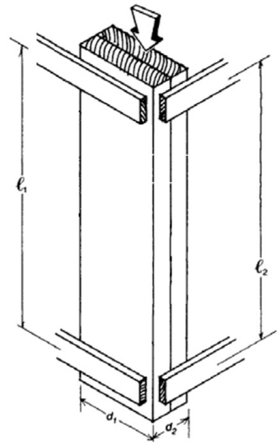
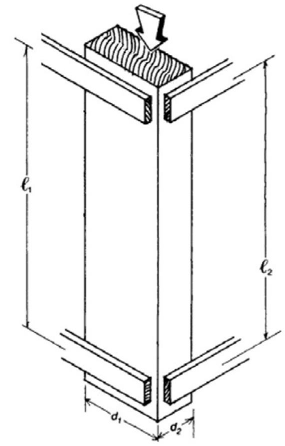
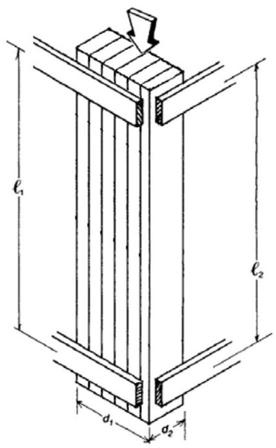
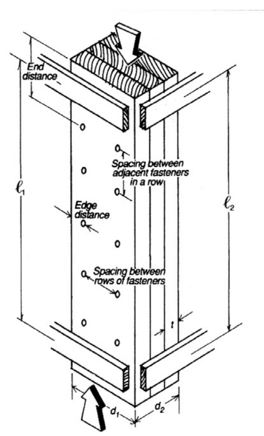
5 Columns

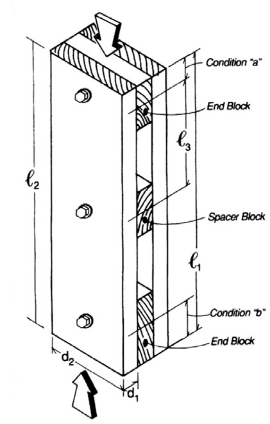
- Combined
- Solid
- Glulam
- Built-up
- Spaced







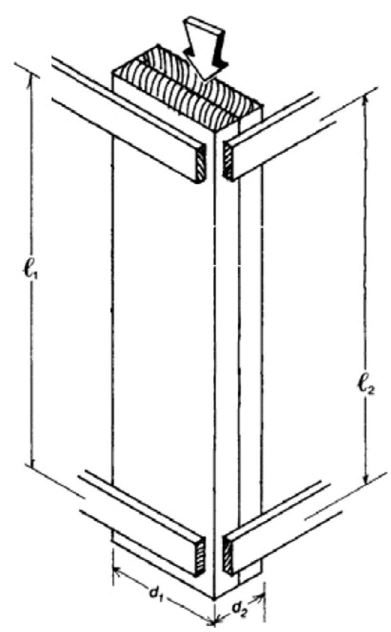




1 - Combined Dimensioned Lumber

Required:

- Capacity



1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50
2. Find adjustment factors
   C_D C_M C_t C_F C_i
3. Calculate C_P
4. Determine F'c by multiplying the tabulated Fc by all the above factors
5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A

1 - Combined Dimensioned Lumber

HEM-FIR N°2
2 x 1.5" x 7.25"
A = 10.88 in² (EACH)
F_c = 1300 psi
E_{MIN} = 470000 psi
ℓ = 6' K_e = 1.0

Required:

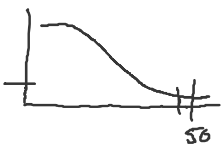
- Capacity for roof LL

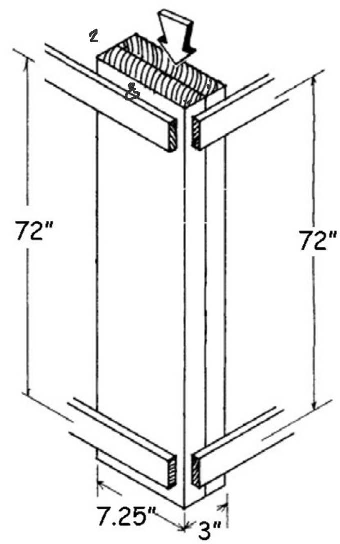
1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50

$\ell_e = 6' = 72"$

SLENDERNESS Y-Y

$\frac{\ell_e}{d} = \frac{72"}{1.5"} = 48 < 50$





2. Find adjustment factors ($C_M = C_t = C_i = 0$)
   C_D C_M C_t C_F C_i

$C_D = 1.25$ (FOR L_r)
$C_F = 1.05$ (FOR F_c)

1 - Combined Dimensioned Lumber

HEM-FIR N°2
2 x 1.5" x 7.25"
A = 10.88 in² (EACH)
F_c = 1300 psi
E_{MIN} = 470000 psi
ℓ = 6' K_e = 1.0

3. Calculate C_P

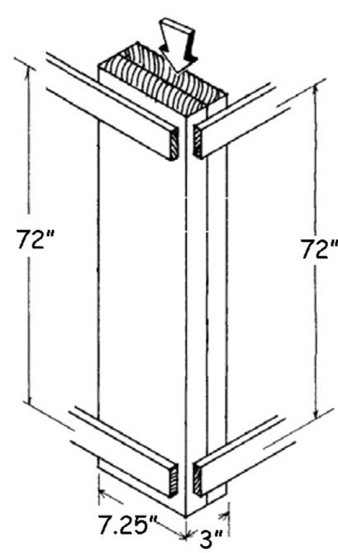
C_P:

$F_{cE} = \frac{0.822 E'_{min}}{(\ell_e/d)^2} = \frac{0.822(470000)}{48^2} = 167.7$ psi

$F_c^* = 1706$ psi

$c = 0.8$

$C_P = 0.0962$



4. Determine F'c by multiplying the tabulated Fc by all the determining factors

$F'_c = 1300(\overset{C_D}{1.25}\ \overset{C_F}{1.05}\ \overset{C_P}{0.0962}) = 164.2$ psi

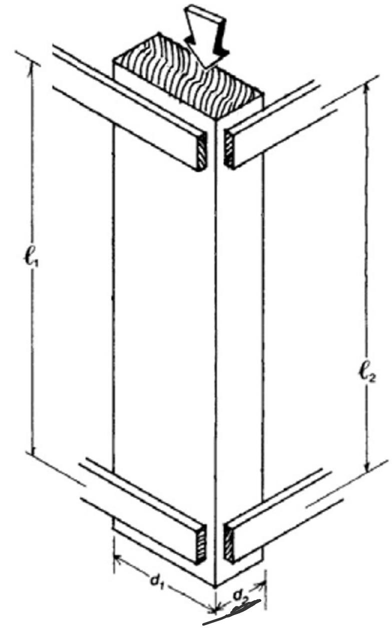
5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A

$P_{MAX} = F'_c A = 164(10.88 \times 2) = 3\,571$ LBS

2 - Solid Dimensioned Lumber

Required:

