Combined Stress 4/19

HW – Combined Stress

Lab – Combined Stress

Structure II
Section 004

Yifan Ma
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Full span of truss	13 FT
Height of truss	5 FT
On Center spacing of trusses	24 IN
Size of bottom chord	2x8
Actual width, b	1.5 IN
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Snow Load on roof, w1	30 PSF
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Factored allowable bending stress, F'b	1064 PSI
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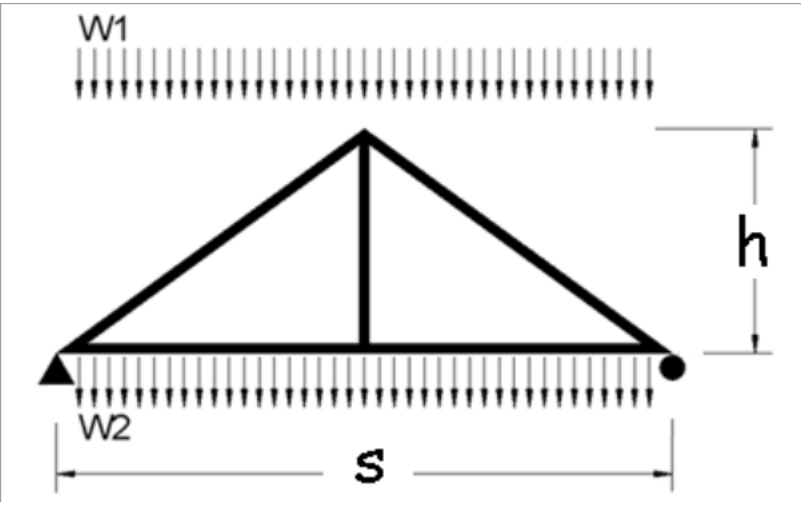
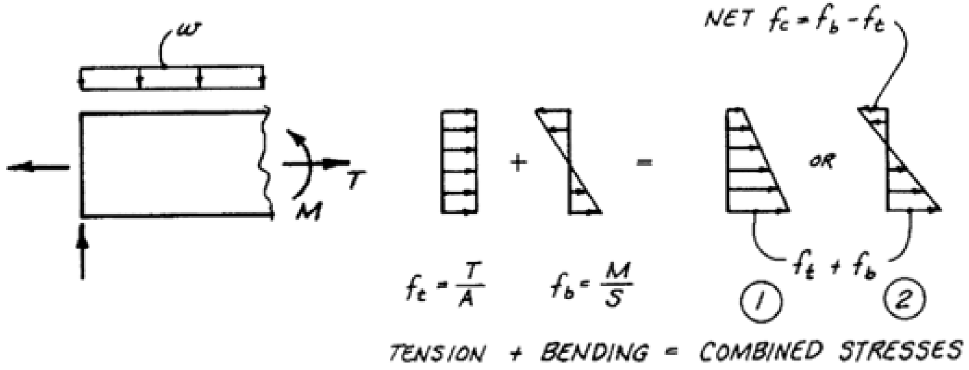


Data:
geometry, load

Required:
pass or fail

1. Determine truss joint loading
2. Determine the external end reactions of the whole truss.
3. Use an FBD of the reaction joint to find the chord forces. Sum the forces horizontal and vertical to find the components.
4. Calculate the actual axial and flexural stress.
5. Determine allowable stresses using applicable factors
6. Check NDS equations



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:

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

and

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

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

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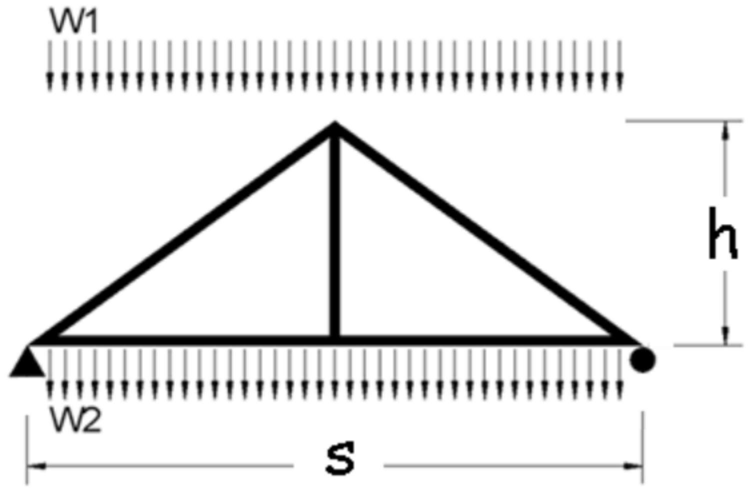

