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AITC 404-2005

STANDARD FOR RADIALLY REINFORCING CURVED GLUED LAMINATED TIMBER MEMBERS TO RESIST RADIAL TENSION

Adopted as Recommendations, October 28, 2005

404.1. SCOPE

This Standard covers recommended procedures for radially reinforcing curved glued laminated timber members at the time of manufacture when design calculations show that reinforcement is needed to resist radial tension stresses. Two methods are included: The use of fully threaded lag screws; or the use of a reinforcing dowel system consisting of a bar (usually, but not limited to, steel) and a thermo-setting structural void-filling adhesive. This Standard may also be used as a guideline for providing radial reinforcement for members, which were not reinforced at the time of original manufacture, when the reinforcement performed in the field is done from the top of the members.

For dry conditions of use, the moisture content of the laminations prior to gluing shall not exceed 12% when mechanical radial reinforcement is used.

404.2. FULLY THREADED LAG SCREW SYSTEM

Lag screws shall be threaded for the entire length (the unthreaded length shall not exceed one shank diameter) and made of material conforming to ASTM A307, Specification for Carbon Steel Externally Threaded Standard Fasteners.

404.2.1 In general, lag screws from 5/8 to 1 inch in diameter have been found satisfactory for most reinforcing requirements. See Table 404-1 for maximum recommended lengths for lag screws. If greater lengths of reinforcement are required, larger diameter lag screws should be specified. The size and spacing of lag screws shall be such that they can carry the design load in tension. In order to minimize the reduction in cross section of the glued laminated timber member, the size of lag screw used should be limited. The sizes shown in Table 404-2 can be used as guides. Other sizes can be used provided proper design procedures are used.

The spacing of lag screws varies with the size of the lag screw used and the radial tension forces. It is recommended that the spacing not exceed 1/2 the member depth measured at mid-point.

Table 404-1. *Recommended maximum lengths for lag screws.*

Lag Screw Diameter (in.)	0.5	0.625	0.75	1	1.25
Lag Screw Length (in.)	20	30	40	60	66

Table 404-2. *Maximum size lag screw based on beam width.*

Beam Width (in.)	3 1/8	5 1/8	6 3/4	8 3/4	10 3/4
Lag Screw Diameter (in.)	1/2	3/4	1	1	1 1/4

404.2.2 Lag screws need to be located only in the curved portion of the member as shown in Figure 404-1.

Neither the drilled holes nor the lag screw should extend to the bottom lamination. It is recommended that 2 in. of clearance be provided from the end of the lag screws and the bottom of the hole to the face of the bottom lamination as shown in Figure 404-1.

