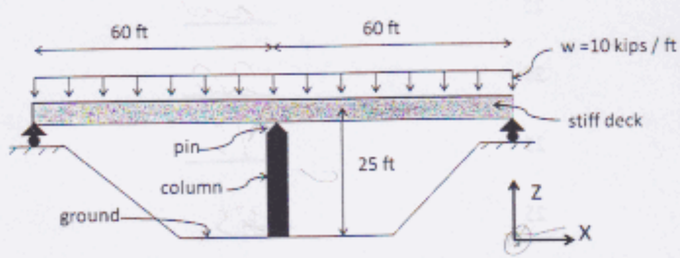
Problem 1 (25 points)

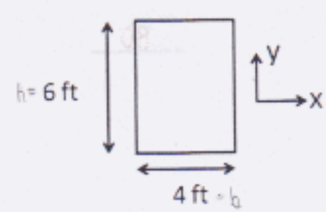
The reinforced concrete (RC) bridge structure shown in figure (a) is considered. The single column of the bridge is fixed at its base. A pin connection is used between the column and the stiff deck. Our aim is to design the RC column for earthquake loading in the x direction.

The uniformly distributed **factored** seismic weight, w = 10 kips / ft, includes the self weight of the deck, the permanent loads, half of the weight of the column as well as the live load contributing to the seismic weight. The design elastic acceleration is $\mathbf{S_a} = 0.8g$. Use a response modification factor $\mathbf{R} = 4$ to obtain design forces. The yield strength of steel used is $\mathbf{f_y}$ = 60 ksi and the concrete compressive strength is $\mathbf{f_c'}$ = 6 ksi.

The RC column has the rectangular section shown in Figure (b). Design the RC column to have adequate **flexural** and **shear** strength for the design seismic load. Use 2 inches of clear concrete cover and #5 stirrups. Use #11 bars for the longitudinal reinforcement. The section area of a #11 bar is 1.56 in^2 and its diameter is 1.4 in. Draw a clear sketch of the section of the column showing the reinforcement details.



(a) Elevation view of the bridge



(b) Section of the reinforced concrete column

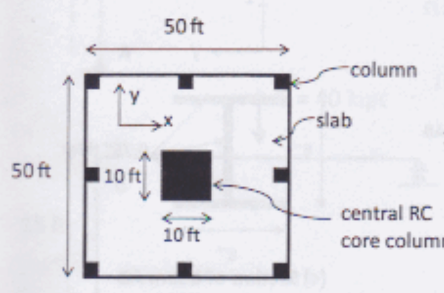
Problem 2 (25 points)

We consider the reinforced concrete (RC) building shown in Figures (a) and (b). The structural system consists of a central core RC column coupled through the floor slab with columns in the perimeter of the building. At its bottom 15 ft the entire building is supported on the central RC core column. The section and reinforcing details of the central RC core column are shown in Figure (c). The concrete has compressive strength $f_c' = 5$ ksi and the steel yield strength $f_y = 60$ ksi.

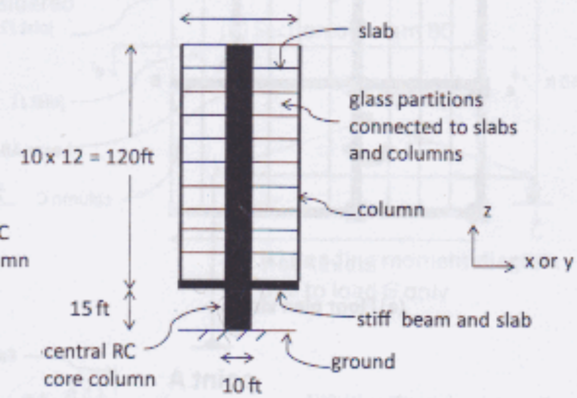
We consider the design of the building for wind loading. The design wind velocity is V = 70 mph. The wind pressure distribution for wind acting in the x direction is shown in Figure (d) with $q_w = 0.00256\ V^2$. The wind pressure is constant along the height of the building.

1) Calculate the nominal shear strength of the central RC column for shear force in the x or y direction.

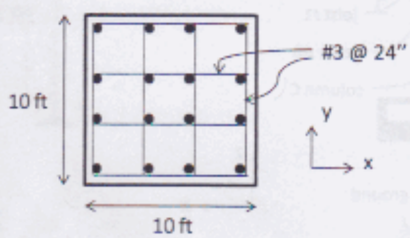
2) Does the column have adequate shear strength to resist the design wind load? Assume that the flexural strength of the column is adequate.



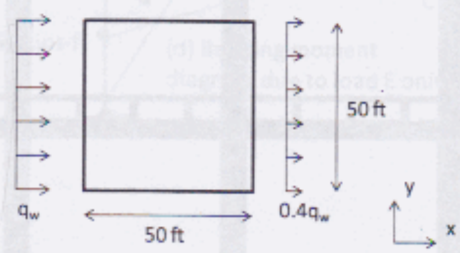
(a) Floor plan view above 15 ft from the ground



(b) Building elevation in xz or yz plane



(c) Section of central RC column



(d) Plan view of wind pressure distribution

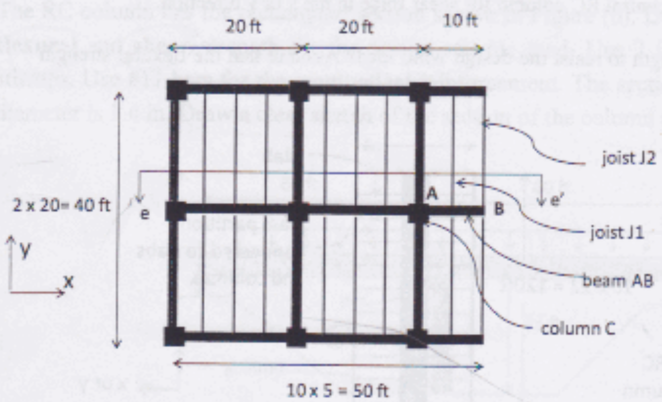
Problem 3 (25 points)

The two-story frame building with the floor plan view shown in Figure (a) is considered. The floor system consists of a slab with joists which is simply supported on the beams of the frame. The uniformly distributed **factored** vertical load of each floor including the self weight of the slab, joists, other permanent loads, and live loads is 200 psf.