1. Load on one truss-top chord, w1

w1_top = w1(area) * o.c.spacing = 30*24/12 = 60 plf

2. Load on one truss-bottom chord, w2

w2_bottom = w2(area) * o.c. spacing = 35*24/12 = 70 plf

3. Total left reaction due to total load (w1 and w2)

R_left= R_right=Total load /2 = (w1_top + w2_bottom)*span/2
=(60+70)*13/2 = 845 lbs

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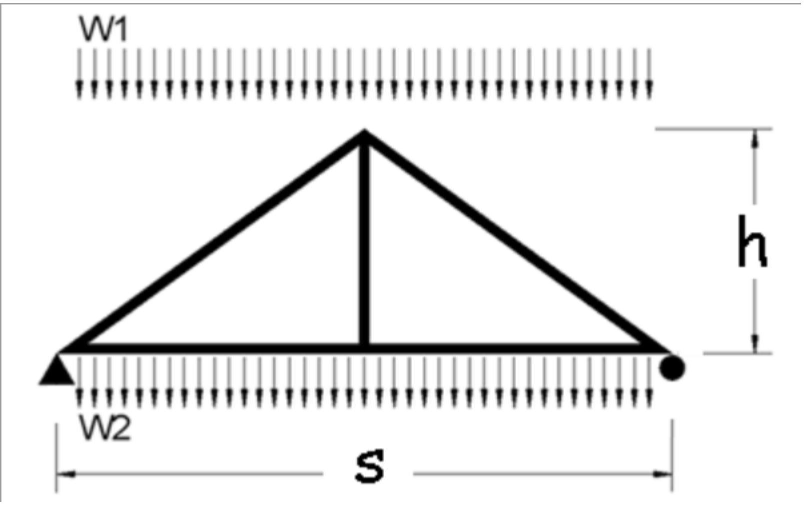
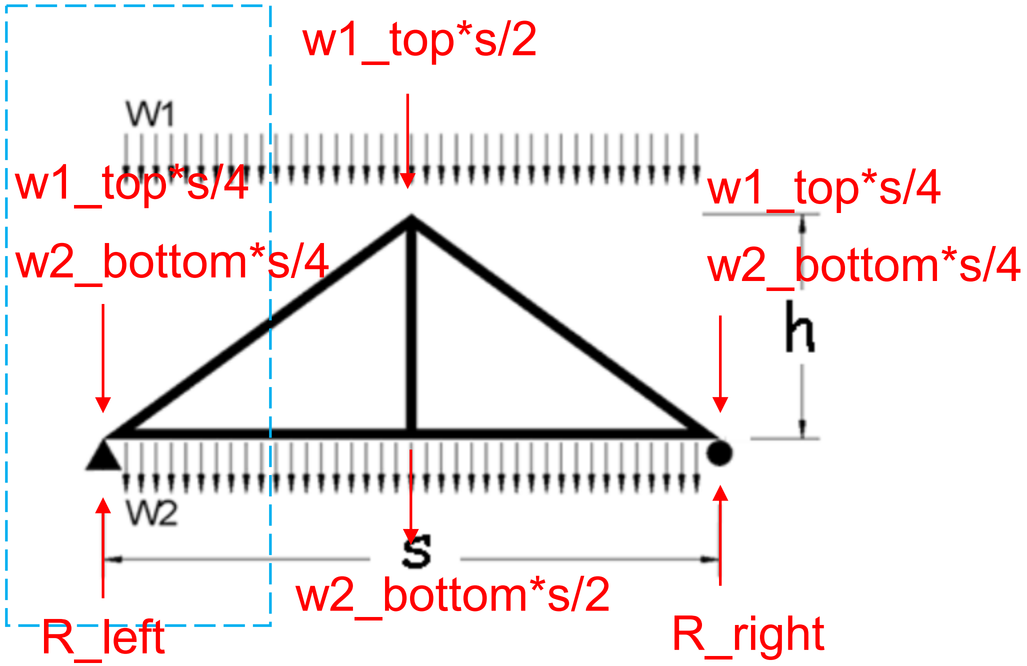


