APA

Glulam

PRODUCT GUIDE

Wood: The Natural Choice

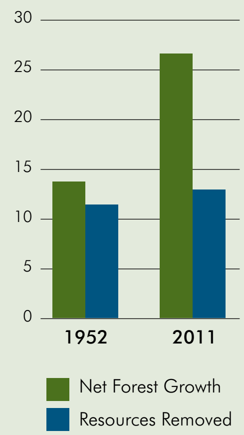
Engineered wood products are among the most beautiful and environmentally friendly building materials. In manufacture, they are produced efficiently from a renewable resource. In construction, the fact that engineered wood products are available in a wide variety of sizes and dimensions means there is less jobsite waste and lower disposal costs. In completed buildings, engineered wood products are carbon storehouses that deliver decades of strong, dependable structural performance. Plus, wood's natural properties, combined with highly efficient wood-frame construction systems, make it a top choice in energy conservation.

A few facts about wood:

We're growing more wood every day. For the past 100 years, the amount of forestland in the United States has remained stable at a level of about 751 million acres.[1] Forests and wooded lands cover over 40 percent of North America's land mass.[2] Net growth of forests has exceeded net removal since 1952[3]; in 2011, net forest growth was measured at double the amount of resources removed.[4] American landowners plant more than two-and-a-half billion new trees every year.[5] In addition, millions of trees seed naturally.

U.S. Forest Growth and All Forest Product Removals

Billions of cubic feet/year



Source: USDA—Forest Service

Manufacturing wood is energy efficient. Over 50 percent of the energy consumed in manufacturing wood products comes from bioenergy such as tree bark, sawdust, and other harvesting by-products.[6] Very little of the energy used to manufacture engineered wood comes from fossil fuels. Plus, modern methods allow manufacturers to get more out of each log, ensuring that very little of the forest resource is wasted.

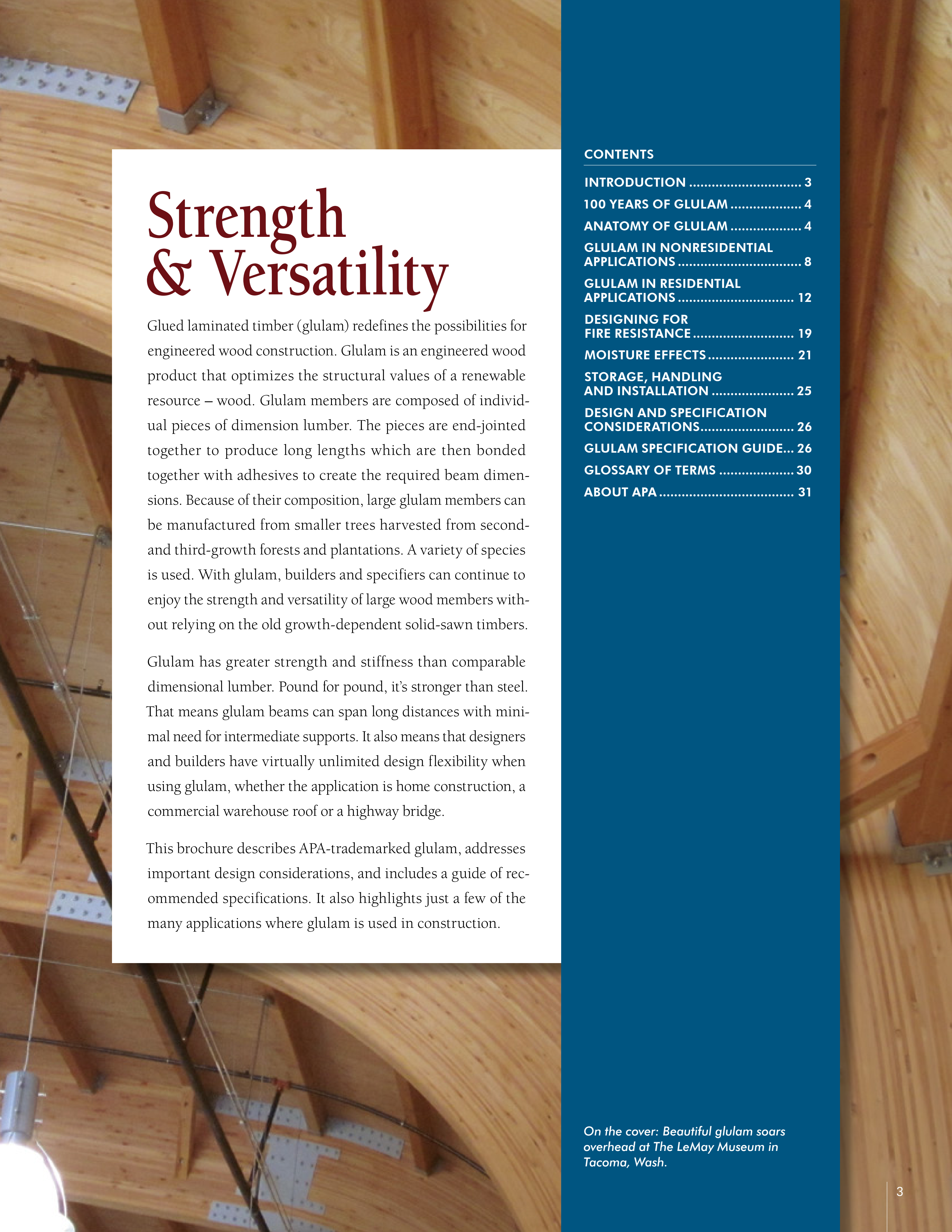
Life Cycle Assessment measures the long-term green value of wood. Studies by CORRIM (Consortium for Research on Renewable Industrial Materials) give scientific validation to the strength of wood as a green building product. In examining building products' life cycles—from extraction of the raw material to demolition of the building at the end of its long lifespan—CORRIM found that wood had a more positive impact on 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.

Wood adds environmental value throughout the life of a structure. When the goal is energy-efficient construction, wood's low thermal conductivity makes it a superior material. As an insulator, wood is six times more efficient than an equivalent thickness of brick, 105 times more efficient than concrete, and 400 times more efficient than steel.[7]

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 is the natural choice for the environment, for design, and for strong, resilient construction.

1. United States Department of Agriculture, U.S. Forest Service, FS-979, June 2011; 2. FAO, UN-ECE (1996) North American Timber Trends Study. ECE/TIM/SP/9. Geneva; Smith et al. (1994), Forest Statistics of the United States, 1992. Gen. Tech. Rep. NC-168; 3. United States Department of Agriculture, U.S. Forest Service; FS-801 Revised September 2009; 4. U.S. Department of Agriculture, U.S. Forest Service, August 2014; 5. Forest Landowners Association, 2011; 6. U.S. Environmental Protection Agency, March 2007; 7. Produced for the Commonwealth of Australia by the Institute for Sustainable Futures, University of Technology, Sydney, 2010.



Strength & Versatility

Glued laminated timber (glulam) redefines the possibilities for engineered wood construction. Glulam is an engineered wood product that optimizes the structural values of a renewable resource – wood. Glulam members are composed of individual pieces of dimension lumber. The pieces are end-jointed together to produce long lengths which are then bonded together with adhesives to create the required beam dimensions. Because of their composition, large glulam members can be manufactured from smaller trees harvested from second- and third-growth forests and plantations. A variety of species is used. With glulam, builders and specifiers can continue to enjoy the strength and versatility of large wood members without relying on the old growth-dependent solid-sawn timbers.

Glulam has greater strength and stiffness than comparable dimensional lumber. Pound for pound, it's stronger than steel. That means glulam beams can span long distances with minimal need for intermediate supports. It also means that designers and builders have virtually unlimited design flexibility when using glulam, whether the application is home construction, a commercial warehouse roof or a highway bridge.

This brochure describes APA-trademarked glulam, addresses important design considerations, and includes a guide of recommended specifications. It also highlights just a few of the many applications where glulam is used in construction.

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On the cover: Beautiful glulam soars overhead at The LeMay Museum in Tacoma, Wash.

100 Plus Years of Glulam

In terms of current needs to optimize products from a carefully managed timber resource, glulam is one of the most resource-efficient approaches to wood building products. It is an engineered product manufactured to meet the most demanding structural requirements. But glued laminated timber is not a new product.

Glulam was first used in Europe in the early 1890s. A 1901 patent from Switzerland signaled the true beginning of glued laminated timber construction. One of the first glulam structures erected in the U.S. was a research laboratory at the USDA Forest Products Laboratory in Madison, Wisconsin. The structure was erected in 1934 and is still in service today.

A significant development in the glulam industry was the introduction of fully water-resistant phenol-resorcinol adhesives in 1942. This allowed glulam to be used in exposed exterior environments without concern of glueline degradation.

The first U.S. manufacturing standard for glulam was Commercial Standard CS253-63, which was published by the Department of Commerce in 1963. The most recent standard is ANSI Standard A190.1-2017.

ANATOMY OF GLULAM

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 member width can be custom produced.

Because they are engineered products, glued laminated timbers are manufactured to meet a range of design stresses. Beams are manufactured with the strongest lams on the bottom and top of the beam, where maximum tension and compression stresses occur. This concept allows the lumber resource to be used more efficiently by placing higher grade lumber in zones that have the maximum stresses and lumber with less structural quality in lower stressed zones.

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 ensure 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.

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 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.