- Capacity



1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be ≤ 50
2. Find adjustment factors
   C_D C_M C_t C_F C_i
3. Calculate C_P
4. Determine F'c by multiplying the tabulated Fc by all the above factors
5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A

2 – Solid Dimensioned Lumber

HEM - FIR No 2
3.5" x 7.25"
$A = 25.38\ in^2$
$F_c = 1300$ PSI
$E_{MIN} = 470\,000$ PSI
$\ell = 6'$ $K_e = 1.0$

Required:

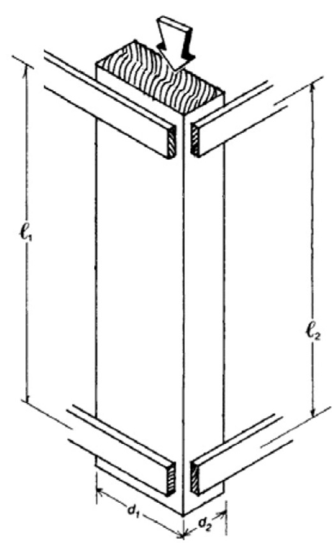
- Capacity for roof LL

1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50

$\ell_e = 6' = 72"$

SLENDERNESS Y-Y

$$\frac{\ell_e}{d} = \frac{72"}{3.5"} = 20.6$$



2. Find adjustment factors ($C_M = C_t = C_i = 0$)
   C_D C_M C_t C_F C_i

$C_D = 1.25$ (FOR L_r)
$C_F = 1.05$ (FOR F_c)

2 – Solid Dimensioned Lumber

HEM - FIR No 2
3.5" × 7.25"
$A = 25.38 \text{ in}^2$
$F_c = 1300$ PSI
$E_{MIN} = 470\,000$ PSI
$\ell = 6'$ $K_e = 1.0$

3. Calculate C_P

$$F_{CE} = \frac{0.822(470\,000)}{20.6^2} = 912.9 \text{ PSI}$$

$$F_c^* = 1300(\overset{C_D}{1.25}\ \overset{C_F}{1.05}) = 1706 \text{ PSI}$$

$$c = 0.8$$

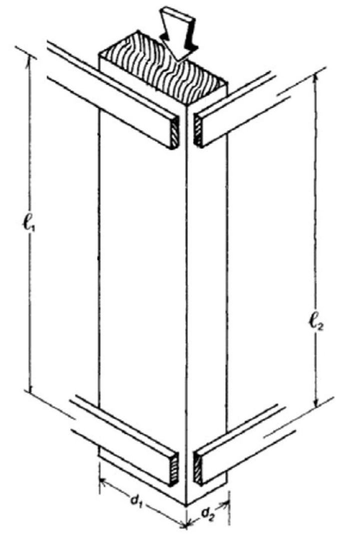
$$C_P = \underline{0.457}$$

4. Determine F'c by multiplying the tabulated Fc by all the determining factors

$$F'_c = 1300(\overset{C_D}{1.25}\ \overset{C_F}{1.05}\ \overset{C_P}{0.457}) = \underline{781} \text{ PSI}$$

5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A

$$P_{MAX} = F'_c A = 781(25.38) = \underline{19\,819 \text{ LBS}}$$



3 – Glulam Column

Brock Commons building, a student residence built for the University of British Columbia in Vancouver, Canada (2016)

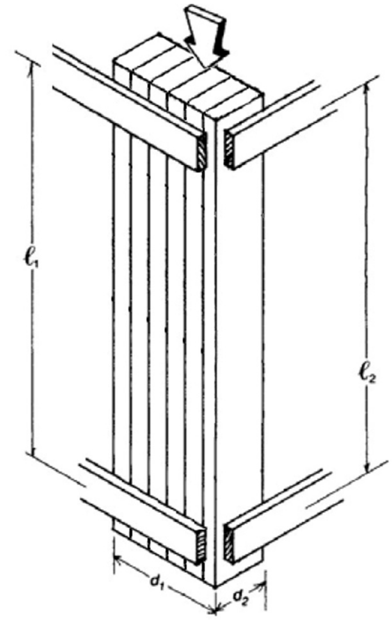
18-story hybrid mass timber building - 2 concrete floors at the base and 16 wood structure floors

3 – Glulam Column

Required:

- Capacity

1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50
2. Find adjustment factors
   C_D C_M C_t C_i (~~No C_V~~) ← C_F
3. Calculate C_P ($c = 0.9$)
4. Determine F'c by multiplying the tabulated Fc by all the above factors
5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A



3 – Glulam Column

Required:

- Capacity for roof LL

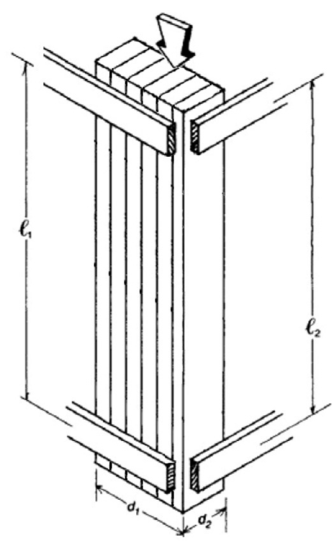
HF L2
3.5" × 7.5"
$A = 26.25\ in^2$
$F_c = 1350$ psi
$E_{MIN} = 740\,000$ psi
$\ell = 6'$ $K_e = 1.0$

1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50

$\ell_e = 6' = 72"$

SLENDERNESS Y-Y

$$\frac{\ell_e}{d} = \frac{72}{3.5} = 20.57$$



3 – Glulam Column HF – L2 5 lams

Table 5B Reference Design Values for Structural Glued Laminated Softwood Timber

(Members stressed primarily in axial tension or compression) (Tabulated design values are for normal load duration and dry service conditions. See NDS 5.3 for a comprehensive description of design value adjustment factors.)

