RECTANGULAR BEAM SPAN DESIGN REPORT

Element: Rectangular Beam 001

Design Code: BS EN 1992-1-1:2004 | Date: 28 October 2026

REFERENCE	CALCULATIONS	OUTPUT
§5.3.2.1 Beam parameters	**BEAM PARAMETERS** Beam breadth, bw = 230.0 mm Beam depth, h = 450.0 mm Span length, L = 4000.0 mm Concrete cover, CC = 30.0 mm Assumed tension reinforcement H = 16.0 mm Assumed link size = 8.0 mm $d = h - \frac{\phi_{main}}{2} - CC - \phi_{link}$ $= 450.0 - \frac{16.0}{2} - 30.0 - 8.0 = 404.0mm$ Design Sagging Moment, MEd = 150.0 kNm	**bw = 230.0 mm** **h = 450.0 mm** **L = 4000.0 mm** **d = 404.0 mm** **MEd = 150.0 kNm**
§6.1 Design Parameters	**FLEXURAL DESIGN** fck = 25.0 N/mm² fyk = 500.0 N/mm² **Moment capacity** For beams , assume 0% moment redistribution and fck ≤ C50/60 Moment redistribution factor δ = 1.0 $k_{bal} = \frac{0.454(1.0-0.44)}{1.25} - \frac{0.182(1.0-0.44)^2}{1.25^2} = 0.167$ $k = \frac{M_{Ed}}{b_w d^2 f_{ck}} = \frac{150.0\times10^6}{230.0\times404.0^2\times25.0} = 0.16$ Since k = 0.16 < kbal = 0.167 → Singly reinforced **Lever arm z** $\frac{z}{d} = 0.5 + \sqrt{0.25 - \frac{k}{1.134}}$ $\frac{z}{d} = 0.5 + \sqrt{0.25 - \frac{0.16}{1.134}} = 0.83$ $z = 0.83 \times d = 0.83 \times 404.0 = 335.3mm$ Limiting values of Z $\frac{z_{lim}}{d} = 0.95$ $z_{lim} = 0.95d = 0.95 \times 404.0 = 383.8mm$ $Therefore, z = min(z, zlim) = min(335.3mm, 383.8mm) = 335.3mm$	**k = 0.16** **kbal = 0.167** **SINGLY REINFORCED** **z = 335.3 mm**

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§6.1 Reinforcement	**LONGITUDINAL REINFORCEMENT** $A_{s,req} = \frac{M_{Ed}}{0.87 f_{yk} z} = \frac{150.0 \times 10^6}{0.87 \times 500.0 \times 335.3} = 1028.0 mm^2$ **Minimum reinforcement** $f_{ctm} = 0.3 \times f_{ck}^{2/3} = 0.3 \times 25.0^{2/3} = 2.565 N/mm^2$ $As, min = 0.26 \times \frac{f_{ctm}}{fyk} \times bw \times d$ $= 0.26 \times \frac{2.565}{500.0} \times 230.0 \times 404.0 = 124.0 mm^2$ $0.0013 \times bw \times d = 0.0013 \times 230.0 \times 404.0 = 121.0 mm^2$ $As, min = max(121.0 mm^2, 124.0 mm^2) = 124.0 mm^2$ **Maximum reinforcement** $As, max = 0.04 \times bw \times h = 0.04 \times 230.0 \times 450.0 = 4140.0 mm^2$ $As, min = 124.0 mm^2 \leq As, req = 1028.0 mm^2 \leq As, max = 4140.0 mm^2$ $As, req, final = 1028.0 mm^2$ **Provided reinforcement (bottom)** Provide 2.0 H16.0 bottom steel $A_{s,prov} = \frac{\pi \phi^2}{4} \times Q = \frac{\pi \times 16.0^2}{4} \times 2.0 = 402 mm^2$ Extra: 1.0 H16.0 bottom steel $A_{s,prov} = \frac{\pi \phi^2}{4} \times Q = \frac{\pi \times 16.0^2}{4} \times 1.0 = 201 mm^2$ $A_{s,prov} = 402 + 201 = 603 mm^2$ Check: As,prov = 603mm² < As,req = 1028.0 mm², INADEQUATE	**As,req = 1028.0 mm²** **As,min = 124.0 mm²** **As,max = 4140.0 mm²** **Provided: 2.0 H16.0 bottom** **As,prov = 603 mm²** **Status: INADEQUATE**

