TAUBMAN COLLEGE
ARCHITECTURE & URBAN PLANNING
UNIVERSITY OF MICHIGAN

Arch324
STRUCTURES II

Winter 2024
Recitation

FACULTY: Prof. Peter von Bülow
GSI: Mohsen Vatandoost

Welcome to Recitation session 04/19

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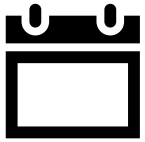
Office: Room 3104
hours:
Fri: 11:30 – 14:30
Mon, Wed: 11:00 - 12:00
walk-ins welcome!



Click here to make an appointment

Please feel free to ask questions.

Welcome to Recitation session 04/19

Outline:

- Quick **Recap** of the week
- Provide the solution for the assignment **(Homework 12)** **-The Final one!**
- Answering student's questions
- Lab: **Combined Stress**
- **Tower Project |** Feedback will be provided soon

Please feel free to ask questions.

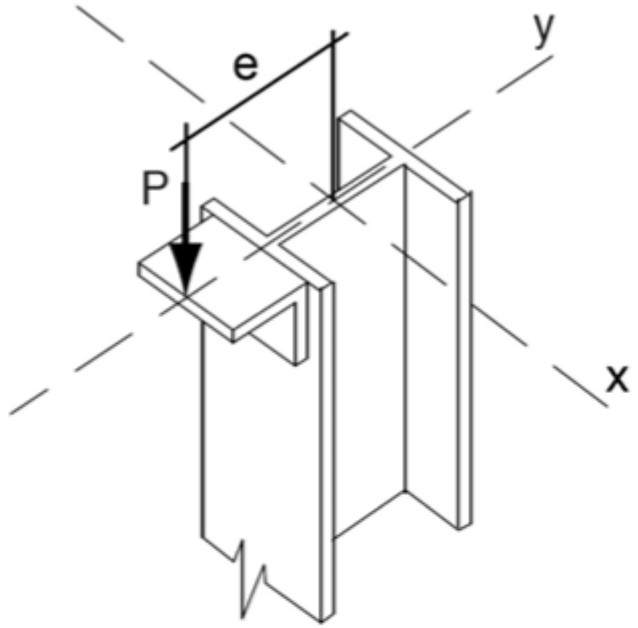
Contact: Mohsenv@umich.edu

Recap of the week

Combined Stress

Eccentric Loads

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



Interaction formula

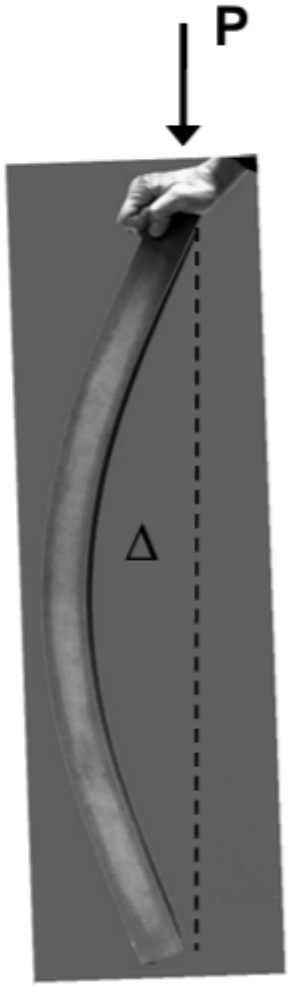
$$f = \frac{P}{A} \pm \frac{Mc}{I}$$

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

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

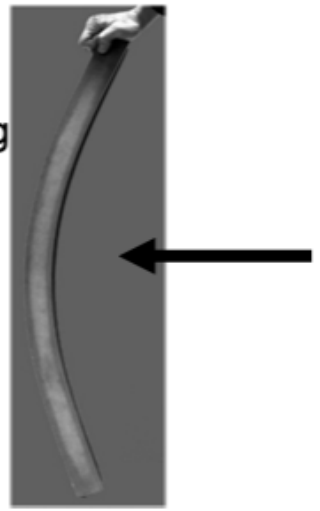


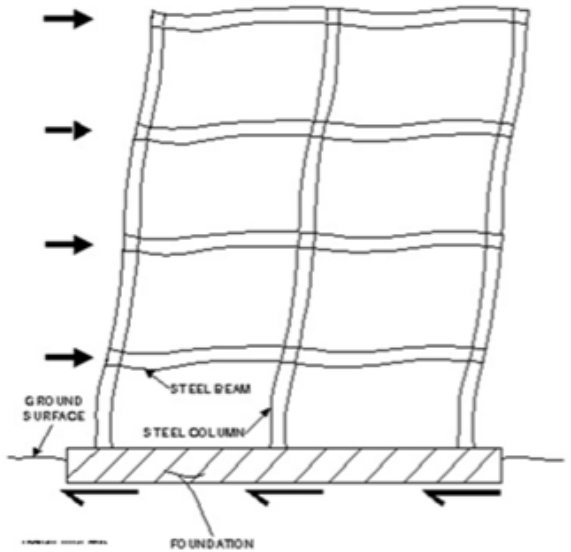
Recap of the week

Combined Stress

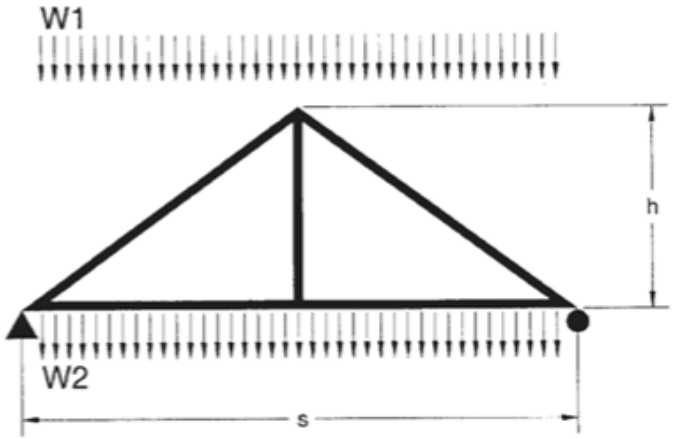
Other Examples of Combined Stress

Columns with side loading





Moment frames



Trusses loaded on members

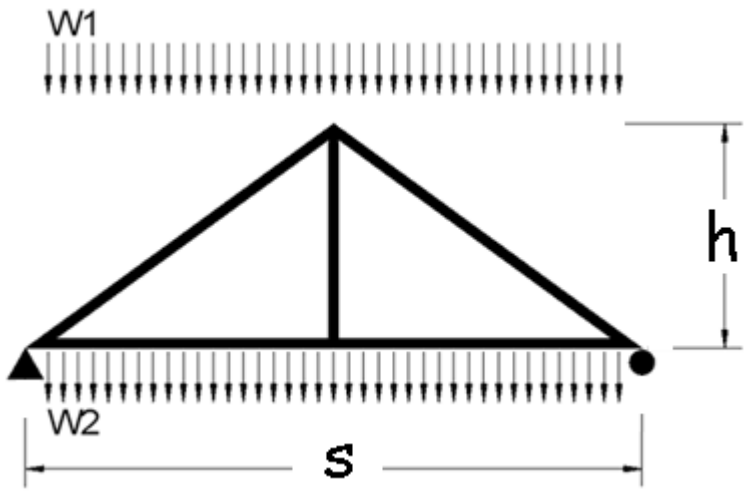
Provide the solution for the assignment – **HW12**

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.

