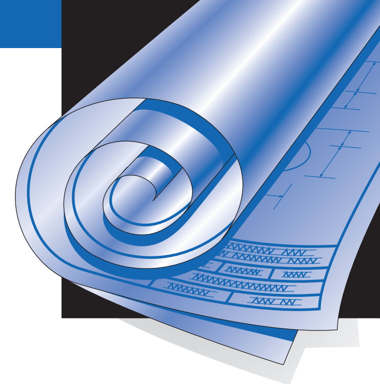


# Calculating Fire Resistance of Glulam Beams and Columns

*Number EWS Y245B*
*December 2009*

## INTRODUCTION

Glulam beams and columns provide architectural warmth and beauty along with structural strength and natural fire resistance. In the presence of fire, the outer portion of a glulam member becomes charred. This layer of charred wood then functions as an insulator, helping to protect the undamaged interior of the member from the heat. The rate of advancement of this insulating char layer into the remaining, undamaged portion of the member has been well documented (approximately 0.025 inches [0.6 mm] per minute) and forms the theoretical basis of the equations used to predict fire endurance.[1] Full-scale fire tests on loaded beams and columns[2] have confirmed the validity of the equations in predicting their load-carrying capability under fire conditions and the method is recognized by the International Building Code (IBC).

## DESIGN METHODOLOGY

Calculation of the ability of a glulam beam or column to resist fire for up to one hour is described in the 2009 International Building Code (IBC), Section 721.6. The equations apply to members with fire on three or four sides.

**Beams:**

Fire on 3 sides $$t = 2.54ZB\left[4 - \frac{B}{D}\right] \text{..............} (1)$$

Fire on 4 sides $$t = 2.54ZB\left[4 - \frac{2B}{D}\right] \text{............} (2)$$

**Columns:**

Fire on 3 sides $$t = 2.54ZB\left[3 - \frac{B}{2D}\right] \text{............} (3)$$

Fire on 4 sides $$t = 2.54ZB\left[3 - \frac{B}{D}\right] \text{..............} (4)$$

Where:

t = fire resistance in minutes

Z = partial load compensation factor (see Figure 3) which is a function of applied load to design capacity

B = the breadth or width of a beam or the smaller dimension of a column (in.) (see Figure 1)

D = the depth of a beam or the larger dimension of a column (in.) (see Figure 1)

(1) Lie, T. T., 1977. A method for assessing the fire resistance of laminated timber beams and columns. Fire Research Section, Division of Building Research, National Research Council of Canada, Ottawa, Ont., Canada.

(2) Fackler, J. P., 1961. Essais de résistance au feu. Centre Scientifique et Technique du Bâtiment, Cahier 415, et al.

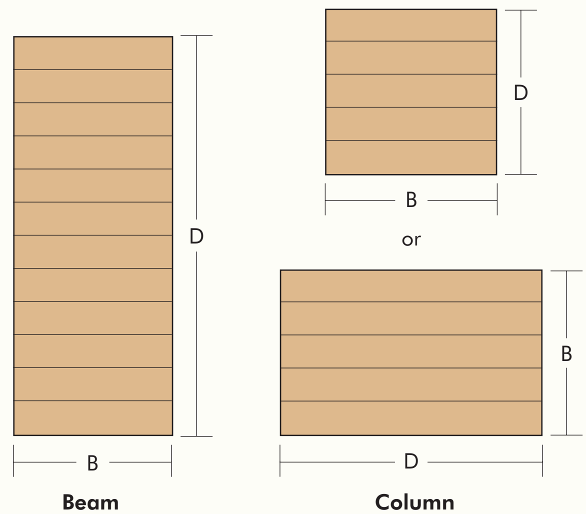
APA

These equations apply to glulams with a minimum nominal size of six inches by six inches before exposure to fire. Equation 3 is accurate only when the smallest dimension (B) is the side not exposed to the fire. When a beam or column is partially recessed into a wall, floor or ceiling, the full dimension of the member, including the portion of the column recessed into the wall, floor or ceiling may be used in the calculations to obtain the maximum calculated fire resistance.

Equations 3 and 4 are slightly altered from the way they appear in the IBC. In the column equations, the dimensions B and D are reversed to maintain consistency and clarity of notation on glulam beams and columns (see Figure 1). B is assumed to be the narrowest dimension of the column (weak axis buckling).

FIGURE 1

**DIMENSIONS FOR CALCULATION OF FIRE RESISTANCE**
**Where B is always the lead dimension.**

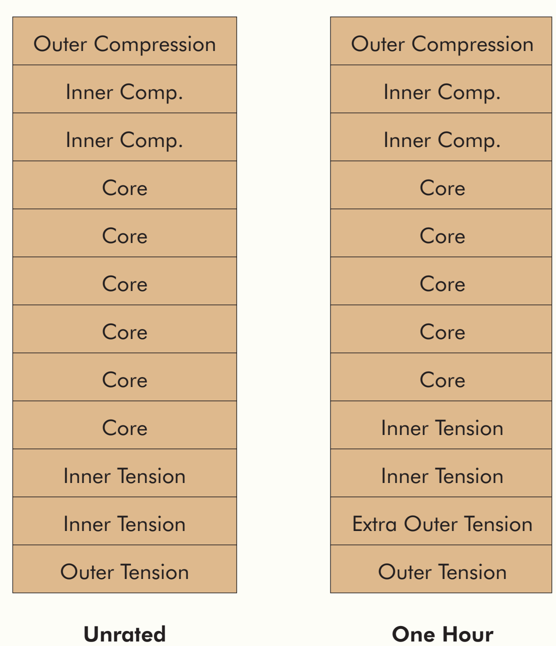



Tables 1a, 1b and 1c show the minimum dimensions of a glulam member that will provide 100 percent design capacity and one-hour fire protection. These tables have been generated using Equations 1–4.

