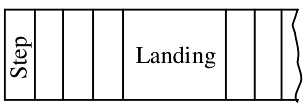
STAIR DESIGN

The simplest form of R.C.C. stair case consists of an inclined slab supported at the ends upon beams or walls or ground foundation, such a stair slab is usually designed as a simple slab with a span equal to the horizontal distance between two supports. Main reinforcement is placed at the bottom like one way slab design and temperature reinforcement rods placed usually one rod to each trade i.e. generally 10 inch c/c is used only to assist the distribution of the load. It is better to keep the unsupported span of stair slab reasonably short. If the span can not be shortened and exceeds unnecessarily, a beam can suitably provide to shorten the span of stair slab for economic purpose.

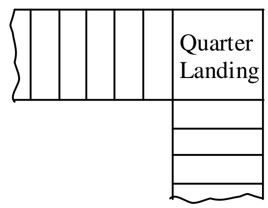
- In public buildings the rise is about 15 cm (6 in) and in residential buildings rise may very from 15 to 18 cm (6 to 7 in)
- The tread in public buildings is kept about 30 cm (12 in) and in residential buildings the tread may very from 20 to 30 cm (8 to 12 in)
- The sum of tread plus twice the rise is kept about 60 cm (24 in)
- The product of tread and rise in cm is kept between 400 to 450 (in inch 160 to 180)

Types of Stair-Cases:

1) Straight Stair

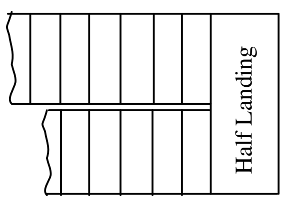


2) Quarter Turn Stair

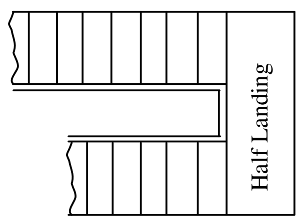


3) Half Turn Stairs/ Stairs of Two Flights

(a) Dogleg Type

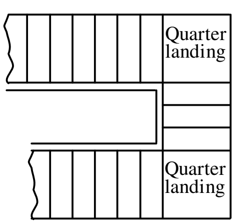


(b) Open Newel Type

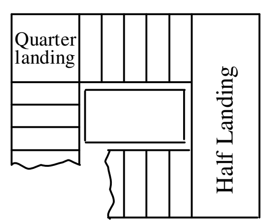


4) Stair Cases of Three Flights

(a) Half Turn Stair

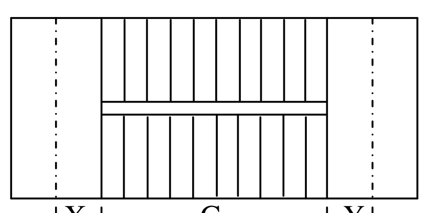


(b) Three Quarter Turn Stair



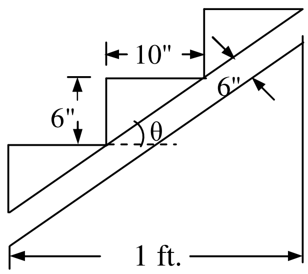
Effective Span of Stairs: The effective span of stairs without stringer beams shall be taken as the following table.

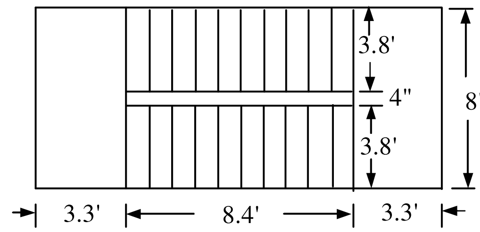
X	Y	Span in Meters
< 1 m	< 1 m	G + X + Y
< 1 m	≥ 1 m	G + X + 1
≥1 m	< 1 m	G + Y + 1
≥ 1 m	≥ 1 m	G + 1 + 1



Problem: Design a suitable stair-case for a multi-storied building having stair case hall 8'×15'. The height between the floors is 10.0 ft. Live load to be taken is 60 lb/ft^2.

Solution: we have to design as shown in figure.





