1

(a) (i) To design for safety.

(ii) The design must be economical.

(iii) The deformation 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 ~~structure~~ failure that can cause the structure to be structurally, 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.

STAIRCASE DESIGN.

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

* Load analysis

A. WAIST $= R \times 24\ kN/m^2$

$= 0.15 \times 24 = 3.6\ kN/m^2$.

B. FINISHES $= 1.2\ kN/m^2$.

C. STEPS $= T \times 1/2 \times 24\ kN/m^2$

$= 0.275 \times 0.5 \times 24 = 3.3\ kN/m^2$.

D. G.K $= ((A+B) \times S.F) + C$

$= (4.8 \times 1.14) + 3.3$

$= 8.77\ kN/m$

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

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

$= 14.68\ kN/m^2$

Span $= T + 0 + 0.1 + 0.5(l_2 + l_6) = (275 \times 12) + 0.5(225 + 225) = 3.525m$

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

$= 150 - 25 - 6 = 119mm$

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

$k = \frac{m}{bd^2 f_{cu}} = \frac{18.24 \times 10^6}{1000 \times 19^2 \times 25} = 0.052$

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

$$Z = l_a d = 0.938 \times 1.19 = 111.622mm.$$

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

$A_{s prov} = 452mm.$

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

Deflection Check.

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

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

$$= 154.69 \ N/mm^2$$

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

$$d_{req} = \frac{Span}{MF \times e d_y} = \frac{3525}{1.78 \times 26} = 76.17mm$$

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

2

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

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

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

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

(b) Designing for P_2.

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

Shortspan Coefficient = 0.054.

Longspan Coefficient = ~~0.058~~ 0.044.

Specification of Slab thickness = 175mm

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

$f_y = 410N/mm^2$

$OL = 1.4Gk + 1.6Qk.$

$Gk =$ weight of slab $= 0.175 \times 24$

partition $= 1.0$

Finishes $= 1.2.$

$6.46\ N/m^2$

Assuming for factory.

$D.L = (1.4 \times 6.4) + (1.6 \times 5)$

$= 16.96 \simeq 17\ kN/m.$

Shortspan coefficient $= 0.044.$

$0.033.$

Long span coefficient $= 0.037$

0.028

Short span mrd = P.

$M = Bx\ \omega l^2 x = 0.044 \times 17 \times 4^2$

$= 11.968$

$d = h - \text{Cover} - \frac{1}{2}\varnothing = 144$

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

$k = 2a = 0.5 \sqrt{0.25 - \frac{k}{0.9}} = 0.97 > 0.95 = 0.75$

$z = a \cdot d = 0.95 \times 144 = 136.8$

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

Provide Y12 @ 377mm.

Continous.

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

$d = 144.$

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

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

$z = a \cdot d = 0.83 \times 144 = 199.52.$

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

Provide Y12 @ 377mm.

Long Span.

Mid.

$d = d(\text{short span}) - \text{steel thickness} = 144 - 12 = 132\,mm$.

$M = \beta x w l^2 x = 0.032 \times 12 \times 4^2 = 10.064$

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

$Za = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.97 > 0.95 = 0.95$.

$Z = Za \cdot d = 0.95 \times 132 = 125.4$.

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

provide Y12 @ 377mm.

Long Span Continous.

$d = 132mm$.

$M = \beta x w l^2 x = 0.028 \times 17 \times 4^2 = 7.616$

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

$Za = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.98 > 0.95 = 0.95$.

$Z = Za \cdot d = 125.4$.

$$A_s = \frac{M}{0.95 f_{y2}} = \frac{7.616 \times 10^6}{0.95 \times 410 \times 125.4} = 155.93$$

Provide Y12 @ 377mm

Deflection Check.

$$k = \frac{2}{3} f_{yv} \; B \; \frac{A_{req}}{A_{s\,approved}}$$

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

$$m_{fk} = 0.55 + \frac{477 - 99.3}{120\left(0.9 + \frac{11.968 \times 10^6}{1000 \times 144^2}\right)} = 2.68 > 2$$

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