TAUBMAN COLLEGE
ARCHITECTURE & URBAN PLANNING
UNIVERSITY OF MICHIGAN

Arch314
STRUCTURES I

Fall 2024
Recitation

FACULTY: Prof. Peter von Bülow
Mohsen Vatandoost

Welcome to Recitation session 11/22

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Office: Room 3122
hours:
Wed: 11:30 – 14:30
Mon, Fri: 11:30 - 13:30
walk-ins welcome!

Please feel free to ask questions.

Welcome to Recitation session 11/22

Outline:

- Quick **Recap** of the week
- Provide the solution for the assignment **(Homework 14)**
- Answering student's questions
- Lab: **Horizontal Shear Stress**
- **Bridge** project (Prepare the Final Report)

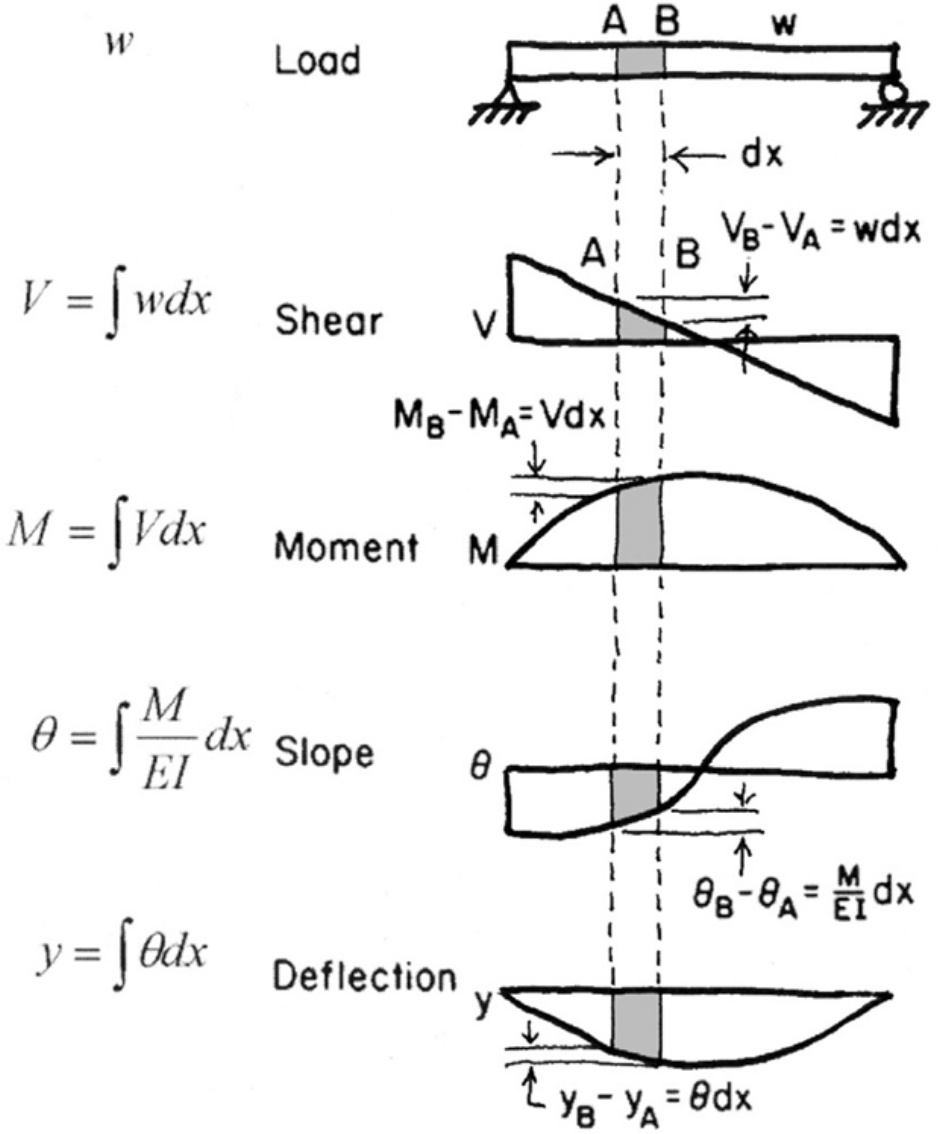
Please feel free to ask questions.

