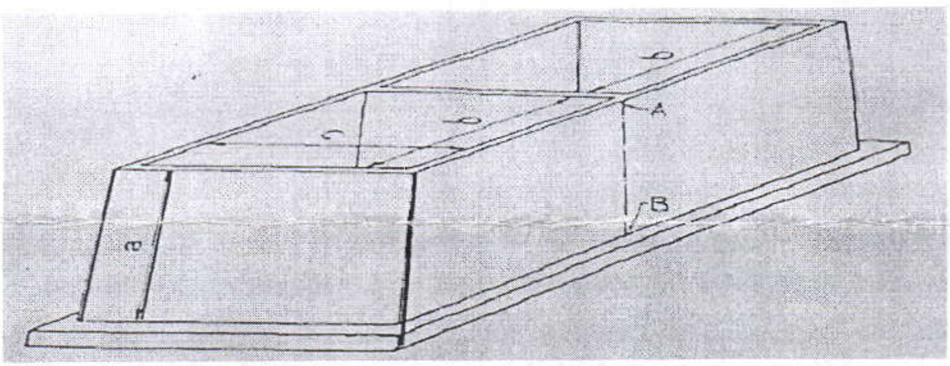
University Of Technology
Building and Construction Eng. Dept.
Final Exam– 2014/2015

Subject :Structural Design — Class: 4^{th} year
Examiners: Ass.Prof.Dr. Asmaa Ali — Time :3 Hour
Lecture Zina Asaad — Date: 1/6/2015

OPEN BOOK EXAM ANSWER FOUR QUATIONS

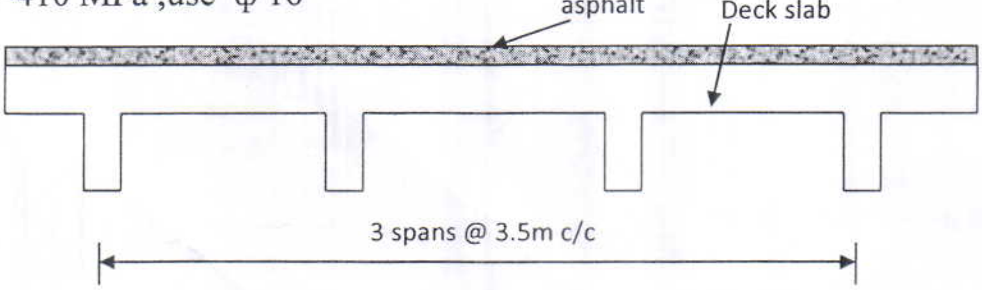
Q:1 A rectangular concrete water tank of two cells having interior dimensions a=4 m, b=12 m, and c=8 m , as shown in figure below. Assume the condition that the tank has hinged at top and bottom. Use $f'_c = 25\ MPa, f_y = 400MPa$. Assuming wall thickness is 350mm find

1- Flexural reinforcement for the absolute maximum (from both horizontal and vertical) moment in short inner wall at edge of intersection between interior wall and exterior wall
2- Required reinforcement for the BS 8007, assuming that crack width must not be more than 0.2mm and bar spacing must not be less than 100mm (Use $T_1=30^0$, $T_2=60$, $\alpha=12*10^{-6}\ /^0c$)