Let: No. of tread = 20

Tread = 10 in Rise of step = 6 in Landing = 3.3 ft

Thickness of slab = 6 in Width of step = 3.8 ft

Here, $X = Y = \frac{3.3}{2} = 1.65$ ft < 3.28 ft (1m)

So, span center to center of landing, $l = 8.4 + 1.65 + 1.65 = 11.7$ ft

Weight of each step $= (\frac{1}{2} \times \frac{6 \times 10}{144}) \times 3.8 \times 150 = 118.8$ lb

Now, weight of steps per horizontal feet run $= 118.8 \times \frac{12}{10} = 142.5$ lb

Weight of slab per horizontal feet run $= (\frac{1}{Cos\theta} \times \frac{6}{12}) \times 3.8 \times 150 = 332.5$ lb

Here, $\theta = \tan^{-}(6/10) = 31^0$

So, total dead load per horizontal feet run = 142.5 + 332.5 = 475 lb

Live load per horizontal feet run = 60 × 3.8 = 228 lb

Total load per feet, $w = 703$ lb

Maximum bending moment, $M = \frac{wl^2}{8} = \frac{703 \times (11.7)^2}{8} = 12029$ lb-ft = 144350 lb-in

Effective depth, $d = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{144350}{165 \times (3.8 \times 12)}} = 4.4$ in

Here, $f_S = 18000$ psi
$j = 0.88$
R = 165 psi

Total depth, t = 4.4 + 1.0 = 5.4 in < 6.0 in

Area of steel, $A_S = \frac{M}{f_S jd} = \frac{144350}{18000 \times 0.88 \times 4.4} = 2.1\,\text{in}^2$

Provide # 4 bar at spacing $= \frac{(3.8 \times 12) \times 0.2}{2.1} = 4.3$ in ≈ 4.0 in c/c

Area of distribution steel, $A_{St} = 0.0015bt = 0.0015 \times (3.8 \times 12) \times 6.0 = 0.41\ \text{in}^2$

Provide # 3 bar at spacing $= \frac{12 \times 0.11}{0.41} = 3.2$ in ≈ 3.0 in c/c

Design of Landing Slab:

Consider width = 1 ft and thickness = 6.0 in

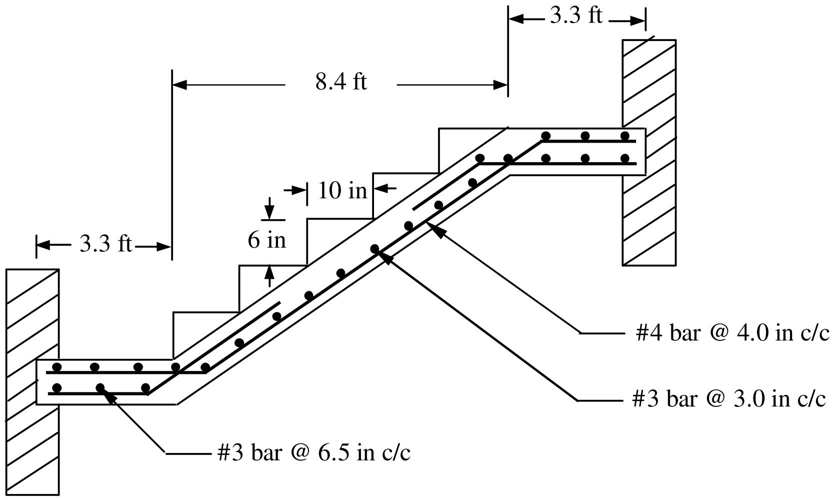
Dead load per feet length = $1 \times \frac{6}{12} \times 150 = 75$ lb

Total load per feet length, $w = 75 + 60 = 135$ lb

Maximum bending moment, $M = \frac{wl^2}{8} = \frac{135 \times (8)^2}{8} =$ 1080 lb-ft = 12960 lb-ft

Area of steel, $A_S = \frac{M}{f_S jd} = \frac{12960}{18000 \times 0.88 \times 4.3} = 0.2 \text{ in}^2$

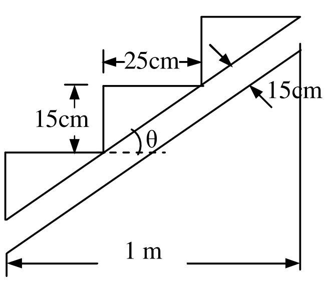
Provide # 3 bar at spacing = $\frac{12 \times 0.11}{0.2} = 7.3$ = 6.6 in 6.5 in c/c

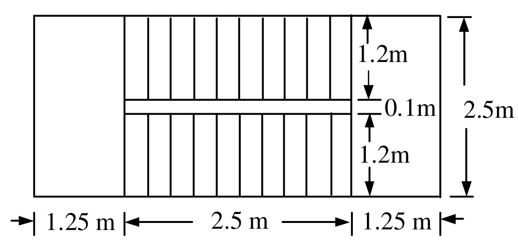


Design sketch

Assignment: Design a suitable stair-case supported by 25 cm (10") wall. The size of the stair case hall is 2.5m×5.0m. The height between the floors is 3.0 m. Live load to be taken is 300 kg/m^2. Rise of steps is 15 cm and tread is 25 cm. Assuming f_S = 1400 kg/cm^2, R = 11.5 kg/cm^2.