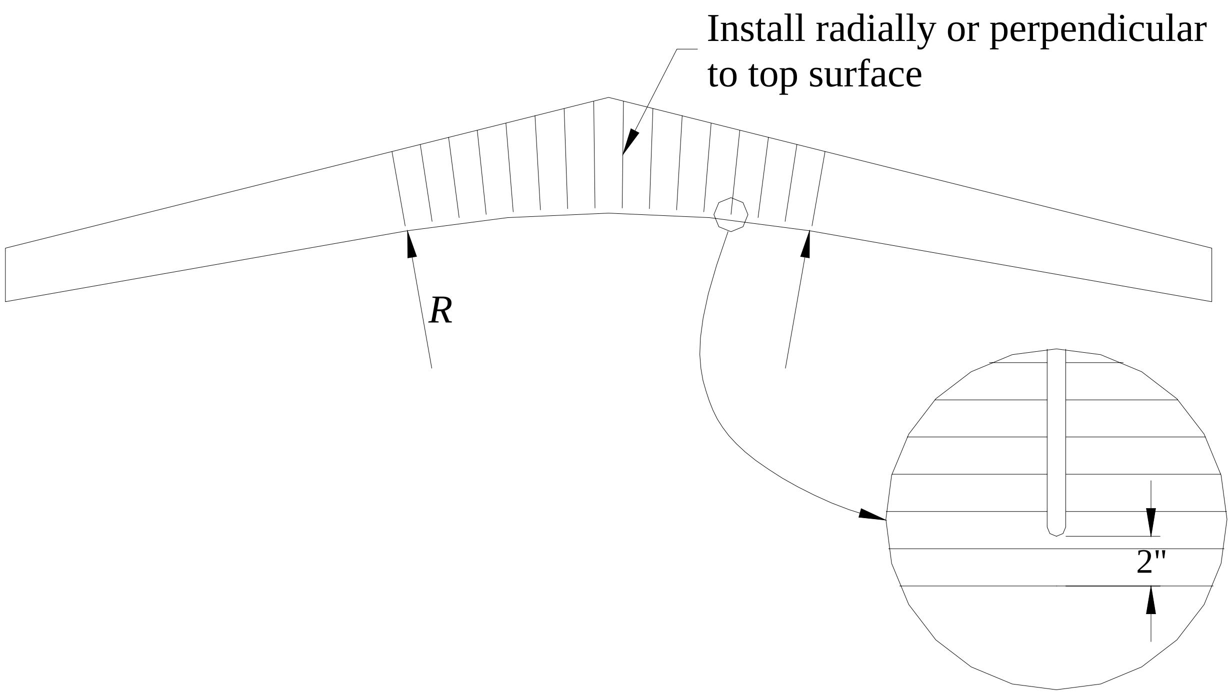


Figure 404-1. *Radially reinforced pitched and tapered curved beam.*

404.2.3 The maximum size of the drilled hole shall not exceed 85% of the shank diameter of the lag screw for Douglas Fir-Larch (DF-L) and 80% for Hem-Fir (HF), Softwood Species (SW) and California Redwood (CR). The minimum size of holes should not be less than 60% of the shank diameter for DF-L and 40% for HF, SW, and CR.

A short lead hole for the shank (diameter plus 1/16 in.) should be drilled to match the short unthreaded portion of the lag screw. If the lag screw head on top of the member is objectionable, the lag screw can be sawn flush with the top of the member or the head can be countersunk. In countersinking, remove only the amount of wood necessary to permit top of lag screw head to be flush with top of member.

404.2.4 The design value in withdrawal in pounds per inch of penetration shall not exceed those shown in Table 404-3.

Table 404-3. *Allowable withdrawal load of threaded portion of lag screw.*

Lag Screw Diameter (in.)	Douglas Fir-Larch (lb/in.)	Hem-Fir (lb/in.)	Softwood Species (lb/in.)	California Redwood (lb/in.)
1/2	321	257	189	205
5/8	380	303	223	242
3/4	436	348	255	277
7/8	490	390	286	312
1	541	432	317	344
1 1/4	639	510	375	407

Allowable loads are based on dry conditions of use and normal duration of load. These design values are 85 % of the values for Lag Screws in ordinary withdrawal due the larger lead hole used for longer lag screws necessary for radial reinforcement.

404.2.5 The design value in withdrawal for lag screws may also be determined by test. The test procedure shall be the same as that given in Section 404.6 where the design values of a dowel system are determined by comparing test results with those obtained with lag screws. The average of the ultimate test values in pounds per lineal inch shall be divided by 4 to determine the design value in lb/in. The design value shall not exceed the lowest test value divided by 3. The lag screw shall not be stressed beyond 60% of its yield strength calculated based on the net area at the root of the threads.

404.3. DOWEL SYSTEM

The dowel system consists of a bar (usually, but not limited to, steel) and a thermo-setting structural void filling adhesive which provides a structural bond between the bar and the sides of the predrilled hole.

404.3.1 Bars. No limitations are set as to shape or area of cross section of the bar. There are no limitations on type of material to be used for the bar; however, its surface must be free of dirt, grease, surface scale or other contaminants that may affect adhesion. The bar manufacturer shall provide the following physical properties for the bar to be used:

(a) Yield strength (if applicable) and ultimate strength in tension
(b) Modulus of elasticity
(c) Elongation
(d) Manufacturing tolerances (dimensional)
(e) Coefficient of linear expansion (temperature)

The preceding requirement may be waived if the material for the bar is manufactured in accordance with a nationally accepted standard (ASTM or other) and is so certified.

404.3.2 Structural Adhesive. The adhesive material shall be suitable for this application. In addition, the following information shall be provided by the adhesive manufacturer:

(a) Pot life at 40, 60, 80, 100, 120°F
(b) Maximum storage life
(c) Mixed viscosities (CPS) at various temperatures for in-use ranges
(d) Mixing, handling and storage recommendations
(e) Mix ratio by volume and/or by weight and recommended batch size
(f) Cured color
(g) Time-temperature relationship to cure

404.3.3 Combination of Dowel and Bar Size. For each different cross sectional area of bar, the diameter of the predrilled hole shall be determined.

