

PRODUCT GUIDE



G L U L A M



WOOD, THE NATURAL CHOICE

Wood is good. It is the earth's natural, energy efficient and renewable building material.

Engineered wood is a better use of wood. It uses less wood to make more wood products.

That's why using APA trademarked I-joists, glued laminated timbers, laminated veneer lumber, plywood, and oriented strand board is the right thing to do.

A few facts about wood.

▪ **We're not running out of trees.** One-third of the United States land base – 731 million acres – is covered by forests. About two-thirds of that 731 million acres is suitable for repeated planting and harvesting of timber. But only about half of the land suitable for growing timber is open to logging. Most of that harvestable acreage also is open to other uses, such as camping, hiking, hunting, etc.

▪ **We're growing more wood every day.** 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.

▪ **Manufacturing wood products 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 right product for the environment.



NOTICE:

The recommendations in this data file apply only to glulam that bears the APA EWS trademark. Only glulam bearing the APA EWS trademark is subject to the Association's quality auditing program.



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 Engineered Wood Systems brochure describes APA EWS 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 today in construction.

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100 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.

The first patents for glulam were issued in Switzerland and Germany in 1900. A 1906 German patent 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 glue-line 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 A190.1-92, which took effect in 1992.

ANATOMY OF A GLULAM

A 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 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.

Balanced members are symmetrical in lumber quality about the mid-height. Balanced beams are used in applications such as 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 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 2400 psi. Similarly, a 26F designation refers to a member with an allowable bending stress of 2600 psi. These different stress levels are achieved by varying the percentages and grade of higher quality lumber in the beam layout. Use of different species may also result in different stress designations.

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 layout using visually graded Douglas-fir lumber, the layout designation is identified as a 24F-V4. The “V” indicates that the layout 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. Some of the most common glulam beam layups with their corresponding allowable stresses are shown in Table 1.

Engineered Wood Systems Technical Note EWS Y117, *Allowable Properties for APA EWS Glulam* provides design stresses for all glulam produced by EWS 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 the *Engineered Wood Systems* Technical Note EWS Y117, *Allowable Properties for APA EWS Glulam*.



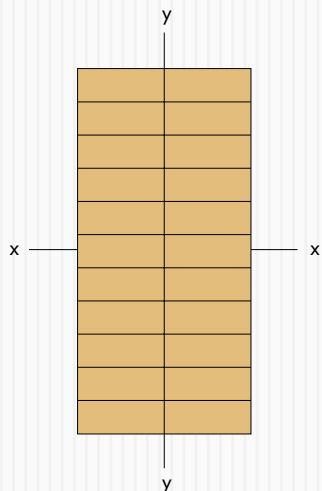
TABLE 1

ALLOWABLE STRESSES (in psi)

Combination	F _b ten.	F _b comp.	F _v	MOE	F _{c//}	F _{c⊥}	F _t
Unbalanced Layups							
24F-1.8E	2400	1600	195	1.8 × 10 ⁶	1200	500	950
24F-V4/DF	2400	1850	240	1.8 × 10 ⁶	1650	650	1100
24F-V3/SP	2400	1950	270	1.8 × 10 ⁶	1700	740	1150
Balanced Layups							
24F-V8/DF	2400	2400	240	1.8 × 10 ⁶	1650	650	1100
24F-V5/SP	2400	2400	270	1.8 × 10 ⁶	1700	740	1150

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", which meet the requirements for most residential construction applications.

Where long spans, unusually heavy loads, or other circumstances control design, custom members are typically specified. Custom members are available in virtually any size and shape that may be required to meet the design conditions.

Some of the common custom shapes that are available include 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. This classification 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.

Industrial. Used for concealed applications or where appearance is not of primary importance.

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.

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



Glulam beam being tested at the APA Research Center.

are possible for different stress level combinations of glulam. Tables giving the load carrying capacities for glulam are included in the *Engineered Wood Systems Data File: Glued Laminated Beam Design Tables*, Form EWS 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 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 exhibit a 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 1600 and 2000 feet although any camber may be specified.

FIGURE 2

BEAM CAMBER PARAMETERS

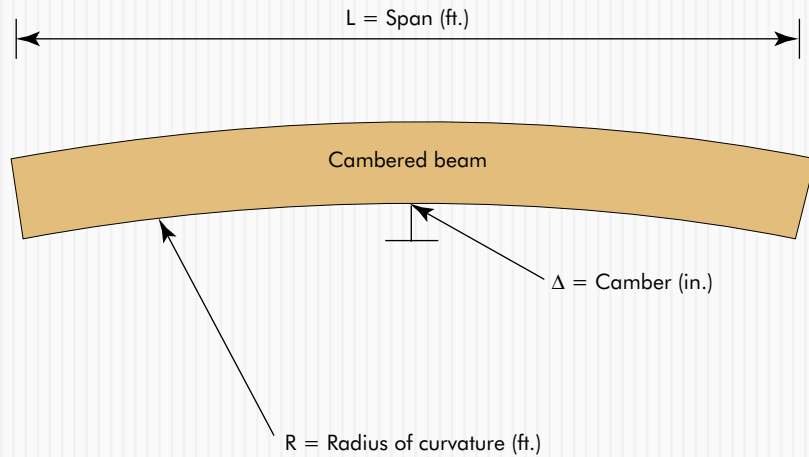


TABLE 2

CAMBER FOR 3500-FOOT RADIUS

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



- (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 Standard A190.1, Structural Glued Laminated Timber. ANSI 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 195 psi) and stiffness (modulus of elasticity of 1.8×10^6 psi) needed for typical residential applications, while greatly simplifying the design specification.
- (7) Designation of appearance grade. INDUSTRIAL, ARCHITECTURAL, PREMIUM, or FRAMING.

