APA

Engineered Wood

CONSTRUCTION GUIDE

WOOD
The Natural Choice

Engineered wood products are a good choice for the environment. They are manufactured for years of trouble-free, dependable use. They help reduce waste by decreasing disposal costs and product damage. Wood is a renewable resource that is easily manufactured into a variety of viable products.

A few facts about wood.

▪ ***We're growing more wood every day.*** Forests fully cover one-third of the United States' and one-half of Canada's land mass. American landowners plant more than two billion trees every year. In addition, millions of trees seed naturally. The forest products industry, which comprises about 15 percent of forestland ownership, is responsible for 41 percent of replanted forest acreage. That works out to more than one billion trees a year, or about three million trees planted every day. This high rate of replanting accounts for the fact that each year, 27 percent more timber is grown than is harvested. Canada's replanting record shows a fourfold increase in the number of trees planted between 1975 and 1990.

▪ ***Life Cycle Assessment shows wood is the greenest building product.*** A 2004 Consortium for Research on Renewable Industrial Materials (CORRIM) study gave scientific validation to the strength of wood as a green building product. In examining building products' life cycles – from extraction of the raw material to demolition of the building at the end of its long lifespan – CORRIM found that wood was better for the environment than steel or concrete in terms of embodied energy, global warming potential, air emissions, water emissions and solid waste production. For the complete details of the report, visit www.CORRIM.org.

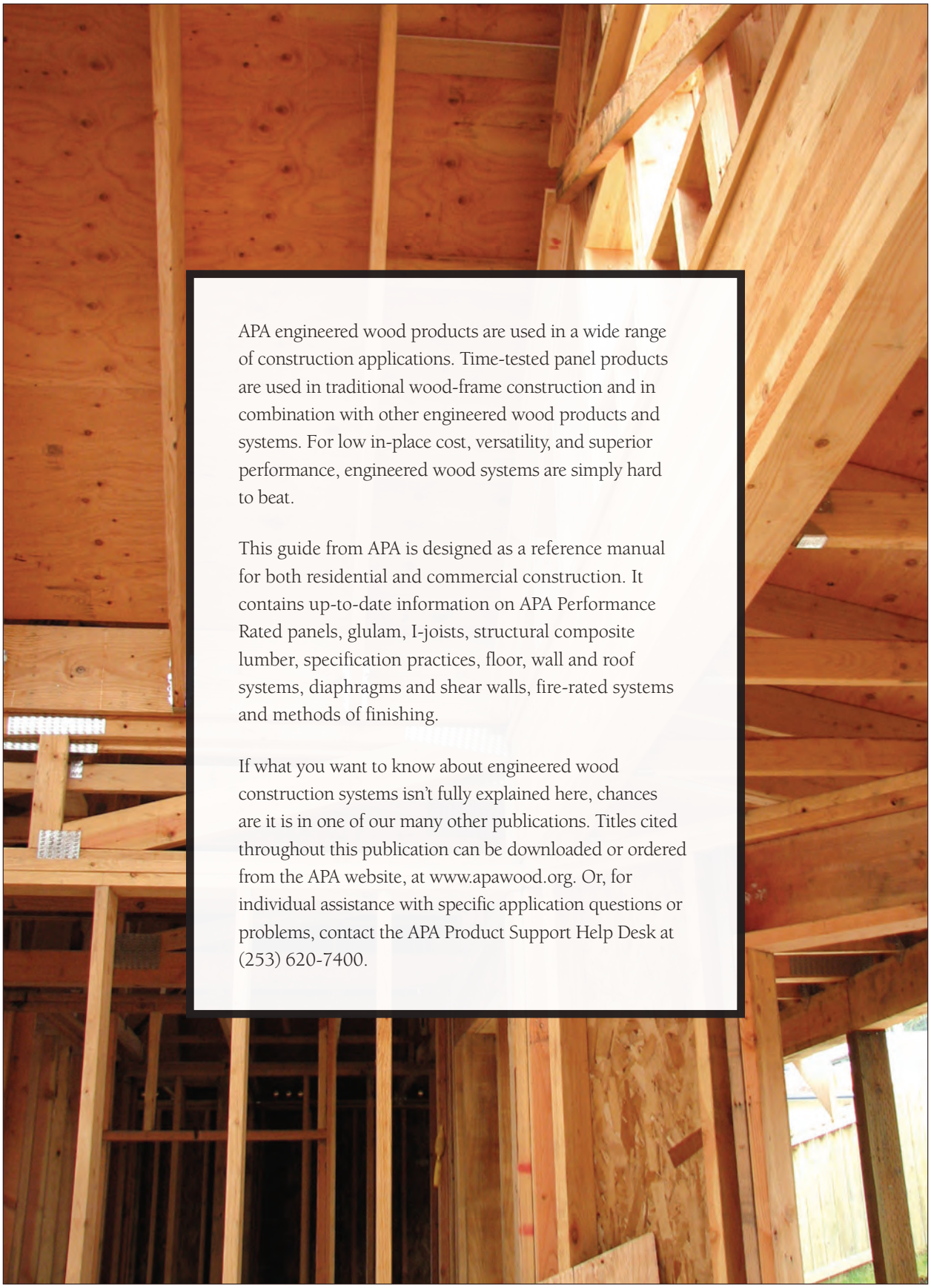
▪ ***Manufacturing wood is energy efficient.*** Wood products made up 47 percent of all industrial raw materials manufactured in the United States, yet consumed only 4 percent of the energy needed to manufacture all industrial raw materials, according to a 1987 study.