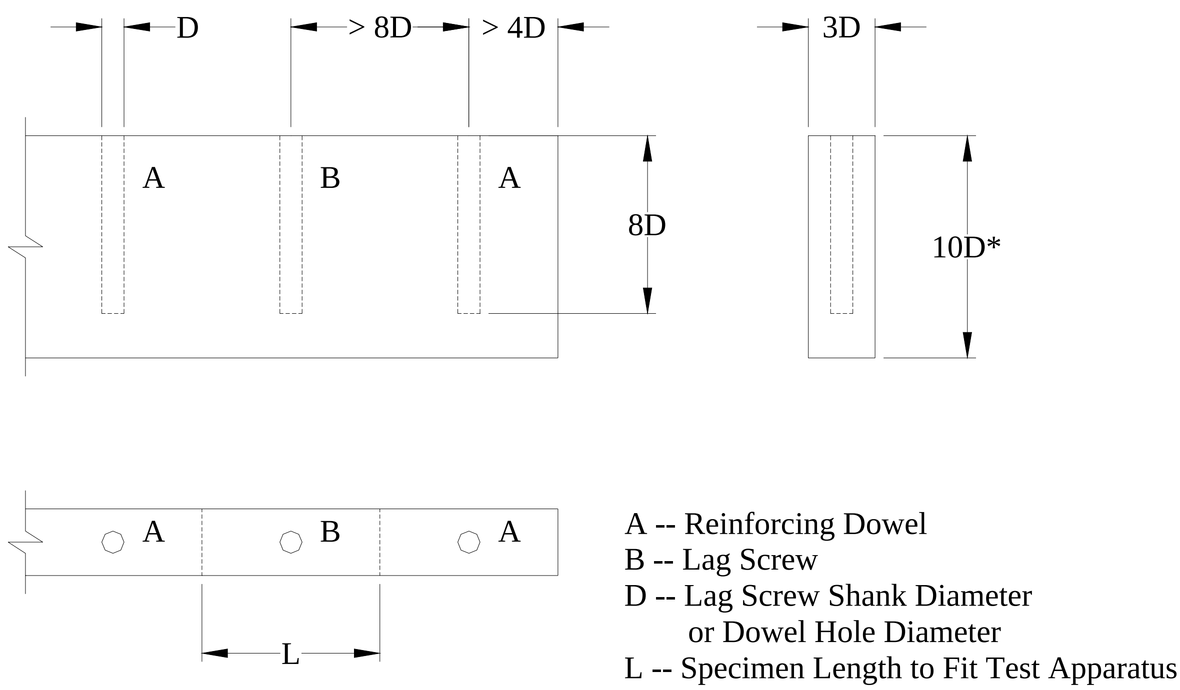
404.3.4 Design Value of Dowel. The design value of each bar size and type proposed for use shall be determined by test for:

(a) Each species
(b) Each dowel hole and bar size combination
(c) Each adhesive used
(d) Each type of material used for the bars.

The design value shall be equal to the lesser of 1/4 the average ultimate tensile strength test value or 1/3 the minimum tensile strength test value per inch of embedment of 10 dowels tested in accordance with this section (or Section 404.6) and as determined in accordance with Section 404.5, but shall not be greater than 60% of the yield strength of bars made of steel nor shall the design values for other materials be greater than the appropriate design values established by conventional methods.

404.4. TEST SPECIMENS

404.4.1 Preparation. A single piece of glued laminated timber shall be used for the test block. The specific gravity of the individual pieces of lumber in the laminated member shall be within a range of plus or minus 0.02 of the average specific gravity of the species. Dense material shall be excluded. The moisture content shall be 12% (plus or minus 2%). The width of the laminated timber shall be at least 3 times the diameter of the predrilled hole. The length shall be such that the 10 dowel holes can be drilled at least 8 diameters apart measured center to center and the end distance shall be at least 4 diameters measured from the centerline of the hole. The depth of the predrilled hole shall be 8 times the hole diameter (see Figure 404-2).



*This dimension is 10D plus one inch when D for the lag screw shank diameter controls.