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

Trademarks and Acceptances

Glulam beams manufactured by *Engineered Wood Systems* 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 Standard A190.1-92, American National Standard for Structural Glued Laminated Timber.

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

The APA EWS trademark is recognized by all major model building codes for the certification of glued laminated timber produced by *Engineered Wood Systems* members.

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.

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 ft.

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.



Two lane highway bridge in Colorado using glulam radial arches.

Spans using glulam arches are virtually unlimited. For example, in reticulated glulam framed dome structures, arches span more than 500 feet.

Glulam trusses also take many shapes including simple pitched trusses, complicated scissors 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.

When manufactured with waterproof 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. And, the railroads are finding glulam to be a viable structural product for use in their heavily loaded bridge structures.

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.



The Disney ICE rink in Anaheim, California features glulam arches curved to a 75-foot radius to form the ice center's roof system.



Glulam cantilevered frame for curling rink, Calgary, Canada.



REI, an outdoor sports equipment retailer, used glulam columns and beams in its Minneapolis, Minnesota store.



Lincoln School in Spreckles, California is home for the local county library where Alaska Yellow Cedar and Douglas-fir glulam members add light and warmth.



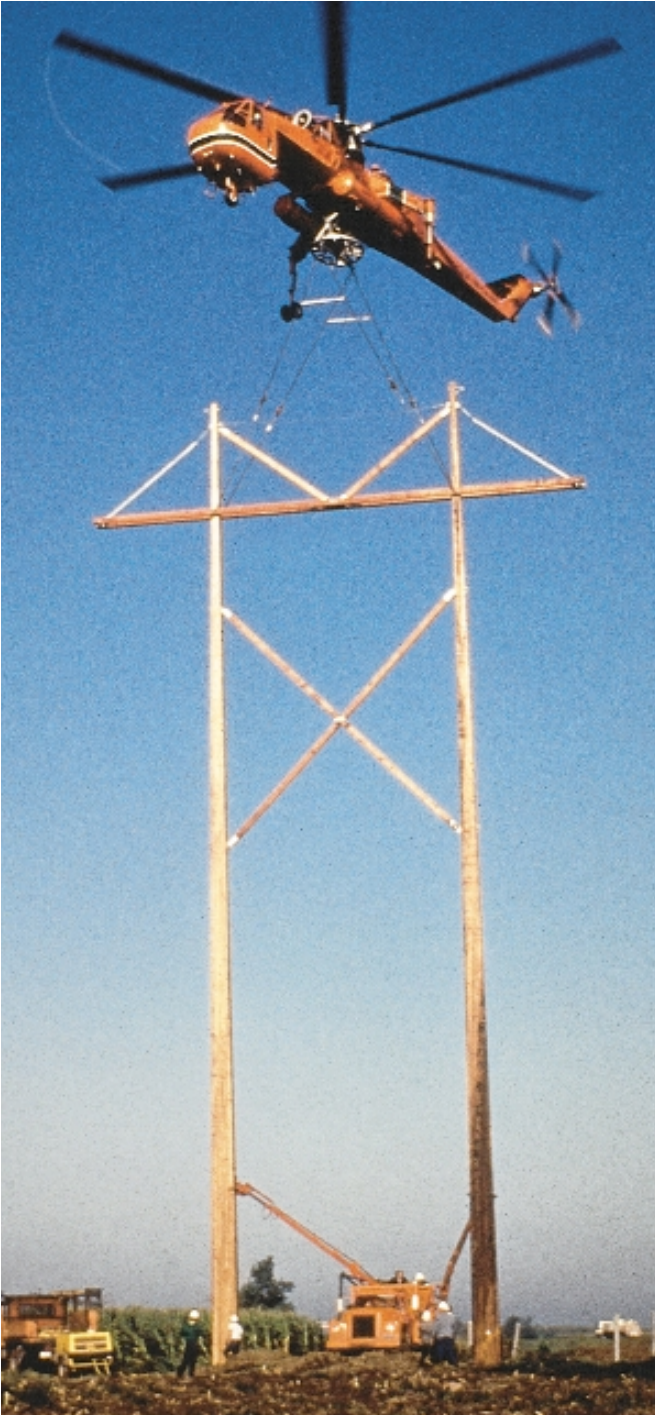
Curved beams define the building design in the Steinbeck Center, Salinas, California.



Panelized wood roof with open web glulam trusses and beams.



Glulam pedestrian and light vehicular golf course bridge under construction in Orlando, Florida.



Glulam tower for Nebraska Power and Light transmission line.



Glulam arches support the roof of the Chicago Bears practice facility in Lake Forest, Illinois.



This 236,000-square-foot potash storage building in Portland, Oregon features APA EWS glulam arches.



Glulam truss highway bridge, Hiroshima, Japan.



Panelized wood roof system featuring glulam beams and purlin trusses in the PepsiCo Distribution Center, Hayward, California.

GLULAM IN RESIDENTIAL APPLICATIONS

In residential construction, APA EWS 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.

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.

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.

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



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

warping are minimized. In addition, glulam beams have excellent fastener-holding capability, which means a firm subfloor with minimal nail popping or squeaks.

In the photo above, the depth of the glulam matches the depth of the I-joists it is supporting. This is called an I-joist compatible glulam or IJC beam. IJC beams are supplied in depths of 9-1/2", 11-7/8", 14" and 16" to match the depths of I-joists used in residential construction. This allows ceilings to be framed flush with no need for extra furring out.

In the application shown at top right, a glulam supports the second floor I-joist framing. The glulam beam was chosen for its size, strength and availability.

