Standard Plans for Southern Pine Bridges

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Michael A. Ritter
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Abstract

The development of standardized timber bridge plans and specifications is a key element in improving design and construction practices. The bridge plans presented were developed as a cooperative effort between the USDA Forest Service, Forest Products Laboratory (FPL), the University of Alabama, and the Southern Pine Council and are the first step in developing standardized designs for the southern United States where Southern Pine is the primary structural wood species group. This publication contains standardized designs and details for three timber bridge superstructure types, including stress-laminated sawn timber bridges, stress-laminated glued-laminated timber (glulam) bridges, and longitudinal sawn timber stringer bridges with transverse plank deck.

Each set of plans encompasses numerous span length and width combinations, design loadings for AASHTO HS-20-44 and HS-25-44 vehicles, and two options for live-load deflection criteria.

Keywords: Bridge, stress laminated, Southern Pine, stringer, glulam.
Introduction
Interest in timber bridges has increased significantly in recent years, primarily as a result of programs implemented through the Timber Bridge Initiative proposed by Congress in 1988. During this period, the development of standardized timber bridge plans and specifications has been continually enhanced by bridge designers and builders as a key element for contributing to improved design and construction practices. Additionally, standard plans have been viewed as a beneficial tool for helping engineers address the critical transportation infrastructure needs of state, county, and rural regions. To meet this need, several projects to develop standardized timber bridge plans have been initiated at the Federal and local levels based on modern technology for design, fabrication, and construction.

The bridge plans presented in this publication are the first step in developing standardized designs for the Southern United States where Southern Pine is the primary structural wood species group. The plans were developed as a cooperative effort between the USDA Forest Service, Forest Products Laboratory (TPL), the University of Alabama, and the Southern Pine Council. The plans include standardized designs and details for timber bridge superstructure types including: stress-laminated sawn timber bridges, stress-laminated glued laminated timber (glulam) bridges, and longitudinal sawn timber stringer bridges with transverse planks decks. The stress-laminated designs were developed at TPL, and the sawn timber stringer designs were developed at the University of Alabama. The plans are intended to serve as a useful guide to state, county, and local highway departments in the development of practical and economical bridge designs using Southern Pine timber and glulam. They should be particularly valuable to smaller highway departments with limited engineering staffs.

In the development of these plans, every effort has been made to provide complete information for bridge superstructure design and fabrication for a range of design options. Each set of plans encompasses numerous span length and width combinations, design loadings for AASHTO HS 20-44 and HS 25-44 vehicles, and two options for live load deflection criteria. However, specific site conditions may necessitate modification because plans were developed for right-angle crossings only. In all cases, these designs must be verified by a registered professional engineer prior to construction.

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Acknowledgments
We express appreciation to Mr. Marc Lohfend, formerly from the Southern Forest Products Association, and Mr. Mac Lapidus, F. E. Paperboard Inc., for their assistance in the design and review of these plans. We are also grateful to the many individuals who provided review comments and suggestions during plan development.

Comments
Comments and suggestions for improvement of these drawings are appreciated and should be addressed to the Timber Bridge Team, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI, 53705 (FAX 608-231-9303).

Specifications
ASTM A36-90 Standard Specification for Structural Steel
ASTM A479-84 Standard Specification for Ferritic Malleable Iron Castings
ASTM A207-76a Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A272-90 Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete

References
Table 3 - Table of Material Quantities

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Construction Recommendations and Procedures

The performance and longevity of any bridge depends on the materials and construction practices. Abbreviated recommendations for proper installation of stress-laminated barge blocks and barges are included. It is advisable to check and understand these recommendations prior to beginning construction. For additional information, refer to the drawings and the Southern Pine Bridge Design, Construction, Inspection, and Maintenance Manual (1990).

MATERIALS

The following recommendations should be followed for materials:

1. Lumber must be stress graded and properly treated with wood preservative.
2. Laminations should be strong and free of distortion. Laminate with warp, sweep, or cupping will make bar installation difficult.
3. The width of the lumber laminations must be selected to ensure uniform laminating thickness. Variations in laminating thickness may cause the deck to deflect and stay away from contact/laminating force loss will be minimized. If lumber is placed at a high moisture content, it will eventually dry and shrink, which will result in bar losses.
4. The moisture content of the laminations should not exceed the maximum specified. Lumber that is dry will result in better bar performance because stress losses and accumulated force loss will be minimized. If lumber is placed at a high moisture content, it will eventually dry and shrink, which will result in bar losses.
5. The location and orientation of the laminations in the stringer bars should be verified before bridge erection. Misaligned or understated bolts will make bar installation difficult and may require field bending. Overstated bolts may shorten the bridge lasting capacity.
6. Nuts for gusseted stressing bars must be oversized to compensate for the gusseting nuts that are not oversized or well fitted and will not be released during stressing.
7. Proper material certification and quality assurance certificates should be received and verified for all materials.
8. Field cutting and grading of treated wood members must be monitored. Defects where field fabrication is required, proper field tending is essential.

Bridge Assembly

The stress-laminated bridge deck is fabricated three in the shop and transported to the site on a self-propelled. The deck is then set on the abutments and is later erected by using small cranes or derricks to lift the deck into place. The gusseting nuts are then tightened and the bridge is assembled.

Assembly on the Abutments

1. The deck is erected in sections. Using this method, the first 4 to 8 (bar) sections are placed on the deck edge location and nailed together so that the joints are not covered. The remaining sections are then placed on the deck, moved to the edges, and nailed together. When the deck is placed on the crossbeams, the laminates are cut to length and the bar connections are made. If there is any difficulty, the bar connections may be made after the deck is fully nested. If the deck is not fully nested, the bar connections may be made before the deck is fully nested. If the deck is fully nested, the bar connections may be made before the deck is fully nested.

Conclusion

The performance and longevity of any bridge depends on the materials and construction practices. Abbreviated recommendations for proper installation of stress-laminated barge blocks and barges are included. It is advisable to check and understand these recommendations prior to beginning construction. For additional information, refer to the drawings and the Southern Pine Bridge Design, Construction, Inspection, and Maintenance Manual (1990).
4. Tighten the bar nut against the bridge anchor plate. As soon as the gage pressure on the hydraulic pump begins to drop slightly, the nut may begin to tighten, and the gage pressure must be increased to a point slightly greater than the anchor plate.

5. Release the pump hydraulic pressure slowly and remove the tensioning equipment.

6. Several large backnuts should be kept on hand during bar tensioning. A tool shall be available to tighten the nut. It is important to tighten the nut to a point slightly less than the anchor plate.

7. After the bar has been tensioned, the barback shall be tightened to the proper tension. The barback shall be tightened securely to the proper tension. The barback shall be tightened securely to the proper tension.

Figure 3 - Typical Coupler and Extension Bar Assembly

During all bar tensioning procedures, it is important that the bars are not twisted or bent. After the bar has been tensioned, the barback shall be tightened securely to the proper tension. The barback shall be tightened securely to the proper tension.