Figure 404-2. *Test Block.*

404.4.1.1 Bars. The bars for the dowels shall be cut to a length which allows an adequate grip length in the test apparatus.

404.4.1.2 Adhesive. The adhesive shall be mixed in accordance with the manufacturer's recommendation. The adhesive shall first be poured into the hole in sufficient quantity to insure that it is at the top of the hole after insertion of the bar. Small additional amounts may be necessary if volumetric shrinkage or significant absorption takes place. All excess adhesive shall be removed before it hardens.

404.4.1.3 Curing. After placement of all dowels in a given test block, the test block shall be allowed to stand undisturbed until the adhesive has reached an estimated 90% of its full cure strength (based on the manufacturer's recommendations).

At the start of pouring a given mix, a sample of the adhesive shall be retained for observations on the "set" time and material hardness after complete cure. Additional samples may be desired to verify the length of time required to reach an estimated 90% of full cure for the adhesive used. (Compression testing may be used in accordance with the manufacturer's recommendation).

404.4.1.4 Cutting Test Specimens. After the adhesive has reached at least 90% of full cure, the member shall be cut through the cross section halfway between each dowel. The length of the test block shall be such that the block will fit in the test apparatus, but shall not be less than the size given in 404.4.1 (See Figure 404-2).

404.4.2 Test Grips. Any wedge type grip (see ASTM A370) may be used to grip the bar. The free running cross head speed of the test machine (rate of grip separation) shall not exceed 1/2 in. per minute.

Clear area around hole shall extend a minimum of 2 times the diameter of predrilled hole in all directions.

404.5. EVALUATION OF TEST DATA

Determine the average test values in withdrawal in lb per in. of embedment for each dowel size group and species tested. The design value in withdrawal (lb per in. of embedment) shall not exceed 1/4 the average test value or 1/3 the minimum test value. The total design load in tension shall not exceed 60% of the yield strength of steel rod used in the dowel system or the design values determined by conventional methods for other materials.

404.6. ALTERNATE TEST PROCEDURE FOR DOWEL SYSTEMS

An alternate method for establishing the design value of a dowel system is to compare the withdrawal value of a dowel system to the withdrawal value of a comparable lag screw inserted in the same test member.

404.6.1 Combination of Dowel and Bar Size. The diameter of the predrilled hole shall be determined for each different bar diameter. The nominal bar diameter shall be correlated with the root diameters of the control lag screws as shown in Table 404-4.

Table 404-4. Comparison of lag screw and dowel systems.

Lag Screw System				Dowel System			
Lag Screw Diameter (in.)	Lag Screw Root Diameter (in.)	Lead Hole Diameter [a,b] (in.)	Load Determined by Steel Strength [c] (lb)	Rebar Size for Dowel Diameter (in.)		Drilled Hole Diameter (in.)	Load Determined by Steel Strength [d] (lb)
				Nominal	Max [e]		
1/2	0.371	0.425	2160	0.375	0.438	0.5625	3980
5/8	0.471	0.531	3480	0.5	0.563	0.6875	7070
3/4	0.579	0.638	5270	0.625	0.688	0.8125	11040
7/8	0.683	0.744	7330	0.75	0.813	0.9375	15900
1	0.78	0.85	9560	1	1.125	1.25	28270
1 1/4	1.012	1.06	16090				

a. Hole diameter based on the use of Douglas Fir-Larch. For other Western Species decrease by 6%.
b. Select drill diameter to the nearest 1/16 in.
c. Allowable steel stress of 20,000 psi used for lag screws. (F_y = 33.3 ksi)
d. Allowable steel stress of 36,000 psi used for rebar. (F_y = 60 ksi)
e. Maximum diameter of rebar at deformed section.

404.6.2 Lag Screws. Lag screws to be used for controls shall be tested in withdrawal from predrilled holes. The diameters of these holes shall not exceed those shown in 404.2.3. The ratio of the withdrawal value determined by test to the design value in withdrawal from Table 404-3 shall be established. This ratio is used to calculate the design value of the dowel system.