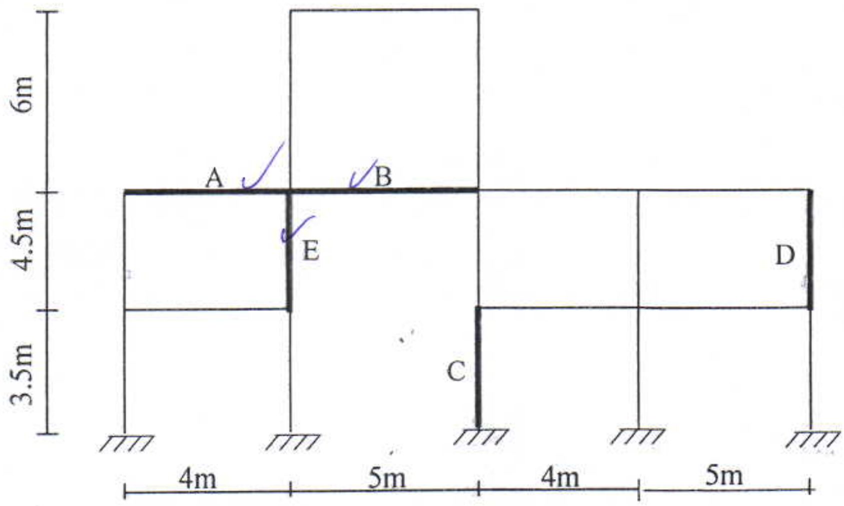


Q:2 A column Corbel is designed to carry a factored shear force *Vu* equal to *600kN* and factored horizontal tensile load Nuc equal to *200 kN* at *av=150mm* from the column face, take $f'_c = 35MPa$, $f_y = 400MPa$, *b=500, h=450 ,d=375* . Assuming the concrete surface of the Corbel is intentionally roughened according to ACI – 11.6.9. Required to check the code limitation of the corbel and design the steel area according to ACI – 318 M.08 with detailed drawing.

Q:3 By using the Ultimate Strength Design method, design and detail the main reinforcement for interior span having 270mm thick deck slab with total width 15m supported on cast in situ four rectangular girders of width 350mm each as shown below. Assume wearing surface is made of asphalt of 7cm thick of density $23kN/m^3$. Live load is HS15 according to AASHTO, $f'_c=25MPa$, $f_y=410\ MPa$,use ϕ 16



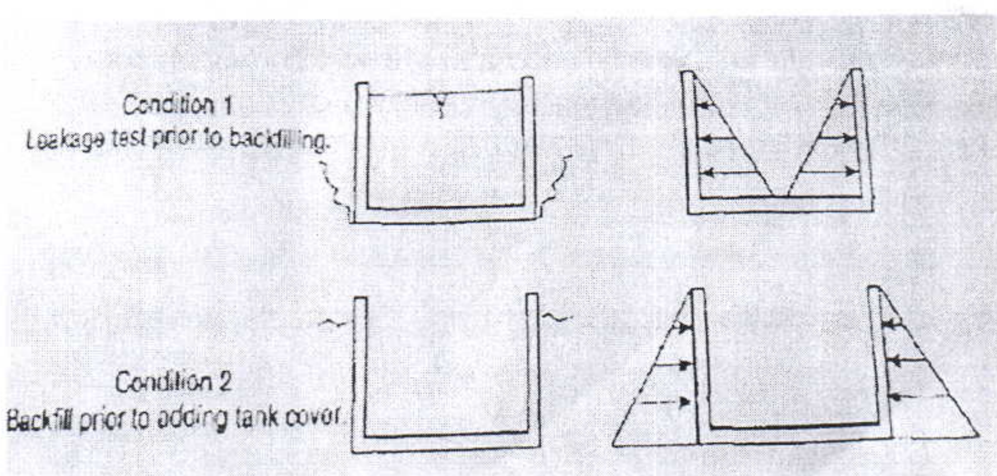
Q:4 By using Sub frame Analysis method and alternate pattern loading find the maximum moment , end reactions for beams A & B in the precast concrete frame shown in figure. More over find the maximum end moments for the columns C,D & E. Assume the beam column connections are pinned and the ground supports are fixed. The distance from edge of the column to the center of the beam end reaction is 110mm, D.L.=45kN/m and L.L.=30 kN/m for any floor except roof where L.L.=12kN/m. Beams section is 300*600 mm and column is circular having 300 mm diameter.



Q:5 A reinforced concrete, circular water tank having inside diameter 8.7m , inside height 5.1m wall thickness 300mm , use d = 242mm , shrinkage coefficient is 0.0003, $f'_c = 25\ MPa$, $f_y = 400 MPa$, $E_s = 2*10^5\ MPa$ and, $E_c = 4700\sqrt{f'c}$

1- Determine the required wall reinforcement for maximum tension considering that wall is hinged base and free top and the tank is under loading of water only to its full height and check for cracking stress (condition 1).

