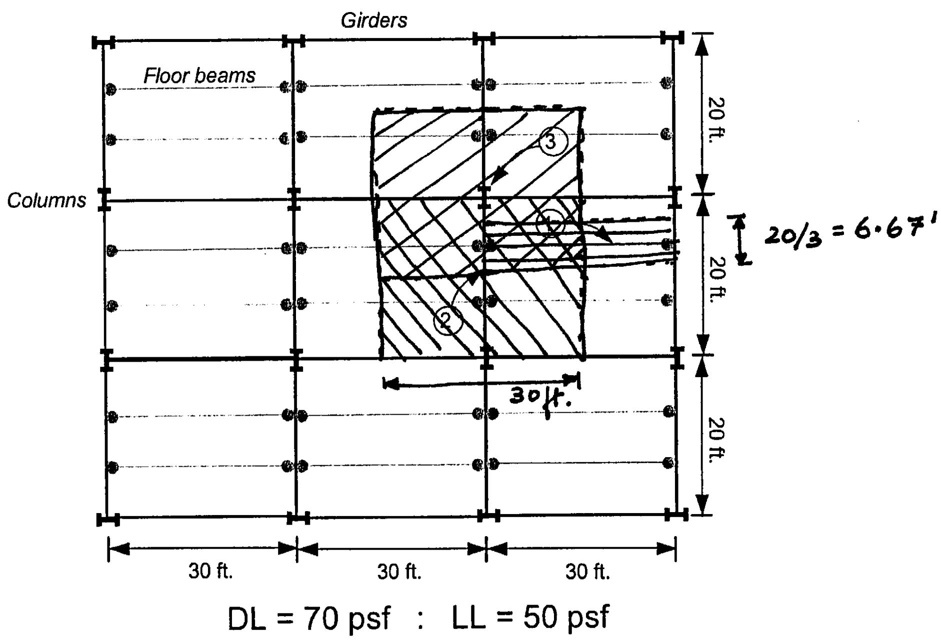
Name: AMIT H. VARMA

Problem No. 1. (40 points)

Calculate the reduced live load and the ultimate factored loads (magnitude and distribution) for the structural components 1, 2, and 3 identified in the figure below. The figure shows the intermediate story floor plan for a multistory structure. It includes relevant details needed for the calculation. As shown, 1 is a floor beam, 2 is a girder, and 3 is a column.

For each of these components, your approach shall be to: (a) compute the tributary area, (b) select the element factor from the table below, (c) calculate the influence area, (d) calculate the reduced live load, and (e) calculate the factored design load.



Reference material from ASCE 7-05 is also given below:

4.8 REDUCTION IN LIVE LOADS

Except for roof uniform live loads, all other minimum uniformly distributed live loads, L_o in Table 4-1, may be reduced according to the following provisions.

4.8.1 General. Subject to the limitations of Sections 4.8.2 through 4.8.5, members for which a value of $K_{LL}A_T$ is 400 ft^2 (37.16 m^2) or more are permitted to be designed for a reduced live load in accordance with the following formula:

$$L = L_o\left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}}\right) \qquad (4\text{-}1)$$

where

L = reduced design live load per ft^2 (m^2) of area supported by the member

L_o = unreduced design live load per ft^2 (m^2) of area supported by the member (see Table 4-1)

K_{LL} = live load element factor (see Table 4-2)

A_T = tributary area in ft^2 (m^2)

L shall not be less than $0.50L_o$ for members supporting one floor and L shall not be less than $0.40L_o$ for members supporting two or more floors.

TABLE 4-2 LIVE LOAD ELEMENT FACTOR, K_{LL}

Element	K_{LL}[a]
Interior columns Exterior columns without cantilever slabs	4 ✓ 4
Edge columns with cantilever slabs	3
Corner columns with cantilever slabs Edge beams without cantilever slabs Interior beams	2 2 2 ✓
All other members not identified including: Edge beams with cantilever slabs Cantilever beams One-way slabs Two-way slabs Members without provisions for continuous shear transfer normal to their span	1

[a] In lieu of the preceding values, K_{LL} is permitted to be calculated.

