**QUESTION ONE**

1. The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and resistance to the effects of misuse and fire.
2. The difference between working stress design (elastic design) and limit state design (plastic design), is the assumption of the behavior of a structure. In working stress design, we assume that the structure has failed when it reached the elastic limit. In limit states design, we consider the structure to have failed when it reaches the lower yield point.
3. fy=410N/mm2, fcu= 25N/mm2, rise = 150mm, tread = 275mm, slab thickness =150 mm. Check for deflection. Assume 12 steps.

**SOLUTION**

Waist A = 0.15×24 = 3.6kN/m2

Finishes B = 1.2kN/m2

Steps C = 0.275×0.5×24 = 3.3kN/m2

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

Dead load, Gk = (3.6+1.2) ×1.4+3.3 = 8.77kN/m

Design load, DL = 1.4×8.77+1.6×1.5 = 14.68kN/m

Span = Ttotal+0.5(la+lb)

= 275×12+0.5(225+225) = 3.53m

Moment, M = $\frac{FL^{2}}{8}=\frac{14.68×3.53^{2}}{8}=22.87kNm$

Effective depth, d = h-cover-0.5Ø

= 150 – 25 – 0.5(12) = 119mm

K = $\frac{M}{bd^{2}f\_{cu}}$ = $\frac{22.87×10^{6}}{1000×119^{2}×25}=0.065$

Ia = 0.5+$\sqrt{0.25-\frac{0.065}{0.9}}=0.92$

Z = Iad = 0.92×119 = 109.74

As =$\frac{22.87×10^{6}}{0.95×109.74×410}=535.05mm^{2}$\

 ⁖ Provide Y12@ 200 C/C (A = 566mm2)

**DEFLECTION CHECK**

ρ = $\frac{As\_{required}}{bd}= \frac{535.05}{1000×119 }=0.0045$

ρo = $\sqrt{f\_{cu}} (10^{-3})$ = 0.005

ρ0 > ρ, structural system = 1.5

$\frac{L}{d} $= k (11 + 1.5$\sqrt{f\_{cu}}$ ($\frac{ρo }{ρ}$) + 3.2$\sqrt{f\_{cu}}$ (($\frac{ρo }{ρ}$)-1)3/2)

$\frac{L}{d} $= 1.5 (11 + 8.25 + 1.6)

$\frac{L}{d} \_{basic}$= 31.275

Modification factor, $\frac{As\_{prov}}{As\_{req}}$= $\frac{566}{535.05}$= 1.06 < 1.5

$\frac{L}{d} \_{allowed}$= 31.275 x 1.06 = 33.08

$\frac{L}{d} \_{actual}$ = 3530/119 = 29.66 < $\frac{L}{d} \_{allowed}$, OK!

**QUESTION 2**

|  |  |
| --- | --- |
| PANELS | TYPE |
| P1 | 2 way slab |
| P2 | 2 way slab |
| P3 | 2 way slab |
| P4 | 2 way slab |
| P5 | 2 way slab |
| P6 | 2 way slab |
| P7 | 2 way slab |
| P8 | 2 way slab |
| P9 | 2 way slab |
| P10 | 1 way slab |
| P11 | 1 way slab |
| P12 | 1 way slab |

Solution

Designing for panel 8:

Ly=4500mm, Lx=4000mm, assuming depth of slab to be 175mm.

$$\frac{l\_{y}}{l\_{x}}=\frac{4.5}{4}=1.125≅1.13$$

Short span coefficients: mid span = 0.028, continuous edge = -0.037

Long span coefficients: mid span = 0.024, continuous edge = -0.032

Loading: slab = 0.175×24 = 4.2kN/m2

Partition = 1.0kN/m2

Finishes = 1.2kN/m2

Sum = 6.4kN/m2

Design load = 1.4×6.4+1.6×3.0 = 13.76$ ≅$ 14kN/m2 (assuming the area would be used for a kitchen)

SHORT SPAN

Mid span:

M = βxwlx2 = 0.028×14×42 = 6.272kNm

Effective depth, d = h-cover-0.5Ø = 175 – 25 – 0.5(12) = 144mm

K = $\frac{M}{bd^{2}f\_{cu}}$ = $\frac{6.272×10^{6}}{1000×144^{2}×25}=0.012$

Ia = 0.5+$\sqrt{0.25-\frac{0.012}{0.9}}=0.99 ≅0.95$

Z = Iad = 0.95×144 = 136.8mm

As =$\frac{6.272×10^{6}}{0.95×136.8×410}=117.71mm^{2}$

 ⁖ Provide Y12@ 300 C/C (A = 377mm2)

Continuous edge:

M = βxwlx2 = 0.037×14×42 = 8.288kNm

Effective depth, d = h-cover-0.5Ø = 175 – 25 – 0.5(12) = 144mm

K = $\frac{M}{bd^{2}f\_{cu}}$ = $\frac{8.288×10^{6}}{1000×144^{2}×25}=0.016$

Ia = 0.5+$\sqrt{0.25-\frac{0.016}{0.9}}=0.98 ≅0.95$

Z = Iad = 0.95×144 = 136.8mm

As =$\frac{8.288×10^{6}}{0.95×136.8×410}=155.55mm^{2}$

 ⁖ Provide Y12@ 300 C/C (A = 377mm2)

LONG SPAN

Mid span:

M = βxwlx2 = 0.024×14×4.52 = 6.804kNm

Effective depth, d = h-cover-0.5Ø = 144 - 12 = 132mm

K = $\frac{M}{bd^{2}f\_{cu}}$ = $\frac{6.804×10^{6}}{1000×132^{2}×25}=0.017$

Ia = 0.5+$\sqrt{0.25-\frac{0.017}{0.9}}=0.98 ≅0.95$

Z = Iad = 0.95×132 = 125.4mm

As =$\frac{6.804×10^{6}}{0.95×125.4×410}=139.3mm^{2}$

 ⁖ Provide Y12@ 300 C/C (A = 377mm2)

Continuous edge:

M = βxwlx2 = 0.032×14×4.52 = 9.072kNm

Effective depth, d = h-cover-0.5Ø = 144 - 12 = 132mm

K = $\frac{M}{bd^{2}f\_{cu}}$ = $\frac{9.072×10^{6}}{1000×132^{2}×25}=0.021$

Ia = 0.5+$\sqrt{0.25-\frac{0.021}{0.9}}=0.98 ≅0.95$

Z = Iad = 0.95×132 = 125.4mm

As =$\frac{9.072×10^{6}}{0.95×125.4×410}=185.74mm^{2}$

 ⁖ Provide Y12@ 300 C/C (A = 377mm2)

DEFLECTION CHECK

dreq = $\frac{Span}{mf×d\_{eff}}$

mf = $\frac{477- f\_{s}}{120(0.9+\frac{M}{bd^{2}})}$

fs = $\frac{2}{3}×β×\frac{A\_{s\_{req}}}{A\_{s\_{prov}}}×f\_{y}$ = $\frac{2}{3}×1×\frac{185.74}{377}×250$ = 82.11

mf = $\frac{477- 82.11}{120(0.9+\frac{9.072}{1000×132^{2}})}$ = 2.46

dreq = $\frac{4500}{2.46×16}$ = 114.33mm

since dreq < d, ⁖ conditions are ok