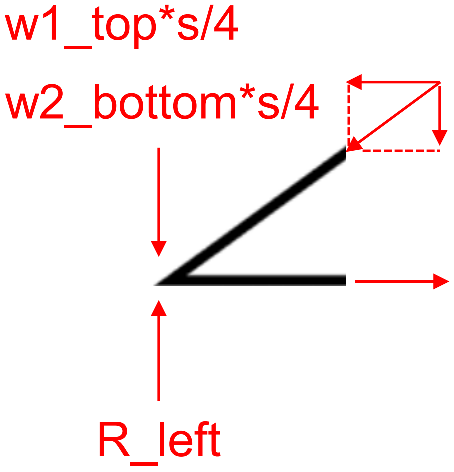
4. Vertical force component in truss top chord (no sign)

$$\sum F_v = F_{v\_top} + w1\_top*s/4 + w2\_bottom*s/4 - R\_left = 0$$

$$F_{v\_top} = R\_left - w1\_top*s/4 - w2\_bottom*s/4$$

$$= 845-60*13/4-70*13/4= 422.5 \text{ lbs}$$





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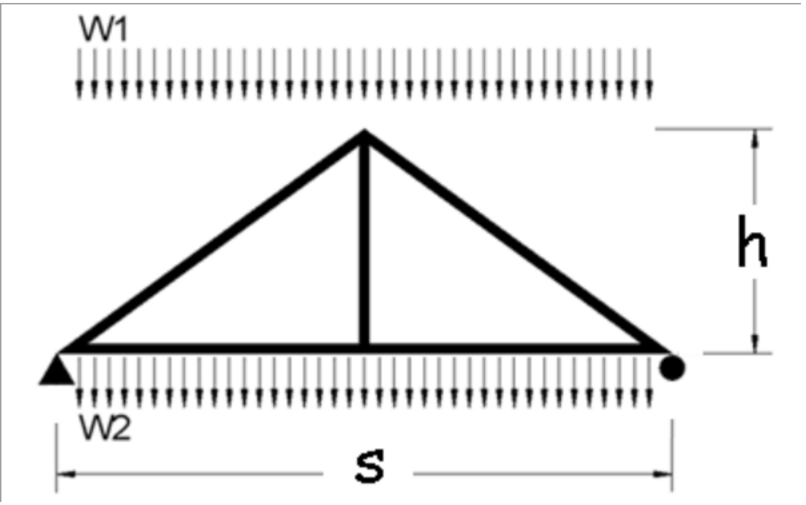