Use with Table 5B Adjustment Factors

			All Loading				Axially Loaded			Bending about Y-Y Axis (Loaded Parallel to Wide Faces of Laminations)				Bending About X-X Axis (Loaded Perpendicular to Wide Faces of Laminations)		Fasteners
			Modulus of Elasticity(6)				Tension Parallel to Grain	Compression Parallel to Grain		Bending			Shear Parallel to Grain(1)(2)(3)	Bending	Shear Parallel to Grain(3)	
Combination Symbol	Species	Grade	For Deflection Calculations E_{axial} (10^6 psi)	0.95 E_{axial} (10^6 psi)	For Stability Calculations $E_{axial\,min}$ (10^6 psi)	Compression Perpendicular to Grain $F_{c\perp}$ (psi)	2 or More Laminations F_t (psi)	4 or More Laminations F_c (psi)	2 or 3 Laminations F_c (psi)	4 or More Laminations F_{by} (psi)	3 Laminations F_{by} (psi)	2 Laminations F_{by} (psi)	F_{vy} (psi)	2 Laminations to 15 in. Deep(4) F_{bx} (psi)	F_{vx} (psi)	Specific Gravity for Fastener Design G
Visually Graded Western Species																
1	DF	L3	1.6	1.5	0.79	560	950	1550	1250	1450	1250	1000	230	1250	265	0.50
2	DF	L2	1.7	1.6	0.85	560	1250	1950	1600	1800	1600	1300	230	1700	265	0.50
3	DF	L2D	2.0	1.9	1.00	650	1450	2300	1900	2100	1850	1550	230	2000	265	0.50
4	DF	L1CL	2.0	1.9	1.00	590	1400	2100	1950	2200	2000	1650	230	2100	265	0.50
5	DF	L1	2.1	2.0	1.06	650	1650	2400	2100	2400	2100	1800	230	2200	265	0.50
14	HF	L3	1.4	1.3	0.69	375	800	1100	1050	1200	1050	850	190	1100	215	0.43
15	HF	L2	1.5	1.4	0.74	375	1050	1350	1350	1500	1350	1100	190	1450	215	0.43
16	HF	L1	1.7	1.6	0.85	375	1200	1500	1500	1750	1550	1300	190	1600	215	0.43
17	HF	L1D	1.8	1.7	0.90	500	1400	1750	1750	2000	1850	1550	190	1900	215	0.43
22(5)	SW	L3	1.1	1.0	0.53	315	525	850	725	800	700	575	170	725	195	0.35
69	AC	L3	1.3	1.2	0.63	470	725	1150	1100	1100	975	775	230	1000	265	0.46
70	AC	L2	1.4	1.3	0.69	470	975	1450	1450	1400	1250	1000	230	1350	265	0.46
71	AC	L1D	1.7	1.6	0.85	560	1250	1900	1900	1850	1650	1400	230	1750	265	0.46
72	AC	L1S	1.7	1.6	0.85	560	1250	1900	1900	1850	1650	1400	230	1900	265	0.46
73	POC	L3	1.4	1.3	0.69	470	775	1500	1200	1200	1050	825	230	1050	265	0.46
74	POC	L2	1.5	1.4	0.74	470	1050	1900	1550	1450	1300	1100	230	1400	265	0.46
75	POC	L1D	1.8	1.7	0.90	560	1350	2300	2050	1950	1750	1500	230	1850	265	0.46
Visually Graded Southern Pine																
47	SP	N2M12	1.5	1.4	0.74	650	1200	1900	1150	1750	1550	1300	260	1400	300	0.55
47 1:10	SP	N2M10	1.5	1.4	0.74	650	1150	1700	1150	1750	1550	1300	260	1400	300	0.55
47 1:8	SP	N2M	1.5	1.4	0.74	650	1000	1500	1150	1600	1550	1300	260	1400	300	0.55
48	SP	N2D12	1.8	1.7	0.90	740	1400	2200	1350	2000	1800	1500	260	1600	300	0.55
48 1:10	SP	N2D10	1.8	1.7	0.90	740	1350	2000	1350	2000	1800	1500	260	1600	300	0.55
48 1:8	SP	N2D	1.8	1.7	0.90	740	1150	1750	1350	1850	1800	1500	260	1600	300	0.55
49	SP	N1M16	1.8	1.7	0.90	650	1350	2100	1450	1950	1750	1500	260	1800	300	0.55
49 1:14	SP	N1M14	1.8	1.7	0.90	650	1350	2000	1450	1950	1750	1500	260	1800	300	0.55
49 1:12	SP	N1M12	1.8	1.7	0.90	650	1300	1900	1450	1950	1750	1500	260	1800	300	0.55
49 1:10	SP	N1M	1.8	1.7	0.90	650	1150	1700	1450	1850	1750	1500	260	1800	300	0.55
50	SP	N1D14	2.0	1.9	1.00	740	1550	2300	1700	2300	2100	1750	260	2100	300	0.55
50 1:12	SP	N1D12	2.0	1.9	1.00	740	1500	2200	1700	2300	2100	1750	260	2100	300	0.55
50 1:10	SP	N1D	2.0	1.9	1.00	740	1350	2000	1700	2100	2100	1750	260	2100	300	0.55

1. For members with 2 or 3 laminations, the reference shear design value for transverse loads parallel to the wide faces of the laminations, F_{vy}, shall be reduced by multiplying by a factor of 0.84 or 0.95, respectively.
2. The reference shear design value for transverse loads applied parallel to the wide faces of the laminations, F_{vy}, shall be multiplied by 0.4 for members with 5, 7, or 9 laminations manufactured from multiple piece laminations (across width) that are not edge bonded. The reference shear design value, F_{vy}, shall be multiplied by 0.5 for all other members manufactured from multiple piece laminations with unbonded edge joints. This reduction shall be cumulative with the adjustments in footnotes 1 and 3.
3. The reference design values for shear, F_{vx} and F_{vy}, shall be multiplied by the shear reduction factor, C_{vr}, for the conditions defined in NDS 5.3.10.
4. For members greater than 15 in. deep, the reference bending design value, F_{bx}, shall be reduced by multiplying by a factor of 0.88.
5. When Western Cedars, Western Cedars (North), Western Woods, and Redwood (open grain) are used in combinations for Softwood Species (SW), the reference design value for modulus of elasticity, E, shall be reduced by 100,000 psi and E_{min} shall be reduced by 52,800 psi. When Coast Sitka Spruce, Coast Species, Western White Pine, and Eastern White Pine are used in combinations for Softwood Species (SW) reference design values for shear parallel to grain, F_{vx} and F_{vy}, shall be reduced by 10 psi, before applying any other adjustments.
6. Notations: E_{axial} = Axial moduli of elasticity for use in axial deformation calculation for compression and tension members as defined by NDS 5.2.7 (E_{axial} is equal to $E_{x\,true}$ and $E_{y\,true}$ as defined in Tables 5A and 5A Extended when layups are used as beams).
   0.95 E_{axial} = Apparent moduli of elasticity in either the X-X or Y-Y direction for use in beam deflection calculations when layups are used as beams.
   $E_{axial\,min}$ = Minimum axial moduli of elasticity for use in column stability calculations.

3 – Glulam Column

HF L2
3.5" × 7.5"
A = 26.25 in²
F_c = 1350 psi
E_{min} = 740 000 psi
ℓ = 6' K_e = 1.0

Required:

- Capacity for roof LL

2. Find adjustment factors
   C_D C_M C_t C_p

C_D = 1.25 (for L_r)
(no C_v for F_c)

$C_M = C_t = 1$

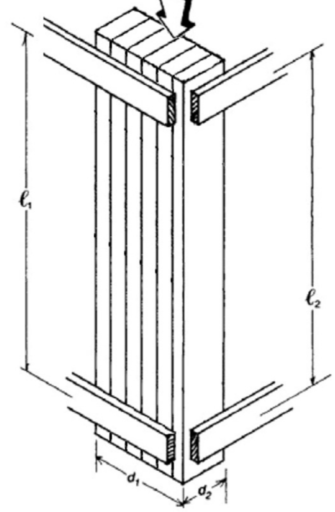
Table 5.3.1 Applicability of Adjustment Factors for Structural Glued Laminated Timber