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 2,400 psi. Similarly, a 30F designation refers to a member with an allowable bending stress of 3,000 psi. These different stress levels are achieved by varying the 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 Douglas-fir lumber, the layup designation is identified as a 24F-V4. The "V" indicates that the layup uses visually graded lumber. ("E" is used for mechanically graded lumber.) The number "4" further identifies a specific combination of lumber used to which a full set of design stresses, such as horizontal shear, MOE, etc., are assigned.

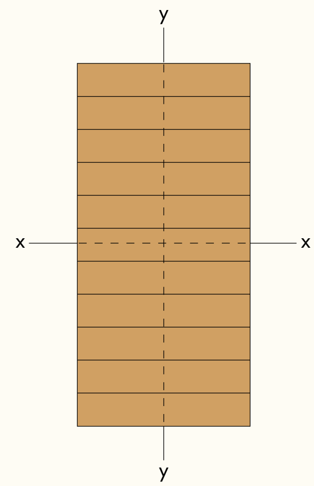
ANSI 117, *Standard Specification for Structural Glued Laminated Timber of Softwood Species*, *Glulam Design Specification,* Form Y117, and ICC-ES *Report ESR-1940* (www.icc-es.org) provide design stresses for all glulam produced by APA members.

Axis Orientation

Glulam beams are typically installed with the wide face of the laminations perpendicular to the applied load, as shown in Figure 1. These are commonly referred to as horizontally laminated members. If this same member is rotated 90 degrees, such that the load is applied parallel to the wide face of the laminations, it is considered to be a vertically laminated member. Glulam members have different tabulated stress properties depending on whether the member is used in a horizontal or vertical orientation. (For more information, refer to ANSI 117, *Standard Specification for Structural Glued Laminated Timber of Softwood Species*, *Glulam Design Specification,* Form Y117, or ICC-ES Report ESR-1940.)

FIGURE 1

BEAM CROSS SECTION



Sizes

Glulam is available in both custom and stock sizes. Stock beams are manufactured in commonly used dimensions and cut to length when the beams are ordered from a distributor or dealer. Typical stock beam widths 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. Custom members 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 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 laminations are 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 laminations are used for the 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 *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 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. These beam capacities are based on loading perpendicular to the wide faces of the laminations; that is, bending about the x-x axis of the beam, as shown in Figure 1.

Camber

One of the most important design considerations for wood framing is deflection. For longer spans, deflection is often the controlling design factor. While any wood bending member can be designed to minimize deflection, glulam is the only engineered wood product that can be easily cambered to reduce the aesthetic effect of in-service deflections. Camber is curvature built into a fabricated member (see Figure 2) which is opposite in direction and magnitude to the calculated deflection that occurs under gravity loads.

FIGURE 2

BEAM CAMBER PARAMETERS

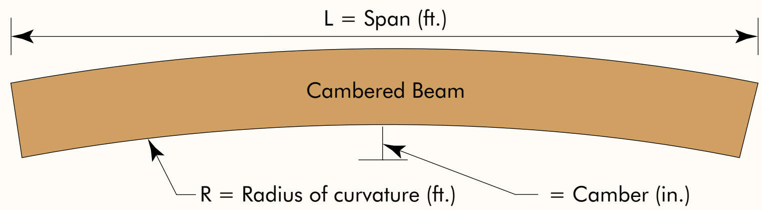


TABLE 1

CAMBER FOR 3500-FOOT RADIUS

Span in feet:	10	12	14	16	18	20	22	24	26	28
Camber in 1/100 inch:	.04	.06	.08	.11	.14	.17	.21	.25	.29	.34

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 1 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 *Technical Note: Glulam Beam Camber,* Form S550, which provides a camber table for various beam spans and radii of curvature.

Hybrid Beams Offer New Design Options

In response to market demands for increased structural performance, APA worked with its member manufacturers to develop a high strength "hybrid" glulam beam. This beam uses laminated veneer lumber (LVL) as the outermost top and bottom laminations. The beam has a balanced layup, eliminating the concern about losing structural value if the beam is inadvertently installed upside down. The hybrid glulam is rated at 30F – 2.1E as compared to the traditional 24F – 1.8E glulam. These beam layups have been incorporated in *Glulam Design Specification,* Form Y117, and ICC-ES *Report ESR-1940*.

Since these high-strength hybrid beams are often used to support wood I-joist floor framing, they are typically supplied in I-joist compatible (IJC) sizes. This means the depths match the typical residential I-joist depths of 9-1/2, 11-7/8, 14 and 16 inches, and the widths match conventional 2x4 and 2x6 wall framing. Beam depths greater than 16 inches are available up to 30 inches.

Hybrid glulam beams are only available in Framing-L and Industrial-L appearance classifications and will typically have "hit or miss" surfacing of the wide faces.

Formaldehyde Emissions

Formaldehyde emissions from glulam manufactured to ANSI A190.1 are extremely low. ANSI A190.1 compliant glulam meets or is exempt from the most stringent formaldehyde emission standards and regulations, including the California Air Resources Board (CARB) Air Toxic Control Measure for Composite Wood Products and the Japanese Agricultural Standards (JAS).

Trademarks and Acceptances

Glulam beams manufactured by APA members are certified with the APA trademark. 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 ANSI A190.1, American National Standard for Structural Glued Laminated Timber.

Typical information included in an APA trademark is shown on the sample trademark on page 28. This information may vary depending on whether the member is supplied as a custom or stock product. The APA trademark is recognized by all major model building codes for the certification of glued laminated timber produced by APA members.

APA also issues APA Product Reports to specific glulam manufacturers whose proprietary products are meeting the code requirements and suitable for use in building construction. For more information on APA Product Reports, please visit the APA website, www.apawood.org/product-reports.

GLULAM IN NONRESIDENTIAL APPLICATIONS

Visible Beauty, Hidden Strength

Glulam has a reputation for being used in striking applications, such as vaulted ceilings and other designs with soaring open spaces. In churches, schools, restaurants and other commercial buildings, glulam is often specified for its beauty, as well as its strength, for good reason. Glulam has the classic natural wood appearance that holds a timeless appeal.

The Placer River Trail Bridge in Alaska uses glulam spans.

Aesthetics aside, there are many other applications where the strength and durability of glulam beams make them the ideal structural choice. Typical uses range from simple purlins, ridge beams, floor beams and cantilevered beams to complete commercial roof systems. In some instances, warehouse and distribution centers with roof areas exceeding 1 million square feet have been constructed using glulam framing. In large open spaces, glulam beams can span more than 100 feet.

One of the greatest advantages of glulam is that it can be manufactured in a wide range of shapes, sizes and configurations. In addition to straight prismatic sections, beams can also be produced in a variety of tapered configurations, such as single tapered, double tapered and off-centered ridges. Curved shapes range from a simple curved beam to a pitched and tapered curved beam to a complex arch configuration. Spans using glulam arches are virtually unlimited. For example, in reticulated glulam framed dome structures, arches span more than 500 feet.

Glulam Trusses Add Design Options for Long Spans

Glulam trusses also take many shapes, including simple pitched trusses, complicated scissor configurations and long span bowstring trusses with curved upper chords. When designed as space frames, glulam truss systems can create great clear spans for auditoriums, gymnasiums and other applications requiring large, open floor areas.

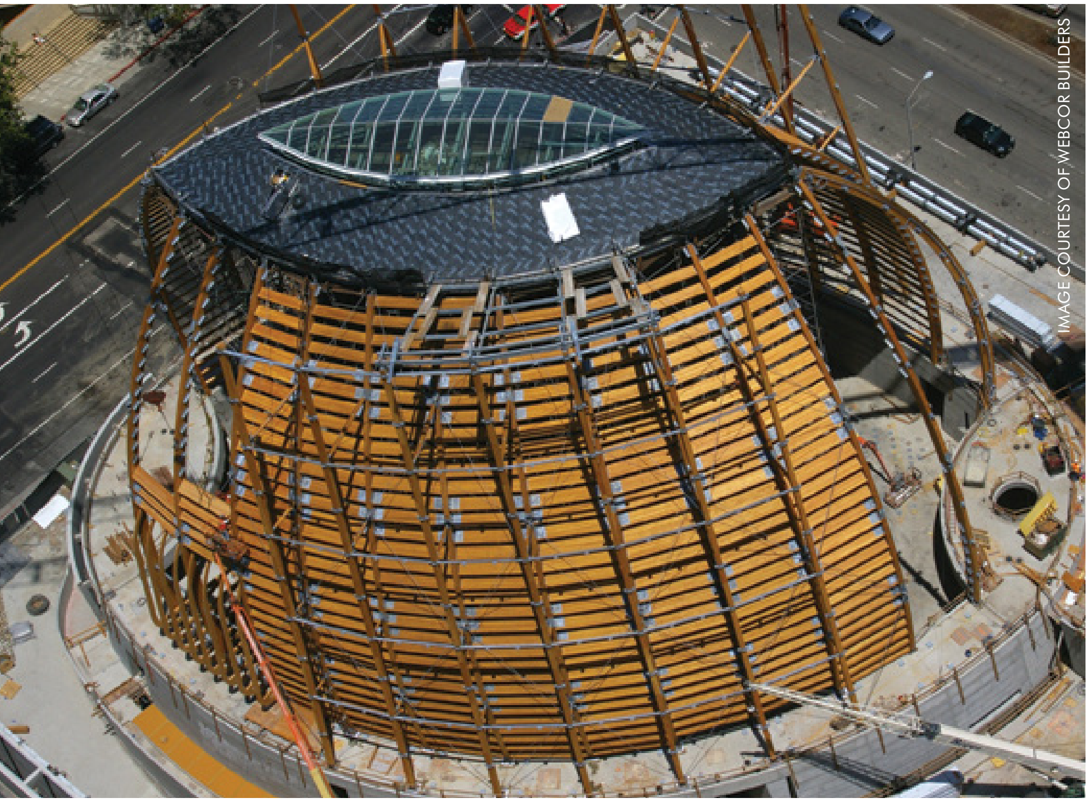
Exposed Applications

When manufactured with moisture resistant adhesives, glulam products can be fully exposed to the environment provided they are properly pressure-preservative treated. Exposed applications include utility poles and crossarms, marinas, docks and other waterfront structures and bridges.