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Design Guidelines for Stress-Laminated Bridge Decks Constructed with Visually Graded No. 2 Southern Pine Dimension Lumber

Background
The concept of stress-laminated wood bridges is relatively new in the United States. Although bridges of this type have been built in Canada since 1979, they were not introduced in the U.S. until the late 1980s. In April 1991, the American Association of State Highway and Transportation Officials (AASHTO) published Guide Specifications for the Design of Stress-Laminated Wood Bridges (AASHTO 1991). As a guide specification, the publication represents the recommendations of AASHTO and is intended for comment and revision prior to adoption in the AASHTO Standard Specifications for Highway Bridges. It is anticipated that design provisions for stress-laminated wood bridges will be included in the AASHTO within the next several years.

The design criteria for stress-laminated Southern Pine bridge superstructures presented on the preceding sheets are based on design recommendations presented in the following references:


In general, the criteria follow the recommendations of the AASHTO Guide Specifications for the Design of Stress-Laminated Wood. However, minor modifications have been made to improve stress design or simplify the design process.

Design Procedures
The following procedures are for stress-laminated decks constructed of No. 2 visually graded Southern Pine lumber. The lumber is dressed (S4S) with a nominal thickness of 2 in. (51.0 mm) actual and widths of 8, 10, and 12 in. (203.2, 254.0, and 304.8 mm) actual, respectively. Design references are included to AASHTO specifications with the notation "AASHTO", signifying the Standard Specifications for Highway Bridges and "AASHTO GS" signifying the Guide Specifications for the Design of Stress-Laminated Wood Decks. Calculations and summary tables are included to illustrate the design methodology and values used for the plans. Numbers noted in the calculations and summaries are rounded for the final solution, but generally were not rounded for intermediate steps. For additional design information, refer to the above references.

1. Define deck geometry and design live load.

2. Select a species and grade of lumber and compute allowable design values.

3. Choose a deck thickness and compute the distribution width and effective deck section properties.

The design of stress-laminated decks is based on beam theory and assumes that one wheel line of the design vehicle is supported by a strip of deck width, measured normal to the bridge span, defined as the wheel load distribution width (AASHTO GS 3.25.5.2). The distribution width as a function of the deck thickness is the design vehicle maximum wheel load. Thus, a deck thickness must be estimated for initial distribution width calculations. This estimated thickness may be revised later in the design process if it is found to be insufficient or too conservative.

Values shown in Table 2 are used to estimate deck thickness for No. 2 visually graded Southern Pine lumber, 8, 10, or 12 in. wide. Options are given for loading and deflection limits of L/300 and L/500. Note that in most cases, the same deck thickness is required for both the L/300 and L/500 deflection limits.

4. Compute the dead load, dead load moment, and live load.

The dead load of the deck is comprised primarily of the 400 lb/ft² (2,268 N/m²) dead load of the bridge rail and stringing hardware normally assumed to be equally distributed across the deck width.

The dead load acting across the distribution width is computed by the following equation:

\[ \frac{D_{1}}{D_{2}} \leq \frac{P_{1}}{P_{2}} \]

where:
- \( D_{1} \) = dead load acting across the distribution width (lb/ft);
- \( D_{2} \) = dead load acting (lb/ft²).

The distribution width is computed by the following equations:

\[ b_{l} = 0.232P \]

where:
- \( b_{l} \) = wheel load live width (in.); (AASHTO 8.3.30);
- \( P \) = maximum wheel load (lb); (AASHTO 8.3.2);
- \( b_{l} = 0.200 \) for the HS 20-44 axle;
- \( b_{l} = 0.200 \) for the HS 24-42 axle.

\[ b_{l} = \frac{D_{1}}{D_{2}} \]

where:
- \( S \) = modulus of section (in.²);
- \( D_{1} = \) moment of inertia (in.⁴).

A summary of deck section properties is given in Table 3.

Table 1 - Tabulated Design Values

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<tr>
<th>Nominal Lumber Width (in.)</th>
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Table 2 - Estimated Deck Thickness

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Calculations for distribution width and section properties, as well as subsequent calculations for stresses and deflection, are based on actual lane lengths rather than the nominal size. For nominal 8, 10, and 12 in. laminations, the actual dimensions are 7.25, 9.25, and 11.25 in., respectively (AASHTO Table 13.2.1 A).
The maximum dead load moment for a simple span deck with a uniformly distributed load computed by the following equation:

$$M_{DL} = \frac{3}{8} w L^4$$  \hspace{1cm} (7)

where:

- $M_{DL}$ = maximum dead load moment (ft-lb)
- $L$ = bridge span measured center to center of bearings (ft)

A summary of dead load values is given in Table 4.

### Table 4 - Dead Load Summary

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>Actual (in.)</th>
<th>DC (in.)</th>
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6. Compute maximum dead load bending stress.

The maximum applied bending stress is computed by the following equation:

$$f_{DL} = \frac{M_{DL}}{S}$$  \hspace{1cm} (8)

### Table 6 - Bending Stresses

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>Actual (in.)</th>
<th>DC (in.)</th>
<th>HS 20-44 Lb</th>
<th>HS 25-44 Lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>9.7</td>
<td>176.0</td>
<td>9.7</td>
<td>176.0</td>
<td>176.0</td>
</tr>
<tr>
<td>11.75</td>
<td>11.75</td>
<td>138.9</td>
<td>9.75</td>
<td>138.9</td>
<td>138.9</td>
</tr>
<tr>
<td>16.25</td>
<td>16</td>
<td>138.9</td>
<td>11.5</td>
<td>138.9</td>
<td>138.9</td>
</tr>
</tbody>
</table>

7. Determine the required prestress level.

The level of compressive prestress between the loadings must be sufficient to offset flexural stresses caused by transverse bending and vertical slip caused by transverse shear. Different methods for determining the prestress level are given in several publications (AASHTO 1981; Ritter 1990). For these designs, an initial prestress of 100,000 psi was selected because it has been widely used and has provided good performance for Southern Pine decks.

**Table 9 - Prestressing Bar Anchorage Summary**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal deck thickness, t (in.)</th>
<th>Nominal bending force, $F_b$ (kip)</th>
<th>Anchor plate area, $A_b$ (in.²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>10</td>
<td>12</td>
<td>7 x 7</td>
</tr>
<tr>
<td>9.5</td>
<td>9.5</td>
<td>11.5</td>
<td>9 x 9</td>
</tr>
<tr>
<td>10.25</td>
<td>10.25</td>
<td>11.75</td>
<td>11 x 11</td>
</tr>
<tr>
<td>11.75</td>
<td>11.75</td>
<td>12.75</td>
<td>11 x 11</td>
</tr>
</tbody>
</table>

8. Determine the size and spacing of the prestressing bars and the required prestressing force.

The size and spacing of prestressing bars must satisfy the following equations (AASHTO 1981.13.11.2.3):

$$A_p \leq \frac{P_{req}}{f_{y}}$$  \hspace{1cm} (10)

**Table 10 - Bearing Summary**

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>Actual (in.)</th>
<th>DC (in.)</th>
<th>HS 20-44 Lb</th>
<th>HS 25-44 Lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>9.7</td>
<td>176.0</td>
<td>9.7</td>
<td>176.0</td>
<td>176.0</td>
</tr>
<tr>
<td>11.75</td>
<td>11.75</td>
<td>138.9</td>
<td>9.75</td>
<td>138.9</td>
<td>138.9</td>
</tr>
<tr>
<td>16.25</td>
<td>16</td>
<td>138.9</td>
<td>11.5</td>
<td>138.9</td>
<td>138.9</td>
</tr>
</tbody>
</table>

The required prestress force, $F_{p} (kip)$, is computed by the following equation:

$$F_p = \frac{W}{k}$$  \hspace{1cm} (11)

For all spans and deck thicknesses, $k$ is the same as determined for ASTM A722 bars (AASHTO 9.15.1).