5. Horizontal force component in truss top chord(no sign)

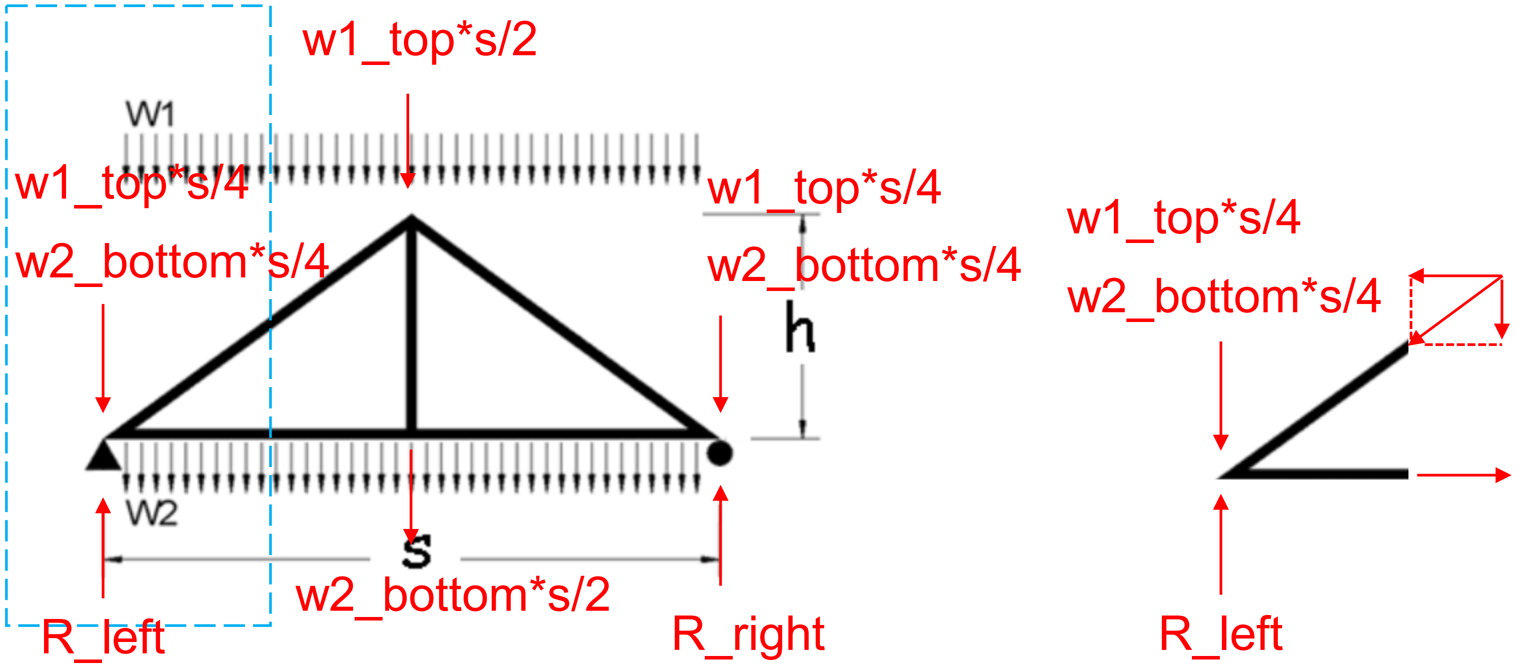
$$\frac{Fv\_top}{Fh\_top} = \frac{h}{s/2}$$

Fh_top =(Fv_top * s/2) /h = (422.5*13/2) / 5 = 549.25 lbs

6. Axial force in the truss bottom chord(- if Compression)

∑Fh =Fh_bottom-Fh_top = 0

F_bottom= Fh_bottom= Fh_top = 549.25 lbs In Tension



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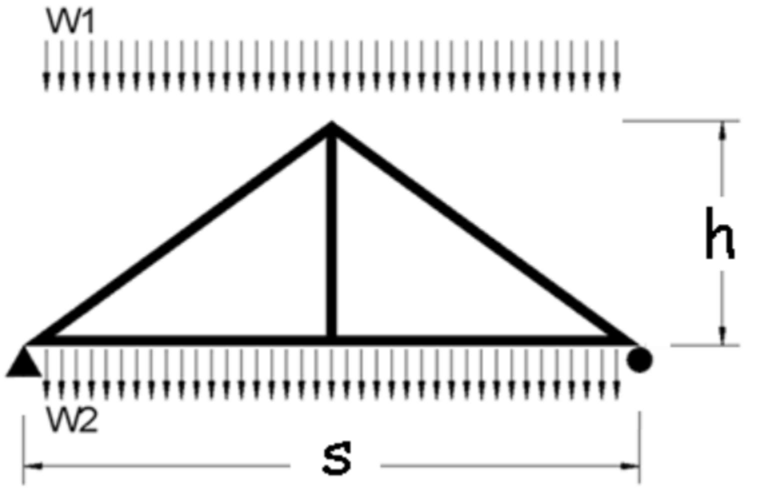


