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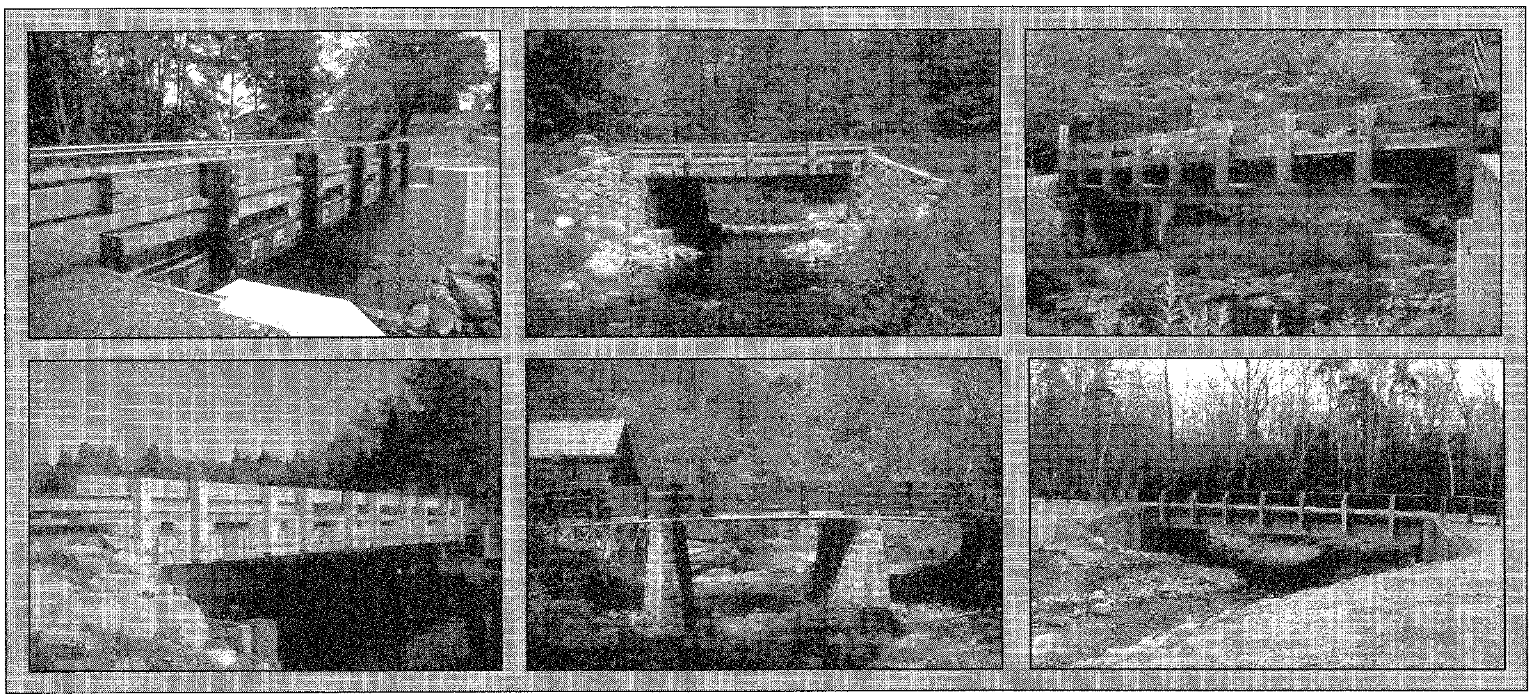
In cooperation With the

United States Department of Transportation

Federal Highway Administration

Standard Plans for Timber Bridge Superstructures

James P. Wacker
Matthew S. Smith



Abstract

These standardized bridge plans are for superstructures consisting of treated timber. Seven superstructure types are included: five longitudinal and two transverse deck systems. Both HS20 and HS25 loadings are included, along with L/360 and L/500 deflection criteria.

Keywords: timber bridge, design, standards, superstructures, plans

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Standard Plans for Timber Bridge Superstructures

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Introduction

Interest in timber bridges has increased significantly in recent years, primarily as a result of two national programs established by Congress: the Timber Bridge Initiative (TBI) passed in 1988 and the Intermodal Surface Transportation and Efficiency Act (ISTEA) passed in 1991. These legislative actions provided national emphasis on wood transportation structures and resulted in programs focusing on demonstration bridges, research, and technology transfer. Within the area of technology transfer, a high-priority need identified by bridge designers and builders has been the development of standardized timber bridge designs and specifications. By providing the basic design information on specific timber bridge types, standard plans and specifications should assist engineers who are not familiar with timber design.

The bridge plans presented in this publication are part of a series of standardized plans being developed for timber highway bridges. The plans were developed as a cooperative effort between the USDOT Federal Highway Administration (FHWA), the USDA Forest Service, Forest Products Laboratory (FPL),and Laminated Concepts, Incorporated (LCI). The plans include standardized designs and details for seven timber bridge superstructure types including five longitudinal deck and two beam systems utilizing both sawn lumber and glued-laminated timber (glulam).

In the development of these designs, every effort has been made to present standardized design information in a user-friendly format and allow maximum flexibility for the use of different wood materials, species, and grades. Each set of plans encompasses numerous span length and width combinations, design loadings for AASHTO HS20-44 and HS25-44 vehicles, and two options for live load deflection criteria. In addition, information specific to skewed crossings is provided when appropriate. In all cases, these designs must be verified by a registered professional engineer prior to construction.

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We express appreciation to Merv Eriksson of the USDA Forest Service, Wood in Transportation Program, Maureen Mathias (former FPL student engineer), and Sheila Rimal Duwadi of the Federal Highway Administration for their assistance in the development of these plans.

Comments and Recommendations

Any comments or recommendations regarding these drawings are appreciated and can be sent as follows:

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Websites: www.fpl.fs.fed.us/wit/ or www.fs.fed.us/na/wit/

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M133	Preservatives and Pressure Treatment Process for Timber
M168	Wood Products
M232	Zinc Coating (Hot-Dip) on Iron and Steel Hardware

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AWPA P8	Oil-borne Preservatives

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Summary and Commentary

Introduction

These timber bridge standards and specifications apply to superstructure design for highway loading applications. Substructures must be designed and analyzed by a qualified professional engineer for each specific site. The primary purpose of these standards is to aid engineers who may not be familiar with timber bridge design. The following information should help the designer by summarizing key configuration and design features of each bridge system. The designer can utilize these standards during the preliminary design phase to determine viable timber bridge superstructure systems for their site location. The designer is strongly encouraged to obtain the references listed on the previous page, especially the *AASHTO Standard Specifications for Highway Bridges*, and *Timber Bridges: Design, Construction, Inspection, and Maintenance* (EM7700-8). A limited number of free copies of EM7700-8 are available from the National Wood In Transportation Information Center located in Morgantown, West Virginia, and may be ordered via telephone at (304) 285-1591 or via internet at www.fs.fed.us/na/wit

Design Configuration

These standards include seven different bridge superstructure systems that are adaptable to spans ranging from 10 to 80 ft. Table A summarizes key configuration information for the bridge systems included in these standards.

These standards permit the use of numerous wood species and wood preservatives, within certain parameters. The wood species, including softwoods and hardwoods, must be included in the AASHTO or the NDS design tables, and the wood preservative must be compatible with the wood species. Refractory wood species are not allowed due to poor preservative penetration. The Glulam Stringer and Transverse Glulam Deck system is restricted to southern pine and western species glulam. The use of waterborne preservatives is not recommended for glulam members.

These standards are best suited for single–span or multiple simple–span bridges. Multiple–span continuous superstructures can be constructed with these standards, but this requires further design by a qualified professional engineer. Single– and double–lane and non-skewed and skewed bridge configurations are included. Longitudinal deck systems are most adaptable for spans ranging from 10 to 38 ft. An exception, however, is the Stress–Laminated Glulam Deck system which can span up to 58 ft. The beam systems include transverse glulam decks on either glulam stringers or steel beams. The Glulam Stringer and Transverse Glulam Deck system includes spans from 20 to 80 ft for these standards. However, glulam stringer systems can be built for spans much longer than 80 ft, but this will require further analysis by a qualified professional engineer.

Table A. – Bridge Configuration Summary

	Superstructure Type	Material type	Wood species	Wood preservative[f]	Material size	Deck thickness (in.)	Bridge length (ft)	Roadway width (ft)
Longitudinal Deck Systems	Nail–Laminated Decks[a]	Sawn lumber	Any listed in AASHTO or NDS	Any oilborne or waterborne type	2 in.	8 – 16	10 – 28	Variable
	Spike–Laminated Decks[a]				4 in.	8 – 16	12 – 34	
	Stress–Laminated Sawn Lumber Decks[a]				2 – 4 in.	8 – 16	10 – 34	
	Stress–Laminated Glulam Decks[b]	Glued–laminated timber		Any oilborne type	3 – 9 in.	12 – 21	18 – 58	
	Longitudinal Glulam Decks[c]				42 – 51 in.	8-1/2 – 16-1/4	12 – 38	12, 16, 24, 28, 32
Beam Systems	Glulam Stringers and Transverse Glulam Decks[d]		So. Pine and/or Western Species		Stringer sizes predetermined	5-1/8 only	20 – 80	12, 16, 24, 28, 32, 36
	Transverse Glulam Decks for Steel Beam Bridges[e]		Any in AASHTO or NDS		4 ft	5 – 8-3/4	Determined by steel beam bridge	Variable

a – Material size (i.e., face width) availability limits deck thickness. Bridge length limited by deck thickness. Bridge width varied by adding/subtracting deck laminations.
b – Glulam beam may vary from 3 to 9 in. width, but is limited to 21 in. deck thickness (i.e., beam lamination depth) due to stress–laminating concerns with a sinlge tensioning bar at mid–height. Bridge width varied by adding/subtracting deck laminations.
c – Longitudinal panel width ranges 42–51 in. to achieve different bridge widths: 12 and 16 ft (single lane), and 24, 28, 32, and 36 ft (double lane).
d – Transverse panel width typically 4 ft; panel thickness 5–1/8 in. Bridge widths: 12 and 16 ft (single lane), and 24, 28, 32, and 36 ft (double lane). Bridge lengths longer than 80 ft are possible but beyond scope of these standards.
e – Transverse panel width typically 4 ft; panel thickness varies; panel length can be adjusted to match roadway width requirements.
f – Wood preservative must be compatible with wood species.

Design Considerations

With few noted exceptions, these standards were developed to comply with the American Association of State Highway and Transportation Officials (AASHTO) *1996 Standard Specifications for Highway Bridges*, including 1998 Interims. In addition, these standards are based upon the Allowable Stress Design (ASD) and do not include any provisions for Load and Resistance Factor Design (LRFD). Refer to **Table B** for a summary of the bridge design values used in the development of these standards.

Design Loading

Design tables include provisions for AASHTO HS20–44 and HS25–44 lane live loads. Site specific loading conditions, such as seismic and substructure bearing capacity loads, must be determined and designed for by a qualified professional engineer. Assumed dead loads are 38 lb/ft^2 for asphalt wearing surface and 10 lb/ft^2 for the rail and curb system. AASHTO also requires a unit weight of 50 lb/ft^3 for determining dead loads for treated timber members.

Deflection Criteria

AASHTO recommends a deflection limit of L/500 for timber bridge superstructures. Design tables for the five longitudinal deck systems include L/360 and L/500 deflection criteria. The larger deflection limit of L/360 is applicable and acceptable for low-volume, low-speed bridge applications, where an asphalt wearing surface would not be used. Design tables for the beam systems are based on L/500 deflection criteria for the glulam stringers and a 0.10 inch maximum deflection for transverse glulam deck panels.

Load Distribution

The load distribution criteria used to develop these standards complies with current AASHTO requirements. However, a more conservative load distribution width was used for nail-laminated decks to minimize delamination after prolonged service.

Table B. – Bridge Design Summary

Superstructure Type	Load distribution[a]: Used for design	Load distribution[a]: AASHTO	Design values[b]: AASHTO table reference	Design values[b]: Applicable F_b modification factors
Nail–Laminated Decks	Tire width + (deck thickness)	Tire width + 2(deck thickness)	13.5.1A - Visually graded lumber and timbers	C_M C_D C_F C_r
Spike–Laminated Decks	Tire width + 2(deck thickness)			C_M C_D C_F C_r
Stress–Laminated Sawn Lumber Decks	Tire width + 2(deck thickness)			C_M C_D C_F C_{LS}
Stress–Laminated Glulam Decks	Tire width + 2(deck thickness)		13.5.3A - Members stressed primarily in bending about x-x axis	C_M C_D C_V
Longitudinal Glulam Decks	Based on AASHTO load fraction method		13.5.3B - Members stressed primarily in axial tension or compression about y-y axis	C_M C_D C_F
Glulam Stringer with Transverse Glulam Decks[c]	$(15 + t) \leq$ panel width		Designer does not need to determine member sizes	
Transverse Glulam Decks for Steel Beam Bridges[c]	$(15 + t) \leq$ panel width		13.5.3B - Members stressed primarily in axial tension or compression about y-y axis	C_M C_D C_F

a – Load distribution criteria meets AASHTO, except nail–laminated decks, where a more conservative approach is intended; t = deck thickness; see AASHTO 3.30 for tire width definition.
b – See AASHTO and/or NDS for more information on modification factors: C_M = wet service factor; C_D = load duration factor; C_F = bending size factor; C_r = repetitive member factor; C_{LS} = load sharing factor; C_V = volume factor; F_b = tabulated bending stress (lb/in^2).
c – Transverse decks are designed as non-interconnected; see AASHTO for additional information on interconnected transverse decks using steel dowels.

Tabulated Design Values

Tabulated design values are typically found in the AASHTO tables listed in **Table B**. Additional design values may be found in the following sources: For sawn lumber, the latest edition of the NDS. For glulam, the latest editions of *AITC 117-93 Design Values / Specifications* should be used for softwoods and *AITC 119-96 Standard Specifications for Structural Glued Laminated Timber of Hardwood Species* should be used for hardwoods.

Modification of Tabulated Design Values

Most design errors occur when the designer incorrectly applies modification factors to tabulated bending strength (F_b) design values. Therefore, to assist the designer, the appropriate modifications factors for F_b are listed in **Table B** for each superstructure type. Modification factors are further defined as follows:

C_M Wet service factor — Applies to all F_b and E values. AASHTO requires that timber bridge superstructures be designed for wet service conditions, unless dry service conditions are met (for sawn lumber, see footnotes to AASHTO Table 13.5.1A; and for softwood glulam, see footnotes to AASHTO Table 13.5.3A). For sawn lumber, dry service conditions are met when the maximum moisture content in-service is less than 19 percent. For glulam, dry service conditions are met when the maximum moisture content in-service is less than 16 percent. Typically, dry service conditions only apply to glulam stringers in the Glulam Stringer with Transverse Glulam Decks system, glulam stiffener beams, and covered bridge applications.

C_D Load duration factor — Applies to all F_b values. For vehicle live loads, use $C_D = 1.15$ for all bridge types.

C_F Bending size factor — Applies to sawn lumber (excluding Southern Pine) 2 to 4 inches thick and to glulam panels where the load is applied parallel to the wide face of the laminations. See footnotes to AASHTO Table 13.5.1A.

C_r Repetitive member factor — Applies to sawn lumber, 2 to 4 inches thick. Use $C_r = 1.15$ for nail– and spike–laminated decks only.

C_{LS} Load sharing factor — To compensate for improved load distribution characteristics of Stress–Laminated Decks over Nail–Laminated Decks systems. Use $C_{LS} = 1.50$ (for grades No. 1 and No. 2) and $C_{LS} = 1.30$ (for select structural grades) for the Stress–Laminated Sawn Lumber Decks system only. (Refer to AASHTO Guide Specification)

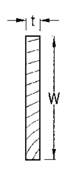
C_V Volume factor — Applies to glulam members when the load is applied perpendicular to the wide face of the laminations. This applies only to the Stress-Laminated Glulam Decks system, see AASHTO 13.6.4.3.

Member Sizes

The dimensioning of sawn lumber and glulam members can be confusing. The following information is provided to clarify the difference between nominal and net (actual) dimensions of sawn lumber and glulam members.

Sawn Lumber

Fully dressed, or surfaced on all four sides (S4S), lumber has been planed on all four surfaces. Rough sawn refers to lumber which has not been planed, or surfaced.

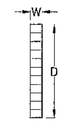


Sawn lumber lamination

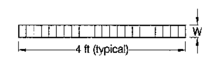
	Dimensions of sawn lumber deck laminations[a]						
Surface condition	Thickness, t (in.)		Face width, W (in.)				
Nominal or rough sawn	2	4	8	10	12	14	16
Fully dressed (S4S)	1-1/2	3-1/2	7-1/4	9-1/4	11-1/4	13-1/4	15-1/4

a – These dimensions apply to sawn lumber used in Nail–, Spike–, and Stress–Laminated Decks systems.

Glulam



Glulam beam



Glulam panel

Glulam bending members are designed differently depending on whether the loads causing the bending are applied perpendicular to the wide face of the laminations (as is the case with beams and stringers) or loads are applied parallel to the wide face of the laminations (as is the case with transverse and longitudinal deck panels). Glulam bending members are specified using different combination symbol tables.

Beams and stringers are designed using bending combinations that use higher quality laminations in the high tension and compression zones. Beams and stringers are generally chosen from tables for "Members Stressed Primarily in Bending" (AASHTO 13.5.3A or NDS 5A). Transverse and longitudinal deck panels are designed using bending combinations in which all laminations have the same strength and stiffness. Although they are designed for bending, transverse and longitudinal panels are generally chosen from tables for "Members Stressed Primarily in Axial Tension or Compression" (AASHTO 13.5.3B or NDS 5.B). The reason for this apparent contradiction is that the deck panels must have consistent strength and stiffness characteristics across their entire width.

As stringer width and/or depth of glulam deck panels increases, the use of multiple piece laminations may become an economical option. Edge gluing of multiple piece laminations is recommended for all face laminations.

	Net finished dimensions of glulam members																
	Width (W)									Depth (D)						
										No. of laminations[a]						
Nominal dimension (in.)	3	4	6	8	10	12	14	16	18	8	9	10	11	12	13	14
Net finished dimension (in.)	Western species									Western species						
	2-1/8	3-1/8	5-1/8	6-3/4	8-3/4	10-3/4	12-1/4	14-1/4	16-1/4	12	13-1/2	15	16-1/2	18	19-1/2	–
	Southern Pine									Southern Pine						
	–	3	5	6-3/4	8-1/2	10-1/2	12-1/4	14-1/4	16-1/4	–	12-3/8	13-3/4	15-1/8	16-1/2	17-7/8	19-1/4

a – Actual lamination thickness is 1-1/2 in. for western species and 1-3/8 in. for Southern Pine (fabricators will usually provide either lamination size)

Moisture Content

AASHTO recommends a maximum moisture content of 19 percent for all sawn lumber and glulam members at installation. Drying sawn lumber members to a 19–percent maximum moisture content is often not enforced by bridge owners, even when it is clearly specified in the contract drawings. As sawn lumber dries in–service, shrinkage of wood members can cause loosening of connections. When using waterborne preservatives, it is important to re–dry members to a 19–percent maximum moisture content after the preservative treatment process.

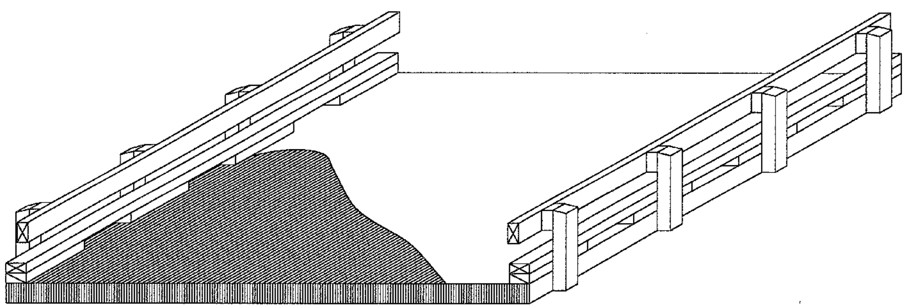
Crash–Tested Rail Systems

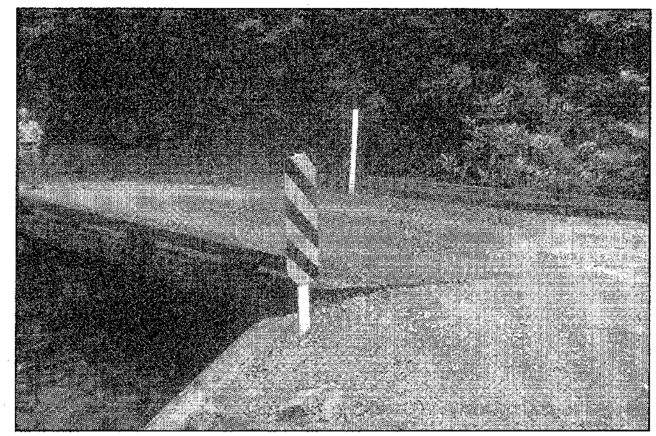
Crash–tested bridge railings meeting NCHRP Report 350 are required at many sites but are not included as part of these standards. Crash–tested designs can be found in the following references: for longitudinal decks, see Ritter et al. (1995); for transverse decks, see Ritter et al. (In Press); for low-volume roads applications for longitudinal decks, see Ritter et al. (1998).

Camber

A positive camber, equal to three times the dead load deflection but not less than ½ inch, should be introduced into the following superstructure systems: Stress–Laminated Glulam Decks, Glulam Stringer and Transverse Glulam Decks, and Stress–Laminated Sawn Lumber Decks (with butt–joints). It is important to position the topside (which is usually marked) up when placing glulam stringers.

Longitudinal Deck Systems:
Nail-Laminated Decks





The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.	Nail-Laminated Decks	Title Page
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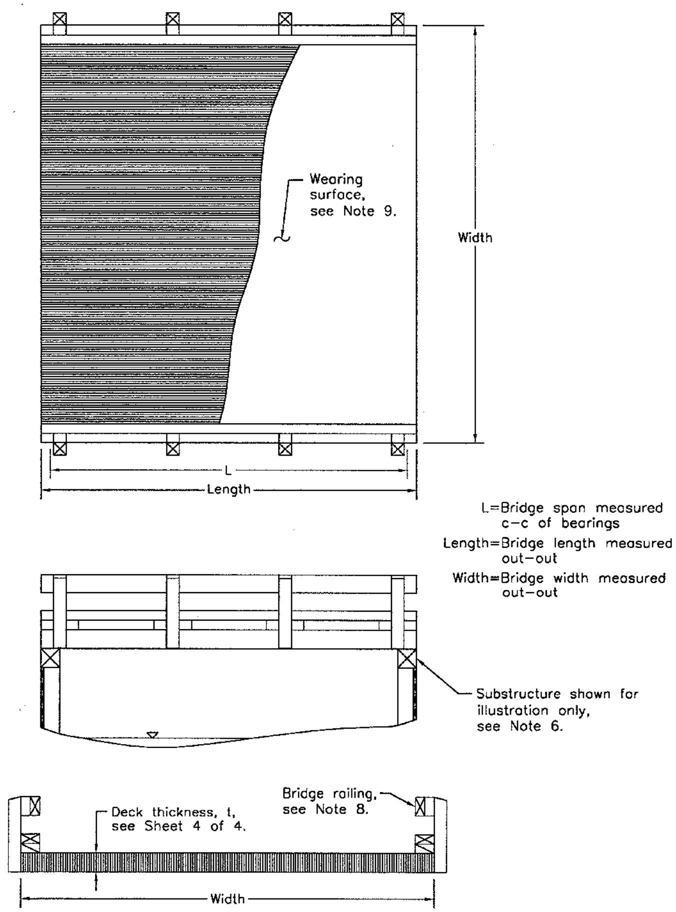
Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for longitudinal nail-laminated timber bridge decks. The decks consist of a series of nominal 2–in. dimension lumber laminations that are placed on edge and nailed together on their wide faces to form a continuous deck. Lumber laminations shall be continuous (full length) between supports with no butt–joints. The designs are applicable for single– and double–lane and unskewed and skewed bridges up to 28 ft long. Design truck loading is AASHTO HS 20–44 or HS 25–44, with live load deflection limits of L/360 or L/500.

2. Nail–laminated timber bridge decks are well suited to low–volume road applications. They are less suitable for high–volume applications where the repetitive traffic loads may cause the nails to loosen, resulting in lamination movement and excessive asphalt pavement cracking.

3. The designs comply with the 1996 *Standard Specifications for Highway Bridges,* with 1998 Interims, published by the American Association of State Highway and Transportation Officials (AASHTO), except where noted. Load distribution widths are assumed to be the width of the tire (as defined by AASHTO) plus the deck thickness.

4. Minimum required timber design values are provided for single-span bridge lengths of 10 to 28 ft in 2–ft increments. The required minimum deck thickness for a specific bridge length can be selected from the table on Sheet 4 of 4, based on material, loading, and deflection

5.Bridge width is variable by adjusting the number of lumber laminations.

6. The design assumes a uniform bearing length of 12–in. at both bridge ends and a span length, L, measured center–to–center of bearings. A longer bearing length will result in a slightly more conservative design. Substructure connection details are provided on Page 34.

7. Multiple span bridges may be constructed using a series of simple spans based on the designs presented in these drawings. Multiple span continuous bridges are also commonly used and may be more economical but require site specific design. Refer to Page 34 for intermediate support connection details for both simple and continuous spans.

8. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft^2 for the rail and curb system. Crashworthy rail designs are available in *Plans for Crash- Tested Bridge Railings for Longitudinal Wood Decks* (Ritter et al.1995) and *Plans for Crash-Tested Bridge Railings for Longitudinal Wood Decks on Low-Volume Roads* (Ritter et al.1998).

9. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. Deck designs are based on an assumed dead load of 38 lb/ft^2 for an asphalt wearing surface (approximately 3 –in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

10. These designs are intended for informational purposes only and, due to potential variations in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood

11. Sawn lumber shall comply with the requirements of AASHTO M168 and may be any species, provided it is treatable with wood preservatives and tabulated design values are provided in the AASHTO *Standard Specifications for Highway Bridges*. The moisture content of lumber shall not exceed 19 percent at the time of installation.

12. Sawn lumber may be rough-sawn or dressed (S4S). Rough–sawn lumber shall be surfaced on one side (S1S) to ensure uniform thickness for all laminations.

13. Insofar as is practical, all lumber shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives.

Preservative Treatment

14. All lumber shall be treated in accordance with AASHTO M133 and AWPA Standard C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13.
b. Suitable oilborne preservative conforming to AWPA Standard P8 in hydrocarbon solvent, Type A or Type C.
c. Suitable waterborne preservative conforming to AWPA Standard P5. Lumber treated with a waterborne preservative shall be re–dried to a maximum moisture content of 19 percent.

15. Treated material shall follow the post treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are adequately fixated in the wood.

16. Preservative treatment shall be inspected and certified in accordance with AASHTO M133 and AWPA Standard M2.

Steel Fasteners and Hardware

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

18. Nails shall be common wire or deformed shank conforming to ASTM F1667.

19. Bolts and lag screws shall comply with the requirements of ANSI/ASME Standard B18.2.1-1981, Grade 2.

20. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or otherwise protected from corrosion.

21. Washers shall be provided under bolt and lag screw heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome–head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

22. Decks may be assembled by placing laminations on edge and nailing them together along the wide faces, in accordance with the procedures and nailing patterns given on Sheet 3 of 4.

23. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

24. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Any commercially available roofing cement is effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Nail-Laminated Decks	Superstructure Drawings and General Notes	
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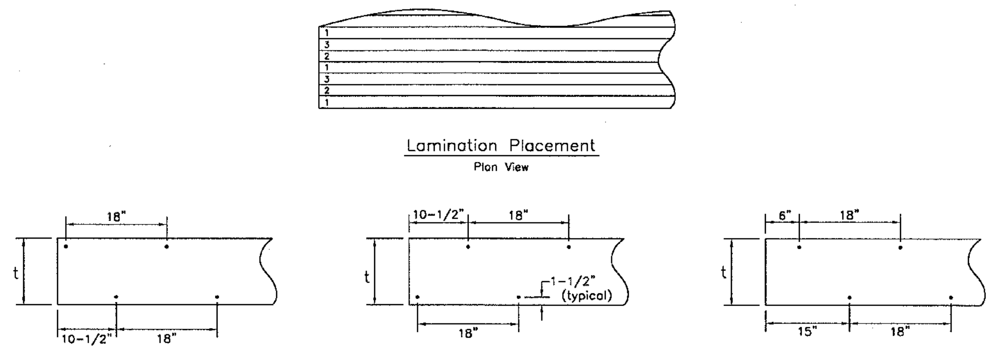
Lamination Nail Pattern - Unskewed Crossing



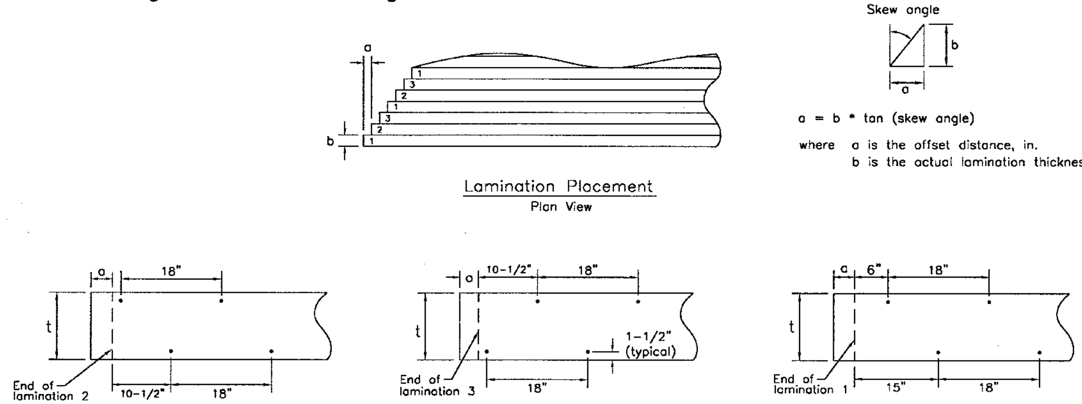
Lamination Placement
Plan View

Lamination 1
Side View

Lamination 2
Side View

Lamination 3
Side View

Lamination Nailing Pattern - Skewed Crossing



Lamination Placement
Plan View

Lamination 1
Side View

Lamination 2
Side View

Lamination 3
Side View

Skew angle

a = b * tan (skew angle)

where a is the offset distance, in.
b is the actual lamination thickness, in.

Notes

1. Nail-laminated timber bridge decks are constructed by sequentially nailing laminations together on their wide faces until the required deck width is achieved. The nailing involves a repetitive series of three laminations, as detailed on this sheet.

2. When beginning construction, at least three laminations should be nailed together and attached to the substructure along one bridge edge. The remaining laminations are then sequentially nailed to the interior face of this lamination group.

