Guide for Bridge Curb/Rail and Approach Treatment for Extremely Low Volume Roads

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U.S. Department of Transportation
Federal Highway Administration

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ACRONYMS

ADT	average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
BDS	Bridge Design Specification
FEA	finite element analysis
FHWA	Federal Highway Administration
LRFD	Load and Resistance Factor Design
MASH	Manual for Assessing Safety Hardware
mph	miles per hour
MUTCD	Manual on Uniform Traffic Control Devices
NBI	National Bridge Inventory
NCHRP	National Cooperative Highway Research Program
PL	performance level
RDG	Roadside Design Guide
TL	test level
vpd	vehicles per day

1 INTRODUCTION AND APPLICABILITY

This Guide addresses bridge rails, approach guardrails, and transitions on bridges on extremely low-volume and low-speed roads. The methodology is applicable to both single- and two-lane bridges. For the purpose of this Guide, extremely low-volume roads are defined as roads with less than 50 vehicles per day (vpd) and posted speed ranges equal to 5-15 miles per hour (mph), 16-30 mph, and 31-45 mph. Throughout this Guide the posted and travel speeds on the subject bridges are assumed to be equal, and the terms are used interchangeably. The focus of this Guide is assessing the need for and practicality of providing bridge rails to contain passenger vehicles while accommodating other vehicle types like agricultural equipment, timber harvesting equipment, recreational vehicles, and other associated service vehicles on the subject bridges.

This Guide leads inspectors and engineers to practical, low-cost solutions based on the characteristics of the bridge, anticipated traffic, and the intended use of the bridge. The outcome of using the Guide is the determination of:

- Whether the existing bridge rails can be left as-is.
- Whether the associated roadside hardware can be left as-is.
- When improvements should be considered to achieve the safety performance goal.
- What potential solutions might be implemented to achieve the safety performance goal.

When new hardware is recommended, the Guide provides construction details for new hardware in appendix A, B, and C. An inspection checklist is provided in appendix D that can be used to collect the information during the inspection. Evaluating the need to provide roadside barriers, such as w-beam for shielding obstacles on the roadside, beyond the approaches to the bridge, is beyond the scope of this Guide.

The Guide follows a two-step process:

1. Inspect and evaluate the existing conditions at the bridge site.
2. Consider possible improvements to the bridge rails and approach hardware.

2 EVALUATION PROCESS

The first step is to inspect and evaluate the existing bridge rail and any associated hardware. The variables and terminology used through this Guide are defined in Section 2.1. The evaluation process is guided by the two-part decision matrix discussed in Section 2.2.

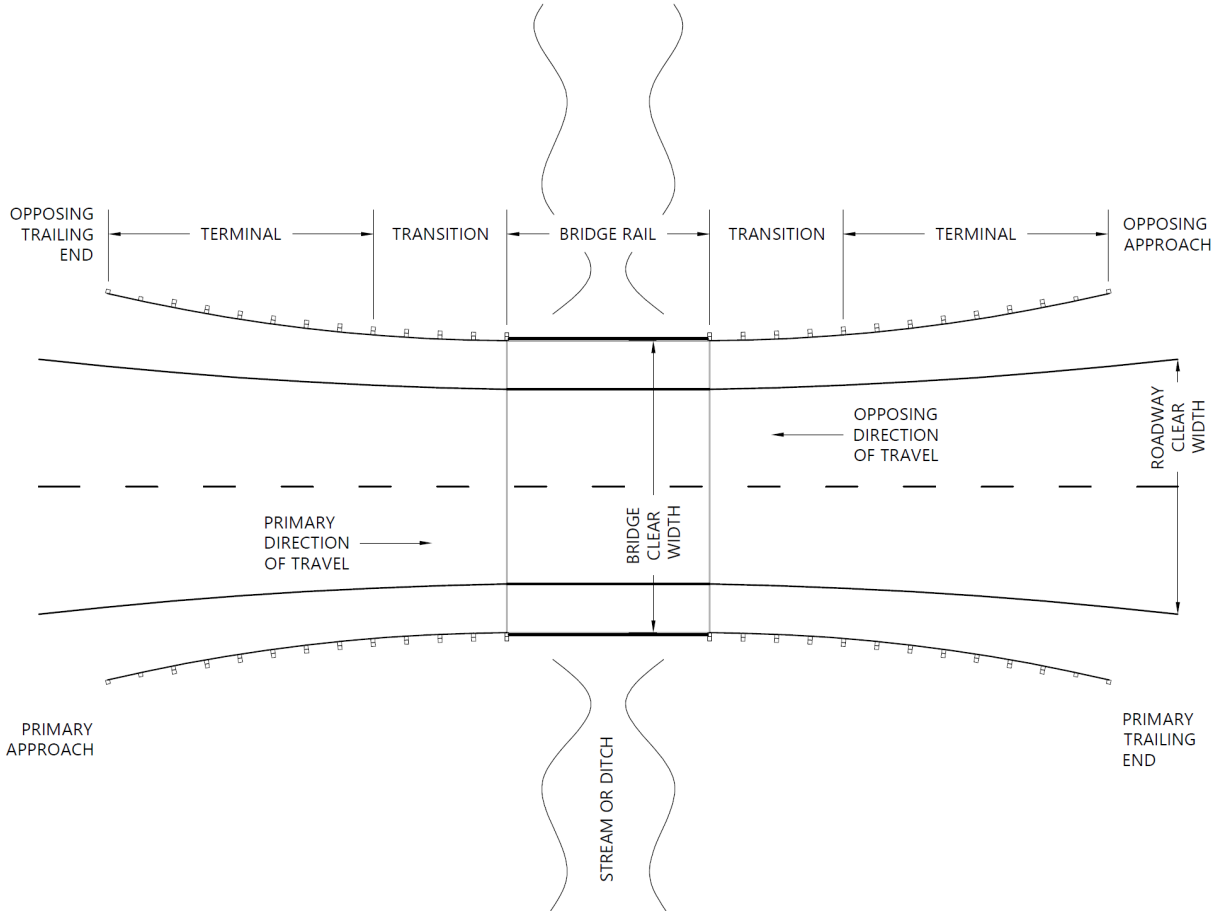
2.1 KEY TERMS

Key terms used throughout this Guide are defined as follows:

- **BDS:** AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specification (BDS).
- **Bridge clear width:** The shortest clear distance on a bridge between the faces of opposite bridge rails or curbs measured in feet. See figure 1.
- **Bridge diaphragm:** Bridge diaphragms are transverse stiffeners positioned between the bridge girders to restrict lateral movement of the girders under load. See figure 2.
- **Bridge rail:** A longitudinal barrier whose primary function is to reduce the risk of an errant vehicle going over the side of the bridge structure. See figure 1.
- **Bridge rail system:** The bridge rail and its structural mount connection to the bridge structure.
- **Crashworthy:** The crash performance has been successfully evaluated in full-scale crash tests (e.g., Manual for Assessing Safety Hardware [MASH], Report 350, etc.), through engineering calculations (e.g., AASHTO LRFD Bridge Design Specifications Chapter 13) and/or finite element analysis (FEA).
- **Continuous bridge rail elements:** Bridge rail elements are all spliced together or there is one continuous concrete bridge rail.
- **Deck overhang:** Distance from the edge of deck to the mount location on the bridge fascia beam measured in feet. See figure 2.
- **Delineation:** Retroreflective signs and object markers in conformance with the Federal Highway Administration's (FHWA's) Manual on Uniform Traffic Control Devices (MUTCD).
- **Drop height**: Drop height is the maximum height measured from anywhere along the bridge travel surface to the surface (i.e., water or ground) under the bridge. See figure 2.
- **Fascia Beam:** An exposed outermost girder/beam/stringer of a bridge span. See figure 2.
- **KA:** Fatal and serious injury passenger vehicle crashes based on the KABCO injury scale.
- **Narrow Bridge**: A bridge having a two-way roadway clearance width of 16 to 18 ft, or a bridge having a roadway clearance less than the width of the approach travel lanes, or as defined by the current edition of the MUTCD.
- **Number of Posts:** For post and beam type bridge rails, the number of posts on one travel edge of the bridge.

- **One-lane bridge:** A structure designed for travel in one direction at a given time. A one-lane bridge can be on a one-way or a two-way road.
- **Overriding:** Overriding is when a vehicle impacts a longitudinal barrier in such a way that it goes over the barrier. Overriding is similar to vaulting and is sometimes used synonymously but a vehicle overriding a barrier may or may not completely go over the barrier. See figure 3.
- **Parapet height:** The distance from the bridge deck to the top of the parapet. See figure 4.
- **Performance goal:** A reduction in the risk of a fatal or serious injury passenger vehicle crash to justify implementing a proposed improvement.
- **PL:** The performance level (PL) used to classify bridge rail crashworthiness prior to the introduction of the test level (TL).
- **Pocketing:** Pocketing is an undesirable behavior of a redirective device like a bridge rail, transition, or terminal involving a relatively large lateral displacement within a relatively short longitudinal distance. Such behaviors tend to generate large longitudinal decelerations as the front of the vehicle contacts a portion of the downstream barrier deformed at a sharp angle relative to the vehicle path. See figure 5.
- **Post setback:** For post and beam type bridge rails, the post setback is the distance from the traffic face of the bridge rail to the traffic face of the post as shown in BDS Figure A13.1.1-1. See figure 2.
- **Post spacing:** The horizontal center-to-center distance of posts.
- **Rail height:** The distance from the bridge deck surface to the top of the topmost rail of the bridge rail. See figure 2.
- **Rail lapping:** Guardrail and bridge rail elements are usually lapped in the adjacent direction of travel. This means when splicing two panels together, the approach panel is placed over the trailing panel such that there are no exposed edges. On a one-way bridge, the rail is lapped in the travel direction nearest that edge. See figure 7.
- **Rail spacing:** The vertical center-to-center distance of horizontal rail elements if there is more than one horizontal rail element on a side. See figure 6.
- **Roadway clear width:** The shortest perpendicular distance between the edges of travel on the approach roadway measured in feet. See figure 1.
- **Snagging:** Snagging is contact between a portion of the vehicle and barrier like the vehicle tire engaging the side of a bridge rail post. The degree of snagging depends on the degree of engagement. Such vehicle-to-barrier engagement can cause large vehicle decelerations. See figure 8.
- **Terminal:** A terminal is a crashworthy anchorage for the transition and/or rail that also shields an errant vehicle from the bridge end or rail end. See figure 1.

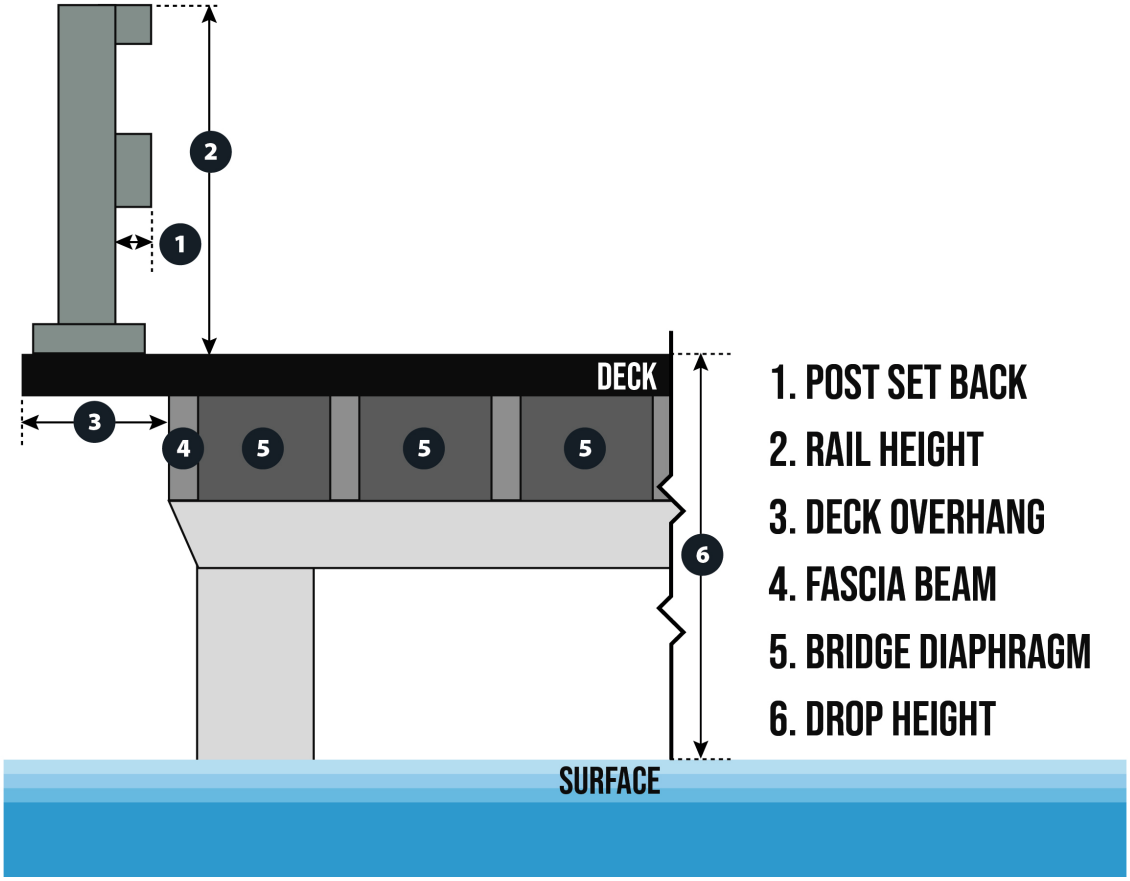
- **TL:** The test level (TL) of a bridge rail, transition, or terminal refers to the set of conditions used to conduct crash tests including the vehicle type and mass, vehicle impact speed and angle. There are six TLs, however this Guide only addresses TL 1 through 3.
- **Transition:** A section of longitudinal barrier between a terminal or standard rail section and a bridge rail. The transition produces a gradual stiffening of the approach rail so that vehicle pocketing, snagging, or penetrating at the connection is minimized. See figure 1.
- **Two-lane bridge:** A structure designed for travel in two directions at the same time. Typically, a bridge that has a clear roadway width greater than 16 ft is considered a two-lane bridge.
- **Vaulting:** Vaulting is when a vehicle engages with a longitudinal barrier in such a way that it is lifted up and over the barrier. The vehicle typically goes completely over the barrier. See figure 3.



Note: This figure shows two travel lanes, however, this Guide is applicable to both one-lane and two-lane bridges.

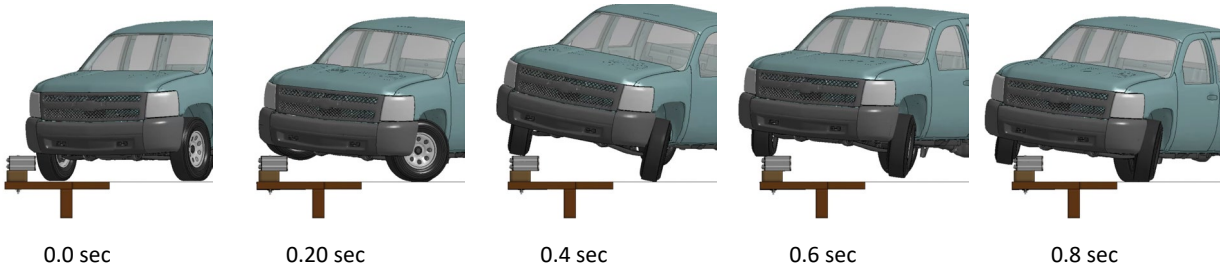
Source: FHWA

Figure 1. Graphic. Plan view of typical bridge and approaches.



Source: FHWA

Figure 2. Graphic. View of major components of a typical bridge.

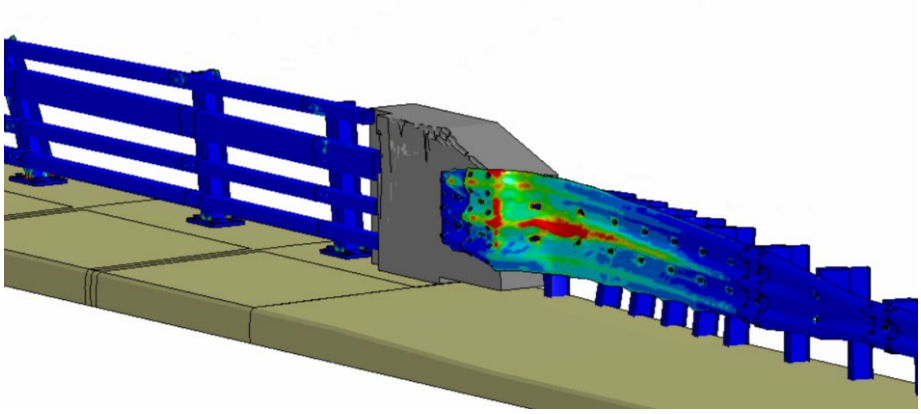


Source: FHWA

Figure 3. Graphic. Low rail height that might promote vaulting or override.

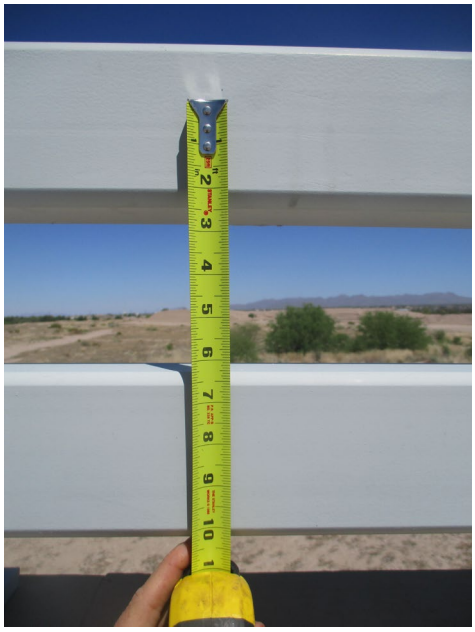
Source: FHWA

Figure 4. Photograph. Demonstration of measuring Parapet height.



Source: FHWA

Figure 5. Graphic. Demonstration of rail pocketing.

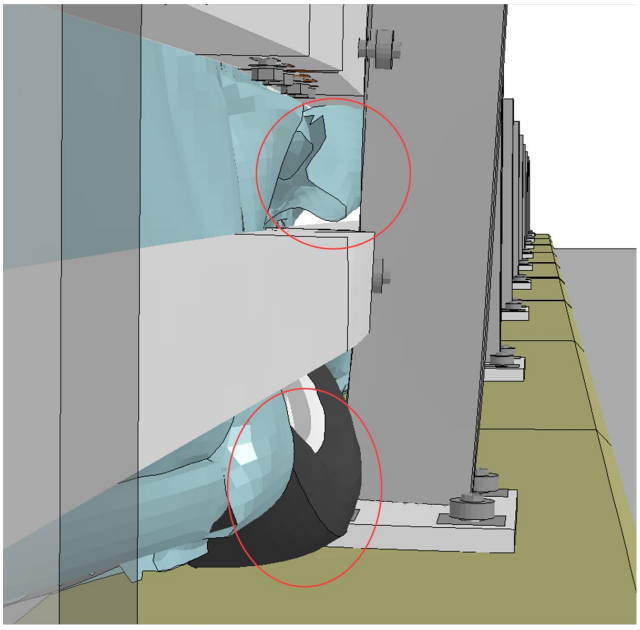


Source: FHWA

Figure 6. Photograph. Demonstration of measuring the rail spacing.

Source: FHWA

Figure 7. Photograph. Rail lapping, looking downstream in the direction of travel.



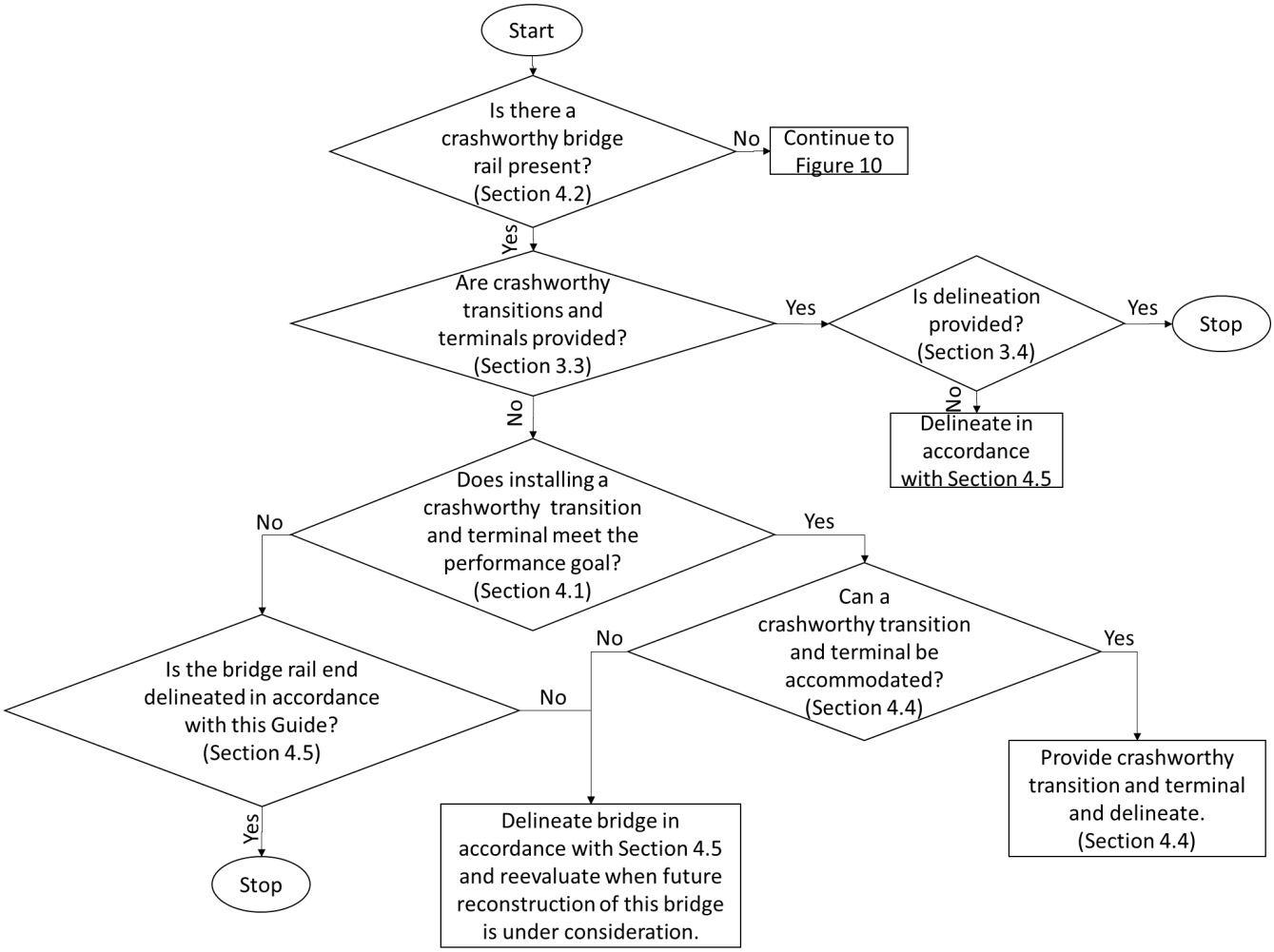
Source: FHWA

Figure 8. Graphic. Components of the bridge rail that might allow snagging.

2.2 DECISION MATRICES

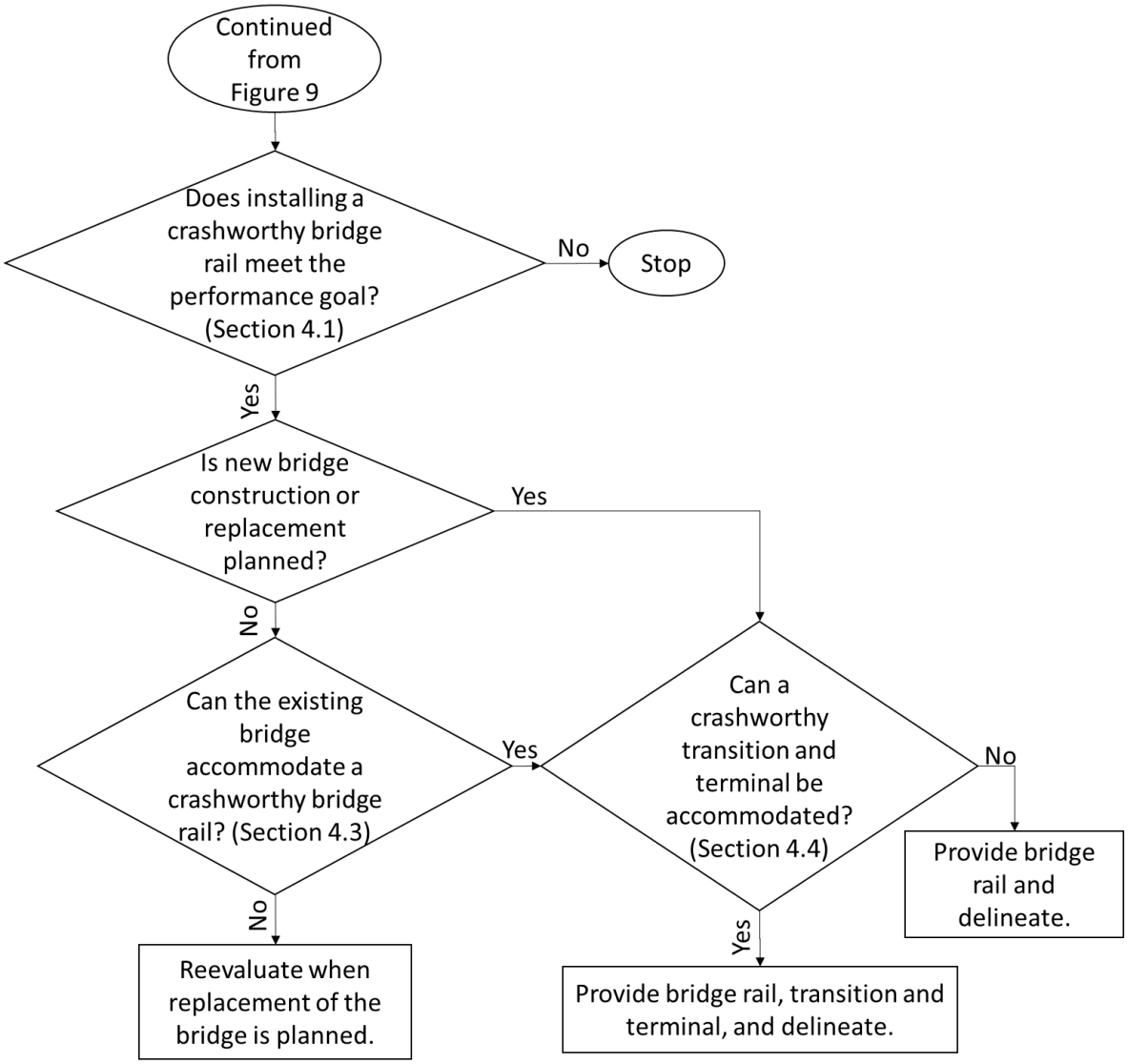
Figure 9 and figure 10 provide a workflow to determine practical solutions for reducing the risk of fatal and serious passenger vehicle collisions. Figure 9 and figure 10 also reference the appropriate sections in this Guide. After initiating the workflow, the first step is to determine if there is a crashworthy bridge rail present. If a crashworthy bridge rail is present, the next step is to determine if crashworthy transitions and terminals are provided. If it is determined that one or more of these items is not present, then the workflow outlines the next steps.

When a crashworthy bridge rail, transition, or terminal are not present, figure 10 outlines the steps to determine if the installation of any of these items would reduce the risk of fatal and serious passenger vehicle crashes. When it is determined that providing a crashworthy bridge rail, transition, and/or terminal would reduce the risk of serious or fatal crashes, then an assessment is made to determine if it is practical to provide these items.



Source: FHWA

Figure 9. Graphic. Step 1 of workflow to determine practical solutions for reducing the risk of fatal and serious passenger vehicle collisions.



Source: FHWA

Figure 10. Graphic. Step 2 of workflow to determine practical solutions for reducing the risk of fatal and serious passenger vehicle collisions.

3 INSPECTING AND ASSESSING THE EXISTING CONDITIONS

3.1 CHARACTERIZE THE BRIDGE RAIL

The first step is to determine if there is a crashworthy bridge rail present. If there is no bridge rail present at the existing subject site, go to Section 4.1. When a bridge rail is present, determine the answers to the following:

1. What is the bridge rail height?
2. Are there parts or components of the bridge rail that might allow snagging on a part of the impacting vehicle? If so, what are they?
3. Are there continuous bridge rail elements from the start to the end of the structure on both sides?
4. If the bridge rail is a post and rail system, does the rail terminate at a post, abutment, or anchor block?
5. What is the drop height?
6. What is the posted speed limit? If the speed is not posted, what is the estimated travel speed?
7. The conditions under the bridge are one of the following:
   A = An ephemeral or intermittent stream channel with water depth less than 6 inches during the majority of the time the bridge is in use.
   B = A stream channel with year-round flow or ephemeral/intermittent stream channels with water depths greater than or equal to 6 inches for at least 3 months.

Photographs illustrating the answers to each of these questions should be taken to document the existing bridge rail and associated hardware. A checklist is provided in appendix D that can be used to collect the information from the inspection.

3.2 CHARACTERIZE THE BRIDGE DECK

Document and assess the deck material, condition, and thickness by answering the following questions:

- What is the deck material (e.g., sawn lumber, laminated wood, reinforced concrete, steel, etc.)?
- What is the deck thickness?
- What is the deck overhang?
- What is the condition of the deck (i.e., level of deterioration or other damage)? For example, if the deck is concrete, is there spalling or exposed rebar? For steel decks, is there significant rust and corrosion? For wood decks, is there visible rot or splitting?
- What is the fascia beam material (e.g., sawn lumber, laminated wood, reinforced concrete, steel, etc.)?
- What is the fascia beam size and shape (e.g., W14x30, 6x18, 6 ¾ x 18 glulam)?
- What is the condition of the fascia beam (level of deterioration or other damage)? For a concrete beam, is there spalling or exposed rebar? For a steel fascia beam, is there significant rust and corrosion? For wood beams, is there visible rot or splitting?
- What is the size and type of bridge diaphragm members?

- What is the size and type of the connector elements, when applicable, that connect the diaphragm members to the inside of the fascia beams?

Appendix D includes a checklist that can be used to collect information from the inspection.

3.3 ARE CRASHWORTHY TRANSITIONS AND TERMINALS PROVIDED?

When transitions and/or terminals are present, determine if the terminal and/or transition is crashworthy, and its TL based on the following:

1. Documentation (e.g., the original plans and specifications, National Bridge Inventory [NBI] data, maintenance records) indicates a crashworthy terminal and/or transition was used.
2. The terminals and/or transitions at the existing site appear to be the same as one of the examples shown in appendix B (terminals) or C (transitions). Also determine the TL that was used to evaluate the crashworthiness of the transition and/or terminal if documentation is available.

The inspection will answer the following questions:

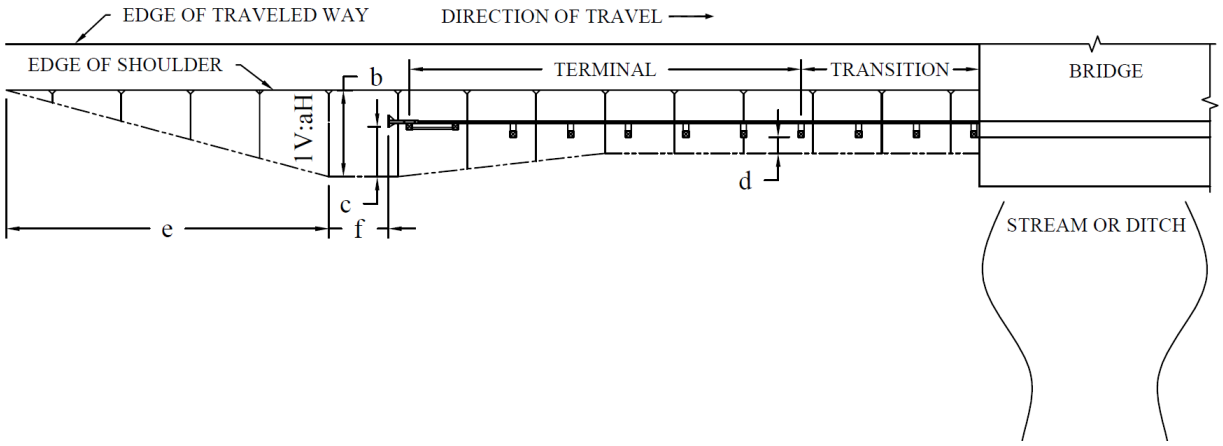
1) Is a crashworthy terminal present?

   If yes, please answer the following questions about the transitions:

   (a) Is there a transition between the bridge rail and the terminal?
   (b) Does the height of the transition at the connection point to the terminal match the height of the terminal?
   (c) Does the height of the transition at the connection point to the bridge rail/parapet match the height of the bridge rail/parapet?
   (d) Is there a smooth transition in rail height from end-to-end of the transition?
   (e) Does the rail provide a smooth, continuous face to prevent snag points?
   (f) When there are bridge rail posts, are the posts set back from the rail face to minimize contact with a vehicle striking the bridge rail?
   (g) Transitions should be structurally attached to the bridge rail and spliced to the terminal. Are there secure connections to both the terminal and the bridge rail?
   (h) Is there at least two feet of level fill behind the posts of the transition and the terminal?

2) If a terminal is present, take the following measurements (see figure 11):
   (a) Horizontal distance in feet on the approach slope perpendicular to the traveled way corresponding to a 1-ft vertical drop.
   (b) Distance from the edge of the shoulder to the change in slope, in feet. Indicate if the slope does not change.
   (c) Distance from the back of the first post of the terminal to the change in slope in feet.

(d) Distance in feet from the back of the last guardrail terminal post to the change in slope. Indicate if the slope does not change.
(e) Length in feet of the approach slope taper. Indicate if there is no taper.
(f) Distance in feet from the approach face of the terminal to the end of the approach slope taper. Indicate if there is no taper.



Note: There will often be situations encountered where the shoulder width is zero.

Source: FHWA

Figure 11. Graphic. Guardrail terminal layout (plan view).

Appendix D includes a checklist that can be used to collect information from the inspection.

3.4 Is Delineation Provided?

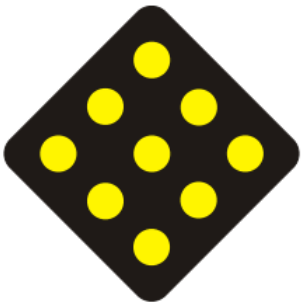
Answer the following questions during inspection:

1) Are Type 3 object markers present at the ends of the bridge (see figure 12)?
2) If there are terminals, are Type 3 object markers present at the ends of the terminals (see figure 12)?
3) If there are terminals, are OM1-2 object markers present at the ends of the terminals (see figure 12)?
4) What is the bridge clear width?
5) What is the roadway clear width?
6) Is the approach roadway two-way?
7) Is a narrow bridge sign (W5-2) provided (see figure 12)?
8) Is a one lane bridge sign (W5-3) provided (see figure 12)?

Appendix D includes a checklist that can be used to collect information from the inspection.

Source: FHWA

A. Subfigure Type 3 marker.



Source: FHWA

B. Subfigure OM1-2 marker.

Source: FHWA

C. Subfigure one-lane bridge sign (W5-3) on a bridge.

Source: FHWA

D. Subfigure narrow bridge sign (W5-2) on a bridge.

Figure 12. Graphics. Compound subfigures illustrating object marker delineation to address inspection questions.

4 CONSIDERING IMPROVEMENTS

4.1 DOES INSTALLING A CRASHWORTHY BRIDGE RAIL MEET THE PERFORMANCE GOAL?

The second step in the process is to consider potential safety improvements to the bridge rail or associated hardware. Use this section to determine whether a crashworthy bridge rail is appropriate at the site.

If a bridge rail is found to be appropriate and there is an existing rail present, determine if the existing rail is crashworthy based on Section 4.2. If there is no existing crashworthy rail present and, through this section of the Guide, it is determined a bridge rail is appropriate, proceed to Section 4.3.

Given the posted speed limit, under-bridge condition (e.g., A or B), and drop height, determine what TL is appropriate from table 1. The conditions in table 1 should result in a reduction in the risk of a passenger vehicle KA crash compared to not having a bridge rail at all. Notice that bridges 20 ft or less above an ephemeral or intermittent stream (i.e., Condition A) on a road with a posted speed limit of 15 mph or less do not meet the goal, therefore, a bridge rail is not necessary.

Table 1. TL selection for bridge rails on roads with ADT ≤ 50 vpd and posted speed ≤ 45 mph.

Posted Speed Limit (mph)	**Dry Environment Under Bridge** (Condition A)			**Water Under Bridge** (Condition B)		
	Drop Height - H (ft)					
	H ≤ 20	**20 < H ≤ 50**	**H > 50**	**H ≤ 20**	**20 < H ≤ 50**	**H > 50**
5 - 15	NRB	12-in curb rail or TL-1				
16 - 30	TL-1 or higher bridge rail					
31 - 45	TL-2 or higher bridge rail					

Note: Surface condition under bridge:
A = An ephemeral or intermittent stream channel with water depth less than six inches during the majority of the time the bridge is in use.
B = Any stream channel with year-round flow or ephemeral or intermittent stream channels with water depths greater than or equal to six inches for at least three months.
NRB =Not risk beneficial.

Where it is determined appropriate to install a bridge rail, proceed to Section 4.3.

Refer to appendix A for a variety of crashworthy curb rails, TL1, and TL2 bridge rails. Over time, it is expected that additional bridge rails will be developed that will meet the MASH TL1 and TL2 requirements. These may be used as they become available.

4.2 IS THERE A CRASHWORTHY BRIDGE RAIL PRESENT?

If a bridge rail is present at the existing site, determine if the bridge rail crash performance has been verified based on one of the following:

- The original construction plans or specifications, NBI data, or maintenance and repair records are available and indicate the bridge rail was evaluated by full-scale crash testing.
- Documentation is available showing that the bridge rail is crashworthy based on engineering calculations (e.g., AASHTO LRFD, BDS, and/or FEA).
- When documentation of the bridge rail is not available, compare the inspection photographs of the bridge rail with the systems tabulated in appendix A. If the bridge rail matches one of the bridge rails in appendix A it can be assumed to be crashworthy.

From the same sources, also determine the TL that was used to evaluate the crashworthiness of the bridge rail (e.g., NCHRP Report 350 or MASH TL1, TL2, etc.). If the crashworthiness of the bridge rail could not be determined using one of the three methods listed above, then an engineering analysis may be performed using the procedures outlined in Section 13 of the BDS.[3] The evaluation procedures include assessment criteria for verification as follows:

1. The bridge rail height meets the BDS specifications (i.e., Table A13.2.-1 or BDS 13.7.3.2).
2. The bridge rail geometry and anchorage meet the criteria specified in BDS A13.1.
3. The design capacity meets or exceeds the values in BDS Table A13.2-1 for the appropriate TL (i.e., TL1 or TL2).
    - For concrete rails see BDS Section A13.3.1.
    - For steel post-and-beam rails see BDS Section A13.3.2.
    - For concrete parapet and metal rail see BDS Section A13.3.3.
    - For wood barriers see BDS Section A13.3.4.

A minimum rail height of 27 inches is specified for TL1 bridge rails in BDS Table A13.2-1; however, it does not take into consideration the lower-profile rails that have been shown to meet NCHRP Report 350 TL1 or MASH TL1 (see appendix A) performance criteria. Thus, if a TL1 bridge rail design is less than 27 inches tall and has not been tested for TL1, then it is recommended that the crash performance be evaluated through full-scale crash testing or FEA.

Assess the potential for vehicle snagging on the bridge rail posts based on post set-back from the face of rail, open space between rails, and contact area on face of barrier (post-and-beam designs only). The vertical clearance and post setback should plot in the preferred area of BDS Figure A13.1.1-2. The ratio of rail width to rail height and setback should also plot in the preferred area of BDS Figure A13.1.1-3.

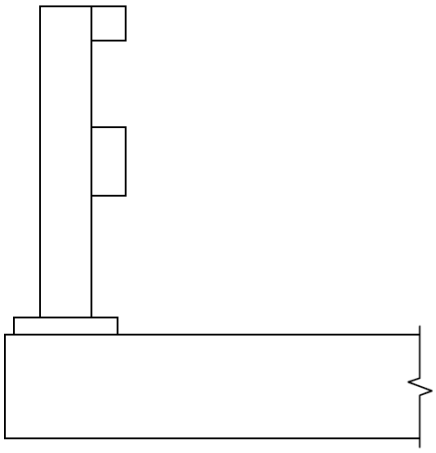
If the existing bridge rail is determined to be crashworthy according to any of the methods discussed in this section, stop, and proceed to Section 4.4. If the bridge rail is not crashworthy and a bridge rail was found to be appropriate for this location through Section 4.1, then proceed to Section 4.3.

4.3 CAN THE EXISTING BRIDGE DECK ACCOMMODATE A CRASHWORTHY BRIDGE RAIL?

If new bridge construction or replacement is not planned, then the existing bridge conditions must be assessed to determine if the bridge structure can support the design loads for a crashworthy bridge rail when such a rail would meet the performance goal. The effectiveness of a bridge rail is dependent upon the structural integrity of the bridge structure to which it is attached. In other words, the mounting point on the bridge structure must be capable of supporting the design impact loads (e.g., moment, shear, bearing, etc.) for the bridge rail. The strength of the mounting point on the bridge structure is dependent on the type of material (e.g., laminated timber, concrete, steel, etc.) as well as the thickness and condition of the material (e.g., deterioration) to which the bridge rail is mounted.

When detailed drawings and/or design information for the bridge are available, that information may be used to determine the structural adequacy of the bridge deck and structure for resisting the impact loads associated with a bridge rail collision. When the existing design details are not available, observations and measurements taken during the inspection are used in properly categorizing the existing bridge structure for structural adequacy. Depending on the age of the bridge, it may also be necessary for an inspector to assess the condition of the bridge structure (e.g., deck and/or fascia beam) to evaluate the level of deterioration, wear, or damage.

Most of the existing bridge rails on extremely low-volume bridges are mounted directly to the bridge deck using either a top-mounted or a side-mounted bridge rail design, while other designs involve mounting to the bridge fascia beam. Figure 13 illustrates these various rail attachments. If the strength of the existing bridge deck is equivalent to, or greater than, the strength of the deck for the rails shown in appendix A, then the existing deck can be considered suitable for that particular bridge rail design.



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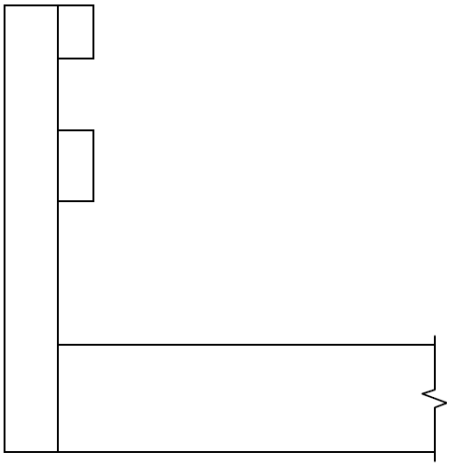
A. Subfigure top mounted deck attachment.



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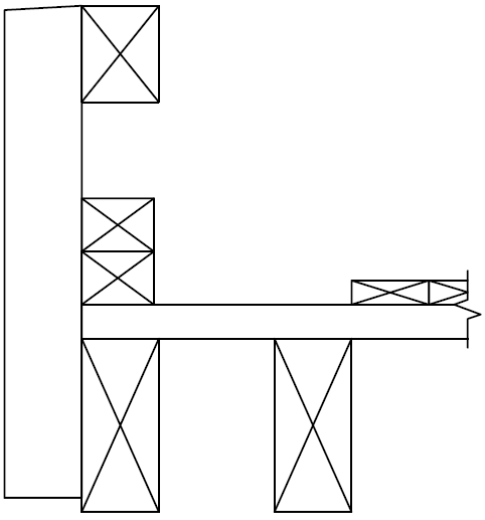
B. Subfigure side mounted deck attachment.



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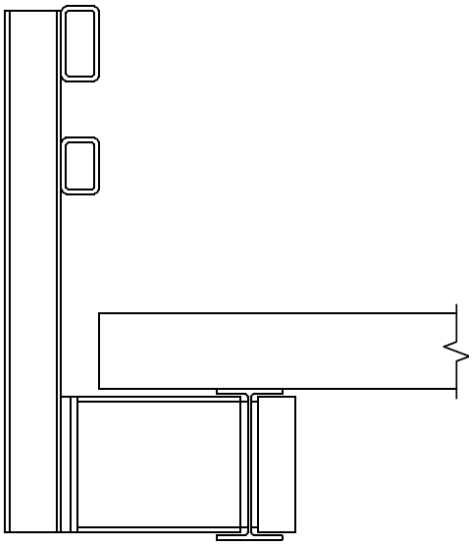
C. Subfigure fascia beam attachment (without overhang).



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D. Subfigure fascia beam attachment (with overhang).

Figure 13. Graphics. Compound figures describing types of bridge rail attachments.

Article A13.4 of the AASHTO LRFD BDS provides assessment criteria for the bridge deck overhang for supporting transverse, longitudinal, and vertical design forces for bridge rail. The forces that are to be transmitted from the bridge rail to the bridge deck may be determined from an ultimate strength analysis of the bridge rail using the design loads defined in BDS Table A13.2-1.

4.3.1 Top Mounted or Side Mounted Bridge Deck Attachment

The majority of post-and-beam bridge rail designs are mounted directly to the top of the bridge deck surface using through bolts. These cases also include side-mounted bridge rail designs which use mounting brackets bolted directly through the top of the deck. Some timber rail designs use a combination mount design involving a mounting bracket bolted directly through the top of the deck as well as a side-mount connection (e.g., bolted or nailed to the side of the deck). The latter case is commonly used on longitudinal-laminate timber bridge decks. For the top-mounted designs listed in appendix A, the MASH compliance tests were performed on timber decks with thicknesses of 5 – 8 inches or on concrete decks with thicknesses of 7.25 – 8 inches.

4.3.2 Bridge Fascia Beam Attachment

In some cases, it may be necessary or desirable to use a bridge rail system that mounts to the fascia beam of the bridge superstructure rather than the deck. This approach could be considered when it is determined that the existing bridge deck cannot support the design loads for available bridge rail designs, but the fascia beam can.

Many bridges on local road systems use steel superstructures to support various deck types (e.g., timber boards, asphalt filled steel stay-in-place forms, fiber reinforced composite, etc.) where the deck may not be able to support a bridge rail. The bridge rail systems typically installed on these bridges are steel-post-and-beam designs mounted directly to the steel fascia beam of the bridge superstructure. Most of these designs have not been crash tested, although the crash performance of at least one design was evaluated to Report 350 TL3 using FEA. That particular bridge rail design is a steel two-tube bridge rail, shown in appendix A, that is applicable to bridge structures meeting the size specifications for the bridge components, as defined in table 2, and for deck thicknesses less than 8 inches.

Table 2. Recommended size specifications for bridge components and corresponding post-mount design for the fascia mounted bridge rail system.[4]

Fascia Beam			Diaphragm			WT Connector			Mounting Tube			Post-Stiffener Design
Min. Size	Min. Thickness		Min. Size	Min. Thickness		Min. Size	Min. Thickness		Min. Size	Min. Thickness (in)	Max. Length (in)	
	Flange (in)	Web (in)		Flange (in)	Web (in)		Flange (in)	Web (in)				
W14x30 and larger W14 sections	0.385	0.27	C12x 25	0.501	0.387	WT6 x36	0.67	0.43	TS12x 6x0.25	0.25	15	B (horz. Plates)
W16x40 and larger section sizes	0.505	0.305	C12x 25	0.501	0.387	WT6 x36	0.67	0.43	TS14x 6x0.25	0.25	15	B (horz. Plates)

In cases where the existing bridge structure is not the same as that for which the bridge rail was designed and crash tested, then engineering analysis may be used to determine if the existing structure can support the bridge rail. If the bridge structure cannot support the design loads defined in BDS Table A13.2-1, then it may be necessary to strengthen the bridge superstructure at the mount locations (e.g., add gussets or plates, increase size of diaphragm elements, etc.) or to redesign the mount to distribute the loading more effectively over a larger area of the fascia beam.

4.3.3 Other Alternatives

If it is determined that the bridge structure cannot support the design loads defined in BDS Table A13.2-1 for the available crashworthy bridge rail designs but a crashworthy bridge rail is appropriate to meet the performance goal, then the bridge owner may choose to rehabilitate, strengthen, or replace the bridge structure to accommodate the bridge rail. Provided the deck strength is equal to or greater than those deck strengths shown in appendix A, then variations in the deck would be considered inconsequential to the crash performance of the rail provided there were no other changes made to the selected bridge rail (e.g., overall system height, railing type, railing position, post type, post spacing, etc.).[4, 5]

BDS Section 13.7.3.1.2 indicates that provisions be made to transfer design loads from the railing system to the bridge structure based on load requirements specified in BDS Table A13.2-1. The BDS further specifies that for concrete decks, the minimum deck thickness at the bridge rail connection point must be:

- 8 inches – for concrete deck overhangs supporting either a deck-mounted post-and-beam bridge rail or concrete parapet.
- 12 inches – for side-mounted bridge rails.

4.4 Does Installing Crashworthy Transitions and Terminals Meet the Performance Goal?

The result of this section will be a determination about the appropriateness of providing crashworthy approach guardrail terminals and transitions. If the posted speed limit is 30 mph or less and the rail is terminated at a post when a post and rail bridge rail system is used, the installation of new terminals and/or transitions is generally not risk beneficial and no further analysis is necessary before proceeding to Section 4.5. If the posted speed limit is greater than 30 mph, the installation of terminals and transitions are risk beneficial, so continue with this section before proceeding to Section 4.5.

Consider installing crashworthy terminals and transitions on bridge approaches where the posted speed limit is greater than 30 mph. Refer to appendix B and C for a selection of crashworthy terminals and transitions. Over time, it is expected that additional terminals and transitions will be developed, and they may be used as they become available. For guidance about the grading around the terminal, see RDG Section 8.3.3 and Figures 8.2 and 8.3.

If there is insufficient distance from the intersecting roadway to the bridge to accommodate the transition and terminal, lower the posted speed limit to 30 mph, delineate the bridge in accordance with Section 4.5 of this Guide, and terminate the rail at a post when a post and rail bridge rail system is used.

4.5 Is Delineation Needed?

Reference the current edition of the MUTCD Sections 2C.63, 2C.64, and 2C.65 for guidance on the necessity of delineation of bridge structures and railing systems with object markers. Provide Type 3 object markers or OM1-2 object markers as required.

When the bridge clear width is less than that of the approach roadway clear width, provide a narrow bridge sign (W5-2) in accordance with the MUTCD Section 5C.05.

When the bridge carries a two-way roadway and has a bridge clear width of 16 to 18 ft, provide a narrow bridge sign (W5-2) in accordance with the MUTCD Section 2C.20.

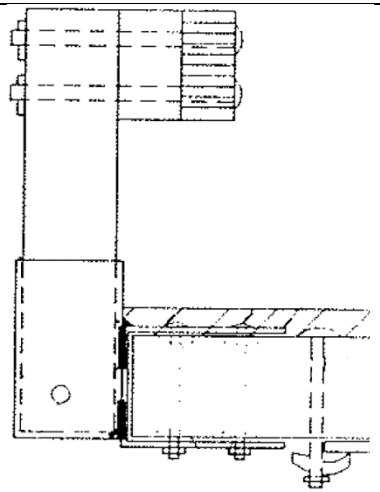
When the approach roadway carries a two-way roadway and there is a bridge clear width of less than 16 ft, provide a one-lane bridge sign (W5-3) in accordance with Section 2C.21 of the MUTCD.

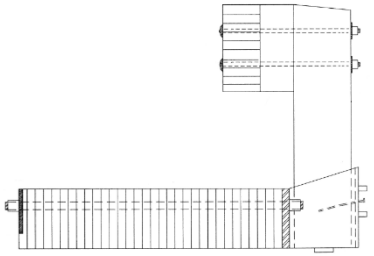
5 REFERENCES

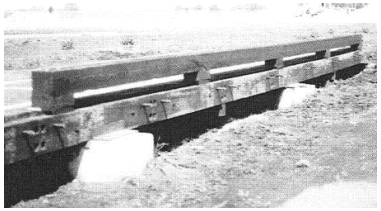
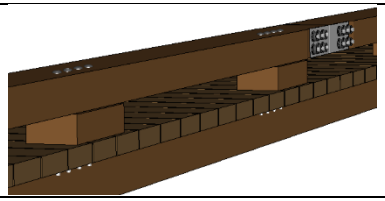
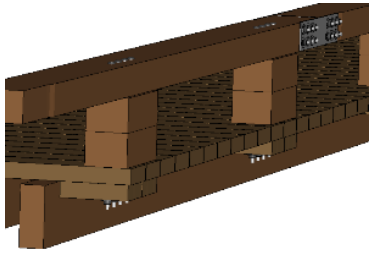
1. Ray MH. Development of Safety Performance Based Guidelines for the Roadside Design Guide [Project]. Washington, D.C.: Transportation Research Board, National Cooperative Highway Research Program; 2021 Expected. Contract No.: NCHRP 15-65.
2. AASHTO. Roadside Design Guide. 4th ed. AASHTO, editor. Washington, D.C: American Association of State Highway and Transportation Officials; 2011.
3. AASHTO. AASHTO LRFD Bridge Design Specifications. Eighth Edition ed. Washington, D.C.: American Association of State Highway and Transportation Officials; 2018.
4. Plaxico CA, Johnson TO. Design and Evaluation of a Fascia Mounted Bridge Rail for Steel Bridges on Local Roadways. International Roadside Safety Conference; June 2017; San Francisco, CA: Tranportation Research Board; 2017.
5. Plaxico CA, editor Designing a TL-3 Bridge Guardrail System Mounted to Steel Fascia Beams for use on Ohio's Local System. 70th Ohio Transportation Engineering Conference (OTEC); 2016 October 24-26, 2016; Columbus, OH.

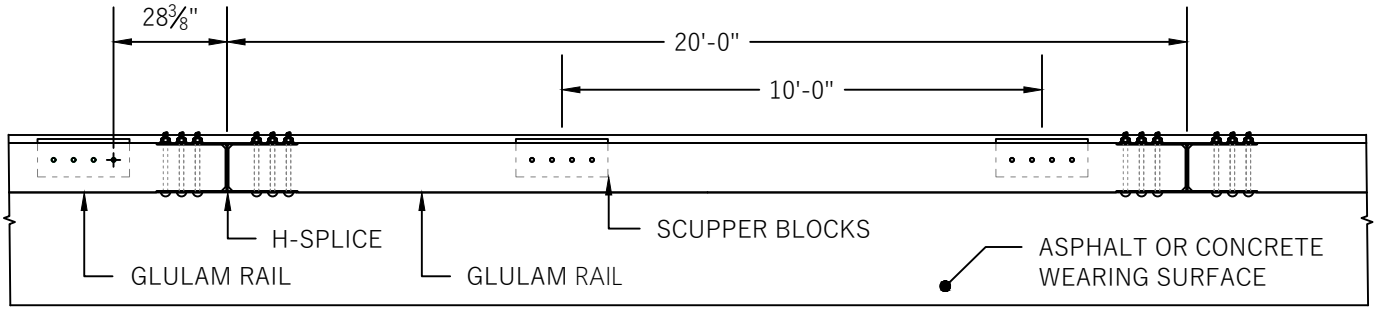
APPENDIX A: CRASH TESTED BRIDGE RAIL DESIGNS

Appendix A. Crash Tested Bridge Rail Designs

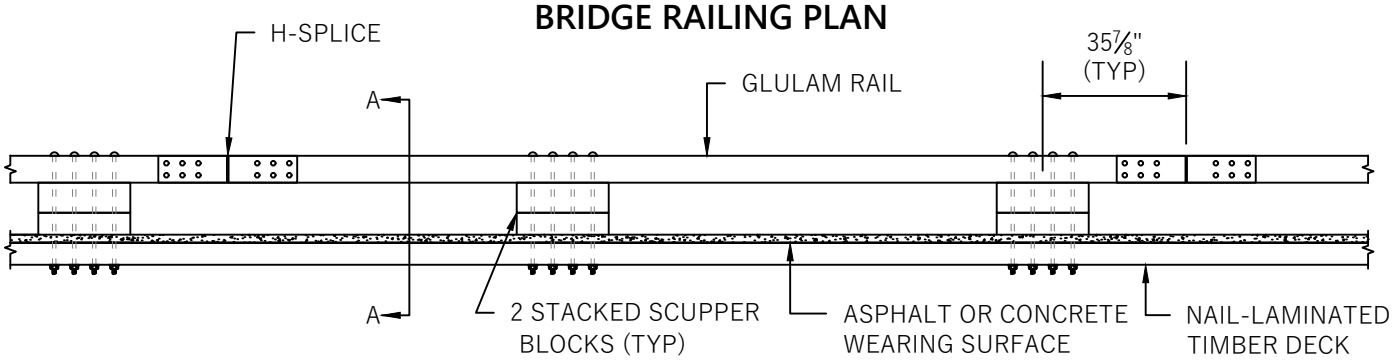
System Name	Test Number	Test Level	Photo/Sketch	Deck		Rail			Ref
				Type	Thick (in)	Type	Mount	Height (in)	
West Virginia Curb-Type Bridge Rail	WVBR-1	MASH TL-1		Nail laminated timber	5.50	Curb-type timber post and beam.	Bolted through rail, post, & deck, nut secured under deck.	19.75	1
Timber Curb-Type Bridge Railing for Low Volume Roads	CTBR-1	R350 TL-1		2” Bituminous wearing surface on top of longitudinal glulam timber	10.75	Single glulam timber post and timber beam.	Top bolted through top of rail, post, & deck with (4) 3/4”Ø A307 bolts.	17.75	2
Timber Bridge Rail System One	7212-4 7212-5	PL-1		2” wearing surface on top of Glulam timber	6.75	Glulam rail, timber block, and timber post.	Post seated in steel bracket, bracket bolted to u-shape fastener with (4) 3/8”x2.5”L fillet welds, u-shape fastener bolted to top/bottom of bridge deck with (4) ¾”Ø A325 bolts.	27.00	3

System Name	Test Number	Test Level	Photo/Sketch	Deck		Rail			Ref
				Type	Thick (in)	Type	Mount	Height (in)	
Wood System – Bridge Railing	WRPB-1	R350 TL-2		2” concrete wearing surface on top of transverse glulam timber	5.125	Single glulam timber rail, timber blockout, and timber posts.	Angle brackets bolted through top/bottom of the timber portion of the bridge deck with (6) 7/8”Ø bolts.	28.40	4
TxDOT T631 Bridge Rail	490023-6-1a 490023-6-2	MASH TL-2		Concrete (4000 psi)	8.00	W-beam attached to steel posts.	Base plate bolted through bridge deck with (4) 5/8”Ø 10”L A325 bolts.	31.00	5
Single Longitudinal Glulam Bridge Railing (Shoe-Box System)	FSSB-1 FSSB-2	PL-1		Glulam timber	10.75	Single glulam rail attached to sawn timber blockout and timber post.	Post seated in metal “shoe-box” and tacked with 6”L nail spike. Shoe-box through bolted into bridge deck with (2) 1”Ø x 48”L A722 high-strength threaded rods.	32.00	6

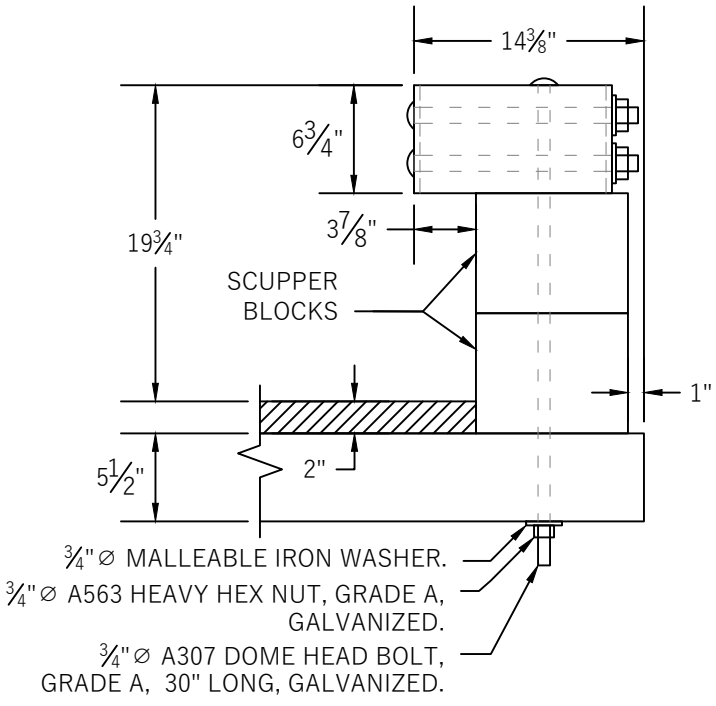
System Name	Test Number	Test Level	Photo/Sketch	Deck		Rail			Ref
				Type	Thick (in)	Type	Mount	Height (in)	
Low-Cost, Energy Absorbing Bridge Rail	MGSBR-1 MGSBR-2	MASH TL-3		4000 psi concrete	8.00	W-beam rail attached to steel posts with back-up plates.	Side mounted using a weak post assembly through bolted (top-bottom) with 1”Ø bolt.	31.00	7
Square-Shape Timber Curb Rail	LVCS-4	R350 TL-1		2” Bituminous wearing surface on top of longitudinal glulam timber	10.75	Single timber beam and timber post.	Top bolted through top of rail, post, & deck with (2) 5/8”Ø A307 bolts.	12.00	8
Modified 12-inch bridge rail for plank deck				4” x 12” Timber Planks	3.50	Curb-type timber post and beam.	Bolted through rail, post, & deck, nut secured under deck.	12.00	9
Modified 19.75-inch bridge rail for plank deck		MASH TL-1		4” x 12” Timber Planks	3.50	Curb-type timber post and beam.	Bolted through rail, post, & deck, nut secured through 4” x 12” stiffener plate under deck.	19.75	10



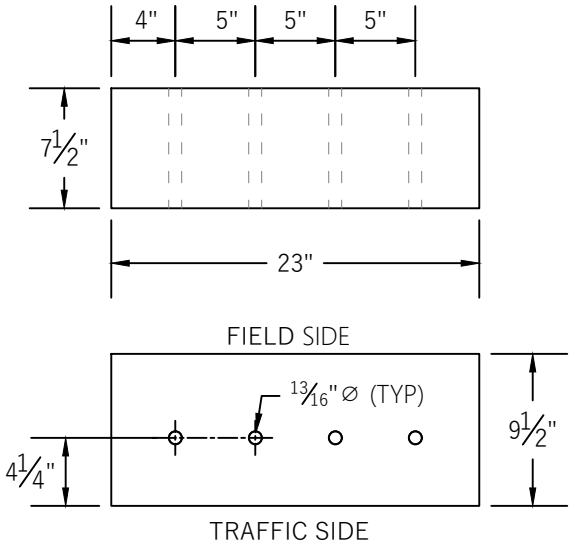
BRIDGE RAILING PLAN



BRIDGE RAILING PROFILE



SECTION A-A
BRIDGE RAILING CROSS SECTION

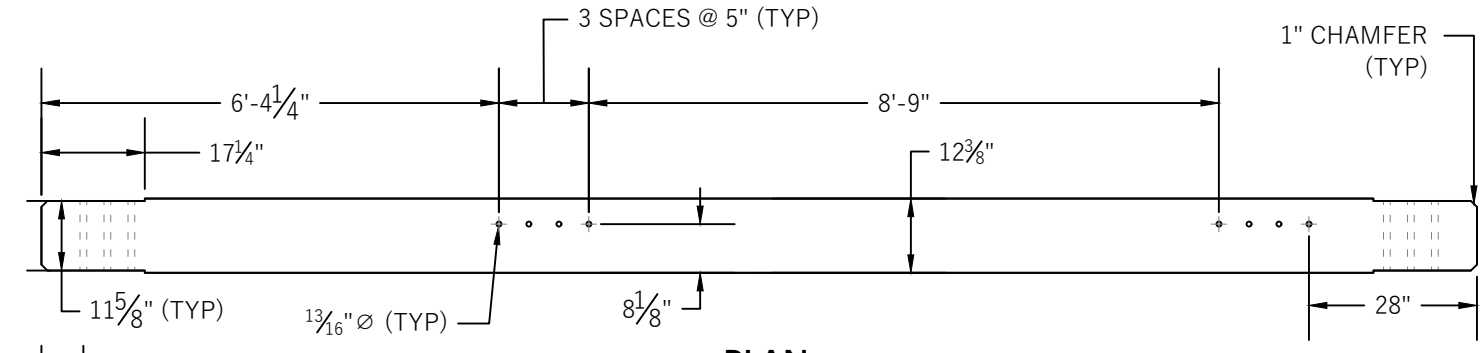


THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: SCUPPER BLOCK SHALL BE SOUTHERN YELLOW PINE GRADE NO. 1 OR DOUGLAS FIR GRADE NO. 1. TREATMENT WITH PENTACHLOROPHENOL IN HEAVY OIL - 0.6 LBS/CU. FT.