	ASD only	ASD and LRFD										LRFD only		
	Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor[1]	Volume Factor[1]	Flat Use Factor	Curvature Factor	Stress Interaction Factor	Shear Reduction Factor	Column Stability Factor	Bearing Area Factor	Format Conversion Factor K_F	Resistance Factor ϕ	Time Effect Factor
$F_b' = F_b$ x	C_D	C_M	C_t	C_L	C_V	C_{fu}	C_c	C_I	-	-	-	2.54	0.85	λ
$F_t' = F_t$ x	C_D	C_M	C_t	-	-	-	-	-	-	-	-	2.70	0.80	λ
$F_v' = F_v$ x	C_D	C_M	C_t	-	-	-	-	-	C_{vr}	-	-	2.88	0.75	λ
$F_{rt}' = F_{rt}$ x	C_D	C_M^2	C_t^2	-	-	-	-	-	-	-	-	2.88	0.75	λ
$F_c' = F_c$ x	C_D	C_M	C_t	-	-	-	-	-	-	C_P	-	2.40	0.90	λ
$F_{c\perp}' = F_{c\perp}$ x	-	C_M	C_t	-	-	-	-	-	-	-	C_b	1.67	0.90	-
$E' = E$ x	-	C_M	C_t	-	-	-	-	-	-	-	-	-	-	-
$E_{min}' = E_{min}$ x	-	C_M	C_t	-	-	-	-	-	-	-	-	1.76	0.85	-

1. The beam stability factor, C_L, shall not apply simultaneously with the volume factor, C_v, for structural glued laminated timber bending members (see 5.3.6). Therefore, the lesser of these adjustment factors shall apply.
2. For radial tension, F_{rt}, the same adjustment factors (C_M and C_t) for shear parallel to grain, F_v, shall be used.

3 – Glulam Column

HF L2
3.5" × 7.5"
$A = 26.25\ in^2$
$F_c = 1350$ psi
$E_{MIN} = 740\,000$ psi
$\ell = 6'$ $K_e = 1.0$



3. Calculate C_P

$$F_{cE} = \frac{0.822(740\,000)}{20.57^2} = 1437 \text{ psi}$$

$$F_c^* = 1350(\overset{C_D}{1.25}) = 1687 \text{ psi}$$

$c = \underline{0.9}$ (GLULAM)

$C_P = \underline{0.694}$

4. Determine F'c by multiplying the tabulated Fc by all the determining factors

$$F_c' = 1350(\overset{C_D}{1.25}\ \overset{C_P}{0.694}) = \underline{1171} \text{ psi}$$

5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A

$$P_{MAX} = F_c' A = 1171(26.25) = 30742 \text{ LBS}$$

4 – Built-Up Column

15.3 Built-Up Columns

15.3.1 General

The following provisions apply to nailed or bolted built-up columns with 2 to 5 laminations in which:

(a) each lamination has a rectangular cross section and is at least 1-1/2" thick, t ≥ 1-1/2".
(b) all laminations have the same depth (face width), d.
(c) faces of adjacent laminations are in contact.
(d) all laminations are full column length.
(e) the connection requirements in 15.3.3 or 15.3.4 are met. (NAIL) (BOLT)

Nailed or bolted built-up columns not meeting the preceding limitations shall have individual laminations designed in accordance with 3.6.3 and 3.7. Where individual laminations are of different species, grades, or thicknesses, the lesser adjusted compression parallel to grain design value, F_c', and modulus of elasticity for beam and column stability, E_{min}', for the weakest lamination shall apply.

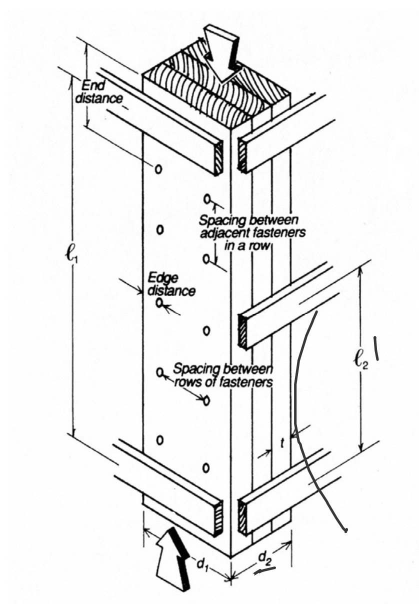
4 – Built-Up Column

4 – Built-Up Column

Required:

- Capacity

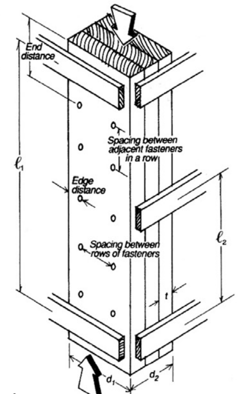
1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50
   If the slenderness across the lams (l_2/d_2) controls
   then use K_f with C_p
2. Find adjustment factors
   C_D C_M C_t C_F C_i
3. Calculate C_P. If controlling slenderness is l_2/d_2, use K_f
4. Determine F'c by multiplying the tabulated Fc by all the above factors. F'c need not be smaller than case 1 above (individual unfastened lams)
5. Set the actual stress = allowable F'c = P/A
6. Solve for capacity, P = F'c A



4 – Built-Up Column

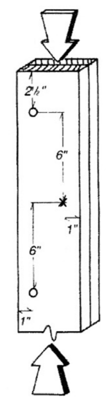
Nailing criteria 15.3.3

Figure 15B **Mechanically Laminated Built-Up Columns**

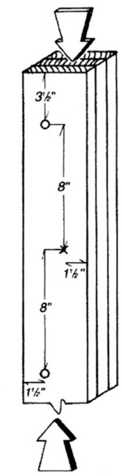


D = NAIL DIAM.

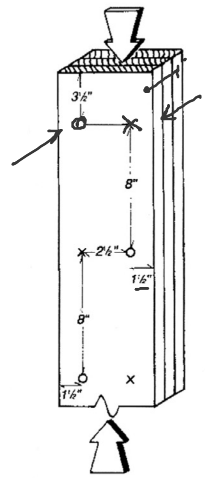
Figure 15C **Typical Nailing Schedules for Built-Up Columns**



Two 2"x 4" laminations with one row of staggered 10d common wire nails (D = 0.148", L = 3")



Three 2"x 4" laminations with one row of staggered 30d common wire nails (D = 0.207", L = 4-1/2")



Three 2"x 6" laminations with two rows of 30d common wire nails (D = 0.207", L = 4-1/2")

15.3.3 Nailed Built-Up Columns

15.3.3.1 The provisions in 15.3.1 and 15.3.2 apply to nailed built-up columns (see Figure 15C) in which:

(a) adjacent nails are driven from opposite sides of the column
(b) all nails penetrate all laminations and at least 3/4 of the thickness of the outermost lamination
(c) $15D \le$ end distance $\le 18D$
(d) $20D \le$ spacing between adjacent nails in a row $\le 6t_{min}$
(e) $10D \le$ spacing between rows of nails $\le 20D$
(f) $5D \le$ edge distance $\le 20D$
(g) 2 or more longitudinal rows of nails are provided where $d > 3t_{min}$

where:

D = nail diameter

d = depth (face width) of individual lamination

t_{min} = thickness of thinnest lamination

Where only one longitudinal row of nails is required, adjacent nails shall be staggered (see Figure 15C). Where three or more longitudinal rows of nails are used, nails in adjacent rows shall be staggered.

