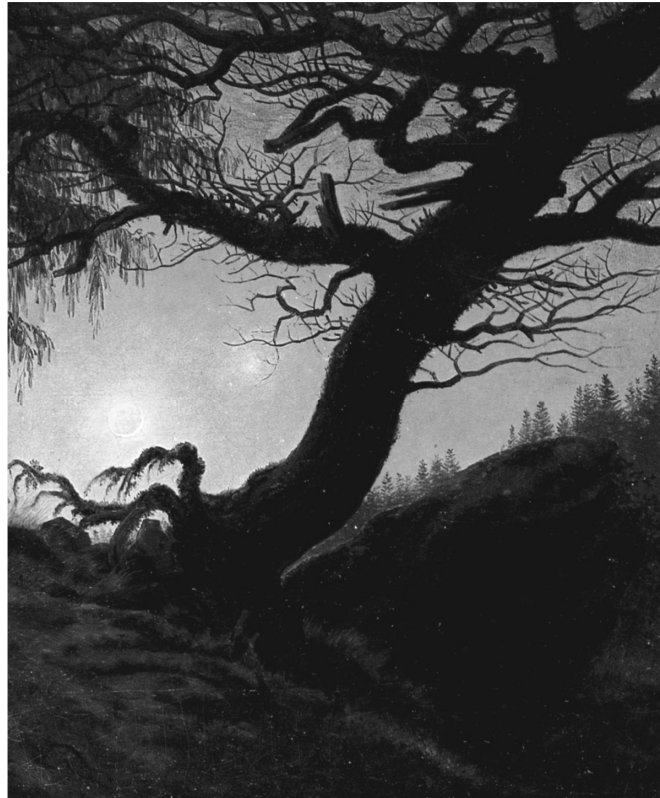


Combined Stress

- Axial vs. Eccentric Load
- Combined Stress
- Interaction Formulas



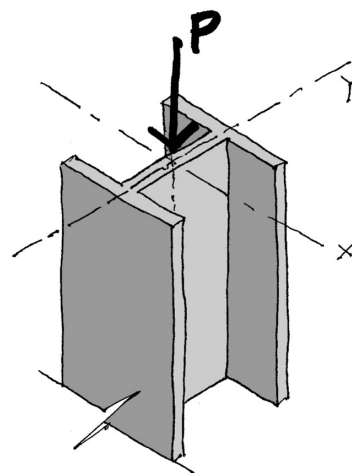
from "Man und Frau den Mond betrachtend"
1830-35 by Caspar David Friedrich
Alte Nationalgalerie, Berlin

Axial Stress

- Loads pass through the centroid of the section, i.e. axially loaded
- Member is straight
- Load less than buckling load

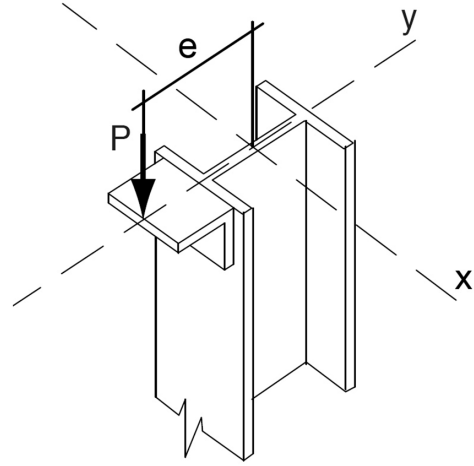
Then:

$$f_a = \frac{P}{A}$$



Eccentric Loads

- Load is offset from centroid
- Bending Moment = $P e$
- Total load = $P + M$



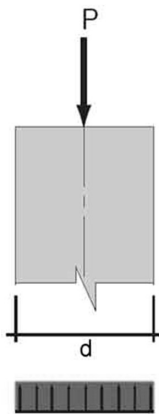
Interaction formula

$$f = \frac{P}{A} \pm \frac{Mc}{I}$$

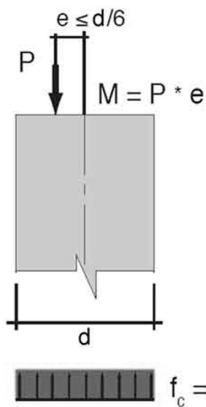
$$\frac{f_a}{F_a} \pm \frac{f_b}{F_b} \leq 1.0$$

Combined Stress

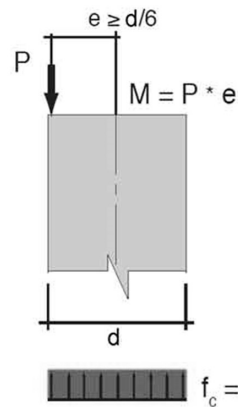
- Stresses combine by superposition
- Values add or subtract by sign



axial loaded - uniform compressive stress.



small eccentricity - linearly varying stress.



large eccentricity - tensile stress on part of cross section.

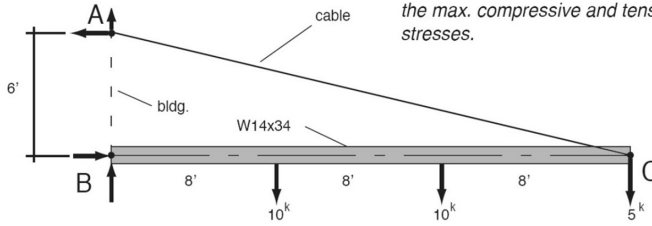
$$f'_c = \frac{P}{A} + \frac{M \cdot c}{I}$$

$$f'_c = \frac{P}{A} + \frac{M \cdot c}{I}$$

Example

CANOPY CONSTRUCTION PROJECTING FROM FACE OF BUILDING.
The supporting cable is pin-connected on the centroidal axis of the steel beam.

Reactions at face of building.



FOR THE W14x34:
Determine the magnitude and location of the max. compressive and tensile unit stresses.