Bridges represent a growing market for glulam in pedestrian and light vehicular applications for stream and roadway crossings. Glulam is also used in secondary highway bridge designs ranging from straight girders to soaring arches.

The railroads are finding glulam to be a viable structural product for use in their heavily loaded bridge structures. As loads increase on the main lines, it is necessary to upgrade bridge capacities. Adding glulam "helper" stringers is a viable solution for increasing capacities.

In all of these uses, the strength and stiffness of glulam give builders and designers more design versatility than they have with other structural products. And, these advantages come at a cost that is competitive with other structural systems.



Cathedral of Christ the Light in Oakland, Calif.

2125 Franklin Student Housing in Eugene, Ore.

Two 107-foot poles are bolted together in this utility pole design.

The architect achieved cost savings and energy savings with the wood design of Gunter Primary School in Gunter, Texas.

Campbell Basin Lodge at Crystal Mountain, Wash.

Durable glulam forms a stair tread.

The One North office complex in Portland, Ore., uses glulam framing with tongue-and-groove cedar decking.

The Great Wolf Lodge in Grand Mound, Wash., features 65-foot glulam beams over the enclosed water park.

This glulam bridge connects the Sheshan Golf Course with a nearby luxury residential community, providing both style and functionality.

Hybrid trusses combine glulam arches, glulam purlins, and steel bottom chords at HarborCenter in Buffalo, N.Y.

The LeMay Museum in Tacoma, Wash., features a curved roof made of custom glulam members and purlins.

Our Lady of Loreto in Foxfield, Colo., uses three glulam members connected by a central dome.

GLULAM IN RESIDENTIAL APPLICATIONS

In residential construction, APA-trademarked glulam beams are often chosen for their beauty in exposed designs, such as rafters in vaulted ceilings or long clear-span ridge beams. They're also ideal for hidden structural applications, such as floor beams and headers. No other product combines the strength and natural beauty of wood like glulam, and nothing provides builders and designers with the design flexibility demanded by today's homeowner.

I-joist compatible (IJC) glulam beams are supplied in depths of 9-1/2, 11-7/8, 14 and 16 inches.

Stock Beams and Custom Beams

For most residential applications, stock beams are the product of choice. Stock beams, readily available from distributors throughout North America, are manufactured in widths of 3-1/8, 3-1/2, 5-1/8, 5-1/2 and 6-3/4 inches with depths ranging from 9 to 36 inches. Often, stock beams are supplied as an architectural appearance classification making them suitable for exposed applications. These are typically a 24F-1.8E stress combination.

Custom glulam beams are also readily available in most market areas and are used when a larger cross-section, longer length, curved shape or different appearance classification is needed. Examples of curved custom applications include curved fascia members and arches over clear span areas, such as great rooms and interior pool enclosures.

Hybrid beams, described on page 7, are also an option for residential construction. These are typically used when higher design properties have been specified by the designer.

Floor Beams

The superior strength of glulam allows longer clear spans than solid-sawn lumber. Because glulam is manufactured from kiln-dried lumber, shrinkage and warping are minimized. In addition, glulam beams have excellent fastener-holding capability, which means a firm subfloor with minimal nail popping or squeaks.

Glulam floor beams offer several advantages over steel beams. They are lighter in weight, easy to install with typical residential construction equipment, and are a better value on an installed cost basis. When attaching glulam to other framing members, construction crews can use standard tools and fasteners because they are making wood-to-wood connections. If necessary, a glulam beam can be cut to length at the job site, while cutting a steel beam requires a torch and a second trade crew.

Glulam is available in I-joist compatible depths to easily permit flush framing without special furring, as shown in the photo above. I-joist compatible beams (IJC), are supplied in depths of 9-1/2, 11-7/8, 14 and 16 inches to match the depths of I-joists used in residential construction. In the application shown above, a glulam supports the second floor I-joist framing. The glulam beam was chosen for its size, strength, cost competitiveness and availability.

Ridge and Rafter Beams

The open, airy designs and high ceilings common in residential construction today make glulam the perfect choice for ridge beam applications as shown on page 14. They can span long distances and carry virtually any design load. Sloping glulam rafter beams are the perfect complement to ridge beams in exposed applications.

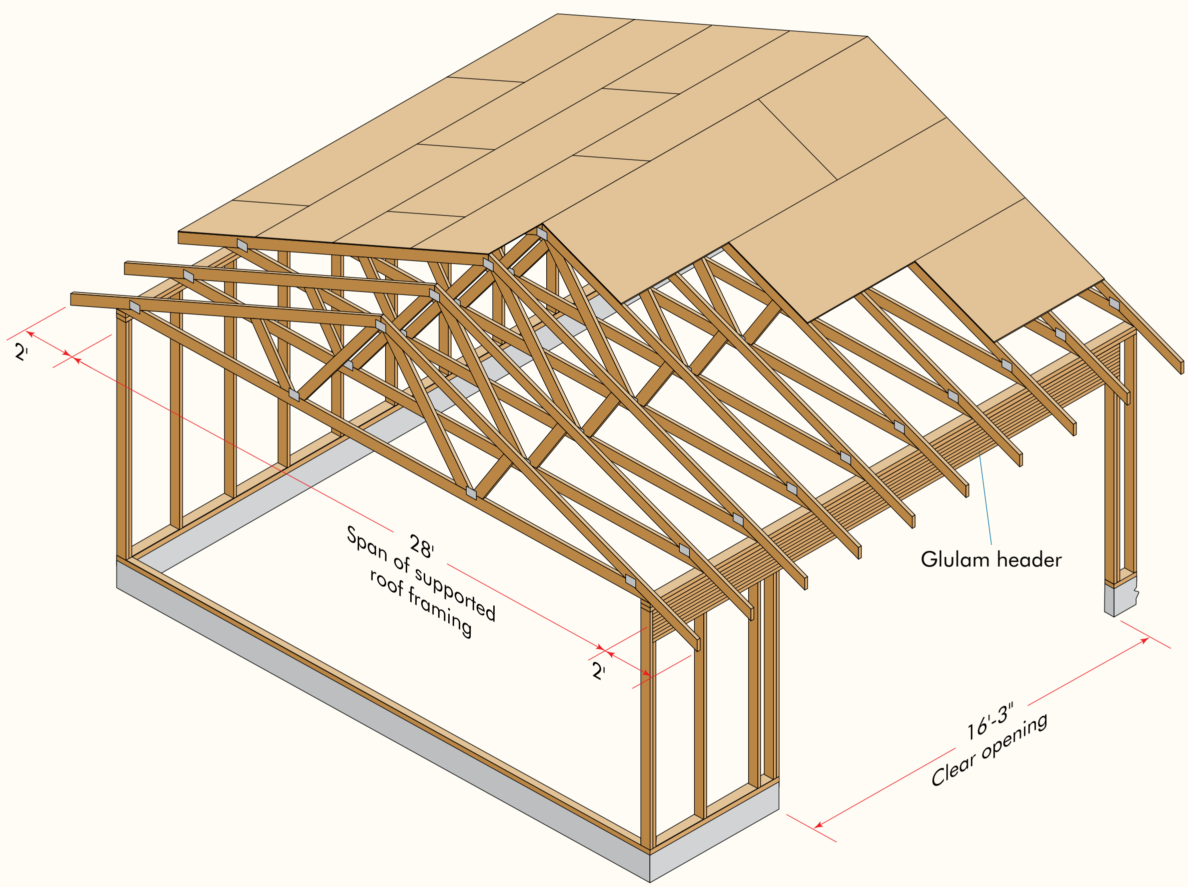
Garage Door Headers

Glulam headers can easily span distances long enough to allow garage door openings for two or three cars. And because they are cut to length when you buy them, you pay only for the length you need—nothing is wasted. A common width of glulam garage door header is 3-1/2 inches, which fits conventional 2x4 wall construction. For 2x6 wall construction, a 5-1/2-inch-wide glulam provides the perfect fit. Beams with widths of 3-1/8 inches and 5-1/8 inches are also used for these applications, but may require shimming.

FIGURE 3

GLULAM GARAGE DOOR HEADERS – DESIGN EXAMPLE

The 16'-3" beam span in this figure supports roof trusses on a 28-foot-wide house with 2' overhangs, under a 15 psf design dead load and 25 psf design snow load. According to the data in Tables 2A and 2B (pages 17-18), four different sizes of glulam beams could be selected: 3-1/8" by 15", 3-1/2" by 13-1/2", 5-1/8" by 12" and 5-1/2" by 11", all suitable to carry the required design loads with the final choice being based on local availability, cost, framing compatibility and designer preference.



Exposed glulam ridge beams and intermediate supports for this condominium residence provide both visual drama and structural integrity.