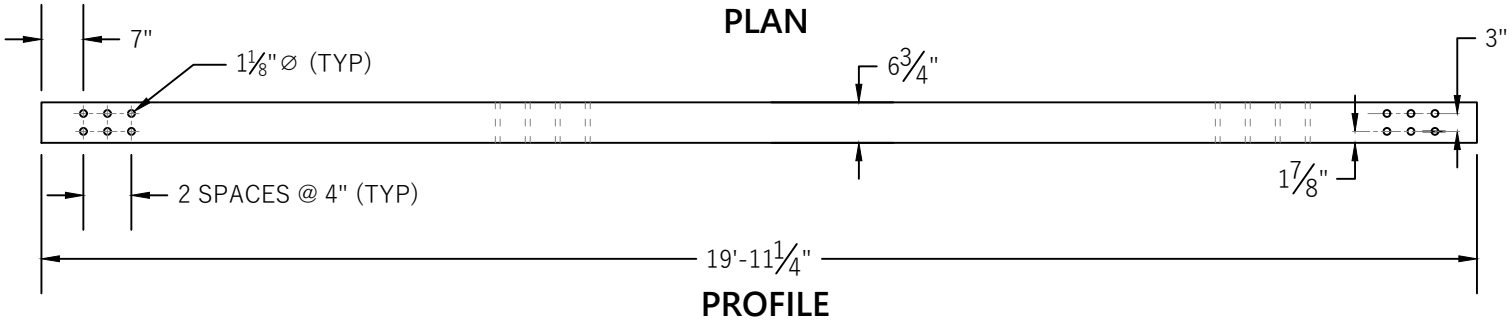
SCUPPER BLOCK DETAIL

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA CURB TYPE BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-1	**BRIDGE RAIL HEIGHT:** 19.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 1 SOURCE: TRP-03-211-09	**SHEET #** 1 OF 2



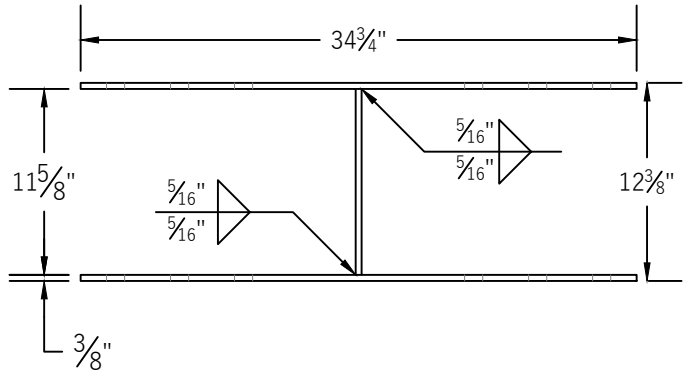
PLAN

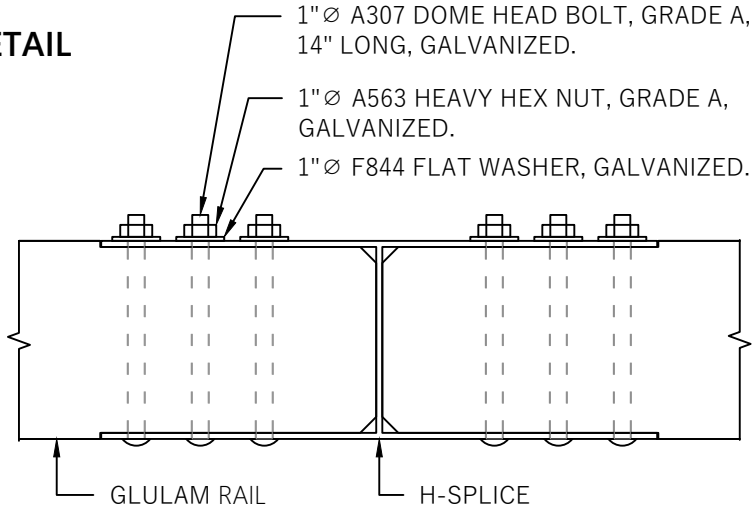


PROFILE

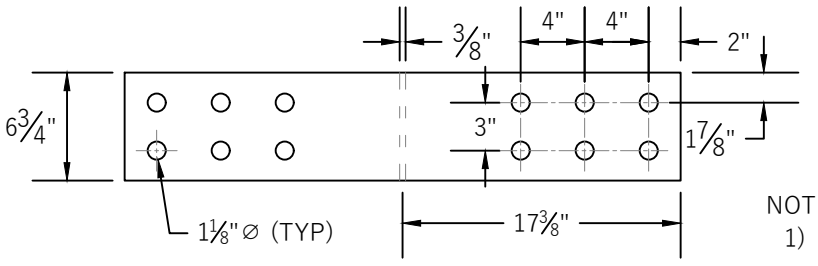
THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM RAIL SHALL BE COMBINATION NO. 48 SOUTHERN YELLOW PINE OR COMBINATION NO. 2 DOUGLAS FIR. TREATMENT WITH PENTACHLOROPHENOL IN HEAVY OIL - 0.6 LBS/CU. FT.

GLULAM RAIL DETAIL





SPLICE DETAIL

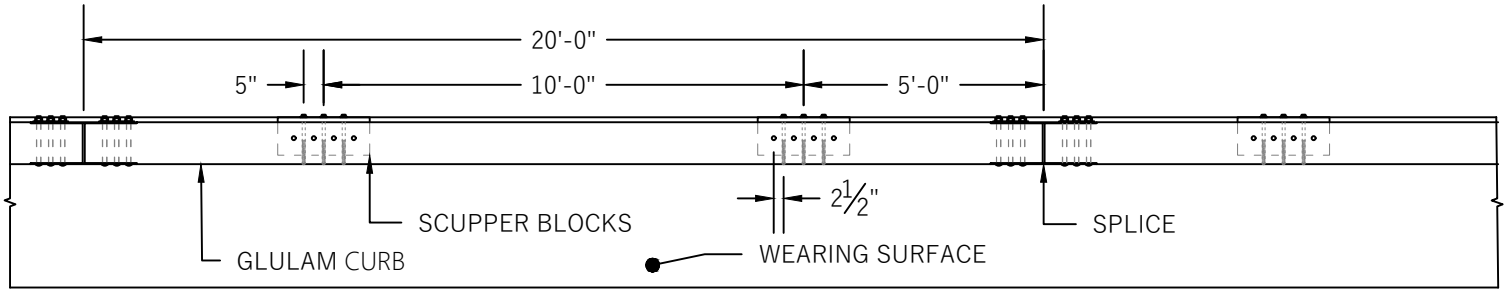


H-SPLICE DETAIL

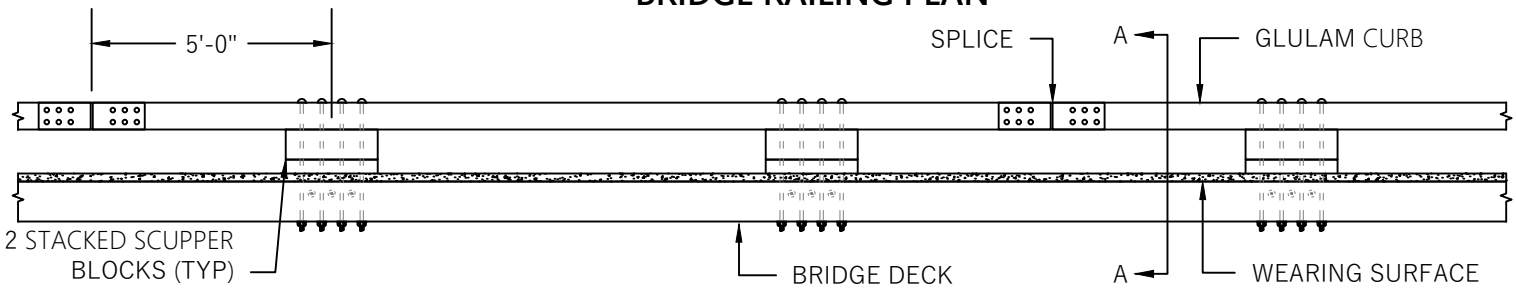
NOTES:

1) H-SPLICE IS A572 GRADE 42. SHALL BE GALVANIZED AFTER SIDE PLATES AND INTERIOR GUSSET PLATE ARE WELDED TOGETHER.
2) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

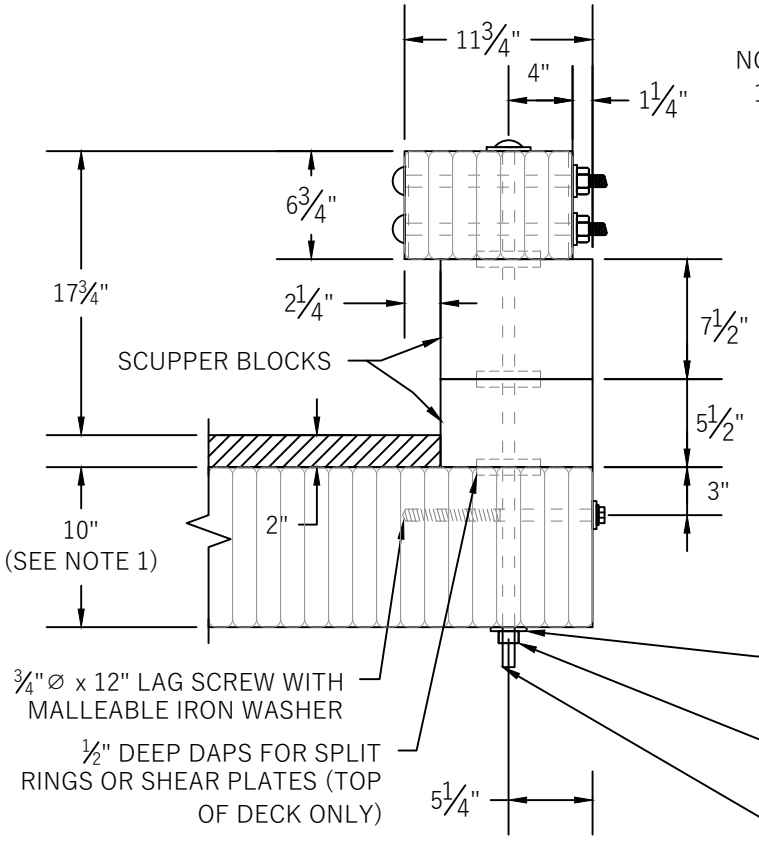
SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA CURB TYPE BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-1	**BRIDGE RAIL HEIGHT:** 19.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 1 SOURCE: TRP-03-211-09	**SHEET #** 2 OF 2



BRIDGE RAILING PLAN



BRIDGE RAILING PROFILE



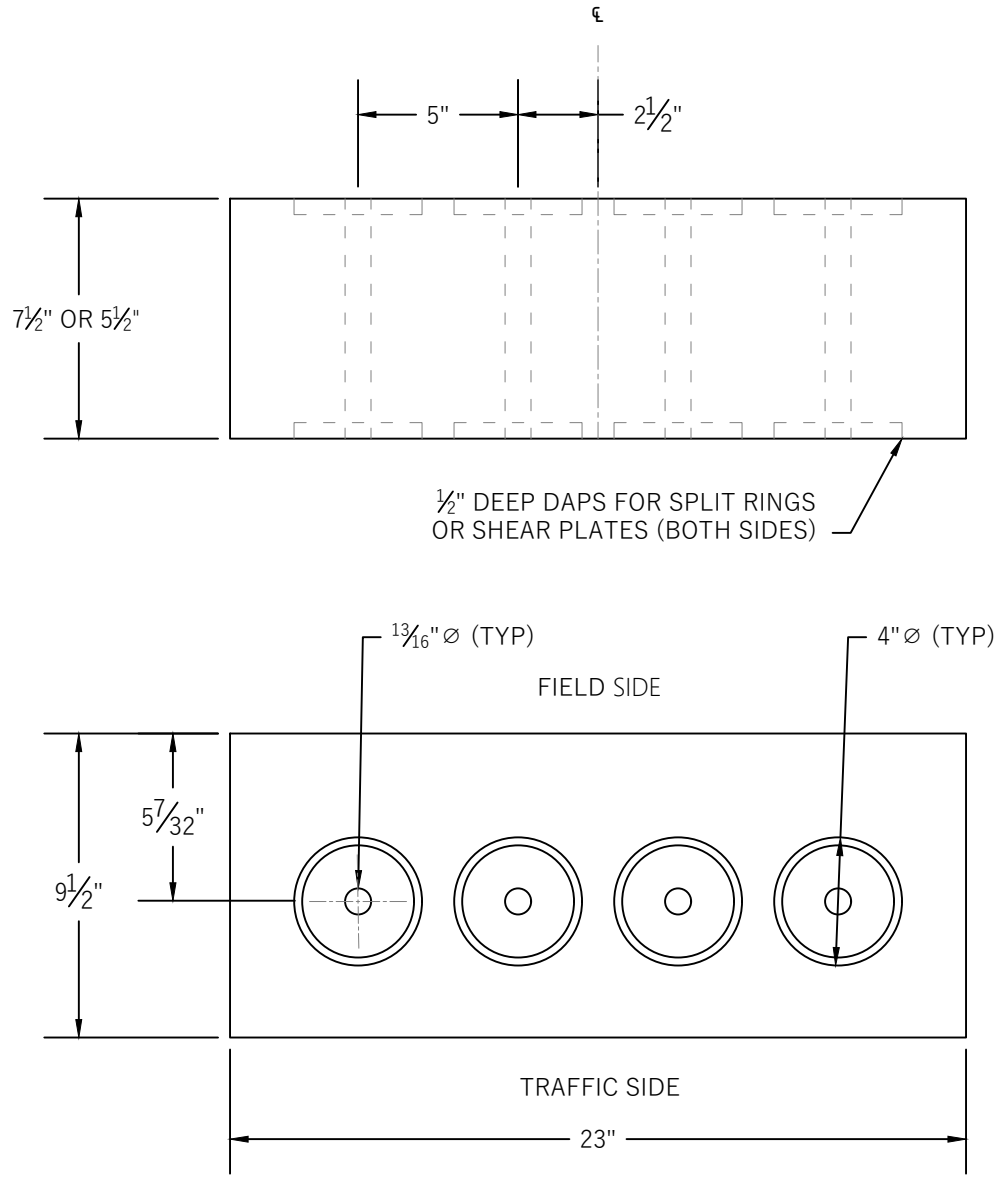
NOTES:

1) SYSTEM WAS TESTED ON A 10¾" THICK LONGITUDINAL GLUE-LAMINATED DECK (SOURCE 1). ACCORDING TO DRAWING SBD07A ON TF13GUIDES.ORG, THE SYSTEM IS ADAPTABLE TO LONGITUDINAL STRESS-LAMINATED, SPIKE-LAMINATED, NAIL-LAMINATED, AND GLUED-LAMINATED (GLULAM) TIMBER DECKS THAT ARE 10 INCHES OR GREATER IN ACTUAL THICKNESS (SOURCE 2).

SECTION A-A
BRIDGE RAILING CROSS SECTION

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER CURB TYPE BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 17.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 2 SOURCE 1: TRP-03-54-96 SOURCE 2: TF13GUIDES.ORG DRAWING SBD07A	**SHEET #** 1 OF 4

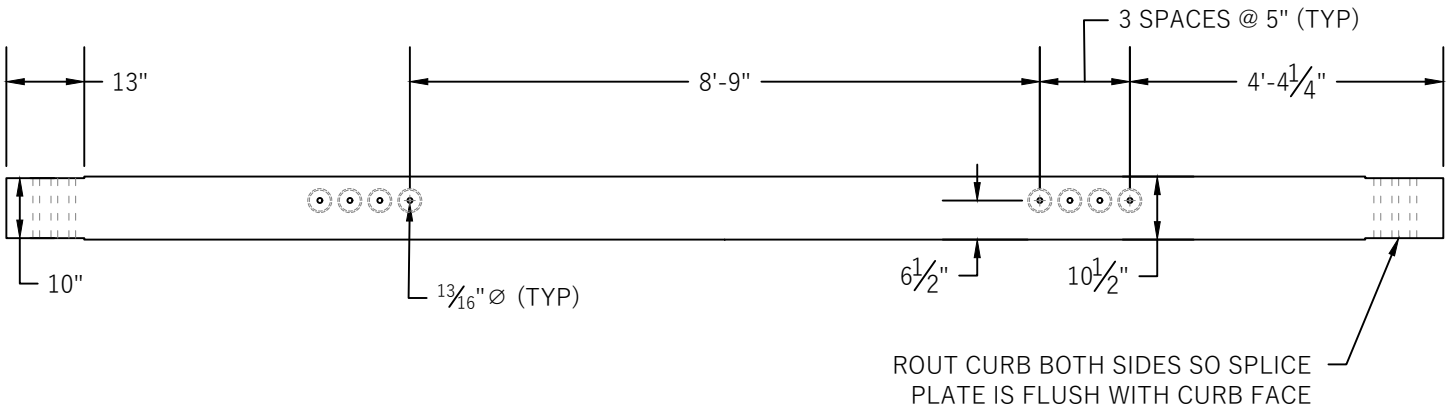


NOTES:

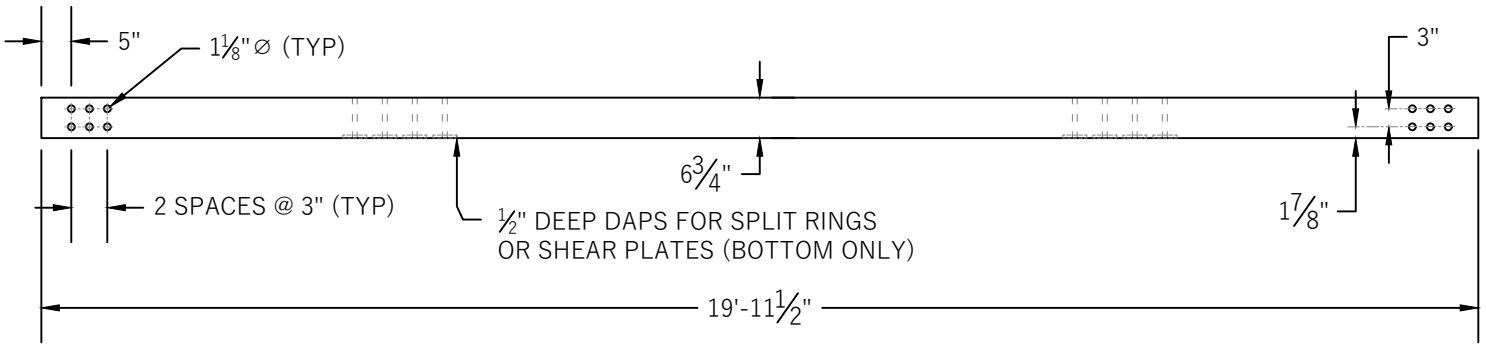
1) THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: SCUPPER BLOCKS MAY BE SAWN LUMBER OR GLULAM. IF SAWN LUMBER: VISUALLY GRADED NO. 1 SOUTHERN PINE OR DOUGLAS FIR-LARCH. GLULAM AND OTHER SPECIES AND GRADES OF SAWN LUMBER MAY BE USED, PROVIDED THE MINIMUM TABULATED VALUES ARE NO LESS THAN THE FOLLOWING: Fb = 1,350 LB/IN^2 E = 1,500,000 LB/IN^2. SHALL BE PRESSURE TREATED WITH WOOD PRESERVATIVE IN ACCORDANCE WITH AASHTO M 133.
2) SPLIT RINGS SHALL BE MANUFACTURED FROM SAE 1010 HOT-ROLLED CARBON STEEL IN ACCORDANCE WITH SAE J412 (SAE 1989). SHEAR PLATES SHALL BE MALLEABLE IRON MANUFACTURED ACCORDING TO ASTM A47, GRADE 32510.

SCUPPER BLOCK DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER CURB TYPE BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 17.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 2 SOURCE 1: TRP-03-54-96 SOURCE 2: TF13GUIDES.ORG DRAWING SBD07A	**SHEET # 2 OF 4**



PLAN

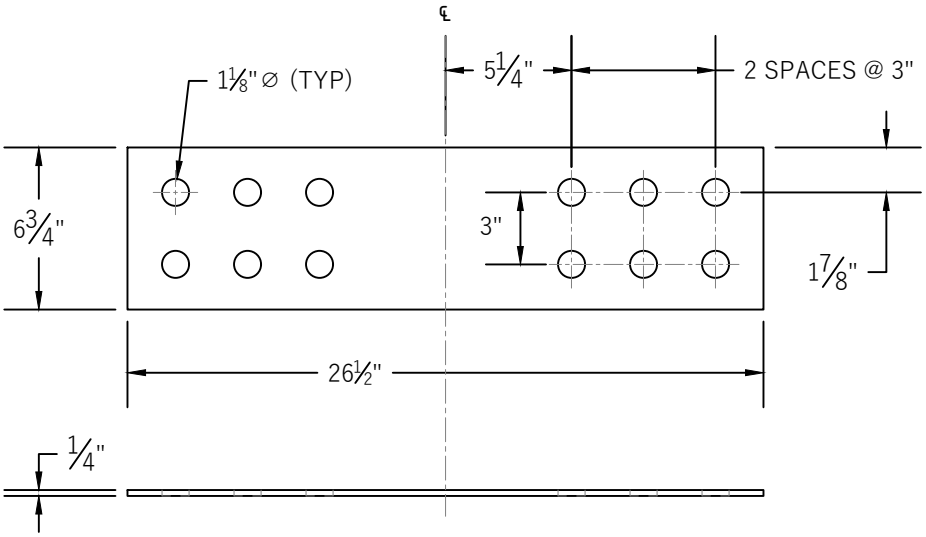


PROFILE

THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM CURB SHALL BE VISUALLY GRADED GLULAM WESTERN SPECIES COMBINATION NO. 2 OR COMBINATION NO. 48 SOUTHERN PINE. OTHER SPECIES AND GRADES OF GLULAM MAY BE USED, PROVIDED THE MINIMUM TABULATED VALUES ARE NOT LESS THAN THE FOLLOWING: Fb = 1,800 LB/IN^2, E = 1,800,000 LB/IN^2. SHALL BE PRESSURE TREATED WITH WOOD PRESERVATIVE IN ACCORDANCE WITH AASHTO M 133. SHALL BE MANUFACTURED USING WET USE ADHESIVES TO AN INDUSTRIAL APPEARANCE GRADE.

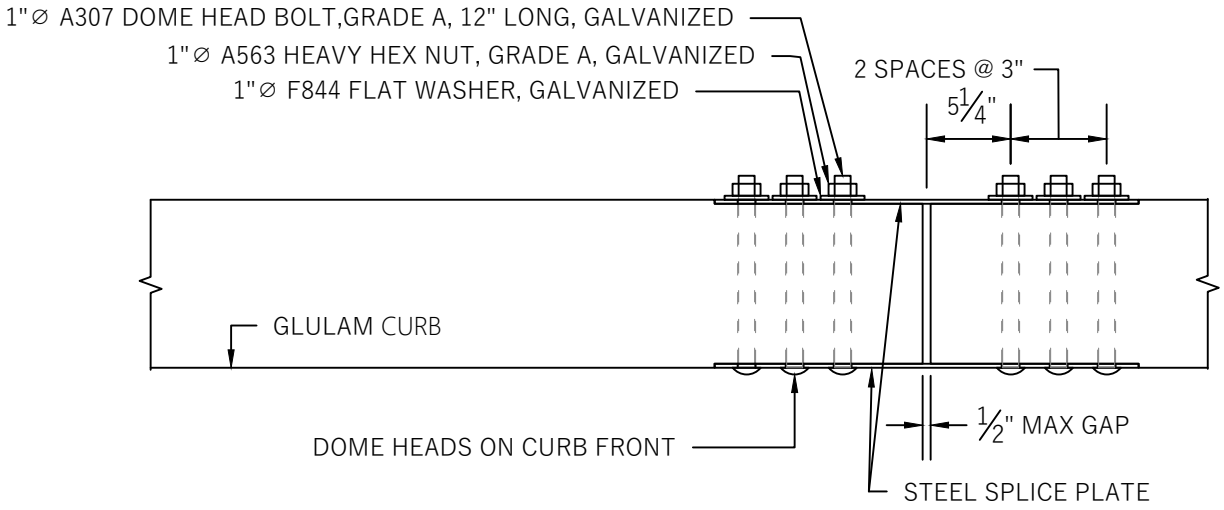
GLULAM CURB

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER CURB TYPE BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 17.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 2 SOURCE 1: TRP-03-54-96 SOURCE 2: TF13GUIDES.ORG DRAWING SBD07A	**SHEET # 3 OF 4**



NOTES:
1) A36
2) GALVANIZED IN ACCORDANCE WITH AASHTO M111 OR M232

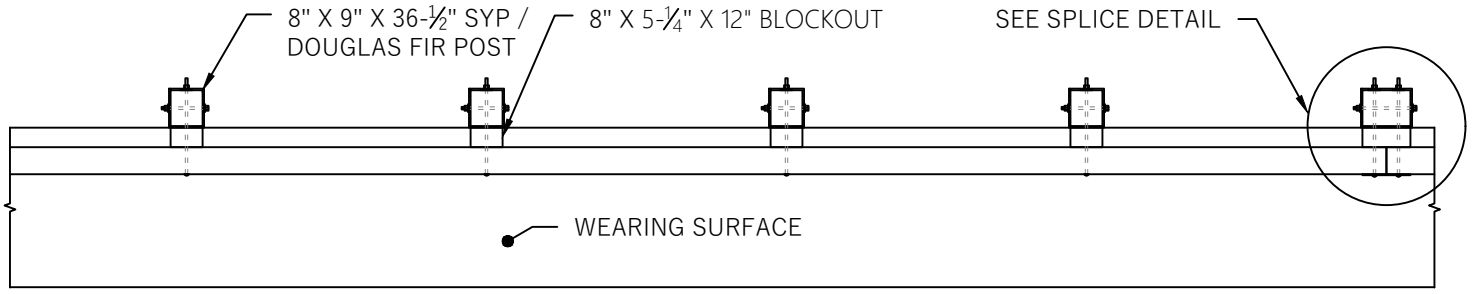
STEEL SPLICE PLATE DETAIL



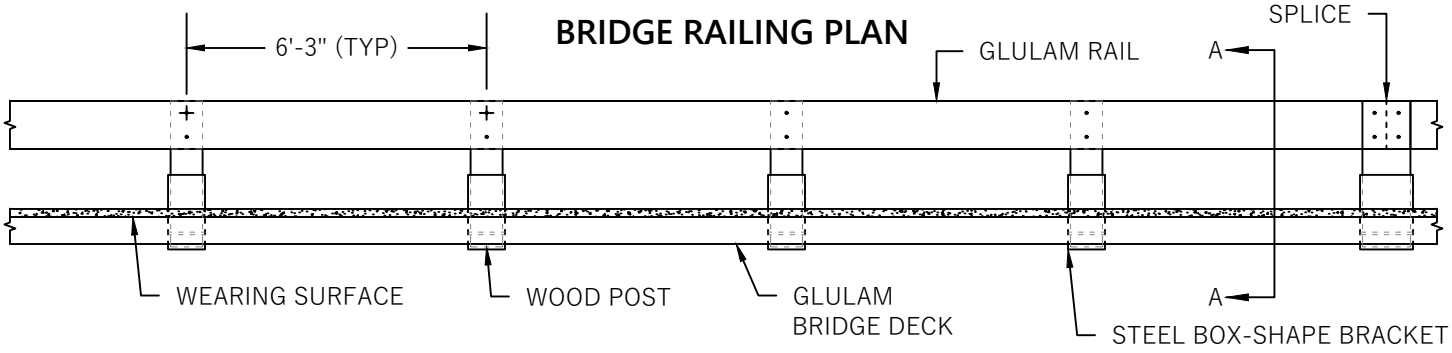
NOTES:
1) SPLICES ARE MIDWAY BETWEEN SCUPPERS AND SHALL BE LOCATED SO THAT CURB IS CONTINUOUS OVER NOT LESS THAN TWO SCUPPERS.

SPLICE DETAIL

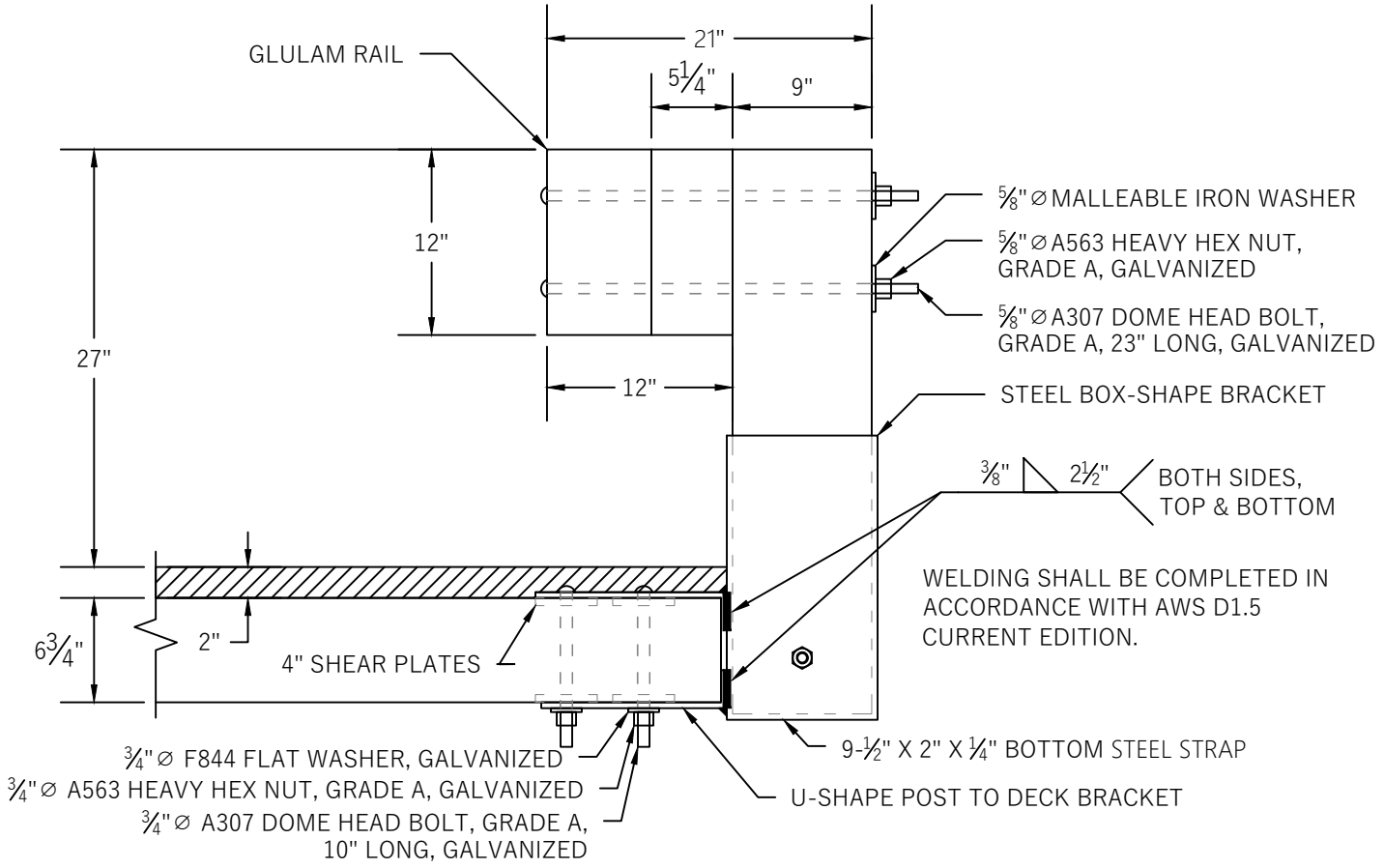
SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER CURB TYPE BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 17.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 2 SOURCE 1: TRP-03-54-96 SOURCE 2: TF13GUIDES.ORG DRAWING SBD07A	**SHEET # 4 OF 4**



BRIDGE RAILING PLAN



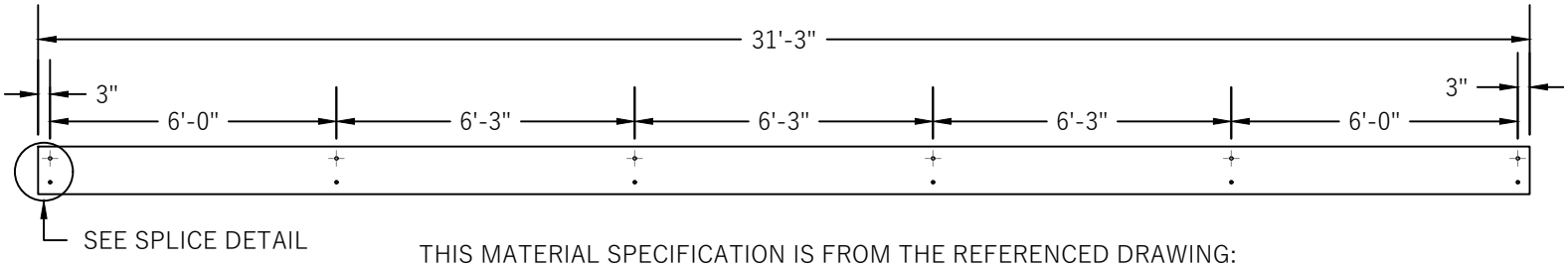
BRIDGE RAILING PROFILE



SECTION A-A BRIDGE RAILING CROSS SECTION

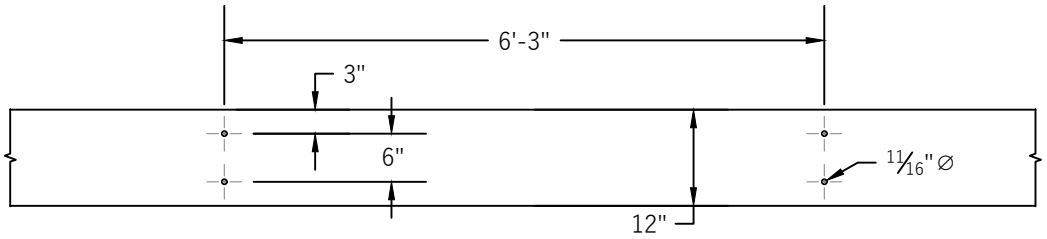
NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER BRIDGE RAIL SYSTEM ONE		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 3 SOURCE: TTI TEST 7212-4 AND TEST 7212-5	**SHEET #** 1 OF 5

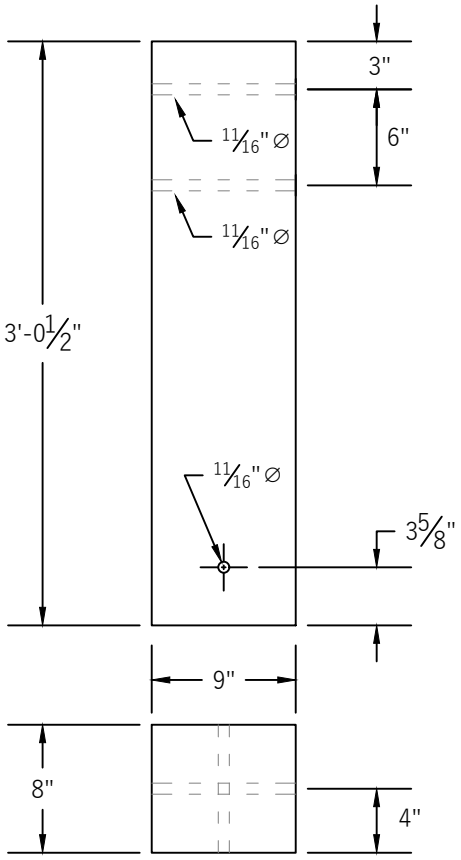


THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING:
GLULAM RAIL SHALL BE COMBINATION NO. 48 SOUTHERN YELLOW PINE.

GLULAM RAIL PROFILE

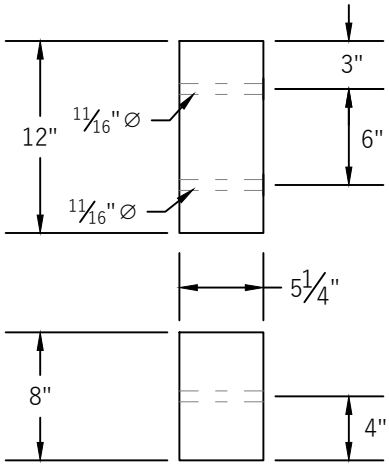


GLULAM RAIL HOLE PATTERN



THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: TIMBER POST SHALL BE DOUGLAS FIR / SYP NO.1

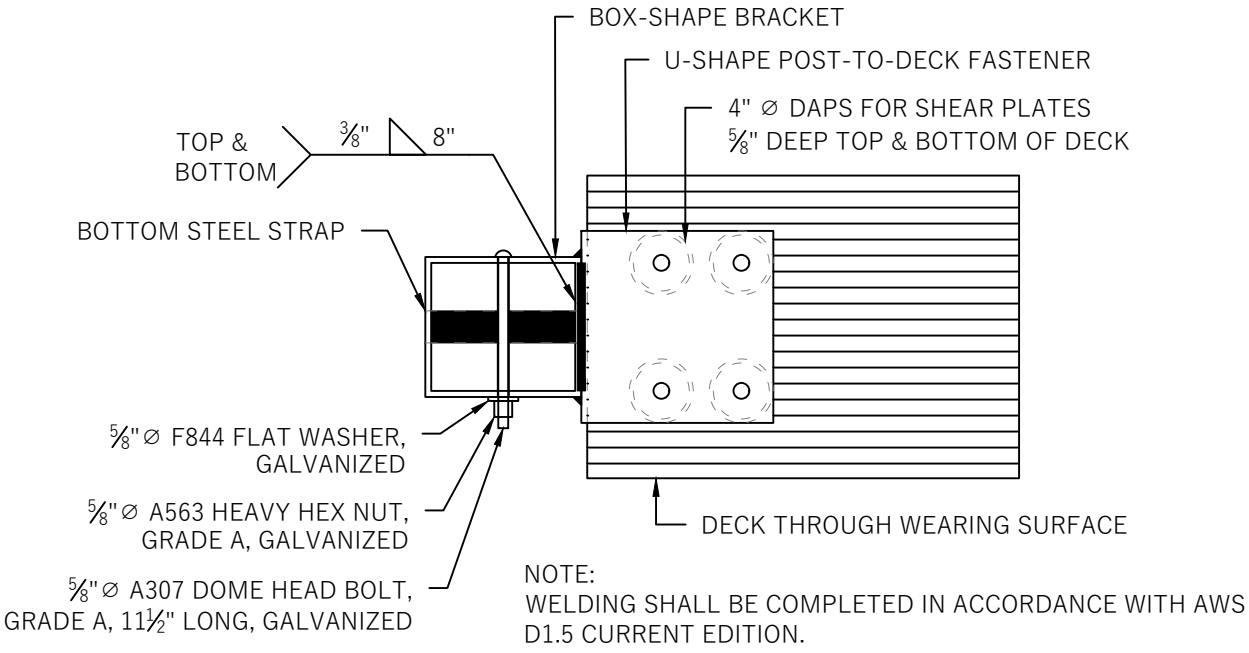
TIMBER POST



THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDB01A-B: BLOCKS SHALL BE MADE OF TIMBER WITH A STRESS GRADE OF AT LEAST 1160 PSI [8MPa]. SHALL BE EITHER ROUGH-SAWN OR S4S WITH NOMINAL DIMENSIONS INDICATED. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER ALL END CUTS ARE MADE AND HOLES ARE DRILLED. THE VARIATION IN SIZE OF BLOCKOUTS IN THE DIRECTION PARALLEL TO THE AXIS OF THE BOLT HOLES SHALL NOT BE MORE THAN 1/4"

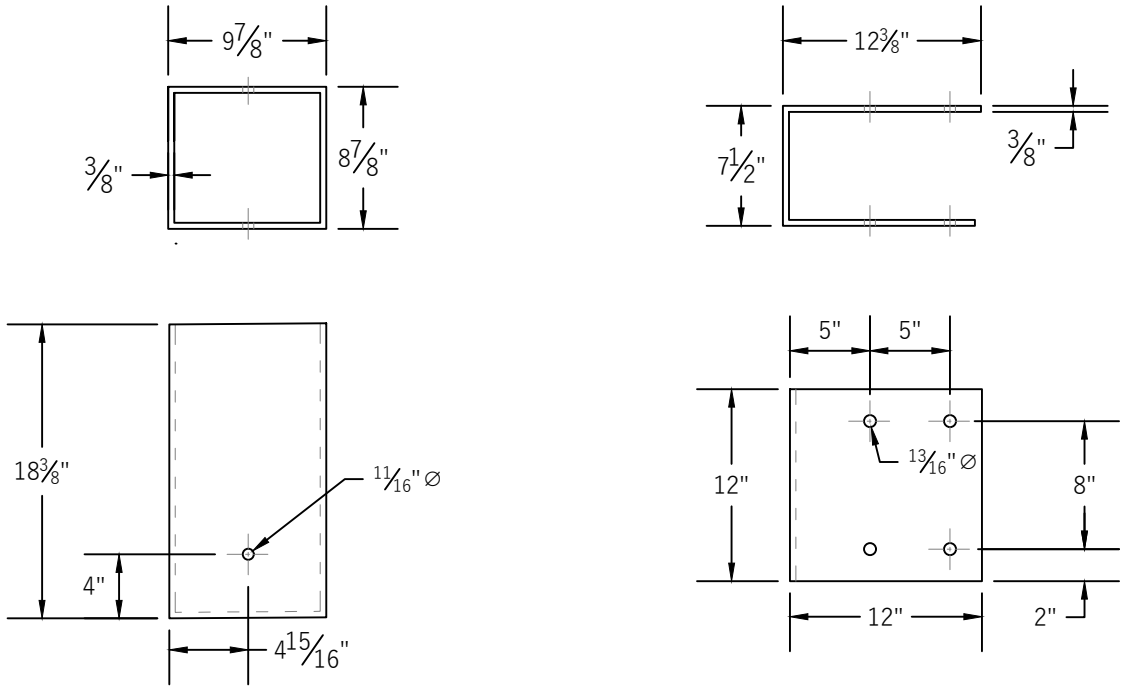
BLOCKOUT

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER BRIDGE RAIL SYSTEM ONE		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 3 SOURCE: TTI TEST 7212-4 AND TEST 7212-5	**SHEET #** 2 OF 5



NOTE:
WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

TYPICAL DECK ATTACHMENT DETAIL



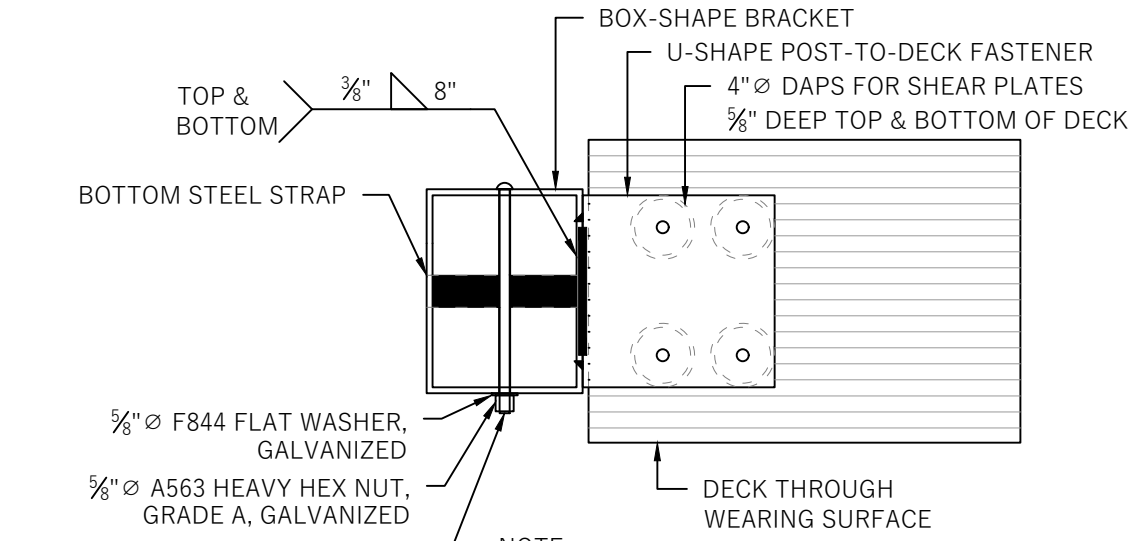
NOTE:
1) A36, GALVANIZED

BOX-SHAPE BRACKET

NOTE:
1) A36, GALVANIZED

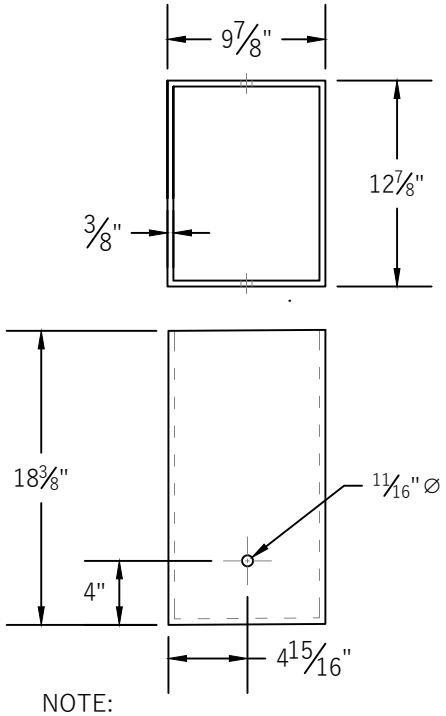
U-SHAPE POST-TO-DECK BRACKET

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER BRIDGE RAIL SYSTEM ONE		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 3 SOURCE: TTI TEST 7212-4 AND TEST 7212-5	**SHEET #** 3 OF 5



NOTE:
WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

DECK ATTACHMENT AT SPLICE

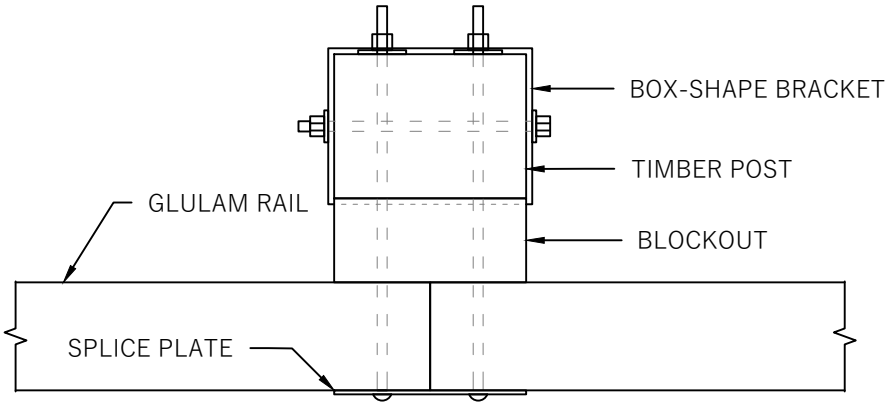


NOTE:
1) A36, GLAVANIZED

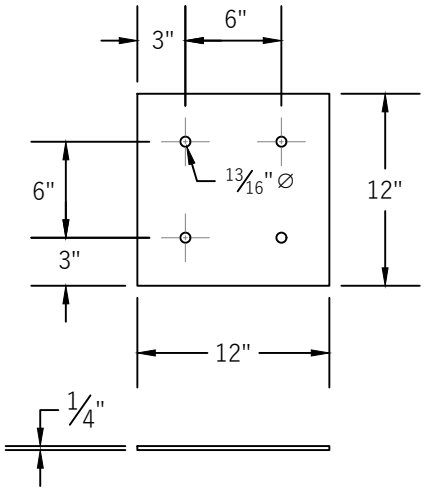
NOTE:
THE BOX-SHAPE BRACKET AT SPLICE LOCATIONS WAS NOT DETAILED IN THE REFERENCED DRAWING. THE TYPICAL BOX SHAPE BRACKET WAS MODIFIED TO FIT WITH THE 12" X 9" POST AT THE SPLICE USING THE SAME DIMENSIONAL TOLERANCE. THE U-SHAPE POST-TO-DECK FASTENER WAS UNCHANGED FROM THE TYPICAL SIZE.

BOX-SHAPE BRACKET AT SPLICE

SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER BRIDGE RAIL SYSTEM ONE		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 3 SOURCE: TTI TEST 7212-4 AND TEST 7212-5	**SHEET # 4 OF 5**

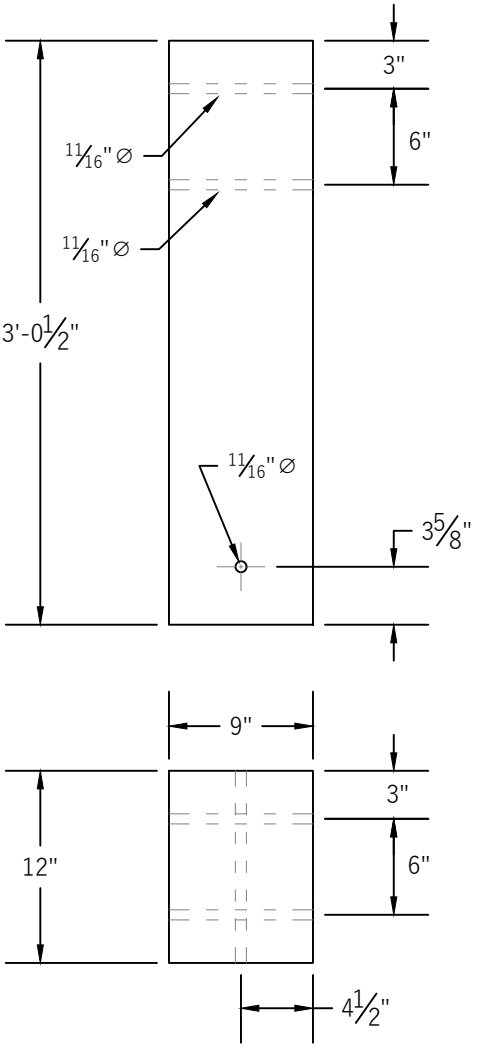


SPLICE DETAIL



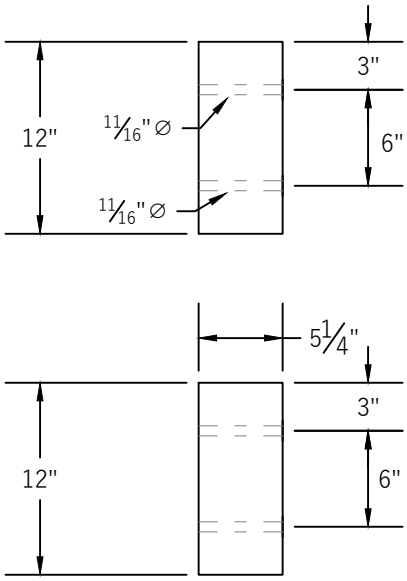
NOTE:
1) A36, GALVANIZED

SPLICE PLATE



THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: TIMBER POST AT SPLICE SHALL BE DOUGLAS FIR / SYP NO.1

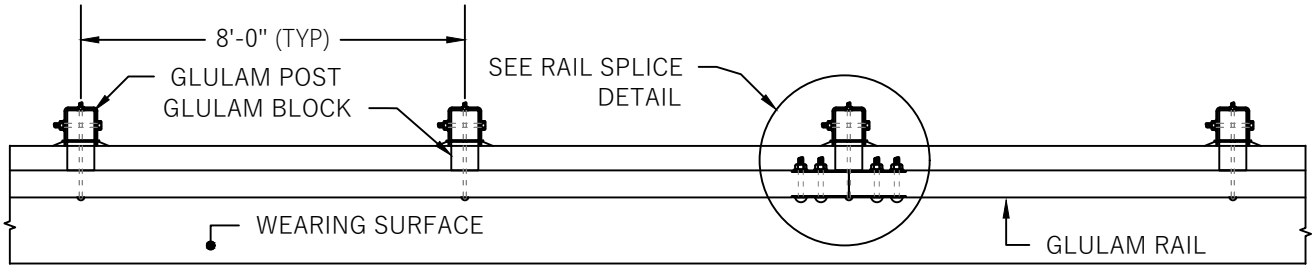
TIMBER POST AT SPLICE



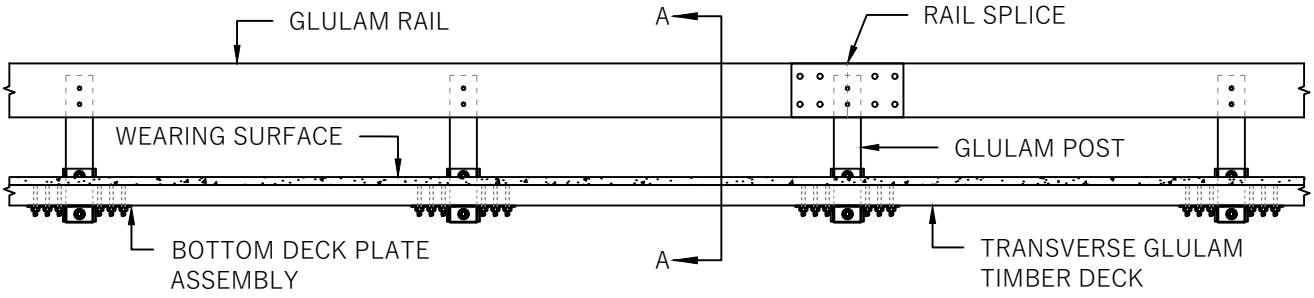
THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDB01A-B: BLOCKS SHALL BE MADE OF TIMBER WITH A STRESS GRADE OF AT LEAST 1160 PSI [8MPa]. SHALL BE EITHER ROUGH-SAWN OR S4S WITH NOMINAL DIMENSIONS INDICATED. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER ALL END CUTS ARE MADE AND HOLES ARE DRILLED. THE VARIATION IN SIZE OF BLOCKOUTS IN THE DIRECTION PARALLEL TO THE AXIS OF THE BOLT HOLES SHALL NOT BE MORE THAN 1/4"

BLOCKOUT AT SPLICE

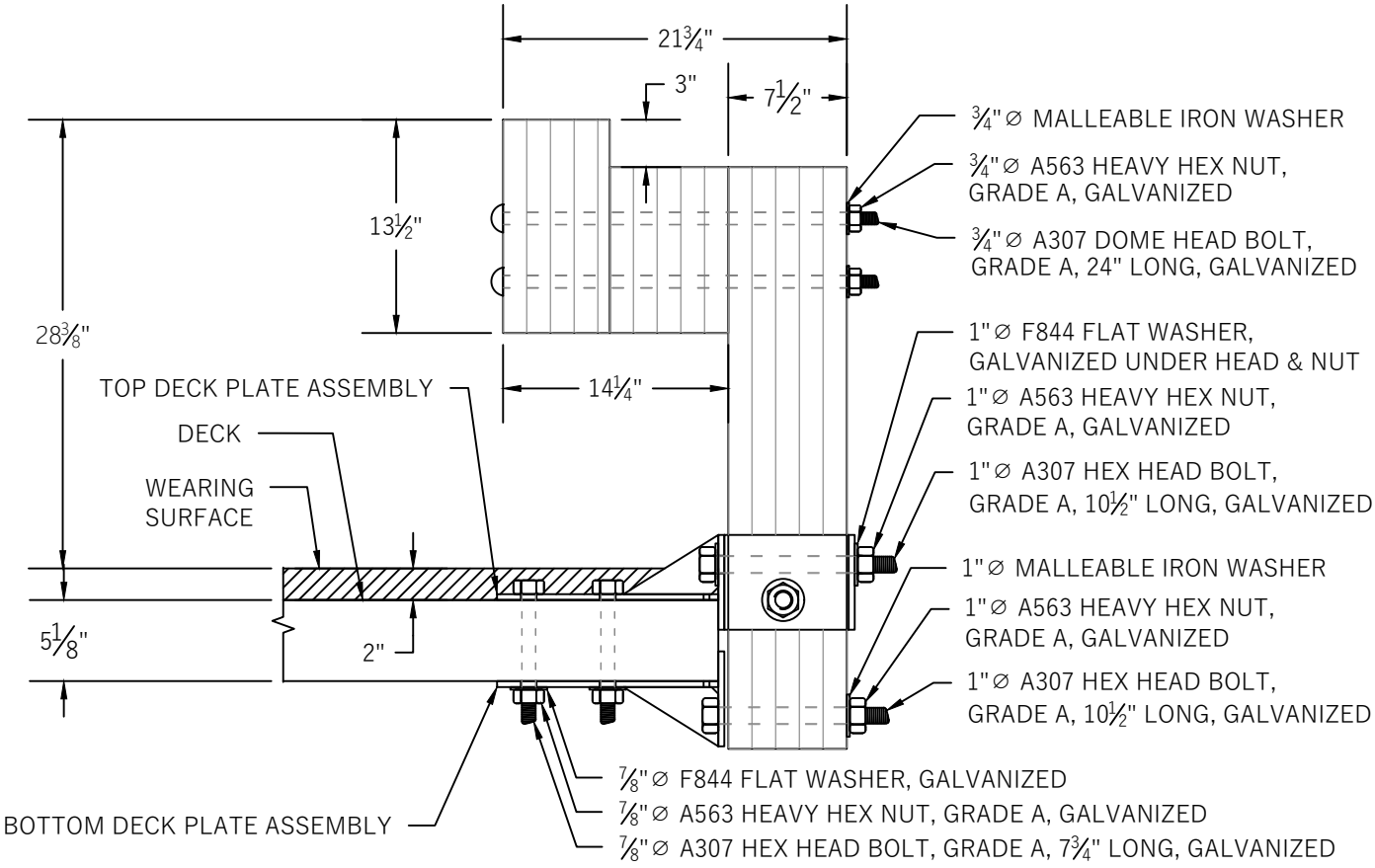
SOURCE: FHWA	**BRIDGE RAIL NAME:** TIMBER BRIDGE RAIL SYSTEM ONE		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 3 SOURCE: TTI TEST 7212-4 AND TEST 7212-5	**SHEET #** 5 OF 5



BRIDGE RAIL PLAN



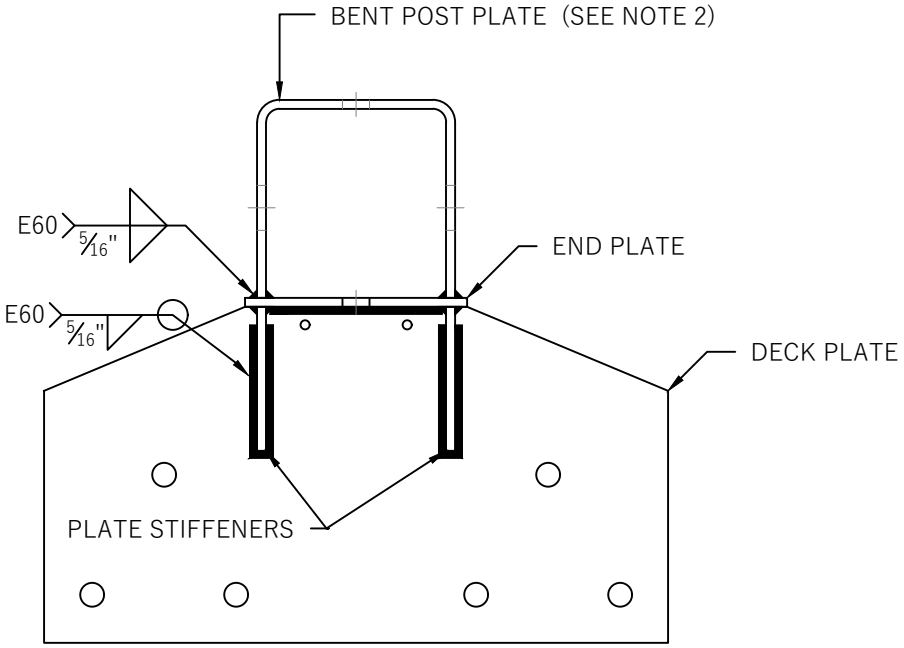
BRIDGE RAIL PROFILE

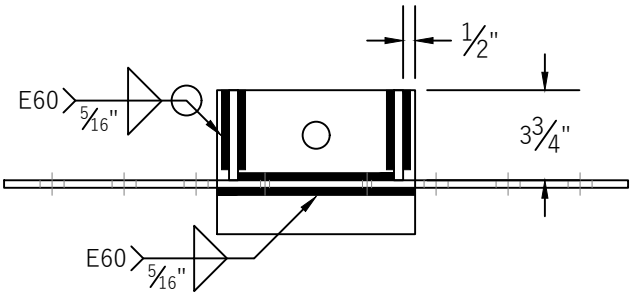


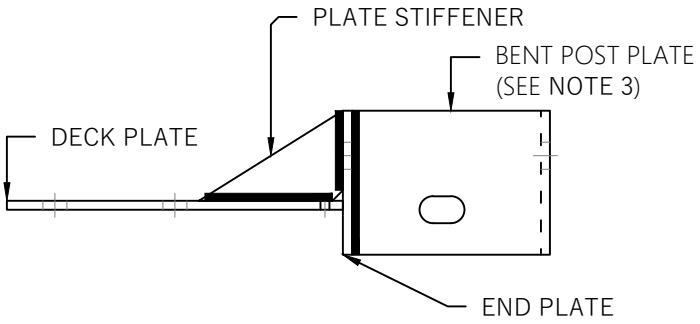
SECTION A-A BRIDGE RAILING CROSS SECTION

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 28.40 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 4 SOURCE: TRP-03-125-03	**SHEET #** 1 OF 6





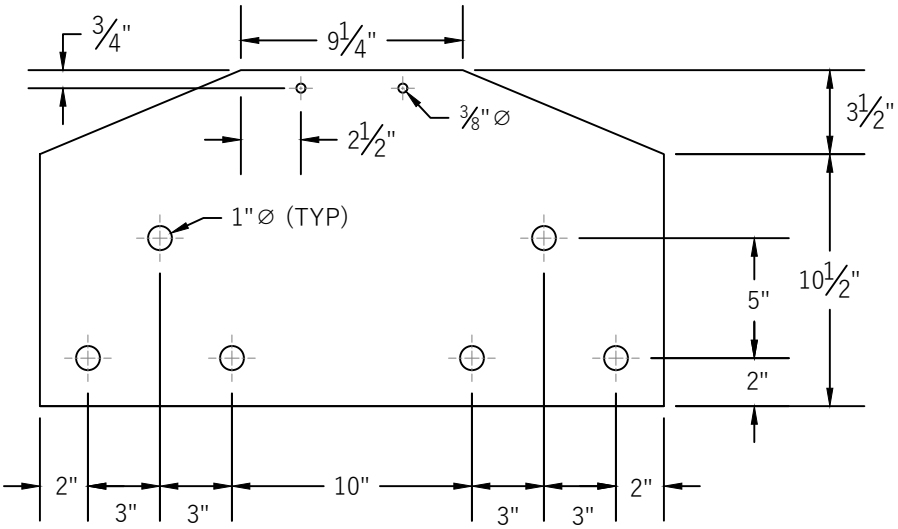


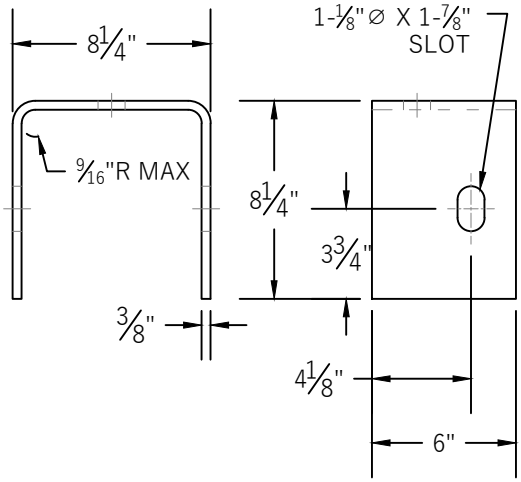
NOTES:

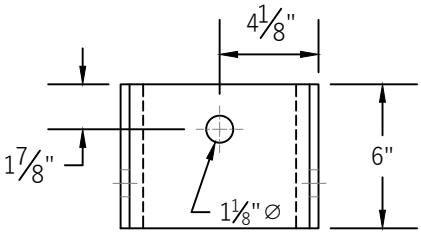
1) ALL STEEL IS A36, PAINTED
2) USE BENT POST PLATE FOR TOP POST PLATE ASSEMBLY ONLY. DO NOT INCLUDE BENT POST PLATE FOR BOTTOM POST PLATE ASSEMBLY.
3) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

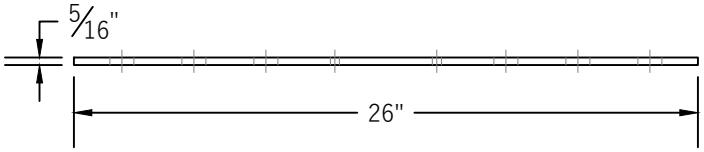
POST PLATE ASSEMBLIES

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 28.40 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 4 SOURCE: TRP-03-125-03	**SHEET #** 2 OF 6



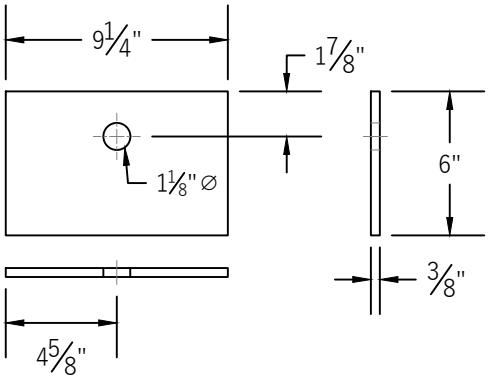


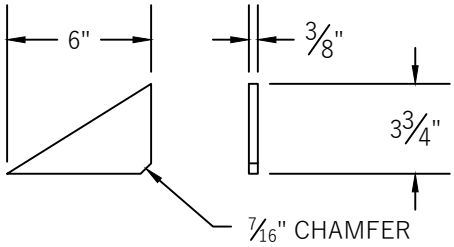




DECK PLATES

BENT POST PLATES

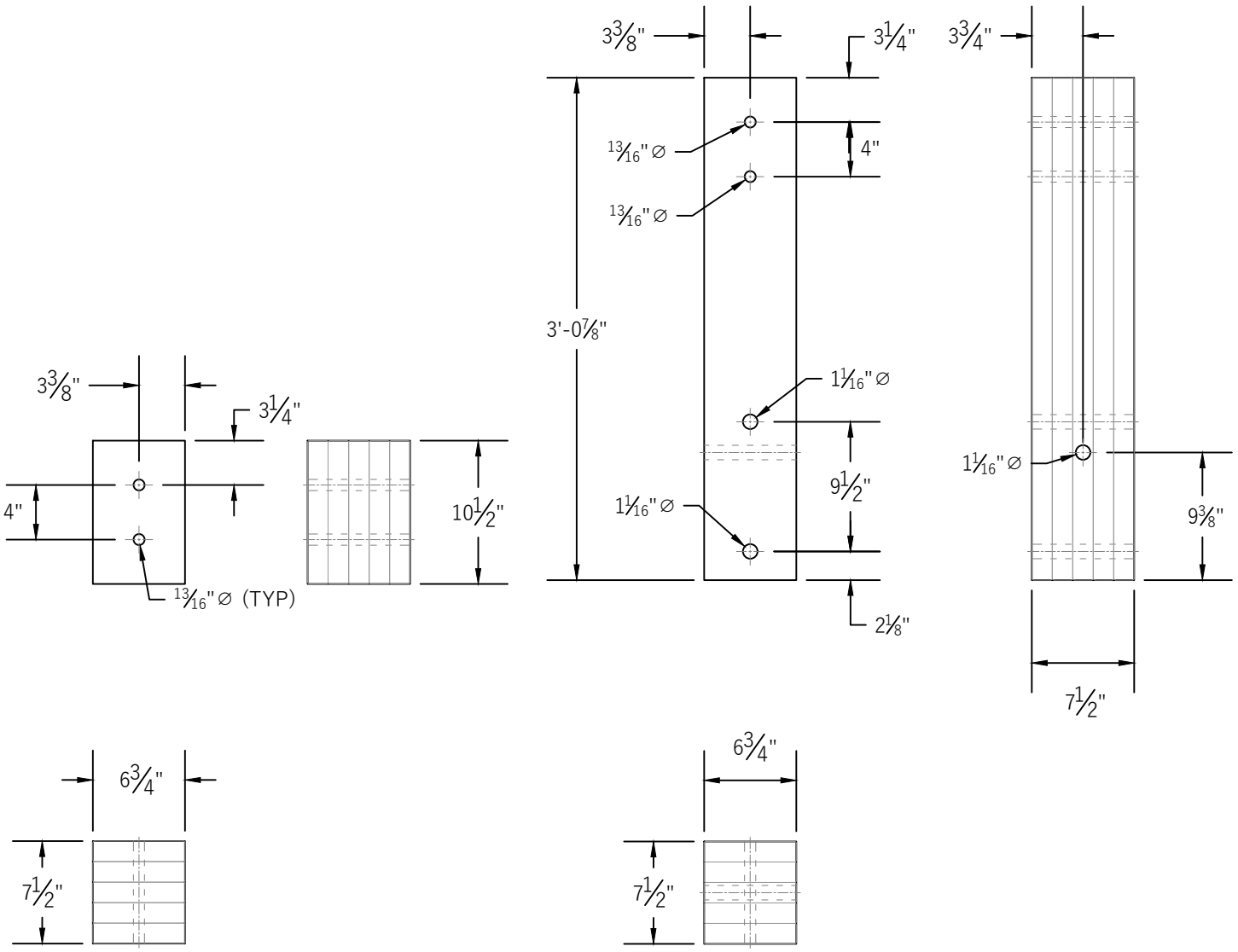




END PLATES

PLATE STIFFENER

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 28.40 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 4 SOURCE: TRP-03-125-03	**SHEET #** 3 OF 6



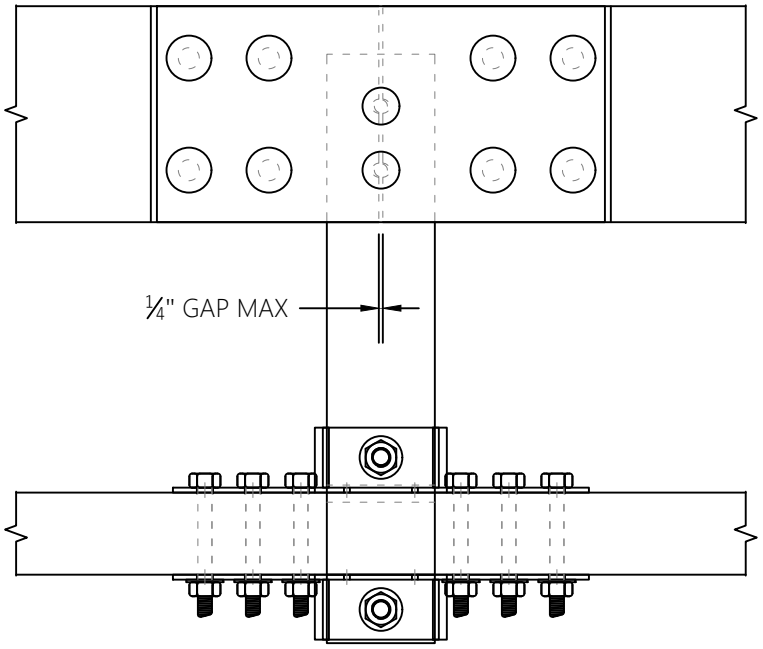
THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM BLOCK SHALL BE SOUTHERN YELLOW PINE COMBINATION NO. 47 OR DOUGLAS FIR COMBINATION NO. 1 TREATED WITH PENTACHLOROPHENOL IN HEAVY OIL TO A MINIMUM NET RETENTION OF 9.61 KG/M^3 AS SPECIFIED IN AWPA C14.