4 – Built-Up Column Nailing criteria

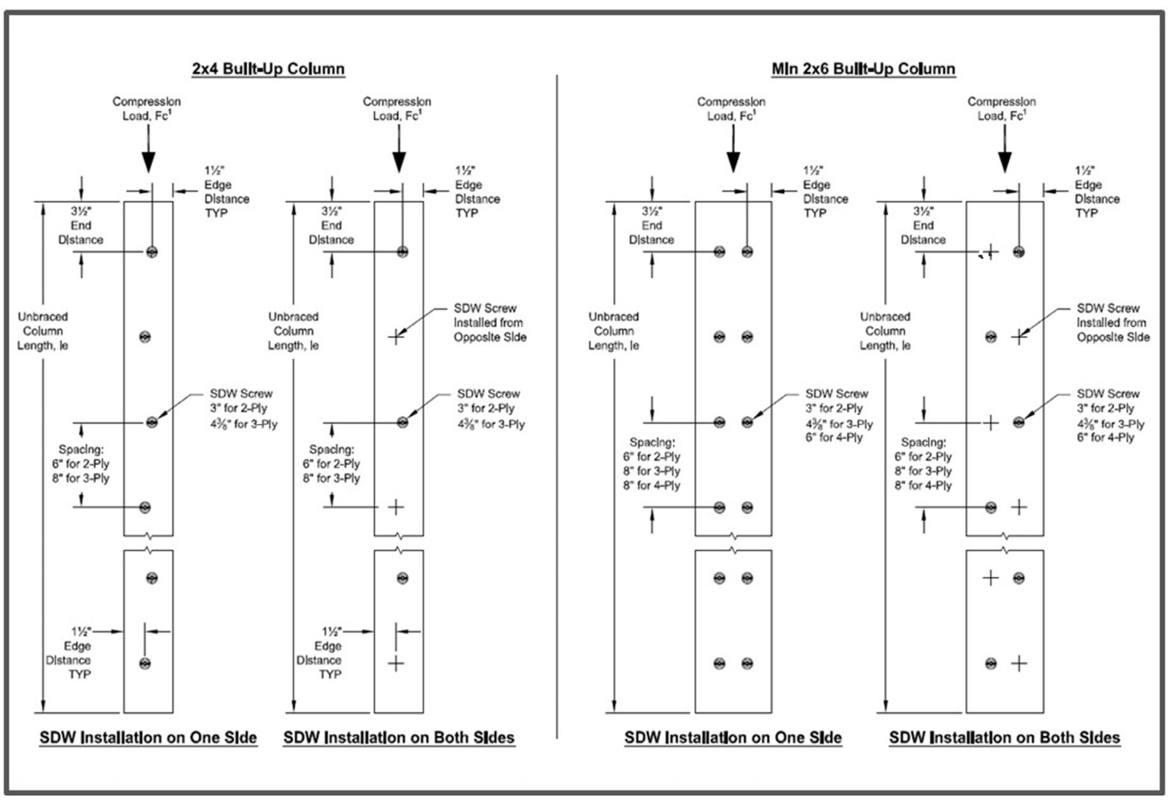


Figure 5. Fastener Schedule for Built-Up Columns Fastened with Strong-Drive® SDW Truss-Ply Screws.

4 – Built-Up Column

Required:

- Capacity for roof LL

HEM-FIR N°2
2x 1.5" x 7.25"
$A = 10.88\ in^2$ (EACH)
$F_c = 1300$ psi
$E_{MIN} = 470000$ psi
$\ell = 6'$ $K_e = 1.0$

1. Calculate slenderness ratio l_e/d
   largest ratio governs. Must be < 50

$\ell_e = 6' = 72"$

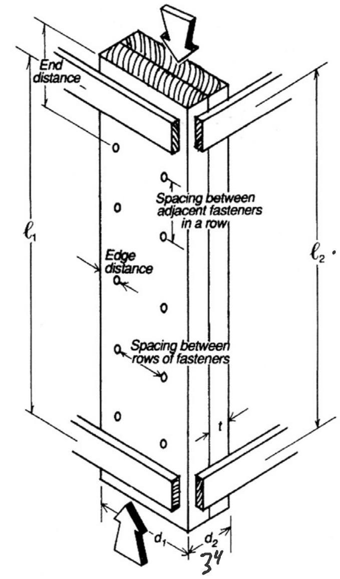
SLENDERNESS Y-Y

$$\frac{\ell_e}{d_2} = \frac{72"}{3"} = 24$$

2. Find adjustment factors ($C_M = C_t = C_i = 0$)
   C_D C_M C_t C_F C_i

$C_D = 1.25$ (FOR L_r)

$C_F = 1.05$ (FOR F_c) ✓



4 – Built-Up Column

HEM-FIR N°2
2x 1.5" x 7.25"
$A = 10.88\ in^2$ (EACH)
$F_c = 1300$ psi
$E_{MIN} = 470000$ psi
$\ell = 6'$ $K_e = 1.0$

3. Calculate C_P

$$C_P = K_f\left[\frac{1+\left(F_{cE}/F_c^*\right)}{2c} - \sqrt{\left[\frac{1+\left(F_{cE}/F_c^*\right)}{2c}\right]^2 - \frac{F_{cE}/F_c^*}{c}}\right] \quad (15.3\text{-}1)$$

where:

F_c^* = reference compression design value parallel to grain multiplied by all applicable modification factors except C_P (see 2.3)

$$F_{cE} = \frac{0.822\,E_{min}'}{\left(\ell_e/d\right)^2}$$

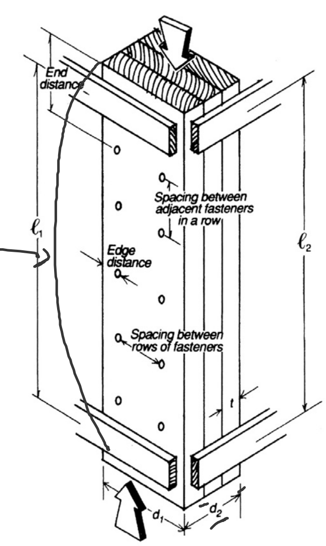
K_f = 0.6 for built-up columns where ℓ_{e2}/d_2 is used to calculate F_{cE} and the built-up columns are nailed in accordance with 15.3.3

K_f = 0.75 for built-up columns where ℓ_{e2}/d_2 is used to calculate F_{cE} and the built-up columns are bolted in accordance with 15.3.4

K_f = 1.0 for built-up columns where ℓ_{e1}/d_1 is used to calculate F_{cE} and the built-up columns are either nailed or bolted in accordance with 15.3.3 or 15.3.4, respectively

c = 0.8 for sawn lumber

c = 0.9 for structural glued laminated timber or structural composite lumber



4 – Built-Up Column

HEM-FIR N° 2
2 x 1.5" x 7.25"
$A = 10.88\ in^2$ (EACH)
$F_c = 1300$ PSI
$E_{MIN} = 470000$ PSI
$\ell = 6'$ $K_e = 1.0$

