

PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 www.planningapplications.com support@planningapplications.com	Project BEAM 4 - plus plate	Project ref 2023-7459
	Calcs for Connor McKitrich	Date 31 May 2023

Steel Beam Design

To Eurocode BS EN 1993-1-1/NA:2008

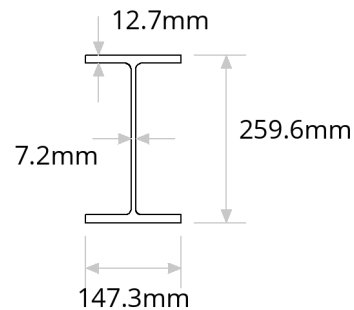
BEAM 4 - with 280mm x 8mm plate with 6mm fillet weld full length both sides. See additional Beam details with plate. Beam length 5000mm + 150mm + 150mm = 5300mm total length (150mm bearing each end).

Design summary

	Resistance / Limit	Applied / Actual	Utilisation	
Shear	321 kN	28.1 kN	9 %	OK
Bending moment	156 kNm	35.1 kNm	23 %	OK
Buckling	98 kNm	35.1 kNm	36 %	OK
Total deflection	25 mm	4.8 mm	19 %	OK
Deflection due to variable actions	13.9 mm	1.3 mm	10 %	OK

Section details

Type	Universal beam
Section	254 x 146 x 43 UB
Steel grade	S275
Width	b = 147 mm
Depth	h = 260 mm
Web thickness	t _w = 7.2 mm
Flange thickness	t _f = 12.7 mm
Root radius	r = 7.6 mm
Mass per metre	w = 43 kg/m



Span and restraints

Effective span	L = 5,000 mm
Buckling length	L _{cr} = 5,000 mm

Deflection limits

Variable action deflection limit	$\Delta_Q = L / 360 = \mathbf{13.9 mm}$
Total deflection limit	$\Delta_{G+Q} = L / 200 = \mathbf{25 mm}$

PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 www.planningapplications.com support@planningapplications.com	Project BEAM 4 - plus plate	Project ref 2023-7459
	Calcs for Connor McKitrich	Date 31 May 2023

Safety factors

Partial factor for permanent actions	$\gamma_G = 1.35$
Partial factor for variable actions	$\gamma_Q = 1.5$

Loading details



Self weight

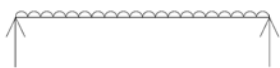
Permanent action $SW = w \times 9.81 / 1000 = 0.422 \text{ kN/m}$



Load 1: UDL - 100mm Lightweight blockwork + Plaster or render on ONE side

Permanent action $G_1 = 1 \text{ kN/m}^2 \times 0.6 \text{ m} = 0.6 \text{ kN/m}$

Variable action $Q_1 = 0 \text{ kN/m}^2 \times 0.6 \text{ m} = 0 \text{ kN/m}$



Load 2: UDL - 102.5mm Brickwork + Plaster or render on ONE side

Permanent action $G_2 = 2.25 \text{ kN/m}^2 \times 0.6 \text{ m} = 1.35 \text{ kN/m}$

Variable action $Q_2 = 0 \text{ kN/m}^2 \times 0.6 \text{ m} = 0 \text{ kN/m}$



Load 3: UDL - Sloping roof, 0° to 30°

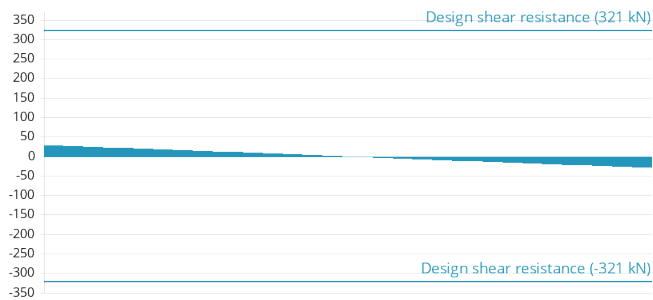
Permanent action $G_3 = 1.15 \text{ kN/m}^2 \times 3 \text{ m} = 3.45 \text{ kN/m}$

Variable action $Q_3 = 0.75 \text{ kN/m}^2 \times 3 \text{ m} = 2.25 \text{ kN/m}$

Reactions

	Permanent (unfactored)	Variable (unfactored)	Total (unfactored)	Total (factored)
Left reaction	14.6 kN	5.62 kN	20.2 kN	28.1 kN
Right reaction	14.6 kN	5.62 kN	20.2 kN	28.1 kN