Beams and columns with dimensions less than those shown in Tables 1a, 1b and 1c, but at least 6 inches by 6 inches nominal size, may meet the requirements for one-hour fire resistance when the member is over-designed for the applied load. This principle is demonstrated in the design examples that follow.

FIGURE 2

**TYPICAL UNBALANCED GLULAM BEAM LAYUPS**
**FOR UNRATED AND ONE-HOUR FIRE-RATED GLULAM**
**One extra tension lamination added for one-hour resistance.**




## SPECIFYING A ONE-HOUR FIRE-RATED GLULAM

Tension laminations of glulam beams are always positioned as the outermost laminations of the beam subjected to maximum tension stresses, and in a fire, the outermost fibers in a wood member are the first to be damaged. For this reason, when a one-hour rating is required for a glulam beam, the designer should specify one additional tension lamination in place of a core lamination (see Figure 2) and the glulam should be marked “Fire-rated one-hour” by the manufacturer. For a balanced beam layup, an additional tension lamination should be added to both outer zones. An additional tension lamination is not required for columns and arches.

TABLE 1a

| Member Type | Beam | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fire Exposure** | **Fire Three Sides** | | | | | **Fire Four Sides** | | | | |
| **Beam Width (in.)** | **6-3/4** | **8-1/2** | **8-3/4** | **10-1/2** | **10-3/4** | **6-3/4** | **8-1/2** | **8-3/4** | **10-1/2** | **10-3/4** |
| Minimum Depth (in.): 1-1/2" thick Laminations | 13-1/2 | – | 7-1/2 | – | 6 | 27 | – | 13-1/2 | – | 12 |
| Minimum Depth (in.): 1-3/8" thick Laminations | 13-3/8 | 6-7/8 | – | 6-7/8 | – | 27-1/2 | 13/3-4 | – | 12-3/8 | – |

TABLE 1b

| Member Type | Column | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Fire Exposure** | **Fire Three Sides*** | | | | | | | |
| **$K_e$l/d Condition[(a)]** | **≤ 11** | | | | **> 11** | | | |
| **Column Width (in.)** | **8-1/2** | **8-3/4** | **10-1/2** | **10-3/4** | **8-1/2** | **8-3/4** | **10-1/2** | **10-3/4** |
| Minimum Depth (in.): 1-1/2" thick Laminations | – | 9 | – | 7-1/2 | – | 15 | – | 10-1/2 |
| Minimum Depth (in.): 1-3/8" thick Laminations | 8-1/4 | – | 8-1/4 | – | 19-1/4 | – | 9-5/8 | – |

*Minimum dimensions are only valid when the unexposed side of the column is the smaller side.

(a) See Figure 8.

TABLE 1c

| Member Type | Column | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Fire Exposure** | **Fire Four Sides** | | | | | | | |
| **$K_e$l/d Condition[(a)]** | **≤ 11** | | | | **> 11** | | | |
| **Column Width (in.)** | **8-1/2** | **8-3/4** | **10-1/2** | **10-3/4** | **8-1/2** | **8-3/4** | **10-1/2** | **10-3/4** |
| Minimum Depth (in.): 1-1/2" thick Laminations | – | 12 | – | 10-1/2 | – | 30 | – | 13-1/2 |
| Minimum Depth (in.): 1-3/8" thick Laminations | 12-3/8 | – | 9-5/8 | – | 38-1/2 | – | 13-3/4 | – |

(a) See Figure 8.

**General Note for Tables 1a, 1b and 1c:**
Glulam members having a net width of 8-1/2" or 10-1/2" are typically manufactured using 1-3/8" thick laminations. Glulam members having a net width of 8-3/4" or 10-3/4" are typically manufactured using 1-1/2" thick laminations.

## FASTENERS

Because metal fasteners conduct heat directly into the member, exposed fasteners must be given rated protection from fire that is equivalent to that expected of the member. For a one-hour rating, sufficient wood, gypsum wallboard or other material must be applied to protect the exposed portions of the fasteners for one hour. This may be 1-1/2 inches (38 mm) of wood, 5/8 inch (16 mm) Type X gypsum board or other approved material. Example details can be found in Figures 9–14.

## DESIGN EXAMPLE 1: GLULAM BEAM FOR ONE-HOUR FIRE RATING IN ACCORDANCE WITH THE 2009 INTERNATIONAL BUILDING CODE

Assume a simply supported roof beam is to span 30 feet, carry 240 lb/ft of total load (dead load plus snow load) and be used in a dry service condition. It is continuously supported along its compression side and will have three sides exposed to fire. A one-hour rating is required. The beam used will be a 24F-V4/DF (Douglas-fir) with the following allowable design stresses:
$F_b = 2400$ psi
$E = 1.8 \times 10^6$ psi
$F_v = 265$ psi

What size glulam beam should be used?

From Table 3 of EWS Data File *Glued Laminated Beam Design Tables,* Form EWS S475, select a 5-1/8 x 15 beam with total capacity of 266 plf, which is greater than 240 plf. (Note that the tabulated capacity in EWS S475 has considered the dead weight of the beam.)

Determining the actual beam depth that will continue to carry the design load for one hour is aided by the use of Figure 4, *Beams – Fire 3 Sides*. From this graph, the range of depths that might be practical to use can be anywhere from approximately 12 to 30 inches. Obviously, this beam must be deeper than 15 inches as the beam in this example is stressed to approximately 90 percent of design capacity.

All of the 5-1/8-inch-wide beams in the depth range of 12 to 30 inches will retain 50–60 percent of design capacity after one hour. An initial estimate of a percentage that corresponds with this range of beam depths is 55 percent, which corresponds to a beam depth of 18 inches.