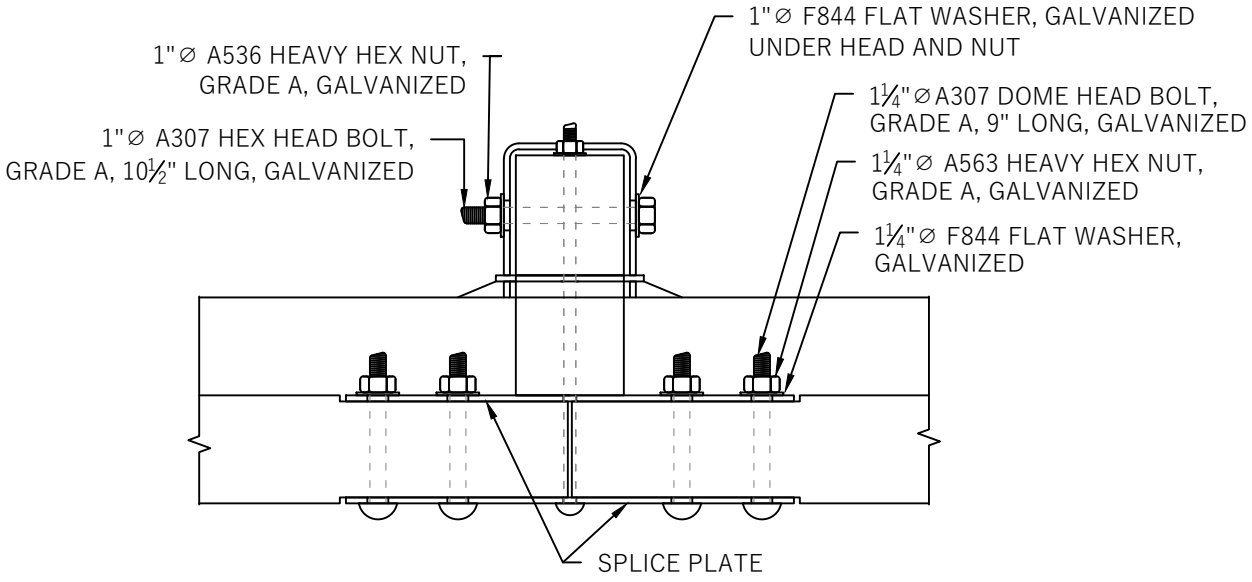
GLULAM BLOCK

THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM POST SHALL BE SOUTHERN YELLOW PINE COMBINATION NO. 48 OR DOUGLAS FIR COMBINATION NO. 2 TREATED WITH PENTACHLOROPHENOL IN HEAVY OIL TO A MINIMUM NET RETENTION OF 9.61 KG/M^3 AS SPECIFIED IN AWPA C14.

GLULAM POST

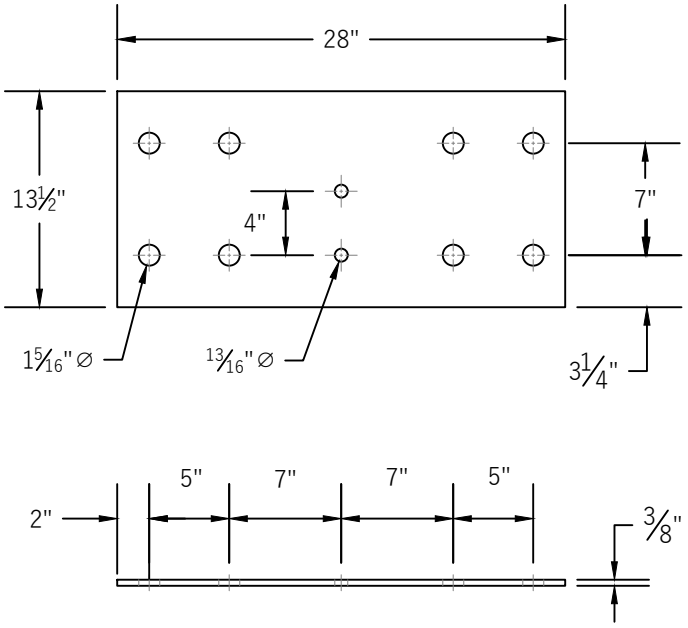
SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 28.40 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 4 SOURCE: TRP-03-125-03	**SHEET #** 4 OF 6





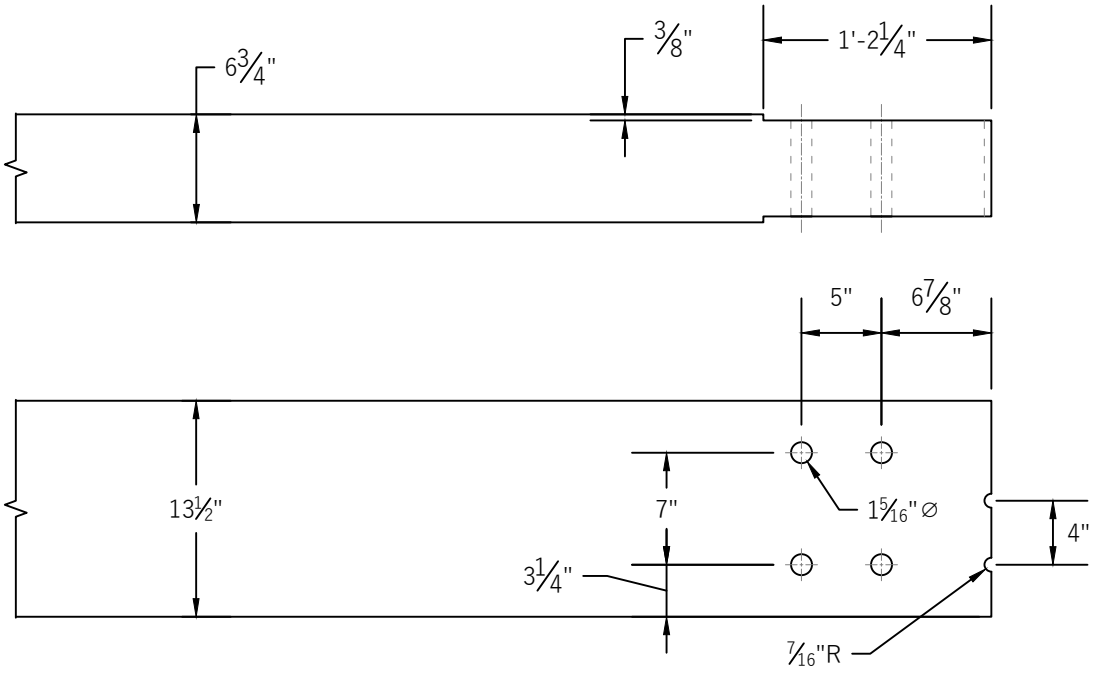
RAIL SPLICE DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 28.40 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 4 SOURCE: TRP-03-125-03	**SHEET #** 5 OF 6



SPLICE PLATE SHALL BE A36, PAINTED.

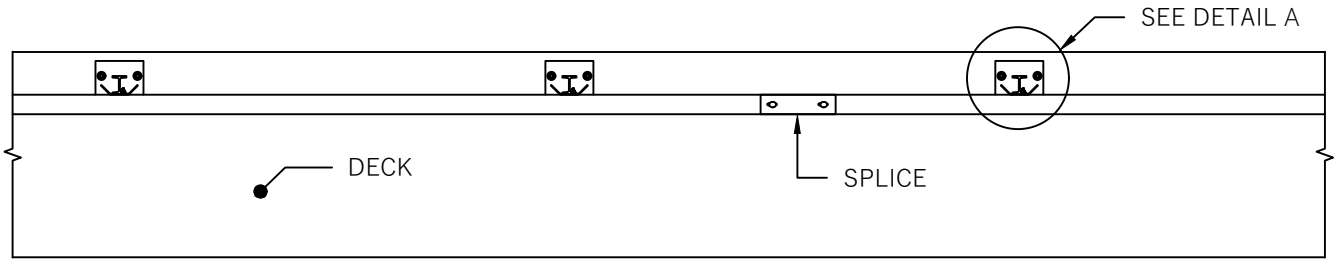
SPLICE PLATE



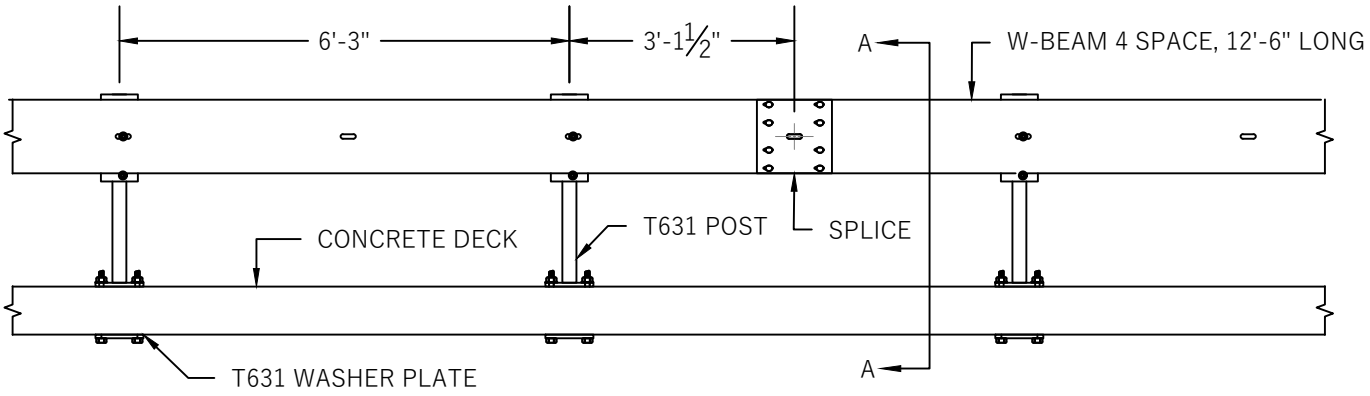
THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM RAIL SHALL BE SOUTHERN YELLOW PINE COMBINATION NO. 48. SHALL BE TREATED WITH PENTACHLOROPHENOL IN HEAVY OIL TO A MINIMUM NET RETENTION OF 9.61 KG/M^3 AS SPECIFIED IN AWPA C14

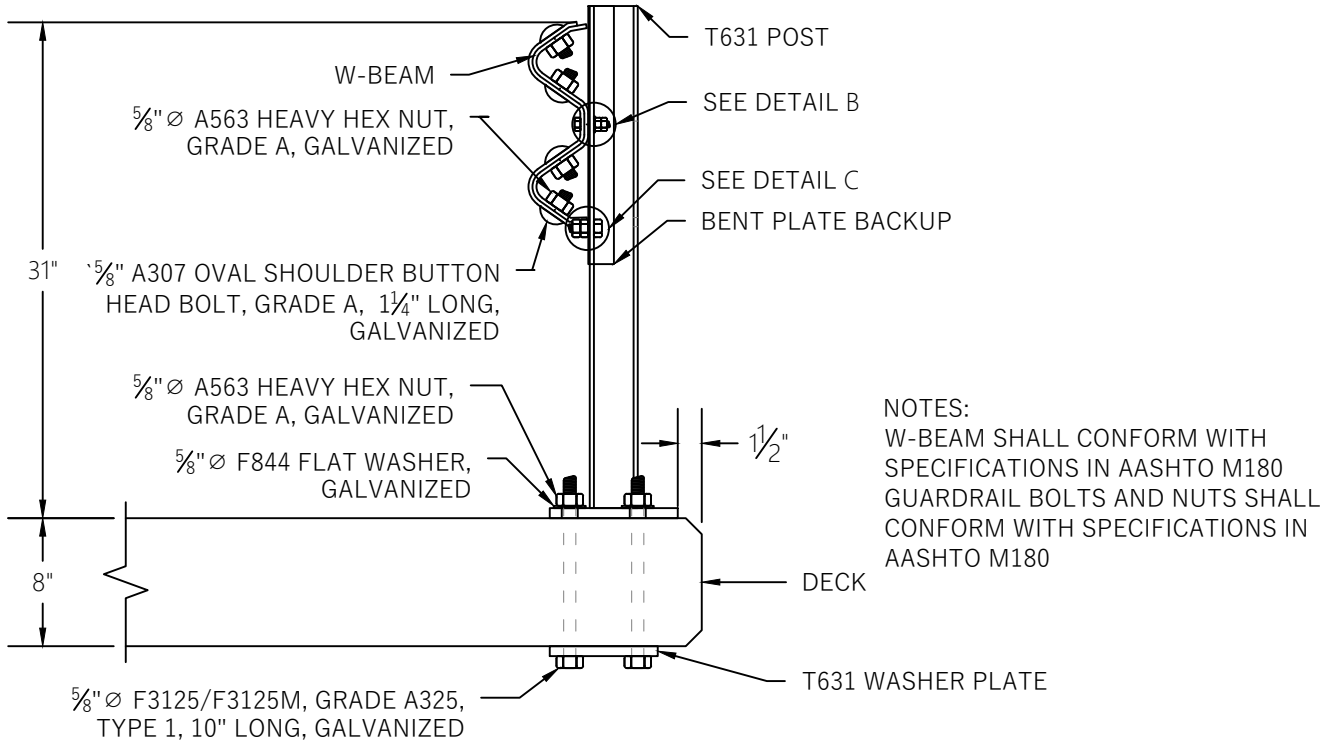
GLULAM RAIL - SPLICE BORING

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM BRIDGE RAILING		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 28.40 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 4 SOURCE: TRP-03-125-03	**SHEET #** 6 OF 6



BRIDGE RAIL PLAN

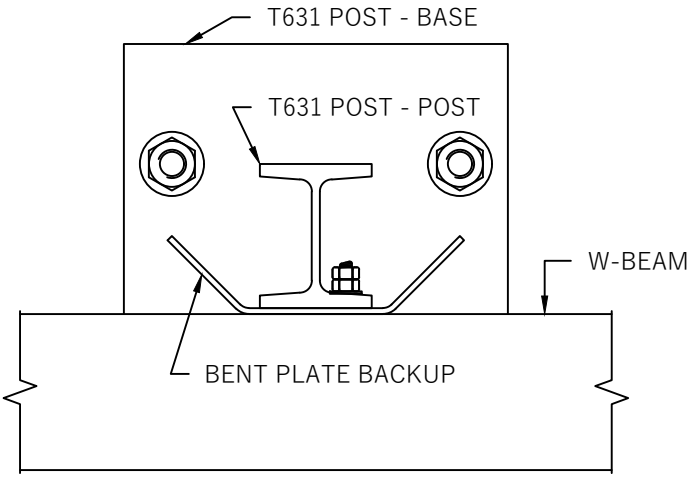




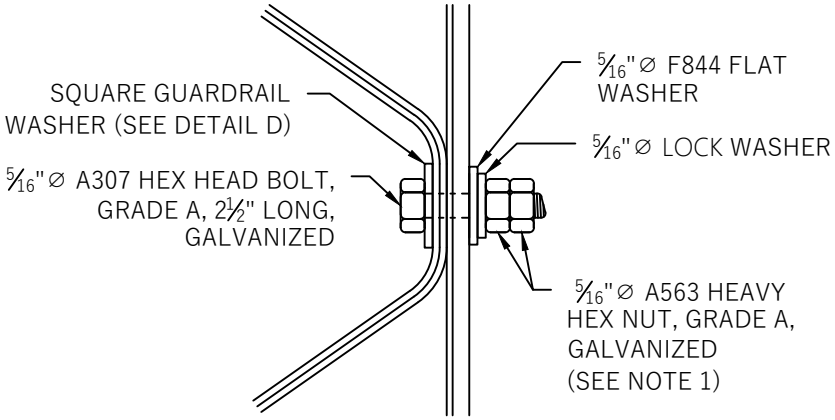
SECTION A-A
BRIDGE RAILING CROSS SECTION

MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

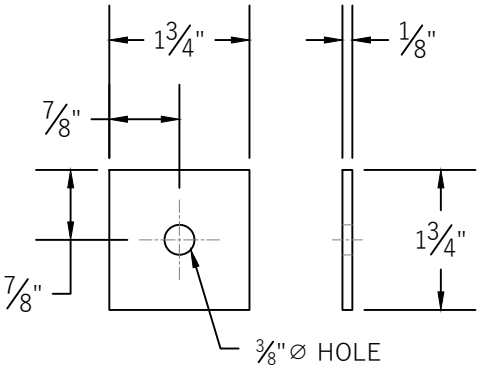
SOURCE: FHWA	**BRIDGE RAIL NAME:** TX DOT T631 BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-2	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 5 SOURCE: TTI 9-1002-12	**SHEET #** 1 OF 4



DETAIL A

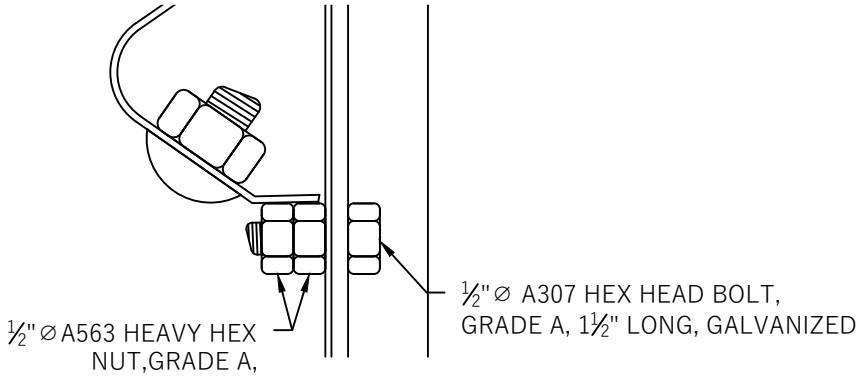


DETAIL B



SHALL BE A36, GALVANIZED IN ACCORDANCE WITH AASHTO M 111

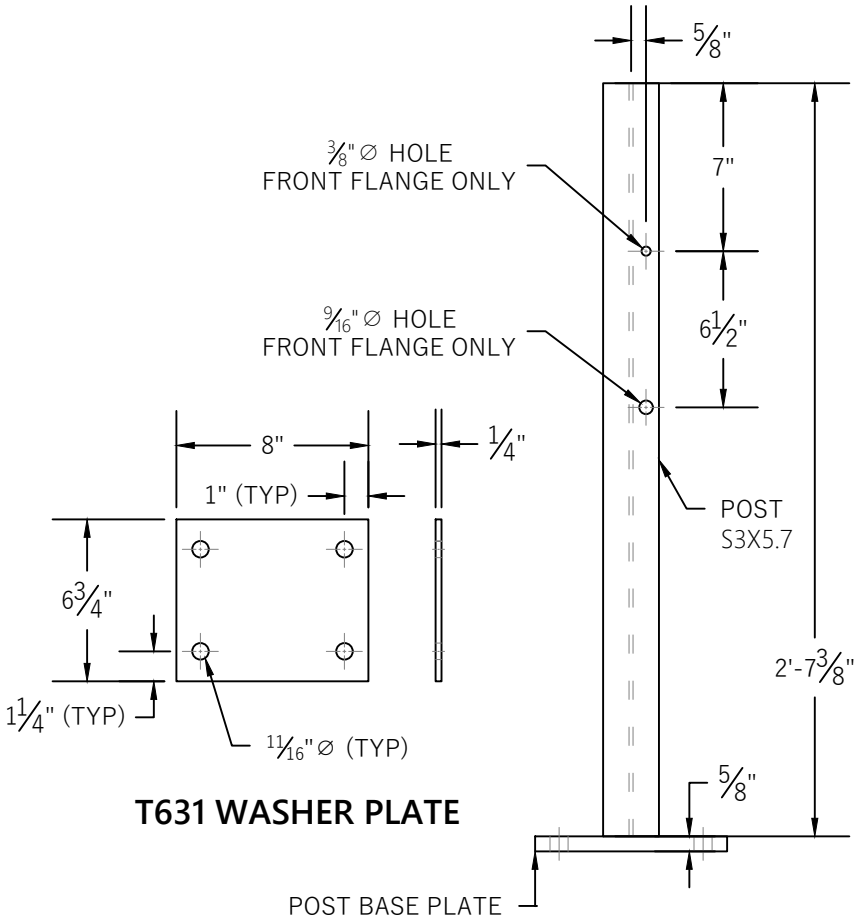
DETAIL D
SQUARE GUARDRAIL WASHER



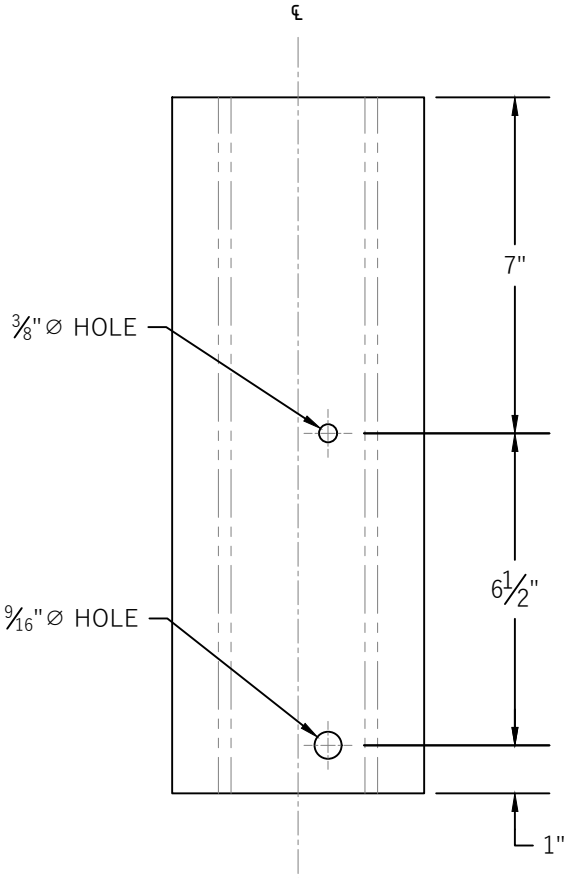
DETAIL C

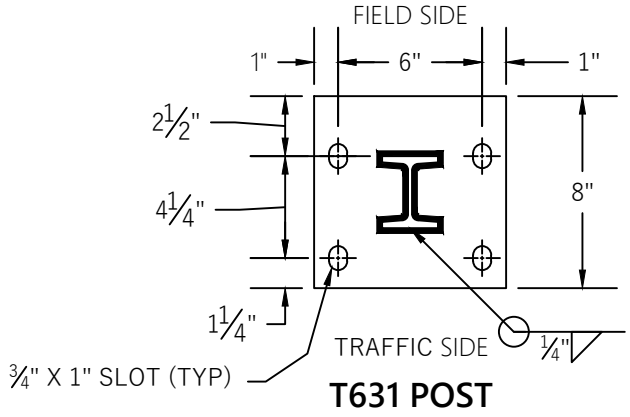
NOTES
TIGHTEN THE FIRST NUT BY HAND UNTIL THE TOP AND BOTTOM EDGES OF THE RAIL ENGAGE THE BENT PLATE BACKUP (THE BENT PLATE BACKUP SHOULD BE SNUG AGAINST THE POST). THEN TIGHTEN ONE ROUND WITH A WRENCH AND SECURE WITH SECOND NUT.

SOURCE: FHWA	**BRIDGE RAIL NAME:** TX DOT T631 BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-2	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 5 SOURCE: TTI 9-1002-12	**SHEET #** 2 OF 4

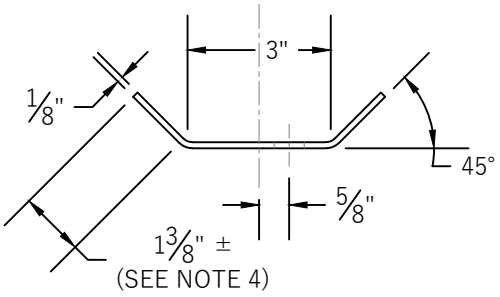


T631 WASHER PLATE





T631 POST

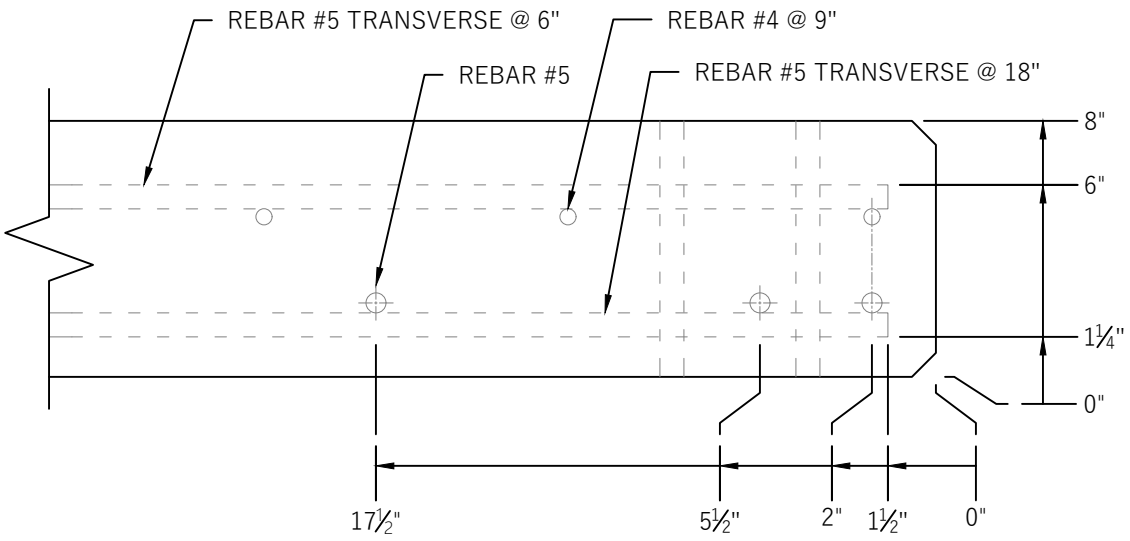


BENT PLATE BACKUP

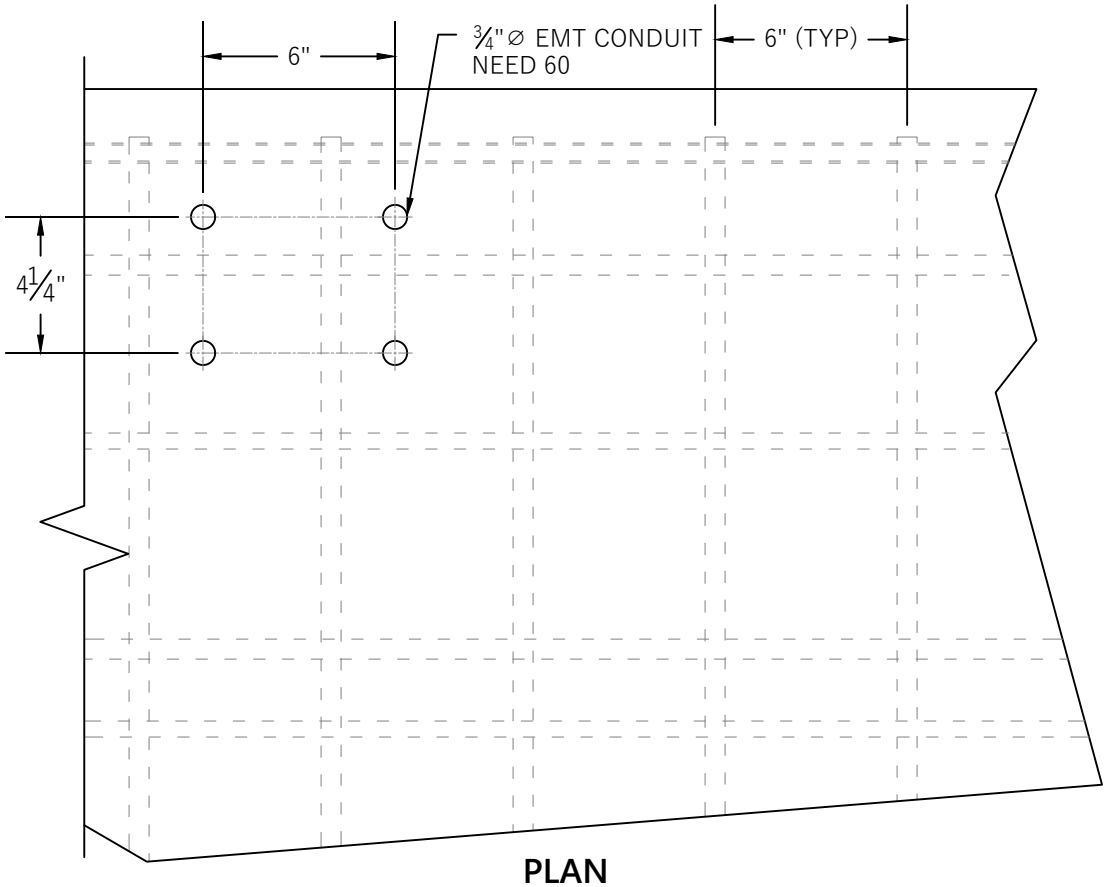
NOTES:

1) T631 POST - BASE PLATE IS A529 GRADE 55
2) T631 POST - POST IS A992
3) T631 WASHER PLATE IS A36
4) THIS DIMENSION IS APPROXIMATE.
5) BENT PLATE BACKUP IS MADE FROM 6" WIDE A36 PLATE.
6) USE INDUSTRY STANDARD FOR BENT PLATE BACKUP BEND RADIUS.
7) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

SOURCE: FHWA	**BRIDGE RAIL NAME:** TX DOT T631 BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-2	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 5 SOURCE: TTI 9-1002-12	**SHEET #** 3 OF 4



CROSS SECTION



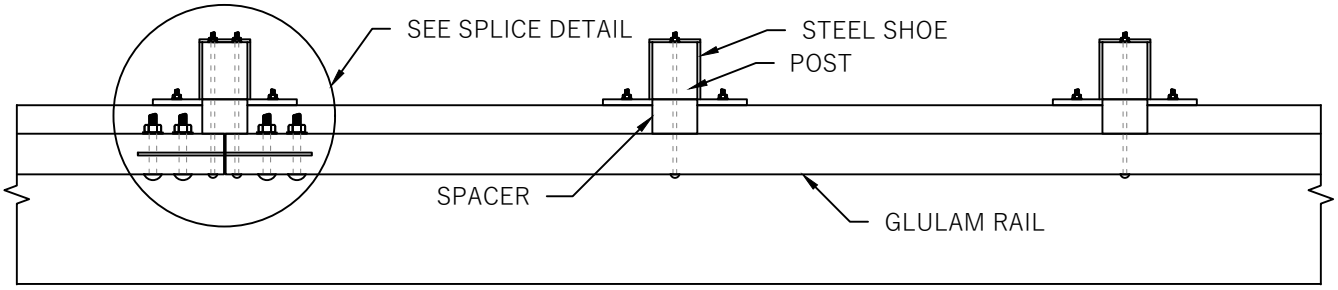
PLAN

CONCRETE AND REBAR DETAILS

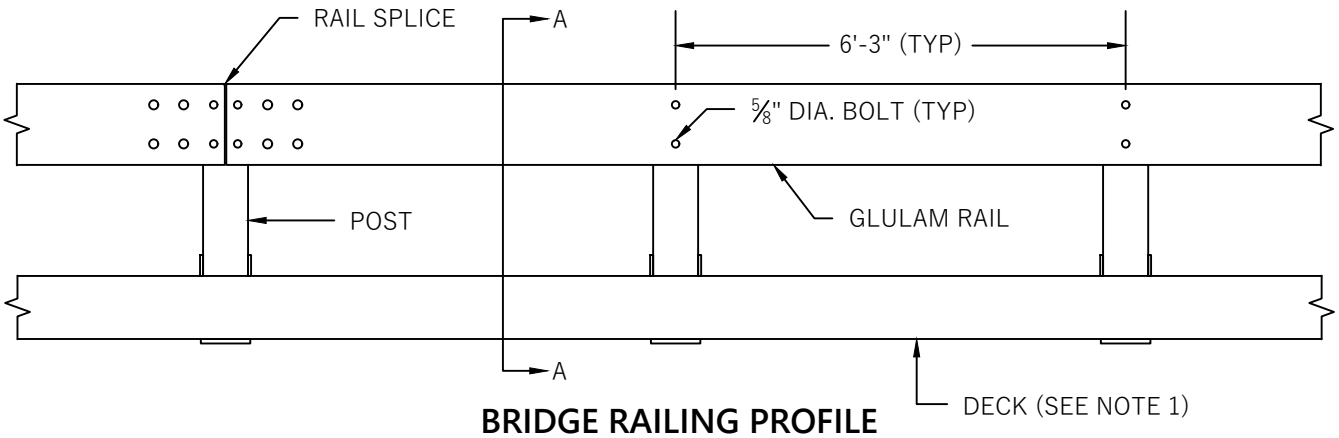
NOTES:

1) CONCRETE IS CLASS S (4,000 PSI). REBAR IS GRADE 60. MINIMUM REBAR LAPS ARE 15" FOR #4 BARS (TOP MAT) AND 19" FOR #5 BARS (BOTTOM MAT)
2) CHAMFER EXPOSED EDGES OF THE DECK ¾"

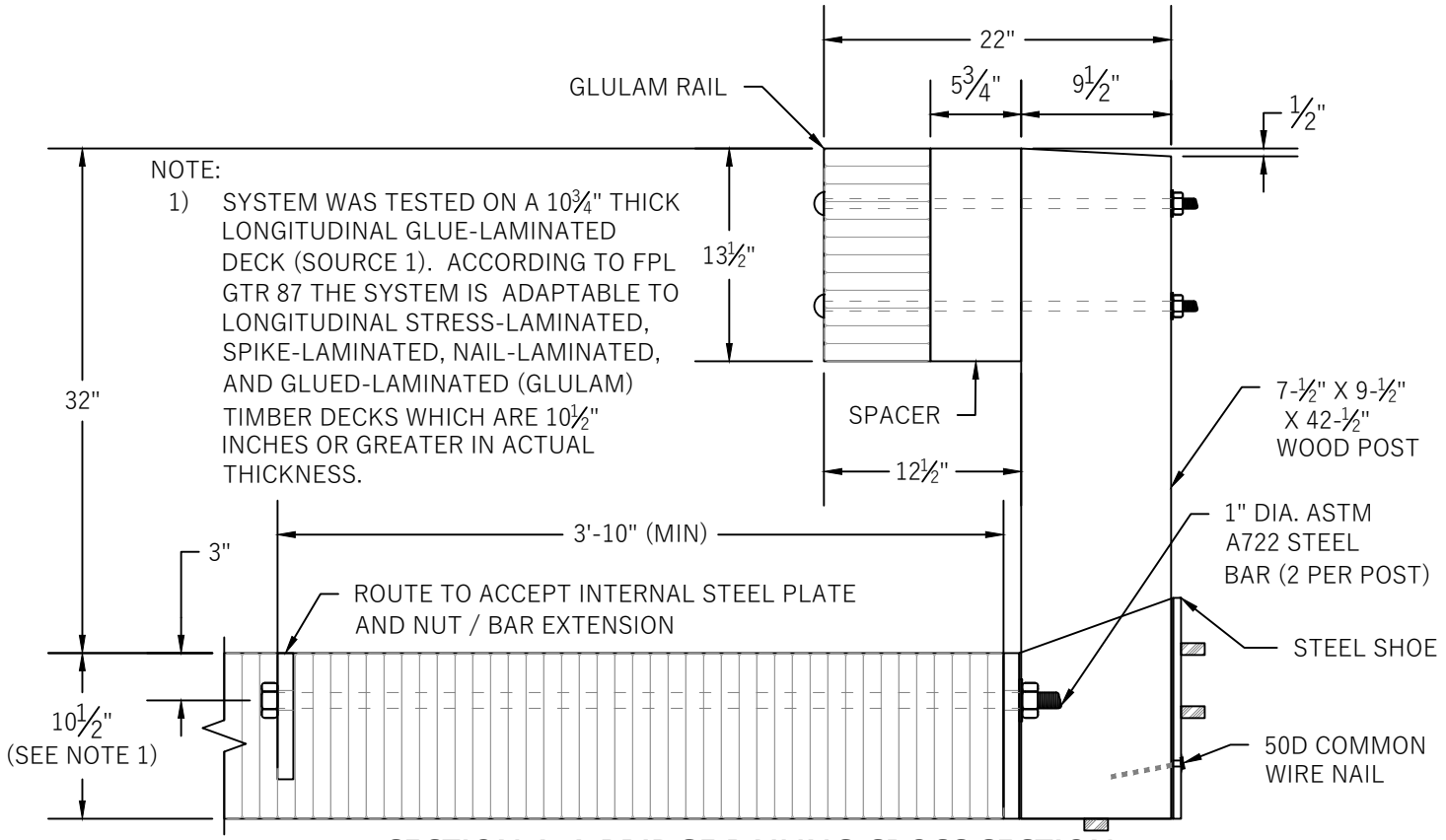
SOURCE: FHWA	**BRIDGE RAIL NAME:** TX DOT T631 BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-2	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 5 SOURCE: TTI 9-1002-12	**SHEET #** 4 OF 4



BRIDGE RAILING PLAN



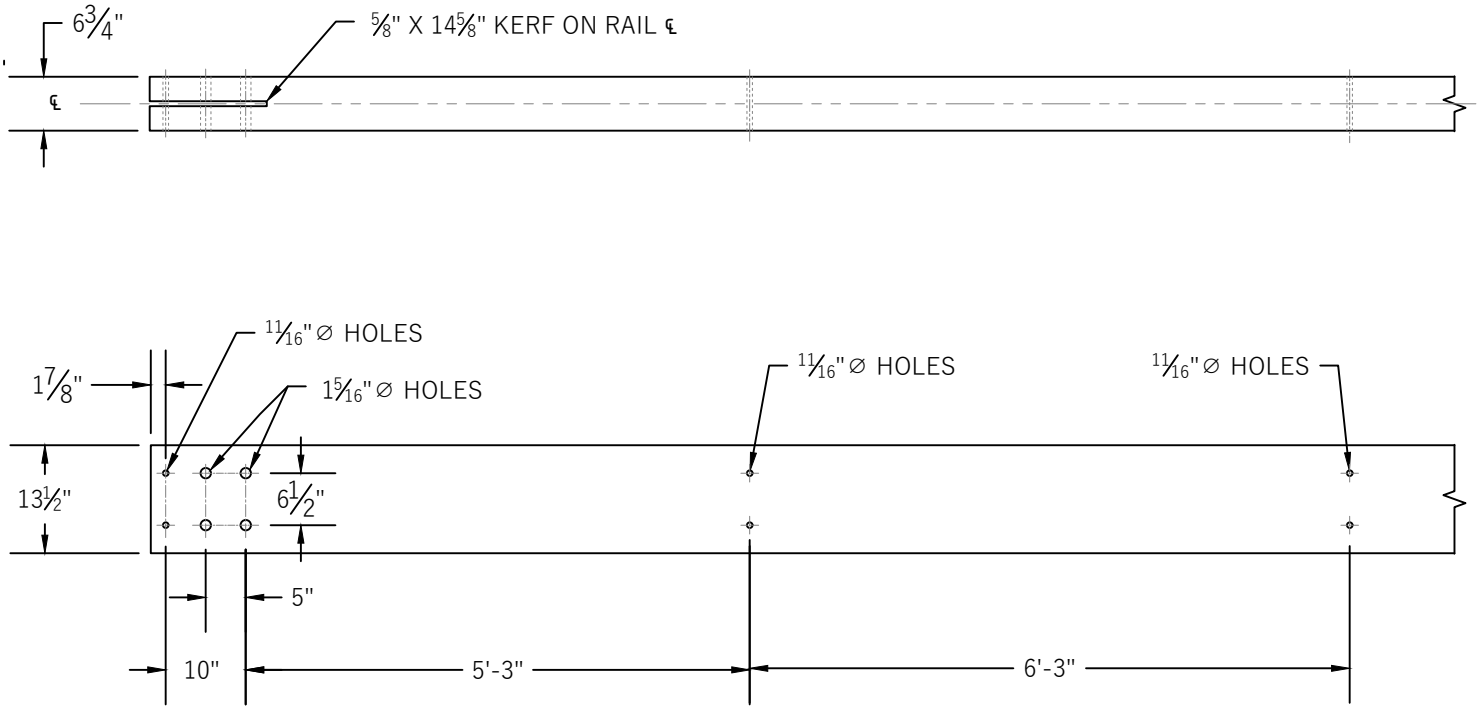
BRIDGE RAILING PROFILE



SECTION A-A BRIDGE RAILING CROSS SECTION

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

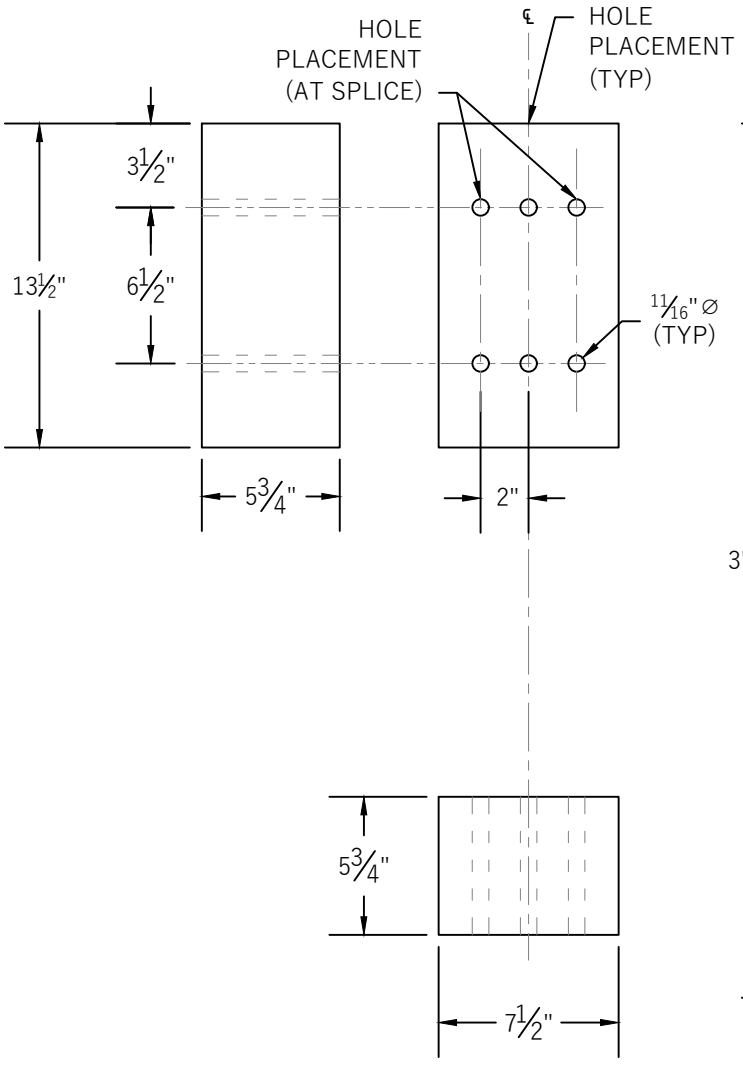
SOURCE: FHWA	**BRIDGE RAIL NAME:** GLULAM BRIDGE RAILING (SHOE BOX)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 32.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 6 SOURCE 1: TRP-03-429-20-R1 SOURCE 2: FPLGTR87	**SHEET #** 1 OF 6



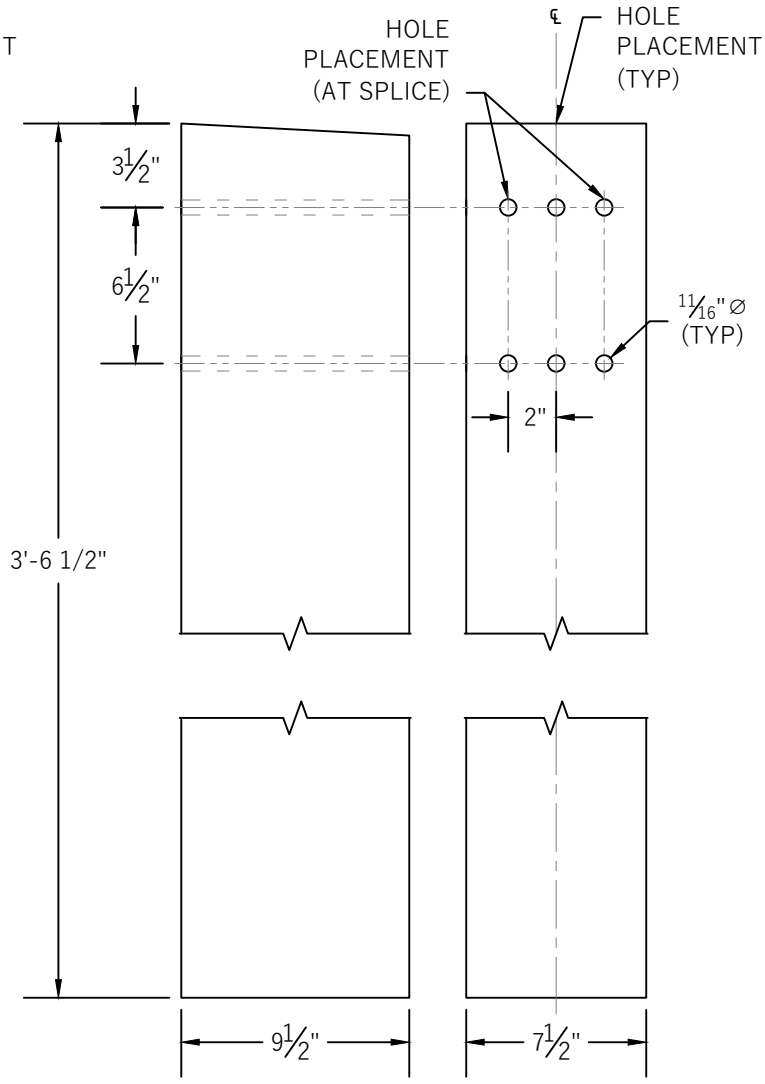
GLULAM RAIL BORING

THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM RAIL SHALL BE HORIZONTALLY LAMINATED GLULAM TIMBER: VISUALLY GRADED WESTERN SPECIES COMBINATION NO. 2 OR VISUALLY GRADED SOUTHERN YELLOW PINE COMBINATION NO. 48. OTHER SPECIES AND GRADES OF GLULAM TIMBER MAY BE USED PROVIDED THAT THE MINIMUM TABULATED VALUES ARE NOT LESS THAN THE FOLLOWING: F_{byy}= 1,800 LB/IN^2, E = 1,800,000 LB/IN^2. GLULAM TIMBER SHALL COMPLY WITH THE REQUIREMENTS OF OF AASHTO M 168 AND SHALL BE PRESSURE TREATED WITH WOOD PRESERVATIVE IN ACCORDANCE WITH AASHTO M 133.

SOURCE: FHWA	**BRIDGE RAIL NAME:** GLULAM BRIDGE RAILING (SHOE BOX)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 32.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 6 SOURCE 1: TRP-03-429-20-R1 SOURCE 2: FPLGTR87	**SHEET #** 2 OF 6



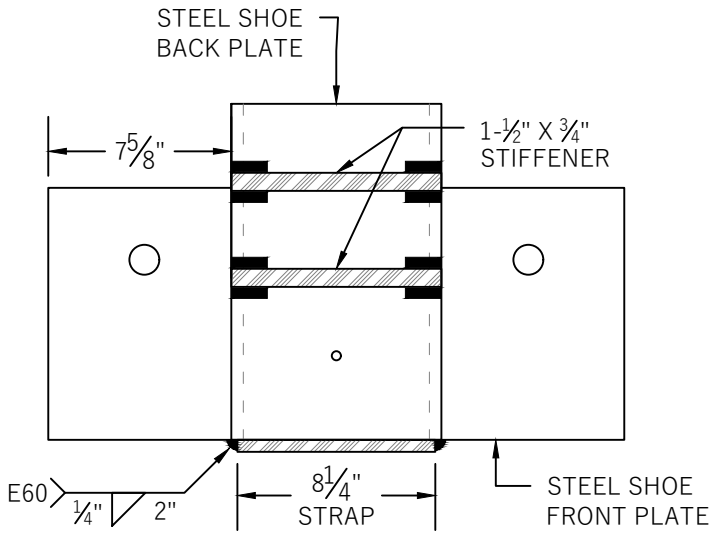
SPACER



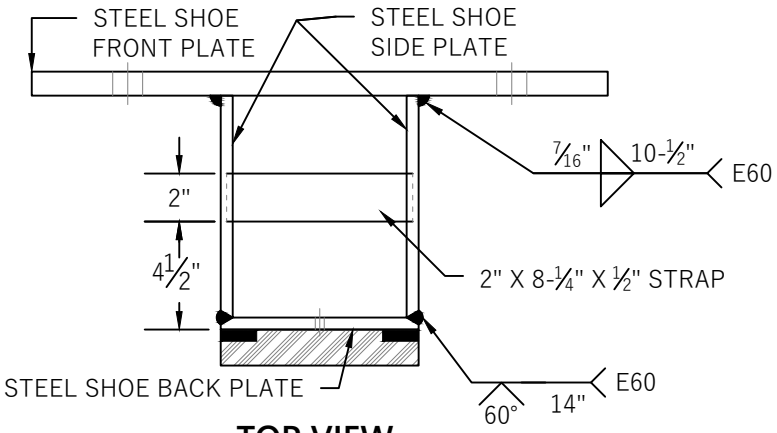
WOOD POST

THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: POSTS AND SPACER BLOCKS MAY BE SAWN LUMBER OR GLULAM. IF SAWN LUMBER: VISUALLY GRADED NO. 1 SOUTHERN YELLOW PINE OR DOUGLAS FIR LARCH. GLULAM AND OTHER SPECIES OF SAWN LUMBER MAY BE USED, PROVIDED THE MINIMUM TABULATED VALUES ARE NO LESS THAN THE FOLLOWING: F_b =1,350 LB/IN^2 E = 1,500,000 LB/IN^2. SAWN LUMBER AND GLULAM TIMBER SHALL COMPLY WITH THE REQUIREMENTS OF AASHTO M 168 AND SHALL BE PRESSURE TREATED WITH WOOD PRESERVATIVE IN ACCORDANCE WITH AASHTO M 133

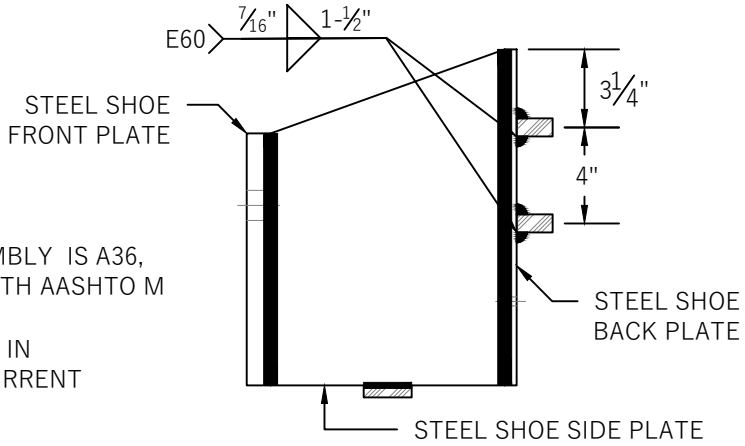
SOURCE: FHWA	**BRIDGE RAIL NAME:** GLULAM BRIDGE RAILING (SHOE BOX)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 32.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 6 SOURCE 1: TRP-03-429-20-R1 SOURCE 2: FPLGTR87	**SHEET #** 3 OF 6



BACK VIEW



TOP VIEW



SIDE VIEW

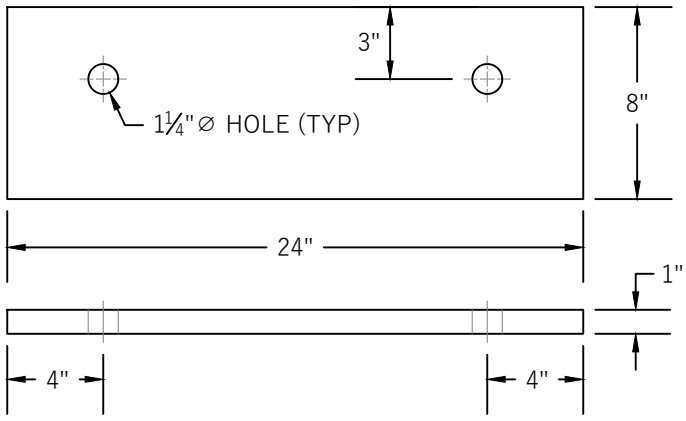
NOTE:

1) ALL STEEL FOR THE SHOE ASSEMBLY IS A36, GALVANIZED IN ACCORDANCE WITH AASHTO M 111 OR M 232.
2) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION

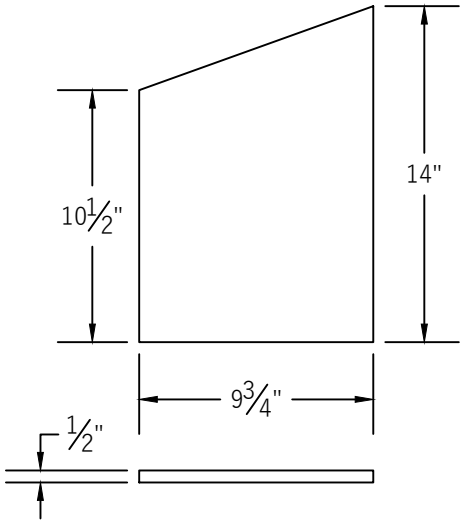
STEEL SHOE DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** GLULAM BRIDGE RAILING (SHOE BOX)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 32.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 6 SOURCE 1: TRP-03-429-20-R1 SOURCE 2: FPLGTR87	**SHEET #** 4 OF 6

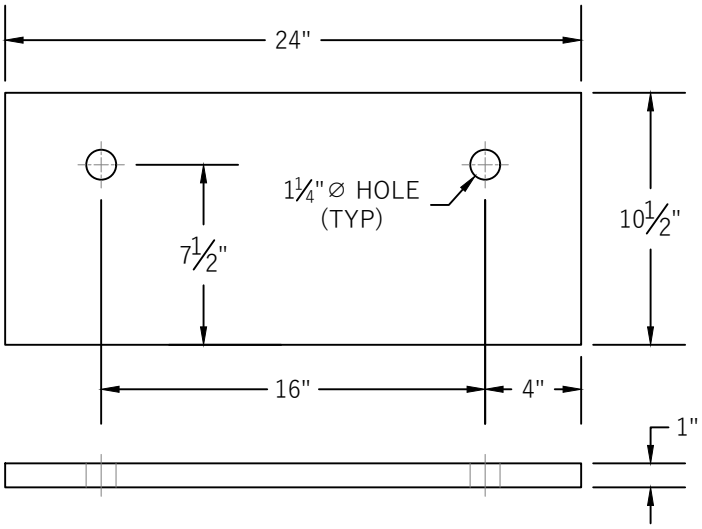
INTERNAL STEEL PLATE IS A36, GALVANIZED IN ACCORDANCE WITH AASHTO M 111 OR M 232



