

Midterm Examination

Duration one hour and fifteen minutes (75 minutes)

Open Books, Notes & Other stuff.

No Neighborly Participation

"The fine print": Notes on the whole examination:

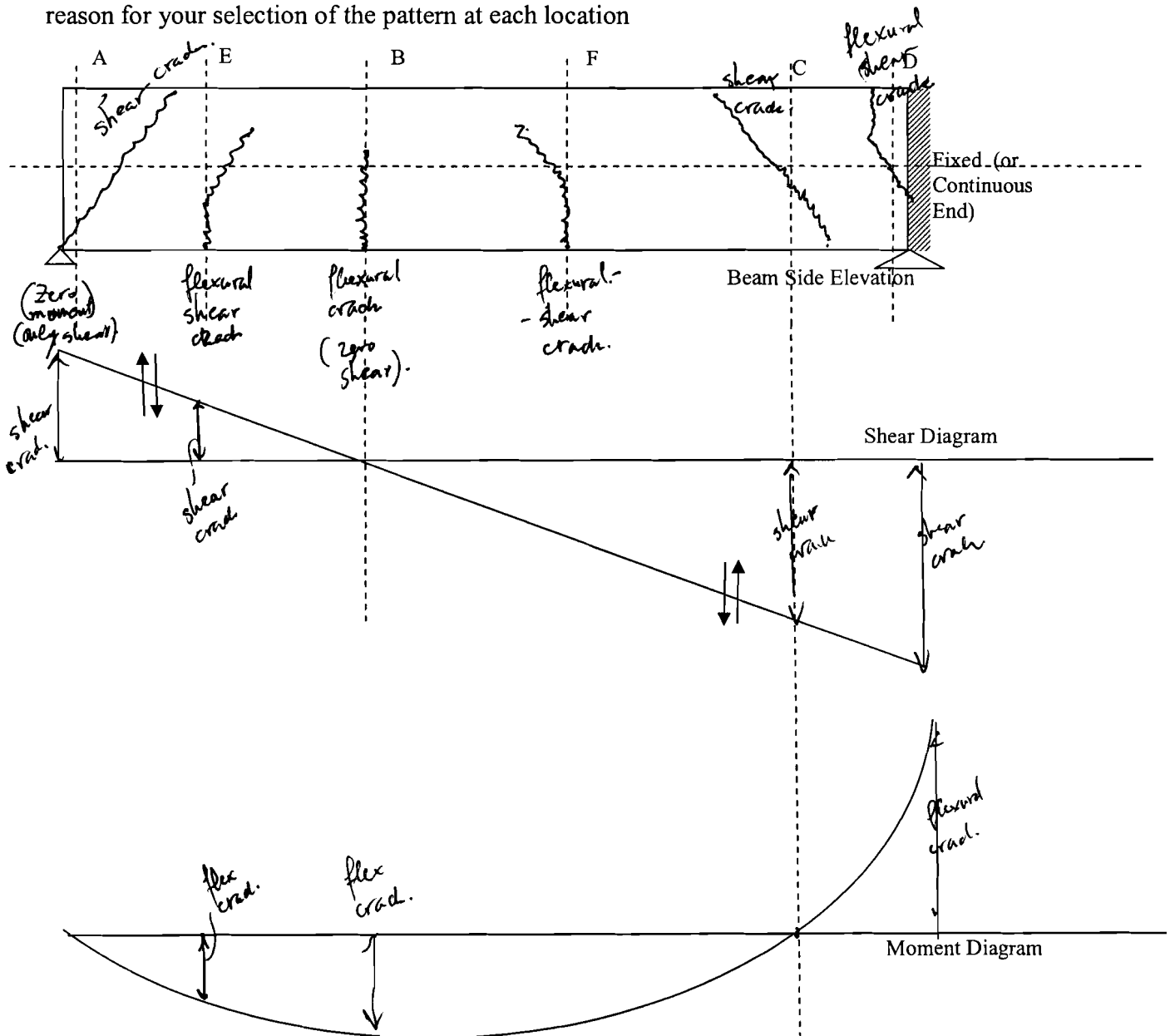
- 1) The total points on the exam are 120. You are given an extra 20 points to account for computational and inadvertent errors. However your grade will not exceed 100 even if your score is more than 100. If you score 93, you will get a 93. If you score 110 your score will be 100.
- 2) **PLEASE BUDGET YOUR TIME. YOU MAY WANT TO ANSWER FIRST THE SHORT (OR BEST KNOWN ANSWER) QUESTIONS.**
- 3) If you feel that you are missing some data, ask or make a reasonable assumption.