2- Determine the required wall reinforcement for maximum flexure considering that the tank is under loading of soil backfill only to its full height (condition 2). (soil pressure at base is 15 kN/m^3 and the wall is hinged base and free top)



Q1 center wall

$b/a = 3$ $\qquad$ $c/a = 2$

x/a	L		F		$L - \frac{L-F}{3}$	
x/a	Mx	Mz	Mx	Mz	Mx	Mz
1/4	-.008	-.038	-0.007	-0.037	-.0077	-.0377
1/2	-0.012	-.062	-0.012	-0.059	-.012	-0.061
3/4	-0.011	-0.054	-0.011	-.053	-.011	-0.0537

coeff of $M_x = -0.012$ $\qquad$ coef $M_z = -0.061$

$M_z = \text{coff} * a^3 * w_u$

$M_z = 84.717 \text{ kN.m}$, $d = 350 - 50 - 10 = 290 \text{ mm}$

$R_u = \frac{M}{\phi b (d^2)} = 1.12$

$m = \frac{f_y}{0.85 f_c} = 18.82$

$\rho = 0.0029 > \rho_{min}$

$A_{s_1} = \rho \, b d = 835.5 \text{ mm}^2/\text{m}$

$N_u = 0.4 \, w a^2 = 175.9$

$A_{s_2} = \frac{N_u}{0.9 f_y} = 488$

$As_{horizontal} = 1080$ mm²/m

A_b of $\Phi 16 = 201$

No. bar = 5.37

S = 186

∴ Use Φ16 @ 180 mm horizontal in both faces

$Mx =$ ~~...~~ $coff * w\, a^3$

$Mx = 16.6$ ✗ This gives less than ρ_{min}

$\rho = 0.0028$

Use Φ16 @ 240 mm vertical in both faces

b) $0.2 = S_{max} \frac{12(10)^{-6}}{2} (90) \longrightarrow S_{max} = 370$

$S_{max} = \frac{f_{ct}}{f_{cb}} \frac{\Phi}{2\rho} \rightsquigarrow \rho = 0.0145$

$As = \rho \frac{t}{2} * b = 2535$

No. bar = 12.6

Spacing = b / No. bar = 79 < 100 ∴ use Φ20 → ρ = 0.018

As = 3170 → S = 100

Use ~~Φ20~~ Φ20 @ 100 mm C/C

Q2

$$\frac{a_v}{d} = \frac{150}{375} < 1 \text{ o.k}$$

$$2 < \frac{N_u}{V} = 0.33 < 1 \text{ o.k}$$

$V_u \ngtr 0.2 f_c \Phi b d = 984$
OR $(3.3 + 0.08 f_c) \Phi b d = 857$
$11 (\Phi) b d = 1546$
} $V_u = 857$

$V_u = 600^{kN} < 857$ kN

$$A_n = \frac{N_u}{\Phi f_y} = 666.7$$

$$A_{vf} = \frac{V}{\phi \cdot f_M f_y} = 2000$$

$M_{cu} = [V_u \cdot a_v + N_u (h - d)] = 105$

$R_u = 1.65 \rightsquigarrow M = 13.44 \quad \rho = 0.00427$

$A_f = 800.6$

$$A_{sc} \geq \begin{cases} 1467.3 \\ 2000 \\ 656.25 \end{cases} \rightsquigarrow A_s = 2026.7 \text{ mm}^2$$

