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CVE 308
17/ENG03/049.

Question 1:

(a) (i) To design for safety
(ii) The design must be economical.
(iii) The deformation of the structure must not impair with 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 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.

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

4 load Analysis

A waist $= h \times 24\,kN/m^2$
$= 0.15 \times 24 = 3.6\,kN/m^2$

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

C. Steps $= T \times 1/2 \times 24\,kN/m^2$
$= 0.275 \times 0.5 \times 24 = 3.5\,kN/m^2$

D. $G_k = ((A+B) \times S_f) + C$
$= (4.8 + 1.14) + 3.3$
$= 8.77\,kN/m$

D.L, $f = 1.4\,G_k + 1.60\,Q_k$

A-315-7E

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

$= 14.68 \text{ kN/m}^2$

Span = $l_{total} + 0.5(10+10) = (2.75 \times 12) + 0.5(225+225) = 3.525\text{m}$

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

$= 150 - 25 - 6 = 119\text{mm}$

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

$k = \frac{M}{bd^2 f_{cu}} = \frac{18.24 \times 10^6}{1000 \times 119^2 \times 26} = 0.052$

~~$k = \frac{M}{bd^2 f_{cu}} = 18.24 \times 10^6$~~

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

$z = z_a d = 0.938 \times 119 = 111.622\text{mm}$

$A_s = \frac{M}{0.95 f_y z} = \frac{18.24 \times 10^6}{0.95 \times 460 \times 111.622} = 419.53$

$A_{sprov} = 452\text{mm}$

provide Y12 @ 259 c/c ($A_{sprov} = 452\text{mm}$)

Deflection check

$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{A_{sreq}}{A_{sprov}} \times f_y$

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

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

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

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

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

Question 2

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

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

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

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

b) Designing of P_2

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

Shortspan coefficient = $\frac{-}{0.054}$

Long span coefficent = 0.058
0.044

Assuming specification of slab
thickness = 175mm
$f_{cu} = 25N/mm^2$
$f_y = 460N/mm^2$

$DL = 1.4 G_k + 1.6 Q_k$
$G_k =$

weight of slab = 0.175 × 24
partition = 1.0
finishes = 1.2

6.4 kN/m²

Assuming for factor
D.L = (1.6 × 6.4) + (1.6 × 5)
= 16.96 ≈ 17 kN/m²

Short span coefficient = 0.044
= 0.033
long span coefficient = 0.037
= 0.028

Short span mid = P
$M = \beta_{sx} w l_x^2 = 0.044 \times 17 \times 4^2$
$= 11.968$

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

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

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

$z = z_a d = 0.95 \times 144 = 136.8$

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

Provide Y12 @ 377mm

Continuous

$M = \beta_{sx} w l_x^2 = 0.033 \times 17 \times 4^2 = 8.976$

$d = 144$

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

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

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

$A_s = \frac{M}{0.95 f_y Z} = \frac{8.976 \times 10^6}{0.95 \times 460 \times 119.52} = 192.81 mm$

provide Y10 @ 377mm

Long span

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

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

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

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

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

$A_s = \frac{M}{0.95 f_y Z} = \frac{10.064 \times 10^6}{0.95 \times 460 \times 125.4} = 206.04$

Provide Y10 @ 377mm.

long span Continuous

$d = 132mm$

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

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

$z_a = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.987 \quad 0.95 = 0.95$

$z = z_a d = 0.95 \times 132 = 125.4$

$A_s = \frac{M}{0.95 f_y z} = \frac{7.616 \times 10^6}{0.95 \times 410 \times 125.4} = 155.95$

Provide $\phi 12$ @ 377mm

Deflection check

$f_s = 2/3 f_y \cdot \beta \frac{A_{req}}{A_{sprov}}$

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

$mf = 0.55 + \frac{422 - 99.3}{120\left(0.9 + \frac{11.968 \times 10^6}{1000 \times 144^2}\right)} = 2.6872$

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

Deflection is OK