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Mack-Blackwell Transportation Center

PRE-DESIGNED TIMBER BRIDGES OF THREE TYPES FOR ARKANSAS COUNTY ROADS

MBTC FR-1057-2 (Drawings)

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16. Abstract

According to the annual National Bridge Inventory, the highest percentage of US bridges that are "structurally deficient" or "functionally obsolete" is in the "city/county/township" category. In recent years the major causes of rapid deterioration of bridges with typical steel or concrete superstructures have been deicer chemicals and lack of adequate maintenance monies.

Well-designed "modern" timber bridges could be a cost-effective alternative for the replacement of substandard bridges on county and city roads. Three types of simple span timber bridges have been designed with accompanying specifications for ready use: (1) solid sawn stringers with transverse solid sawn deck planks, (2) glulam stringers with transverse glulam decks, and (3) stress-laminated full-span glulam stringers, all constructed of southern pine (SP). This report contains designs for the first type using 6 different SP stringer sections, for the second type using 4 different standard widths of SP glulam stringers, and for the third type using the same 4 separate widths of SP glulam stringers. Designs focused on flexural adequacy. Procedures are included for changing span length or depth of the primary bending sections to fit with any desired allowable deflection limitation or smaller "load duration factor."

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PRE-DESIGNED TIMBER BRIDGES OF THREE TYPES FOR ARKANSAS COUNTY ROADS

by
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and
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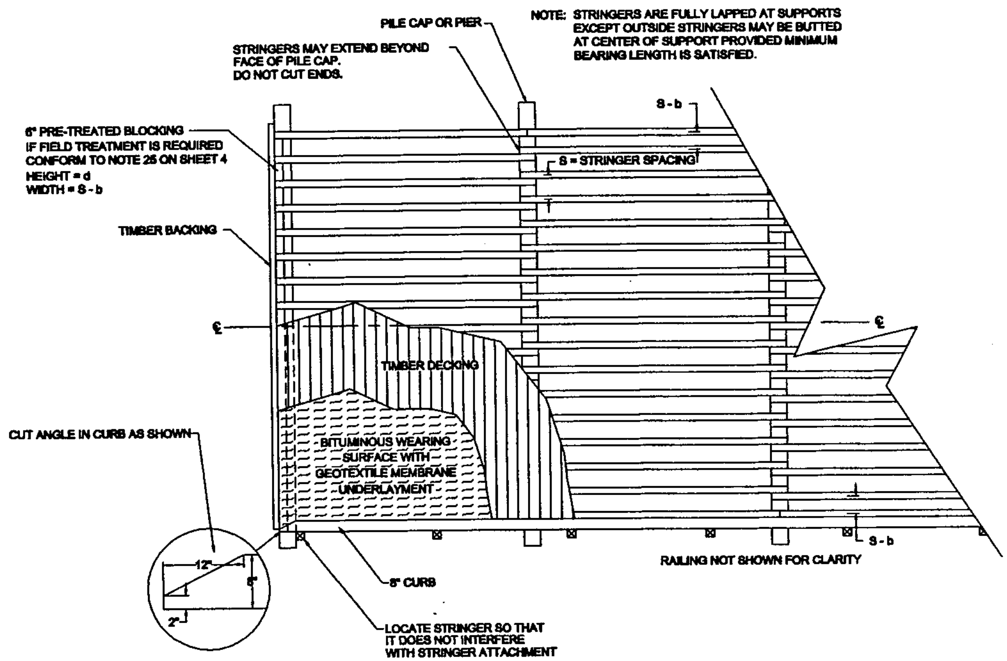
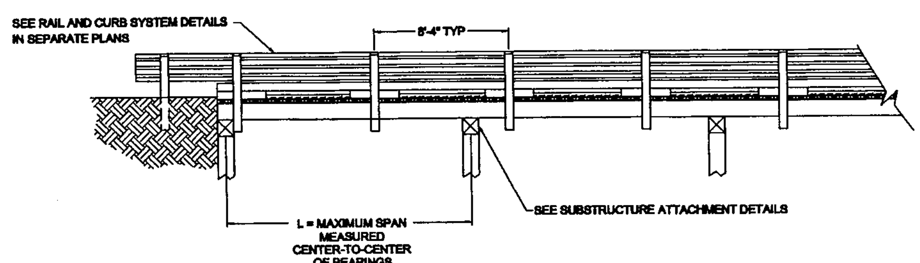


PLAN VIEW



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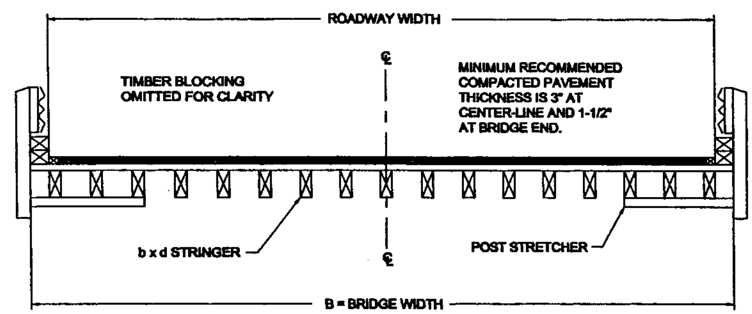

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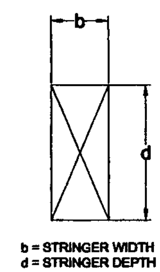
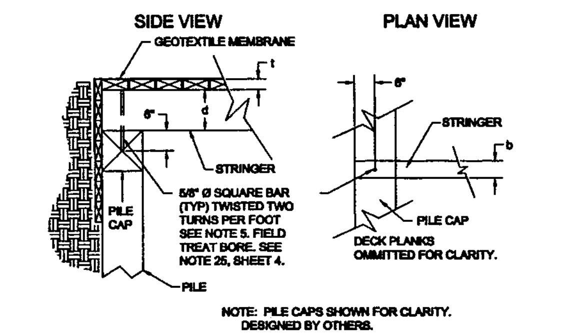


STRINGER

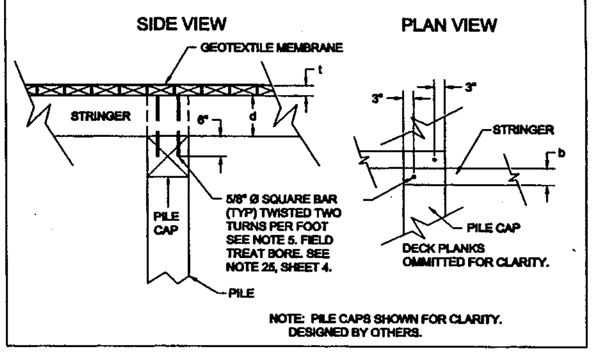
MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK	GENERAL LAYOUT SHEET 1 OF 4	1

SUGESTED DECK/SUBSTRUCTURE ATTACHMENT DETAILS

TIMBER ABUTMENT ATTACHMENT



TIMBER BENT ATTACHMENT



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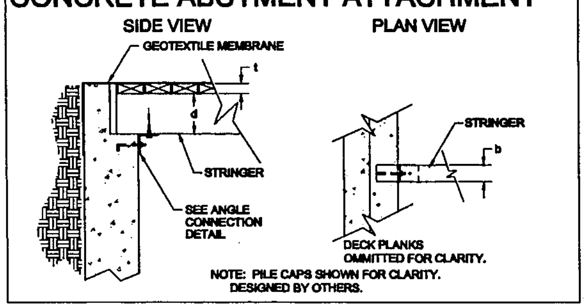

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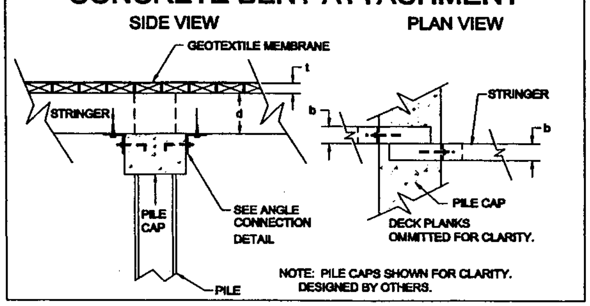
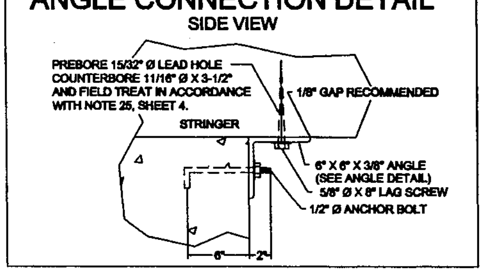
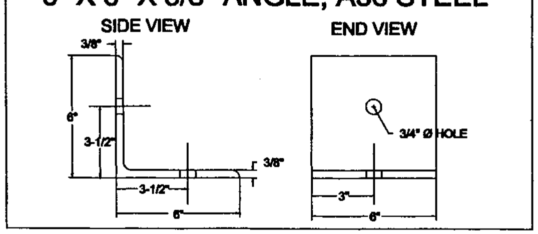


ANGLE CONNECTION DETAIL



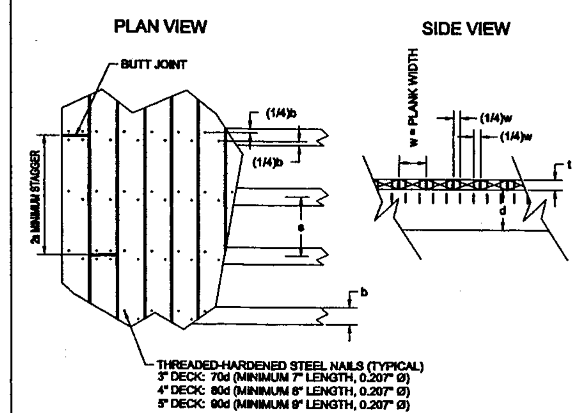
ANGLE DETAIL
6" X 6" X 3/8" ANGLE; A36 STEEL



DECK/SUBSTRUCTURE ATTACHMENT NOTES

1. SUBSTRUCTURE DETAILS ARE FOR ILLUSTRATION ONLY AND MUST BE DESIGNED FOR SPECIFIC LOCATIONS.
2. USE OF EXISTING PILE CAPS AND ABUTMENTS MAY REQUIRE ALTERNATE DETAILING.
3. GEOTEXTILE FABRIC SHALL WRAP OVER ABUTMENT ENDS A MINIMUM OF 2 FT VERTICALLY. SEE NOTE 22, SHEET 5.
4. STRINGER ATTACHMENTS SHALL BE DESIGNED FOR SPECIFIC SITE CONDITIONS. RECOMMENDATIONS GIVEN ON THIS SHEET.
5. FOR 5/8" Ø SQUARE BARS, PREBORE 11/16" Ø LEAD HOLE. COUNTERBORE 3/4" Ø X (d - 6").

PLANK DECK ATTACHMENT



PLANK DECK ATTACHMENT NOTES

1. EDGE SAWN DECK PLANKS ARE PREFERABLE.
2. IF FLAT SAWN DECK PLANKS ARE USED, ORIENT BARK SIDE UP.
3. DRIVE NAILS AT SLIGHT ANGLE.
4. BUTT JOINTS ARE CENTERED ON A STRINGER WITH JOINTS FOR ADJACENT PLANKS STAGGERED A MINIMUM OF TWO STRINGER SPACINGS.
5. ALL PLANKS MUST BE CONTINUOUS OVER AT LEAST FIVE STRINGERS.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK	ATTACHMENT DETAILS SHEET 2 OF 4	2

Design Notes

DESIGN

1. These drawings are for solid sawn longitudinal stringer/transverse deck timber bridges constructed of Southern Pine. The designs are applicable for double lane rectangular bridges of the width shown (no skew) with center-to-center spans according to the tables on Sheet 3. The designs can be modified for other widths and number of lanes. Bridges may be multiple span with any combination of acceptable span lengths.

2. Except as noted, designs comply with the Standard Specifications for Highway Bridges (15th Edition, 1992 with Interims through 1994), 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 static criteria.

- Bearing length for stringers on abutments is 4.5 inches.

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, drilled, 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 dimensions are 3" x 10" for all decks in these plans.

7. Planks are rough sawn green, (unseasoned) 3 inches in nominal thicknesses.

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

Minimum Rough Sizes for Planks

Thickness (in.)		Width (in.)	
Nominal	Actual	Nominal	Actual
3	2-11/16	10	9-5/8

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

Stringers

10. Stringers shall be visually graded No. 1 Dense, No. 2 or better Southern Pine timbers as specified in the tables on Sheet 3.

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

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

Curbs, Scupper Blocks, and Rail Posts

13. Curbs and scupper blocks shall be visually graded No. 2 or better Southern Pine rough sawn timbers with a minimum size of 3/8 inch less than normal.

14. Rail posts shall be visually graded No. 2 or better nominal 6 x 6 inch surfaced all sides (S4S) with a minimum dressed size of 5-1/2 x 5-1/2 in.

Preservative Treatment

15. All sawn lumber shall be treated in accordance with the requirements of AWPA Standard C14 with one of the following preservatives:
a. Creosote conforming to AWPA Standard P1
b. Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9.

16. 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 dripping to ensure that preservative will not bleed.

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

Steel Fasteners and Hardware

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

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

20. Washers shall be provided with 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.

21. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232.

Miscellaneous

22. Geotextile fabric shall be an impregnated, nonwoven fabric which provides a watertight 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 roofing cement.

