Achonwa - Nzemanze Chukwuma

17/ENG03/003

Civil Engineering

Structural design Assignment

CVE 308

Question I

Answers

1a The purpose of structural Design is to

i Every structure must be safe

ii Every Structure must be economical

iii Deformation of structure must not interfere to the integrity of the structure

1b Limit state design consider's or takes care of the load factor design, disadvantage of the modular ratio and any other failure that can cause the structure to be structurally unfit. while Elastic design is the method of analysis which the design of a structural member is based on a linear - stress - strain relationship, assuming that the working stress are only a fraction of the elastic limit of the material.

1c Staircase design

$$\text{Slope F factor} = \frac{\sqrt{R^2+T^2}}{T} = \frac{150^2+275^2}{275} = 1.14$$

Load Analysis

Waist A: $R \times 24\,kN/m^3$

$= 0.15 \times 24 = 3.6\,kN/m^2$

Finishes B: $1.2\,kN/m^2$

Steps C: $T \times 1/2 \times 24\,kN/m^2$

$= 0.275 \times 1/2 \times 24 = 3.3\,kN/m^2$

$G.k = (A+B) \times 5 - f) + C$
$= (4.8 + 1.14) + 3.3$
$= 8.77 \, kN/m$

$D.L, F = 1.4 Gk + 1.6 Qk$
$= 1.4(8.77) + 1.6(1.5)$
$= 14.68 \, kN/m^2$

$Span(L) = T_{total} + 0.5(la + lb)$
$= 275 \times 12 + 0.5(225 + 225)$
$= 3.525 m$

$d = h - cover - \frac{1}{2}\phi$
$= 150 - 25 - 6 = 119 mm$

$M = \frac{FL^2}{10} = \frac{14.68 \times 3.525^2}{10} = 18.24 \, kNm$

$k = \frac{M}{bd^2 f_{cu}} = \frac{18.24 \times 10^6}{1000 \times 119^2 \times 25} = 0.052$

$Ia = 0.5 + \sqrt{0.25 - k/0.9} = 0.5 + \sqrt{0.25 - \frac{0.052}{0.9}} = 0.938$

$z = Iad = 0.938 \times 119 = 111.622 mm$

$A_s = \frac{M}{0.95 f_y z} = \frac{18.24 \times 10^6}{0.95 \times 460 \times 111.622} = 419.53$

$A_{s prov} = 452 mm$
Provide Y12 @ 250 c/c (A_{prov} 452mm)

Deflection check

$f_s = 2/3 \times 1/\beta \times A_{req}/A_{sprov} \times f_y$

$f_s = 2/3 \times 1 \times \frac{419.53}{452} \times 250 = 154.69 \, N/mm^2$

$M.F = 0.55 + \frac{477 - 154.69}{120(0.9 + \frac{18.24 \times 10^6}{1000 \times 119^2})} = 1.78$

$d_{req} = \frac{Span}{m.f \times cdr} = \frac{3.525}{1.78 \times 26} = 76.17mm$

Since $d_{req} < d$, Deflection is Ok

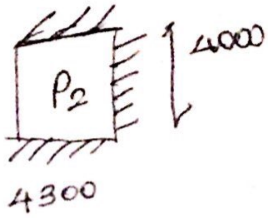
$P_1 = P_2 = P_3 = \frac{4300}{4000} = 1.075 < 2 = 2$ way slab

$P_7 = P_8 = P_9 = \frac{4500}{4000} = 1.125 < 2 = 2$ way slab

$P_4 = P_5 = P_6 = \frac{4300}{4000} = 1.075 < 2 = 2$ way slab

$P_{10} = P_{11} = P_{12} = \frac{4000}{1500} =$ ~~2.667 <~~ $2.667 > 2 = 1$ way slab