Material	Percent of Production	Percent of Energy Use
Wood	47	4
Steel	23	48
Aluminum	2	8

▪ ***Good news for a healthy planet.*** For every ton of wood grown, a young forest produces 1.07 tons of oxygen and absorbs 1.47 tons of carbon dioxide.

Wood: It's the natural choice for the environment, for design and for strong, lasting construction.

NOTICE:
The recommendations in this guide apply only to products that bear the APA trademark. Only products bearing the APA trademark are subject to the Association's quality auditing program.



APA engineered wood products are used in a wide range of construction applications. Time-tested panel products are used in traditional wood-frame construction and in combination with other engineered wood products and systems. For low in-place cost, versatility, and superior performance, engineered wood systems are simply hard to beat.

This guide from APA is designed as a reference manual for both residential and commercial construction. It contains up-to-date information on APA Performance Rated panels, glulam, I-joists, structural composite lumber, specification practices, floor, wall and roof systems, diaphragms and shear walls, fire-rated systems and methods of finishing.

If what you want to know about engineered wood construction systems isn't fully explained here, chances are it is in one of our many other publications. Titles cited throughout this publication can be downloaded or ordered from the APA website, at www.apawood.org. Or, for individual assistance with specific application questions or problems, contact the APA Product Support Help Desk at (253) 620-7400.

GLULAM SELECTION AND SPECIFICATION

Glued laminated timber (glulam) is made up of wood laminations, or "lams," that are bonded together with adhesives. The grain of all laminations runs parallel with the length of the member. Individual lams typically are 1-3/8 inches thick for southern pine and 1-1/2 inches thick for Western species, although other thicknesses may also be used. Glulam products typically range in net widths from 2-1/2 to 10-3/4 inches, although virtually any width can be custom produced.

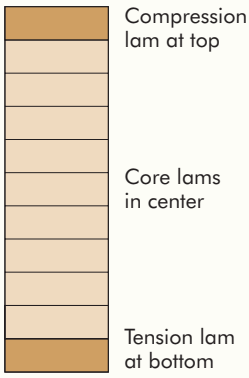
Balanced and Unbalanced Beams

Glulam may be manufactured as unbalanced or balanced members.

The most critical zone of a glulam bending member with respect to controlling strength is the outermost tension zone. In unbalanced beams, the quality of lumber used on the tension side of the beam is higher than the lumber used on the corresponding compression side, allowing a more efficient use of the timber resource. Therefore, unbalanced beams have different bending stresses assigned to the compression and tension zones and must be installed accordingly. To assure proper installation of unbalanced beams, the top of the beam is clearly stamped with the word "TOP." Unbalanced beams are primarily intended for simple-span applications even though they can also be used in multiple-span applications when properly designed.

Balanced members are symmetrical in lumber quality about the mid-height. Balanced beams are used in applications, such as long cantilevers or continuous spans, where either the top or bottom of the member may be highly stressed in tension due to service loads. They can also be used in single-span applications, although an unbalanced beam is more cost-efficient for this use.