1. Determine external reactions

$$\sum M_A = 0 = -B_H(6') + 10^k(8') + 10^k(16') + 5^k(24')$$

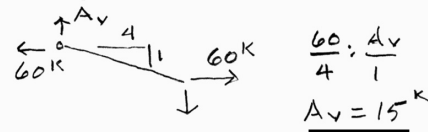
$$B_H = 60^k$$

$$\sum M_B = 0 = -A_H(6') + 10^k(8') + 10^k(16') + 5^k(24')$$

$$A_H = 60^k$$

$$\text{CHECK } \sum F_H = 0 = 60^k - 60^k \quad \checkmark$$

FBD @ A



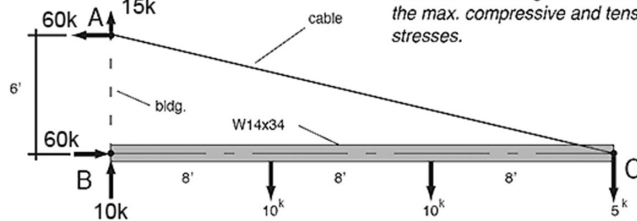
$$\sum F_V = 0 = 15^k - 10^k - 10^k - 5^k + B_V$$

$$B_V = 10^k$$

Example

CANOPY CONSTRUCTION PROJECTING FROM FACE OF BUILDING.
The supporting cable is pin-connected on the centroidal axis of the steel beam.

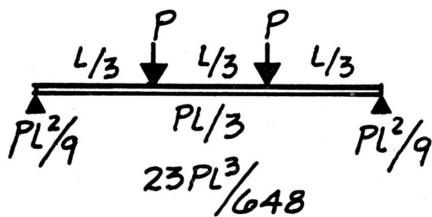
Reactions at face of building.



FOR THE W14x34:
Determine the magnitude and location of the max. compressive and tensile unit stresses.

2. Determine internal member forces: Axial and Flexural

3. Determine axial and flexural stresses



$$W14 \times 34 \quad A = 10.0 \text{ in}^2$$

$$S_x = 48.6 \text{ in}^3$$

FORCE:

$$\text{AXIAL} = 60^k$$

$$\text{FLEXURAL} = M = PL/3 = 10^k(8') = 80 \text{ k-ft}$$

STRESS:

$$\text{AXIAL} = f_a = \frac{P}{A} = \frac{60^k}{10 \text{ in}^2} = 6.0 \text{ KSI}$$

$$\text{FLEXURAL} = f_b = \frac{M}{S} = \frac{80 \text{ k-ft}(12)}{48.6 \text{ in}^3} = 19.75 \text{ KSI}$$

Example

2. Use interaction formula to determine combined stresses at key locations (e.g. extreme fibers)

COMBINED STRESS

TOP SIDE :

$$f_a + f_b = 6.0 + 19.75 = 25.75 \text{ KSI (COMP)}$$

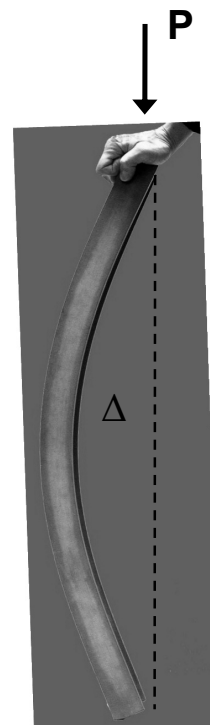
BOTTOM SIDE :

$$f_a - f_b = 6.0 - 19.75 = -13.75 \text{ KSI (TENS)}$$

Second Order Stress “P Delta Effect”

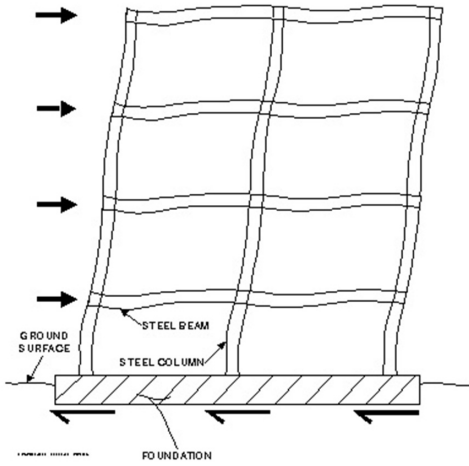
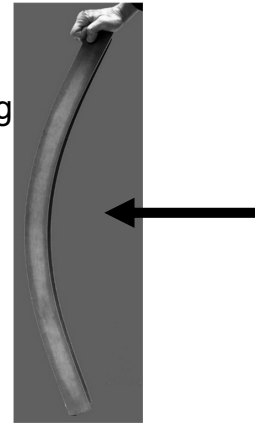
With larger deflections this can become significant.

1. Eccentric load causes bending moment
2. Bending moment causes deflection, Δ
3. $P \times \Delta$ causes additional moment

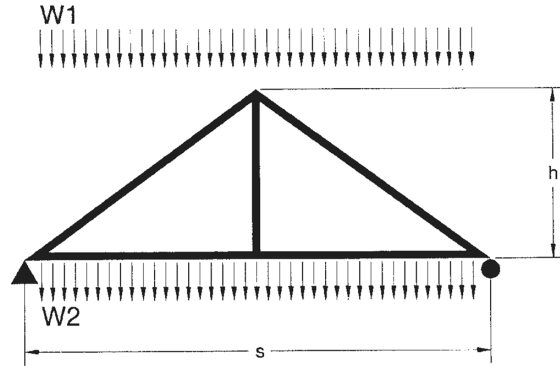


Other Examples of Combined Stress

Columns with side loading

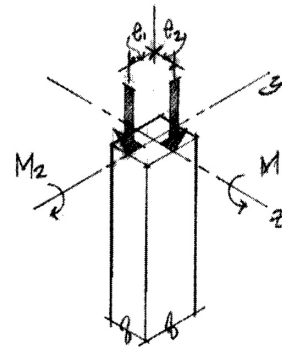
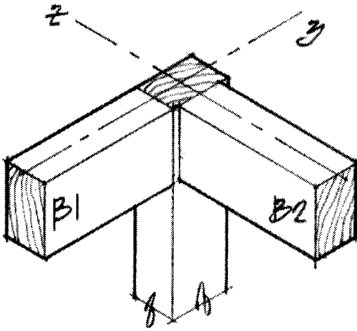