An entryway to this Chelan, Wash., residence welcomes visitors with the warmth and beauty of wood.

I-joist compatible glulam is ideal for floor construction.

Glulam columns and headers provide primary support in this condominium construction.

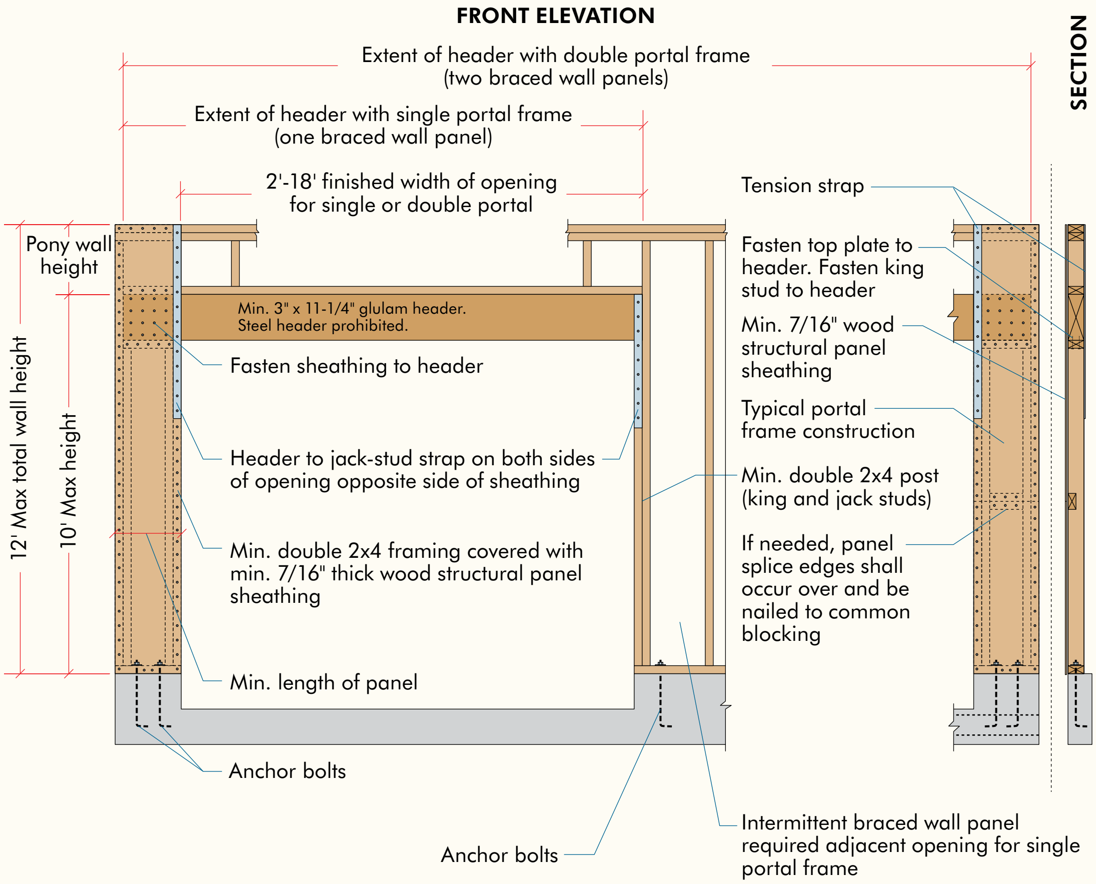
This test in the APA Research Center simulates seismic lateral loads over dozens of cycles to the same wall line. APA researchers can then determine the suitability of various bracing details for seismic performance, such as extending the glulam header over the narrow end wall.

I-joist compatible glulam beams are used for a range of framing needs in residential buildings.

Glulam garage door header extends over adjacent narrow shear wall. (See Figure 4 for further details.)

FIGURE 4

WALLS WITH 6:1 ASPECT RATIO USED WITH CONTINUOUS WOOD STRUCTURAL PANEL SHEATHING
Over Concrete or Masonry Block Foundation



Note:

a. Adapted from 2015 IRC Figure R602.10.6.4

b. See IRC for detailed requirements.

Full-length glulam headers at an end-wall provide an excellent nailing surface for wood structural panels, which help tie the beam to wall framing members on either side of the garage door opening to improve bracing. The APA Narrow Wall Bracing Method (as shown above) addresses such applications, where narrow wall sections must withstand the same lateral forces that bear on other larger wall and roof sections of the home. The connections in the frame add rigidity and improve resistance to wind and earthquake loads by effectively creating a narrow shear wall, as shown in Figure 4.

For more information on the Narrow Wall Bracing Method, refer to www.apawood.org/walls.

Columns

Glulam columns are straight and dimensionally true, making framing an easy task. Because glulam columns are available in long lengths, the members don't have to be spliced together, as is often necessary with sawn lumber. And, glulam columns can be exposed to view as a unique architectural feature of the framing system. Reference *Data File: Design of Structural Glued Laminated Timber Columns,* Form Y240.

TABLE 2A

APA 24F-1.8E GRADE GLULAM GARAGE DOOR HEADERS FOR SINGLE-STORY APPLICATIONS

Rough Door Opening = 9'-3" (Beam depths based on 1-1/2" laminations.)

	Span of supported roof trusses (ft)							
	22	**24**	**26**	**28**	**30**	**32**	**34**	**36**
Non-Snow Load (125%) 15 psf Dead 20 psf Live	3-1/8 x 7-1/2 3-1/2 x 7-1/2 5-1/8 x 6 5-1/2 x 6	3-1/8 x 7-1/2 3-1/2 x 7-1/2 5-1/8 x 6 5-1/2 x 6	3-1/8 x 7-1/2 3-1/2 x 7-1/2 5-1/8 x 6 5-1/2 x 6	3-1/8 x 7-1/2 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 6	3-1/8 x 7-1/2 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2
Snow Load (115%) 15 psf Dead 25 psf Live	3-1/8 x 7-1/2 3-1/2 x 7-1/2 5-1/8 x 6 5-1/2 x 6	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 6	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2
Snow Load (115%) 15 psf Dead 30 psf Live	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 7-1/2 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2
Snow Load (115%) 15 psf Dead 40 psf Live	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 9 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 9 5-1/8 x 7-1/2 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 10-1/2 5-1/8 x 9 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 10-1/2 5-1/8 x 9 5-1/2 x 7-1/2	3-1/8 x 10-1/2 3-1/2 x 10-1/2 5-1/8 x 9 5-1/2 x 9	3-1/8 x 12 3-1/2 x 10-1/2 5-1/8 x 9 5-1/2 x 9

Rough Door Opening = 16'-3" (Beam depths based on 1-1/2" laminations.)

	Span of supported roof trusses (ft)							
	22	**24**	**26**	**28**	**30**	**32**	**34**	**36**
Non-Snow Load (125%) 15 psf Dead 20 psf Live	3-1/8 x 12 3-1/2 x 12 5-1/8 x 10-1/2 5-1/2 x 10-1/2	3-1/8 x 12 3-1/2 x 12 5-1/8 x 10-1/2 5-1/2 x 10-1/2	3-1/8 x 13-1/2 3-1/2 x 12 5-1/8 x 10-1/2 5-1/2 x 10-1/2	3-1/8 x 13-1/2 3-1/2 x 12 5-1/8 x 12 5-1/2 x 10-1/2	3-1/8 x 13-1/2 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 10-1/2	3-1/8 x 13-1/2 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12
Snow Load (115%) 15 psf Dead 25 psf Live	3-1/8 x 13-1/2 3-1/2 x 12 5-1/8 x 10-1/2 5-1/2 x 10-1/2	3-1/8 x 13-1/2 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 10-1/2	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 10-1/2	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12	3-1/8 x 15 3-1/2 x 15 5-1/8 x 12 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 12 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 13-1/2 5-1/2 x 12
Snow Load (115%) 15 psf Dead 30 psf Live	3-1/8 x 13-1/2 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 10-1/2	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12	3-1/8 x 15 3-1/2 x 13-1/2 5-1/8 x 12 5-1/2 x 12	3-1/8 x 15 3-1/2 x 15 5-1/8 x 12 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 12 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 13-1/2 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 13-1/2 5-1/2 x 12	3-1/8 x 18 3-1/2 x 16-1/2 5-1/8 x 13-1/2 5-1/2 x 13-1/2
Snow Load (115%) 15 psf Dead 40 psf Live	3-1/8 x 15 3-1/2 x 15 5-1/8 x 12 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 12 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 15 5-1/8 x 13-1/2 5-1/2 x 12	3-1/8 x 16-1/2 3-1/2 x 16-1/2 5-1/8 x 13-1/2 5-1/2 x 13-1/2	3-1/8 x 18 3-1/2 x 16-1/2 5-1/8 x 13-1/2 5-1/2 x 13-1/2	3-1/8 x 18 3-1/2 x 16-1/2 5-1/8 x 13-1/2 5-1/2 x 13-1/2	3-1/8 x 18 3-1/2 x 18 5-1/8 x 15 5-1/2 x 13-1/2	3-1/8 x 19-1/2 3-1/2 x 18 5-1/8 x 15 5-1/2 x 15

Notes:

a. This table is for preliminary design use only. Final design should include a complete analysis, including bearing stresses and lateral stability.

b. Service condition = dry.

c. Maximum deflection under live load = span/240.

d. Maximum deflection under total load = span/180.

e. Maximum 2' roof truss overhangs.

f. Beam weight = 36 pcf.

g. Assumes a maximum bearing length of 4-1/2".

h. Design properties at normal load duration and dry service conditions F_b = 2,400 psi, F_v = 215 psi, E_x = 1.8 x 10^6 psi.

i. Beam widths of 3" and 5" may be substituted for 3-1/8" and 5-1/8", respectively, at the same tabulated depth.