STANDARD BEAM LAYUP



Allowable Design Properties

Allowable design properties are a key factor in specifying glulam. Bending members are typically specified on the basis of the maximum allowable bending stress of the member. For example, a 24F designation indicates a member with an allowable bending stress of 2400 psi. Similarly, a 30F designation refers to a member with an allowable bending stress of 3000 psi. These different stress levels are achieved by varying the species and percentages and grade of higher quality lumber in the beam layup.

To identify whether the lumber used in the beam is visually or mechanically graded, the stress combination also includes a second set of designations. For example, for an unbalanced 24F layup using visually graded lumber, the layup designation may be identified as a 24F-V4. The "V" indicates that the layup uses visually graded lumber. ("E" is used for E-rated or mechanically graded lumber.) The number "4" further indicates a specific combination of lumber used to which a full set of

TABLE 6
DESIGN VALUES FOR STRUCTURAL GLUED LAMINATED TIMBER OF SOFTWOOD SPECIES
(Members stressed primarily in bending)
(Tabulated design values are for normal load duration and dry service conditions.)

	Bending About X-X Axis Loaded Perpendicular to Wide Faces of Laminations					Bending About Y-Y Axis Loaded Parallel to Wide Faces of Laminations				Axially Loaded			Fasteners
	Extreme Fiber in Bending												
	Tension Zone Stressed in Tension (Positive Bending)	Compression Zone Stressed in Tension (Negative Bending)	Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain (Horizontal)	Modulus of Elasticity	Tension Parallel to Grain	Compression Parallel to Grain	Modulus of Elasticity	Specific Gravity for Fastener Design
Stress Class	F_{bx}^{+} (psi)	F_{bx}^{-}[a] (psi)	$F_{c\perp x}$ (psi)	F_{vx}[d] (psi)	E_x (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy}[e] (psi)	E_y (10^6 psi)	F_t (psi)	F_c (psi)	E_{axial} (10^6 psi)	G
16F-1.3E	1600	925	315	195	1.3	800	315	170	1.1	675	925	1.2	0.42
20F-1.5E	2000	1100	425	210[f]	1.5	800	315	185	1.2	725	925	1.3	0.42
24F-1.7E	2400	1450	500	210[f]	1.7	1050	315	185	1.3	775	1000	1.4	0.42
24F-1.8E	2400	1450[b]	650	265[c]	1.8	1450	560	230	1.6	1100	1600	1.7	0.50
26F-1.9E[g]	2600	1950	650	265[c]	1.9	1600	560	230[c]	1.6	1150	1600	1.7	0.50[j]
28F-2.1E SP[g]	2800	2300	740	300	2.1[i]	1600	650	260	1.7	1250	1750	1.7	0.55
30F-2.1E SP[g][h]	3000	2400	740	300	2.1[j]	1750	650	260	1.7	1250	1750	1.7	0.55t

(a) For balanced layups, F_{bx}^{-} shall be equal to F_{bx}^{+} for the stress class. Designer shall specify when balanced layup is required.

(b) Negative bending stress, F_{bx}^{-}, is permitted to be increased to 1850 psi for Douglas-fir and to 1950 psi for southern pine for specific combinations. Designer shall specify when these increased stresses are required.

(c) For structural glued laminated timber of southern pine, the basic shear design values, F_{vx} and F_{vy}, are permitted to be increased to 300 psi, and 260 psi, respectively.

(d) The design value for shear, F_{vx}, shall be decreased by multiplying by a factor of 0.72 for non-prismatic members, notched members, and for all members subject to impact or cyclic loading. The reduced design value shall be used for design of members at connections that transfer shear by mechanical fasteners. The reduced design value shall be used for determination of design values for radial tension and torsion.

(e) Design values are for timbers with laminations made from a single piece of lumber across the width or multiple pieces that have been edge bonded. For timbers manufactured from multiple piece laminations (across width) that are not edge bonded, value shall be multiplied by 0.4 for members with 5, 7, or 9 laminations or by 0.5 for all other members. This reduction shall be cumulative with the adjustment in footnote d.