Section modulus, $S = \dfrac{5.125(18)^2}{6} = 276.75 \text{ in.}^3$

Determine if this beam will have sufficient strength left after one hour of fire exposure to continue to carry the design load by determining the ratio of applied moment to design flexural capacity. Beam size will also have to be checked for shear and deflection.

### Determine $F_b'$

Volume factor $= C_v = \left(\dfrac{12}{D}\right)^{\frac{1}{10}} \left(\dfrac{5.125}{B}\right)^{\frac{1}{10}} \left(\dfrac{21}{L}\right)^{\frac{1}{10}}$

$$C_v = \left(\frac{12}{18}\right)^{\frac{1}{10}} \left(\frac{5.125}{5.125}\right)^{\frac{1}{10}} \left(\frac{21}{30}\right)^{\frac{1}{10}} = 0.9266$$

$F_b' = F_b C_D C_v = (2{,}400)(1.15)(0.9266) = 2{,}557 \text{ lb/in.}^2$

### Determine $f_b$

Calculate beam weight using 35 lb/ft$^3$

Beam weight $= \dfrac{(5.125)(18)(12)}{12^3}(35) = 22.4$ lb/ft

$$M_{Applied} = w\frac{L^2}{8} = (240 + 22.4)\frac{30^2}{8} = 29{,}520 \text{ ft-lb} = 354{,}240 \text{ in.-lb}$$

$$f_b = \frac{M}{S} = \frac{354{,}240}{276.75} = 1{,}280 \text{ lb/in.}^2$$

### Check the ratio of applied moment to flexural capacity

$$\frac{f_b}{F_b'} = \frac{1{,}280}{2{,}557} = 0.50 < 55\% \Rightarrow \textbf{OK}$$

### Check fire endurance:

From Figure 3, for a beam loaded to 50% of capacity, Z is approximately 1.3.

Using Equation 1:

$$t = 2.54(1.3)(5.125)\left[4 - \frac{5.125}{18}\right] = 62.9 \text{ minutes} > 60 \Rightarrow$$ **OK;** use 5-1/8-inch x 18-inch 24F-V4 Douglas-fir glulam beam.

This beam has a moment capacity that is significantly greater than is needed if the one-hour fire resistance is not a requirement. In some cases, a wider beam may be required to satisfy a beam depth limitation while still meeting the one-hour fire resistance requirement. For instance, a 6-3/4-inch-wide beam that is 13-1/2-inch deep, and has the extra tension lamination, will carry 100 percent of its design load after one hour of fire exposure on three sides. See Table 1a and Figure 4.

The designer will also need to confirm that the design shear and deflection values for the trial beam size are less than 50 percent of these capacities.

When specifying the beam, advise the manufacturer to eliminate one core lamination and substitute one additional tension lamination (Figure 2) and mark the beam “Fire-rated one-hour.”

## ALTERNATIVE SOLUTION IN ACCORDANCE WITH THE 2005 NATIONAL DESIGN SPECIFICATION, CHAPTER 16

Step 1: From Table 3 of Data File, *Glued Laminated Beam Design Tables,* Form EWS S475, select a 5-1/8-inch by 15-inch beam with total capacity of 266 plf which is greater than 240 plf (note that the tabulated capacity in EWS S475 has considered the dead weight of the beam).

Step 2: Determine the actual beam depth that will continue to carry the design load when exposed to a one-hour fire as follows:

Step 2a: From Chapter 16 of NDS,

$$\beta_{eff} = \frac{1.2\beta_n}{t^{0.187}}$$

Where:

$\beta_n$ = nominal char rate of 1.5 in./hr
$\beta_{eff}$ = effective char rate (in./hr)
t = exposure time (hrs)

Therefore, when t = 1 hr, $\beta_{eff}$ = 1.8 in./hr

Step 2b: The residual cross section after a one-hour fire exposure on three sides (top of the beam is protected from fire damage) can be calculated as:

$b_{residual}$ = 5.125 – (1.8 x 2) = 1.525 in.
$h_{residual}$ = 15 – 1.8 = 13.2 in.
$S_{residual}$ = 1.525 x $13.2^2/6$ = 44.3 $in.^3$

Step 2c: The residual moment capacity after a one-hour fire exposure on three sides can be calculated based on Table 16.2.2 of the 2005 NDS.

$M_{residual} = 2.85\ F_b'\ x\ S_{residual}$ = 2.85 x 2,400 x 0.9437 x 44.3/12 = 23,821 ft-lb.

Where:

$F_b'$ = adjusted allowable bending stress, including beam volume effect factor, but not the load duration factor.

0.9437 = glulam beam volume effect factor (see Appendix A of EWS S475)

Step 2d: The applied moment due to the 240 lb/ft of total load and the beam weight of 18.7 lb/ft can be calculated as:

$$M_{applied} = \frac{\omega \ell^2}{8} = \frac{(240 + 18.7) \times 30^2}{8} = 29{,}102 \text{ ft-lb} > 23{,}821 \text{ ft-lb} \Rightarrow \textbf{NG}$$

Step 2e: Therefore, the beam size should be increased to accommodate the one-hour fire exposure. Select a 5-1/8-inch by 18-inch beam. From Table 3 of EWS S475, the load carrying capacity of this beam is 470 plf which is greater than 240 plf.