9. Design the prestressing bar anchorage system.

The bar anchorage system consists of a steel bearing plate and a smaller steel anchorage plate that transfer the force of the stressing bars into the wood laminations. They must be designed conservatively to ensure that compressive stress applied to the exterior laminations does not cause wood crushing.

The minimum area of the steel bearing plate in square inches, $A_{p}$, is given by Equation 12 (AASHTO 1981.13.11.2.4).

$$A_p \geq \frac{P_{req}}{f_{y}}$$  \hspace{1cm} (12)

**Table 11 - Bearing Summary**

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>Actual (in.)</th>
<th>DC (in.)</th>
<th>HS 20-44 Lb</th>
<th>HS 25-44 Lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>9.7</td>
<td>176.0</td>
<td>9.7</td>
<td>176.0</td>
<td>176.0</td>
</tr>
<tr>
<td>11.75</td>
<td>11.75</td>
<td>138.9</td>
<td>9.75</td>
<td>138.9</td>
<td>138.9</td>
</tr>
<tr>
<td>16.25</td>
<td>16</td>
<td>138.9</td>
<td>11.5</td>
<td>138.9</td>
<td>138.9</td>
</tr>
</tbody>
</table>

### Standard Plans for Southern Pine Bridges

**Stress-Laminated Sawn Lumber Decks**

**Design Procedure**
Stress-Laminated Glued Laminated Timber Bridge Decks
NOTES AND REQUIREMENTS

DESIGN

1. These drawings are for cross-laminated timber bridge decks constructed of Southern Pine glulam laminated timber. The designs are subject to change and should be reviewed before construction.

2. Unless noted, designs comply with the Standard Drawings for Highway Bridges (1996 Edition), AASHTO, American Association of State Highway and Transportation Officials, Design and Structures. Procedures are shown in Section 13, Attachment 12.

3. Designs are applicable to simple and continuous bridges, 12 to 30 ft. in length. Guidelines for determining the required number of laminations, lengths, and other material quantities are given in Section 13.

4. The plans are based upon bending lengths of 10 to 24 ft. for the bridge beam. A detailed study of the bridge beam is necessary to determine the bending lengths.

5. The bending beam described in Section 13 is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

6. Unless noted, the design beam is based upon a load factor of 1.2 for the bridge beam and a load factor of 1.0 for the supporting structure.

7. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

8. Unless noted, the design beam is based upon a load factor of 1.2 for the bridge beam and a load factor of 1.0 for the supporting structure.

9. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

10. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

11. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

12. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

13. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

14. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

15. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

16. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

17. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

18. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

19. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

20. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

21. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

22. The design beam is for a depth of 12 in. (305 mm). For different beam depths, the bending lengths are reduced by 12 in. (305 mm) for each 2 in. (50 mm) of beam depth.

TABLE 1. Minimum Required Deck Thickness (in.)

<table>
<thead>
<tr>
<th>Bridge Span (in)</th>
<th>Minimum Deck Thickness (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>13.2</td>
</tr>
<tr>
<td>22</td>
<td>13.2</td>
</tr>
<tr>
<td>25</td>
<td>13.2</td>
</tr>
<tr>
<td>27</td>
<td>13.2</td>
</tr>
<tr>
<td>30</td>
<td>13.2</td>
</tr>
<tr>
<td>32</td>
<td>13.2</td>
</tr>
</tbody>
</table>

The bridge superstructure depicted on these drawings was developed under a cooperative research agreement between the USA Forest Service, Forest Products Laboratory, the University of Alabama and the Southern Forest Products Association.

Standards Plans for Southern Pine Bridges

Stress-Laminated Glulam Timber Decks

General Layout and Notes

August 1995

Sheet 2 of 11
Rail Option Configuration and Scupper Spacing

20' Length

22' Length

24' Length

26' Length

28' Length

30' Length

32' Length

Roll Detail

Side View

Curb Splice Detail

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the USDA Forest Service, Forest Products Laboratory, the University of Alabama and the Southern Forest Products Association.

Standard Plans for Southern Pine Bridges

Stress-Laminated Glulam Timber Decks

Rail Option Details

August 1995

Sheet 4 of 11
### Rail Option

#### 6 x 12 in. Curb, No. 1 SP 545

|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|

#### Table 1: Minimum Camber Requirements

<table>
<thead>
<tr>
<th>Bridge Length (ft)</th>
<th>Deck Thickness (in)</th>
<th>Minimum Camber (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>12-3/8</td>
<td>1/2</td>
</tr>
<tr>
<td>22</td>
<td>12-5/8</td>
<td>1/2</td>
</tr>
<tr>
<td>24</td>
<td>12-7/8</td>
<td>1/2</td>
</tr>
<tr>
<td>26</td>
<td>12-9/8</td>
<td>1/2</td>
</tr>
<tr>
<td>28</td>
<td>15-1/2</td>
<td>1/2</td>
</tr>
<tr>
<td>30</td>
<td>15-3/4</td>
<td>1/2</td>
</tr>
<tr>
<td>32</td>
<td>15-5/8</td>
<td>1/2</td>
</tr>
</tbody>
</table>

---

**Typical Boring Details for Curb**

**Post/Scupper Connection**

**Splice**

---

The bridge superstructures depicted on these drawings were developed under a cooperative research agreement between the USDA Forest Service, Forest Products Laboratory, the University of Alabama and the Southern Forest Products Association.

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### Standard Plans for Southern Pine Bridges

**Stress-Laminated Glulam Timber Decks**

**Fabrication Details**

August 1995

Sheet 8 of 11
## Table 4 - Table of Material Quantities

<table>
<thead>
<tr>
<th>Item</th>
<th>Mark/Size</th>
<th>Bridge Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Bridge Deck</td>
<td>See Note 3</td>
<td>NK-5</td>
</tr>
<tr>
<td>Deck laminates</td>
<td>See Note 3</td>
<td>10</td>
</tr>
<tr>
<td>Steel beam</td>
<td>See Note 5</td>
<td>24</td>
</tr>
<tr>
<td>Steel</td>
<td>See Note 5</td>
<td>10</td>
</tr>
<tr>
<td>Support plate</td>
<td>MK-13 through MK-14</td>
<td>10</td>
</tr>
<tr>
<td>Weakening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete (cf)</td>
<td>See Note 6</td>
<td></td>
</tr>
<tr>
<td>Aggregate (percent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remover strip</td>
<td>MK-02</td>
<td>20 in. x 18 in.</td>
</tr>
<tr>
<td>Drop saw</td>
<td>7-in. x 4-in.</td>
<td>55</td>
</tr>
<tr>
<td>Curing water</td>
<td>20-ft. x 20-ft.</td>
<td>0.12</td>
</tr>
</tbody>
</table>

## Construction Recommendations and Procedures

The performance and longevity of any bridge depends on the materials and construction procedures used. This paper provides recommendations for the proper construction of stress-laminated bridges given in the drawings. It is advisable to consult and understand the drawing notes for details. The following information is not intended to serve as complete specifications, but to provide guidance to the design and construction personnel.