use $\Phi 20$ @ 150 mm c/c

$A_h = 0.5 (A_{sc} - A_n) = 666$

use $\Phi 10 \rightsquigarrow N_o = A_h / 2A_b = 4.3$

Use 5 Layer of 10 mm

Q5 $\frac{H^2}{Dt} = 10$

$w_u = S.F \times 1.7 \times 9.8 = 27.5$

$w_u \, H \, R = 610.1$

$T_{max} = coff \times w H R = 445.37$

$A_s = \frac{T}{0.9 f_y} = 1237$

bar Φ12 mm $A_b = 113 \rightarrow No. = A_s / 2A_b = 5.47$

$S = 1000 / 5.47 = 183$ mm

Use Φ12 @ 180 c/c in both sides for tension

A_s req $= 2(113)(1000/180) = 1250$ mm^2/m

check for cracking stress $n = 8.51$

$f_c = 0.57 < 0.1(25) = 2.5$ o.k

(b) $M = \frac{15 \times 1.3 \times 1.4 \times (5.1)^2}{2 * 3} = 118$ kN.m/m

$d = 249$

$R_u = 2.25 \rightarrow M = 18.82 \rightarrow \rho = 0.006 > \rho_{min}$

$A_s$req $= 1440$ No. $= 7.16$

$S = 139 \rightarrow$ use Φ16 @ 130 mm in both faces

(Q.3)

t deck slab = 270 mm

t wearing = 7 cm

dead weight :-

$W_{DC} = 6.48$ kN/m²

$W_{DW} = 1.61$ kN/m²

Scince the slab supported by casted girders then $S = 3.2$ m .

$M = \frac{WL^2}{10}$

$\therefore M_{DC} = 6.636$ kN.m/m

$M_{DW} = 1.649$ kN.m/m

M_{LL} ⇒ from AASHTO table A4-1
= 32.5 kN.m/m

$M_{LL} = \frac{S+2}{32} P_{15} = 16.68$ kN.m/m

$I = \frac{15.24}{L+38}$ ⇒ use 0.3

$\therefore M_{LL} = 21.684$ kN.m/m < 32.5 kN.m/m

o.k

$M_T = 1.2\ M_D + 1.6\ M_L = 44.636\ kN.m/m$

use bar diameter = 16 mm

$\therefore d_{eff.} = 237\ mm$

$R_u = 0.883\ MPa$

$m = 19.294$

$\rho = 2.198 \times 10^{-3} > \rho_{min} = 0.0018$

$A_{s\,req.} = \rho b d = 520.926\ mm^2/m$

No. of bars = 2.592 ≃ 3

Spacing = 333.333 mm ≃ 300 mm

$\Rightarrow$ use $\phi 16$ @ 300 mm c/c as main reinforcement perpendicular to traffic top & bottom

check Min. & Max. Spacing of bars (AASHTO)

$> 1.5\ d_b$ > 1.5 Max. agg. size $> 38\ mm$ $\therefore 300 > 38$ o.k	$< 1.5\ h$ $< 450\ mm$ $\therefore 300 < 405\ mm$ o.k

Col. (D) :-

$$M = (P_2 e_2 - P_1 e_1) * \frac{\frac{EI}{h})_D}{\frac{EI}{h})_D + \frac{EI}{h}}$$

$\therefore$ Mupper = 47.580 kN/m

Mlower = 28.974 kN/m

Col. (E) :-

$$M = (P_2 e_2 - P_1 e_1) * \frac{\frac{EI}{h})_E}{\frac{EI}{h})_E + \frac{EI}{h}}$$

$\therefore$ Mupper = 22.257 kN/m

Mlower = 23.179 kN/m

Q.4)

$W_u(max.) = 1.2\ D.L + 1.6\ L.L = 102\ kN/m$

$W_u(min.) = 1.2\ D.L = 54\ kN/m$

$W_u(max.)$ for roof $= 1.2\ D.L + 1.6\ L.L = 73.2\ kN/m$

$W_u(min.)$ for roof $= 1.2\ D.L = 54\ kN/m$

$e = 260\ mm$

Beam (A) :-

$$M_{max.} = \frac{W_{max.}(L-2e)^2}{8} = 110.810\ kN/m$$

$$R = \frac{W_{max.} L}{2} = 146.4\ kN$$

Beam (B) :-

$M_{max.} = 255.898\ kN/m$

$R = 255\ kN$

Col. (C) :-

$$M_{upper} = (R_2 e_2 - R_1 e_1) * \frac{\frac{EI}{h})_c}{\frac{EI}{h})_c + \frac{EI}{h}}$$

$= 29.861\ kN/m$

$M_{lower} = 14.931\ kN/m$