START SOLUTION HERE:

For member 1:

$A_T = \frac{20}{\cancel{3}} \times \cancel{30}^{10}\ ft^2 = 200\ ft.$ 3

$K_{LL} = 2$ 2

$\therefore\ K_{LL} A_T = 400\ ft^2 = A_I$ 5

$\therefore\ L = L_o \left\{0.25 + \frac{15}{\sqrt{K_{LL} A_T}}\right\}$

$= L_o \left\{0.25 + \frac{15}{\sqrt{400}}\right\}$

$L = L_o * 1$

$\therefore\ LL = 50\ psf$

For member 2:

$A_T = 30 \times 20\ ft^2 = 600\ ft^2$ 3

$K_{LL} = 2$ 2

$\therefore\ K_{LL} A_T = 1200\ ft^2 = A_T$ 5

$\therefore\ L = L_o \left\{0.25 + \frac{15}{\sqrt{K_{LL} A_T}}\right\}$

$= L_o \left\{0.25 + \frac{15}{\sqrt{1200}}\right\}$

$L = L_o \times 0.68$

$\therefore\ LL = 34\ psf$

For member 3:

3

$A_T = 30 \times 20 \text{ ft}^2$

$= 600 \text{ ft}^2$

2

$K_{LL} A_T = 4 \times 600 = 2400 \text{ ft}^2$

5

$\therefore L = L_o \times \left\{ 0.25 + \frac{15}{\sqrt{K_{LL} A_T}} \right\}$

$= L_o \times \left\{ 0.25 + \frac{15}{\sqrt{2400}} \right\}$

$= L_o \times 0.556$

$\therefore LL = 27.8$ psf.

For member 3:

3

$FL = 1.2\,DL + 1.6\,LL$

$FL = 128.48$ psf

$\therefore$ column load

$P = 600 \times 128.48$

$= 77.09$ kips.

For member 1:

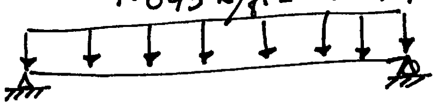
4

$FL = 1.2\,DL + 1.6\,LL$

$= 1.2 \times 70 + 1.6 \times 50$

$FL = 164$ psf.

1.093 k/ft = 164 psf × 6.67 ft



For member 2:

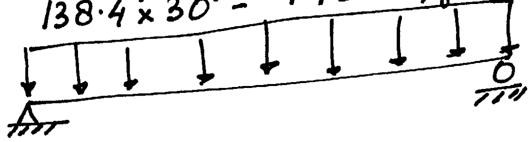
4

$FL = 1.2\,DL + 1.6\,LL$

$= 1.2 \times 70 + 1.6 \times 34$

$= 138.4$ psf.

$\therefore$ 138.4 psf × 30 ft = 4.152 k/ft



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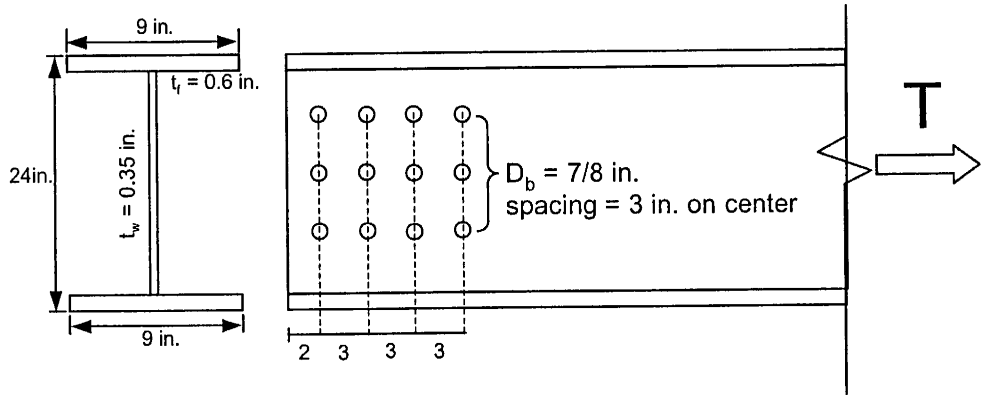
Problem No. 2 (40 points)

The figure below shows a built-up section made from A36 steel. The section dimensions and the relevant details of the connection region are included below. Calculate the design strength of the member in tension. Consider both the gross yielding and the net section fracture limit states. Consider both applicable cases for U to select the appropriate value.



Section End connection region

START SOLUTION HERE:

STEP I: CALCULATE AREAS

$$A_g = 9 \times 0.6 \times 2 + (24 - 1.2) \times 0.35$$
$$= 10.8 + 7.98$$
$$A_g = 18.78 \text{ in}^2$$

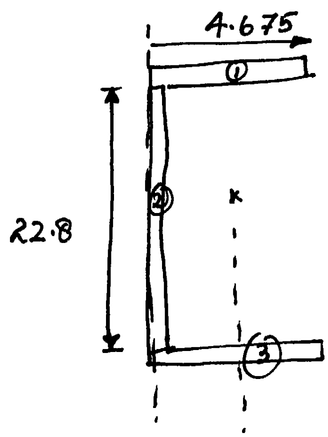
4

$$A_n = A_g - 3 \times (7/8 + 1/8) \times 0.35$$
$$= A_g - 1.05$$
$$A_n = 17.73 \text{ in}^2$$