CONSTRUCTION

24. All wood and metal components shall be handled and stored carefully so as to not damage the material. If damage does occur, wood shall be field treated in accordance with note 25. Damage to the galvanizing 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.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
6 X 12 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
11	14	21.69[1]	0.306	0.264	84.0
12	15	20.14	0.368	0.288	90.0
13	16	18.80	0.437	0.312	96.0
14	17	17.63	0.512	0.336	102.0
15	18	16.59	0.592	0.360	108.0
16	19	15.67[2]	0.679	0.384	114.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requiring colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
10 X 12 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
16	12	25.27[1]	0.657	0.384	120.0
17	13	23.17	0.723	0.408	130.0
18	14	21.38[2]	0.792	0.432	140.0
20	15	19.86[2]	1.009	0.480	150.0
21	16	18.53[2]	1.090	0.504	160.0
22	17	17.38[2]	1.175	0.528	170.0
23	18	16.35[2]	1.263	0.552	180.0
24	19	15.44[2]	1.356	0.576	190.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requiring colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
8 X 14 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
18	13	23.33[1]	0.680	0.432	121.3
20	14	21.54[1]	0.861	0.480	130.7
21	15	20.00	0.926	0.504	140.0
22	16	18.67[2]	0.993	0.528	149.3
24	17	17.50[2]	1.209	0.576	158.7
25	18	16.47[2]	1.286	0.600	168.0
26	19	15.56[2]	1.366	0.624	177.3

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requiring colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
8 X 12 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
14	13	23.33[1]	0.508	0.336	104.0
15	14	21.54[1]	0.577	0.360	112.0
16	15	20.00	0.650	0.384	120.0
17	16	18.67[2]	0.728	0.408	128.0
18	17	17.50[2]	0.810	0.432	136.0
19	18	16.47[2]	0.897	0.456	144.0
20	19	15.56[2]	0.988	0.480	152.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requiring colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
6 X 14 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

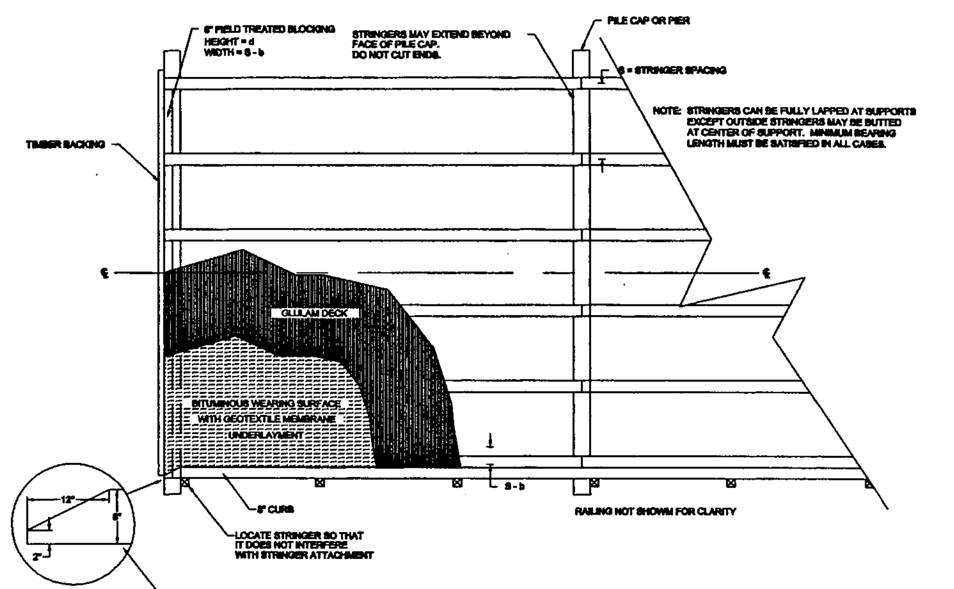
MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
14	13	23.50[1]	0.430	0.336	91.0
15	14	21.69[1]	0.488	0.360	98.0
16	15	20.14	0.550	0.384	105.0
17	16	18.80	0.616	0.408	112.0
18	17	17.63	0.685	0.432	119.0
19	18	16.59[2]	0.758	0.456	126.0
20	19	15.67[2]	0.835	0.480	133.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requiring colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

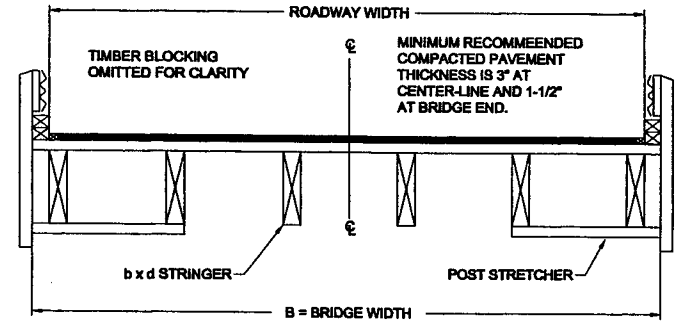
SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
10 X 14 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
21	12	25.27[1]	0.936	0.504	140.0
22	13	23.17	0.528	0.528	151.7
24	14	21.38[2]	0.576	0.576	163.3
25	15	19.86[2]	0.600	0.600	175.0
27	16	18.53[2]	0.648	0.648	186.7
28	17	17.38[2]	0.672	0.672	198.3
30	18	16.35[2]	0.720	0.720	210.0
31	19	15.44[2]	0.744	0.744	221.7

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requiring colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.



PLAN VIEW



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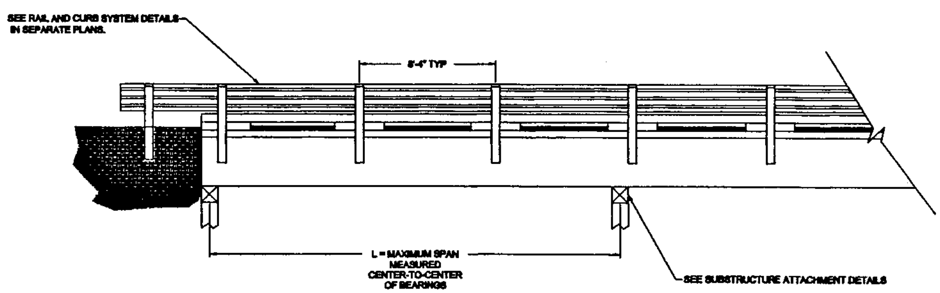

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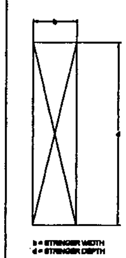
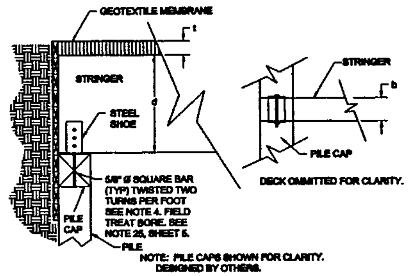


STRINGER

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS	GENERAL LAYOUT SHEET 1 OF 4	5

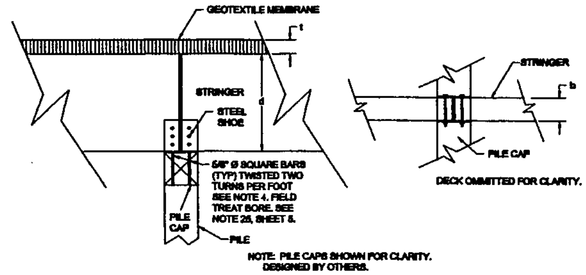
TIMBER ABUTMENT ATTACHMENT

SIDE VIEW PLAN VIEW



TIMBER BENT ATTACHMENT

SIDE VIEW PLAN VIEW

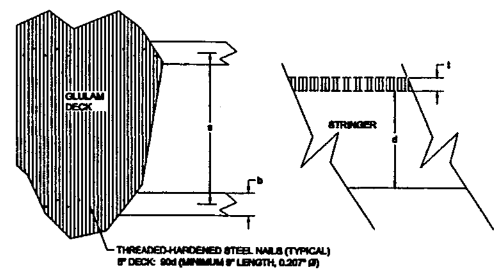


DECK/SUBSTRUCTURE ATTACHMENT NOTES

1. SUBSTRUCTURE DETAILS ARE FOR ILLUSTRATION ONLY AND MUST BE DESIGNED FOR SPECIFIC LOCATIONS.
2. GEOTEXTILE FABRIC SHALL WRAP OVER ABUTMENT ENDS A MINIMUM OF 2 FT VERTICALLY. SEE NOTE 22, SHEET 5.
3. STRINGER ATTACHMENTS SHALL BE DESIGNED FOR SPECIFIC SITE CONDITIONS. RECOMMENDATIONS GIVEN ON THIS SHEET.
4. FOR 5/8" Ø SQUARE BARS, PREBORE 11/16" Ø LEAD HOLE. COUNTERBORE 3/4" Ø X (4 - 6").

PLANK DECK ATTACHMENT

PLAN VIEW SIDE VIEW

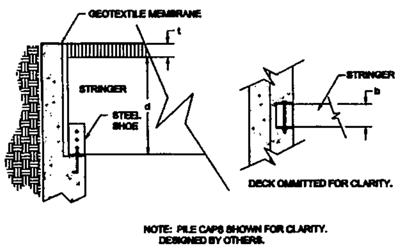


PLANK DECK ATTACHMENT NOTES

1. DRIVE NAILS AT SLIGHT ANGLE.
2. STAGGER NAILS AS DEPICTED.
3. NAIL SPACING NOT TO EXCEED 5 INCHES.
4. ALL GLULAM SLABS MUST BE CONTINUOUS OVER AT LEAST FIVE STRINGERS.

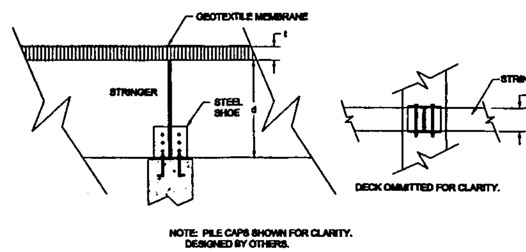
CONCRETE ABUTMENT ATTACHMENT

SIDE VIEW PLAN VIEW



CONCRETE BENT ATTACHMENT

SIDE VIEW PLAN VIEW



MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS	ATTACHMENT DETAILS SHEET 2 OF 4	6

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
5 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 8.5 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
28	7/4	24.750	47.17	1.028	0.672	72.2
30	7/4	26.125	47.17	1.281	0.720	76.2
32	7/4	28.875	47.17	1.313	0.768	84.2
34	7/4	33.000	47.17	1.169	0.816	96.3
36	7/4	34.375	47.17	1.335	0.864	100.3
38	7/5	33.000	47.17	1.901	0.912	96.3
40	7/5	35.750	47.17	1.849	0.960	104.3
42	7/5	39.875	47.17	1.622	1.008	116.3

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
8.5 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 6.0 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
46	6/5	28.875	55.90	3.894	1.104	122.7
48	6/5	30.250	55.90	3.969	1.152	123.6
50	6/5	31.625	55.90	4.036	1.200	134.4
52	6/5	33.000	55.90	4.655	1.245	134.4
54	6/5	34.375	55.90	4.693	1.296	140.3
56	6/5	35.750	55.90	4.726	1.344	146.1
58	6/5	37.125	55.90	4.756	1.392	151.9
60	6/5	37.125	55.90	4.783	1.440	157.8
62	6/5	38.500	55.90	4.807	1.488	163.6

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
6.75 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 7.0 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
36	6/5	26.125	56.25	2.517	0.864	88.2
38	6/5	27.500	56.25	2.701	0.912	92.8
40	6/5	28.875	56.25	2.869	0.960	97.5
42	6/5	30.250	56.25	3.023	1.008	102.1
44	6/5	31.625	56.25	3.165	1.056	106.7
46	6/5	33.000	56.25	3.296	1.104	111.4
48	6/5	34.375	56.25	3.417	1.152	116.0
50	6/5	37.125	56.25	3.152	1.200	125.3
52	6/5	38.500	56.25	3.259	1.248	129.9

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
10.5 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 6.0 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
56	5/5	33.000	69.375	4.796	1.344	144.4
58	5/5	34.375	69.375	4.795	1.392	150.4
60	5/5	35.750	69.375	4.793	1.440	156.4
62	5/5	35.750	69.375	5.364	1.488	156.4
64	5/5	37.125	69.375	5.339	1.536	162.4
66	5/5	38.500	69.375	5.314	1.584	168.4
68	5/5	38.500	69.375	5.879	1.632	168.4
70	5/5	39.875	69.375	5.834	1.680	174.6
72	5/5	41.250	69.375	5.791	1.728	180.5

NOTES AND REQUIREMENTS

DESIGN

1. These drawings are for glued laminated stringer/ glued laminated transverse deck (w/o dowels) timber bridge decks constructed of Southern Pine glued laminated timber. The designs are applicable to double-lane rectangular bridges (no skew) with simple span lengths of 28 to 72 ft. Design truck loading is AASHTO HS20-44.

2. Unless noted, designs comply with the Standard Specifications for Highway Bridges (15th Edition, 1992) (with interims through 1994)

3. Designs are applicable to double-lane bridges, 24 ft wide. The designs can be modified for other widths and numbers of lanes.

4. The minimum bearing lengths are specified in the tables on sheet 3.

5. The controlling design criteria for deck thickness are both live load deflection and flexural strength
The required deck thicknesses for stated bridge lengths based on deflection and flexural strength are shown in the tables on Sheet 3, and are based on the design loadings and limits of 1/500 of the bridge span (L), measured center-to-center of bearings and allowable maximum flexural stress in the supporting glulam members.

6. Unless noted, plan dimensions for sawn lumber are nominal dimensions. Dimensions for glulam timber are actual dimensions. Fabrication details are based on actual dimensions.

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

MATERIAL AND FABRICATION

Wood

8. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168.

9. Glued laminated timber used as deck laminations shall be Combination 24F-V3 Southern Pine, cambered as specified in tables on Sheet 3. Glued laminated timber rail material shall be Combination No. 48 Southern Pine.

10. Unless noted, all lumber shall be dressed (S4S) Southern Pine. Lumber 2 to 4 inches in thickness shall be visually graded No. 2 or better. Lumber 5 inches or greater in thickness shall be visually graded No. 1 or better.

11. All glulam deck members shall be continuous between supports with no butt joints.

12. Unless noted, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives.

13. The moisture content of sawn lumber prior to and after treatment shall not exceed 15% for lumber 2 to 4 in. thick, and 19% for lumber thicker than 4 in. Moisture content of glued laminated timber shall not exceed 16% prior to and after treatment.

14. Curbs and scupper block shall be visually graded No. 2 or better Southern Pine rough sawn timbers with a minimum size of 3/8 inch less than nominal.

15. Rail posts shall be visually graded No. 2 or better nominal 6 x 6 inch surfaced all sides (S4S) with a minimum dressed size of 5-1/2 x 5-1/2 inches.

Preservative Treatment

16. All sawn lumber shall be treated in accordance with the requirements of AWPA Standard C14 with one of the following preservatives:
a. Creosote conforming to AWPA Standard P1
b. Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9.
c. CCA conforming to AWPA Standard P5.

17. Glulam timber shall be treated to the above requirements with creosote or pentachlorophenol.

18. Material treated with creosote or pentachlorophenol shall be free of excess preservative on the wood surface. The treating process for these preservatives shall include an expansion bath, steaming and/or dripping to ensure that preservative will not bleed.

