Midterm Examination

Duration one hour and fifteen minutes (75 minutes)

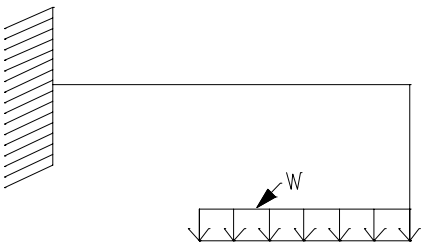
Open Book, Notes & Other stuff.

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 THE SHORT ANSWER QUESTIONS FIRST.*

Problem #1: (35 points)



For the frame shown in the sketch determine:

a) The deflected shape
b) The moment diagram
c) The shear diagram
d) Indicate the position of reinforcement for flexure in a separate sketch

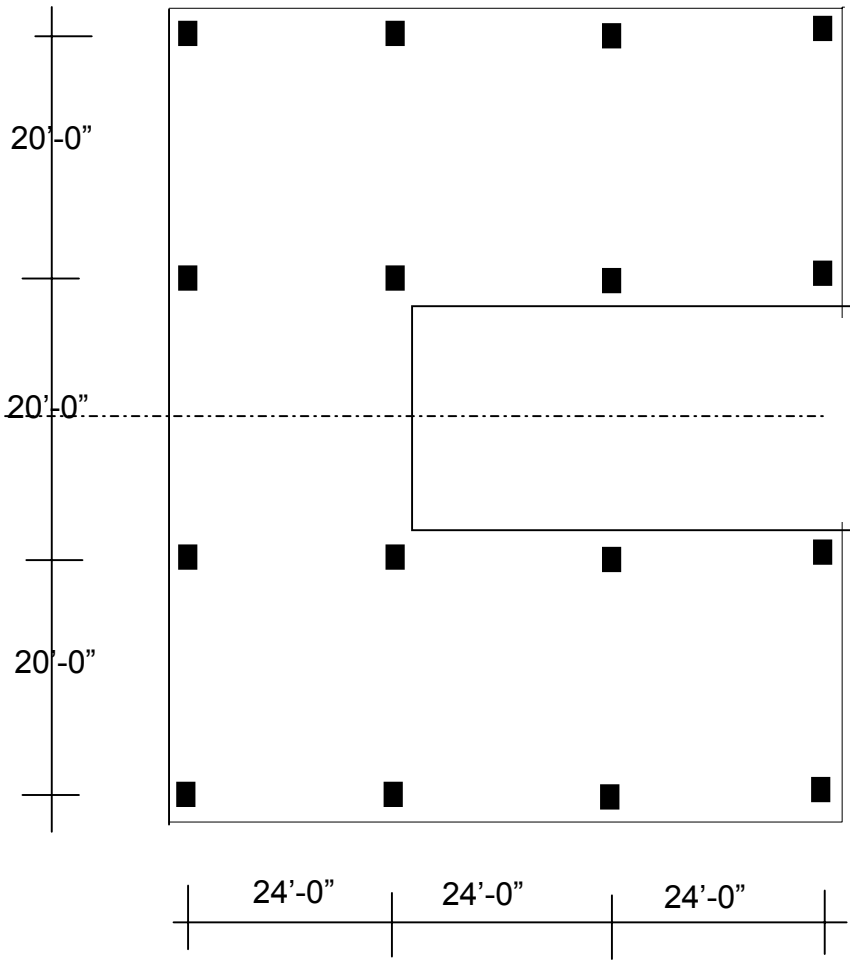
Notes: *Show the answer graphically. Indicate the critical points. Indicate moments on the tension side and indicate the shear force pair (sign) for orientation.*

Problem #2 (35 points)

Overall: Design a floor for a structure using approximations and determine the load cases for the typical floor slab

Detailed requirements:

1) Label (with numbers) all columns starting from the upper left corner.
2) Choose a layout of beams between the columns and label them (either horizontal or vertical – but not both)
3) Layout one way ribbed (joists) slab supported by the beams, which you chose in (2) and show in the sketch with proper arrows and labels. Show typical cross sectional sketch of slab.
4) Determine the thickness of the slab (unique for whole floor) using approximations (h=l*/m or h=L_{eq}/m or ACI recommendations).
5) 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.