A two-car garage is directly below the upper story room and the glulam beam

allows a long clear span with no intermediate supports. Eliminating the need for a post in the middle of the garage means there's more room to open and close car doors and maneuver vehicles.

Conventional solid-sawn timbers or other structural framing members would not have been able to span the necessary distance without additional supports. A glulam was the ideal solution. It met the design needs and was available for timely, cost-effective delivery.

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 at right. 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.



Glulam beam supports second floor I-joist construction.



No other material combines the strength and natural beauty of wood like glulam.



Glulam ridge beams complement the spacious, open designs common in modern residential construction.



Long, curved custom glulam beams form the distinctive shape of this ocean view home in Malibu, California.



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



Glulam headers support framing in this two-story home.

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" and 5-1/8" are also used for these applications.

Full-length glulam headers at an end-wall provide an excellent nailing surface for structural wood panels, which help tie the beam to wall framing members on either side of the garage door opening to improve bracing. This construction method adds rigidity and improves resistance to wind and earthquake loads by effectively creating a narrow shear wall as shown in Figure 4.

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.

FIGURE 3

GLULAM GARAGE DOOR HEADERS – DESIGN EXAMPLE

The 16-foot 3-inch beam span in this figure supports roof trusses on a 28-foot-wide house with 2-foot overhangs, under a 15 psf design dead load and 25 psf design snow load. According to the data in Tables 3A and 3B (Pages 18-19), four different sizes of glulam beams could be selected: 3-1/8 by 15 inches, 3-1/2 by 13-1/2 inches, 5-1/8 by 12 inches and 5-1/2 by 12 inches, all suitable to carry the required design loads with the final choice being based on local availability, cost and designer preference.

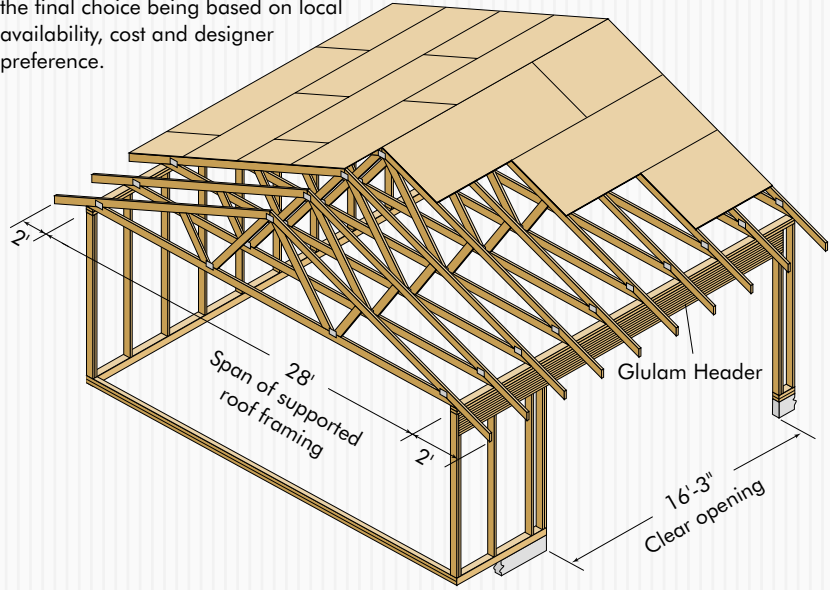


FIGURE 4

BRACED WALL DETAIL FOR GARAGE DOOR OPENING IN ONE-STORY BUILDING Check local building code requirements or contact APA for additional information.

