Structure II Recitation 4/19

Combined Stress

Before we start ...

Today's Tasks:

Homework Example (Combined Stress)

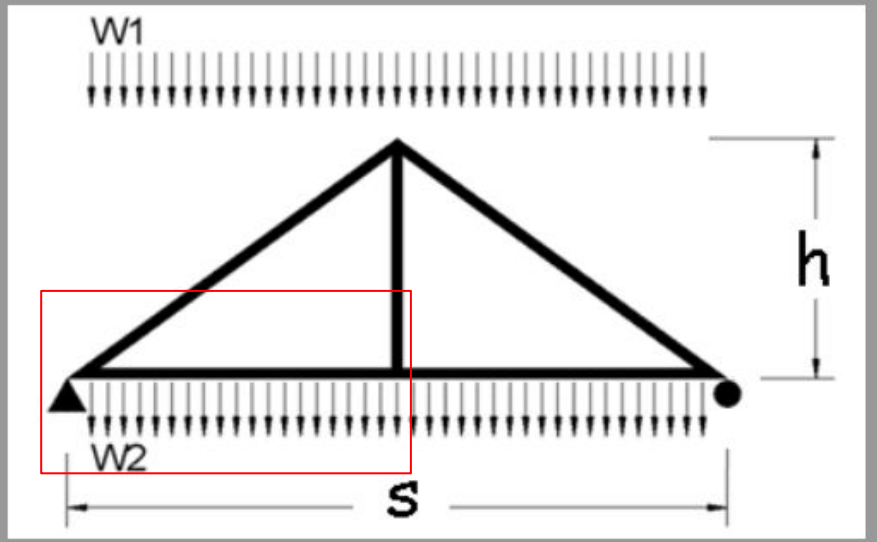
Lab Session (Combined Stress)

12. Combined Stress

The given roof truss carries both an exterior snow load and an interior (attic) floor load. Determine the member forces and stresses and calculate the combined stress levels (top and bottom) for the lower chord member using the NDS combined stress equations. Consider all joints pinned, with simple (joint to joint) members. The given allowable stresses (F't and F'b) are for southern pine with all adjustment factors already applied.

DATASET: 1 -2- -3-

Full span of truss	23 FT
Height of truss	10 FT
On Center spacing of trusses	16 IN
Size of bottom chord	4x5
Actual width, b	3.5 IN
Actual depth, d	4.5 IN
Snow Load on roof, w1	30 PSF
Live Load in attic, w2	85 PSF
Factored allowable bending stress, F'b	1150 PSI
Factored allowable tension stress, F't	690 PSI



Force, M, fb & ft, Combined Stress

Q1: Load on the Truss - Top Chord (W1)

W1 = w1 x on center spacing = 30 x 16 / 12 = **40 PLF**

in to ft

Q2: Load on the Truss - Bottom Chord (W2)

W2 = w2 x on center spacing = 85 x 16 / 12 = **113.33 PLF**

in to ft

Q3: Total Left Reaction Due to W1 & W2

$\sum F_v = 0$:
Since Symmetric:
R = (W1 +W2) x Span / 2
(40 + 113.33) x 23 / 2 = **1763.3 LBS**

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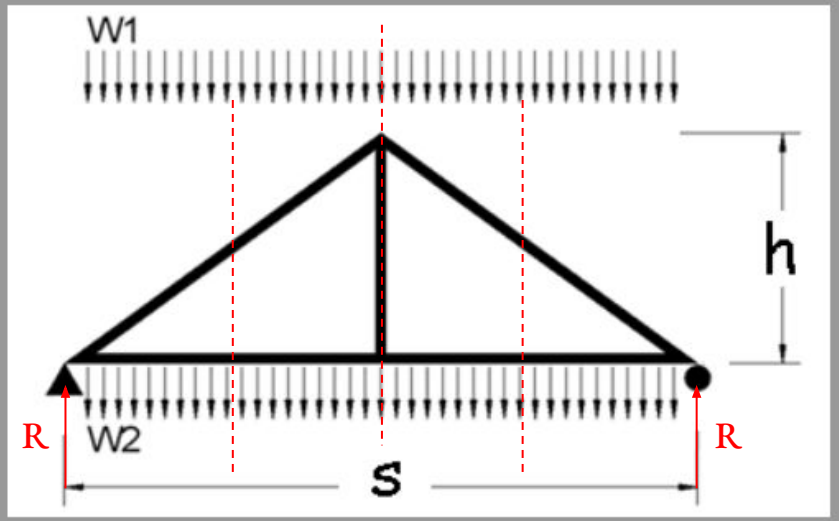

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Q4: Vertical Force Component in Truss Top Chord (No Sign)

Look at Free Body Diagram(Left End):

Q1 Q2

$\Sigma F_v = 0$:

$R - V - ((W1+W2) \times Span / 4) = 0$

$1763.3 - V - ((40 + 113.33) \times 23 / 4) = 0$

V = **881.6 LBS**

Q5: Horizontal Force Component in Truss Top Chord (No Sign)

Look at the ratio:

