1a) To design for safety
b.) The design must be economical.
c.) The deformation of the structure must not impose with the integrity structure.

Staircase Design

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

$= 1.14$

Load Analysis

A. waist = R × 24 kN/m³

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

B. finishes = 1.2 kN/m²

C. steps = $T \times \frac{1}{2} \times 24\,kN/m^2$

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

D. G.k ((A+B) × 3 + D) + C

$= (4.8 + 1.14) + 3.3$

$= 8.77\,kN/m$

U.L.F = 1.4 Gk + 1.6 Qk

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

$= 14.68\ KN/m^2$

Span = Total + 0.5 (la+lb) = (275 × 12) + 0.5 (225 + 225) = 3.525 m

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

$= 150 - 25 - 6 = 119 mm$

$M = \frac{Fl^2}{10} = \frac{14.68 \times 3.525}{10} = 18.24\ KNm$

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

$= 0.052$

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

$= 0.938$

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

$A_s = \frac{M}{0.95 f_y Z} = \frac{18.24 \times 10^6}{0.95 \times 410 \times 111.622} = 419.52$

As for = 452 mm

Provide Y12 @ 259 c/c (Aspr = 452 mm)

Deflection check

$$f_s = \frac{2}{3} \times \frac{1}{\beta} \times \frac{Area}{A_{pro}} \times f_{yk}$$

$$f_s = \frac{2}{3} \times 1 \times \frac{419.52}{452} \times 250$$

$$= 154.69 \ N/mm^2$$

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

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

Since $d_{req} < d$, Deflection is OK.

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

$= 2$ way slab

$P_2 = P_{s} = P_9 = \frac{4500}{4000}$

$= 1.125 < 2$

$= 2$ way slab

$P_4 = B_5 = P_6 = \frac{4300}{4000} = 1.075 < 2$

$= 2$ way slab

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

$= 1$ way slab

2b.) Designing for P_2

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

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

Longspan coefficient $= \frac{0.058}{0.044}$

Assuming specification of slab thickness = 175mm

f_{cu} = 25N/mm²

$f_y = 410 N/mm^2$.

DL = $1.4 G_k + 1.6 Q_k$

G_k = weight slab = 0.175×24

partition = 1.0

finishes = 1.2

$6.4 KN/m^2$

Assuming for factory

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

= 16.96 ≃ $17 kN/m^2$

Short span coefficient = 0.044

0.033

Long span coefficient = 0.032

0.028

Short span m/2 = P

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

= 11.968

$d = h - cover - 1/2 D = 144$

$k = \frac{m}{bd^2 f_{cu}} = \frac{11.968 \times 10^6}{1000 \times 144^2 \times 20}$

provide y12 at 377mm

Long span Continuous

$d = 132mm$

$m = \beta xwl^2 x = 0.028 \times 17 \times 4^2$

$= 7.616$

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

$= 0.017$

$la = 0.5 + \sqrt{0.25 - \frac{k}{0.9}} = 0.98 > 0.95$

$= 0.95$

$z = la \cdot d = 125.4$

$As = \frac{m}{0.95 f_y z} = \frac{7.616 \times 10^6}{0.95 \times 410 \times 125.4}$

$= 155.93$

provide y12 @ 377mm

Deflection check

$fs = \frac{2}{3} f_y \times \frac{As\ req}{As\ provided}$

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

$= 192.8/mm$

provide $y12$ @ 377mm

Long span

m.d

d = d (short span) - steel thickness = 144 - 12

= 132mm

$m = \beta x\, wl^2 x = 0.037 \times 17 \times 4^2 = 10.064$

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

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

$= 0.95$

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

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

$= 206.04$

$= 0.023$

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

$= 0.95$

$Z = la \cdot d = 0.95 \times 144 = 136.8$

$As = \frac{M}{0.95 fy Z} = \frac{11.968 \times 10^6}{0.95 \times 410 \times 136.8} = 224.61$

provide Y12 @ 377mm.

<u>Continuous</u>

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

$= 8.976$

$d = 144$

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

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

$= 0.83$

$Z = la \cdot d = 0.83 \times 144$

$= 119.52$

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

$$= 99.3$$

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

$$= 2.68 > 2$$

$$= 2.$$

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