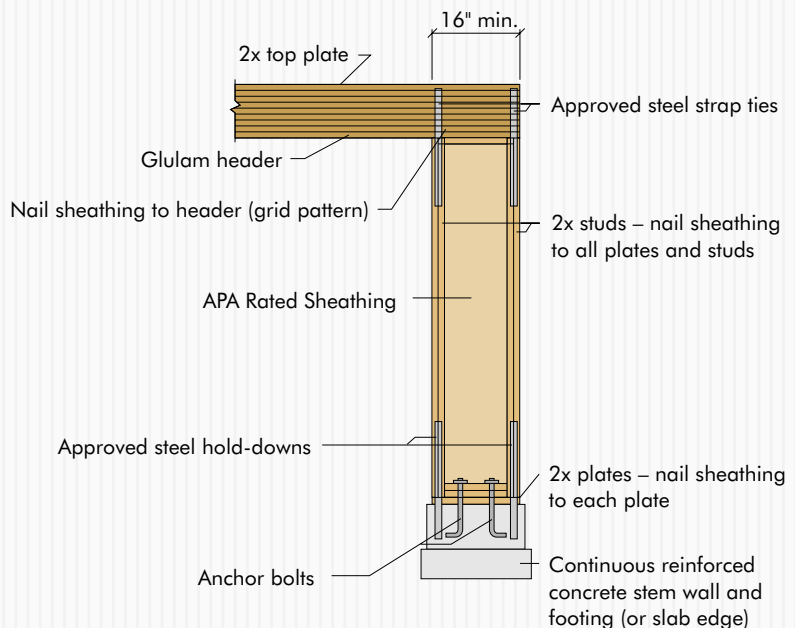


TABLE 3A

APA EWS 24F-1.8E GRADE GLULAM GARAGE DOOR HEADERS FOR SINGLE-STORY APPLICATIONS
Rough Door Opening = 9 ft 3 in. (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%)	3-1/8 x 7-1/2	3-1/8 x 7-1/2	3-1/8 x 7-1/2	3-1/8 x 7-1/2	3-1/8 x 7-1/2	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9
15 psf Dead	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2
20 psf Live	5-1/8 x 6	5-1/8 x 6	5-1/8 x 6	5-1/8 x 6	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2
Snow Load (115%)	5-1/2 x 6	5-1/2 x 6	5-1/2 x 6	5-1/2 x 6	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2
15 psf Dead	3-1/8 x 7-1/2	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 10-1/2
25 psf Live	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9
15 psf Dead	5-1/8 x 6	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2
25 psf Live	5-1/2 x 6	5-1/2 x 6	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2
Snow Load (115%)	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 9	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2
15 psf Dead	3-1/2 x 7-1/2	3-1/2 x 7-1/2	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9
30 psf Live	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2
30 psf Live	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2
Snow Load (115%)	3-1/8 x 9	3-1/8 x 9	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 10-1/2	3-1/8 x 12
15 psf Dead	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9	3-1/2 x 9	3-1/2 x 10-1/2	3-1/2 x 10-1/2	3-1/2 x 10-1/2	3-1/2 x 10-1/2
40 psf Live	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 7-1/2	5-1/8 x 9	5-1/8 x 9	5-1/8 x 9	5-1/8 x 9
40 psf Live	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 7-1/2	5-1/2 x 9	5-1/2 x 9

Rough Door Opening = 16 ft 3 in. (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%)	3-1/8 x 12	3-1/8 x 12	3-1/8 x 13-1/2	3-1/8 x 13-1/2	3-1/8 x 13-1/2	3-1/8 x 13-1/2	3-1/8 x 15	3-1/8 x 15
15 psf Dead	3-1/2 x 12	3-1/2 x 12	3-1/2 x 12	3-1/2 x 12	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 13-1/2
20 psf Live	5-1/8 x 10-1/2	5-1/8 x 10-1/2	5-1/8 x 10-1/2	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12
Snow Load (115%)	5-1/2 x 10-1/2	5-1/2 x 10-1/2	5-1/2 x 10-1/2	5-1/2 x 10-1/2	5-1/2 x 10-1/2	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12
15 psf Dead	3-1/8 x 13-1/2	3-1/8 x 13-1/2	3-1/8 x 15	3-1/8 x 15	3-1/8 x 15	3-1/8 x 15	3-1/8 x 16-1/2	3-1/8 x 16-1/2
25 psf Live	3-1/2 x 12	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 15	3-1/2 x 15	3-1/2 x 15
15 psf Dead	5-1/8 x 10-1/2	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 13-1/2
30 psf Live	5-1/2 x 10-1/2	5-1/2 x 10-1/2	5-1/2 x 10-1/2	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12
Snow Load (115%)	3-1/8 x 13-1/2	3-1/8 x 15	3-1/8 x 15	3-1/8 x 15	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 18
15 psf Dead	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 13-1/2	3-1/2 x 15	3-1/2 x 15	3-1/2 x 15	3-1/2 x 15	3-1/2 x 16-1/2
30 psf Live	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 12	5-1/8 x 13-1/2	5-1/8 x 13-1/2	5-1/8 x 13-1/2
30 psf Live	5-1/2 x 10-1/2	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 13-1/2
Snow Load (115%)	3-1/8 x 15	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 18	3-1/8 x 18	3-1/8 x 18	3-1/8 x 19-1/2
15 psf Dead	3-1/2 x 15	3-1/2 x 15	3-1/2 x 15	3-1/2 x 16-1/2	3-1/2 x 16-1/2	3-1/2 x 16-1/2	3-1/2 x 18	3-1/2 x 18
40 psf Live	5-1/8 x 12	5-1/8 x 12	5-1/8 x 13-1/2	5-1/8 x 13-1/2	5-1/8 x 13-1/2	5-1/8 x 13-1/2	5-1/8 x 15	5-1/8 x 15
40 psf Live	5-1/2 x 12	5-1/2 x 12	5-1/2 x 12	5-1/2 x 13-1/2	5-1/2 x 13-1/2	5-1/2 x 13-1/2	5-1/2 x 13-1/2	5-1/2 x 15

Notes:

- (1) This table is for preliminary design use only. Final design should include a complete analysis, including bearing stresses and lateral stability.
- (2) Service condition = dry.
- (3) Maximum deflection under live load = span/240.
- (4) Maximum deflection under total load = span/180.
- (5) Maximum 2-ft roof truss overhangs.
- (6) Beam weight = 36 pcf.
- (7) Assumes a maximum bearing length of 4-1/2 inches.
- (8) Design properties at normal load duration and dry service conditions $F_b = 2,400$ psi, $F_v = 195$ psi, $E_x = 1.8 \times 10^6$ psi.
- (9) Beam widths of 3 and 5 inches may be substituted for 3-1/8 and 5-1/8 inches, respectively, at the same tabulated depth.