404.6.3 Test Specimens.

404.6.3.1 Preparation. Test blocks shall be sized to allow 10 lag screws to be grouped with 10 dowels placed alternately along the block length. Lag screws and dowels are grouped by relating the lag screw root diameters to the diameters of the bar in the dowel system. A single piece of glued laminated timber shall be used for the test block. The specific gravity of the individual pieces of lumber in the laminated member shall be within a range of plus or minus 0.02 of the average specific gravity for the species. Dense material shall be excluded. The moisture content shall be 12% (plus or minus 2%).

The test block shall have a minimum width of 3 times the nominal diameter (shank diameter) of the lag screw or the predrilled hole for the radial reinforcing dowel with a minimum edge distance of 1-1/2 times the nominal shank diameter of the lag screw or dowel hole (Figure 404-2).

The depth of the test block shall be equal to at least 10 times the diameter of the predrilled hole for the bar, or 10 times the shank diameter of the lag screw plus one inch, whichever of the two dimensions is greater. In either case, the depth of the holes for lag screws and the dowels shall be the same.

404.6.3.2 Selection of Lag Screws. Lag screws to be used for the control portion of the test shall be selected for size and length to correlate with the dowels to be tested (see 404.6.1). The lag screw lengths shall be selected to correspond with the desired dowel penetrations in individual test blocks in groups of 10 (10 lag screws grouped with 10 dowels). Only the threaded portion of the lag screws shall penetrate the test block. The gimlet point portion of the lag screw shall be subtracted when calculating the length of the threaded portion.

404.6.3.3 Insertion of Lag Screws. The threaded portion of the lag screw shall be inserted in its lead hole by turning with a wrench, not by driving with a hammer. Soap or other lubricant shall be used in the lead hole to facilitate insertion and prevent damage to the lag screw or the test block.

404.6.3.4 Dowel Systems. Holes shall be drilled to the desired diameter for a given size of bar. For each bar size, 10 holes with a depth equal to 8 times the corresponding lag screw shank diameter shall be used for Douglas Fir-Larch species.

Every other fastener along the length of the test block shall be a dowel. The adhesive shall be mixed in accordance with the manufacturer's recommendations. The adhesive shall first be poured into the hole in sufficient quantity to insure that it is at the top of the hole after insertion of the bar. Small additional pours may be necessary to compensate for shrinkage and absorption. Any excess adhesive shall be removed before it hardens.

After placement of all dowels in the test block, the test block shall be allowed to stand undisturbed until the adhesive has reached an estimated 90% of its full cure strength (based on the manufacturer's recommendations).

At the start of the pouring of a given mix, a sample of the adhesive shall be retained for observations on the "set" time and material hardness after complete cure. Additional samples may be desired to verify the length of time required to reach an estimated 90% of full cure for the adhesive used. (Compression testing may be used in accordance with the manufacturer's recommendations). After the lag screws have been installed in the given test block and the adhesive in the dowel system has reached an estimated 90% of full cure in the test block, the block shall be cut through the cross section halfway between each lag screw and the adjacent dowel.

404.6.4 Testing Procedure. Each block with one lag screw or one dowel shall be subjected to withdrawal tests on the screw or dowel. The grips and the speed of testing shall be as described in 404.4.2. The ultimate withdrawal load for each lag screw or dowel shall be recorded.

404.7. EVALUATION OF TEST DATA

404.7.1 The average test values for the lag screws and the dowel systems for each specimen size group (10 specimens per average)shall be computed in lb/in. A preliminary design value for the dowel system for a given size and penetration shall be determined as follows:

$$DesignValue \le \frac{\left(Avg_{DowelTest}\right)\left(DesignValue_{LagScrew}\right)}{Avg_{LagScrewTest}}$$

404.7.2 The same computation shall be performed using the lowest values from the corresponding dowel and lag screw test groups as follows:

$$DesignValue \le \frac{\left(Minimum_{DowelTest}\right)\left(DesignValue_{LagScrew}\right)}{Minimum_{LagScrewTest}}$$

404.7.3 The design value for the bar used in the dowel system tested based on 60% of yield strength for steel bars or conventional methods for other materials shall also be determined.

404.7.4 The final design value for the dowel system (for a given size and penetration) shall be the lowest value in lb/in. determined in 404.7.1 or 404.7.2 limited by the value determined in 404.7.3. Penetration shall be the depth in inches of penetration below the mid-depth of the member (toward the tension side).

Final design values derived for radially reinforced dowel systems shall be keyed to the dowel bar size, the predrilled hole diameter and the properties of void filling material used.

