Adesipe Daniel Olunlaseri
17/SCi04/002
Civil Engineering
Structural design

(1a) (i) - To design for safety
(ii) - The design must be economical
iii - The defformation 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 structure member is based on a linear stress relationship

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stair case design

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

* load Analysis

I- Waist = $h \times 24$ kN/m²

= 0.15 × 24 = 3.6 kN/m²

II = finishes = 1.2 kN/m²

III = steps = T × ½ × 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

= 8.772 kN/m

D.L.f = 1.4 Gk + 1.6 Qk

= 1.4 (8.77) + 1.6 (1.5)

= 14.68 kN/m²

Span = Total + 0.5 (a+b) = (275 × 12) + 0.5 (225+ ...

= 3.525 m

d = h − cover − ½ Ø

= 150 − 25 − 6 = 119 mm

$M = \frac{f l^2}{10} = \frac{14.68 \times 3.525^2}{10} = 18.24$ kNm

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

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

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

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

A_s pro = 452mm

provide Y12 @ 250 ck (As pro = 452mm)

Deflection check

$f_s = 2/3 \times 1/\beta \times \frac{A_{req}}{A_{pro}} \times f_{y}$

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

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

$d_{req} = \frac{Span}{efx \ edr} = \frac{3525}{1.78 \times 26} = 76.17mm$

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

(2a) $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

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

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

(2b) designing for P_2

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

short span coefficient = $-$ 0.054

Long span co-efficient = 0.088

0.044

Specification of slab thickness = 175 mm

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

$f_y = 410 N/mm^2$

DL = 1.4Gk + 1.6Qk

G.k = weight slab = 0.175 x 24
partition = 1.0
finishes = 1.2
6.4 kN/m²

Assuming for factory

D.L = (1.4 x 6.4) + (1.6 x 5)
= 16.96 ≃ 17 kN/m²

Short span co-efficient = 0.044
0.033

~~for~~
Long span co-efficient = 0.037
0.028

Short span mid = P
M = β x wl² = 0.044 x 17 x 4²
= 11.968

d = h - cover - ½ Ø = 144

k = M / bd² fcu = 11.968 x 10⁶ / 1000 x 144² x 25 = 0.023

$k = p_a = 0.5 + \sqrt{0.25 - k/0.9} = 0.975 > 0.95 = 0.95$

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

$As = \frac{M}{0.95 f_y z} = \frac{11.968 \times 10^6}{0.95 \times 460 \times 136.8} = 224.61$

provide $7 \phi 12$ @ 377mm

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

$d = 144$

$k = \frac{M}{bd^2 f_{cu}} = \frac{8.970 \times 10^6}{1000 \times 144^2 \times 25} = 0.0173$

$P_a = 0.5 + \sqrt{0.25 - k/0.9} = 0.5 + \sqrt{0.25 - \frac{0.0173}{0.9}}$

$= 0.83$

$z = P_a \cdot d = 0.83 \times 144 = 119.52$

$As = M / 0.95 f_y z = \frac{8.976 \times 10^6}{0.95 \times 460 \times 119.52} = 192.81 mm$

Provide ~~Y12~~ @ 377mm

Long span

Mid

~~d~~ d = d(short span) = steel thickness = 144 − 12

= 132mm

$M = \beta x \, a l^2 x = 0.032 \times 17 \times 4^2 = 10.064$

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

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

$Z = la \cdot d = 0.95 \times 132 = 125.4$

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

Provide Y12 @ 377mm

Cong Sxn : Continuous

$d = 132mm$

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

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

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

$Z = Ia \cdot d = 125.4$

$As = \frac{M}{0.95 f_y z} = \frac{7.616 \times 10^6}{0.95 \times 460 \times 125.4} = 138.93$

provide $Y12$ @ $377mm$

deflection check

$f_s = \frac{2}{3} f_y \cdot B \cdot \frac{Area}{Approved}$

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

$$M_{ik} = 0.55 + \frac{422 - 99.3}{120\left(0.9 + \frac{11.968 \times 10^6}{1000 \times 144^2}\right)} =$$

$= 2.68 > 2$

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