TABLE 3B

APA EWS 24F-1.8E GRADE GLULAM GARAGE DOOR HEADERS FOR SINGLE-STORY APPLICATIONS
Rough Door Opening = 9 ft 3 in. (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%)	3-1/8 x 6-7/8	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4
15 psf Dead	3-1/2 x 6-7/8	3-1/2 x 6-7/8	3-1/2 x 6-7/8	3-1/2 x 6-7/8	3-1/2 x 6-7/8	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4
20 psf Live	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8
Snow Load (115%)	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8
15 psf Dead	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8
25 psf Live	3-1/2 x 6-7/8	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 9-5/8
15 psf Dead	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 8-1/4
25 psf Live	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8
Snow Load (115%)	3-1/8 x 8-1/4	3-1/8 x 8-1/4	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8
15 psf Dead	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 9-5/8	3-1/2 x 9-5/8	3-1/2 x 9-5/8
30 psf Live	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 8-1/4	5-1/8 x 8-1/4	5-1/8 x 8-1/4
30 psf Live	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 8-1/4	5-1/2 x 8-1/4
Snow Load (115%)	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 9-5/8	3-1/8 x 11	3-1/8 x 11	3-1/8 x 11	3-1/8 x 11
15 psf Dead	3-1/2 x 8-1/4	3-1/2 x 8-1/4	3-1/2 x 9-5/8	3-1/2 x 9-5/8	3-1/2 x 9-5/8	3-1/2 x 9-5/8	3-1/2 x 9-5/8	3-1/2 x 11
40 psf Live	5-1/8 x 6-7/8	5-1/8 x 6-7/8	5-1/8 x 8-1/4	5-1/8 x 8-1/4	5-1/8 x 8-1/4	5-1/8 x 8-1/4	5-1/8 x 8-1/4	5-1/8 x 8-1/4
40 psf Live	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 6-7/8	5-1/2 x 8-1/4	5-1/2 x 8-1/4	5-1/2 x 8-1/4	5-1/2 x 8-1/4	5-1/2 x 8-1/4

Rough Door Opening = 16 ft 3 in. (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%)	3-1/8 x 12-3/8	3-1/8 x 12-3/8	3-1/8 x 12-3/8	3-1/8 x 13-3/4	3-1/8 x 13-3/4	3-1/8 x 13-3/4	3-1/8 x 13-3/4	3-1/8 x 15-1/8
15 psf Dead	3-1/2 x 12-3/8	3-1/2 x 12-3/8	3-1/2 x 12-3/8	3-1/2 x 12-3/8	3-1/2 x 12-3/8	3-1/2 x 12-3/8	3-1/2 x 13-3/4	3-1/2 x 13-3/4
20 psf Live	5-1/8 x 11	5-1/8 x 11	5-1/8 x 11	5-1/8 x 11	5-1/8 x 11	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8
20 psf Live	5-1/2 x 9-5/8	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 12-3/8
Snow Load (115%)	3-1/8 x 13-3/4	3-1/8 x 13-3/4	3-1/8 x 13-3/4	3-1/8 x 15-1/8	3-1/8 x 15-1/8	3-1/8 x 15-1/8	3-1/8 x 16-1/2	3-1/8 x 16-1/2
15 psf Dead	3-1/2 x 12-3/8	3-1/2 x 12-3/8	3-1/2 x 13-3/4	3-1/2 x 13-3/4	3-1/2 x 13-3/4	3-1/2 x 13-3/4	3-1/2 x 15-1/8	3-1/2 x 15-1/8
25 psf Live	5-1/8 x 11	5-1/8 x 11	5-1/8 x 11	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8
25 psf Live	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 12-3/8
Snow Load (115%)	3-1/8 x 13-3/4	3-1/8 x 15-1/8	3-1/8 x 15-1/8	3-1/8 x 15-1/8	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 17-7/8
15 psf Dead	3-1/2 x 13-3/4	3-1/2 x 13-3/4	3-1/2 x 13-3/4	3-1/2 x 13-3/4	3-1/2 x 15-1/8	3-1/2 x 15-1/8	3-1/2 x 15-1/8	3-1/2 x 16-1/2
30 psf Live	5-1/8 x 11	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 13-3/4	5-1/8 x 13-3/4
30 psf Live	5-1/2 x 11	5-1/2 x 11	5-1/2 x 11	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 12-3/8
Snow Load (115%)	3-1/8 x 15-1/8	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 16-1/2	3-1/8 x 17-7/8	3-1/8 x 17-7/8	3-1/8 x 17-7/8	3-1/8 x 19-1/4
15 psf Dead	3-1/2 x 13-3/4	3-1/2 x 15-1/8	3-1/2 x 15-1/8	3-1/2 x 16-1/2	3-1/2 x 16-1/2	3-1/2 x 16-1/2	3-1/2 x 17-7/8	3-1/2 x 17-7/8
40 psf Live	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 12-3/8	5-1/8 x 13-3/4	5-1/8 x 13-3/4	5-1/8 x 13-3/4	5-1/8 x 15-1/8	5-1/8 x 15-1/8
40 psf Live	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 12-3/8	5-1/2 x 13-3/4	5-1/2 x 13-3/4	5-1/2 x 13-3/4	5-1/2 x 13-3/4

Notes:

- (1) This table is for preliminary design use only. Final design should include a complete analysis, including bearing stresses and lateral stability.
- (2) Service condition = dry.
- (3) Maximum deflection under live load = span/240.
- (4) Maximum deflection under total load = span/180.
- (5) Maximum 2-ft roof truss overhangs.
- (6) Beam weight = 36 pcf.
- (7) Assumes a maximum bearing length of 4-1/2 inches and minimum bearing length of 3 inches.
- (8) Design properties at normal load duration and dry service conditions $F_b = 2,400$ psi, $F_v = 195$ psi, $E_x = 1.8 \times 10^6$ psi.
- (9) Beam widths of 3 and 5 inches may be substituted for 3-1/8 and 5-1/8 inches, 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 wall-board, 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 range from 1290° F to 1650° F. 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 480° 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 the same rate as the wood and do not affect the overall fire performance of the member. The char which 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 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 4 and 5 on page 21 illustrate this principle for glulam timber.

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 its full design load for at least one hour during standard fire test conditions which simulate an actual fire. The model building codes provide a methodology for calculating the minimum size of glulam to provide a one-hour fire rating under given design conditions.

