CE 120 – Spring 2022
Instructor: M.J. DeJong

Name: Han Liu

CE 120 – Structural Engineering

Mid-Term Examination No. 2

Instructions:

- Do not open the exam until instructed to do so.
- You may use a calculator and watch, but no other electronic devices are permitted.
- Do all problems. Show all relevant work.
- Start solutions alongside or immediately following problem statements. If additional space is required, insert additional sheets.
- Organize and write solutions neatly. Points may be taken off for messy solutions.
- Indicate units in final solutions. Points will be taken off if units are missing or signs are unclear.
- If you have any questions, or need any paper or other materials, walk to the front of the classroom and ask the instructor. Do not raise your hand to get the instructor's attention, and do not call out questions from your seat.

Please sign the following Honor Pledge before submitting your exam:

"I have neither given nor received aid during this examination. I have not concealed any violation of the Honor Code. I did not use any unapproved notes or electronic devices during the examination."

Signature: Han Liu

Some potentially useful equations and tables:

elongation, $e = TL/AE$
curvature, $\kappa = M/EI$

Internal work (axial load) = T^*e
Internal work (bending) = $\int M_x^* \kappa \, dx = \frac{1}{EI} A_m m_{\bar{x}_m}^*$

$$q_z = 0.00256 K_z K_{zt} K_d V^2 \ (psf); \ p = qGC_p; \ G = 0.85; \ K_{zt} = 1;$$

Velocity Pressure Exposure Coefficient K_z			
Height z above ground level	Exposure		
ft	B	C	D
0-15	0.57	0.85	1.03
20	0.62	0.90	1.08
25	0.66	0.94	1.12
30	0.70	0.98	1.16
40	0.76	1.04	1.22
50	0.81	1.09	1.27

Wind Directionality Factor K_d	
Structural Type	K_d
Buildings	
Main wind force-resisting system	0.85
Components and cladding	0.85

Wall Pressure Coefficients C_p			
Surface	L/B	C_p	Use with
Windward wall	All values	0.8	q_z
Leeward wall	0-1	-0.5	q_h
	2	-0.3	q_h
	≥4	-0.2	q_h
Side wall	All values	-0.7	q_h

Possible Points	Score	
Problem 1	8	
Problem 2	12	
Problem 3	30	
Problem 4	25	
Problem 5	25	
TOTAL	100	

CE 120 – Spring 2022
Midterm Exam 2

** The figures below show an elevation view and a plan view of a three-story building which is to be used for Problems 1 and 2. Note that the two braced frames shown in elevation A-A are identical, and that elevation A-A is the same for both the North and South sides of the building.