Problem 2: Continued on next page

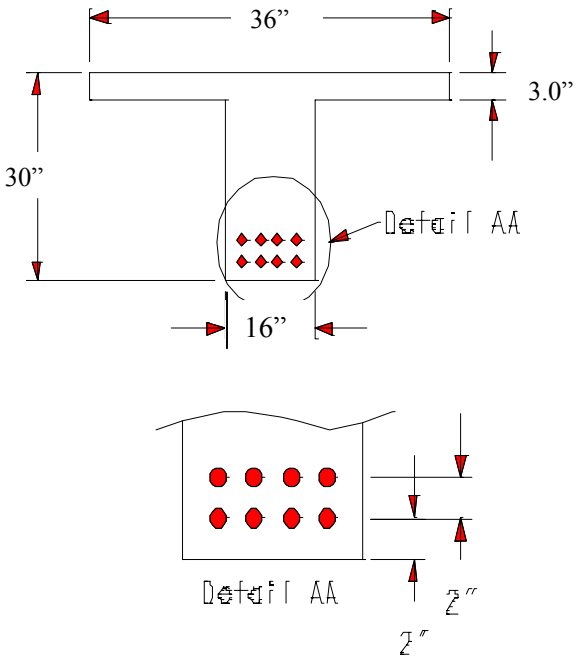
Problem 2: Continued form previous page:

6) Determine the thickness of the slab if it was made a one-way flat plate.
7) Compare the total approximated weight of the floor for the two alternatives of design, ((3) and (4)) versus (6). Comment on the efficiency of each alternative.
8) Show the tributary loading area to each of the beams, with proper dimensions

Note: you may use the examination page drawing for presentation of your answer

Problem #3: (50 points)

1) Determine the moment capacity M_{cap} of the T section shown in the figure on the right, if the compression in concrete extends for 8" from the top.



2) Determine the corresponding reinforcement, to be arranged in two layers as shown in Detail AA, if the moment demand is equal to the moment capacity M_{cap} .