Moment frames



Trusses loaded on members

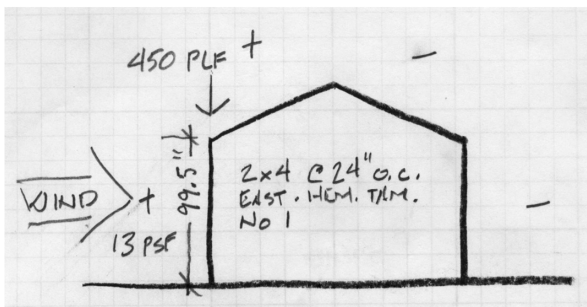
Other Examples of Combined Stress



$$M_1 = P_1 \times e_1 \text{ (ABOUT THE } z\text{-axis)}$$

$$M_2 = P_2 \times e_2 \text{ (ABOUT THE } y\text{-axis)}$$

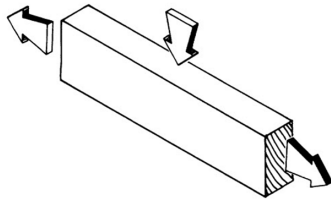
Eccentrically loaded columns



Wind load on walls

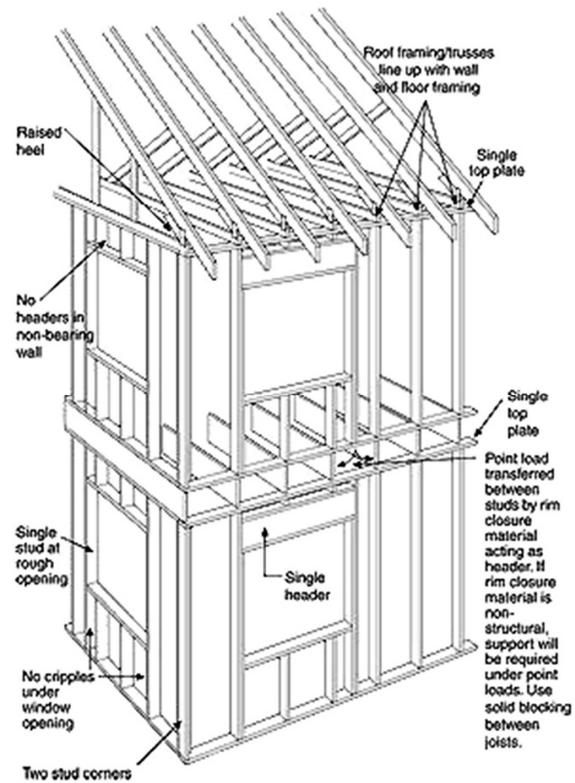
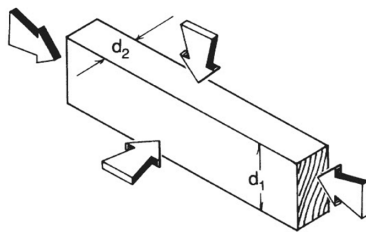
Combined Stress in NDS

Figure 3G Combined Bending and Axial Tension



3.9.2 Bending and Axial Compression

Figure 3H Combined Bending and Axial Compression



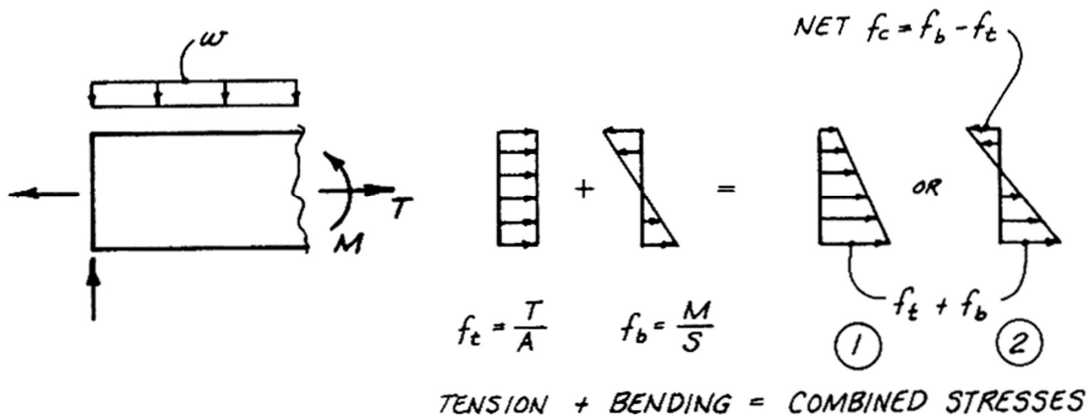
Tension + Flexure NDS Equations

CASE 1. Tension is critical. Eq. 3.9-1
* no C_L

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b'} \leq 1.0$$

CASE 2. Flexure is critical. Eq. 3.9-2
** no C_V

$$\frac{f_b - f_t}{F_b''} \leq 1.0$$



Tension + Flexure

3.9.1 Bending and Axial Tension

Members subjected to a combination of bending and axial tension (see Figure 3G) shall be so proportioned that:

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b^*} \leq 1.0 \quad \text{TENSION CRIT.} \quad (3.9-1)$$

and

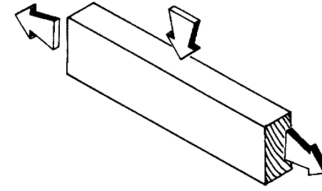
$$\frac{f_b - f_t}{F_b^{**}} \leq 1.0 \quad \text{FLEXURE CRIT.} \quad (3.9-2)$$

where:

F_b^* = reference bending design value multiplied by all applicable adjustment factors except C_L

F_b^{**} = reference bending design value multiplied by all applicable adjustment factors except C_v

Figure 3G Combined Bending and Axial Tension



Example Problem

Given: Queen Post truss
 Hem-Fir No.1 & Better
 $F_b = 1100$ psi
 $F_t = 725$ psi
 $F_c = 1350$ psi
 $E_{min} = 550000$ psi

span = 30 ft. spaced 48" o.c.
 D + S Load = 44 psf (projected)
 D (attic + ceiling) = 8 psf