6

10

STEP 2: CALCULATE $\bar{x}$:



$$\bar{x} = \frac{\sum A_i x_i}{\sum A_i}$$

$$\therefore \bar{x} = \frac{4.675 \times 0.6 \times 2 \times \frac{4.675}{2} + 22.8 \times 0.35 \times \frac{0.35}{2}}{4.675 \times 0.6 \times 2 + 22.8 \times 0.35}$$

$$\bar{x} = 1.0677 \text{ in.}$$

STEP 3: CALCULATE U

6

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.0677}{9} = 0.88$$

3

COMPARE WITH CASE 7 $U = 0.8$

Use Larger value $= 0.88$ 1

STEP 4: TENSION DESIGN STRENGTH 5

$$\therefore \ \phi T_n = 0.9 \times A_g \times F_y = 0.9 \times 18.75 \times 36 = 607.5\ ^k$$

or 5

$$0.75 \ A_e \times F_u = 0.75 \times 0.88 \times 17.73 \times 58 = 678.7\ ^k$$

Smaller will govern

$\therefore \ \phi T_n = 607.5\ ^k \longrightarrow$ gross yielding will govern.

Name:

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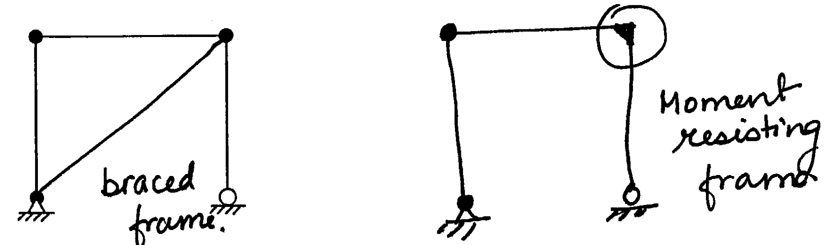
Problem set 3. (20 points)

1] The figure below shows an unstable structural frame. Make one simple modification to convert it into a fundamental (and stable) type of steel structure. Identify (name) the fundamental steel structure you have created. 1



2] A 2D steel frame can resist only planar loads. It cannot resist any out of plane forces. 0.5

True or False – circle one.

3] A 3D steel structure is made by combining 2D steel frames in 3D space. 0.5

True or False – circle one.

4] Steel is made by combining iron and carbon. Additional impurities like manganese & copper are present in small amounts or traces. 1

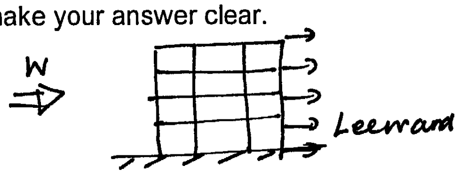
5] The yield strength of steel can be increased by the following two methods: 2

(i) quenching and tempering

(ii) adding alloys

6] For a building with a rectangular plan, the leeward side is always subjected to what direction of wind pressure? Draw a graphic if you need to make your answer clear. 1

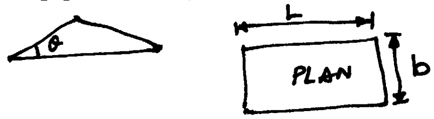
Suction Pressure



7] The wind pressure acting on sloping roofs depends on the building geometric parameters. Name at least two of them from your memory. 2

① Roof angle θ

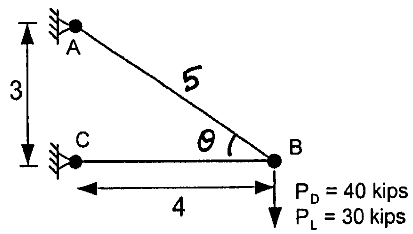
② length-to-width (L/b) ratio

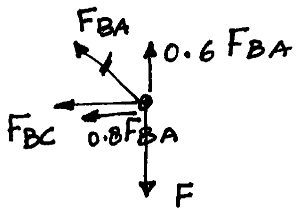


8] The wind velocity pressure is calculated as $0.00256\ V^2\ (K_z\ K_d\ K_{zt}\ I)$. What does the term $0.00256\ V^2$ represent? 1

Kinetic Energy of air $= \frac{1}{2} m V^2$

9] For the truss structure shown below. Calculate the factored ultimate design load for member AB. 3





$\therefore\ 0.6 F_{BA} = F$

$\therefore\ F_{BA} = \frac{F}{0.6}$

$\therefore\ F_{BA} = 1.667\ F$

$FL = 1.2 DL + 1.6 LL$

$= 1.2 \times 40 + 1.6 \times 30$

$FL = 96$ kips

$\therefore\ F_{BA}\big|_{design} = 1.667 \times 96$

$= 160$ kips