Contact: Mohsenv@umich.edu

Recap of the week

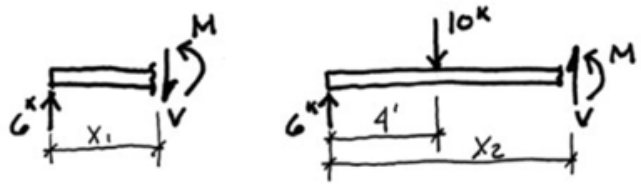
Integral

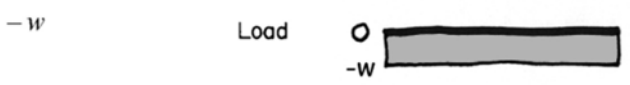
Derivation



Recap of the week

1. Equilibrium Method - example

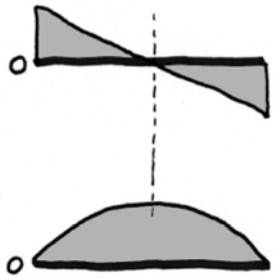




$$V = \int w dx$$

$$V = -wx + C$$

$$V = -wx + \frac{wl}{2}$$



$$M = \int V dx$$

$$M = -\frac{w}{2}x^2 + \frac{wl}{2}x + C$$

$$M = -\frac{w}{2}x^2 + \frac{wl}{2}x$$

Methods to Determine Values of Shear and Moment

1. Equilibrium Method
   - Select a point along the beam
   - Cut a section and draw the FBD
   - Solve for the internal shear and moment forces at the section
2. Integration of Equations
   - Write the equation of the load function
   - Integrate load equation to get shear equation
   - Solve integration constant (use end reaction)
   - Integrate shear equation to get moment equation
   - Solve integration constant (use point with zero moment, e.g. end point)
3. Semi-graphical Method
   - Draw load diagram and solve end reactions with equilibrium equations.
   - Start at left and construct the shear diagram using point loads and areas on load diagram
   - Calculate areas of shear diagram to find change in value on moment diagram
   - Find points of zero moment to begin moment diagram, e.g. end points
4. Superposition of Equations
   - Break the loading into standard cases
   - Use given equations to solve shear and moment for each case
   - Add the cases to get combined values of original loading

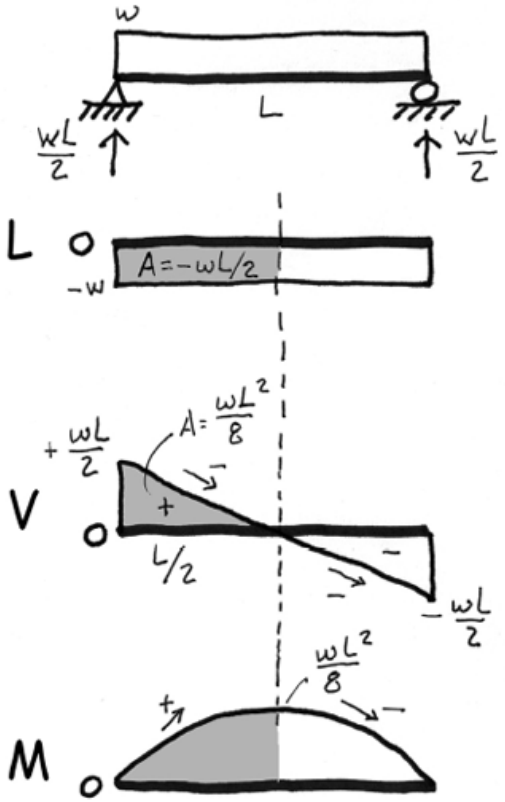
Recap of the week

3. Shear and Moment by Semi-graphical Method – diagram relationships

By recognizing the diagrammatic relationships between curves and their derivatives and integrals, shear and moment diagrams can be constructed based on areas and slopes of those curves.

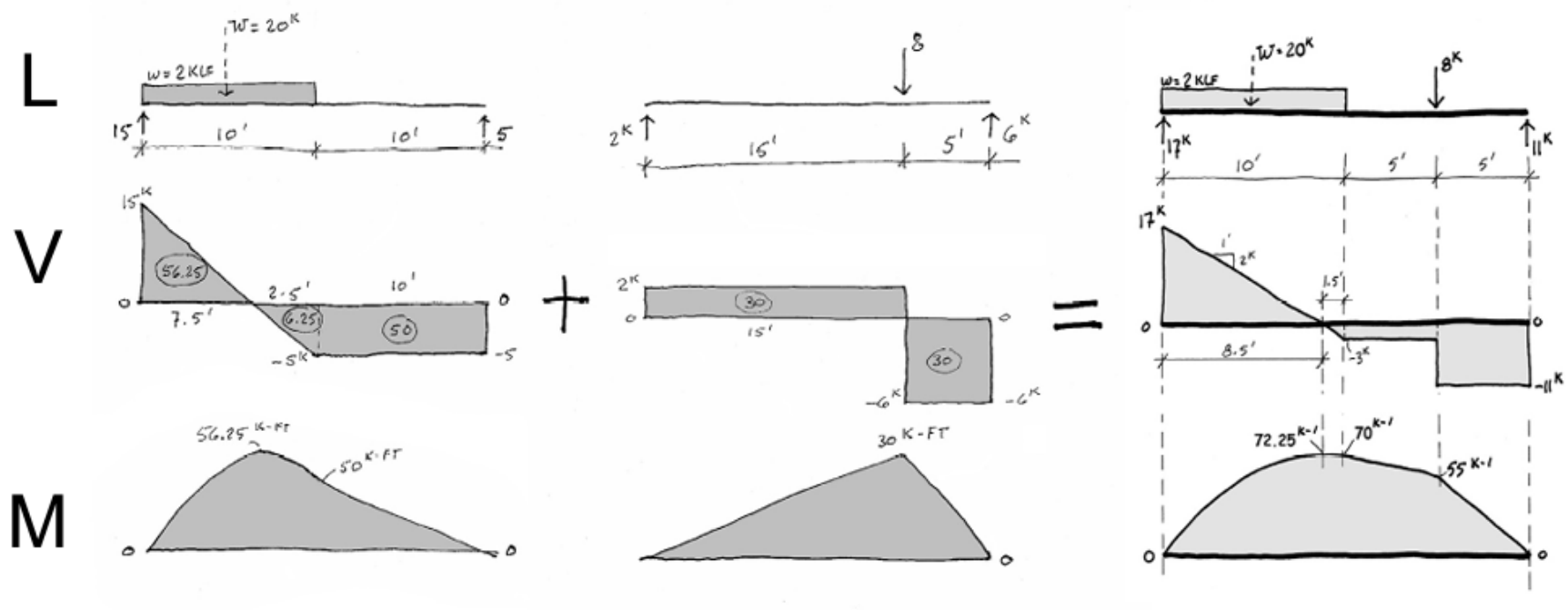
Moving from Upper to Lower Diagrams:

- The area between any two points on the upper diagram is equal to the change in value between same points on the lower diagram.
- The degree of the curve increases by one for each diagram.
- The value on the upper diagram is equal to the slope of the lower diagram.
- Where the upper diagram crosses 0 on the axis, the lower diagram is at a maximum or minimum.
- Points of inflection or "contraflexure" (between + and – curvature) on the elastic curve (deflected shape) are points of zero moment.