### Materials

- **Laminates**: The following recommendations should be followed for laminates:
  - Glue laminates must comply with the requirements of ANSI/AITC 1012-3-88 and be properly treated with wood preservatives.
  - Glue is generally manufactured at a moisture content of 10% to 16%. Laminations should be protected from excessive moisture at the job site and maintained at this low moisture content prior to construction.
  - The location and size of holes in the laminations for stressing bars should be checked before bridge erection. Misaligned or undersized holes will make bar insertion difficult and may require field drilling. oversized holes may reduce the bridge load capacity.
  - Holes for grouted stressing bars must be covered to prevent concrete from entering.
  - All other materials such as screws, nails, etc., should be the same as those used for comparable wood members.

### Equipment and Procedures

- Stress-laminated bridges are stressed with a hydraulic jacks that apply tension to the prestressing bar by pulling the bar away from the anchor points. After the tension is applied, the bar is tightened against the anchor plate and the requirements in the bar are stressed on stressing the bar for stressing the bar. The ejection equipment for stressing the bar is designed to temporary end: backfilling, backfilling backfilling, and backfilling (Figure 1). The following should be considered regarding equipment:

## Standard Plans for Southern Pine Bridges

**August 1965**

**Stress-Laminated Glue Lam Timbers**

**Materials and Construction Recommendations**

**Figure 1 - Tensioning Equipment and Configuration**

**Stress-Laminated Bridge Deck**

- The bridge superstructure is depicted in the drawings was developed under a cooperative research agreement between the USDA Forest Service, Forest Products Laboratory, the University of Alabama and the Southern Forest Products Association.

--

<table>
<thead>
<tr>
<th>Item</th>
<th>Mark/Size</th>
<th>Bridge Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

**Assembly Adjacent to the Site**

Stress-laminated bridge should be assembled adjacent to the site and lifted into place with a crane. To accomplish this, a level site is essential and extra blocking or other supports are needed at the bridge end to serve as temporary supports. Laminations may be placed on the bottom in one or in panels as previously described. After assembly, the bars must be fully tensioned, as described before, before the bridge is stressed. When lifting the assembled bridge, see lifting equipment through the top of the bridge or use appropriate beams under the bridge. Do not lift the bridge by the stressing bars as this may cause the bars to start laminating or slip.

**Bar Tensioning**

The stressing system is perhaps the most important part of a stress-laminated bridge because it holds the bridge together and develops the necessary friction between the laminations. Thus, it is important that a sufficient level of uniform, compressive stress is maintained between the laminar layers in order for a stress-laminated bridge to perform properly.

**Recommendations for bar tensioning using a single hydraulic jack, which is the most economical and commonly used, are given below:**

- **Stress-laminated bridges are stressed with a hydraulic jacks that apply tension to the prestressing bar by pulling the bar away from the anchor points. After the tension is applied, the bar is tightened against the anchor plate and the requirements in the bar are stressed on stressing the bar for stressing the bar. The ejection equipment for stressing the bar is designed to temporary end: backfilling, backfilling backfilling, and backfilling (Figure 1). The following should be considered regarding equipment:**

**Bridge Assembly**

- The stress-laminated bridge decks shown in these plans are typically assembled and erected on the site. Another option is to assemble the bridge adjacent to the site and lift the stressed bridge into place with a crane. Guidelines for bridge assembly using both approaches follow. In both cases, the laminations must be placed with the correct orientation.

**Assembly on the Abutments**

When the bridge is placed on the abutments, there are two common/laid out options for placing the laminations:

- **Laminations are placed away from the abutments, using this method, 6 to 8 laminations are placed on the abutments starting at the edge location. All laminations are used to align the ends. When the ends are aligned, stressing bars are adjusted and pulled through the holes. Connect to push the bars through the holes as subsequent laminations are added. It is important that the bars be supported on the free end so that they are not stressed to bend excessively. If bending may damage the bar or the grouting proprietary:**

- **Laminations are prestressed as panels. In this case, panels 2 to 4 are assembled by connecting laminations together with metal bands. When placing laminations, corner gussets must be provided to prevent damage to the wood when the bands are tightened. The laminations must be placed on the end of the bar. This will cause the steel to "mockup" and the nut cannot be properly tightened. The bond could be lost and otherwise damage the bar. Fabrication can be reduced without sacrificing laminating. Sheet laminations are necessary, as well as the holes align properly.
1. The capacity of the jack must be sufficient to provide the design tension force.

2. The pump may be hand operated or electric. Hand operated pumps are less expensive but slower than electric pumps. Electric pumps also require an on-site source of power.

3. The scale of the hydraulic gauge attached to the pump may be calibrated in tons or kips, it is generally easier to work in tons. If the gauge is calibrated in kips, the value of the jack force must be provided.

4. The stressing chair is normally fabricated. An example is a typical welded steel tee. The chair for the bridge in these plans is shown in Figure 2. It is important that the holes be large enough to fit over the bar anchoer plate, and remain on the bearing plate. The chair must be designed flexibly so that the chair will not brace directly on the tension lines. The height of the chair should be 3 to 4 times the length of the bar plus the plate thicknes.

5. The hole in the hydraulic jack and stressing chair are large enough to fit over the coupler.

6. Several extra back-ups should be kept on hand during bar stressing. After repeated stressing, the back-ups may tend to bind and should be replaced.

7. To prevent the bars from moving in place, the stressing equipment must be properly secured. It is generally better to use a D-shape coupler and place the bar extension on that edge. On the opposite edge, bars should be approximately 2 x 4 ft. beyond the nut. If there is any chance that the length of the stressing equipment, a temporary coupler and bar extension may be used (Figure 2). If in use, it is blood that each bar be thinned fully into the couple length. Failure to do so may result in coupler breakage. It is also important to verify that the holes in the hydraulic jack and stressing chair are large enough to fit over the coupler.

8. During all stressing procedures, it is important that personnel stand in front of the bar, or where possible, on the side of the bar to avoid movement of the bars.

9. The pump pressure should be checked on the stressing equipment, as the bar will fail at the highest pressure and force can cause serious injury or death. It is also important to check the pressure in the hydraulic hose, as the hose may have damage and cause rupture under high pressure. To aid in handling, a tape meausure should be kept at the pump.