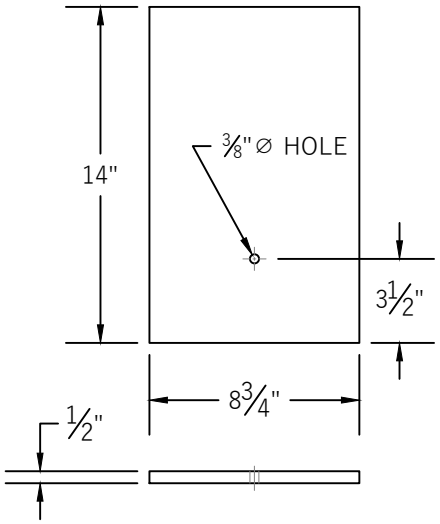
INTERNAL STEEL PLATE



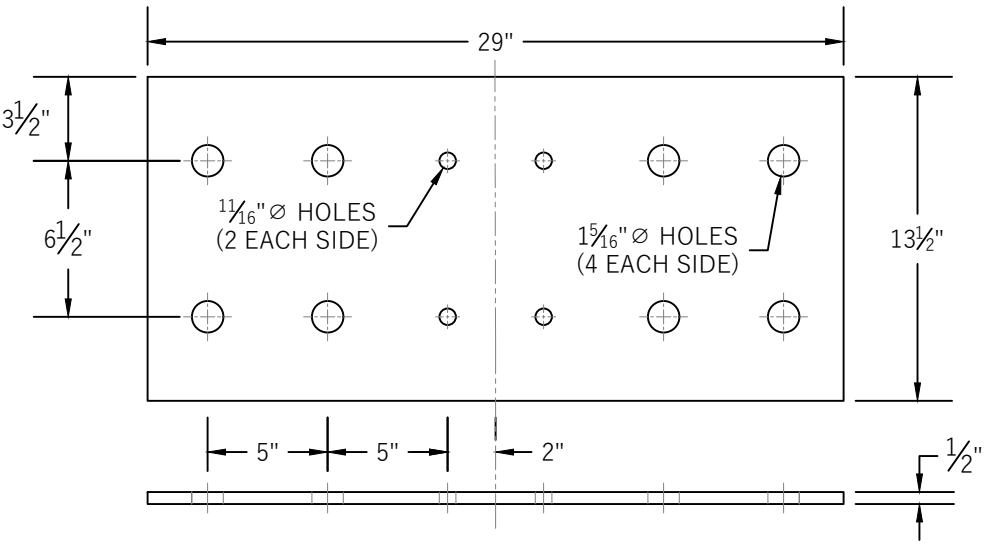
STEEL SHOE SIDE PLATE



STEEL SHOE FRONT PLATE



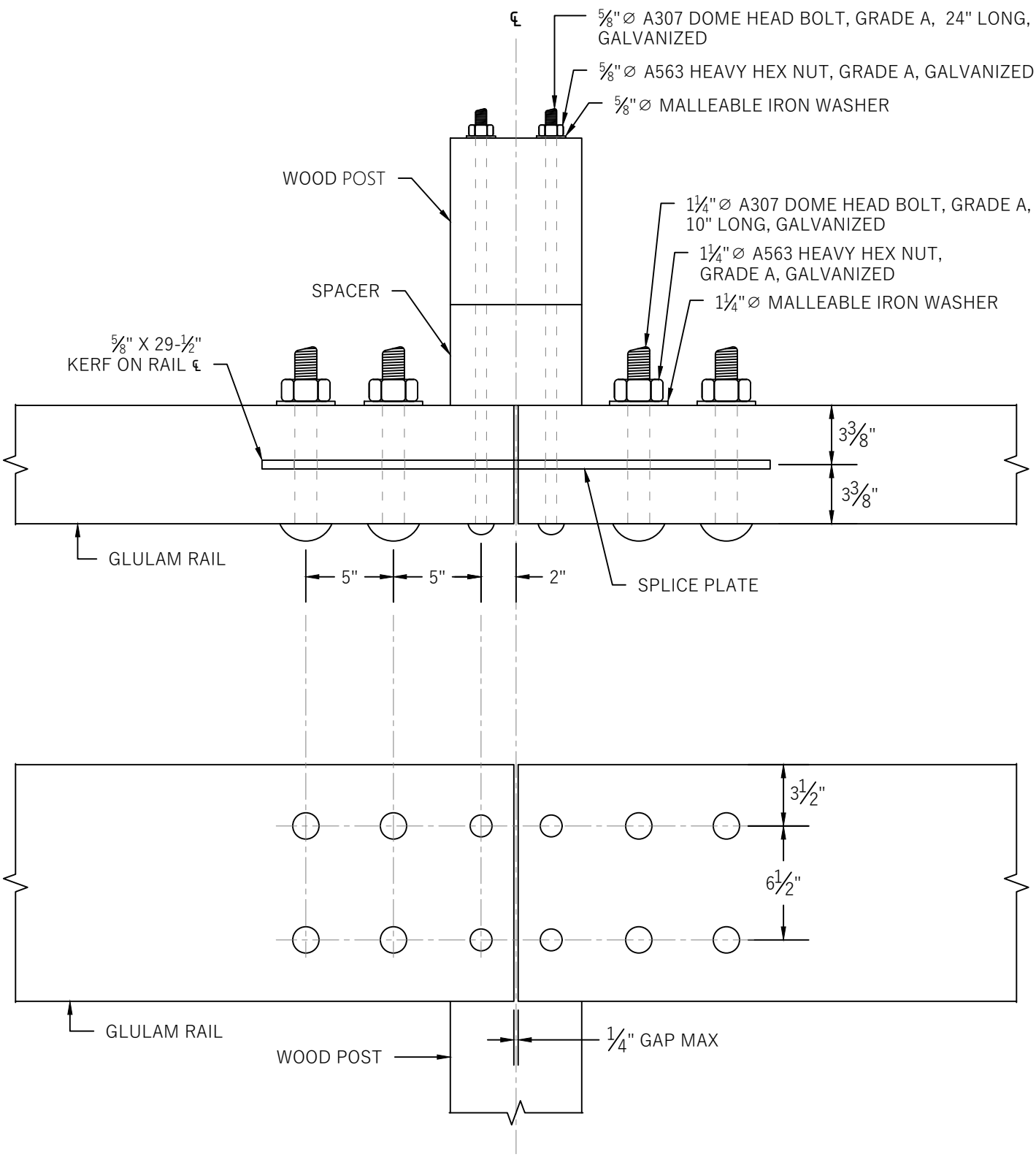
STEEL SHOE BACK PLATE



SPLICE PLATE IS A36, GALVANIZED IN ACCORDANCE WITH AASHTO M 111 OR M 232

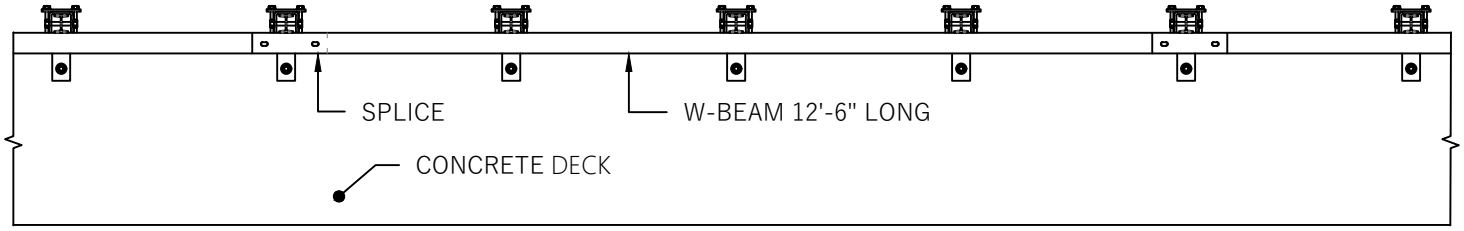
SPLICE PLATE

SOURCE: FHWA	**BRIDGE RAIL NAME:** GLULAM BRIDGE RAILING (SHOE BOX)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 32.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 6 SOURCE 1: TRP-03-429-20-R1 SOURCE 2: FPLGTR87	**SHEET #** 5 OF 6

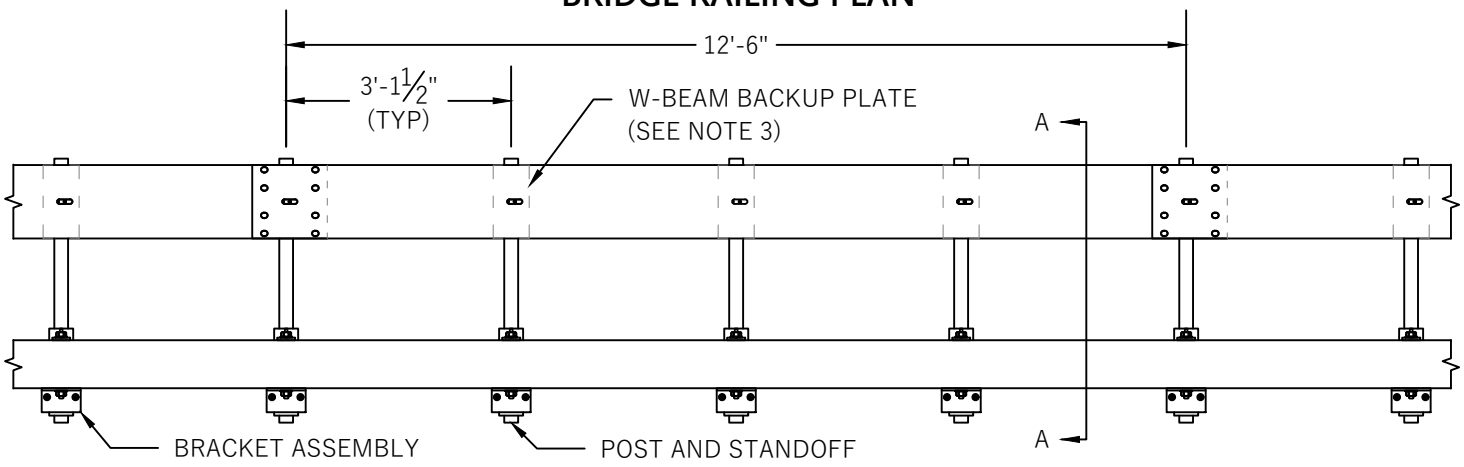


SPLICE DETAIL

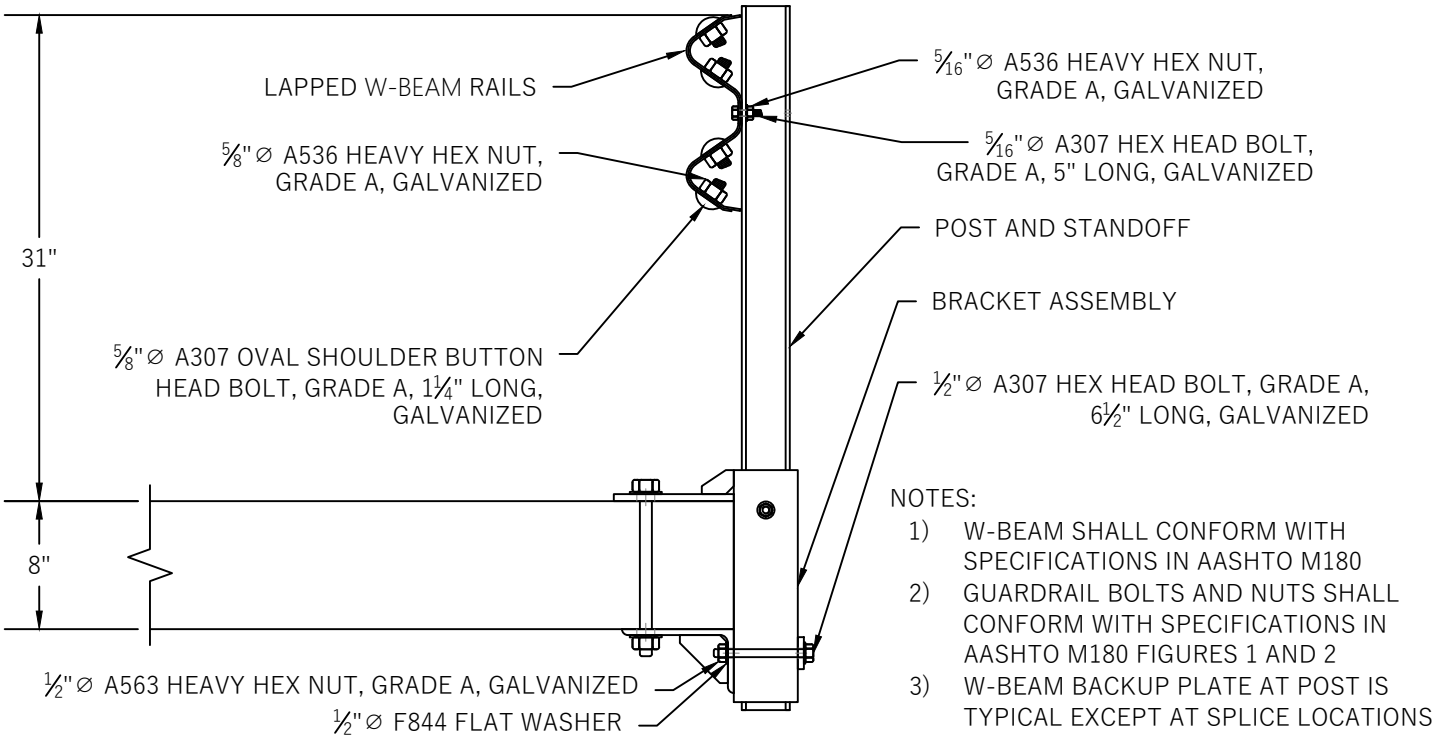
SOURCE: FHWA	**BRIDGE RAIL NAME:** GLULAM BRIDGE RAILING (SHOE BOX)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 32.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 6 SOURCE 1: TRP-03-429-20-R1 SOURCE 2: FPLGTR87	**SHEET #** 6 OF 6



BRIDGE RAILING PLAN



BRIDGE RAILING PROFILE



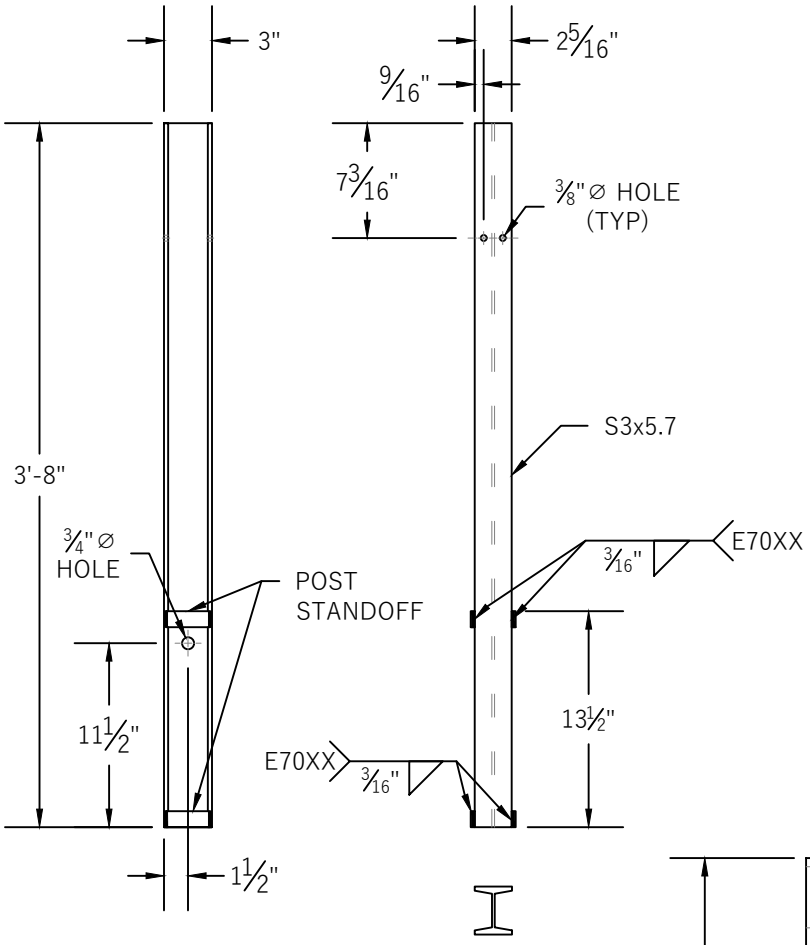
NOTES:

1) W-BEAM SHALL CONFORM WITH SPECIFICATIONS IN AASHTO M180
2) GUARDRAIL BOLTS AND NUTS SHALL CONFORM WITH SPECIFICATIONS IN AASHTO M180 FIGURES 1 AND 2
3) W-BEAM BACKUP PLATE AT POST IS TYPICAL EXCEPT AT SPLICE LOCATIONS

SECTION A-A BRIDGE RAILING CROSS SECTION

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

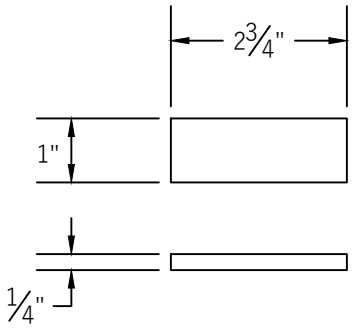
SOURCE: FHWA	**BRIDGE RAIL NAME:** LOW COST ENERGY ABSORBING BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-3	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 7 SOURCE: TRR NO. 2262 PP. 107-118	**SHEET #** 1 OF 6



NOTES:

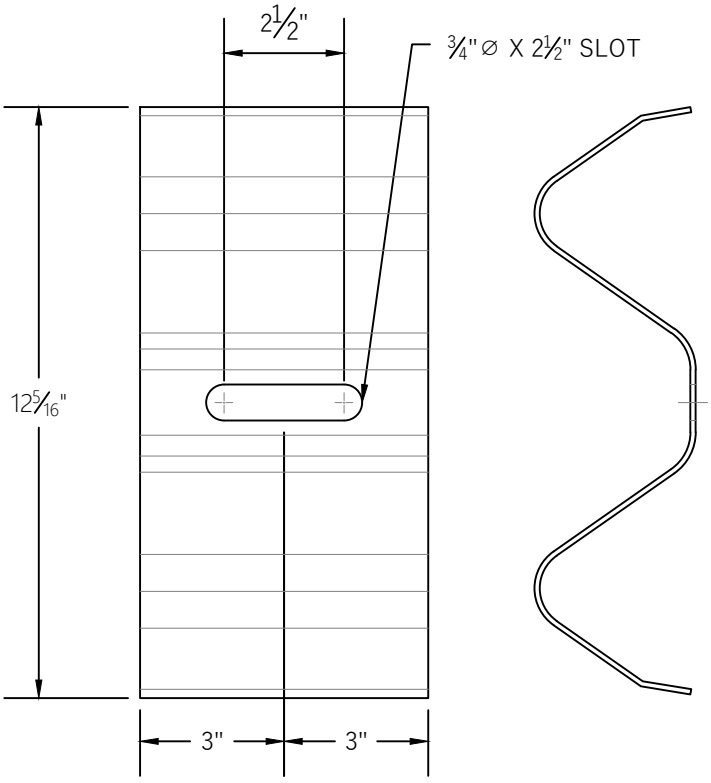
1) POST SHALL BE A992 GRADE 50, GALVANIZED
2) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

POST AND STANDOFF



STANDOFFS SHALL BE A992 GRADE 50, GALVANIZED

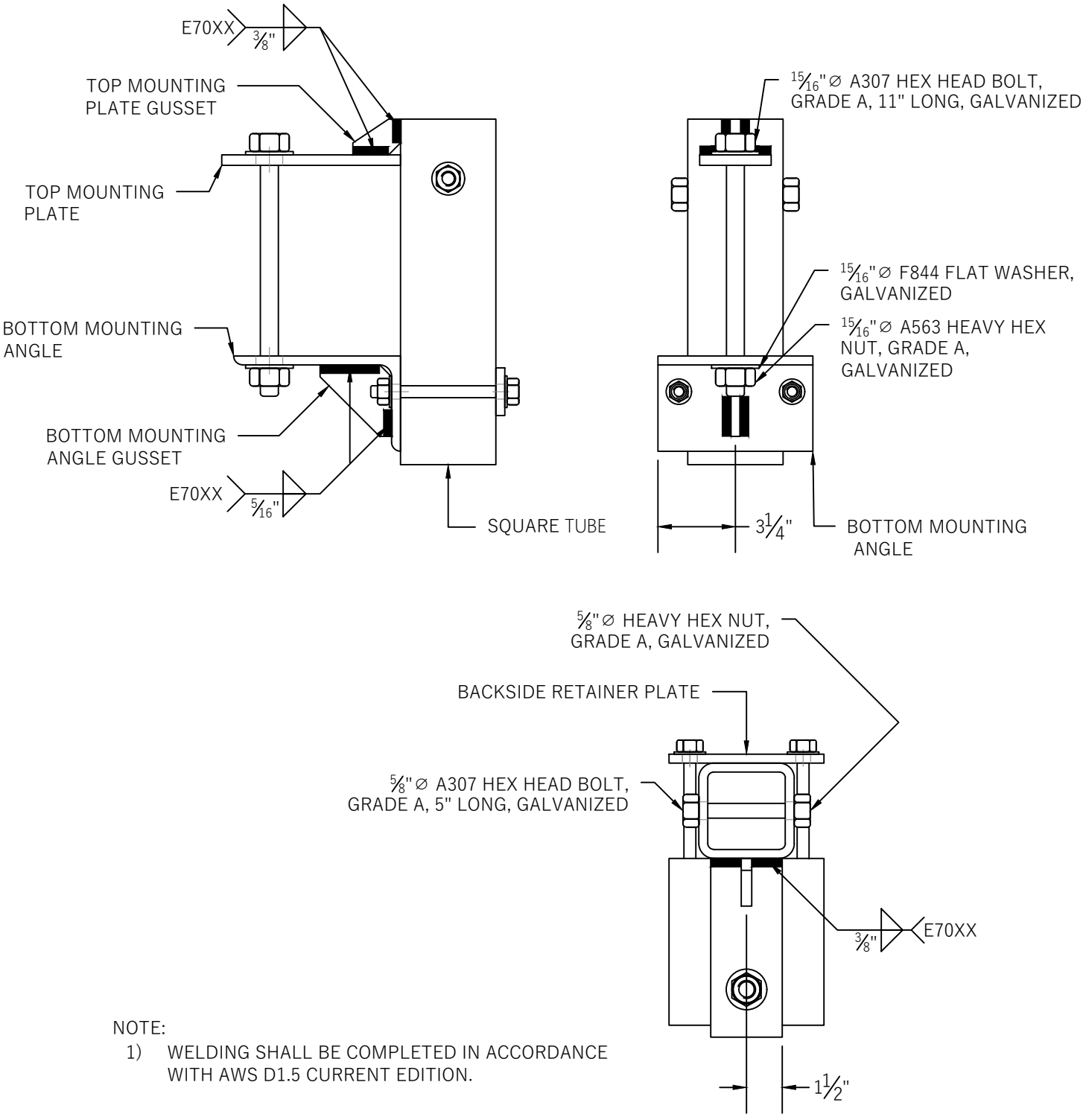
POST STANDOFF



W-BEAM BACKUP PLATE SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M 180 CLASS A.

W-BEAM BACKUP PLATE

SOURCE: FHWA	**BRIDGE RAIL NAME:** LOW COST ENERGY ABSORBING BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-3	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 7 SOURCE: TRR NO. 2262 PP. 107-118	**SHEET #** 2 OF 6

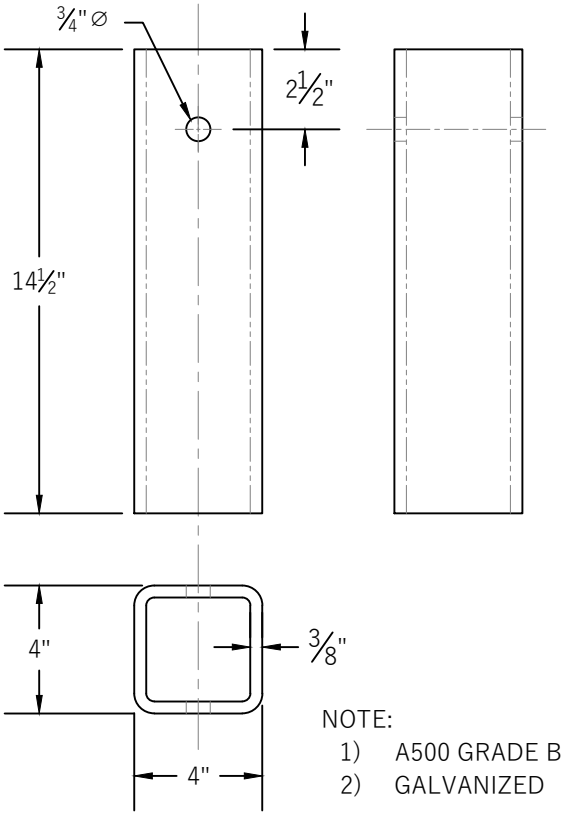


NOTE:

1) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

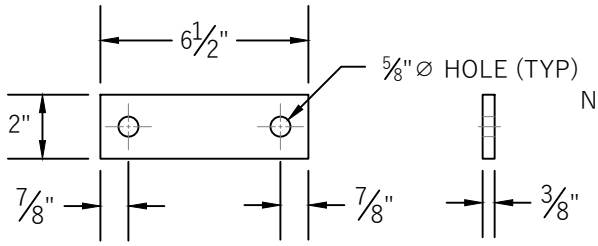
BRACKET ASSEMBLY

SOURCE: FHWA	**BRIDGE RAIL NAME:** LOW COST ENERGY ABSORBING BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-3	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 7 SOURCE: TRR NO. 2262 PP. 107-118	**SHEET #** 3 OF 6



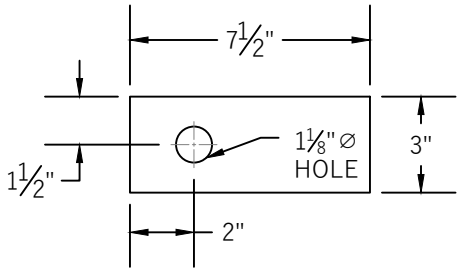
NOTE:
1) A500 GRADE B
2) GALVANIZED

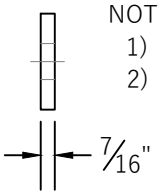
4X4 IN. SQUARE TUBE



NOTE:
1) A36
2) GALVANIZED

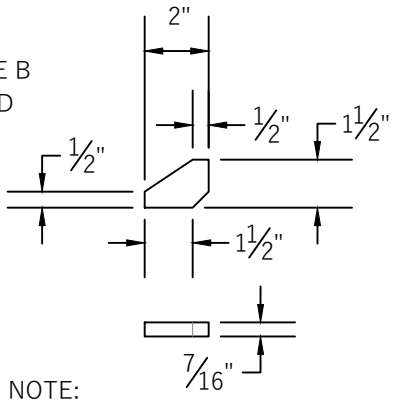
BACKSIDE RETAINER PLATE





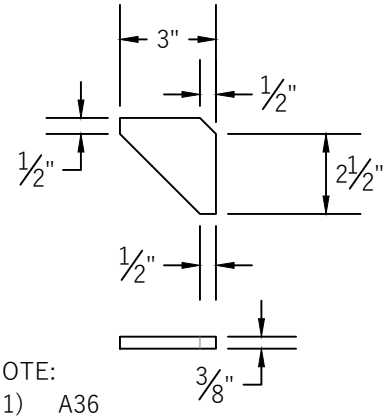
NOTE:
1) A572 GRADE 50
2) GALVANIZED

TOP MOUNTING PLATE



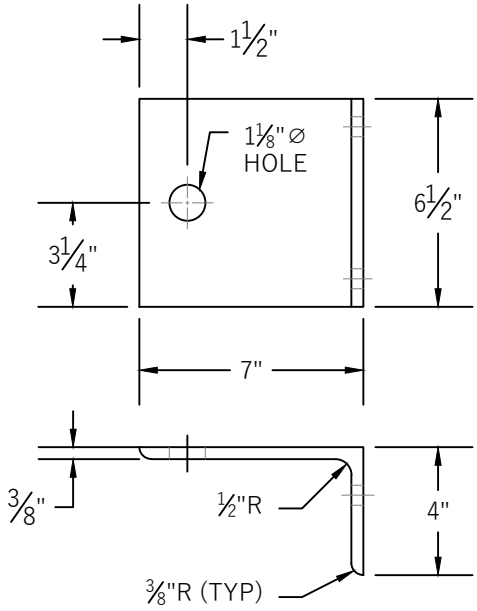
NOTE:
1) A36
2) GALVANIZED

TOP MOUNTING GUSSET



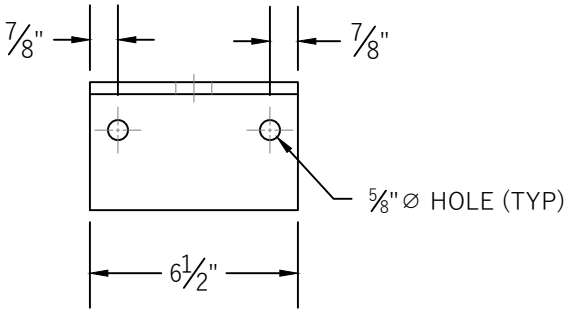
NOTE:
1) A36
2) GALVANIZED

BOTTOM MOUNTING GUSSET



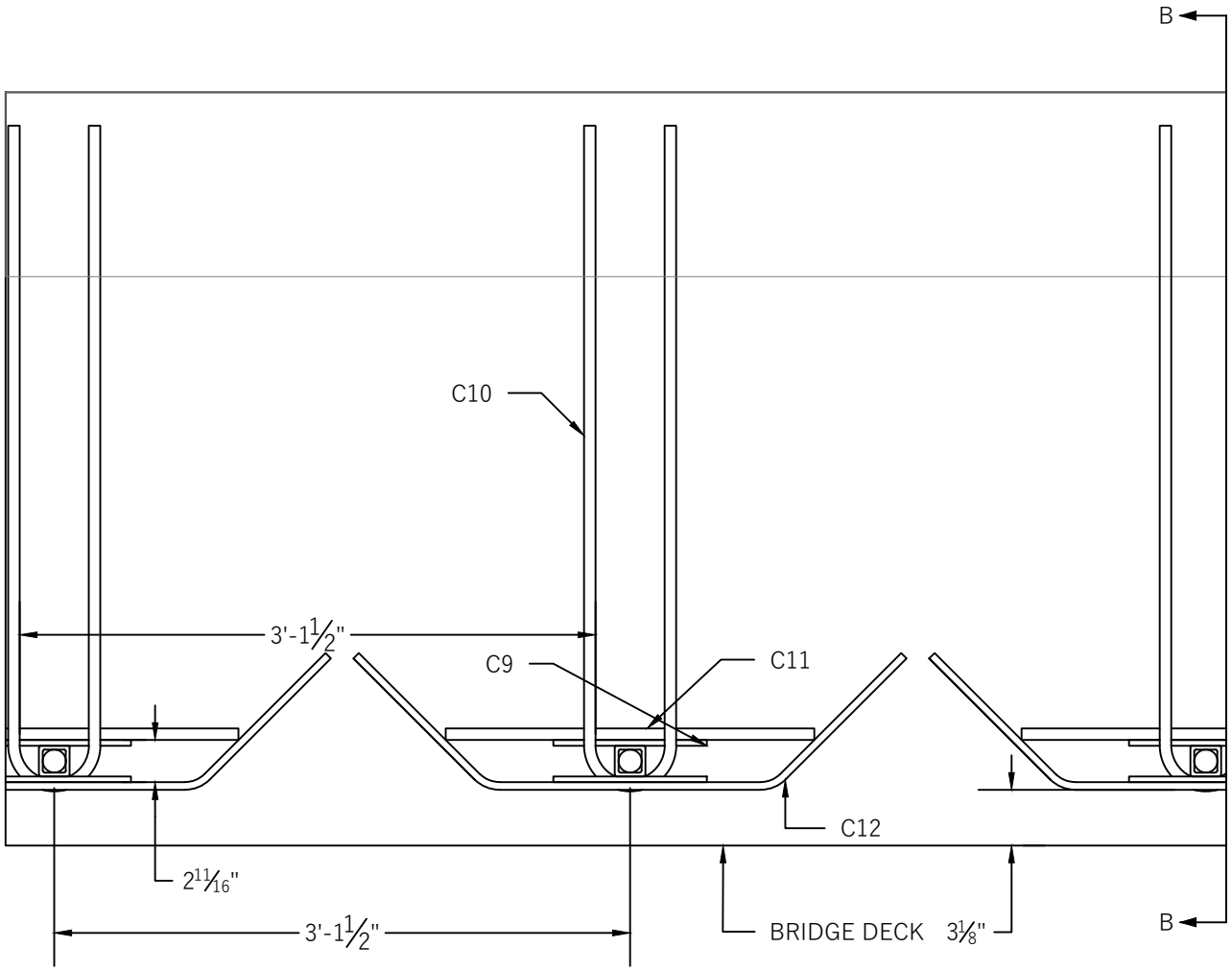
NOTE:
1) A36
2) GALVANIZED

BOTTOM MOUNTING ANGLE



BRACKET ASSEMBLY COMPONENTS

SOURCE: FHWA	**BRIDGE RAIL NAME:** LOW COST ENERGY ABSORBING BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-3	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 7 SOURCE: TRR NO. 2262 PP. 107-118	**SHEET #** 4 OF 6

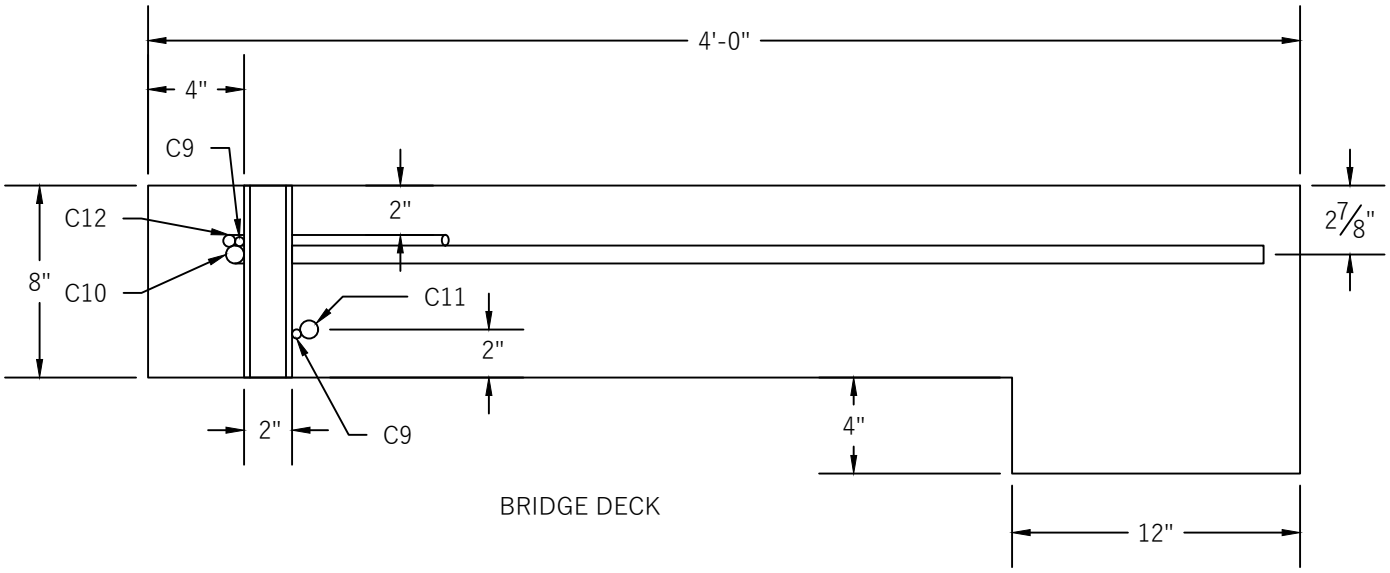


NOTES:

1) REBAR IS GRADE 60
2) THE ADDITIONAL REINFORCING REBAR PLACED IN THE BRIDGE DECK ARE SHOWN
3) FOR C9 AND C11, THE REBAR IS TIGHT AGAINST THE TUBE IN THE DECK AND TIED IN PLACE
4) C9 IS #3 STRAIGHT REBAR, 10" LONG
5) C10 IS #6 REBAR LOOP, TOTAL LENGTH UNBENT IS 89"
6) C11 IS #6 STRAIGHT REBAR, 24" LONG
7) C12 IS #4 BENT REBAR, TOTAL LENGTH UNBENT IS 42.5"

DECK REINFORCEMENT
PLAN VIEW

SOURCE: FHWA	**BRIDGE RAIL NAME:** LOW COST ENERGY ABSORBING BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-3	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 7 SOURCE: TRR NO. 2262 PP. 107-118	**SHEET #** 5 OF 6

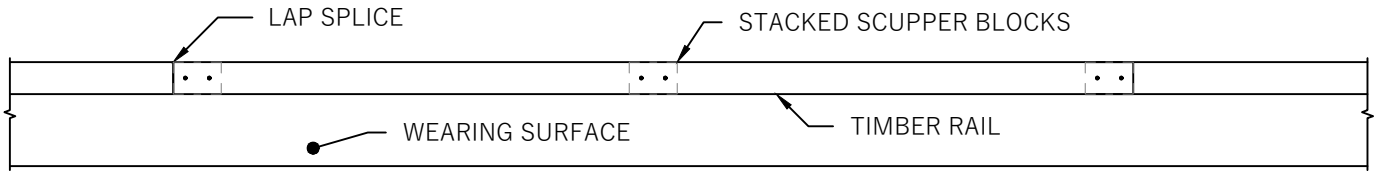


NOTES:

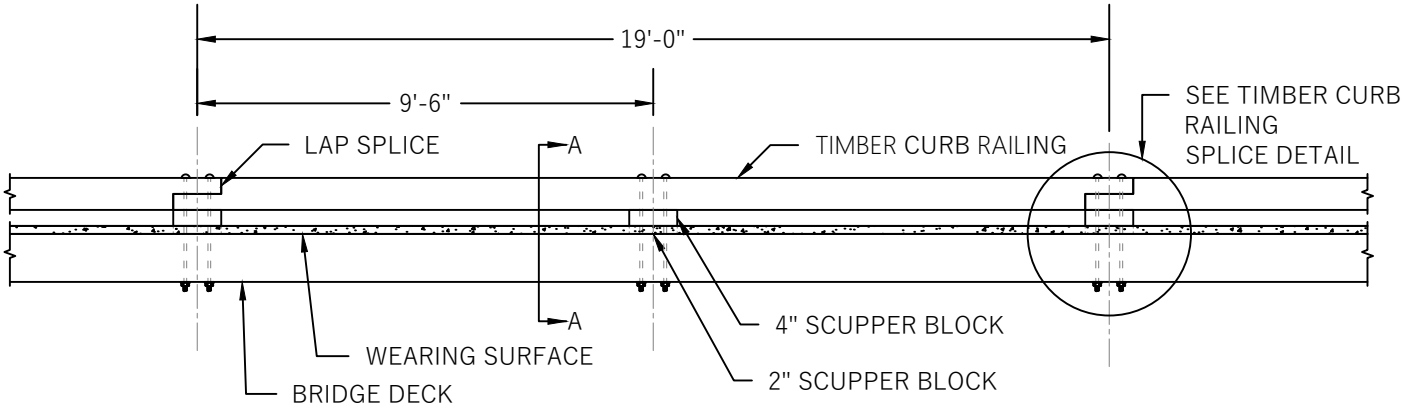
1) TO FURTHER STRENGTHEN THE DECK, ADDITIONAL REINFORCEMENT WAS PLACED AROUND EACH BOLT-SLEEVE ASSEMBLY. BENT #4 BARS, PART NUMBER C12, WERE PLACED ABOVE THE UPPER REINFORCEMENT TO THE EXTERIOR OF THE BOLT-SLEEVE ASSEMBLIES. LONGITUDINAL #6 BARS, PARTY NUMBER C11, WERE PLACED TO THE INTERIOR OF THE BOLT-SLEEVES, JUST ABOVE THE LOWER TRANSVERSE REINFORCEMENT, TO PREVENT LOCAL CRUSHING IN THE CONCRETE IN THE LOWER PORTION OF THE DECK.

SECTION B-B
DECK REINFORCEMENT

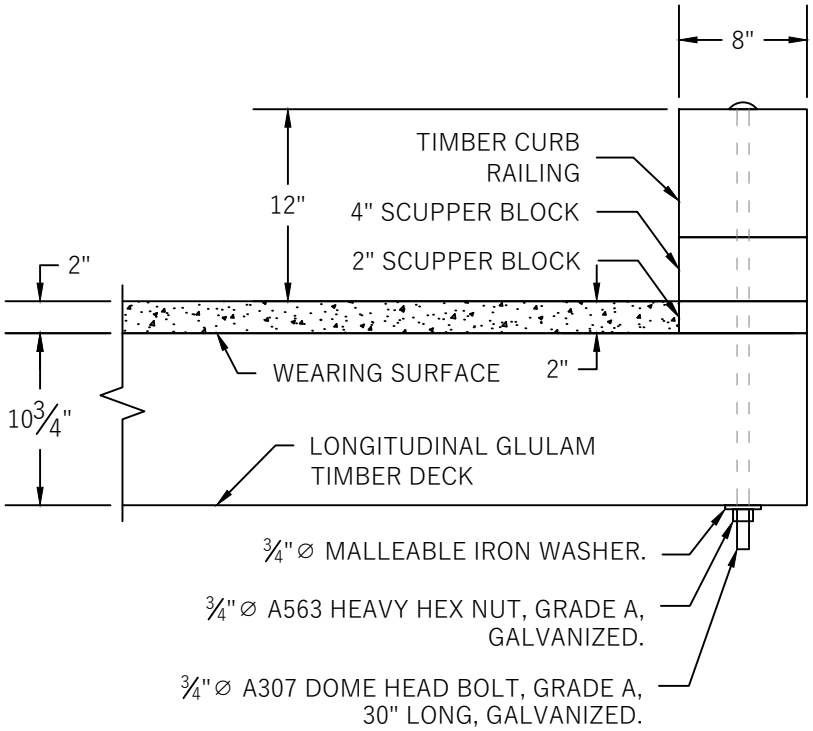
SOURCE: FHWA	**BRIDGE RAIL NAME:** LOW COST ENERGY ABSORBING BRIDGE RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-3	**BRIDGE RAIL HEIGHT:** 31.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 7 SOURCE: TRR NO. 2262 PP. 107-118	**SHEET #** 6 OF 6



BRIDGE RAILING PLAN



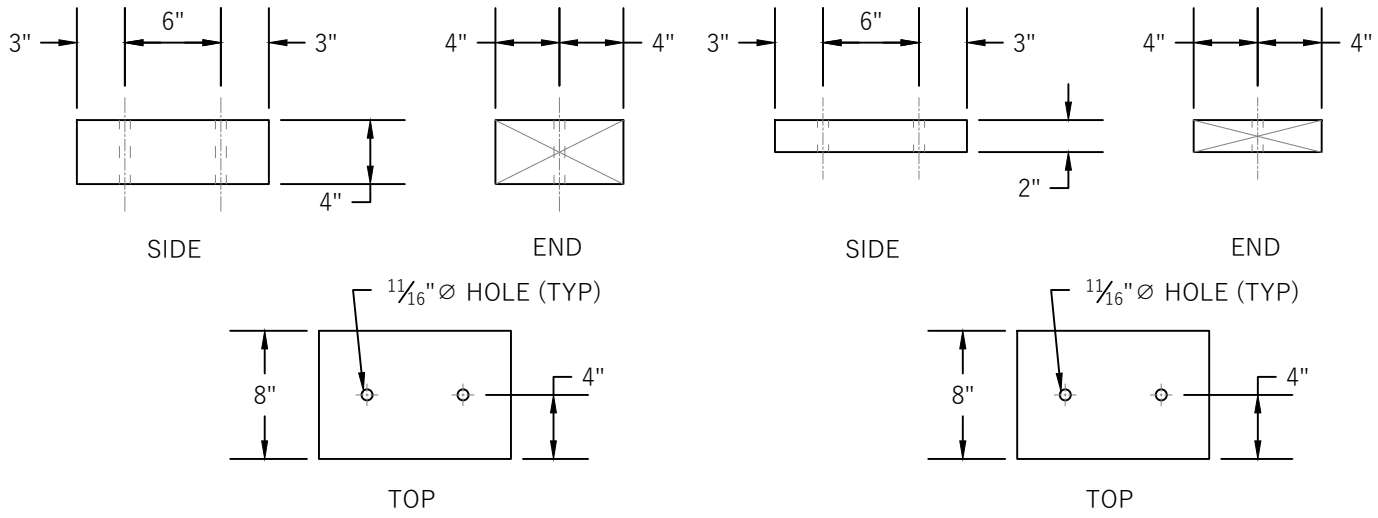
BRIDGE RAILING PROFILE



SECTION A-A
BRIDGE RAILING CROSS SECTION

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

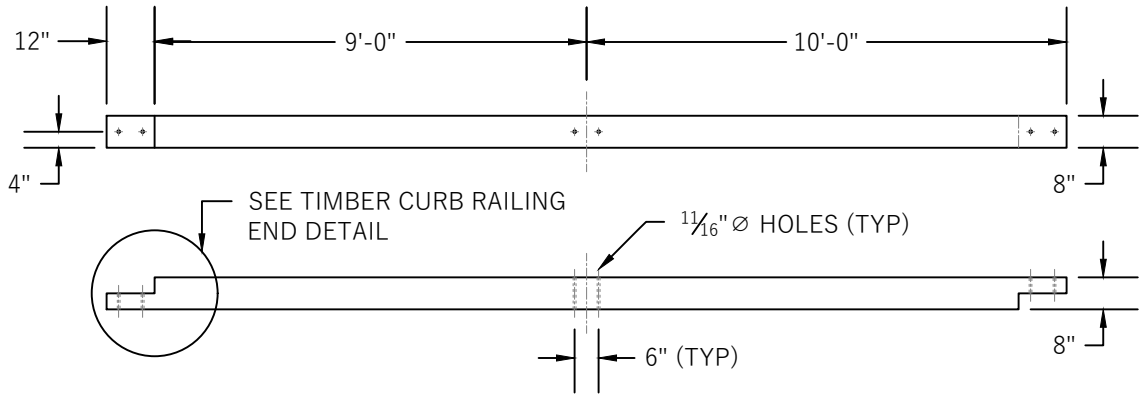
SOURCE: FHWA	**BRIDGE RAIL NAME:** SQUARE SHAPE TIMBER CURB RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 12.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 8 SOURCE: TRP-03-31-93	**SHEET #** 1 OF 3



THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: SCUPPER BLOCKS SHALL BE DOUGLAS FIR, SOUTHERN PINE, ETC. GRADE NO.1. TREAT TO MEET AWPA STANDARD C14 WITH 12CPF CREOSOTE.

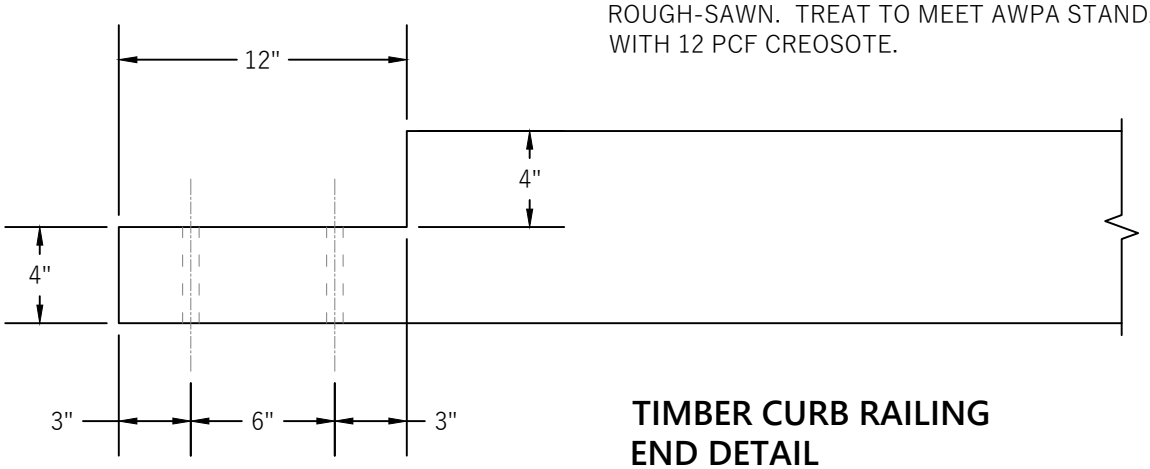
4" SCUPPER BLOCK DETAIL

2" SCUPPER BLOCK DETAIL



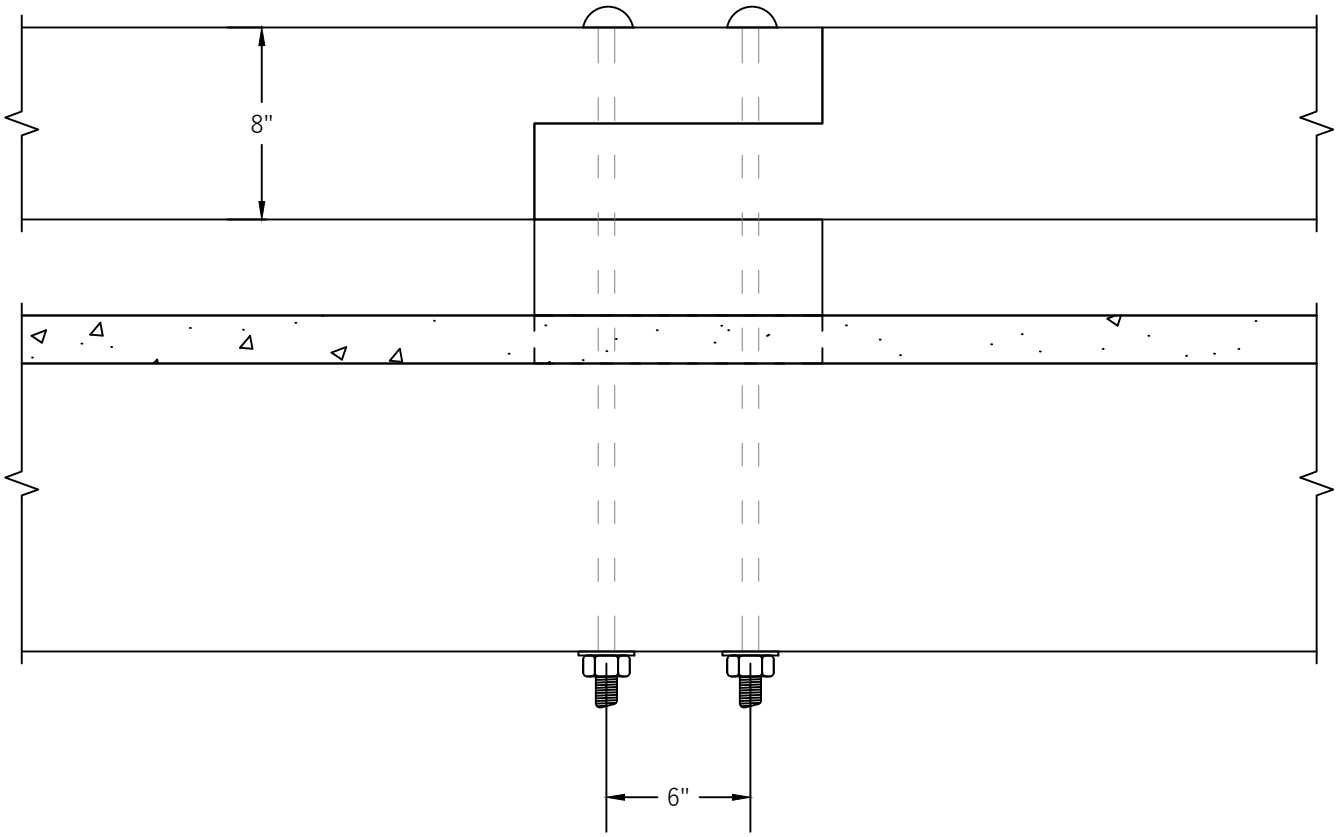
TIMBER CURB RAILING

THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: CURB RAILING SHALL BE DOUGLAS FIR, SOUTHERN PINE, ETC. GRANDE NO. 1, ROUGH-SAWN. TREAT TO MEET AWPA STANDARD C14 WITH 12 PCF CREOSOTE.



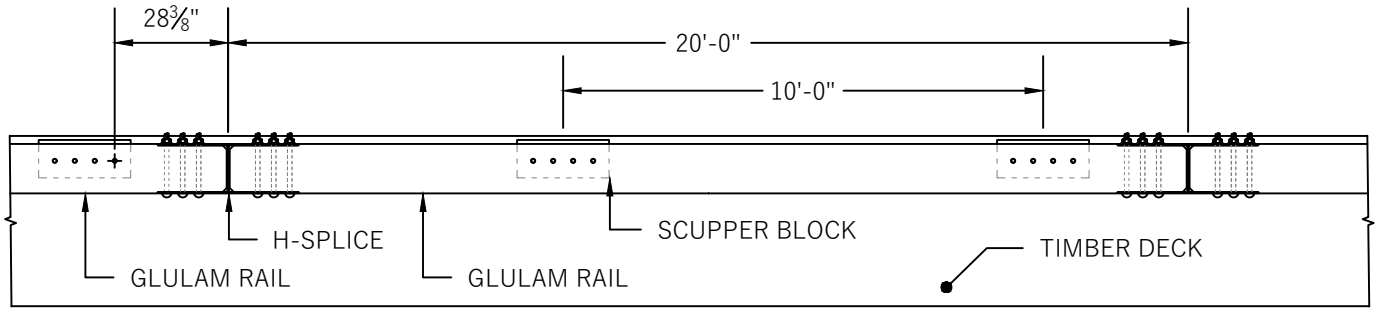
TIMBER CURB RAILING END DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** SQUARE SHAPE TIMBER CURB RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 12.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 8 SOURCE: TRP-03-31-93	**SHEET #** 2 OF 3

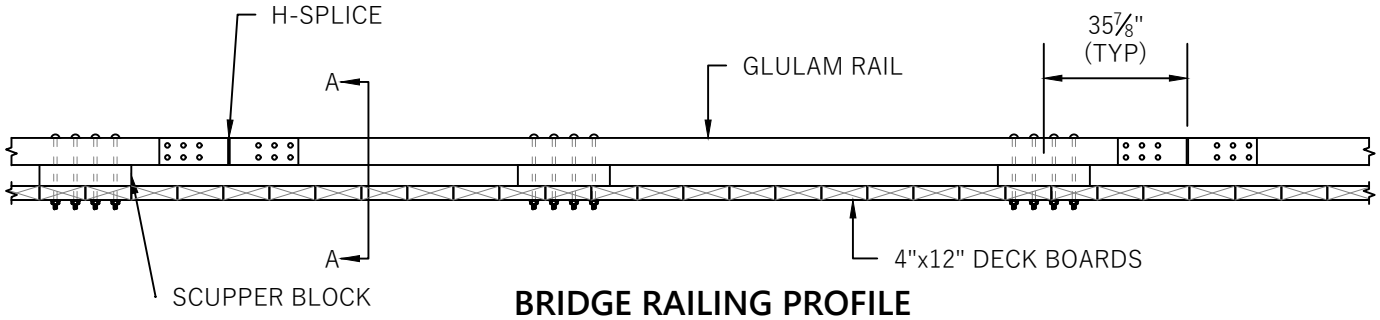


TIMBER CURB RAILING SPLICE DETAIL

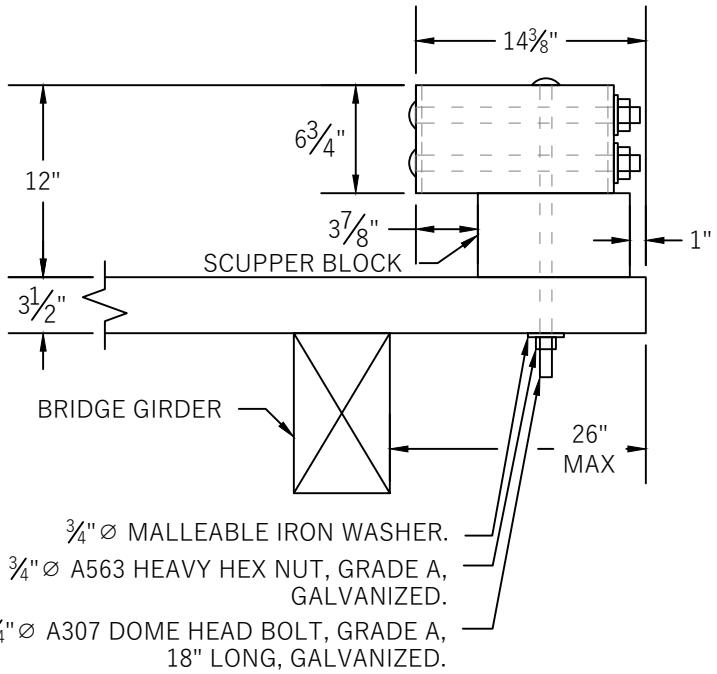
SOURCE: FHWA	**BRIDGE RAIL NAME:** SQUARE SHAPE TIMBER CURB RAIL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-1	**BRIDGE RAIL HEIGHT:** 12.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 8 SOURCE: TRP-03-31-93	**SHEET #** 3 OF 3



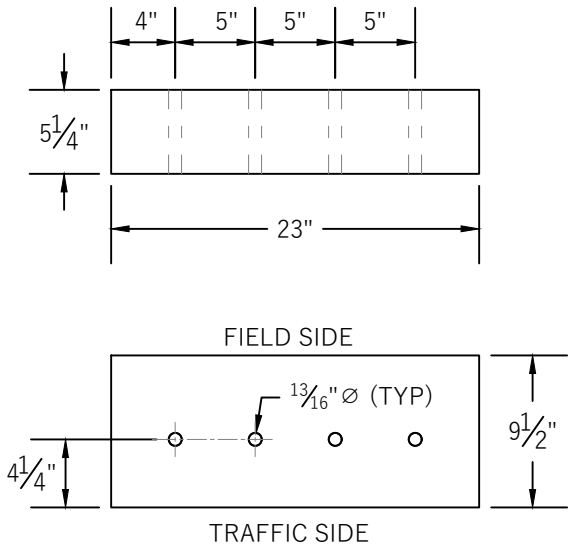
BRIDGE RAILING PLAN



BRIDGE RAILING PROFILE



SECTION A-A
BRIDGE RAILING CROSS SECTION

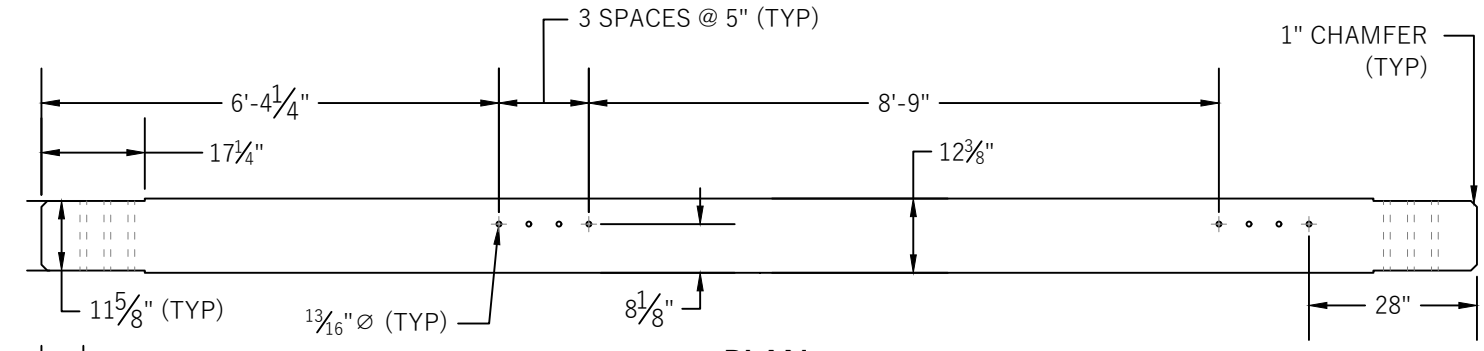


THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: SCUPPER BLOCK SHALL BE SOUTHERN YELLOW PINE GRADE NO. 1 OR DOUGLAS FIR GRADE NO. 1. TREATMENT WITH PENTACHLOROPHENOL IN HEAVY OIL - 0.6 LBS/CU. FT.

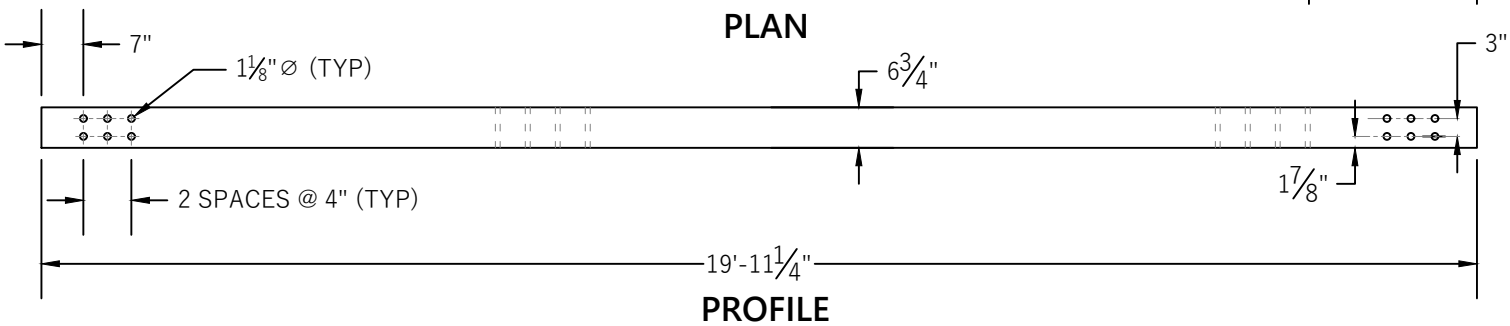
SCUPPER BLOCK DETAIL

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED 12 INCH BRIDGE RAIL FOR PLANK DECK		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL:	**BRIDGE RAIL HEIGHT:** 12.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 9 SOURCE: TOPR NO. HRDS02200006PR FINAL REPORT	**SHEET #** 1 OF 2



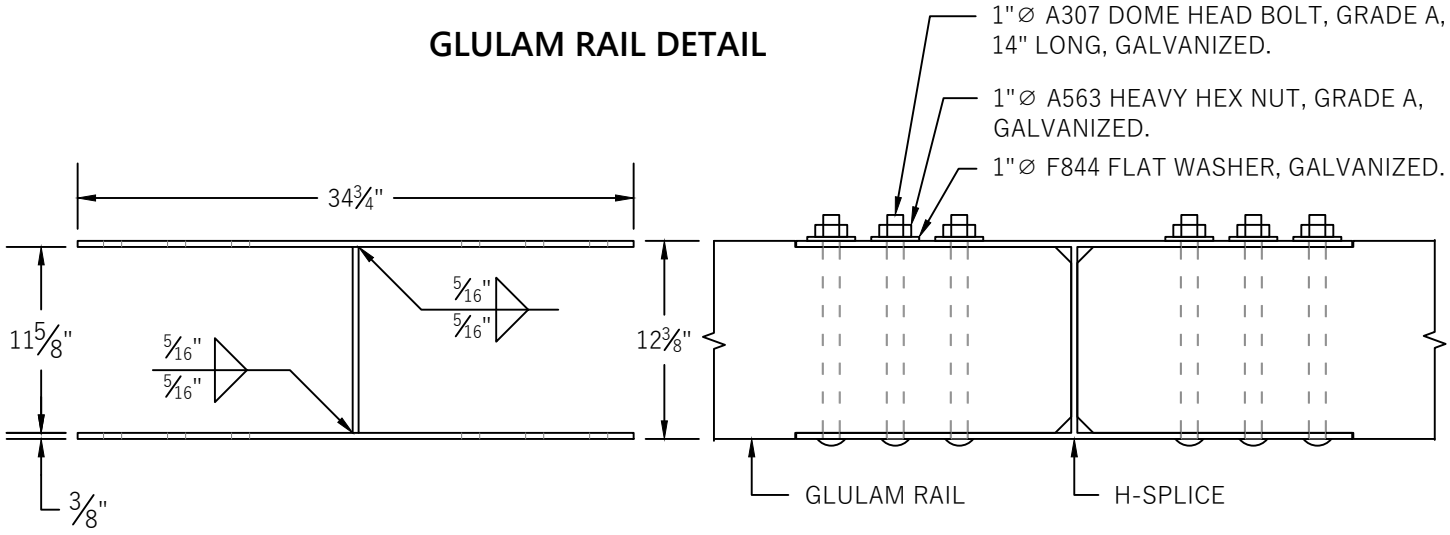
PLAN



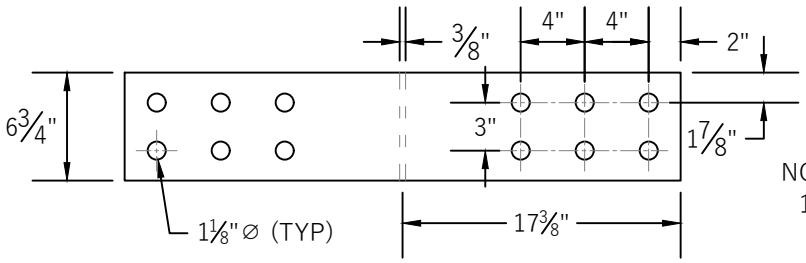
PROFILE

THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM RAIL SHALL BE COMBINATION NO. 48 SOUTHERN YELLOW PINE OR COMBINATION NO. 2 DOUGLAS FIR. TREATMENT WITH PENTACHLOROPHENOL IN HEAVY OIL - 0.6 LBS/CU. FT.