3. Nails should be placed approximately 1-1/2 in. from the lamination edges and ends. Interior nail spacing is typically 18-in. but may be reduced to fit the bridge length.

4. Nails shall be of sufficient length to penetrate at least 2-1/2 laminations and may be common wire or deformed shank nails. Deformed shank nails, such as ring-shank or spiral decking nails, are recommended because they provide increased resistance to withdrawal and improved long-term deck performance. Nails should be galvanized or otherwise protected from corrosion, particularly if the wood is not treated with an oilborne preservative (the oil solvents coat and provide some protection of steel components).

5. Nails may be installed manually or placed with a pneumatic gun. If lamination splitting occurs during nail placement, lead holes shall be prebored. Prebore diameters shall not exceed three-quarters of the nail shank diameter.

Deformed shank nails

Spiral decking or helically threaded

Ring shank or annular threaded

Table 1.1 – Recommended nail sizes for 2-in. deck laminations.

Deck laminations			Recommended nails		
Nominal thickness (in.)	Surface condition	Actual thickness (in.)	Size	Length (in.)	Diameter (in.)
2	S4S	1.5	20d	4.0	0.177
	Rough-sawn	2.0	40d	5.0	0.177

S4S—surfaced four sides; d—pennyweight.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Nail-Laminated Decks

Nailing Specifications

Standard Plans for Timber Bridge Superstructures

December 2000

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Table 1.2 — Nail-Laminated Deck Design Table

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading									AASHTO HS25-44 Loading								
			Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values for Actual Deck Thickness[a] (t) ranging from 8 to 16-in.																	
			8	9¼	10	11¼	12	13¼	14	15¼	16	8	9¼	10	11¼	12	13¼	14	15¼	16
10	9	F_b'	1,523	1,097	918							1,744	1,259	1,055						
		E' for L/360	1.17	0.73	0.56							1.35	0.84	0.65						
		E' for L/500	1.63	1.01	0.78							1.88	1.17	0.90						
12	11	F_b'	1,882	1,357	1,137	869							1,555	1,305	999	862				
		E' for L/360	1.75	1.08	0.84	0.56							1.25	0.97	0.66	0.53				
		E' for L/500		1.51	1.16	0.78							1.74	1.35	0.91	0.73				
14	13	F_b'		1,623	1,361	1,041	898						1,858	1,559	1,195	1,032	823			
		E' for L/360		1.51	1.17	0.79	0.63						1.75	1.35	0.92	0.74	0.53			
		E' for L/500			1.62	1.09	0.88							1.88	1.27	1.03	0.73			
16	15	F_b'			1,590	1,218	1,052	839	739					1,819	1,395	1,206	962	849		
		E' for L/360			1.56	1.05	0.84	0.60	0.50					1.80	1.22	0.98	0.70	0.59		
		E' for L/500				1.46	1.17	0.84	0.70						1.69	1.36	0.98	0.81		
18	17	F_b'			1,825	1,400	1,209	966	852	701					1,600	1,384	1,106	976	803	
		E' for L/360			2.00	1.35	1.08	0.78	0.64	0.48					1.57	1.26	0.90	0.75	0.56	
		E' for L/500				1.87	1.51	1.08	0.89	0.67						1.75	1.26	1.04	0.78	
20	19	F_b'				1,585	1,371	1,096	967	797	714				1,810	1,566	1,252	1,106	911	817
		E' for L/360				1.68	1.35	0.97	0.80	0.67	0.56				1.96	1.58	1.13	0.94	0.70	0.60
		E' for L/500					1.88	1.34	1.11	0.83	0.71						1.57	1.30	0.97	0.83
22	21	F_b'					1,536	1,230	1,086	896	804					1,752	1,403	1,239	1,022	917
		E' for L/360					1.65	1.18	0.98	0.73	0.62					1.93	1.38	1.15	0.86	0.73
		E' for L/500						1.64	1.36	1.02	0.86						1.92	1.59	1.19	1.01
24	23	F_b'						1,367	1,208	997	896						1,557	1,376	1,136	1,020
		E' for L/360						1.58	1.31	0.98	0.83						1.84	1.53	1.15	0.97
		E' for L/500							1.82	1.36	1.15								1.59	1.35
26	25	F_b'							1,373	1,134	1,019							1,561	1,291	1,158
		E' for L/360							1.72	1.28	1.09							2.00	1.50	1.27
		E' for L/500								1.78	1.51									1.77
28	27	F_b'								1,302	1,170								1,481	1,329
		E' for L/360								1.61	1.37								1.89	1.60
		E' for L/500									1.90									

a — Rough sawn sizes are 8, 10, 12, 14, and 16-in.; dressed sizes are 9¼, 11¼, 13¼, and 15¼-in.

Table Instructions

The table on this sheet is for determining the required deck thickness for longitudinal nail-laminated timber bridge decks. The criteria for deck thickness selection are based on the span length, vehicle loading, live load deflection limit, and material properties for the grade and species of lumber. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E'), based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb and 38 lb/ft^2 for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the grade and species of the lumber are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the material grade and species are unknown, minimum required F_b' and E' values may be obtained from the table based on the span length, deck thickness, loading, and deflection limit. A grade and species of lumber that meets these minimum allowable design values may then be selected. Specific procedures for table use follow:

<u>Material Grade and Species Known</u>

1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the grade and species of lumber lamination using the following equations:

$$F_b' = F_b\, C_M\, C_F\, C_D\, C_r \qquad E' = E\, C_M$$

where

F_b' = allowable bending stress (lb/in^2)
F_b = tabulated bending stress (lb/in^2)
E' = allowable modulus of elasticity (lb/in^2)
E = tabulated modulus of elasticity (lb/in^2)
C_M = wet service factor
C_F = size factor
C_D = load duration factor
C_r = repetitive member factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

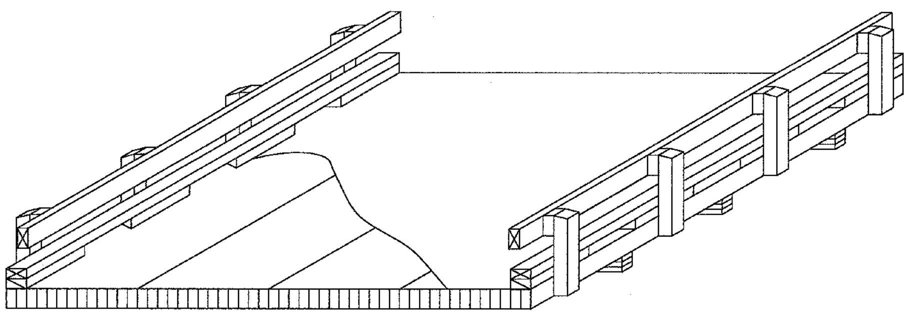
<u>Material Grade and Species Unknown</u>

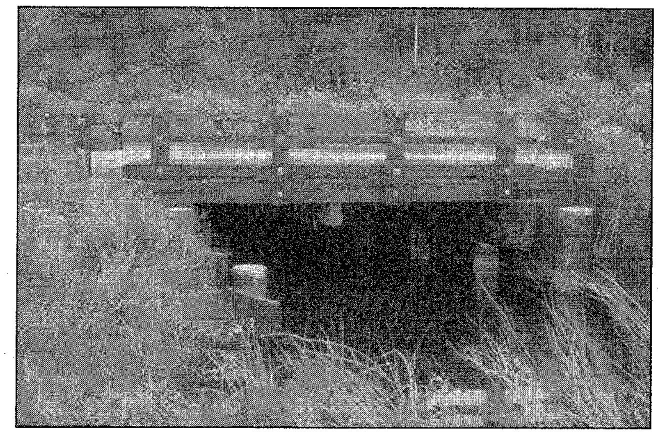
1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

3. Select a grade and species of dimension lumber that provides the minimum allowable design values.

Longitudinal Deck Systems: Spike-Laminated Decks

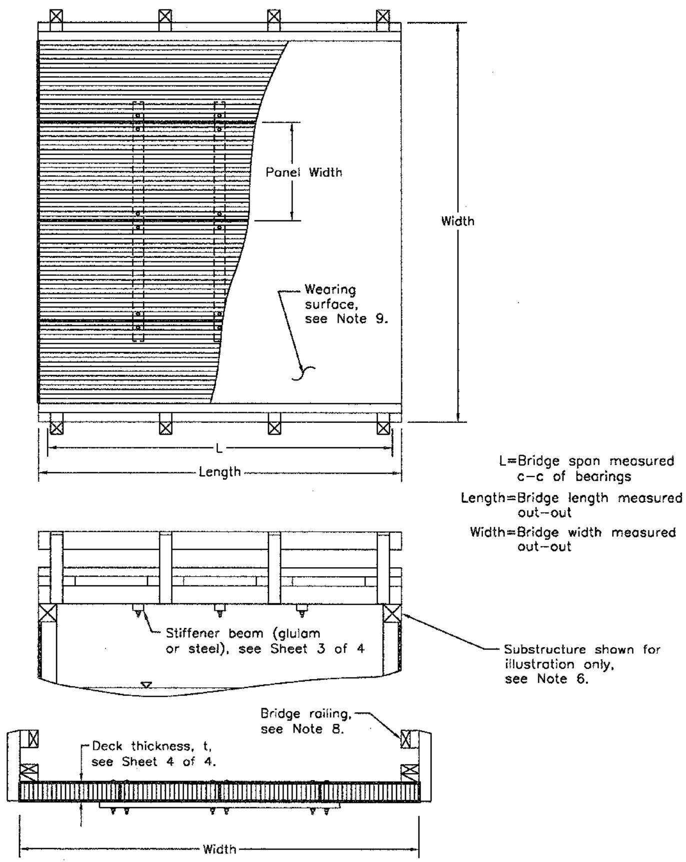




The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Spike-Laminated Decks	Title Page	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 1 of 4

Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for longitudinal spike–laminated timber bridge decks. The decks consist of a series of nominal 4–in. dimension lumber laminations that are prefabricated into a series of partial–width deck panels. The panels are placed side–by–side between supports and interconnected with transverse stiffener beams. Lumber laminations shall be continuous (full length) between supports with no butt–joints. The designs are applicable for single– and double–lane and unskewed and skewed bridges up to 34 ft long. Design truck loading is AASHTO HS 20–44 or HS 25–44, with live load deflection limits of L/360 or L/500.

2. Deck panels shall be prefabricated at a manufacturing facility by placing spikes with a hydraulic press into prebored holes as specified in *Timber Bridges: Design, Construction, Inspection, and Maintenance* (Ritter, 1990).

3. The designs comply with the *1996 AASHTO Standard Specifications for Highway Bridges*, with1998 Interims, published by the American Association of State Highway and Transportation Officials (AASHTO), except where noted. Load distribution widths are assumed to be the width of the tire (as defined by AASHTO) plus twice the deck thickness.

4. Minimum required timber design values are provided for single span bridge lengths of 12 to 34 ft in 2–ft increments. The required minimum deck thickness for a specific bridge length can be selected from the table on Sheet 4 of 4, based on material, loading, and deflection.

5. Bridge width is variable by adjusting the width of the deck panels.

6. The design assumes a uniform bearing length of 12 in. at both bridge ends and a span length, L, measured center–to–center of bearings. A longer bearing length will result in a slightly more conservative design. Substructure connection details are provided on Page 34.

7. Multiple span bridges may be constructed using a series of simple spans based on the designs presented in these drawings. Multiple span continuous bridges are also commonly used and may be more economical but require site–specific design. Refer to Page 34 for intermediate support connection details for both simple and continuous spans.

8. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft^2 for the rail and curb system. Crashworthy rail designs are available in *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Decks (Ritter et al.1995)* and *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Decks on Low-Volume Roads (Ritter et al.1998).*

9. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. Deck designs are based on an assumed dead load of 38 lb/ft^2 for an asphalt wearing surface (approximately 3 in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

10. These designs are intended for informational purposes only and, due to potential variations in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood
11. Sawn lumber shall comply with the requirements of AASHTO M168 and may be any species, provided it is treatable with wood preservatives and tabulated design values are provided in the AASHTO *Standard Specifications for Highway Bridges.*

12. Sawn lumber may be rough sawn or dressed (S4S). Rough–sawn lumber shall be surfaced on one side (S1S) to ensure uniform thickness for all laminations.

13. Insofar as is practical, all wood members shall be cut, drilled, and otherwise fabricated prior to pressure treatment with wood preservatives.

Preservative Treatment
14. All lumber shall be treated in accordance with AASHTO M133 and AWPA Standard C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13.
b. Suitable oilborne preservative conforming to AWPA Standard P8 in hydrocarbon solvent, Type A or Type C.
c. Suitable waterborne preservative conforming to AWPA Standard P5. Lumber treated with a waterborne preservative shall be re–dried to a maximum moisture content of 19 percent.

15. Treated material shall followpost treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are fixated in the wood.

Steel Fasteners and Hardware
16. Steel components shall comply with the requirements of ASTM A36.

17. Spikes shall be common wire or deformed shank conforming to ASTM 1667.

18. Bolts and lag screws shall comply with the requirements of ANSI/ASME Standard B18.2.1-1981, Grade 2.

19. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232, or otherwise protected from corrosion.

20. Washers shall be provided under bolt and lag screw heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome–head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

21. Deck panels shall be interconnected with transverse stiffener beams as shown on Sheet 3 of 4.

22. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

23. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Vertical joint surfaces, between deck panels, may also be coated to minimize moisture penetration. Any commercially available roofing cement is effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Spike-Laminated Decks	Superstructure Drawings and General Notes	
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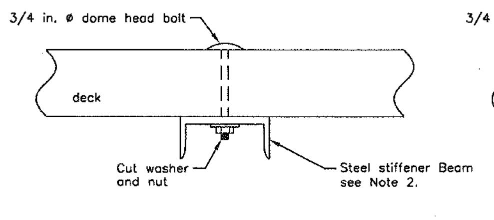
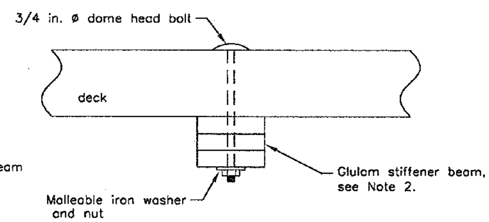
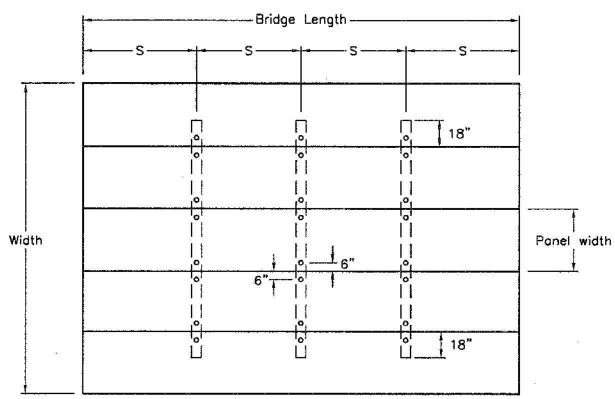
Deck Panel and Transverse Stiffener Beam Layout



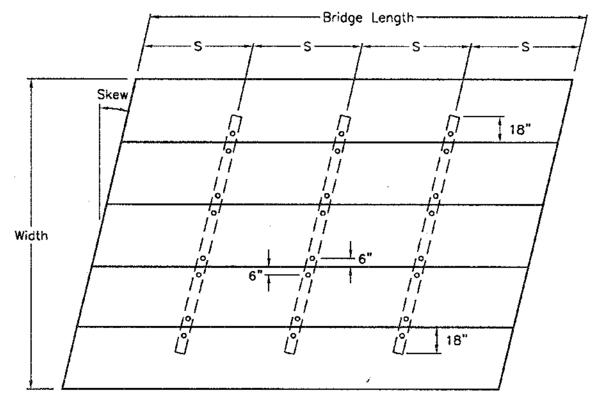
Transverse Stiffener Beam Connection - Steel Channel
Side View



Transverse Stiffener Beam Connection - Glulam Beam
Side View



Transverse Stiffener Beam - Unskewed Crossings
Plan View



Transverse Stiffener Beam - Skewed Crossings
Plan View

Notes

1. Transverse stiffener beams shall be attached to the deck underside to transfer loads between adjacent panels. Transverse stiffener beams are placed at midspan and at intermediate locations, while not exceeding a 10-ft spacing (see Table 2.1). For unskewed crossings, stiffener beams shall be placed perpendicular to the bridge span. For skewed crossings, stiffener beams shall be placed parallel to the abutments.

2. Transverse stiffener beams shall be manufactured of glulam or steel. For western species glulam, a Combination Symbol No. 2 beam measuring 6-3/4-in. wide and 4-1/2-in. deep may be used. For southern pine glulam, a Combination Symbol No. 48 beam measuring 5-in. wide and 5-1/2-in. deep may be used. For steel, a miscellaneous channel (MC6x15.1) beam may be used. Other glulam combinations or steel shapes may be used provided they are of sufficient size and stiffness to provide a minimum E'I of 80,000 lb-in^2.

3. Transverse stiffener beams shall be attached to the deck panels with 3/4-in.-diameter thru-bolts placed approximately 6-in. from the panel edges. For the exterior panels, the stiffener beam shall extend a minimum of 18-in. beyond the panel interface.

Table 2.1 - Transverse Stiffener Layout

Bridge Length (ft)	No.	S (ft)
12	1	6.0
14	1	7.0
16	1	8.0
18	1	9.0
20	3	5.0
22	3	5.5
24	3	6.0
26	3	6.5
28	3	7.0
30	3	7.5
32	3	8.0
34	3	8.5

S = transverse stiffener beam spacing

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Table 2.2 – Spike-Laminated Deck Design Table

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading: Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values For Actual Deck Thickness[a] (t) Values Ranging from 8 to 16-in.									AASHTO HS25-44 Loading								
			8	9¼	10	11¼	12	13¼	14	15¼	16	8	9¼	10	11¼	12	13¼	14	15¼	16
12	11	F_b'	1,490	1,053	873							1,727	1,223	1,015	765					
		E' for L/360	1.36	0.82	0.63							1.60	0.97	0.74	0.49					
		E' for L/500	1.89	1.14	0.87								1.35	1.03	0.68					
14	13	F_b'	1,785	1,264	1,049	791							1,465	1,217	918	786				
		E' for L/360	1.90	1.15	0.88	0.58							1.36	1.03	0.69	0.55				
		E' for L/500		1.60	1.22	0.80							1.88	1.44	0.95	0.76				
16	15	F_b'		1,481	1,230	929	796						1,713	1,424	1,076	923	728			
		E' for L/360		1.53	1.17	0.77	0.61						1.80	1.38	0.91	0.73	0.51			
		E' for L/500			1.62	1.07	0.85							1.91	1.27	1.01	0.71			
18	17	F_b'		1,704	1,417	1,072	919	727						1,637	1,239	1,063	840	737		
		E' for L/360		1.97	1.50	0.99	0.79	0.55						1.77	0.17	0.94	0.66	0.54		
		E' for L/500				1.38	1.10	0.77							1.63	1.30	0.92	0.75		
20	19	F_b'			1,609	1,219	1,047	829	728						1,406	1,207	955	839	685	
		E' for L/360			1.87	1.24	0.99	0.69	0.57						1.47	1.17	0.82	0.68	0.50	
		E' for L/500				1.72	1.37	0.96	0.79							1.62	1.14	0.94	0.69	
22	21	F_b'				1,371	1,178	934	821	673	602				1,577	1,355	1,074	944	772	690
		E' for L/360				1.51	1.20	0.85	0.69	0.51	0.43				1.79	1.43	1.01	0.83	0.61	0.51
		E' for L/500					1.67	1.17	0.96	0.71	0.60					1.98	1.40	1.15	0.85	0.71
24	23	F_b'					1,314	1,044	918	753	675					1,508	1,196	1,052	862	771
		E' for L/360					1.61	1.13	0.93	0.68	0.57					1.91	1.34	1.11	0.82	0.69
		E' for L/500						1.57	1.29	0.95	0.80						1.87	1.54	1.13	0.95
26	25	F_b'						1,189	1,047	859	770						1,361	1,197	982	879
		E' for L/360						1.48	1.22	0.89	0.75						1.76	1.45	1.07	0.90
		E' for L/500							1.69	1.24	1.04								1.48	1.25
28	27	F_b'						1,365	1,202	988	885							1,375	1,128	1,009
		E' for L/360						1.86	1.53	1.13	0.95							1.82	1.34	1.13
		E' for L/500								1.56	1.31								1.87	1.57
30	29	F_b'							1,362	1,120	1,003								1,279	1,144
		E' for L/360							1.87	1.38	1.16								1.64	1.38
		E' for L/500								1.91	1.61									1.92
32	31	F_b'								1,255	1,125								1,431	1,282
		E' for L/360								1.65	1.39								1.97	1.66
		E' for L/500									1.92									
34	33	F_b'								1,395	1,251									1,423
		E' for L/360								1.94	1.63									1.95
		E' for L/500																		

a – Rough-sawn sizes are 8, 10, 12, 14, and 16-in. and dressed sizes are 9¼, 11¼, 13¼, and 15¼-in.

Table Instructions

The table on this sheet is for determining the required deck thickness for spike-laminated timber bridge decks. The criteria for deck thickness selection are based on the span length, vehicle loading, live load deflection limit, and material properties for the grade and species of lumber. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E'), based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb and 38 lb/ft^2 for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the grade and species of the lumber are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the material grade and species are unknown, minimum required F_b' and E' values may be obtained from the table based on the span length, deck thickness, loading, and deflection limit. A grade and species of lumber that meets these minimum allowable design values may then be selected. Specific procedures for table use follow:

Material Grade and Species Known

1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the grade and species of lumber lamination using the following equations:

$$F_b' = F_b\, C_M\, C_F\, C_D\, C_r \qquad E' = E\, C_M$$

where

F_b' = allowable bending stress (lb/in^2)
F_b = tabulated bending stress (lb/in^2)
E' = allowable modulus of elasticity (lb/in^2)
E = tabulated modulus of elasticity (lb/in^2
C_M = wet service factor
C_F = size factor
C_D = load duration factor
C_r = repetitive member factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

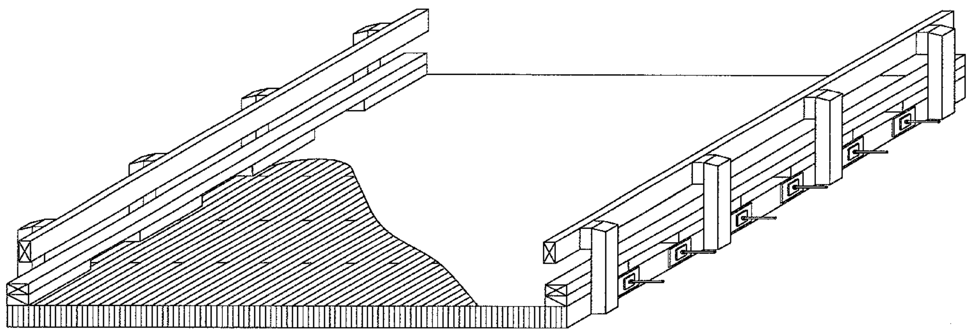
Material Grade and Species Unknown

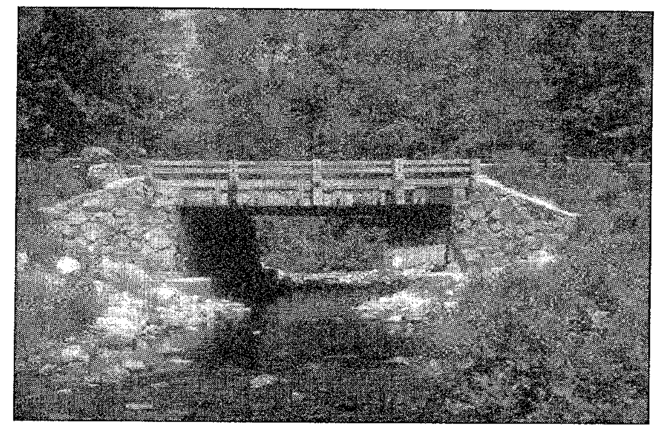
1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

3. Select a grade and species of dimension lumber that provides the minimum allowable design values.

Longitudinal Deck Systems: Stress-Laminated Sawn Lumber Decks

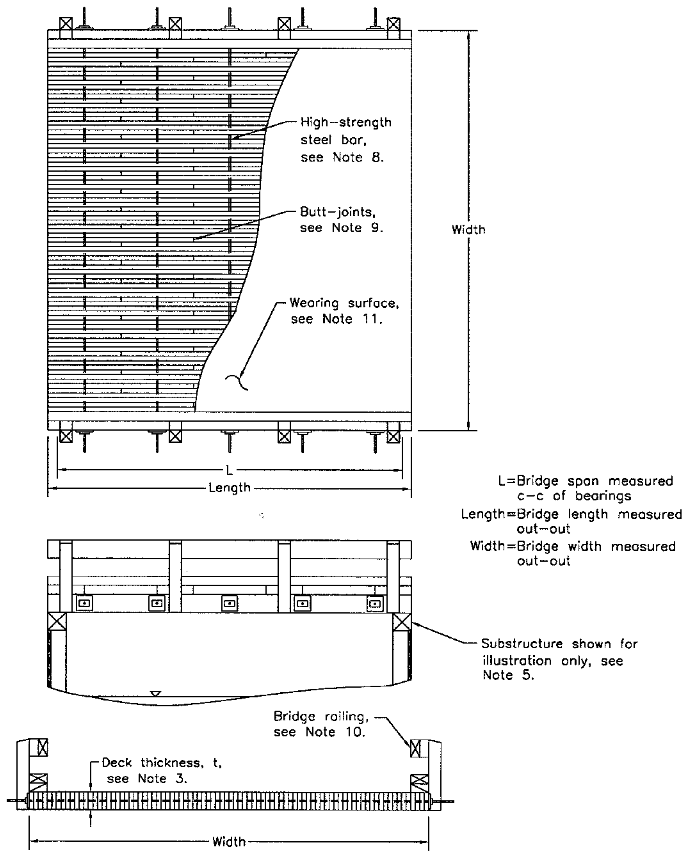




The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stress-Laminated Sawn Lumber Decks	Title Page	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 1 of 9

Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for longitudinal stress-laminated timber bridge decks. The decks consist of a series of nominal 2– to 4–in.–thick sawn lumber laminations that are placed on edge between supports and transversely compressed with high–strength steel bars. Deck laminations of various lengths may be placed in a repetitive butt joint pattern when full-span lumber is not available. The designs are applicable for single– and double–lane and unskewed and skewed bridges up to 34 ft long. Design truck loading is AASHTO HS 20–44 or HS 25–44, with live load deflection limits of L/360 or L/500.

2. The designs comply with the 1996 *Standard Specifications for Highway Bridges,* with 1998 Interims, and the 1991 *Guide Specifications for the Design of Stress-Laminated Wood Decks,* published by the American Association of State Highway and Transportation Officials (AASHTO), except where noted. Load distribution widths are assumed to be the width of the tire (as defined by AASHTO) plus twice the deck thickness and have been adjusted by a factor of 1.15 for deflection calculations. The designs are based upon an interlaminar prestress of 100 lb/in^2 which has been shown to provide optimum field performance.

3. Minimum required timber design values are provided for single-span bridge lengths of 10 to 34 ft in 2–ft increments. The required minimum deck thickness for a specific bridge length can be selected from tables on Sheet 6 of 9 and Sheet 8 of 9, based on material, loading, and deflection.

4. Bridge width is variable by adjusting the number of lumber laminations.

5. The design assumes a uniform bearing length of 12–in. at both bridge ends and a span length, L, measured center–to–center of bearings. A longer bearing length will result in a slightly more conservative design. Substructure connection details are provided on Page 34.

6. Multiple span bridges may be constructed using a series of simple spans based on the designs presented in these drawings. Multiple span continuous bridges are also commonly used and may be more economical but require site–specific design. Refer to Page 34 for intermediate support connection details for both simple and continuous spans.

7. Skewed crossings are limited to 15° maximum by AASHTO. Refer to Sheet 4 of 9 for information regarding design considerations and stressing bar layout for skewed bridges.

8. High-strength steel bars are nominal 5/8 or 1 in. diameter. The diameter and spacing of bars depends on the deck thickness and span as shown on Sheet 5 of 9 and Sheet 7 of 9.

9. Butt joints are permitted for longer spans as shown on Sheet 7 of 9. Butt–joints are limited transversely to 1 joint in every 4 adjacent laminations and are spaced 4–ft longitudinally.

10. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site–specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft^2 for the rail and curb system. Crashworthy rail designs are available in *Plans for Crash –Tested Bridge Railings for Longitudinal Wood Decks* (Ritter et al.1995) and *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Decks on Low-Volume Roads* (Ritter et al. 1998).

11. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. For stress–laminated decks, the wearing surface should be installed after the first re–tensioning is completed (see Note 25). Deck designs are based on an assumed dead load of 38 lb/ft^2 for an asphalt wearing surface (approximately 3–in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

12. These designs are intended for informational purposes only and, due to potential variations in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood

13. Sawn lumber shall comply with the requirements of AASHTO M168 and may be any species, provided it is treatable with wood preservatives and tabulated design values are provided in the AASHTO *Standard Specifications for Highway Bridges*. The moisture content of lumber shall not exceed 19 percent at the time of installation.

14. Sawn lumber may be rough–sawn or dressed (S4S). Rough sawn lumber shall be surfaced on one side (S1S) to ensure uniform thickness for all laminations.

15. Insofar as is practical, all lumber shall be cut, drilled, and completely fabricated prior to pressure treatment with wood preservatives. Refer to Sheet 5 of 9 and Sheet 7 of 9 for information on stressing bar hole layout and diameter.

Preservative Treatment

16. All lumber shall be treated in accordance with AASHTO M133 and AWPA Standard C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13.
b. Suitable oilborne preservative conforming to AWPA Standard P8 in hydrocarbon solvent, Type A or Type C.
c. Suitable waterborne preservative conforming to AWPA Standard P5. Lumber treated with a waterborne preservative shall be re–dried to a maximum moisture content of 19 percent.

17. Treated material shall follow post treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are fixated in the wood.

18. Preservative treatment shall be inspected and certified in accordance with AASHTO M133 and AWPA Standard M2.

Steel Fasteners and Hardware

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

20. Stressing bars shall be 5/8 or 1–in. nominal diameter and shall comply with the requirements of ASTM A722. Order bars at least 3–ft longer than total deck width. Nuts and couplers for stressing bars shall be provided by the bar manufacturer and should be re–threaded, after galvanizing, to ensure proper fit.

21. Bolts and lag screws shall comply with the requirements of ANSI/ASME Standard B18.2.1–1981, Grade 2.

22. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or otherwise protected from corrosion. Galvanizing of stressing bars shall follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the high–strength steel.