7. Area of the bottom chord member

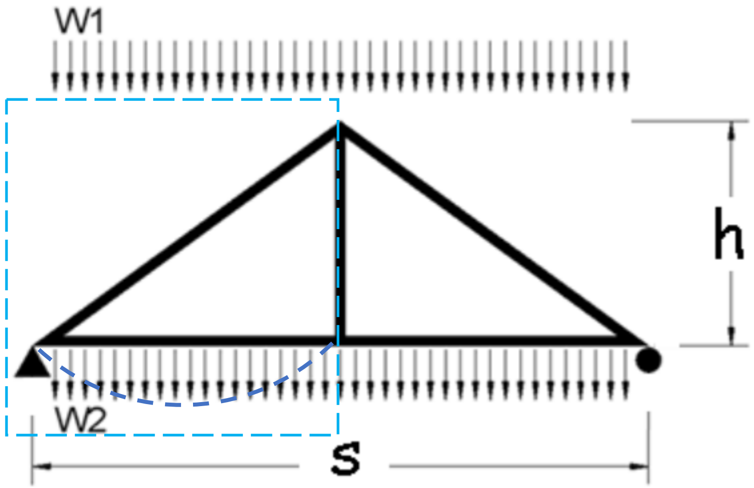
Area_bottom = b x d = 1.5*7.25 = 10.875 in²

8. Axial stress in the bottom chord(-Compression)

f_bottom = F_bottom / Area_bottom = 549.25/10.875 = 50.51 psi

9. Maximum bending moment in the bottom chord member

M = wl²/8 = w2*(s/2)²/8 = 70*(13/2)²/8 = 369.69 ft-lbs



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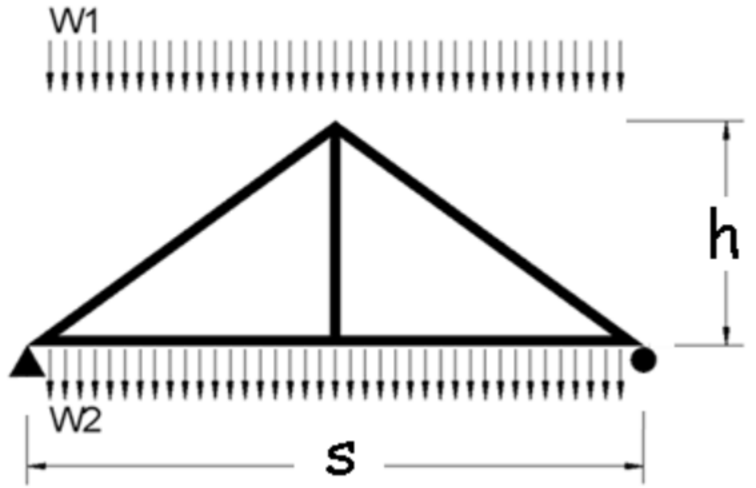

10. Section modulus of the bottom chord member Sx

NDS supplement Table 1B

$S_x = 13.14\ in^3$

Table 1B Section Properties of Standard Dressed (S4S) Sawn Lumber

Nominal Size b x d	Standard Dressed Size (S4S) b x d in. x in.	Area of Section A $in.^2$	X-X AXIS Section Modulus S_{xx} $in.^3$	X-X AXIS Moment of Inertia I_{xx} $in.^4$	Y-Y AXIS Section Modulus S_{yy} $in.^3$	Y-Y AXIS Moment of Inertia I_{yy} $in.^4$	Approximate weight in pounds per linear foot (lbs/ft) of piece when density of wood equals: 25 lbs/ft^3	30 lbs/ft^3	35 lbs/ft^3	40 lbs/ft^3	45 lbs/ft^3	50 lbs/ft^3
Boards[1]												
1 x 3	3/4 x 2-1/2	1.875	0.781	0.977	0.234	0.088	0.326	0.391	0.456	0.521	0.586	0.651
1 x 4	3/4 x 3-1/2	2.625	1.531	2.680	0.328	0.123	0.456	0.547	0.638	0.729	0.820	0.911
1 x 6	3/4 x 5-1/2	4.125	3.781	10.40	0.516	0.193	0.716	0.859	1.003	1.146	1.289	1.432
1 x 8	3/4 x 7-1/4	5.438	6.570	23.82	0.680	0.255	0.944	1.133	1.322	1.510	1.699	1.888
1 x 10	3/4 x 9-1/4	6.938	10.70	49.47	0.867	0.325	1.204	1.445	1.686	1.927	2.168	2.409
1 x 12	3/4 x 11-1/4	8.438	15.82	88.99	1.055	0.396	1.465	1.758	2.051	2.344	2.637	2.930
Dimension Lumber (see NDS 4.1.3.2) and Decking (see NDS 4.1.3.5)												
2 x 3	1-1/2 x 2-1/2	3.750	1.56	1.953	0.938	0.703	0.651	0.781	0.911	1.042	1.172	1.302
2 x 4	1-1/2 x 3-1/2	5.250	3.06	5.359	1.313	0.984	0.911	1.094	1.276	1.458	1.641	1.823
2 x 5	1-1/2 x 4-1/2	6.750	5.06	11.39	1.688	1.266	1.172	1.406	1.641	1.875	2.109	2.344
2 x 6	1-1/2 x 5-1/2	8.250	7.56	20.80	2.063	1.547	1.432	1.719	2.005	2.292	2.578	2.865
2 x 8	1-1/2 x 7-1/4	10.88	13.14	47.63	2.719	2.039	1.888	2.266	2.643	3.021	3.398	3.776
2 x 10	1-1/2 x 9-1/4	13.88	21.39	98.93	3.469	2.602	2.409	2.891	3.372	3.854	4.336	4.818
2 x 12	1-1/2 x 11-1/4	16.88	31.64	178.0	4.219	3.164	2.930	3.516	4.102	4.688	5.273	5.859
2 x 14	1-1/2 x 13-1/4	19.88	43.89	290.8	4.969	3.727	3.451	4.141	4.831	5.521	6.211	6.901

