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Section = B

Subject = Plain AND Reinforced Concreate Design – II

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QNo#(2)

Ans:⇒ Design slab, beams, girder, coloums and footings of a 90'x60' Hall. Minimum obstruction to mobility inside the hall requires that only two coloums can be allowed inside the hall. Height of the hall is 20'.

* Concrete compressive strength (f_c') = 3 ksi.
* Steel yield strength (f_y) = 40 ksi.

* Slab Design:-

⇒ Sizes:- • $h = 1/28 \times (0.4 + f_y/100000) = 3.8''$ (Minimum by ACI for end span) [$l = 9.5'$]

• $h = 1/28 \times (0.4 + f_y/100000) = 3''$ (Minimum by ACI for Interior span) [$l = 9'$].

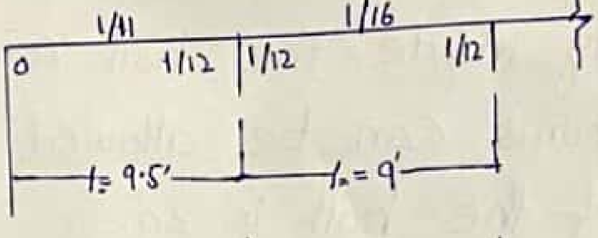
• End span governs. Finally take assumed h = 6".
* Effective depth(d) = $h_f - 0.75 - (3/8)/2 = 5''$ (for #3 main bar)

⇒ Loads:-

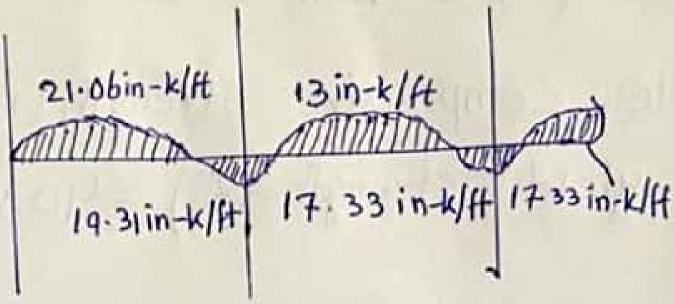
Material	Thickness(in)	γ(kcf)	load = Thickness x γ(kcf)
slab	6	0.5	$(6/12) \times 0.15 = 0.075$
Mud	3	0.12	$(3/12) \times 0.12 = 0.03$
Tile	2	0.12	$(2/12) \times 0.12 = 0.02$
		Total	0.125 kcf

Factored load $(w_u) = 1.2D.L + 1.6L = 1.2 \times 0.125 + 1.6 \times 0.04 = 0.214\,ksf$

⇒ **Analysis:-** Bending moment diagram for slab

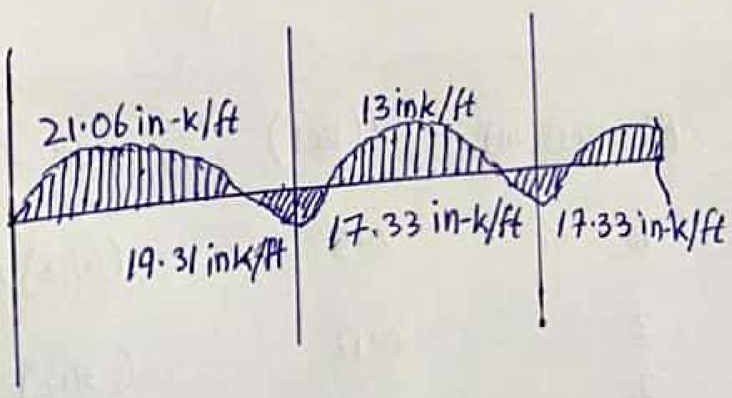


$M = \text{Coefficient} \times w_u \times l_n^2$



⇒ **Design:-**

* Calculate moment capacity provided by minimum reinforcement in slab.
  - $A_{smin} = 0.002bh_f = 0.002 \times 12 \times 6 = 0.144\ in^2/ft$
  - $\phi M_n = \phi A_{smin} f_y (d - a/2) = 0.9 \times 0.144 \times 40 \times 40 \times (5 - 0.188/2) = 25.4\ in\text{-}k/ft$
  - ϕM_n Calculated from A_{smin} is > all moments calculated in step NO 3
  - Therefore $A_s = A_{smin} = 0.1449\ in^2/ft$ (#3 @ 9.166" c/c)
  - This will work for both positive and negative steel as A_{smin} governs.



⇒ **Main reinforcement Spacing:-** Maximum Spacing for main steel reinforcement in one way slab according to ACI 7.6.5 is minimum of:

- $3h_f = 3 \times 6 = 18$.
- $18"$
- Finally use. #3 @ 9" c/c.

⇒ **Shrinkage steel or Temperature steel (A_{st}):-**

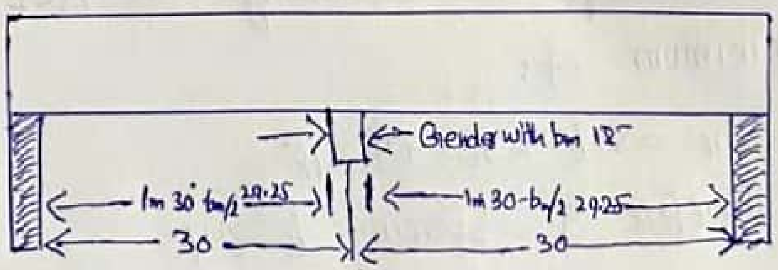
- $A_{st} = 0.002bh_f$ $A_{st} = 0.002 \times 12 \times 6 = 0.144 \text{ in}^2/\text{ft}$
- shrinkage reinforcement is same as main reinforcement, because:
- $A_{st} = A_{s\,min} = 0.144 \text{ in}^2$
- Maximum spacing for temperature steel reinforcement in one way slab according to ACI 7.12.2.2 is minimum of:
- $5h_f = 5 \times 6 = 30"$ OR $18"$
- Therefore 9" spacing is O.K.