23. Washers shall be provided under bolt and lag screw heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome–head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

24. Decks may be assembled by placing laminations on edge, side–by–side on the substructure. Temporary supports at butt–joint locations may be required during construction. After placing all deck laminations, steel stressing bars are inserted into prebored holes and bar anchorage plates and nuts are attached. Tensioning of the high–strength stressing bars is typically performed with a single hydraulic jack and steel stressing chair in a repetitive manner beginning at one end of the bridge. When initially tensioning bars, it is important that the full tension not be applied until all laminations are aligned and in full contact with adjacent laminations. For additional information and alternative assembly methods, refer to *Recommended Construction Practices for Stress-Laminated Wood Bridge Decks* (Ritter and Lee 1996).

25. Stressing bars shall be fully tensioned to the values specified on Sheet 3 of 9 and Sheet 4 of 9 in accordance with the following sequence:

1. Initially tensioned at construction.
2. Re-tensioned 1–2 weeks after the initial tensioning.
3. Re-tensioned 6–8 weeks after the first re–tensioning.

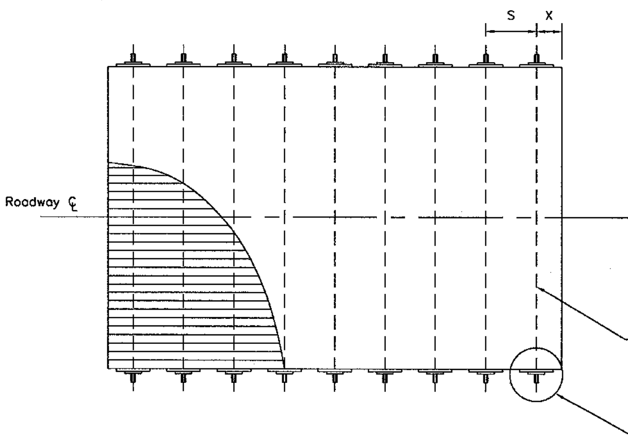
It is recommended that the bars be checked and re–tensioned as required, 1 year after construction and at 1–2 year intervals thereafter until the bar force stabilizes above 50 percent of the design level. If excess bar length is to be trimmed, leave a minimum of 8–in. beyond the anchor nut to allow for re–tensioning.

26. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

27. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Any commercially available roofing cement effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stressing Bar Requirements - Unskewed Bridges



S = Bar spacing measured center–center.

X = End spacing measured from bridge end to center of 1st bar.

See Table 3.1 for bar spacing requirements.

Table 3.1 – Recommended Bar and End Spacings

Bridge Length (ft)	5/8–in.–Diameter Bars		1–in.–Diameter Bars	
	Bar Spacing, S (ft)	End Spacing, X (ft)	Bar Spacing, S (ft)	End Spacing, X (ft)
10	2	1		
12	2	1		
14	2	1		
16	2	1		
18	2	1	4	1
20	2	1	4	2
22	2	1	4	1
24	2	1	4	2
26	2	1	4	1
28			4	2
30			4	1
32			4	2
34			4	1

Table 3.2 – Recommended Design Bar Tension Forces

Bar Diameter (in.)	Design Bar Tension Force (lb) for Actual Deck Thickness (t) Ranging from 8– to 16–in.								
	8	9¼	10	11¼	12	13¼	14	15¼	16
5/8	19,200	22,200	24,000	27,000	28,800				
1						63,600	67,200	73,200	76,800

Notes

1. This sheet provides stressing bar requirements for unskewed bridges. Bar requirements for skewed bridges are given on Sheet 4 of 9.

2. All stressing bars shall be perpendicular to the longitudinal bridge centerline and conform to the requirements of ASTM A722. For a deck thickness less than, or equal to 12–in., bar diameter is 5/8 in. For decks greater than 12 in. thick, bar diameter is 1 in.

3. Bar spacing (S) is 2–ft for 5/8–in.–diameter bars and 4–ft for 1–in.–diameter bars. End spacing (X) is based on bridge length and is given in Table 3.1. Refer to Sheet 5 of 9 for layout of non–butt–jointed decks and Sheet 7 of 9 for layout of butt–jointed decks.

4. Bar tension force is based on deck thickness and bar spacing. Bars shall be tensioned, in multiple passes, to the design bar tension force specified in Table 3.2. Bars shall be re–tensioned as specified in Note 25, Sheet 2 of 9.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stressing Bar Requirements - Skewed Bridges

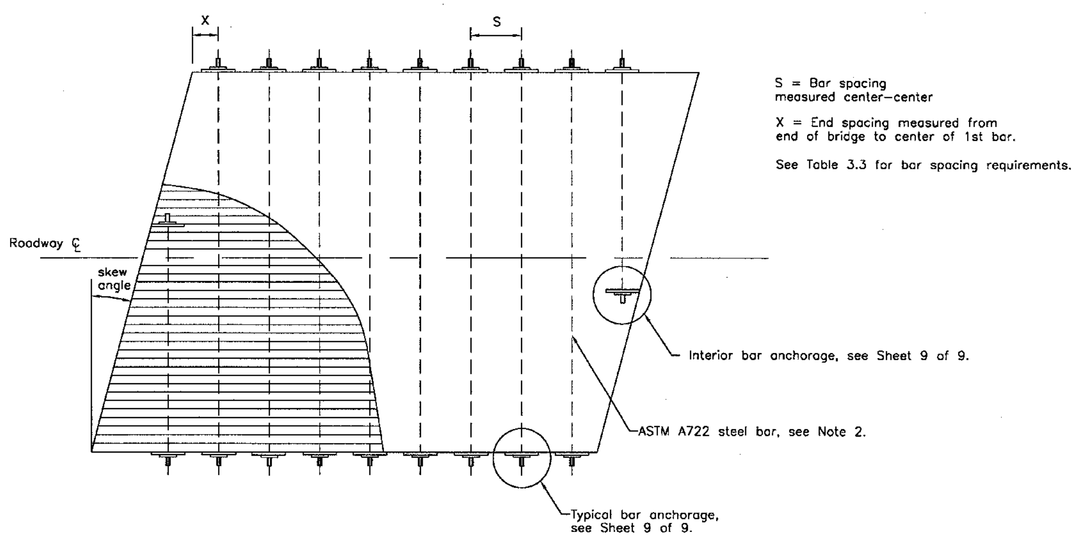


Table 3.3 – Recommended Bar and End Spacings

Bridge Length (ft)	5/8–in.–Diameter Bars		1–in.–Diameter Bars	
	Bar Spacing, S (ft)	End Spacing, X (ft)	Bar Spacing, S (ft)	End Spacing, X (ft)
10				
12				
14				
16				
18	2	1		1
20				2
22				1
24				2
26			4	1
28				2
30				1
32				2
34				1

Table 3.4 – Recommended Design Bar Tension Forces

Bar Diameter (in.)	Design Bar Tension Force (lb) for Actual Deck Thickness (t) Ranging from 8– to 16–in.								
	8	9¼	10	11¼	12	13¼	14	15¼	16
5/8	19,200	22,200	24,000	27,000	28,800				
1						63,600	67,200	73,200	76,800

Notes

1. This sheet provides stressing bar requirements for skewed bridges with a maximum skew angle of 15°. Bar requirements for unskewed bridges are given on Sheet 3 of 9.

2. All stressing bars shall be perpendicular to the longitudinal bridge centerline and conform to the requirements of ASTM A722. For a decks less than, or equal to 12–in.–thick, bar diameter is 5/8 in. For decks greater than 12–in.–thick, bar diameter is 1–in.

3. Bar spacing (S) is 2–ft for 5/8–in.–diameter bars and 4–ft for 1–in.–diameter bars. Typical end spacing (X) is based on bridge length and is given in Table 3.3. Refer to Sheet 5 of 9 for layout of non–butt–jointed decks and Sheet 7 of 9 for layout of butt–jointed decks.

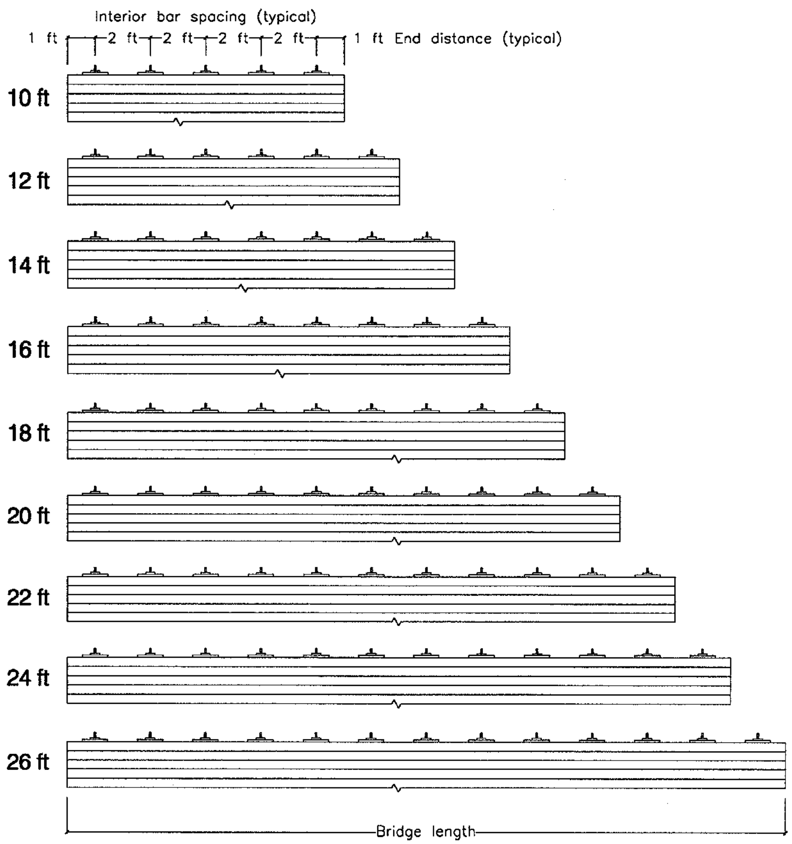
4. Because the bridge deck is skewed, bars in the skewed zone are not full–length and must be anchored at interior deck locations using the bar anchorage details given on Sheet 9 of 9. The number of bars that must be so anchored depends on the bridge width and skew angle. Bar spacing adjustment may be required to achieve full bearing plate contact at the obtuse corner or to maintain a minimum 6–ft bar length at the acute corner. Spacing adjustments for bars in the skewed zone should be made based on engineering judgement; however, the bar spacing in the skewed zone shall not exceed the bar spacing specified in Table 3.3. End spacing may be increased to the bar spacing in the skewed zone.

5. Bar tension force is based on deck thickness and bar spacing. Bars shall be tensioned, in multiple passes, to the design bar tension force specified in Table 3.4. Bars shall be re–tensioned as specified in Note 25, Sheet 2 of 9.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Deck Lamination Layouts; No Butt-Joints

5/8-in.-Diameter Bars; Deck Thickness Less Than or Equal to 12 in.



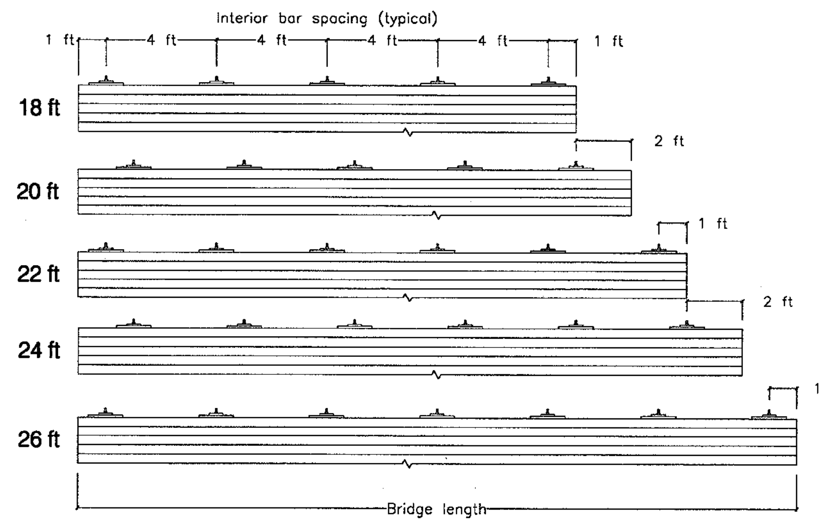
Notes

1. This sheet shows lamination layouts for decks with no butt–joints and 5/8–in. and 1–in. nominal bar diameters. Use 5/8–in. bars if the deck thickness is less than or equal to 12–in., and 1–in. bars if the deck thickness is greater than 12–in.

2. Holes in the laminations for stressing bars shall be prebored at the specified bar spacing at the mid–depth of the lamination. For 5/8–in. bars, use a 1–in. hole diameter. For 1–in. bars, use a 2–in. hole diameter. The hole diameter may be increased 1/4–in. if protective tubing (Sheet 9 of 9) is used.

3. Refer to Table 3.5 (Sheet 6 of 9) for the required deck thickness (t) based on lumber properties, span length, loading, and deflection limit.

1-in.-Diameter Bars; Deck Thickness Greater Than 12 in.



The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stress-Laminated Sawn Lumber Decks	Deck Lamination Layouts; No Butt-Joints
Standard Plans for Timber Bridge Superstructures	December 2000 / Sheet 5 of 9

Table 3.5 – Design Table for Sawn Lumber Decks with No Butt–Joints

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20–44 Loading									AASHTO HS25–44 Loading								
			Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values For Actual Deck Thickness[a] (t) Ranging from 8 to 16–in.																	
			8	9¼	10	11¼	12	13¼	14	15¼	16	8	9¼	10	11¼	12	13¼	14	15¼	16
10	9	F_b'	1202	848	702	527						1396	988	819	616	526				
		E′ for L/360	0.79	0.48	0.37	0.24						0.93	0.57	0.43	0.29	0.23				
		E′ for L/500	1.10	0.67	0.51	0.34						1.29	0.78	0.60	0.40	0.32				
12	11	F_b'	1,490	1,053	873	657	561					1,728	1,224	1,016	765	655				
		E′ for L/360	1.18	0.72	0.55	0.36	0.29					1.39	0.84	0.64	0.43	0.34				
		E′ for L/500	1.64	0.99	0.76	0.50	0.40					1.93	1.17	0.89	0.59	0.47				
14	13	F_b'	1,785	1,264	1,049	791	677						1,466	1,218	919	787				
		E′ for L/360	1.65	1.00	0.76	0.50	0.40						1.18	0.90	0.60	0.48				
		E′ for L/500		1.39	1.06	0.70	0.56						1.64	1.25	0.83	0.66				
16	15	F_b'		1,481	1,230	929	796						1,714	1,425	1,077	923				
		E′ for L/360		1.33	1.01	0.67	0.53						1.57	1.20	0.79	0.63				
		E′ for L/500		1.85	1.41	0.93	0.74							1.66	1.10	0.88				
18	17	F_b'		1,704	1,417	1,072	919	727	637	520				1,638	1,240	1,063	840	737	601	536
		E′ for L/360		1.71	1.30	0.86	0.69	0.48	0.40	0.29				1.54	1.02	0.81	0.57	0.47	0.35	0.29
		E′ for L/500			1.81	1.20	0.95	0.67	0.55	0.40					1.42	1.13	0.80	0.66	0.48	0.41
20	19	F_b'			1,609	1,219	1,047	829	728	595	532			1,856	1,407	1,208	956	839	686	612
		E′ for L/360			1.63	1.08	0.86	0.60	0.49	0.36	0.31			1.92	1.27	1.02	0.72	0.59	0.43	0.37
		E′ for L/500				1.49	1.19	0.84	0.69	0.51	0.42				1.77	1.41	0.99	0.82	0.60	0.51
22	21	F_b'			1,807	1,371	1,178	934	821	673	602				1,578	1,356	1,075	945	773	691
		E′ for L/360			1.99	1.31	1.05	0.74	0.60	0.44	0.37				1.56	1.24	0.88	0.72	0.53	0.45
		E′ for L/500				1.83	1.45	1.02	0.84	0.62	0.52					1.72	1.22	1.00	0.74	0.62
24	23	F_b'				1,527	1,314	1,044	918	753	675					1,509	1,197	1,053	863	772
		E′ for L/360				1.76	1.40	0.98	0.81	0.59	0.50					1.66	1.17	0.96	0.71	0.60
		E′ for L/500					1.94	1.36	1.12	0.82	0.69						1.62	1.34	0.98	0.83
26	25	F_b'					1,496	1,189	1,04	859	770						1,362	1,198	983	880
		E′ for L/360					1.83	1.29	1.06	0.78	0.65						1.53	1.26	0.93	0.78
		E′ for L/500						1.79	1.47	1.08	0.91							1.75	1.29	1.09

a – Rough–sawn sizes are 8, 10, 12, 14, and 16–in. and dressed sizes are 9¼, 11¼, 13¼, and 15¼–in.

Table Instructions

The table on this sheet is for determining the required deck thickness for stress–laminated sawn lumber bridge decks. The criteria for deck thickness selection are based on the span length, vehicle loading, live load deflection limit, and material properties for the grade and species of lumber. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E') based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb and 38 lb/ft^2 for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the material grade and species of the lumber are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the material grade and species are unknown, minimum required F_b' and E' values may be obtained from the table based on the span length, deck thickness, loading, and deflection limit. A grade and species of lumber that meets these minimum allowable design values may then be selected. The following procedures are recommended for table use:

<u>Material Grade and Species Known</u>

1. Determine the required design criteria for
   a. span length measured center–to–center of bearings;
   b. vehicle loading, AASHTO HS20–44 or HS25–44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the grade and species of lumber laminations using the following equations

$$F_b' = F_b\, C_M\, C_F\, C_D\, C_{LS} \qquad E' = E\, C_M$$

where

F_b' = allowable bending stress (lb/in^2) — C_M = wet service factor
F_b = tabulated bending stress (lb/in^2) — C_F = size factor
E' = allowable modulus of elasticity (lb/in^2) — C_D = load duration factor
E = tabulated modulus of elasticity (lb/in^2) — C_{LS} = load sharing factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

<u>Material Grade and Species Unknown</u>

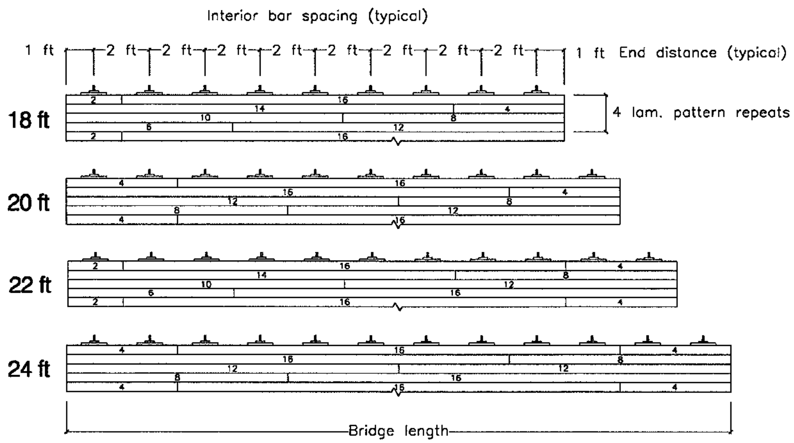
1. Determine the required design criteria for
   a. span length measured center–to–center of bearings;
   b. vehicle loading, AASHTO HS20–44 or HS25–44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

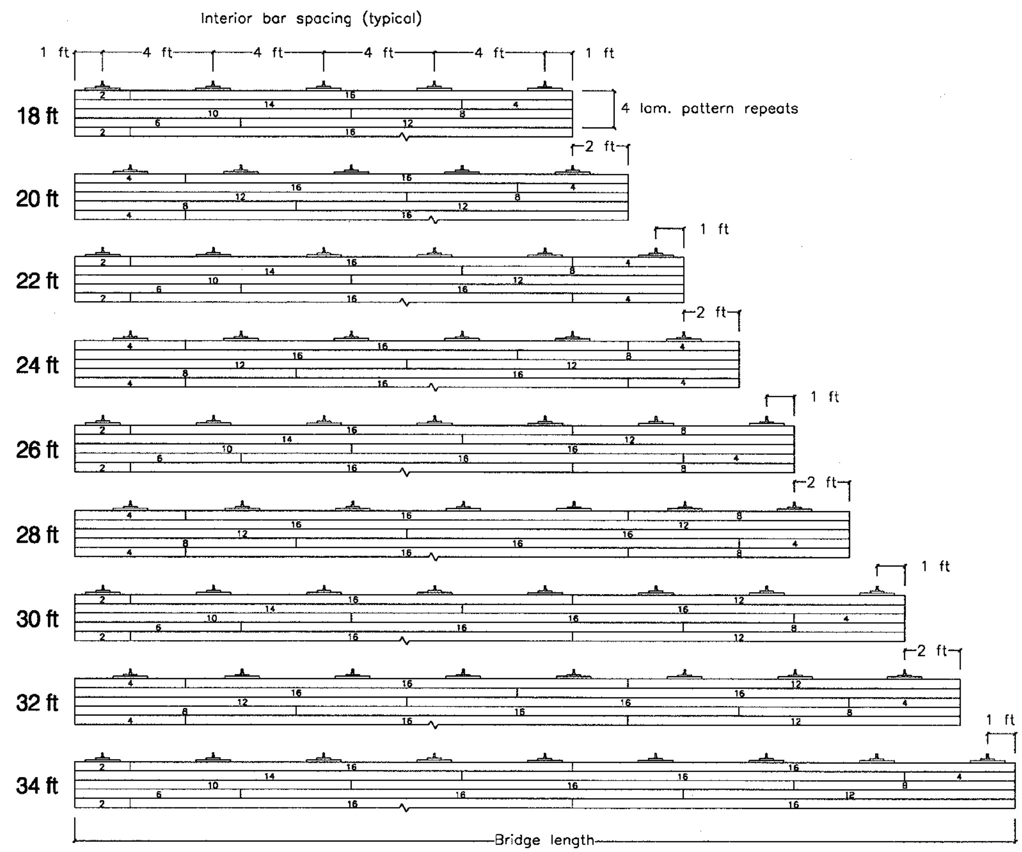
3. Select a grade and species of dimension lumber that provides the minimum allowable design values.

Deck Lamination Layouts; With Butt-Joints

5/8-in.-Diameter Bars; Deck Thickness Less Than or Equal to 12 in.



1-in.-Diameter Bars; Deck Thickness Greater Than 12 in.



Notes

1. This sheet shows lamination layouts for decks with butt-joints and 5/8- and 1-in. nominal bar diameters. Use a 5/8-in. bar if the deck thickness is less than or equal to 12-in., and use a 1-in. bar if the deck thickness is greater than 12-in.

2. Butt-joint layouts are based on a repetitive pattern of four laminations. Butt-joints are limited to one joint in four adjacent laminations within a longitudinal 4-ft distance. The length of each lamination is noted on the drawings. To facilitate construction, it may be beneficial to slightly reduce lamination length to provide a 1/4- to 1/2-in. gap at the butt-joint. For additional information about construction methods, refer to *Recommended Construction Practices for Stress-Laminated Wood Bridge Decks* (Ritter and Lee 1996).

3. Holes in the laminations for stressing bars shall be prebored at the specified bar spacing at the mid-depth of the laminations. For 5/8-in. bars, use a 1-in.-diameter hole. For 1-in. bars, use a 2-in.-diameter hole. The hole diameter may be increased 1/4-in. if protective tubing (Sheet 9 of 9) is used.

4. Refer to Table 3.6 (Sheet 8 of 9) for the required deck thickness (t) based on lumber properties, span length, loading, and deflection limit.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Table 3.6 -- Design Table for Sawn Lumber Decks with Butt-Joints

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading							AASHTO HS25-44 Loading					
			Minimum Required F_b' (lb/in²) and E' Values[a] ($\times 10^6$ lb/in²) for Actual Deck Thickness[b] (t) Ranging from 10- to 16-in.												
			10	11¼	12	13¾	14	15¼	16	11¼	12	13¾	14	15¼	16
18	17	F_b'	1,771	1,340	1,149	909	796	650	580	1,550	1,329	1,050	921	751	670
		E' for L/360	1.63	1.08	0.86	0.60	0.50	0.36	0.31	1.27	1.02	0.72	0.59	0.43	0.37
		E' for L/500		1.58	1.19	0.84	0.69	0.50	0.43	1.77	1.41	0.99	0.82	0.60	0.51
20	19	F_b'		1,524	1,309	1,036	910	744	665	1,759	1,510	1,195	1,049	858	765
		E' for L/360		1.35	1.08	0.75	0.61	0.45	0.39	1.59	1.28	0.90	0.74	0.54	0.46
		E' for L/500		1.86	1.49	1.05	0.86	0.64	0.53		1.76	1.24	1.03	0.75	0.64
22	21	F_b'		1,714	1,473	1,168	1,026	841	753	1,973	1,695	1,344	1,181	966	864
		E' for L/360		1.64	1.31	0.93	0.75	0.55	0.46	1.95	1.55	1.10	0.90	0.66	0.56
		E' for L/500			1.81	1.28	1.05	0.78	0.65			1.53	1.25	0.93	0.78
24	23	F_b'			1,643	1,305	1,148	941	844			1,496	1,316	1,079	965
		E' for L/360			1.75	1.23	1.01	0.74	0.63			1.46	1.20	0.89	0.75
		E' for L/500				1.70	1.40	1.03	0.86				1.68	1.23	1.04
26	25	F_b'				1,486	1,309	1,074	963			1,702	1498	1,229	1,100
		E' for L/360				1.61	1.33	0.98	0.81			1.91	1.58	1.16	0.98
		E' for L/500					1.84	1.35	1.14					1.61	1.36
28	27	F_b'					1,503	1,235	1,106				1,720	1,411	1,263
		E' for L/360					1.66	1.23	1.03				1.99	1.46	1.23
		E' for L/500						1.70	1.43						1.71
30	29	F_b'						1,400	1,254					1,599	1,431
		E' for L/360						1.50	1.26					1.79	1.50
		E' for L/500							1.75						
32	31	F_b'						1,569	1,406						1,604
		E' for L/360						1.79	1.50						1.80
		E' for L/500													
34	33	F_b'							1,564						
		E' for L/360							1.78						
		E' for L/500													

a -- Table values have been adjusted with a butt-joint factor (C_{bj}) of 0.80 for the specified butt-joint layout of 1:4 at 4-ft as shown on Sheet 7 of 9.
b -- Rough-sawn sizes are 8, 10, 12, 14, and 16-in.; dressed sizes are 9¾, 11¼, 13¾, and 15¼-in.

Table Instructions

The table on this sheet is for determining the required deck thickness for stress-laminated sawn lumber bridge decks. The criteria for deck thickness selection are based on the span length, vehicle loading, live load deflection limit, and material properties for the grade and species of lumber. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E') based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft² for the railing/curb and 38 lb/ft² for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the grade and species of the lumber are known, the designer must determine the allowable design values for the material, then compare it to the values given in the table. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the material grade and species are unknown, minimum required F_b' and E' values may be obtained from the table based on the span length, deck thickness, loading, and deflection limit. A grade and species of lumber that meets these minimum allowable design values may then be selected. The following procedures are recommended for table use:

Material Grade and Species Known

1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the grade and species of lumber laminations the following equations

$$F_b' = F_b\, C_M\, C_F\, C_D\, C_{LS} \qquad E' = E\, C_M$$

where

F_b' = allowable bending stress (lb/in²) — C_M = wet service factor
F_b = tabulated bending stress (lb/in²) — C_F = size factor
E' = allowable modulus of elasticity (lb/in²) — C_D = load duration factor
E = tabulated modulus of elasticity (lb/in²) — C_{LS} = load sharing factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

Material Grade and Species Unknown

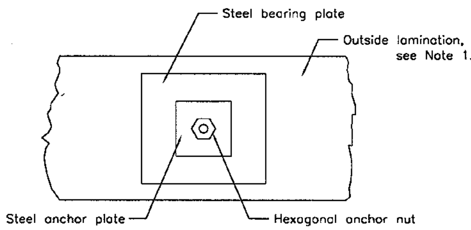
1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

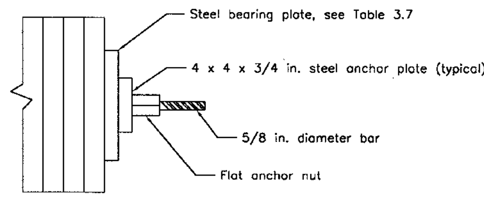
3. Select a grade and species of dimension lumber that provides the minimum allowable design values.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

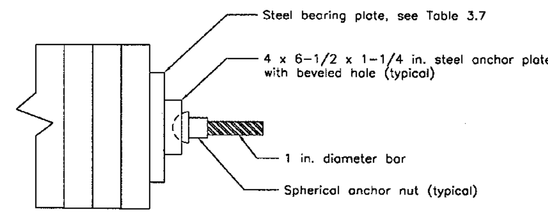
Stressing Bar Anchorage Details



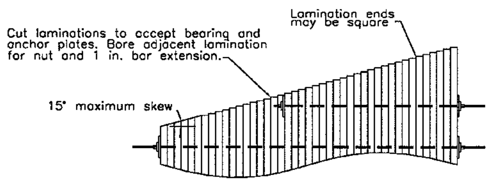
Bar Anchorage
Side view



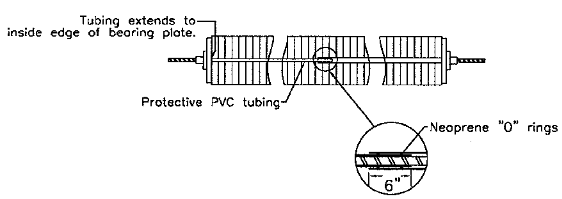
5/8 in. Bar Anchorage
End view



1 in. Bar Anchorage
End view



Bar Anchorage - Skew Zone
Plan View



Corrosion Protection for Bars
Section view

Table 3.7 — Bearing Plate Dimensions

$F^{a}_{c\perp}$ (lb/in²)	5/8–in.–Diameter Bar 1–in.–Thick Bearing Plate with 3/4–in.–Diameter Center Hole					1–in.–Diameter Bars 1½–in.–Thick Bearing Plate with 1-5/16–in.–Diameter Center Hole			
	Deck Thickness (in.)					Deck Thickness (in.)			
	8	9¼	10	11¼	12	13¼	14	15¼	16
550 - 750	8 x 8			9 x 9		14 x 14		15 x 15	
750 - 900	7 x 7		8 x 8			12 x 12		13 x 13	

a – These requirements for compression perpendicular–to–grain values apply only to the exterior (two) laminations along each bridge edge.

Notes

1. The minimum compression perpendicular to grain tabulated stress for the exterior (two) laminations along each bridge edge is 550 lb/in². The interior deck laminations can be of lower compression perpendicular to grain strength.