11. Maximum bending stress in the bottom chord member

$f_b = M/S_x = 369.69*12/13.14 = 337.62\ PSI$

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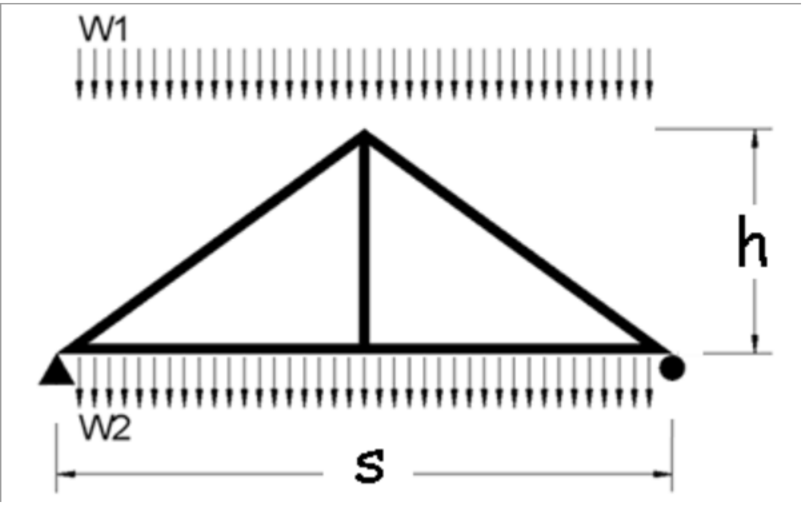


12. Combined stress using NSD equation 3.9-1

ft/F’t + fb/F’b = 50.51/633+337.62/1064
= 0.397 < 1

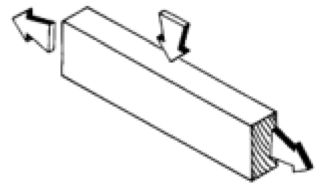
13.Combined stress using NSD equation 3.9-2

(fb-ft)/F’b = (337.62-50.51)/1064
= 0.270 < 1

14. Does member pass?

Pass,1

Figure 3G Combined Bending and Axial Tension



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

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where:

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

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LAB – Combined Stress

Description

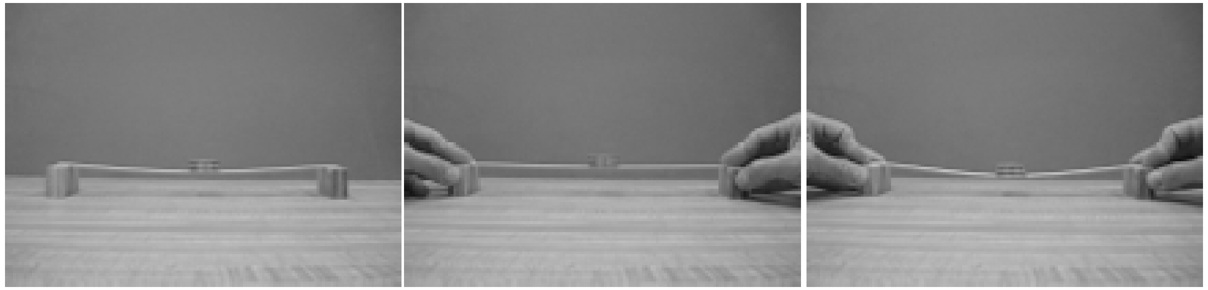
This project uses observation of a physical trial to see the effects of flexure combined with tension or compression.