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§7.4.2 Deflection Check	**DEFLECTION CHECK** **Step 1: Reference reinforcement ratio** $\rho_0 = \sqrt{f_{ck}} \times 10^{-3}$ $= \sqrt{25.0} \times 10^{-3} = 0.005$ **Step 2: Tension reinforcement ratio** $\rho = \frac{A_{s,req}}{b_w d}$ $= \frac{1028.0}{230.0 \times 404.0} = 0.0111$ **Step 3: Structural system factor** K = 1.5 **Step 4: Basic L/d ratio** $\rho > \rho_0 \rightarrow \frac{L}{d} = K\left[11 + 1.5\sqrt{f_{ck}} \times \frac{\rho_0}{\rho}\right]$ Basic L/d = 21.58 **Step 5: Modification factors** **(i) Steel stress modification factor** $\beta_s = \frac{A_{s,prov}}{A_{s,req}} = \frac{603}{1028.0} = 0.59$ $\beta_s = \min(1.5, 0.59) = 0.59$ **(ii) Span modification factor** $\beta_L = \frac{7}{L_m} = \frac{7}{4.00} = 1.0$ $\beta_L = \min(1.0, 1.0) = 1.0$ **Step 6: Permitted L/d** $L/d)_{permitted} = \beta_s \times \beta_L \times (L/d)_{basic}$ $= 0.59 \times 1.0 \times 21.58 = 12.66$ **Step 7: Actual L/d** $L/d)_{actual} = \frac{L}{d} = \frac{4000.0}{404.0} = 9.9$ **Step 8: Check** 9.90 > 12.66 (inadequate reinforcement) → FAIL Message: Deflection check fails due to inadequate reinforcement	**Permitted L/d = 12.66** **Actual L/d = 9.9** **Status: FAIL**

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§6.2.1-6.2.3 Shear Design – Part 1	**SHEAR DESIGN** **Step 1: Shear resistance of concrete ($V_{Rd,c}$)** $C_{Rd,c} = \frac{0.18}{\gamma_c} = \frac{0.18}{1.5} = 0.12$ $k = 1 + \sqrt{\frac{200}{d}} \leq 2.0$ $k = 1 + \sqrt{\frac{200}{404.0}} = 1.704$ $\rho_1 = \frac{A_{s,prov}}{b_w d} \leq 0.02$ $\rho_1 = \frac{603}{230.0 \times 404.0} = 0.0065$ $\rho_1 = min(0.0065, 0.02) = 0.0065$ $V_{Rd,c} = [C_{Rd,c} \cdot k \cdot (100 \cdot \rho_1 \cdot f_{ck})^{1/3}] \cdot b_w \cdot d$ $= [0.12 \times 1.704 \times (100 \times 0.0065 \times 25.0)^{1/3}] \times 230.0 \times 404.0 \times 10^{-3} = 48.09kN$ $V_{Rd,c,min} = 0.035 \cdot k^{3/2} \cdot \sqrt{f_{ck}} \cdot b_w \cdot d$ $= 0.035 \times 1.704^{3/2} \times \sqrt{25.0} \times 230.0 \times 404.0 = 36.16kN$ $V_{Rd,c} = \max(48.09, 36.16) = 48.09kN$ **Step 2: Check requirement for shear reinforcement** $V_{Ed} = 146.0kN$ $Check: 146.0kN > 48.09kN$ Provide shear reinforcement **Step 3: Shear forces at critical sections** At face of support: V_{sf} UDL: w_u = 44.0 kN/m Support member width:bs = 300.0 mm $V_{sf} = V_{Ed} - \frac{w_u \cdot b_s}{2}$ $= 146.0 - \frac{44.0 \times 300.0}{2000} = 139.4kN$ $V_{sf} = 139.4kN$ At distance d from face of supporting member: V_{sd} $V_{sd} = V_{sf} - w_u \cdot d$ $= 139.4 - \frac{44.0 \times 404.0}{1000} = 121.62kN$ $V_{sd} = 121.62kN$	**$V_{Rd,c}$ = 48.09 kN** **V_{Ed} = 146.0 kN** **Shear reinforcement required: YES** **V_{sf} = 139.4 kN** **V_{sd} = 121.62 kN**

