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AIENG03/011
Civil Engineering
CVE 308

(1)

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

(b) Limit state design considers the disadvantage of load factor design and any other failure that can cause the structure to be unfit, while Elastic design is a method of analysis which the design of a member is based on a linear stress-strain relationship, assuming that the working stress are only a factor of the elastic limit of the material.

(c) Slope factor $= \frac{\sqrt{R^2+T^2}}{T} = \frac{\sqrt{150^2+278^2}}{275}$

$= 1.14$

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 $= T \times 1/2 \times 24\,kN/m^2$
$= 0.275 \times 0.5 \times 24 = 3.3\,kN/m^2$

D. $G_k = ((A+B) \times S_f) + C$
$= (4.8 \times 1.14) + 3.3$
$= 3.77\,kN/m$

D.L. $f = 1.4G_k + 1.6Q_k$
$= 1.4(3.77) + 1.6(1.5)$
$= 14.08\,kN/m^2$

Span $= T_{total} + 0.5(l_1/l_2) = (275 \times 12) + 0.5(225 + 225) = 3.525\,m$

$d = h - cover - 1/2\,\phi$
$= 150 - 25 - 6 = 119\,mm$

$M = \frac{fl^2}{10} = \frac{14.68 \times 3.525^2}{10} = 18.24\,kNm$

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

$Z/d = 0.5 + \sqrt{0.25 - K/0.9} = 0.5 + \sqrt{0.25 - 0.052/0.9}$
$= 0.938$

$Z = Z/d \cdot d = 0.938 \times 119 = 111.62\,mm$

$A_s = M/0.95 f_y z = 18.24 \times 10^6 / 0.95 \times 460 \times 111.62$
~~× 111.62~~ $= 418.93$ × 416.4

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

Deflection check -

$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{A_{st\,req}}{A_{st\,pro}} \times f_y$

$f_s = \frac{2}{3} \times 1 \times \frac{419.53}{482} \times 250$

$= 134.69\ N/mm^2$

$m.f = 0.55 + \frac{477 - 134.69}{120(0.9 + \frac{18.24 \times 10^6}{1000 \times 114^2})}$

$= 1.78$

$l_{req} = \frac{span}{m.f \times d} = \frac{3525}{1.78 \times 26} = 76.17mm$

since $l_{req} < 2$ deflection is ok.

(2)

a) $R_1 = R_2 = R_3 = \frac{4300}{4000} = 1.075 < 2$

= 2 way slab

$R_7 = R_8 = R_9 = \frac{4500}{4000} = 1.125 < 2$

2 way slab.

$R_4 = R_5 = R_6 = \frac{4300}{4000} = 1.075 < 2$

= 2 way slab.

$R_{10} = R_{11} = R_{12} = \frac{4000}{1500} = 2.667 > 2$

1 way slab

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

short span coefficient = 0.05x

long span coefficient = 0.038

0.044

Assuming spec of slab thickness 175mm

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

$f_y = 460N/mm^2$

$D_L = 1.4G_k + 1.6Q_k$

G_k = weight of slab = 0.175 × 24

Partions 1.0

finishes 1.2

$6.4\ kN/m^2$

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

$= 16.96 \approx 17kN/m^2$

short span coefficient = 0.044

0.033

Long span coefficient = 0.037

0.028

Short span m = P

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

$= 11.968$

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

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

$= 0.023.$

$l_a = 0.5 + \sqrt{0.25 - K/0.9}$
$= 0.97 > 0.95 = 0.95$
$z = l_a \cdot d = 0.95 \times 144 = 136.8$

$A_s = \frac{M}{0.95 f_y z} = \frac{11.968 \times 10^6}{0.95 \times 410 \times 136.8}$
$= 224.61$
Provide Y12 @ 377mm

Continuous
$M = \beta_{sx} n l_x^2 = 0.033 \times 17 \times 4^2$
$= 8.976$
$d = 144$
$K = \frac{M}{bd^2 f_{cu}} = \frac{8.976 \times 10^6}{1000 \times 144^2 \times 25}$
$= 0.0173$
$l_a = 0.5 + \sqrt{0.25 - K/0.9}$
$= 0.83$

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

$A_s = M / 0.95 f_y z = \frac{8.976 \times 10^6}{0.95 \times 410 \times 119.52}$
$= 192.81$ mm
Provide Y12 @ 377mm

long span
M-2
$d = d$ (short span) − steel thickness
$= 144 - 12 = 132$mm
$M = \beta_{sx} n l_x^2 = 0.037 \times 17 \times 4^2 = 10.064$

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

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

$z = l_a \cdot d = 0.95 \times 132 = 125.4$

$A_s = M / 0.95 f_y z = \frac{10.064 \times 10^6}{0.95 \times 125.4 \times 410}$
$= 206.04$
Provide Y12 @ 377mm

long span continuous
$d = 132$mm
$M = \beta_{sx} n l_x^2 = 0.028 \times 17 \times 4^2$
$= 7.616$
$K = \frac{M}{bd^2 f_{cu}} = \frac{7.616 \times 10^6}{1000 \times 132^2 \times 25}$
$= 0.017$
$l_a = 0.5 + \sqrt{0.25 - K/0.9} = 0.98 > 0.95$
$= 0.95$
$z = l_a \cdot d = 0.95 \times 132 = 125.4$

$A_s = \frac{M}{0.95 f_y Z} = \frac{26.68\times10^6}{0.95\times410\times454}$

$= 155.93$

Provide Y12 @ 377mm

Deflection check

$f_s = \frac{2}{3} \times f_y \cdot b \cdot \frac{A_{s,req}}{A_{s,prov}}$

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

$= 99.3$

$M.F = 0.55 + \frac{477 - 99.3}{120(0.9 + 1000\times44^2)}$

$= 2.6872$

$Z_{req} = \frac{40\times1000}{2\times26} = 76.97$

$= Ok$