Design shear force



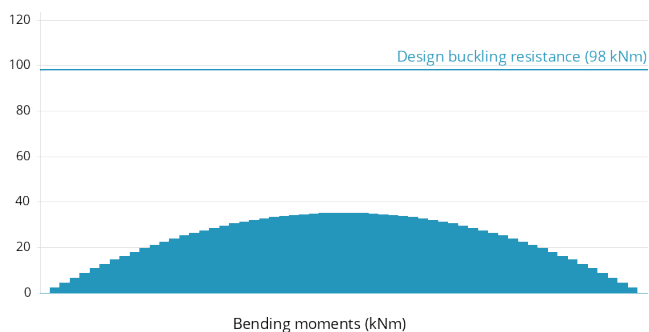
Shear force (kN)

Design shear force	$V_{Ed} = 28.1 \text{ kN}$
Design shear resistance	$V_{c,Rd} = 321 \text{ kN}$
Utilisation	$V_{Ed} / V_{c,Rd} = 9 \%$

OK

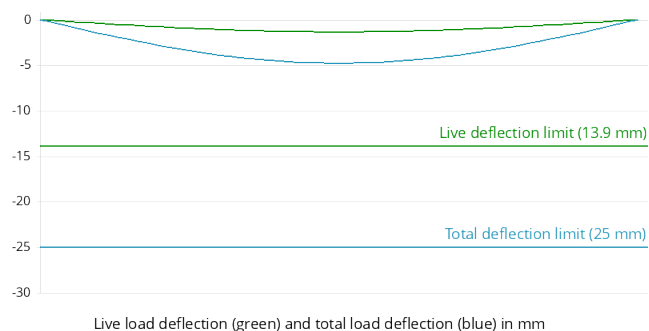
PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 www.planningapplications.com support@planningapplications.com	Project BEAM 4 - plus plate	Project ref 2023-7459
	Calcs for Connor McKitrich	Date 31 May 2023

Design bending moment



Design bending moment, major axis	$M_{Ed} = 35.1$ kNm
Design resistance for bending	$M_{c,Rd} = 156$ kNm
Bending utilisation	$M_{Ed} / M_{c,Rd} = 23\%$ OK
Design resistance for buckling	$M_{b,Rd} = 98$ kNm
Buckling utilisation	$M_{Ed} / M_{b,Rd} = 36\%$ OK

Deflection



Variable action deflection limit	$\Delta_Q = 13.9$ mm
Variable action deflection	$\delta_Q = 1.3$ mm OK
Total deflection limit	$\Delta_{G+Q} = 25$ mm
Total deflection	$\delta_{G+Q} = 4.8$ mm OK

Section properties

Elastic modulus - major axis, yy	$W_{el} = 504$ cm ³
Plastic modulus - major axis, yy	$W_{pl} = 566$ cm ³
Second moment of area - major axis, yy	$I_y = 6,540$ cm ⁴
Second moment of area - minor axis, zz	$I_z = 677$ cm ⁴
Warping constant	$I_w = 0.103$ dm ⁶
Torsional constant	$I_T = 23.9$ cm ⁴
Area of section	$A = 5,480$ mm ²

Factors and design values of material coefficients (EN 1993-1-1:2005 and National Annex)

Young's modulus of elasticity	$E = 210,000$ N/mm ²	cl.3.2.6
Poisson's ratio in elastic stage	$\nu = 0.3$	cl.3.2.6
Shear modulus	$G_s = 81,000$ N/mm ²	cl.3.2.6
Partial factor for resistance of cross-sections	$\gamma_{M0} = 1$	cl.6.1(1)B / BS-EN NA
Partial factor for resistance to instability	$\gamma_{M1} = 1$	cl.6.1(1)B / BS-EN NA
Factor for shear area	$\eta = 1$	EN 1993-1-5:2006 cl.5.1(2) / BS-EN NA
Limiting non dimensional slenderness ratio	$\bar{\lambda}_{LT,0} = 0.4$	cl.6.3.2.3(1) / BS-EN NA

PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 www.planningapplications.com support@planningapplications.com	Project BEAM 4 - plus plate	Project ref 2023-7459
	Calcs for Connor McKitrich	Date 31 May 2023

Beta factor for buckling reduction factor calculation $\beta = 0.75$ cl.6.3.2.3(1) / BS-EN NA