GLULAM RAIL DETAIL



SPLICE DETAIL

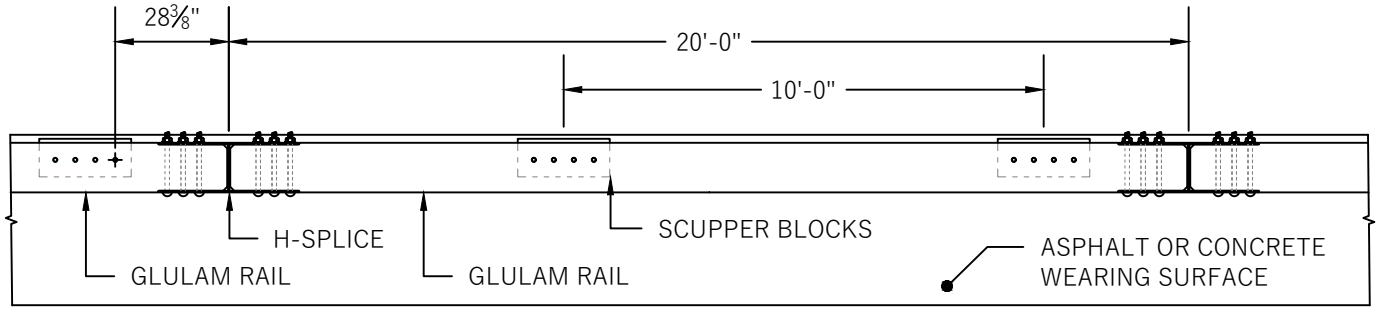


H-SPLICE DETAIL

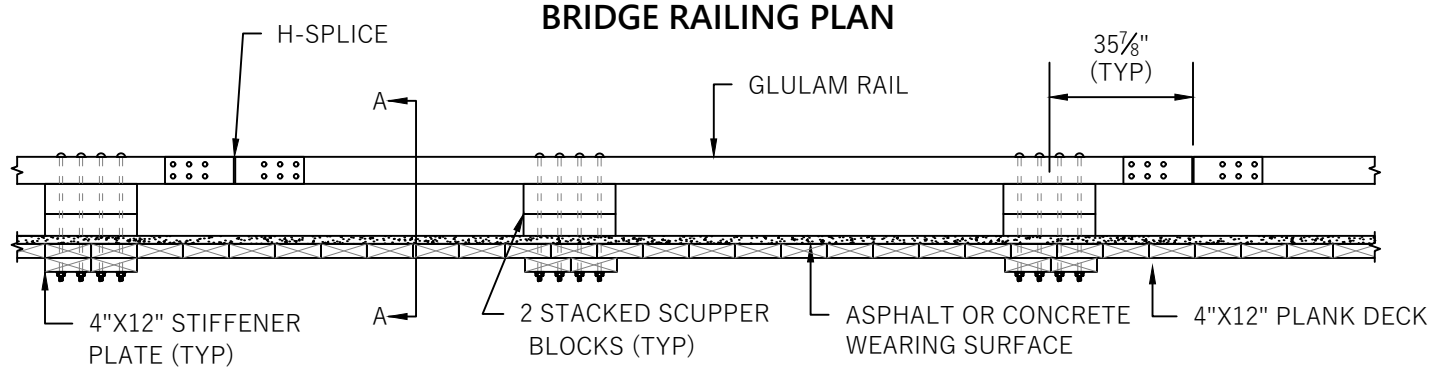
NOTES:

1) H-SPLICE IS A572 GRADE 42. SHALL BE GALVANIZED AFTER SIDE PLATES AND INTERIOR GUSSET PLATE ARE WELDED TOGETHER.
2) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED 12 INCH BRIDGE RAIL FOR PLANK DECK		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL:	**BRIDGE RAIL HEIGHT:** 12.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 9 SOURCE: TOPR NO. HRDS02200006PR FINAL REPORT	**SHEET #** 2 OF 2

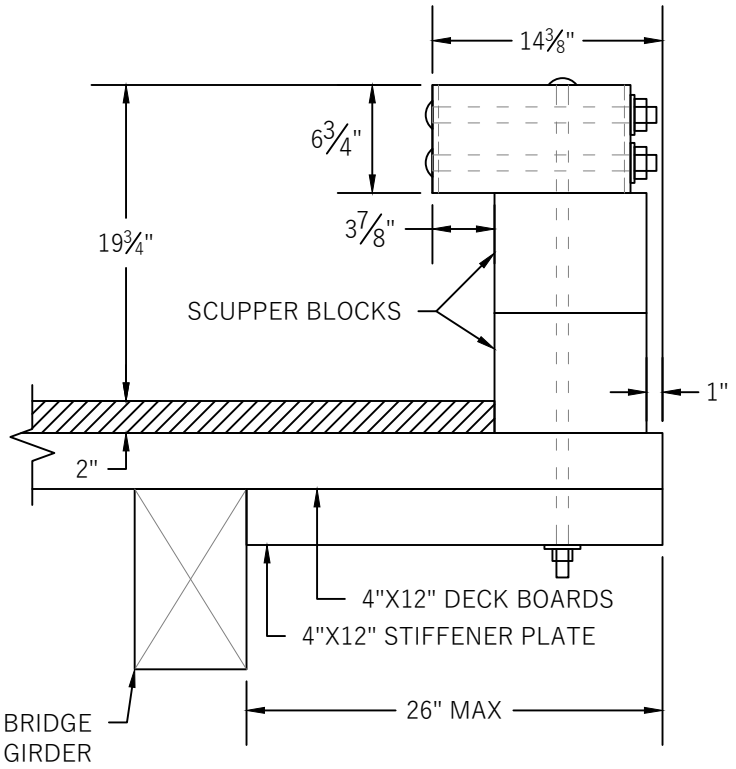


BRIDGE RAILING PLAN

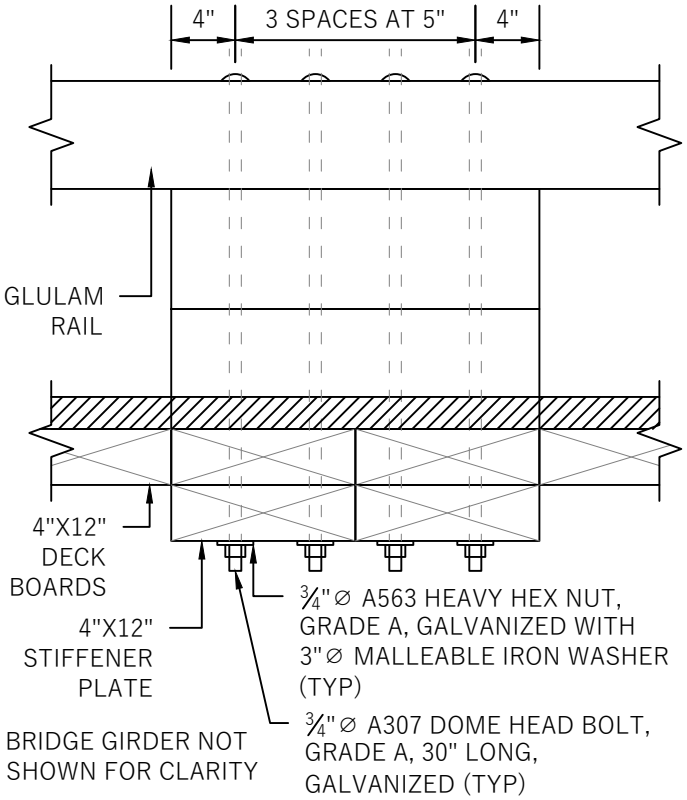


BRIDGE GIRDER NOT SHOWN FOR CLARITY

BRIDGE RAILING PROFILE



SECTION A-A
BRIDGE RAILING CROSS SECTION

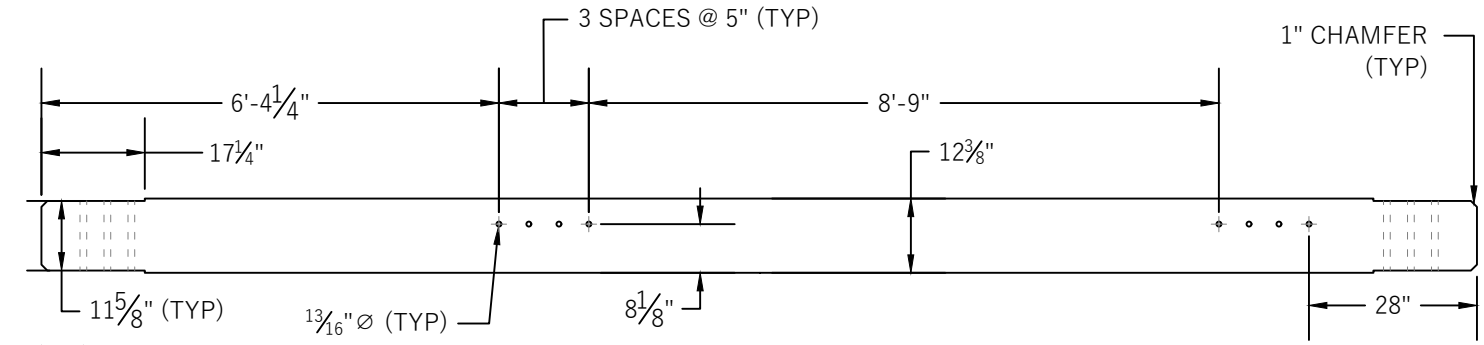


BRIDGE GIRDER NOT
SHOWN FOR CLARITY

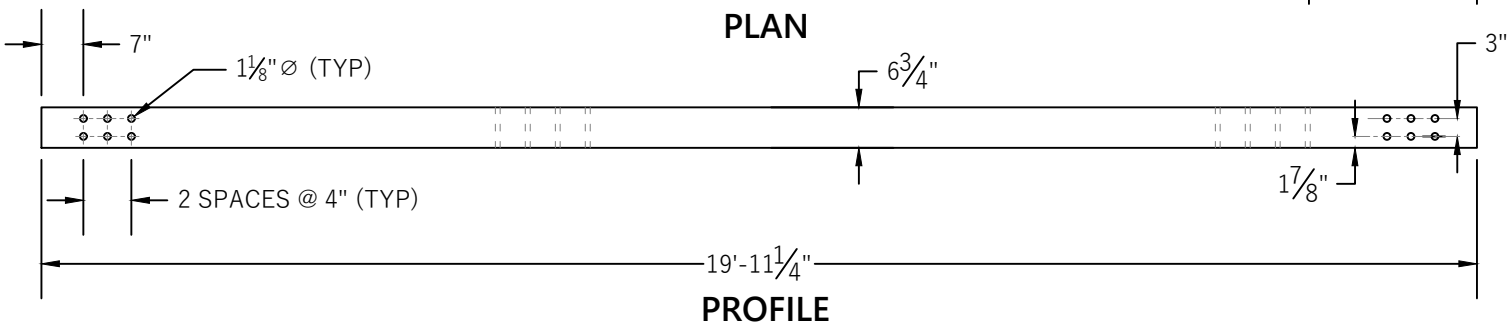
PLAN VIEW

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED 19.75 INCH BRIDGE RAIL FOR PLANK DECK		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-1	**BRIDGE RAIL HEIGHT:** 19.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 10 SOURCE: TRP-03-211-09 /	**SHEET #** 1 OF 3



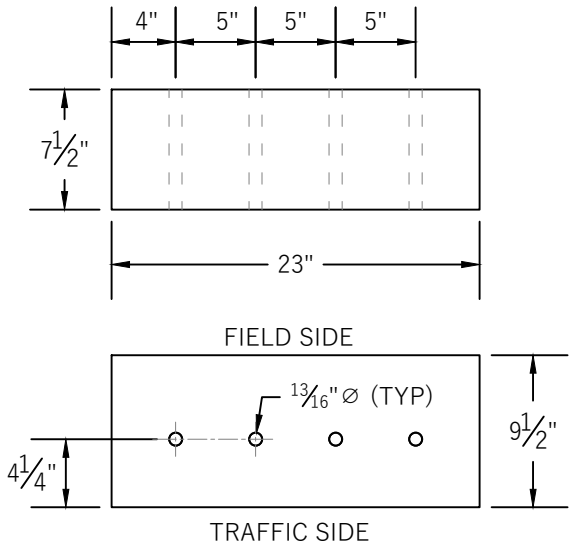
PLAN



PROFILE

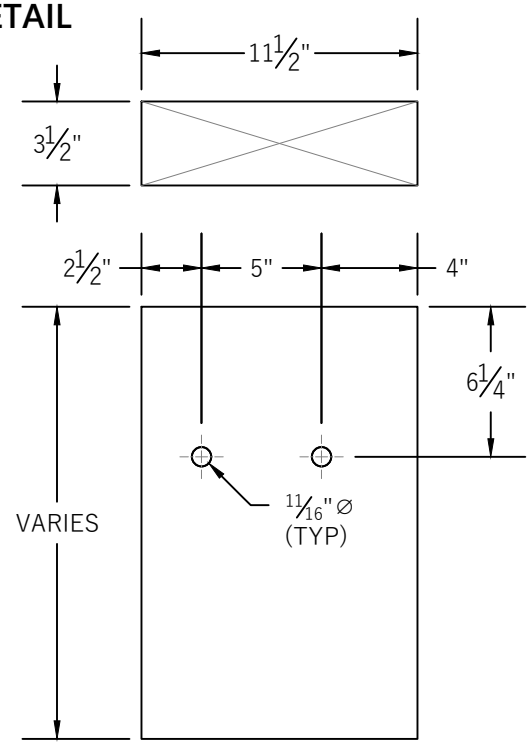
THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: GLULAM RAIL SHALL BE COMBINATION NO. 48 SOUTHERN YELLOW PINE OR COMBINATION NO. 2 DOUGLAS FIR. TREATMENT WITH PENTACHLOROPHENOL IN HEAVY OIL - 0.6 LBS/CU. FT.

GLULAM RAIL DETAIL



THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: SCUPPER BLOCKS SHALL BE SOUTHERN YELLOW PINE GRADE NO. 1 OR DOUGLAS FIR GRADE NO. 1. TREATMENT WITH PENTACHLOROPHENOL IN HEAVY OIL - 0.6 LBS/CU. FT.

SCUPPER BLOCK DETAIL

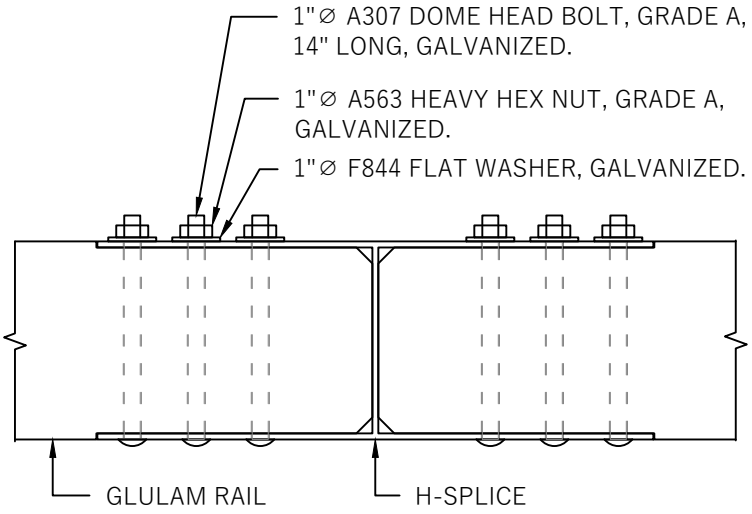


NOTES:

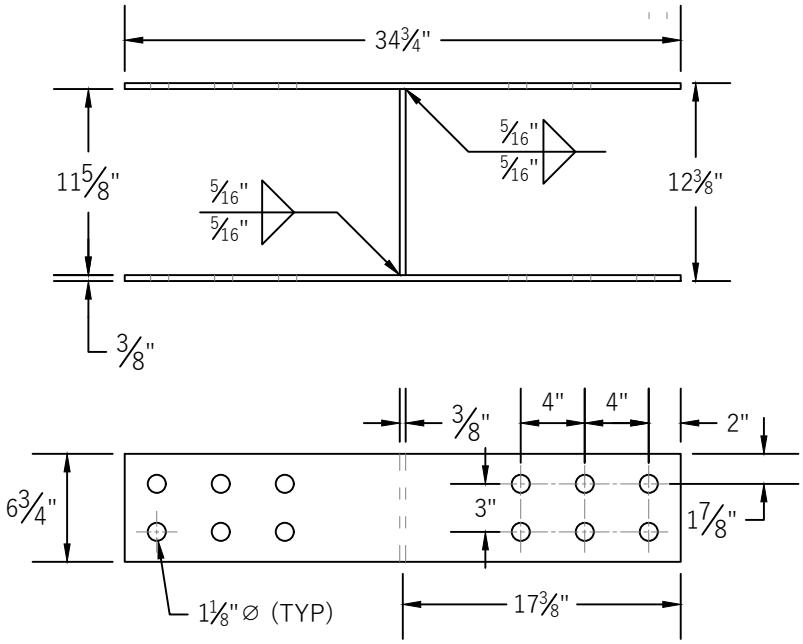
1) 4"X12" STIFFENER PLATE SHALL BE VISUALLY GRADED NO. 1 DENSE, NO.2, OR BETTER SOUTHERN PINE DIMENSIONAL LUMBER.
2) THE STIFFENER PLATE LENGTH VARIES DEPENDING ON DECK OVERHANG BUT SHALL BUTT AGAINST THE FACE OF THE BRIDGE GIRDER BEAM.

STIFFENER PLATE

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED 19.75 INCH BRIDGE RAIL FOR PLANK DECK		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-1	**BRIDGE RAIL HEIGHT:** 19.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 10 SOURCE: TRP-03-211-09 /	**SHEET #** 2 OF 3



SPLICE DETAIL



H-SPLICE DETAIL

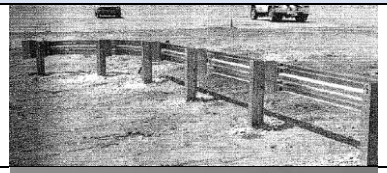
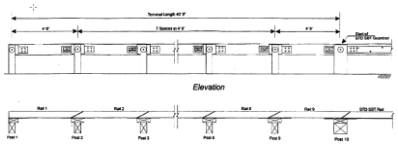
NOTES:

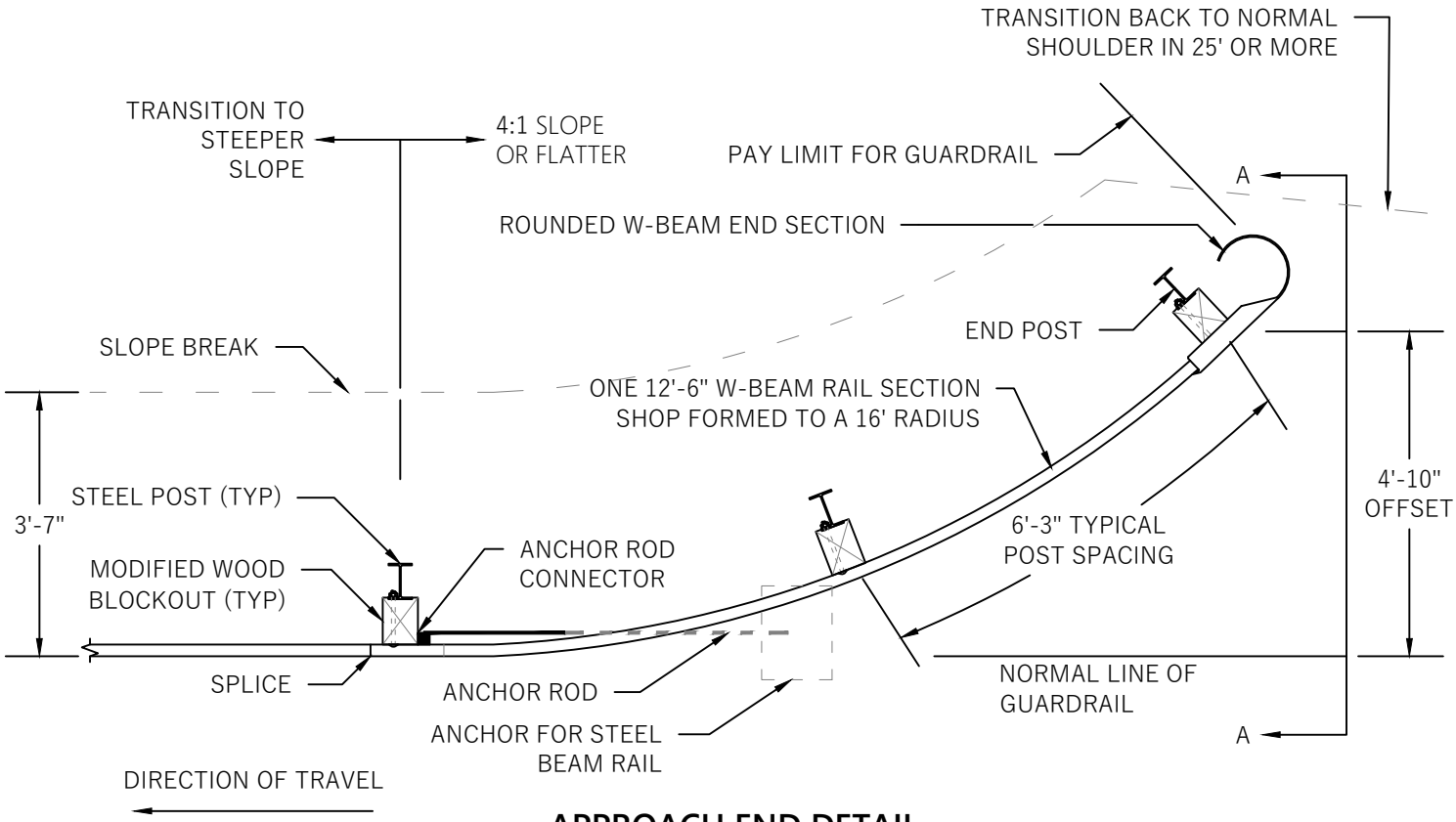
1) H-SPLICE IS A572 GRADE 42. SHALL BE GALVANIZED AFTER SIDE PLATES AND INTERIOR GUSSET PLATE ARE WELDED TOGETHER.
2) WELDING SHALL BE DONE IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED 19.75 INCH BRIDGE RAIL FOR PLANK DECK		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: MASH TL-1	**BRIDGE RAIL HEIGHT:** 19.75 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX A REF 10 SOURCE: TRP-03-211-09 /	**SHEET #** 3 OF 3

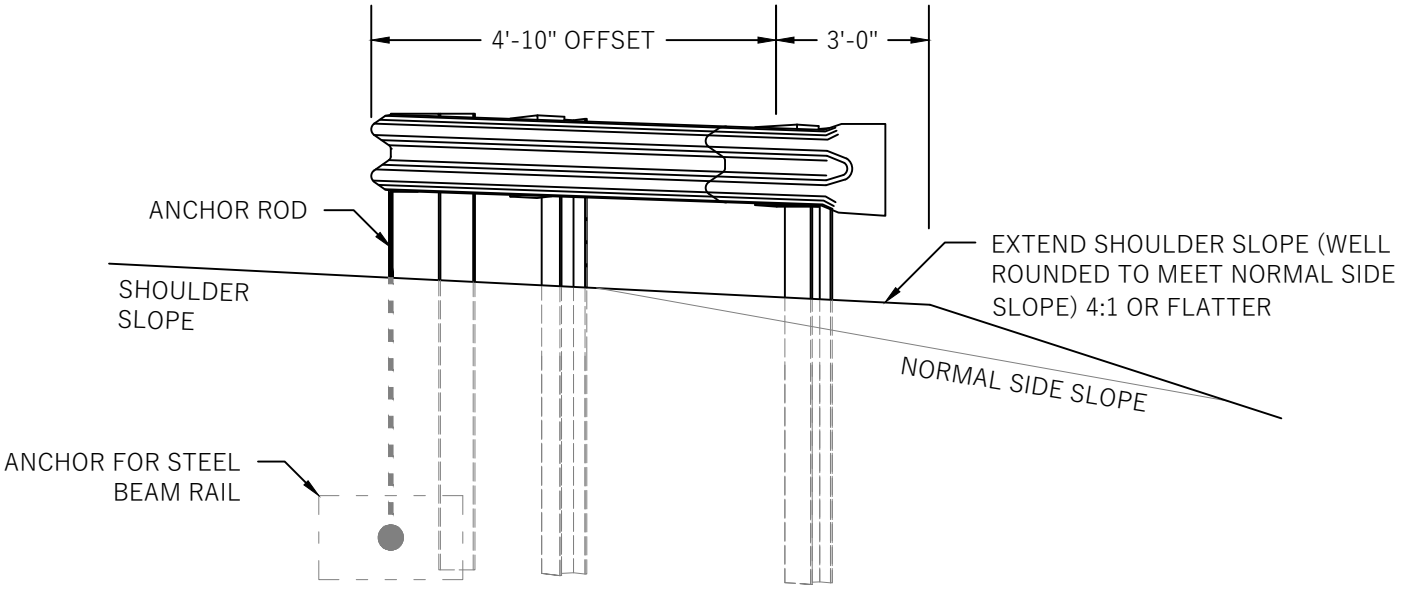
APPENDIX B: CRASH TESTED BRIDGE RAIL TERMINAL DESIGNS

Appendix B. Crash Tested Bridge Rail Terminal Designs

System Name	Test Number	Test Level	Photo/Sketch	Downstream Connection	Terminal			Ref
					Type	End	Height (in)	
Vermont G1-d W-beam Terminal	47380-2 47380-3 47380-4	R350 TL-2		W-beam / W-beam transition	W-beam rail with steel blocks and steel posts	W-beam radius with buffer end (Radius=15.75')	27.00	1
NETC-MELT Guardrail End Terminal	400401-1 400401-2	R350 TL-2		W-beam / W-beam transition	W-beam rail with wood blocks and wood posts	Flared W-beam with buffer end (Flare=4')	27.00	2
Steel Backed Timber Guardrail Tangent End Terminal	09005 09006 09008 09009	R350 TL-2		Steel Backed Timber Barrier	Timber rail with timber blocks and timber breakaway posts in steel tubes	90-degree blunt end of timber rail and post	27.00	3



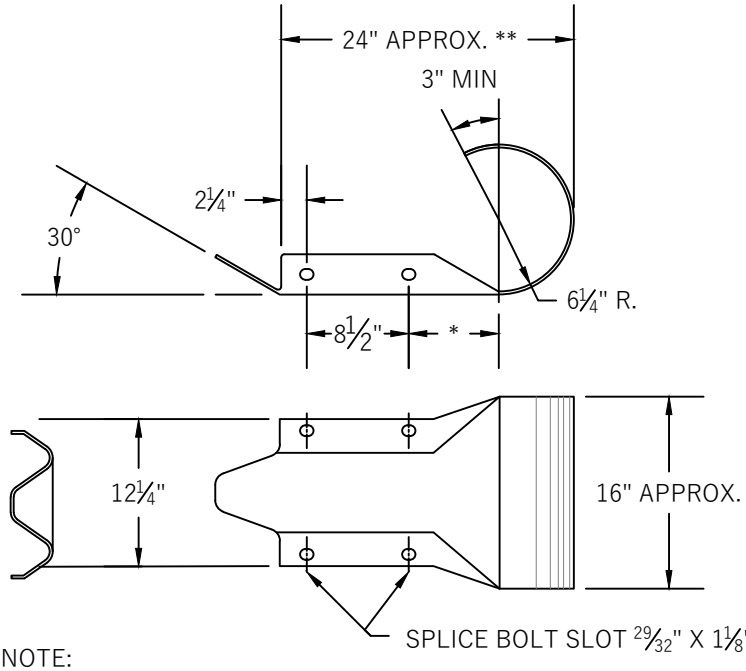
APPROACH END DETAIL



SECTION A-A

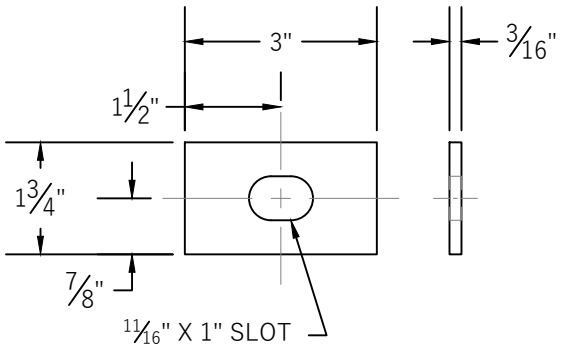
NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** VERMONT W-BEAM GUARDRAIL TERMINAL FOR LOW SPEED AREAS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.875 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 1 SOURCE: TESTING AND EVALUATION OF THE VERMONT W-BEAM	**SHEET #** 1 OF 6



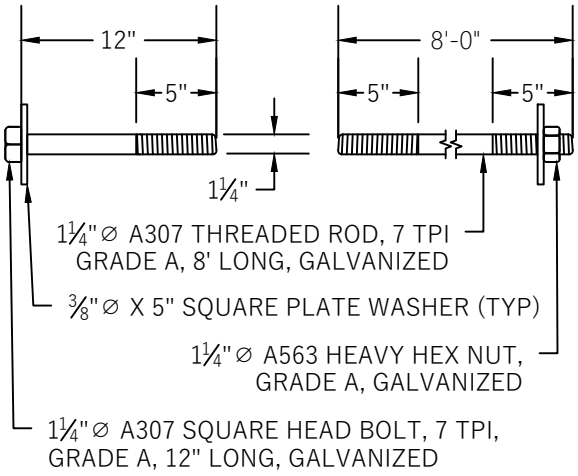
NOTE:
1) SHALL CONFORM TO REQUIREMENTS OF M 180, CLASS A, TYPE 2
2) *DIMENSION SHOWN AS 7½" IN RE-7-79 WHICH PROVIDES AN ACCEPTABLE OVERALL LENGTH OF APPROXIMATELY 2'-0".

ROUNDED W-BEAM END SECTION

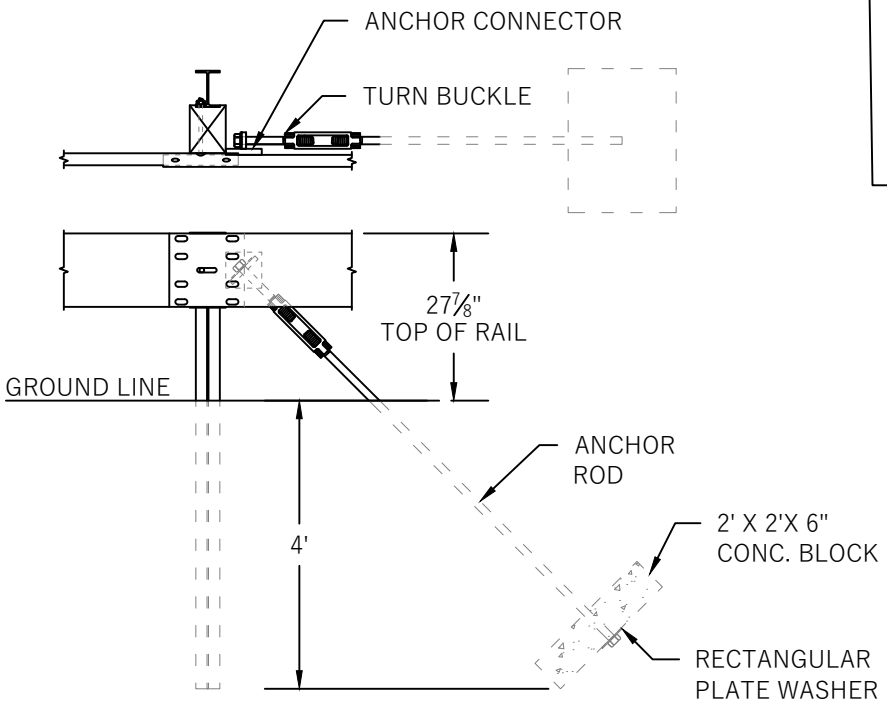


NOTE:
1) A653 SS GRADE 37, GALVANIZED

RECTANGULAR PLATE WASHER



ANCHOR ROD

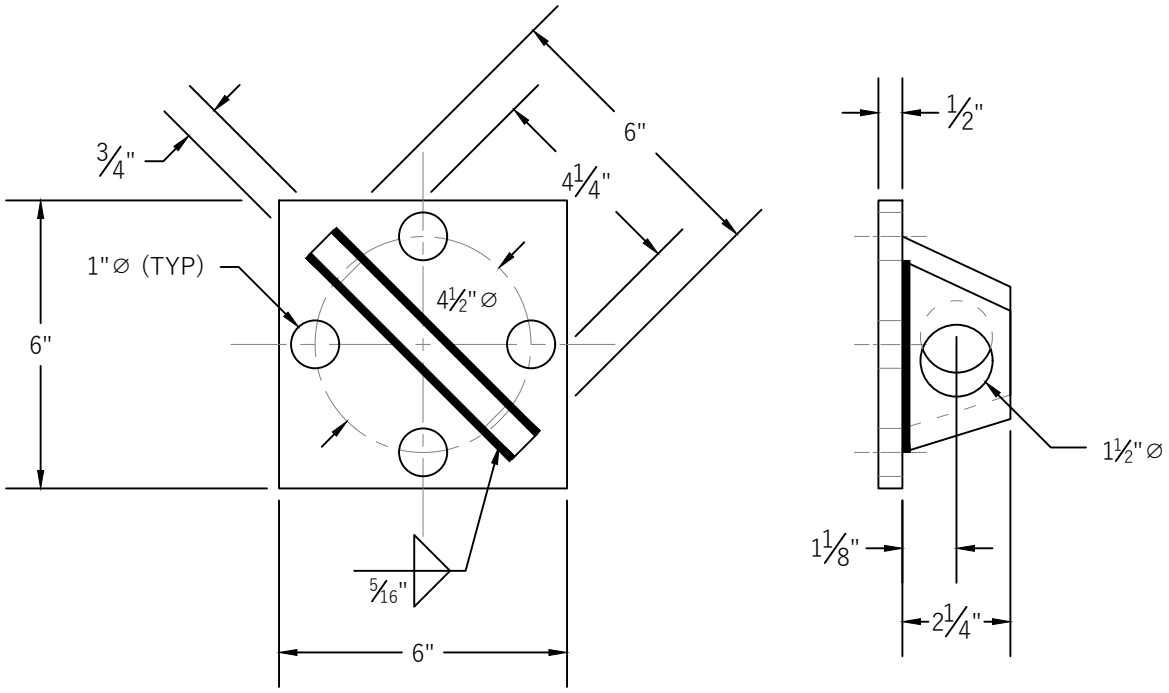


ANCHOR ROD CONNECTION

NOTES:
1) 1¼" 8LH THREADS
2) MIN. TENSILE STRENGTH 60,000 LBS. LOAD APPLIED THROUGH ASSEMBLY.

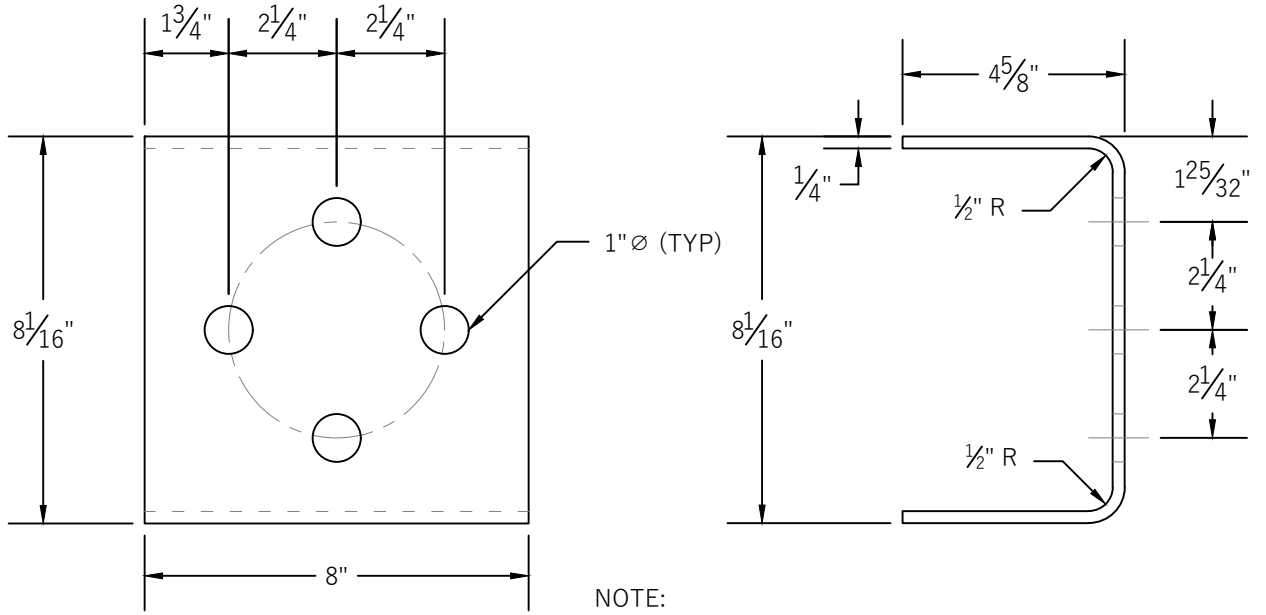
TURNBUCKLE

SOURCE: FHWA	**BRIDGE RAIL NAME:** VERMONT W-BEAM GUARDRAIL TERMINAL FOR LOW SPEED AREAS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.875 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 1 SOURCE: TESTING AND EVALUATION OF THE VERMONT W-BEAM	**SHEET #** 2 OF 6



WELDING SHALL BE COMPLETED IN
ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

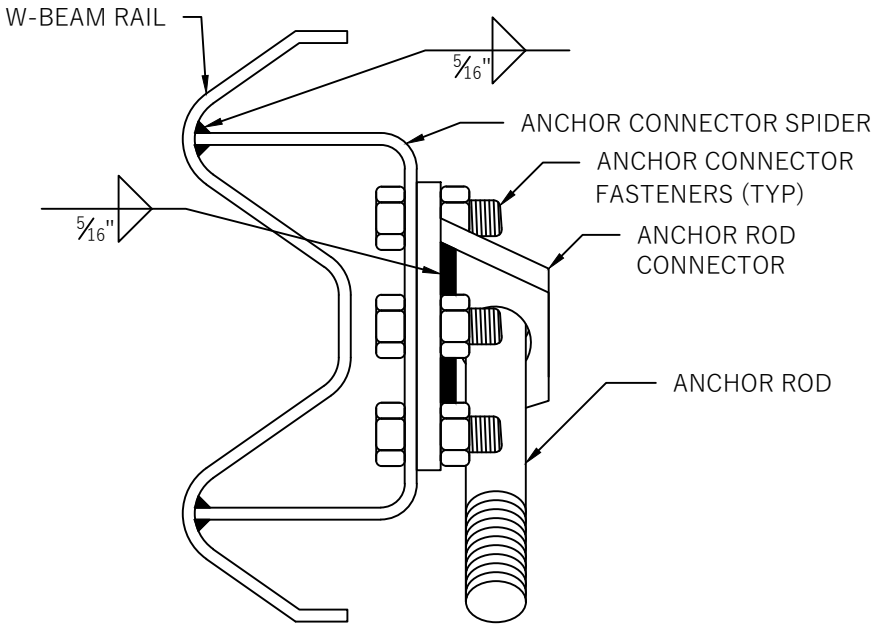
ANCHOR ROD CONNECTOR



NOTE:
1) ALL STEEL IS A36, GALVANIZED
2) ANCHOR CONNECTOR SPIDER IS 8" X 16", BENT TO CONFORM TO W-BEAM

ANCHOR CONNECTOR SPIDER

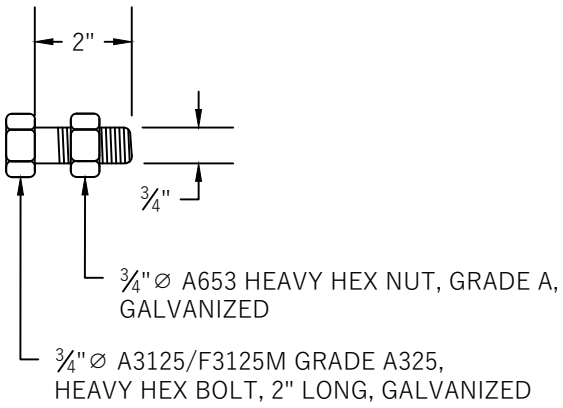
SOURCE: FHWA	**BRIDGE RAIL NAME:** VERMONT W-BEAM GUARDRAIL TERMINAL FOR LOW SPEED AREAS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.875 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 1 SOURCE: TESTING AND EVALUATION OF THE VERMONT W-BEAM	**SHEET #** 3 OF 6



NOTES:

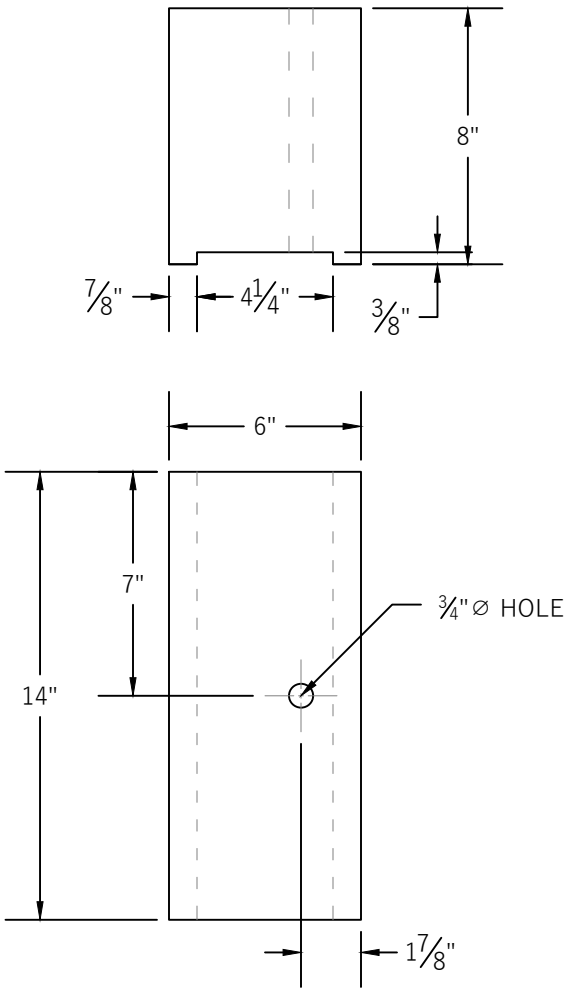
1) ALL STEEL IS A36, GALVANIZED.
2) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

ANCHOR CONNECTOR ASSEMBLY



ANCHOR CONNECTOR FASTENERS

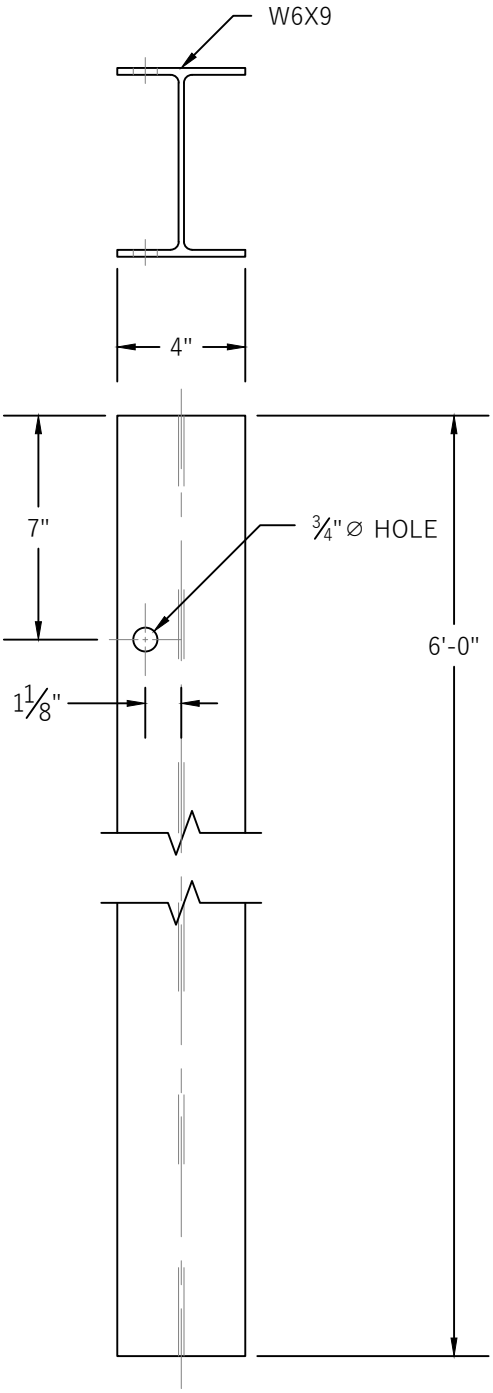
SOURCE: FHWA	**BRIDGE RAIL NAME:** VERMONT W-BEAM GUARDRAIL TERMINAL FOR LOW SPEED AREAS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.875 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 1 SOURCE: TESTING AND EVALUATION OF THE VERMONT W-BEAM	**SHEET #** 4 OF 6



NOTES:

1) THESE MATERIAL SPECIFICATIONS ARE PROVIDED IN VTRANS STANDARD G-1.
2) BLOCKS SHALL BE MADE OF TIMBER WITH A STRESS GRADE OF 1200 PSI OR MORE. TESTING SHALL BE IN ACCORDANCE WITH WEST COAST LUMBER INSPECTION BUREAU, SOUTHERN PINE INSPECTION BUREAU OR OTHER APPROPRIATE ASSOCIATION. TIMBER FOR BLOCKS SHALL BE ROUGH SAWN (UNPLANED) WITH DIMENSIONS INDICATED. THE SIZE TOLERANCE OF ROUGH SAWN BLOCKS IN THE DIRECTION OF THE BOLT HOLE SHALL BE NOT MORE THAN ± ¼".
3) SUPPLY WOOD BLOCKS PER AASHTO M 168.
4) TREAT WITH PRESERVATIVES PER AASHTO M 133.
5) BLOCKOUTS MAY ALSO BE MADE OF APPROVED ALTERNATE MATERIAL.

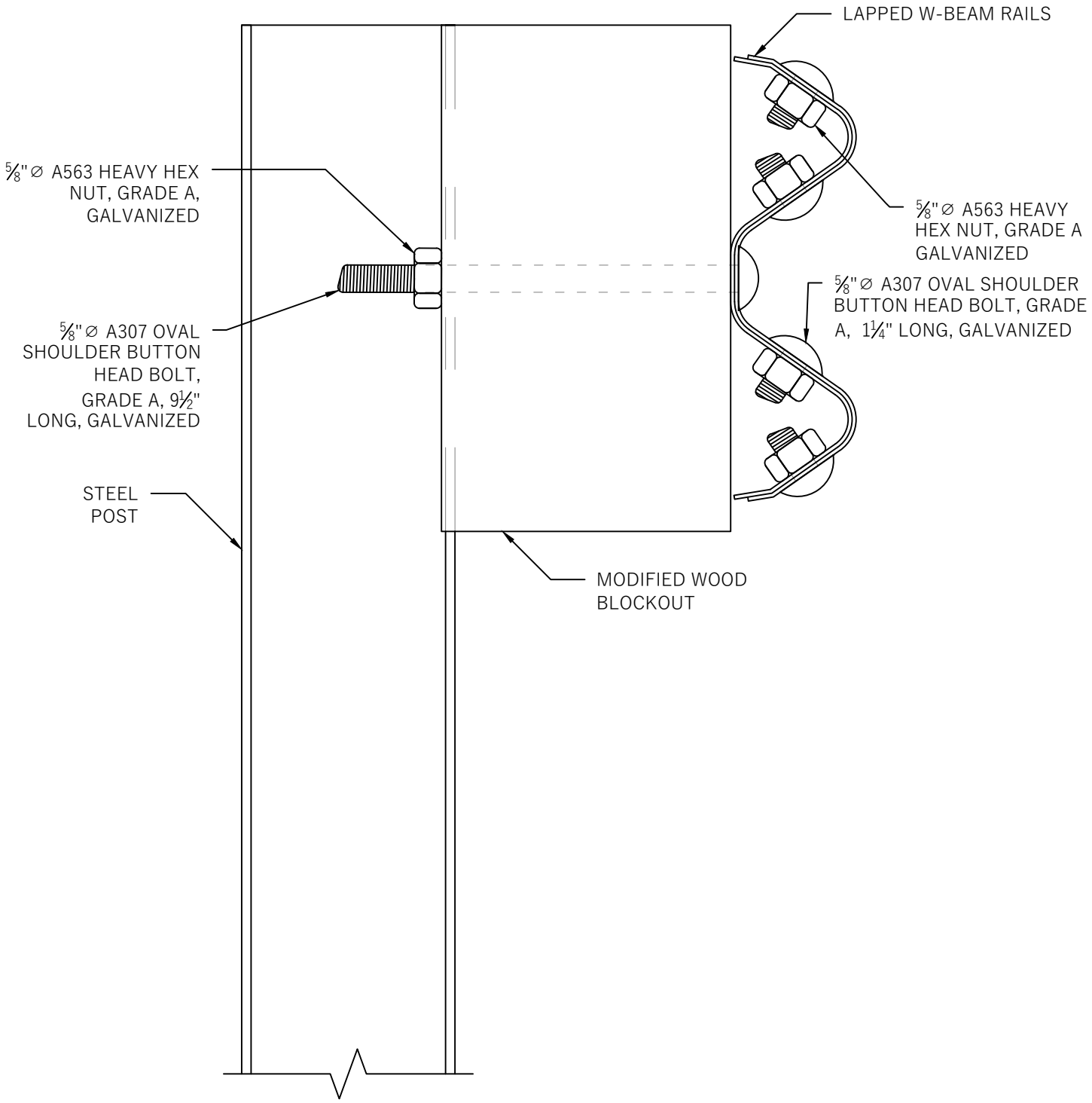
MODIFIED WOOD BLOCKOUT



A36, GALVANIZED

STEEL POST

SOURCE: FHWA	**BRIDGE RAIL NAME:** VERMONT W-BEAM GUARDRAIL TERMINAL FOR LOW SPEED AREAS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.875 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 1 SOURCE: TESTING AND EVALUATION OF THE VERMONT W-BEAM	**SHEET #** 5 OF 6

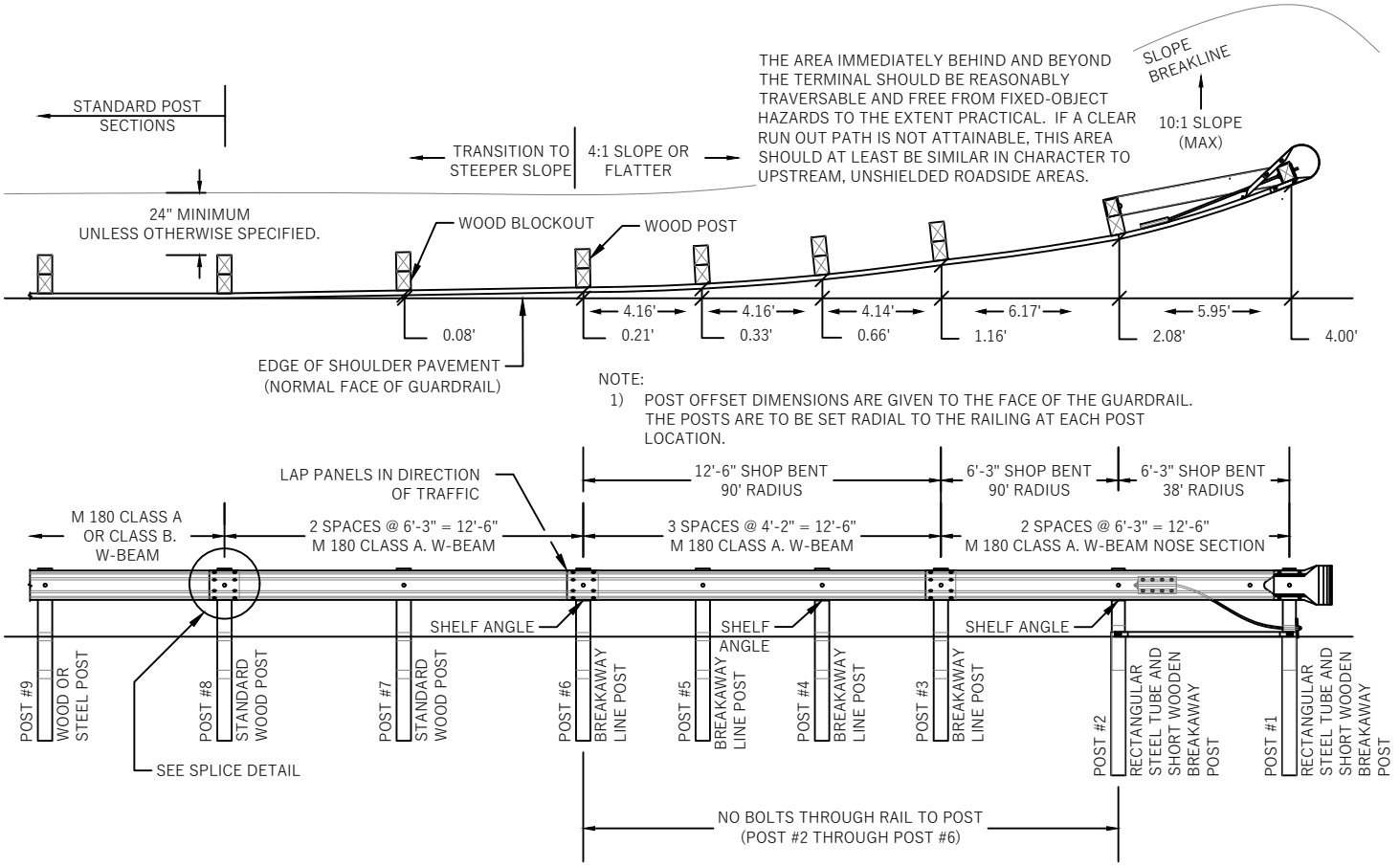


NOTES:

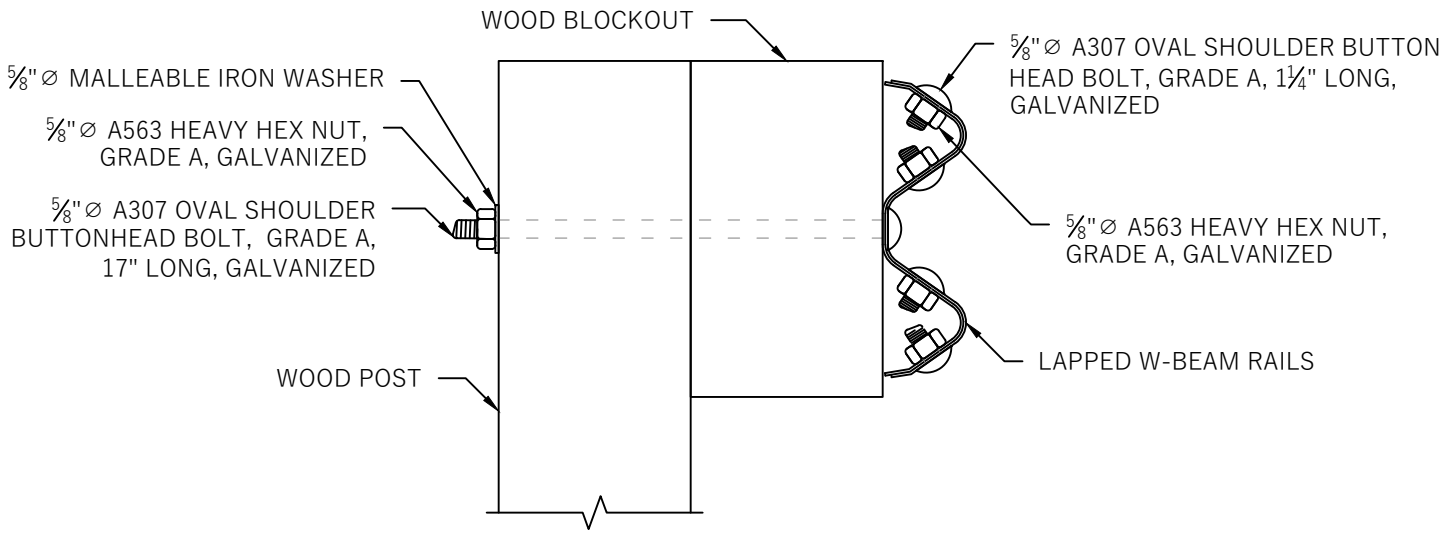
1) GUARDRAIL SECTIONS SHALL BE LAPPED IN DIRECTION OF TRAFFIC FOR THE LANE NEAREST THE GUARDRAIL
2) W-BEAM SHALL CONFORM WITH SPECIFICATIONS IN AASHTO M 180.
3) GUARDRAIL BOLTS AND NUTS SHALL CONFORM WITH SPECIFICATIONS IN AASHTO M 180.

SPLICE DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** VERMONT W-BEAM GUARDRAIL TERMINAL FOR LOW SPEED AREAS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.875 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 1 SOURCE: TESTING AND EVALUATION OF THE VERMONT W-BEAM	**SHEET #** 6 OF 6



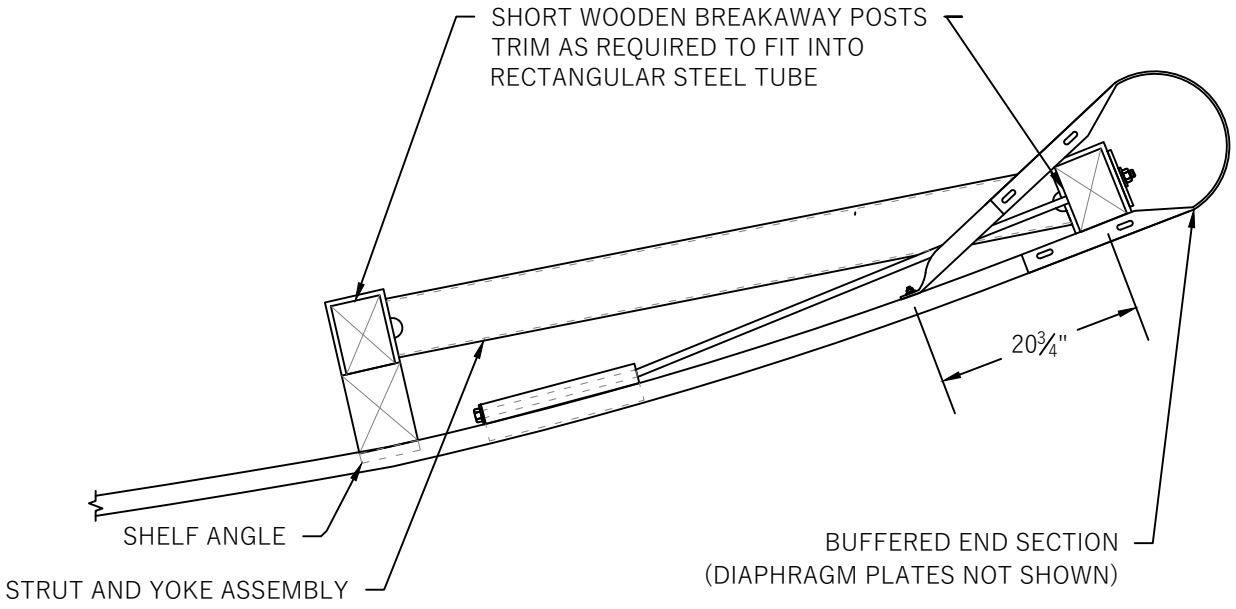
TERMINAL LAYOUT

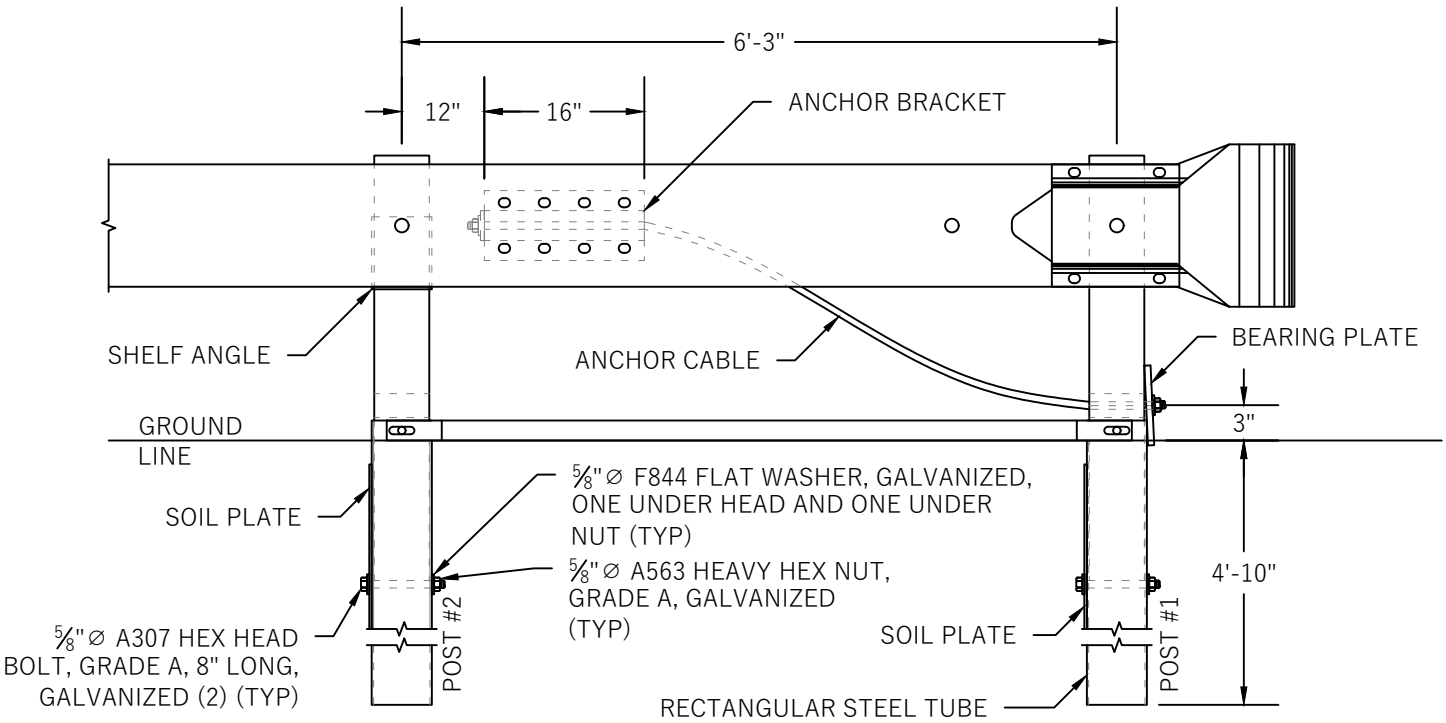


SPLICE DETAIL

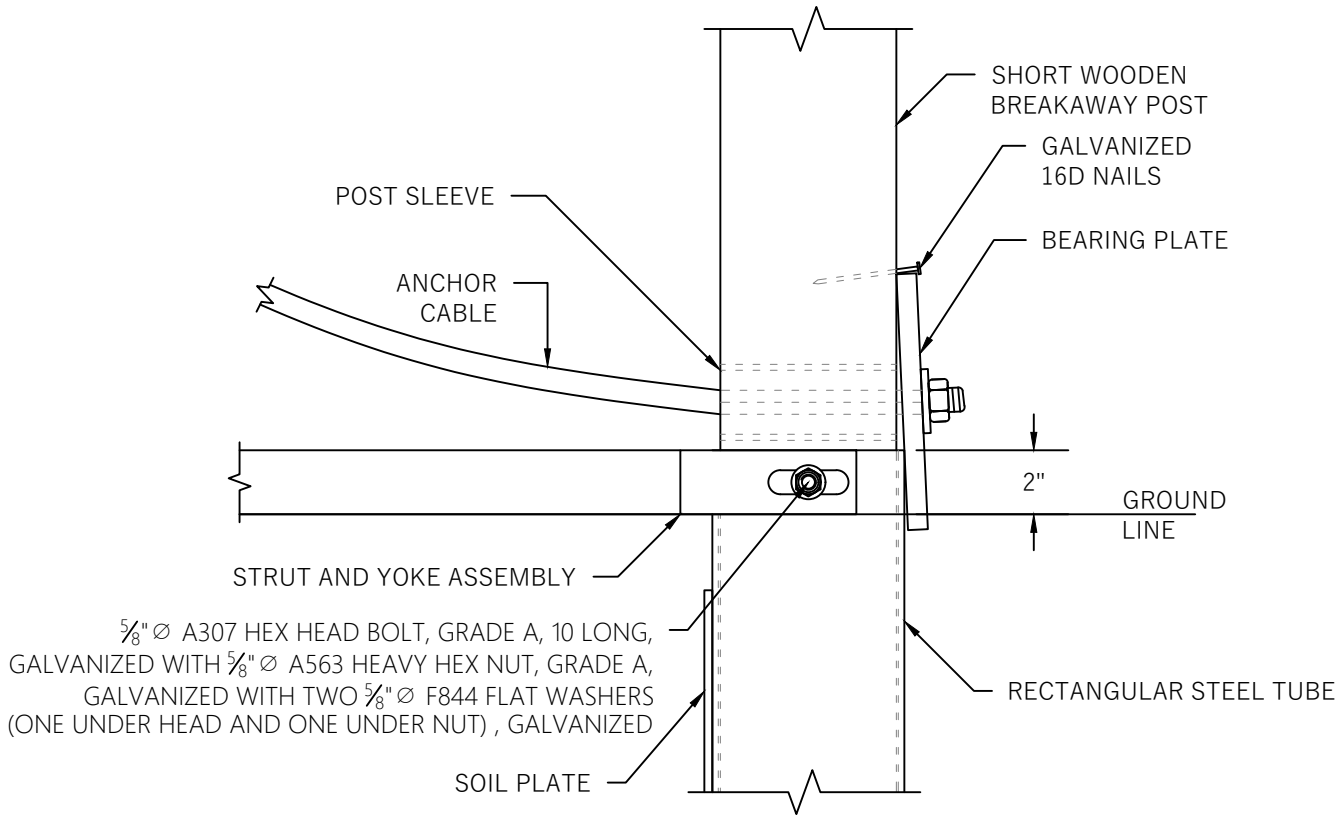
NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 1 OF 7

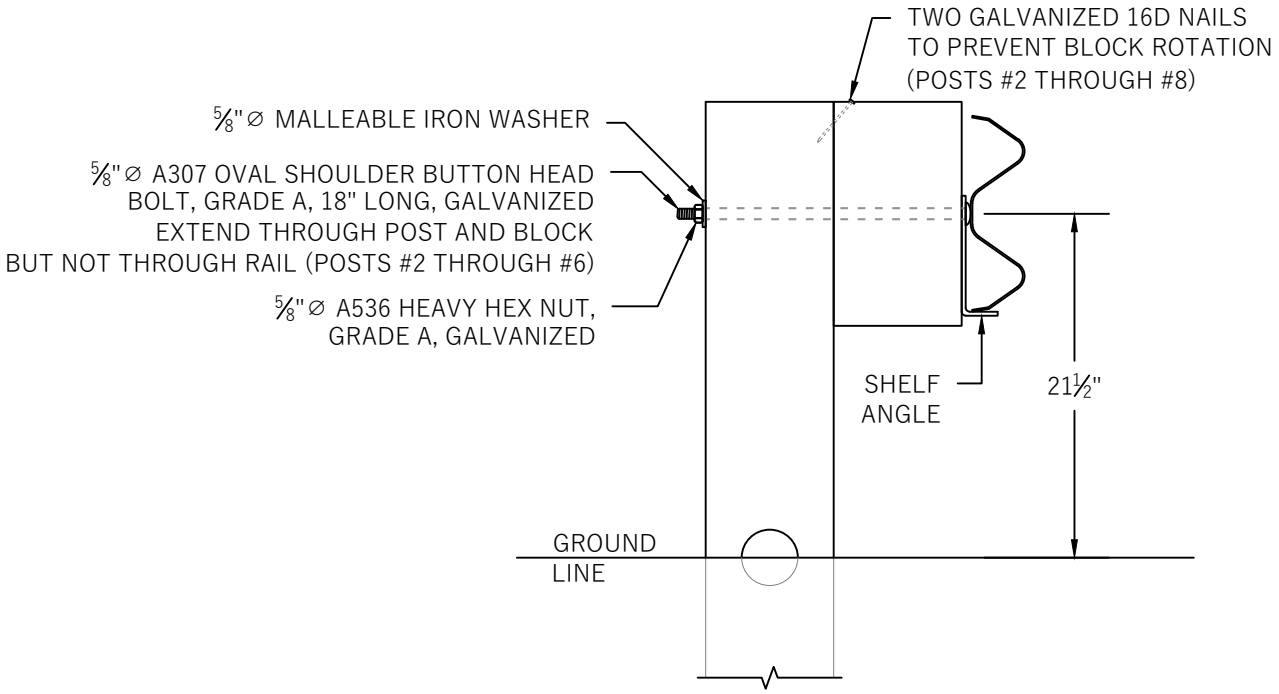




SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 2 OF 7

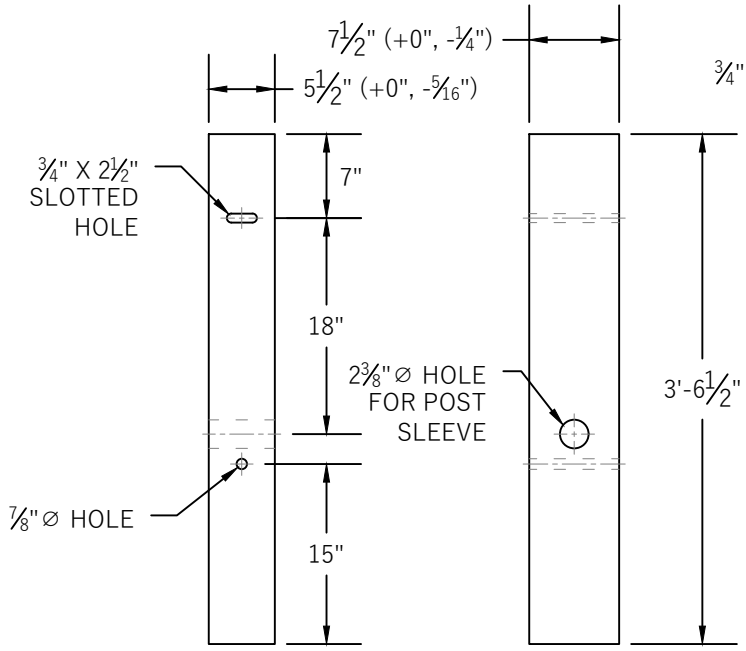


POST ONE DETAIL



BREAKAWAY LINE POST DETAIL

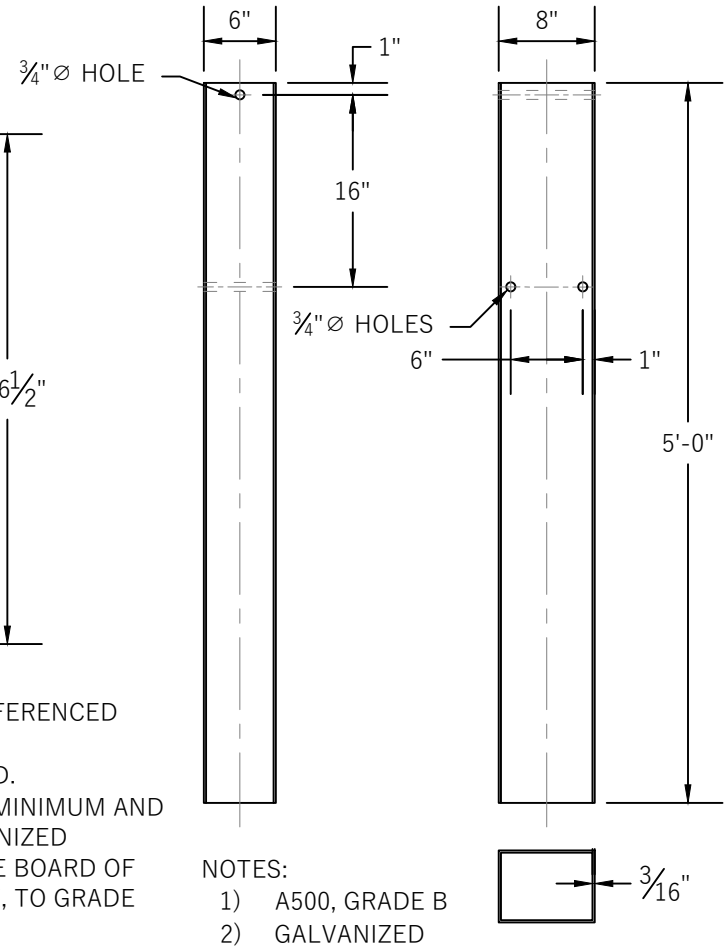
SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 3 OF 7



NOTES:

1) THESE MATERIAL SPECIFICATIONS ARE FROM THE REFERENCED CRASH TEST REPORT.
2) SHALL BE S4S WITH FINISHED DIMENSIONS INDICATED.
3) SHALL HAVE A BENDING STRESS GRADE OF 1,200 PSI MINIMUM AND SHALL BE GRADE MARKED OR CERTIFIED BY A RECOGNIZED ASSOCIATION OR AGENCY WHICH IS CERTIFIED BY THE BOARD OF REVIEW, AMERICAN LUMBER STANDARDS COMMITTEE, TO GRADE THE SPECIES.
4) WOOD POST SHALL CONFORM TO AASHTO M 168.
5) TREAT WITH PRESERVATIVES PER AASHTO M 133 AFTER ANY TRIMMING OR DRILLING.

