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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



Crash-Tested Bridge Rails for Longitudinal Wood Decks

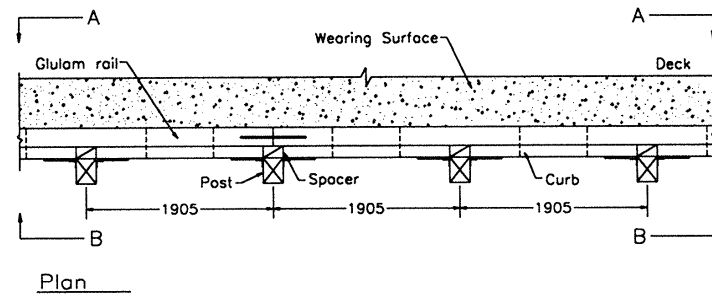
Steel Rail
AASHTO Performance Level 2

September 1995

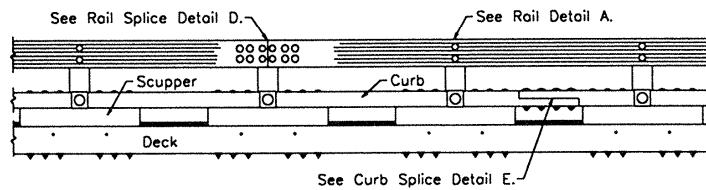
Sheet 4 of 4

General Configuration

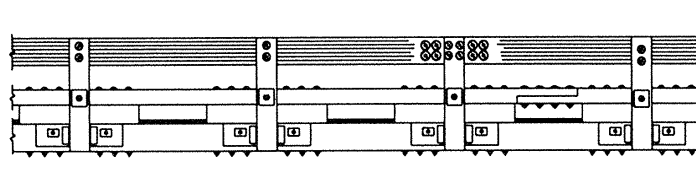
All units are in millimeters based on a soft conversion from customary U.S. units.



Section A-A



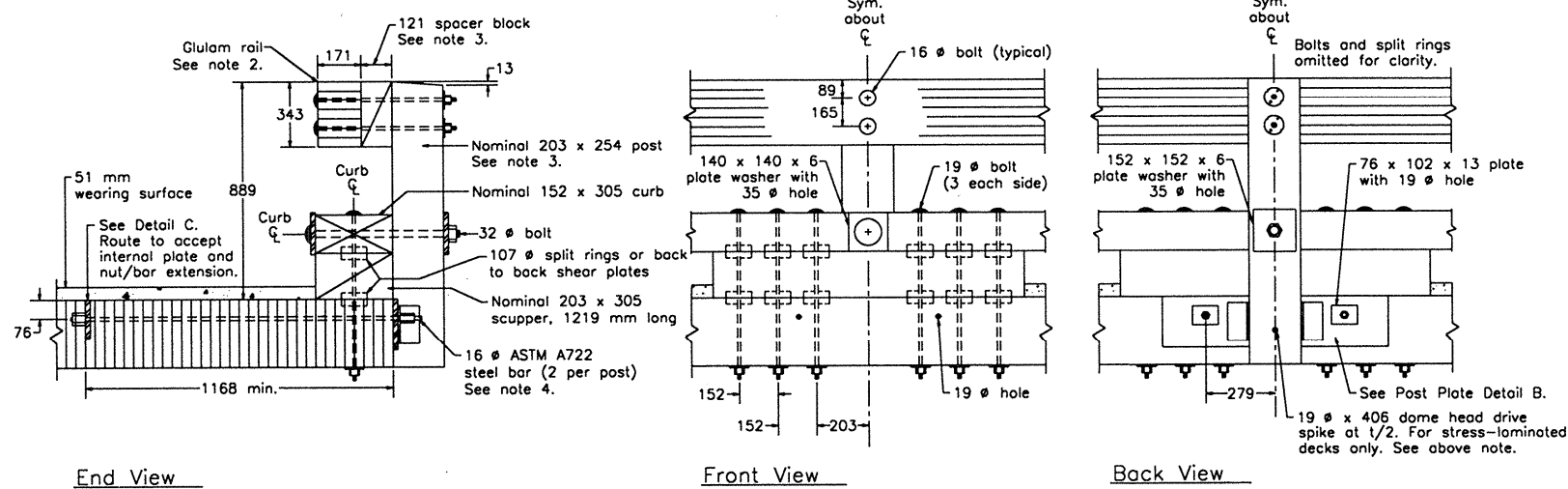
Section B-B



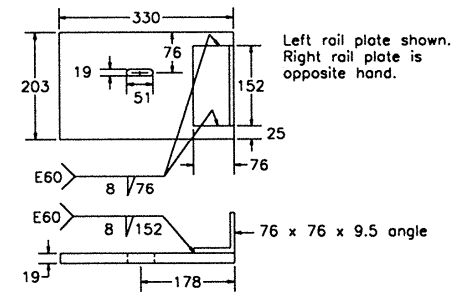
Refer to Sheet 2 for Approach Rail Transition.