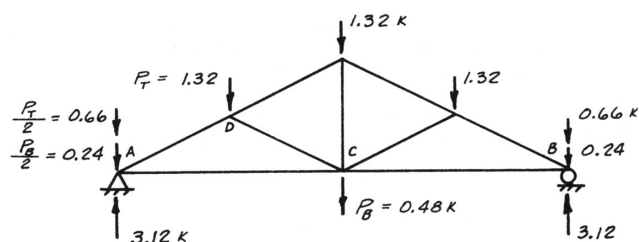
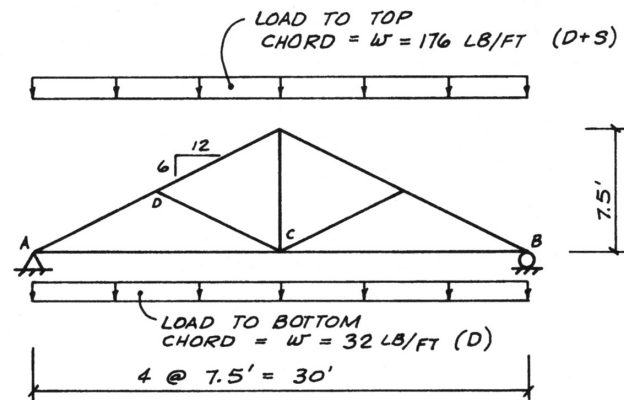
bottom chord: 2x8
 top chord: 2x10

Find: pass/fail

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b^*} \leq 1.0$$

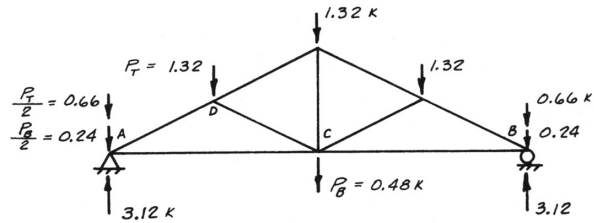
$$\frac{f_b - f_t}{F_b^{**}} \leq 1.0$$

1. Determine truss joint loading



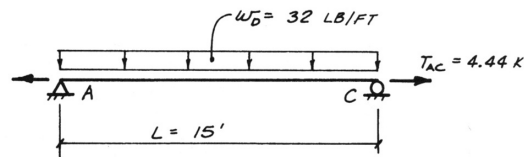
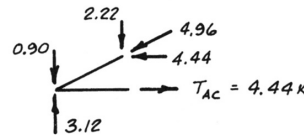
Example (cont.)

2. Determine the external **end reactions** of the whole truss. The geometry and loads are symmetric, so each reaction is $\frac{1}{2}$ of the total load.



3. Use an FBD of the reaction joint to find the **chord forces**. Sum the forces horizontal and vertical to find the components.

Top chord = 4.96 k compression
Bottom chord = 4.44 k tension



Example

bottom chord 2x8

$A = 10.875 \text{ in.}^2$

$S_x = 13.13 \text{ in.}^3$

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b''} \leq 1.0$$

and

$$\frac{f_b - f_t}{F_b''} \leq 1.0$$

4. Calculate the **actual** axial and flexural stress.

$$f_t = 408.3 \text{ psi}$$

$$f_b = 821.9 \text{ psi}$$

5. Determine **allowable** stresses using applicable factors:

(tension: D+S)

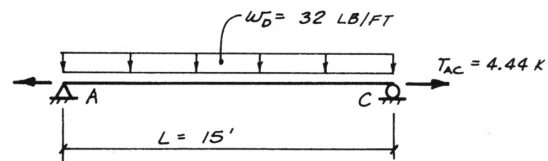
$$F_t' = F_t (C_D C_F)$$

$$F_t' = 725 (1.15 \cdot 1.2) = 1000 \text{ psi} > 408.3$$

(flexure: D+S)

$$F_b' = F_b (C_D C_L C_F)$$

$$F_b' = 1100 (1.15 \cdot 1.0 \cdot 1.2) = 1518 \text{ psi} > 821.9 \text{ psi}$$



$$f_t = \frac{P}{A} = \frac{4440 \text{ lbs}}{10.875 \text{ in.}^2} = 408.3 \text{ psi}$$

$$f_b = \frac{M}{S_x} = \frac{900 (12)}{13.14} = 821.9 \text{ psi}$$

$$M = \frac{w l^2}{8} = \frac{32 (15)^2}{8} = 900 \text{ ft-k}$$

$$S_x = 13.14 \text{ in.}^3$$

C_L is 1.0 BY 4.4.1
 $d/b < 4$, ENDS ARE HELD

Example
bottom chord 2x8

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b^*} \leq 1.0$$

and

$$\frac{f_b - f_t}{F_b^{**}} \leq 1.0$$

5. Determine **allowable** stresses using applicable factors:

(tension: D+S)

$$F_t' = F_t (C_D C_F)$$

$$F_t' = 725 (1.15 \cdot 1.2) = 1000 \text{ psi} > 408.3$$

(flexure: D+S)

$$F_b^* = F_b (C_D C_L C_F)$$

$$F_b^* = 1100 (1.15 \cdot 1.0 \cdot 1.2) = 1518 \text{ psi} > 821.9 \text{ psi}$$

Size Factors, C_F

Grades	Width (depth)	Thickness (breadth)		F_t	F_c
		2" & 3"	4"		
		2", 3", & 4"	1.5		
Select Structural, No.1 & Btr, No.1, No.2, No.3	5"	1.4	1.4	1.4	1.1
	6"	1.3	1.3	1.3	1.1
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.0
	12"	1.0	1.1	1.0	1.0
Stud	14" & wider	0.9	1.0	0.9	0.9
	2", 3", & 4"	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.0
Construction Standard	8" & wider	Use No.3			
	2", 3", & 4"	1.0	1.0	1.0	1.0
	4"	1.0	1.0	1.0	1.0
Utility	2" & 3"	0.4	—	0.4	0.6

4.4.1 Stability of Bending Members

3.3.3.2 When rectangular sawn lumber bending members are laterally supported in accordance with 4.4.1, $C_L = 1.0$.

4.4.1.2 As an alternative to 4.4.1.1, rectangular sawn lumber beams, rafters, joists, or other bending members, shall be designed in accordance with the following provisions to provide restraint against rotation or lateral displacement. If the depth to breadth, d/b , based on nominal dimensions is:

- (a) $d/b \leq 2$; no lateral support shall be required.
- (b) $2 < d/b \leq 4$; the ends shall be held in position, as by full depth solid blocking, bridging, hangers, nailing, or bolting to other framing members, or other acceptable means.

