Assignment 1

1a) i) Structure must be Safe

ii) Structure must be economical

iii) Deformation of the Structure must not impair the integrity 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.

Elastic design is a method of analysis which the design of the 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.

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1c) STAIRCASE DESIGN

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

→ Load Analysis;

A - Waist $= R \times 24$ kN/m²

$= 0.15 \times 24 = 3.6$ kN/m²

B - Finishes $= 1.2$ kN/m²

C - Steps $= T \times \frac{1}{2} \times 24$

$= 0.275 \times \frac{1}{2} \times 24 = 3.3$ kN/m²

~~F = 1.4 GK + 1.6 QK~~

D - G.K $= ((A+B) \times S_f) + C$

$= (4.8 \times 1.14) + 3.3$

$= 8.77$ kN/m

D.L, F $= 1.4$ GK $+ 1.6$ Q.K

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

$= 14.68$ kN/m²

Span $= T_{total} + 0.5(L_a + L_b) = (275 \times 12) + 0.5(225 + 225)$

$= 3.525$ m

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

$= 150 - 25 - 6 = 119$ mm

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$$M = \frac{F l^2}{10} = \frac{14.68 \times 3.525^2}{10} = 18.24 \text{ kN/m}$$

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

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

$$Z = I_a d = 0.938 \times 119 = 111.622 \text{ mm}$$

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

$A_{s\,prov} = 432 \text{mm}$

Provide Y12 @ 259 c/c ($A_{s\,prov} = 452 \text{mm}$)

Deflection Check;

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

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

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

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

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$d_{req} = \frac{Span}{mf \times ed} = \frac{3525}{1.73 \times 26} = 76.17mm$

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

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

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

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

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

Designing for P_2;

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

Shortspan Coefficient $= \frac{\quad}{0.054}$

Longspan Coefficient = 0.058

0.047

Assuming Specification of Slab thickness = 175mm

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

$f_y = 410 N/mm^2$

Q.L = 1.4 G.K + 1.6 Q.K

G.K = Weight of Slab = 0.175 × 24

Partition = 1.0 KN/m²

Finishes = 1.2 KN/m²

6.4 KN/m²

Assuming Q.K for factory;

Q.L = 1.4 (6.4) + 1.6 (5)

= 16.96 ≃ 17 KN/m²

Shortspan Coefficient = 0.044

0.033

Longspan Coefficient = 0.037

0.028

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Short Span mid = P

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

$= 11.968$

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

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

$K = l_a = 0.5 + \sqrt{0.25 - \frac{K}{0.9}} = 0.97 > 0.95$

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

$A_s = \frac{M}{0.95 f_y Z} = \frac{11.968 \times 10^6}{0.95 \times 410 \times 136.8} = 224.61$

Provide Y12 @ 377 mm

Continous :

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

$d = 144$

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

$l_a = 0.5 + \sqrt{0.23 - \frac{K}{0.9}}$

$l_a = 0.5 + \sqrt{0.25 - \frac{0.0173}{0.9}} = 0.83$

$Z = l_a d = 0.83 \times 144 = 119.52$

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$$A_s = \frac{M}{0.95 f_y Z} = \frac{8.976 \times 10^6}{0.95 \times 410 \times 119.52} = 192.81 mm$$

Provide Y12 @ 377 mm

Long Span: mid

$d = d(\text{short span}) - \text{Steel thickness} = 144 - 12$
$= 132$

$M = \beta_x w l_x^2 = 0.03 \times 17 \times 4^2 = 10.064$

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

$$l_a = 0.5 + \sqrt{0.25 - \frac{K}{0.9}} = 0.97 > 0.95$$

$Z = l_a . d = 0.95 \times 132 = 125.4 mm$

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

$= 206.08 mm$

Provide Y12 @ 377 mm

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Continuous

$d = 132mm$

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

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

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

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

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

Provide Y12 @ 377mm

Deflection Check:

$f_s = \frac{2}{3} \times f_{yr} \times \beta \times \frac{A_{s\,req}}{A_{s\,prov}}$

$f_s = \frac{2}{3} \times 250 \times 1 \times \frac{224.61}{337} = 99.3$

$m.f = 0.55 + \frac{477 - 99.3}{120\left(0.9 + \frac{11.768 \times 10^6}{1000 \times 144^2}\right)} = 2.68 > 2$

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

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