10. The following steps outline the typical procedure for bar stressing.

   a. Place the chair and jack on the bar. Place the jack so that the cylinder extends away from the bridge. Place the cylinder against the bridge to eliminate the chair.

   b. Place the back-up on the bar. Allow a small gap of approximately 1/4 inch between the back-up and the jack to prevent binding.

   c. Apply hydraulic pressure to the jack until the gauge begins to reach the required reading. It is common to apply only approximately 50% of the force to compensate for lack of pressure when the nut is tightened. Ensure that the proper gauge scale is used. Most gauges have several scales for different jacks.

   d. Tighten the bar nut against the bridge anchor plate. An open-end wrench generally works best. As the nut is tightened, the gauge pressure on the hydraulic pump will drop slightly. On occasion, the nut may bind slightly on the gasketing. It is important to tighten the nut sufficiently to ensure that it bears rigidity against the anchor plate.
Design Guidelines for Stress-Laminated Bridge Decks Constructed with Combination 24F-V3 Southern Pine Glued Laminated Timber

Background
The concept of stress-laminated wood bridges is relatively new in the United States. Although bridges of this type have been built in Canada since 1978, they were not introduced in the U.S. until the late 1980s. In April 1991, the American Association of State Highway and Transportation Officials (AASHTO) published Guide Specifications for the Design of Stress-Laminated Wood Bridges (AASHTO 1993). As a guide specification, the publication includes recommendations for the design of Stress-Laminated Wood Bridges. AASHTO is open to comment and revision prior to adoption in the AASHTO Standard Specifications for Highway Bridges. If accepted, these design provisions for stress laminated wood bridges will be included in the AASHTO within the next several years.

The design criteria for stress-laminated Southern Pine bridge structures presented on the preceding sheets are based on design recommendations presented in the following references:


In general, the criteria follow the recommendations of the AASHTO Guide Specifications for the Design of Stress-Laminated Wood Decks. However, minor modifications have been made in order to improve performance or simplify the design process.

Design Procedures
The following procedures are for stress-laminated decks constructed of combination 24F-V3 Southern Pine glued laminated timber. The recommendations have an actual moisture content of 6.5% in and structural thickness of 11.5", 12.5", 13.75", 15", and 18.5/16". Design references in AASHTO specifications are included. The notation "AASHTO" applies to the entire text of AASHTO specifications for Highway Bridges and "AASHTO GS" signifies the Guide Specifications for the Design of Stress-Laminated Wood Decks.

Calculations and summary tables are included to illustrate the design methodology and methods used for the plans. Notations in the calculations and summaries were rounded for the final solution, but generally were not rounded for intermediate steps. For additional design information, refer to the summary tables above.

1. Define deck geometry and design live load.

Deck Geometry
Definitions and options for deck geometry are as follows:
Width: Bridge width is the total deck width measured at mid-span.
Length: Bridge length is the total length, measured longitudinally.
Span: Bridge span is the distance measured center-to-center of the bearings.
Bracing: The plans are based on a minimum bearing length at each bridge and/or column. Thus, the bridge spans a 10' x 10' box, with the bridge length equal to the slightly conservative design.

Design Live Load
There are options for the AASHTO HS 20-44 or 4E-254-4 vehicle live loads (AASHTO 3.7). For both loads, the design is controlled by the truck loads rather than lane loads.

2. Select a species and grade of glulam and compute allowable design values.

The design is based on Southern Pine glued laminated timber, combination 24F-V3 with the exception of F_a, which is based on hardwood glulam classification 2F-V3. The following tables are adopted from AASHTO Table 15.3.4.3.

Table 1 - Tabulated Values for Southern Pine Glulam, Comb. 24F-V3

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_a (ksi)</td>
<td>15</td>
</tr>
<tr>
<td>F_c (ksi)</td>
<td>25</td>
</tr>
<tr>
<td>E (ksi)</td>
<td>1.5E6</td>
</tr>
</tbody>
</table>

Allowable design values are based on wet service conditions and are computed in accordance with the following equations for bending, modulus of elasticity and compression perpendicular to grain.

Bending (24F-V3):

\[ F_a = \frac{F \cdot C_c}{L} \]

where:
- \( F_a \) = tabulated bending stress (ksi);
- \( F \) = allowable design load (ksi);
- \( C_c \) = wet service factor (AASHTO 15.3.4.1) = 0.80
- \( E \) = modulus of elasticity (ksi); and
- \( L \) = actual deck thickness (in.) (AASHTO 15.3.4.3).

Modulus of elasticity (24F-V3):

\[ E = E_c \]

where:
- \( E \) = allowable modulus of elasticity (ksi); and
- \( E_c \) = tabulated modulus of elasticity (AASHTO 36). The value for service factor is 0.832 (AASHTO 35.4.1).

For SP Comb. 24F-V3, E = (180000000)*0.8331 = 149400000 (ksi).

Compression perpendicular to grain (24F-V3):

\[ F_c = \frac{F \cdot C_c}{L} \]

where:
- \( F_c \) = allowable compression perpendicular to grain (ksi);
- \( F \) = allowable design load (ksi);
- \( C_c \) = wet service factor (AASHTO 15.3.4.1); and
- \( L \) = actual deck thickness (in.) (AASHTO 15.3.4.3).

3. Choose a deck thickness and compute the distribution load and effective deck section properties.

The design of stress-laminated timber beam is based on beam theory and assumes one wheel line of the design vehicle is supported by a strip of deck width, measured normal to the bridge span, along which the wheel load is distributed (AASHTO 25.2.6). The distribution width is a function of the deck thickness and the design vehicle is minimum wheel load. Thus, a deck thickness must be estimated for initial distribution width calculations. This allowable thickness may be revised later in the design process if it is found to be insufficient or too conservative.

Values shown in Table 2 are used to estimate deck thickness for Comb. 24F-V3 Southern Pine Glulam. Options are given for loading and deflection limits of L500 and L5000. Note that in most cases, the same deck thickness is required for both the L500 and L5000 deflection limits.

Table 2 - Estimated Deck Thickness

<table>
<thead>
<tr>
<th>Bridge Length (ft)</th>
<th>Bending Span (in)</th>
<th>L5000</th>
<th>L500</th>
<th>L5000</th>
<th>L500</th>
</tr>
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<tbody>
<tr>
<td>20</td>
<td>17</td>
<td>11</td>
<td>1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>17</td>
<td>11</td>
<td>1</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>17</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>17</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>17</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>17</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>

The distribution width is computed by the following equation:

\[ b = \frac{b_0}{2} \]

where:
- \( b_0 \) = wheel load (ksi) (AASHTO 3.30);
- \( P = \) maximum wheel load (lbs.

For the HS 20-44 vehicle, \( P = 20000 \) lbs.

For the HS 25-44 vehicle, \( P = \frac{25}{25} \times 20000 \) lbs.

The distribution width is computed by the following equation:

\[ b_0 = \frac{b}{2} \]

where:
- \( b \) = wheel load (lbs);
- \( b_0 \) = wheel load (ksi).

The maximum dead load moment for a single span deck with a uniformly distributed load is computed by the following equation:

\[ M_{DL} = \frac{b_0}{2} \]

where:
- \( b_0 \) = maximum dead load (lbs).

A summary of dead load values is given in Table 4.