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§6.2.3 Concrete Strut & Minimum Links	**SHEAR DESIGN** **Step 4: Check crushing strength of concrete strut** $At, \theta = 22° : V_{Rd,max} = 0.124 \cdot b_w \cdot d \cdot \left(1 - \frac{f_{ck}}{250}\right) \cdot f_{ck}$ $= 0.124 \times 230.0 \times 404.0 \times \left(1 - \frac{25.0}{250}\right) \times 25.0 \times 10^{-3} = 259.25kN$ $Check : V_{sf} = 139.4kN < 259.25kN$ $At, \theta = 45° : V_{Rd,max} = 0.18 \cdot b_w \cdot d \cdot \left(1 - \frac{f_{ck}}{250}\right) \cdot f_{ck}$ $= 0.18 \times 230.0 \times 404.0 \times \left(1 - \frac{25.0}{250}\right) \times 25.0 \times 10^{-3} = 376.33kN$ $Check : V_{sf} = 139.4kN < 376.33kN$ **Step 5: Determine strut angle θ** $V_{sf} = 139.4kN \leq V_{Rd,max}(22°) = 259.25kN$ Strut adequate with θ = 22° $\theta = 22.0$ $\cot\theta = 2.5$ **Step 6: Required shear reinforcement near supports** $\frac{A_{sw}}{s} = \frac{V_{sd}}{0.78 \cdot f_{yk} \cdot d \cdot \cot\theta}$ $= \frac{121.62 \times 10^3}{0.78 \times 500.0 \times 404.0 \times 2.5} = 0.3088mm^2/m$ **Step 7: Minimum shear reinforcement** Near supports: $\frac{A_{sw,min}}{s} = 0.00085 \times b_w = 0.00085 \times 230.0 = 0.1955mm^2/m$ Midspan: $\frac{A_{sw,min}}{s} = \frac{0.08 \cdot \sqrt{f_{ck}} \cdot b_w}{f_{yk}} = \frac{0.08 \times \sqrt{25.0} \times 230.0}{500.0} = 0.184mm^2/m$	**$V_{Rd,max}$(22°) = 259.25 kN** **$V_{Rd,max}$(45°) = 376.33 kN** **Strut angle θ = 22.0** **cotθ = 2.5** **Result: Vsf (139.40 kN) ≤ VRd,max(22°) (259.25 kN) → θ = 22°** **Required A_{sw}/s = 0.3088 mm²/m** **Min A_{sw}/s (support) = 0.1955 mm²/m** **Min A_{sw}/s (midspan) = 0.184 mm²/m**

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§9.2.2 Spacing & Provided Links	**SHEAR DESIGN** **Step 8: Maximum spacing of shear links** $s_{max} = \min(0.75d, 600) = \min(0.75 \times 404.0, 600) = 303.0mm$ Provided spacing near support = 150.0 mm Check: Provided 150.0 mm < 303.0 mm → OK Provided spacing midspan = 150.0 mm **Step 9: Provided shear reinforcement** **Near support:** 2.0 legs of H8.0 @ 150.0 mm c/c $Provided; \frac{A_{sw}}{s} = 0.6702mm^2/m$ Required A_{sw}/s = 0.3088 mm²/m Check: 0.6702 > 0.3088 → Adequate **Midspan:** 2.0 legs of H8.0 @ 150.0 mm c/c $Provided; \frac{A_{sw}}{s} = 0.6702mm^2/m$ Required A_{sw}/s = 0.184 mm²/m Check: 0.6702 > 0.184 → Adequate **Step 10: Shear resistance of provided links : VRd,s** $V_{Rd,s} = \frac{A_{sw}}{s} \cdot 0.78 \cdot f_{yk} \cdot d \cdot cot\theta$ $= 0.6702 \times 0.78 \times 500.0 \times 404.0 \times 2.5$ $V_{Rd,s} = 263.99kN$ $V_{Rd,s} = 263.99kN > V_{sd} = 121.62kN$ Implying → Midspan links are sufficient across the whole span. Therefore provide H8.0 @ 150.0 mm c/c throughout the beam span. Additional longitudinal force: ΔF_{td} $\Delta F_{td} = 0.5 \times V_{sd} \times \cot\theta$ $= 0.5 \times 121.62 \times 2.5 = 152.0kN$ This additional longitudinal tensile force is provided for by extending the curtailment point of longitudinal reinforcement.	**Max spacing = 303.0 mm** **Provided spacing (support) = 150.0 mm** **Provided A_{sw}/s = 0.6702 mm²/m** **Provided A_{sw}/s (midspan) = 0.6702 mm²/m** **Status support: Adequate** **Status midspan: Adequate** **$V_{Rd,s}$ = 263.99 kN** **ΔF_{td} = 152.0 kN** **Status: ADEQUATE**