TABLE 2B

APA 24F-1.8E GRADE GLULAM GARAGE DOOR HEADERS FOR SINGLE-STORY APPLICATIONS

Rough Door Opening = 9'-3" (Beam depths based on 1-3/8" laminations.)

	Span of supported roof trusses (ft)							
	22	**24**	**26**	**28**	**30**	**32**	**34**	**36**
Non-Snow Load (125%) 15 psf Dead 20 psf Live	3-1/8 x 6-7/8 3-1/2 x 6-7/8 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 6-7/8 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 6-7/8 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 6-7/8 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8
Snow Load (115%) 15 psf Dead 25 psf Live	3-1/8 x 8-1/4 3-1/2 x 6-7/8 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 6-7/8
Snow Load (115%) 15 psf Dead 30 psf Live	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 8-1/4 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 8-1/4	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 8-1/4
Snow Load (115%) 15 psf Dead 40 psf Live	3-1/8 x 9-5/8 3-1/2 x 8-1/4 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 6-7/8 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 6-7/8	3-1/8 x 9-5/8 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 8-1/4	3-1/8 x 11 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 8-1/4	3-1/8 x 11 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 8-1/4	3-1/8 x 11 3-1/2 x 9-5/8 5-1/8 x 8-1/4 5-1/2 x 8-1/4	3-1/8 x 11 3-1/2 x 11 5-1/8 x 8-1/4 5-1/2 x 8-1/4

Rough Door Opening = 16'-3" (Beam depths based on 1-3/8" laminations.)

	Span of supported roof trusses (ft)							
	22	**24**	**26**	**28**	**30**	**32**	**34**	**36**
Non-Snow Load (125%) 15 psf Dead 20 psf Live	3-1/8 x 12-3/8 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 9-5/8	3-1/8 x 12-3/8 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 11	3-1/8 x 12-3/8 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 11	3-1/8 x 13-3/4 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 11	3-1/8 x 13-3/4 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 11	3-1/8 x 13-3/4 3-1/2 x 12-3/8 5-1/8 x 12-3/8 5-1/2 x 11	3-1/8 x 13-3/4 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 12-3/8
Snow Load (115%) 15 psf Dead 25 psf Live	3-1/8 x 13-3/4 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 11	3-1/8 x 13-3/4 3-1/2 x 12-3/8 5-1/8 x 11 5-1/2 x 11	3-1/8 x 13-3/4 3-1/2 x 13-3/4 5-1/8 x 11 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 12-3/8 5-1/2 x 12-3/8
Snow Load (115%) 15 psf Dead 30 psf Live	3-1/8 x 13-3/4 3-1/2 x 13-3/4 5-1/8 x 11 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 11	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 13-3/4 5-1/2 x 12-3/8	3-1/8 x 17-7/8 3-1/2 x 16-1/2 5-1/8 x 13-3/4 5-1/2 x 12-3/8
Snow Load (115%) 15 psf Dead 40 psf Live	3-1/8 x 15-1/8 3-1/2 x 13-3/4 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 15-1/8 5-1/8 x 12-3/8 5-1/2 x 12-3/8	3-1/8 x 16-1/2 3-1/2 x 16-1/2 5-1/8 x 13-3/4 5-1/2 x 12-3/8	3-1/8 x 17-7/8 3-1/2 x 16-1/2 5-1/8 x 13-3/4 5-1/2 x 13-3/4	3-1/8 x 17-7/8 3-1/2 x 16-1/2 5-1/8 x 13-3/4 5-1/2 x 13-3/4	3-1/8 x 17-7/8 3-1/2 x 17-7/8 5-1/8 x 15-1/8 5-1/2 x 13-3/4	3-1/8 x 19-1/4 3-1/2 x 17-7/8 5-1/8 x 15-1/8 5-1/2 x 13-3/4

Notes:

a. This table is for preliminary design use only. Final design should include a complete analysis, including bearing stresses and lateral stability.

b. Service condition = dry.

c. Maximum deflection under live load = span/240.

d. Maximum deflection under total load = span/180.

e. Maximum 2' roof truss overhangs.

f. Beam weight = 36 pcf.

g. Assumes a maximum bearing length of 4-1/2" and minimum bearing length of 3".

h. Design properties at normal load duration and dry service conditions F_b = 2,400 psi, F_v = 215 psi, E_x = 1.8 x 10^6 psi.

i. Beam widths of 3" and 5" may be substituted for 3-1/8" and 5-1/8", respectively, at the same tabulated depth.

DESIGNING FOR FIRE RESISTANCE

Fire Performance of Wood Construction

The truly fireproof building does not exist. In nearly all buildings, the contents are flammable and are the critical factor in a fire. The smoke and heat generated by the burning contents can cause extensive damage and loss of life long before the structural components of the building are affected.

The primary objective in any fire-rated construction is protection of human life. The combination of a variety of products and construction methods can slow flame spread and make a building fire-safe. In addition to the structural materials used, the variables involved in creating a fire-safe environment include the use of sprinkler systems, gypsum wallboard, acoustical tiles and separation walls. Sprinkler systems may be used to increase allowable floor areas for most occupancies and in some instances, sprinklers may be substituted for one-hour fire-resistive construction in certain sections of a building. Building codes vary widely, so it is important to review the codes for the geographic area in which the building is being constructed to determine fire safety requirements.

Glulam Performance in Fire

Glulam performs very well in the intense heat of a fire, where temperatures can achieve 1,650° F or higher. Unprotected steel members typically buckle and twist in such high temperatures, causing catastrophic collapse of both the roof and supporting walls.

Wood ignites at about 450-500° F, but charring may begin as low as 300° F. Wood typically chars at a rate of 1/40 inch per minute. Thus, after 30 minutes of fire exposure, only the outer 3/4 inch of the glulam will be damaged. It is important to note that the adhesives used in the manufacture of a glulam beam burn at about the same rate as the wood and do not affect the overall fire performance of the member. The char that develops insulates the glulam member and, hence, raises the temperatures it can withstand. Most of the cross section of a large glulam will remain intact when exposed to fire, and the member will continue to support load.

Thus, depending on the severity of the fire and after a structural re-analysis by a qualified design professional, it is often possible to salvage the glulam members by merely removing the fire-damaged material and refinishing the surface of the member.

One-hour Fire Resistance

To assure a safe structure in the event of a fire, authorities base fire and building code requirements on research and testing, as well as fire histories. Based on these and other considerations, the model building codes, including the International Building Code (IBC), classify Heavy Timber as a specific type of construction and set minimum sizes for roof and floor beams to assure fire performance.

Procedures are also available to determine the minimum glulam size for projects in which one-hour fire resistance of components is required. Tables 3 and 4 on page 20 illustrate this principle for glulam timber. Additional details are provided in *Technical Note: Calculating Fire Resistance of Glulam Beams and Columns,* Form Y245.

A structural member's fire resistance is measured by the time it can support its design load during a fire. An exposed beam or column sized for a minimum one-hour fire resistance will support a design load for at least one hour during standard fire test conditions which simulate an actual fire. The IBC provide a methodology for calculating the minimum size of glulam to provide a one-hour fire rating under given design conditions. An alternate procedure is given in Chapter 16 of the *2015 National Design Specifications*.

TABLE 3

MINIMUM DEPTHS AT WHICH 6-3/4" AND 8-3/4" WIDE BEAMS CAN BE ADAPTED FOR ONE-HOUR FIRE RATINGS

Beam Width (in.)	Depth 3 Sides Exposed (in.)	Depth 4 Sides Exposed (in.)
6-3/4	13-3/8	27
8-3/4	7-1/2	13-1/2

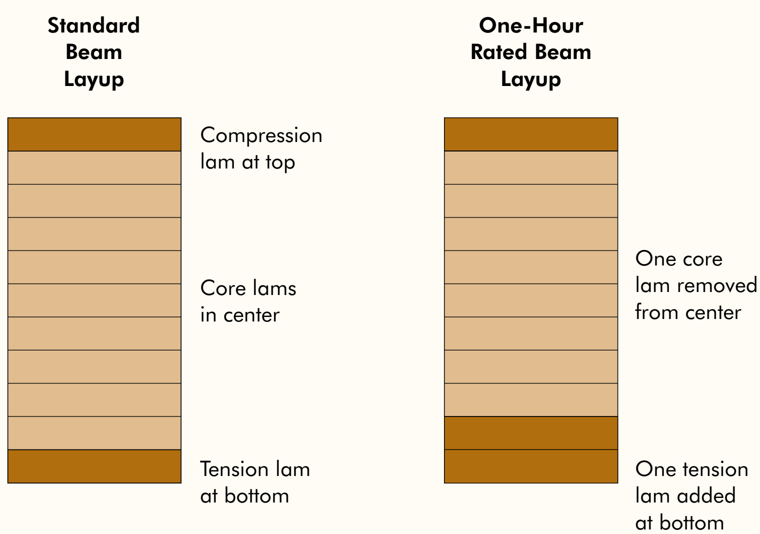
TABLE 4

MINIMUM DEPTHS AT WHICH 8-3/4" AND 10-3/4" COLUMN WIDTHS QUALIFY FOR ONE-HOUR RATING FOR GIVEN ℓ/D

ℓ/d Criteria	Column Width (in.)	Depth 3 Sides Exposed (in.)	Depth 4 Sides Exposed (in.)
ℓ/d > 11	10-3/4	10-1/2	13-1/2
ℓ/d ≤ 11	8-3/4	9	12
	10-3/4	7-1/2	10-1/2

FIGURE 5

SIMPLE SPAN UNBALANCED LAYUP



It is important to note that to qualify for a one-hour fire rating for a glulam member, it is necessary to replace one core lamination with one tension lamination, as illustrated by Figure 5.