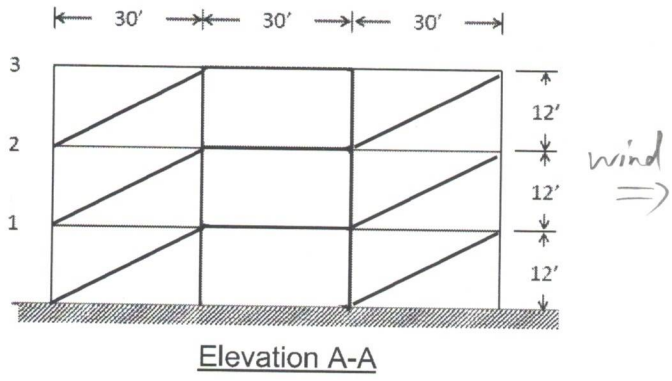


Figure 1

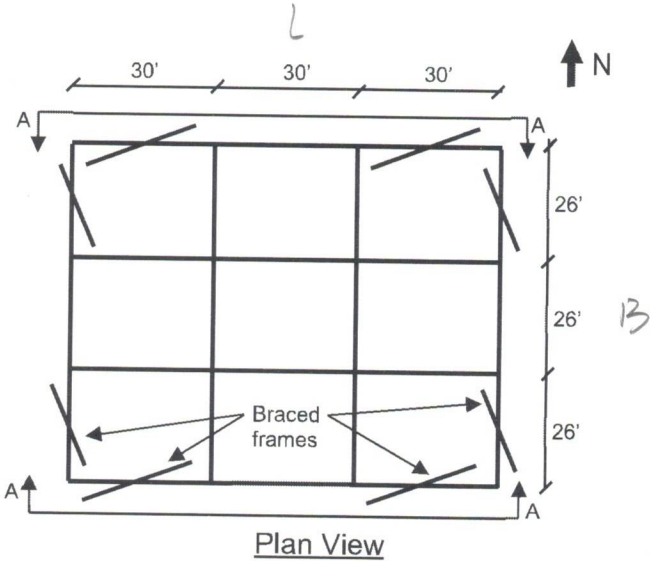


Figure 2

CE 120 – Spring 2022
Midterm Exam 2

Problem 1 (8 points) – The enclosed building in Figure 1 needs to be designed for a basic wind speed of 120 mph. The exposure category is B. Only consider wind coming from the west.

Calculate the wind pressure on the north and south walls of the building. Sketch and label these pressures on a plan view of the building.