It is important to note that to achieve a one-hour fire rating for a glulam, 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 glulams. 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 paint or stain 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 glulams, refer to the *APA Design/Construction Guide: Fire-Rated Systems*, Form No. W305.

Relative Insurance Costs

Installation costs and insurance rates are important considerations in any building design. It is a common misconception that buildings constructed of concrete, masonry or steel always have lower insurance rates. Since many building codes require sprinkler systems regardless of the building materials used, rates for wood and nonwood buildings are often comparable. Even where rates for buildings framed with “combustible materials” are higher, initial construction costs may be lower for timber framing and much lower if the steel must be one-hour fire protected. Together with long-term savings on interest, lower initial costs can mean overall savings when wood is selected.

In a study of four occupancy use types of commercial buildings in Florida, Georgia, Ohio, and Indiana, insurance rates for wood- and steel-framed buildings were comparable when the buildings were sprinklered.

TABLE 4

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	13-1/2	27
8-3/4	7-1/2	13-1/2

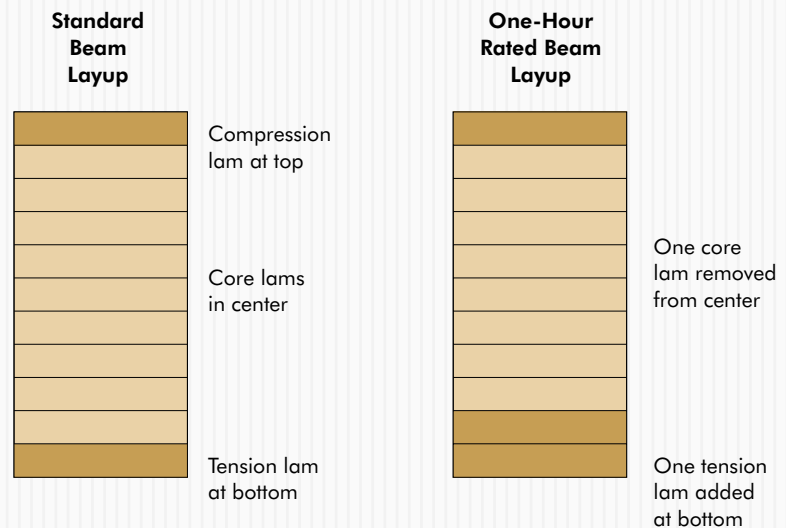
TABLE 5

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.)
$\ell/d > 11$	10-3/4	10-1/2	13-1/2
$\ell/d \leq 11$	8-3/4	7-1/2	12
	10-3/4	7-1/2	10-1/2

FIGURE 5

SIMPLE SPAN UNBALANCED LAYUP



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 size and can be substantial for large glulam beams.

Model building codes specify minimum requirements for ventilation of floor and roof spaces. These ventilation requirements can vary depending on whether or not vapor retarders are used and whether or not roofs are pitched and to what degree.

Glulam can be protected from surface moisture intrusion during transit and the construction cycle by the use of protective 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 *Engineered Wood Systems Technical Notes: Controlling Decay in Wood Construction*, Form EWS R495 and *Moisture Control in Low Slope Roofs*, Form EWS R525.

Checking

A common moisture related phenomenon in wood is checking. Checking occurs naturally to wood in service. Checks are openings that occur in 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 glue-line in a glulam member where differential drying stresses are greatest. This most often occurs near the outermost glue-line where the amount of surface exposed by the outermost lamination is greatest. Checks are a natural characteristic of wood and are not normally considered to have a detrimental effect on the strength of the member.

For additional information on checking and the effects of checking on the strength of glulam, refer to *Engineered Wood Systems Technical Notes, Checking in Glued Laminated Timber*, Form EWS R465 and *Evaluation of Check Size in Glued Laminated Timber Beams*, Form EWS 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 or Western Red 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.

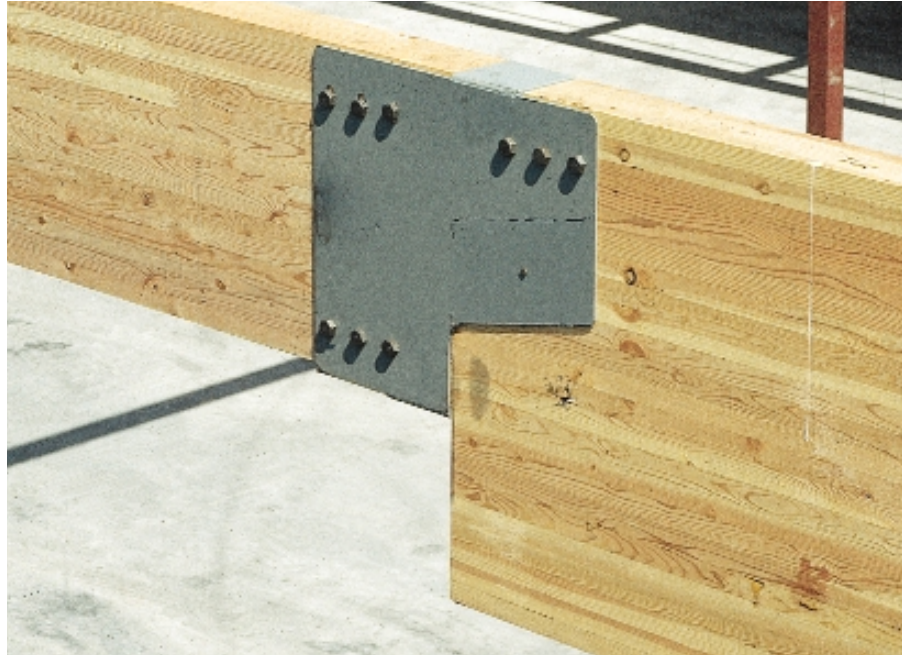
When glulam beams are to be preservative-treated after gluing, members should be ordered to exact dimensions with all hole drilling and fabrication done prior to the treatment process. This will eliminate breaking the treatment envelope by post treatment cutting and drilling and help insure a long life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

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

Connection Detailing

As with any structural material, proper connection detailing is essential to assure the structural performance of the member. This is particularly true with glulam since an improperly designed and installed connection detail can 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.