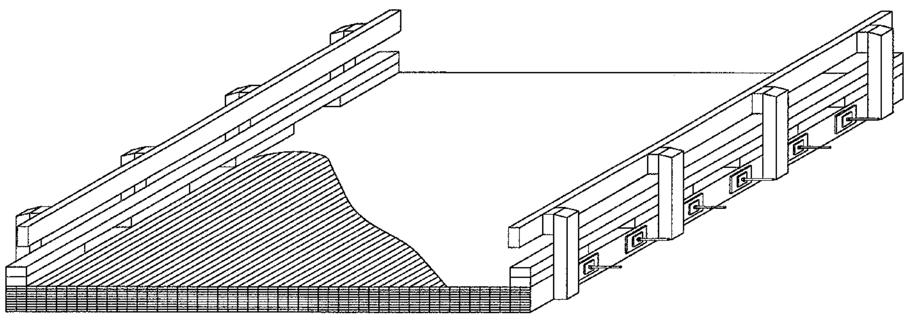
2. Anchorage systems shall consist of a steel bearing plate, anchor plate, and a high–strength steel nut. The anchor plate size is 4 x 4 x 3/4–in. for 5/8–in. diameter bars and 4 x 6-1/2 x 1-1/4–in. for 1–in. diameter bars. Bearing plate size is given in Table 3.7 and depends on the deck thickness, bar spacing, and the unadjusted tabulated compressive stress perpendicular to grain ($F_{c\perp}$) of the exterior (two) laminations along each bridge edge.

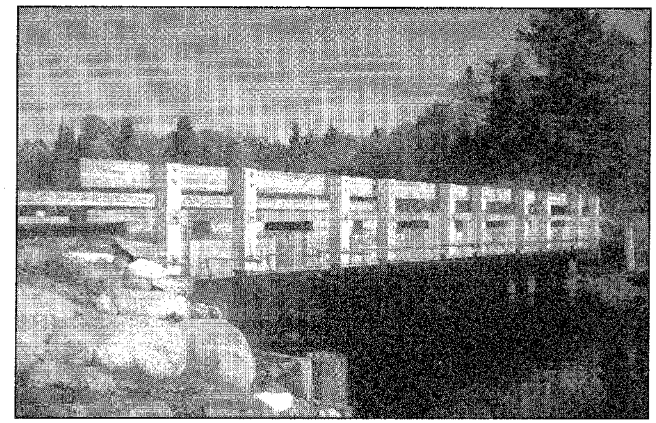
3. For a 1–in. bar diameter, a spherical anchor nut with a beveled hole in the anchor plate, supplied by the bar manufacturer, is typically used. A flat hex nut and anchor plate may be used at the discretion of the designer.

4. To prevent corrosion of galvanized stressing bars, protective tubing (see detail this page) is recommended when the laminations are not treated with oilborne preservatives (the oil solvents coat and provide some protection of steel components) or when the bridge will be subjected to deicing salt. To be flexible as the deck compresses during bar tensioning, two PVC tube diameters are used with an overlap section near the center of the bridge which is sealed with O–rings.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

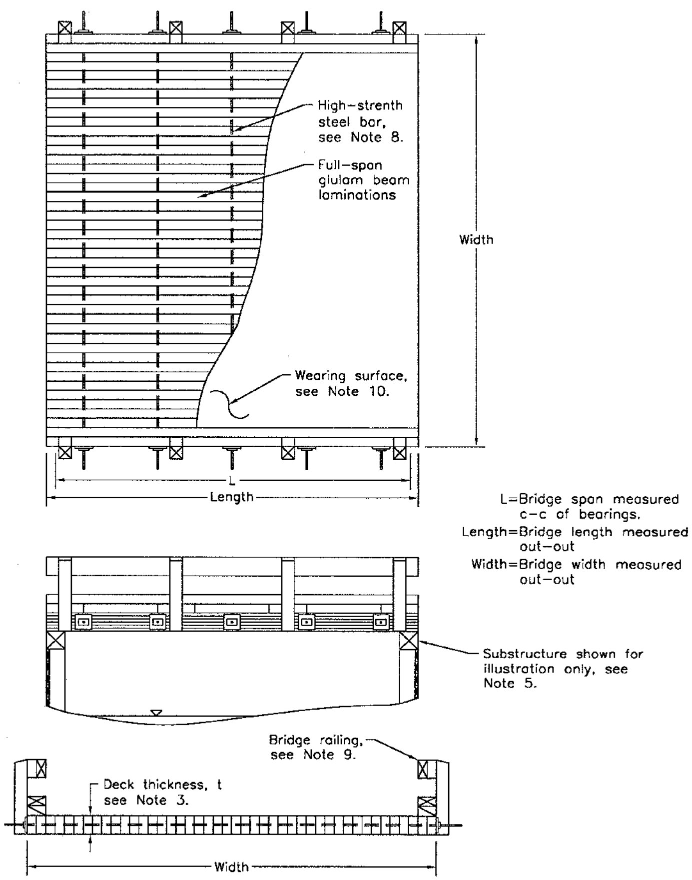
Longitudinal Deck Systems:
Stress-Laminated Glulam Decks





The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.	Stress-Laminated Glulam Decks	Title Page	
	Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 1 of 7

Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for longitudinal stress–laminated glulam timber bridge decks. The deck consists of a series of glulam timber beams with widths ranging from 3– to 8-3/4–in. that are placed on edge between supports and transversely compressed with high–strength steel bars. The glulam beams shall be continuous (full length) between supports with no butt–joints. The designs are applicable for single– and double–lane and unskewed and skewed bridges up to 58–ft long. Design truck loading is AASHTO HS 20–44 or HS 25–44 with live load deflection limits of L/360 or L/500.

2. The designs comply with the 1996 *Standard Specifications for Highway Bridges*, with 1998 Interims, and the 1991 *Guide Specification for the Design of Stress-Laminated Wood Decks*, published by the American Association of State Highway and Transportation Officials (AASHTO), except as noted. Load distribution widths are assumed to be width of the tire (as defined by AASHTO) plus twice the deck thickness. The designs assume an interlaminar prestress of 100 lb/in^2 which has been shown to provide optimum field performance.

3. Minimum required timber design values are provided for single–span bridge lengths of 18– to 58–ft in 2–ft increments. Deck thicknesses (or beam depths) are specified for standard Southern Pine and Western Species glulam sizes ranging from 12– to 21–in. The required minimum deck thickness for a specific bridge length can be selected from tables on Sheet 5 of 7 and Sheet 6 of 7, based on material, loading, and deflection requirements.

4. Bridge width is variable by adjusting the number of glulam beams or individual glulam beam width.

5. The plans assume a uniform bearing length of 12–in. at both bridge ends and a span length, L, measured center–to–center of bearings. A longer bearing length will result in a slightly more conservative design. Substructure connection details are provided on Page 34.

6. Multiple span bridges may be constructed using a series of simple spans based on the designs presented in these drawings. Multiple span continuous bridges are also commonly used and may be more economical but require site–specific design. Refer to Page 34 for intermediate support connection details for both simple and continuous spans.

7. Skewed crossings are limited to 15° by AASHTO. Refer to Sheet 4 of 7 for information regarding design considerations and stressing bar layout for skewed bridges.

8. High–strength steel bars are 1–in. nominal diameter. The diameter and spacing of bars depends on the deck thickness and span as shown on Sheet 3 of 7 and Sheet 4 of 7.

9. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site–specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft^2 for the rail and curb system. Crashworthy rail designs are available in *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Decks* (Ritter et al.1995) and *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Deck on Low–Volume Roads* (Ritter et al.1998).

10. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. For stress–laminated decks, the wearing surface should be installed after the first re–tensioning is completed (see Note 24). Deck designs are based on an assumed dead load of 38 lb/ft^2 for an asphalt wearing surface (approximately 3–in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

11. These designs are intended for informational purposes only and, due to potential variations in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood

12. Glulam timber beams shall comply with the requirements of AASHTO M168 and ANSI/AITC A190.1 and shall be manufactured to an industrial appearance grade using wet–use adhesives.

13. Any species of glulam may be used provided it is treatable with wood preservatives and tabulated design values are provided in the AASHTO *Standard Specifications for Highway Bridges*. Combinations should be selected from the "members stressed primarily in bending" table.

14. Insofar as is practical, all glulam shall be cut, drilled, and completely fabricated prior to pressure treatment with wood preservatives. Refer to Sheet 3 of 7 and Sheet 4 of 7 for information on stressing bar hole layout and diameter.

Preservative Treatment

15. All Glulam shall be treated in accordance with AASHTO M133 and AWPA C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13.
b. Suitable oilborne preservative conforming to AWPA Standard P8 in hydrocarbon solvent, Type A or Type C.

16. Treated material shall follow post–treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are fixated in the wood.

17. Preservative treatment shall be inspected and certified in accordance with AASHTO M133 and AWPA Standard M2.

Steel Fasteners and Hardware

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

19. Stressing bars shall be nominal 1–in. diameter and shall comply with the requirements of ASTM A722. Order bars at least 3–ft longer than total deck width. Nuts and couplers for stressing bars shall be provided by the bar manufacturer and shall be re–threaded to ensure proper fit after galvanizing.

20. Bolts and lag screw shall comply with the requirements of ANSI/ASME Standard B18.2.1–1981, Grade 2.

21. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or otherwise protected from corrosion. Galvanizing of stressing bars shall also follow the recommendations of the bar manufacturer so as not to adversely affect the mechanical properties of the high–strength steel.

22. Washers shall be provided under bolt and lag screw heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome–head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

23. Decks may be assembled by placing glulam timber beams on edge, side–by–side on the substructure. After placing all glulam timber beams, steel stressing bars are inserted into prebored holes and bar anchorage plates and nuts are attached. Tensioning of the high–strength stressing bars is typically performed with a single hydraulic jack and steel stressing chair in a repetitive manner beginning at one end of the bridge. When initially tensioning bars, it is important that the full tension not be applied until all glulam timber beams are aligned and in full contact with adjacent glulam timber beams. For additional information and alternative assembly methods, refer to *Recommended Construction Practices for Stress-Laminated Wood Bridge Decks* (Ritter and Lee 1996).

24. Stressing bars shall be fully tensioned to the values specified on Sheet 3 of 7 and Sheet 4 of 7 in accordance with the following sequence:

1. Initially tensioned at construction.
2. Re-tensioned 1–2 weeks after the initial tensioning.
3. Re-tension 6–8 weeks after the first re–tensioning.

It is recommended that the bars be checked and retensioned as required, 2 years after construction and at 3–5 year intervals thereafter until the bar force stabilizes above 50 percent of the design level. If excess bar length is to be trimmed, leave a minimum of 8–in. beyond the anchor nut to allow for re–tensioning.

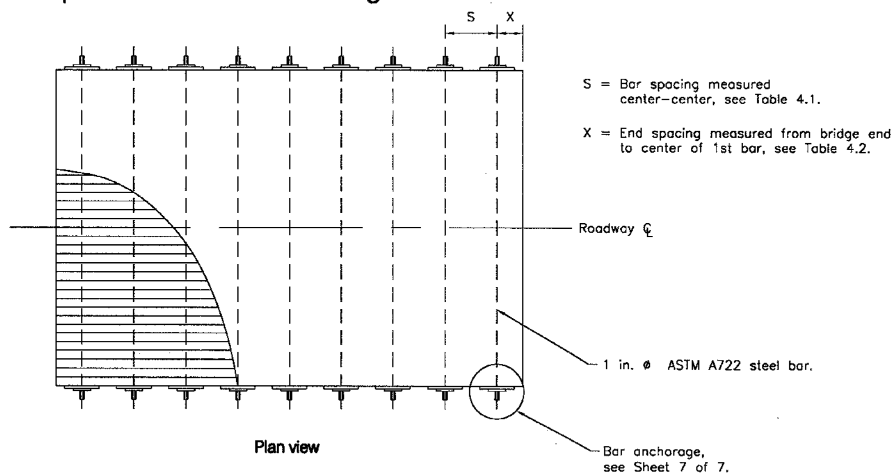
25. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

26. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Any commercially available roofing cement is effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stress-Laminated Glulam Decks	Superstructure Drawings and General Notes
Standard Plans for Timber Bridge Superstructures	December 2000 — Sheet 2 of 7

Stressing Bar Requirements - Unskewed Bridges



Plan view

Notes

1. This sheet provides stressing bar requirements for unskewed bridges. Bar requirements for skewed bridges are given on Sheet 4 of 7.

2. All stressing bars shall be perpendicular to the longitudinal bridge centerline and are 1–in. nominal diameter high–strength steel bars conforming to the requirements of ASTM A722.

3. Bar spacing (S) is specified in Table 4.1 based on deck thickness. End spacing (X) is based on bridge length and is given in Table 4.2.

4. Bars are placed through holes prebored at mid–depth of the glulam beams. A hole diameter of 1–3/4–in. is recommended. The hole diameter may be increased to 2–in. if protective tubing (Sheet 7 of 7) is used.

5. Bar tension force is based on deck thickness and bar spacing. Bars shall be tensioned, in multiple passes, to the design bar tension specified in Table 4.1. Bars shall be re–tensioned as specified in Note 24, Sheet 2 of 7.

Table 4.1 – Bar Spacing and Design Bar Tension Forces

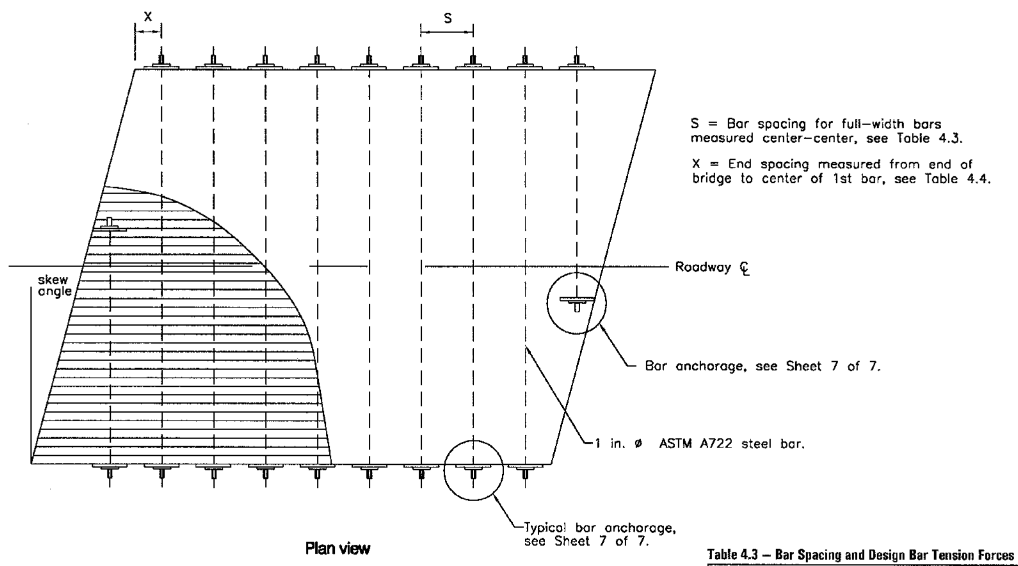
Deck Thickness, t (in.)	Bar Spacing, S (ft)	Design Bar Tension Force[a] (lb)
12	4	57,600
12 3/8		59,400
13 1/2		64,800
13 3/4		66,000
15		72,000
15 1/8		72,600
16 1/2		79,200
17 7/8		85,800
18	3	64,800
19 1/4		69,300
19 1/2		70,200
20 5/8		74,250
21		75,600

a – Based upon 100 lb/in^2 deck interlaminar prestress.

Table 4.2 – End Spacings

4–ft Bar Spacing		3–ft Bar Spacing	
Bridge Length, L (ft)	End Spacing, X (ft)	Bridge Length, L (ft)	End Spacing, X (ft)
18	1	32	2.5
20	2	34	2.0
22	1	36	1.5
24	2	38	2.5
26	1	40	2.0
28	2	42	1.5
30	1	44	2.5
32	2	46	2.0
34	1	48	1.5
36	2	50	2.5
38	1	52	2.0
40	2	54	1.5
42	1	56	2.5
44	2	58	2.0

Stressing Bar Requirements - Skewed Bridges



Plan view

S = Bar spacing for full-width bars measured center-center, see Table 4.3.

X = End spacing measured from end of bridge to center of 1st bar, see Table 4.4.

Notes

1. This sheet provides stressing bar requirements for skewed bridges with a maximum skew angle of 15°. Bar requirements for unskewed bridges are given on Sheet 3 of 7.

2. All stressing bars are perpendicular to the longitudinal bridge centerline and are nominal 1-in.-diameter high-strength steel bars conforming to the requirements of ASTM A722.

3. Bar spacing (S) is specified in Table 4.3. Typical end spacing (X) is based on bridge length and is given in Table 4.4.

4. Because the bridge deck is skewed, bars in the skewed zone are not full length and must be anchored at interior deck locations using the bar anchorage details given on Sheet 7 of 7. The number of bars that must be so anchored depends on the bridge width and skew angle. Bar spacing adjustment may be required to achieve full bearing plate contact at the obtuse corner or to maintain a minimum 6-ft bar length at the acute corner. Spacing adjustments for bars in the skewed zone should be made based on engineering judgement; however, the bar spacing in the skewed zone shall not exceed the bar spacing specified in Table 4.3. End spacing may be increased to the bar spacing.

5. Bars are placed through holes prebored at mid-depth of the glulam beams. A hole diameter of 1-3/4-in. is recommended. The hole diameter may be increased to 2-in. if protective tubing (Sheet 7 of 7) is used.

6. Bar tension force is based on deck thickness and bar spacing. Bars shall be tensioned to the design bar tension specified in Table 4.3. Bars shall be re-tensioned as specified in Note 24, Sheet 2 of 7.

Table 4.3 – Bar Spacing and Design Bar Tension Forces

Deck Thickness, t (in.)	Bar Spacing, S (ft)	Design Bar Tension Force[a] (lb)
12	4	57,600
12 ⅜		59,400
13 ½		64,800
13 ¾		66,000
15		72,000
15 ⅛		72,600
16 ½		79,200
17 ⅞		85,800
18	3	64,800
19 ¼		69,300
19 ½		70,200
20 ⅝		74,250
21		75,600

a – Based upon 100 lb/in² deck interlaminar prestress.

Table 4.4 – End Spacings

4 ft Bar Spacing		3 ft Bar Spacing	
Bridge Length, L (ft)	End Spacing, X (ft)	Bridge Length, L (ft)	End Spacing, X (ft)
18	1	32	2.5
20	2	34	2.0
22	1	36	1.5
24	2	38	2.5
26	1	40	2.0
28	2	42	1.5
30	1	44	2.5
32	2	46	2.0
34	1	48	1.5
36	2	50	2.5
38	1	52	2.0
40	2	54	1.5
42	1	56	2.5
44	2	58	2.0

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Table 4.5 – Stress-Laminated Glulam Deck Design Table

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading											AASHTO HS25-44 Loading										
			Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values for Actual Deck Thickness[a] (t) Ranging from 12- to 21-in.																					
			12	12⅝	13½	13¾	15	15⅛	16½	17⅞	18	19¼	19½	12	12⅝	13½	13¾	15	15⅛	16½	17⅞	18	19¼	19½
18	17	F_b'	919	855	595	665								1,063	989	804	769	625	613					
		E' for L/360	0.69	0.61	0.45	0.42								0.81	0.73	0.54	0.50	0.37	0.36					
		E' for L/500	0.95	0.85	0.63	0.59								1.13	1.01	0.75	0.70	0.51	0.50					
20	19	F_b'	1,047	974	793	759	619	607						1,208	1,123	914	876	718	699					
		E' for L/360	0.86	0.77	0.56	0.53	0.39	0.37						1.02	0.91	0.67	0.63	0.46	0.45					
		E' for L/500	1.19	1.07	0.78	0.73	0.54	0.52						1.41	1.27	0.93	0.87	0.64	0.62					
22	21	F_b'	1,178	1,096	894	857	699	686						1,356	1,262	1,029	985	803	788	643				
		E' for L/360	1.05	0.94	0.69	0.64	0.47	0.46						1.24	1.11	0.82	0.77	0.56	0.55	0.40				
		E' for L/500	1.45	1.30	0.96	0.89	0.65	0.64						1.72	1.55	1.14	1.07	0.78	0.76	0.56				
24	23	F_b'	1,314	1,223	999	958	783	768	626					1,509	1,404	1,146	1,098	897	880	719	597			
		E' for L/360	1.40	1.25	0.92	0.86	0.63	0.61	0.45					1.66	1.49	1.09	1.02	0.75	0.73	0.53	0.40			
		E' for L/500	1.94	1.74	1.28	1.20	0.87	0.85	0.62							1.52	1.42	1.04	1.01	0.74	0.56			
26	25	F_b'	1,496	1,393	1,138	1,091	893	876	718	598						1,304	1,250	1,021	1,002	819	682	671		
		E' for L/360	1.83	1.64	1.20	1.13	0.83	0.80	0.58	0.44						1.43	1.34	0.98	0.96	0.70	0.52	0.51		
		E' for L/500			1.67	1.57	1.15	1.11	0.81	0.61						1.99	1.86	1.37	1.33	0.97	0.73	0.71		
28	27	F_b'			1,307	1,253	1,026	1,006	825	688	677						1,435	1,173	1,150	941	783	771	661	642
		E' for L/360			1.52	1.42	1.04	1.01	0.74	0.55	0.54						1.69	1.24	1.20	0.88	0.66	0.64	0.50	0.48
		E' for L/500				1.97	1.44	1.40	1.02	0.76	0.75							1.72	1.67	1.22	0.92	0.89	0.70	0.67
30	29	F_b'			1,481	1,420	1,163	1,141	936	780	768	661	642					1,328	1,303	1,067	888	874	750	729
		E' for L/360			1.85	1.74	1.27	1.23	0.90	0.67	0.66	0.51	0.49					1.52	1.47	1.08	0.81	0.79	0.62	0.59
		E' for L/500					1.76	1.71	1.25	0.93	0.91	0.71	0.68							1.50	1.12	1.09	0.86	0.82

a – Western species glulam sizes are 12, 13 ½, 15, 16 ½, 18, and 19 ½-in.; Southern pine glulam sizes are 12 ⅝, 13 ¾, 15 ⅛, 16 ½, 17 ⅞, and 19 ¼-in.

Table Instructions

The table on this sheet is for determining the deck thickness for stress-laminated, glulam bridge decks. The criteria for deck thickness selection are based on span length, vehicle loading, live load deflection limit, and the material properties for the species and glulam combination. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E') based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb and 38 lb/ft^2 for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the species and glulam combination are known, the designer must determine the allowable design values for the material, then compare them to the values given in the tables above. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the species and glulam combination are unknown, minimum required F_b' and E' values may be obtained from the tables based on the span length, deck thickness, loading, and deflection limit. A species and glulam combination that meets these minimum allowable design values may then be selected. The following procedures are recommended for table use:

Species and Glulam Combination Known

1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the species and glulam combination using the following equations:

   $F_b' = F_b\, C_M\, C_V\, C_D$ $\qquad$ $E' = E\, C_M$

   where
   - F_b' = allowable bending stress (lb/in^2)
   - F_b = tabulated bending stress (lb/in^2)
   - E' = allowable modulus of elasticity (lb/in^2
   - E = tabulated modulus of elasticity (lb/in^2)
   - C_M = wet service factor
   - C_V = volume factor
   - C_D = load duration factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

Species and Glulam Combination Unknown

1. Determine the required design criteria for
   a. span length measured center-to-center of bearings;
   b. vehicle loading, AASHTO HS20-44 or HS25-44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

3. Select a species and combination of glulam that provides the minimum allowable design values. Glulam combinations should be selected from the "members stressed primarily in bending" table.

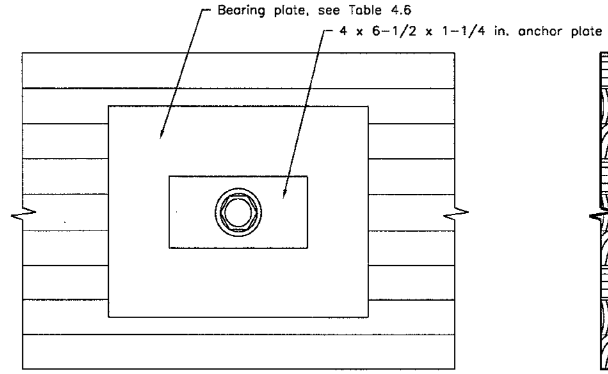
Table 4.5 -- Stress-Laminated Glulam Deck Design Table, Continued

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading: Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values for Actual Deck Thickness[a] (t) Ranging from 12- to 21-in.									AASHTO HS25-44 Loading								
			15	15⅛	16½	17⅞	18	19¼	19½	20⅝	21	15	15⅛	16½	17⅞	18	19¼	19½	20⅝	21
32	31	F_b'	1,304	1,279	1,049	876	862	742	721	637	612			1,195	996	980	842	817	720	692
		E' for L/360	1.52	1.48	1.08	0.81	0.79	0.62	0.59	0.48	0.45			1.29	0.97	0.94	0.74	0.70	0.57	0.54
		E' for L/500			1.50	1.12	1.09	0.85	0.81	0.66	0.62			1.79	1.34	1.31	1.03	0.98	0.80	0.75
34	33	F_b'	1,448	1,421	1,166	974	959	826	802	709	682			1,327	1,106	1,089	935	909	801	770
		E' for L/360	1.79	1.74	1.27	0.95	0.92	0.72	0.69	0.56	0.53			1.52	1.14	1.11	0.87	0.83	0.68	0.63
		E' for L/500			1.76	1.32	1.28	1.00	0.96	0.78	0.73				1.58	1.54	1.21	1.15	0.94	0.88
36	35	F_b'			1,293	1,081	1,064	916	891	787	753			1,462	1,226	1,207	1,037	1,008	889	854
		E' for L/360			1.47	1.10	1.07	0.84	0.80	0.65	0.61			1.76	1.32	1.28	1.01	0.96	0.78	0.73
		E' for L/500				1.53	1.49	1.16	1.11	0.90	0.85				1.83	1.79	1.40	1.34	1.09	1.02
38	37	F_b'			1,428	1,193	1,175	1,012	984	870	827				1,353	1,332	1,145	1,113	982	943
		E' for L/360			1.68	1.26	1.23	0.96	0.92	0.75	0.70				1.51	1.47	1.15	1.10	0.90	0.84
		E' for L/500				1.75	1.71	1.33	1.27	1.04	0.97						1.60	1.53	1.25	1.17
40	39	F_b'			1,565	1,309	1,289	1,111	1,080	955	902				1,483	1,460	1,255	1,220	1,076	1,034
		E' for L/360			1.91	1.43	1.39	1.09	1.04	0.85	0.79				1.71	1.67	1.31	1.25	1.02	0.95
		E' for L/500				1.99	1.74	1.51	1.45	1.18	1.10						1.82	1.74	1.42	1.33
42	41	F_b'				1,426	1,404	1,211	1,177	1,041	1,002				1,614	1,589	1,367	1,329	1,173	1,127
		E' for L/360				1.62	1.58	1.23	1.18	0.96	0.90				1.94	1.89	1.48	1.41	1.15	1.08
		E' for L/500						1.71	1.63	1.33	1.25							1.96	1.60	1.50
44	43	F_b'				1,546	1,523	1,313	1,277	1,130	1,087						1,482	1,440	1,272	1,222
		E' for L/360				1.82	1.78	1.39	1.33	1.08	1.01						1.67	1.60	1.30	1.22
		E' for L/500						1.93	1.84	1.50	1.40								1.81	1.69
46	45	F_b'					1,643	1,418	1,379	1,221	1,174						1,598	1,553	1,372	1,319
		E' for L/360					1.99	1.56	1.49	1.21	1.13						1.87	1.79	1.46	1.36
		E' for L/500								1.68	1.57									1.89
48	47	F_b'						1,525	1,483	1,313	1,263							1,669	1,475	1,418
		E' for L/360						1.73	1.65	1.35	1.26							1.99	1.62	1.52
		E' for L/500								1.87	1.75									

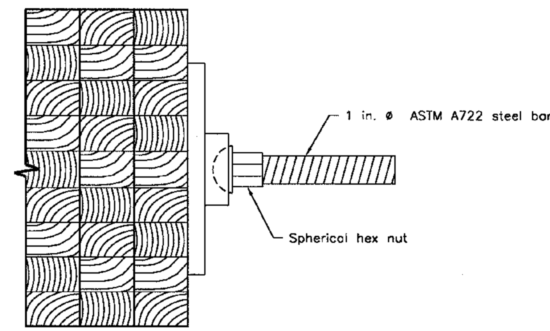
Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading: Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values for Actual Deck Thickness[a] (t)				AASHTO HS25-44 Loading			
			19¼	19½	20⅝	21	19¼	19½	20⅝	21
50	49	F_b'	1,634	1,589	1,408	1,354				1,518
		E' for L/360	1.92	1.83	1.49	1.39				1.68
		E' for L/500				1.93				
52	51	F_b'			1,504	1,447				1,621
		E' for L/360			1.64	1.53				1.84
		E' for L/500								
54	53	F_b'			1,602	1,542				
		E' for L/360			1.79	1.68				
		E' for L/500								
56	55	F_b'			1,702	1,639				
		E' for L/360			1.95	1.83				
		E' for L/500								
58	57	F_b'				1,737				
		E' for L/360				1.98				
		E' for L/500								

a – Western species glulam sizes are 15, 16 ½, 18, 19 ½ , and 21–in.;
Southern pine glulam sizes are 15 ⅛, 16 ½, 17 ⅞, 19 ¼, and 20 ⅝–in.

Refer to Sheet 5 of 7 for table instructions.