Solution: we have to design as shown in figure.





Let: No. of tread = 20

Tread = 25 cm Rise of step = 15 cm Landing = 1.25 m

Thickness of slab = 15 cm Width of step = 1.2 m

Here, X = Y = $\frac{1.25}{2}$ = 0.63 m < 1m

So, span center to center of landing, l = 2.5 + 0.63 + 0.63 = 3.76 m

Weight of each step $= (\frac{1}{2} \times \frac{15 \times 25}{100 \times 100}) \times 1.2 \times 2400$ = 54 kg

Now, weight of steps per horizontal meter run = $54 \times \frac{100}{25}$ = 216 kg

Weight of slab per horizontal meter run = $(\frac{1}{Cos\theta}\times\frac{15}{100})\times 1.2\times 2400 = 504$ kg

Here, $\theta = \tan^{-}(15/25)$ $= 31^0$

So, total dead load per horizontal meter run = 216 + 504 = 720 kg

Live load per horizontal feet run = 300 ×1.2 = 360 kg

Total load per meter, w = 1080 kg

Maximum bending moment, $M = \frac{wl^2}{8} = \frac{1080\times(3.76)^2}{8} = 1908.6$ kg-m = 190860 kg-cm

Effective depth, $d = \sqrt{\frac{M}{Rb}} = \sqrt{\frac{190860}{11.5\times(1.2\times 100)}} = 11.8$ cm

Here, $f_S = 1400$ kg/cm^2, $j = 0.88$, $R = 11.5$ kg/cm^2

[1 psi = 0.0703 kg/cm^2 = 0.00689 N/mm^2]

Total depth, t = 11.8 + 2.5 = 14.3 cm < 15.0 cm

Area of steel, $A_S = \frac{M}{f_S jd} = \frac{190860}{1400\times 0.88\times 11.8} = 13.2$ cm^2

Provide 12 mm φ bar at spacing = $\frac{(1.2\times 100)\times 1.13}{13.2}$ = 10.3 cm ≈ 10 cm c/c

Area of distribution steel, $A_{St} = 0.0015bt = 0.0015\times(1.2\times 100)\times 15 = 2.7$ cm^2

Provide 8 mm φ bar at spacing = $\frac{100\times 0.5}{2.7} = 18.5$ cm c/c

Design of Landing Slab:

Consider width = 1 m and thickness = 15 cm

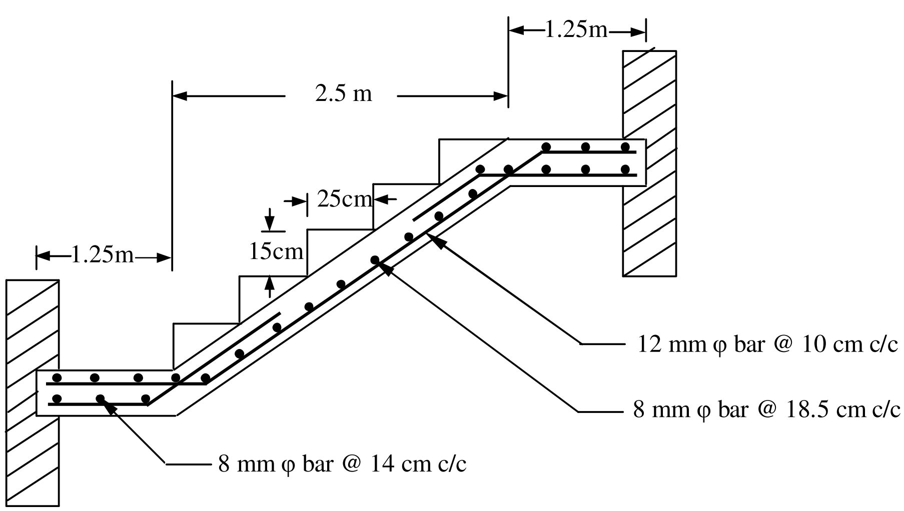
Dead load per metre length $= 1\times\frac{15}{100}\times 2400 = 360$ kg

Total load per metre length, w = 360 + 300 = 660 kg

Maximum bending moment, $M = \frac{wl^2}{8} = \frac{660\times(2.5)^2}{8}$ = 515.62 kg-m = 51562 kg-cm

Area of steel, $A_S = \frac{M}{f_S jd} = \frac{51562}{1400\times 0.88\times 11.8} = 3.5$ cm^2

Provide 8 mm φ bar at spacing = $\frac{100\times 0.5}{3.5} = 14.3$ cm ≈ 14.0 cm c/c



Design sketch