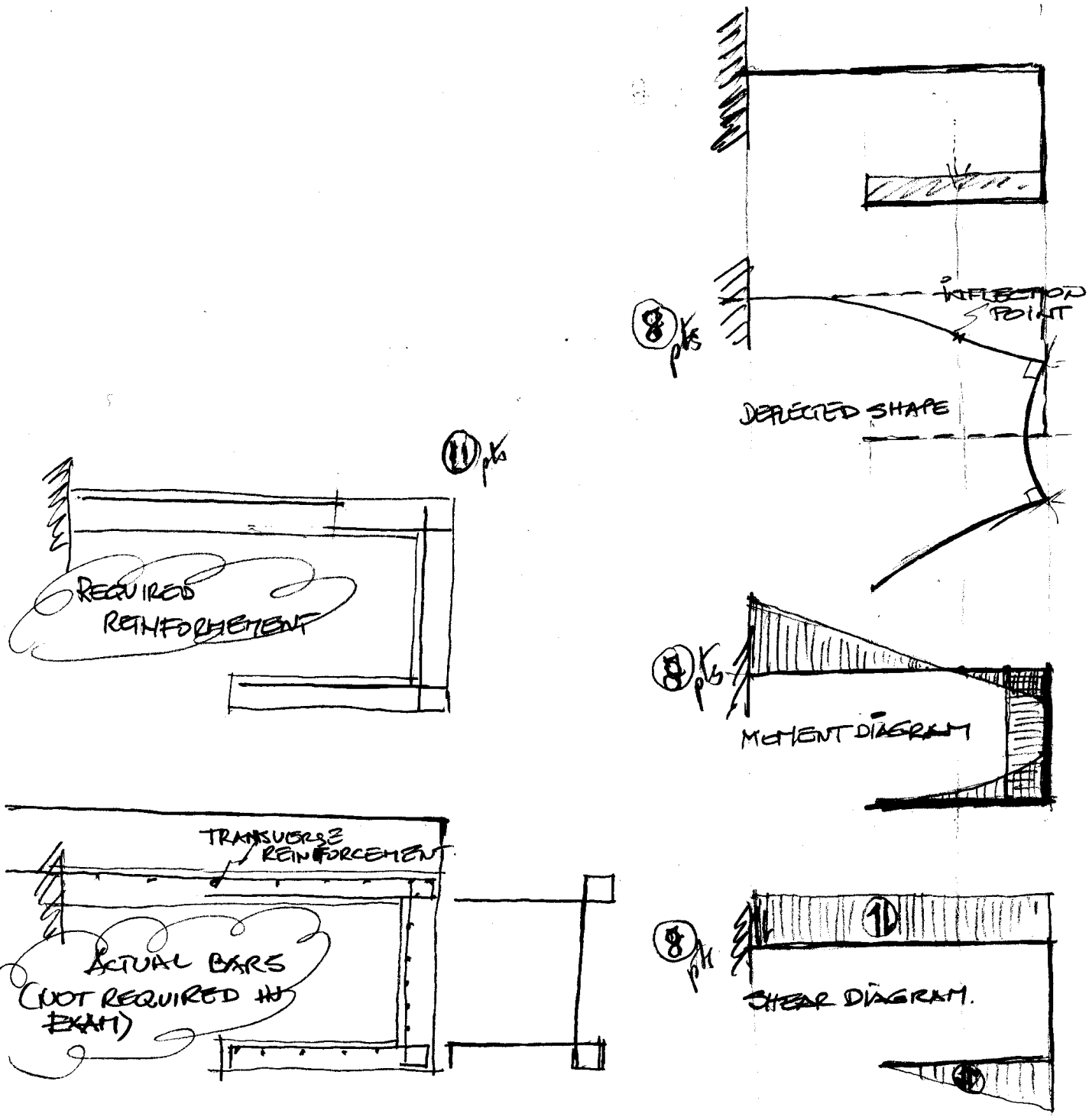
3) Determine the reinforcement of the section for an acting moment equal to 1.5 times the size of the moment capacity which you calculated in (1) above, i.e. M_{demand} = 1.5 x $M_{,cap}$, without increasing the area of compressed concrete . You may extend the height to accommodate additional reinforcement in three layers.

4) Show the final arrangement of reinforcement to fit the dimensions of the beam and cover requirements.

5) If the section is loaded by a ***design*** shear force (V_d) of 400 kips, determine the required shear reinforcement. Explain your decisions.

Parameters: $\mathbf{f_c' = 4\ ksi,\ f_y = 60\ ksi,\ \rho_{min} = 200/f_y\ [psi]}$

PROBLEM #1 - SOLUTION



PROBLEM #2

3 1) SEE SKETCH.

3 2) SEE SKETCH.

7 3) SEE SKETCH — THICKNESS OF SLAB (RIBBED) $h = \frac{l^*_{max}}{20-28} = \frac{20\times12}{20} \simeq 12''$ (S_2 GOVERNS.)

7 4) MASSIVE SLAB THICKNESS (S_2 GOVERNS) $= h = \frac{l^*_{max}}{35} \simeq \frac{20\times12}{35} \simeq 7$ in.

7 5) BEAMS TYPICAL SECTION: $h = \frac{l^*}{10} = \frac{0.8\cdot24\times12}{10} \simeq 24$ in. (B1 or B2 GOVERNS.)