Problem #1: (20 points)

For the beam shown below determine and sketch the cracking pattern expected:

- 1) Show the cracking pattern at locations A through D.
- 2) For extra 10 points show the cracking pattern at locations E-F.

Mark the type (flexural or shear), show the direction, and within one short sentence explain the reason for your selection of the pattern at each location



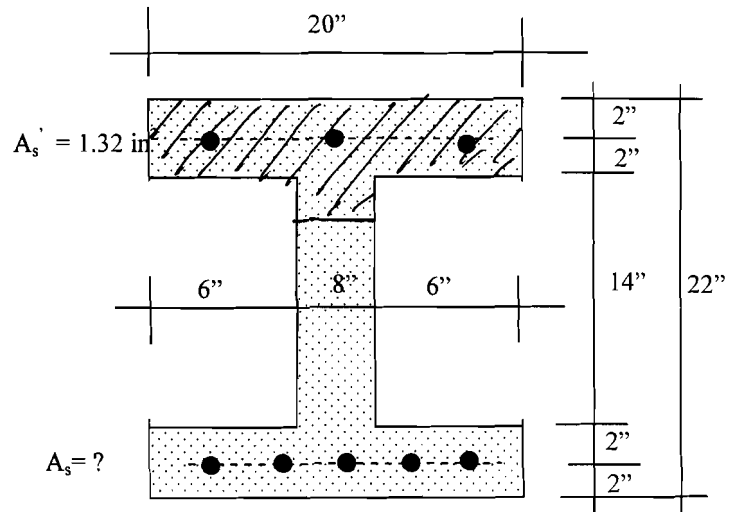
Information for Problem 1

Problem #2: (40 points)

Determine the maximum reinforcement and the associated moment capacity M_{cap} of the section shown in the figure on the right according to ACI 318-05. The section is compressed in the top side.

- 1) Determine the allowable maximum value of the concrete compressed block acc to ACI 318-05 (5)
- 2) Determine the moment contributed by the reinforcement provided in the compressed zone (7)
- 3) Determine the **maximum (ultimate)** moment capacity (18)
- 4) Determine the total tension reinforcement (5)
- 5) Determine the **design** moment capacity (5)

Parameters: $f'_c = 5 \text{ ksi}$, $f_y = 50 \text{ ksi}$



$d = 20''$ $d' = 2$ $\bar{t} = 0.10$

① $\beta = 0.85 - (f'_c - 4) \cdot 0.05 = 0.85 - 0.05 = 0.80$

① $k = \beta_1 \cdot \frac{E_{cu}}{E_{cu} + E_s} = 0.8 \cdot \frac{0.003}{0.003 + 0.005} = 0.30$

$a = 0.30 \times 20 = 6.0'' > t_{flange}$

or

$k = 0.30$ $\bar{t} = 4/20 = 0.20$ $k > k_{min} = 0.20$

Beam acts as a T beam doubly reinforced:

② $M' = f_y A_s' \times (d - d') = 50 \times 1.32 \times 20(1 - 0.1) = 23.76 \times 50 = 1188 \text{ k-in.}$

$M_{flange} = (B - b) \cdot d^2 \times 0.85 f'_c \cdot \bar{t} (1 - \frac{\bar{t}}{2}) = 0.85 \times 5 \times (20 - 8) \times 20^2 \times 0.2 (1 - \frac{0.2}{2}) = 3672 \text{ k-in}$

$M_{web} = 0.85 b d^2 \cdot k (1 - \frac{k}{2}) = 0.85 \cdot 8 \times 20^2 \times 0.30 (1 - \frac{0.30}{2}) = 3468 \text{ k-in}$

③ $M_{TOT} = 1188 + 3672 + 3468 = 8328 \text{ k-in} = 694 \text{ k-ft}$

④ $A_s = A_s' + \frac{M_{flange}}{f_y d (1 - \frac{\bar{t}}{2})} + \frac{M_{web}}{f_y d (1 - \frac{k}{2})} = 1.32 + 4.08 + 4.08 = 9.48 \text{ in}^2$