Recap of the week

4. Semi-graphical Method - Superposition



Provide the solution for the assignment – **HW15**

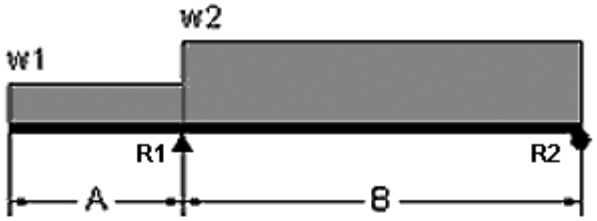
- Problem:

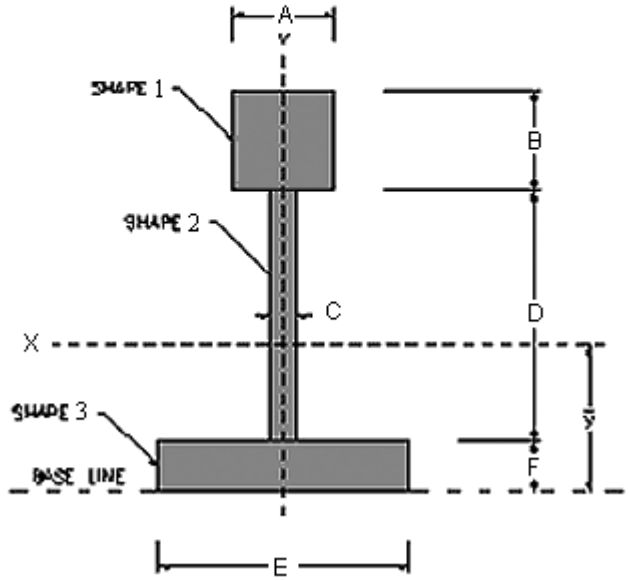
15. Horizontal Shear

Determine the maximum overall shear force and the horizontal shear stress at that location. Then find the horizontal shear stress at each end of the center web (top and bottom).

DATASET: 1 -2- -3-

Section dimension A	5 IN
Section dimension B	2 IN
Section dimension C	2 IN
Section dimension D	7 IN
Section dimension E	10 IN
Section dimension F	2 IN
Beam span A	12 FT
Beam span B	20 FT
Beam load w1	32 PLF
Beam load w2	16 PLF

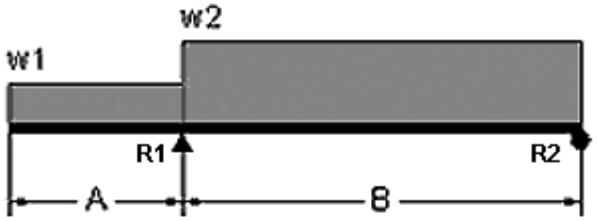


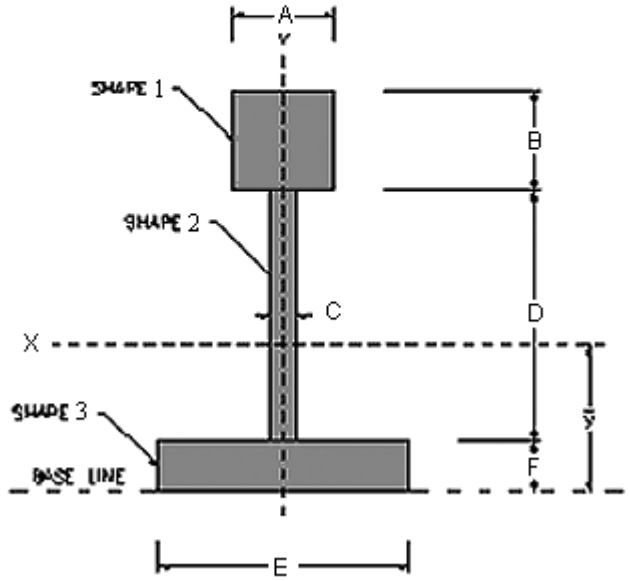


Provide the solution for the assignment – **HW15**

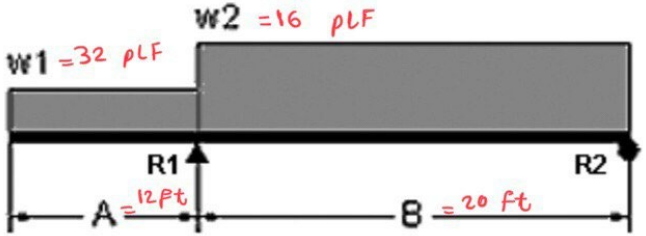
- Problem:

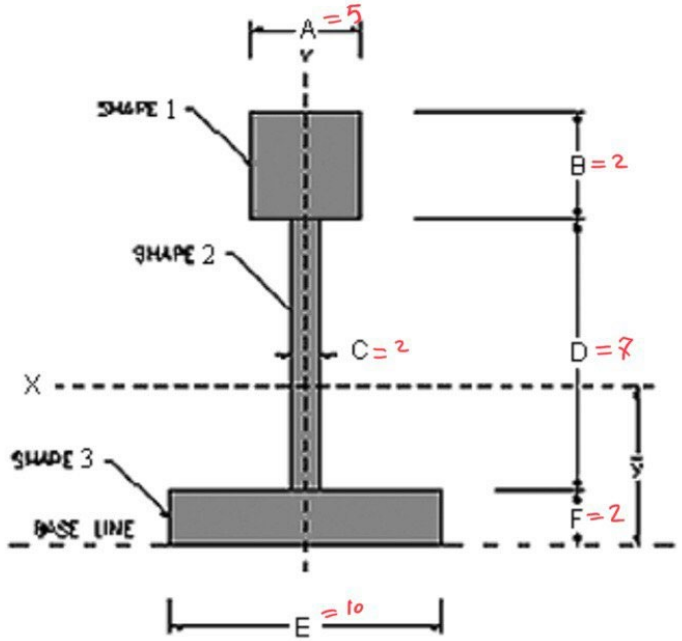
#	Question	Your Response	
1	Beam reaction R1 (upward is +)		LBS
2	Beam reaction R2 (upward is +)		LBS
3	Negative shear at R1 (use - sign)		LBS
4	Positive shear at R1		LBS
5	Shear at R2 (use - or + sign)		LBS
6	Maximum shear force (absolute value)		LBS
7	Static Moment (Q) at top of shape 2		IN^3
8	Static Moment (Q) at bottom of shape 2		IN^3
9	Static Moment (Q) at the neutral axis		IN^3
10	Moment of Inertia about the neutral axis		IN^4
11	Section width at the neutral axis		IN
12	Horizontal shear stress at the top of shape 2 for Vmax		PSI
13	Horizontal shear stress at the bottom of shape 2 for Vmax		PSI
14	Horizontal shear stress at the neutral axis for Vmax		PSI





Provide the solution for the assignment – **HW15**





$W_1 = w_1 A = 32 \times 12 = 384$ lbs

$W_2 = w_2 B = 16 \times 20 = 320$ lbs

$\sum M_{@2} = 0$

$-W_2\left(\frac{B}{2}\right) + R_1(B) - W_1\left(\frac{A}{2} + B\right) = 0$

$-320\left(\frac{20}{2}\right) + R_1(20) - 384\left(\frac{12}{2} + 20\right) = 0$

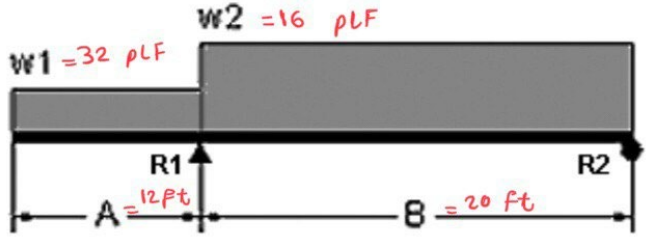
$\rightarrow R_1 = 659.2$ lbs

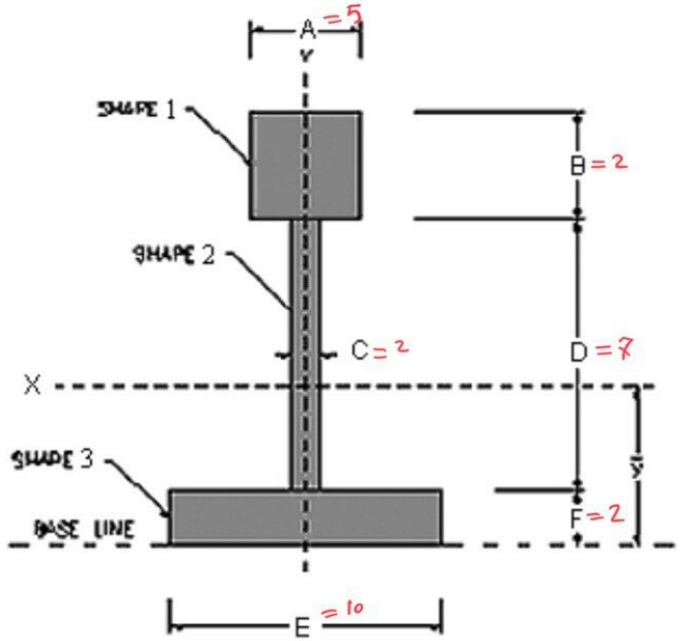
$\sum F_y = 0 \rightarrow R_1 + R_2 - W_1 - W_2 = 0$

