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=1*/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 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 \( M_{\text{cap}} \) 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 \( M_{\text{cap}} \).

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. \( M_{\text{demand}} = 1.5 \times M_{\text{cap}} \), 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: \( f'_c = 4 \text{ ksi, } f_y = 60 \text{ ksi, } \rho_{\text{min}} = 200/f_y \) [psi]
Problem #1 - Solution

Required Reinforcement

Deflected Shape

Moment Diagram

Shear Diagram

Transverse Reinforcement

Actual Bars (Not Required on Exam)
**Problem #2**

3 1) **See sketch.**

3 2) **See sketch.**

4) **Massive slab thickness:**

   \[ h = \frac{f_{ck}}{35} \leq 20 \times 12 \leq 7^\prime \]

5 1) **Beam's typical section:**

   \[ h = \frac{f_{ck}}{10} = \frac{0.8 \times 24 \times 12}{10} = 24^\prime \]

5 6) **Equivalent thickness of ribbed slab:**

   \[ h_{equiv} = (2 + \frac{5 \times 10}{30}) = \frac{10}{2} = 4^\prime \]

5 7) **Weight of ribbed slab vs massive is:**

   \[ \frac{4}{7} = 57\% \]

5 8) **See sketch.**

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**Detailed requirements:**

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

5 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.

5 4) Determine the thickness of the slab (unique for whole floor) using approximations (h=1'/m or h=1/20/m or ACI recommendations).

5 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) \( k = \frac{8''}{27''} = 0.297 \)

\( M_{cap} = 0.85 \times 4 \times (36-16) \times 27^2 \times 0.111 (1-0.297) + \)

\( 0.85 \times 4 \times 16 \times 27^2 \times 0.297 (1-0.297) = 5150 + 10030 = \)

\( = 15180 \text{ k-in} = 1265 \text{ k-ft} \)

\( d = 30 - 2 - 1 = 27'' \)

\( f = \frac{3}{27} = 0.111 \)

\( f_{max} = 0.75 \times f_{c6} = 0.375 \) \( \text{last required} \)

\( f_{min} = \frac{3}{27} = 0.111 \)

\( f = \frac{200}{0.85} = 0.0860 \)

\( d = 2''/27 = 0.075 \)

\( \frac{10030}{60 \times 27^2 (1-0.297)} = \frac{5150}{60 \times 27^2 (1-0.297)} = \frac{7.27''^3 + 3.36''^3}{10.63''^3} = 5 \# 10 + 5 \# 9 \) \( \text{two layers} \)

\( \text{two layers} \)

\( \text{with reqd.} \) \( 2 \times 15'' + 5 \times 1'' \) \( = 14'' < 16'\) \( \text{OK} \)

(2) \( A_s = A_{5} + A_{3} = \)

\( = \frac{10030}{60 \times 27^2 (1-0.297)} + \frac{5150}{60 \times 27^2 (1-0.297)} = 7.27''^3 + 3.36''^3 = 10.63''^3 = 5 \# 10 + 5 \# 9 \) \( \text{two layers} \)

\( \text{with reqd.} \) \( 2 \times 15'' + 5 \times 1'' \) \( = 14'' < 16'\) \( \text{OK} \)

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

\( A_s = \frac{4M}{f_d (1-d/2)} = \frac{0.5 \times 4 \times 5180}{60 \times 27 (1-0.075/2)} = 1.11''^2 \)

\( \text{Increase height of section by 2'' to accommodate bar at bottom.} \)

\( \text{5#9} \)

(4) SEE SKETCH.

\( d = 27-28 \)

\( 32'' \)

\( 25'' \)

\( 27'' \)

\( 27'' \)

\( 27'' \)

\( 5 \# 10 + 10 \# 9 \) \( \text{in} \)

\( \text{three layers} \)

(5) \( f_{pc} = 20'' f_{c} = 126 \text{ psi} \)

\( f_{allowed} = 10'' f_{c} = 686 \text{ psi} \)

\( f_{demand} = \frac{400 \times 1000}{0.85} = 1089 \text{ psi} > 686 \text{ psi} \)

\( \text{Must increase width from 16'' to 26''}. \)

\( \text{5#9} \)

\( \text{three layers} \)

\( A_s = \frac{(67'' - 12'') \times 26 \times 3}{60 \times 4 \times 1000 \times 1000} = 0.066 \)

\( h = = 3'' \rightarrow A_v = 0.028 \rightarrow \# 4 \text{ (top) } \)