As with all other structural framing, specifications of members designed to have one-hour fire resistance should be carefully checked by a professional engineer or architect to assure compliance with all local building codes.

Fire Treatments

While pressure impregnated fire retardant chemicals are often used to reduce flame spread of some wood products, they are not recommended for use with glulam. If a fire retardant treatment is used, it is the responsibility of the design professional to determine the effects of the treatment on the strength of the glulam by consulting the manufacturer of the fire retardant treatment. Another option for reducing flame spread is to apply an intumescent coating to the surface of the glulam, which does not affect the structural integrity of the member.

For more information on fire-rated construction systems and one-hour rated glulam, refer to *Fire-Rated Systems*, Form W305.

MOISTURE EFFECTS

Moisture Control in Wood Systems

Wood is a natural, porous material which always contains some degree of moisture. Wood moisture content is a measure of the total weight of moisture in the wood as a percentage of the oven-dried weight of the wood. Wood production processes generally involve some drying. At the time of production, glulam beams typically have an average moisture content of about 12 percent. As a comparison, the moisture content of green lumber can range from 20 to 50 percent, with kiln-dried lumber at 16 percent.

Once installed, glulam beams in interior applications will equilibrate to approximately 8 to 12 percent moisture content. Exact equilibrium moisture content is primarily a function of interior relative humidity and temperature. The time it takes for the moisture content of a wood member to equilibrate with its environment is a function of the beam size and interior humidity levels and can be substantial for large glulam beams.

Model building codes specify minimum requirements for ventilation of floor and roof spaces. These ventilation requirements vary depending on whether or not vapor retarders are used. Consult with local codes to assure compliance.

Glulam can be protected from surface moisture intrusion during transit and the construction cycle by the use of protective plastic wrapping or sealers. 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 of a penetrating sealant is recommended if beams are to be stained or given a natural finish. Sealants can be applied to the beams before they leave the mill or they can be field applied by the contractor. The application of sealants must be part of the specification if they are to be applied at the mill.

Sealants applied to the ends of beams also help guard against moisture penetration and excessive end grain checking. A coat of sealant should be field applied to the ends of beams if they are trimmed to length or otherwise field cut.

For more information on moisture control in wood construction, refer to *Build A Better Home: Mold and Mildew*, Form A525, and *Technical Notes: Controlling Decay in Wood Construction,* Form R495, and *Moisture Control in Low Slope Roofs,* Form R525.

Effect of Mold and Mildew Growth on Wood Components

As an organic material, mold and mildew readily grow on wood if excessive moisture is present. Mold grows on wood if exposed to water or prolonged humidity in excess of 70 percent.

Mold and mildew are of a different type of fungi than those that cause wood to rot. Unlike wood decay fungi, molds do not cause significant loss of the strength of wood products. Nonetheless, mold and mildew on wood may raise a health concern and indicate high moisture conditions are present. Prolonged periods of high moisture may also support the growth of wood decay fungi, which is another reason why it is important to follow proper methods of design, handling, installation and maintenance that will control moisture and inhibit the growth of mold and mildew.

Checking

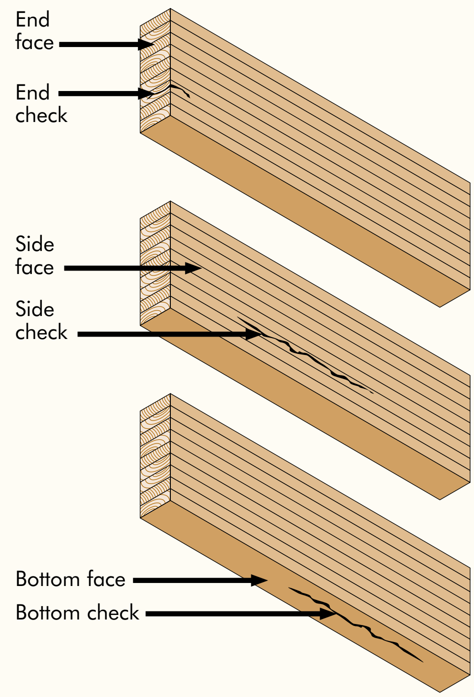
A common moisture-related phenomenon in wood is checking. Checking occurs naturally to wood in service. Checks are openings that occur on the surface of the wood and follow parallel to the natural grain direction of the piece. A close visual evaluation of a check will always reveal torn wood fibers. The cause of checking is shrinkage of the wood fibers as moisture is lost to the surrounding environment. Rapid drying increases this differential moisture content between the inner and outer fibers and increases the chance for checking to occur.

Glulam beams typically exhibit fewer and less severe checks than comparable size sawn timbers due to their relatively low moisture content at time of manufacture. It is often difficult, however, to control the exposure of glulam to the elements during shipping, storage and erection. Glulam may pick up surface moisture during any of these stages of the construction process.

Checks are often observed near a glueline in a glulam member where differential drying stresses are greatest. This most often occurs near the outermost glueline where the amount of surface exposed by the outermost lamination is greatest. Checks are a natural characteristic of wood and are not considered to have a detrimental effect on the strength of the member unless they develop into a full width split.

FIGURE 6

CHECKING



In bending members (beams, rafters, girders, etc.), checks are commonly observed in the face of the bottom lamination, in the side of the members, and at the end of the members.

For additional information on checking and the effects of checking on the strength of glulam, refer to *Owner's Guide to Understanding Checks in Glued Laminated Timber,* Form F450, and *Technical Note: Evaluation of Check Size in Glued Laminated Timber Beams,* Form R475.

Preservative Treatments

Decay growth in wood occurs when the wood moisture content exceeds 20–25 percent for a prolonged time. Proper detailing and maintenance can help control moisture content and prevent decay fungi growth; however, in many applications directly exposed to the elements, or other high humidity environments, this is not possible. In these cases, it is necessary to specify the use of an appropriate pressure impregnated preservative treatment to eliminate decay and insect hazards or to specify the use of heartwood of a naturally durable species, such as Alaska Yellow Cedar, Western Red Cedar or Port Orford Cedar.

Glulam may be treated after gluing and fabrication or the individual laminations may be treated prior to gluing, depending on the species of wood used and the treatment specified. The availability of preservative-treated glulam varies from one geographic area to another, so check with your supplier before specifying a particular treatment.

When glulam beams are to be preservative-treated after gluing, members should be ordered to exact dimensions with all hole drilling and fabrication done prior to the treatment process. This will eliminate penetrating the treatment envelope by post-treatment cutting and drilling and help insure a long life for the member. Glulam beams that are pressure-preservative treated must be bonded with wet-use adhesives conforming to ANSI A190.1.

For further information on this subject, refer to *Technical Note: Preservative Treatment of Glued Laminated Timber,* Form S580.

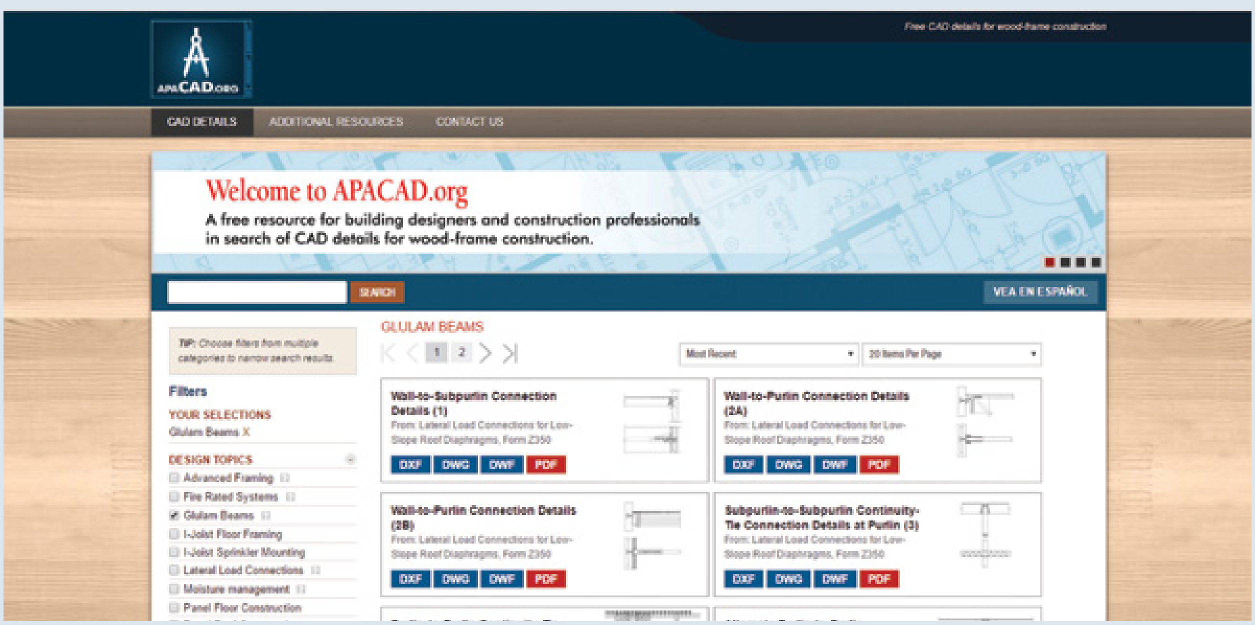
Connection Detailing

As with any structural material, proper connection detailing is essential to assure the structural performance of the member. This is also true with glulam since an improperly designed and installed connection detail may lead to a serious failure. The designer must consider the effects of moisture changes in the glulam member, proper positioning of the mechanical fasteners and the number of fasteners required to carry the loads to develop an adequate connection detail.