Design of P_2



$l_y / l_x = \frac{4300}{4000} = 1.075 = 1.1$

Shortspan Coefficient
- 0.044, 0.033

Long span Coefficient
- 0.037, 0.028

Assumed, slab thickness = 175mm

$F_{cu} = 25 N/mm^2$

$F_y = 400 N/mm^2$

G_k = wt of slab = $0.175 \times 24 = 4.2 kN/m^2$

Partition = $1.0 kN/m^2$

Finishes = $1.2 kN/m^2$

$6.4 kN/m^2$

Design load = $1.4 G_k + 1.6 Q_k$

$= (1.4 \times 6.4) + (1.6 \times 5)$

$= 16.96 \simeq 17 \text{ kN/m}$

Short span

- mid span

$M = \beta_x w l_x^2 = 0.044 \times 17 \times 4^2$

$= 11.968 \text{ kNm}$

$d = h - \text{cover} - \frac{1}{2}\phi = 144$

$$K = \frac{M}{bd^2 f_{cu}} = \frac{11.968 \times 10^6}{1000 \times 144^2 \times 25} = 0.023$$

$$I_a = 0.5 + \sqrt{0.25 - K/0.9}$$

$$= 0.5 + \sqrt{0.25 - \frac{0.023}{0.9}} = 0.97 \ (\leq 0.95)$$

$z = I_a d = 0.95 \times 144 = 136.8 \text{mm}$

$$A_s = \frac{M}{0.95 f_y z} = \frac{11.968 \times 10^6}{0.95 \times 400 \times 136.8} = 224.61 \text{mm}^2$$

Provide Y_{12} @ 300 c/c ($A_s = 377 \text{mm}^2$)

- Continuous Edge

$M = \beta_x w l_x^2 = 0.033 \times 17 \times 4^2 = 8.976 \text{ kNm}$

$d = 144$

$$k = \frac{M}{bd^2 f_{cu}} = \frac{8.976 \times 10^6}{1000 \times 144^2 \times 25} = 0.0173$$

$$I_a = 0.5 + \sqrt{0.25 - k/0.9} = 0.5 + \sqrt{0.25 - \frac{0.0173}{0.9}} = 0.83 \ (\leq 0.95)$$

$Z = I_a d = 0.83 \times 144 = 119.52mm$

$A_s = \frac{M}{0.95 f_y z} = \frac{8.976 \times 10^6}{0.95 \times 400 \times 119.52} = 192.81mm$

Long Span

- mid Span

$d = 144 - 12 = 132mm$

$M = \beta_x w l_x^2 = 0.037 \times 17 \times 4^2 = 10.064 kNm$

$k = \frac{M}{bd^2 f_{cu}} = \frac{10.064 \times 10^6}{1000 \times 132 \times 25} = 0.0231$

$I_a = 0.5 + \sqrt{0.25 - k/0.9} = 0.5 + \sqrt{0.25 - \frac{0.0231}{0.9}} = 0.97 \ (\leq 0.95)$

$Z = I_a d = 0.95 \times 132 = 125.4$

$A_s = \frac{M}{0.95 \times f_y z} = \frac{10.064 \times 10^6}{0.95 \times 400 \times 125.4} = 206.04 mm^2$

Provide Y12 @ 300%c [$377mm^2$]

- Continuous Edge

$M = \beta_x w l_x^2 = 0.028 \times 17 \times 4^2 = 7.616 kN/m$

$k = \frac{M}{bd^2 f_{cu}} = \frac{7.616 \times 10^6}{1000 \times 132 \times 25} = 0.017$

$d = 132mm$

$I_a = 0.5 + \sqrt{0.25 - k/0.9} = 0.5 + \sqrt{0.25 - \frac{0.017}{0.9}} = 0.98 \ (\leq 0.95)$

$Z = I_a d = 0.95 \times 132 = 125.4$

$A_s = \frac{M}{0.95 f_y z} = \frac{7.616 \times 10^6}{0.95 \times 400 \times 125.4} = 155.93mm^2$ Provide Y12@ 300%c [377mm].

Deflection check

$f_s = 2/3 \times f_y \nu \times 1/\beta \times A_{s\,req} / A_{s\,prov}$

$= 2/3 \times 250 \times 1 \times \frac{224.61}{377} = 99.3 \, N/mm^2$

$m.f = 0.55 + \frac{477 - f_s}{120(0.9 + M/bd^2)} \quad (\leq 2)$

$m.f = 0.55 + \frac{477 - 99.3}{120\left(0.9 + \frac{11.968 \times 10^6}{1000 \times 144^2}\right)}$

$= 2.68 > 2$

$d_{req} = \frac{Span}{mf \times eff.\ depth\ ratio}$

$= \frac{4000}{2 \times 26} = 76.92$

$d_{req} < d$ ∴ deflection is Ok.