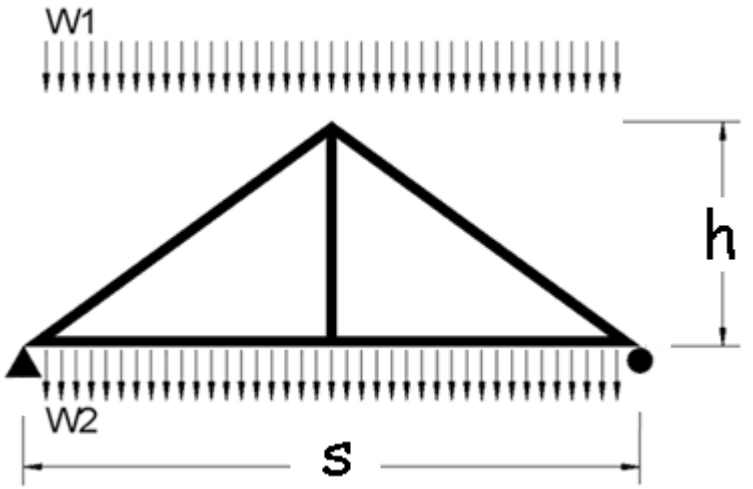
DATASET: 1 -2- -3-

Full span of truss	21 FT
Height of truss	5 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	35 PSF
Live Load in attic, w2	100 PSF
Factored allowable bending stress, F'b	1150 PSI
Factored allowable tension stress, F't	690 PSI

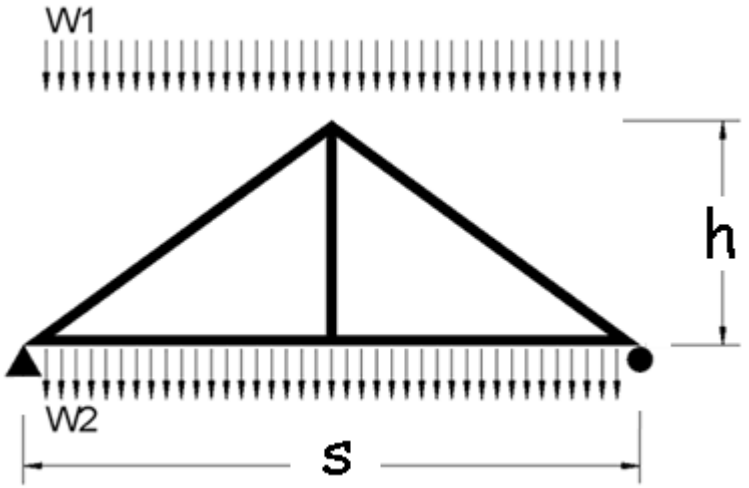


Provide the solution for the assignment – **HW12**

#	Question	Your Response	
1	Load on one truss - top chord, w1		PLF
2	Load on one truss - bottom chord, w2		PLF
3	Total left reaction due to w1 and w2		LBS
4	Vertical force component in truss top chord (no sign)		LBS
5	Horizontal force component in truss top chord (no sign)		LBS
6	Axial force in the truss bottom chord. (- if compression)		LBS
7	Area of the bottom chord member		IN2
8	Axial stress in the bottom chord. (- if compression)		PSI
9	Maximum bending moment in the bottom chord member		FT-LBS
10	Section modulus of the bottom chord member, Sx		IN3
11	Maximum bending stress in the bottom chord member		PSI
12	Combined stress using NSD equation 3.9-1		
13	Combined stress using NSD equation 3.9-2		
14	Does member pass? 1=passes 0=fails		(1 or 0)