Exposure B. $z = 12' \times 3 = 36'$

$k_z = 0.70 + \frac{36-30}{40-30} \times (0.76 - 0.70) = 0.736$

$q_z = 0.00256\, k_z k_{zt} k_d V^2$

$= 0.00256\,(0.736)(1)(0.85)(120^2)$

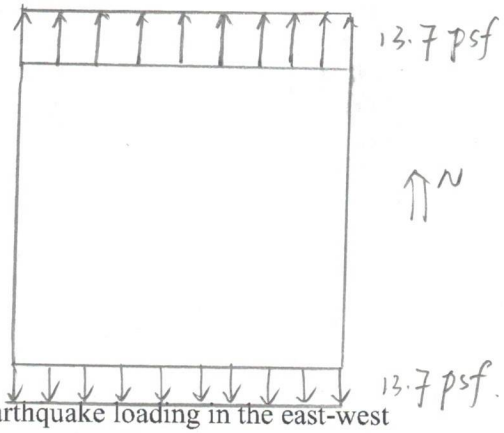
$= 23.06$ psf

$L/B = \frac{30' \times 3}{26' \times 3} = 1.15$

North and south walls are side walls

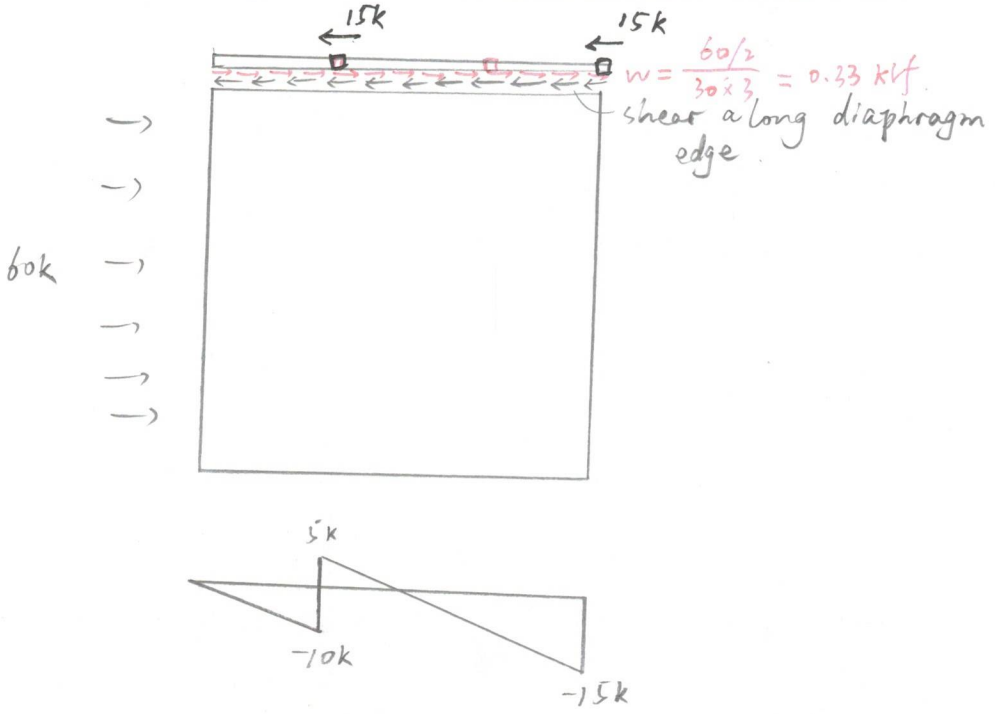
$C_p = -0.7$

$p = q_G C_p = 23.06\,(0.85)(-0.7) = -13.7$ psf



Problem 2 (12 points) – You are asked to design the building in Figure 1 for earthquake loading in the east-west direction. Your colleague calculates the total horizontal seismic design force that needs to be applied at the roof to be 60 kips.

Determine the maximum magnitude of the collector element force at the roof level.



Max collector force is 15k (compression).

CE 120 – Spring 2022
Midterm Exam 2

Problem 3 (30 points) –The beam shown is subjected to a 1 klf dead load along its entire length. It is also subjected to a single point live load of 5 kips that can be applied anywhere, and a 2 klf live load which can be applied to any span, or to multiple spans. The spans are defined as segments ab, bc, cd, de, and ef. All loads only act downwards.

(a) Draw the influence line for the shear just the left of point e.

(b) Draw the influence line for the moment at point d.

(c) Determine the maximum magnitude (either positive or negative) of the moment at point d.

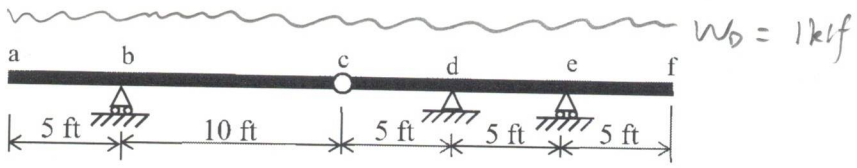
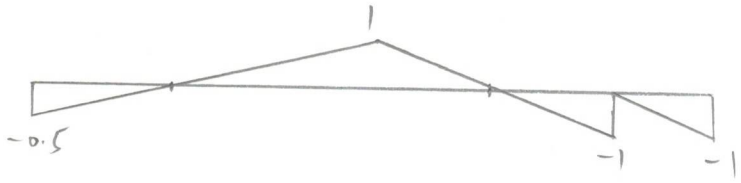
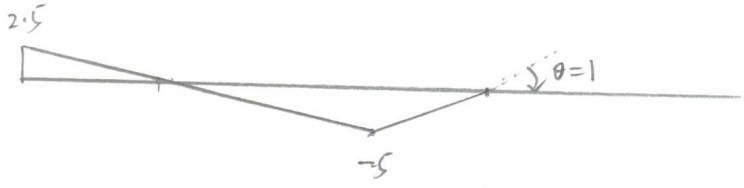


Figure 3

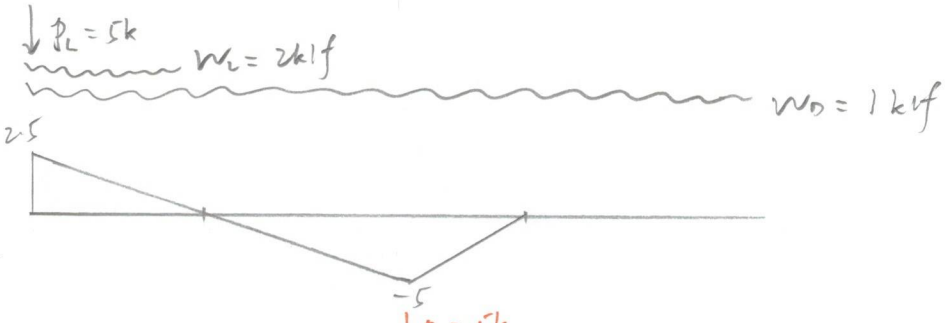
(a)