3. Calculate C_P

C_P

$K_f = 0.6$

$$F_{CE} = \frac{0.822(470\,000)}{24^2} = 670.7 \text{ PSI}$$

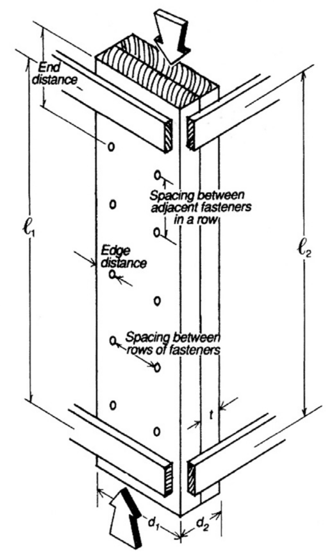
$$F_c^* = 1300(\overset{C_D}{1.25}\ \overset{C_F}{1.05}) = 1706 \text{ PSI}$$

$$\frac{F_{CE}}{F_c^*} = 0.39$$

$C = 0.8$ (SAWN LUMBER)

$$C_P = 0.6\left[\frac{1+0.39}{2(0.8)} - \sqrt{\left(\frac{1+0.39}{2(0.8)}\right)^2 - \frac{0.39}{0.8}}\right]$$

$C_P = \underline{0.2125}$



4 – Built-Up Column

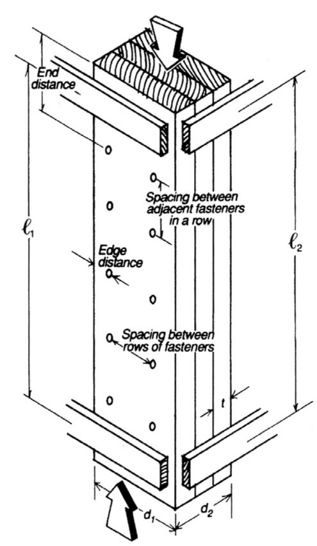
HEM-FIR N° 2
2 x 1.5" x 7.25"
$A = 10.88\ in^2$ (EACH)
$F_c = 1300$ PSI
$E_{MIN} = 470000$ PSI
$\ell = 6'$ $K_e = 1.0$

4. Determine F'c by multiplying the tabulated Fc by all the determining factors

$$F_c' = 1300(\overset{C_D}{1.25}\ \overset{C_F}{1.05}\ \overset{C_P}{0.212}) = 362.6 \text{ PSI}$$

4. Set the actual stress = allowable F'c = P/A
5. Solve for capacity, P = F'c A

$$P_{max} = F_c'\ A = 362.6\ (21.75) = \underline{7888 \text{ LBS}}$$



4 – Built-Up Column

Nailing requirements for 2 2x8's

(a) adjacent nails are driven from opposite sides of the column
(b) all nails penetrate all laminations and at least 3/4 of the thickness of the outermost lamination

b) 3/4 (1.5") = 1.125"
MIN. NAIL LENGTH = 1.5" + 1.125" = 2.625"
USE 10d COMMON L = 3" D = 0.148"

Table L4 Standard Common, Box, and Sinker Steel Wire Nails[1,2]

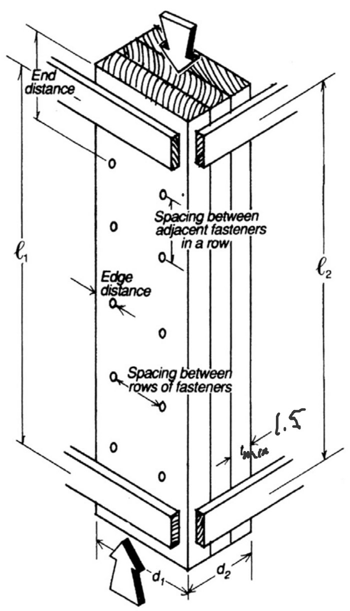
D = diameter, in.
L = length, in.
H = head diameter, in.

Type		6d	7d	8d	10d	12d	16d	20d	30d	40d	50d	60d
		Pennyweight										
Common	L	2	2-1/4	2-1/2	3"	3-1/4	3-1/2	4	4-1/2	5	5-1/2	6
	D	0.113	0.113	0.131	0.148	0.148	0.162	0.192	0.207	0.225	0.244	0.263
	H	0.266	0.266	0.281	0.312	0.312	0.344	0.406	0.438	0.469	0.5	0.531
Box	L	2	2-1/4	2-1/2	3	3-1/4	3-1/2	4	4-1/2	5		
	D	0.099	0.099	0.113	0.128	0.128	0.135	0.148	0.148	0.162		
	H	0.266	0.266	0.297	0.312	0.312	0.344	0.375	0.375	0.406		
Sinker	L	1-7/8	2-1/8	2-3/8	2-7/8	3-1/8	3-1/4	3-3/4	4-1/4	4-3/4		5-3/4
	D	0.092	0.099	0.113	0.12	0.135	0.148	0.177	0.192	0.207		0.244
	H	0.234	0.250	0.266	0.281	0.312	0.344	0.375	0.406	0.438		0.5

1. Tolerances are specified in ASTM F1667. Typical shape of common, box, and sinker steel wire nails shown. See ASTM F 1667 for other nail types.
2. It is permitted to assume the length of the tapered tip is 2D.

4 – Built-Up Column

Nailing requirements for 2 2x8's



(a) adjacent nails are driven from opposite sides of the column
(b) all nails penetrate all laminations and at least 3/4 of the thickness of the outermost lamination
(c) 15D ≤ end distance ≤ 18D
(d) 20D ≤ spacing between adjacent nails in a row ≤ $6t_{min}$
(e) 10D ≤ spacing between rows of nails ≤ 20D
(f) 5D ≤ edge distance ≤ 20D
(g) 2 or more longitudinal rows of nails are provided where $d > 3t_{min}$

b) 3/4 (1.5") = 1.125"
MIN. NAIL LENGTH = 1.5" + 1.125" = 2.625"
USE 10d COMMON L = 3" D = 0.148"

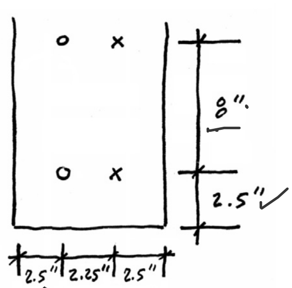
c) 15D = 2.22" 2.5 18D = 2.664"
USE END DISTANCE = 2.5"

d) 20D = 2.96" $6t_{min}$ = 6 (1.5) = 9"
ROW SPACING - USE 8"

e) 10D = 1.48" 2.25 / 20D = 2.96"
DISTANCE BETWEEN NAILS
USE 2.25"

f) 5D = 0.74" 2.5 20D = 2.96"
EDGE DISTANCE – USE 2.5"