Goals

To observe the behavior of tension + flexure
To observe the behavior of compression + flexure
To estimate the addition of combined stress profiles
To observe the results of P + delta loading

Procedure

1. Load the 12 inch wood stick with 4 washers at midspan as shown below. The stick is 1/16"x1/2" $A=0.03125\ in^2$ $Sy=0.0003255\ in^3$ 4 washers = 0.15 lbs.
2. Note the deflection caused by the load. Calculate the flexure stress.
3. Next apply an additional axial tension force to the stick of approximately 10 lb (pull on it) and note the change in deflection. Calculate the additional axial stress.
4. Make a sketch showing the addition of the stress profiles of flexure + tension.
5. Now apply (or try) an axial compression load of approximately 10 lb to the stick and again note the change in deflection. Again calculate the axial stress.
6. Make a sketch showing the addition of the stress profiles of flexure + compression.
7. What additional load and stress is being neglected in the case of compression + flexure?



$$M = \frac{P\,L}{4} \qquad f_b = \frac{M}{S_y} \qquad f_t = \frac{P}{A} \qquad f_c = \frac{P}{A} \qquad f_{comb} = \pm\frac{M}{S_y} \pm \frac{P}{A}$$

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2. Note the deflection caused by the load. Calculate the flexure stress.

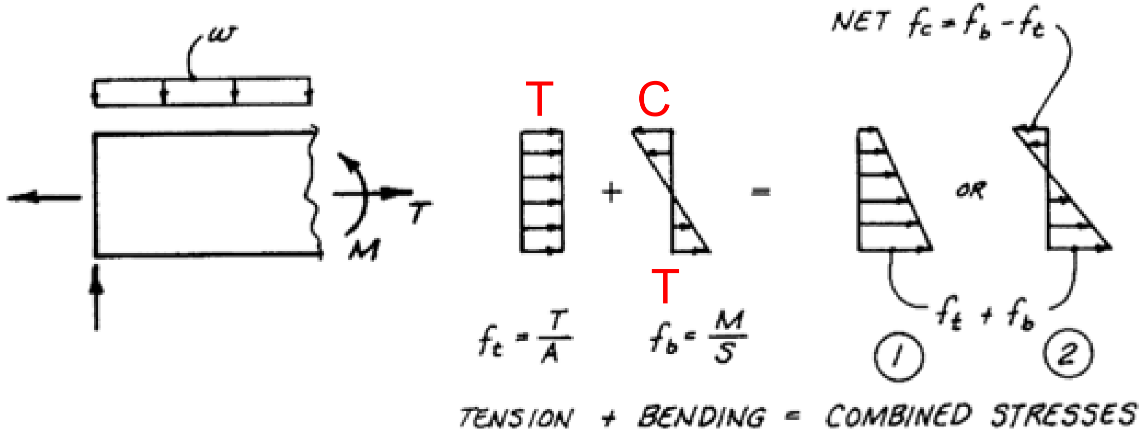
M= PL/4 = 0.15*12/4 = 0.45 in-lbs

fb= M/Sy = 0.45/0.0003255 = 1382.49 psi

3. Next apply an additional axial tension force to the stick of approximately 10 lb (pull on it) and note the change in deflection. Calculate the additional axial stress.

ft= P/A = 10/0.03125 = 320 psi

4. Make a sketch showing the addition of the stress profiles of flexure + tension.



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$f_c = P/A = 10/0.03125 = 320$ psi

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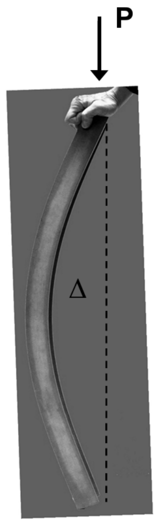
Second Order Stress
"P Delta Effect"

With larger deflections this can become significant.