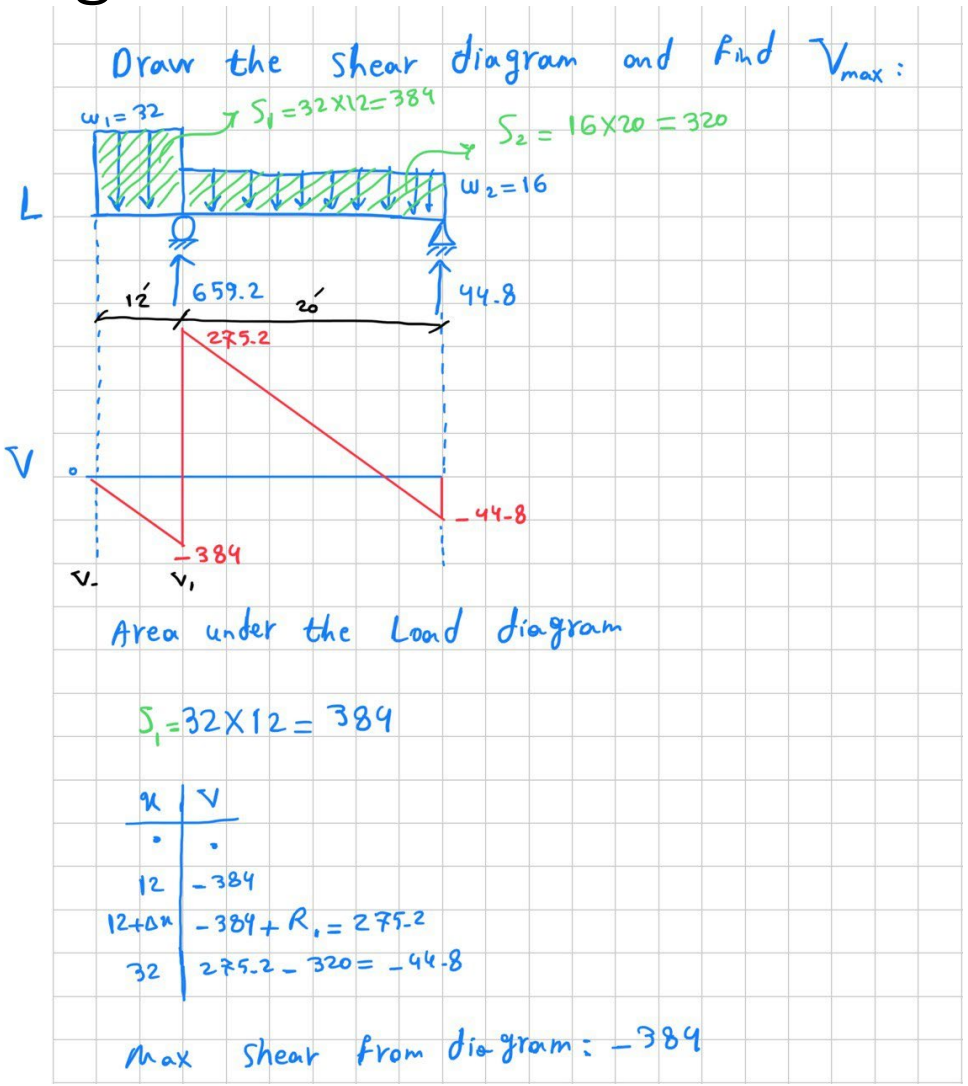
$659.2 + R_2 - 384 - 320 = 0$

$\rightarrow R_2 = 44.8$ lbs

Provide the solution for the assignment – **HW15**







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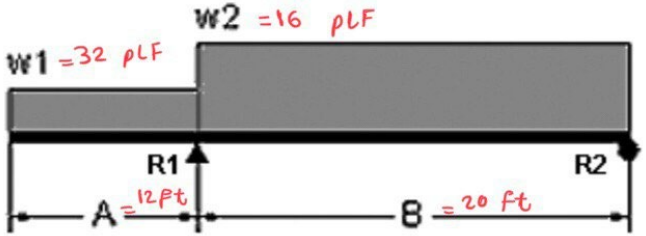
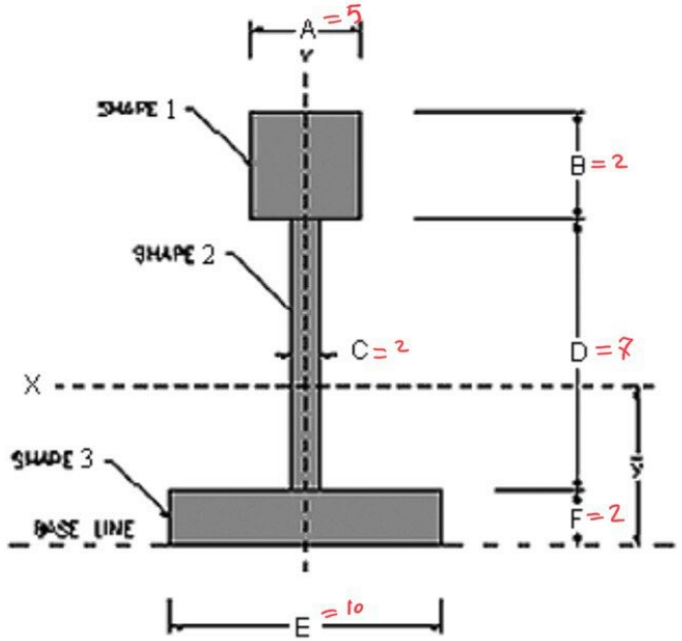


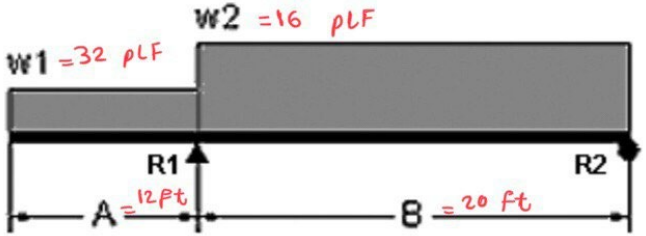


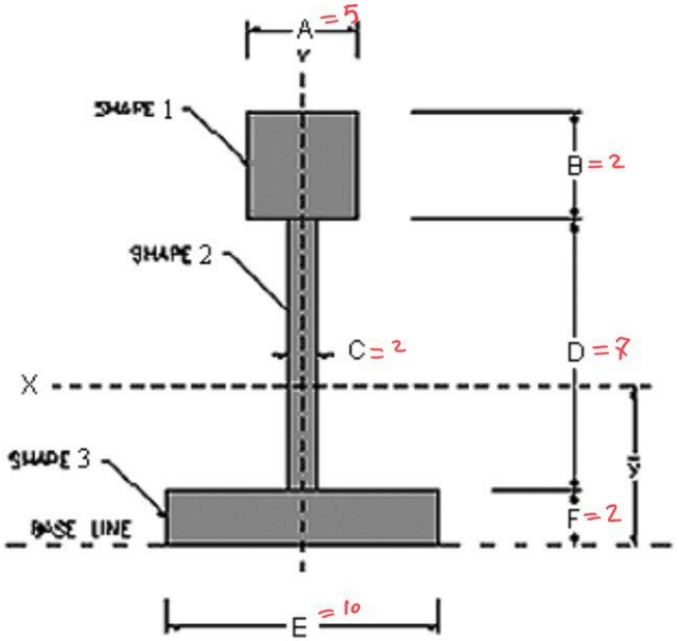
Calculation of Centeroid

	A	d (y)	Axd
shape 1	5x2=10	10	100
Shape 2	7x2=14	5.5	77
Shape 3	10x2=20	1	20
Sum	44	—	197