Step 2f: Repeat Steps 2b and 2c for one-hour fire exposure,

$b_{residual}$ = 5.125 – (1.8 x 2) = 1.525 in.
$h_{residual}$ = 18 – 1.8 = 16.2 in.
$S_{residual}$ = 1.525 x $16.2^2/6$ = 66.7 $in.^3$
$M_{residual} = 2.85\ F_b'\ x\ S_{residual}$ = 2.85 x 2,400 x 0.9266 x 66.7/12 = 35,213 ft-lb.

$$M_{applied} = \frac{\omega \ell^2}{8} = \frac{(240 + 22.4) \times 30^2}{8} = 29{,}522 \text{ ft-lb} < 35{,}213 \text{ ft-lb} \Rightarrow \textbf{OK}$$

Therefore, <u>use a 5-1/8-inch by 18-inch 24F-V4 Douglas-fir glulam beam.</u>

## DESIGN EXAMPLE 2: GLULAM COLUMN FOR ONE-HOUR FIRE RATING IN ACCORDANCE WITH THE 2009 INTERNATIONAL BUILDING CODE

An existing building is to be remodeled with a change of occupancy requiring that the glulam columns meet a one-hour fire-resistance requirement. The existing glulam column is 20-foot high, measures B = 8-3/4-inches wide by D = 10-1/2-inches deep and will remain dry in service. It supports a concentrated total floor load (DL + LL) of 50,000 lb. ($C_D$ = 1.0) applied concentrically to the top of the column. The column is not subjected to any lateral loads. From the original specifications, the glulam is a Douglas-fir Combination 2 (see Table 3, Form EWS Y240). Determine if the column is adequate to carry the imposed axial load for one hour with fire on four sides and how long it can be expected to carry the applied load. If it is not adequate, determine what size column is required.

To address these issues, the total load capacity of the column must be determined along with the percentage of the total load capacity used by the applied load and the partial-load compensation factor, Z.

### Determine Load Capacity

$B = 8.75$ in.

$D = 10.5$ in.

$A = B \times D = 8.75(10.5) = 91.875$ in.$^2$

$C_D = 1.0$ for DL plus floor LL

$E = 1{,}600{,}000$ lb/in.$^2$

$F_c = 1{,}950$ lb/in.$^2$

$\ell = 20(12) = 240$ in.

$K_e = 1.0$ (see Figure 8) Column is assumed to be pinned at both ends.

$\ell_e = \ell\, K_e = 240(1.0) = 240$ in.

$$\frac{\ell_e}{B} = \frac{240}{8.75} = 27.43$$

$c = 0.9$

Where:

$E$ = tabulated modulus of elasticity (lb/in.$^2$)

$E'$ = adjusted modulus of elasticity (lb/in.$^2$)

$F_c$ = tabulated compression design value parallel to grain (lb/in.$^2$)

$A$ = area of cross section (in.$^2$)

$B$ = least dimension being evaluated for potential buckling (in.)

$\ell$ = length of column (in.)

$\ell_e$ = $\ell\, K_e$ = effective length of column (in.)

$K_e$ = buckling length coefficient for compression members

$c$ = coefficient that depends on member type (0.9 for glulam)

$$E'_{min.} = \frac{(E'[1 - 1.645\ COV_E]\ 1.05)}{1.66} = \frac{(1{,}600{,}000[1 - (1.645)(0.10)]\ 1.05)}{1.66} = 845{,}566\ \text{lb/in}^2$$

Where:

$COV_E$ = coefficient of variation in modulus of elasticity = 0.10 for glulam

1.05 = conversion factor to obtain true E (1.05 for glulam)

1.66 = factor of safety

$F_c^*$ = tabulated compression design value multiplied by all applicable adjustment factors except $C_p$ (lb/in.$^2$)

$$F_{cE} = \frac{0.822\ E'_{min.}}{\left(\frac{l_e}{B}\right)^2} = \frac{0.822(845{,}566)}{27.43^2} = 924\ \text{lb/in.}^2$$

$$\frac{F_{cE}}{F_c^*} = \frac{924}{1{,}950} = 0.474$$

$$C_p = \frac{1 + \frac{F_{cE}}{F_c^*}}{2c} - \sqrt{\left[\frac{1 + \frac{F_{cE}}{F_c^*}}{2c}\right]^2 - \frac{\left(\frac{F_{cE}}{F_c^*}\right)}{c}} = \frac{1 + 0.474}{2(0.9)} - \sqrt{\left[\frac{1 + 0.474}{2(0.9)}\right]^2 - \frac{0.474}{0.9}} = 0.440$$

$F_c' = F_c^* C_p$ = allowable compressive stress (lb/in.$^2$)

$F_c' = 1{,}950(0.440) = 857$ psi

Axial load capacity = $AF_c' = 91.875(857) = 78{,}737$ lb > 50,000 ⇒ **OK** for concentric axial load without fire endurance consideration

## Check fire endurance based on ratio of applied load to design capacity

$$\frac{\text{Applied Load}}{\text{Design Capacity}} = \frac{50{,}000}{78{,}737} = 0.635 = 63.5\%$$

From Figure 7, for a column 8-3/4-inches wide and $l_e/B > 11$, 63.5% corresponds to about a 13-1/2-inch depth which is greater than the existing column's depth of 10-1/2 inches. The existing column will therefore **not** carry the applied load for the full duration of the prescribed one-hour fire.

## To check this conclusion, calculate the fire endurance

From Figure 3, for a column with $l_e/B > 11$ and the load at 63.5% of capacity, Z is approximately 1.16.

Using Equation 4:

B = 8.75 in.

D = 10.5 in.

$$t = 2.54ZB\left[3 - \frac{B}{D}\right] = 2.54(1.16)(8.75)\left[3 - \frac{8.75}{10.5}\right] = 56 \text{ minutes} < 60 \Rightarrow \textbf{NG}$$

The existing column is inadequate to meet the one-hour fire-resistance requirement even though it is adequate to carry the applied load in occupancies not requiring a one-hour fire rating.

### Determine column size necessary to carry the design load and meet the one-hour requirement

Using Figure 7 as a guide, try a 10-3/4-inch x 10-1/2-inch glulam, Douglas-fir Combination 2, assuming a depth of 10-1/2 inches is a design requirement.