Based on many years of experience, the glulam industry has developed typical details for most connection situations. These details illustrate the right and wrong way to make these connections and indicate the consequences of an incorrect detail. The details are illustrated and described in *Engineered Wood Systems Technical Note, Glulam Connection Details* Form EWS T300.



Cantilever hinge connector used in panelized roof application.



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

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, *Engineered Wood Systems* has published a Technical Note, *Field Notching and Drilling of Glued Laminated Timber Beams*, Form EWS S560.



DESIGN AND SPECIFICATION CONSIDERATIONS

Beam and Column Design

To determine the load capacity and recommended size for a glulam beam, consult the following *Engineered Wood Systems* publications:

Data File: *Glued Laminated Beam Design Tables*, Form EWS S475

Data File: *Substitution of Glulam Beams for Steel and Solid-Sawn Lumber*, Form EWS S570.

Data File: *Design of Structural Glued Laminated Timber Columns*, Form EWS Y240

As an alternative to using tables such as those included in the above Data Files, *Engineered Wood Systems*, in association with Eagle Point Software, has developed computer software to aid in the design process. This software, WOODCAD, consists of two modules. One module is a beam design program and the other is a column design program.

Both modules have many unique features. For example, by simply entering the appropriate model building code jurisdiction, all required code live loads are automatically applied. In addition, by entering the postal zip code for the location of the structure being designed, all model building code requirements for snow, wind and seismic load designs are applied.

The beam module permits the design of both sawn lumber and glulam beams and the new APA EWS PRI-400 I-joist



products. I-joist compatible glulam beams can also be sized using this program. The program enables the user to design a beam or analyze the structural capacity of an existing beam. The program checks all code-required load combinations, which can be 10 or more for a complicated framing member, many of which are not considered in traditional load/span tables.

The column module also permits the use of sawn lumber and glulam and can greatly simplify the design of complex multiple story columns. In addition to designing columns for concentrically applied loads, the program allows the user to input any degree of eccentricity.

For more information on the WOODCAD software, contact *Engineered Wood Systems*.

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 26-27. 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, 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.

2. For custom orders, shop drawings and details shall be furnished and approved before fabrication is commenced.

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.

TABLE 6

SPECIFIC REQUIRED DESIGN STRESSES

Application	Structural Use (Identification Symbol)	Design Stress	psi
Bending Member loaded perpendicular to wide face of the lamination	Simple span member (B)	Bending, F_b	_____
		Horizontal shear, F_v	_____
	Continuous or cantilevered span member (CB)	Compression (perpendicular to grain), $F_{c\perp}$ Top lamination	_____
		Bottom lamination	_____
		Modulus of elasticity, E	_____
Concentric ⁽¹⁾ Axially Loaded Member	Tension member (T)	Tension parallel to grain, F_t	_____
		Modulus of elasticity, E	_____
	Compression member (C)	End grain bearing	_____
Compression (parallel to grain), F_c		_____	
		Modulus of elasticity, E	_____

(1) For members subjected to combined bending and axial loading, additional design values for all other applicable stresses such as but not limited to F_{bx} , F_{by} , F_{vx} , F_{vy} must also be specified.

B. Manufacture

1. Materials, Manufacture and Quality Assurance.

Structural glued laminated timber shall be in conformance with ANSI 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 Cantilevered span bending member – CB
Compression member – C
Tension member – T

3A. Design Values. Structural glued laminated timber shall provide design values as shown in the table on page 26 for normal load duration and dry-use condition.⁽¹⁾

3B. Lamination Combination Number. An alternative to specifying the required design stresses is to specify a specific laminating combination symbol if known.⁽²⁾

4. Appearance Classification. Members shall be (framing) (industrial) (architectural) (premium) classification in accordance with industry recommendations⁽³⁾

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. Camber radius shall be (1600) (2000) (3500) or (other) feet or a specific amount of camber may be specified in inches.

7. Preservative Treatment (when applicable). Members shall be pressure treated in accordance with American Wood Preservers Association (AWPA) Standard C28 with (creosote, or creosote/coal tar solution) (pentachlorophenol in oil) (pentachlorophenol in light solvent) (waterborne) preservatives as required for (soil contact) (above ground) exposure.⁽⁴⁾

8. Fire Resistance (when applicable). Members shall be sized and manufactured for one-hour fire resistance.⁽⁵⁾

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 primer/sealer coating) (other).⁽⁶⁾

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

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

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

Footnotes

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

(2) Laminating combination should be based on design requirements and section capacities published in *Engineered Wood Systems* or manufacturer's brochures. National Evaluation Report 486 provides a tabulation of laminating combinations available from EWS member manufacturers.

(3) Appearance grades are described as follows.

FRAMING. Use in concealed, traditional 2x4 and 2x6 framing applications. These full-width beams eliminate the need for additional furring or framing around the glulam.

Description: Natural lumber growth characteristics may be visible. Faces of members surfaced to a "hit and miss" characteristic.

INDUSTRIAL. Use where appearance is not of primary importance, or where members are not exposed visually.

Description: Natural lumber growth characteristics may be visible. Voids on edges of laminations are not required to be filled, except voids and knotholes may be filled in some applications.