Slotted bolt holes permit horizontal movement of pitched and curved glulam beam.

Based on many years of experience, the glulam industry has developed details for typical connection situations. These details illustrate the correct and incorrect way to make these connections and indicate the consequences of an incorrect detail. The details are illustrated and described in *Technical Note: Glulam Connection Details,* Form T300. Additional connection recommendations are illustrated in the *Data File: Lateral Load Connections for Low-Slope Roof Diaphragms,* Form Z350. The connection details shown in the Data File may be downloaded in PDF and several CAD formats from APA's CAD website, located at www.APACAD.org.

CAD Details: Glulam Connections



Connection details for glulam framing are available in CAD format at www.APACAD.org.

Notching and Drilling of Glulam

Closely related to connection details is notching and drilling of glulam. Since glulam timbers are highly engineered components manufactured from specially selected and positioned lumber laminations, an improperly cut notch or a hole drilled in the wrong place can seriously affect the load-carrying capacity of the member. Only holes, notches and tapered cuts approved by the design professional of record and detailed on shop drawings should be made in a glulam member.

Field notching, cutting or drilling of a glulam beam, particularly on the tension side of the member, should be avoided. Field conditions may require making a cut, notch or hole that was not originally anticipated. In some instances, these can be made in areas of the glulam which are not highly stressed and will thus have minimal effect on the structural capacity of the member. To address these specific conditions, APA has published *Technical Note: Field Notching and Drilling of Glued Laminated Timber Beams*, Form S560.

Holes and notches must be precisely located and detailed for architectural appearance and accounted for in the design of beam connections and column capacity.

These glulam members use notches and hidden connectors, resulting in a clean, uncluttered design.

STORAGE, HANDLING AND INSTALLATION

Glulam beams must be stored properly and handled with care to assure optimum performance. Beams may be protected with sealants, primers or paper wrap when they leave the manufacturing plant. Sealants on the ends of beams help guard against moisture penetration and checking. A coat of sealant should be applied to the ends of any beams trimmed or otherwise cut in the field. 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 exposure to moisture, dirt and scratches during transit, storage and erection. Because sunlight can discolor beams, opaque wrappings are recommended. Beams can be wrapped individually, by the bundle or by the load. If it is necessary to remove portions of the wrapping during the erection sequence to facilitate making connections, remove all of the wrapping to avoid uneven discoloration due to exposure to the sun.

Glulam beams are commonly loaded and unloaded with a fork lift. For greater stability, the sides of the beams, rather than the bottoms, should rest on the forks. Supporting extremely long beams on their sides, however, can cause them to flex excessively, increasing the risk of damage. Use multiple forklifts to lift long glulam members. If a crane with slings is used to load or unload beams, provide adequate blocking between the cable and the member. Use wooden cleats or blocking to protect corners. Only non-marring fabric slings should be used to lift glulams. Using spreader bars can reduce the likelihood of damage when lifting especially long beams with a crane.

When transporting beams, stack them on lumber blocking or skids when loading them on rail cars or trucks. Beams can rest on their sides or bottoms. Secure the load with straps to keep it from shifting. Protect beam corners with "softeners" when strapping down the load.

In the distribution yard and on the job site, a well-drained covered storage site is recommended. Keep glulam members off the ground with lumber blocking, skids or rack systems. Beams should remain wrapped to protect them from moisture, dirt, sunlight and scratches. Cut slits in the bottom of the wrapping to allow ventilation and water drainage. At the job site, use similar storage provisions when possible.

One of the advantages of the high strength-to-weight ratio of glulam beams is that in many residential and light commercial applications they can be installed with forklifts, front-end loaders and other commonly available construction equipment. That eliminates the time and cost required to have a crane on the job site.

Additional information can be found in *Builder Tip: Keep Glulam Looking Its Best With Proper Storage and Handling,* Form F455.

DESIGN AND SPECIFICATION CONSIDERATIONS

Beam and Column Design

To determine the load capacity and recommended size for a glulam beam, consult the following APA publications:

- *Data File: Glued Laminated Beam Design Tables,* Form S475
- *Data File: Substitution of Glulam Beams for Steel and Solid-Sawn Lumber,* Form S570
- *Data File: Design of Structural Glued Laminated Timber Columns,* Form Y240

Proper Specification

In many residential and light commercial applications, stock glulam beams meet the requirements for the job. Other residential applications and many commercial designs require custom members. In either case, the member capacity and size specified must be verified by a design professional.

To properly specify a glulam member, use the Specification Guide on pages 26-29. While all possible design considerations cannot be covered by a general specification of this type, most of the common specification concerns are incorporated.

GLULAM SPECIFICATION GUIDE

The following is a guide for preparing specifications for structural glued laminated timber used for bending members such as purlins, beams, 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 begins.

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 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 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.[a b] The design should specify a layup combination from ANSI 117 or *Data File: Glulam Design Specification*, Form Y117, or specify a stress class from Table 5.

4. ***Appearance Grade***—Glulam shall be (framing) (industrial) (architectural) (premium) grade[c] in accordance with ANSI 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.[a]

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-Preservers' 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.[d]

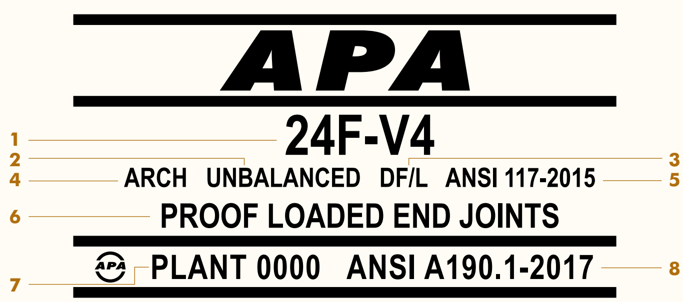
8. ***Fire Resistance (when applicable)***—Glulam shall be sized and manufactured for one-hour fire resistance.[e] The use of pressure impregnated fire retardant treatment is not recommended.

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).[f]

10. ***Trademarks***—Members shall be marked with the APA trademark indicating conformance with the manufacturing, quality assurance and marking provisions of ANSI A190.1.

11 ***Certificates (when applicable)***—A Certificate of Conformance may be provided by the (manufacturer) (seller) to indicate conformance with ANSI 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.



1. Combination symbol.
2. Unbalanced layup.
3. The species or species group of lumber in the timber.
4. Designation of appearance grade.
5. Applicable design and manufacturing specification.
6. Indicates the member has the required laminations proof loaded.
7. Mill number.
8. Identification of ANSI A190.1, the *American National Standard for Structural Glued Laminated Timber*.

Notes to Specifiers

a. 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.

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

c. Appearance classifications are described in *Technical Note: Glued Laminated Timber Appearance Classifications for Construction Applications*, Form Y110.

d. See *Technical Note: Preservative Treatment of Glued Laminated Timber*, Form S580.

e. 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 sheathing, or 1-1/2" wood, to provide the needed protection. See page 20.

f. 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.

TABLE 5

REFERENCE DESIGN VALUES FOR STRUCTURAL GLUED LAMINATED SOFTWOOD TIMBER
(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						
	Extreme Fiber in Bending				Modulus of Elasticity		
	Bottom of Beam Stressed in Tension (Positive Bending)	Top of Beam Stressed in Tension (Negative Bending)	Compression Perpendicular to Grain	Shear Parallel to Grain	For Deflection Calculations		For Stability Calculations
Stress Class	F_{bx}^{+} (psi)	F_{bx}^{-} [a] (psi)	$F_{c\perp x}$ (psi)	F_{vx} [b] (psi)	$E_{x\ true}$ (10^6 psi)	$E_{x\ app}$ (10^6 psi)	$E_{x\ min}$ (10^6 psi)
16F-1.3E	1600	925	315	195	1.4	1.3	0.69
20F-1.5E	2000	1100	425	195[d]	1.6	1.5	0.79
24F-1.7E	2400	1450	500	210[d]	1.8	1.7	0.90
24F-1.8E	2400	1450[e]	650	265[f]	1.9	1.8	0.95
26F-1.9E[g]	2600	1950	650	265[f]	2.0	1.9	1.00
28F-2.1E SP[g]	2800	2300	805	300	2.2[i]	2.1[i]	1.09
30F-2.1E SP[g,h]	3000	2400	805	300	2.2[i]	2.1[i]	1.09