5 6) EQUIVALENT THICKNESS OF RIBBED SLAB:

$$h_{equiv} = \left(2 + \frac{5\times10}{30}\right) = 3.66 \simeq 4 \text{ in}$$

3 7) WEIGHT OF RIBBED SLAB VS THE MASSIVE (4) IS $4''/7'' = 57\%$
[IS PROPORTIONAL TO THICKNESS] (3)

5 8) SEE SKETCH

floor slab

Detailed requirements:

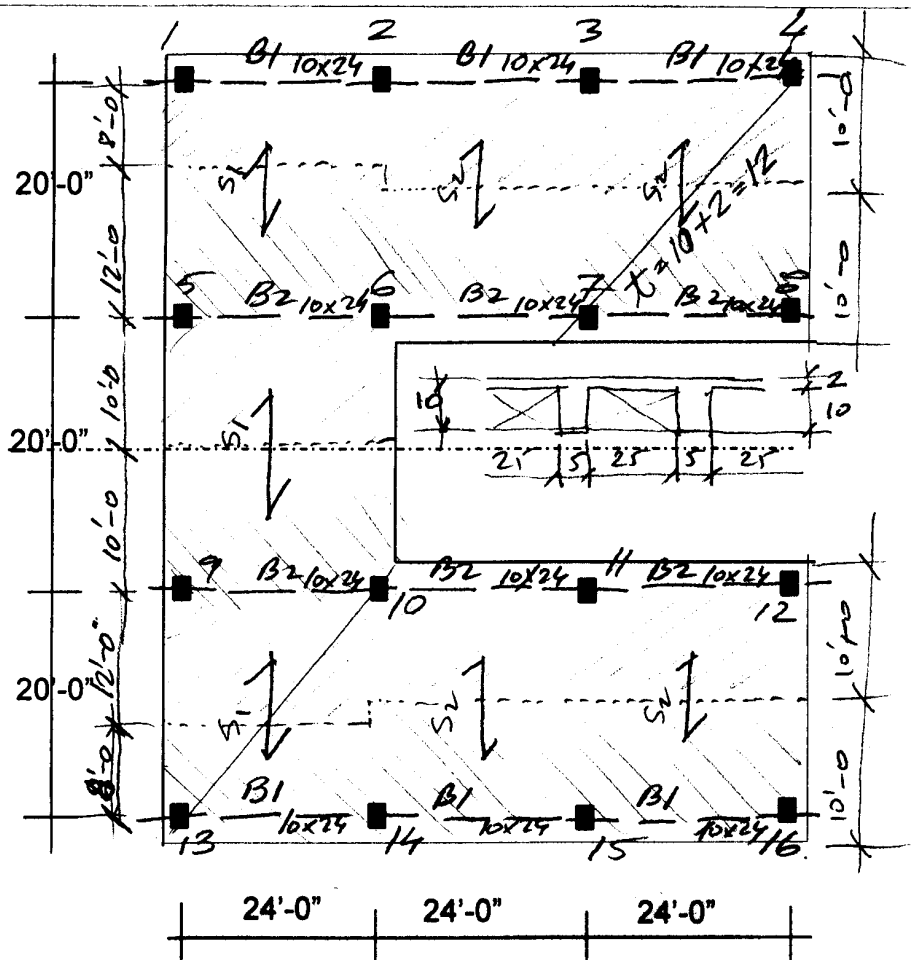
3 ✓ 1) Label (with numbers) all columns starting from the upper left corner.

3 ✓ 2) Choose a layout of beams between the columns and label them (either horizontal or vertical – but not both)

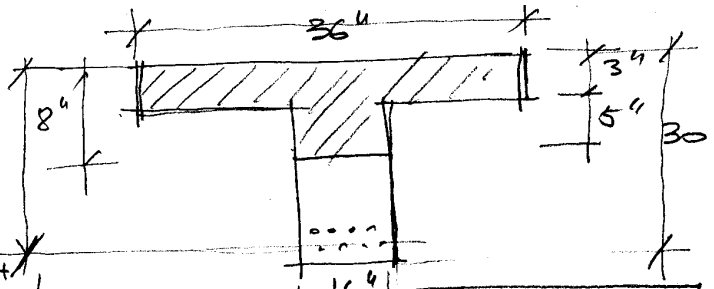
5 ✓ 3) Layout one way ribbed (joists) slab supported by the beams, which you chose in (2) and show in the sketch with proper arrows and labels. Show typical cross sectional sketch of slab.