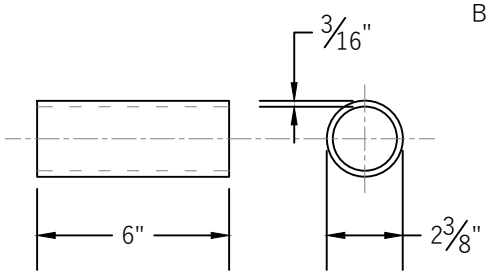
SHORT WOODEN BREAKAWAY POST



NOTES:

1) A500, GRADE B
2) GALVANIZED

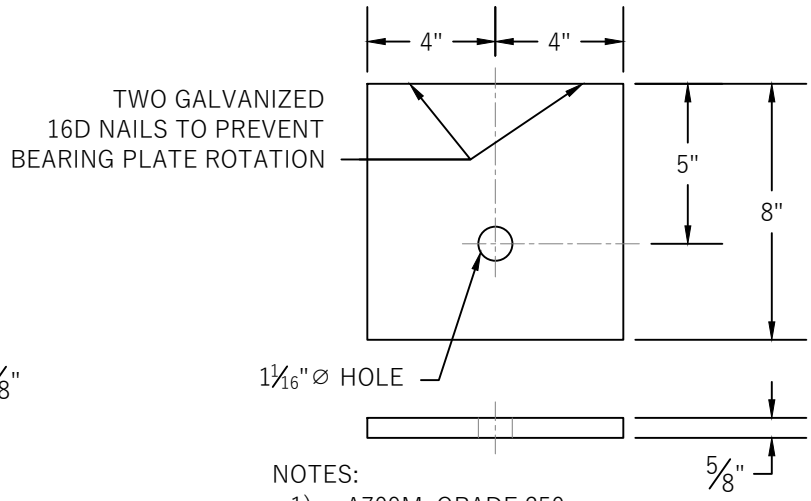
RECTANGULAR STEEL TUBE



NOTES:

1) A53, GRADE B
2) GALVANIZED IN ACCORDANCE WITH AASHTO M 111

POST SLEEVE

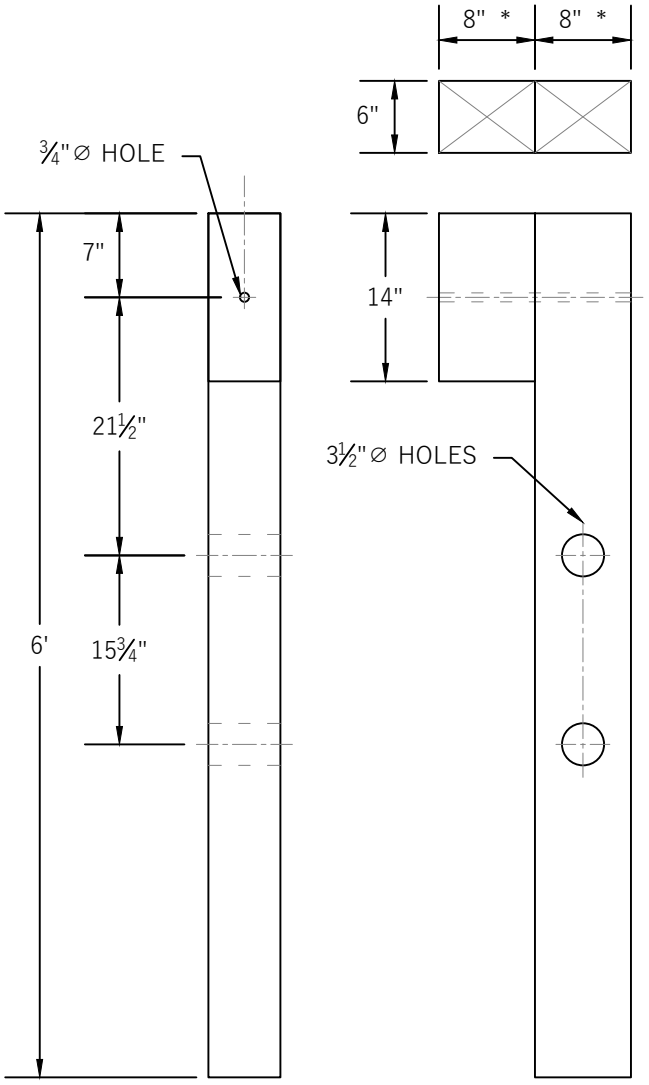


NOTES:

1) A709M, GRADE 250
2) GALVANIZED IN ACCORDANCE WITH AASHTO M 111

BEARING PLATE

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 4 OF 7

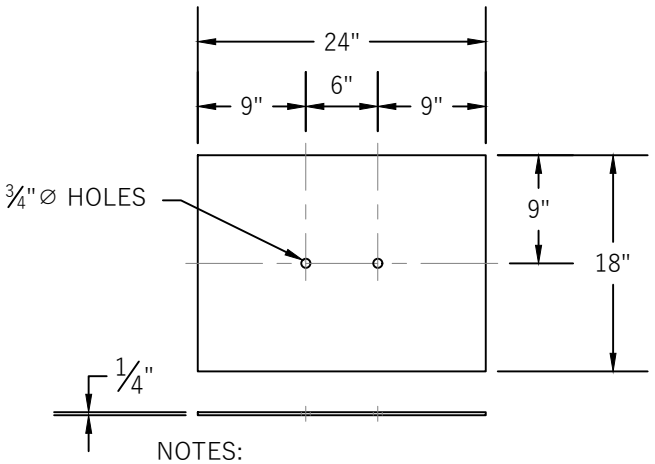


* ± ¼" TOLERANCE ALLOWED FOR ROUGH SAWN POSTS.

NOTES:

1) THESE MATERIAL SPECIFICATIONS ARE FROM THE REFERENCED CRASH TEST REPORT.
2) MAY BE S4S OR ROUGH SAWN WITH NOMINAL DIMENSIONS INDICATED.
3) SHALL HAVE A BENDING STRESS GRADE OF 1,200 PSI MINIMUM AND SHALL BE GRADE MARKED OR CERTIFIED BY A RECOGNIZED ASSOCIATION OR AGENCY WHICH IS CERTIFIED BY THE BOARD OF REVIEW, AMERICAN LUMBER STANDARDS COMMITTEE, TO GRADE THE SPECIES.
4) WOOD POST AND BLOCKS SHALL CONFORM TO AASHTO M 168.
5) TREAT WITH PRESERVATIVES PER AASHTO M 133 AFTER ANY TRIMMING OR DRILLING.

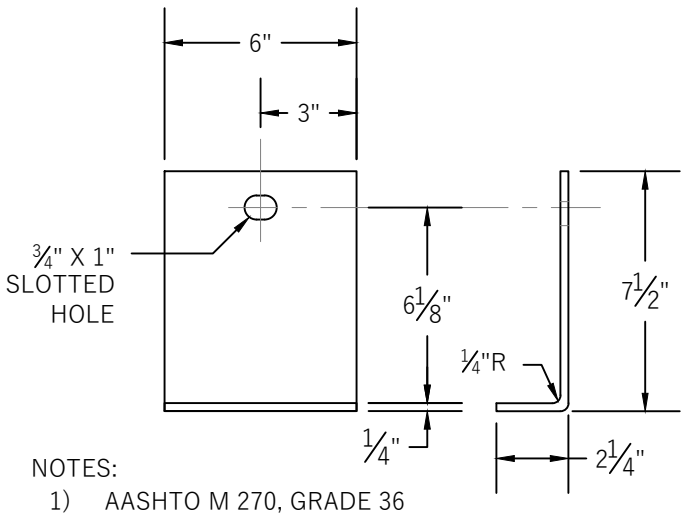
BREAKAWAY LINE POST



NOTES:

1) AASHTO M 270, GRADE 36
2) GALVANIZED

SOIL PLATE

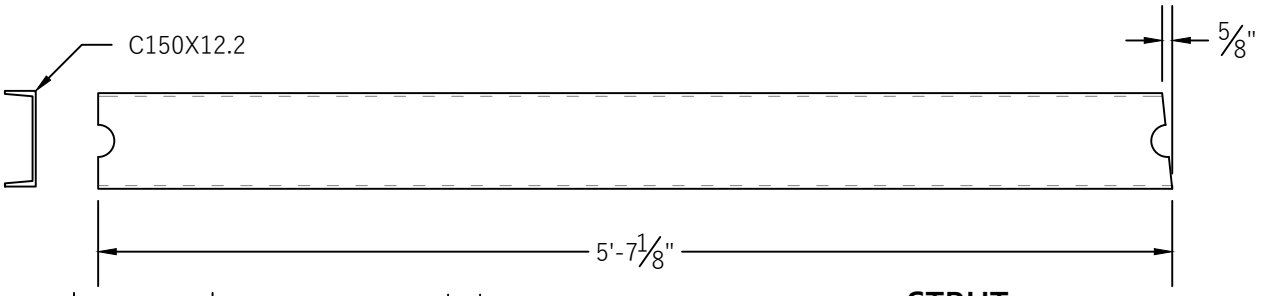


NOTES:

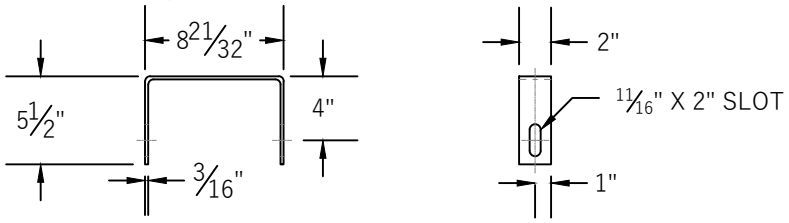
1) AASHTO M 270, GRADE 36
2) GALVANIZED

SHELF ANGLE

SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 5 OF 7

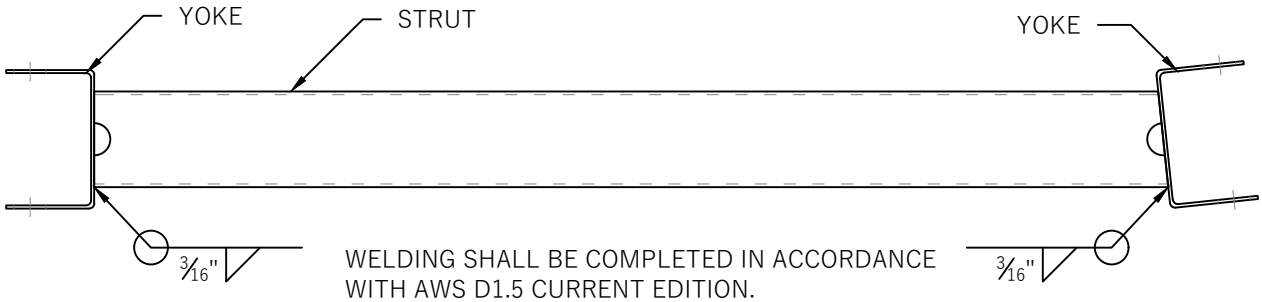


STRUT



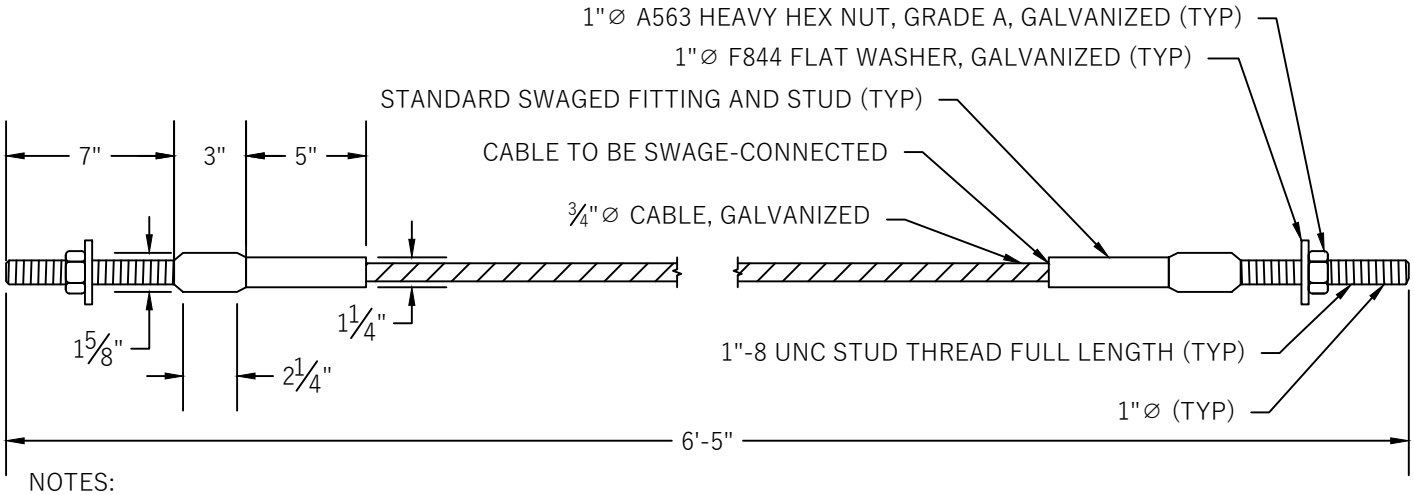
NOTES:
1) AASHTO M 270, GRADE 36
2) GALVANIZED
3) WELDING SHALL MEET THE CURRENT REQUIREMENTS OF AWS D1.5.

YOKE



WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

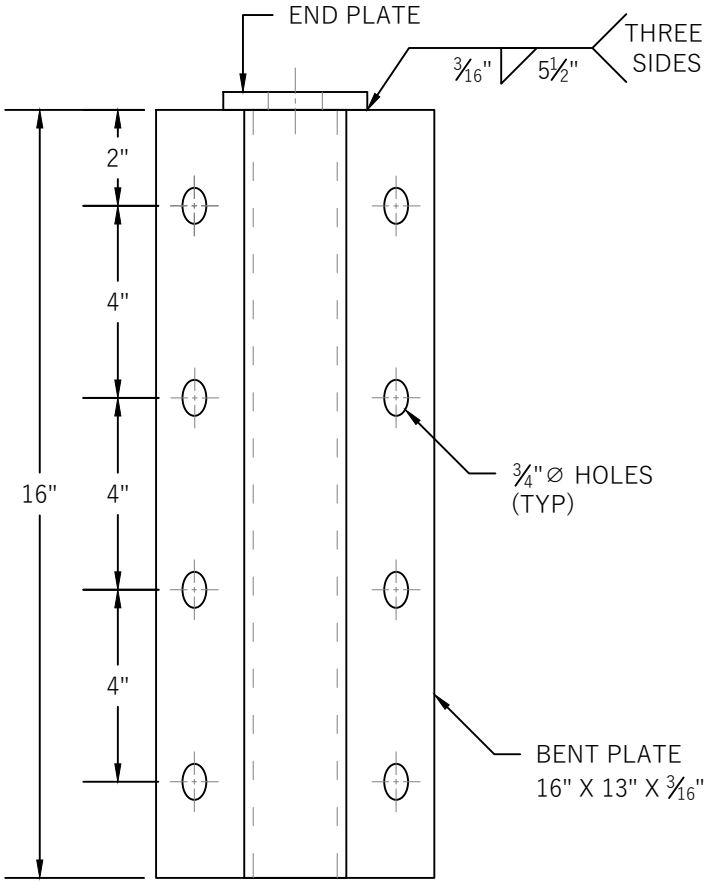
STRUT AND YOKE ASSEMBLY



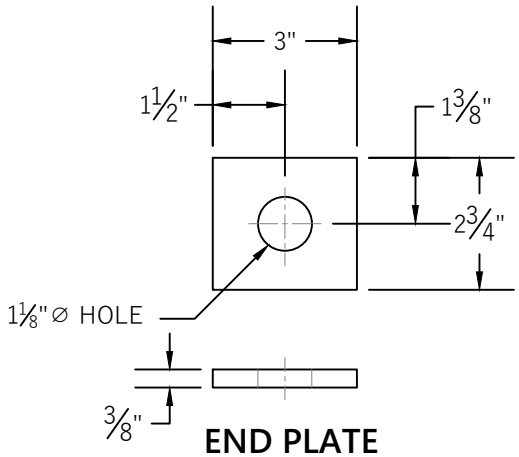
NOTES:
1) SWAGED FITTINGS SHALL BE MACHINED FROM HOT ROLLED CARBON STEEL CONFORMING TO A576, GRADE 1035 AND GALVANIZED TO AASHTO M 111 BEFORE SWAGING. A LOCK PIN HOLE TO ACCOMMODATE A ¼" PLATED SPRING-STEEL PIN SHALL BE DRILLED THROUGH THE HEAD OF THE SWAGED FITTING TO RETAIN THE STUD IN THE PROPER POSITION.
2) CABLE SHALL BE METALLIC-COATED WIRE ROPE, TYPE II(a) 6X19 WIRE-STRAND CORE OR TYPE II INDEPENDENT WIRE ROPE CORE, CLASS A ZINC COATED, RIGHT REGULAR LAY WIRE ROPE CONFORMING TO AASHTO M 30. THE WIRE ROPE SHALL BE IMPROVED STEEL WITH A MINIMUM BREAKING STRENGTH OF 42.8 KIPS. THE SWAGED FITTING, STUD AND NUT SHALL DEVELOP THE FULL BREAKING STRENGTH OF THE WIRE ROPE.

ANCHOR CABLE

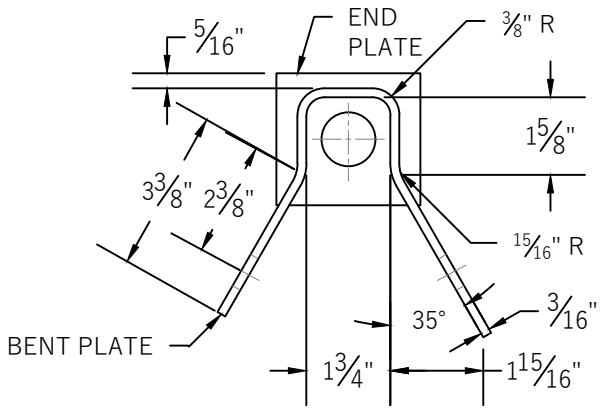
SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 6 OF 7



ANCHOR BRACKET

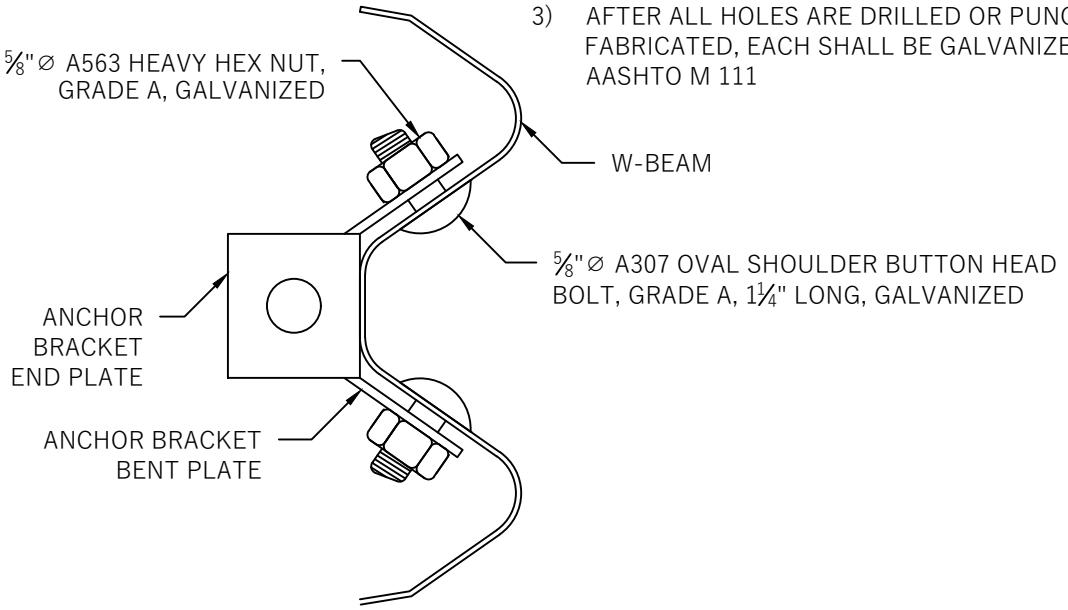


END PLATE



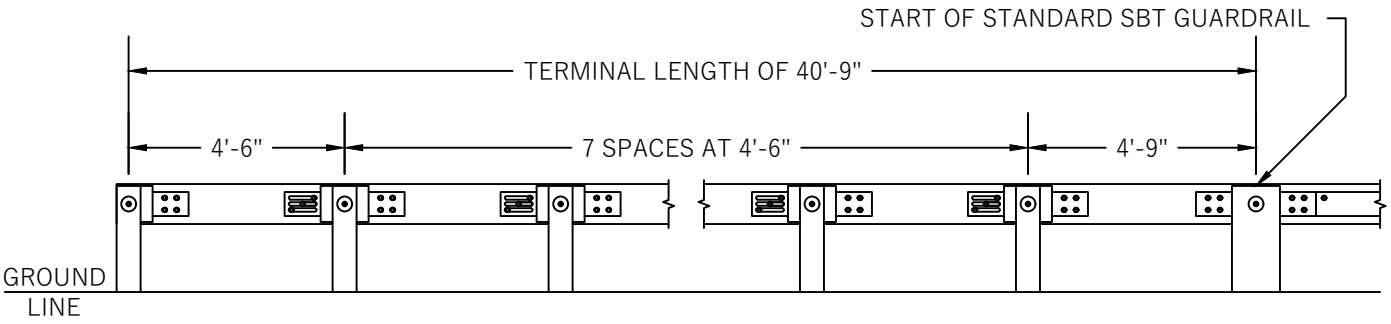
NOTES:

1) BENT PLATE AND END PLATE SHALL CONFORM TO AASHTO M 270, GRADE 36.
2) WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.
3) AFTER ALL HOLES ARE DRILLED OR PUNCHED AND THE BRACKET FABRICATED, EACH SHALL BE GALVANIZED IN ACCORDANCE WITH AASHTO M 111

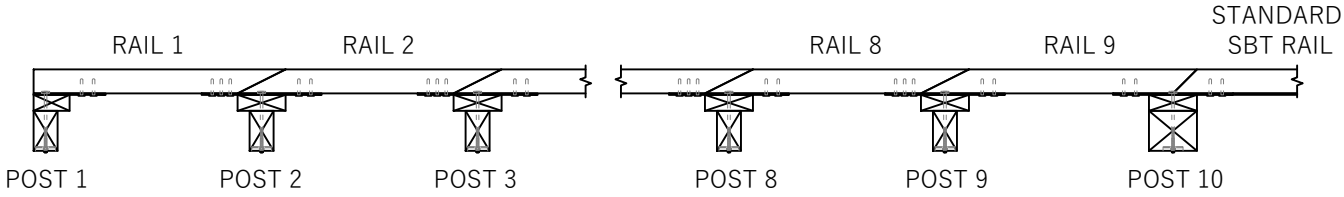


ANCHOR BRACKET CONNECTION DETAIL

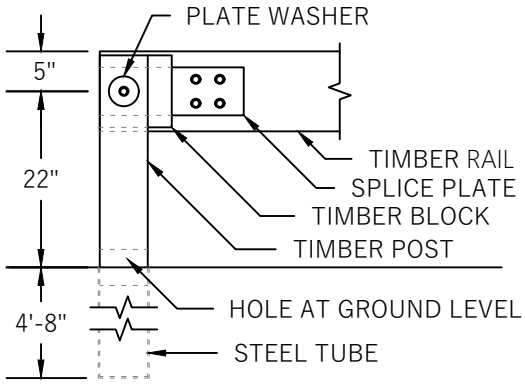
SOURCE: FHWA	**BRIDGE RAIL NAME:** MODIFIED ECCENTRIC LOADER TERMINAL WITH WOOD POSTS		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 2 SOURCE: NETCR 35	**SHEET #** 7 OF 7

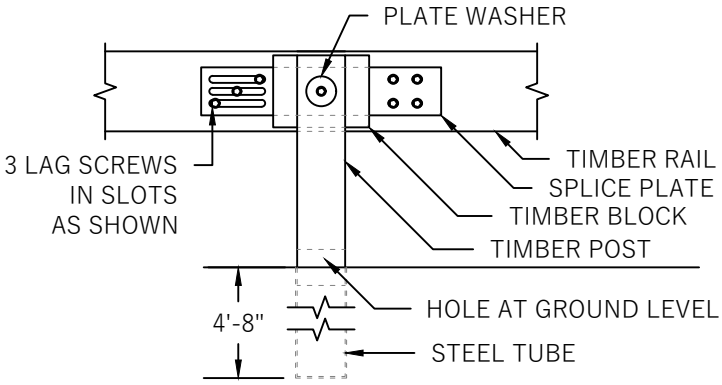


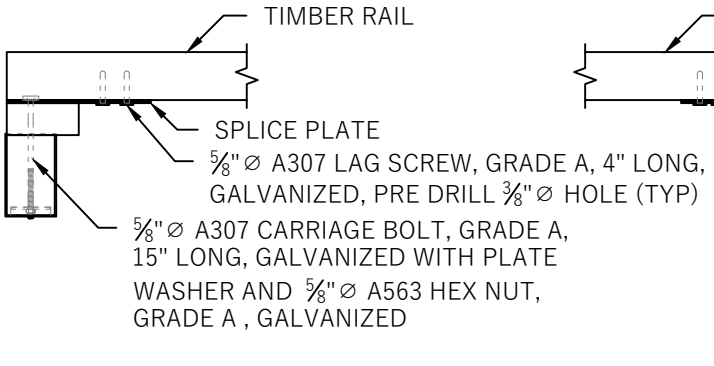
ELEVATION VIEW

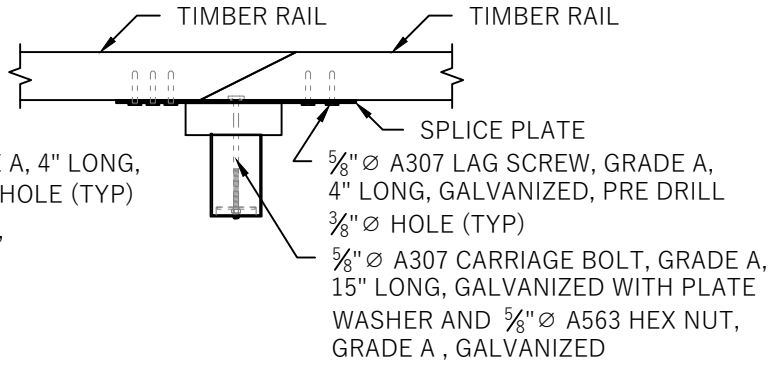


PLAN VIEW







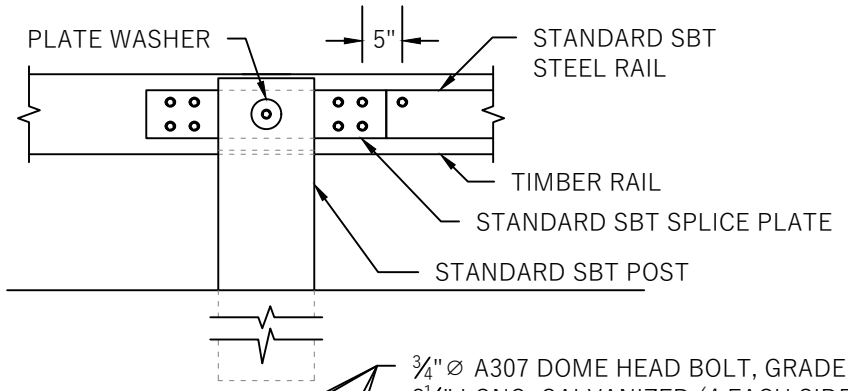


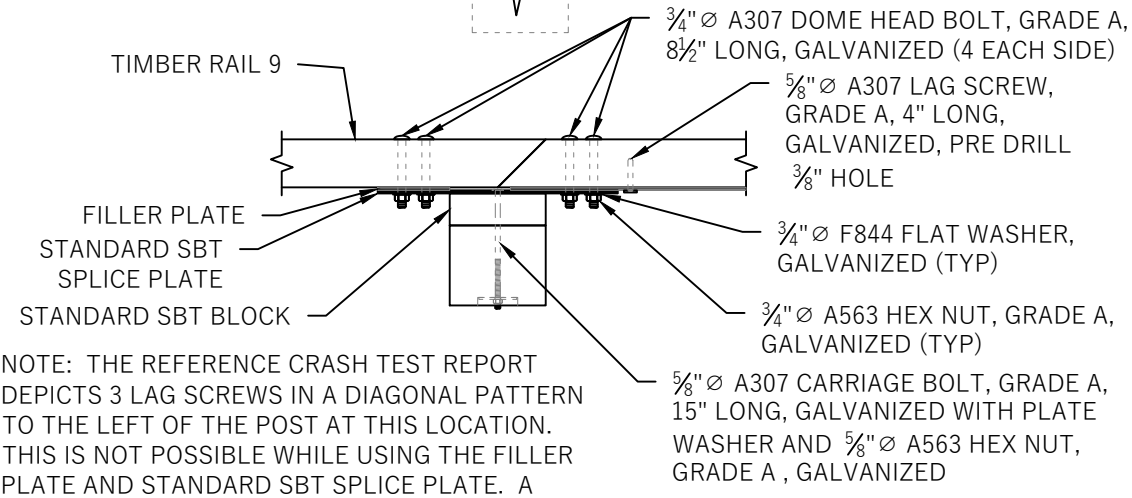
POST / RAIL CONNECTION AT POST 1

POST / RAIL CONNECTION AT POST 2-9

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL-BACKED TIMBER GUARDRAIL TANGENT END TERMINAL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 3 SOURCE: CC-116	**SHEET #** 1 OF 4





NOTE: THE REFERENCE CRASH TEST REPORT DEPICTS 3 LAG SCREWS IN A DIAGONAL PATTERN TO THE LEFT OF THE POST AT THIS LOCATION. THIS IS NOT POSSIBLE WHILE USING THE FILLER PLATE AND STANDARD SBT SPLICE PLATE. A STANDARD SBT RAIL SPLICE CONNECTION DETAIL WAS USED.

POST / RAIL CONNECTION AT POST 10

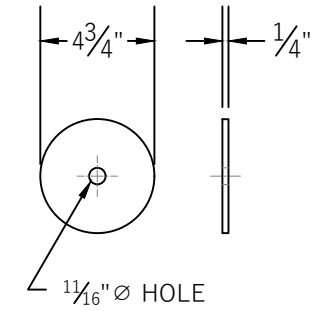
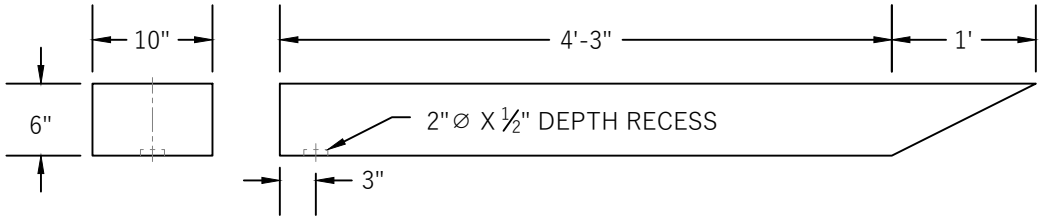
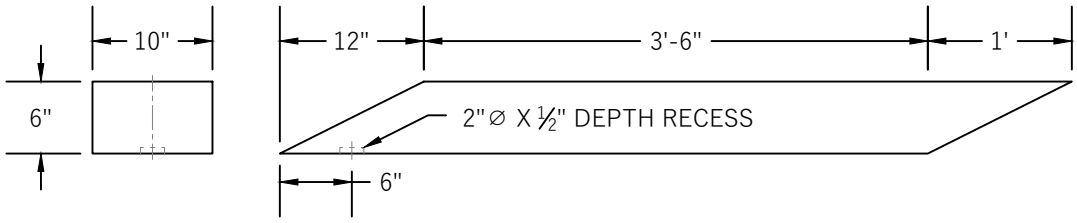


PLATE WASHER

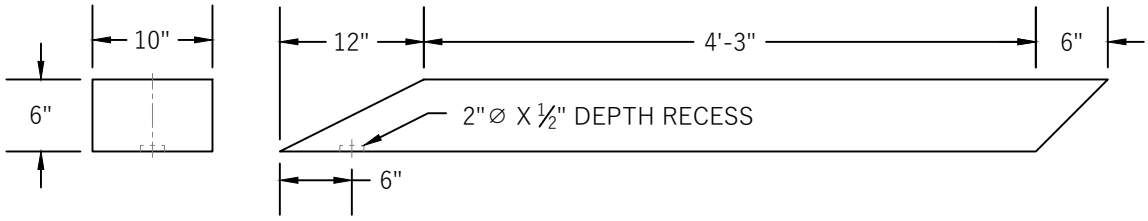
TIMBER RAIL 1



TIMBER RAIL 2-8

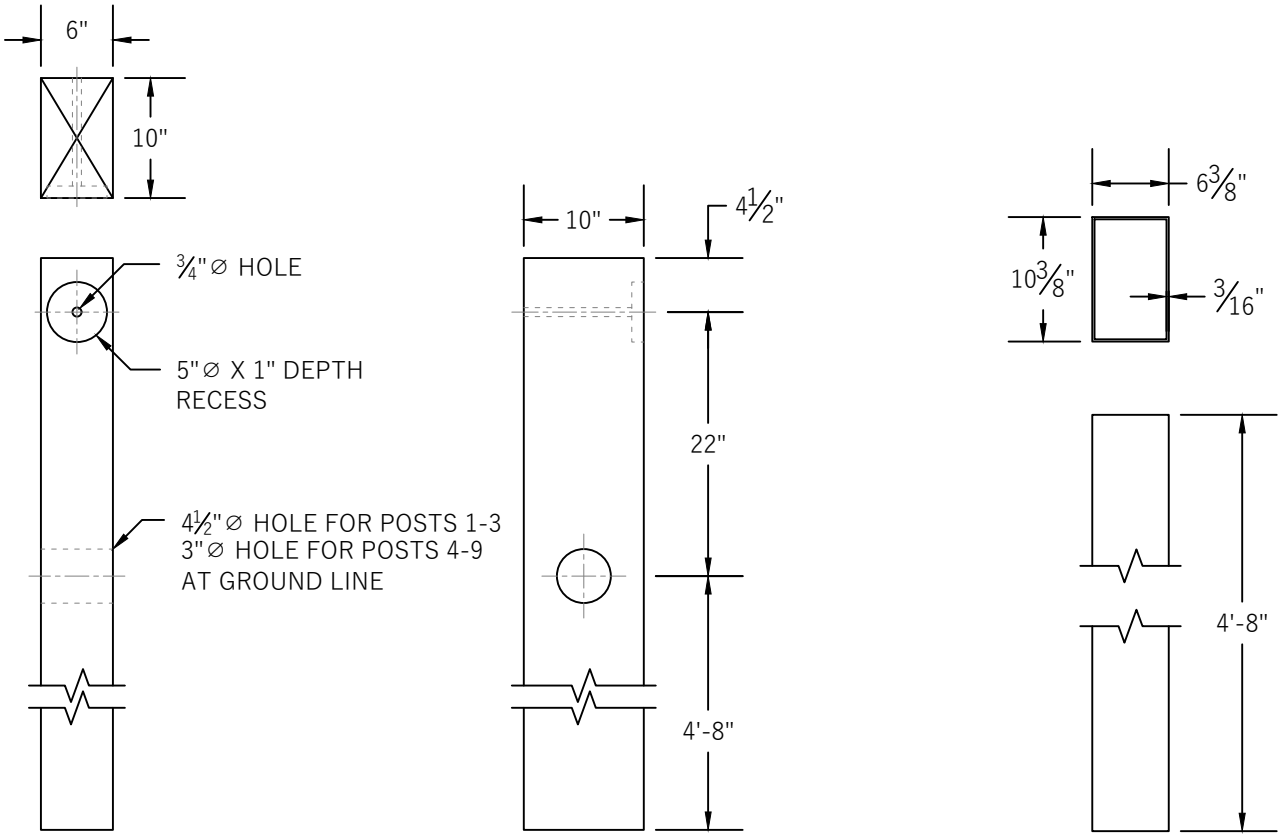


TIMBER RAIL 9



NOTE: THESE MATERIAL SPECIFICATIONS ARE FROM APPENDIX A REF 8 / TRP-03-31-93: TIMBER RAILS SHALL BE DOUGLAS FIR, SOUTHERN PINE, ETC. GRADE NO. 1, ROUGH-SAWN. TREAT TO MEET AWPA STANDARD C14 WITH 12 PCF CREOSOTE.

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL-BACKED TIMBER GUARDRAIL TANGENT END TERMINAL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 3 SOURCE: CC-116	**SHEET #** 2 OF 4

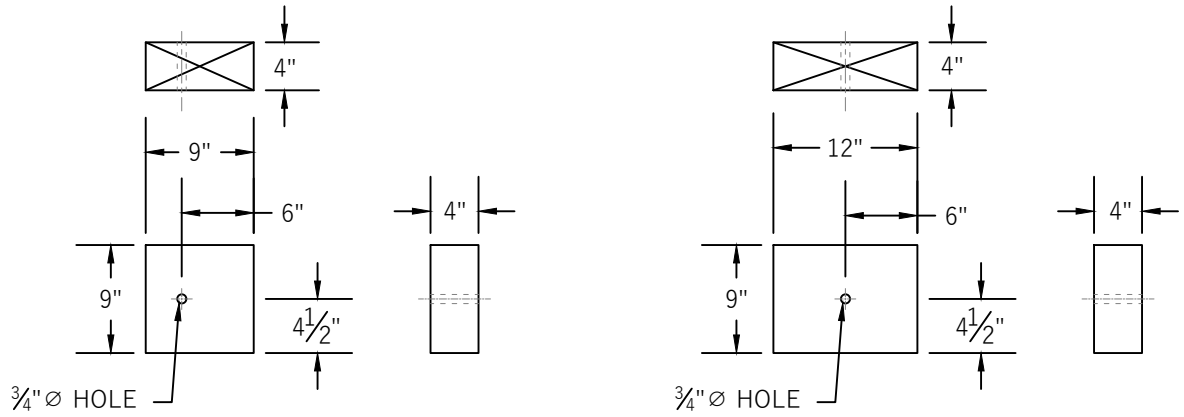


THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDP20-24: POSTS SHALL BE S4S WITH NOMINAL DIMENSIONS INDICATED. MAY BE SOUTHERN PINE GRADE 2, DOUGLAS FIR GRADE 2, WESTERN HEMLOCK GRADE 1, PONDEROSA PINE GRADE 2, RED PINE GRADE 2, OR WESTERN RED CEDAR GRADE 1. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER POST IS SAWN, DRESSED AND END TRIMMED.

A36, GALVANIZED

TIMBER POST 1-9

STEEL TUBE

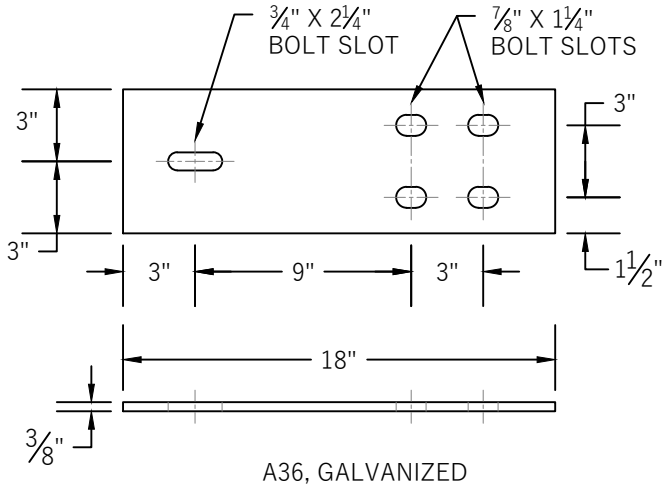


THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDB01A-B: BLOCKS SHALL BE MADE OF TIMBER WITH A STRESS GRADE OF AT LEAST 1160 PSI [8MPa]. SHALL BE EITHER ROUGH-SAWN OR S4S WITH NOMINAL DIMENSIONS INDICATED. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER ALL END CUTS ARE MADE AND HOLES ARE DRILLED. VARIATION IN SIZE IN THE DIRECTION PARALLEL TO THE AXIS OF THE BOLT HOLES SHALL NOT BE MORE THAN ¼"

TIMBER BLOCK AT POST 1

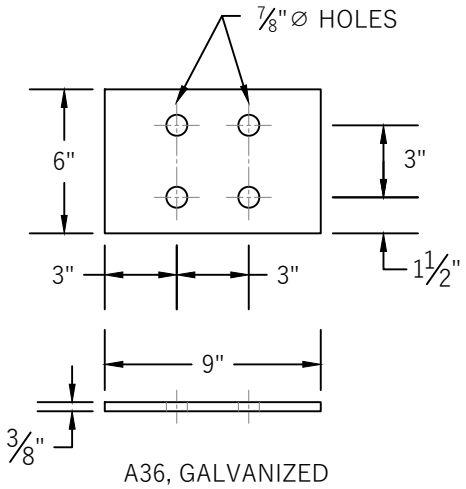
TIMBER BLOCK AT POST 2-9

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL-BACKED TIMBER GUARDRAIL TANGENT END TERMINAL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 3 SOURCE: CC-116	**SHEET #** 3 OF 4



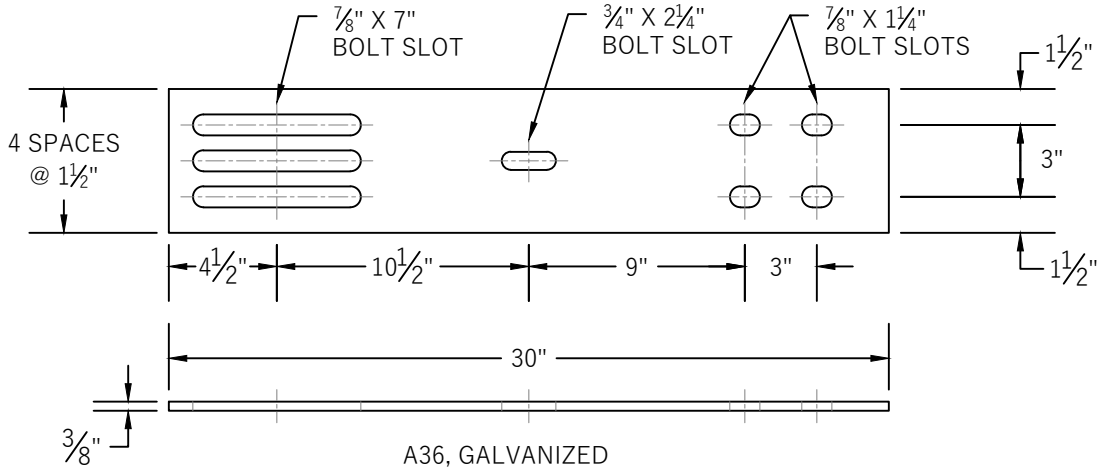
A36, GALVANIZED

SPLICE PLATE AT POST 1



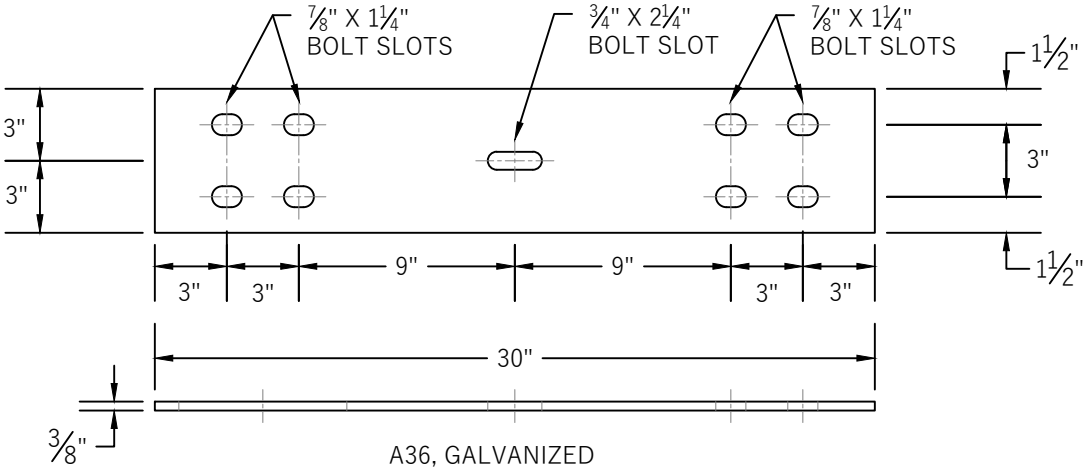
A36, GALVANIZED

FILLER PLATE AT POST 10



A36, GALVANIZED

SPLICE PLATE AT POST 2-9



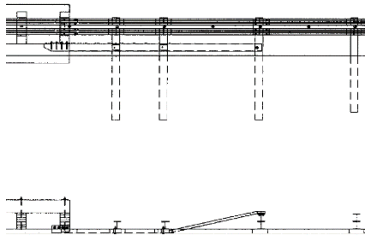
A36, GALVANIZED

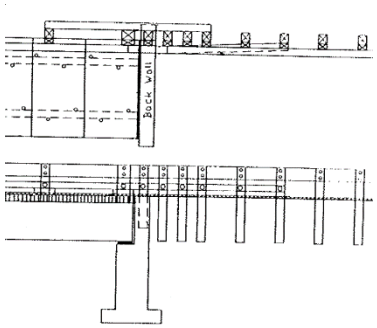
STANDARD SBT SPLICE PLATE AT POST 10

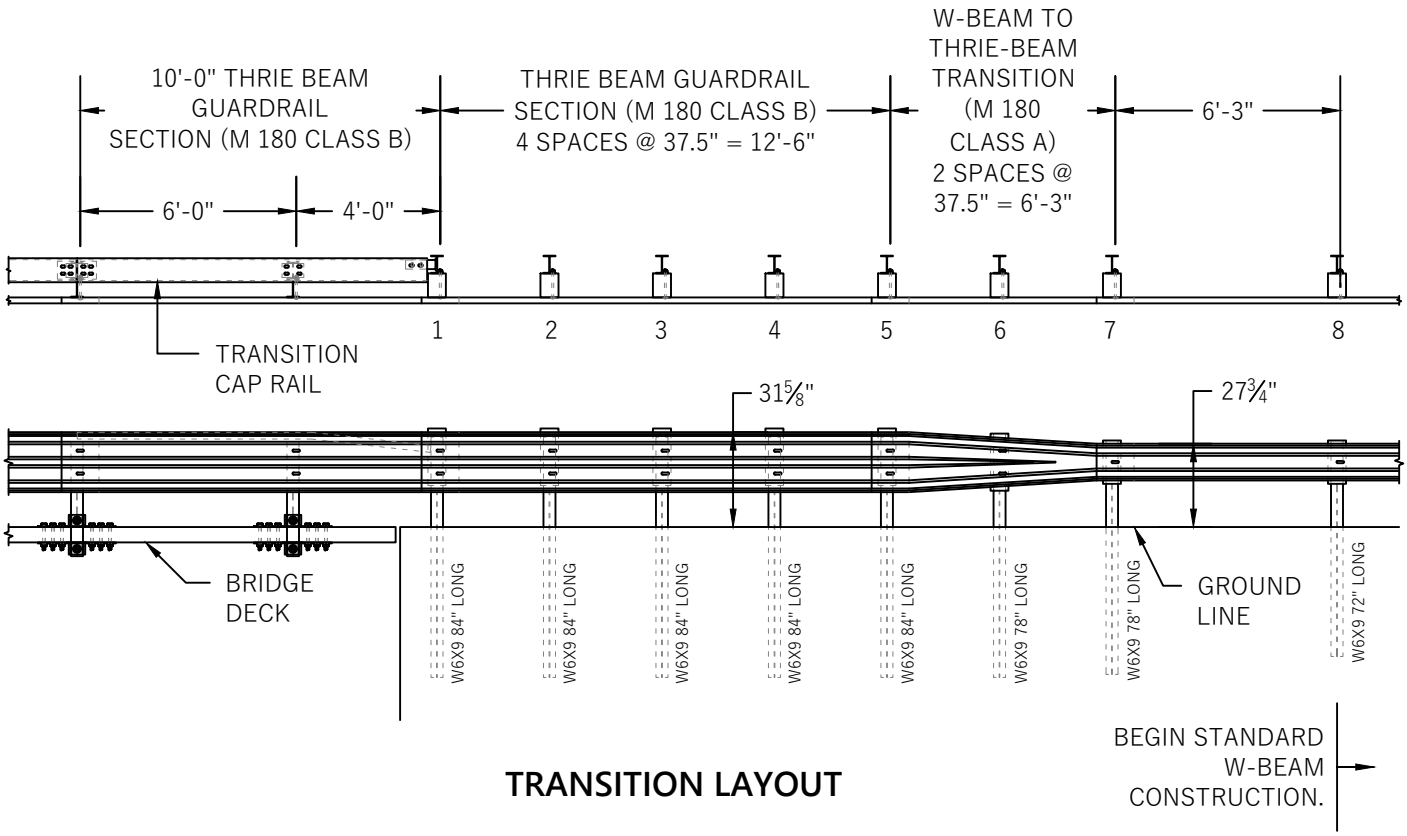
SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL-BACKED TIMBER GUARDRAIL TANGENT END TERMINAL		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX B REF 3 SOURCE: CC-116	**SHEET #** 4 OF 4

APPENDIX C: CRASH TESTED TRANSITION DESIGNS

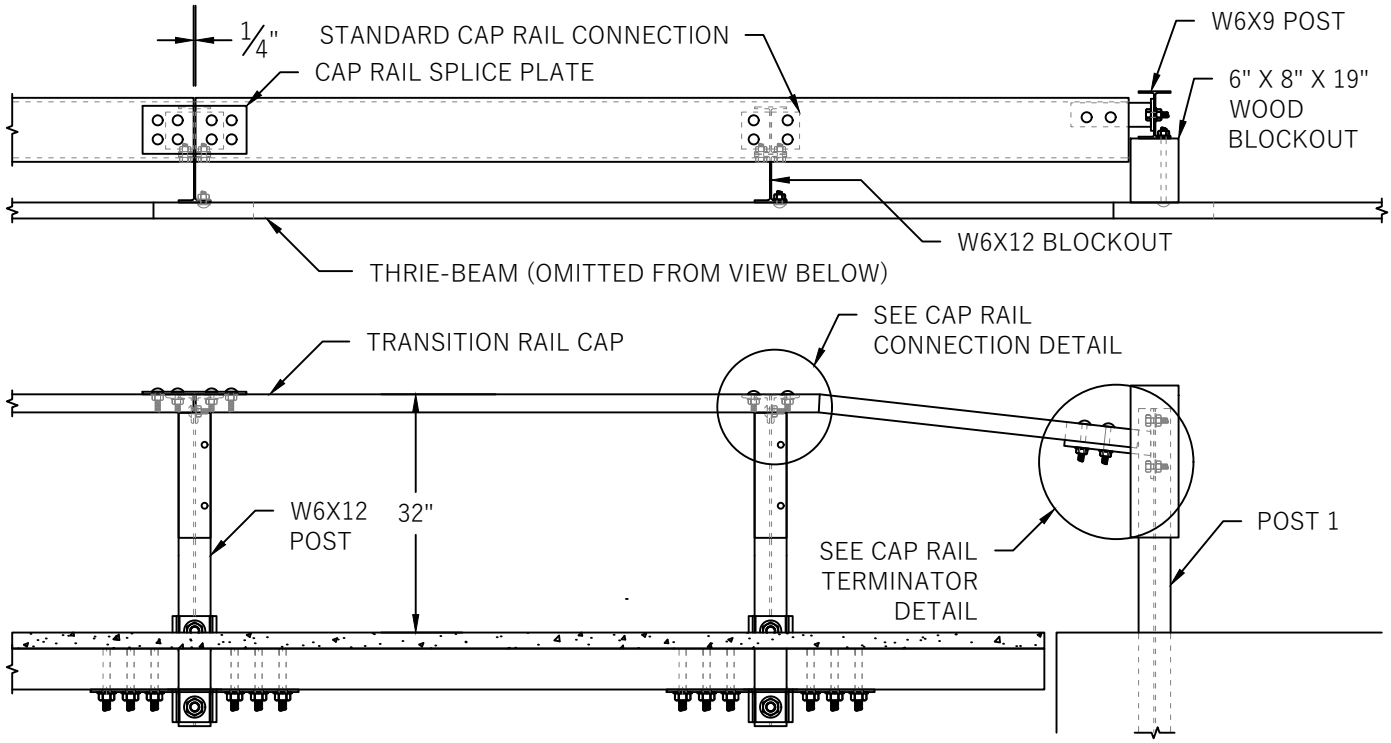
Appendix C. Crash Tested Transition Designs

System Name	Test Number	Test Level	Photo/Sketch	Guardrail	Transition			Bridge Rail	Ref
				Type	Type	Post	Connection	Type	
Steel System Approach Guardrail Transition	STCR-2	R350 TL-2		27.78” tall standard w-beam guardrail.	Symmetrical transition section to 12’6” thrie beam section.	Seven steel posts with wood blockouts installed @ 37.5” spacing embedded 49”-54” deep.	Typical thrie-to-thrie beam splice using (12) 5/8”Ø bolts and cap rail transition using (2) 5/8”Ø bolts.	31.65” tall thrie beam with steel channel cap rail.	1
Wood System Approach Guardrail Transition	WRBP-2	R350 TL-2		27.78” tall standard w-beam guardrail.	W-beam guardrail (reduced post spacing) to nested w-beam guardrail.	Seven steel posts with wood blockouts installed @ 37.5” spacing embedded 43”-55” deep.	W-beam terminal connector and transition splice plate with (8) 7/8”Ø A307 bolts.	28.4” tall glulam timber bridge rail.	2
W-Beam Retrofit Transition	472070-3 472070-4	R350 TL-2		27” tall standard w-beam guardrail - G4(1S).	Nested w-beam guardrail with steel channel rub rail.	Three steel posts with steel blockouts installed with (2) @ 37.5” spacing and (1) @ 6’3” spacing embedded 50” deep.	Typical w-to-w beam splice using (8) 5/8”Ø bolts and rub rail using (2) 5/8”Ø bolts and (4) 7/8”Ø DFS wedge anchors.	29” tall w-beam retrofit bridge rail, supported by wood posts, and backed by concrete rail	3

System Name	Test Number	Test Level	Photo/Sketch	Guardrail	Transition			Bridge Rail	Ref
				Type	Type	Post	Connection	Type	
West Virginia Timber Bridge Rail Transition (Timber Bridge Rail System 2)	7212-3	AASHTO PL-1		None installed, report assumed 6’3” post spacing on standard guardrail section.	Glulam rail with timber rub rail. Glulam stiffening rail installed on last 4 posts of transition and first 2 bridge rail posts.	Ten wood posts with wood blocks installed with (4) @18.75” spacing, (4) @37.5” spacing and (1) @6’3” spacing embedded 44” deep.	Glulam transition-bridge rail spliced using (4) 7/8”Ø bolts through transition rail, block, post, and stiffening rail. Rub rail splice using (2) 5/8”Ø bolts and bolted to the deck using (4) 7/8”Ø bolts.	27” tall w-beam over steel tubes with timber blocks and posts seated in a steel bracket.	4



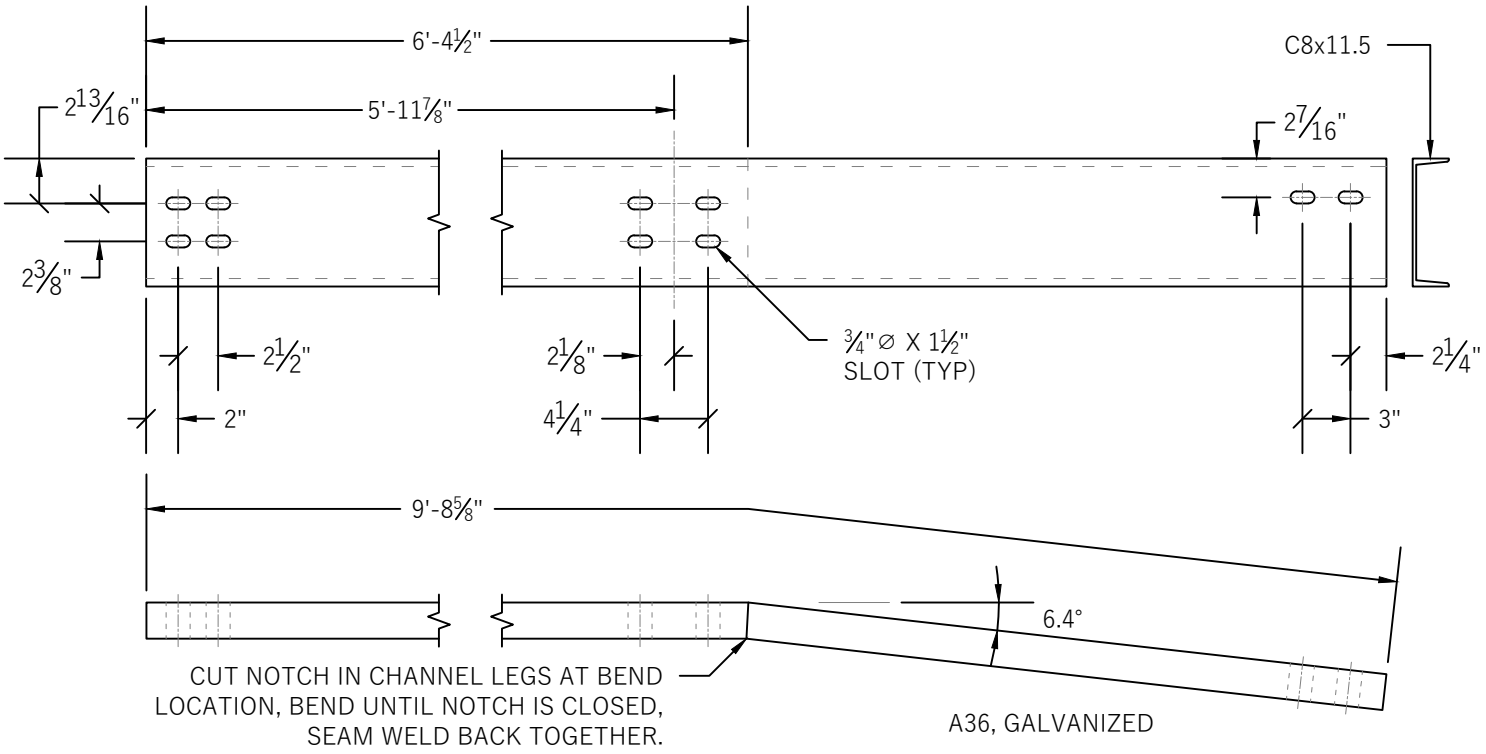
TRANSITION LAYOUT



TRANSITION CAP RAIL DETAIL

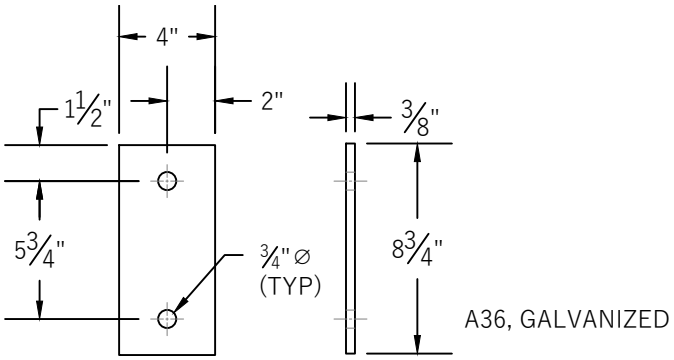
NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 - 31.65 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 1 SOURCE: TRP-03-125-03	**SHEET #** 1 OF 7

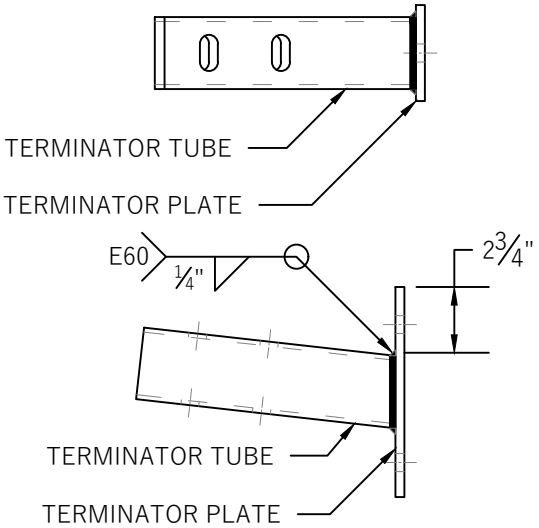


WELDING SHALL BE DONE IN ACCORDANCE WITH
AWS D1.5 CURRENT EDITION.