$$\bar{y} = \frac{\sum A \times d}{\sum A} = \frac{197}{44} = 4.47 \text{ in}$$

Provide the solution for the assignment – **HW15**



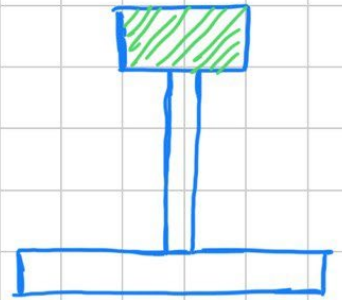


Static moment calculation (Q)

Top of shape-2

	A	y (distance from centroid)	Ay
Shape-1	5x2 = 10	10 − 4.47 = 5.53	55.3
Sum	10	—	553

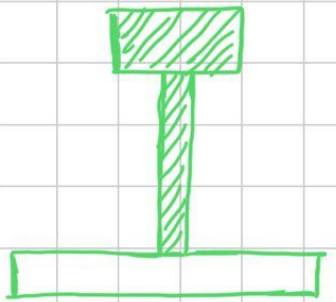
Q_1 = 553 in^3



Bot of shape-2

	A	y (distance from centroid)	Ay
Shape-1	5x2 = 10	10 − 4.47 = 5.53	55.3
Shape-2	2x7 = 14	5.5 − 4.47 = 1.03	14.42
Sum	—	—	69.72

Q_2



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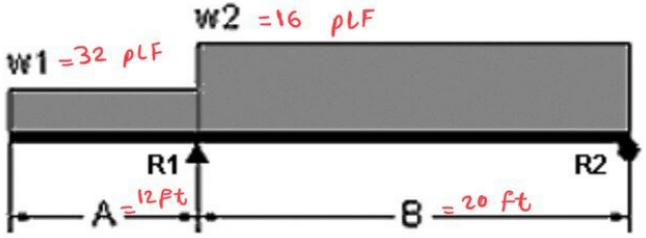
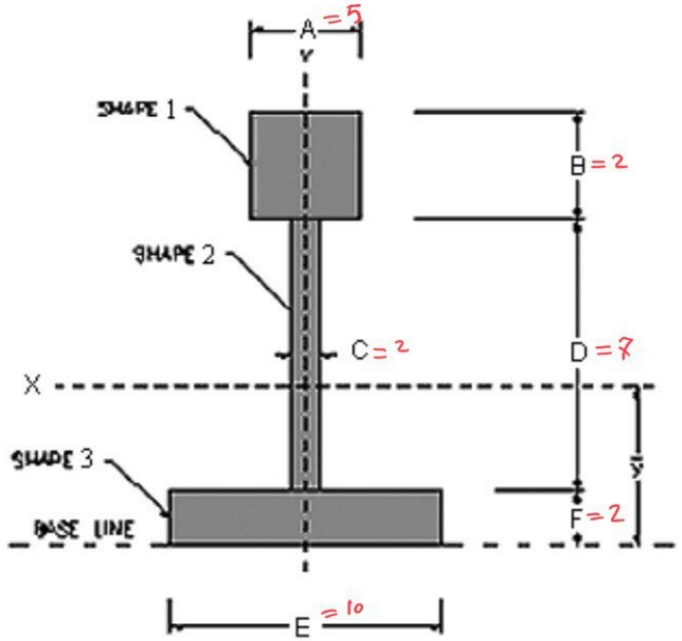
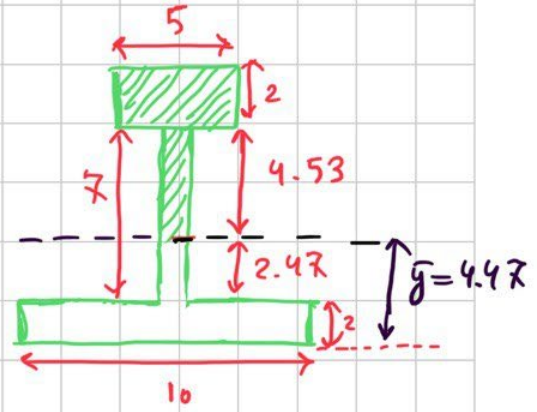




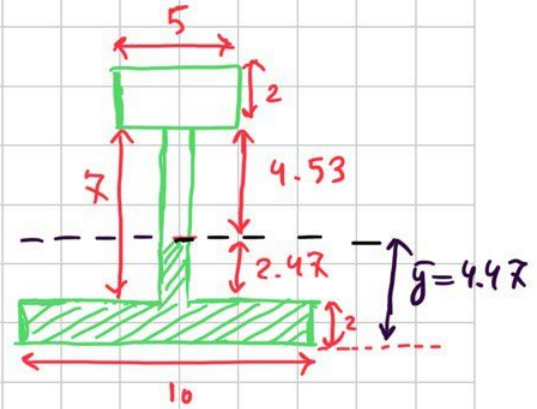
@ at neutral axis :