$A = 10.75(10.5) = 112.875 \text{ in.}^2$

Slenderness ratio $= l_e/B = 240/10.5 = 22.86$

$$F_{cE} = \frac{0.822\,E'_{min}}{\left(\frac{l_e}{B}\right)^2} = \frac{0.822(845{,}566)}{22.86^2} = 1{,}330 \text{ lb/in.}^2$$

$F_c^* = 1{,}950 \text{ lb/in.}^2$

$$\frac{F_{cE}}{F_c^*} = \frac{1{,}330}{1{,}950} = 0.682$$

$$C_p = \frac{1+\frac{F_{cE}}{F_c^*}}{2c} - \sqrt{\left[\frac{1+\frac{F_{cE}}{F_c^*}}{2c}\right]^2 - \frac{\left(\frac{F_{cE}}{F_c^*}\right)}{c}} = \frac{1+0.682}{2(0.9)} - \sqrt{\left[\frac{1+0.682}{2(0.9)}\right]^2 - \frac{0.682}{0.9}} = 0.595$$

$F_c' = 1{,}950(0.595) = 1{,}160 \text{ lb/in.}^2$

Axial load capacity $= AF_c' = 112.875(1{,}160) = 130{,}939$ lb > 50,000 lbs. ⇒ **OK**

### Check the fire endurance

$$\frac{\text{Applied Load}}{\text{Maximum Capacity}} = \frac{50{,}000}{130{,}939} = 0.382 = 38.2\%$$

Z, from Figure 3, is 1.3.

Using Equation 4:

B = 10.5 in.

D = 10.75 in.

$$t = 2.54ZB\left[3 - \frac{B}{D}\right] = 2.54(1.30)(10.5)\left[3 - \frac{10.5}{10.75}\right] = 70 \text{ minutes} > 60 \Rightarrow \textbf{OK};$$

<u>use 10-3/4-inch x 10-1/2-inch Combination 2 Douglas-fir glulam column.</u>

## ALTERNATIVE SOLUTION IN ACCORDANCE WITH THE 2005 NATIONAL DESIGN SPECIFICATION, CHAPTER 16

Step 1: The 8-3/4-inch by 10-1/2-inch glulam column capacity can be calculated based on Section 3.7.1 of the 2005 NDS as 78,713 lb > 50,000 lb ⇒ **OK**

Step 2: Determine the actual column size that will continue to carry the design load when exposed to a one-hour fire as follows:

Step 2a: From Chapter 16 of NDS,

$$\beta_{eff} = \frac{1.2\beta_n}{t^{0.187}}$$

Where:

- $\beta_n$ = nominal char rate of 1.5 in./hr
- $\beta_{eff}$ = effective char rate (in./hr)
- t = exposure time (hrs)

Therefore, when t = 1 hr, $\beta_{eff}$ = 1.8 in./hr

Step 2b: The residual cross section after a one-hour fire exposure on four sides can be calculated as:

$b_{residual}$ = 8.75 – (1.8 x 2) = 5.15 in.
$h_{residual}$ = 10.5 – (1.8 x 2) = 6.90 in.
$A_{residual}$ = 5.15 x 6.90 = 35.54 in.$^2$

Step 2c: The residual axial capacity after a one-hour fire exposure on four sides can be calculated based on Table 16.2.2 of the 2005 NDS.

$F_c'$ = 2.58 x $F_c$ x $C_p$ = 2.58 x 1,950 x 0.1273 = 640.4 psi
$P_{residual}$ = $F_c'$ x $A_{residual}$ = 640.4 x 35.54 = 22,755 lb < 50,000 lb ⇒ **NG**

Where:

$C_p$ = column stability factor, which can be calculated based on Section 3.7.1 of the 2005 NDS with the exception that the column buckling strength $F_{cE}$ is determined using equation given in Table 16.2.2 of the 2005 NDS

Step 2d: Therefore, the column size would need to be increased to accommodate the one-hour fire exposure. Select 10-3/4 inches by 10-1/2 inches. The column capacity can be calculated based on Section 3.7.1 of the 2005 NDS as 130,939 lb > 50,000 lb ⇒ **OK**

Step 2e: Repeat Steps 2b and 2c for one-hour fire exposure,

$b_{residual}$ = 10.75 – (1.8 x 2) = 7.15 in.
$h_{residual}$ = 10.5 – (1.8 x 2) = 6.90 in.
$A_{residual}$ = 7.15 x 6.90 = 49.34 in.$^2$
$F_c'$ = 2.58 x $F_c$ x $C_p$ = 2.58 x 1,950 x 0.2253 = 1,133.3 psi
$P_{residual}$ = $F_c'$ x $A_{residual}$ = 1,133.3 x 49.34 = 55,911 lb > 50,000 lb ⇒ **OK**

Therefore a 10-3/4-inch by 10-1/2-inch Combination 2 Douglas-fir glulam column is required to meet the one-hour fire rating.

## Summary

As shown by the preceding examples, glued laminated timber members can be designed to provide a one-hour fire rating when required. Based on the 2009 IBC, Tables 1a, 1b and 1c provide basic minimum dimensions for one-hour fire-rated glulam beams and columns when the applied load represents 100 percent of the member design capacity. Figures 4, 5, 6 and 7 provide estimated sizes of beams and columns that will satisfy a requirement for a one-hour fire rating when the member is loaded to less than 100 percent of capacity. Alternatively, the design methodology provided in Chapter 16 of the 2005 NDS can be used to design one-hour fire-rated glulam beams and columns.

For additional information related to the design of glulams, contact APA Product Support Help Desk, 7011 South 19th St., Tacoma, Washington 98466-5333, Phone (253) 620-7400.