Yield strength

Nominal yield strength for S275 grade and nominal section thickness 12.70 mm $f_y = 275 \text{ N/mm}^2$ Tata blue book

Section classification (EN 1993-1-1:2005 cl.5.5)

Epsilon $\epsilon = 0.924$ EN 1993-1-1:2005 Table 5.2

Flange ratio for local buckling $c_f / t_f = 4.92$

Flange ratio limit for class 1 $9 \epsilon = 8.32$ Table 5.2 (sheet 2 of 3)

Flange class $\text{Class}_f = 1$

Web ratio for local buckling $c_w / t_w = 30.4$

Web ratio limit for class 1 $72 \epsilon = 66.6$ Table 5.2 (sheet 1 of 3)

Web class $\text{Class}_w = 1$

Section class $\text{Class} = 1$

Shear resistance (EN 1993-1-1:2005 cl.6.2.6)

Height of web $h_w = 234 \text{ mm}$

Shear area for I and H sections $A_v = 2,020 \text{ mm}^2$ cl.6.2.6 (3)

Design shear resistance $V_{pl,Rd} = 321 \text{ kN}$ eq (6.18)

Shear buckling (EN 1993-1-5:2006 cl.5)

The shear buckling resistance for webs should be verified according to Section 5 of EN 1993-1-5 if $(h_w / t_w) > (72 \epsilon / \eta)$

Web ratio for shear buckling $h_w / t_w = 32.5$ EN 1993-1-5:2006 cl.5.1 (2)

Shear buckling limit $72 \epsilon / \eta = 66.6$ EN 1993-1-5:2006 cl.5.1 (2)

$(h_w / t_w) \leq (72 \epsilon / \eta)$ therefore shear buckling calculation not required

Bending resistance (EN 1993-1-1:2005 cl.6.2.5)

The shear force (28 kN) is less than half of the plastic shear resistance ($321 \text{ kN} / 2 = 161 \text{ kN}$), therefore its effect on moment resistance may be neglected.

Class 1 section, therefore use plastic modulus $W_{pl} = 566,000 \text{ mm}^3$

Design bending resistance $M_{c,Rd} = 156 \text{ kNm}$ eq (6.13)

Design buckling resistance (EN 1993-1-1:2005 cl.6.3.2)

C1 factor $C1 = 1$

Shear modulus of elasticity $G_s = 81,000 \text{ N/mm}^2$ cl.3.2.6 (1)

Buckling length $L_{cr} = 5,000 \text{ mm}$

Critical buckling moment $M_{CR} = 125 \text{ kNm}$ NCCI SN003b-EN-EU

Class 1 section, therefore use plastic modulus $W_{pl} = 566,000 \text{ mm}^3$ cl.6.3.2.1(3)

Non-dimensional slenderness ratio $\bar{\lambda}_{LT} = 1.12$ cl.6.3.2.2 (1)

Depth to width ratio for buckling curve $h / b = 1.76$

Buckling curve for h / b ratio Buckling curve = b Table 6.5 / BS-EN NA

Imperfection factor for buckling curve b $\alpha_{LT} = 0.34$ Table 6.3 / BS-EN NA

PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 www.planningapplications.com support@planningapplications.com	Project BEAM 4 - plus plate	Project ref 2023-7459
	Calcs for Connor McKitrich	Date 31 May 2023

Intermediate factor for reduction factor calculation	$\phi_{LT} = \mathbf{1.09}$	cl.6.3.2.3 (1)
Buckling reduction factor	$\chi_{LT} = \mathbf{0.629}$	eq (6.57)
Correction factor for moment distribution	$k_c = \mathbf{1}$	Table 6.6
Moment distribution modification factor	$f = \mathbf{1}$	cl.6.3.2.3 (2)
Modified buckling reduction factor	$\chi_{LT,mod} = \mathbf{0.629}$	eq (6.58)
Design buckling resistance	$M_{b,Rd} = \mathbf{98}$ kNm	eq (6.55)

Notes

C1 value conservatively taken as 1.0

Ends of beam are to be laterally restrained. Ends of beams can be laterally restrained using one of the following methods;

- 1) End of beam built into masonry wall.
- 2) End of beam fixed to a masonry wall.
- 3) End of beam fixed to a column or a beam.

The designer is to ensure that the proposed detail adequately ensures that the end of the beam is laterally restrained.

No allowance has been made for destabilising loads which are outside the scope of these calculations (Destabilising loads would not normally occur in a traditional masonry structure)