404.8. SUBSTITUTION OF DOWEL SYSTEM FOR LAG SCREWS

404.8.1 If there is concurrence by the designer, the dowel system may be substituted for the lag screw system provided:

(a) The design value in withdrawal and tension strength for the dowel system as determined in Section 404.5 or 404.7 equals or exceeds the comparable lag screw value.

(b) The same number of dowels are installed at the same locations and the same spacing as the specified lag screw system.

(c) The decrease in effective section modulus caused by the drilled hole in the dowel system is not greater than that of the lag screw system for which the dowel is being substituted.

404.8.2 In the event that the dowel system has a smaller design value than the specified lag screw, the substitution can be made by decreasing the spacing proportionally to the design values provided the designer agrees.

404.8.3 Table 404-4 contains a summary of properties for both lag screws and the dowel system based on steel reinforcing bars (rebar) with a minimum yield strength of 60,000 psi. The "Load Determined by Steel" shown for the lag screws and rebars is based on the maximum strength of the steel which cannot be exceeded. Withdrawal design values in lb/in. of embedment for lag screws are shown in Table 404-3. The design values for the dowel system shall be determined by test.

404.8.4 Decrease in Section Modulus Caused by Hole. The removal of wood by drilling holes for radial reinforcement results in a decrease in section modulus of the member which should be considered in design. The portion of the hole above the neutral axis can be considered effective in transferring compressive stress in both the lag screw and dowel systems. Therefore, only the portion of the hole below the neutral axis is not considered effective (Figure 404-3).

The distance from the bottom of the beam to the neutral axis, *c*, at the section containing reinforcement, is determined using the following equation:

$$c = \frac{bd^2 - b'c^2 + b'a^2}{2\left(bd - b'c + b'a\right)}$$

with *a*, *b*, *c*, and *d* as shown in Figure 404-3.

The reduced moment of inertia, $I_{reduced}$, of the section is determined using the following equation:

$$I_{reduced} = \frac{b\left(d-c\right)^3 + bc^3 - b'\left(c-a\right)^3}{3}$$

The reduced section modulus, $S_{reduced}$, is calculated as follows:

$$S_{reduced} = \frac{I_{reduced}}{c}$$

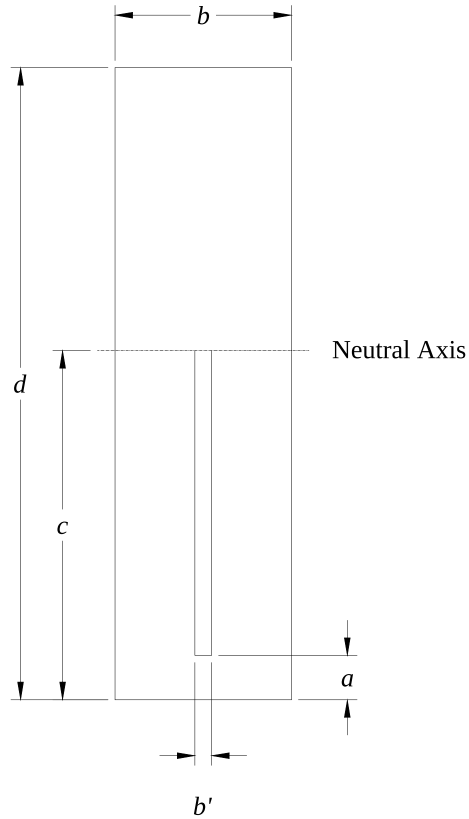


Figure 404-3. *Location of shifted neutral axis due to radial reinforcement.*

404.8.4.1 Lag Screw. Lag screw threads cut into the surrounding wood to a depth approximately equal to the nominal diameter of the lag screw. Therefore, a hole with a diameter corresponding to the shank diameter of the lag screw and extending to a point 2 in. above the soffit face as shown in Figure 404-3 is subtracted in determining the section modulus.

404.8.4.2 Dowel System. For dowel systems, the diameter of the drilled hole is subtracted for determining the reduced section modulus. The diameter of the hole for the dowel system with rebars is 1/8 in. larger than the maximum rebar diameter. The maximum rebar diameter including the bar deformations is 1/16 in. larger than the nominal diameter for rebars of 3/4 in. nominal diameter (No. 6 bar) and smaller and 1/8 in. larger than the nominal diameter for rebars over 3/4 in. Diameters of the holes used for standard rebar sizes are shown in Table 404-4.