Provide the solution for the assignment – **HW12**

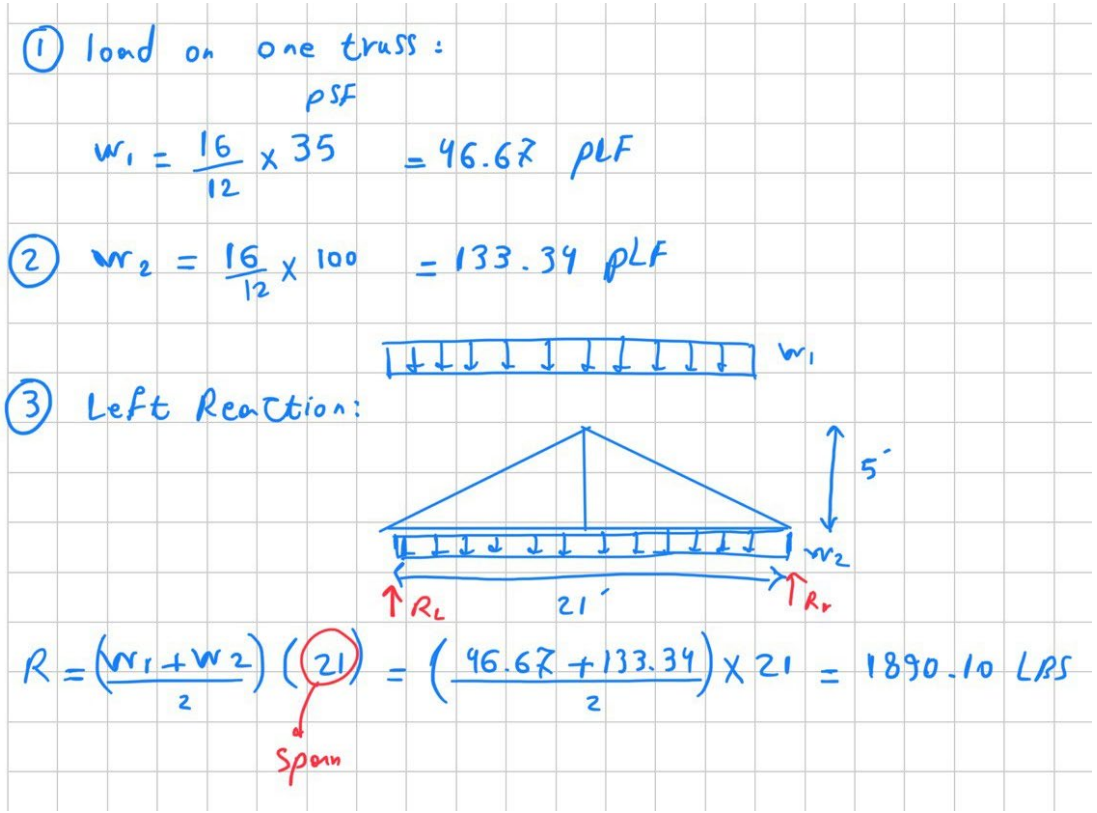


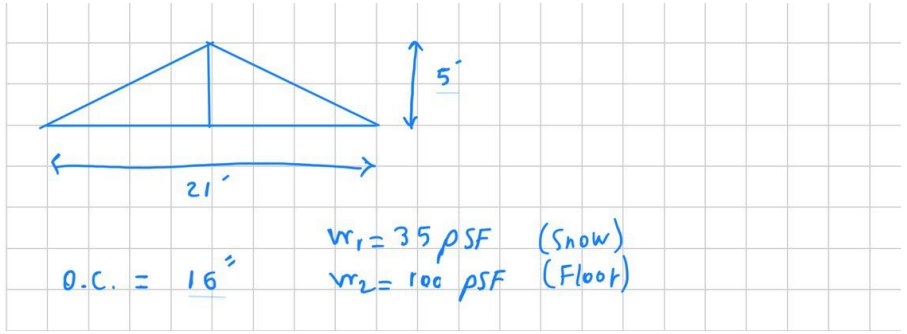
Procedure

w1 is a uniform snow load and w2 is a uniform floor load acting on a King-Post roof truss shown below. The bottom chord is axially stressed due to the truss action and in flexure due to the floor loading.