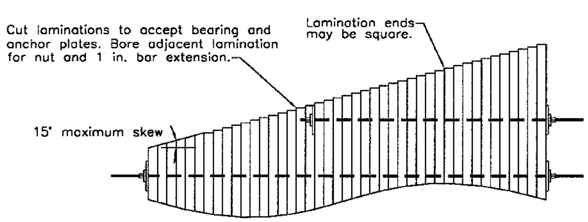
Bar Anchorage
Side view



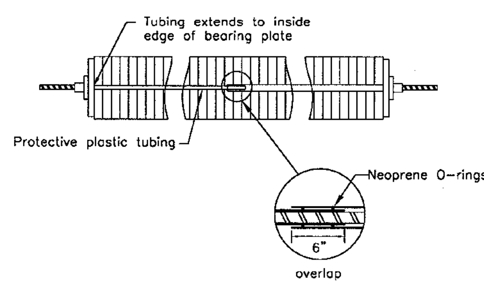
Bar Anchorage
End view

Table 4.6 – Required Plate Dimensions

Deck Thickness (in.)	Bar Spacing (ft)	Fc⊥ Range 560 thru 650 lb/in²		Fc⊥ Range 650 thru 800 lb/in²	
		Bearing Plate (in.)	Anchor Plate (in.)	Bearing Plate (in.)	Anchor Plate (in.)
12	4	12 x 16 x 1	4 x 6½ x 1¼	12 x 14 x 1	4 x 6½ x 1¼
12⅝		12 x 17 x 1		12 x 15 x 1	
13½		13 x 17 x 1		13 x 15 x 1	
13¾					
15		14 x 17 x 1		15 x 15 x 1	
15⅛					
16½		16 x 17 x 1			
17⅞		16 x 18 x 1		16 x 16 x 1	
18	3	15 x 15 x 1	4 x 6½ x 1¼	14 x 14 x 1	4 x 6½ x 1¼
19¼				15 x 15 x 1	
19½					
20⅝					
21					



Bar Anchorage Embedded in Skewed Zone
Plan view



Protective PVC Tubing for Galvanized Bars
Section view

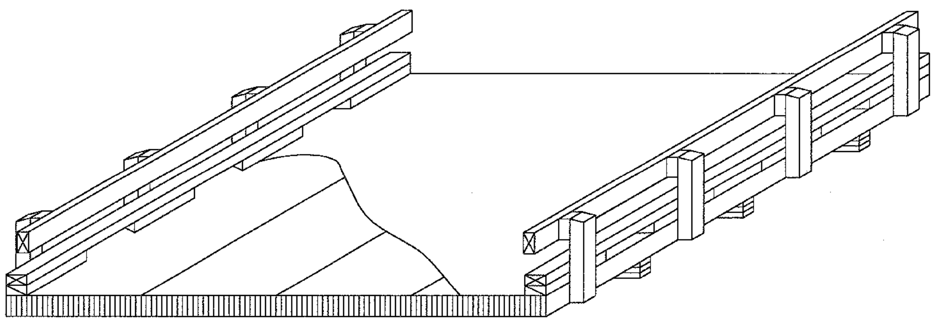
Notes

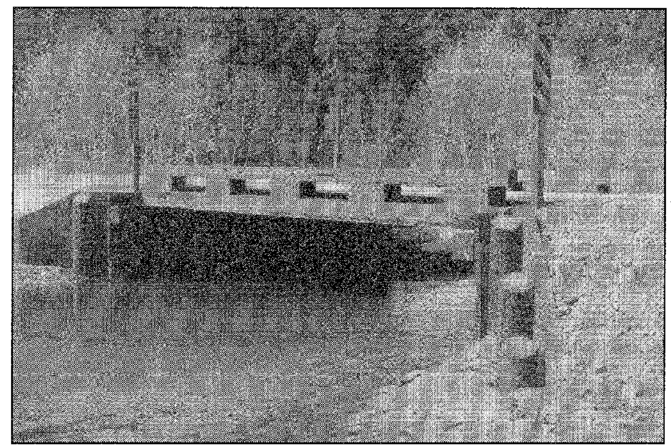
1. The minimum compression perpendicular to grain tabulated stress for the exterior (two) glulam laminations along each bridge edge is 560 lb/in². The interior glulam laminations can be of lower compression perpendicular to grain strength.

2. Anchorage systems shall consist of a steel bearing plate, anchor plate, and a high-strength steel nut. The anchor plate size is 4 x 6-1/2 x 1-1/4-in. for all cases. Bearing plate size is given in Table 4.6 and depends on the deck thickness, bar spacing, and the unadjusted tabulated compressive stress perpendicular to grain ($F_{c\perp}$) of the exterior (two) glulam laminations along each edge.

3. To prevent corrosion of galvanized stressing bars, protective tubing (see detail on this page) is recommended when the bridge will be subjected to deicing salt. To be flexible as the deck compresses during bar tensioning, two PVC tube diameters are used with an overlap section near the center of the bridge that is sealed with O-rings.

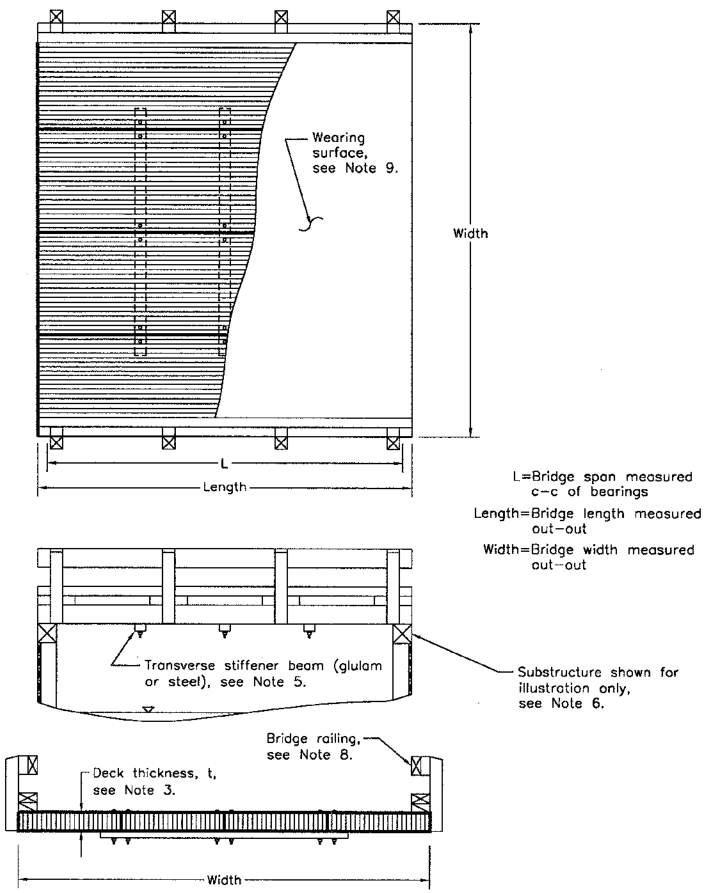
Longitudinal Deck Systems:
Longitudinal Glulam Panel Decks





The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.	Longitudinal Glulam Panel Decks	Title Page	
	Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 1 of 6

Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for longitudinal glulam timber decks. The decks consist of a series of glulam panels that are placed side–by–side between supports and interconnected with transverse stiffener beams. The designs are applicable for single– and double–lane and unskewed and skewed bridges up to 38–ft long. Design truck loading is AASHTO HS20–44 or HS25–44, with live load deflection limits of L/360 or L/500.

2. The designs comply with the 1996 *Standard Specifications for Highway Bridges*, with 1998 Interims, published by the American Association of State Highway and Transportation Officials (AASHTO), except where noted. Load distribution is based on a load fraction (as specified in AASHTO) applied to each panel based on the panel width and bridge span. Deck panels with multiple–piece laminations are assumed to have unbonded edges.

3. Minimum required timber design values are provided for single–span bridge lengths of 12– to 38–ft in 2–ft increments. Deck thicknesses are specified for standard Southern Pine and Western Species glulam sizes ranging from 8–1/2 to 16–1/4 in. The required minimum deck thickness for a specific bridge length can be selected from tables on Sheet 5 of 6 and Sheet 6 of 6, based on material, loading, and deflection requirements.

4. Design calculations are based on actual deck panel widths of 42–in. for single–lane bridges and 50.9–in. for double–lane bridges. Bridge widths are variable by adjusting the number and width of deck panels as shown on Sheet 3 of 6.

5. Deck panels are interconnected with glulam or steel–channel transverse stiffener beams through–bolted to the panel undersides. Refer to Sheet 4 of 6 for transverse stiffener beam layout and connection details.

6. The design assumes a uniform bearing length of 12–in. at both bridge ends and a span length, L, measured center–to–center of bearings. A longer bearing length will result in a slightly more conservative design. Substructure connection details are provided on Page 34.

7. Multiple span bridges may be constructed using a series of simple spans based on the designs presented in these drawings. Multiple span continuous bridges are also commonly used and may be more economical but require site–specific design. Refer to Page 34 for intermediate support connection details for both simple and continuous spans.

8. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft^2 for the rail and curb system. Crashworthy rail designs are available in *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Decks* (Ritter et al. 1995) and *Plans for Crash–Tested Bridge Railings for Longitudinal Wood Decks on Low–Volume Roads* (Ritter et al. 1998).

9. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. Deck designs are based on an assumed dead load of 38 lb/ft^2 for an asphalt wearing surface (approximately 3–in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

10. These designs are intended for informational purposes only and, due to potential variations in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood

11. Glulam deck panels shall comply with the requirements of AASHTO M168 and ANSI/AITC A190.1 and shall be manufactured to an Industrial appearance using wet–use adhesives.

12. Any species of glulam may be used provided it is treatable with wood preservatives and tabulated design values are provided in the AASHTO *Standard Specifications for Highway Bridges*. Deck panel glulam combinations should be selected from the tables for "members stressed primarily in axial tension or compression".

13. Insofar as is practical, all glulam shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives. Refer to Sheet 3 of 6 and Sheet 4 of 6 for layout details.

Preservative Treatment

14. All glulam shall be treated in accordance with AASHTO M133 and AWPA Standard C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13
b. Suitable oil borne preservatives conforming to AWPA Standard P8 in hydrocarbon solvent, Type A or Type C.

15. Treated material shall follow post–treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are fixated in the wood.

16. Preservative treatment shall be inspected and certified in accordance with AASHTO M133 and AWPA Standard M2.

Steel Fasteners and Hardware

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

18. Bolts and lag screws shall comply with the requirements of ANSI/ASME Standard B18.2.1–1981, Grade 2.

19. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or otherwise protected from corrosion.

20. Washers shall be provided under bolt and lag screw heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome–head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

21. Longitudinal glulam decks are typically constructed by placing the center panels first, then placing the outside panels. Stiffener beams should be attached as the panels are placed, but connecting bolts should not be tightened beyond hand tight until all panels are in place.

22. Glulam panels may swell slightly in the transverse direction due to moisture content increases in–service. In constructing supports, space should be left at the bridge edges to allow for possible lateral expansion. Provisions for longitudinal expansion, parallel to traffic, are not required since little expansion will occur in this direction.

23. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed, untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

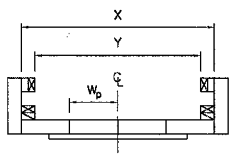
24. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Vertical joint surfaces, between glulam panels, should also be coated to minimize moisture penetration. Any commercially available roofing cement is effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

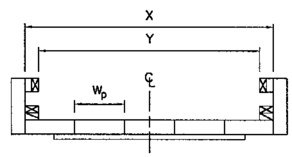
Longitudinal Glulam Panel Decks	Superstructure Drawings and General Notes
Standard Plans for Timber Bridge Superstructures	December 2000 — Sheet 2 of 6

Deck Panel Layouts

Single-Lane Bridges



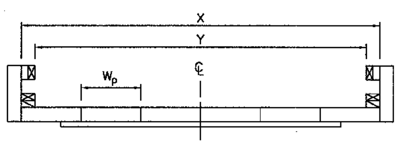
12 ft Roadway Width
End view



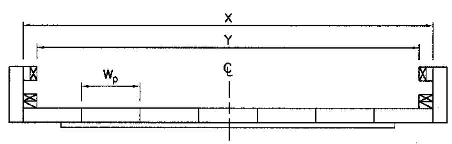
16 ft Roadway Width
End view

X = Nominal bridge width (out–out)
Y = Nominal roadway width
W_p = Deck panel width

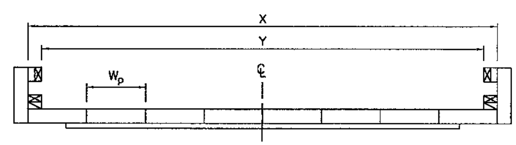
Double-Lane Bridges



24 ft Roadway Width
End view



28 ft Roadway Width
End view



32 ft Roadway Width
End view

Notes

1. Deck panel layouts on this sheet are for single–lane bridges of nominal 12– and 16–ft roadway widths and double–lane bridges of nominal 24–, 28–, and 32–ft roadway widths. Actual bridge widths vary slightly from nominal widths depending on the panel width, which is a multiple of the standard lamination thickness.

2. Actual bridge widths are given in Table 5.1 based on 1–1/2–in.–thick laminations for Western Species glulam and 1–3/8–in.–thick laminations for Southern Pine glulam. The nominal bridge width (X) assumes a 1–ft wide curb/railing along each deck edge.

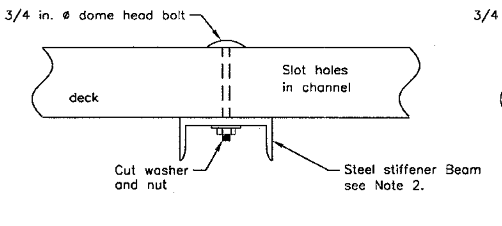
3. Load distribution for longitudinal glulam deck panels is a function of the panel width. These designs are based on a panel width of 42–in. for single–lane bridges and 50.9–in. for double–lane bridges. Panel widths larger than the assumed values result in a slightly more conservative design which is typically negligible for the widths given in Table 5.1.

4. Refer to Sheet 4 of 6 for transverse stiffener beam layouts and Sheet 5 of 6 and Sheet 6 of 6 for deck thickness requirements.

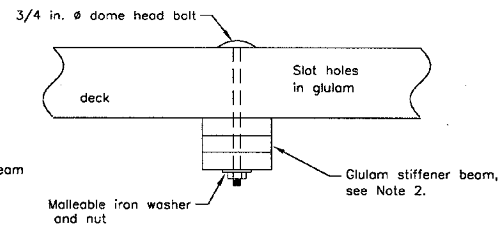
Table 5.1 – Deck Panel Summary

Nominal Roadway Width, Y	Nominal Bridge Width, X	Total Number of Panels	Western Species Glulam (1–1/2 in. thick laminations)		Southern Pine Glulam (1–3/8 in. thick laminations)	
			Panel Width, W_p	Bridge Width Out–Out	Panel Width, W_p	Bridge Width Out–Out
(ft)	(ft)		(in.)	(ft)	(in.)	(ft)
12	14	4	42.0	14.00	42.6	14.20
16	18	5	43.5	18.13	44.0	18.33
24	26	6	52.5	26.13	52.3	26.13
28	30	7	51.0	29.75	52.3	30.47
32	34	8	51.0	34.00	50.9	33.92

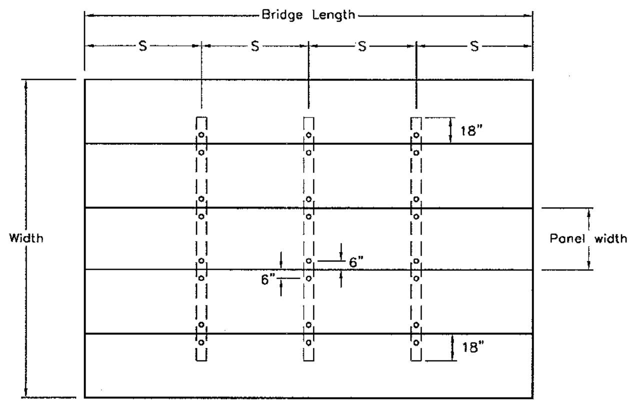
Transverse Stiffener Beam Layout



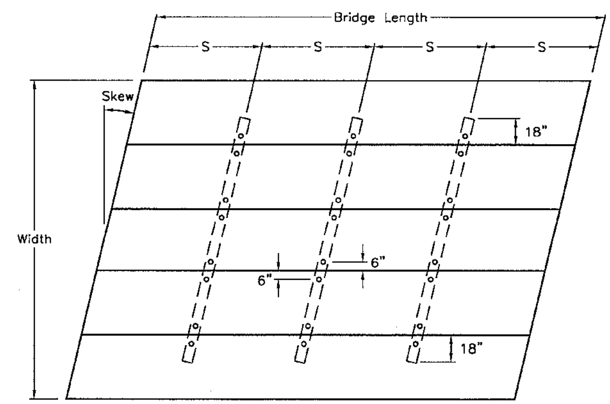
Steel Channel Connection
Side View



Glulam Beam Connection
Side View



Transverse Stiffener Layout - Unskewed Crossings
Plan View



Transverse Stiffener Layout - Skewed Crossings
Plan View

Notes

1. Transverse stiffener beams shall be attached to the deck underside to transfer loads between adjacent panels. Transverse stiffener beams are placed at midspan and at intermediate locations, while not exceeding a 10–ft spacing (see Table 5.2). For unskewed and skewed crossings, stiffener beams shall be placed parallel to the abutments.

2. Transverse stiffener beams shall be manufactured of glulam timber or steel. For Western Species glulam, a Combination 2 beam measuring 6–3/4–in.–wide and 4–1/2–in.–deep may be used. For Southern Pine glulam, a Combination 48 beam, 5–in.–wide and 5–1/2–in.–deep may be used. For steel, a miscellaneous channel (MC6x15.1) beam may be used. Other glulam combinations or steel shapes may be used provided they are of sufficient size and stiffness to provide a minimum E'I of 80,000 $lb–in^2$.

3. Transverse stiffener beams shall be attached to the deck panels with 3/4–in.–diameter through–bolts placed approximately 6–in. from panel edges. For the exterior panels, the transverse stiffener beam shall extend a minimum of 18–in. beyond the panel interface. Bolt holes in the transverse stiffener beams shall be slotted (twice bolt diameter) in the direction of the stiffener beam length to allow for possible deck panel swelling.

Table 5.2 – Stiffener Requirements

Bridge Length (ft)	Number of Stiffeners	Stiffener Spacing, S (ft)
12	1	6.0
14	1	7.0
16	1	8.0
18	1	9.0
20	3	5.0
22	3	5.5
24	3	6.0
26	3	6.5
28	3	7.0
30	3	7.5
32	3	8.0
34	3	8.5
36	3	9.0
38	3	9.5

S – Transverse stiffener beam spacing

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Table 5.3 – Longitudinal Glulam Deck Design Table for Single Lane Bridges

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading							AASHTO HS25-44 Loading						
			Minimum Required F_b' (lb/in^2) and E′ (x10^6 lb/in^2) Values for Actual Deck Thickness[a] (t) Ranging from 8–½ to 16–¼–in.													
			8½	8¾	10½	10¾	12¼	14¼	16¼	8½	8¾	10½	10¾	12¼	14¼	16¼
12	11	F_b'	891	842						1,088	1,028	720	688			
		E′ for L/360	0.73	0.67						0.92	0.84	0.49	0.45			
		E′ for L/500	1.02	0.93						1.27	1.17	0.68	0.63			
14	13	F_b'	1,061	1,003	705	674				1,290	1,220	855	817	635		
		E′ for L/360	1.01	0.93	0.54	0.50				1.26	1.15	0.67	0.62	0.42		
		E′ for L/500	1.41	1.29	0.75	0.70				1.75	1.60	0.93	0.86	0.58		
16	15	F_b'	1,235	1,168	822	786	612			1,496	1,413	993	948	737		
		E′ for L/360	1.32	1.21	0.70	0.65	0.44			1.65	1.52	0.88	0.82	0.55		
		E′ for L/500	1.83	1.68	0.97	0.91	0.61					1.22	1.14	0.77		
18	17	F_b'	1,411	1,335	941	900	702				1,609	1,132	1,082	842	631	
		E′ for L/360	1.67	1.53	0.89	0.83	0.56				1.92	1.11	1.04	0.70	0.44	
		E′ for L/500			1.23	1.15	0.78					1.54	1.44	0.97	0.62	
20	19	F_b'		1,505	1,063	1,017	794					1,273	1,217	948	712	
		E′ for L/360		1.89	1.09	1.02	0.69					1.37	1.27	0.86	0.55	
		E′ for L/500			1.52	1.41	0.96					1.90	1.77	1.20	0.76	
22	21	F_b'			1,188	1,136	889	670				1,417	1,354	1,057	795	621
		E′ for L/360			1.32	1.23	0.83	0.53				1.65	1.53	1.04	0.66	0.44
		E′ for L/500			1.83	1.70	1.15	0.73						1.44	0.91	0.62
24	23	F_b'			1,316	1,259	986	745						1,167	879	688
		E′ for L/360			1.74	1.62	1.09	0.69						1.37	0.87	0.58
		E′ for L/500					1.52	0.96							1.20	0.81

a – Western species glulam sizes are 8 ¾, 10 ¾, 12 ¼, 14 ¼, and 16 ¼–in.; Southern pine glulam sizes are 8 ½, 10 ½, 12 ¼, 14 ¼, and 16 ¼–in.

Bridge Length (ft)	Span L (ft)	Required Value	Table Continued					
			HS20-44			HS25-44		
			Minimum Required Values for Actual Deck Thickness[a] (t) Ranging from 8–½ to 16–¼–in.					
			12¼	14¼	16¼	12¼	14¼	16¼
26	25	F_b'	1,114	842	663	1,315	991	777
		E′ for L/360	1.41	0.90	0.60	1.76	1.12	0.76
		E′ for L/500	1.96	1.24	0.84		1.56	1.05
28	27	F_b'	1,268	959	755		1,127	884
		E′ for L/360	1.75	1.11	0.75		1.39	0.94
		E′ for L/500		1.54	1.04		1.93	1.30
30	29	F_b'		1,078	849		1,265	993
		E′ for L/360		1.35	0.91		1.68	1.13
		E′ for L/500		1.87	1.26			1.57
32	31	F_b'		1,199	945		1,404	1,103
		E′ for L/360		1.59	1.07		1.99	1.34
		E′ for L/500			1.49			1.86
34	33	F_b'		1,322	1,042			1,214
		E′ for L/360		1.84	1.24			1.55
		E′ for L/500			1.72			
36	35	F_b'			1,147			1,333
		E′ for L/360			1.42			1.78
		E′ for L/500			1.97			
38	37	F_b'			1,267			
		E′ for L/360			1.61			
		E′ for L/500						

Table Instructions

The table on this sheet is for determining the required deck thickness for longitudinal glulam timber decks for single–lane bridges (14– and 18–ft nominal widths). The criteria for selecting deck thickness are based on span length, vehicle loading, live load deflection limit, and the material properties of the glulam panels. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E′) based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb and 38 lb/ft^2 for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the combination and material species of glulam are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the combination and material species are unknown, minimum required F_b' and E′ values may be obtained from the table based on the span length, deck thickness, loading, and deflection limit. A combination and species of glulam that meets these minimum allowable design values may then be selected. The following procedures are recommended for table use:

<u>Material Combination and Species Known</u>

1. Determine the required design criteria for
   a. span length measured center–to–center of bearings;
   b. vehicle loading, AASHTO HS20–44 or HS25–44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the glulam combination and species using the following equations:

$$F_b' = F_b\, C_M\, C_F\, C_D \qquad E' = E\, C_M$$

where
- F_b' = allowable bending stress (lb/in^2)
- E′ = allowable modulus of elasticity (lb/in^2)
- E = tabulated modulus of elasticity (lb/in^2)
- C_D = load duration factor
- F_b = tabulated bending stress (lb/in^2)
- C_F = size factor
- C_M = wet service factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E′ must be greater than or equal to the corresponding table values for the deck thickness selected. If they are not, the design criteria and/or material properties must be revised until acceptable values are achieved.

<u>Material Combination and Species Unknown</u>

1. Determine the required design criteria for
   a. span length measured center–to–center of bearings;
   b. vehicle loading, AASHTO HS20–44 or HS25–44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable values for F_b' and E′.

3. Select a Glulam Combination that provides the minimum allowable design values. Glulam combinations should be selected from the "members stressed primarily in axial tension or compression" table.

Table 5.4 – Longitudinal Glulam Deck Design Table for Double-Lane Bridges

Bridge Length (ft)	Span L (ft)	Required Value	AASHTO HS20-44 Loading: Minimum Required F_b' (lb/in^2) and E′ (x10^6 lb/in^2) Values for Actual Deck Thickness[a] (t) Ranging from 8–½ to 16–¼–in.							AASHTO HS25-44 Loading						
			8½	8¾	10½	10¾	12¼	14¼	16¼	8½	8¾	10½	10¾	12¼	14¼	16¼
12	11	F_b'	986	932	653	624				1,207	1,140	798	762			
		E′ for L/360	0.82	0.75	0.44	0.41				1.03	0.94	0.54	0.51			
		E′ for L/500	1.14	1.05	0.61	0.56				1.43	1.31	0.76	0.71			
14	13	F_b'	1,170	1,106	776	742				1,426	1,348	944	902	700		
		E′ for L/360	1.13	1.04	0.60	0.56				1.41	1.29	0.75	0.70	0.47		
		E′ for L/500	1.57	1.44	0.83	0.78				1.96	1.79	1.04	0.97	0.65		
16	15	F_b'	1,356	1,282	902	862	671			1,647	1,556	1,092	1,043	811	606	
		E′ for L/360	1.47	1.35	0.78	0.73	0.49			1.85	1.69	0.98	0.91	0.62	0.39	
		E′ for L/500		1.88	1.09	1.01	0.68					1.36	1.27	0.86	0.54	
18	17	F_b'	1,545	1,461	1,029	983	766					1,241	1,186	922	690	
		E′ for L/360	1.87	1.71	0.99	0.92	0.62					1.24	1.15	0.78	0.50	
		E′ for L/500			1.38	1.28	0.87					1.72	1.60	1.08	0.69	
20	19	F_b'			1,158	1,107	864	650				1,392	1,330	1,036	776	606
		E′ for L/360			1.22	1.13	0.77	0.49				1.52	1.42	0.96	0.61	0.41
		E′ for L/500			1.69	1.57	1.06	0.68					1.97	1.33	0.85	0.57
22	21	F_b'			1,290	1,233	964	726				1,544	1,476	1,150	864	674
		E′ for L/360			1.46	1.36	0.92	0.58				1.83	1.70	1.15	0.73	0.49
		E′ for L/500				1.89	1.28	0.81						1.60	1.02	0.69
24	23	F_b'			1,424	1,362	1,065	803	630					1,266	952	745
		E′ for L/360			1.92	1.79	1.21	0.77	0.52					1.51	0.96	0.65
		E′ for L/500					1.68	1.07	0.72						1.34	0.90

a – Western species glulam sizes are 8 ¾, 10 ¾, 12 ¼, 14 ¼, and 16 ¼–in.;
Southern pine glulam sizes are 8 ½, 10 ½, 12 ¼, 14 ¼, and 16 ¼–in.

Table Continued

Bridge Length (ft)	Span L (ft)	Required Value	HS20-44: Minimum Required Values for Actual Deck Thickness[a] (t)			HS25-44		
			12¼	14¼	16¼	12¼	14¼	16¼
26	25	F_b'	1,201	907	712	1,424	1,071	839
		E′ for L/360	1.56	0.99	0.67	1.95	1.24	0.84
		E′ for L/500		1.38	0.93		1.72	1.16
28	27	F_b'	1,364	1,031	810		1,216	953
		E′ for L/360	1.94	1.23	0.83		1.54	1.04
		E′ for L/500		1.71	1.15			1.44
30	29	F_b'		1,156	909		1,362	1,068
		E′ for L/360		1.49	1.00		1.85	1.25
		E′ for L/500			1.39			1.74
32	31	F_b'		1,284	1,010			1,184
		E′ for L/360		1.75	1.18			1.48
		E′ for L/500			1.64			
34	33	F_b'			1,112			1,301
		E′ for L/360			1.37			1.71
		E′ for L/500			1.90			
36	35	F_b'			1,222			1,427
		E′ for L/360			1.56			1.95
		E′ for L/500						
38	37	F_b'			1,349			
		E′ for L/360			1.77			
		E′ for L/500						

Table Instructions

The table on this sheet is for determining the required deck thickness for longitudinal glulam decks for double-lane bridges (26–, 30–, and 34–ft nominal widths). The criteria for selecting deck thickness are based on span length, vehicle loading, live load deflection limit, and the material properties of the glulam panels. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E′) based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb and 38 lb/ft^2 for the asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the combination and material species of glulam are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The allowable design values must be greater than or equal to the table values based on the selected deck thickness, span length, vehicle loading, and deflection limit. Alternatively, when the combination and material species are unknown, minimum required F_b' and E′ values may be obtained from the table based on the span length, deck thickness, loading, and deflection limit. A grade and species of glulam that meets these minimum allowable design values may then be selected. The following procedures are recommended for table use:

Material Combination and Species Known

1. Determine the required design criteria for
   a. span length measured center–to–center of bearings;
   b. vehicle loading, AASHTO HS20–44 or HS25–44; and
   c. live load deflection limit, L/360 or L/500.

2. Compute the allowable design values for the combination and species of the glulam using the following equations:

$$F_b' = F_b\, C_M\, C_F\, C_D \qquad E' = E\, C_M$$

where
F_b' = allowable bending stress (lb/in^2)
E′ = allowable modulus of elasticity (lb/in^2)
E = tabulated modulus of elasticity (lb/in^2)
C_D = load duration factor
F_b = tabulated bending stress (lb/in^2)
C_F = size factor
C_M = wet service factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E′ must be greater than or equal to the corresponding table values for the deck thickness selected. If they are not, the design criteria and/or material properties must be revised until acceptable values are achieved.

Material Combination and Species Unknown

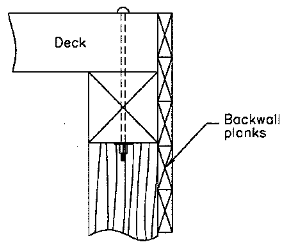
1. Determine the required design criteria for
   a. span length measured center–to–center of bearings;
   b. vehicle loading, AASHTO HS20–44 or HS25–44; and
   c. live load deflection limit, L/360 or L/500.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable values for F_b' and E′.

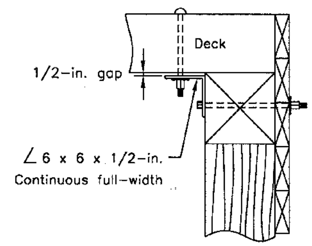
3. Select a Glulam Combination that provides the minimum allowable design values. Glulam combinations should be selected from the "members stressed primarily in axial tension or compression" table.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Suggested Substructure Connections

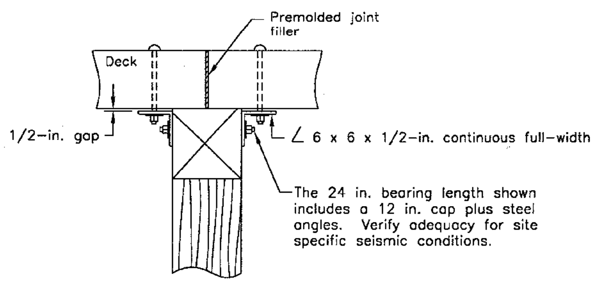


Thru-Bolt Abutment Connection
Side view

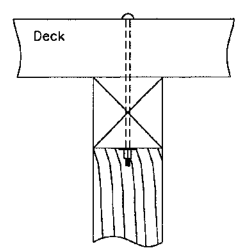


Steel Angle Abutment Connection
Side view

Minimum bearing length is 12 in. for all cases
All bolts are minimum 3/4 in. ø



Multiple Simple Span Bent Connection
Side view



Continuous Span Bent Connection
Side view

Notes

1. This page presents suggested substructure connection details for longitudinal timber deck superstructures with timber abutments. If concrete abutments are used, threaded bolt inserts or anchor bolts, cast or drilled into the concrete, should be used. Connections should be designed to resist appropriate design loads (including seismic) and be based on site-specific conditions.

2. These five longitudinal deck system standards assume 12-inch bearing lengths at all supports. Site-specific seismic conditions may require additional bearing length. All bridges should be evaluated by a qualified professional engineer for AASHTO seismic requirements.