19. Preservative treatment shall be inspected and certified in accordance with AWPA Standard M2.

Steel Fasteners and Hardware

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

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

22. Washers shall be provided with 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.

23. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232. 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.

24. All nuts for bolts shall be oversized or re-threaded to ensure proper fit after galvanizing.

Miscellaneous

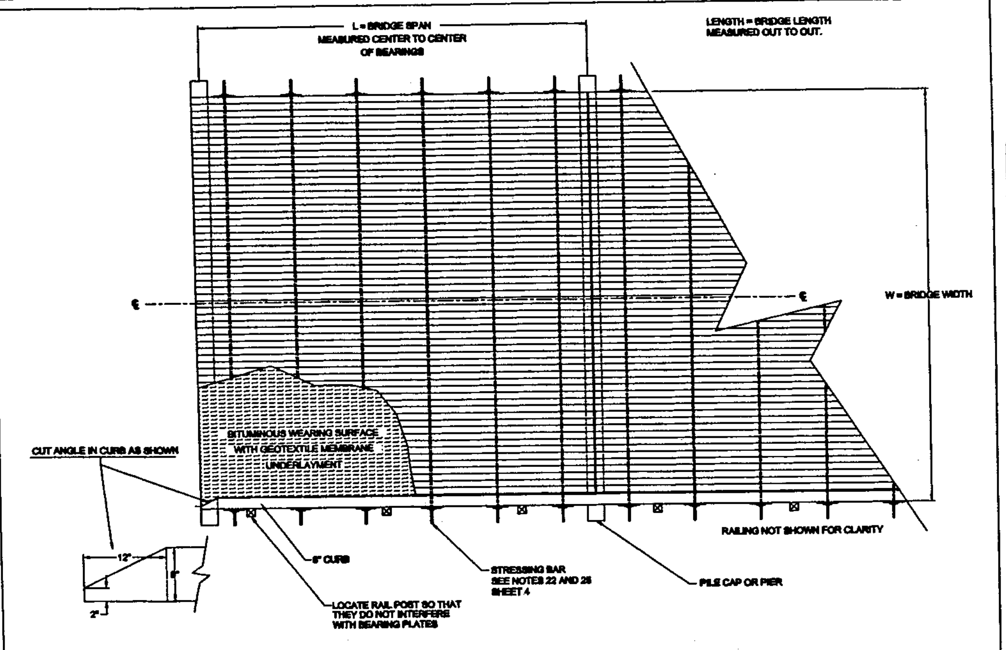
25. Geotextile fabric should be an impregnated, non-woven fabric that provides a watertight membrane over the deck surface. Application procedures and compatibility of the fabric with the preservative treatment shall be verified with the manufacturer prior to fabric placement.

26. Sealer for wood end grain is typically a commercial roofing cement.

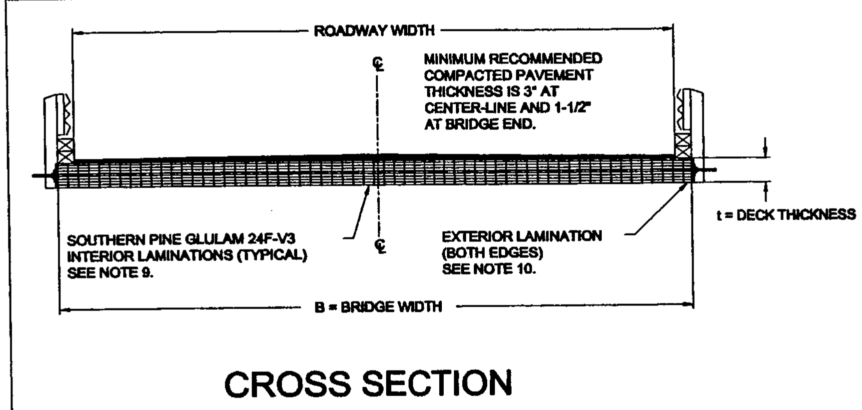
CONSTRUCTION

27. 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 30. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

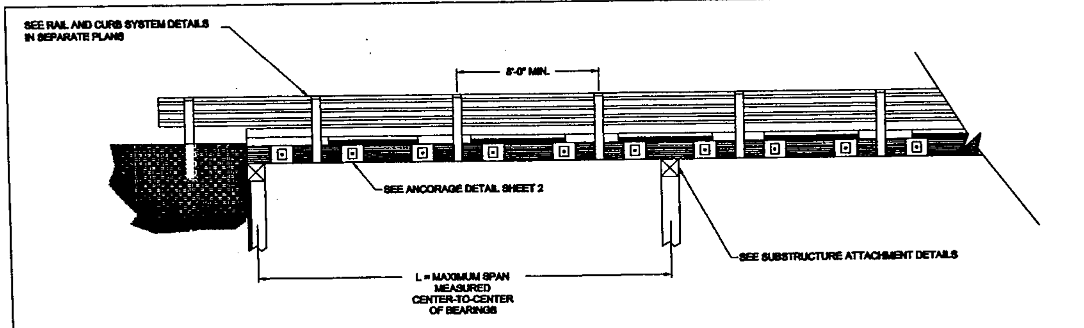
38. When field fabrication of wood is required or if wood is damaged, all cuts, bore holes, and damage shall be immediately field treated with wood preservative in accordance with AWPA Standard M4.



PLAN VIEW



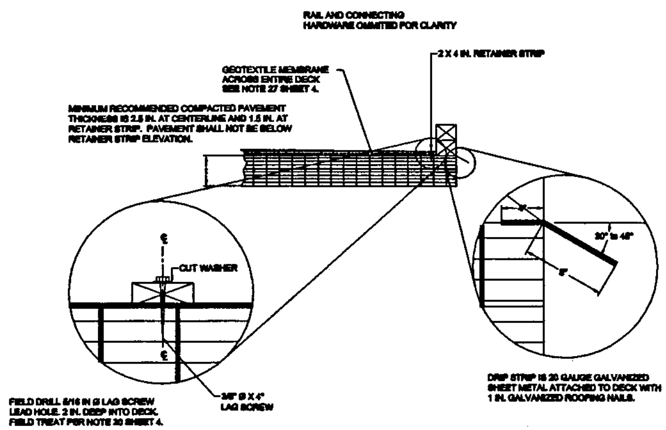
CROSS SECTION



ELEVATION

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAMINATED STRINGERS STRESS LAMINATED TO FORM ORTHOTROPIC DECK	GENERAL LAYOUT SHEET 1 OF 6	9

WEARING SURFACE



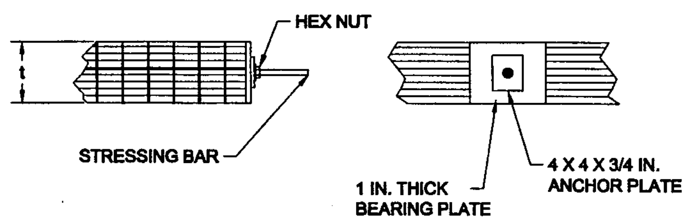
2" X 4" RETAINER STRIP

DRIP STRIP

ANCHORAGE CONFIGURATION

SIDE VIEW

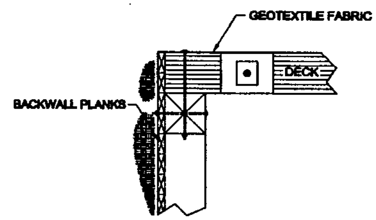
END VIEW



SUGGESTED DECK/SUBSTRUCTURE ATTACHMENT

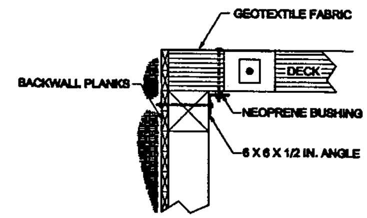
TIMBER ABUTMENT ATTACHMENT

SIDE VIEW



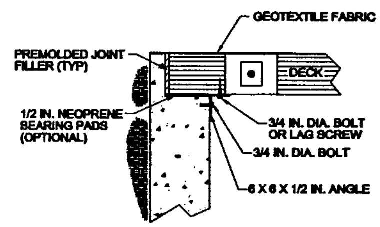
TIMBER ABUTMENT ATTACHMENT

SIDE VIEW



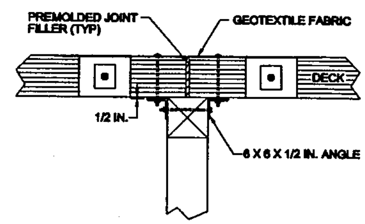
CONCRETE ABUTMENT ATTACHMENT

SIDE VIEW



TIMBER BENT ATTACHMENT

SIDE VIEW



These details are representative of common substructure attachments and are shown for illustrative purposes only. The attachments must be designed for specific locations. The following recommendations are applicable in most circumstances.

1. Attachment bolt spacing shall not exceed 4 ft. over the entire bridge width.
2. Minimum bearing shall be 10 in. at abutments and 7 in. at bents.
3. Geotextile fabric shall wrap over abutment ends a minimum of 2 ft. vertically. See note 27, Sheet 4.
4. Bolts are 3/4 in. dia. Use dome head bolts in wood contact and hex bolts in steel contact. Field drill deck bolt holes 13/16 in. dia. and field treat in accordance with note 30, Sheet 4.
5. Lag screws for deck attachment are as follows:
   A. For 8 in. deck, 3/4 in. dia. X 6 in.; Prebore 11/16 in. dia. lead hole. Counterbore 13/16 in. dia. X 2-12 in.
   B. For 10 and 12 in. deck, 3/4 in. dia. X 8 in.; Prebore 11/16 in. dia. lead hole. Counterbore 13/16 in. dia. X 3-1/2 in.
6. Apply preservative to all field borings. See note 30, Sheet 4.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAMINATED STRINGERS STRESS LAMINATED TO FORM ORTHOTROPIC DECK	GENERAL DETAILS SHEET 2 OF 6	10

CURB DETAIL

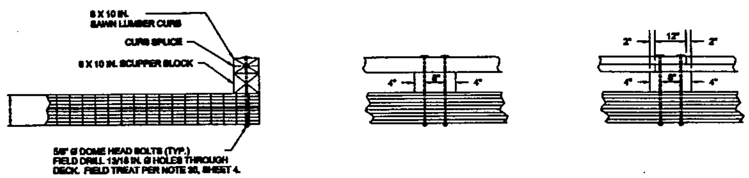
END VIEW

CURB DETAIL

SIDE VIEW

CURB DETAIL

SIDE VIEW



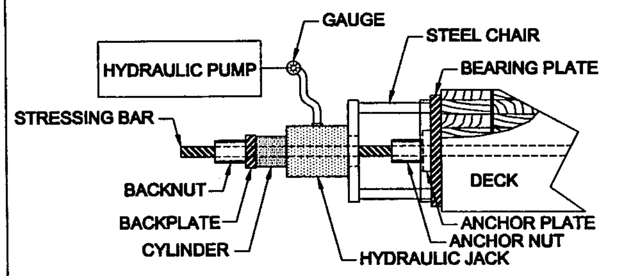


FIGURE 1 - TENSIONING EQUIPMENT AND CONFIGURATION

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
5 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
22	58	11	0.680	0.508	265.8	0.77	1	52,800	14 X 11 X 1	6 X 4 X 3/4
24	58	12.375	0.661	0.556	299.1	0.81	1	59,400	14.5 X 12 X 1	6 X 4 X 3/4
28	58	13.75	0.874	0.652	332.3	1.18	1	66,000	15 X 13 X 1	6 X 4 X 3/4
32	58	15.125	1.037	0.748	365.5	1.60	1	72,600	14.5 X 15 X 1	6 X 7 X 3/4
36	58	16.5	1.155	0.844	398.8	2.09	1	79,200	14.5 X 16 X 1	6 X 7 X 3/4

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
6.75 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
40	43	17.875	1.248	0.94	432.4	2.63	1	85,800	15 X 17 X 1	6 X 7 X 3/4
44	43	19.25	1.337	1.036	465.6	3.24	1.25	92,400	15 X 18 X 1	6 X 7 X 3/4
48	43	20.625	1.463	1.132	498.9	3.90	1.25	99,000	16 X 18 X 1	6 X 7 X 3/4
52	43	22	1.501	1.228	532.1	4.61	1.25	105,600	16.5 X 19 X 1	7 X 8 X 3/4

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
8.5 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
56	34	23.375	1.535	1.324	562.9	5.38	1.25	112,200	17.5 X 19 X 1	7 X 8 X 3/4
60	34	24.75	1.559	1.420	596.1	6.21	1.25	118,800	17.5 X 20 X 1	7 X 8 X 3/4
64	34	26.125	1.572	1.516	629.2	7.09	1.25	125,400	17.5 X 21 X 1	7 X 8 X 3/4
68	34	27.5	1.579	1.612	662.3	8.02	1.375	132,000	17.5 X 22 X 1	7 X 8 X 3/4

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
10.5 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
72	28	28.875	1.584	1.708	707.4	9.01	1.375	138,600	18.5 X 22 X 1	8 X 9 X 3/4
76	28	30.25	1.574	1.804	741.1	10.05	1.375	145,200	18.5 X 23 X 1	8 X 9 X 3/4
80	28	31.625	1.573	1.900	774.8	11.14	1.375	151,800	18.5 X 24 X 1	8 X 9 X 3/4

NOTE: Stress laminated spans should be a multiple of two. This allows four foot spacing of the rods with either two or one foot at each end.

NOTE: Minimum Bearing length for these spans is 10 inches.

NOTES AND REQUIREMENTS

DESIGN

1. These drawings are for stress-laminated timber bridge decks constructed of Southern Pine glued laminated timber. The designs are applicable to double-lane rectangular bridges (no skew) with simple span lengths of 22 to 80 ft. Design truck loading is AASHTO HS20-44.

2. Unless noted, designs comply with the Standard Specifications for Highway Bridges (15th Edition, 1992) (with interims through 1994) and Guide Specifications for Design of Stress-Laminated Wood Decks (1991), published by the American Association of State Highway and Transportation Officials.

3. Designs are applicable to double-lane bridges, 24 ft wide. The designs can be modified for other widths and numbers of lanes.

4. The minimum bearing lengths are 10" for these designs.

5. The controlling design criteria for deck thickness are both live load deflection and flexural strength The required deck thicknesses for stated bridge lengths based on deflection and flexural strength are shown in the tables on Sheet 3, and are based on the design loadings and limits of 1/500 of the bridge span (L), measured center-to-center of bearings and allowable maximum flexural stress in the supporting glulam members.