Example
bottom chord 2x8

$$f_t = 408.3 \text{ psi}$$

$$f_b = 821.9 \text{ psi}$$

$$F_t' = 1000 \text{ psi}$$

$$F_b^* = 1518 \text{ psi}$$

3.9.1 Bending and Axial Tension

Members subjected to a combination of bending and axial tension (see Figure 3G) shall be so proportioned that:

$$\frac{f_t}{F_t'} + \frac{f_b}{F_b^*} \leq 1.0 \quad \text{TENSION CRIT.} \quad (3.9-1)$$

and

$$\frac{f_b - f_t}{F_b^{**}} \leq 1.0 \quad \text{FLEXURE CRIT.} \quad (3.9-2)$$

where:

F_b^* = reference bending design value multiplied by all applicable adjustment factors except C_L

F_b^{**} = reference bending design value multiplied by all applicable adjustment factors except C_v

(3.9-1)

$$\frac{408.3}{1000} + \frac{821.9}{1518}$$

$$0.4083 + 0.5414 = 0.95$$

$$0.95 < 1.0 \quad \checkmark \text{PASS}$$

(3.9-2)

$$\frac{821.9 - 408.3}{1518} = 0.2724$$

$$0.27 < 1.0 \quad \checkmark \text{PASS}$$

Bending + Axial Compression

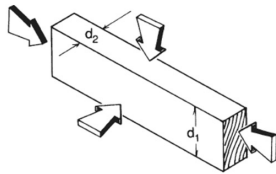
3.9.2 Bending and Axial Compression

Members subjected to a combination of bending about one or both principal axes and axial compression (see Figure 3H) shall be so proportioned that:

$$\left[\frac{f_c}{F_c'} \right]^2 + \frac{f_{b1}}{F_{b1}' \left[1 - (f_c/F_{cE1}) \right]} + \frac{f_{b2}}{F_{b2}' \left[1 - (f_c/F_{cE2}) - (f_{b1}/F_{bE})^2 \right]} \leq 1.0 \quad (3.9-3)$$

and

$$\frac{f_c}{F_{cE2}} + \left(\frac{f_{b1}}{F_{bE}} \right)^2 < 1.0 \quad (3.9-4)$$



where:

$$f_c < F_{cE1} = \frac{0.822 E_{min}'}{(\ell_{e1}/d_1)^2} \quad \text{for either uniaxial edgewise bending or biaxial bending}$$

and

$$f_c < F_{cE2} = \frac{0.822 E_{min}'}{(\ell_{e2}/d_2)^2} \quad \text{for uniaxial flatwise bending or biaxial bending}$$

and

$$f_{b1} < F_{bE} = \frac{1.20 E_{min}'}{(R_B)^2} \quad \text{for biaxial bending}$$

f_{b1} = actual edgewise bending stress (bending load applied to narrow face of member), psi

f_{b2} = actual flatwise bending stress (bending load applied to wide face of member), psi

d_1 = wide face dimension (see Figure 3H), in.

d_2 = narrow face dimension (see Figure 3H), in.

Example

top chord 2x10

4. Calculate the **actual** axial and flexural stress.

2x10:

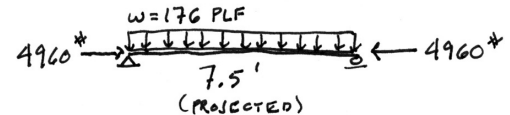
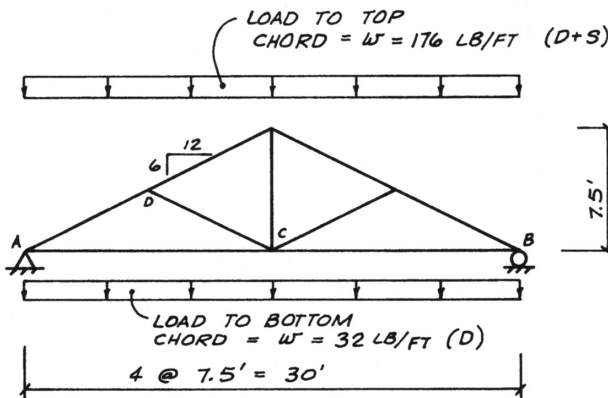
$A = 9.25 \text{ in}^2$

$f_c = 357.5 \text{ psi}$

$S_x = 21.39 \text{ in}^3$

$f_{b1} = 694.2 \text{ psi}$

$$\left[\frac{f_c}{F_c'} \right]^2 + \frac{f_{b1}}{F_{b1}' \left[1 - (f_c/F_{cE1}) \right]}$$

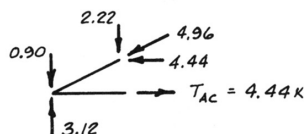


$$f_c = \frac{P}{A} = \frac{4960^*}{1.5 \times 9.25} = 357.5 \text{ psi}$$

$$f_b = \frac{M}{S_x} = \frac{1237.5(12)}{21.39} = 694.2 \text{ psi}$$

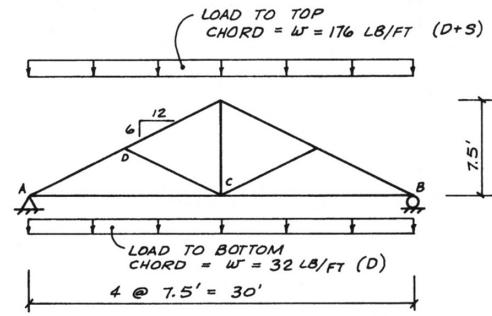
$$M = \frac{w l^2}{8} = \frac{176 \text{ PLF}(7.5')^2}{8} = 1237.5 \text{ ft-lb}$$

$$S_x = 21.39 \text{ in}^3$$



Example
top chord 2x10

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F_{b1}' \left[1 - (f_c/F_{cE1}) \right]}$$