3. Superstructures should be attached to the substructure soon after placing the timber deck, except stress-laminated decks should not be connected to the substructure until after the first bar re-tensioning, due to possible transverse deck movement.

4. Deck attachment bolts should be 3/4-in. nominal diameter and have dome-type heads. Bolt holes should be pre-bored to a diameter of 13/16-in. The transverse spacing of connectors to anchor the superstructure to the substructure should not exceed 4-ft over the width of the bridge.

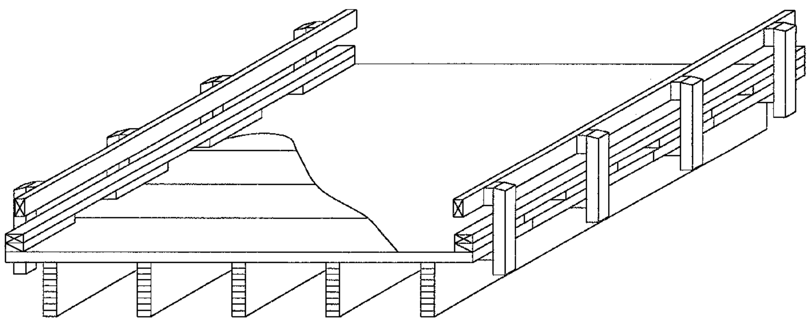
5. Steel angles should meet the requirements for ASTM standard A36. The use of transversely slotted bolt holes will allow for transverse movement of the deck in-service and is recommended, especially for glulam decks.

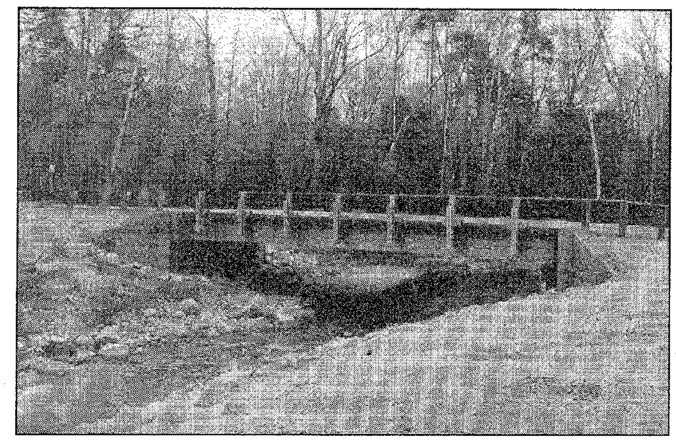
6. All steel components should be galvanized in accordance with AASHTO standards M111 and M232, or otherwise protected from corrosion.

7. All borings done after preservative treatment should be field treated, in accordance with AASHTO M133, with an appropriate wood preservative.

8. The use of neoprene bearing pads, 1/2-in. minimum thickness, is recommended for concrete abutments. Plain elastomeric rubber, 50 to 60 durometer, should be specified. Timber decks on timber abutment caps do not usually require bearing pads.

Beam Systems:
Glulam Stringer and Transverse Glulam Deck

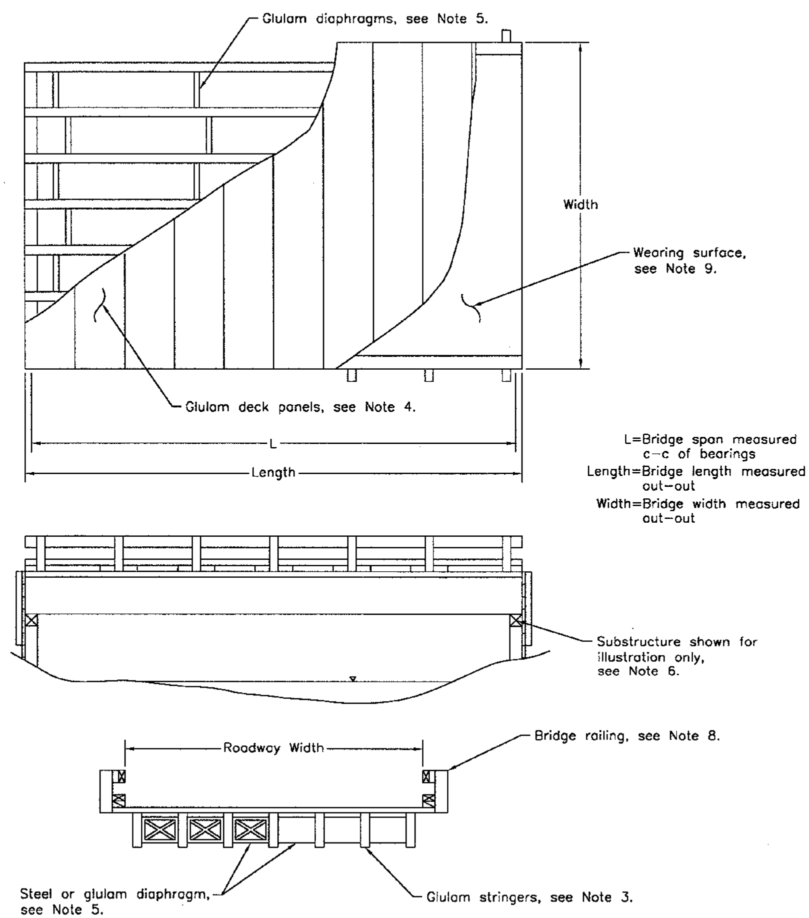




The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Stringer and Transverse Deck	Title Page	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 1 of 11

Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for glulam stringer bridges with transverse glulam panel decks. The designs are applicable for single- and double- lane and unskewed and skewed bridges up to 80-ft long. Design truck loading is AASHTO HS 20-44 or HS 25-44 with a live load deflection limit of L/500.

2. The designs comply with the 1996 *Standard Specifications for Highway Bridges*, with 1998 Interims, published by the American Association of State Highway and Transportation Officials (AASHTO), except where noted. Glulam stringers were designed assuming dry-use conditions (C_M = 1.0), except for bearings which were assumed to be wet-use conditions (C_M = 0.53). Stringer design live load deflection is limited to L/500. Stringers should be specified with a minimum camber equal to 3 times the dead load, but not less than ½ inch. Glulam deck panels were designed as non-interconnected panels continuous over more than two spans. Glulam deck panels may also be interconnected using steel dowels (refer to AASHTO for detailed design information). To account for the effects of span continuity, maximum moment and deflection are reduced to 80 percent of equivalent simple-span values. Deck panel design live load deflection is limited to a maximum of 0.10-in.

3. Minimum required timber design values are provided for single-span bridge lengths of 20- to 80-ft in 2-ft increments. Stringer configuration and size requirements for both unskewed and skewed bridges are given on Sheet 3 of 11 for single-lane roadway widths of 12- and 16-ft, and on Sheet 4 of 11 for double-lane roadway widths of 24- and 28-ft, and on Sheet 5 of 11 for double-lane roadway widths of 32- and 36-ft.

4. Deck panels are 5-1/8-in.-thick (6-in. nominal) and are typically 4-ft wide. The number, width, and layout of deck panels for unskewed and skewed bridges are shown on Sheet 6 of 11 and Sheet 7 of 11, respectively. Deck panels are attached to supporting stringers with 5/8-in. diameter dome-head bolts and cast aluminum alloy deck brackets as shown on Sheet 8 of 11.

5. Lateral support for stringers is provided by glulam or steel diaphragms. Diaphragm layout and connection requirements are given on Sheet 9 of 11 for glulam and Sheet 10 of 11 for steel.

6. The design assumes a uniform stringer bearing length of 12-in. at both bridge ends and a span length, L, measured center-to-center of bearings. A longer bearing length will result in a slightly more conservative design. Substructure connection details are provided on Sheet 11 of 11.

7. Multiple span bridges may be constructed using a series of simple spans based on the designs presented in these drawings. Multiple span continuous bridges are also commonly used and may be more economical but require site-specific design.

8. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft² for the rail and curb system. Crashworthy rail designs are available in *Development of Two TL-2 Bridge Railings and Transitions for Use on Transverse Glue-Laminated Deck Bridges* (Faller et al. In Press)

9. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. Designs are based on an assumed dead load of 38 lb/ft² for an asphalt wearing surface (approximately 3-in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

10. These designs are intended for informational purposes only and, due to potential changes in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood

11. Glulam shall comply with the requirements of AASHTO M168 and ANSI/AITC A190.1 and shall be manufactured to an industrial appearance grade using wet-use adhesives.

12. Glulam stringers are limited to Western and Southern Pine species treated with a suitable oilborne preservative. Refer to Sheet 3, 4, and 5 of 11 for stringer designations and sizes. Stringers consist of glulam bending combinations with horizontal laminations. Deck panels consist of glulam axial combinations with vertical laminations.

13. Insofar as is practical, all glulam shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives.

Preservative Treatment

14. All glulam shall be treated in accordance with AASHTO M133 and AWPA Standard C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13
b. Suitable oilborne preservative conforming to AWPA Standard C28 and P8 in hydrocarbon solvent, Type A or Type C.

15. Treated material shall follow post-treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are fixated in the wood.

16. Preservative treatment shall be inspected and certified in accordance with AASHTO M133 and AWPA Standard M2.

Steel Fasteners and Hardware

17. Steel plates and shapes shall comply with the requirements of ASTM A36. Cast aluminum alloy deck brackets shall comply with the requirements of ASTM A356.

18. Bolts and lag screws shall comply with the requirements of ANSI/ASME Standard B18.2.1-1981, Grade 2.

19. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232 or otherwise protected from corrosion.

20. Washers shall be provided under bolt and lag screw heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome-head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

21. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

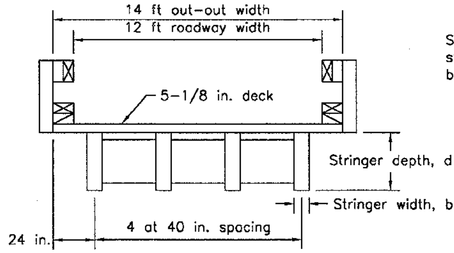
22. Stringers are often placed with bearing hardware attached. During stringer placement, diaphragms are attached and connections are hand-tightened to allow for minor adjustments as remaining diaphragms are placed. After all diaphragms are placed, and alignment is verified, connections should be securely tightened.

23. Deck panels should be placed after stringers and diaphragms are set and secured. A common construction procedure is to place the first panel at midspan, then sequentially place remaining panels outward toward the abutments. Attachment hardware should be hand tightened as the panels are placed, then securely tightened after all panels are placed and aligned.

24. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Tops of glulam beams and vertical joint surfaces, between glulam deck panels, should also be coated to minimize moisture penetration. Any commercially available roofing cement is effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stringer Configuration and Size - 12-ft Roadway Width

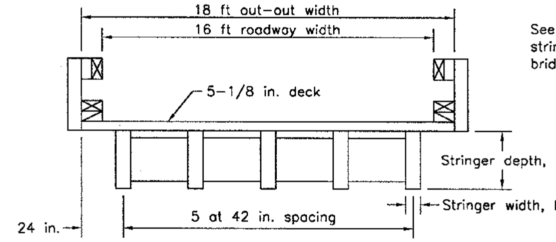


See table below for stringer size based on bridge length

Table 6.1 – Glulam Stringer Sizes for Single Lane Bridges with a 12-ft Roadway Width

Bridge Length (ft)	Bridge Span (ft)	Stringer Dimensions (in.)											
		Southern Pine 24F-V3				Southern Pine 26F-V3				Western Species 24F-V4			
		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading	
		b	d	b	d	b	d	b	d	b	d	b	d
20	19		16½		17⅞		16½		17⅞		16½		19½
22	21		17⅞		19¼		17⅞		19¼		18		19½
24	23		19¼		22		19¼		20⅝		19½		21
26	25		22		23⅜		22		23⅜		21		24
28	27		23⅜		24¾		23⅜		24¾		24		25½
30	29		24¾		26⅛		24¾		26⅛		25½		27
32	31	6¾	26⅛		28⅞	6¾	26⅛		27½		27	6¾	28½
34	33		27½	6¾	30½		27½		28⅞		28½		30
36	35		28⅞		31⅝		28⅞	6¾	30¼	6¾	28½		31½
38	37		30¼		33		30¼		31⅝		30		33
40	39		31⅝		34⅜		31⅝		33		31½		34½
42	41		33		35¾		33		34⅜		33		36
44	43		34⅜		37⅛		34⅜		35¾		34½		39
46	45		35¾		38½		34⅜		37⅛		36		36
48	47		37⅛		39⅞		35¾		38½		37½		37½
50	49		38½		38½		37⅛		39⅞		39		39
52	51		39⅞		39⅞		38½		38½		37½		40½
54	53		39⅞		39⅞		39⅞		39⅞		37½		42
56	55		38½		41¼		38½		41¼		39		43½
58	57		39⅞		42⅝		38½		42⅝		40½	8¾	45
60	59		41¼		44		39⅞		42⅝		42		45
62	61		41¼	8½	45⅜		41¼	8½	44		43½		46½
64	63		42⅝		45⅜		42⅝		45⅜	8¾	45		48
66	65		44		46¾		42⅝		46¾		46½		49½
68	67	8½	45⅜		48⅛	8½	44		46¾		48		51
70	69		46¾		49½		45⅜		48⅛		49½		48
72	71		46¾		49½		45⅜		49½		49½		49½
74	73		48⅛		48⅛		46¾		46¾		51		51
76	75		48⅛		48⅛		48⅛		48¾		48	10¾	52½
78	77		49½	10½	49½		48⅛	10½	48¾	10¾	49½		54
80	79	10½	46¾		50⅞		49½		49½		51		55½

Stringer Configuration and Size - 16-ft Roadway Width



See table below for stringer size based on bridge length

Table 6.2 – Glulam Stringer Sizes for Single Lane Bridges with a 16-ft Roadway Width

Bridge Length (ft)	Bridge Span (ft)	Stringer Dimensions (in.)											
		Southern Pine 24F-V3				Southern Pine 26F-V3				Western Species 24F-V4			
		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading	
		b	d	b	d	b	d	b	d	b	d	b	d
20	19		16½		19¼		16½		17⅞		16½		19½
22	21		17⅞		19¼		17⅞		19¼		18		19½
24	23		19¼		22		17⅞		20⅝		19½		21
26	25		22		22		19¼		22		21		22½
28	27		22		23⅜		20⅝		23⅜		22½		25½
30	29		23⅜		26⅛		23⅜		24¾		24		27
32	31		24¾		28⅞		23⅜		26⅛		25½	6¾	28½
34	33		26⅛	6¾	28⅞		24¾		27½	6¾	27		30
36	35	6¾	27½		30¼		26⅛	6¾	28⅞		28½		31½
38	37		28⅞		33	6¾	27½		30¼		30		33
40	39		30¼		33		28⅞		31⅝		33		36
42	41		31⅝		34⅜		30¼		33		34½		37½
44	43		33		37⅛		31⅝		35¾		36		39
46	45		34⅜		38½		33		37⅛		37½		36
48	47		35¾		39⅞		34⅜		38½		39		37½
50	49		37⅛		37⅛		35¾		39⅞		36		39
52	51		38½		38½		37⅛		37⅛		37½		40½
54	53		39⅞		39⅞		38½		37⅛		39		42
56	55		37⅛		41¼		39⅞		38½		40½	8¾	43½
58	57		38½		42⅝		37⅛		39⅞		40½		45
60	59		39⅞	8½	42⅝		38½		41¼		42		46½
62	61		41¼		44		39⅞	8½	42⅝	8¾	43½		48
64	63		42⅝		45⅜		39⅞		44		45		49½
66	65	8½	44		46¾		41¼		45⅜		46½		51
68	67		44		48⅛		42⅝		46¾		48		48
70	69		45⅜		49½	8½	44		46¾		49½		49½
72	71		46¾		46¾		45⅜		48⅛		51		49½
74	73		48⅛		46¾		45⅜		49½		48		51
76	75		49½	10½	48⅛		46¾		46¾		49½	10¾	52½
78	77	10½	45⅜		49½		48⅛	10½	46¾	10¾	49½		54
80	79		46¾		50⅞		49½		48⅛		51		55½

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Stringer and Transverse Deck

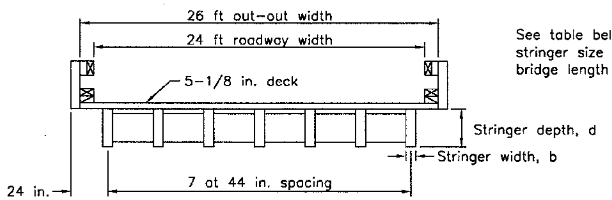
Stringer Configuration and Sizes - Single Lane

Standard Plans for Timber Bridge Superstructures

December 2000

Sheet 3 of 11

Stringer Configuration and Size - 24-ft Roadway Width

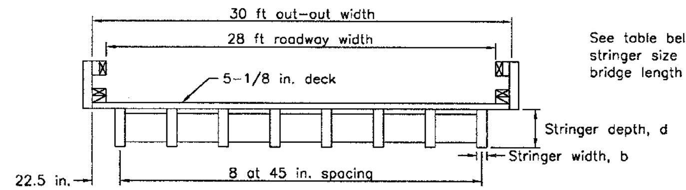


See table below for stringer size based on bridge length

Table 6.3 – Glulam Stringer Sizes for Double Lane Bridges with a 24-ft Roadway Width

Bridge Length (ft)	Bridge Span (ft)	Stringer Dimensions (in.)											
		Southern Pine 24F-V3				Southern Pine 26F-V3				Western Species 24F-V4			
		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading	
		b	d	b	d	b	d	b	d	b	d	b	d
20	19	6¾	17⅞	6¾	19¼	6¾	17⅞	6¾	19¼	6¾	18	6¾	19½
22	21	6¾	19¼	6¾	22	6¾	17⅞	6¾	19¼	6¾	19½	6¾	21
24	23	6¾	22	6¾	22	6¾	20⅝	6¾	22	6¾	21	6¾	22½
26	25	6¾	22	6¾	24¾	6¾	22	6¾	23⅜	6¾	22½	6¾	24
28	27	6¾	24¾	6¾	26⅛	6¾	23⅜	6¾	26⅛	6¾	24	6¾	25½
30	29	6¾	26⅛	6¾	27½	6¾	26⅛	6¾	27½	6¾	25½	6¾	28½
32	31	6¾	27½	6¾	30¼	6¾	27½	6¾	28⅞	6¾	27	6¾	30
34	33	6¾	28⅞	6¾	31⅝	6¾	28⅞	6¾	30¼	6¾	28½	6¾	31½
36	35	6¾	30¼	6¾	33	6¾	30¼	6¾	31⅝	6¾	30	6¾	33
38	37	6¾	31⅝	6¾	34⅜	6¾	31⅝	6¾	33	6¾	31½	6¾	34½
40	39	6¾	33	6¾	35¾	6¾	33	6¾	34⅜	6¾	33	6¾	36
42	41	6¾	34⅜	6¾	37⅛	6¾	34⅜	6¾	37⅛	6¾	34½	6¾	37½
44	43	6¾	35¾	6¾	38½	6¾	35¾	6¾	38½	6¾	36	6¾	39
46	45	6¾	37⅛	6¾	39⅞	6¾	37⅛	6¾	39⅞	6¾	37½	8¾	37½
48	47	6¾	38½	8½	38½	6¾	38½	8½	37⅛	6¾	39	8¾	37½
50	49	6¾	39⅞	8½	39⅞	6¾	38½	8½	38½	8¾	36	8¾	39
52	51	8½	38½	8½	41¼	6¾	39⅞	8½	39⅞	8¾	37½	8¾	40½
54	53	8½	39⅞	8½	42⅝	8½	38½	8½	41¼	8¾	39	8¾	42
56	55	8½	39⅞	8½	44	8½	39⅞	8½	42⅝	8¾	40½	8¾	43½
58	57	8½	41¼	8½	44	8½	41¼	8½	44	8¾	42	8¾	45
60	59	8½	42⅝	8½	45⅜	8½	41¼	8½	45⅜	8¾	43½	8¾	46½
62	61	8½	44	8½	46¾	8½	42⅝	8½	46¾	8¾	45	8¾	48
64	63	8½	44	8½	48⅛	8½	44	8½	46¾	8¾	45	8¾	49½
66	65	8½	45⅜	8½	49½	8½	45⅜	8½	48⅛	8¾	46½	8¾	51
68	67	8½	46¾	10½	46¾	8½	45⅜	8½	49½	8¾	48	10¾	48
70	69	8½	48⅛	10½	48⅛	8½	46¾	10½	46¾	8¾	49½	10¾	49½
72	71	8½	48⅛	10½	49½	8½	48⅛	10½	48⅛	8¾	51	10¾	51
74	73	8½	49½	10½	49½	8½	49½	10½	49½	10¾	48	10¾	52½
76	75	10½	46¾	10½	50⅞	8½	49½	10½	49½	10¾	49½	10¾	52½
78	77	10½	48⅛	10½	52¼	10½	46¾	10½	50⅞	10¾	51	10¾	54
80	79	10½	49½	10½	52¼	10½	48⅛	10½	52¼	10¾	52½	10¾	55½

Stringer Configuration and Size - 28-ft Roadway Width



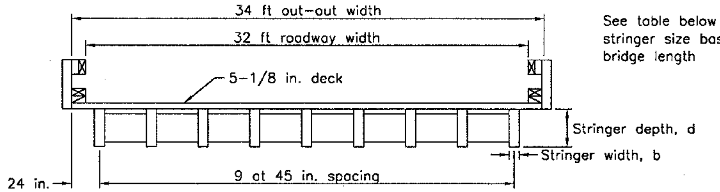
See table below for stringer size based on bridge length

Table 6.4 – Glulam Stringer Sizes for Double Lane Bridges with a 28-ft Roadway Width

Bridge Length (ft)	Bridge Span (ft)	Stringer Dimensions (in.)											
		Southern Pine 24F-V3				Southern Pine 26F-V3				Western Species 24F-V4			
		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading		HS20-44 Loading		HS25-44 Loading	
		b	d	b	d	b	d	b	d	b	d	b	d
20	19	6¾	16½	6¾	19¼	6¾	16½	6¾	17⅞	6¾	18	6¾	19½
22	21	6¾	17⅞	6¾	20⅝	6¾	17⅞	6¾	19¼	6¾	18	6¾	21
24	23	6¾	19¼	6¾	20⅝	6¾	19¼	6¾	20⅝	6¾	19½	6¾	22½
26	25	6¾	22	6¾	23⅜	6¾	20⅝	6¾	23⅜	6¾	21	6¾	24
28	27	6¾	23⅜	6¾	24¾	6¾	23⅜	6¾	24¾	6¾	24	6¾	25½
30	29	6¾	24¾	6¾	26⅛	6¾	24¾	6¾	26⅛	6¾	25½	6¾	27
32	31	6¾	26⅛	6¾	28⅞	6¾	26⅛	6¾	27½	6¾	27	6¾	28½
34	33	6¾	27½	6¾	30¼	6¾	27½	6¾	28⅞	6¾	28½	6¾	30
36	35	6¾	28⅞	6¾	31⅝	6¾	28⅞	6¾	30¼	6¾	30	6¾	31½
38	37	6¾	30¼	6¾	33	6¾	30¼	6¾	31⅝	6¾	31½	6¾	34½
40	39	6¾	31⅝	6¾	34⅜	6¾	31⅝	6¾	33	6¾	33	6¾	36
42	41	6¾	33	6¾	35¾	6¾	33	6¾	34⅜	6¾	34½	6¾	37½
44	43	6¾	34⅜	6¾	37⅛	6¾	34¾	6¾	35¾	6¾	36	6¾	39
46	45	6¾	35¾	6¾	38½	6¾	34⅜	6¾	37⅛	6¾	37½	8¾	36
48	47.00	6¾	37⅛	6¾	39⅞	6¾	35¾	6¾	38½	6¾	39	8¾	37½
50	49	6¾	38½	8½	38½	6¾	37⅛	6¾	39⅞	8¾	36	8¾	39
52	51	6¾	39⅞	8½	39⅞	6¾	38½	8½	38½	8¾	37½	8¾	40½
54	53	8½	37⅛	8½	39⅞	6¾	39⅞	8½	39⅞	8¾	39	8¾	42
56	55	8½	38½	8½	41¼	8½	38½	8½	41¼	8¾	40½	8¾	43½
58	57	8½	39⅞	8½	42⅝	8½	38½	8½	42⅝	8¾	42	8¾	45
60	59	8½	41¼	8½	44	8½	39⅞	8½	42⅝	8¾	43½	8¾	46½
62	61	8½	41¼	8½	45⅜	8½	41¼	8½	44	8¾	43½	8¾	48
64	63	8½	42⅝	8½	45⅜	8½	42⅝	8½	45⅜	8¾	45	8¾	49½
66	65	8½	44	8½	46¾	8½	42⅝	8½	46¾	8¾	46½	8¾	51
68	67	8½	45⅜	8½	48⅛	8½	44	8½	46¾	8¾	48	10¾	48
70	69	8½	45⅜	8½	49½	8½	45⅜	8½	48⅛	8¾	49½	10¾	49½
72	71	8½	46¾	10½	46¾	8½	45⅜	8½	49½	8¾	51	10¾	51
74	73	8½	48⅛	10½	48⅛	8½	46¾	10½	46¾	10¾	48	10¾	52½
76	75	8½	49½	10½	48⅛	8½	48⅛	10½	48⅛	10¾	49½	10¾	52½
78	77	10½	46¾	10½	49½	8½	48⅛	10½	48⅛	10¾	51	10¾	54
80	79	10½	46¾	10½	50⅞	8½	49½	10½	49½	10¾	51	10¾	55½

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Stringer Configuration and Size - 32-ft Roadway Width

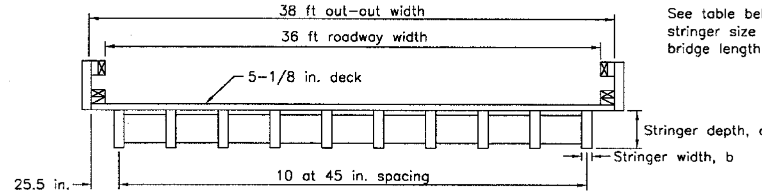


See table below for stringer size based on bridge length

Table 6.5 – Glulam Stringer Sizes for Double Lane Bridges with a 32-ft Roadway Width

Bridge Length	Bridge Span	Stringer Dimensions (in.)											
		Southern Pine 24F–V3				Southern Pine 26F–V3				Western Species 24F–V4			
(ft)	(ft)	HS20–44 Loading		HS25–44 Loading		HS20–44 Loading		HS25–44 Loading		HS20–44 Loading		HS25–44 Loading	
		b	d	b	d	b	d	b	d	b	d	b	d
20	19		17⅞		19¼		16½		17⅞		18		19½
22	21		17⅞		20⅝		17⅞		19¼		18		21
24	23		19¼		20⅝		19¼		20⅝		19½		22½
26	25		22		22		20⅝		22		21		24
28	27		22		24¾		22		23⅜		22½		25½
30	29		24¾		26⅛		23⅜		24¾		24		27
32	31		24¾		27½		24¾		26⅛		27	6¾	28½
34	33		26⅛	6¾	28⅞		26⅛	6¾	28⅞	6¾	28½		30
36	35	6¾	28⅞		30¼	6¾	27½		30¼		30		31½
38	37		30¼		33		28⅞		31⅝		31½		34½
40	39		31⅝		34⅜		30¼		33		33		36
42	41		33		35¾		31⅝		34⅜		34½		37½
44	43		34⅜		37⅛		33		35¾		36		39
46	45		35¾		38½		34⅜		37⅛		37½		36
48	47		37⅛		39⅞		35¾		38½		39		37½
50	49		38½		37⅛		37⅛		39⅞		36		39
52	51		39⅞		38½		39⅞		37⅛		37½		40½
54	53		37⅛		39⅞		35¾		38½		39		42
56	55		38½		41¼		37⅛		39⅞		40½	8¾	43½
58	57		39⅞		42⅝		37⅛		41¼		42		45
60	59		39⅞	8½	44		38½		42⅝		43½		46½
62	61		41¼		45⅜		39⅞	8½	42⅝	8¾	45		48
64	63		42⅝		46¾		41¼		44		46½		49½
66	65	8½	44		48⅛		42⅝		45⅜		46½		51
68	67		45⅜		48⅛	8½	42⅝		46¾		48		48
70	69		46¾		49½		44		48⅛		49½		49½
72	71		48⅛		46¾		45⅜		49½		51		51
74	73		48⅛		48⅛		46¾		45⅜		48	10¾	52½
76	75		49½	10½	49½		48⅛		46¾		49½		54
78	77	10½	46¾		49½		49½	10½	48⅛	10¾	51		55½
80	79		48⅛		50⅞		49½		49½		52½		55½

Stringer Configuration and Size - 36-ft Roadway Width



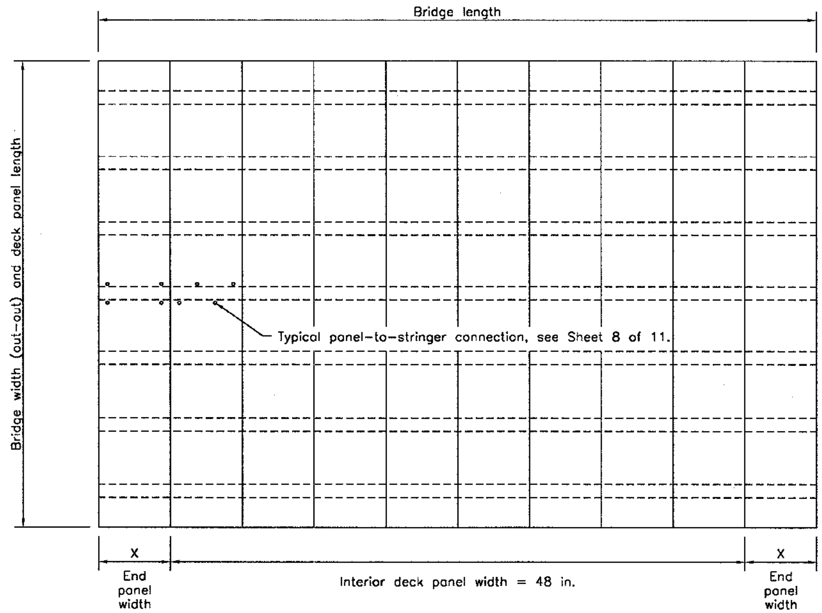
See table below for stringer size based on bridge length

Table 6.6 – Glulam Stringer Sizes for Double Lane Bridges with a 36-ft Roadway Width

Bridge Length	Bridge Span	Stringer Dimensions (in.)											
		Southern Pine 24F–V3				Southern Pine 26F–V3				Western Species 24F–V4			
(ft)	(ft)	HS20–44 Loading		HS25–44 Loading		HS20–44 Loading		HS25–44 Loading		HS20–44 Loading		HS25–44 Loading	
		b	d	b	d	b	d	b	d	b	d	b	d
20	19		17⅞		19¼		16½		17⅞		18		19½
22	21		19¼		20⅝		17⅞		19¼		19½		21
24	23		19¼		22		19¼		20⅝		21		22½
26	25		20⅝		23⅜		20⅝		22		22½		24
28	27		23⅜		24¾		22		23⅜		24		25½
30	29		24¾		26⅛		23⅜		26⅛		25½	6¾	27
32	31		26⅛	6¾	27½		24¾		27½	6¾	27		30
34	33		27½		30¼		26⅛	6¾	28⅞		28½		31½
36	35	6¾	28⅞		31⅝	6¾	27½		30¼		30		33
38	37		30¼		33		28⅞		31⅝		31½		34½
40	39		31⅝		34⅜		30¼		33		33		36
42	41		33		35¾		31⅝		34⅜		34½		39
44	43		34⅜		38½		33		35¾		36		36
46	45		35¾		39⅞		34⅜		37⅛		39		37½
48	47		37⅛		37⅛		35¾		38½		36		39
50	49		38½		38½		37⅛		37⅛		37½		40½
52	51		39⅞		39⅞		39⅞		37⅛		39		42
54	53		37⅛		41¼		39⅞		38½		40½	8¾	43½
56	55		38½		42⅝		37⅛		39⅞		40½		45
58	57		39⅞	8½	44		38½		41¼	8¾	42		46½
60	59		41¼		44		39⅞		42⅝		43½		48
62	61		42⅝		45⅜		41¼	8½	44		45		49½
64	63	8½	44		46¾		41¼		45⅜		46½		51
66	65		45⅜		48⅛	8½	42⅝		46¾		48		48
68	67		45⅜		49½		44		48⅛		49½		49½
70	69		46¾		46¾		45⅜		49½		51		51
72	71		48⅛		48⅛		46¾		49½		48	10¾	52½
74	73		49½	10½	48⅛		48⅛		46¾		49½		52½
76	75		46¾		49½		48⅛	10½	48⅛	10¾	51		54
78	77	10½	46¾		50⅞		49½		49½		52½		55½
80	79		48⅛		52¼	10½	46¾		49½		52½		57

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Deck Panel Layout for Unskewed Bridges



Plan view

Notes

1. This sheet depicts glulam deck panel layouts for unskewed bridges. Refer to Sheet 7 of 11 for deck panel layouts for skewed bridges.