6. Unless noted, plan dimensions for sawn lumber are nominal dimensions . Dimensions for glulam timber are actual dimensions. Fabrication details are based on actual dimensions.

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

MATERIAL AND FABRICATION

Wood

8. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168.

9. Glued laminated timber used as deck laminations shall be Combination 24F-V3 Southern Pine, cambered as specified in tables on Sheet 3. Glued laminated timber rail material shall be Combination No. 48 Southern Pine.

10. The exterior laminations along each deck edge shall be Southern Pine Combination No. 48.

11. Unless noted, all lumber shall be dressed (S4S) Southern Pine. Lumber 2 to 4 inches in thickness shall be visually graded No. 2 or better. Lumber 5 inches or greater in thickness shall be visually graded No. 1 or better.

12. All glulam deck members shall be continuous between supports with no butt joints.

13. Unless noted, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives.

14. The moisture content of sawn lumber prior to and after treatment shall not exceed 15% for lumber 2 to 4 in. thick, and 19% for lumber thicker than 4 in. Moisture content of glued laminated timber shall not exceed 16% prior to and after treatment.

15. Fabrication for wood members should allow for 4 foot spacing of stressing bars. Each member shall be legibly marked with the designated mark number to aid in construction. The upper surface of each deck member in proper flexural orientation should be so marked to avoid error in orientation during construction.

16. Curbs and scupper block shall be visually graded No. 2 or better Southern Pine rough sawn timbers with a minimum size of 3/8 inch less than nominal.

17. Rail posts shall be visually graded No. 2 or better nominal 6 x 6 inch surfaced all sides (S4S) with a minimum dressed size of 5-1/2 x 5-1/2 inches.

Preservative Treatment

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

a. Creosote conforming to AWPA Standard P1
b. Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9.
c. CCA conforming to AWPA Standard P5.

17. Glulam timber shall be treated to the above requirements with creosote or pentachlorophenol.

18. Material treated with creosote or pentachlorophenol shall be free of excess preservative on the wood surface. The treating process for these preservatives shall include an expansion bath, steaming and/or dripping to ensure that preservative will not bleed.

19. Preservative treatment shall be inspected and certified in accordance with AWPA Standard M2.

Steel Fasteners and Hardware

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

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

22. Stressing bars shall be the diameter shown on tables in Sheet 3 and shall comply with the requirements of ASTM A722. Nuts and couplers for stressing bars shall be provided by the bar manufacturer.

23. Split rings shall be manufactured from SAE 1010 hot rolled carbon steel. Shear plates shall be malleable iron manufactured according to Grade 32510 of ASTM A47.

24. Washers shall be provided with 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.

25. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232. 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.

26. All nuts for bolts and stressing bars shall be oversized or re-threaded to ensure proper fit after galvanizing.

Miscellaneous

27. Geotextile fabric should be an impregnated, non-woven fabric that provides a watertight 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.

28. Sealer for wood end grain is typically a commercial roofing cement.

CONSTRUCTION

29. 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 30. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

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

31. Stressing bars shall be fully tensioned to the values specified in the tables on Sheet 3, in accordance with the following sequence:
   1. Initially at construction
   2. 1 week after the initial stressing
   3. 6-8 weeks after the second stressing

In addition, it is recommended that the bars be checked, and re-tensioned as required, 2 years after construction and at approximately 3 year intervals thereafter until bar force stabilizes.

32. Refer to Sheets 5 and 6 for recommended bar stressing procedures and considerations.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAMINATED STRINGERS STRESS LAMINATED TO FORM ORTHOTROPIC DECK	NOTES & REQUIREMENTS SHEET 4 OF 6	12

Construction Recommendations and Procedures

The performance and longevity of any bridge depends on the materials and construction practices. Abbreviated recommendations for the proper construction of stress-laminated bridges given in these drawings follow. It is advisable to read and understand all these recommendations prior to beginning construction. For additional information, refer to the drawing notes and Timber Bridges: Design, Construction, Inspection, and Maintenance (Ritter 1990).

MATERIALS

The following recommendations should be followed for materials:

1. Glulam timber must comply with the requirements of ANSI/AITC A190.1 and be properly treated with wood preservatives.

2. Glulam is generally manufactured at a moisture content of 10% to 16%. Laminations should be protected from exposure at the job site to maintain this low moisture content prior to construction.

3. The location and size of holes in the laminations for stressing bars should be verified 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.

4. Nuts for galvanized stressing bars must be oversized to compensate for the galvanizing. Nuts that are not oversized or reamed will not fit on the stressing bars.

5. Proper material certification and/or quality assurance certificates should be received and verified for all materials.

6. Field cutting and drilling of treated wood members must be minimized. In cases where field fabrication is required, proper field treating is essential.

BRIDGE ASSEMBLY

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

Assembly on the Abutments

When the bridge is assembled on the abutments, there are two commonly used options for placing laminations:

1. The laminations are placed individually. Using this method, 4 to 8 laminations are placed on the abutments starting at the deck edge location. Wood dowels may be used to align holes. When holes are aligned, stressing bars are inserted and pushed through the holes. Continue 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 allowed to bend excessively. Bar bending may damage the bar or the galvanizing coating.

2. The laminations are preassembled into panels. In this case, panels 2 to 4 ft wide are assembled by banding laminations together with metal bands. When placing laminations, corner guards must be provided to prevent damage to the wood when the bands are tightened. The holes must be aligned so that stressing bars can be easily inserted. After assembly, the panels are lifted onto the abutments and the bars are inserted and tensioned. When lifting panels, use full support across the bottom of the panels so that individual laminations do not move relative to one another.

If bars are difficult to insert through the laminations try gently striking the bar aids assembly, place a wood block over the end of the bar to protect the steel. Do not hammer directly on the end of the bar. This will cause the steel to mushroom and the nut cannot be properly threaded. Also be careful not to bend or otherwise damage the bar. If bars cannot be inserted without excessive hammering, shift the laminations as necessary until the holes align properly.

Assembly Adjacent to the Site

Stress-laminated bridges may be completely assembled adjacent to the site and lifted into place with a crane. To accomplish this, a level site is necessary and wood blocking or other supports are needed at the bridge ends to serve as temporary abutments. Laminations may be placed on the supports individually or in panels as previously described. After assembly, the bars must be fully tensioned, as discussed below, before the bridge is lifted. When lifting the assembled bridge, use lifting eyes through the top of the bridge or use spreader beams under the bridge. Do not lift the bridge by the stressing bars as this may cause the bars to bend or laminations to slip.

BAR TENSIONING

The pre-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 prestress be maintained between timber laminations 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.

Equipment and Procedures

Stress-laminated bridges are stressed together with a hydraulic jack that applies tension to the pre-stressing bar by pulling the bar away from the steel anchor plate. After the tension is applied, the nut is tightened against the anchor plate and the tension remains in the bar when jack pressure is released. The typical equipment for bar tensioning consists of a hydraulic hollow-core jack, pump, hose and gauge, a steel tensioning chair, backplate, and backnut (Figure 1, Page 3). The folowing should be considered regarding equipment.

1. The capacity of the jack must be sufficient to provide 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 onsite source of power.

3. The scale of the hydraulic gauge attached to the pump may be calibrated in lb/in.^{2}, or tons. It is generally easier to work in tons. If the gauge is calibrated in lb/in.^{2}, a table which converts lb/in.^{2} values to the jack force must be provided.

4. The stressing chair is normally locally fabricated. It is important that the base of the chair be large enough to fit over the bar anchor plate, but remain on the bearing plate. The chair must not bear directly on the lumber laminations. The height of the chair should be 2 to 3 times the length of the bar nut plus the anchor plate thickness.

5. The backplate is generally the same size as the bar anchor plate.

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

To tension the bars properly, there must be sufficient bar length beyond the nut on which to place the tensioning equipment. It is generally beneficial to select one bridge side and place all bar extensions on that side. On the opposite edge, bars should extend approximately 1 inch beyond the nut. If there is insufficient bar length for the tensioning equipment, a temporary coupler and bar extension may be used. If this is done, it is critical that each bar be threaded fully into half the coupler 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.

During all bar tensioning procedures, it is important that personnel not stand in front of the bar, or place hands and other body parts on or near the tensioning equipment. At the high force during tensioning, a broken bar will exit at great speed and force and can cause serious injury or death. It is also important not to lift the jack by the hydraulic hose as this may damage the hose and cause rupture under high oil pressure. To aid in handling, a rope securely tied to the jack may be beneficial.

The following steps outline the typical procedure for bar tensioning.

1. Place the chair and jack on the bar. Place the jack so that the cylinder extends away from the bridge. Placing the cylinder against the chair may cause the chair to bend.

2. Place the backplate and backnut on the bar. Allow a small gap of approximately ¼ inch between the backplate and the jack to prevent bending.

3. Apply hydraulic pressure to the jack until the gauge is at the required reading. It is common to apply approximately 10% greater force to compensate for lockoff losses when the nut is tightened. Ensure that the proper gauge scale is used. Most gauges have several scales for different jacks.

4. 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 galvanizing. It is important to tighten the nut sufficiently to ensure that it bears tightly against the anchor plate.

5. Release the pump hydraulic pressure slowly and remove the tensioning equipment. If the outside nut binds, tap it gently along the bar axis to loosen the threads.

<u>Tensioning Sequence</u>

For a stress-laminated bridge to function properly, all bars must be tensioned uniformly to the design force. As the bars are tensioned, the laminations compress and the bridge deck narrows. When using a single hydraulic jack, tensioning one bar compresses the bridge and causes the force in adjacent bars to decrease. This effect is most pronounced when the bridge is initially tensioned and decreases as the force in all bars becomes equal. To compensate for this effect, bars must be sequentially tensioned several times to equalize force. This is generally accomplished by tensioning the first bar on one end of the bridge and sequentially tensioning each successive bar down the bridge length. The process is then repeated several times until all bars are fully tensioned to the design level.

As described in Note 31, Sheet 4, the bar tensioning must be completed three times during the construction process.

1. at the time of bridge erection

2. approximately one week after the first tensioning

3. 6 to 8 weeks after the second tensioning

When initially tensioning bars with a single jack, it is important that the tension be applied gradually to prevent distortion along the bridge edges. If bars are initially tensioned to the full design level, the bridge edges may become distorted. For best results, the following procedure is recommended for the first tensioning.

1. Starting at one end of the bridge, sequentially tension each bar to approximately 25% of the design level. During this process, a stringline may be used to ensure that the edges of the bridge remain straight.

2. Following the same procedure, tension each bar to approximately 50% of the design level. The force level may be varied slightly to ensure that bridge edges remain straight.

3. Sequentially tension each bar to the full design level. Again, the force level may be varied slightly to ensure that the bridge edges remain straight.

4. Return to first bar, and repeat step 3.

5. Check the force in several bars using the procedure described below. If the force is 10% or more below the design level, retension the bar. Generally, the above steps are sufficient to achieve uniform bar tension; however, in some cases step 3 will have to be repeated one or two more times.

After the above initial tensioning, the bars must be retensioned a second and third time in accordance with the tensioning sequence previously discussed. At the conclusion of each bar tensioning, the force level should be checked to verify that all bars are at the design level. When the last two tensionings are completed, the bar force should stabilize and should not drop below 40% of the design level. However, the decrease in bar force depends on many factors and should be checked periodically after construction. It is recommended that the bar force be checked 2 years after construction and at approximately 3 year intervals thereafter until the bar force stabilizes. This typically requires little time or equipment and will ensure that the bridge performs properly over the design life.

<u>Checking Bar Force</u>

The force in tensioning bars can be checked quickly with the same equipment used for tensioning. The two methods given below provide acceptable estimates of bar force. The nut turn method is applicable to both the manual and electric pumps and the gauge method is applicable only to hand-operated hydraulic pumps.

<u>Nut Turn Method</u>

To determine the bar force using the nut turn method, a wrench is placed on the bar nut adjacent to the anchor plate and force is slowly applied to the hydraulic jack. During the application of jack force, the wrench is pushed in the direction to loosen the nut. The gauge reading at the point where the nut just begins to turn can be converted to the approximate force in the bar. In some cases, the nut may slightly bind on the bar and may not turn when the bar force is applied. In this case, jack the bar until the nut is pulled away from the plate and turn the nut slightly in both directions to loosen the binding. After turning the nut, be sure to return it to the original position prior to releasing the jack force. After this is accomplished, the procedure to check bar force can be completed using the free turning nut.

<u>Gauge Method</u>

When the hydraulic jack applies tension to the bar, the gauge needle moves relatively quickly as the load is initially applied. As the force increases, and the full bar becomes tensioned, the needle movement is slower. When the bar force is overcome and the jack begins to apply force to the entire bar, there is a slight pause in the gauge needle rise. This occurs approximately at the point where the force in the jack equals the force in the bar. To check the bar force using this method, slowly pump the hydraulic pump and watch the movement of the gauge needle. When the jack is pumped, and the needle stops moving momentarily, note the gauge reading. This reading represents the approximate bar force. At this time, it will also become slightly more difficult to pump the jack. Using this method requires a "feel" for the release point and should be practiced prior to determining the bar force.

<u>Tensioning Considerations</u>

As the bars are tensioned, the laminations compress and the bridge width will narrow slightly. This is most pronounced when the bars are initially tensioned and decreases with subsequent retensioning. It is therefore advisable to delay substructure attachment and curb and rail placement until after the second bar tensioning. It is also advisable to wait until after the second or third bar tensioning to apply the asphalt wearing surface.

After the bars in a bridge have been tensioned, it is important that sufficient bar length remain along one edge to allow retensioning of the bars. If a coupler and extension bar will be used for future tensionings, bars may be cut short, but a minimum of 10 inches of bar should remain beyond the nut. When no coupler and extension bar will be used for future tensionings, the bar length beyond the nut should be 18 to 24 inches, depending on the bar length required for the tensioning equipment.