A Railing Details

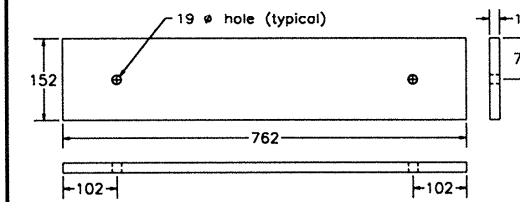
For stress-laminated decks, omit internal plate, post plates, and ASTM A722 steel bars.



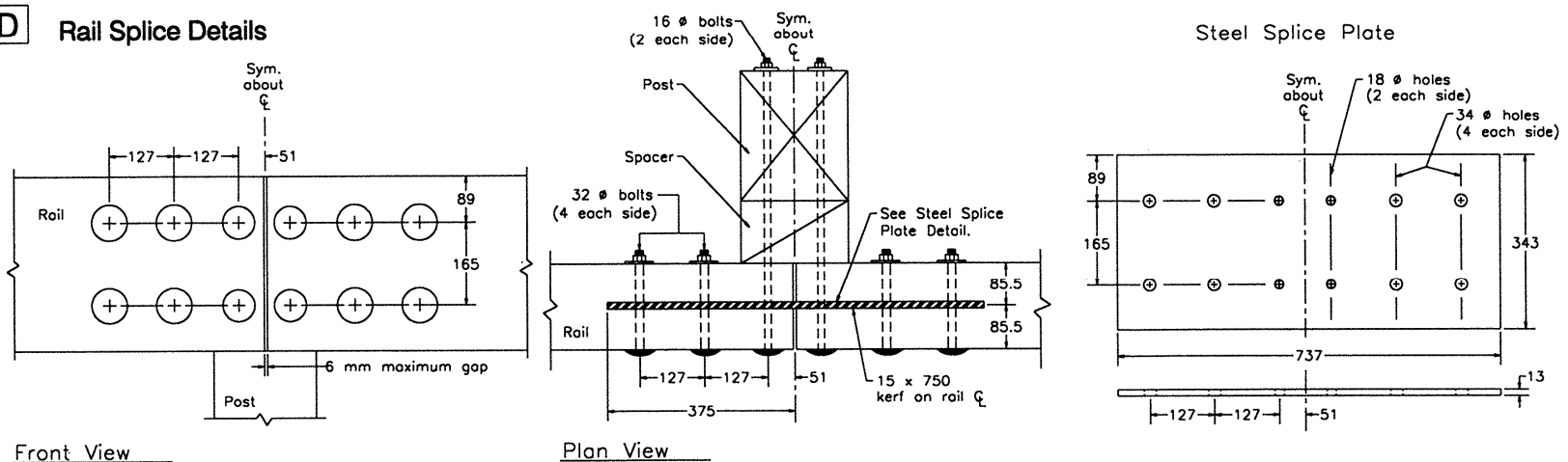
B Steel Post Plate



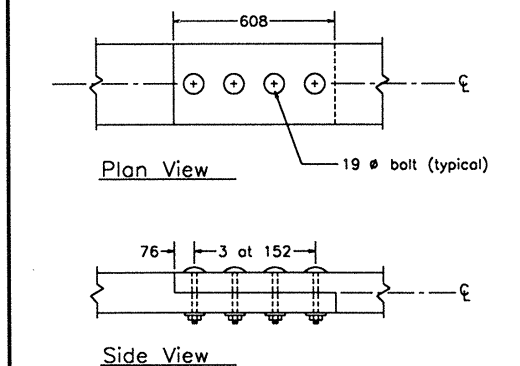
C Internal Steel Plate



D Rail Splice Details



E Curb Splice Detail



DESIGN

1. This bridge rail was successfully crash tested to the requirements for Test Level 4 (TL-4), as outlined in NCHRP Report 350. In addition, the rail meets crash test requirements for Performance Level 2 (PL-2), as outlined in the 1989 AASHTO Guide Specifications for Bridge Railings. It is adaptable to longitudinal stress-laminated, spike-laminated, nail-laminated and glued laminated timber decks which are 267 mm or greater in actual thickness.
2. Dimensions given for glued laminated timber rails are actual dimensions. The depth of the glulam timber rail may be increased to a maximum of 349 mm to allow for other standard glulam timber sizes. In such cases detail dimensions shall be verified and modified accordingly.
3. Dimensions for wood posts, curbs, and scuppers are given as nominal dimensions. Actual dimensions may be a maximum of 13 mm less than the stated nominal dimensions depending on material surfacing. Dimensions for spacer block depth are actual dimensions.
4. Steel deck reinforcing bars shall be 16 mm diameter ASTM A722 bars.
5. Curb and rail splices shall be located so that curb and rail members are continuous over not less than 2 posts. Curb splices shall be located a minimum of 1.5 post spacings away from rail splices. It is recommended that glulam rails be continuous over the bridge length.

MATERIALS

6. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168 and shall be pressure treated with wood preservative in accordance with AASHTO M133.
7. The bridge rail shall be horizontally laminated glued laminated timber; visually graded Western Species Combination No. 2 or visually graded Southern Pine Combination No. 48. Other species and grades of glued laminated timber may be used provided that the minimum tabulated values are not less than the following:
 $F_{b,95} = 12.4 \text{ MPa}$ $E = 12410 \text{ MPa}$
8. Posts, curbs, scuppers, and spacer blocks may be sawn lumber or glued laminated timber. When sawn lumber is used, material shall be visually graded No. 1 Southern Pine or visually graded No. 1 Douglas Fir-Larch. Glued laminated timber and other species and grades of sawn lumber may be used provided that the minimum tabulated values are not less than the following:
 $F_b = 9.3 \text{ MPa}$ $E = 10342 \text{ MPa}$
9. Steel plates and shapes shall comply with the requirements of ASTM A36.
10. Bolts shall comply with the requirements ASTM A307, Grade 2 and should preferably be dome head timber bolts. Bolts on traffic face of rail shall be dome head.
11. Split rings shall be manufactured from SAE 1010 hot rolled carbon steel. Shear plates shall be malleable iron manufactured according to ASTM A47, Grade 32510.
12. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or shall otherwise be provided with adequate corrosion protection. Galvanizing of high-strength steel bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the steel. Galvanize steel components after welding.

FABRICATION AND CONSTRUCTION

13. 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 field treated with wood preservative in accordance with AASHTO M133.
14. Unless noted, malleable iron washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of dome-head timber bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.
15. The tops of rail posts and the top of the rail splice plate kerf 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, the USDA Forest Service, Forest Products Laboratory and the Federal Highway Administration.



Crash Tested Bridge Rails for Longitudinal Wood Decks

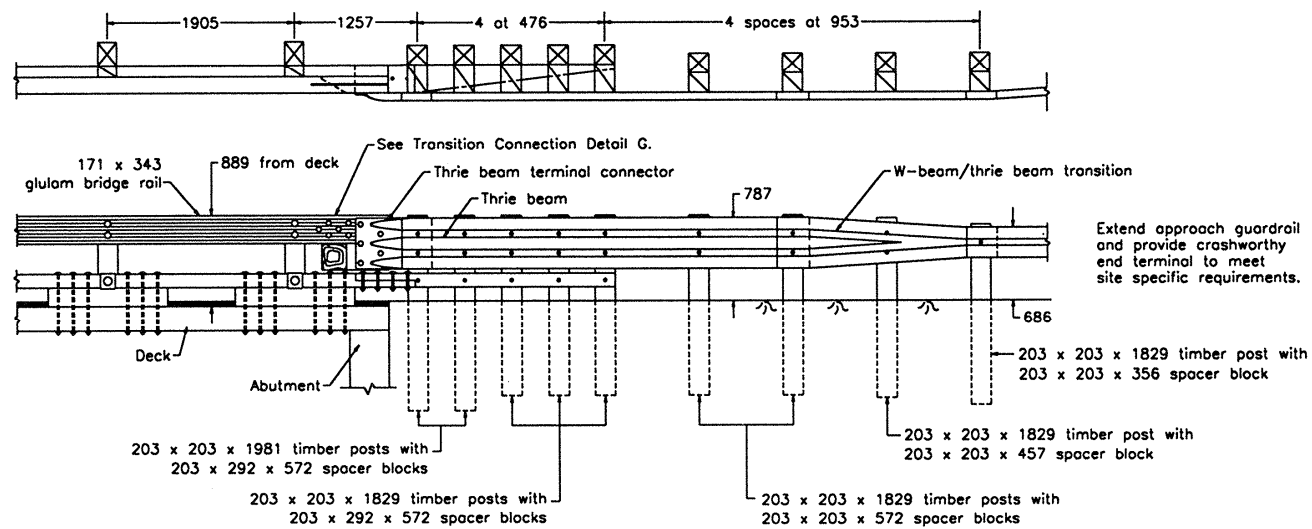
Glulam Timber Rail with Curb
NCHRP 350 Test Level 4

