1 ~~The purpose~~ IBIWANYE DANIEL · T· CVE 308
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CIVIL ENGINEERING

1 ⓐ The purpose or objective of structural design is to produce a structure capable of resisting all applied load without failure during its intended life.
ⓑ In limit state design method, the structure is considered to have failed when it reaches its lower yield point while in Elastic method, the design ~~stress~~ strength is calculated such that the stress in the material is restrained to its yield point, under which the material follows Hooke's law.

Z=

Staircase Design

$f_y = 410N/mm^2$, $f_{cu} = 25N/mm^2$, rise = 150mm, thread = 275mm

slab ~~thick~~ thickness = 150mm

Steps = 12

Slope factor (SF) = $\frac{\sqrt{R^2+T^2}}{T} = \frac{\sqrt{150^2+275^2}}{275} = 1.14$

~~Lot~~ Loading

Waist A: $0.15 \times 24 = 3.6KN/m^2$

finishes B: $1.2KN/m^2$

Steps C: $0.275 \times \frac{1}{2} \times 24 = 3.3KN/m^2$

$G_k = (A+B) \times SF + C$

$= (3.6 + 1.2) \times 1.14 + 3.3$

$= 8.77KN/m^2$

Design Load, F, $= (1.4 \times 7.7) + (1.6 \times 1.5) = 14.68KN/m^2$ ⓑ

Span = $T_{total} + 0.5(l_a + l_b)$

$= (275 \times 12) + 0.5(225 + 225) = 3525mm$

$= 3.525m$

Since it spans between two landings

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

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

$= 150 - 25 - 6 = 119mm$ ⓑ

$\therefore M = \frac{14.68 \times 3.525^2}{10} = 18.24KNm$

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

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

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

$$\therefore Z = I_a d = 0.938 \times 119 = 111.622 mm$$

$$A_s = \frac{M}{0.95 f_y Z} = \frac{18.24 \times 10^6}{0.95 \times 410 \times 111.622} = 419.53 mm^2$$

$\therefore$ Provide Y12 @ 257 c/c (A_s prov = 452mm)

Deflection Check

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

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

$$= 154.69 N/mm^2$$

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

$$d_{req} = \frac{span}{mf \times X d_v} = \frac{3525}{1.78 \times 26} = 76.17mm$$

Since $d_{req} < d$, deflection is fine

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

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

1.075

$P_4 = P_5 = P_6 = \frac{4300}{4000} =$ ~~1.125~~ $< 2 = 2$ way slab

$P_{10} = P_{11} = P_{12} = \frac{4000}{1500} = 2.67 > 2 = 1$ way slab

(b) Designing P_1

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

Shortspan coefficient = —

0.034

longspan coefficient = 0.058

0.044

Using specification of: slab thickness = 195mm

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

$f_y = 410N/mm^2$

Design Load = $1.4g_k + 1.6q_k$

g_k = Weight of slab = $0.195 \times 24 = 4.68 KN/m^2$

finishes = 1.2

Partition = 1.0

$6.88 KN/m^2$

Assuming for factory

~~D.L = (1.4×6.4) + (1.6~~

D.L = $(1.4 \times 6.88) + 1.6 + 5)$

$= 17.632 \simeq$ ~~17.6KN/m~~ $18KN/m^2$

Short span mid ~~= P~~

$M = B_x w l^2 x = 0.044 \times 18 \times 4^2$

$= 12.672 KN/m^2$

$d = h - cover - \frac{1}{2}\phi$ = ~~144mm~~ $195 - 25 - 6 = 164mm$

$K = \frac{M}{bd^2 f_{cu}} = \frac{12.672 \times 10^6}{1000 \times 164^2 \times 25}$ = ~~0.024~~ 0.019

$I_a = 0.5 + \sqrt{0.25 - \frac{K}{0.9}} = 0.5 + \sqrt{0.25 - \frac{0.019}{0.9}}$ (~~0.024~~)

= ~~0.987~~ 0.95

= 0.95

$Z = I_a d = 0.95 \times 164$ = ~~136.8~~ 155.8mm

$A_s = \frac{M}{0.95 f_y Z} = \frac{12.672 \times 10^6}{0.95 \times 410 \times 155.8}$ (~~136.8~~) = ~~237.82~~ $208.82mm^2$

Provide Y12 @ 377mm

For continuous

$M = B_x w l^2 x = 0.033 \times 18 \times 4^2 = 9.504 KN/m^2$

~~d = 144mm~~ d = 164mm

$K = \frac{M}{bd^2 f_{cu}} = \frac{9.504 \times 10^6}{1000 \times 164^2 \times 25} = 0.014$

$I_a = 0.5 + \sqrt{0.25 - \frac{0.014}{0.9}} = 0.984 > 0.95$

$\therefore = 0.95$

$Z = 0.95 \times 164 = 155.8mm$

$A_s = \frac{9.504 \times 10^6}{0.95 \times 410 \times 155.8} = 156.81mm^2$

Provide Y12 @ 377mm

Long Span mid

$d = d(\text{short span}) - \text{steel thickness} = 164 - 12 = 152mm$

$M = B_x W l^2 x = 0.037 \times 18 \times 4^2 = 10.656 KN/m^2$

$K = \frac{M}{bd^2 f_{cu}} = \frac{10.656 \times 10^6}{1000 \times 152^2 \times 25} = 0.018$

$I_a = 0.5 + \sqrt{0.25 - \frac{K}{0.9}} = 0.5 + \sqrt{0.25 - \frac{0.018}{0.9}} = 0.98 > 0.95$

$\therefore = 0.95$

$Z = 0.95 \times 152 = 144.4mm$

$A_s = \frac{M}{0.95 f_y z} = \frac{10.656 \times 10^6}{0.95 \times 410 \times 144.4} = 189.46mm^2$

Provide Y12 @ 377mm

For Continuous

$M = B_x W l^2 x = 0.028 \times 18 \times 4^2 = 8.064 KN/m^2$

$K = \frac{8.064 \times 10^6}{1000 \times 152^2 \times 25} = 0.014$

$I_a = 0.5 + \sqrt{0.25 - \frac{0.014}{0.9}} = 0.98 > 0.95$

$\therefore = 0.95$

$Z = 0.95 \times 152 = 144.4mm$

$A_s = \frac{8.064 \times 10^6}{0.95 \times 410 \times 144.4} = 143.38mm^2$

Provide Y12 @ 377mm

Deflection Check

$F_s = 2/3 \, F_{yv} \, B \, \frac{A_{req}}{A_{appr}}$

$$F_s = \frac{2}{3} \times 250 \times 1 \times \frac{208.82}{377} = 92.3$$

$$MiR = 0.55 + \frac{477 - 92.3}{120\left(0.7 + \frac{11.968 \times 10^6}{1000 \times 164^2}\right)} = 2.68 > 2$$

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