PRE-DESIGNED TIMBER BRIDGES OF THREE TYPES FOR ARKANSAS COUNTY ROADS

by
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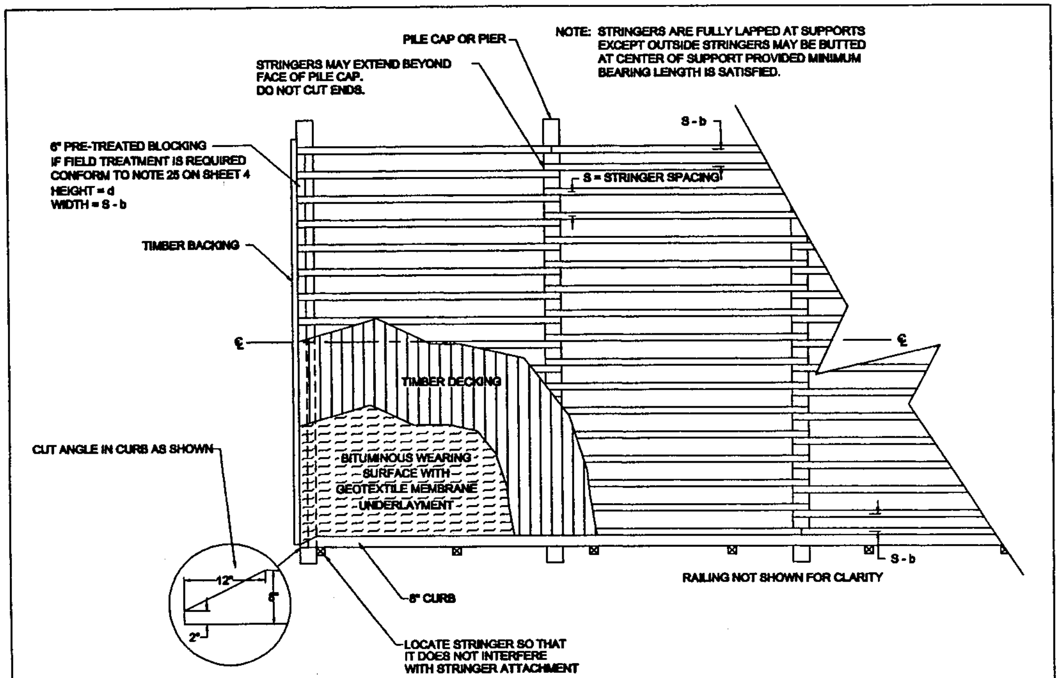
Fayetteville, Arkansas 72701

Contents | Page



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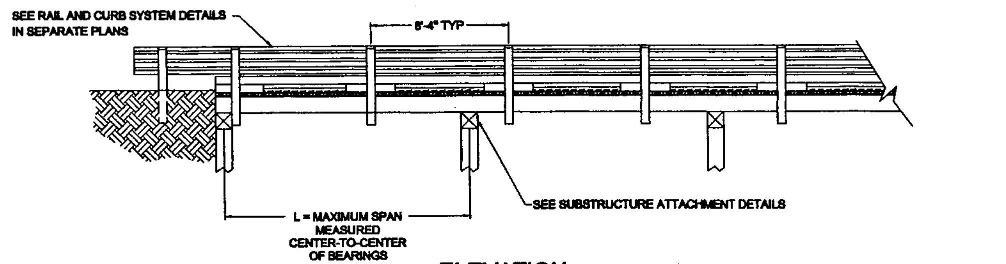

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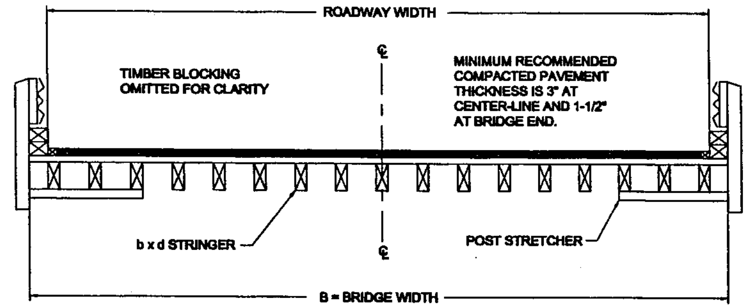

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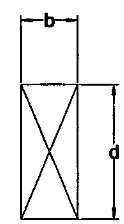


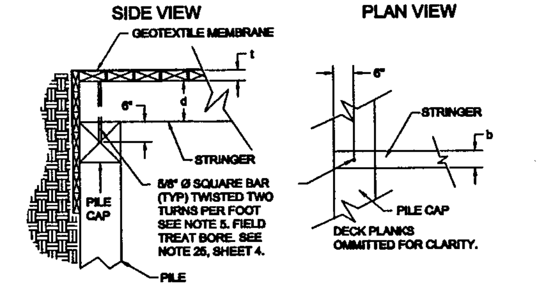
b = STRINGER WIDTH
d = STRINGER DEPTH

STRINGER

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK	GENERAL LAYOUT SHEET 1 OF 4	1

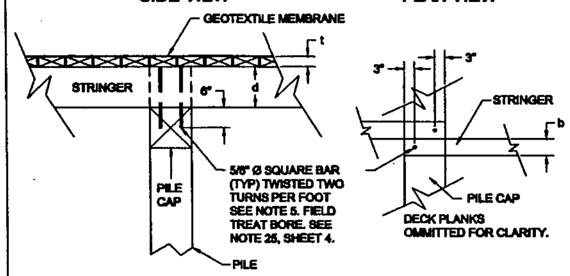
SUGESTED DECK/SUBSTRUCTURE ATTACHMENT DETAILS

TIMBER ABUTMENT ATTACHMENT



NOTE: PILE CAPS SHOWN FOR CLARITY. DESIGNED BY OTHERS.

TIMBER BENT ATTACHMENT

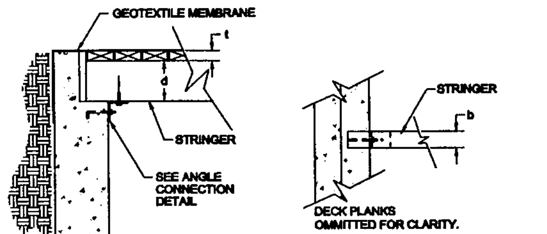


NOTE: PILE CAPS SHOWN FOR CLARITY. DESIGNED BY OTHERS.

DECK/SUBSTRUCTURE ATTACHMENT NOTES

1. SUBSTRUCTURE DETAILS ARE FOR ILLUSTRATION ONLY AND MUST BE DESIGNED FOR SPECIFIC LOCATIONS.
2. USE OF EXISTING PILE CAPS AND ABUTMENTS MAY REQUIRE ALTERNATE DETAILING.
3. GEOTEXTILE FABRIC SHALL WRAP OVER ABUTMENT ENDS A MINIMUM OF 2 FT VERTICALLY. SEE NOTE 22, SHEET 5.
4. STRINGER ATTACHMENTS SHALL BE DESIGNED FOR SPECIFIC SITE CONDITIONS. RECOMMENDATIONS GIVEN ON THIS SHEET.
5. FOR 5/8" Ø SQUARE BARS, PREBORE 11/16" Ø LEAD HOLE. COUNTERBORE 3/4" Ø X (d - 6").

CONCRETE ABUTMENT ATTACHMENT



NOTE: PILE CAPS SHOWN FOR CLARITY. DESIGNED BY OTHERS.

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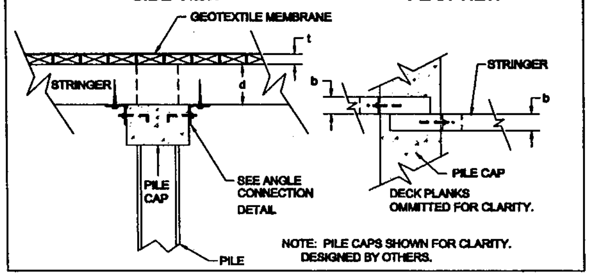
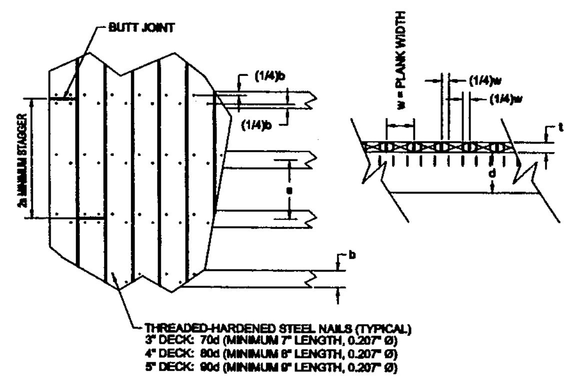


NOTE: PILE CAPS SHOWN FOR CLARITY. DESIGNED BY OTHERS.

PLANK DECK ATTACHMENT

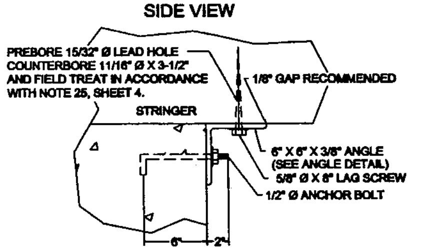


PLANK DECK ATTACHMENT NOTES

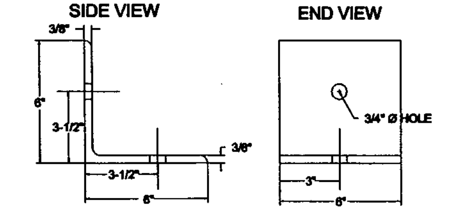
1. EDGE SAWN DECK PLANKS ARE PREFERABLE.
2. IF FLAT SAWN DECK PLANKS ARE USED, ORIENT BARK SIDE UP.
3. DRIVE NAILS AT SLIGHT ANGLE.
4. BUTT JOINTS ARE CENTERED ON A STRINGER WITH JOINTS FOR ADJACENT PLANKS STAGGERED A MINIMUM OF TWO STRINGER SPACINGS.
5. ALL PLANKS MUST BE CONTINUOUS OVER AT LEAST FIVE STRINGERS.

ANGLE CONNECTION DETAIL

SIDE VIEW



ANGLE DETAIL
6" X 6" X 3/8" ANGLE; A36 STEEL



MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK	ATTACHMENT DETAILS SHEET 2 OF 4	2

Design Notes

DESIGN

1. These drawings are for solid sawn longitudinal stringer/transverse deck timber bridges constructed of Southern Pine. The designs are applicable for double lane rectangular bridges of the width shown (no skew) with center-to-center spans according to the tables on Sheet 3. The designs can be modified for other widths and number of lanes. Bridges may be multiple span with any combination of acceptable span lengths.

2. Except as noted, designs comply with the Standard Specifications for Highway Bridges (15th Edition, 1992 with interims through 1994), 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 static criteria.

- Bearing length for stringers on abutments is 4.5 inches.

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, drilled, 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 dimensions are 3" x 10" for all decks in these plans.

7. Planks are rough sawn green, (unseasoned) 3 inches in nominal thicknesses.

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

Minimum Rough Sizes for Planks

Thickness (in.)		Width (in.)	
Nominal	Actual	Nominal	Actual
3	2-11/16	10	9-5/8

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

Stringers

10. Stringers shall be visually graded No. 1 Dense, No. 2 or better Southern Pine timbers as specified in the tables on Sheet 3.

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

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

Curbs, Scupper Blocks, and Rail Posts

13. Curbs and scupper blocks shall be visually graded No. 2 or better Southern Pine rough sawn timbers with a minimum size of 3/8 inch less than normal.

14. Rail posts shall be visually graded No. 2 or better nominal 6 x 6 inch surfaced all sides (S4S) with a minimum dressed size of 5-1/2 x 5-1/2 in.

Preservative Treatment

15. All sawn lumber shall be treated in accordance with the requirements of AWPA Standard C14 with one of the following preservatives:
a. Creosote conforming to AWPA Standard P1
b. Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9.

16. 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 dripping to ensure that preservative will not bleed.

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

Steel Fasteners and Hardware

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

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

20. Washers shall be provided with 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.

21. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232.

Miscellaneous

22. Geotextile fabric shall be an impregnated, nonwoven fabric which provides a watertight 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 roofing cement.

CONSTRUCTION

24. All wood and metal components shall be handled and stored carefully so as to not damage the material. If damage does occur, wood shall be field treated in accordance with note 25. Damage to the galvanizing 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.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK	DESIGN NOTES SHEET 4 OF 4	3

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
6 X 12 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
11	14	21.69[1]	0.306	0.264	84.0
12	15	20.14	0.368	0.288	90.0
13	16	18.80	0.437	0.312	96.0
14	17	17.63	0.512	0.336	102.0
15	18	16.59	0.592	0.360	108.0
16	19	15.67[2]	0.679	0.384	114.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requireing colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
10 X 12 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
16	12	25.27[1]	0.657	0.384	120.0
17	13	23.17	0.723	0.408	130.0
18	14	21.38[2]	0.792	0.432	140.0
20	15	19.86[2]	1.009	0.480	150.0
21	16	18.53[2]	1.090	0.504	160.0
22	17	17.38[2]	1.175	0.528	170.0
23	18	16.35[2]	1.263	0.552	180.0
24	19	15.44[2]	1.356	0.576	190.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requireing colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
8 X 14 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
18	13	23.33[1]	0.680	0.432	121.3
20	14	21.54[1]	0.861	0.480	130.7
21	15	20.00	0.926	0.504	140.0
22	16	18.67[2]	0.993	0.528	149.3
24	17	17.50[2]	1.209	0.576	158.7
25	18	16.47[2]	1.286	0.600	168.0
26	19	15.56[2]	1.366	0.624	177.3

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requireing colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
8 X 12 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
14	13	23.33[1]	0.508	0.336	104.0
15	14	21.54[1]	0.577	0.360	112.0
16	15	20.00	0.650	0.384	120.0
17	16	18.67[2]	0.728	0.408	128.0
18	17	17.50[2]	0.810	0.432	136.0
19	18	16.47[2]	0.897	0.456	144.0
20	19	15.56[2]	0.988	0.480	152.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requireing colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
6 X 14 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

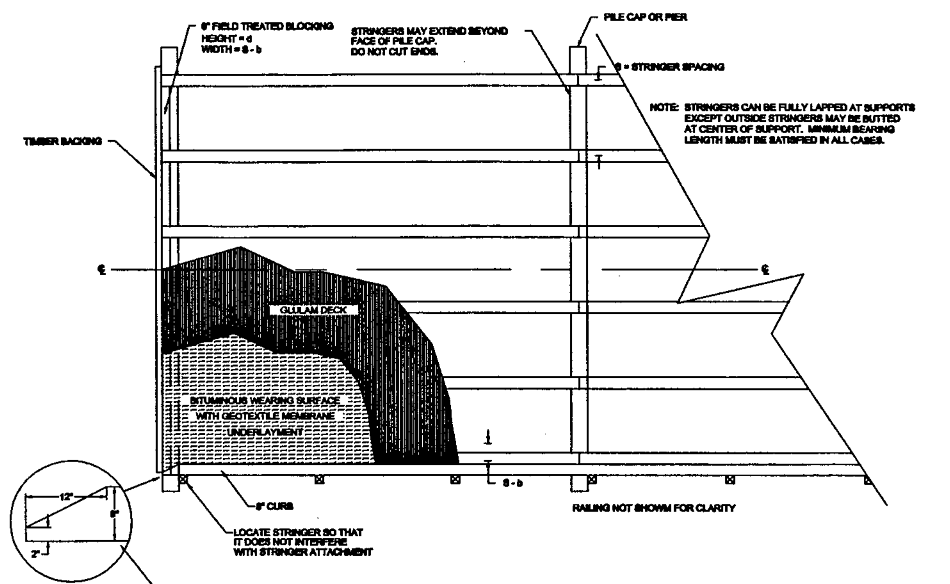
MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
14	13	23.50[1]	0.430	0.336	91.0
15	14	21.69[1]	0.488	0.360	98.0
16	15	20.14	0.550	0.384	105.0
17	16	18.80	0.616	0.408	112.0
18	17	17.63	0.685	0.432	119.0
19	18	16.59[2]	0.758	0.456	126.0
20	19	15.67[2]	0.835	0.480	133.0

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requireing colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.

