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Civil Engineering 17/ENG03/038

1a) Purpose of structural design
i. Every structure must be safe
ii. Every structure must be economical
iii. Deformation of the structure must not impair with the integrity of the structure (test of time)

(b) the elastic method of design considers concrete to be elastic in nature such that it continues to expand up to its elastic limit after being subjected to load while the limit state design consider the disadvantages of the elastic method and load factor design and any other failure that causes the structure to be unfit.

(c) $f_y = 410N/mm^2$, $f_{cu} = 25N/mm^2$, rise, $R = 150mm$, thread, $T = 275mm$, thickness, $t = 150mm$, 12 steps

Solution

$$S_F = \frac{\sqrt{R^2+T^2}}{T} = \frac{\sqrt{150^2+275^2}}{275} = 1.14$$

loading

Waist, $A = R \times 24kN/m^2 = 0.15 \times 24 = 3.6kN/m^2$
Finishes, $B = 1.2kN/m^2$
Steps, $C = T \times 0.5 \times 24kN/m^2 = 0.275 \times 0.5 \times 24 = 3.3kN/m^2$
Dead load, $D = G_K = (A+B) \times S_F + C$
$= 4.8 \times 1.14 + 3.3$
$= 8.77kN/m$
Design Load, $F = 1.4G_K + 1.6Q_K$
$= 1.4(8.77) + 1.6(1.5)$
$= 14.68kN/m^2$

effective depth, $d = h - \text{cover} - \frac{1}{2}\phi$

$= 150 - 25 - \frac{1}{2}(12)$

$= 119\text{mm}$

Span L = Total + 0.5(a + b)

$= (275 \times 12\text{steps}) + 0.5(225 + 225)$

$= 3.525\text{m}$

$M = \frac{Fl^2}{10} = \frac{14.68 \times 3.525^2}{10}$ ~~= 18.24kNm~~ $= 18.24\text{kNm}$

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

$l_a = 0.5 + \sqrt{0.25 - K/0.9} = 0.5 + \sqrt{0.25 - \frac{0.052}{0.9}} = 0.938$

$Z = l_a d = 0.938 \times 119 = 111.622$

$A_s = \frac{M}{0.95 f_y Z} = \frac{18.24 \times 10^6}{0.95 \times 410 \times 111.622} = 419.53$

$A_{req} = 419.53\text{mm}$

$A_{prov} = 452\text{mm}$

Provide Y12 @ 259 c/c (452mm)

Deflection check

$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{A_{req}}{A_{prov}} \times f_y$

$f_s = \frac{2}{3} \times \frac{1}{1} \times \frac{419.53}{452} \times 250$

$f_s = 154.69\ \text{N/mm}^2$

$m.f = 0.55 + \frac{477 - 154.69}{120\left(0.9 + \frac{18.24 \times 10^6}{1000 \times 119^2}\right)}$

$= 1.78\ (\leq 2)$

Make use of 1.78

$d_{req} = \frac{\text{Span}}{mf \times cdr}$

$= \frac{3.525 \times 1000}{1.78 \times 26}$

$= 76.17\text{mm}$

Deflection is OK ($d_{req} < d$)

2a) $K = \frac{l_y}{l_x} < 2$ (Two way slab)

$K = \frac{l_y}{l_x} > 2$ (One way slab)

Identification of the panels

$P_1 = P_2 = P_3 = \frac{4300}{4000} = 1.1 < 2$ (two-way slab ↕↔)

$P_4 = P_5 = P_6 = \frac{4300}{4000} = 1.1 < 2$ (Two-way slab ↕↔)

$P_7 = P_8 = P_9 = \frac{4500}{4000} = 1.1 < 2$ (Two-way slab ↕↔)

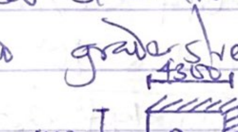
$P_{10} = P_{11} = P_{12} = \frac{4000}{1500} = 2.7 > 2$ (One-way slab ⟶)

Designing for P_2

$K = 4300/4000 = 1.1$

Assumed slab thickness = 125mm

Assumed grade stress = 25-410N/mm²



Loading

slab weight = 4.2kN/m²

partition = 1.0kN/m²

finishes = 1.2kN/m²

$G_k = 6.4$kN/m²

Short span coefficient

0.044, 0.033
-ve

Long span coefficient

0.037, 0.028

Assuming Q_k to be designed for factory

Design Load, $w = 1.4 \times 6.4 + 1.6 \times 5$

$= 17$kN/m²

Short span

Midspan

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

$K = \frac{M}{bd^2 f_{cu}} = \frac{8.976 \times 10^6}{1000 \times 144^2 \times 25} = 0.017$

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

$= 175 - 25 - 6 = 144mm$

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

$Z = I_a . d = 0.95 \times 144 = 136.8$

$A_s = \frac{M}{0.95 f_y Z} = \frac{8.976 \times 10^6}{0.95 \times 410 \times 136.8} = 168.46mm$

Provide Y12 @

Continuous edge

$M = \beta_x w l_x^2 = 0.044 \times 17 \times 4^2 = 11.968 kNm$

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

$I_a = 0.5 + \sqrt{0.25 - 0.023/0.9} = 0.973 \ (\leq 0.95)$

$Z = I_a . d = 0.95 \times 114 = 136.8$

$A_s = \frac{M}{0.95 f_y Z} = \frac{11.968 \times 10^6}{0.95 \times 410 \times 136.8} = 224.6 mm$

Provide Y12 @

Long span

Mid span

$d = 144 - 12 = 132mm$

$M = 0.028 \times 17 \times 4^2 = 7.616 kNm$

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

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

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

$A_s = \frac{m}{0.95 f_y z} = \frac{7.616 \times 10^6}{0.95 \times 410 \times 125.4} = 155.93 mm$

Provide Y12 @

Continuous edge

$m = 0.037 \times 17 \times 4^2 = 10.064 kNm$

$k = \frac{m}{bd^2 f_{cu}} = \frac{10.064 \times 10^6}{1000 \times 132^2 \times 25} = 0.023$

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

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

$A_s = \frac{m}{0.95 f_y Z} = \frac{10.064 \times 10^6}{0.95 \times 410 \times 125.4} = 206.05 mm$

Provide Y12 @

Deflection check

$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{A_{req}}{A_{prov}} \times f_y V = \frac{2}{3} \times 1 \times \frac{168.46}{377} \times 250 = 74.47 N/mm^2$

$mf = 0.55 + \frac{477 - f_s}{120 - \left(0.9 + \frac{m}{bd^2}\right)} = 0.55 + \frac{477 - 74.47}{120 - 0.9 + \left(\frac{8.976 \times 10^6}{1000 \times 144^2}\right)}$

$d_{req} = \frac{Span}{mf \times edr}$ $\qquad mf = 3.91 \ (\leq 2)$

~~Deflection check for short span~~

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

$(d_{req} < d)$ – Deflection is Ok