TRANSITION RAIL CAP

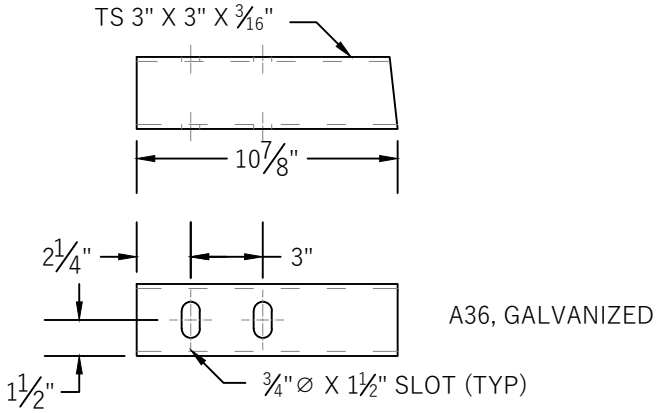


TERMINATOR PLATE



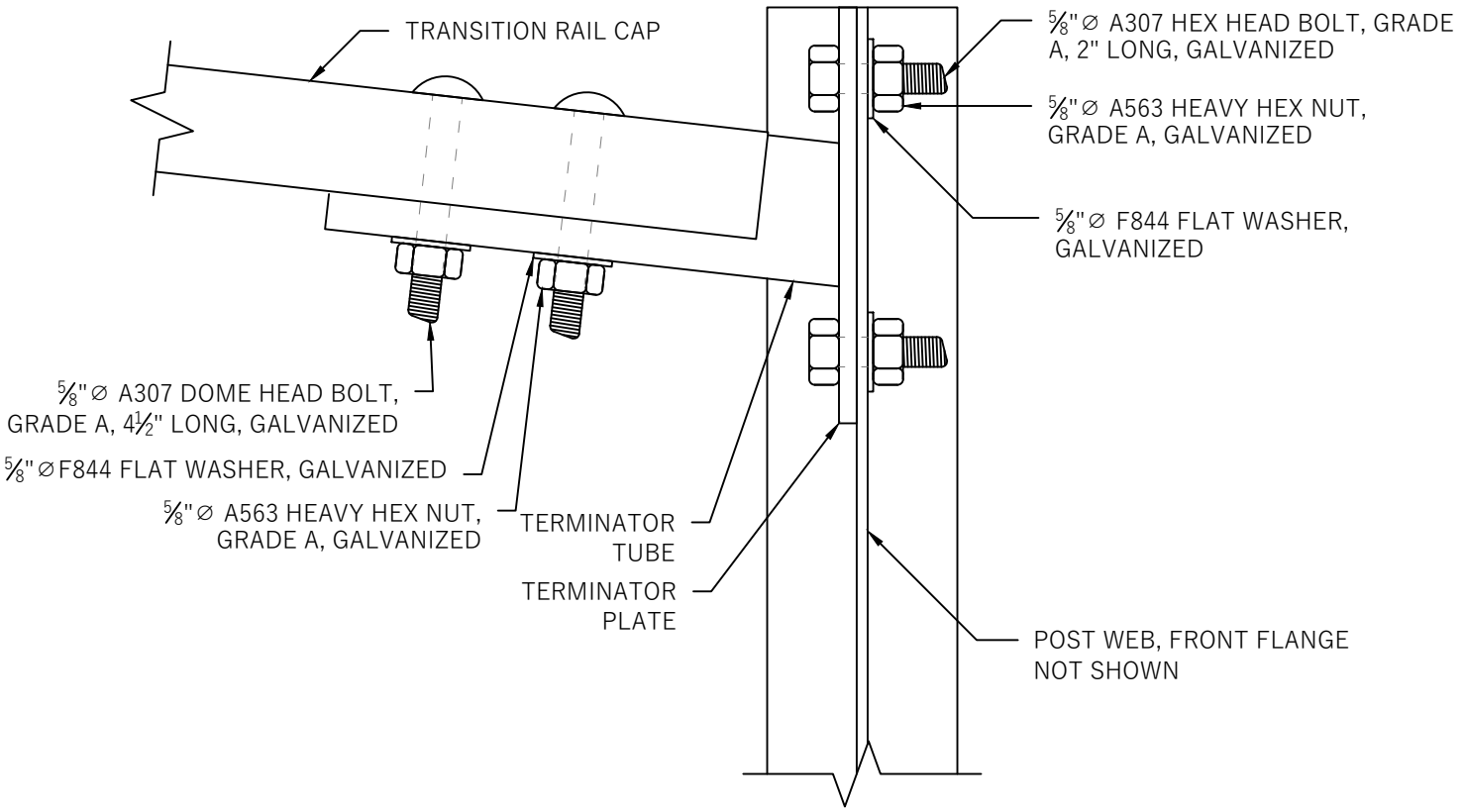
WELDING SHALL BE DONE IN ACCORDANCE
WITH AWS D1.5 CURRENT EDITION.

TERMINATOR ASSEMBLY

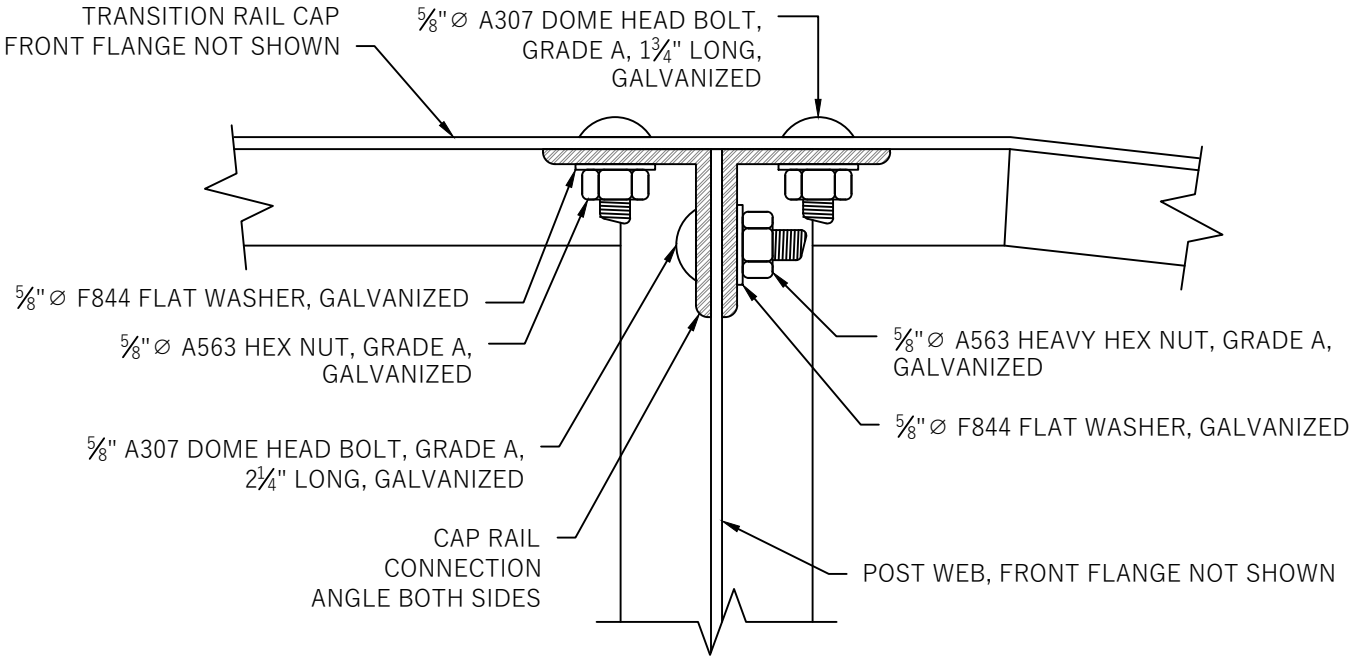


TERMINATOR TUBE

SOURCE: FHWA	BRIDGE RAIL NAME: STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		DRAWING SCALE: NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	BRIDGE RAIL HEIGHT: 27.78 - 31.65 INCHES	BRIDGE RAIL REFERENCE: APPENDIX C REF 1 SOURCE: TRP-03-125-03	SHEET # 2 OF 7

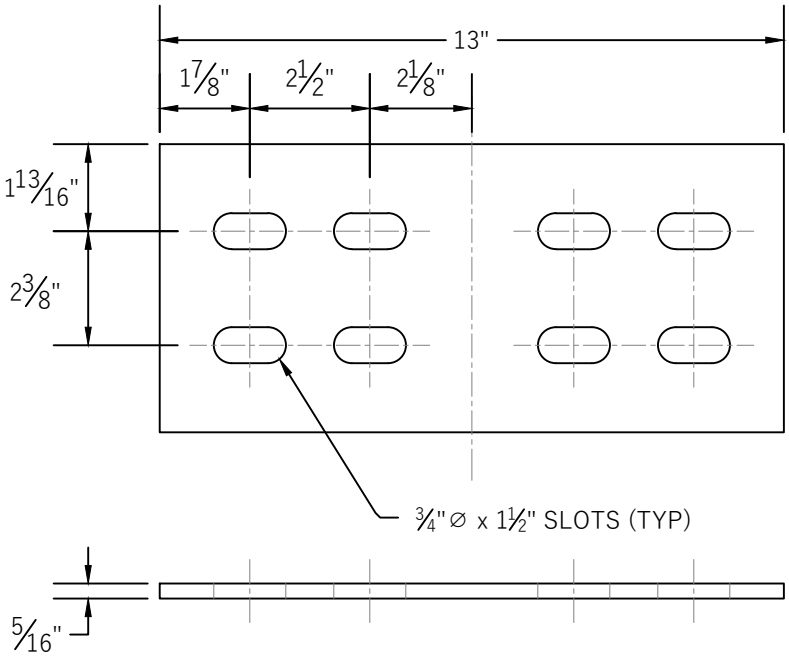


CAP RAIL TERMINATOR DETAIL



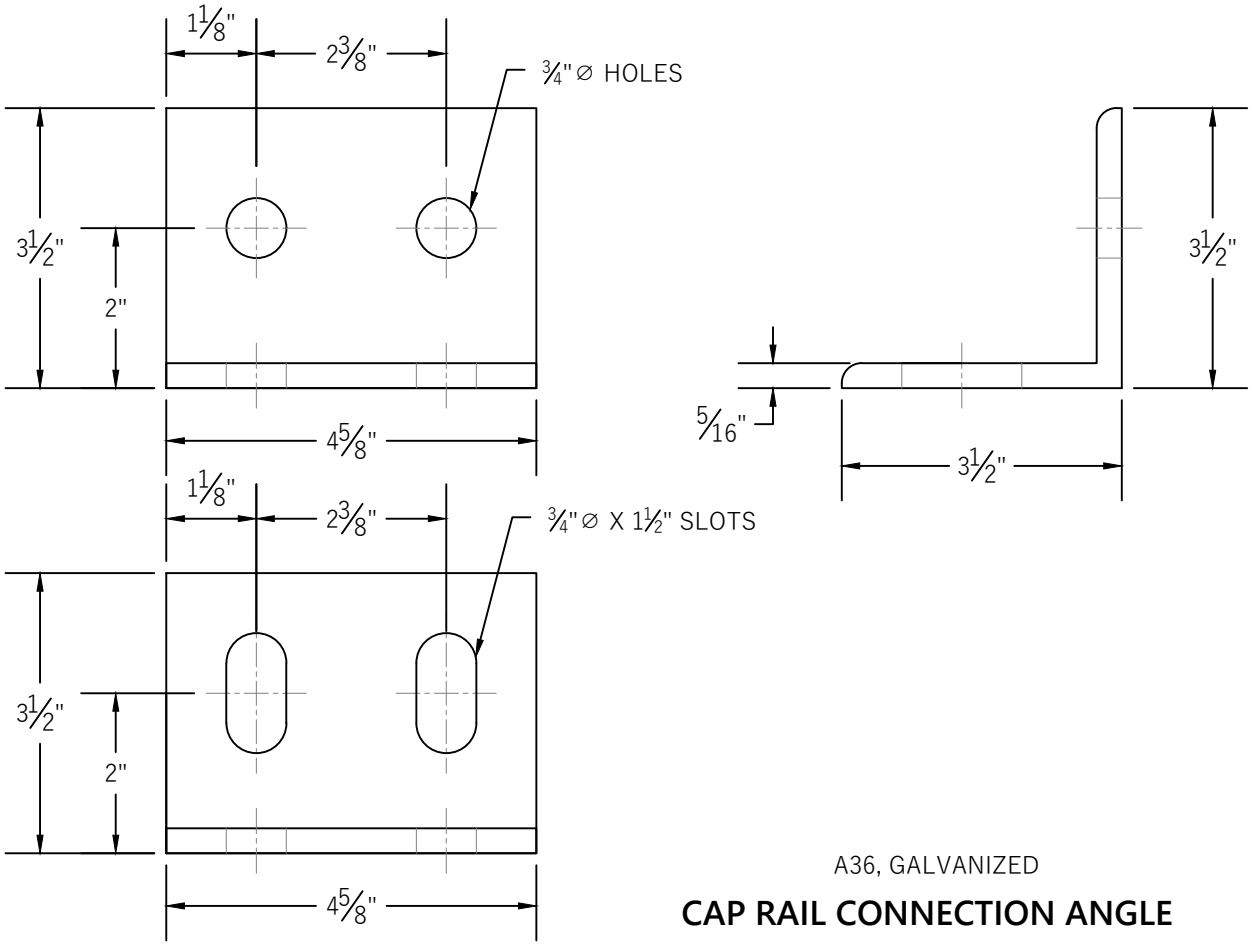
CAP RAIL CONNECTION DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 - 31.65 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 1 SOURCE: TRP-03-125-03	**SHEET #** 3 OF 7



A36, GALVANIZED

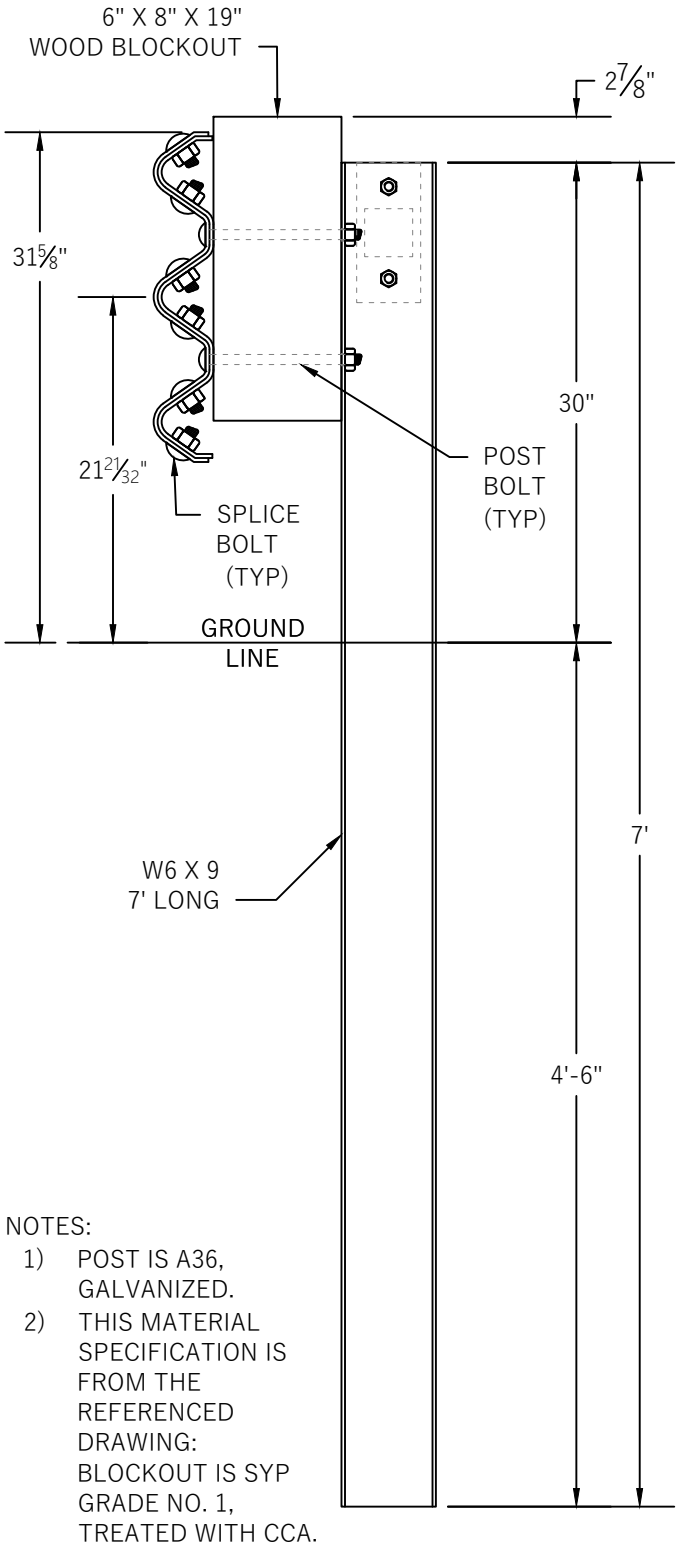
CAP RAIL SPLICE PLATE



A36, GALVANIZED

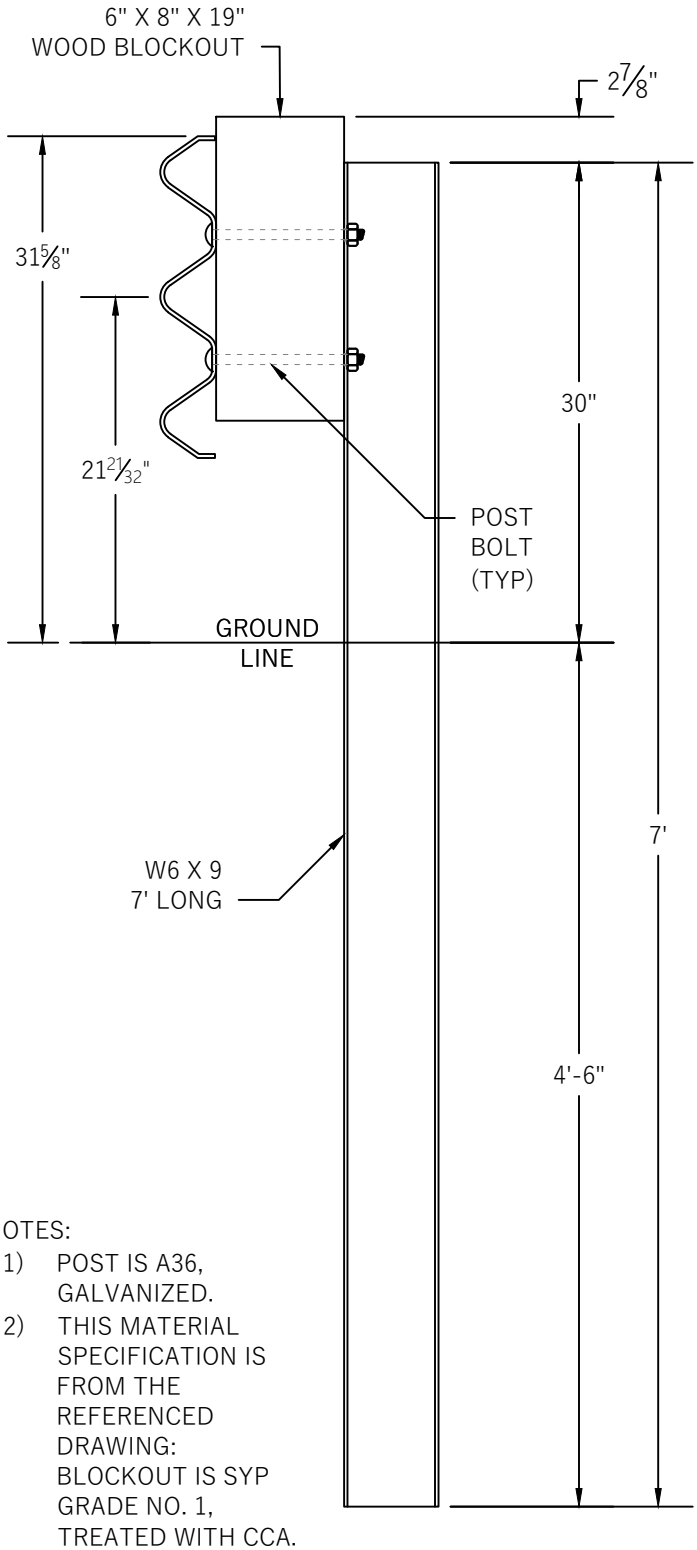
CAP RAIL CONNECTION ANGLE

SOURCE: FHWA	BRIDGE RAIL NAME: STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		DRAWING SCALE: NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	BRIDGE RAIL HEIGHT: 27.78 - 31.65 INCHES	BRIDGE RAIL REFERENCE: APPENDIX C REF 1 SOURCE: TRP-03-125-03	SHEET # 4 OF 7



NOTES:
1) POST IS A36, GALVANIZED.
2) THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: BLOCKOUT IS SYP GRADE NO. 1, TREATED WITH CCA.

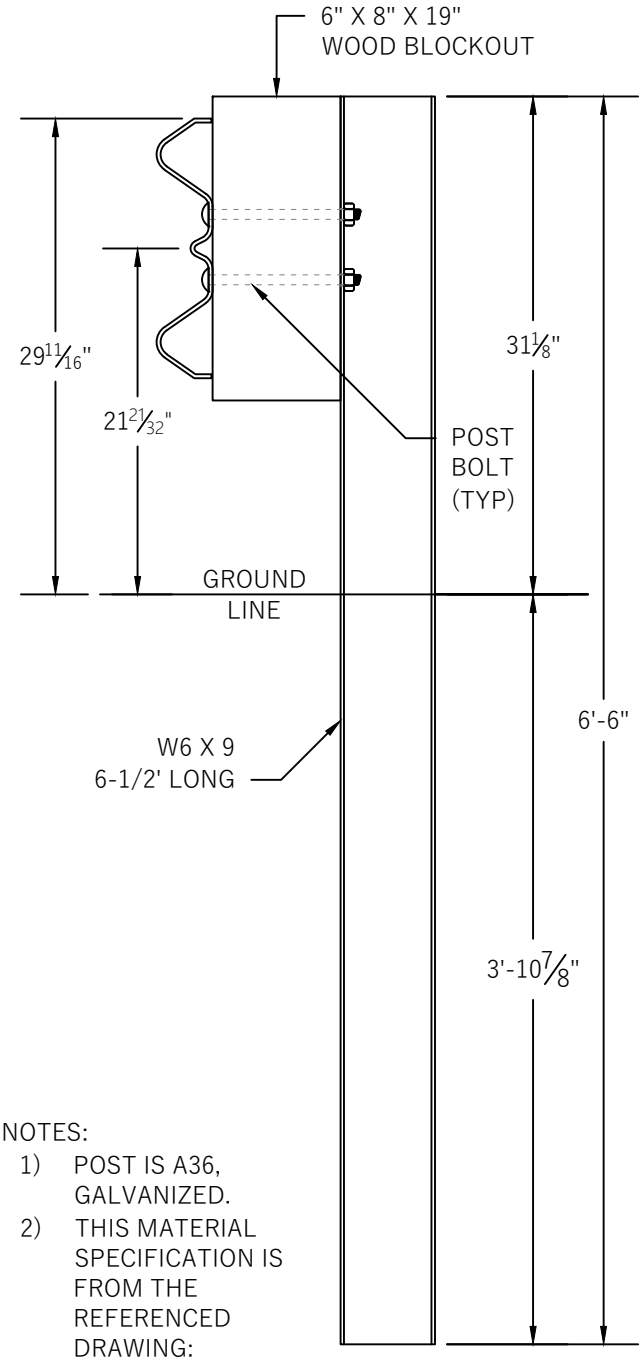
TRANSITION POST 1



NOTES:
1) POST IS A36, GALVANIZED.
2) THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: BLOCKOUT IS SYP GRADE NO. 1, TREATED WITH CCA.

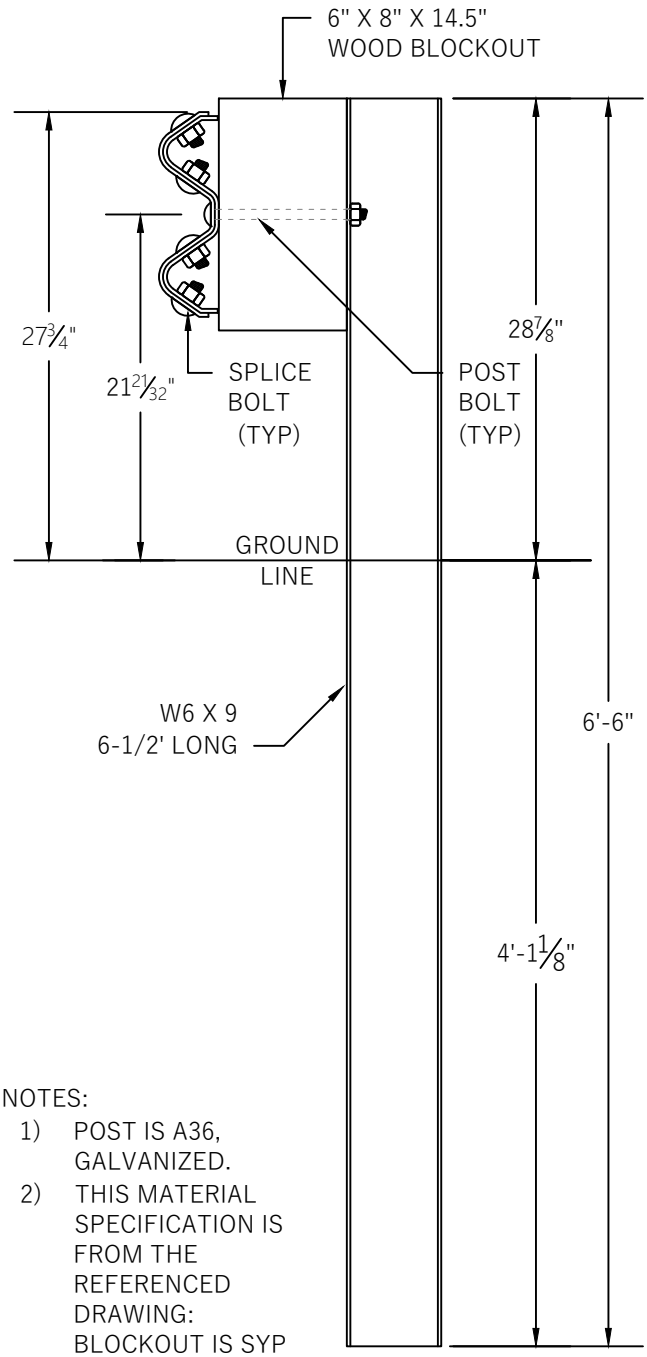
TRANSITION POSTS 2-5

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 - 31.65 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 1 SOURCE: TRP-03-125-03	**SHEET #** 5 OF 7



NOTES:
1) POST IS A36, GALVANIZED.
2) THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: BLOCKOUT IS SYP GRADE NO. 1, TREATED WITH CCA

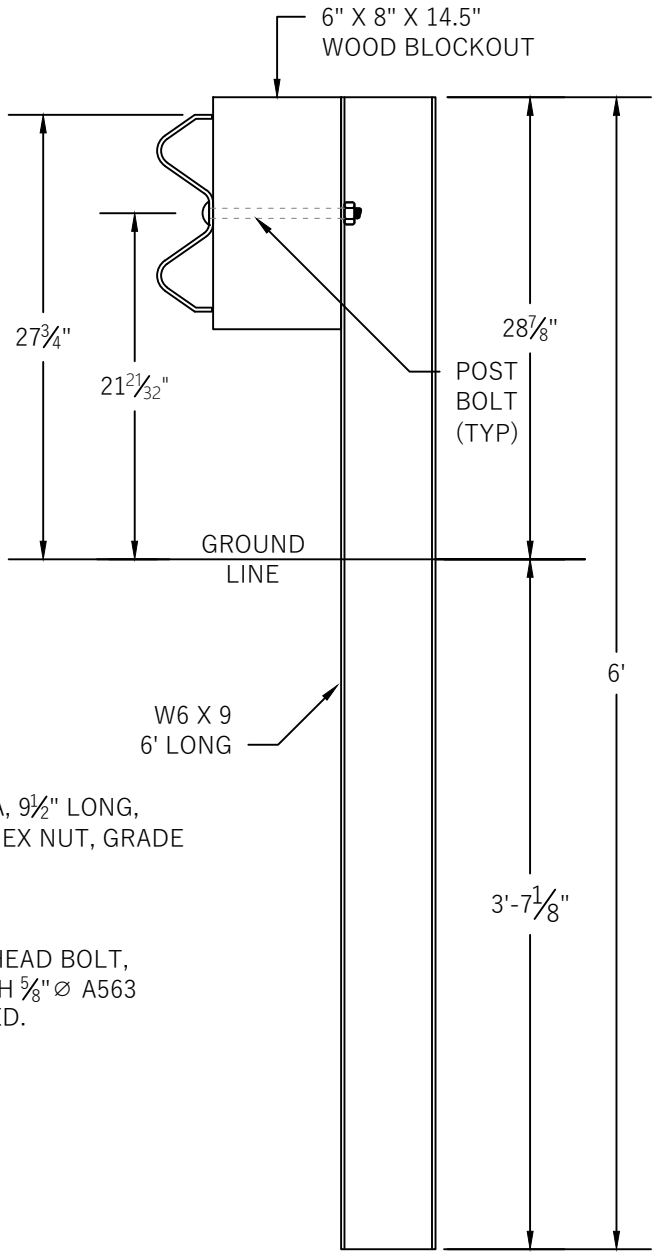
TRANSITION POST 6



NOTES:
1) POST IS A36, GALVANIZED.
2) THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: BLOCKOUT IS SYP GRADE NO. 1, TREATED WITH CCA

TRANSITION POST 7

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 - 31.65 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 1 SOURCE: TRP-03-125-03	**SHEET #** 6 OF 7



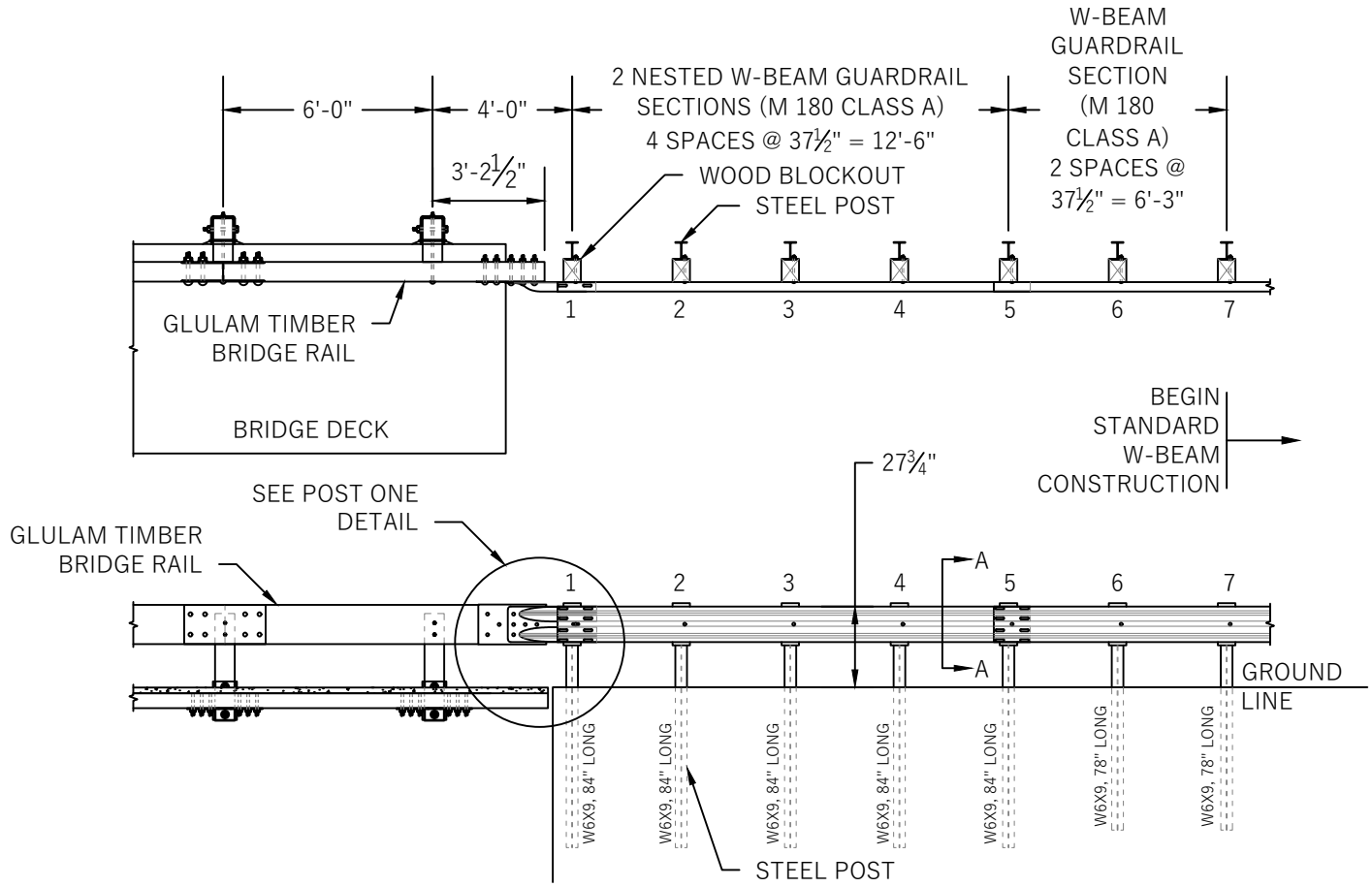
POST BOLT:
⅝"∅ A307 DOME HEAD BOLT, GRADE A, 9½" LONG, GALVANIZED WITH ⅝"∅ A563 HEAVY HEX NUT, GRADE A, GALVANIZED.

SPLICE BOLT:
⅝"∅A307 OVAL SHOULDER BUTTON HEAD BOLT, GRADE A, 1¼" LONG, GALVANIZED WITH ⅝"∅ A563 HEAVY HEX NUT, GRADE A, GALVANIZED.

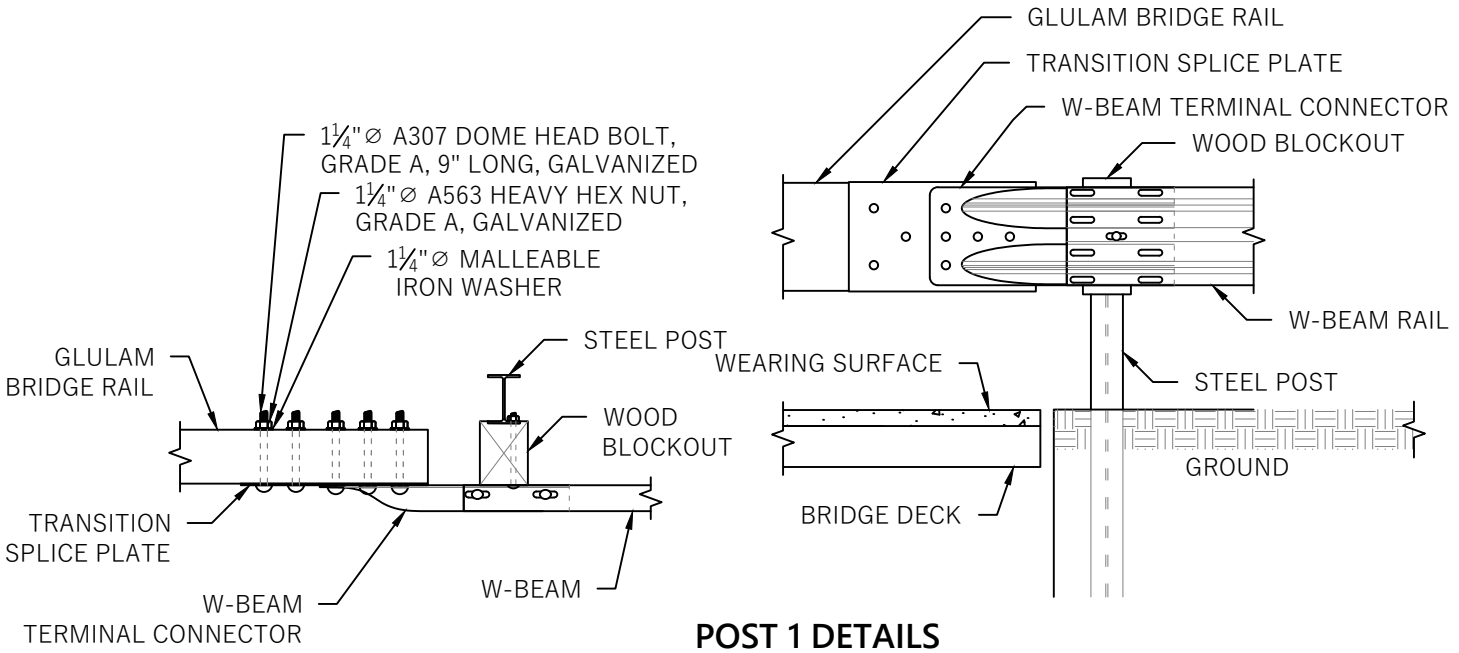
NOTES:
1) POST IS A36, GALVANIZED.
2) THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: BLOCKOUT IS SYP GRADE NO. 1, TREATED WITH CCA

STANDARD W-BEAM POST

SOURCE: FHWA	**BRIDGE RAIL NAME:** STEEL SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: R350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 - 31.65 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 1 SOURCE: TRP-03-125-03	**SHEET #** 7 OF 7



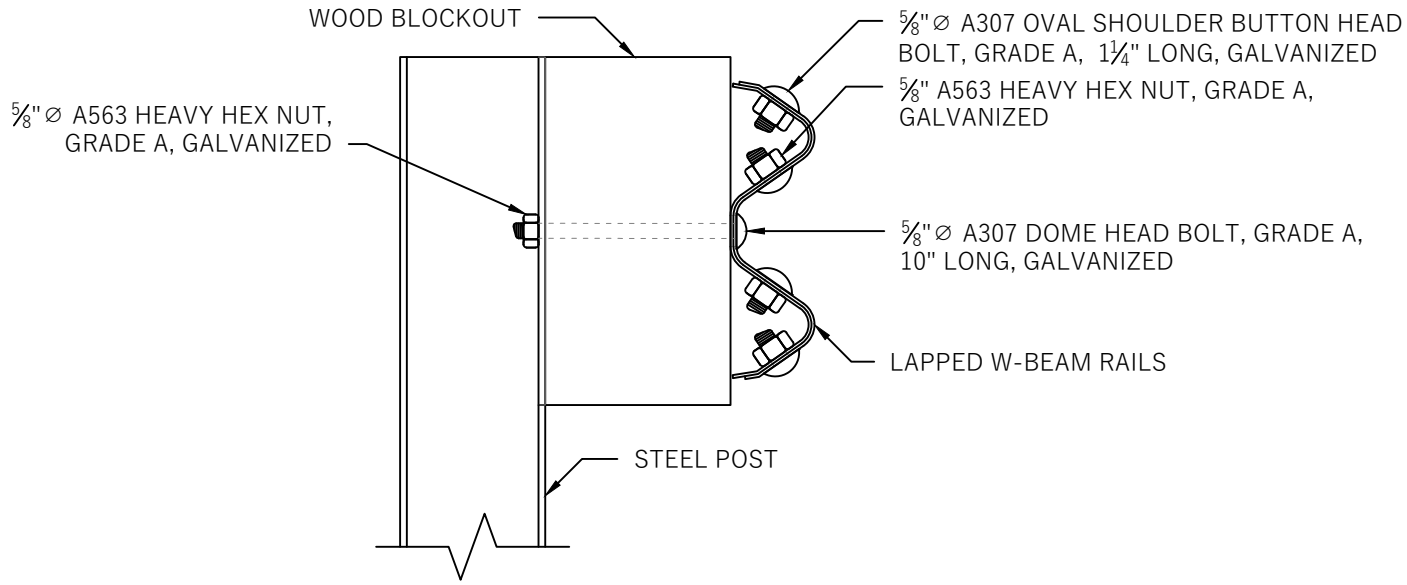
TRANSITION LAYOUT



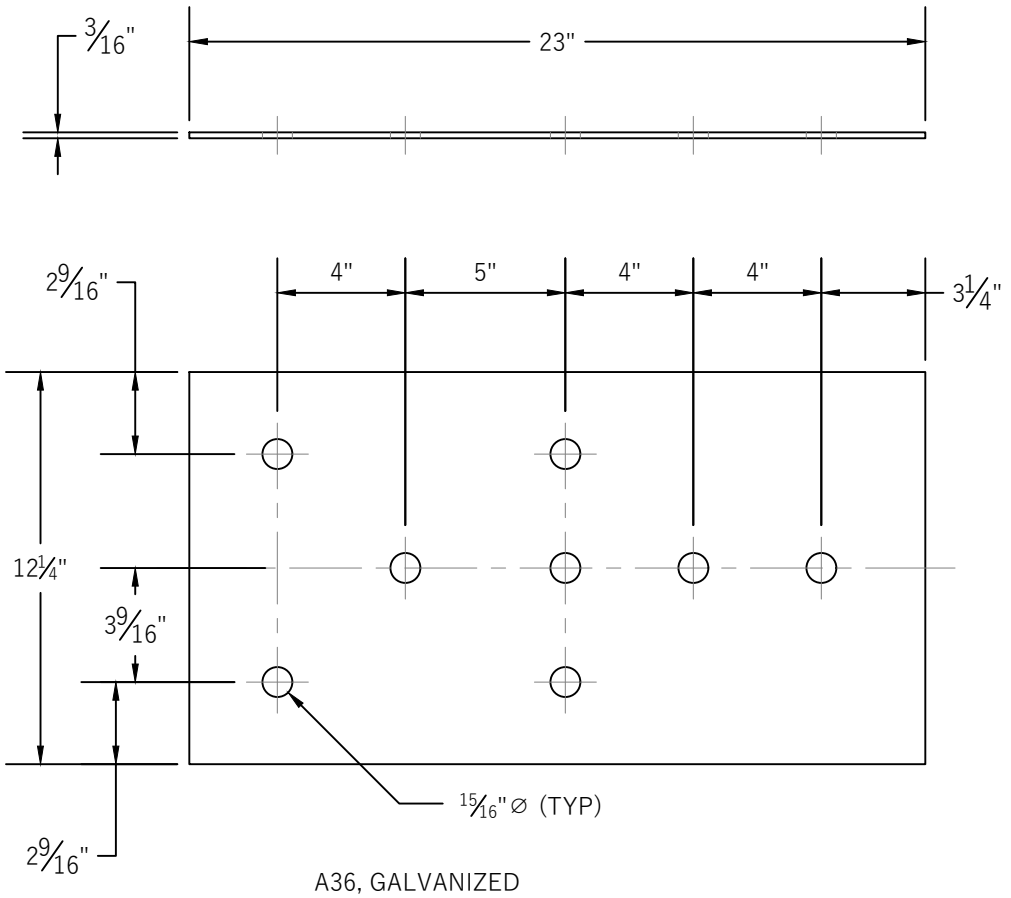
POST 1 DETAILS

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 2 SOURCE: TRP-03-125-03	**SHEET #** 1 OF 4



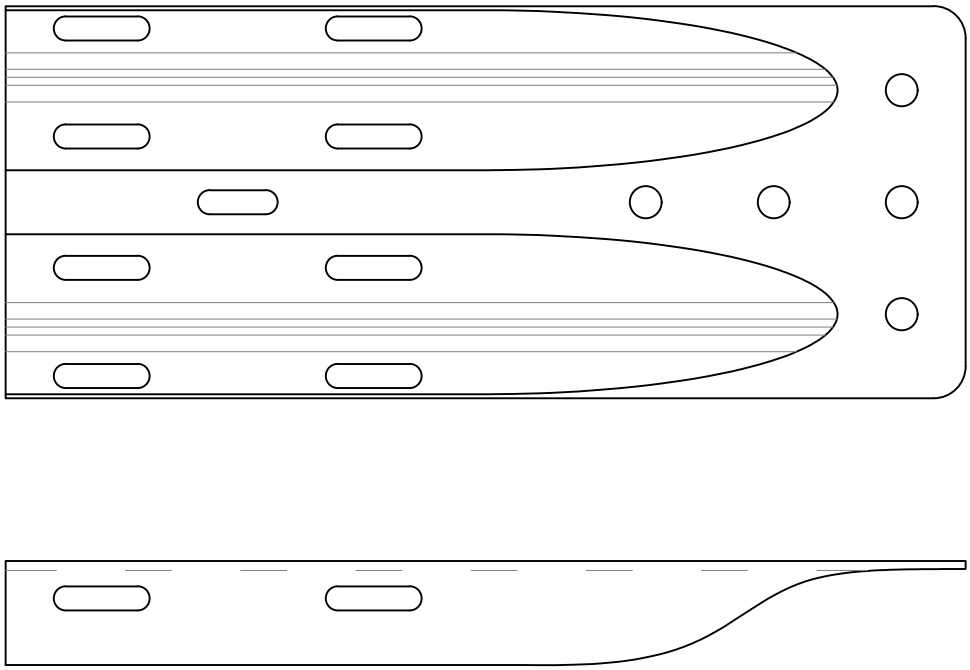
SECTION A-A



A36, GALVANIZED

TRANSITION SPLICE PLATE

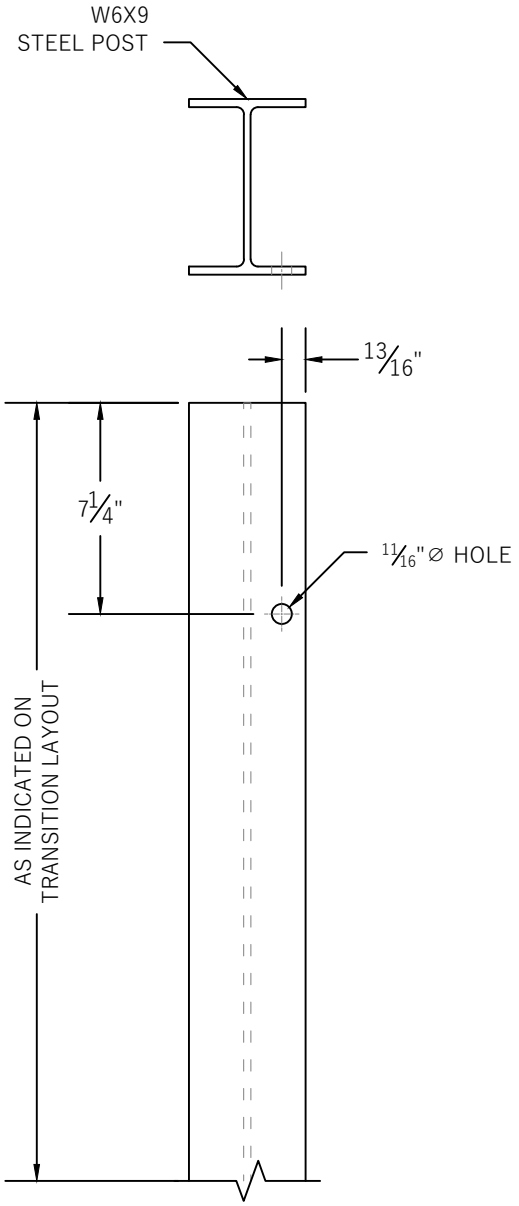
SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 2 SOURCE: TRP-03-125-03	**SHEET #** 2 OF 4



SHALL CONFORM TO THE CURRENT REQUIREMENTS OF AASHTO M 180 AND SHALL BE GALVANIZED.

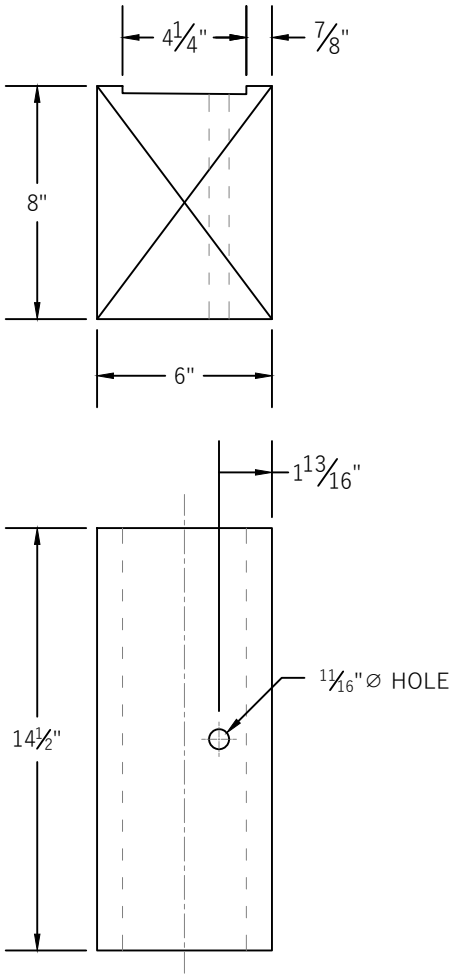
W-BEAM TERMINAL CONNECTOR

SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 2 SOURCE: TRP-03-125-03	**SHEET #** 3 OF 4



STEEL POSTS ARE A36, GALVANIZED

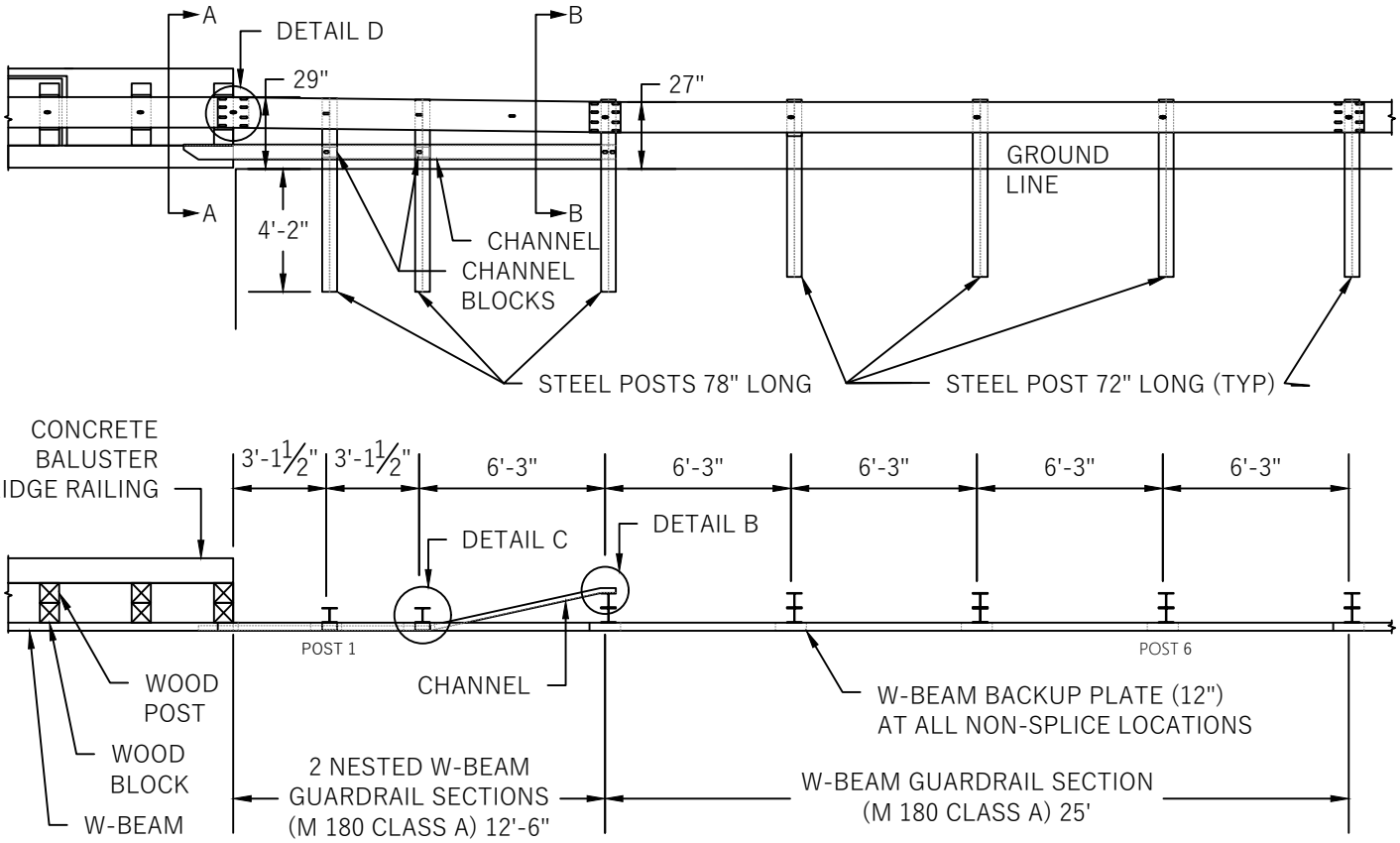
STEEL POST



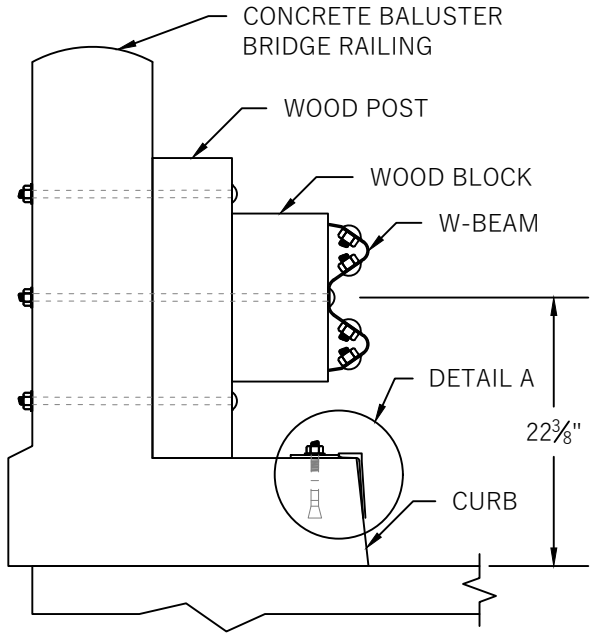
THIS MATERIAL SPECIFICATION IS FROM THE REFERENCED DRAWING: WOOD BLOCKOUTS ARE SYP GRADE NO. 1, TREATED WITH CCA

WOOD BLOCKOUT

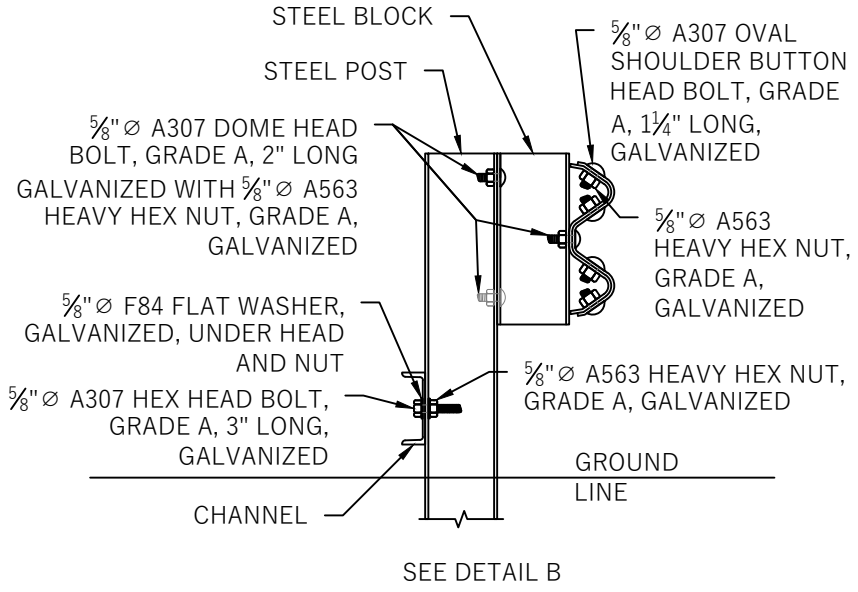
SOURCE: FHWA	**BRIDGE RAIL NAME:** WOOD SYSTEM APPROACH GUARDRAIL TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.78 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 2 SOURCE: TRP-03-125-03	**SHEET #** 4 OF 4



TRANSITION LAYOUT



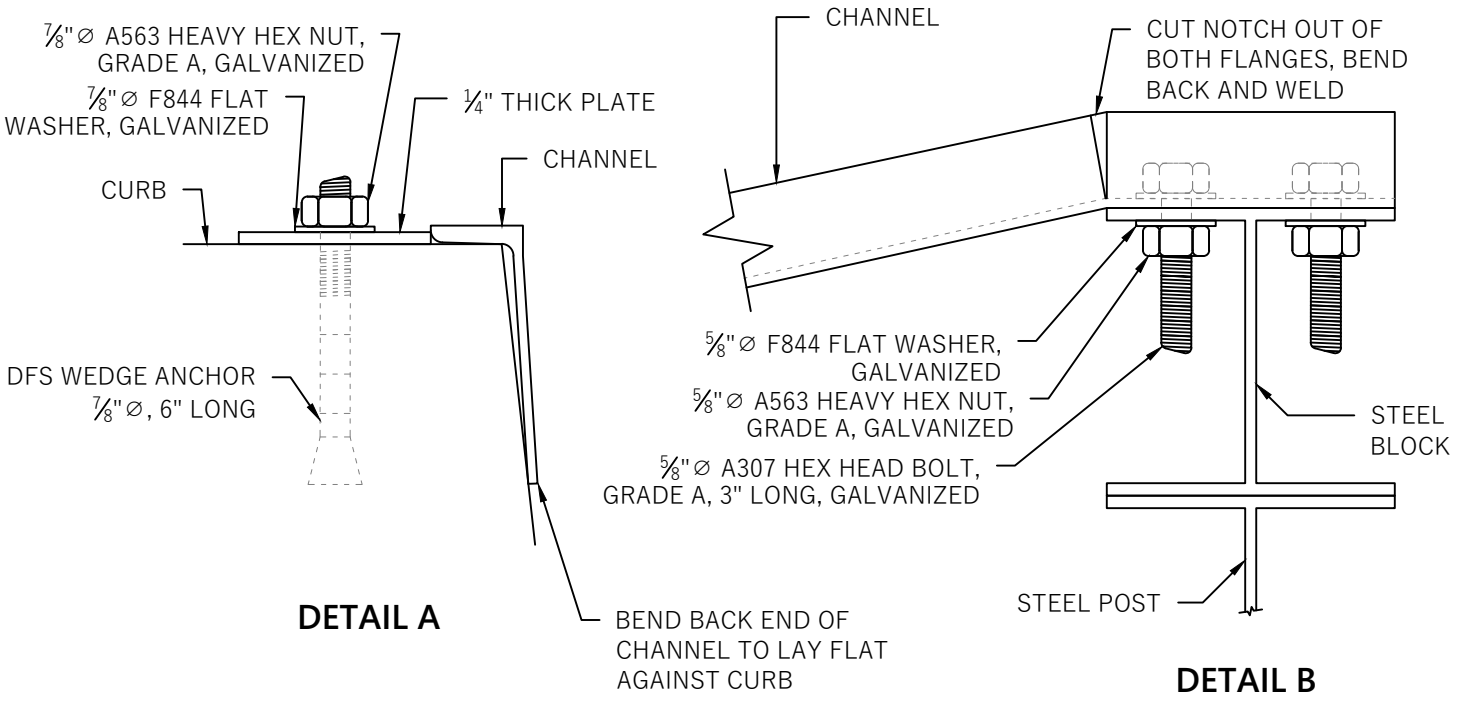
SECTION A-A

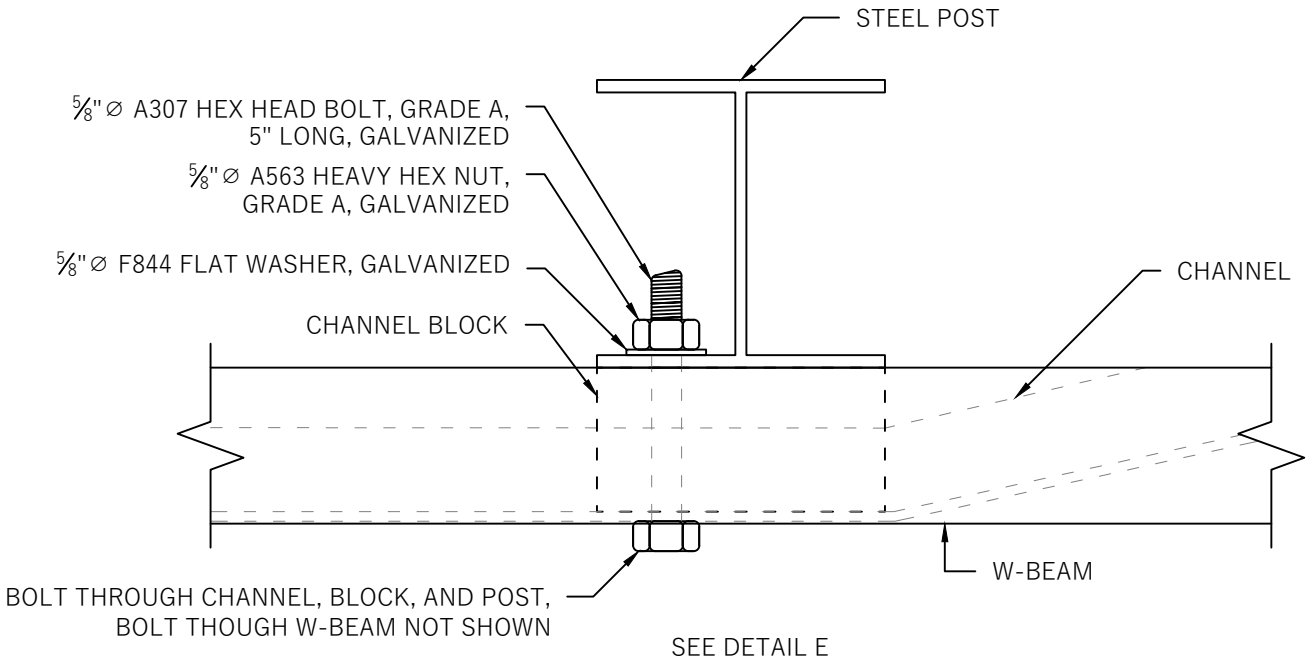


SECTION B-B

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

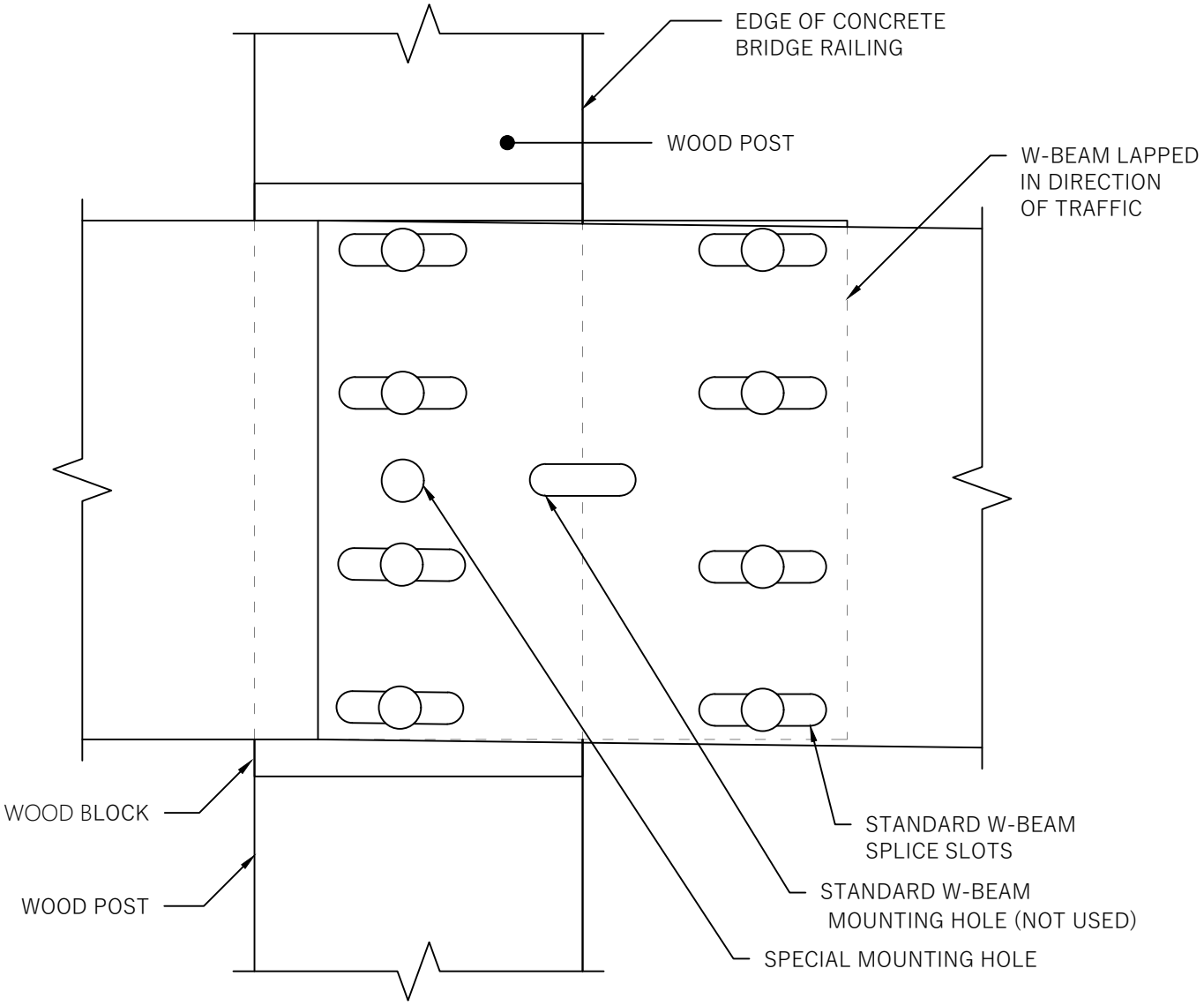
SOURCE: FHWA	**BRIDGE RAIL NAME:** W-BEAM RETROFIT TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 3 SOURCE: FHWA-RD-96-032	**SHEET #** 1 OF 6