FIGURE 3

**FACTOR Z AS A PERCENTAGE OF DESIGN CAPACITY**

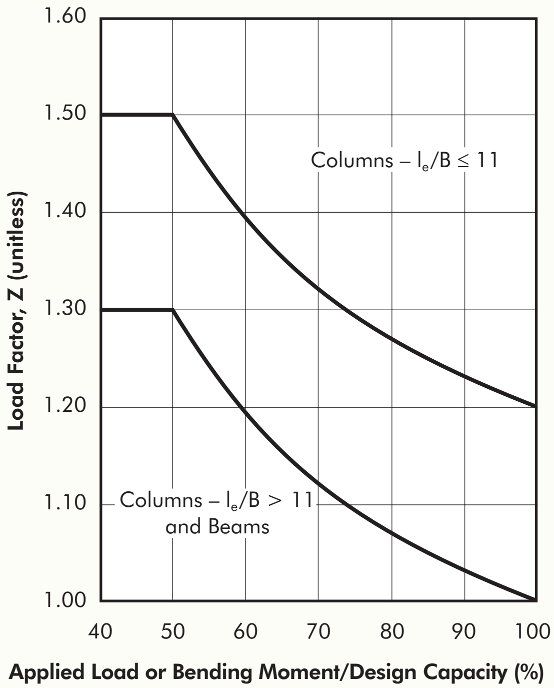
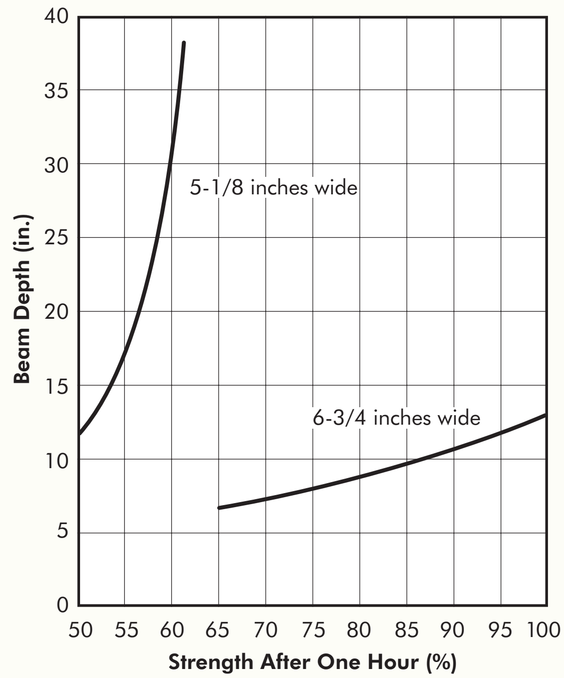



FIGURE 4

**BEAMS – FIRE 3 SIDES**




(Beams wider than 6-3/4" will generally carry 100% of capacity for 1 hour provided they are as deep as they are wide.)