(f) Certain southern pine combinations may contain lumber with wane. If lumber with wane is used, the design value for shear parallel to grain, F_{vx}, shall be multiplied by 0.67 if wane is allowed on both sides. If wane is limited to one side, F_{vx} shall be multiplied by 0.83. This reduction shall be cumulative with the adjustment in footnote d.

(g) 26F, 28F, and 30F beams are not produced by all manufacturers, therefore, availability may be limited. Contact supplier or manufacturer for details.

(h) 30F combinations are restricted to a maximum 6 in. nominal width.

(i) For 28F and 30F members with more than 15 laminations, E_x = 2.0 million psi.

(j) For structural glued laminated timber of southern pine, specific gravity for fastener design is permitted to be increased to 0.55.

Design values in this table represent design values for groups of similar glued laminated timber combinations. Higher design values for some properties may be obtained by specifying a particular combination in *APA Data File: Glulam Design Specification,* Form Y117. Design values are for members with 4 or more laminations. Some stress classes are not available in all species. Contact manufacturer for availability.

design stresses, such as horizontal shear, MOE, etc., are assigned. The glulam industry recently introduced the concept of specifying glulam based on a stress class system similar to that used for MSR lumber or SCL. This requires only specifying an Fb - E value. Typical stress classifications are in Table 6. See also *APA Data Files: Glulam Design Specification* and *Glulam Layup Combinations*, Forms Y117 and Y117SUP, respectively.

Sizes

Glulam is available in both custom and stock sizes. Stock beams are manufactured in commonly used dimensions and cut to length when the beam is ordered from a distributor or dealer. Typical stock beam widths used in residential construction include: 3-1/8, 3-1/2, 5-1/8, 5-1/2, and 6-3/4 inches.

For nonresidential applications, where long spans, unusually heavy loads, or other circumstances control design, custom members are typically specified. Common custom shapes include straight beams, curved beams, pitched and curved beams, radial arches and tudor arches.

Appearance Classification

Glulam is available in a range of appearances, all looking different but having the same structural characteristics for a given strength grade. Glulam appearance classifications are:

Framing. A classification that denotes the member is intended only for use in concealed applications. Beams with this appearance classification are provided in widths designed to fit flush with 2x4 and 2x6 wall framing. **Framing-L** is the same as Framing but denotes that LVL has been used for the outer tension laminations.

Industrial. Used for concealed applications or where appearance is not of primary importance. **Industrial-L** is the same as Industrial but denotes that LVL has been used for outer tension laminations.

Architectural. The appearance of choice in applications where members are exposed to view, because they have a smooth, attractive finish. Stock beams are often supplied with this appearance so they may be exposed to view in the finished structure.

Premium. Available only as a custom order where finished appearance is of primary importance.

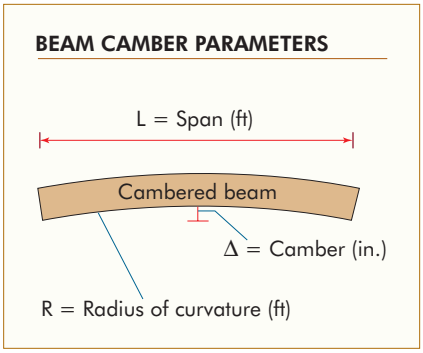
All appearance classifications permit natural growth characteristics with varying degrees of open voids permitted. Voids are filled as required by the appearance grade specified using inserts and wood fillers. The appearance classification is not related to lumber layup requirements and thus does not affect design values for the beam. For additional information, refer to *APA Technical Note: Glulam Appearance Classifications for Construction Applications,* Form Y110.

Section Properties and Capacities

When selecting a glulam member, the builder, designer, or specifier must use a member with the required section properties and the applicable design values to satisfy the load carrying requirements. Different load capacities are possible for different stress level combinations of glulam. Tables giving the load carrying capacities for glulam are included in the *APA Data File: Glued Laminated Beam Design Tables,* Form S475.

Camber

Camber is curvature built into a fabricated member (see figure at right) which is opposite in direction and magnitude to the calculated deflection which will occur under gravity loads.



The glulam industry recommends that roof beams be cambered for 1-1/2 times the calculated dead load deflection. This will generally be sufficient to assure that the beam will not visibly sag over a period of many years of loading, as may occur with non-cambered wood products. To achieve a level profile, it is recommended that floor beams be only cambered for 1.0 times the calculated dead load deflection.