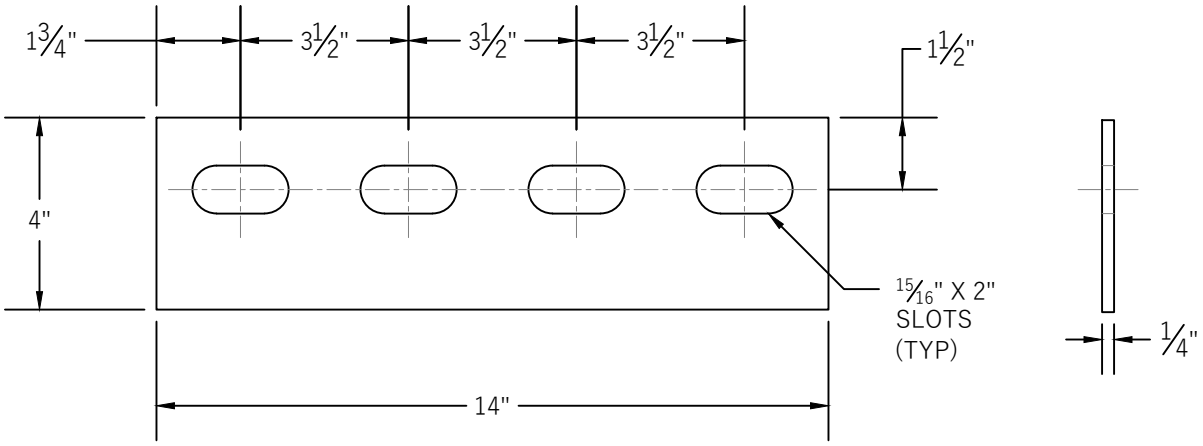
DETAIL C

SOURCE: FHWA	**BRIDGE RAIL NAME:** W-BEAM RETROFIT TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 3 SOURCE: FHWA-RD-96-032	**SHEET #** 2 OF 6



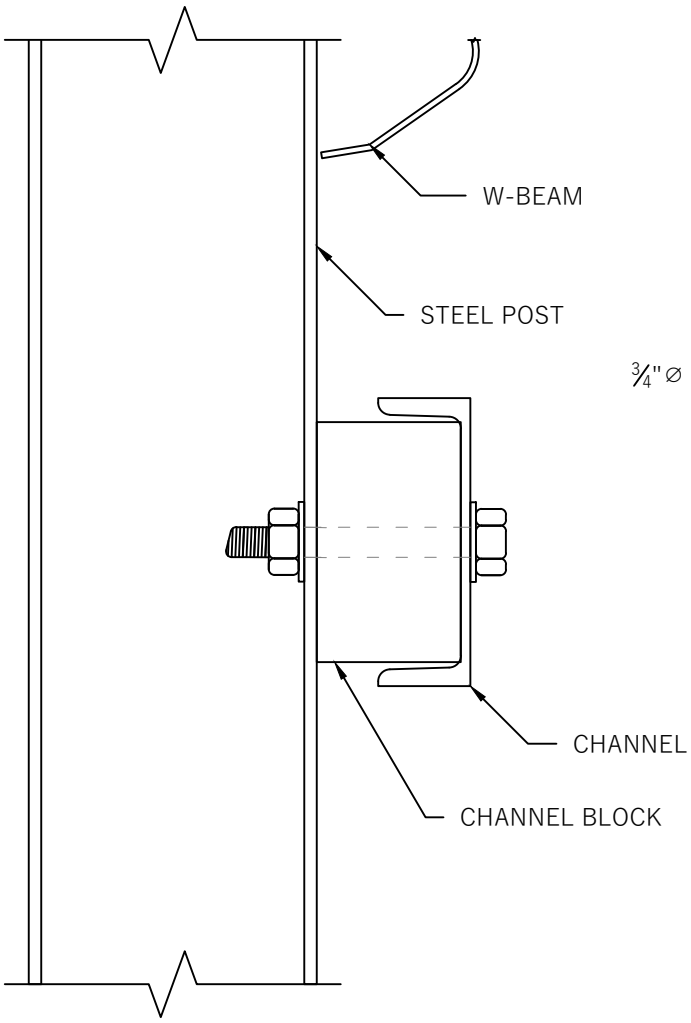
DETAIL D

SOURCE: FHWA	**BRIDGE RAIL NAME:** W-BEAM RETROFIT TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 3 SOURCE: FHWA-RD-96-032	**SHEET #** 3 OF 6

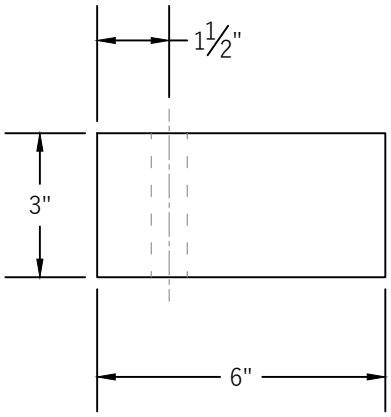


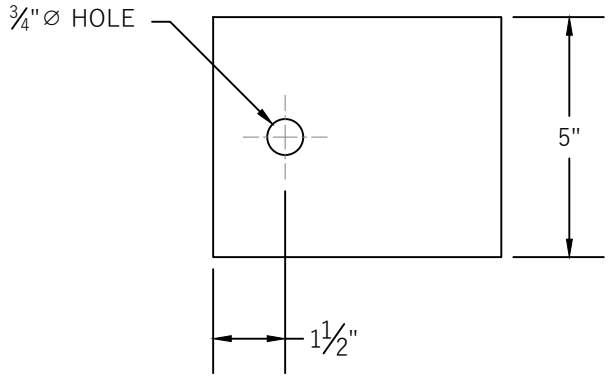
A36, GALVANIZED

¼" THICK PLATE



DETAIL E

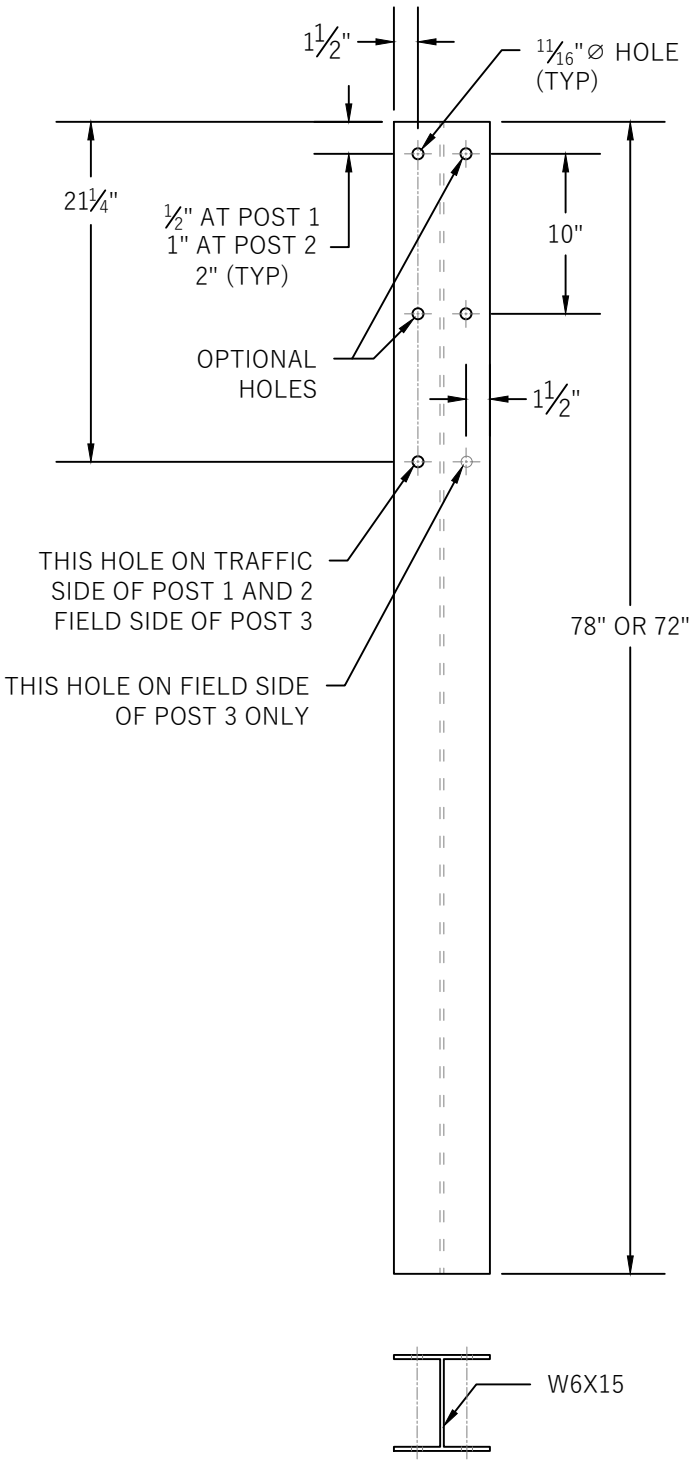




THESE MATERIAL SPECIFICATIONS ARE FROM APPENDIX A REF 8 / TRP-03-31-93: BLOCKS SHALL BE DOUGLAS FIR, SOUTHERN PINE, ETC. GRADE NO. 1, ROUGH-SAWN. TREAT TO MEET AWPA STANDARD C14 WITH 12 PCF CREOSOTE.

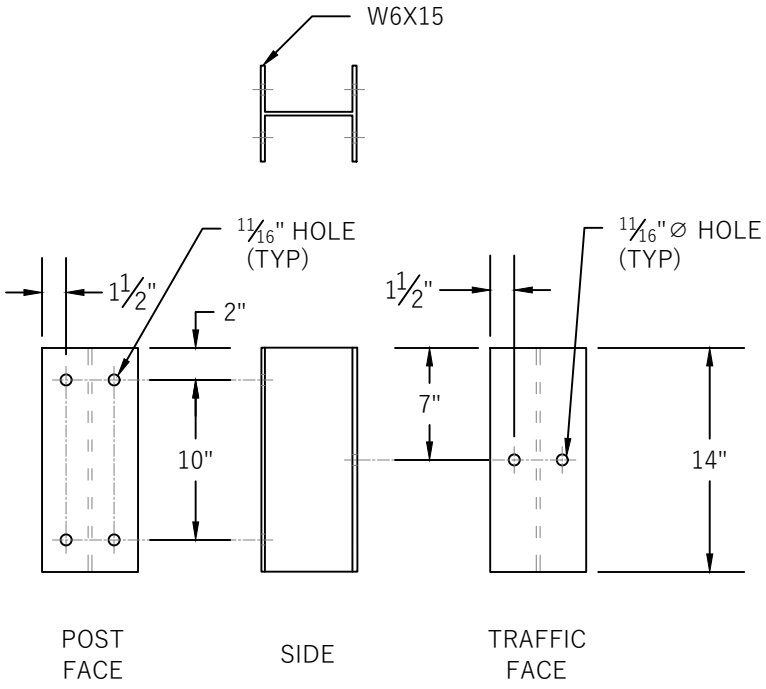
CHANNEL BLOCK

SOURCE: FHWA	**BRIDGE RAIL NAME:** W-BEAM RETROFIT TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 3 SOURCE: FHWA-RD-96-032	**SHEET #** 4 OF 6



A36, GALVANIZED

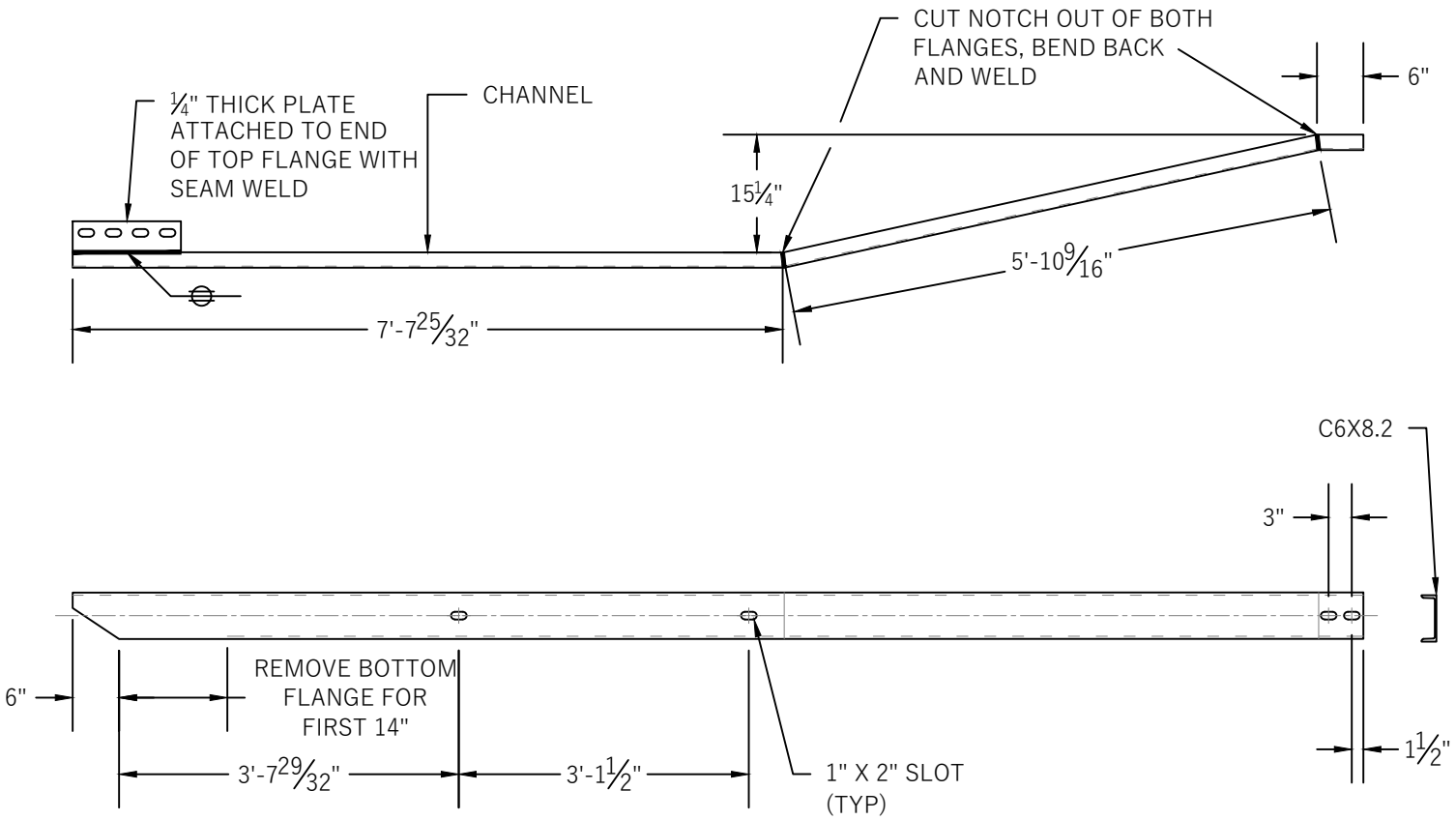
STEEL POST



A36, GALVANIZED

STEEL BLOCK

SOURCE: FHWA	**BRIDGE RAIL NAME:** W-BEAM RETROFIT TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 3 SOURCE: FHWA-RD-96-032	**SHEET #** 5 OF 6

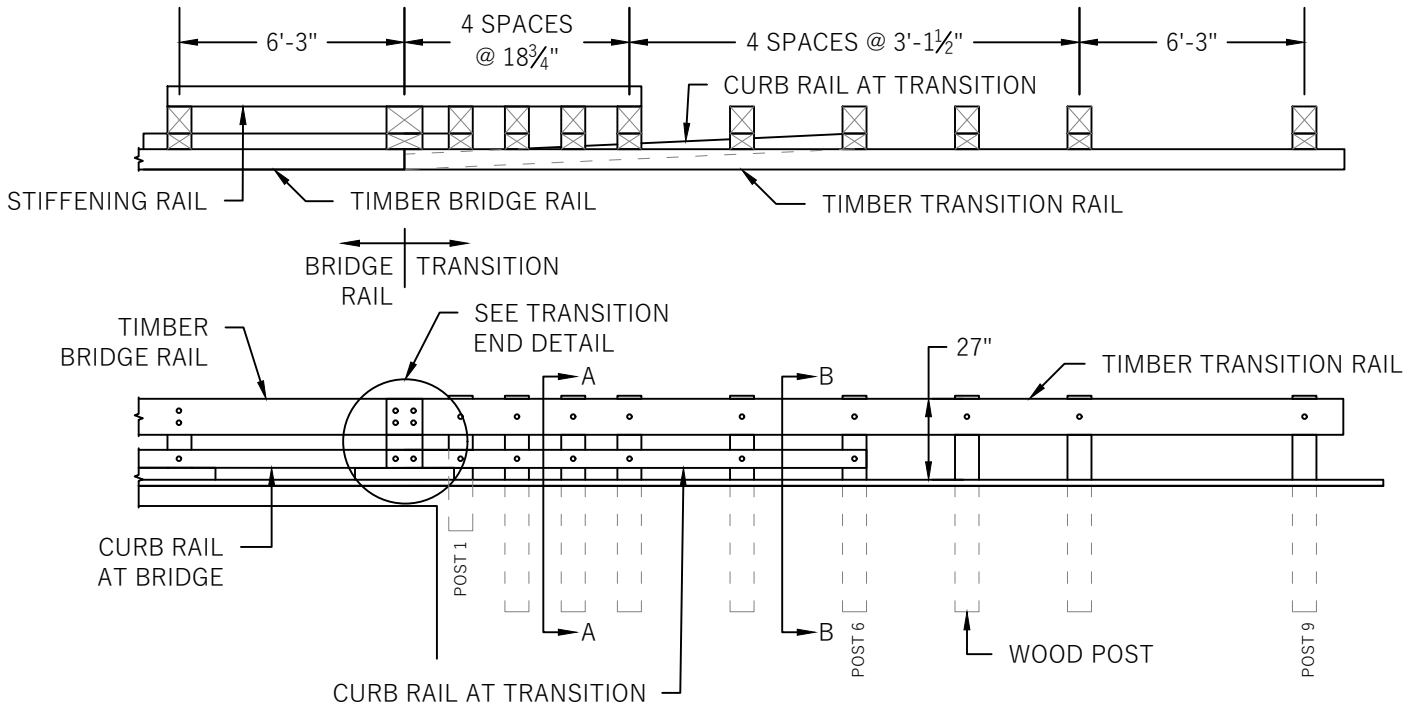


A36, GALVANIZED

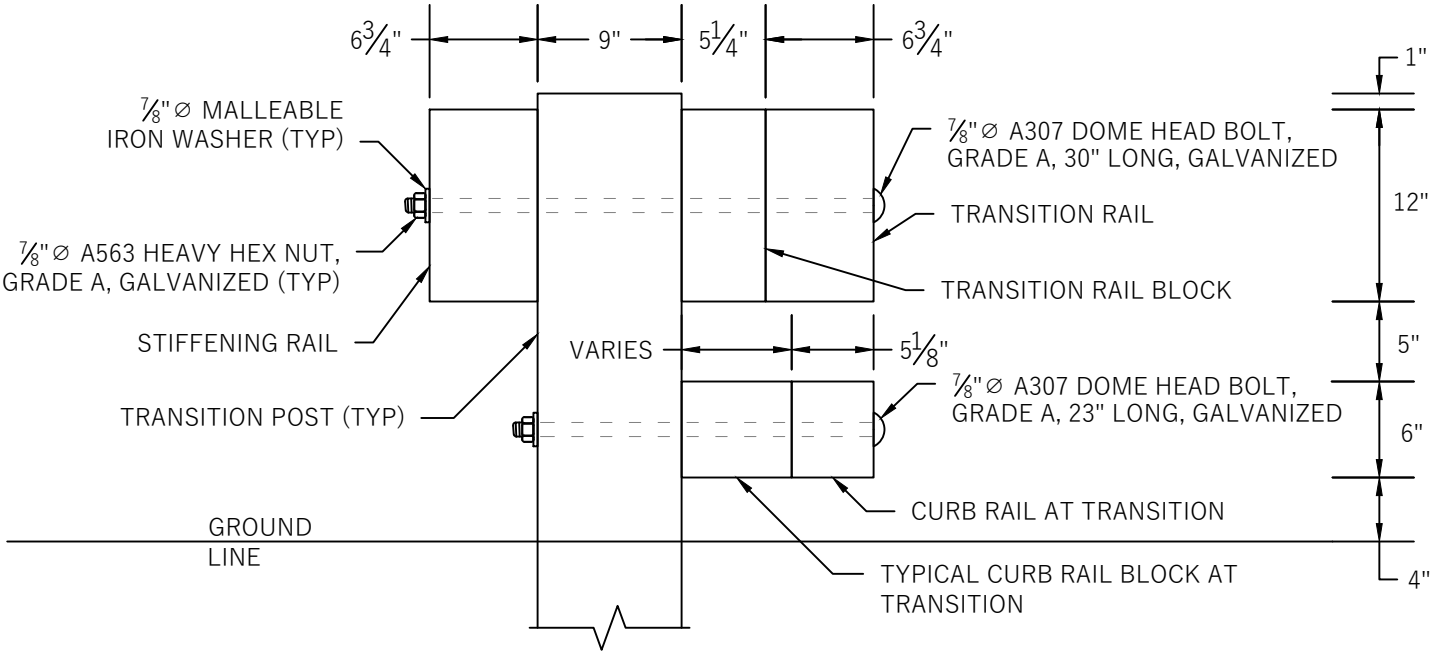
WELDING SHALL BE COMPLETED IN ACCORDANCE WITH AWS D1.5 CURRENT EDITION.

CHANNEL

SOURCE: FHWA	**BRIDGE RAIL NAME:** W-BEAM RETROFIT TRANSITION		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: REPORT 350 TL-2	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 3 SOURCE: FHWA-RD-96-032	**SHEET #** 6 OF 6



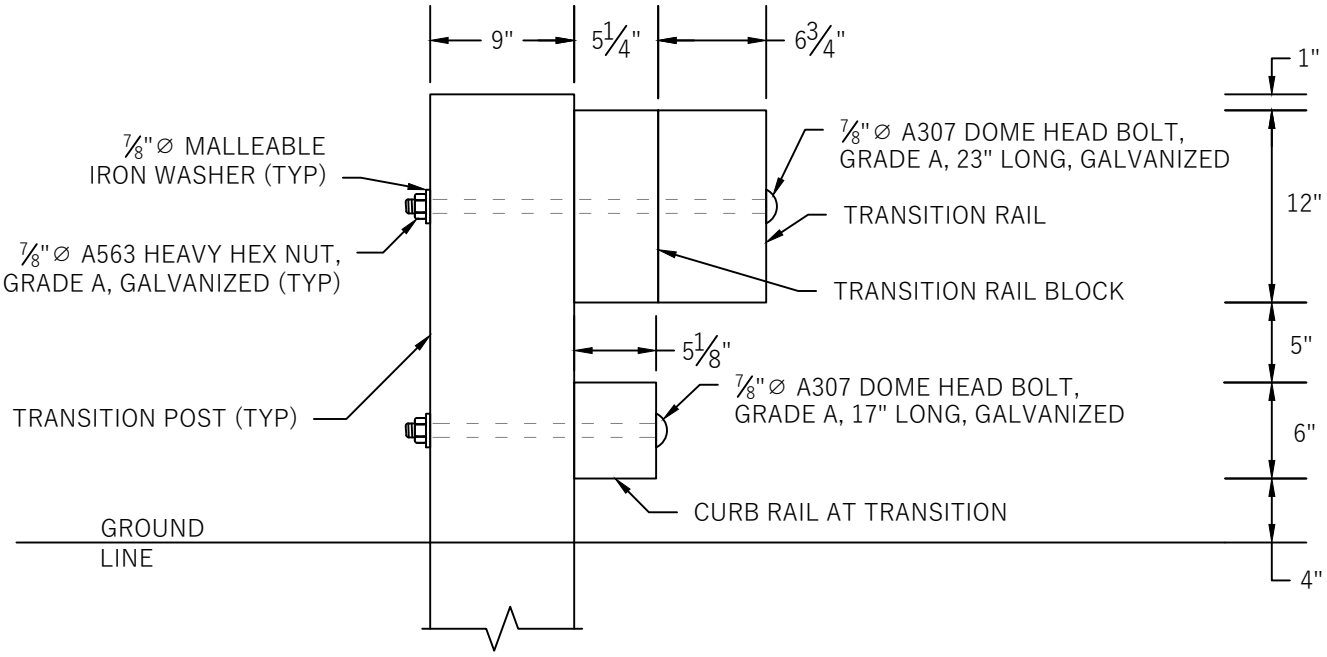
TRANSITION LAYOUT



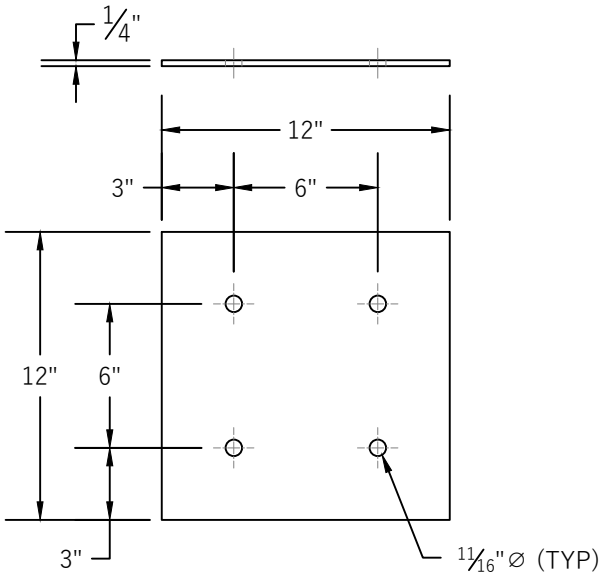
SECTION A-A

NOTE: MATERIAL SPECIFICATIONS WERE TAKEN FROM THE REFERENCED CRASH TEST REPORTS WHEN PROVIDED. WHEN MATERIAL SPECIFICATIONS WERE NOT PROVIDED IN THE REFERENCED REPORT, AASHTO M 180 VALUES WERE USED WHEN APPLICABLE; OTHERWISE, DOCUMENTED VALUES USED FOR SIMILAR COMPONENTS IN SIMILAR SYSTEMS WERE ADOPTED.

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 1 OF 7

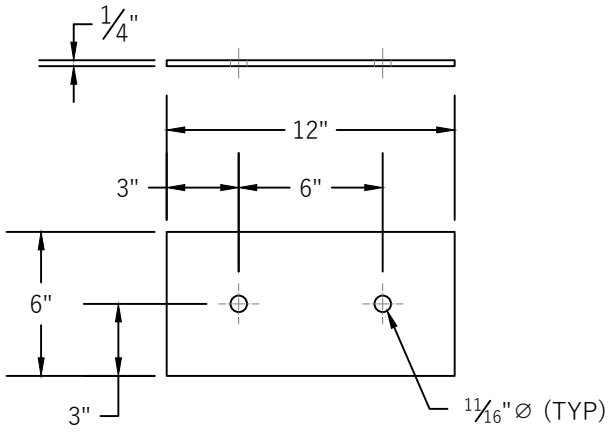


SECTION B-B



A36, GALVANIZED

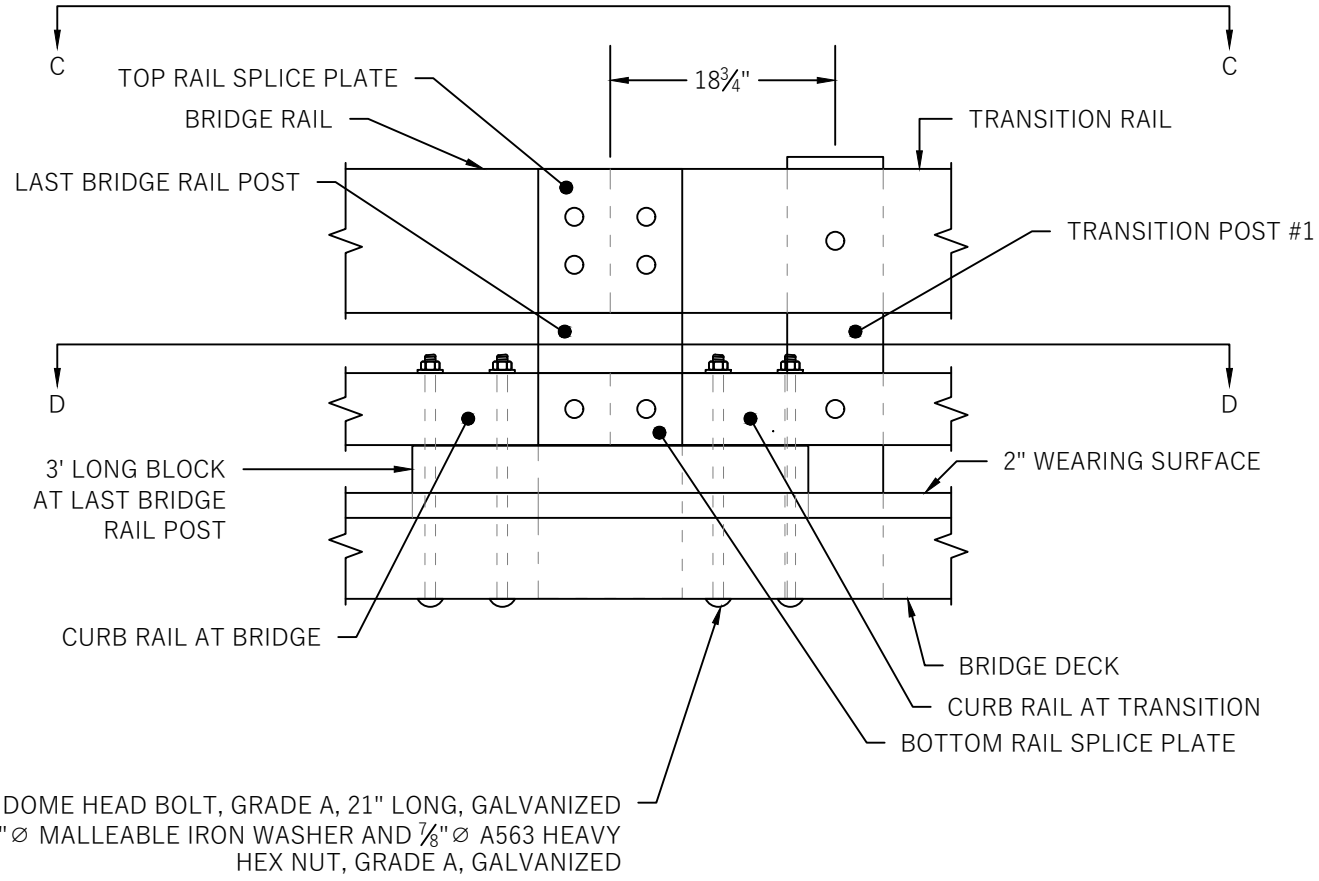
TOP RAIL SPLICE PLATE



A36, GALVANIZED

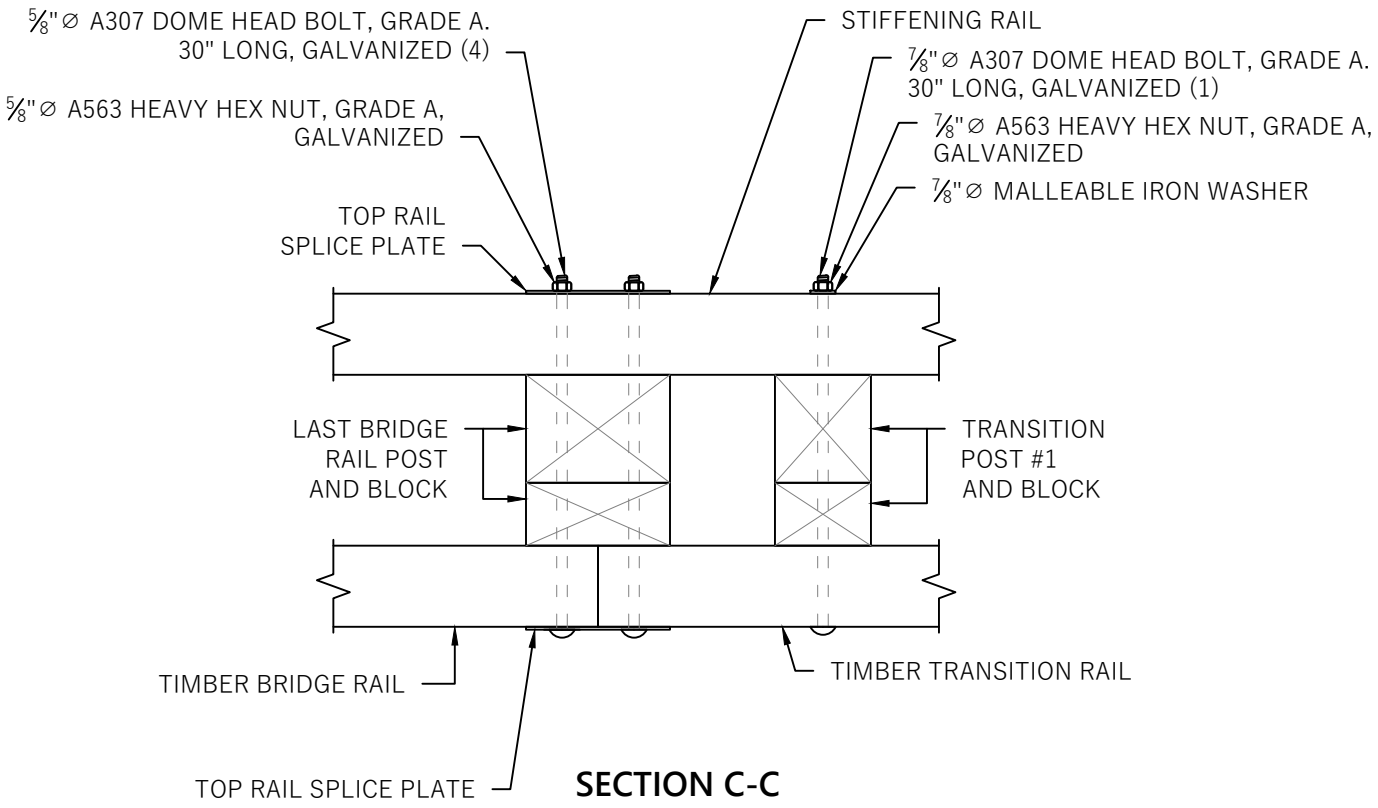
BOTTOM RAIL SPLICE PLATE

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 2 OF 7

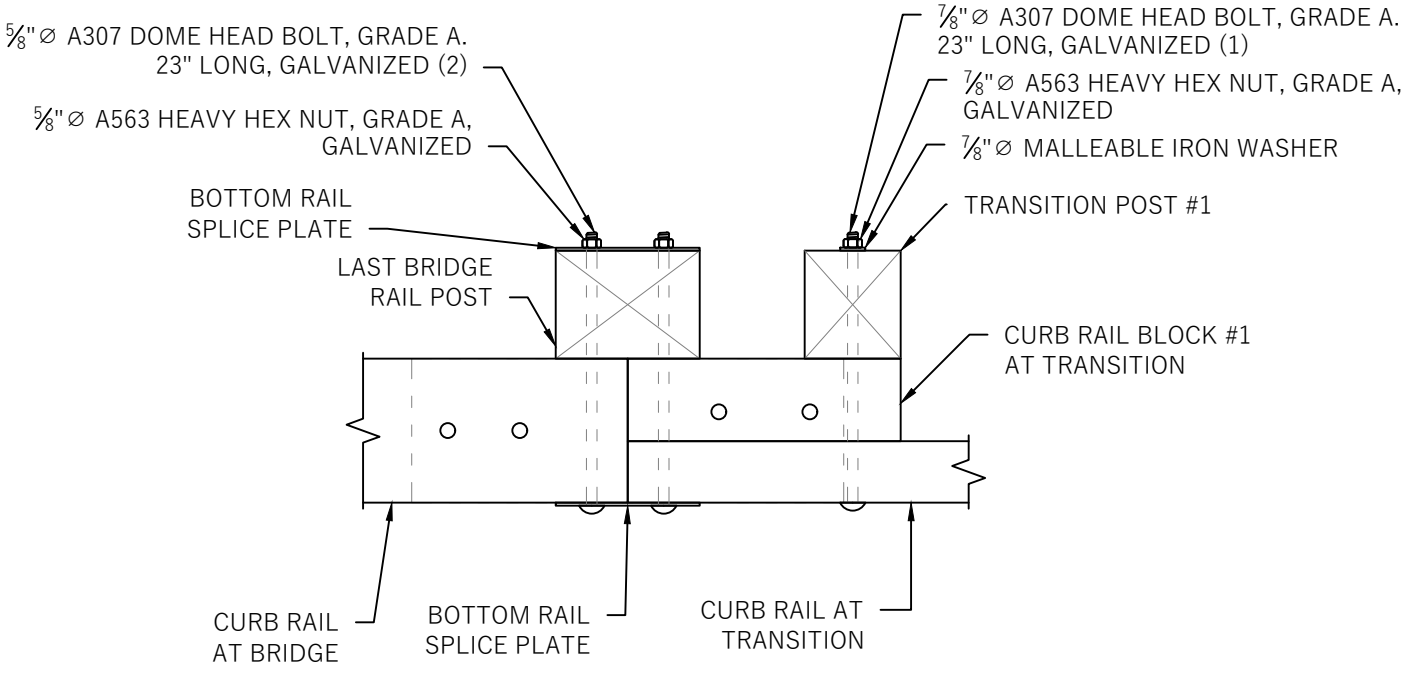


TRANSITION END DETAIL

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 3 OF 7

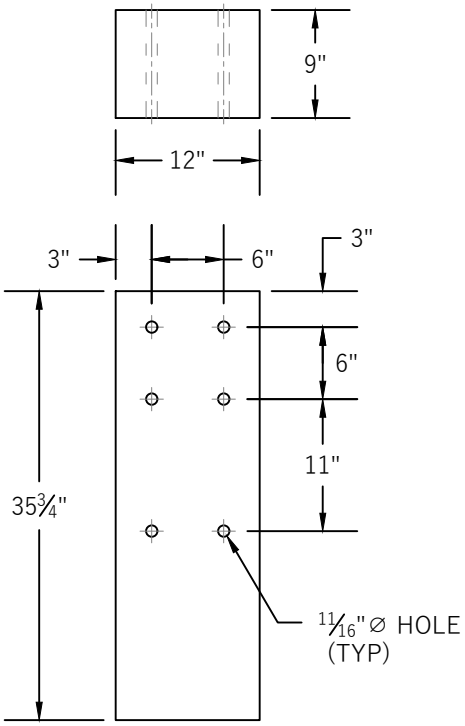


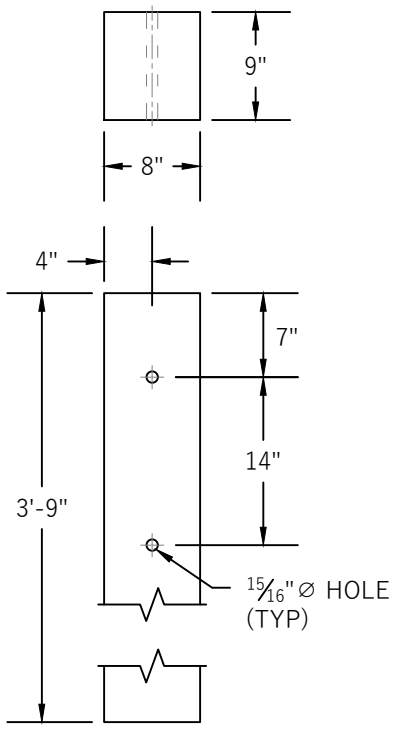
SECTION C-C

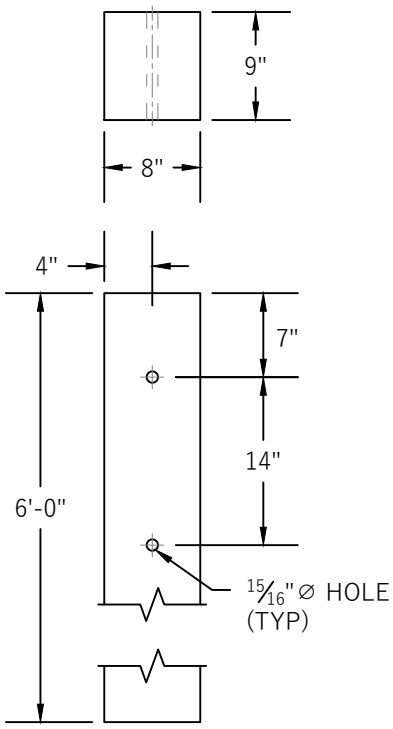


SECTION D-D

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 4 OF 7

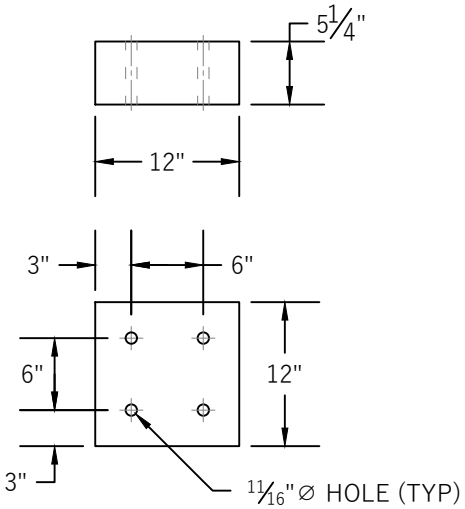


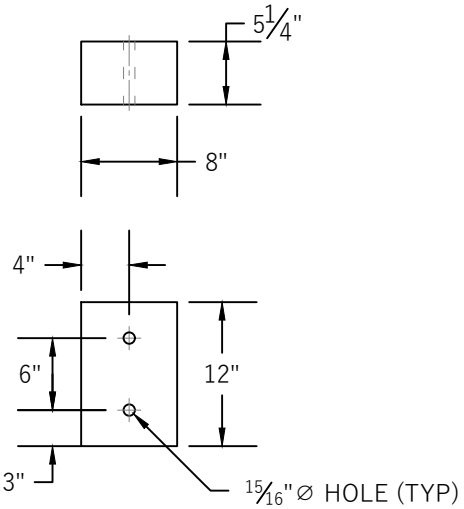




THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDP20-24: POSTS SHALL BE S4S WITH NOMINAL DIMENSIONS INDICATED. MAY BE SOUTHERN PINE GRADE 2, DOUGLAS FIR GRADE 2, WESTERN HEMLOCK GRADE 1, PONDEROSA PINE GRADE 2, RED PINE GRADE 2, OR WESTERN RED CEDAR GRADE 1. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER POST IS SAWN, DRESSED AND END TRIMMED.

LAST BRIDGE RAIL POST **TRANSITION POST #1** **TRANSITION POST (TYP)**

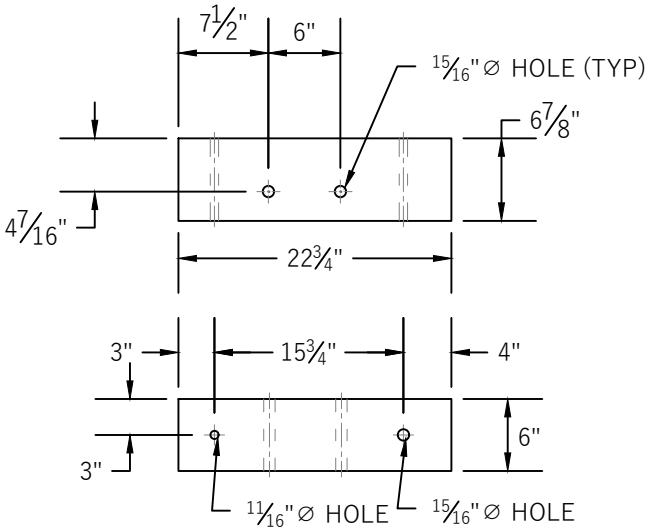




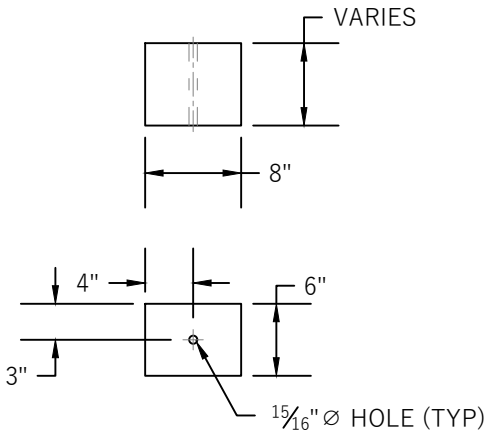
THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDB01A-B: BLOCKS SHALL BE MADE OF TIMBER WITH A STRESS GRADE OF AT LEAST 1160 PSI [8MPa]. SHALL BE EITHER ROUGH-SAWN OR S4S WITH NOMINAL DIMENSIONS INDICATED. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER ALL END CUTS ARE MADE AND HOLES ARE DRILLED. THE VARIATION IN SIZE OF BLOCKOUTS IN THE DIRECTION PARALLEL TO THE AXIS OF THE BOLT HOLES SHALL NOT BE MORE THAN 1/4"

LAST BRIDGE RAIL BLOCK **TRANSITION RAIL BLOCK**

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 5 OF 7

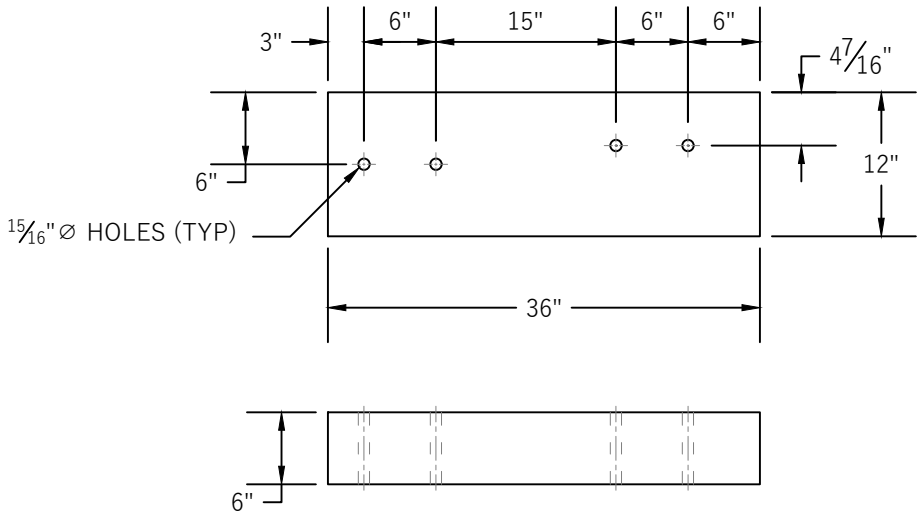


CURB RAIL BLOCK #1 AT TRANSITION



NOTE: USE BLOCKS OF VARYING DEPTH TO TAPER THE CURB RAIL FROM FULL BLOCKOUT DEPTH AT THE CONNECTION TO THE BRIDGE RAIL TO NO BLOCKOUT AT POST 6.

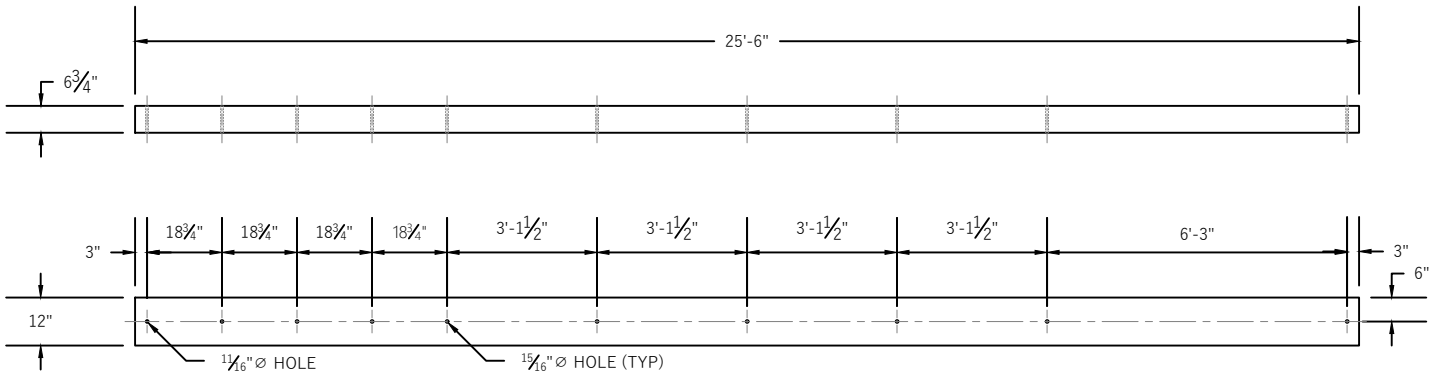
TYPICAL CURB RAIL BLOCK AT TRANSITION



3' LONG BLOCK AT LAST BRIDGE RAIL POST

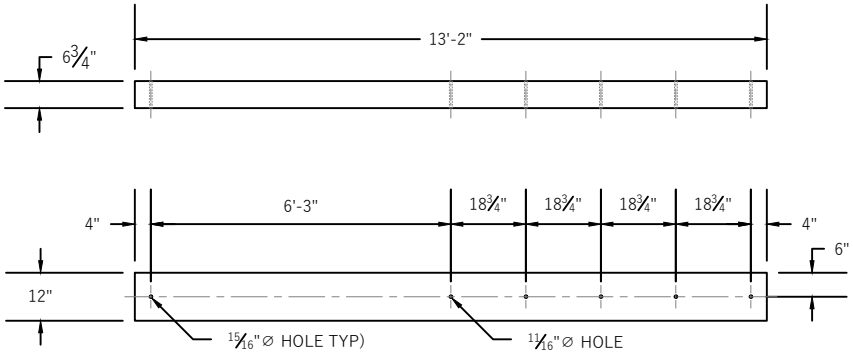
THESE MATERIAL SPECIFICATIONS ARE FROM TF13 DRAWING PDB01A-B: BLOCKS SHALL BE MADE OF TIMBER WITH A STRESS GRADE OF AT LEAST 1160 PSI [8MPa]. SHALL BE EITHER ROUGH-SAWN OR S4S WITH NOMINAL DIMENSIONS INDICATED. SHALL BE TREATED IN ACCORDANCE WITH AASHTO M 133 AFTER ALL END CUTS ARE MADE AND HOLES ARE DRILLED. THE VARIATION IN SIZE OF BLOCKOUTS IN THE DIRECTION PARALLEL TO THE AXIS OF THE BOLT HOLES SHALL NOT BE MORE THAN 1/4".

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 6 OF 7



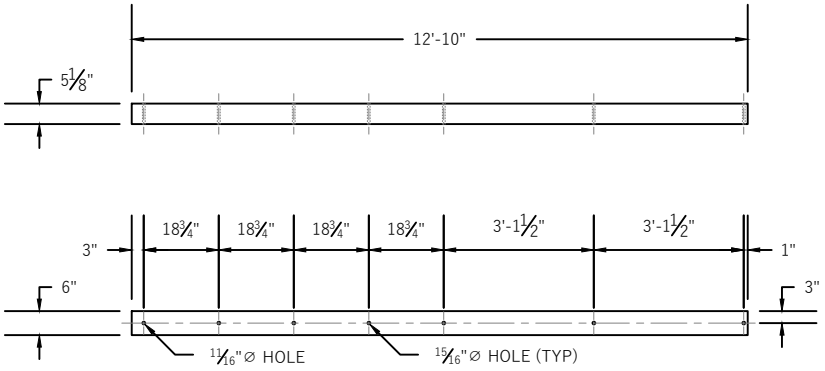
THIS MATERIAL SPECIFICATION IS FROM THE REFERENCE DRAWING: SHALL BE COMBINATION NO. 48 SOUTHERN YELLOW PINE.

TIMBER TRANSITION RAIL



THIS MATERIAL SPECIFICATION IS FROM THE REFERENCE DRAWING: SHALL BE COMBINATION NO. 48 SOUTHERN YELLOW PINE.

STIFFENING RAIL



THESE MATERIAL SPECIFICATIONS ARE FROM APPENDIX A REF 8 / TRP-03-31-93: TIMBER RAILS SHALL BE DOUGLAS FIR, SOUTHERN PINE, ETC. GRADE NO. 1, ROUGH-SAWN. TREAT TO MEET AWPA STANDARD C14 WITH 12 PCF CREOSOTE.

CURB RAIL AT TRANSITION

SOURCE: FHWA	**BRIDGE RAIL NAME:** WEST VIRGINIA TIMBER BRIDGE RAIL TRANSITION (TIMBER BRIDGE RAIL SYSTEM 2)		**DRAWING SCALE:** NOT TO SCALE
BRIDGE RAIL TEST LEVEL: PL-1	**BRIDGE RAIL HEIGHT:** 27.00 INCHES	**BRIDGE RAIL REFERENCE:** APPENDIX C REF 4 SOURCE: TTI TEST 7212-3	**SHEET #** 7 OF 7

APPENDIX D: INSPECTION CHECKLIST

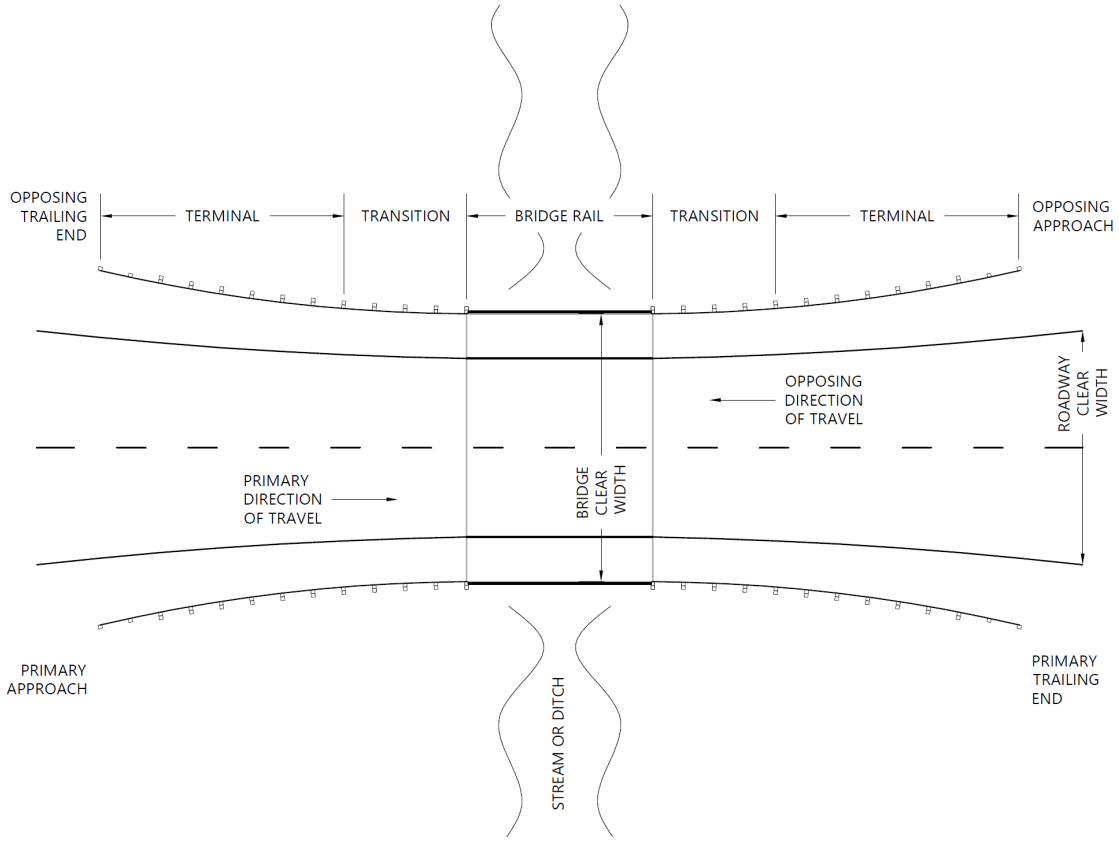
An inspection checklist for use in collecting the suggested on-site data is provided in the next pages. User agencies may modify and change this checklist to meet their own needs and local circumstances.

Low-Speed, Low-Volume Bridge Rail Inspection Checklist

This checklist can be used to collect information to assess the need for bridge rails and approach hardware on bridges on roads with posted speed limits of 45 mph or less and ADT volumes of 50 vpd or less.

Characterizing the Bridge Rail			**Photograph Included?**
The bridge rail height is:		inches	□
The posted speed limit is:		mi/hr	□
The average annual daily traffic is:		vehicles/day	□
The drop height from the bridge deck to the ground or water surface below is:		ft	□
The condition under the bridge is: □ An ephemeral or intermittent stream with water depth less than 6 inches during the majority of time the bridge is in use. □ Any live stream channel with year-round flow or ephemeral or intermittent stream channels with water depths greater than or equal to 6 inches for at least 3 months. □ Other:			□
There is potential for a passenger vehicle overriding or vaulting the bridge rail:	□Yes □No	Explain:	□
There are parts or components of the bridge rail that might snag on a passenger vehicle:	□Yes □No	Explain:	□
The rail element is not continuous from the beginning to the end of the bridge:	□Yes □No	Explain:	□
The rail element at the ends of the bridge terminate at a post, abutment, or anchor block:	□Yes □No	Explain:	□

Characterizing the Bridge Deck	**Photograph Included?**
The deck material is: **Material** **Condition** □ Wood □ Good □ Poor: □ Rotten □ Splits □ Glue laminated wood □ Good □ Poor: □ Rotten □ Splits □ Reinforced concrete □ Good □ Poor: □ Spalling □ Exposed bars □ Steel □ Good □ Poor: □ Extensive rust/corrosion □ Other: _____ □ Good □ Poor	□
The bridge deck thickness is: _____ inches	□
The bridge deck overhang is: _____ ft	□
The fascia material and condition are: **Material** **Condition** □ Wood □ Good □ Poor: □ Rotten □ Splits □ Glue laminated wood □ Good □ Poor: □ Rotten □ Splits □ Reinforced concrete □ Good □ Poor: □ Spalling □ Exposed bars □ Steel □ Good □ Poor: □ Extensive rust/corrosion □ Other: _____ □ Good □ Poor	□
The fascia beam size/shape is: _____	□
The bridge diaphragm elements material and condition are: **Material** **Condition** □ Wood □ Good □ Poor: □ Rotten □ Splits □ Glue laminated wood □ Good □ Poor: □ Rotten □ Splits □ Reinforced concrete □ Good □ Poor: □ Spalling □ Exposed bars □ Steel □ Good □ Poor: □ Extensive rust/corrosion □ Other: _____ □ Good □ Poor	□
The bridge diaphragms size/shape are: _____	□
Size and type of connector elements connecting diaphragm elements to the fascia beam: _____	□

Characterizing transitions and terminals			**Photograph Included?**
			
Distance to the nearest intersecting roadway in the primary approach direction.		ft	☐
Distance to the nearest intersecting roadway in the primary trailing end direction.		ft	☐
Distance to the nearest intersecting roadway in the opposing approach direction.		ft	☐
Distance to the nearest intersecting roadway in the opposing trailing direction.		ft	☐

The following are provided (check all that apply):

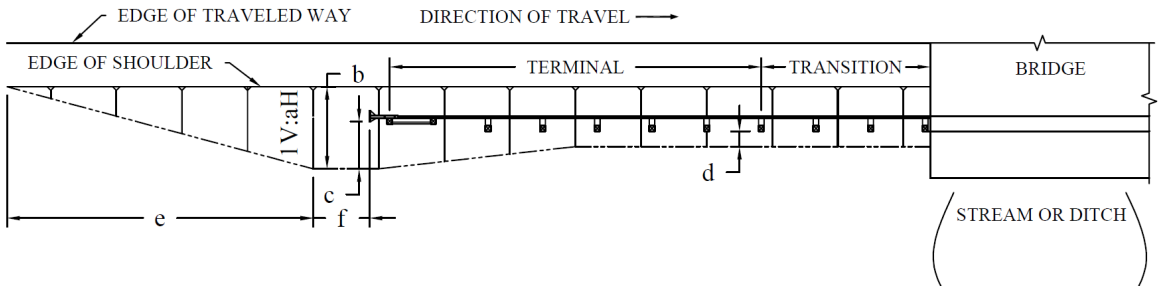
Primary ☐ Terminal ☐ Transition ☐ Structural attachment to the bridge rail.
Approach:

Primary: ☐ Terminal ☐ Transition ☐ Structural attachment to the bridge rail.
Trailing End:

Opposing ☐ Terminal ☐ Transition ☐ Structural attachment to the bridge rail.
Approach:

Opposing ☐ Terminal ☐ Transition ☐ Structural attachment to the bridge rail.
Trailing End:

There are parts or components of the transitions that might snag on a passenger vehicle:	☐Yes ☐No	Explain:	☐
There are parts or components of the terminals that might snag on a passenger vehicle:	☐Yes ☐No	Explain:	☐

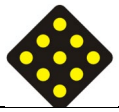


Note: Plan view, not to scale

If an approach guardrail terminal is present, measure the following:
(*Where Values are referenced below, refer to diagram above*)

(a) Horizontal distance in feet on the approach slope perpendicular to the traveled way corresponding to a 1-ft vertical drop. *(Value a)*		ft
(b) Distance from the edge of the shoulder to the change in slope. ☐ Not applicable. The slope does not change. *(Value b)*		ft
(c) Distance from the back of the first post of the terminal to the change in slope. *(Value c)*		ft
(d) Distance in feet from the back of the last guardrail terminal post to the change in slope. ☐ Not applicable. The slope does not change. *(Value d)*		ft

(e) Length in feet of the approach slope taper. ☐ Not applicable. There is no taper.		ft
(f) Distance in feet from the approach face of the terminal to the end of the approach slope taper. ☐ Not applicable. There is no taper.		ft

Characterizing the Delineation			**Photograph Included?**
The roadway clear width is:		ft	□
The bridge clear width is:		ft	□
The approach roadway has traffic in ☐ one ☐ two directions.			
Are MUTCD Type 3 object markers provided?	□Yes □No		□
Are MUTCD OM1-2 object markers provided?	□Yes □No		□
Are MUTCD W5-3 signs provided?	□Yes □No		□
Are MUTCD W5-2 signs provided?	□Yes □No		□