(b)



(c)



P_L = 5k
w_L = 2klf

① $M_{max} = 1\,klf\left(\frac{1}{2}\times 2.5\times 5 - \frac{1}{2}\times 5\times 15\right) + 2klf\left(\frac{1}{2}\times 2.5\times 5\right) + 5\times 2.5$
$= -6.25\,k\cdot ft$

② $M_{max} = 1\,klf\left(\frac{1}{2}\times 2.5\times 5 - \frac{1}{2}\times 5\times 15\right) + 2klf\left(-\frac{1}{2}\times 5\times 15\right) - 5\times 5$
$= -131.25\,k\cdot ft$.

$\Rightarrow$ $M_{max} = 131.25\,k\cdot ft$ (neg).

CE 120 – Spring 2022
Midterm Exam 2

Problem 4 (25 points) – A pin-jointed truss is shown in Figure 4 with a vertical load at point C. The axial stiffness of each member is EA = 10,000 kips.

For the loading shown, determine the horizontal displacement of point C.

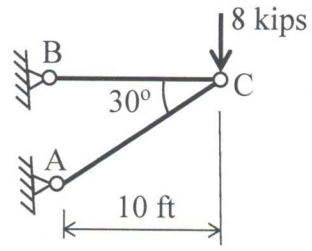
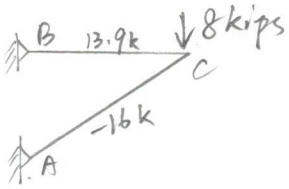
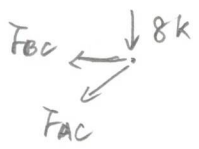


Figure 4

Real



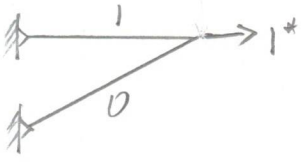


$$\begin{cases} +\uparrow \Sigma F_y = -8 - F_{AC}\cdot \sin 30^\circ = 0 \\ \pm\rightarrow \Sigma F_x = -F_{BC} - F_{AC}\cdot \cos 30^\circ = 0 \end{cases}$$

$$\Rightarrow F_{AC} = -16\,k$$

$$F_{BC} = 13.9\,k$$

Virtual



$$\delta W_{int} = \Sigma T^* e = 1 \cdot \frac{13.9\,k\cdot(10'\times 12)}{10000} = 0.167 = 1^*\cdot \delta_c$$

$$\Rightarrow \boxed{\delta_c = 0.167''} \rightarrow$$

CE 120 – Spring 2022
Midterm Exam 2

Problem 5 (25 points) – A cantilever beam is shown in Figure 5 with an applied moment at point C. The bending stiffness of the beam is $EI = 100{,}000$ kip-in^2.

For the loading shown, use virtual work to determine the vertical displacement of point B.

Real

(M)

[k-ft]

(곡률)

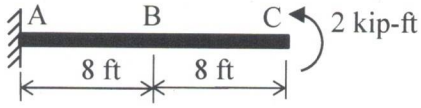
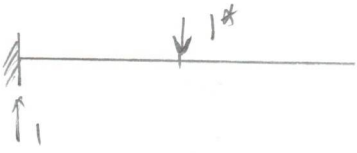


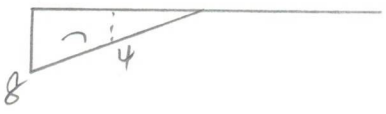
Figure 5

Virtual

M^*

[k-ft] & (처짐)





$$\delta W_{int} = \frac{A_m}{EI} \cdot M^*_{\bar{x}_m} = \frac{2 \times 8 \times (12^2)}{1 \times 10^5} \cdot (4 \times 12) = -1.1 \text{ k-in} = 1^* \cdot \delta_B$$

$$\Rightarrow \boxed{\delta_B = 1.1 \text{ in} \uparrow}$$