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MAT NO. 17/ENG03/050

COURSE STRUCTURAL DESIGN (CVE 308)

1a) The design must be economical

ii To design for safety

iii The deformation of the structure must not impose with the integrity of the structure

1b limit state design considers the disadvantages of load factor design and any other failure that can cause the structure to be structurally unfit while elastic design is a 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.

STAIR CASE DESIGN

Slope Factor = $\frac{\sqrt{R^2 + T^2}}{T}$ = $\frac{\sqrt{150^2 + 275^2}}{275^2}$

= 1.14

* Load Analysis

- WAIST = R × 24 kN/m³
  = 0.15 × 24 = 3.6 kN/m²
- FINISHES = 1.2 kN/m²
- STEPS = T × 1/2 × 24 kN/m²
  0.275 × 0.5 × 24 = 3.3 kN/m²

D.G.K = ((A + B) × S_F) + C
= (4.8 × 1.14) + 3.3
= 8.27 kN/m

D.L.F = 1.4 Gk + 1.6 Qk
1.4 (8.77) + 1.6 (1.5)
14.68 kN/m²

Span = Ttotal + 0.5 (la + lb)

$(275 \times 12) + 0.5(225 + 225) = 3.525\,m$

$d = h - \text{Cover} - \frac{1}{2}\varnothing$

$= 150 - 25 - 6 = 119mm$

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

$K = \frac{18.24 \times 10^6}{1000 \times 19^2 \times 25} = 0.052$

$I_a = 0.5 + \sqrt{0.25 - 0.052/0.9} = 0.938$

$Z = I_a d = 0.938 \times 19 = 111.622\,mm$

$A_s = \frac{18.24 \times 10^2}{0.95 \times 410 \times 111.622} = 419.53$

$A_{sPar} = 452\,mm$

Provide Y12 @ 259 ck ($A_{sPar} = 452\,mm$)

Deflection check

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

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

$d_{req} = 3525 / 1.78 \times 26 = 76.17\,mm$

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

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

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

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

$P_{10} = P_{11} = P_{12} = \frac{4000}{1500} = 2.66 > 2 = 1$ way slab

2b) Designing P_2

$l_y/l_x = 4300/4000 = 1.075 \cong 1.1$

Short span coefficient = ~~0.054~~ 0.058

Long span coefficient = 0.044

Assuming specifications

Height of slab = 0.175×24

Partition = 1.0

finishes = 1.2

6.4 kN/m²

Assuming for factory

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

$= 16.96 \simeq 17 \ kN/m^2$

Shortspan Coefficient $= \begin{matrix} 0.044 \\ 0.033 \end{matrix}$

long span Coefficient $= \begin{matrix} 0.032 \\ 0.028 \end{matrix}$

Short span mid = P

$M = \beta x w l^2 x = 0.044 \times 17 \times 4^2 = 11.968$

$d = h - cover - \phi/2 = 144$

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

$I_a = 0.5 + \sqrt{0.25 - K/0.9} = 0.97 > 0.95$

$Z = I_a d = 0.95 \times 1.44 = 136.8$

$A_s = \dfrac{11.968 \times 10^6}{0.95 \times 410 \times 136.8} = 224.61$

Provide Y_{12} @ 377mm

$M = \beta_x w l^2 x = 0.033 \times 17 \times 4^2 = 8.976$

$d = 144$

$$k = \frac{8.976 \times 10^6}{1000 \times 144^2 \times 2.5} = 0.0173$$

$$I_a = 0.5 + \sqrt{0.25 - k/0.9} = 0.83$$

$z = I_a d = 0.83 \times 144 = 119.52$

$$As = \frac{8.976 \times 10^6}{0.95 \times 410 \times 119.52} = 192.81 \text{ mm}$$

Provide Y_{12} @ 377 mm

Long Span Mid

d(short span) − Steel thickness = 144 − 12 = 132 mm

$M = 0.037 \times 17 \times 4^2 = 10.064$

$$K = \frac{10.064 \times 10^6}{1000 \times 132^2 \times 25} = 0.0281$$

$$I_a = 0.5 + \sqrt{0.25 - 0.0281/0.9} = 0.97 > 0.95$$

$z = 0.95 \times 132 = 125.4$

$$As = \frac{10.064 \times 10^6}{0.95 \times 125.4 \times 410} = 206.04$$

Provide Y_{12} @ 377 mm

Continuous

$d = 132\ mm$

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

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

$l_a = 0.5 + \sqrt{0.25 - 0.017/0.9} = 0.98 > 0.95$

$Z = 0.95 \times 132 = 125.4$

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

Provide $\phi 12$ @ 377 mm

Deflection check

$f_s = 2/3 \times 250 \times 1 \times \frac{224.61}{377} = 99.3$

$m_{1R} = 0.55 + \frac{422 - 99.3}{120\left(0.9 + \frac{11.968 \times 10^6}{1000 \times 144^2}\right)} = 2.68 > 2$

$d_{req} = \frac{4 \times 1000}{2 \times 26} = 76.92 = n$

d_{req} is ok