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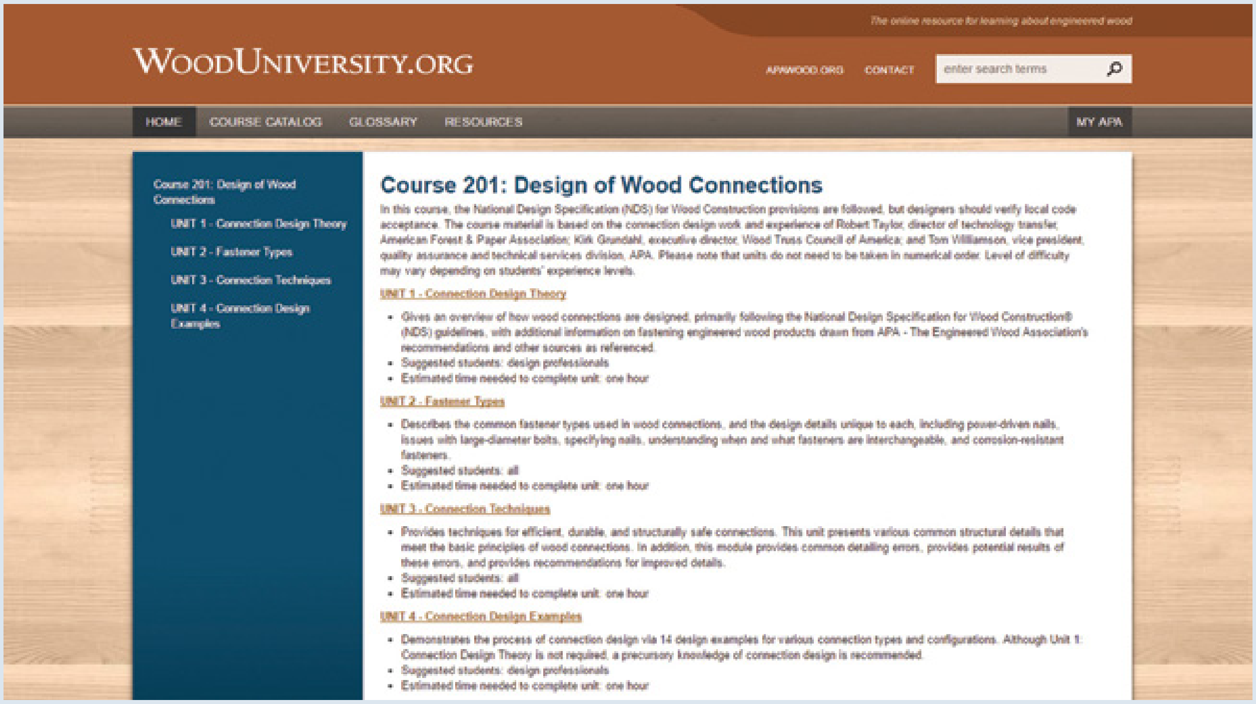
Wood University: Design of Wood Connections



Wood University is a free online training center designed for architects, builders and building designers. Accredited for continuing education by the American Institute of Architects and the American Institute of Building Designers, Wood University offers both introductory and advanced learning modules on engineered wood products and wood design. Log on at www.wooduniversity.org.

TABLE 5 (Continued)

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

	Bending About Y-Y Axis Loaded Parallel to Wide Faces of Laminations						Axially Loaded		Fasteners
				Modulus of Elasticity					
	Extreme Fiber in Bending	Compression Perpendicular to Grain	Shear Parallel to Grain	For Deflection Calculations		For Stability Calcu-lations	Tension Parallel to Grain	Com-pression Parallel to Grain	Specific Gravity for Fastener Design
Stress Class	F_{by} (psi)	$F_{c\perp y}$ (psi)	F_{vy} [b,c] (psi)	$E_{y\ true}$ (10^6 psi)	$E_{y\ app}$ (10^6 psi)	$E_{y\ min}$ (10^6 psi)	F_t (psi)	F_c (psi)	G
16F-1.3E	800	315	170	1.2	1.1	0.58	675	925	0.41
20F-1.5E	800	315	170	1.3	1.2	0.63	725	925	0.41
24F-1.7E	1050	315	185	1.4	1.3	0.69	775	1000	0.42
24F-1.8E	1450	560	230[f]	1.7	1.6	0.85	1100	1600	0.50[j]
26F-1.9E[g]	1600	560	230[f]	1.7	1.6	0.85	1150	1600	0.50[j]
28F-2.1E SP[g]	1600	650	260	1.8	1.7	0.90	1250	1750	0.55
30F-2.1E SP[g,h]	1750	650	260	1.8	1.7	0.90	1250	1750	0.55

Notes:

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. The design values for shear, F_{vx} and F_{vy}, 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 also be used for determination of design values for radial tension and torsion.

c. 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.

d. 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.

e. 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.

f. 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.

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 unless the manufacturer has qualified for wider widths based on full-scale tests subject to approval by an accredited inspection agency.

i. For 28F and 30F members with more than 15 laminations, $E_{x\ true} = 2.1 \times 10^6$ psi and $E_{x\ app} = 2.0 \times 10^6$ 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 *Data File: Glulam Design Specification,* Form Y117, and ANSI 117. Design values are for members with 4 or more laminations. Some stress classes are not available in all species. Contact manufacturer for availability.

GLOSSARY OF TERMS

Appearance Classification: Defines the surface finish of the beam. Architectural and Industrial are the most common appearance classifications. Premium appearance beams are available as custom orders. The structural quality of glulam has no relation to the appearance grade specified.

Beam: Normally a horizontal or sloping member that is designed to carry vertical loads:

- *Simple Span:* A member that is supported at both ends.
- *Continuous:* A single member that is supported at more than two bearing locations.
- *Cantilever:* A member that has one or both supports away from the ends; one of which overhangs its support.

Camber: The curvature built into a beam (in a direction opposite to the expected deflection) to prevent it from appearing to sag under a loaded condition.

Column: Normally a vertical member that is designed to carry loads from a beam:

- *Concentrically Loaded:* When the resultant load acts parallel to the axis of the member and is applied at its centerline.
- *Eccentrically Loaded:* When the resultant load acts parallel to the axis of the member but is applied away from its centerline.

Combination Number: The identification used to describe the type of lamination layup in the glulam member, the associated allowable design stresses, and if the lumber used was visually or mechanically graded.

Deflection: The vertical displacement that occurs when a beam is loaded, generally measured at positions between supports or at the end of a cantilever.

Deflection Limit: The maximum amount the beam is permitted to deflect under load. Different deflection limits are normally established for live load and total load.

Design Values: Allowable stress values as they are established for each glulam beam, described in terms of Bending (F_b), Horizontal Shear (F_v), Modulus of Elasticity (E) and other stresses.

Equilibrium Moisture Content: Any piece of wood will give off or take on moisture from the surrounding atmosphere until the moisture in the wood comes to equilibrium with that in the atmosphere. The moisture content of wood at the point of balance is called the equilibrium moisture content and is expressed as a percentage of the weight of the oven-dried wood.

Header: A beam that is used to support walls and/or floor and roof joists that run perpendicular to it.

Laminations: Individual pieces of lumber that are glued together end to end for use in the manufacture of glued laminated timber. These end-jointed laminations are then face-bonded together to create the desired member shape and size.

Lamination Layup: The physical arrangement of different grades of laminations throughout the depth of a glulam member.

Moisture Content: The amount of water contained in the wood, usually expressed as a percentage of the weight of oven-dry wood.

Purlin: A secondary structural framing member, such as a joist or rafter, that is normally supported by walls or primary beams.

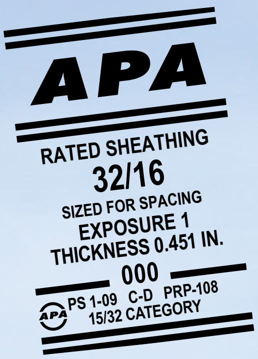
Radius of Curvature: A dimension that is commonly used as a means of describing the camber requirements in a glulam beam.

"Stock" Glulams: Glulams that are manufactured to common, standard dimensions and characteristics, and kept in inventory by distributors or dealers for immediate job site delivery. (May be cut to customer-specified lengths.)

Stress Class: A group of glulam beam combinations with similar design stresses are grouped into stress classes, as tabulated in Table A1 of ANSI 117.

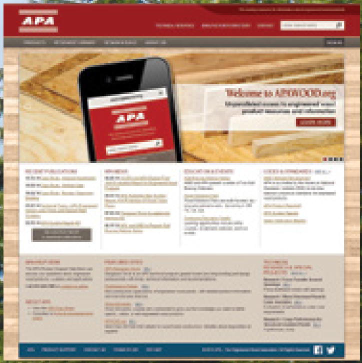
About APA

Always insist on engineered wood products bearing the mark of quality—the APA or APA 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 an APA performance standard, the Voluntary Product Standard PS 1-09, *Structural Plywood* or Voluntary Product Standard PS 2-10, *Performance Standard for Wood-Based Structural-Use Panels*. Panel quality of all APA-trademarked products is subject to verification through APA audit.

APA's services go far beyond quality testing and inspection. Research and promotion programs play important roles in developing and improving plywood and other panel construction systems, and in helping users and specifiers to better understand and apply engineered wood products. For more information on wood construction systems, contact APA, 7011 S. 19th St., Tacoma, Washington 98466, or visit the Association's web site at www.apawood.org.



Glulam Product Guide

We have field representatives in many major U.S. cities and in Canada
who can help answer questions involving APA trademarked products.
For additional assistance in specifying engineered wood products, contact us:

APA HEADQUARTERS

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