404.8.4.3 Percent Reduction in Section Modulus. Table 404-5 contains the percent reduction in section modulus caused by the holes required for radial reinforcement. This table can be used for design or in comparing section modulus reductions in substituting the dowel system for the lag screw system.

Table 404-5. *Percent Reduction in Section Modulus Caused by the Hole Drilled for Radial Reinforcement*

Width of Member (in.)	3 1/8				5 1/8						6 3/4						8 3/4					
Reinforcement Type	Lag Screws		Rebar		Lag Screws			Rebar			Lag Screws			Rebar			Lag Screws			Rebar		
Reinforcement Diameter (in.)	1/2	5/8	3/8	1/2	1/2	5/8	3/4	3/8	1/2	5/8	5/8	3/4	1	1/2	5/8	3/4	3/4	1	1 1/4	5/8	3/4	1
Depth of Member (in.)	Percent Reduction in Section Modulus (%)																					
12	4.27	5.38	4.82	5.94	2.57	3.23	3.90	2.90	3.56	4.23	2.44	2.94	3.94	2.69	3.19	3.94	2.26	3.02	3.80	2.45	3.02	3.80
14	5.10	6.43	5.76	7.10	3.08	3.86	4.66	3.47	4.26	5.06	2.92	3.51	4.72	3.21	3.81	4.72	2.70	3.61	4.54	2.93	3.61	4.54
16	5.79	7.30	6.54	8.06	3.49	4.38	5.29	3.94	4.83	5.74	3.31	3.99	5.35	3.65	4.33	5.35	3.06	4.10	5.16	3.32	4.10	5.16
18	6.37	8.03	7.19	8.86	3.84	4.82	5.81	4.33	5.31	6.31	3.64	4.38	5.88	4.01	4.76	5.88	3.36	4.51	5.67	3.65	4.51	5.67
20	6.86	8.64	7.74	9.54	4.13	5.19	6.25	4.66	5.72	6.79	3.92	4.72	6.33	4.32	5.12	6.33	3.62	4.86	6.10	3.93	4.86	6.10
22	7.27	9.16	8.21	10.12	4.38	5.50	6.63	4.94	6.07	7.20	4.15	5.00	6.72	4.58	5.43	6.72	3.84	5.15	6.47	4.17	5.15	6.47
24	--	9.61	8.62	10.62	--	5.77	6.96	5.18	6.37	7.56	4.36	5.25	7.05	4.80	5.70	7.05	4.03	5.40	6.79	4.37	5.40	6.79
26	--	10.01	8.97	11.05	--	6.01	7.25	5.40	6.63	7.87	4.54	5.46	7.34	5.00	5.93	7.34	4.20	5.62	7.07	4.55	5.62	7.07
28	--	10.35	9.28	11.43	--	6.22	7.50	5.58	6.85	8.14	4.69	5.65	7.59	5.17	6.13	7.59	4.34	5.82	7.31	4.71	5.82	7.31
30	--	10.66	9.55	11.77	--	6.40	7.72	5.75	7.06	8.38	4.83	5.82	7.81	5.33	6.32	7.81	4.47	5.99	7.53	4.85	5.99	7.53
32	--	10.93	9.80	12.07	--	6.56	7.91	5.89	7.24	8.59	4.96	5.97	8.01	5.46	6.48	8.01	4.58	6.14	7.72	4.97	6.14	7.72
36	--	--	10.21	12.58	--	--	8.25	6.14	7.54	8.96	--	6.22	8.35	5.69	6.75	8.35	4.78	6.40	8.05	5.18	6.40	8.05
40	--	--	10.55	13.00	--	--	8.52	6.35	7.79	9.25	--	6.43	8.63	5.88	6.98	8.63	4.94	6.62	8.31	5.35	6.62	8.31
44	--	--	10.83	13.34	--	--	8.75	6.52	8.00	9.50	--	6.60	8.86	6.04	7.16	8.86	5.07	6.79	8.54	5.50	6.79	8.54
48	--	--	11.07	13.64	--	--	--	6.66	8.18	9.71	--	--	9.06	6.17	7.32	9.06	--	6.94	8.73	5.62	6.94	8.73
52	--	--	11.28	13.89	--	--	--	6.79	8.33	9.89	--	--	9.23	6.29	7.46	9.23	--	7.07	8.89	5.72	7.07	8.89
56	--	--	11.46	14.11	--	--	--	6.89	8.46	10.05	--	--	9.37	6.39	7.58	9.37	--	7.18	9.03	5.81	7.18	9.03
60	--	--	11.61	14.30	--	--	--	6.99	8.58	10.19	--	--	9.50	6.47	7.68	9.60	--	7.28	9.15	5.89	7.28	9.15
64	--	--	11.75	14.47	--	--	--	7.07	8.68	10.31	--	--	--	6.55	7.77	9.61	--	7.37	9.26	5.96	7.37	9.26
68	--	--	11.87	14.62	--	--	--	7.14	8.77	10.41	--	--	--	6.62	7.85	9.71	--	--	9.36	6.03	7.44	9.36