September 1995

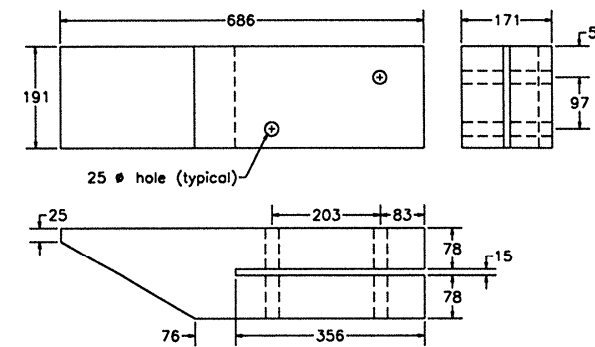
Sheet 1 of 2

Approach Rail Transition General Configuration

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



F Curb Transition Block

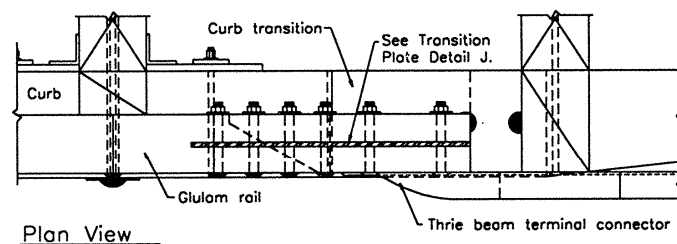


Depth of transition block is based on rail depth of 267 mm and dressed curb and scupper (140 and 191 mm in height, respectively). If dimensions of any components increase, depth of transition block must be verified and reduced as necessary.

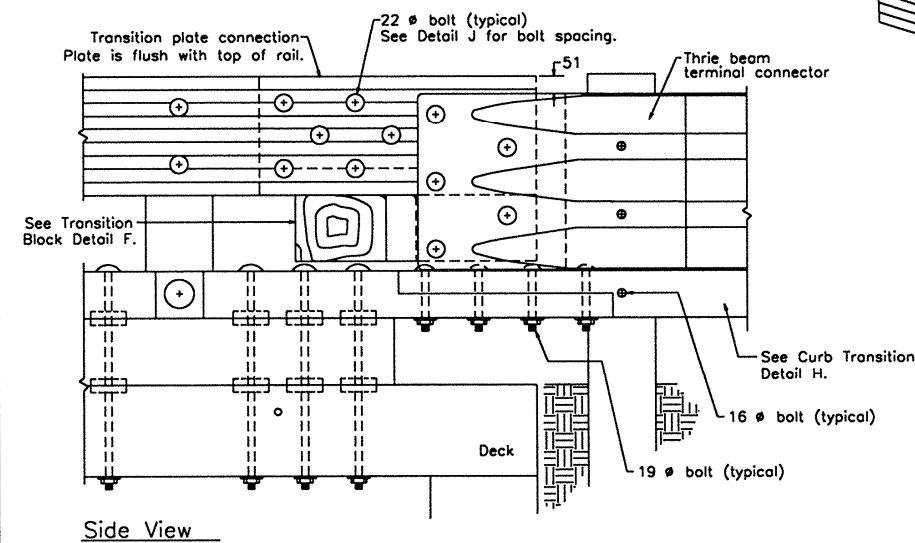
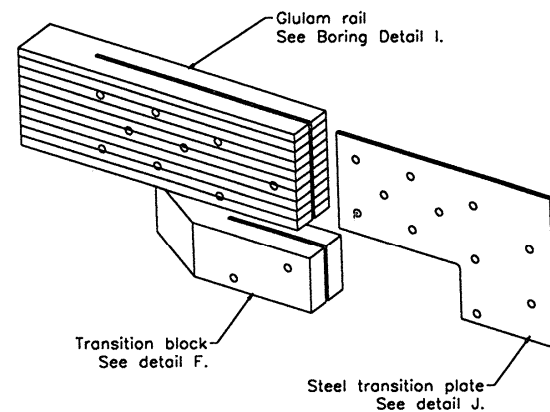
In addition to the notes on Sheet 1, the following apply to the approach rail transition:

1. The approach rail transition was successfully crash tested to the requirements for Service Level 2 (SL-2), as outlined in NCHRP Report 230.
2. Thrie beam and thrie beam terminal connector shall be 10 gage. W-beam/thrie beam transition and w-beam shall be 12 gage. All shall comply with the requirements of AASHTO M180.
3. W-beam and thrie beam rail splice bolts and post bolts shall comply with AASHTO M180.

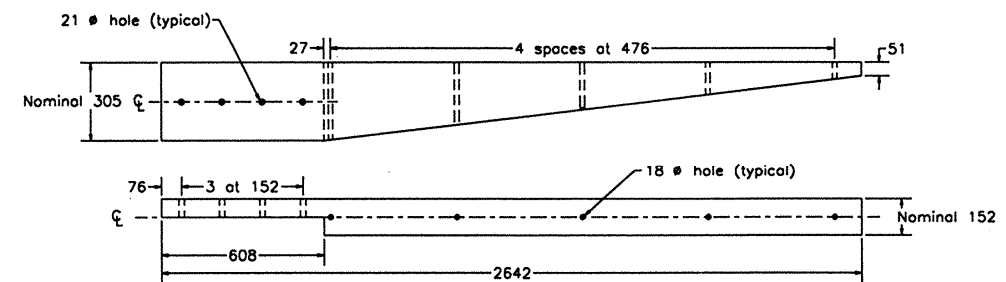
G Transition Connection Details



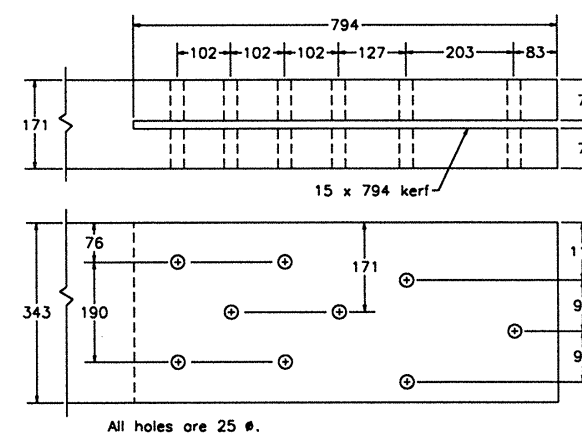
3 Dimensional Explosion of Transition Connection



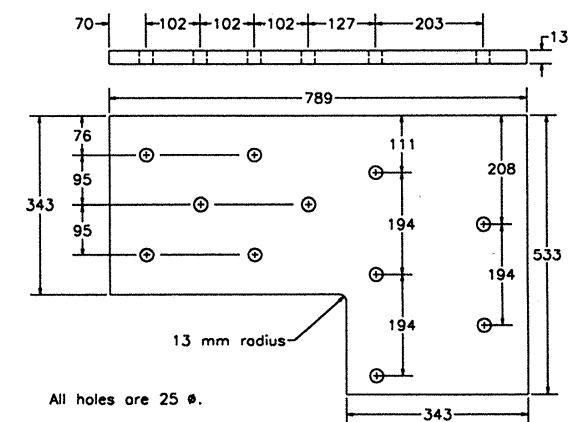
H Curb Transition



I Transition Glulam Rail Boring Detail



J Transition Plate



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Crash-Tested Bridge Rails for Longitudinal Wood Decks

Glulam Timber Rail with Curb
NCHRP 350 Test Level 4

September 1995

Sheet 2 of 2

Ritter, Michael A.; Fuller, Ronald K.; Lee, Paula D. Hilbrick; Rosson, Barry T.; Duwadi, Sheila Rimal. 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. 27 p.