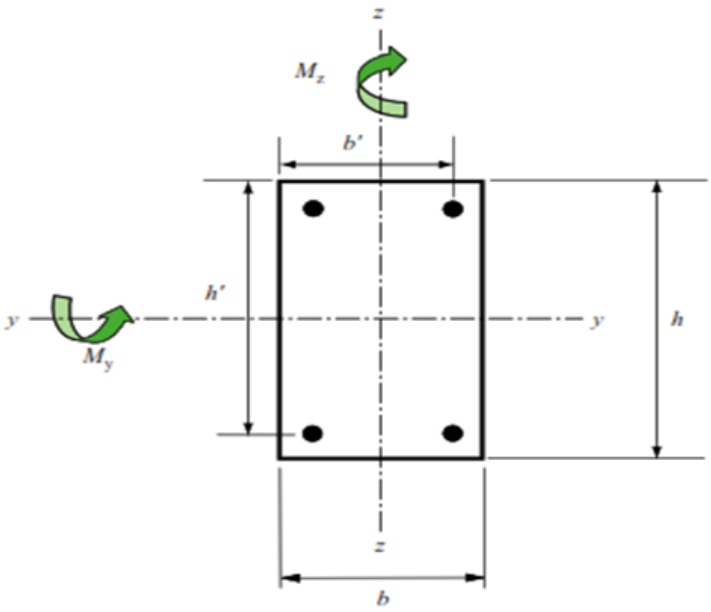
BIAXIAL COLUMN DESIGN REPORT

Element: Biaxially loaded Short Column

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

REFERENCE	CALCULATIONS	OUTPUT
§5.8.8 Geometry & Effective Dimensions	**COLUMN GEOMETRY**  b = 275.0 mm h = 275.0 mm Concrete cover, CC = 30.0 mm Link diameter, φ_{link} = 8.0 mm Main rebar diameter, φ = 32.0 mm $d' = CC + \phi_{link} + \frac{\phi}{2} = 30.0 + 8.0 + \frac{32.0}{2} = 54.0mm$ $h' = h - d' = 275.0 - 54.0 = 221.0mm$ $b' = b - d' = 275.0 - 54.0 = 221.0mm$ Storey height, Lo = 3500.0 mm Effective length factor Y-Y-axis: F_Y = 0.59 Effective length factor Z-Z-axis: F_Z = 0.59 $l_{e,y} = F_Y \times L_0 = 0.59 \times 3500.0 = 2065.0mm$ $l_{e,z} = F_Z \times L_0 = 0.59 \times 3500.0 = 2065.0mm$ fck = 25.0 N/mm² fyk = 500.0 N/mm² Ac = b × h = 275.0 × 275.0 = 75625.0 mm² $f_{cd} = 0.85 \times \frac{f_{ck}}{1.5} = 0.85 \times \frac{25.0}{1.5} = 14.17N/mm^2$ $f_{yd} = \frac{f_{yk}}{1.15} = \frac{500.0}{1.15} = 434.78N/mm^2$	**Column: 275.0 × 275.0 mm** **Effective: 221.0 × 221.0 mm** **d' = 54.0 mm** **$l_{e,y}$ = 2065.0 mm** **$l_{e,z}$ = 2065.0 mm**