g) $3t_{min}$ = 3 (1.5) = 4.5" < 7.25" d
∴ 2 LONGITUDINAL ROWS



4 – Built-Up Column

Bolted Provisions

15.3.4 Bolted Built-Up Columns

15.3.4.1 The provisions in 15.3.1 and 15.3.2 apply to bolted built-up columns in which:

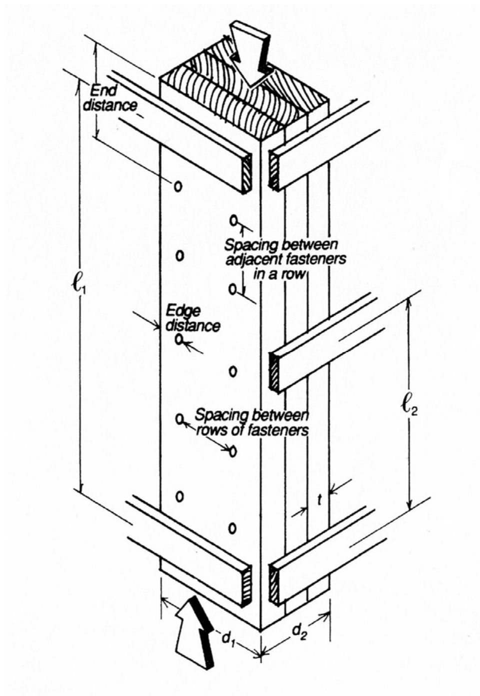
(a) a metal plate or washer is provided between the wood and the bolt head, and between the wood and the nut
(b) nuts are tightened to insure that faces of adjacent laminations are in contact
(c) for softwoods: $7D \leq$ end distance $\leq 8.4D$
for hardwoods: $5D \leq$ end distance $\leq 6D$
(d) $4D \leq$ spacing between adjacent bolts in a row $\leq 6t_{min}$
(e) $1.5D \leq$ spacing between rows of bolts $\leq 10D$
(f) $1.5D \leq$ edge distance $\leq 10D$
(g) 2 or more longitudinal rows of bolts are provided where $d > 3t_{min}$

where:

D = bolt diameter

d = depth (face width) of individual lamination

t_{min} = thickness of thinnest lamination



4 – Built-Up Column

Bolted Provisions

15.3.4 Bolted Built-Up Columns

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(a) a metal plate or washer is provided between the wood and the bolt head, and between the wood and the nut
(b) nuts are tightened to insure that faces of adjacent laminations are in contact
(c) for softwoods: $7D \leq$ end distance $\leq 8.4D$
for hardwoods: $5D \leq$ end distance $\leq 6D$
(d) $4D \leq$ spacing between adjacent bolts in a row $\leq 6t_{min}$
(e) $1.5D \leq$ spacing between rows of bolts $\leq 10D$
(f) $1.5D \leq$ edge distance $\leq 10D$
(g) 2 or more longitudinal rows of bolts are provided where $d > 3t_{min}$

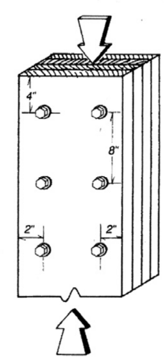
where:

D = bolt diameter

d = depth (face width) of individual lamination

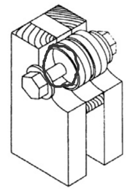
t_{min} = thickness of thinnest lamination

Figure 15D Typical Bolting Schedules for Built-Up Columns

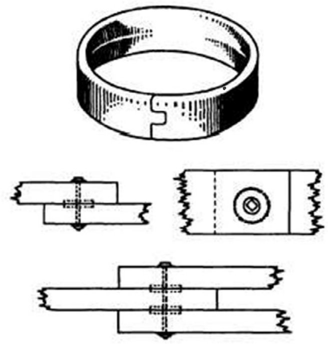


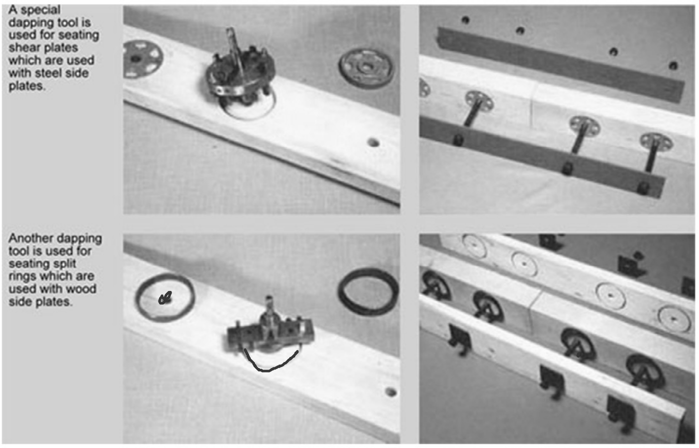
Four 2" x 8" laminations (softwoods) with two rows of ½" diameter bolts.

5 – Spaced Column



Typical shear plate connection in end block of spaced column

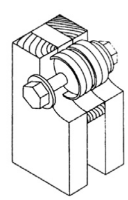




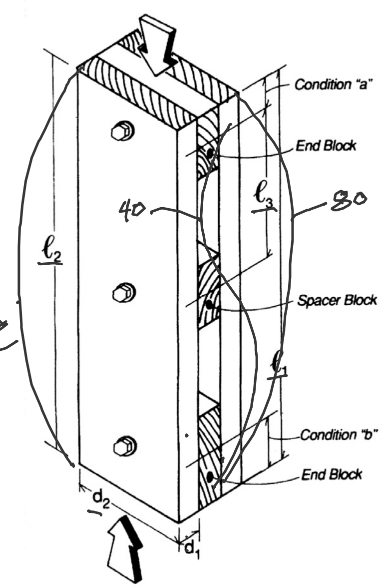
5 – Spaced Column

Required:

- Capacity



Typical shear plate connection in end block of spaced column



1. Determine end fixity condition "a" or "b"
2. Calculate slenderness ratios:
3. $l_1/d_1 < 80$
   $l_2/d_2 < 50$
   $l_3/d_1 < 40$
4. Find adjustment factors
   C_D C_M C_t C_F C_i
5. Calculate C_P. Kx is based on end condition "a" or "b"
6. Determine F'c by multiplying the tabulated Fc by all the above factors.
7. Set the actual stress = allowable F'c = P/A
8. Solve for capacity, P = F'c A

Condition "a": end distance $\le \ell_1/20$

ℓ_1 and ℓ_2 = distances between points of lateral support in planes 1 and 2, measured from center to center of lateral supports for continuous spaced columns, and measured from end to end for simple spaced columns, inches.

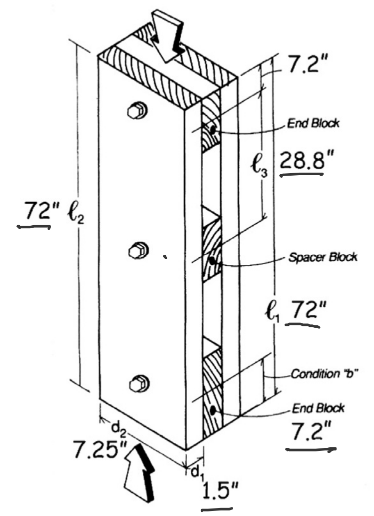
ℓ_3 = Distance from center of spacer block to centroid of the group of split ring or shear plate connectors in end blocks, inches.

d_1 and d_2 = cross-sectional dimensions of individual rectangular compression members in planes of lateral support, inches.