5. Determine **allowable** stresses using applicable factors:

(compression: D+S)

$$F'_c = F_c (C_D C_F C_P)$$

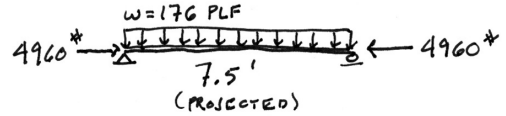
$$F'_c = 1350 (1.15 \cdot 1.0 \cdot 0.897) = 1392.6 \text{ psi} > 357.5$$

(flexure: D+S)

$$F'_b = F_b (C_D C_L C_F)$$

$$F'_b = 1100 (1.15 \cdot 1.0 \cdot 1.1) = 1391.5 \text{ psi} > 694.2$$

$$C_p = \frac{1 + (F_{cE}/F'_c)}{2c} - \sqrt{\left[\frac{1 + (F_{cE}/F'_c)}{2c} \right]^2 - \frac{F_{cE}/F'_c}{c}} \quad (3.7-1)$$



C_p

$$l_e = 8.385' \quad d = 9.25"$$

$$l_e/d = \frac{8.385(12)}{9.25} = 10.88$$

$$F_{cE} = \frac{0.822 E_{min}}{(l_e/d)^2} = \frac{0.822 (550000)}{10.88^2} = 3820 \text{ psi}$$

$$F_c^* = 1350 (1.15 \cdot 1.0) = 1552.5 \text{ psi}$$

$$F_{cE}/F_c^* = \frac{3820}{1552} = 2.46 \quad c = 0.8$$

$$C_p = 0.897$$

Example
top chord 2x10

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F_{b1}' \left[1 - (f_c/F_{cE1}) \right]}$$

5. Determine **allowable** stresses using applicable factors:

(compression: D+S)

$$F'_c = F_c (C_D C_F C_P)$$

$$F'_c = 1350 (1.15 \cdot 1.0 \cdot 0.897) = 1392.6 \text{ psi} > 357.5$$

(flexure: D+S)

$$F'_b = F_b (C_D C_L C_F)$$

$$F'_b = 1100 (1.15 \cdot 1.0 \cdot 1.1) = 1391.5 \text{ psi} > 694.2$$

Size Factors, C_F

		F_b		F_t	F_c
Grades	Width (depth)	Thickness (breadth)			
		2" & 3"	4"		
Select Structural, No.1 & Btr, No.1, No.2, No.3	2", 3", & 4"	1.5	1.5	1.5	1.15
	5"	1.4	1.4	1.4	1.1
	6"	1.3	1.3	1.3	1.1
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.0
	12"	1.0	1.1	1.0	1.0
	14" & wider	0.9	1.0	0.9	0.9
Stud	2", 3", & 4"	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.0
	8" & wider	Use No.3			
Construction Standard	2", 3", & 4"	1.0	1.0	1.0	1.0
Utility	4"	1.0	1.0	1.0	1.0
	2" & 3"	0.4	—	0.4	0.6

3.3.3 Beam Stability Factor, C_L

3.3.3.3 When the compression edge of a bending member is supported throughout its length to prevent lateral displacement, and the ends at points of bearing have lateral support to prevent rotation, $C_L = 1.0$.

Example

top chord 2x10

Eq. 3.9-3

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F_{b1}' [1 - (f_c/F_{cE1})]} \leq 1.0$$

COMP. + FLEXURE X-X

where:

$f_c < F_{cE1} = \frac{0.822 E_{min}'}{(\ell_{e1}/d_1)^2}$ EULER 1 for either uniaxial edge-wise bending or biaxial bending

and

$f_c < F_{cE2} = \frac{0.822 E_{min}'}{(\ell_{e2}/d_2)^2}$ EULER 2 for uniaxial flatwise bending or biaxial bending

and

$f_{b1} < F_{bE} = \frac{1.20 E_{min}'}{(R_b)^2}$ LTB for biaxial bending

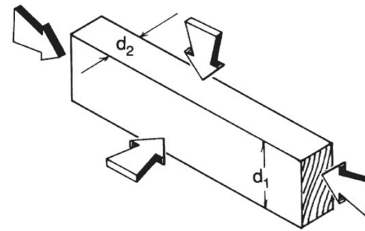
f_{b1} = actual edgewise bending stress (bending load applied to narrow face of member)

f_{b2} = actual flatwise bending stress (bending load applied to wide face of member)

d_1 = wide face dimension (see Figure 3H)

d_2 = narrow face dimension (see Figure 3H)

Figure 3H Combined Bending and Axial Compression



COMPRESSION:

$$\left[\frac{f_c}{F'_c} \right]^2 = \left[\frac{357.5}{1392.6} \right]^2 = 0.0659$$

Example

top chord 2x10

Eq. 3.9-3

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F_{b1}' [1 - (f_c/F_{cE1})]} \leq 1.0$$