V/H = height / half of span = 10 / 11.5

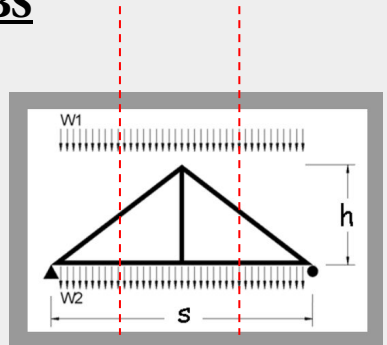
H = V / 10 x 11.5 = 881.6 /10 x 11.5 = **1013.9 LBS**

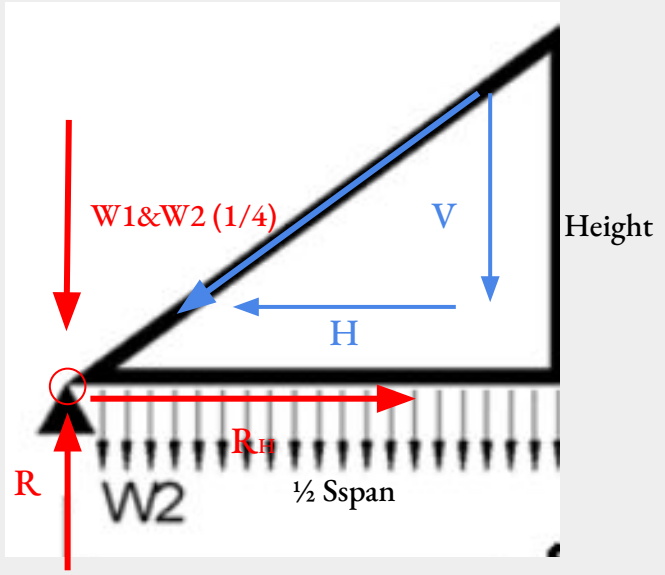
Q6: Axial Force in the Truss Bottom Chord

$\Sigma F_H = 0$:

$R_H - H = 0$

H = **1013.9 LBS (Tension, since pulling out)**





Q7: Area of the Bottom Chord Member

Area = b x d = 3.5 x 4.5 = **15.75 in^2**

Q8: Axial Stress in the Bottom Chord (ft)

Q6 Q7

Axial Stress = Axial Force / Area

Axial Stress = 1013.9 / 15.75 = **64.375 PSI**

Q9: Maximum Bending Moment in the Bottom Chord Member (fb)

Use Moment Equation:

M = w x L^2 / 8 = 113.33 x (½ x 23)^2 / 8 = **1873.5 FT-LBS**

W2(Q2)

½ span

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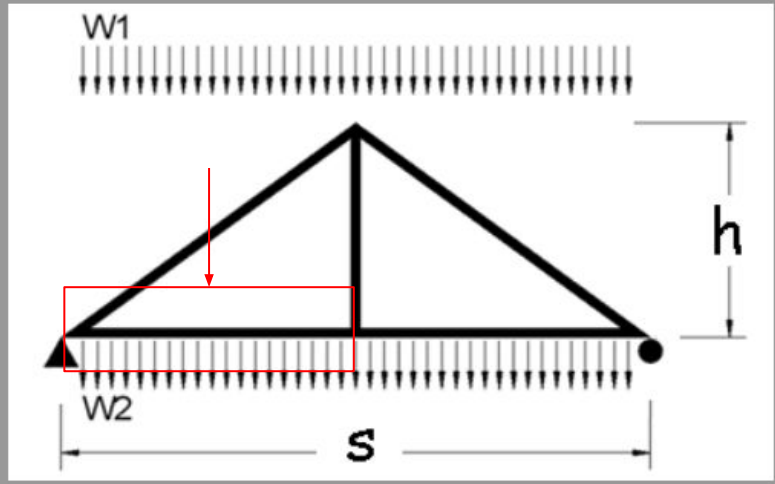

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Q10: Section Modulus of the Bottom Chord Member (Sx)

$Sx = \frac{1}{6} \times b \times d^2 = \frac{1}{6} \times 3.5 \times 4.5^2 =$ **$11.8125\ in^3$**

Q11: Maximum Bending Stress in the Bottom Chord Member (fb)

Bending Stress = M/Sx = 1873.5 x 12 / 11.8125 = **1903.2 PSI**

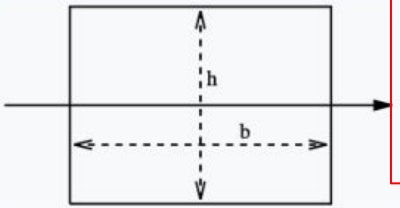
Q9

Q10

ft to in

Sectional Modulus

Bending Stress

Cross-sectional shape	Figure	Equation
Rectangle		$S = \frac{bh^2}{6}$

$$f = \frac{M}{S}$$

Q12: Combined Stress Using NSD Equation 3.9-1

ft/Ft' + fb/Fb' = 64.375 / 690 + 1903.2 / 1150 = **1.748**

Q8 Q11

Q13: Combined Stress Using NSD Equation 3.9-2

(fb - ft) / Fb' = (1903.2 - 64.375) / 1150 = **1.599**

Q14: Does Member Pass?

Both Q12 & Q13 have to <= 1

For my situation, **It's a Fail!**

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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:

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

and

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

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

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?

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

Lab Session:

Q2: fb = M / S, M= P x L/4

Q3: ft = P / A

Q5: fc = P / A

Q4 & Q6