FIGURE 5

**BEAMS – FIRE 4 SIDES**

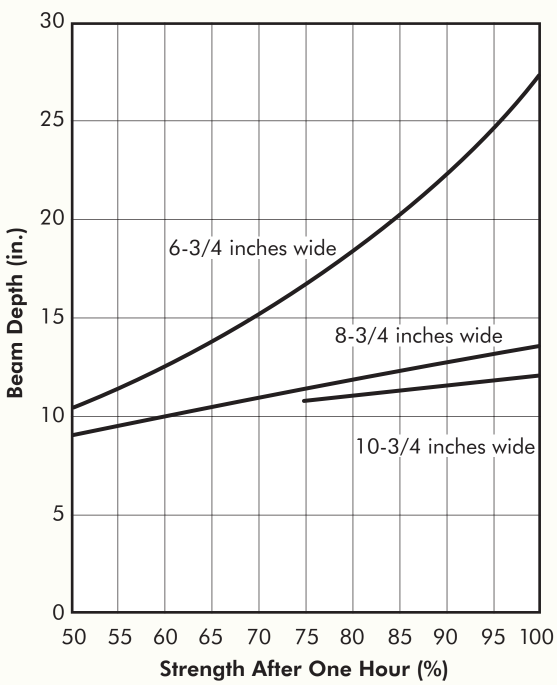



FIGURE 6

**COLUMNS – FIRE 3 SIDES**

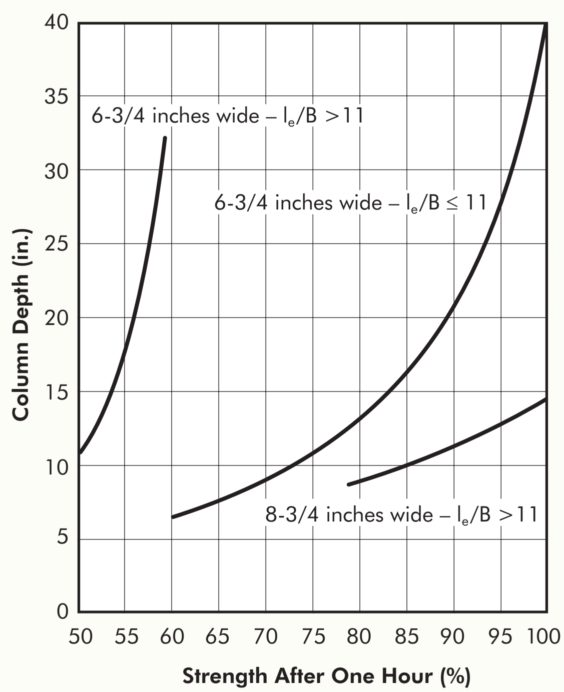


FIGURE 7

**COLUMNS – FIRE 4 SIDES**

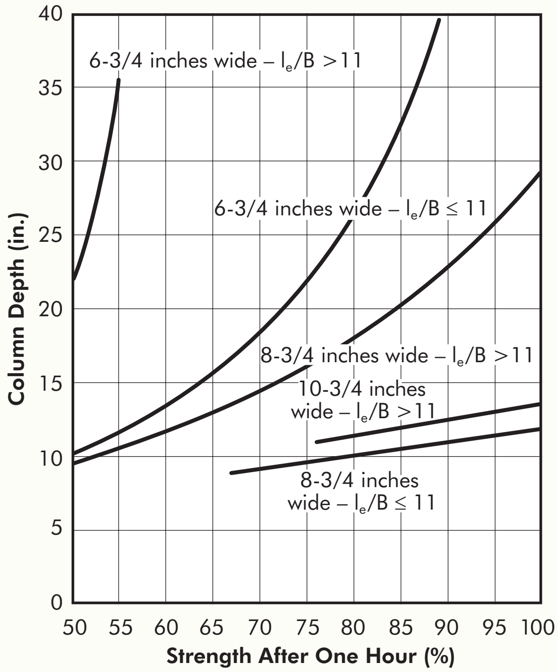
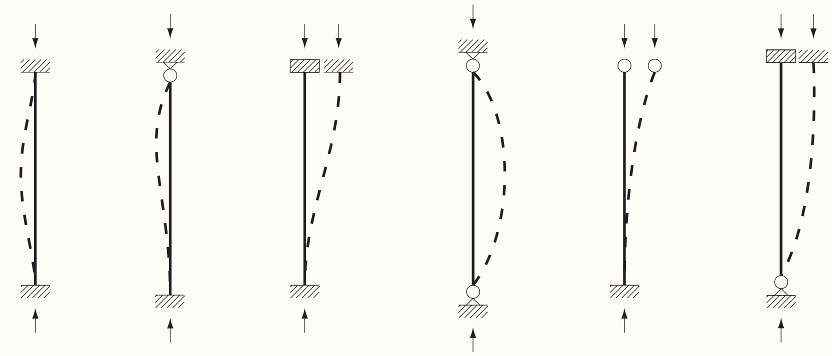



FIGURE 8

**APPENDIX G, 2005 NDS – EFFECTIVE COLUMN LENGTH**

Buckling modes



| | | | | | | |
|---|---|---|---|---|---|---|
| Theoretical $K_e$ value | 0.5 | 0.7 | 1.0 | 1.0 | 2.0 | 2.0 |
| Recommended design $K_e$ when ideal conditions approximated | 0.65 | 0.8 | 1.2 | 1.0 | 2.1 | 2.4 |

End condition code

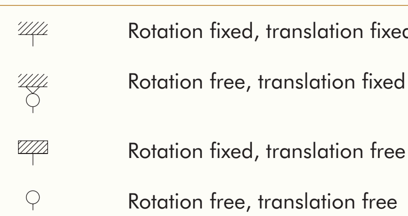
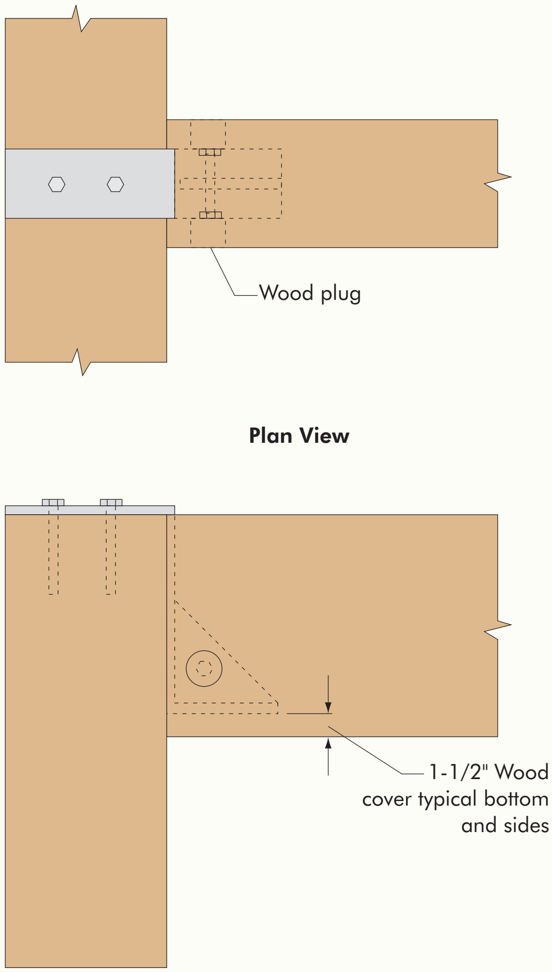


FIGURE 9

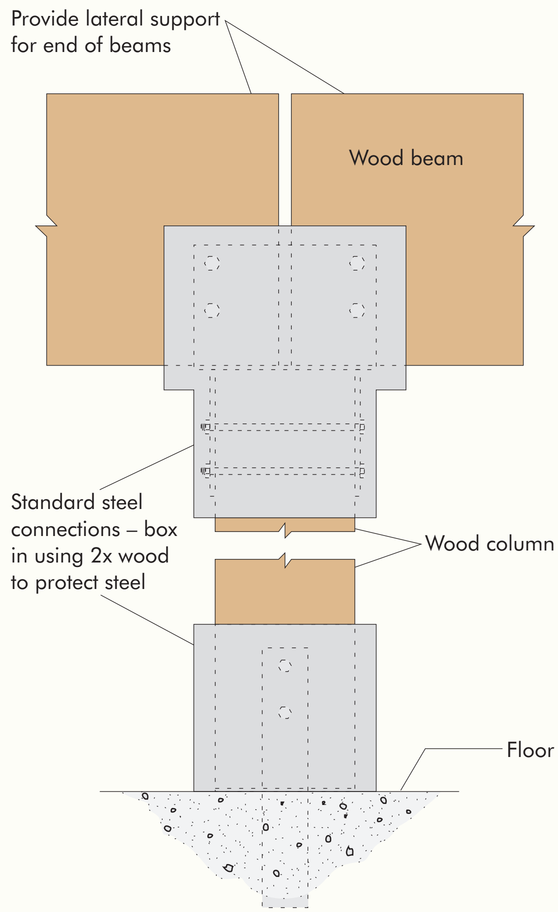
**BEAM TO GIRDER – CONCEALED CONNECTION**