Condition "b": $\ell_1/20 <$ end distance $\le \ell_1/10$

5 – Spaced Column

HEM-FIR No 2
2x 1.5" x 7.25"
A = 10.88 in² (EACH)
$F_c = 1300$ psi
$E_{MIN} = 470000$ psi
$\ell = 6'$ $K_e = 1.0$



Required:

- Capacity for roof LL

1. Assuming end condition "b"
   72/10=7.2"

$$\frac{\ell_1}{20} = \frac{72}{20} = 3.6''$$
$$\frac{\ell_1}{10} = \frac{72}{10} = 7.2''$$

2. Calculate slenderness ratios:

$$\ell_1/d_1 = 72''/1.5'' = 48 < 80 \checkmark$$
$$\ell_2/d_2 = 72''/7.25'' = 9.9 < 50 \checkmark$$
$$\ell_3/d_1 = 28.8''/1.5'' = 19.2 < 40 \checkmark$$

Condition "a": end distance ≤ $\ell_1/20$ 3.6
ℓ_1 and ℓ_2 = distances between points of lateral support in planes 1 and 2, measured from center to center of lateral supports for continuous spaced columns, and measured from end to end for simple spaced columns, inches.
ℓ_3 = Distance from center of spacer block to centroid of the group of split ring or shear plate connectors in end blocks, inches.
d_1 and d_2 = cross-sectional dimensions of individual rectangular compression members in planes of lateral support, inches.
Condition "b": $\ell_1/20$ < end distance ≤ $\ell_1/10$
7.2

3. Find adjustment factors
   ($C_M = C_t = C_i = 0$)
   C_D C_M C_t C_F C_i

$$C_D = 1.25 \text{ (FOR } L_r) \checkmark$$
$$C_F = 1.05 \text{ (FOR } F_c)$$

5 – Spaced Column

$$F_{cE} = \frac{0.822\, K_x\, E_{min}'}{(\ell_e / d)^2}$$

K_x = 2.5 for fixity condition "a"
= 3.0 for fixity condition "b"

HEM-FIR No 2
2x 1.5" x 7.25"
A = 10.88 in² (EACH)
$F_c = 1300$ psi
$E_{MIN} = 470000$ psi
$\ell = 6'$ $K_e = 1.0$

4. Calculate C_P

$K_x = 3.0$ (CONDITION "b")
$c = 0.8$

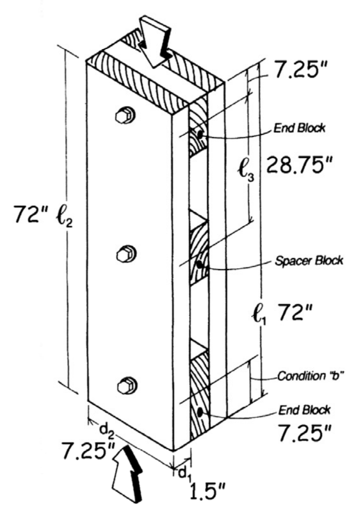
$$F_c^* = 1300(1.25\ 1.05) = 1706 \text{ psi}$$
(C_D, C_F)

$$F_{cE} = \frac{0.822\, K_x\, E_{min}'}{(\ell_e/d)^2} = \frac{0.822(3.0)(470000)}{(48)^2} = 503 \text{ psi}$$

$$F_{cE}/F_c^* = 503/1706 = 0.29$$

$$C_P = 0.274$$

$$\frac{\ell_1}{20} = \frac{72}{20} = 3.6''$$
$$\frac{\ell_1}{10} = \frac{72}{10} = 7.2''$$



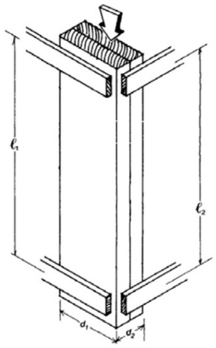
5. Determine F'c by multiplying the tabulated Fc by all the determining factors

$$F_c' = 1300(1.25\ 1.05\ 0.274) = 467.7 \text{ psi}$$
(C_D, C_F, C_P)

6. Set the actual stress = allowable F'c = P/A
7. Solve for capacity, P = F'c A

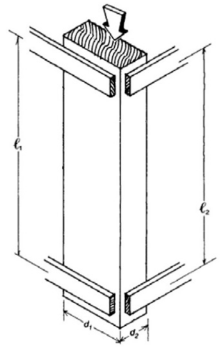
$$P_{max} = F_c' A = 467.7(21.75) = 10173 \text{ LB}$$

combined



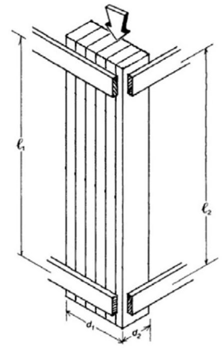
X 3.5k

solid



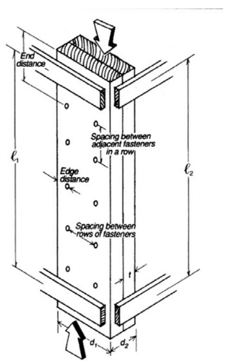
19.8k

glulam



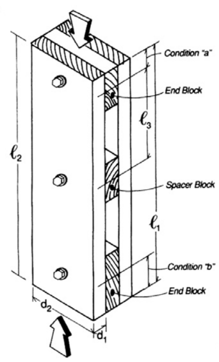
30.7k $

built-up



7.8k

spaced



10.1k $

Built-Up Column

capacity example

3 X 2x6 (1.5 x 5.5) S-P-F No.2
Fc = 1150 psi
Emin = 510000 psi NDS

height = 10 ft Ke = 1.0

C_D (snow) = 1.15
C_F = 1.1

$l_e/d = 120''/4.5'' = 26.67$

3x1.5

NAILED

Built-Up Column
capacity example

3 X 2x6 (1.5 x 5.5) S-P-F No.2
Fc = 1150 psi
Emin = 510000 psi

height = 10 ft Ke = 1.0

C_D (snow) = 1.15
C_F = 1.1

C_P :

$$F_{CE} = \frac{0.822(510000)}{26.67^2} = 589.5 \text{ psi}$$

$$F_C^* = 1150(1.15\ 1.10) = 1454.7 \text{ psi}$$

$$F_{CE}/F_C^* = \frac{589.5}{1454.7} = 0.405$$

$$c = 0.8$$

$$K_f = 0.6 \text{ (NAILED)}$$

$$C_P = 0.6\left[\frac{1+0.405}{2(0.8)} - \sqrt{\left(\frac{1+0.405}{2(0.8)}\right)^2 - \frac{0.405}{0.8}}\right]$$

$$C_P = 0.218$$

$$F_C' = 1150(1.15\ 1.10\ 0.218) = 317.4 \text{ psi}$$

$$P_{MAX} = F_C' A = 317.4(24.75) = 7856\ \#$$

TRIB. AREA = 18' x 6' = 108 SF

TOTAL LOAD CAPACITY = 7856/108 = 72.7 PSF