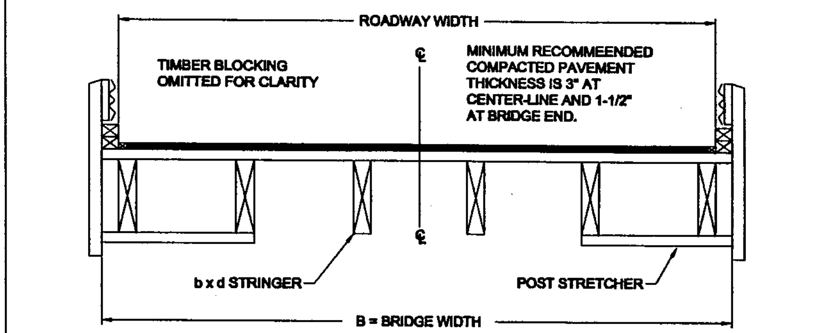
SOLID SAWN STRINGERS WITH SOLID SAWN TRANSVERSE PLANK DECK
MAXIMUM SPANS FOR SELECTED NUMBER OF STRINGERS
10 X 14 SOLID SAWN STRINGERS
3 X 10 SOLID SAWN PLANK DECK
24 FOOT WIDE ROADWAY

MAXIMUM SPAN (feet)	NUMBER OF STRINGERS	STRINGER SPACING (inches)	CALCULATED DEFLECTION (inches)	ALLOWABLE DEFLECTION (inches)	VOLUME IN STRINGERS (b.ft/ft)
21	12	25.27[1]	0.936	0.504	140.0
22	13	23.17	0.528	0.528	151.7
24	14	21.38[2]	0.576	0.576	163.3
25	15	19.86[2]	0.600	0.600	175.0
27	16	18.53[2]	0.648	0.648	186.7
28	17	17.38[2]	0.672	0.672	198.3
30	18	16.35[2]	0.720	0.720	210.0
31	19	15.44[2]	0.744	0.744	221.7

[1] requires 4 X 10 transverse plank section because of large clear spacing between stringers
[2] stringer spacing approaching or less than 2 times stringer width requireing colinear placement of stringers in succeeding spans rather than lapping stringers as per plan details.



PLAN VIEW



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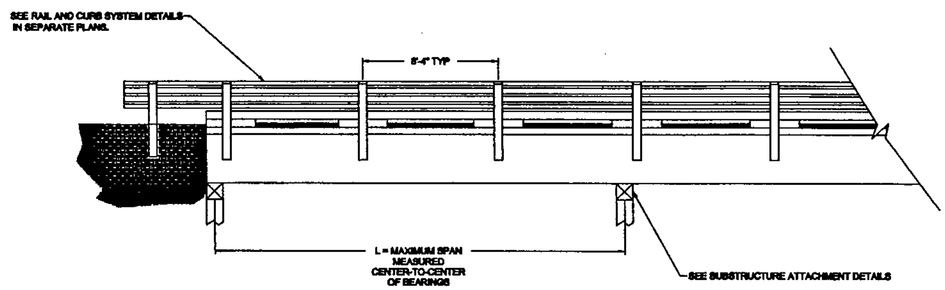

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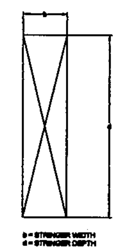
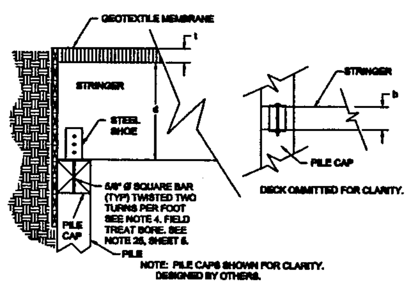


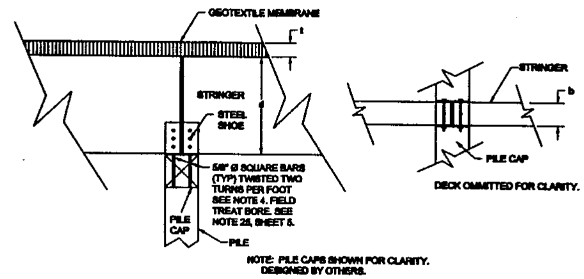
STRINGER

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS	GENERAL LAYOUT SHEET 1 OF 4	5

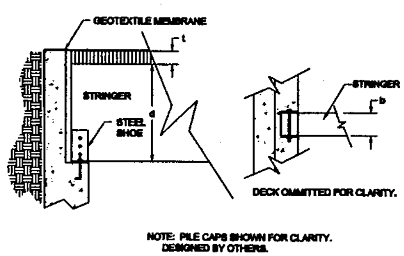
TIMBER ABUTMENT ATTACHMENT



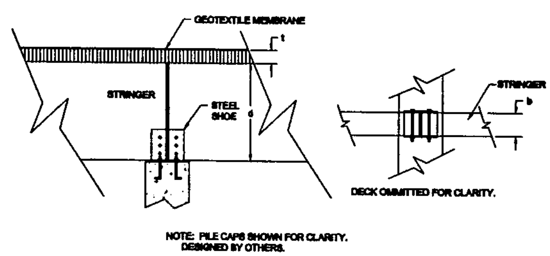
TIMBER BENT ATTACHMENT



CONCRETE ABUTMENT ATTACHMENT



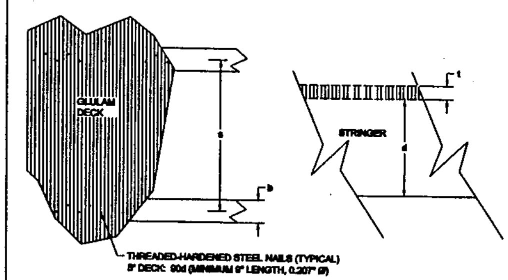
CONCRETE BENT ATTACHMENT



DECK/SUBSTRUCTURE ATTACHMENT NOTES

1. SUBSTRUCTURE DETAILS ARE FOR ILLUSTRATION ONLY AND MUST BE DESIGNED FOR SPECIFIC LOCATIONS.
2. GEOTEXTILE FABRIC SHALL WRAP OVER ABUTMENT ENDS A MINIMUM OF 2 FT VERTICALLY. SEE NOTE 22, SHEET 5.
3. STRINGER ATTACHMENTS SHALL BE DESIGNED FOR SPECIFIC SITE CONDITIONS. RECOMMENDATIONS GIVEN ON THIS SHEET.
4. FOR 5/8" Ø SQUARE BARS, PREBORE 11/16" Ø LEAD HOLE. COUNTERBORE 3/4" Ø X (d - 6").

PLANK DECK ATTACHMENT



PLANK DECK ATTACHMENT NOTES

1. DRIVE NAILS AT SLIGHT ANGLE.
2. STAGGER NAILS AS DEPICTED.
3. NAIL SPACING NOT TO EXCEED 5 INCHES.
4. ALL GLULAM SLABS MUST BE CONTINUOUS OVER AT LEAST FIVE STRINGERS.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS	ATTACHMENT DETAILS SHEET 2 OF 4	6

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
5 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 8.5 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
28	7/4	24.750	47.17	1.028	0.672	72.2
30	7/4	26.125	47.17	1.281	0.720	76.2
32	7/4	28.875	47.17	1.313	0.768	84.2
34	7/4	33.000	47.17	1.169	0.816	96.3
36	7/4	34.375	47.17	1.335	0.864	100.3
38	7/5	33.000	47.17	1.901	0.912	96.3
40	7/5	35.750	47.17	1.849	0.960	104.3
42	7/5	39.875	47.17	1.622	1.008	116.3

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
8.5 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 6.0 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
46	6/5	28.875	55.90	3.894	1.104	122.7
48	6/5	30.250	55.90	3.969	1.152	123.6
50	6/5	31.625	55.90	4.036	1.200	134.4
52	6/5	33.000	55.90	4.655	1.245	134.4
54	6/5	34.375	55.90	4.693	1.296	140.3
56	6/5	35.750	55.90	4.726	1.344	146.1
58	6/5	37.125	55.90	4.756	1.392	151.9
60	6/5	37.125	55.90	4.783	1.440	157.8
62	6/5	38.500	55.90	4.807	1.488	163.6

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
6.75 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 7.0 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
36	6/5	26.125	56.25	2.517	0.864	88.2
38	6/5	27.500	56.25	2.701	0.912	92.8
40	6/5	28.875	56.25	2.869	0.960	97.5
42	6/5	30.250	56.25	3.023	1.008	102.1
44	6/5	31.625	56.25	3.165	1.056	106.7
46	6/5	33.000	56.25	3.296	1.104	111.4
48	6/5	34.375	56.25	3.417	1.152	116.0
50	6/5	37.125	56.25	3.152	1.200	125.3
52	6/5	38.500	56.25	3.259	1.248	129.9

GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS
Maximum Spans for Selected Number and Depth of Stringers
10.5 inch Width Glulam Stringers
5 inch Thick Glulam Deck without Dowels
24 foot wide Roadway
Use minimum 6.0 inch bearing length

Maximum Span (feet)	Number Stringers/ Lat. Sup.	Stringer Depth (inches)	Stringer Spacing (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (b.ft/ft)
56	5/5	33.000	69.375	4.798	1.344	144.4
58	5/5	34.375	69.375	4.796	1.392	150.4
60	5/5	35.750	69.375	4.793	1.440	156.4
62	5/5	35.750	69.375	5.364	1.488	156.4
64	5/5	37.125	69.375	5.339	1.536	162.4
66	5/5	38.500	69.375	5.314	1.584	168.4
68	5/5	38.500	69.375	5.879	1.632	168.4
70	5/5	39.875	69.375	5.834	1.680	174.5
72	5/5	41.250	69.375	5.791	1.728	180.5

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS	DESIGN TABLES SHEET 3 OF 4	7

NOTES AND REQUIREMENTS

DESIGN

1. These drawings are for glued laminated stringer/ glued laminated transverse deck (w/o dowels) timber bridge decks constructed of Southern Pine glued laminated timber. The designs are applicable to double-lane rectangular bridges (no skew) with simple span lengths of 28 to 72 ft. Design truck loading is AASHTO HS20-44.

2. Unless noted, designs comply with the Standard Specifications for Highway Bridges (15th Edition, 1992) (with interims through 1994)

3. Designs are applicable to double-lane bridges, 24 ft wide. The designs can be modified for other widths and numbers of lanes.

4. The minimum bearing lengths are specified in the tables on sheet 3.

5. The controlling design criteria for deck thickness are both live load deflection and flexural strength
The required deck thicknesses for stated bridge lengths based on deflection and flexural strength are shown in the tables on Sheet 3, and are based on the design loadings and limits of 1/500 of the bridge span (L), measured center-to-center of bearings and allowable maximum flexural stress in the supporting glulam members.

6. Unless noted, plan dimensions for sawn lumber are nominal dimensions . Dimensions for glulam timber are actual dimensions. Fabrication details are based on actual dimensions.

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

MATERIAL AND FABRICATION

Wood

8. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168.

9. Glued laminated timber used as deck laminations shall be Combination 24F-V3 Southern Pine, cambered as specified in tables on Sheet 3. Glued laminated timber rail material shall be Combination No. 48 Southern Pine.

10. Unless noted, all lumber shall be dressed (S4S) Southern Pine. Lumber 2 to 4 inches in thickness shall be visually graded No. 2 or better. Lumber 5 inches or greater in thickness shall be visually graded No. 1 or better.

11. All glulam deck members shall be continuous between supports with no butt joints.

12. Unless noted, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives.

13. The moisture content of sawn lumber prior to and after treatment shall not exceed 15% for lumber 2 to 4 in. thick, and 19% for lumber thicker than 4 in. Moisture content of glued laminated timber shall not exceed 16% prior to and after treatment.

14. Curbs and scupper block shall be visually graded No. 2 or better Southern Pine rough sawn timbers with a minimum size of 3/8 inch less than nominal.

15. Rail posts shall be visually graded No. 2 or better nominal 6 x 6 inch surfaced all sides (S4S) with a minimum dressed size of 5-1/2 x 5-1/2 inches.

Preservative Treatment

16. All sawn lumber shall be treated in accordance with the requirements of AWPA Standard C14 with one of the following preservatives:
a. Creosote conforming to AWPA Standard P1
b. Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9.
c. CCA conforming to AWPA Standard P5.

17. Glulam timber shall be treated to the above requirements with creosote or pentachlorophenol.

18. Material treated with creosote or pentachlorophenol shall be free of excess preservative on the wood surface. The treating process for these preservatives shall include an expansion bath, steaming and/or dripping to ensure that preservative will not bleed.

19. Preservative treatment shall be inspected and certified in accordance with AWPA Standard M2.

Steel Fasteners and Hardware

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

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

22. Washers shall be provided with 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.

23. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232. 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.

24. All nuts for bolts shall be oversized or re-threaded to ensure proper fit after galvanizing.

Miscellaneous

25. Geotextile fabric should be an impregnated, non-woven fabric that provides a watertight 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.

