RCC Structure – Two Way Slab

Case Example:
A 4.0 x 5.5 meters 175 mm thick slab is resting on a 250 mm thick wall all around. Consider Concrete grade M25, Steel grade Fe415, clear cover 15 mm. Short span 10 mm steel bar @ 120 mm c/c, Long span 10 mm steel bar @ 220 mm c/c. Add 0.8 kN/m^2 finish dead load, assume live load 8 kN/m^2. Analyze the design.

Analysis:
Data:
Characteristic strength of concrete f_{ck} = 25 N/mm^2 = 25e3 kN/m^2
Yield strength of steel = 415 N/mm^2 = 415e3 kN/m^2
Ly/Lx = 5.5/4 = 1.375 (Parameter in Table 27 IS456 to find moment coefficients)

A. Slab Factored Load:
- (i) DL = 0.175 x 25 = 4.375 kN/m^2
- (ii) Finish load = 0.8 kN/m^2
- (iii) Total Dead load = 5.2 kN/m^2
- (iv) Live load = 8 kN/m^2
- (v) Factored load (w) = (DL + LL)*load factor = 19.8 kN/m^2

B. Effective depth (d):
Slab thickness (175 mm) – clear cover (15 mm) – bar diameter (10mm)/2 = 155mm

C. Effective span:
- (i) Short span + wall thickness = 4 + 0.25 = 4.25 m
- (ii) Short span + effective depth = 4 + 0.155 = 4.155 m
- (iii) Clause 22.2 minimum of the above = 4.155 m

D. Moment Calculation (1m x 1m slab)
- (i) Moment coefficients from table 27 IS 456 for Ly/Lx =1.375:
- (ii) After interpolating the values we get αx = 0.098 and αy = 0.052
- (iii) Moment (Mu_x) = $\alpha x*w*lx^2 = 0.098* 19.8*4.155^2$ = 33.5 kNm
- (iv) Moment (Mu_y) = $\alpha y*w*lx^2 = 0.052* 19.8*4.155^2$= 17.8 kNm
- (v) Moment capacity = 0.138 $f_{ck}*b*d^2 = 0.138*25.0e3*1.0*0.155^2$ = 82.9 kNm (greater than applied moment)
- (vi) Above moment capacity is for concrete failure.

E. Steel Area – Short span:
- (i) Calculate x/d = $1.2 – sqrt(1.2^2 – 6.6\ Mu_x/f_{ck}.b.d^2) = 1.2 - \sqrt{(1.44 – (6.6*33.5*10^6/(25*1000*155^2))} = 0.165$
- (ii) Lever arm Z = d*(1- 0.416*x/d) = 145
- (iii) Steel area Ast = $Mux/(0.87*fy*Z) = 33.5*10^6/(0.87*415*145)$ = 640 mm^2
- (iv) Steel area provided 10 mm bar @ 120 mm c/c = 654 mm^2

F. Steel area long span (effective depth d = 155 – 10 =145 mm)

(i) Calculate x/d = 1.2 – sqrt(1.2^2 – 6.6 Muy/f_{ck}.b.d^2) = 1.2 - √(1.44 – (6.6*17.8*10^6/(25*1000*145*145)) = 0. 097

(ii) Lever arm Z = d*(1- 0.416*x/d) = 139

(iii) Steel area Ast = Mu_y/(0.87*fy*Z) = 17.8*10^6/(0.87*415*139) = 354 mm^2

(iv) Steel provided 10 mm bar @ 220 mm c/c = 357 mm^2

G. Control of Deflection: (Clause 23.2)

(i) Span to effective depth (l/d) = 4.15*1000/155.0 = 26.7

(ii) Percent steel Pst = 654*100/(155*1000) = 0.42 %

(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*640/654 = 235

(iv) Modification factor from the graph found to be ≅ 1.45

(v) L/D Permissible for simply support = 20x modification factor = 29.0

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

H. Material Estimates

(i) Concrete volume: 4*5.5*0.175(span area) + 5*0.175(wall area) = 4.725 m^3

(ii) Cement quantity: M25 Volume of cement 1:4.0 = 4.725*1440/4.0 = 1701 kg

(iii) Steel quantity: ϕ-10 mm, 285m length ≅ 176 kg

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