2. All deck panels are 5 1/8-in.-thick with a standard interior panel width of 48-in. The required number of interior deck panels and the end panel width (X) are based on bridge length and are given in Table 6.7. Panel length is equal to the out-out deck width.

3. Deck panels are attached to the supporting stringers with cast aluminum deck brackets and 5/8-in.-diameter bolts as shown on Sheet 8 of 11.

Table 6.7 – Deck Panel Layout

Bridge Length (ft)	End Panel Width, X (ft)	Number of Interior Panels
20	4	3
22	3	4
24	4	4
26	3	5
28	4	5
30	3	6
32	4	6
34	3	7
36	4	7
38	3	8
40	4	8
42	3	9
44	4	9
46	3	10
48	4	10
50	3	11
52	4	11
54	3	12
56	4	12
58	3	13
60	4	13
62	3	14
64	4	14
66	3	15
68	4	15
70	3	16
72	4	16
74	3	17
76	4	17
78	3	18
80	4	18

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Stringer and Transverse Deck

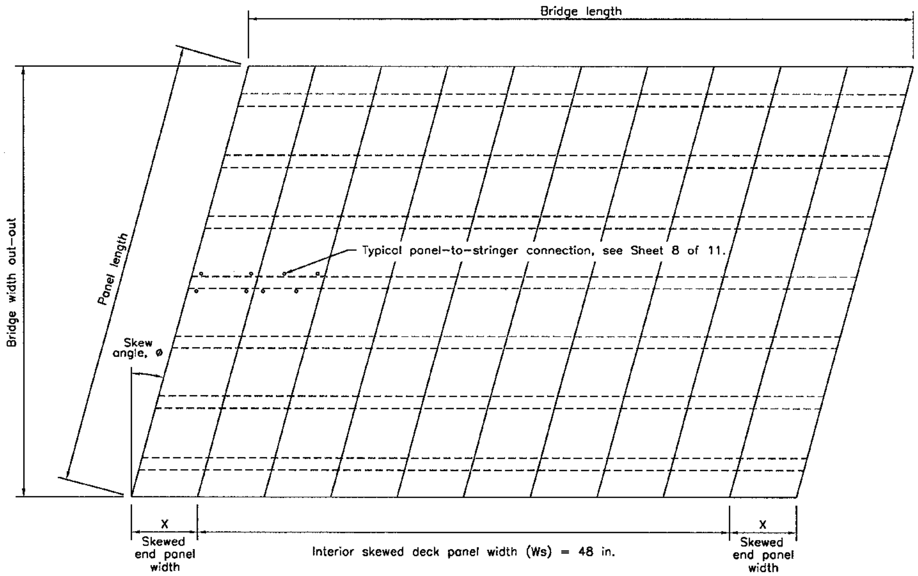
Standard Plans for Timber Bridge Superstructures

Deck Panel Layout - Unskewed Bridges

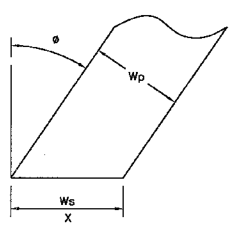
December 2000

Sheet 6 of 11

Deck Panel Layout for Skewed Bridges



Plan view



Wp = (Ws * Cos ø) for interior panels
Wp = (X * Cos ø) for end panels

where
Wp = perpendicular panel width (in.)
Ws = skewed panel width (in.)
X = skewed end panel width (see Table 6.8)
ø = skew angle

Detail A - Panel Widths
Plan view

Notes

1. This sheet depicts glulam deck panel layouts for skewed bridges. Refer to Sheet 6 of 11 for deck panel layouts for unskewed bridges.

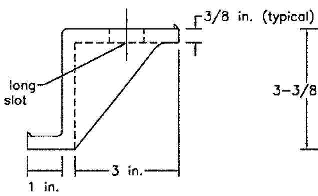
2. All deck panels are 5 1/8-in.-thick with a standard interior panel skewed width (W_s) of 48-in. (see Detail A). The required number of interior deck panels and the end panel skewed width (X) are based on bridge length and are given in Table 6.8. The perpendicular deck panel width (W_p) varies based on skew angle and is calculated using the equation in Detail A. Panel length is equal to the out-out deck width measured parallel to the skew.

3. Deck panels are attached to the supporting stringers with cast aluminum deck brackets and 5/8-in.-diameter bolts as shown on Sheet 8 of 11.

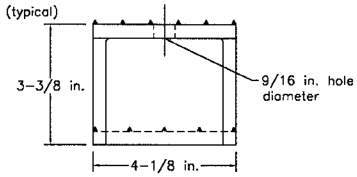
Table 6.8 – Deck Panel Layout

Bridge Length (ft)	Skewed End Panel Width, X (ft)	No. of Interior Panels
20	4	3
22	3	4
24	4	4
26	3	5
28	4	5
30	3	6
32	4	6
34	3	7
36	4	7
38	3	8
40	4	8
42	3	9
44	4	9
46	3	10
48	4	10
50	3	11
52	4	11
54	3	12
56	4	12
58	3	13
60	4	13
62	3	14
64	4	14
66	3	15
68	4	15
70	3	16
72	4	16
74	3	17
76	4	17
78	3	18
80	4	18

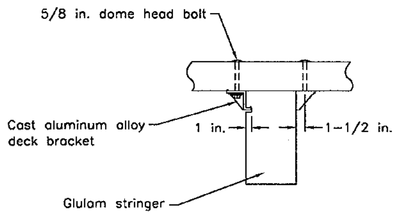
Deck Panel Attachment Details



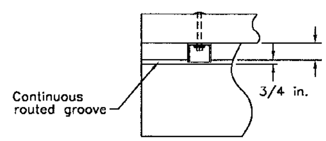
Deck Bracket
Side view



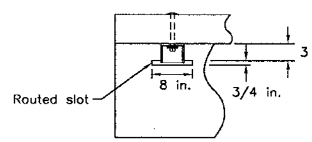
Deck Bracket
End view



Deck Panel Connection
End view



Groove Option
Side view



Slot Option
Side view

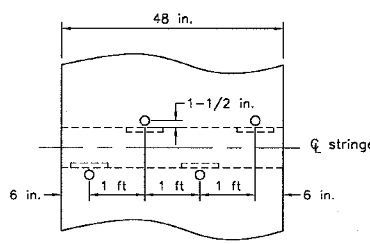
Notes

1. Deck panels are attached to the supporting stringers with 5/8-in.-diameter dome-head bolts and cast aluminum alloy deck brackets. The deck brackets are typically available from glulam manufacturers and bridge suppliers. For additional information on the cast aluminum deck brackets and other deck attachment alternatives, refer to *Timber Bridges: Design, Construction, Inspection, and Maintenance* (Ritter 1990).

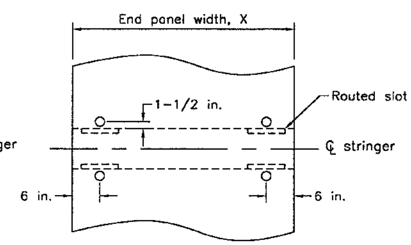
2. As shown on the drawings, deck brackets connect to stringer sides in ¾- by 8-in. slots or in continuous ¾-in.-wide grooves.

3. When placing the deck panels, brackets should be attached to the stringers and nuts hand tightened. Nuts should not be completely tightened until all deck panels are in place and properly aligned.

Deck Panel Connection Placement - Unskewed Bridges



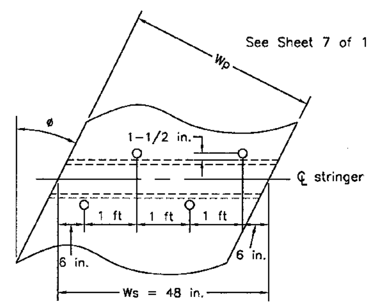
Interior Panel
Plan view



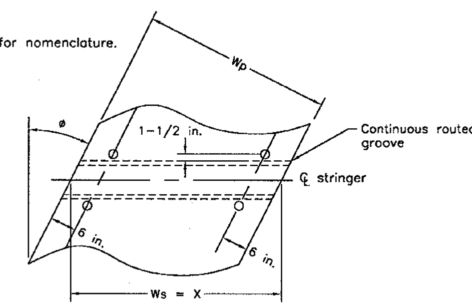
End Panel
Plan view

Deck Panel Connection Placement - Skewed Bridges

See Sheet 7 of 11 for nomenclature.



Interior Panel
Plan view

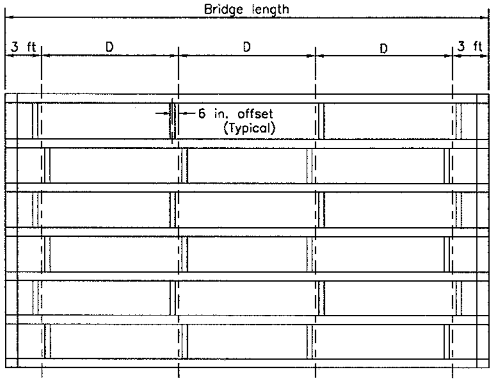


End Panel
Plan view

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

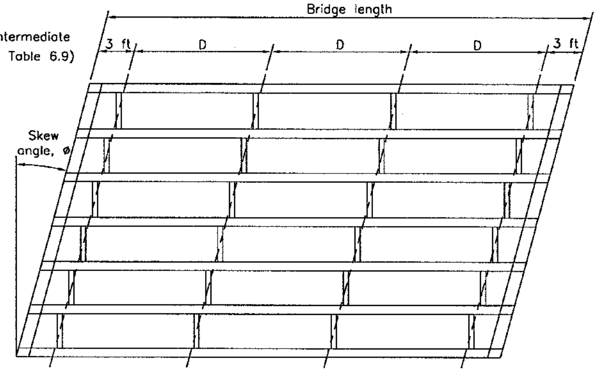
Glulam Stringer and Transverse Deck	Deck Panel Attachment Details	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 8 of 11

Glulam Diaphragm Layout



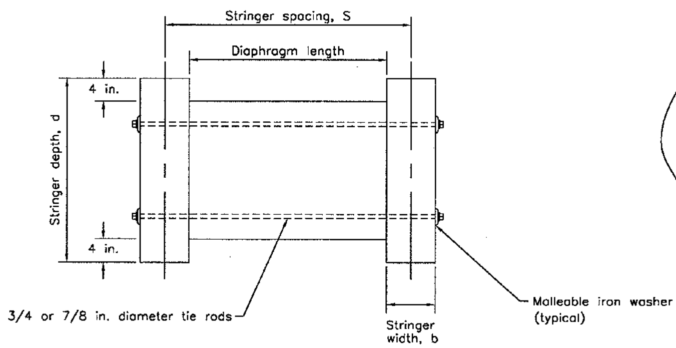
Unskewed Bridges
Plan view

D = Diaphragm intermediate spacing (see Table 6.9)

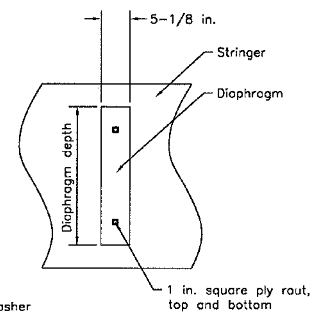


Skewed Bridges
Plan view

Diaphragm-to-Stringer Connection



End view



Side view

Notes

1. This sheet depicts glulam diaphragms. Refer to Sheet 10 of 11 for steel diaphragms.

2. The number and spacing of diaphragms depends on bridge length and is based on requirements for beam stability and alignment. This design limits diaphragm spacing to 18.5-ft. If beams are rigidly attached to an end wall, such as timber backing planks, the diaphragms can be uniformly spaced. If beams are not rigidly supported at their ends, diaphragms must be placed within 3-ft of the bridge ends. See Table 6.9 for intermediate diaphragm spacing and the total number of diaphragms required.

3. All diaphragms are 5-⅛-in.-thick glulam and may be the same combination symbol as the deck panels or the stringers. Alternatively, Southern Pine Combination 48 or Western Species Combination 2 may be used as diaphragms. Diaphragm height is equal to the stringer depth minus 8-in. Diaphragm length is equal to the clear distance between stringers minus ⅛-in.

4. Diaphragms for unskewed and skewed bridges are placed perpendicular to stringers. Adjacent diaphragms are offset to allow placement and access to connection hardware. For unskewed bridges, the typical offset distance is 6-in. For skewed bridges, the offset distance will vary depending on the skew angle.

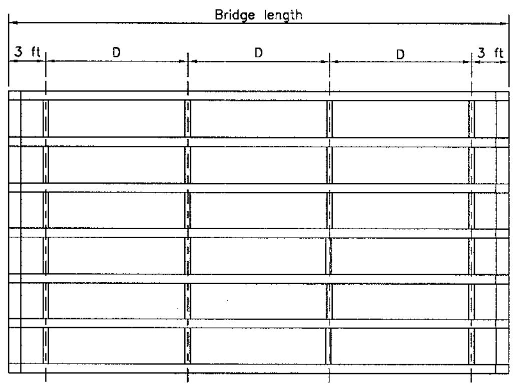
5. Diaphragms are attached between stringers with ¾- or ⅞-in. diameter tie rods that extend through the diaphragms in 1-in.-square ply routs. The ply routs are centered on the diaphragm width and are generally placed at the third glue line from the diaphragm top and bottom.

Table 6.9 – Diaphragm Spacing

Bridge Length (ft)	Required Number	Intermediate Spacing, D (ft)
20	2	14
22	2	16
24	2	18
26	3	10
28	3	11
30	3	12
32	3	13
34	3	14
36	3	15
38	3	16
40	3	17
42	3	18
44	4	12.67
46	4	13.33
48	4	14
50	4	14.67
52	4	15.33
54	4	16
56	4	16.67
58	4	17.33
60	4	18
62	5	14
64	5	14.50
66	5	15
68	5	15.50
70	5	16
72	5	16.50
74	5	17
76	5	17.50
78	5	18
80	5	18.50

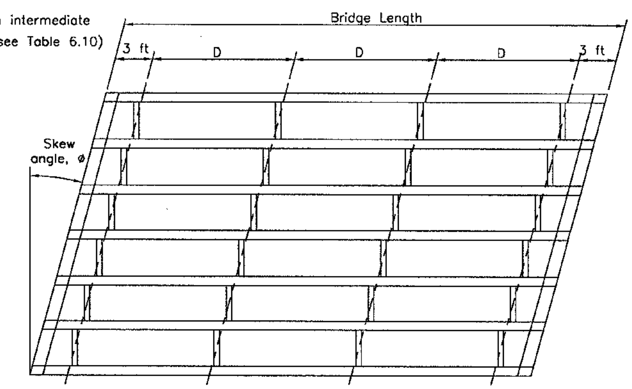
The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Steel Diaphragm Layout



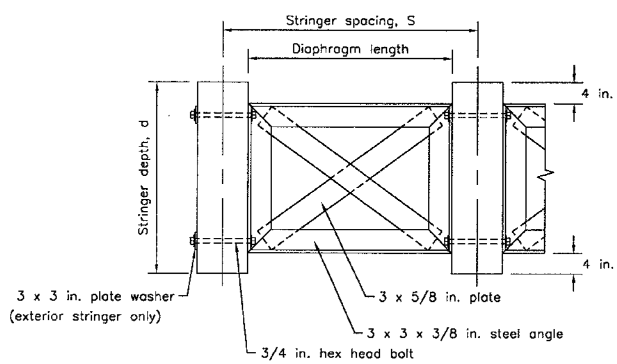
Unskewed Bridges
Plan view

D = Diaphragm intermediate spacing (see Table 6.10)

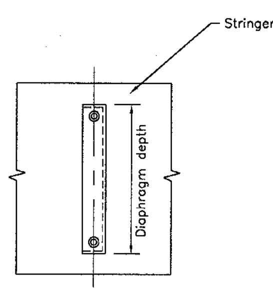


Skewed Bridges
Plan view

Diaphragm-to-Stringer Connection



End view



Side view

Notes

1. This sheet depicts steel diaphragms. Refer to Sheet 9 of 11 for glulam diaphragms.

2. The number and spacing of diaphragms depends on bridge length and is based on requirements for beam stability and alignment. This design limits diaphragm spacing to 18.5–ft. If beams are rigidly attached to an end wall, such as timber backing planks, the diaphragms can be uniformly spaced. If beams are not rigidly supported at their ends, diaphragms must be placed within 3–ft of the bridge ends. See Table 6.10 for intermediate diaphragm spacing and the total number of diaphragms required.

3. Diaphragms are welded from steel angles and plates and shall be galvanized or otherwise protected from corrosion. Diaphragm height is equal to the stringer depth minus 8–in. Diaphragm length is equal to the clear distance between stringers minus ⅛–in.

4. Diaphragms for unskewed and skewed bridges are placed perpendicular to stringers. For unskewed bridges, diaphragms are aligned and connected through the stringers. For skewed bridges, adjacent diaphragms are offset a distance that depends on the skew angle.

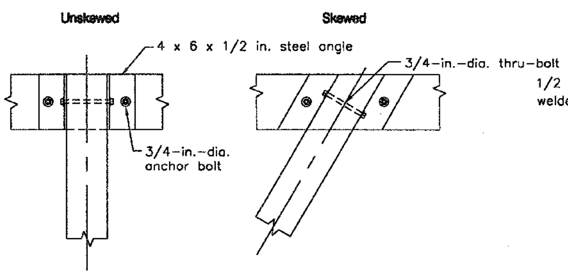
5. Diaphragms are attached to the stringer with ¾–in.–diameter bolts that extend through 13/16–in. prebored bolt holes in the stringers and diaphragms.

Table 6.10 – Diaphragm Spacing

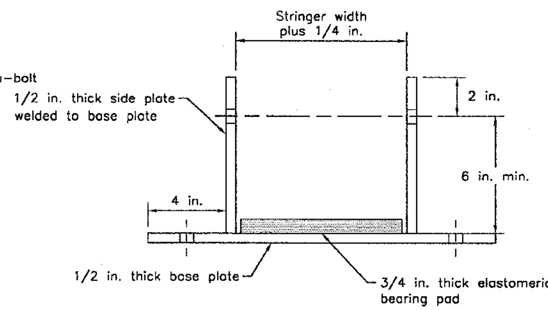
Bridge Length (ft)	Required Number	Intermediate Spacing, D (ft)
20	2	14
22	2	16
24	2	18
26	3	10
28	3	11
30	3	12
32	3	13
34	3	14
36	3	15
38	3	16
40	3	17
42	3	18
44	4	12.67
46	4	13.33
48	4	14
50	4	14.67
52	4	15.33
54	4	16
56	4	16.67
58	4	17.33
60	4	18
62	5	14
64	5	14.50
66	5	15
68	5	15.50
70	5	16
72	5	16.50
74	5	17
76	5	17.50
78	5	18
80	5	18.50

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

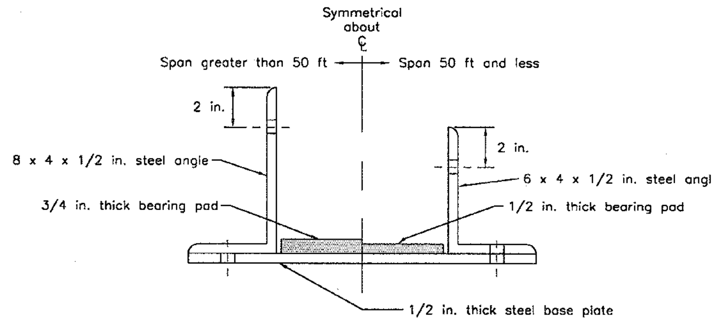
Bearing Connection Details for Glulam Stringers



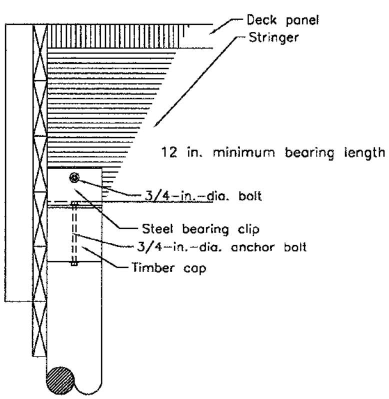
Bearing Clip Configuration
Plan view



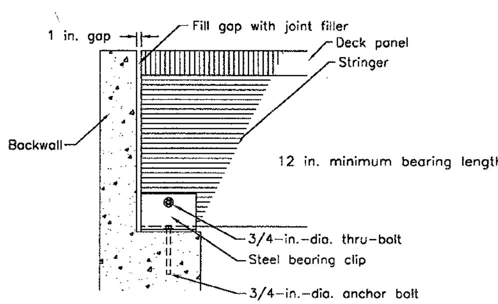
Steel Plate Bearing Shoe
End view



Steel Angle Bearing Shoe
End view



Timber Substructure Connection
Side view



Concrete Substructure Connection
Side view

Notes

1. This sheet shows several suggested substructure attachment details that are commonly used for glulam stringer bridges. Attachment details for specific bridges may vary and should be verified based on site–specific loads and other design requirements. For additional information, refer to *AASHTO Standard Specifications for Highway Bridges* and *Timber Bridges: Design, Construction, Inspection, and Maintenance* (Ritter 1990).

2. This standard assumes 12–in. bearing lengths at all supports. Site–specific seismic conditions may require additional bearing length. All bridges should be evaluated by a qualified professional engineer for AASHTO seismic requirements.

3. The number of attachment bolts used with the bearing clip to fasten the stringer to the abutment sill will depend on specific loading requirements. Bearing clip bolt holes may be slotted or oversized as necessary to allow for stringer rotation and construction tolerances, provided there is adequate restraint to resist applied loads.

4. Bearing pads, when needed, shall be a minimum 50 durometer neoprene with a minimum thickness of 1/2–in. (see detail on this page).

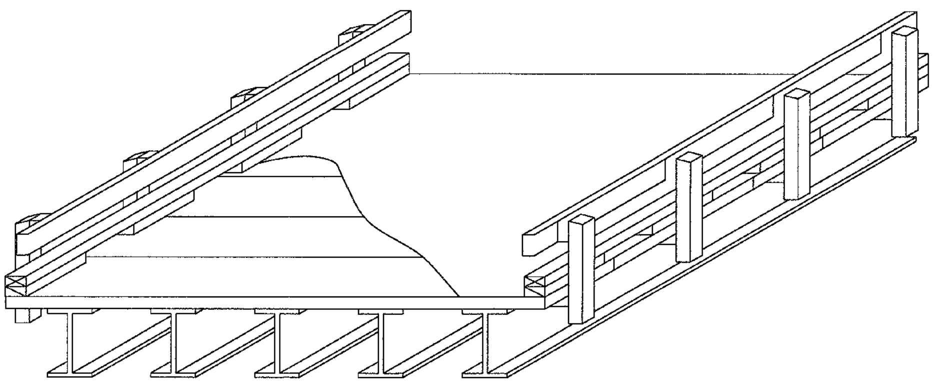
5. When attachment is to a concrete support and backwall, a minimum 1–in. gap should remain between the superstructure and backwall to allow for possible expansion of the deck due to increases in moisture content. The gap should be filled with an expanding joint filler to prevent debris and water from passing through to the bearings.

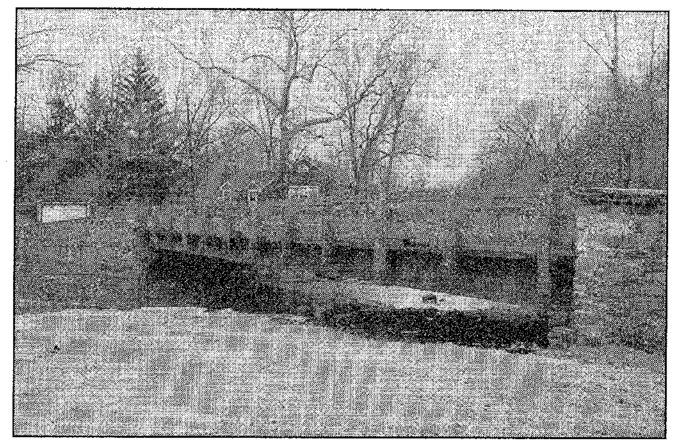
The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Stringer and Transverse Deck	Bearing Connection Details	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 11 of 11

Beam Systems:

Transverse Glulam Decks for Steel Beam Bridges

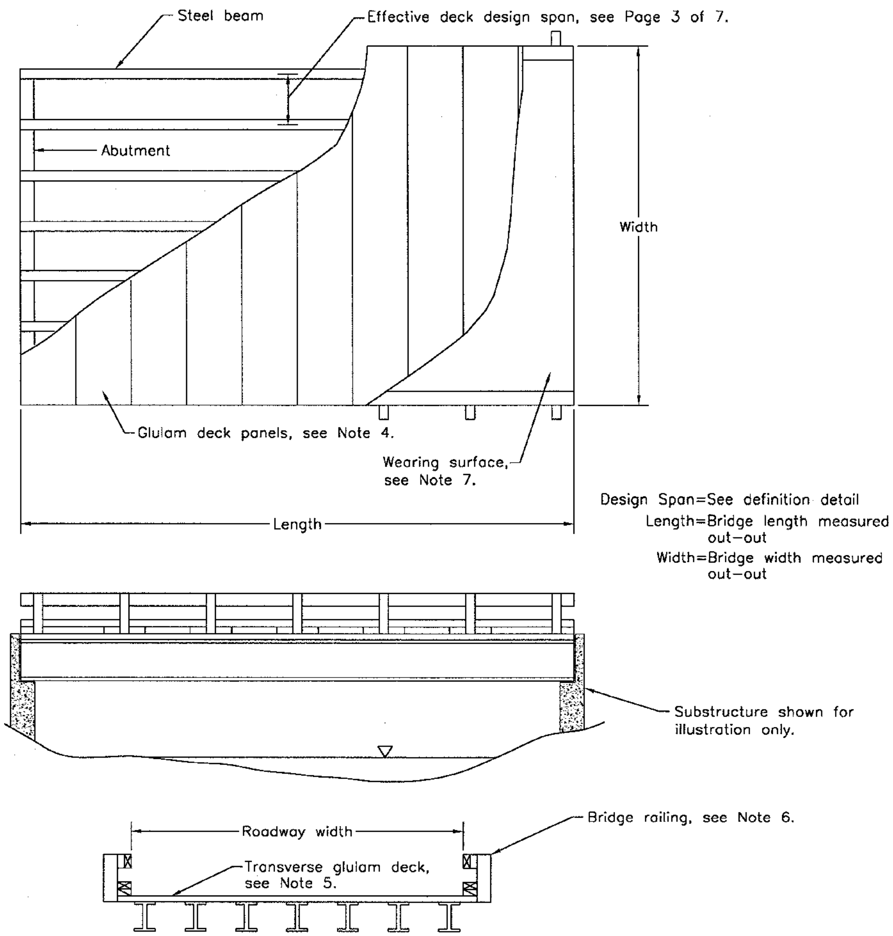




The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Decks for Steel Beam Bridges	Title Page	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 1 of 7

Plan, Profile, and Section Views



General Notes

DESIGN

1. These drawings are for transverse glulam decks on steel wide flange beams or steel plate girders. The designs are applicable for unskewed and skewed bridges with deck thicknesses of 5- to 8-3/4–in. Design truck loading is AASHTO HS 20–44 or HS 25–44 with deck live load deflection limited to 0.10–in.

2. The designs comply with the 1996 *Standard Specifications for Highway Bridges*, with 1998 Interims, published by the American Association of State Highway and Transportation Officials (AASHTO), except where noted. The effective deck design span is equal to the clear distance between supports plus one–half the width of one support, but not greater than the clear span plus the deck thickness. The deck overhang, measured from the deck edge to the center of the outside beam is limited to 2.5–ft. A longer overhang is permissible provided the design is verified by a qualified professional engineer for actual loading and deck material properties. All transverse glulam panels were designed assuming single–piece laminations.

3. As specified by AASHTO, transverse glulam decks that are placed upon two or three steel beams are designed as simple spans. Transverse glulam decks that are place upon four or more steel beams are designed as simple spans but maximum moment and deflection are reduced by 20 percent to account for the effects of span continuity. The transverse glulam decks included in these standards were designed as non–interconnected panels. Transverse glulam decks may also be interconnected using steel dowels (refer to AASHTO for detailed design information).

4. Deck panels are 5- to 8-3/4–in.–thick (standard Southern Pine and Western Species glulam sizes) and are typically 4–ft wide. The width and layout of deck panels are shown on Sheet 4 of 7 for unskewed and Sheet 5 of 7 for skewed bridges. Attachment of deck panels to supporting stringers is with 5/8–in.–diameter dome–head bolts and deck clips or angle brackets as shown on Sheet 3 of 7.

