Okiemute Waterway
17/ENG03/056
Civil Engineering

1a) i) To design for safety
ii) The structure must be economical
iii) The deformation of a structure must not impair with The integrity of the structure.

b) Limit state design considers the disadvantages of elastic and load factor design and any other failure that can cause the structure to be structurally unfit while Elastic design 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 factor 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. Step $= T \times \frac{1}{2} \times 24 kN/m^2$
$= 0.275 \times 0.5 \times 24 = 3.3 kN/m^2$

D. $G_k = ((A+B) \times S_F) + C$
$= (4.8 \times 1.14) + 3.3$
$= 8.772 kN/m$

$D.L,\ F = 1.4G_k + 1.6G_k$
$= 1.4(8.77) + 1.6(1.5)$
$= 14.68\,kN/m^2$

$Span = T_{total} + 0.5(l_a + l_b) = (275 \times 12) + 0.5(225 + 225)$
$= 3.525m$

$d = h - cover - \tfrac{1}{2}\phi$
$= 150 - 25 - 6 = 119mm$

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

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

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

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

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

$A_{s\,prov} = 452mm$

Provided Y_{12} @ 250 c/c ($A_{s\,prov} = 452mm$)

Deflection Check

$f_s = \tfrac{2}{3} \times \tfrac{1}{3} \times \frac{A_{req}}{A_{s\,prov}} \times f_{yv}$

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

$= 154.69\ N/mm^2$

$M.F = 0.56 + \frac{477 - 154.69}{120\left(0.9 + \frac{18.24 \times 10^6}{1000 \times 119^2}\right)} = 1.78$

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$d_{req} = \frac{Span}{\alpha f \cdot x \cdot d_u} = \frac{3525}{1.78 \times 26} = 76.17mm$

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

$P_{10} = P_{11} = P_{12} = \frac{4000}{1500} = 2.667 > 2$ = 1 way slab

Designing for P_2

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

Shortspan coefficient = 0.054

Long Span coefficient = ~~0.088~~ 0.088
~~0.044~~ 0.044

Assuming Specification of slab thickness = 175mm
$f_{cu} = 25N/mm^2$
$f_y = 410N/mm^2$

DL ~~Gk~~ = $1.4G_K + 1.6Q_K$

weight of Slab = 0.175 x 24
Partition = 1.0
Finishes = 1.2
$6.4 kN/m^2$

Assuming for

$DL = (1.4 \times 6.4) + (1.6 \times 5)$

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

Short span coefficient = 0.044

0.033

long span coefficient = 0.032

0.028

Short span mid = P

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

$= 11.968$

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

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

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

$= 0.95$

$z = \frac{z}{d} \cdot d = 0.95 \times 144 = 136.8$

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

Provide Y 12 @ 377mm

Contineous

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

$d = 144$

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

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

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

$$Z = I_a . d = 0.83 \times 144 = 119.52$$

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

Provide Y12 @ 377mm

Long span Mid

$d = d$ (short span) − slab thickness $= 144 - 12 = 132mm$

$$M = B_x w l^2 x = 0.037 \times 17 \times 4^2 = 10.064$$

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

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

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

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

Provide Y12 @ 377mm

Long ~~Conti~~ span Contineous

$d = 132mm$

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

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

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

$= 0.95$

$z = I_a \cdot d = 125.4$

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

Provide Y12 @ 377mm

Deflection check

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

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

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

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