COMP. + FLEXURE X-X

$f_c < F_{cE1} = \frac{0.822 E_{min}'}{(\ell_{e1}/d_1)^2}$ EULER 1 for either uniaxial edge-wise bending or biaxial bending

f_{b1} = actual edgewise bending stress (bending load applied to narrow face of member)

d_1 = wide face dimension (see Figure 3H)

d_2 = narrow face dimension (see Figure 3H)

$$f_c = \frac{P}{A} = \frac{4960^*}{1.5 \times 9.25} = 357.5 \text{ psi}$$

$$f_b = \frac{M}{S_x} = \frac{1237.5 (12)}{21.39} = 694.2 \text{ psi}$$

$$M = \frac{w \cdot l^2}{8} = \frac{176 \text{ PLF} (7.5')^2}{8} = 1237.5 \text{ ft} \cdot \text{ft}$$

$$S_x = 21.39 \text{ in}^3$$

$$f_c = 357.5 \text{ psi}$$

$$E_{min} = 550000 \text{ psi}$$

$$\ell_{e1} = 8.385'$$

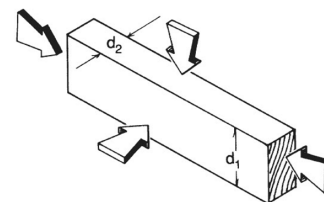
$$d_1 = 9.25''$$

$$\ell_{e1}/d_1 = \frac{8.385 (12)}{9.25''} = 10.88$$

$$F_{cE1} = \frac{0.822 (550000)}{10.88^2}$$

$$= 3820 \text{ psi}$$

Figure 3H Combined Bending and Axial Compression



FLEXURE:

$$\frac{f_{b1}}{F_{b1}'} = \frac{694.2}{1392} = 0.4987$$

AMPLIFICATION FACTOR:

$$\frac{1}{1 - (357.5/3820)} = \frac{1}{0.906}$$

$$0.4987 (1.103) = 0.550$$

COMBINATION:

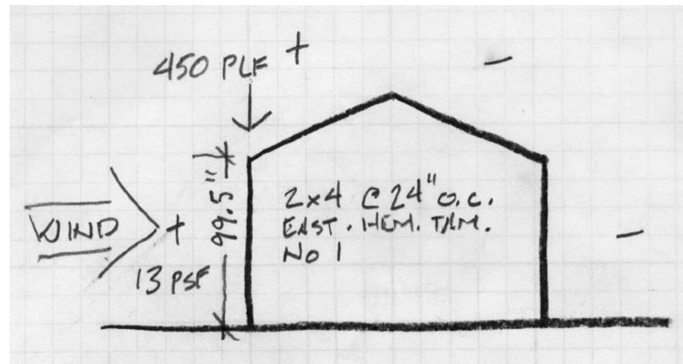
$$0.0659 + 0.550 = 0.616$$

$$0.616 < 1.0 \checkmark \text{ PASS}$$

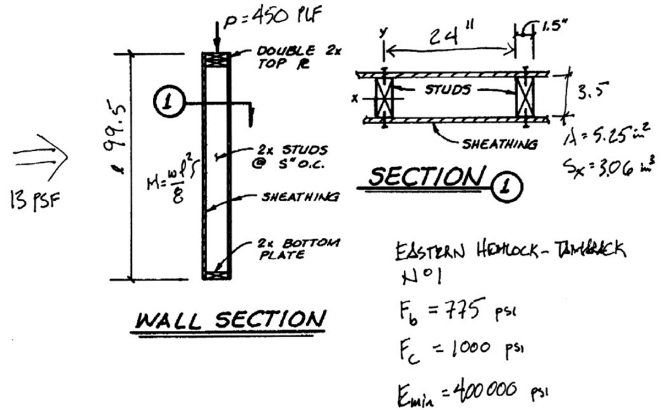
Combined Stress in NDS procedure

Exterior stud wall under bending + axial compression

1. Determine load per stud
2. Use axial load and moment to find actual stresses f_c and f_b
3. Determine load factors
4. Calculate factored stresses
5. Check NDS equations



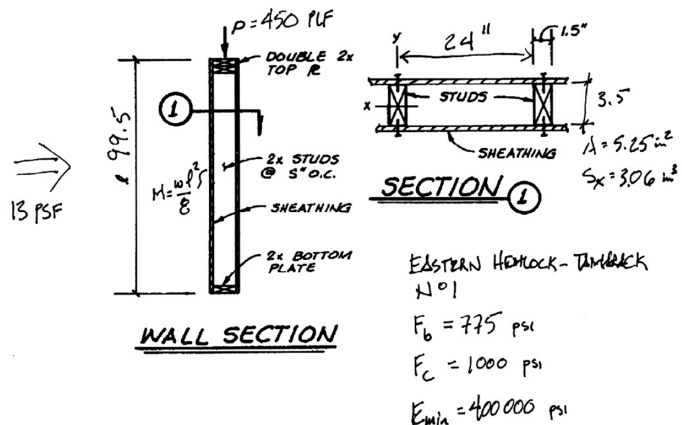
$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_b}{F_{b1} \left[1 - (f_c / F_{cE1}) \right]} \leq 1.0 \quad (3.9-3)$$



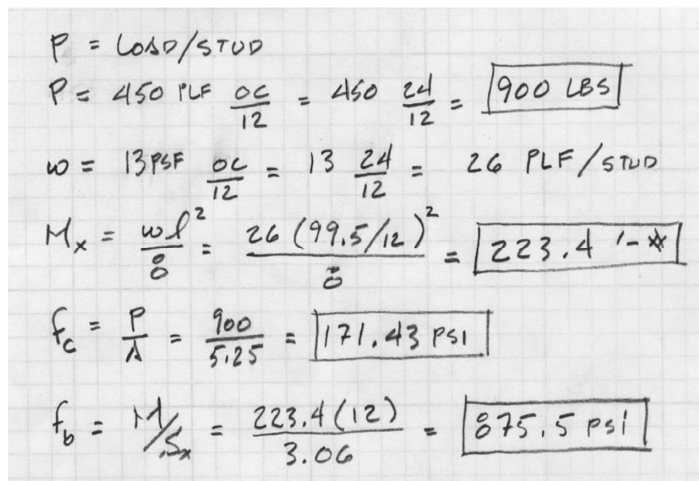
Combined Stress in NDS example

Exterior stud wall under bending + axial compression

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_b}{F_{b1} \left[1 - (f_c / F_{cE1}) \right]} \leq 1.0 \quad (3.9-3)$$