⇒ **Drafting:-**

- Main reinforcement = #3 @ 9" c/c (positive & negative)
- Shrinkage reinforcement = #3 @ 9" c/c
- Supporting bars = #3 @ 18" c/c.

Beam Design:- Sizes:-

- Minimum thickness of beam (simply supported) = h_{min} = $l/18.5$
  l = clear span (l_n) + depth of member (beam) & c/c distance between supports.
- let depth of beam = 2'
  l_n + depth of beam = 29.25' + 2' = 31.25'
  c/c distance between beam supports = 30 + (9/12) = 30.75'
- Therefore l = 30.75
  Depth (h) = (30.75/18.5) × (0.4 + f_y/100000) + 12 = 15.95" (Minimum by ACI 9.5.2.2).
- Take h = 2' = 24
  d = h − 3 = 21.
  b_w = 12" (assumed)



⟹ **Loads:-** • Load on beam will be eaual to

- Factored load on beam from slab + factored Self weight of beam web.
- Factored load on slab = 0.214 ksf
- Factored load on beam from slab = 0.214 ksf × 10 = 2.14 k/ft
- load on

- Factored self load of beam web =
- $= 1.2 \times (18 \times 12 / 144) \times 0.15 = 0.27\ k/ft$
- Total load on beam $= 2.14 + 0.27 = 2.41\ k/ft$

⇒ Design for flexure (for positive moment)

- step (a) According to ACI 8.12, b_{eff} for T-beam is minimum of:
  - $16h_f + b_w = 16 \times 6 + 12 = 108''$
  - (c/c span of beam)/4 $= (30.75'/4) \times 12 = 92.25''$
  - c/c spacing between beams $= 10' \times 12 = 120''$
  - So $b_{eff} = 92.25''$

- step (b) Check if beam is to be designed as rectangular beam or T-beam.
  - Assume $a = h_f = 6''$ and calculate A_s

$$A_s = M_u / \{\phi f_y (d - a/2)\} = 2249 / \{0.9 \times 40 \times (21 - 6/2)\} = 3.47\ in^2$$

  - Re-calculate "a".

$$a = A_s f_y / (0.85 f_y' b_{eff}) = 3.47 \times 40 / (0.85 \times 3 \times 92.25) = 0.6'' < h_f$$

Therefore design beam as rectangular beam.

- Therefore $A_s = 3.01\ in^2$ {4#8 bars}.

⇒ Design of Shear:-

Location	V_u (kip)	$\phi V_c = \phi 2\sqrt{f'_c} b_w d$ (kips)	Reinforcement required?	Smax ACI	$S_d = \phi A_v f_y d/(V_u - \phi V_c)$	Governing S
Exterior	31.03	20.7	Yes	13"	10.5"	10.5"
Interior	35.68	20.7	Yes	9"	10.5"	9"

- S_{max}, ACI is least of $A_v f_y/(50 b_w)$, $d/2$, 24", $A_v f_y / 0.75\sqrt{f'_c} b_w$.

⇒ Check for depth of beam:-

- $\phi V_s \le \phi 8\sqrt{f'_c} b_w d$ (ACI 11.4.7.9)
- $\phi 8\sqrt{f'_c} b_w d = 0.75 \times 8 \times \sqrt{3000} \times 12 \times 21/1000 = 82.4$ kips
- $\phi V_s = (\phi A_v f_y d)/S_d$
  $= (0.75 \times 0.22 \times 40 \times 21)/9 = 15.4 \text{kip} < 82.4 \text{kip}$, OK
- So depth is ok if not increase depth of beam.

⇒ Reinforcement provision:-

It will be practically more feasble to provide #3, 2 legged @ 9" c/c throughout, starting at $S_d/2 = 4.5$" from the face of the Support at both ends.

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QNo (1) Part (A)

* Capacity and Demand on structures:-

* **Capacity:-** The overall ability of a Structure to carry an imposed demand.

Beam will resist the applied load upto its capacity and will fail when demand exceeds capacity.

* **Demand:-** • Demand on a structures refers to all external actions.
  - Gravity, wind, earthquake, snow are external actions.
  - These actions when act on the structure will induce internal disturbance(s) in the structure in the form of stresses (such as compression, tension, bending, shear and torsion.)

The internal stresses are also called load effects.

QNo (1) Part (B):-

Design Method:- In the strength Design Method, the increased loads and the reduced strength of the material are considered, but both based on scientific rationale. For example, it is quite possible that during the life span of a structure, dead and live loads increase.

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- similarly, the strength is not reduced arbitrarly but considering the fact that variation in strength is possible due to imperfections, age factor etc. Strength reduction factors are used for this purpose.
- Factor of safety in strength Design method is thus the combined effect of increased load and reduced strength, both modified based on a valid rationale.

QNo(1) part (C).

Flexural Strength:-

In the design of flexural strength, the strength reduction factor decreases from tension-controlled sections to compression-controlled sections to increase safety with decreasing ductility.

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