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§5.8.3.1 Slenderness Analysis	**SLENDERNESS CHECK** **(i) Radii of gyration** $i_y = \frac{h}{\sqrt{12}} = \frac{275.0}{\sqrt{12}} = 79.39mm$ $i_z = \frac{b}{\sqrt{12}} = \frac{275.0}{\sqrt{12}} = 79.39mm$ **(ii) Slenderness ratios** $\lambda_y = \frac{l_{e,y}}{i_y} = \frac{2065.0}{79.39} = 26.0123$ $\lambda_z = \frac{l_{e,z}}{i_z} = \frac{2065.0}{79.39} = 26.0123$ **(iii) Limiting Slenderness ratios** $n = \frac{N_{Ed}}{A_c f_{cd}}$ $= \frac{1402.0 \times 10^3}{75625.0 \times 14.17} = 1.3086$ From EC2 (Cl:5.8.3 & 5.8.8.3) A = 0.7 B = 1.1 $C = 1.7 - r_m$ $r_m = \frac{M_{01}}{M_{02}}$ $M_{01,yy} = -29.4kNm$ $M_{02,yy} = 58.8kNm$ $M_{01,zz} = -29.4kNm$ $M_{02,zz} = 58.8kNm$ $C_y = 1.7 - \frac{M_{01,yy}}{M_{02,yy}} = 1.7 - (\frac{-29.4}{58.8}) = 2.2$ $C_z = 1.7 - \frac{M_{01,zz}}{M_{02,zz}} = 1.7 - (\frac{-29.4}{58.8}) = 2.2$ **Limiting Slenderness ratio y-axis** $\lambda_{lim,y} = \frac{20 \times A \times B \times C_y}{\sqrt{n}}$ $= \frac{20 \times 0.7 \times 1.1 \times 2.2}{\sqrt{1.3086}} = 29.62$ **Limiting Slenderness ratio z-axis** $\lambda_{lim,z} = \frac{20 \times A \times B \times C_z}{\sqrt{n}}$ $= \frac{20 \times 0.7 \times 1.1 \times 2.2}{\sqrt{1.3086}} = 29.62$ **(iv) Check** Y-axis: λ_y = 26.0123 < $\lambda_{lim,y}$ = 29.62 → SHORT Z-axis: λ_z = 26.0123 < $\lambda_{lim,z}$ = 29.62 → SHORT	**λ_y = 26.0123 (SHORT)** **λ_z = 26.0123 (SHORT)** **$\lambda_{lim,y}$ = 29.62** **$\lambda_{lim,z}$ = 29.62** **n = 1.3086**

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§5.8.8.2 Minimum Design Moments	**MINIMUM DESIGN MOMENTS** **Minimum Design Moments** **y-axis** Minimum eccentricity $e_0 = \frac{h}{30} \geq 20$ $e_0 = \frac{275.0}{30} = 9.167mm$ $e_0 = max(9.167, 20) = 20mm$ $M_{min,y} = e_0 N_{Ed} = \frac{20}{1000} \times 1402.0 = 28.04kNm$ **z-axis** Minimum eccentricity $e_0 = \frac{b}{30} \geq 20$ $e_0 = \frac{275.0}{30} = 9.167mm$ $e_0 = max(9.167, 20) = 20mm$ $M_{min,z} = e_0 N_{Ed} = \frac{20}{1000} \times 1402.0 = 28.04kNm$	**$M_{min,y}$ = 28.04 kNm** **$M_{min,z}$ = 28.04 kNm**
§5.8.8.2 First Order & Second Order Moments	**DESIGN MOMENTS** **Y-axis (Column is short in y-axis)** **Consider First order Effects only** **First order End Moments** Accidental eccentricity $e_{a,y} = \frac{l_{e,y}}{2 \times 200} = \frac{2065.0}{2 \times 200} = 5.163mm$ Accidental moment $M_{YY} = e_{a,y} \times N_{Ed} = \frac{5.163}{1000} \times 1402.0 = 7.238kNm$ First-order design moment including accidental imperfections $M_{02,y} = (e_{a,y} \times N_{Ed}) + M_{02,y} = 7.238 + 58.8 = 66.038kNm$ $M_{Ed,y} = max(28.04, 66.038) = 66.038kNm$	**$M_{Ed,y}$ = 66.038 kNm**
§5.8.8.2 First Order & Second Order Moments	**DESIGN MOMENTS** **Z-axis (Column is short in z-axis)** **Consider First order Effects only** **First order End Moments** Accidental eccentricity $e_{a,z} = \frac{l_{e,z}}{2 \times 200} = \frac{2065.0}{2 \times 200} = 5.163mm$ Accidental moment $M_{ZZ} = e_{a,z} \times N_{Ed} = \frac{5.163}{1000} \times 1402.0 = 7.238kNm$ First-order design moment including accidental imperfections $M_{02,z} = (e_{a,z} \times N_{Ed}) + M_{02,z} = 7.238 + 58.8 = 66.038kNm$ $M_{Ed,z} = max(28.04, 66.038) = 66.038kNm$	**$M_{Ed,z}$ = 66.038 kNm**