⑤ $M_d = \frac{M_{TOT}}{\phi} \times 0.9 = 7495 \text{ k-in} = 624 \text{ k-ft}$

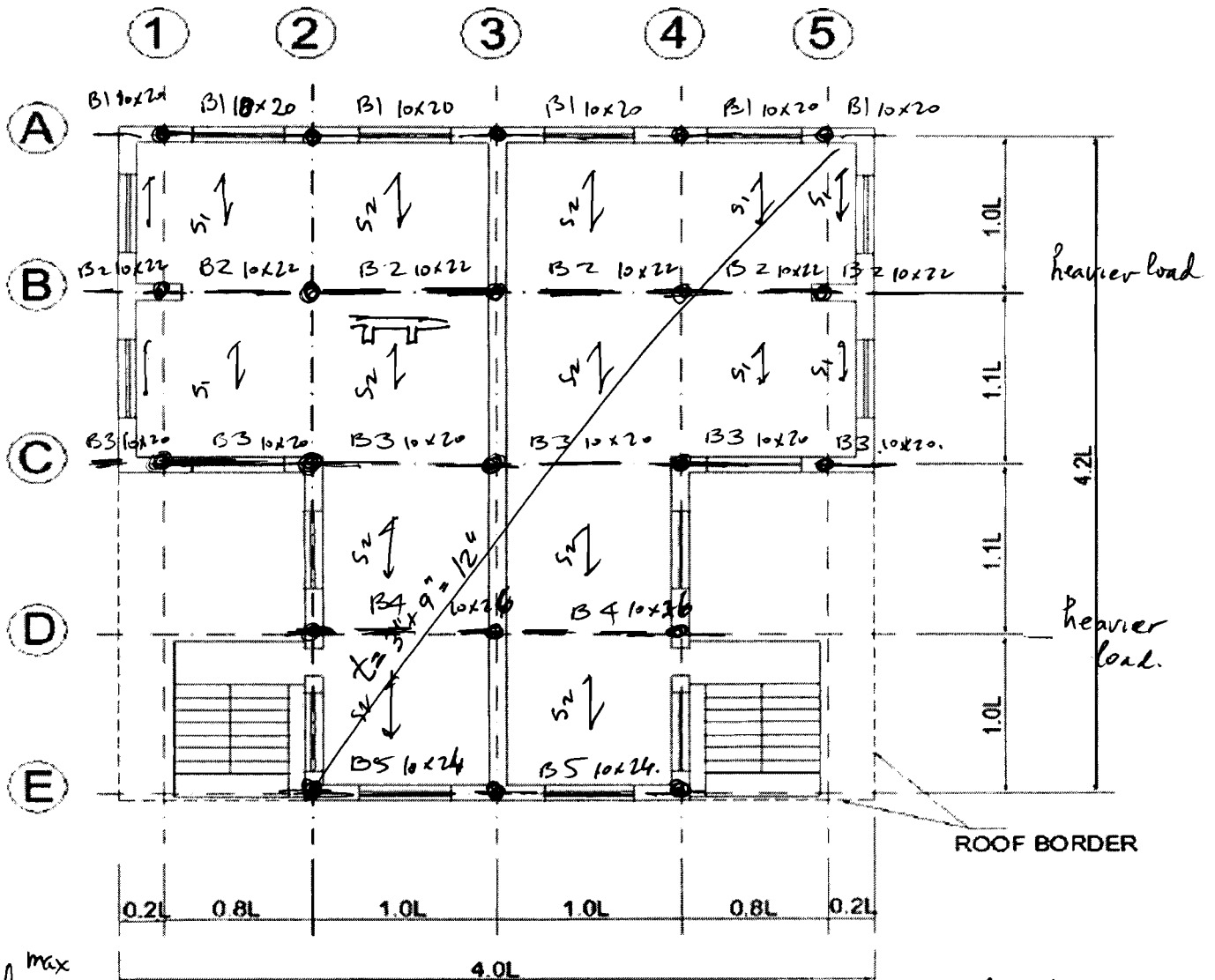
Problem #3 (30 points)

Overall: Design the floor using approximations. Use $L=25$ ft

Detailed requirements:

- ✓ 1) Choose a layout of beams between the columns (either horizontal or vertical – but not both) and mark them in the sketch (4)
- ✓ 2) Layout one way **ribbed (joists) slab** supported by the beams, which you chose in (2) and show in the sketch. (6)
- ✓ 3) Determine the thickness of the slab (unique for whole floor) using approximations ($h=L_{eq}/m$ or ACI recommendations). (10)
- 4) Determine the dimensions of all beams using also approximations with the “width” approximately half of the height but not less than 8”. Make all beams same dimensions. Show dimensions on sketch. (10)

(You may show your sketch on the exam sheet)



(g) $d = \frac{l_{eq}^{max}}{25} = \frac{0.8 \times 1.1 \times 25}{25} = 0.9' \Rightarrow 11''$ from S_1 span BC round off = 12'' = 3'' + 9''

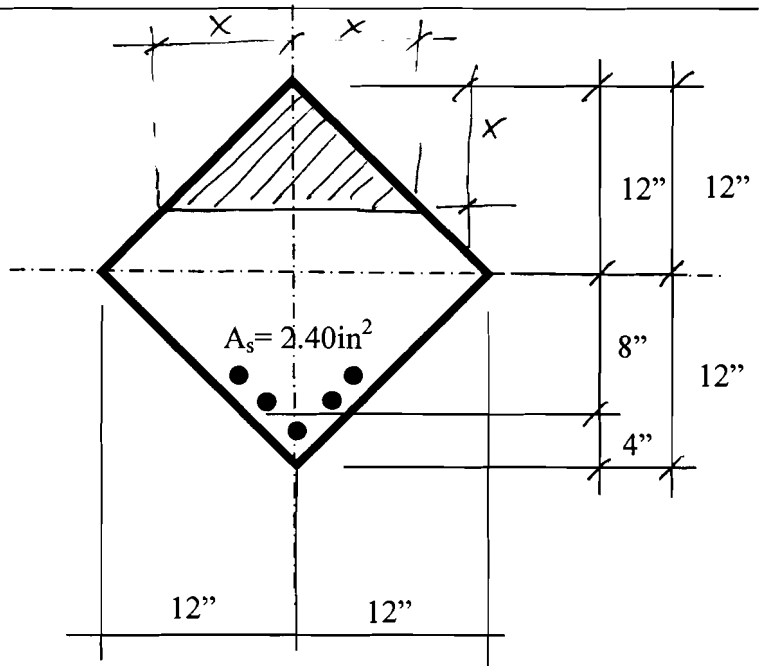
TYPICAL FLOOR PLAN (not in scale)

(h) $B_1 = \frac{l_{eq}^{max}}{10} = \frac{0.8 \times 0.8 \times 25}{10} = 1.6' \approx 20''$ or $\frac{l_{eq}}{10} = \frac{0.6 \times 0.8 \times 25}{10} = 1.5'$

$B_5 = \frac{0.8 \times 1.0 \times 25}{10} = 2.0' \approx 24'' \Rightarrow$ For all beams same dimensions use 10x24. (B4 may need double reinforced section).

Problem #4 (30 points)

Determine the flexural design capacity ϕM_n of the diamond cross section shown in the figure on the right assuming $f'_c = 4.0$ ksi and GR60 steel. (Note: The 4" dimension is the distance from vertex to the centroid of reinforcement).



$x = ?$

$d = 20''$

$f'_c = 4.0$

$f_y = 60.$

$A_c = 2x \cdot x / 2 = x^2.$

$C = 0.85 f'_c \cdot x^2 = 0.85 \cdot 4 \cdot x^2 = 3.4 x^2$ *compression resultant*

$T = A_s \cdot f_y = 2.4 \times 60 = 144 \text{ kips.}$

$x = \sqrt{144 / 3.4} = 6.51 \text{ in}$

$x/d = k = 0.33$

$\text{arm} = d(1 - \frac{2}{3} \frac{x}{d}) = 20 \times (1 - \frac{2}{3} \cdot 0.33) = 15.66 \text{ in}$

$M_{\text{moment},n} = T \times \text{arm} = 144 \times 15.66 = 2255.2 \text{ k-in} = \underline{\underline{187.9 \text{ k-ft.}}}$

$M_d = 0.9 \times M_n = 0.9 \times 2255.2 = 2029.7 \text{ k-in} = 169.1 \text{ k-ft.}$