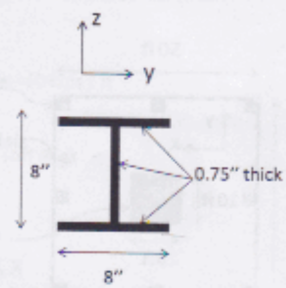
We consider the flexural design of the **steel** beam AB of the second floor, see Figures (a) and (b), which has the I-shape section shown in Figure (c). The yield strength of the steel is $f_y = 60$ ksi.

1) Calculate the nominal section flexural strength of beam AB (bending about the y-axis).

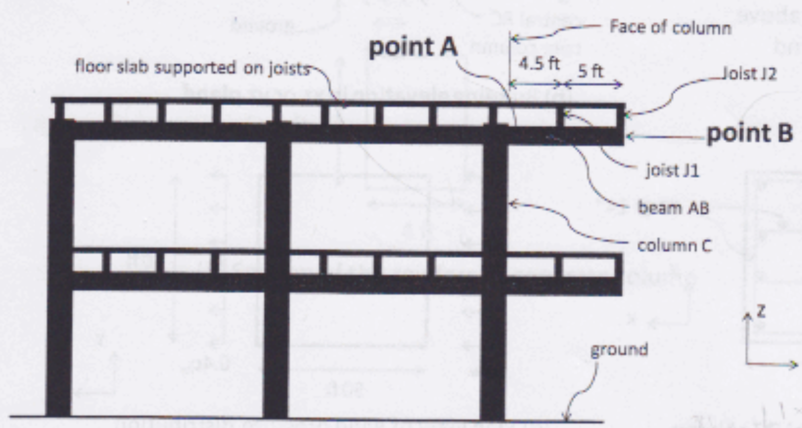
2) If beam AB is fixed at the face of column C at point A, see Figure (b), determine whether it has adequate flexural strength.



(a) Floor plan view



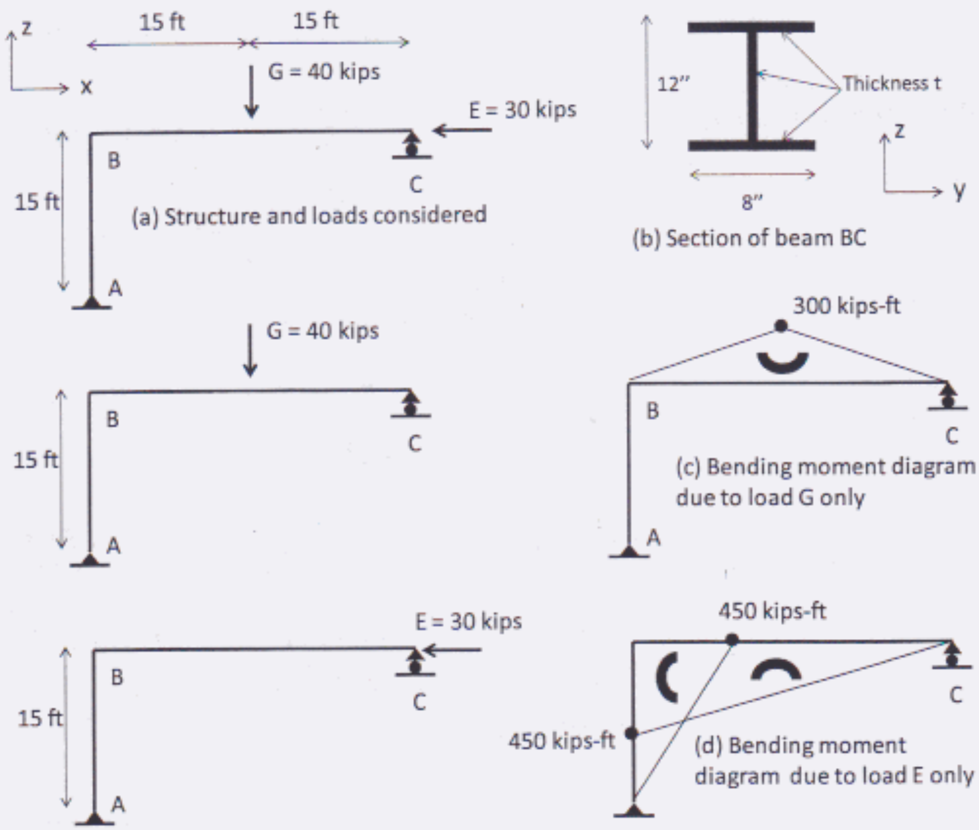
(c) Section of beam AB



(b) Elevation view, section e-e'

Problem 4 (25 points)

The frame ABC shown in Figure (a) is considered. The frame is subjected to the **factored gravity** load G and to the **factored earthquake** load E. The steel beam BC has the I-shape section shown in Figure (b). The bending moment diagrams of the frame subjected individually to the load G and load E are shown in Figures (c), and (d), respectively. The yield strength of the steel is $f_y = 60$ ksi. Determine the thickness t of the section of beam BC in order to have adequate flexural strength.



(a) Structure and loads considered

(b) Section of beam BC

(c) Bending moment diagram due to load G only

(d) Bending moment diagram due to load E only