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Civil Engineering

1 a) i) To design for safety
ii) The design must be economical
iii) The deflection of the structure must not impose with the intensity of the structure

b)

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~~ stress-strain relationship, assuming that the working stress are only a fraction of the elastic limit of the material

c)

Stair case design

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

$= 1.14$

Load analysis

A) $W_{cost} = h \times 24\,kN/m^2$
$= 0.15 \times 24 = 3.6\,kN/m^2$

B) Finishes $= 1.2\,kN/m^2$

C) Steps $= T \times \frac{1}{2} \times 24\,kN/m^2$
$= 0.275 \times \frac{1}{2} \times 24 = 3.3\,kN/m^2$

D) $G.k = ((A + B) \times 3) + C$
$= (4.4 + 1.14) + 3.3$
$= 8.77\,kN/m$

$D.L, F = 1.4G_k + 1.6Q_k$

$= 1.4(8.77) + 1.6(1.5)$

$= 14.08 kN$

$Span = Total + 0.5(l_a + l_b) = (275 \times 12) + 0.5(225 + 225) = 3.525m$

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

$= 150 - 25 - 6 = 119mm$

$M = \frac{Fl^2}{10} = \frac{14.63 \times 3.25^2}{10} = 18.24 kNm$

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

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

$Z = I_a d = 0.938 \times 1.19 = 111.622mm$

$A_s = \frac{M}{0.95 f_y z} = \frac{18.24 \times 10^6}{0.95 \times 111.62 \times 410} = 419.53$

$A_s prov = 452mm$

provide Y12 @ 250 c/c (A_s prov $= 452mm$)

Deflection check

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

$= \frac{2}{3} \times 1 \times \frac{415.53}{452} \times 250$

$= 154.69 N/mm^2$

$MF = 0.56 + \frac{477 - 154.69}{120(0.9 + \frac{18.24 \times 10^6}{1000 \times 119^2})}$

$= 1.78$

$d_{req} = \frac{Span}{M \times ol} = \frac{3525}{1.78 \times 26} = 76.17m$

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

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2a)

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

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

$P_4 = P_5 = P_6 = \frac{4300}{4000} = 1.075$; $1.075 < 2$, i.e 2 way slab

$P_{10} = P_{11} = P_{12} = \frac{4000}{1500} = 2.667$; $2.667 > 2$; i.e 1 way slab

b) Designing for P_2

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

Short span coefficient = —
0.054

Long span coefficient = ~~0.056~~
0.044

Assuming specifications of slab thickness = 175mm
$f_{cu} = 25N/mm^2$
$f_y = 410 N/mm^2$

$DL = 1.4 G_k + 1.6 Q_k$

G_k = weight of slab = 0.175×24
— — Partition = 1.0
— — finishes = 1.2
Total = 6.4 KN/m²

Assuming for factory;
$DL = (1.4 \times 6.4) + (1.6 \times 5) = 16.96 \simeq 17 KN/m^2$

Short span coefficient = 0.044

= 0.033

Long span coefficient = 0.037

= 0.028

Short span mid = P

$M = B_x w l^2 x = 0.004 \times 17 \times 4^2$

$= 11.968$

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

$k = \frac{M}{bd^2 f_{cu}} = \frac{11.964 \times 10^6}{1000 \times 144^2 \times 25} = 0.023$

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

$= 0.97$; $0.97 > 0.95$

∴ we use 0.95

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

$A_s = \frac{M}{0.95 f_y z} = \frac{11.968 \times 10^6}{0.95 \times 410 \times 136.4} = 224.07$

Provide Y12 @ 377mm

Continuous

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

$d = 144$

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

$I_a = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.5 + \sqrt{0.25 - \left(\frac{0.173}{0.9}\right)} = 0.93$

$Z = I_a d = 0.93 \times 144 = 119.52$

$A_s = \frac{M}{0.95 f_y z} = \frac{8.976 \times 10^6}{0.95 \times 410 \times 119.52} = 192.47 \text{ mm}$

∴ Provide Y12 @ 377mm

Long span

M_{s2}

$d = d$ (short span) − steel thickness $= 144 - 12 = 132$ mm

$M = \beta_{sx} w l_x^2 = 0.037 \times 17 \times 4^2 = 10.064$

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

$I_a = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.5 + \sqrt{0.25 - \frac{0.023}{0.9}} = 0.97$

but $0.97 > 0.95$

∴ we use 0.95

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

$A_s = \dfrac{M}{0.95 f_y Z} = \dfrac{10.064 \times 10^6}{0.95 \times 125.4 \times 410} = 206.04$

provide y 12 @ 377mm

Long span continous

$d = 132$ mm

$M = \beta_{sx} w l_x^2 = 0.028 \times 17 \times 4^2 = 7.616$

$k = \dfrac{M}{bd^2 f_{cu}} = \dfrac{7.616 \times 10^6}{1000 \times 132^2 \times 25} = 0.012$

$I_a = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.5 + \sqrt{0.25 - \frac{0.012}{0.9}} = 0.98$

but $0.98 > 0.95$

∴ we use 0.95

$A_s = \dfrac{M}{0.95 f_y Z} = \dfrac{7.616 \times 10^6}{0.95 \times 410 \times 125.4}$

$= 155.93$

prov y 12 @ 377mm

Deflection check

$f_s = \dfrac{2}{3} f_y \times \beta \times \dfrac{A_{req}}{A_{provided}}$

$= \dfrac{2}{3} \times 250 \times 1 \times \dfrac{224.61}{377} = 99.3$

$$M_f = 0.55 + \frac{422 - 99.3}{120\left(0.9 + \frac{11964 \times 10^6}{1000 \times 1442}\right)}$$

$= 2.64$; but $2.64 > 2$; we use 2

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

Deflection is OK