Table 4 - Dead Load Loading

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (in)</th>
<th>Actual (in)</th>
<th>DL (kip-in)</th>
<th>DL (kip-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>17</td>
<td>11</td>
<td>395.7</td>
<td>18.250</td>
</tr>
<tr>
<td>22</td>
<td>17</td>
<td>11</td>
<td>373.5</td>
<td>16.269</td>
</tr>
<tr>
<td>24</td>
<td>17</td>
<td>11</td>
<td>353.7</td>
<td>14.564</td>
</tr>
<tr>
<td>26</td>
<td>17</td>
<td>11</td>
<td>336.3</td>
<td>13.270</td>
</tr>
<tr>
<td>28</td>
<td>17</td>
<td>11</td>
<td>323.7</td>
<td>12.221</td>
</tr>
<tr>
<td>30</td>
<td>17</td>
<td>11</td>
<td>313.7</td>
<td>11.368</td>
</tr>
</tbody>
</table>

A summary of live load values is given in Table 5.

Table 5 - Live Load Values

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_a (ksi)</td>
<td>15</td>
</tr>
<tr>
<td>F_c (ksi)</td>
<td>25</td>
</tr>
<tr>
<td>E (ksi)</td>
<td>1.5E6</td>
</tr>
</tbody>
</table>

The maximum live load moment, \( M_{LL} \), is computed for one wheel line of the design vehicle using statics, or by obtaining the maximum moment value from design tables. Values used for preparation of the plans are shown in Table 6.
5. Compute maximum deck bending stress. The maximum applied bending stress is computed by the following equation:

\[ S = \frac{(M_{u} - M_{l})}{S} \]

The applied bending stress must not exceed the allowable bending stress. If \( S_{u} \) is greater than \( S \), the deck is insufficient in bending. If \( S_{l} \) is greater than \( S \), the deck is insufficient in bending and the deck thickness must be increased.

A summary of bending stresses is given in Table 6.

6. Check live load deflection. The maximum live load deflection is computed for one wheel line of the design vehicle. For deflection only, the wheel load distribution width may be indicated by a factor of 1.15 (AASHO GS 3.25.3.1). Thus, the moment of inertia remains constant based on the deflection width and actual deck thickness is multiplied by 1.15. Deflection is computed by the following handbooks. Using a handbook coefficient.

\[ f_{D} = \frac{f}{(1.15)} \]

where:
- \( f_{D} \) = vehicle load deflection (in.)
- \( f \) = load deflection coefficient (Rinor 19501b-in.)

If the computed live load deflection exceeds the design limit, deck thickness is unsatisfactory and must be increased. AASHTO recommends a maximum live load deflection of 0.06 in. (AASHO GS 13.11.2.1). A summary of live load deflections computed by Equation 9 is given in Table 7.

Table 7 - Live Load Deflection

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>Actual (in.)</th>
<th>HS 20-44 (in.)</th>
<th>HS 25-44 (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>19.17</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
<tr>
<td>21.77</td>
<td>19.77</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
<tr>
<td>23.27</td>
<td>23.27</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
<tr>
<td>24.77</td>
<td>24.77</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
</tbody>
</table>

7. Compute dead load deflection and camber. For longitudinal stressing and tension of girder decks, it is recommended that the girder be considered to be self-caming and bearing by the beam. The amount of camber depends upon the initial dead load deflection resulting from the uniform dead load deflection resulting from the uniform dead load acting over the distribution width, \( D \). For a simple span deck, the dead load deflection is computed by the following equations (AASHO GS 13.11.3.1):

\[ \Delta_{D} = \frac{f_{D} \times (12N_{D})}{B} \]

where:
- \( \Delta_{D} \) = dead load deflection (in.)
- \( f_{D} \) = load deflection coefficient
- \( N_{D} \) = dead load
- \( B \) = beam width

The values given shall be used for the purposes of comparison only. A summary of dead load deflection and minimum camber requirements is given in Table 8.

Table 8 - Dead Load Deflection and Camber

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>Actual (in.)</th>
<th>HS 20-44 Distribution Width (in.)</th>
<th>HS 25-44 Distribution Width (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>19.17</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
<tr>
<td>21.77</td>
<td>21.77</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
<tr>
<td>23.27</td>
<td>23.27</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
<tr>
<td>24.77</td>
<td>24.77</td>
<td>0.5605</td>
<td>0.51</td>
<td>0.5605</td>
</tr>
</tbody>
</table>

8. Determine the required prestress level. The level of compressive prestress between the laminates must be sufficient to offset thermal tension caused by transverse bending and vertical slip caused by transverse forces. Different methods for determining the initial prestress level are given in several publications (AASHO GS 1951; Rinor 1950). For these designs, an initial prestress of 100 ksi was selected because it has been widely used and has provided good performance for Southern Pine decks.

9. Determine the size and spacing of the prestressing bars and the required prestressing force. The size and spacing of prestressing bars must satisfy the following equations (AASHO GS 13.11.2.9):

\[ A_{p} = \frac{P_{c}}{f_{c}} \]

where:
- \( P_{c} \) = compressive prestress in bar
- \( f_{c} \) = prestressing bar stress

A summary of the prestressing bar anchorage system is given in Table 10.

The required prestress force, \( P_{c} \), is computed by the following equation:

\[ P_{c} = \frac{R_{p}}{f_{c}} \]

For all spans and deck thicknesses, 1 in. diameter ASTM A722 bars are selected with a 6/8 in. center-to-center spacing. A summary of prestressing bar information is given in Table 9.

Table 9 - Prestressing Bar Summary

<table>
<thead>
<tr>
<th>Actual (in.)</th>
<th>A_{p} (ksi)</th>
<th>( f_{c} )</th>
<th>( f_{c} )</th>
<th>( f_{c} )</th>
<th>( f_{c} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1</td>
<td>0.55</td>
<td>0.48</td>
<td>0.0016</td>
<td>52.800</td>
<td></td>
</tr>
<tr>
<td>12.3-3.5</td>
<td>0.35</td>
<td>0.48</td>
<td>0.0014</td>
<td>59.400</td>
<td></td>
</tr>
<tr>
<td>13.3-4.0</td>
<td>0.35</td>
<td>0.48</td>
<td>0.0013</td>
<td>66.000</td>
<td></td>
</tr>
<tr>
<td>15.1-6.0</td>
<td>0.35</td>
<td>0.40</td>
<td>0.0012</td>
<td>72.600</td>
<td></td>
</tr>
<tr>
<td>16-7.0</td>
<td>0.35</td>
<td>0.40</td>
<td>0.0011</td>
<td>79.200</td>
<td></td>
</tr>
</tbody>
</table>