5. Minimum required timber design values are provided for deck spans of 2- to 9–ft. The required minimum deck thickness for a specific deck span can be selected from tables on Sheet 6 of 7 (for decks on 4 or more steel beams) and Sheet 7 of 7 (for decks on 2 or 3 steel beams), based on material, loading and beam spacing.

6. Bridge rail and curb drawings are for illustration purposes only and must be designed based on site–specific requirements. Deck designs are based on an assumed dead load of 10 lb/ft^2 for the rail and curb system. Crashworthy rail designs are available in *Development of Two TL–2 Bridge Railings and Transitions for Use on Transverse Glue–Laminated Deck Bridges* (Faller et al. In Press).

7. An asphalt wearing surface with a geotextile fabric or membrane is recommended for most timber bridge applications. Designs are based on an assumed dead load of 38 lb/ft^2 for an asphalt wearing surface (approximately 3–in.). Refer to Page 53 for recommended asphalt wearing surface construction details.

8. These designs are intended for informational purposes only and, due to potential changes in design requirements and use conditions, should be verified by a qualified professional engineer.

MATERIAL AND FABRICATION

Wood
9. Glulam deck panels shall comply with the requirements of AASHTO M168 and ANSI/AITC A190.1 and shall be manufactured to an industrial appearance grade using wet–use adhesives.

10. Any species and combination of glulam may be used provided it is treatable with wood preservatives and tabulated design values are provided in the AASHTO *Standard Specifications for Highway Bridges*. Deck panel glulam combinations should be selected from the tables for "members stressed primarily in axial tension or compression".

11. Insofar as is practical, all glulam shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives. Refer to Sheet 4 of 7 (unskewed bridges) and Sheet 5 of 7 (skewed bridges) for layout details.

Preservative Treatment
12. All glulam shall be treated in accordance with AASHTO M133 and AWPA Standard C14 with one of the following preservatives:

a. Coal tar creosote conforming to AWPA Standard P1/P13
b. Suitable oilborne preservatives conforming to AWPA Standard P8 in hydrocarbon solvent, Type A or Type C.

13. Treated material shall follow post–treatment requirements summarized in *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (WWPI 1996) to ensure all surfaces are free of excess preservative and chemicals are fixated in the wood.

14. Preservative treatment shall be inspected and certified in accordance with AASHTO M133 and AWPA Standard M2.

Steel Fasteners and Hardware
15. Steel plates and shapes shall comply with the requirements of ASTM A36. C–clips should comply with the requirements of grade 30 cast iron.

16. Bolts shall comply with the requirements of ANSI/ASME Standard B18.2.1–1981, Grade 2.

17. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232, or otherwise protected from corrosion.

18. Washers shall be provided under bolt heads and under nuts that are in contact with wood. Washers may be omitted under heads of special timber bolts or dome–head bolts when the size and strength of the head is sufficient to develop connection strength without wood crushing.

CONSTRUCTION

19. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, exposed untreated wood shall be field treated in accordance with AASHTO M133. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

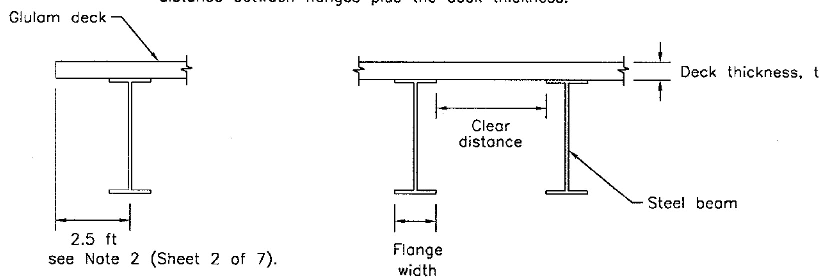
20. Deck panels should be placed after stringers and diaphragms are set and secured. A common construction procedure is to place the first panel at midspan, then sequentially place remaining panels outward toward the abutments. Attachment hardware should be hand–tightened as the panels are placed, then securely tightened after all panels are placed and aligned.

21. The application of a bituminous sealer is recommended to prevent excessive wood checking in areas where the wood end grain is exposed. Vertical joint surfaces between glulam deck panels should also be coated to minimize moisture penetration. Any commercially available roofing cement is effective.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

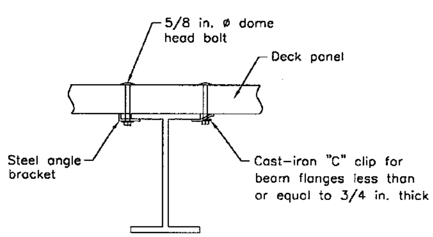
Effective Deck Design Span

Per AASHTO specifications, the effective deck design span shall be equal to the clear distance between beam flanges plus 1/2 the width of one flange, but not greater than the clear distance between flanges plus the deck thickness.



To determine required deck thickness, see Tables 7.1 and 7.2.

Deck Attachment



Thru-Bolt Attachment
End view

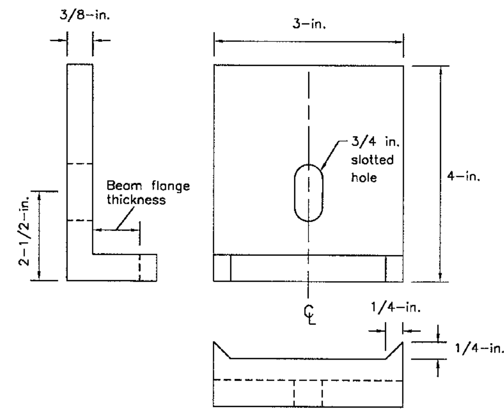
Notes

1. For steel beam flanges less than ¾-in.-thick, use a grade 30, cast iron "C" clip. For steel beam flanges greater than ¾-in.-thick, use an A36 steel angle bracket.

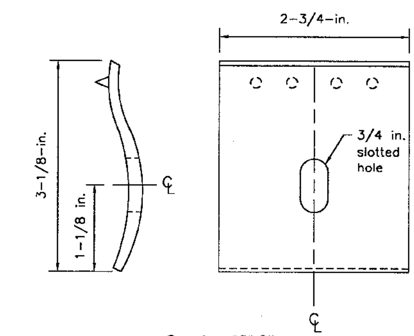
2. Both connector types should have slotted holes sized to two or three times the bolt diameter. See details on this page.

3. For connector hole placement on glulam deck panels, see Sheet 4 of 7 (unskewed bridges) and Sheet 5 of 7 (skewed bridges).

Fabrication Details



Steel Angle Bracket

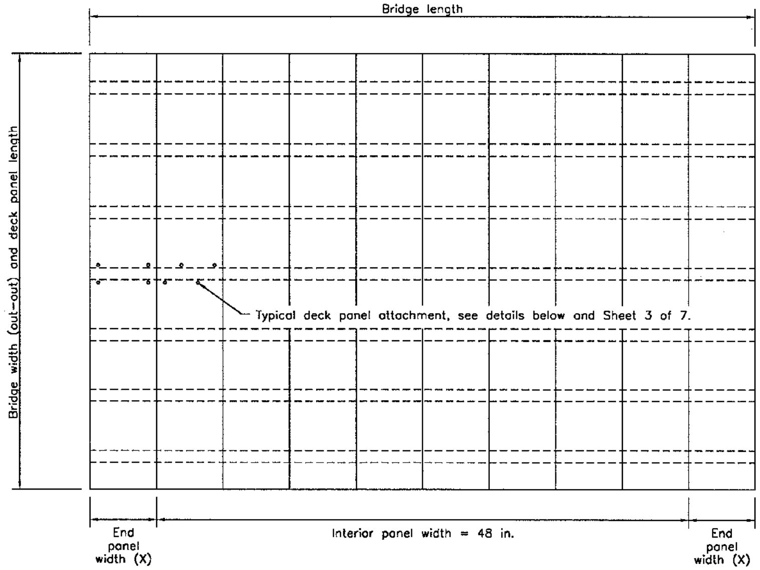


Cast-Iron "C" Clip

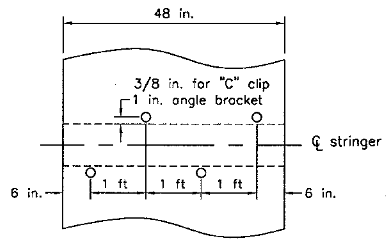
The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Decks for Steel Beam Bridges	Span Definition & Deck Attachment	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 3 of 7

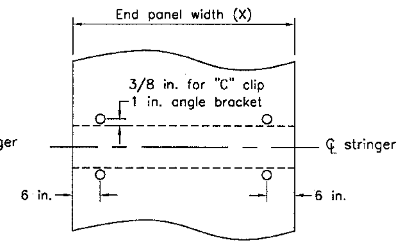
Glulam Deck Panel Layout - Unskewed Bridges



Plan View



Attachment Spacing - Interior Panel
Plan view



Attachment Spacing - End Panel
Plan view

Notes

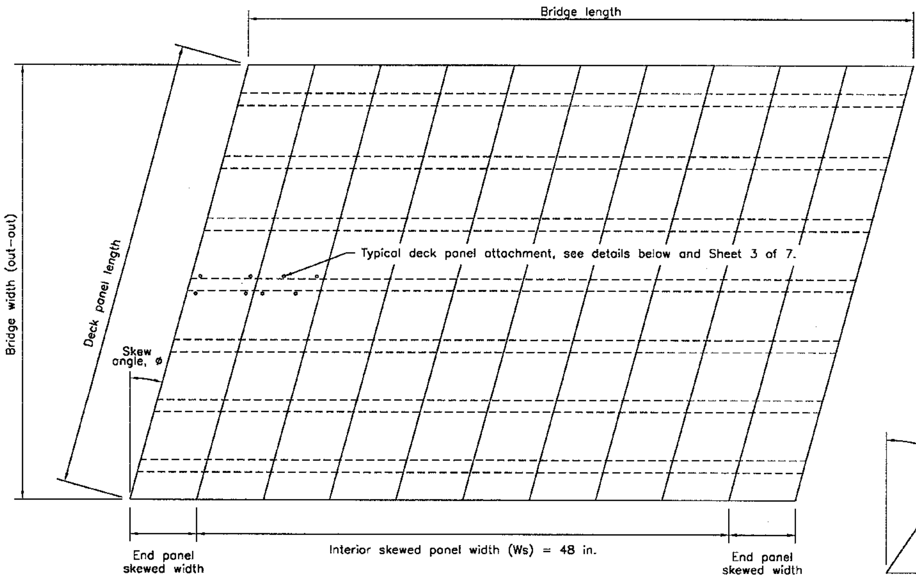
1. This sheet depicts glulam deck panel layouts for unskewed bridges and deck attachment details. Refer to Sheet 5 of 7 for deck panel layouts for skewed bridges.

2. The required number of interior deck panels and the end panel width (X) are based on bridge length. Interior panels have a standard width of 48–in. End panel width depends on bridge span but shall not be less than 3–ft. Deck panel length is equal to the out–out deck width.

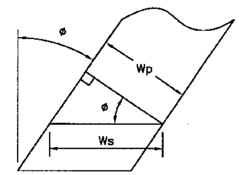
3. Deck panels are attached to the supporting stringers with cast–iron "C" clips or steel angle brackets as shown on Sheet 3 of 7. "C" clips are commonly available from glulam bridge suppliers and are suitable when the beam flange thickness does not exceed 3/4–in. Angle brackets are normally fabricated from A36 steel angles and can be made for any flange thickness.

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Deck Panel Layout - Skewed Bridges



Plan View



Notes

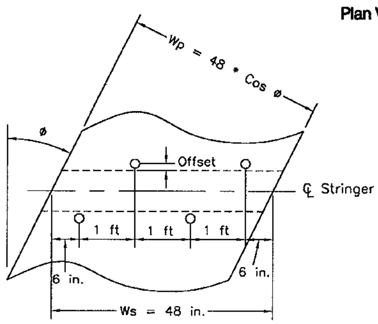
1. This sheet depicts glulam deck panel layouts for skewed bridges. Refer to Sheet 4 of 7 for deck panel layouts for unskewed bridges.

2. The required number of interior deck panels and the end panel skewed width are based on bridge length. Interior panel skewed width (W_s) is 48-in. End panel skewed width depends on bridge span but shall not be less than 3-ft.

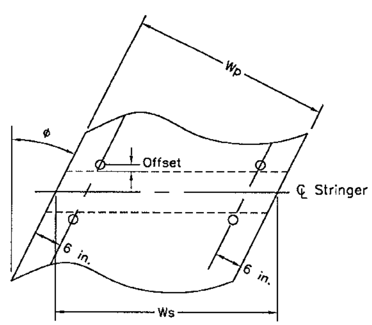
3. Deck panels are attached to the supporting stringers with cast-iron C clips or steel angle brackets as shown on Sheet 3 of 7. "C" clips are commonly available from glulam bridge suppliers and are suitable when the beam flange thickness does not exceed 3/4-in. Angle brackets are normally fabricated from A36 steel angles and can be made for any flange thickness.

Wp = Ws * Cos ø

where
ø = skew angle
Wp = perpendicular panel width (in.)
Ws = interior skewed panel width = 48 in.



Attachment Spacing - Interior Panel
Plan view



Attachment Spacing - End Panel
Plan view

Offset = 3/8-in. for "C" clip
= 1-in. for angle bracket

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the Federal Highway Administration, the USDA Forest Service, Forest Products Laboratory, and Laminated Concepts, Inc.

Glulam Decks for Steel Beam Bridges	Panel Layout - Skewed Bridges	
Standard Plans for Timber Bridge Superstructures	December 2000	Sheet 5 of 7

Table 7.1 – Design Table for Bridges with Four or More Steel Beams

Effective Deck Design Span (ft)	Minimum Required F_b' (lb/in^2) and E' (x10^6 lb/in^2) Values for Actual Deck Thickness[a] Ranging from 5– to 8¾–in.																			
	HS20–44 Loading										HS25–44 Loading									
	5		5⅛		6¾		8½		8¾		5		5⅛		6¾		8½		8¾	
	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'
2.00	449	0.29									622	0.48	589	0.44						
2.17	508	0.34									720	0.56	681	0.52						
2.33	567	0.39									817	0.65	773	0.60						
2.50	626	0.45									914	0.75	865	0.69						
2.67	685	0.51	648	0.47							1,012	0.85	957	0.79						
2.83	744	0.58	704	0.53							1,109	0.96	1,050	0.89						
3.00	803	0.65	760	0.60							1,207	1.08	1,142	1.00	611	0.40				
3.17	863	0.72	816	0.67							1,305	1.20	1,235	1.11	660	0.45				
3.33	922	0.80	872	0.74							1,403	1.33	1,327	1.23	710	0.50				
3.50	982	0.88	929	0.81							1,501	1.47	1,420	1.36	760	0.55				
3.67	1,041	0.97	985	0.89							1,599	1.61	1,513	1.49	809	0.60				
3.83	1,101	1.06	1,042	0.98							1,697	1.76	1,606	1.63	859	0.66				
4.00	1,161	1.15	1,099	1.06							1,796	1.92	1,699	1.77	909	0.71				
4.17	1,221	1.25	1,155	1.15	620	0.47							1,792	1.92	959	0.78				
4.33	1,281	1.35	1,212	1.25	650	0.51									1,009	0.84				
4.50	1,341	1.58	1,269	1.45	681	0.59									1,059	0.98	621	0.45		
4.67	1,402	1.76	1,326	1.62	712	0.66									1,109	1.09	650	0.51	607	0.46
4.83	1,462	1.95	1,384	1.80	742	0.73									1,159	1.22	680	0.56	635	0.51
5.00			1,441	1.99	773	0.81									1,210	1.35	709	0.62	663	0.57
5.17					804	0.89									1,260	1.49	739	0.69	690	0.62
5.33					835	0.98									1,310	1.63	768	0.76	718	0.69
5.50					866	1.07									1,361	1.79	798	0.83	746	0.75
5.67					897	1.18									1,411	1.96	828	0.91	773	0.82
5.83					928	1.28											857	0.99	801	0.90
6.00					959	1.40											887	1.08	829	0.98
6.17					991	1.52											917	1.17	857	1.06
6.33					1,022	1.64	602	0.76									947	1.27	885	1.15
6.50					1,053	1.77	620	0.82									977	1.37	913	1.24
6.67					1,085	1.91	639	0.89									1,007	1.48	941	1.34
6.83							657	0.96	615	0.87							1,037	1.59	969	1.44
7.00							676	1.03	632	0.93							1,067	1.71	997	1.55
7.17							695	1.10	650	1.00							1,097	1.84	1,025	1.67
7.33							714	1.18	667	1.07							1,127	1.97	1,053	1.79
7.50							733	1.26	685	1.15									1,081	1.91
7.67							751	1.35	703	1.22										
7.83							770	1.44	720	1.31										
8.00							789	1.53	738	1.39										
8.17							808	1.63	756	1.48										
8.33							827	1.73	774	1.57										
8.50							846	1.84	792	1.67										
8.67							866	1.95	810	1.77										
8.83									828	1.87										
9.00									846	1.98										

a – Western species glulam sizes are 5⅛–, 6¾–, and 8¾–in.;
Southern pine glulam sizes are 5–, 6¾–, and 8½–in.;

Table Instructions

The table on this sheet is for determining the required deck thickness for transverse glulam decks supported by four or more steel beams. The criteria for selecting deck thickness are based on the effective deck design span, vehicle loading, and material properties for the species and combination of glulam. The effective deck design span is equal to the clear distance between beam flanges plus one–half the width of one flange, but not greater than the clear distance between flanges plus the deck thickness. Live load deflection is limited to 0.10–in. for all deck thicknesses. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E'), based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft^2 for the railing/curb system and 38 lb/ft^2 for an asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the combination symbol and material species of glulam are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The computed allowable values must be greater that the table values in order to select the corresponding deck thickness. Alternatively, when the combination symbol and material species are unknown, minimum required F_b' and E' values may be obtained from the table based on effective deck design span, deck thickness, and vehicle loading. A grade and species of glulam that meets these minimum allowable design values may then be selected. Specific procedures for table use follow:

<u>Glulam Combination and Species Known</u>

1. Determine the required design criteria for
   a. effective deck design span and
   b. vehicle loading, AASHTO HS20–44 or HS25–44.

2. Compute the allowable design values for the combination symbol and species of glulam using the following equations:

$$F_b' = F_b\, C_M\, C_F\, C_D \qquad E' = E\, C_M$$

where
- F_b' = allowable bending stress (lb/in^2)
- F_b = tabulated bending stress (lb/in^2)
- E' = allowable modulus of elasticity (lb/in^2)
- E = tabulated modulus of elasticity (lb/in^2)
- C_M = wet service factor
- C_F = bending size factor
- C_D = load duration factor

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

<u>Glulam Combination Symbol and Species Unknown</u>

1. Determine the required design criteria for
   a. effective deck design span and
   b. vehicle loading, AASHTO HS20–44 or HS25–44.

2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

3. Select a glulam combination that provides the minimum allowable design values.

Table 7.2 – Design Table for Bridges with Two or Three Steel Beams

Effective Deck Design Span[b] (ft)	Minimum Required F_b' (lb/in²) and E' (x10⁶lb/in²) Values for Actual Deck Thickness[a], t, Ranging from 5– to 8¾–in.																			
	HS20-44 Loading										HS25-44 Loading									
	5		5⅛		6¾		8½		8¾		5		5⅛		6¾		8½		8¾	
	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'	F_b'	E'
3.00	1,000	0.78	946	0.72							1,505	1.30	1,424	1.20	761	0.48				
3.17	1,074	0.87	1,016	0.80							1,627	1.44	1,539	1.33	823	0.54				
3.33	1,148	0.96	1,086	0.89							1,749	1.60	1,654	1.48	885	0.60				
3.50	1,222	1.06	1,156	0.98	619	0.40					1,871	1.76	1770	1.63	946	0.66				
3.67	1,296	1.16	1,226	1.07	656	0.43					1,993	1.94	1,885	1.79	1,008	0.72				
3.83	1,370	1.27	1,296	1.17	694	0.47							2,001	1.95	1,070	0.79	626	0.37		
4.00	1,444	1.38	1,367	1.26	732	0.52									1,132	0.86	663	0.40	619	0.36
4.17	1,519	1.50	1,437	1.38	770	0.56									1,194	0.93	699	0.43	653	0.39
4.33	1,593	1.62	1,508	1.50	808	0.61									1,256	1.01	736	0.47	687	0.42
4.50	1,668	1.89	1,578	1.74	846	0.71									1,318	1.18	772	0.55	721	0.50
4.67	1,743	2.11	1,649	1.95	884	0.79									1,381	1.31	809	0.61	755	0.55
4.83			1,720	2.16	922	0.88									1,443	1.46	845	0.68	789	0.61
5.00					960	0.97									1,505	1.62	882	0.75	824	0.68
5.17					998	1.07									1,568	1.78	918	0.83	858	0.75
5.33					1,036	1.18	608	0.55							1,630	1.96	955	0.91	892	0.82
5.50					1,074	1.29	631	0.60									992	1.00	926	0.90
5.67					1,113	1.41	653	0.65	611	0.59							1,028	1.09	961	0.99
5.83					1,151	1.54	676	0.71	632	0.65							1,065	1.19	995	1.08
6.00					1,190	1.67	699	0.78	653	0.70							1,102	1.29	1,030	1.17
6.17					1,228	1.82	722	0.84	674	0.76							1,139	1.40	1,064	1.27
6.33					1,267	1.97	744	0.91	696	0.83							1,176	1.52	1,099	1.38
6.50					1,305	2.13	767	0.99	717	0.90							1,213	1.64	1,133	1.49
6.67							790	1.06	739	0.97							1,250	1.77	1,168	1.61
6.83							813	1.15	760	1.04							1,287	1.91	1,202	1.73
7.00							836	1.23	781	1.12									1,237	1.86
7.17							859	1.32	803	1.20									1,272	2.00
7.33							882	1.42	824	1.29										
7.50							905	1.52	846	1.38										
7.67							928	1.62	868	1.47										
7.83							951	1.73	889	1.57										
8.00							975	1.84	911	1.67										
8.17							998	1.96	933	1.78										
8.33							1,021	2.08	955	1.89										
8.50									976	2.00										

a – Western species glulam sizes are 5⅛, 6¾, and 8¾–in.; Southern pine glulam sizes are 5–, 6¾–, and 8½–in.
b – Bridges with only two steel beams must use an effective deck design span greater than 6.33–ft.

Table Instructions

The table on this sheet is for determining the required deck thickness for transverse glulam decks supported on two or three steel beams. The criteria for selecting deck thickness are based on the effective deck design span, vehicle loading, and material properties for the species and combination of glulam. The effective deck design span is equal to the clear distance between beam flanges plus one-half the width of one flange, but not greater than the clear distance between flanges plus the deck thickness. Live load deflection is limited to 0.10–in. for all deck thicknesses. The table provides the minimum required allowable design values for bending strength (F_b') and modulus of elasticity (E'), based on the vehicle live load, deck dead load, and an assumed dead load of 10 lb/ft² for the railing/curb system and 38 lb/ft² for an asphalt wearing surface. Allowable design values for horizontal shear (F_v') are not listed because horizontal shear is not critical for shallow deck sections. Blank cells in the table denote cases where the required design values exceed those typically available or that result in excessively conservative designs.

The table may be used in two ways. When the combination symbol and material species of glulam are known, the designer must determine the allowable design values for the material, then compare them to the values given in the table. The computed allowable values must be greater that the table values in order to select the corresponding deck thickness. Alternatively, when the combination symbol and material species are unknown, minimum required F_b' and E' values may be obtained from the table based on effective deck design span, deck thickness, and vehicle loading. A grade and species of glulam that meets these minimum allowable design values may then be selected. Specific procedures for table use follow:

<u>Glulam Combination and Species Known</u>

1. Determine the required design criteria for
   a. effective deck design span and
   b. vehicle loading, AASHTO HS20–44 or HS25–44.

2. Compute the allowable design values for the combination symbol and species of glulam using the following equations:

$F_b' = F_b\, C_M\, C_F\, C_D$ $\qquad$ $E' = E\, C_M$

where
- F_b' = allowable bending stress (lb/in²) $\qquad$ C_M = wet service factor
- F_b = tabulated bending stress (lb/in²) $\qquad$ C_F = bending size factor
- E' = allowable modulus of elasticity (lb/in²) $\qquad$ C_D = load duration factor
- E = tabulated modulus of elasticity (lb/in²)

3. Enter the table and select a deck thickness based on the design criteria and allowable material properties previously determined. The allowable material property values for F_b' and E' must be greater than or equal to the corresponding table values for the deck thickness selected. If not, the design criteria and/or material properties must be revised until acceptable values are achieved.

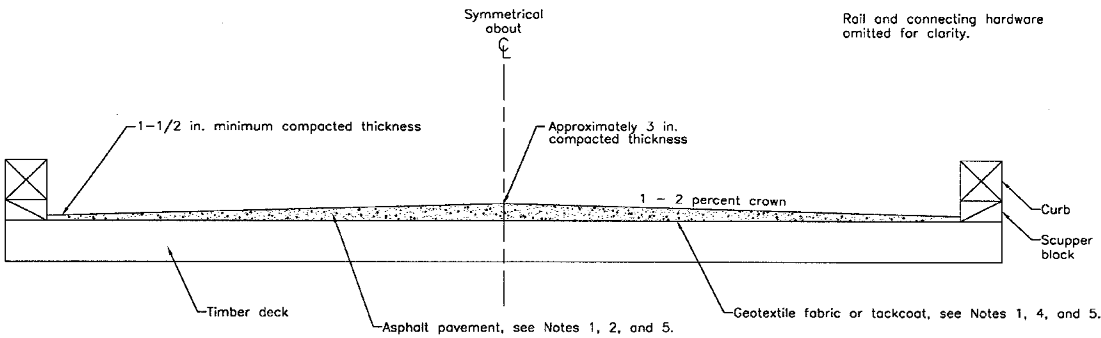
<u>Glulam Combination Symbol and Species Unknown</u>

1. Determine the required design criteria for
   a. effective deck design span and
   b. vehicle loading, AASHTO HS20–44 or HS25–44.

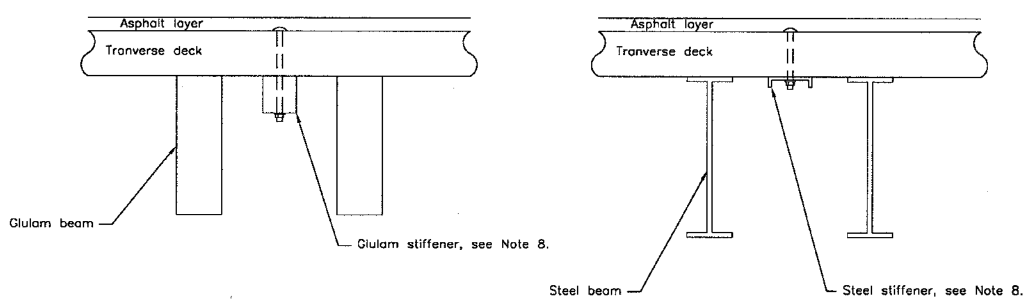
2. Enter the table and select a deck thickness based on the design criteria. Note the required minimum allowable design values for F_b' and E'.

3. Select a glulam combination that provides the minimum allowable design values.

Asphalt Wearing Surface Construction Details



Cross-section view



Longitudinal Stiffener Options for Beam Bridges
End view

Notes

1. These asphalt wearing surface details are recommended for most applications involving the timber bridge superstructures included in these drawings. A crowned asphalt wearing surface, when used in combination with a waterproof asphalt layer, or membrane, will shelter the bridge from moisture and potential deterioration. In low-volume traffic applications, the use of an asphalt wearing surface may not be warranted. For additional information about wearing surfaces for timber bridges, refer to *Timber Bridges: Design, Construction, Inspection, and Maintenance* (Ritter 1990).

2. Bituminous asphalt should be dense-graded and is typically the same mix design specified by state and federal agencies with responsibilities for road paving and maintenance. The asphalt should be placed and compacted to a minimum thickness of 1½-in. at the roadway edge, and approximately 3-in. at centerline.

3. For proper wearing surface bonding and performance, the surface of the timber deck should be clean, dry, and free of excess wood preservative. Excess preservative is normally not present when the treating specifications and procedures recommended in these drawings are followed. If there are accumulations of preservatives on the deck surface, applying a surface blotter before paving can greatly improve geotextile and asphalt bonding. The blotter should be removed from the deck prior to paving. Leaving the deck unpaved for a period of 30-45 days will also help remove excess preservative and solvent from the deck surface.

4. Preformed waterproof paving membranes are typically a geotextile fabric or mesh embedded in rubberized asphalt and should be installed according to the manufacturers' recommendations. Prior to selecting a membrane, compatibility of the membrane material with the wood preservative used for the bridge deck should be verified. Paving membranes should never be used in direct contact with pentachlorophenol treated wood. Improved performance may result when the membrane is placed between two asphalt layers. This is typically accomplished by placing an initial asphalt layer that is crowned as required. The membrane is placed on this initial layer and a final 1- to 1½-in.-thick uniform asphalt layer is placed on the membrane.

5. Preformed waterproof membranes may not adhere well to oilborne-preservative-treated timber bridge decks and the rubber may be incompatible with treatment chemicals. A waterproof layer can be created using asphalt cement or polymer modified asphalt emulsion in combination with a standard paving fabric and asphalt hot mix. Performance-graded asphalt cement and paving fabric should be applied in accordance with AASHTO M288-99, Section 9, and Appendix A6. Polymer modified asphalt emulsions may also be used if residual asphalt content meets the residual application rate recommended by the fabric manufacturer. Sufficient time must be allowed and appropriate weather conditions must exist for emulsions to cure prior to the application of fabric. Asphalt cement will normally be applied at a rate of 0.25 gallons per square yard before placing fabric. Polymer-modified asphalt emulsion would be applied at a rate of 0.37 gallons per square yard to obtain the same asphalt residual. The emulsion must cure until the water has evaporated before placing the fabric. Asphalt hot mix would then be placed and compacted between 250 and 320°F. Polymer modified asphalt emulsions should not be used in direct contact with pentachlorophenol-treated wood.

6. When the bridge deck will be paved on low-volume, unpaved roadways, it is recommended that approach roadways be paved a minimum of 50-ft in each direction, or beyond the approach guardrails, to facilitate roadway maintenance.

7. For stress-laminated bridge decks, it is recommended that asphalt paving not be applied until after the first bar re-tensioning has been completed.

8. For beam bridges, inter-panel movement, or differential deflection between panels, can be minimized by installing a deck panel longitudinal stiffener beams (glulam or steel, see figure at left). This stiffener beam is placed midway between longitudinal bridge beams. Stiffener beams shall be continuous over at least two, but not more than four panel joints (due to moisture changes). See detail on this page and refer to Page 31 for more information regarding types and sizes for stiffener beams.

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Wacker, James P.; Smith, Matthew S. 2001. Standard plans for timber bridge superstructures. Gen. Tech. Rep. FPL-GTR-125. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 53 p.