Camber for glulam beams is specified as either "inches of camber" or as a radius of curvature that is to be used in the manufacturing process. Commonly used curvature radii for commercial applications are 1,600 and 2,000 feet, although any camber may be specified.

Most residential applications require very little or no camber which, in turn, makes glulam the ideal choice. Stock beams are typically supplied with a relatively flat camber radius of 3,500 feet as shown in Table 7, or zero camber. Thus, they have just the right camber for residential construction. If, however, more camber is required, such as for a long-span roof beam, custom beams are available through manufacturers to meet the most exacting specifications.

For additional information on cambering glulam beams, refer to *APA Technical Note: Glulam Beam Camber,* Form S550, which provides a camber table for various beam spans and radii of curvature.

TABLE 7

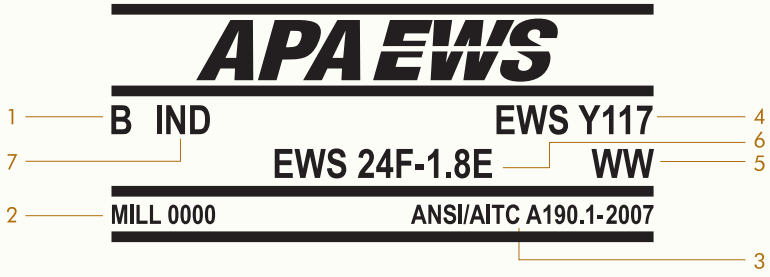
CAMBER FOR 3,500-FOOT RADIUS

Span in feet:	10	12	14	16	18	20	22	24	26	28
Camber in inch:	.04	.06	.08	.11	.14	.17	.21	.25	.29	.34

Trademarks and Acceptances

Glulam beams manufactured by APA members are certified with the *APA EWS* trademark. The mark (as shown) signifies that the manufacturer is committed to a rigorous program of quality verification and testing and that products are manufactured in conformance with ANSI/AITC Standard A190.1-2007, American National Standard for Structural Glued Laminated Timber. The *APA EWS* trademark is recognized by all major model building codes.

Typical information included in an *APA EWS* trademark is shown at right. This information may vary depending on whether the member is supplied as a custom or stock product.



1 Indicates structural use: B-Simple span bending member. C-Compression member. T-Tension member. CB-Continuous or cantilevered span bending member.
2 Mill number.
3 Identification of ANSI/AITC Standard A190.1, Structural Glued Laminated Timber. ANSI/AITC A190.1 is the American National Standard for glulam beams.
4 Applicable laminating specification.
5 Western woods (see note 6).
6 Structural grade designation. The *APA EWS* 24F-1.8E designation is a glulam grade commonly used in residential applications. Combining a group of six layup combinations made with Douglas fir-larch, spruce-pine-fir, southern pine, and/or hem-fir, this grade provides strength (allowable bending stress of 2,400 psi and allowable shear stress of 215 psi) and stiffness (modulus of elasticity of 1.8 x 10^6 psi) needed for typical residential applications, while greatly simplifying the design specification.
7 Designation of appearance grade. FRAMING, FRAMING-L*, INDUSTRIAL, INDUSTRIAL-L*, ARCHITECTURAL, or PREMIUM.
*LVL used for tension laminations.

Glulam Beam Storage and Handling

APA EWS trademarked glulam beams are commonly protected with sealants, primers or wrappings when they leave the mill. But care must be taken during loading, unloading and transporting, as well as in the yard and on the job site.

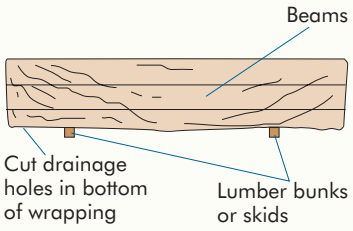
Sealants on the ends of beams help guard against moisture penetration and checking. Apply a coat of sealant to the ends of beams after trimming. Surface sealants, which can be applied to the top, bottom and sides of beams, resist dirt and moisture and help control checking and grain raising. Use a penetrating sealant if beams will be stained or given a natural finish.

A primer coat also protects beams from moisture and dirt and provides a paintable surface.