10. Design the prestressing bar anchorage system. The bar anchorage system consists of a steel bearing plate and a smaller steel anchorage plate that transfers the force of the stressing bars into the wooden laminates. They must be designed conservatively so that the compressive stress applied to the laminates does not cause wood crushing.
Table 10: Prestressing Bar Anchorages Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>11</th>
<th>12-3/8</th>
<th>13-3/4</th>
<th>15-1/2</th>
<th>16-1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing plate size L × W</td>
<td>14 × 11</td>
<td>14-1/2 x 12</td>
<td>15 × 13</td>
<td>14-1/2 x 15</td>
<td>14-1/2 x 16</td>
</tr>
<tr>
<td>Anchor plate size L × W</td>
<td>6 x 4</td>
<td>6 x4</td>
<td>6 x 4</td>
<td>6 x 7</td>
<td>5 x 7</td>
</tr>
<tr>
<td>A&lt;sub&gt;max&lt;/sub&gt; (in.&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>153.3</td>
<td>172.4</td>
<td>190.6</td>
<td>210.7</td>
<td>229.9</td>
</tr>
<tr>
<td>A&lt;sub&gt;actual&lt;/sub&gt; (in.&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>184.0</td>
<td>174.0</td>
<td>195.0</td>
<td>217.5</td>
<td>232.0</td>
</tr>
<tr>
<td>L&lt;sub&gt;min&lt;/sub&gt; (in.)</td>
<td>342.9</td>
<td>341.4</td>
<td>338.5</td>
<td>333.1</td>
<td>341.4</td>
</tr>
<tr>
<td>k</td>
<td>0.40</td>
<td>4.25</td>
<td>4.50</td>
<td>4.25</td>
<td>4.50</td>
</tr>
<tr>
<td>t&lt;sub&gt;min&lt;/sub&gt; (in.)</td>
<td>0.92</td>
<td>0.96</td>
<td>1.01</td>
<td>0.95</td>
<td>1.02</td>
</tr>
</tbody>
</table>

*Note: Spacing is based on interior bar spacing and corresponding force.*

11. Determine the support configuration and check bearing stress.

Supports for stress-laminated decks must be designed to resist the vertical and lateral forces transmitted from the superstructure to the substructure. As with other longitudinal wood superstructures, the required bearing length is normally controlled by considerations for bearing configuration, rather than compressive strength, perpendicular to grain. From a practical standpoint, a minimum bearing length of 10 in. is recommended for stress-laminated decks. Bearing attachments are normally made through the deck to the supporting cap or slab, or from the deck underside. Such attachments are illustrated on Sheet 4.

Bearing stress in compression perpendicular to grain is checked for the maximum reaction at the support due to the bridge dead load and one wheel line of the design vehicle. This load is distributed over an area defined by the distribution width, Z<sub>d</sub>, and the bearing length L<sub>b</sub>.

Bearing in compression perpendicular to grain is computed using the following equation:

\[
L_b = \frac{R_L - R_d}{D_0 f_{ld}}
\]

where:
- \(R_L\) = dead load reaction (lb);
- \(R_d\) = maximum live load reaction for one wheel line of design vehicle (lb);
- \(D_0\) = deck bearing length at the support (in.) = 10 in.

The value of \(f_{ld}\), computed by Equation 16 must be less than \(f_{ld}\). A summary of bearing information is presented in Table 11.

Table 11: Bearing Summary

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>L (ft)</th>
<th>D (in.)</th>
<th>R&lt;sub&gt;L&lt;/sub&gt; (lb)</th>
<th>R&lt;sub&gt;d&lt;/sub&gt; (lb)</th>
<th>f&lt;sub&gt;ld&lt;/sub&gt; (psi)</th>
<th>R&lt;sub&gt;L&lt;/sub&gt; (lb)</th>
<th>R&lt;sub&gt;d&lt;/sub&gt; (lb)</th>
<th>f&lt;sub&gt;ld&lt;/sub&gt; (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>16.17</td>
<td>11</td>
<td>3.567</td>
<td>22.210</td>
<td>57.8</td>
<td>4.190</td>
<td>25.390</td>
<td>65.7</td>
</tr>
<tr>
<td>20</td>
<td>19.17</td>
<td>12-3/8</td>
<td>4.460</td>
<td>22.210</td>
<td>55.3</td>
<td>4.674</td>
<td>25.390</td>
<td>63.8</td>
</tr>
<tr>
<td>22</td>
<td>21.17</td>
<td>11</td>
<td>6.363</td>
<td>21.420</td>
<td>61.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>22</td>
<td>22.17</td>
<td>13-3/4</td>
<td>-</td>
<td>5.704</td>
<td>26.770</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>24</td>
<td>23.17</td>
<td>12-3/8</td>
<td>5.328</td>
<td>22.270</td>
<td>61.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>24</td>
<td>23.17</td>
<td>13-3/4</td>
<td>5.918</td>
<td>22.320</td>
<td>62.6</td>
<td>6.222</td>
<td>27.810</td>
<td>68.8</td>
</tr>
<tr>
<td>26</td>
<td>25.17</td>
<td>13-3/4</td>
<td>6.422</td>
<td>23.100</td>
<td>62.2</td>
<td>6.741</td>
<td>28.870</td>
<td>71.4</td>
</tr>
<tr>
<td>26</td>
<td>26.17</td>
<td>15-1/8</td>
<td>7.106</td>
<td>23.300</td>
<td>60.1</td>
<td>7.439</td>
<td>28.870</td>
<td>69.0</td>
</tr>
<tr>
<td>28</td>
<td>27.17</td>
<td>13-3/4</td>
<td>6.816</td>
<td>23.750</td>
<td>64.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>28</td>
<td>27.17</td>
<td>15-1/8</td>
<td>7.652</td>
<td>23.790</td>
<td>62.6</td>
<td>8.015</td>
<td>29.680</td>
<td>71.7</td>
</tr>
<tr>
<td>28</td>
<td>27.17</td>
<td>16-1/2</td>
<td>-</td>
<td>-</td>
<td>8.800</td>
<td>29.680</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30</td>
<td>29.17</td>
<td>15-1/8</td>
<td>8.198</td>
<td>24.480</td>
<td>65.0</td>
<td>9.584</td>
<td>30.800</td>
<td>74.5</td>
</tr>
<tr>
<td>30</td>
<td>29.17</td>
<td>19-1/2</td>
<td>9.027</td>
<td>24.480</td>
<td>63.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32</td>
<td>31.17</td>
<td>15-1/8</td>
<td>8.745</td>
<td>25.220</td>
<td>67.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>32</td>
<td>31.17</td>
<td>19-1/2</td>
<td>9.628</td>
<td>25.220</td>
<td>65.8</td>
<td>10.057</td>
<td>31.320</td>
<td>75.1</td>
</tr>
</tbody>
</table>
Longitudinal Stringer with Transverse Plank Decks
Roll Detail

End View

Note: Rail design is not crash tested.

Railing Design:

- Rail is 6 x 6 x 13 in. (512)
- Top rail is 2 x 4 in. plate
- Bottom rail is 2 x 4 in. plate
- 3/4 in. dia. holes on 12 in. center

See Curb Attachment Plate Detail.

Curb Attachment Plate Details:

- 4 x 12 x 3/8 in.; A36 steel
- 6 x 8 in. curb
- 6 x 8 in. washer block
- Curb membrane attached for drainage
- Curb attachment plate detail

Post Stretcher Attachment:

- Angle detail: Attach with 3/8 in. dia. bolts
- 6 x 4 in. plate
- Post connection: Q 1/4 in.

Curb Splice Detail

Side View

Note: Beam side omitted for clarity.

See Curb Splice Plate Detail.