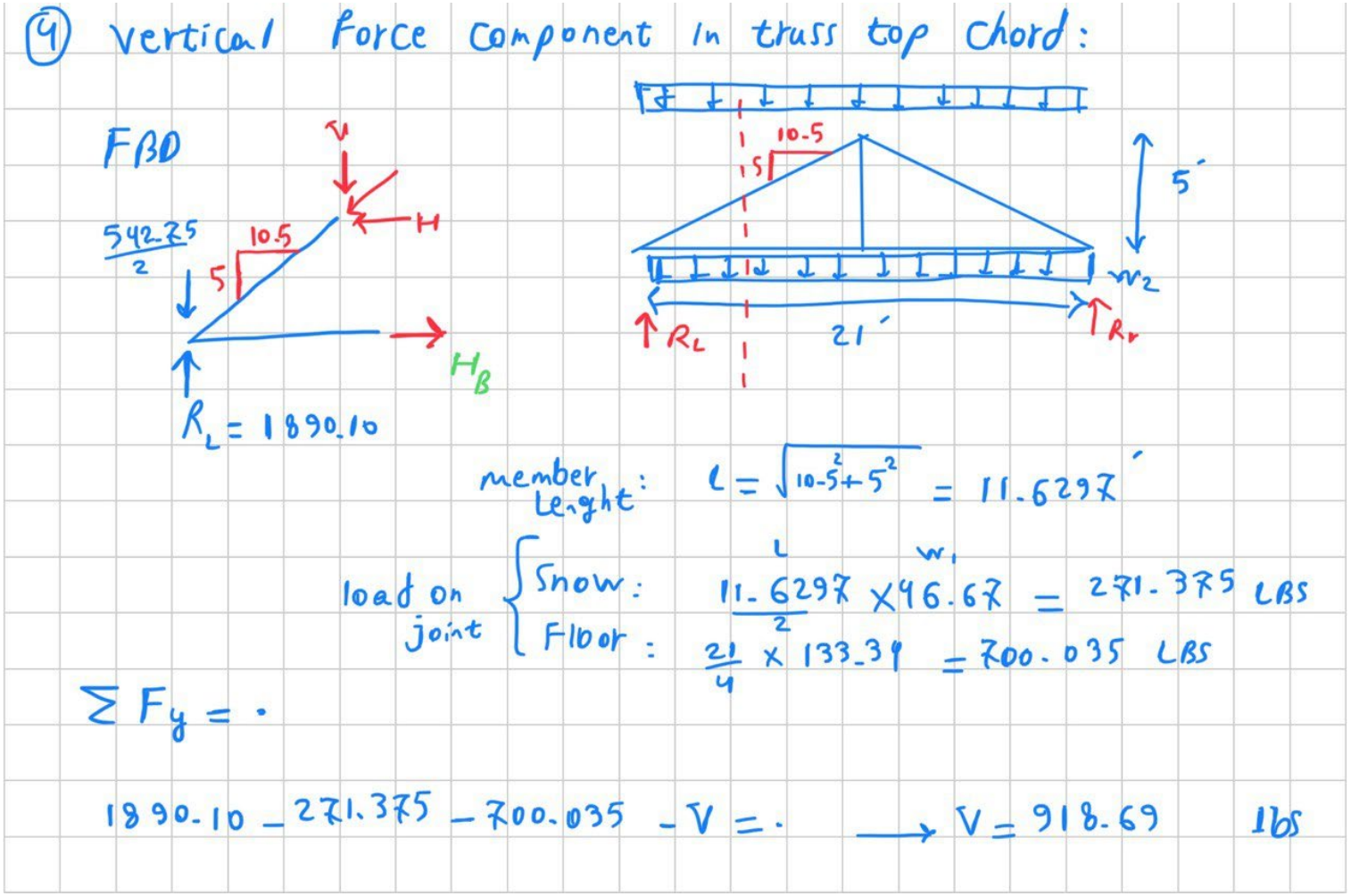
1. Solve the reactions and truss member forces.
2. Calculate the axial stress in the bottom chord.
3. Find the flexure present in the bottom chord.
4. Calculate the combined tensile and compressive stress levels for top side and bottom side of the member using the NDS equations, 3.9-1 & 3.9-2

Provide the solution for the assignment – **HW12**





Provide the solution for the assignment – **HW12**



Provide the solution for the assignment – **HW12**

⑤ Horizontal force component in truss top chord:

$\frac{V}{h} = \frac{5}{10.5}$ ($V = 918.69$) $\longrightarrow h = 1929.25$ LBS

⑥ Axial force in the truss bottom chord:

$\sum F_u = 0$

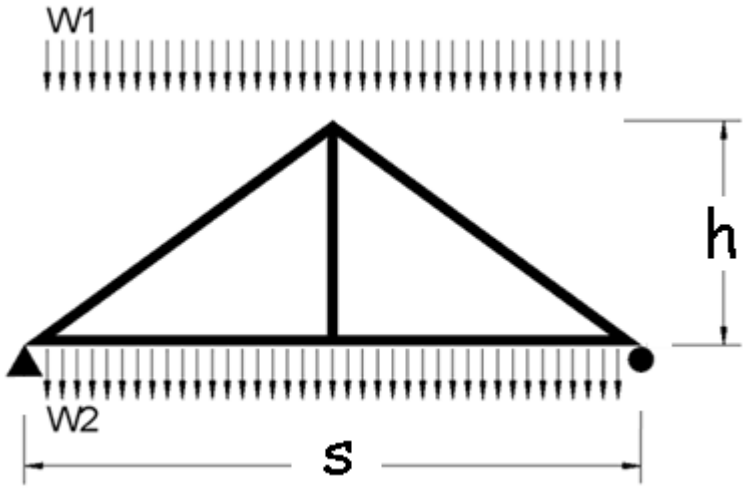
$H_B - H_T = 0 \longrightarrow H_B = 1929.25$ LBS (Tension) +

⑦ Area of Bottom Chord member:

nominal: 4 x 5

$\begin{cases} 3.5 \text{ in} \\ 4.5 \text{ in} \end{cases}$ Actual

$A = 3.5 \times 4.5 = 15.75 \text{ in}^2$



Provide the solution for the assignment – **HW12**

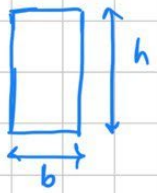
⑧ Axial stress in bottom chord:

$$f_t = \frac{P}{A} = \frac{1929.25}{15.75}\ \frac{LBS}{in^2} = 122.49\ PSI$$

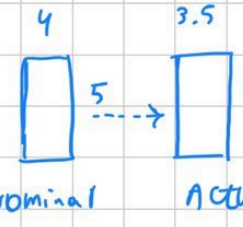
⑨ Maximum Bending moment in the Bottom Chord:

$$M = \frac{w_2 L^2}{8} = \frac{(133.34)\left(21/2\right)^2}{8} = 1837.59\ ft\text{-}LBS$$

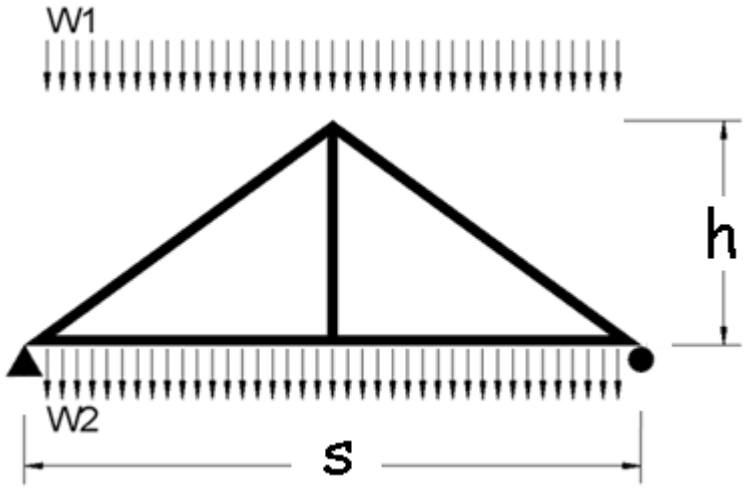
⑩ Section modulus of Bottom Chord:



$\frac{bh^2}{6}$



$$S = \frac{3.5\ (4.5)^2}{6} = 11.8125\ in^3$$



Provide the solution for the assignment – **HW12**

(11) Maximum bending stress in Bottom Chord:

$$f_b = \frac{M}{S} = \frac{1837.59 \times 12}{11.8125} = 1866.7581 \ \frac{lb}{in^2} \ (psi)$$

(12) Combined stress (NDS 3.9_1)

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

F_t' → 690 psi

F_b' → 1150 psi

$$\frac{122.49}{690} + \frac{1866.7581}{1150} = 0.1775 + 1.6232 = 1.8 > 1.0$$

X Fail

(13) Combined stress (NDS 3.9_2)

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

$$\frac{1866.7581 - 122.49}{1150} = 1.5167 > 1.0$$

X Fail

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:

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

and

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

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

Lab : Combined Stress

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

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 results of P + delta loading