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§9.5.2 Reinforcement Design	**REINFORCEMENT DESIGN** **Y-axis: ($M_{Ed,y}$ = 66.038kNm)** Choosing the design chart $\frac{d'}{h} = \frac{54.0}{275.0} = 0.2$ Values for use on the chart axes $x - axis = \frac{M_{Ed}}{bh^2 f_{ck}} = \frac{66.038 \times 10^6}{275.0 \times 275.0^2 \times 25.0} = 0.127$ $y - axis = \frac{N_{Ed}}{bhf_{ck}} = \frac{1402.0 \times 10^3}{275.0 \times 275.0 \times 25.0} = 0.7416$ From the design charts $\frac{A_s \cdot f_{yk}}{b \cdot h \cdot f_{ck}} = 0.69$ Hence after making As the subject, As,req can be determined $A_{s,req,y} = \frac{0.69 \times b \times h \times f_{ck}}{f_{yk}} = \frac{0.69 \times 275.0 \times 275.0 \times 25.0}{500.0} = 2609.0mm^2$	**As,req,y = 2609.0 mm²**
§9.5.2 Reinforcement Design	**REINFORCEMENT DESIGN** **Z-axis: ($M_{Ed,z}$ = 66.038kNm)** Choosing the design chart $\frac{d'}{b} = \frac{54.0}{275.0} = 0.2$ Values for use on the chart axes $x - axis = \frac{M_{Ed}}{hb^2 f_{ck}} = \frac{66.038 \times 10^6}{275.0 \times 275.0^2 \times 25.0} = 0.127$ $y - axis = \frac{N_{Ed}}{bhf_{ck}} = \frac{1402.0 \times 10^3}{275.0 \times 275.0 \times 25.0} = 0.7416$ From the design charts $\frac{A_s \cdot f_{yk}}{b \cdot h \cdot f_{ck}} = 0.69$ Hence after making As the subject, As,req can be determined $A_{s,req,z} = \frac{0.69 \times b \times h \times f_{ck}}{f_{yk}} = \frac{0.69 \times 275.0 \times 275.0 \times 25.0}{500.0} = 2609.0mm^2$	**As,req,z = 2609.0 mm²**
§9.5.2 Reinforcement Design	**REINFORCEMENT DESIGN** **Minimum reinforcement** $A_{s,min1} = \frac{0.1N_{Ed}}{0.87f_{yk}} = \frac{0.1 \times 1402.0 \times 10^3}{0.87 \times 500.0} = 322.0mm^2$ $A_{s,min2} = 0.002bh = 0.002 \times 275.0 \times 275.0 = 151.0mm^2$ $As, min = max(322.0, 151.0) = 322.0mm^2$ $As, max = 0.04bh = 0.04 \times 275.0 \times 275.0 = 3025.0mm^2$ Hence the governing reinforcement can be determined $As, req = max(As_{min}, As_{req,y}, As_{req,z}) = max(322.0, 2609.0, 2609.0) = 2609.0mm^2$ **Provided reinforcement** **Corners:** 4.0 H32.0 Total As,prov = 3217.0 mm² Spacing of links Mid-height = min(20 × 32.0, min(275.0, 275.0), 400) Spacing of links near end restraints = min(12 × 32.0, 0.6 × 275.0) **Links mid-height:** H8.0 @ 275.0 mm c/c (mid-height) **Links near restraints:** H8.0 @ 165.0 mm c/c (near restraints)	**As,req = 2609.0 mm²** **As,prov = 3217.0 mm²** **Status: ✓ OK**