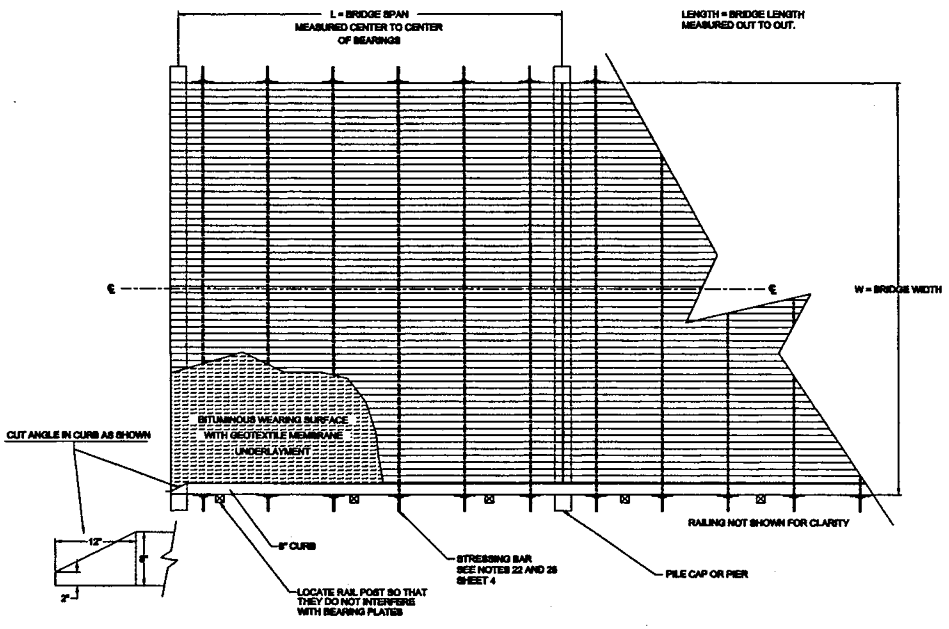
26. Sealer for wood end grain is typically a commercial roofing cement.

CONSTRUCTION

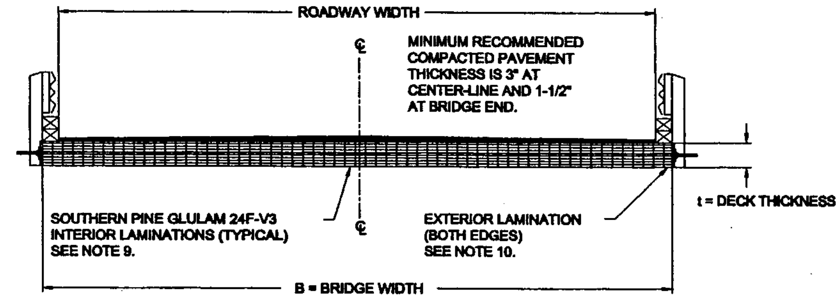
27. All wood and metal components shall be handled and stored carefully so as not to damage the material. If damage does occur, wood shall be field treated in accordance with Note 30. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

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

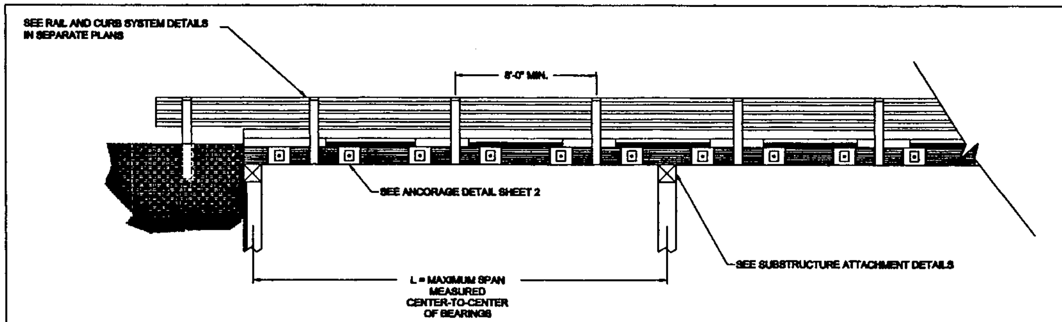
MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAM STRINGERS WITH TRANSVERSE GLULAM DECK W/O DOWELS	DESIGN NOTES SHEET 4 OF 4	8



PLAN VIEW



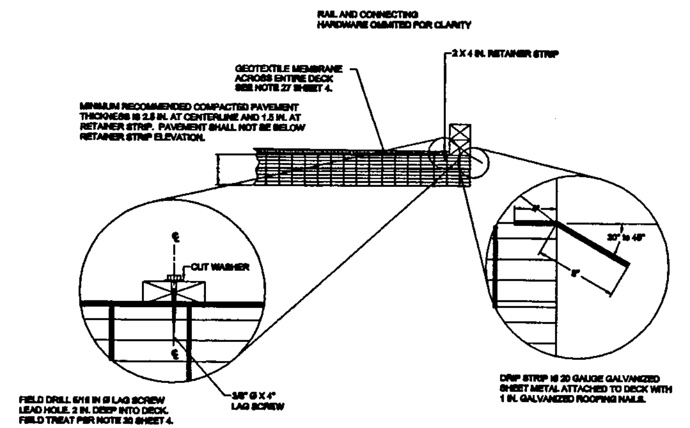
CROSS SECTION



ELEVATION

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAMINATED STRINGERS STRESS LAMINATED TO FORM ORTHOTROPIC DECK	GENERAL LAYOUT SHEET 1 OF 6	9

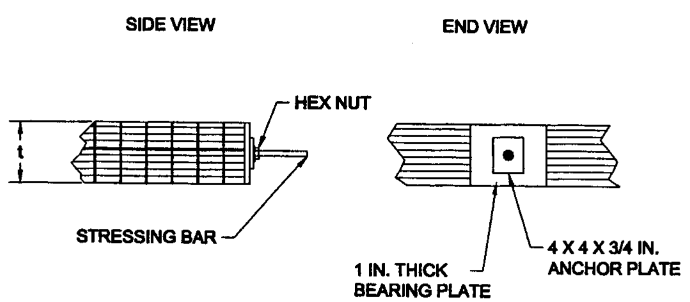
WEARING SURFACE



2" X 4" RETAINER STRIP

DRIP STRIP

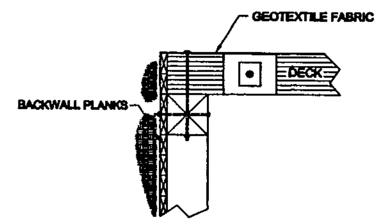
ANCHORAGE CONFIGURATION



SUGGESTED DECK/SUBSTRUCTURE ATTACHMENT

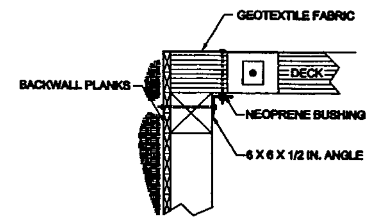
TIMBER ABUTMENT ATTACHMENT

SIDE VIEW



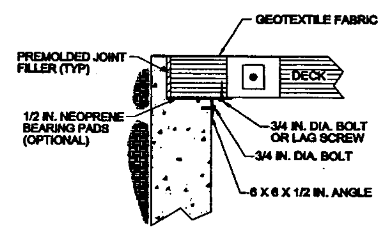
TIMBER ABUTMENT ATTACHMENT

SIDE VIEW



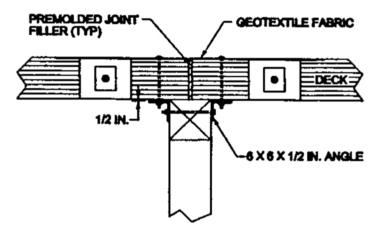
CONCRETE ABUTMENT ATTACHMENT

SIDE VIEW



TIMBER BENT ATTACHMENT

SIDE VIEW

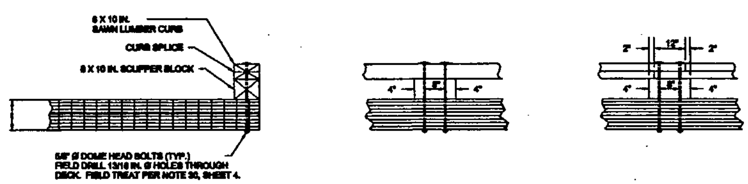


These details are representative of common substructure attachments and are shown for illustrative purposes only. The attachments must be designed for specific locations. The following recommendations are applicable in most circumstances.

1. Attachment bolt spacing shall not exceed 4 ft. over the entire bridge width.
2. Minimum bearing shall be 10 in. at abutments and 7 in. at bents.
3. Geotextile fabric shall wrap over abutment ends a minimum of 2 ft. vertically. See note 27, Sheet 4.
4. Bolts are 3/4 in. dia. Use dome head bolts in wood contact and hex bolts in steel contact. Field drill deck bolt holes 13/16 in. dia. and field treat in accordance with note 30, Sheet 4.
5. Lag screws for deck attachment are as follows:
   A. For 8 in. deck, 3/4 in. dia. X 6 in.; Prebore 11/16 in. dia. lead hole. Counterbore 13/16 in. dia. X 2-12 in.
   B. For 10 and 12 in. deck, 3/4 in. dia. X 8 in.; Prebore 11/16 in. dia. lead hole. Counterbore 13/16 in. dia. X 3-1/2 in.
6. Apply preservative to all field borings. See note 30, Sheet 4.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAMINATED STRINGERS STRESS LAMINATED TO FORM ORTHOTROPIC DECK	GENERAL DETAILS SHEET 2 OF 6	10

CURB DETAIL — END VIEW | CURB DETAIL — SIDE VIEW | CURB DETAIL — SIDE VIEW



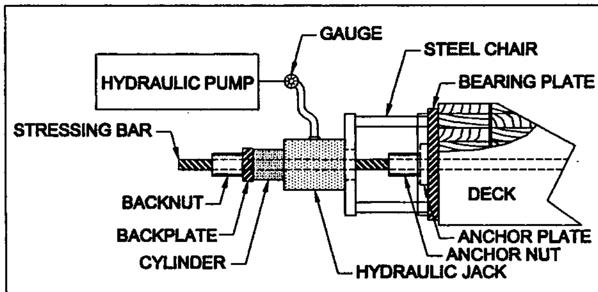


FIGURE 1 - TENSIONING EQUIPMENT AND CONFIGURATION

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
5 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
22	58	11	0.680	0.508	265.8	0.77	1	52,800	14 X 11 X 1	6 X 4 X 3/4
24	58	12.375	0.661	0.556	299.1	0.81	1	59,400	14.5 X 12 X 1	6 X 4 X 3/4
28	58	13.75	0.874	0.652	332.3	1.18	1	66,000	15 X 13 X 1	6 X 4 X 3/4
32	58	15.125	1.037	0.748	365.5	1.60	1	72,600	14.5 X 15 X 1	6 X 7 X 3/4
36	58	16.5	1.155	0.844	398.8	2.09	1	79,200	14.5 X 16 X 1	6 X 7 X 3/4

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
6.75 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
40	43	17.875	1.248	0.94	432.4	2.63	1	85,800	15 X 17 X 1	6 X 7 X 3/4
44	43	19.25	1.337	1.036	465.6	3.24	1.25	92,400	15 X 18 X 1	6 X 7 X 3/4
48	43	20.625	1.463	1.132	498.9	3.90	1.25	99,000	16 X 18 X 1	6 X 7 X 3/4
52	43	22	1.501	1.228	532.1	4.61	1.25	105,600	16.5 X 19 X 1	7 X 8 X 3/4

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
8.5 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
56	34	23.375	1.535	1.324	562.9	5.38	1.25	112,200	17.5 X 19 X 1	7 X 8 X 3/4
60	34	24.75	1.559	1.420	596.1	6.21	1.25	118,800	17.5 X 20 X 1	7 X 8 X 3/4
64	34	26.125	1.572	1.516	629.2	7.09	1.25	125,400	17.5 X 21 X 1	7 X 8 X 3/4
68	34	27.5	1.579	1.612	662.3	8.02	1.375	132,000	17.5 X 22 X 1	7 X 8 X 3/4

GLULAM STRINGERS STRESS-LAMINATED TO ORTHOTROPIC DECK
Maximum Spans for Selected Number and Depth of Stringers
10.5 Inch Width Glulam Stringers Stress Laminated to form Orthotropic Deck
24 foot wide Roadway

Maximum Span (feet)	Number of Stringers	Stringer Depth (inches)	Calculated Deflection (inches)	Allowable Deflection (inches)	Volume in Stringers (bd.ft/ft)	Required Camber (inches)	Prestressing Bar Diameter (inches)	Prestressing Force (pounds)	Bearing Plate L X W X T (inches)	Anchor Plate L X W X T (inches)
72	28	28.875	1.584	1.708	707.4	9.01	1.375	138,600	18.5 X 22 X 1	8 X 9 X 3/4
76	28	30.25	1.574	1.804	741.1	10.05	1.375	145,200	18.5 X 23 X 1	8 X 9 X 3/4
80	28	31.625	1.573	1.900	774.8	11.14	1.375	151,800	18.5 X 24 X 1	8 X 9 X 3/4

NOTE: Stress laminated spans should be a multiple of two. This allows four foot spacing of the rods with either two or one foot at each end.

NOTE: Minimum Bearing length for these spans is 10 inches.

NOTES AND REQUIREMENTS

DESIGN

1. These drawings are for stress-laminated timber bridge decks constructed of Southern Pine glued laminated timber. The designs are applicable to double-lane rectangular bridges (no skew) with simple span lengths of 22 to 80 ft. Design truck loading is AASHTO HS20-44.

2. Unless noted, designs comply with the Standard Specifications for Highway Bridges (15th Edition, 1992) (with interims through 1994) and Guide Specifications for Design of Stress-Laminated Wood Decks (1991), published by the American Association of State Highway and Transportation Officials.

3. Designs are applicable to double-lane bridges, 24 ft wide. The designs can be modified for other widths and numbers of lanes.

4. The minimum bearing lengths are 10" for these designs.

5. The controlling design criteria for deck thickness are both live load deflection and flexural strength
The required deck thicknesses for stated bridge lengths based on deflection and flexural strength are shown in the tables on Sheet 3, and are based on the design loadings and limits of 1/500 of the bridge span (L), measured center-to-center of bearings and allowable maximum flexural stress in the supporting glulam members.