Water-resistant wrappings are another way to protect beams from moisture, dirt and scratches. Because sunlight can discolor beams, opaque wrappings are recommended. Beams can be wrapped individually, by the bundle or by the load. In situations where appearance is especially important, the wrapping can be removed after installation to avoid damage.

If possible, store glulam under cover to protect them from rain and sunlight. Place the beams on spaced lumber bunks on level, well-drained ground. In some instances, the wrappings can be used to protect beams until installation. Again, seal ends of beams immediately after trimming. Once beams are installed, allow them to gradually season and adjust to the temperature and moisture conditions of the structure.

GLULAM BEAM STORAGE



GLULAM SPECIFICATION GUIDE

The following is a guide for preparing specifications for structural glued laminated timber used for bending members such as purlins, beams, or girders or for axially loaded members such as columns or truss chords.

A. General

1. Structural glued laminated timber shall be furnished as shown on the plans and in accordance with the following specifications. (Where other uses or requirements are applicable, modify specifications accordingly.)

2. For custom designed members, shop drawings and details shall be furnished by the (manufacturer) (seller) and approval obtained from the (architect) (engineer) (general contractor) (buyer) before fabrication is begun.

3. The (manufacturer) (seller) (general contractor) shall furnish connection steel and hardware for joining structural glued laminated timber members to each other and to their supports, exclusive of anchorage embedded in masonry or concrete, setting plates, and items field-welded to structural steel. Steel connections shall be finished with a minimum of one coat of rust-inhibiting paint.

B. Manufacture

1. Materials, Manufacture and Quality Assurance – Structural glued laminated timber of softwood species shall be in conformance with ANSI /AITC Standard A190.1, American National Standard for Structural Glued Laminated Timber, or other code-approved design, manufacturing and/or quality assurance procedures.

2. End-Use Application – Structural glued laminated timber members shall be manufactured for the following structural uses as applicable: (Simple span bending member – B) (continuous or cantilever span bending member – CB) (compression member – C) (tension member – T).

3. Design Values – Structural glued laminated timber shall provide design values for normal load duration and dry-use condition.[1][2] The design should specify a layup combination from *APA Data File: Glulam Design Specifications,* Form Y117, or specify a stress combination from Table 6.

4. Appearance Grade – Glulam shall be (framing) (framing-L) (industrial) (industrial-L) (architectural) (premium) grade[3] in accordance with ANSI/AITC Standard A190.1.

5. Laminating Adhesives – Adhesives used in the manufacture of structural glued laminated timber shall meet requirements for (wet-use) (dry-use) service conditions.[1]

6. Camber (when applicable) – Structural glued laminated timber (shall) (shall not) be manufactured with a built-in camber.

7. Preservative Treatment (when applicable) – Glulam shall be pressure treated after manufacture in accordance with American Wood Protection Association (AWPA) Standard U1 with (creosote or creosote/coal tar solution) (pentachlorophenol in oil) (pentachlorophenol in light solvent) (copper naphthenate) preservatives as required for (soil contact) (above ground) exposure.[4]

8. Fire Resistance (when applicable) – Glulam shall be sized and manufactured for one-hour fire resistance.[5] The use of pressure impregnated fire retardant treatments is not recommended.

9. Protective Sealers and Finishes – Unless otherwise specified, sealer shall be applied to the ends of all members. Surfaces of members shall be (not sealed) (sealed with penetrating sealer) (sealed with primer/sealer coating).[6]

10. Trademarks – Members shall be marked with the APA EWS trademark indicating conformance with the manufacturing, quality assurance and marking provisions of ANSI/AITC Standard A190.1.

11. Certificates (when applicable) – A Certificate of Conformance may be provided by the (manufacturer) (seller) to indicate conformance with ANSI/AITC Standard A190.1 if requested.

12. Protection for Shipment – Members shall be (not wrapped) (load wrapped) (bundle wrapped) (individually wrapped) with a water-resistant covering for shipment.

Notes to Specifiers:

(1) Dry service condition – moisture content of the member will be below 16 percent in service; wet service condition – moisture content of the member will be at or above 16 percent in service. When structural glued laminated timber members are to be preservative treated, wet-use adhesives must be specified.