8 ✓ 4) Determine the thickness of the slab (unique for whole floor) using approximations (h=l*/m or h=L_{eq}/m or ACI recommendations).

8 ✓ 5) 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.



PROBLEM #3



(1) 10pts. $k = \frac{8"}{27"} = 0.297$

$M_{cap} = 0.85 \cdot 4 \times (36-16) \cdot 27^2 \cdot 0.111\left(1-\frac{0.111}{2}\right) +$

$+ 0.85 \cdot 4 \times 16 \times 27^2 \times 0.297 \cdot \left(1-\frac{0.297}{2}\right) =$

$= 5150 + 10030 =$

$= 15180 \text{ k-in} = 1265 \text{ k-ft}$

$d = 30 - 2 - 1 = 27"$

$\bar{t} = 3/27 = 0.1111$

$\left(k_{MAX}^{Aci} = 0.75\, k_{Bal} \cong 0.375\right)$ not required here

$\left(k_{min} = \frac{200}{0.85 f'_c} \cong 0.060\right)$

$\bar{d}' = 2"/27 \cong 0.075$

(2) 10pts. $A_s = A_s^{(a)} + A_s^{(b)} =$

$= \frac{10030}{60 \times 27 \times \left(1-\frac{0.297}{2}\right)} + \frac{5150}{60 \times 27 \left(1-\frac{0.111}{2}\right)}$

$= 7.27 \text{ in}^2 + 3.36 \text{ in}^2 = 10.63 \text{ in}^2 \; (11.11 \text{ in}^2)$ = 5#10 + 5#9 in two layers.

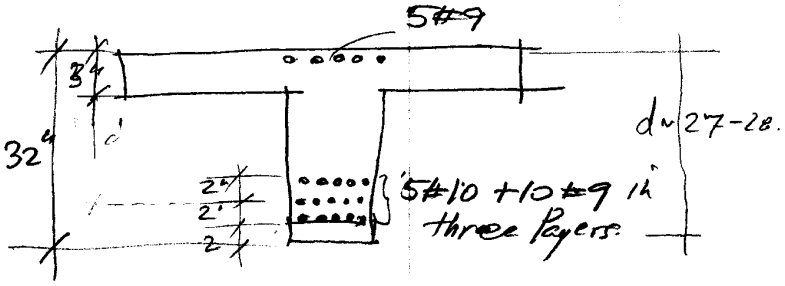
width req'd.. $2 \times 1.5" + 5 \times 1.25 + 4 \times 1 \cong 14" < 16"$ OK.

(3) 10pts. Add reinforcement both sides of beam (top & bottom).

$A_s' = \frac{\Delta M}{f_y d (1-\bar{d}'/2)} = \frac{0.5 M_{cap}}{60 \times 27 (1-0.075/2)} = 4.25 \text{ in}^2 \Rightarrow 5\#9.$ ($M_{cap} = 15180$)

Increase hight of section by 2" to accomodate bars at bottom..

(4) 5pts. SEE SKETCH.



(5) 15pts. $f_{uc} = 2\sqrt{f'_c} = 126 \text{ psi}$ $f_v^{max\ allowed} = 10\sqrt{f'_c} = 686 \text{ psi}$

$f_{v\,demand} = \frac{400 \times 1000/0.85}{16 \times 27} = 1089 \text{ psi} >> 686 \text{ psi}$

Must increase width from 16" to 26". $f_{v\,new} = \frac{400 \times 1000 \times 0.85}{26 \times 27} = 670 \text{ psi} < 686$

$A_s = \frac{(670-126) \times 26 \times 5}{60 \times 4 \text{ (arms)} \times 1000} = 0.295 \text{ in}^2$ $s = 3" \rightarrow A_v = 0.28 \Rightarrow$ #4

2#4 @ 3"

Page 5