	A	y → distance from centeroid	A x y
Shape-1	5x2 = 10	5.53	55.3
shape-2	2x4.53	2.265	20.52
Sum	—	—	75.82 in^3

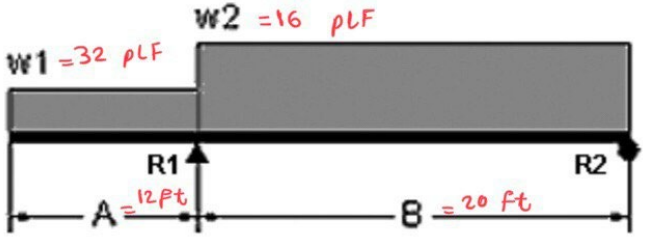


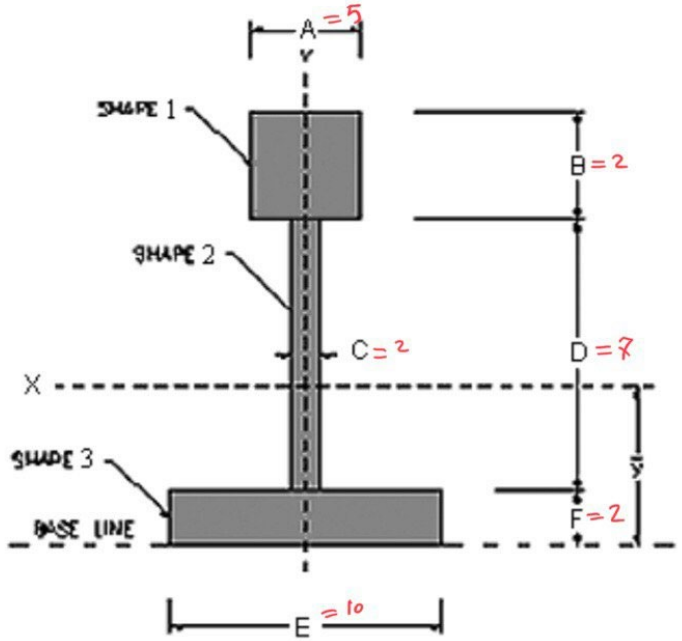
or

	A	y → distance from centeroid	A x y in^3
Shape-3	2x10 = 20	3.47	69.4
shape-2	2x2.47	1.235	6.10
Sum	—	—	75.50



Provide the solution for the assignment – **HW15**





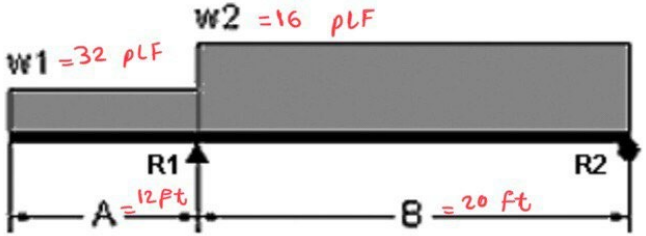
Calculation of moment of Inertia:

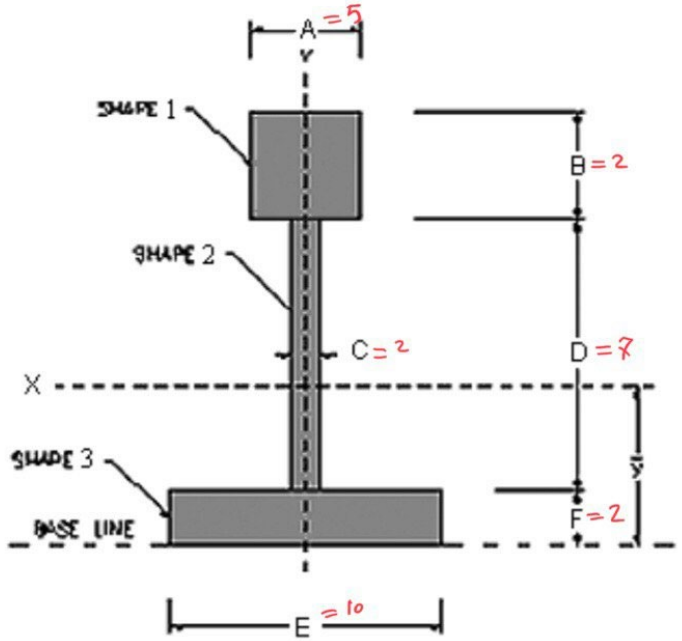
$\frac{bh^3}{12}$ → I_x (IN⁴)

Centroid of shape to the centroid of whole shape → d (in)

	I_x (IN⁴)	A (IN²)	d (in)	Axd² (IN⁴)	$I_x + Ad^2$
Shape1	$\frac{5x2^3}{12} = 3.33$	5X2 = 10	10 − 4.47 = 5.53	305.80	309.13
Shape2	$\frac{2x7^3}{12} = 57.16$	2X7 = 14	5.5 − 4.47 = 1.03	14.85	72.01
Shape3	$\frac{10x2^3}{12} = 6.67$	10X2 = 20	1 − 4.47 = −3.47	240.82	247.49
Sum	67.16	44 IN²	—	561.47 (IN⁴)	628.63 (IN⁴)