(2) An alternative to specifying a layup combination or stress combination is to specify the required allowable design stresses for the specific design application.

(3) Appearance classifications are described in *APA Technical Note: Glulam Appearance Classifications for Construction Applications,* Form Y110.

(4) See *APA Technical Note: Preservative Treatment of Glued Laminated Timber,* Form S580.

(5) When structural glued laminated timber with one-hour fire resistance is specified, minimum size limitations and additional lamination requirements are applicable. Supporting steel connectors and fasteners also must be protected to achieve a one-hour fire rating. Cover with fire-rated (Type X) gypsum wallboard or 1-1/2" wood, to provide the needed protection.

(6) Specify a penetrating sealer when the finish will be natural or a semitransparent stain. Primer/sealer coatings have a higher solids content and provide greater moisture protection, and are suitable for use with opaque or solid-color finishes.

ADDITIONAL INFORMATION

About APA – The Engineered Wood Association

APA – The Engineered Wood Association is a nonprofit trade association of and for structural wood panel, glulam timber, wood I-joist, structural composite lumber, and other engineered wood product manufacturers. Based in Tacoma, Washington, APA represents approximately 150 mills throughout North America, ranging from small, independently owned and operated companies to large integrated corporations.

Always insist on engineered wood products bearing the **mark of quality** – the *APA* or *APA EWS* trademark. Your APA engineered wood purchase is not only your highest possible assurance of product quality, but an investment in the many trade services that APA provides on your behalf. The Association's trademark appears only on products manufactured by member mills and is the manufacturer's assurance that the product conforms to the standard shown on the trademark.

For panels, that standard may be the Voluntary Product Standard PS 1-09 for Structural Plywood, Voluntary Product Standard PS 2-10, Performance Standards for Wood-Based Structural-Use Panels or APA PRP-108 Performance Standards and Qualification Policy for Structural-Use Panels. Panel quality of all APA trademarked products is subject to verification through APA audit.

The *APA* or *APA EWS* trademark appears only on engineered wood products manufactured by members of APA. The mark signifies that the manufacturer is committed to a rigorous program of quality verification and testing and that products are manufactured in conformance with an APA or national standard such as ANSI/AITC A190.1, Standard for Structural Glued Laminated Timber; ANSI/APA PRP 210, Standard for Performance-Rated Engineered Wood Panel Siding; APA PRI-400, Performance Standard for *APA EWS* I-Joists; ANSI/APA PRR 410, Standard for Performance-Rated Engineered Wood Rim Boards; or with a manufacturer's building code evaluation report or APA Product Report (www.apawood.org/ProductReports).

APA's services go far beyond quality testing and inspection. Research and promotion programs play important roles in developing and improving construction systems using wood structural panels, glulam, I-joists, and structural composite lumber, and in helping users and specifiers to better understand and apply engineered wood products. For more information, please see the back cover.

Engineered Wood Construction Guide

APA offers a comprehensive set of services and tools for design and construction professionals specifying and using engineered wood products and building systems. If you're looking for detailed product information, training material, or technical assistance, APA can help.

www.apawood.org, APA's website, is your link to in-depth design and building support, including a library of more than 400 publications available for instant pdf download or hard-copy purchase.

help@apawood.org or (253) 620-7400 is your connection to the APA Product Support Help Desk. Staffed by specialists who have the knowledge to address a diverse range of inquiries related to engineered wood, the Help Desk can answer your questions about specification and application of APA products.

Tap into APA's extensive knowledge and resources.

- Training materials and assistance, including Wood University, APA's online portal for engineered wood education, located at www.wooduniversity.org
- Information to protect homes against damaging moisture infiltration through the Build a Better Home and Free From Mold programs, including guides and details for builders at www.buildabetterhome.org and an inspection regimen for homeowners at www.freefrommold.org
- More than 200 downloadable CAD details, found at www.apacad.org
- Field representatives in many major U.S. cities and Canada who can answer questions about APA trademarked products

For a list of APA and *APA EWS* publications, download the *APA Publications Index,* Form B300, at www.apawood.org/publications.

***APA – THE ENGINEERED WOOD ASSOCIATION* HEADQUARTERS**
7011 So. 19th St. Tacoma, Washington 98466 ▪ (253) 565-6600 ▪ Fax: (253) 565-7265

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