**Elevation**

FIGURE 10

**COLUMN CONNECTIONS – COVERED**




**Elevation**

FIGURE 11

**BEAM-TO-COLUMN CONNECTION**
**Connection not exposed to fire**

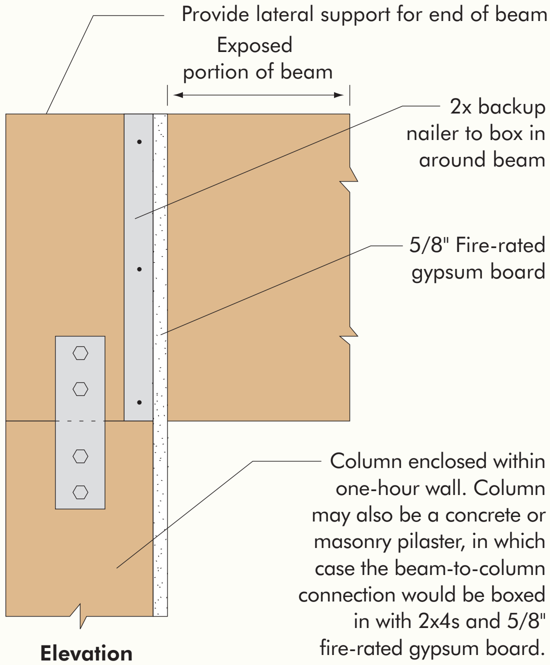



FIGURE 12

**BEAM-TO-COLUMN CONNECTION**
**Connection exposed to fire where appearance is a factor**

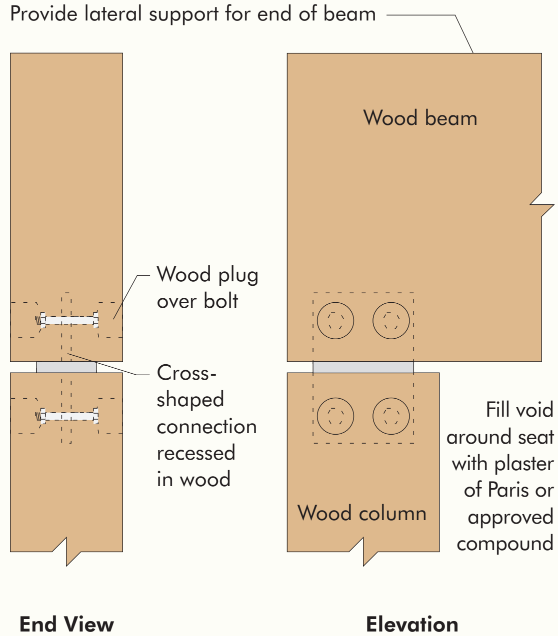


FIGURE 13

**BEAM-TO-COLUMN CONNECTION**
**Connection exposed to fire where appearance is not a factor**

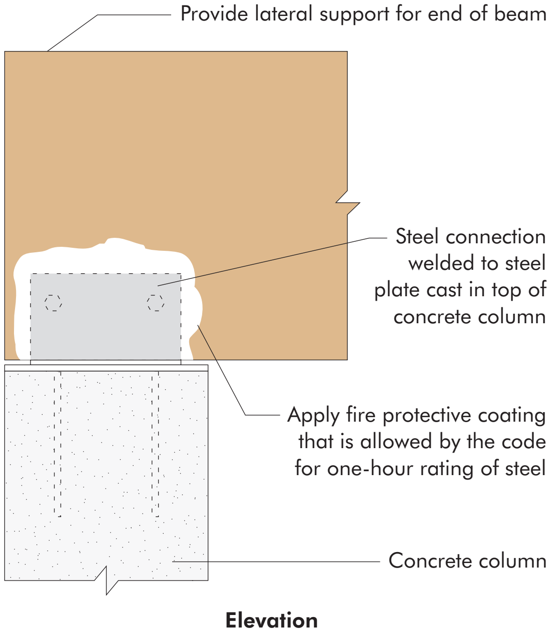
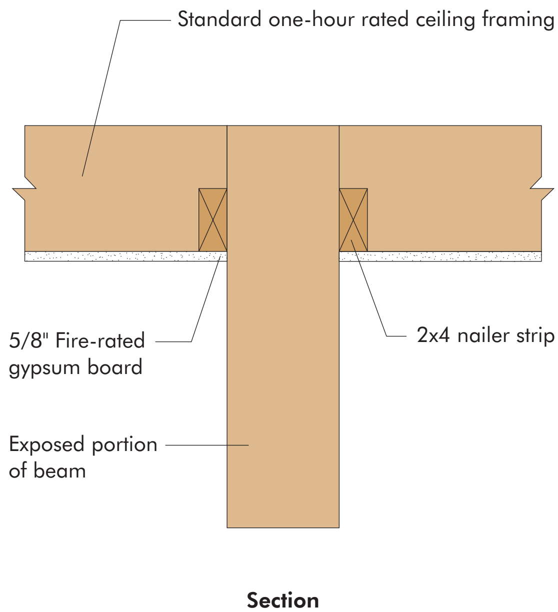



FIGURE 14

**CEILING CONSTRUCTION**



# Calculating Fire Resistance of Glulam Beams and Columns

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