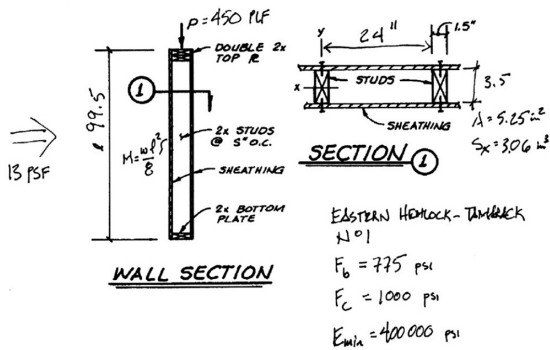
1. Determine load per stud
2. Use axial load and moment to find actual stresses f_c and f_b



Combined Stress in NDS

example

Exterior stud wall under bending + axial compression



3. Determine load factors (bending)

Size Factors, C_F

Grades	Width (depth)	Thickness (breadth)		F_t	F_c
		2" & 3"	4"		
		2", 3", & 4"	1.5		
Select	5"	1.4	1.4	1.4	1.1
Structural, No. 1 & Btr, No. 1, No. 2, No. 3	6"	1.3	1.3	1.3	1.1
	8"	1.2	1.3	1.2	1.05
	10"	1.1	1.2	1.1	1.0
	12"	1.0	1.1	1.0	1.0
	14" & wider	0.9	1.0	0.9	0.9
Stud	2", 3", & 4"	1.1	1.1	1.1	1.05
	5" & 6"	1.0	1.0	1.0	1.0
	8" & wider	Use No. 3			
Construction Standard	2", 3", & 4"	1.0	1.0	1.0	1.0
Utility	4"	1.0	1.0	1.0	1.0
	2" & 3"	0.4	—	0.4	0.6

$F_b = 775 \text{ psi}$ $F_c = 1000 \text{ psi}$ $E_{min} = 400,000 \text{ psi}$

FACTORS :

$C_D = 1.6$ (WIND)
 $C_F = 1.5$ (FOR F_b) 1.15 (FOR F_c)
 $C_L = 1.0$ (BRACED BY SHEATHING)
 $C_r = 1.15$ ($\leq 24" \text{ o.c.}$)

Combined Stress in NDS

example

Exterior stud wall under bending + axial compression

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F'_{b1} \left[1 - (f_c / F_{cE1}) \right]}$$

$F_b = 775 \text{ psi}$

$C_D = 1.6$ $C_F = 1.5$
 $C_M = 1.0$ $C_{F_b} = 1.0$
 $C_t = 1.0$ $C_i = 1.0$
 $C_L = 1.0$ $C_r = 1.15$

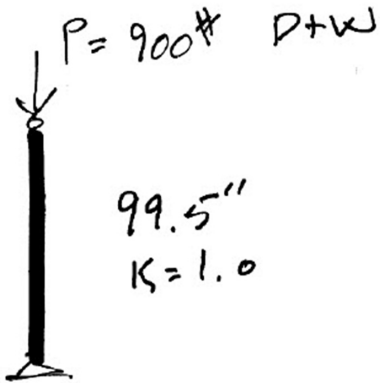
4. Calculate factored stresses (bending stress)

$F'_b = 775 (1.6) (1.5) (1.15)$
 $= 2139 \text{ psi}$

Combined Stress in NDS

example

Exterior stud wall under bending + axial compression



- Determine load factors (compression)

$$C_p = \frac{1 + (F_{CE}/F_c^*)}{2c} - \sqrt{\left[\frac{1 + (F_{CE}/F_c^*)}{2c} \right]^2 - \frac{F_{CE}/F_c^*}{c}}$$

$$F_{CE} = \frac{0.822 E_{min}'}{(l_e/d)^2}$$

$c = 0.8$ for sawn lumber

C_p

$$F_c^* = 1000(1.6)(1.15) = 1840$$

$$F_{CE} = \frac{0.822(400000)}{(99.5/3.5)^2} = 406.8$$

$$c = 0.8$$

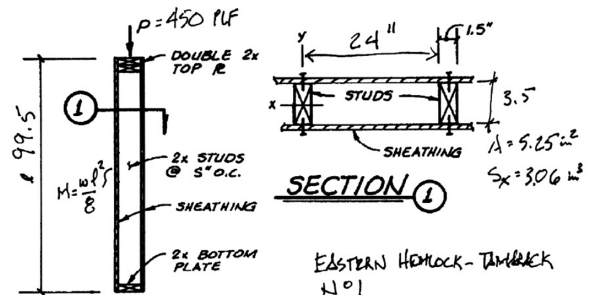
$$C_p = 0.21$$

Combined Stress in NDS

example

Exterior stud wall under bending + axial compression

$$\left[\frac{f_c}{F_c'} \right]^2 + \frac{f_{b1}}{F_{b1}' \left[1 - (f_c/F_{CE1}) \right]}$$



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#1

$F_b = 775$ psi

$F_c = 1000$ psi

$E_{min} = 400000$ psi

- Calculate stresses (compression stress)

Actual Stress

$$f_c = \frac{P}{A} = \frac{900\#}{5.15} = 171.4 \text{ psi}$$

Factored Allowable Stress

$$F_c' = 1000(1.6)(1.15)(0.21) = 386.4 \text{ psi}$$

Combined Stress in NDS

example

Exterior stud wall under
bending + axial compression

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F_{b1}' [1 - (f_c/F_{cE1})]} \leq 1.0$$

COMP. + FLEXURE X-X

$$f_c = \frac{P}{A} = \frac{900}{5.25} = 171.43 \text{ psi}$$

$$f_b = \frac{M}{S_x} = \frac{223.4(12)}{3.06} = 875.5 \text{ psi}$$

5. Combined Stress Calculation (eq. 3.9-3)

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

$$F_{cE} = \frac{0.822(400000)}{(99.5/3.5)^2} = 406.8$$

$$\left[\frac{f_c}{F'_c} \right]^2 + \frac{f_{b1}}{F_{b1}' \frac{1}{1 - (f_c/F_{cE1})}} \leq 1.0$$

$$\left[\frac{171.4}{386.4} \right]^2 + \frac{876}{2139 \frac{1}{1 - (171.4/406.8)}}$$

$$0.1967 + (0.4095)(1.728) =$$

$$0.1967 + 0.7077 = 0.9045 \leq 1.0 \checkmark \text{OK}$$