Curb Splice Plate:

- 5 x 34 x 3/8 in.; A36 steel
- Plate washer
- Plate washer

Standard Plans for Southern Pine Bridges

August 1995

Longitudinal Stringer with Transverse Plank Decks

Rail Details

Sheet 4 of 5
NOTES AND DESIGN

DESIGN

1. These drawings are for cold saw longitudinal stringer-transverse deck timber bridges constructed of Southern Pine. The designs are applicable for single- and double-lane rectangular bridges of any width (no skew) with center-to-center spans according to Table 1, Sheet 2. Bridges may be multiple span with any combination of acceptable span lengths.

2. Unless noted, designs comply with the standard specifications for Highway Bridges (15th Edition, 1955), published by the American Association of State Highway and Transportation Officials (AASHTO). Design truck loading is AASHTO HS20-44. Rail detail does not comply with AASHTO criteria.

3. These designs are intended for informational purposes only, and must be verified by a registered professional engineer prior to construction.

MATERIAL AND FABRICATION

Wood

General

4. Sawn lumber shall comply with the requirements of AASHTO M168.

5. Unless noted, all wood shall be cut, dried, and fabricated prior to pressure treatment with preservatives.

Planks

6. Planks shall be visually graded No. 1 Dense, No. 2, or better Southern Pine dimension lumber or timbers as specified in Table 2, Sheet 2.

7. Planks are rough sawn green, furnace seasoned 3, 4, and 5 in. in nominal thicknesses.

8. Planks shall not be less than maximum sizes listed below.

<table>
<thead>
<tr>
<th>Minimum Rough Sizes for Planks</th>
<th>Thickness (in.)</th>
<th>Width (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal</td>
<td>Actual</td>
<td>Nominal</td>
</tr>
<tr>
<td>3</td>
<td>2-1/10</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>3-1/16</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>4-5/8</td>
<td>12</td>
</tr>
</tbody>
</table>

9. The maximum thickness of a plank shall be no greater than 1/2 in. longer than its nominal thickness. The maximum width along the length of a plank shall not exceed 3/8 in.

10. Stringers shall be visually graded No. 1 Dense, No. 2, or better Southern Pine timber as specified in Table 1, Sheet 2.

11. Stringers are rough sawn (unseasoned) with a minimum size of 3/8 in. less than nominal dimensions.

12. Variation in depth between stringers shall not exceed 3/8 in. so as to provide a flat surface across the width of the bridge to ensure planks have firm contact with all stringers.

13. Curbs, Snapper Blocks, and Rail Posts

14. Curbs and snapper blocks shall be visually graded No. 2, or better Southern Pine rough sawn stringers with a minimum size of 3/8 in. less than nominal.

15. Rail posts shall be visually graded No. 2, or better nominal 6 x 6 in. surfaced all sides (654) with a minimum dressed size of 5-1/2 x 5-1/2 in.

Preservative Treatment

16. All sawn lumber shall be treated in accordance with the requirements of AWPA Standard C14 with one of the following preservatives:

- Creosote conforming to AWPA Standard P6
- Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9

17. Treated material shall be free of excess preservative on the wood surface. The treating process for these preservatives shall include an expansion bath, steaming and/or dipping to ensure that preservative will not bleed.

18. Treated wood shall be inspected and certified in accordance with AWPA Standard M2.

Steel Fasteners and Hardware

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


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

21. All steel connections and fasteners shall be galvanized in accordance with AASHTO M111 in AASHO M232.

Miscellaneous

22. Geotextile fabric shall be an impregnated, nonwoven fabric which provides a water-tight membrane over the deck surface. Application procedures and compatibility of the fabric with the preservative treatment shall be verified with the manufacturer prior to fabric placement.

23. Sealer for wood end grain is typically a commercial rosin cement.

CONSTRUCTION

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

25. When field fabrication of wood is required, or if the wood is damaged, all cuts, bore holes, and damage shall be immediately field treated with wood preservative in accordance with AWPA Standard M4.

ADDITIONAL DESIGN INFORMATION

This section provides additional bridge design information as an aid to the professional engineer verifying the design prior to construction.

Plant Deck Design

Loading

Live load consists of a 12,000 lb vehicular load with the load distributed according to AASHTO 3.25.1.

Dead load consists of a 2 in. asphalt wearing surface and the minimum rough green plank size. Unit weight of asphalt and timber is taken as 150 lb/ft³ and 50 lb/ft³, respectively.

Design Values

Allowable design values to determine the plank sizes in Table 2, Sheet 2 are those tabulated in the National Design Specification (NDS) Supplement with applicable adjustment factors applied.

Allowable design values for 2 and 4 in. thick planks are obtained from the NDS supplement Table 48 with wet sum service factors applied. The frost use factors are also applied to the NDS tabulated bending values. When the planks are continuous over the full bridge width, a shear stress modification factor of 2 is used to adjust the tabulated shear stress.

Allowable design values for 5 in. thick planks are obtained from the NDS supplement Table 40 with no adjustment except, the shear stress is doubled for continuous plank decks.

Calculation of Internal Forces

All section properties are determined using the minimum rough green sizes.

The span used is as specified in AASHTO 3.25.1.2.

Bending

Maximum moment is calculated as 80% of the maximum simple span moment.

Shear

The maximum shear force is calculated assuming a simple span between stringers, neglecting all loads closer than the plank depth from the face of the stringer. The calculation for shear follows the NDS 3.4.3.

Deflection

Maximum deflection is calculated as 80% of the maximum simple span deflection. Shear distortions are neglected. The calculated deflection is limited to an absolute deflection limit of 0.01 in. to prevent reflective cracking in the wearing surface. However, plank decks designed by this criteria may experience reflective cracking problems.

Stringer Design

Loading

Live load consists of the HS20-44 standard truck loading.

Dead load consists of a 2 in. asphalt wearing surface, the weight of the planks based on a thickness of 1/2 in. greater than nominal, and the weight of the stringer based on maximum rough green sizes.

When two plank sizes are specified in Table 2, Sheet 2 for a given stringer size and spacing, the thicker of the two sizes is used to compute the dead load on the stringer.

Design Values

Allowable design values used to determine the stringer sizes given in Table 1, Sheet 2 are those tabulated in the NDS Supplement Table 40 with no adjustment.

Calculation of Internal Forces

All section properties are determined using the minimum rough green sizes. The spans given in Table 1, Sheet 2 are from center-to-center of bearings.

Bending

Maximum moment is determined according to AASHO 3.22.2.

Shear

The maximum live load shear is calculated according to AASHTO 13.3. Maximum dead load shear is calculated according to NDS 3.4.3.

Deflection

Maximum deflection due to live load is limited to a value equal to span/300.

Compression Perpendicular to Grain

Minimum baring lengths given in Table 1, Sheet 2 are based on compression perpendicular to grain requirements.

Rail Design

The rail design shown in this set of plans has not been crash tested.

The maximum outward load on the post is calculated to be 4,000 lb, which is below the 10,000 lb AASHTO requirement.

For designs using 3 in. deck thicknesses, the expected failure mode is the web to deck attachment. For thicker decks, the design is limited...