Provide the solution for the assignment – **HW15**





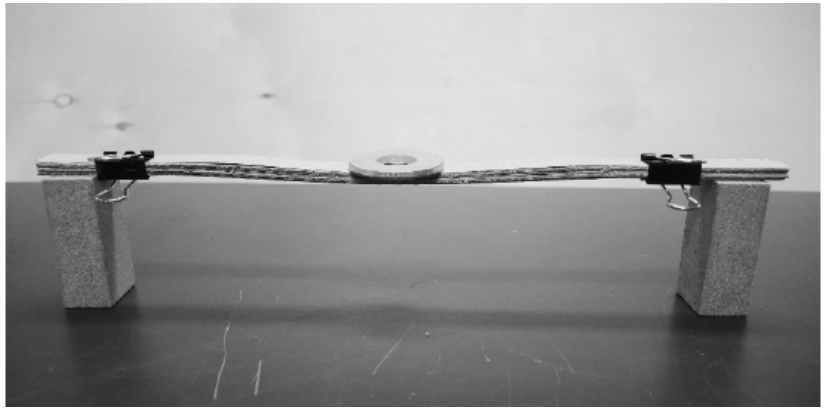
From V diagram = 384

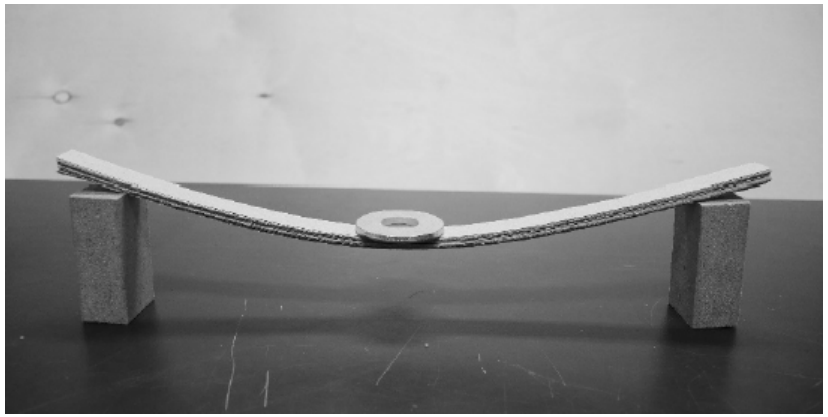
$$f_v = \frac{VQ}{Ib}$$

628.63

	Q in^3	b in	f_v lb/in^2
Top of Sh_2	55.3	2	16.89
Bot Sh_2	69.72	2	21.29
neutral Axis	75.82	2	23.15

Lab: Horizontal Shear Stress





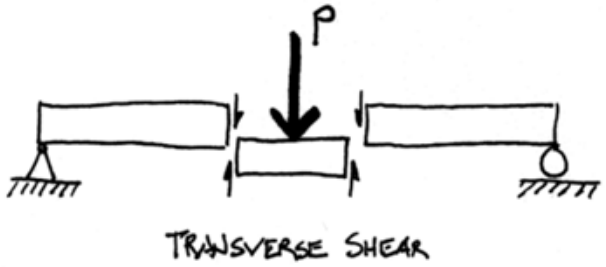
Description

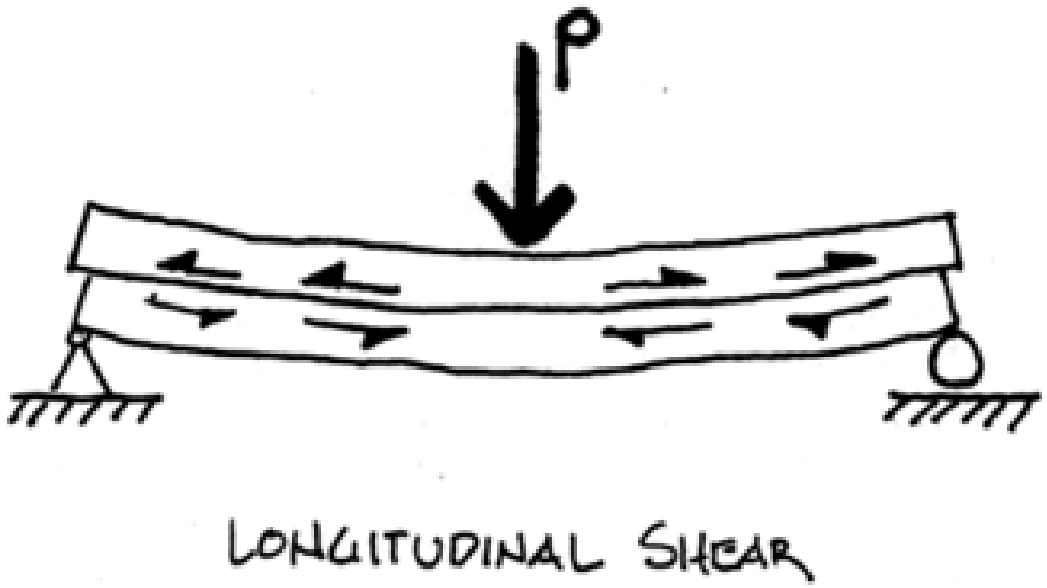
This project examines horizontal shear in a simple beam.

Goals

To observe an example of shear force in an element.
To gage the effect of shear stiffness.
To observe horizontal shear failure.

Lab: Horizontal Shear Stress





Procedure

1. Place the clips at each end of the beam and position it on the supports.
2. Add the washer weight and measure the deflection.
3. Remove the clips and repeat the loading and again measure the deflection.
4. Note the slippage of the planes particularly at each end.
5. Compare the deflections of the two tests.

Bridge Project_ Final Report

- Pay Particular attention to the Tally sheet and requirements. (We Don't want you to lose points!)
- Look at the examples provided in the course website.
- It is not finished yet! Prepare your report Properly.

PRELIMINARY REPORT (re-submit original)	40
TESTING	60
FINAL REPORT REQUIREMENTS	150

Thank you.

Any question?

Please feel free to ask questions.

Contact: Mohsenv@umich.edu