ARCHITECTURAL. Use where appearance is important.

Description: Natural lumber growth characteristics may be visible. Knotholes and voids larger than 3/4" are filled or repaired with wood inserts or inert fillers. Exposed surfaces are surfaced smooth and exposed edges (soffit face) are eased.

PREMIUM. Use where highest-quality visual appearance is required.

Description: Natural lumber growth characteristics may be visible. All knotholes and voids are filled or repaired with wood inserts or inert fillers. Exposed surface of wide face lamination has limit on knot size and no loose knots are permitted. Exposed faces are surfaced smooth, and exposed edges (soffit face) are eased.

(4) When pentachlorophenol in light solvent or waterborne preservative treatments are specified for protection against decay or insect attack, individual laminations usually are treated prior to manufacturing structural glued laminated timber members. These treatments are not available from all manufacturers and the designer should verify availability prior to specification. Note: Waterborne preservatives are not recommended for glulam manufactured using western species.

Where paintable surfaces are required, specify pentachlorophenol in light solvent or a waterborne preservative. Wood treated with creosote, creosote/coal tar solution or pentachlorophenol in oil should not be used in contact with materials subject to staining.

(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 connectors or fasteners with fire-rated (Type X) gypsum wallboard or sheathing, or 1-1/2" wood, to provide the needed protection.

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

STORAGE, HANDLING AND INSTALLATION

APA EWS trademarked 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 yard, 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.



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 which is supported at more than two bearing locations.
- **Cantilever:** A member which 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:

- **Centrally 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 which 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 which 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.)

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ABOUT ENGINEERED WOOD SYSTEMS

Engineered Wood Systems, a related corporation of APA – The Engineered Wood Association, is an organization dedicated to the promotion of engineered wood systems. Operating in close cooperation with APA, Engineered Wood Systems serves manufacturers of engineered wood products, including glued laminated timber (glulam). Engineered Wood Systems member manufacturers certify their products with the APA EWS trademark.

This mark of quality is supported by comprehensive services for quality validation, product research, testing, and marketing. More than 65 percent of the glulam beams currently manufactured in North America bear the APA EWS trademark. The mark appears only on beams manufactured by Engineered Wood Systems members and signifies that beams are produced to the requirements of American National Standards Institute (ANSI) Standard A190.1. This is the national consensus standard used by all agencies inspecting glulam beams.

For More Information

For additional information on APA EWS trademarked engineered wood products, contact Engineered Wood Systems, P.O. Box 11700, Tacoma, WA 98411-0700, or one of the regional field offices listed on the back cover.

Other publications from APA and EWS:

Data File: *Glued Laminated Beam Design Tables*, EWS S475

Data File: *Substitution of Glulam Beams for Steel and Solid-Sawn Lumber*, EWS S570

APA Design/Construction Guide: *Residential and Commercial*, E30

Source List: *Publications Index*, EWS S400

Residential Pocket Guide, EWS X445 (Southern Edition) and EWS X450 (Western Edition)

ing codes for certain occupancies have shown that untreated APA structural panels will develop less spread and smoke values of 200 or less, which puts them in a Class I (or C) category.

Panels are therefore suitable as interior finish for most applications. Certain more restrictive locations, such as stairways, require a Class I or Class II rating which can be achieved by the use of fire-retardant-treated plywood. (See page 15.)

Structural Glued Laminated Timber (Glulams)

structural member's fire resistance is measured by the time it can support its design load during a fire. An exposed end or column sized for a minimum fire resistance will support its design load for at least one hour under standard fire test conditions simulate an actual fire.

glulam beams 6-3/4" and can be adapted to a one-hour fire rating. In accordance with recognized by the model widths, there is a minimum one-hour fire rating. Depth increases when the beam to be other than three sides.

(a) Generic, non-proprietary assembly based on GA file No. WP8105 (also in Gypsum Association Fire Resistance Design Manual, referenced in the model building codes. Mineral or glass fiber batt insulation (optional).
(b) Exterior layer of gypsum sheathing not required under the National Standard Building Codes when separation is greater than 5 feet. Check provisions. See GA file Nos. WP8106 and WP8107 in Gypsum Association Fire Resistance Design Manual, Thirteenth Edition.

FIGURE 29
ONE-HOUR FIRE-RATED GLULAM BEAM
(Layout for simple span)

TABLE 30
ONE-HOUR FIRE-RATED GLULAM BEAMS - MINIMUM WIDTHS
6-3/4" AND 8-3/4"



As with all structural framing, final 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.

Metal connectors for structures using one-hour rated glulam beams must be designed to achieve the same fire rating. A 1-1/2" or

Beam Width
Depth



GLULAM

PRODUCT GUIDE

We have field representatives in most major U.S. cities and in Canada who can help answer questions involving APA and APA EWS trademarked products. For additional assistance in specifying engineered wood products or systems, get in touch with your nearest APA regional office. Call or write:

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PRODUCT SUPPORT HELP DESK

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(Offices: Antwerp, Belgium; Bournemouth, United Kingdom; Hamburg, Germany; Mexico City, Mexico; Tokyo, Japan.) For Caribbean/Latin America, contact headquarters in Tacoma.

The product use recommendations in this publication are based on the continuing programs of laboratory testing, product research, and comprehensive field experience of Engineered Wood Systems. However, because EWS has no control over quality of workmanship or the conditions under which engineered wood products are used, it cannot accept responsibility for product performance or designs as actually constructed. Because engineered wood product performance requirements vary geographically, consult your local architect, engineer or design professional to assure compliance with code, construction, and performance requirements.

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