6. Unless noted, plan dimensions for sawn lumber are nominal dimensions . Dimensions for glulam timber are actual dimensions. Fabrication details are based on actual dimensions.

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

MATERIAL AND FABRICATION

Wood

8. Sawn lumber and glued laminated timber shall comply with the requirements of AASHTO M168.

9. Glued laminated timber used as deck laminations shall be Combination 24F-V3 Southern Pine, cambered as specified in tables on Sheet 3. Glued laminated timber rail material shall be Combination No. 48 Southern Pine.

10. The exterior laminations along each deck edge shall be Southern Pine Combination No. 48.

11. Unless noted, all lumber shall be dressed (S4S) Southern Pine. Lumber 2 to 4 inches in thickness shall be visually graded No. 2 or better. Lumber 5 inches or greater in thickness shall be visually graded No. 1 or better.

12. All glulam deck members shall be continuous between supports with no butt joints.

13. Unless noted, all wood shall be cut, drilled, and completely fabricated prior to pressure treatment with preservatives.

14. The moisture content of sawn lumber prior to and after treatment shall not exceed 15% for lumber 2 to 4 in. thick, and 19% for lumber thicker than 4 in. Moisture content of glued laminated timber shall not exceed 16% prior to and after treatment.

15. Fabrication for wood members should allow for 4 foot spacing of stressing bars. Each member shall be legibly marked with the designated mark number to aid in construction. The upper surface of each deck member in proper flexural orientation should be so marked to avoid error in orientation during construction.

16. Curbs and scupper block shall be visually graded No. 2 or better Southern Pine rough sawn timbers with a minimum size of 3/8 inch less than nominal.

17. Rail posts shall be visually graded No. 2 or better nominal 6 x 6 inch surfaced all sides (S4S) with a minimum dressed size of 5-1/2 x 5-1/2 inches.

Preservative Treatment

16. All sawn lumber shall be treated in accordance with the requirements of AWPA Standard C14 with one of the following preservatives:
a. Creosote conforming to AWPA Standard P1
b. Pentachlorophenol conforming to AWPA Standard P8 in hydrocarbon solvent, Type A, conforming to AWPA Standard P9.
c. CCA conforming to AWPA Standard P5.

17. Glulam timber shall be treated to the above requirements with creosote or pentachlorophenol.

18. Material treated with creosote or pentachlorophenol shall be free of excess preservative on the wood surface. The treating process for these preservatives shall include an expansion bath, steaming and/or dripping to ensure that preservative will not bleed.

19. Preservative treatment shall be inspected and certified in accordance with AWPA Standard M2.

Steel Fasteners and Hardware

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

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

22. Stressing bars shall be the diameter shown on tables in Sheet 3 and shall comply with the requirements of ASTM A722. Nuts and couplers for stressing bars shall be provided by the bar manufacturer.

23. Split rings shall be manufactured from SAE 1010 hot rolled carbon steel. Shear plates shall be malleable iron manufactured according to Grade 32510 of ASTM A47.

24. Washers shall be provided with 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.

25. All steel components and fasteners shall be galvanized in accordance with AASHTO M111 or AASHTO M232. 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.

26. All nuts for bolts and stressing bars shall be oversized or re-threaded to ensure proper fit after galvanizing.

Miscellaneous

27. Geotextile fabric should be an impregnated, non-woven fabric that provides a watertight 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.

28. Sealer for wood end grain is typically a commercial roofing cement.

CONSTRUCTION

29. 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 30. Damage to galvanized surfaces shall be repaired with a cold galvanizing compound or other approved coating.

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

31. Stressing bars shall be fully tensioned to the values specified in the tables on Sheet 3, in accordance with the following sequence:
1. Initially at construction
2. 1 week after the initial stressing
3. 6-8 weeks after the second stressing

In addition, it is recommended that the bars be checked, and re-tensioned as required, 2 years after construction and at approximately 3 year intervals thereafter until bar force stabilizes.

32. Refer to Sheets 5 and 6 for recommended bar stressing procedures and considerations.

MACK-BLACKWELL RURAL TRANSPORTATION STUDY CENTER STANDARD PLANS FOR SOUTHERN PINE BRIDGES	GLULAMINATED STRINGERS STRESS LAMINATED TO FORM ORTHOTROPIC DECK	NOTES & REQUIREMENTS SHEET 4 OF 6	12

Construction Recommendations and Procedures

The performance and longevity of any bridge depends on the materials and construction practices. Abbreviated recommendations for the proper construction of stress-laminated bridges given in these drawings follow. It is advisable to read and understand all these recommendations prior to beginning construction. For additional information, refer to the drawing notes and Timber Bridges: Design, Construction, Inspection, and Maintenance (Ritter 1990).

MATERIALS

The following recommendations should be followed for materials:

1. Glulam timber must comply with the requirements of ANSI/AITC A190.1 and be properly treated with wood preservatives.

2. Glulam is generally manufactured at a moisture content of 10% to 16%. Laminations should be protected from exposure at the job site to maintain this low moisture content prior to construction.

3. The location and size of holes in the laminations for stressing bars should be verified 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.

4. Nuts for galvanized stressing bars must be oversized to compensate for the galvanizing. Nuts that are not oversized or reamed will not fit on the stressing bars.

5. Proper material certification and/or quality assurance certificates should be received and verified for all materials.

6. Field cutting and drilling of treated wood members must be minimized. In cases where field fabrication is required, proper field treating is essential.

BRIDGE ASSEMBLY

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

Assembly on the Abutments

When the bridge is assembled on the abutments, there are two commonly used options for placing laminations:

1. The laminations are placed individually. Using this method, 4 to 8 laminations are placed on the abutments starting at the deck edge location. Wood dowels may be used to align holes. When holes are aligned, stressing bars are inserted and pushed through the holes. Continue 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 allowed to bend excessively. Bar bending may damage the bar or the galvanizing coating.

2. The laminations are preassembled into panels. In this case, panels 2 to 4 ft wide are assembled by banding laminations together with metal bands. When placing laminations, corner guards must be provided to prevent damage to the wood when the bands are tightened. The holes must be aligned so that stressing bars can be easily inserted. After assembly, the panels are lifted onto the abutments and the bars are inserted and tensioned. When lifting panels, use full support across the bottom of the panels so that individual laminations do not move relative to one another.

If bars are difficult to insert through the laminations try gently striking the bar aids assembly, place a wood block over the end of the bar to protect the steel. Do not hammer directly on the end of the bar. This will cause the steel to mushroom and the nut cannot be properly threaded. Also be careful not to bend or otherwise damage the bar. If bars cannot be inserted without excessive hammering, shift the laminations as necessary until the holes align properly.

Assembly Adjacent to the Site

Stress-laminated bridges may be completely assembled adjacent to the site and lifted into place with a crane. To accomplish this, a level site is necessary and wood blocking or other supports are needed at the bridge ends to serve as temporary abutments. Laminations may be placed on the supports individually or in panels as previously described. After assembly, the bars must be fully tensioned, as discussed below, before the bridge is lifted. When lifting the assembled bridge, use lifting eyes through the top of the bridge or use spreader beams under the bridge. Do not lift the bridge by the stressing bars as this may cause the bars to bend or laminations to slip.

BAR TENSIONING

The pre-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 prestress be maintained between timber laminations 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.

Equipment and Procedures

Stress-laminated bridges are stressed together with a hydraulic jack that applies tension to the pre-stressing bar by pulling the bar away from the steel anchor plate. After the tension is applied, the nut is tightened against the anchor plate and the tension remains in the bar when jack pressure is released. The typical equipment for bar tensioning consists of a hydraulic hollow-core jack, pump, hose and gauge, a steel tensioning chair, backplate, and backnut (Figure 1, Page 3). The folowing should be considered regarding equipment.

1. The capacity of the jack must be sufficient to provide 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 onsite source of power.

3. The scale of the hydraulic gauge attached to the pump may be calibrated in lb/in.^{2} or tons. It is generally easier to work in tons. If the gauge is calibrated in lb/in.^{2}, a table which converts lb/in.^{2} values to the jack force must be provided.

4. The stressing chair is normally locally fabricated. It is important that the base of the chair be large enough to fit over the bar anchor plate, but remain on the bearing plate. The chair must not bear directly on the lumber laminations. The height of the chair should be 2 to 3 times the length of the bar nut plus the anchor plate thickness.

5. The backplate is generally the same size as the bar anchor plate.

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

To tension the bars properly, there must be sufficient bar length beyond the nut on which to place the tensioning equipment. It is generally beneficial to select one bridge side and place all bar extensions on that side. On the opposite edge, bars should extend approximately 1 inch beyond the nut. If there is insufficient bar length for the tensioning equipment, a temporary coupler and bar extension may be used. If this is done, it is critical that each bar be threaded fully into half the coupler 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.

During all bar tensioning procedures, it is important that personnel not stand in front of the bar, or place hands and other body parts on or near the tensioning equipment. At the high force during tensioning, a broken bar will exit at great speed and force and can cause serious injury or death. It is also important not to lift the jack by the hydraulic hose as this may damage the hose and cause rupture under high oil pressure. To aid in handling, a rope securely tied to the jack may be beneficial.

The following steps outline the typical procedure for bar tensioning.

1. Place the chair and jack on the bar. Place the jack so that the cylinder extends away from the bridge. Placing the cylinder against the chair may cause the chair to bend.

2. Place the backplate and backnut on the bar. Allow a small gap of approximately ¼ inch between the backplate and the jack to prevent bending.

3. Apply hydraulic pressure to the jack until the gauge is at the required reading. It is common to apply approximately 10% greater force to compensate for lockoff losses when the nut is tightened. Ensure that the proper gauge scale is used. Most gauges have several scales for different jacks.

4. 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 galvanizing. It is important to tighten the nut sufficiently to ensure that it bears tightly against the anchor plate.

5. Release the pump hydraulic pressure slowly and remove the tensioning equipment. If the outside nut binds, tap it gently along the bar axis to loosen the threads.

Tensioning Sequence

For a stress-laminated bridge to function properly, all bars must be tensioned uniformly to the design force. As the bars are tensioned, the laminations compress and the bridge deck narrows. When using a single hydraulic jack, tensioning one bar compresses the bridge and causes the force in adjacent bars to decrease. This effect is most pronounced when the bridge is initially tensioned and decreases as the force in all bars becomes equal. To compensate for this effect, bars must be sequentially tensioned several times to equalize force. This is generally accomplished by tensioning the first bar on one end of the bridge and sequentially tensioning each successive bar down the bridge length. The process is then repeated several times until all bars are fully tensioned to the design level.

As described in Note 31, Sheet 4, the bar tensioning must be completed three times during the construction process.

1. at the time of bridge erection

2. approximately one week after the first tensioning

3. 6 to 8 weeks after the second tensioning

When initially tensioning bars with a single jack, it is important that the tension be applied gradually to prevent distortion along the bridge edges. If bars are initially tensioned to the full design level, the bridge edges may become distorted. For best results, the following procedure is recommended for the first tensioning.

1. Starting at one end of the bridge, sequentially tension each bar to approximately 25% of the design level. During this process, a stringline may be used to ensure that the edges of the bridge remain straight.

2. Following the same procedure, tension each bar to approximately 50% of the design level. The force level may be varied slightly to ensure that bridge edges remain straight.

3. Sequentially tension each bar to the full design level. Again, the force level may be varied slightly to ensure that the bridge edges remain straight.

4. Return to first bar, and repeat step 3.

5. Check the force in several bars using the procedure described below. If the force is 10% or more below the design level, retension the bar. Generally, the above steps are sufficient to achieve uniform bar tension; however, in some cases step 3 will have to be repeated one or two more times.

After the above initial tensioning, the bars must be retensioned a second and third time in accordance with the tensioning sequence previously discussed. At the conclusion of each bar tensioning, the force level should be checked to verify that all bars are at the design level. When the last two tensionings are completed, the bar force should stabilize and should not drop below 40% of the design level. However, the decrease in bar force depends on many factors and should be checked periodically after construction. It is recommended that the bar force be checked 2 years after construction and at approximately 3 year intervals thereafter until the bar force stabilizes. This typically requires little time or equipment and will ensure that the bridge performs properly over the design life.

Checking Bar Force

The force in tensioning bars can be checked quickly with the same equipment used for tensioning. The two methods given below provide acceptable estimates of bar force. The nut turn method is applicable to both the manual and electric pumps and the gauge method is applicable only to hand-operated hydraulic pumps.

Nut Turn Method

To determine the bar force using the nut turn method, a wrench is placed on the bar nut adjacent to the anchor plate and force is slowly applied to the hydraulic jack. During the application of jack force, the wrench is pushed in the direction to loosen the nut. The gauge reading at the point where the nut just begins to turn can be converted to the approximate force in the bar. In some cases, the nut may slightly bind on the bar and may not turn when the bar force is applied. In this case, jack the bar until the nut is pulled away from the plate and turn the nut slightly in both directions to loosen the binding. After turning the nut, be sure to return it to the original position prior to releasing the jack force. After this is accomplished, the procedure to check bar force can be completed using the free turning nut.

Gauge Method

When the hydraulic jack applies tension to the bar, the gauge needle moves relatively quickly as the load is initially applied. As the force increases, and the full bar becomes tensioned, the needle movement is slower. When the bar force is overcome and the jack begins to apply force to the entire bar, there is a slight pause in the gauge needle rise. This occurs approximately at the point where the force in the jack equals the force in the bar. To check the bar force using this method, slowly pump the hydraulic pump and watch the movement of the gauge needle. When the jack is pumped, and the needle stops moving momentarily, note the gauge reading. This reading represents the approximate bar force. At this time, it will also become slightly more difficult to pump the jack. Using this method requires a "feel" for the release point and should be practiced prior to determining the bar force.

Tensioning Considerations

As the bars are tensioned, the laminations compress and the bridge width will narrow slightly. This is most pronounced when the bars are initially tensioned and decreases with subsequent retensioning. It is therefore advisable to delay substructure attachment and curb and rail placement until after the second bar tensioning. It is also advisable to wait until after the second or third bar tensioning to apply the asphalt wearing surface.

After the bars in a bridge have been tensioned, it is important that sufficient bar length remain along one edge to allow retensioning of the bars. If a coupler and extension bar will be used for future tensionings, bars may be cut short, but a minimum of 10 inches of bar should remain beyond the nut. When no coupler and extension bar will be used for future tensionings, the bar length beyond the nut should be 18 to 24 inches, depending on the bar length required for the tensioning equipment.