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§5.8.9 Biaxial Check – Eccentricities	**BIAXIAL BENDING CHECK** **Relative eccentricities** $e_y = \frac{M_{Ed,y}}{N_{Ed}} = \frac{66.038 \times 10^6}{1402.0 \times 10^3} = 47.0mm$ $e_z = \frac{M_{Ed,z}}{N_{Ed}} = \frac{66.038 \times 10^6}{1402.0 \times 10^3} = 47.0mm$ $\frac{e_y/h}{e_z/b} = \frac{47.0/275.0}{47.0/275.0} = 1.0$ $\frac{e_z/b}{e_y/h} = \frac{47.0/275.0}{47.0/275.0} = 1.0$ **No further check if relative eccentricities satisfy any of the conditions** $\frac{e_y/h}{e_z/b} \leq 0.2$ $\frac{e_z/b}{e_y/h} \leq 0.2$	**e_y = 47.0 mm** **e_z = 47.0 mm**
§5.8.9 Biaxial Check - Y-axis	**BIAXIAL BENDING CHECK** **Biaxial check required (neither ratio ≤ 0.2)** **Y-axis (chart to use)** $\frac{d'}{h} = \frac{54.0}{275.0} = 0.2$ $z_{axis} = \frac{A_{s,prov} \cdot f_{yk}}{b \cdot h \cdot f_{ck}} = \frac{3217.0 \times 500.0}{275.0 \times 275.0 \times 25.0} = 0.85$ $y_{axis} = \frac{N_{Ed}}{bhf_{ck}} = \frac{1402.0 \times 10^3}{275.0 \times 275.0 \times 25.0} = 0.7416$ $From - chart \rightarrow \frac{M_{Rd,y}}{b \cdot h^2 \cdot f_{ck}} = 0.17$ **DESIGN ULTIMATE MOMENT OF RESISTANCE,MRdy** $M_{Rdy} = 0.17 \times b \times h^2 \times f_{ck} = 0.17 \times 275.0 \times 275.0^2 \times 25.0 = 88.91kNm$	**M_{Rdy} = 88.91 kNm**
§5.8.9 Biaxial Check - Z-axis	**BIAXIAL BENDING CHECK** **Z-axis (chart to use)** $\frac{d'}{b} = \frac{54.0}{275.0} = 0.2$ $z_{axis} = \frac{A_{s,prov} \cdot f_{yk}}{b \cdot h \cdot f_{ck}} = \frac{3217.0 \times 500.0}{275.0 \times 275.0 \times 25.0} = 0.85$ $y_{axis} = \frac{N_{Ed}}{bhf_{ck}} = \frac{1402.0 \times 10^3}{275.0 \times 275.0 \times 25.0} = 0.7416$ $From - chart \rightarrow \frac{M_{Rd,z}}{h \cdot b^2 \cdot f_{ck}} = 0.17$ **DESIGN ULTIMATE MOMENT OF RESISTANCE,MRdz** $M_{Rdz} = 0.17 \times h \times b^2 \times f_{ck} = 0.17 \times 275.0 \times 275.0^2 \times 25.0 = 88.91kNm$	**M_{Rdz} = 88.91 kNm**

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§5.8.9 Biaxial Check - Exponent & Result	**BIAXIAL BENDING CHECK** **EXPONENT,a** N_{Ed}/N_{Rd} | 0,1 | 0,7 | 1,0 a = | 1,0 | 1,5 | 2,0 $N_{Rd} = A_c f_{cd} + A_s f_{yd} = (75625.0 \times 14.17 + 3217.0 \times 434.78) \times 10^6 = 2470.05kN$ $\frac{N_{Ed}}{N_{Rd}} = \frac{1402.0}{2470.05} = 0.57$ By linear interpolation,we can find exponent a $\frac{0.7 - 0.1}{1.5 - 1.0} = \frac{0.57 - 0.1}{a - 1.0}$ After linear interpolation, a = 1.39 $\left(\frac{M_{Ed,y}}{M_{Rdy}}\right)^a + \left(\frac{M_{Ed,z}}{M_{Rdz}}\right)^a = \left(\frac{66.038}{88.91}\right)^{1.39} + \left(\frac{66.038}{88.91}\right)^{1.39} = 1.323$ Check: 1.323 ≤ 1.0 → FAIL	**Status: FAIL**