# RCC Structure – Staircase on Slab

***Case Example:***

Analyze the staircase design cast with the slab supported between beams c/c 4 meters. There are 16 steps with 270 mm Tread; 160 mm Rise; 250 mm Go; and minimum waist of 160 mm. Width of the staircase is 1.5 m and expected to carry a live load of 5 kN/m^2. Consider M20 concrete grade, Fe415 grade 12 mm steel bars with 15 mm clear cover. Add 15 mm tread top finishing.

***Analysis:***

Data:

Characteristic strength of concrete $f_{ck}$ = 20 N/mm$^2$ = 20e3 kN/m$^2$

Yield strength of steel = 415 N/mm$^2$ = 415e3 kN/m$^2$

Tread T = 270 mm

Rise R = 160 mm

Go G = 250 mm

Waist W = 160 mm

B = $\sqrt{(R^2+G^2)}$ = $\sqrt{(160^2+250^2)}$ = 297 mm

A. Slab Factored Load:

(i) DL = (1/G)(WB + RT/2)* 25 = (1/0.25)(0.16*0.297+0.16*0.27/2)*25 = 6.912 kN/m$^2$

(ii) Finish load = 0.015*T*25.0/G = 0.015*0.27*25/0.25 = 0.405 kN/m$^2$

(iii) Total Dead load = 6.912 + 0.405 = 7.32 ≈ 7.5 kN/m$^2$

(iv) Live load = 5 kN/m$^2$

(v) Factored load = (DL + LL)*load factor = 18.75 kN/m$^2$

B. Effective depth (d):

Waist (160 mm) – clear cover (15 mm) – bar diameter (12mm)/2 = 139 mm

C. Effective span:

(i) Beam c/c L = 4 m

D. Moment Calculation (meter width of stair)

(i) Applied Moment (Mu) = (WL$^2$) /10 = 30 kNm

(ii) Applied shear force (Vu)= (WL/2) = 37.5 kN

(iii) Moment capacity = 0.138 $f_{ck}$*b*d$^2$ = 0.138*20.0e3*1.0*0.139$^2$ = 53.3 kNm (greater than applied moment)

E. Steel Area - primary:

(i) Calculate x/d = 1.2 – sqrt(1.2$^2$ – 6.6 Mu/$f_{ck}$.b.d$^2$) = 1.2 - $\sqrt{(1.44 – (6.6*30*10^6/(20*1000*139^2))}$ = 0.237

(ii) Lever arm Z = d*(1- 0.416*x/d) = 125.3 mm

(iii) Steel area Ast = Mu/(0.87*fy*Z) = 30*10$^6$/(0.87*415*125.2) = 663 mm$^2$.

(iv) Steel area provided 12 mm bar @ 150 mm c/c = 754 mm$^2$

F. Steel area secondary (distribution) Clause 26.3.3

(i) Minimum percent steel = 0.12*b*D/100.0 = 192 $mm^2$

(ii) Steel provided 12 mm bar @ 250 mm c/c = 452 $mm^2$

G. Control of Deflection: (Clause 23.2)

(i) Span to effective depth (l/d) = 4*1000/139 = 29.0

(ii) Percent steel Pst = 754*100/(139*1000) = 0.54 %

(iii) Find modification factor from Figure 4.0 IS 456 for the given percent steel and fs = 0.58*fy*Steel area required/Steel area provided = 0.58*415*663/754 = 212.0

(iv) Modification factor from the graph found to be ≈ 1.3

(v) L/D Permissible for simply support = 26x modification factor = 33.8

(vi) Design L/D value is less than permissible hence design is safe.

H. Material Estimates /meter width of staircase

(i) Concrete volume: waist*slab Len*1 + steps = 0.76 $m^3$

(ii) Cement quantity: M20 Volume of cement 1:5.5 = 0.76*1440/5.5 = 199 kg

(iii) Steel quantity: ϕ-12 mm x 50m length ≅ 45 kg

Add necessary allowances for wastage, shrinkage etc. to the above estimates.