404.8.4.4 Example: A 6-3/4 in. wide double-tapered pitched and curved beam made of Douglas Fir-Larch has been designed with radial reinforcement consisting of fully threaded 3/4 in. diameter lag screws spaced 20 in. o.c. in the curved portion of the beam. From Table 404-3, the design value of a 3/4 in. lag screw in Douglas Fir-Larch is 436 lb/in. A dowel system using a 1/2 in. diameter rebar with a minimum yield strength of 60,000 psi has been tested and a design value of 460 lb/in. has been obtained.

From Table 404-4, the maximum tensile force in a 3/4 in. lag screw as determined by the strength of the steel is 5,270 lb and the maximum tensile force in a 1/2 in. diameter rebar is 7070 lb.

From Table 404-5, the reduction in section modulus caused by using a 3/4 in. diameter lag screw in a 6-3/4 in. wide member 44 in. deep is 6.60%. The reduction for a dowel system using a 1/2 in. diameter rebar is 6.04%. The dowel system with the 1/2 in. diameter rebar could then be substituted for the lag screw provided concurrence has been obtained from the designer.

If the design value of the dowel system as determined by test was less than 436 lb per in., the substitution could also be made provided the spacing was reduced proportionately to the ratio of the dowel system design value and the lag screw design value.

When the design value in withdrawal of the dowel system in lb per in. as determined by test is lower than the corresponding lag screw, it may be possible to develop the required tension force in the dowel system without reducing spacing if the distance between the neutral axis and the end of the dowel (on the tension side of the member) is of sufficient length. This is a design consideration that should be referred to the designer.

404.9. PRODUCTION STANDARDS

404.9.1 Certification of Materials.

(a) The manufacturer of the structural void filling adhesive shall provide certification of each batch delivered to the laminator.

(b) Mill certificates or equivalent warranties shall be furnished by the manufacturer of the bars for the dowel system.

(c) Samples of the structural void filling adhesive mixed in the ratios by weight or volume as recommended by the manufacturer shall be obtained at the beginning and at the end of each pour (small paper cups may be used). Samples shall be marked for identification and retained as part of the plant daily quality control records.

404.10. PLANT QUALIFICATION

The use of the dowel system in a laminating plant shall be qualified by an accredited inspection agency. The procedure used and quality control shall be made a part of the Plant Procedures Manual and Quality Control Manual.

404.11. DEFINITION OF TERMS

BAR DIAMETER. Structural cross section of the reinforcing bar.

DOWEL. A bar plus a structural void filling adhesive placed in a pre-bored hole. It is used to resist radial tension.

DOWEL DIAMETER. The diameter of the hole for the reinforcing bar and the structural void filling adhesive.

GIMLET POINT. The tapered tip section of a lag screw.

LAG SCREW ROOT DIAMETER. The diameter of the lag screw measured at the base of the threads.

LAG SCREW SHANK DIAMETER. Diameter of the unthreaded portion of a lag screw.

POT LIFE (ADHESIVE WORKING LIFE). The period of time during which an adhesive, after mixing with catalyst, solvent or other compounding ingredients, remains suitable for use.

SET TIME. The time required to convert an adhesive into a fixed or hardened state by chemical or physical action.

SOLIDS CONTENT. The percentage by weight of nonvolatile matter in an adhesive.