1. Eccentric load causes bending moment
2. Bending moment causes deflection, Δ
3. P x Δ causes additional moment



Any Questions?

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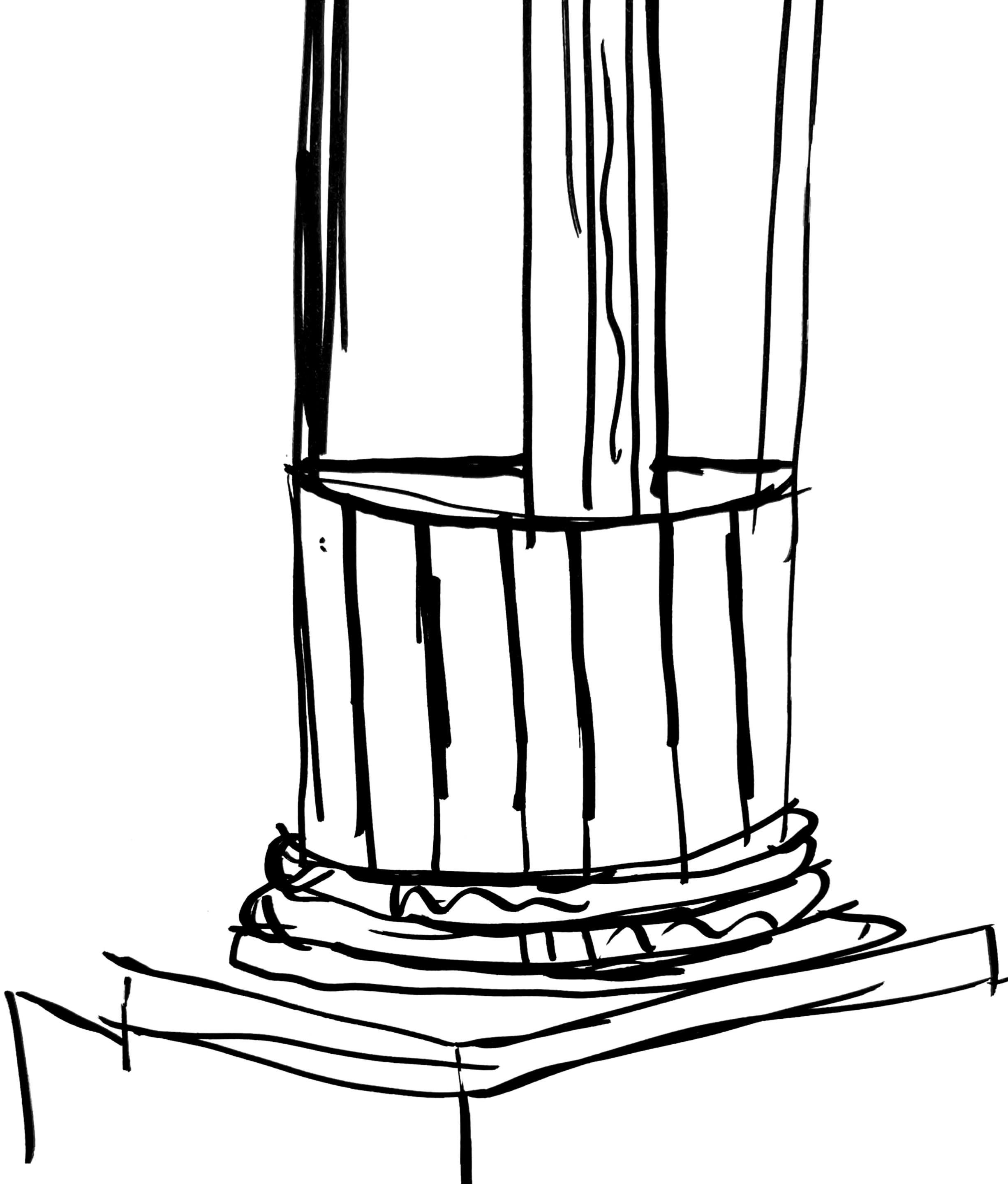

Thank You!