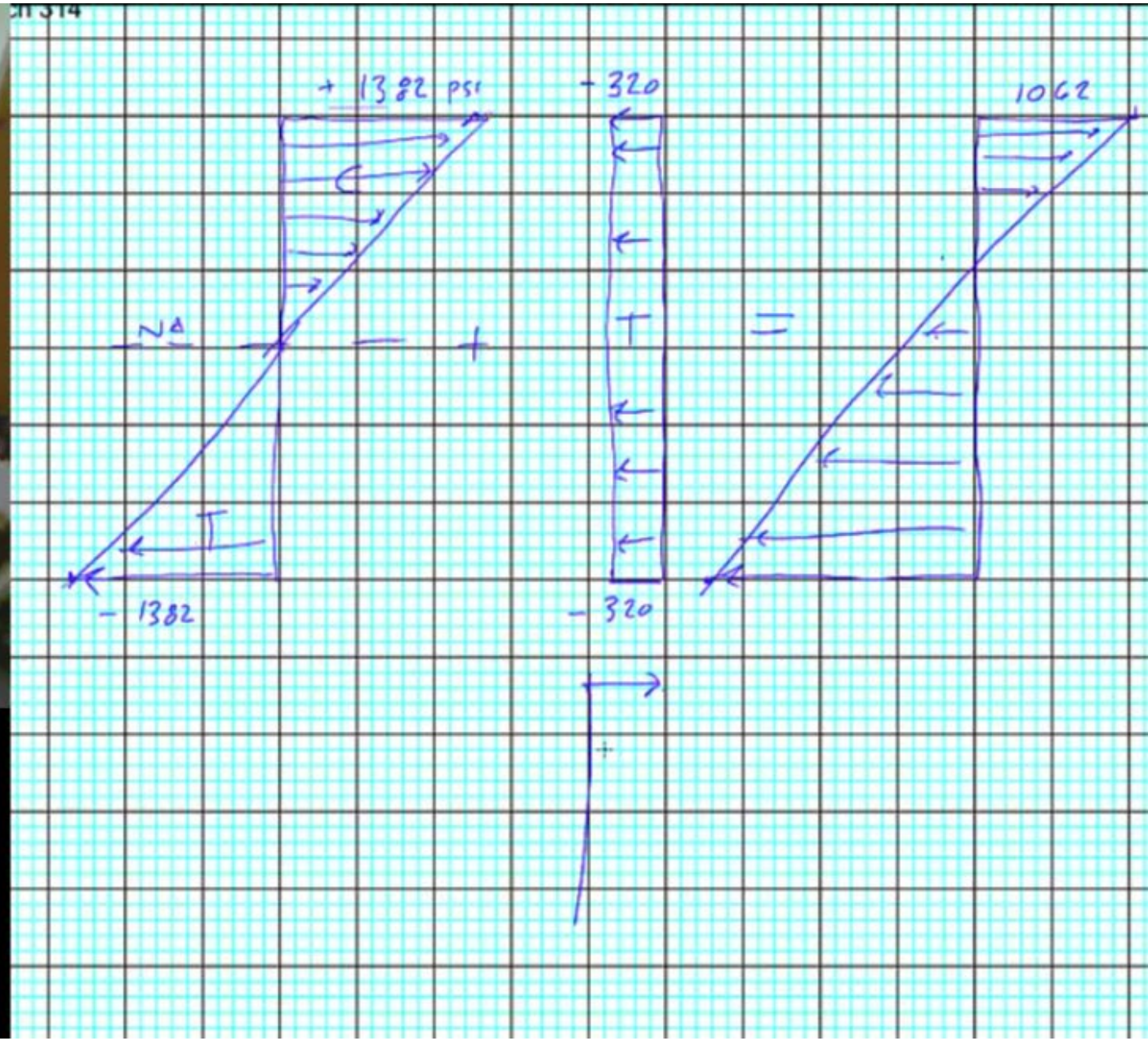
Lab : Combined Stress

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

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?

https://structures.tcaup.umich.edu/recitation/LAB10_CombinedStress.mp4


+ 1382 psi
NA
- 1382
- 320
- 320
1062

Thank you.

Any question?

Please feel free to ask questions.

Contact: Mohsenv@umich.edu