RCC Structure – T-Beam

Case Example 1:

Analyze a T-beam 1000 mm x 400 mm with web width 250mm and flange depth 125 mm. Beam span is 3.5 m with c/c slab width of 3.5 meter.
Assume concrete grade M30, Steel grade Fe415, Clear cover 25 mm.
Tensile reinforcement bars 20 mm 5 No, compressive reinforcement bars 20 mm 2 No. Provide 8 mm Two legged Stirrup bars.

Analysis:

Data:
Characteristic strength of concrete f_{ck} = 30 N/mm^2 = 30e3 kN/m^2
Yield strength of steel = 415 N/mm^2 = 415e3 kN/m^2
Tensile steel area Ast = 0.25π*20^2*5 = 1570 mm^2
Web width bw = 250 mm
Flange depth Df = 125 mm
Flange width fb = 1000 mm

A. Beam Factored Load per meter length:

(i) DL = 0.125 x 25*3.5 = 10.94 kN/m
(ii) Finish load = 0.06 kN/m
(iii) Web self weight = 0.275*0.250*25.0 = 1.72 kN/m
(iv) Total Dead Load = 10.94+0.06+1.05*1.72 = 12.8 kN/m
(v) Live load = 4*3.5 = 14 kN/m
(vi) Factored load = (DL + LL)*load factor = 40.2 kN/m

B. Effective depth (d):
Overall depth (400 mm) – clear cover (25 mm) – bar diameter (20mm)/2 = 365 mm

C. Beam span and flange width:

(i) Effective span (given) = 3.5 m
(ii) Given flange width bf = 1.0 m
(iii) Effective flange width (Clause 23.31.2): 3500/6.0 + 250 + 6*125 = 1583

D. Moment and Shear

(i) Total load = factored load x Effective span = 140.7 kN
(ii) Applied Moment (Mu) = (Total load * Eff. Span) /8 = (140.7*3.5)/8 = 61.56 kNm
(iii) Applied shear force (Vu)= Total load/2 = 140.7/2 = 70.35 kN
(iv) Nominal shear stress = Vu/(b*d) = 70.35e3/(250*365)= 0.77 N/mm^2
(v) Concrete shear τ_c = 0.76 N/mm^2 (Refer table 19 IS 456 for τ_c for given percent steel pt = Ast*100/(bw*d) = 1570*100/(250*365)=1.72%

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E. Moment capacity assuming steel yields (under reinforced structure):

(i) $0.87fy^*Ast = 0.36\ f_{ck}.bf^*x$ Hence $x = (0.87fy^*Ast)/(0.36\ f_{ck}.bf) = (0.87^*415^*1570)/(0.36^*30^*1000.0) = 52.5$ mm < flange depth

(ii) Neutral axis is with in flange

(iii) Lever arm $Z = d^*(1- 0.416^*x/d) = 343.16$ mm

(iv) Moment capacity due to concrete failure $Mu_c = 0.36^*.\ f_{ck}.bf^*x^*Z = 194.5$ kNm

(v) Moment capacity due to steel yielding $Mu_t = 0.87fy^*Ast^*Z = 194.51$ kNm

F. Beam Design

(i) Applied moment 61.56 kNm

(ii) Moment Capacity 195 kNm

G. Stirrup spacing

(i) τ_{sv} = Nominal shear – concrete shear = 0.77 -0.76 = 0.1 N/mm^2

(ii) Two legged stirrup area $Asv = 2^*0.25\pi^*8^2 = 100.48\ mm^2$

(iii) Clause 26..5.1.6 $Asv/sv = (0.4b/0.87fy)$ and $sv = (Asv^*0.87fy)/(0.4b) = (100.48^*0.87^*415)/(0.4^*250) = 362.8$ mm

(iv) Clause 26.3.3-b 0.75*effective depth = 273.75 mm.

(v) Clause 26.3.3-c Not greater than 300 mm

(vi) $\therefore$ Provide stirrup spacing at 274 mm.

H. Material Estimates (web part only)

(i) Concrete volume (web part): $0.25^*0.275^*3.5 = 0241\ m^3$

(ii) Cement quantity: M30 Volume of cement 1:3.5 = $0.241^*1440/3.5 = 99$ kg

(iii) Steel quantity: ϕ-20 mm x 25m length $\approx$ 66 kg

Flange is integral part of the slab. Add necessary allowances for wastage, shrinkage etc. to the above estimates.