PlanningApplications.com Summer House, Upper Court Road, SURREY. CR3 7BF 0203 294 9477 07922 148 701 www.planningapplications.com support@planningapplications.com	Project Rear Extension - Opening to rear elevation	Project ref 2023-7459
	Calcs for Mr Stephen Payne 12 Bennett Way Guildford Surrey GU4 7TN	Date 21 Sep 2023

Steel Beam Design

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

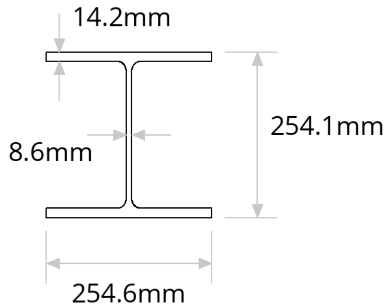
Beam Summary
254x254x73kgUC S275
Total length 4900mm (span 4600mm)

Design summary

	Resistance / Limit	Applied / Actual	Utilisation	
Shear	**407** kN	**83.1** kN	**20** %	**OK**
Bending moment	**273** kNm	**95.6** kNm	**35** %	**OK**
Buckling	**242** kNm	**95.6** kNm	**39** %	**OK**
Total deflection	**23** mm	**6.3** mm	**28** %	**OK**
Deflection due to variable actions	**12.8** mm	**1.6** mm	**12** %	**OK**

Section details

Type	**Universal column**
Section	**254 x 254 x 73 UC**
Steel grade	**S275**
Width	b = **255** mm
Depth	h = **254** mm
Web thickness	t_w = **8.6** mm
Flange thickness	t_f = **14.2** mm
Root radius	r = **12.7** mm
Mass per metre	w = **73.1** kg/m



Span and restraints

Effective span	L = **4,600** mm
Buckling length	L_{cr} = **4,600** mm

Deflection limits

Variable action deflection limit	Δ_Q = L / 360 = **12.8** mm
Total deflection limit	Δ_{G+Q} = L / 200 = **23** mm

Safety factors

Partial factor for permanent actions	γ_G = **1.35**
Partial factor for variable actions	γ_Q = **1.5**

Loading details

Self weight

Permanent action — SW = w × 9.81 / 1000 = **0.717** kN/m

Load 1: UDL - 102.5mm Brickwork

Permanent action — G_1 = **2** kN/m² × **3** m = **6** kN/m

Variable action — Q_1 = **0** kN/m² × **3** m = **0** kN/m

Load 2: UDL - 100mm Lightweight blockwork + Plaster or render on ONE side

Permanent action — G_2 = **2** kN/m² × **3** m = **6** kN/m

Variable action — Q_2 = **0** kN/m² × **3** m = **0** kN/m

Load 3: UDL - Timber floor (domestic dwelling)

Permanent action — G_3 = **0.6** kN/m² × **2.15** m = **1.29** kN/m

Variable action — Q_3 = **1.5** kN/m² × **2.15** m = **3.22** kN/m

Load 4: UDL - Ceiling beneath sloping roof

Permanent action — G_4 = **0.3** kN/m² × **2.15** m = **0.645** kN/m

Variable action — Q_4 = **0.25** kN/m² × **2.15** m = **0.538** kN/m

Load 5: UDL - Sloping roof, 0° to 30°

Permanent action — G_5 = **1.15** kN/m² × **3.5** m = **4.02** kN/m

Variable action — Q_5 = **0.75** kN/m² × **3.5** m = **2.62** kN/m

Load 6: UDL - Solar Panels

Permanent action — G_6 = **0.5** kN/m² × **2** m = **1** kN/m

Variable action — Q_6 = **0** kN/m² × **2** m = **0** kN/m

Reactions

	Permanent (unfactored)	Variable (unfactored)	Total (unfactored)	Total (factored)
Left reaction	**45.3** kN	**14.7** kN	**59.9** kN	**83.1** kN
Right reaction	**45.3** kN	**14.7** kN	**59.9** kN	**83.1** kN

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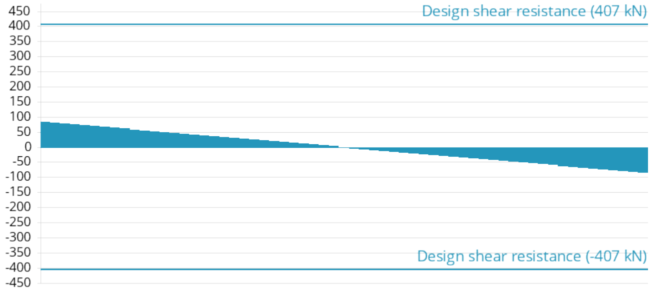
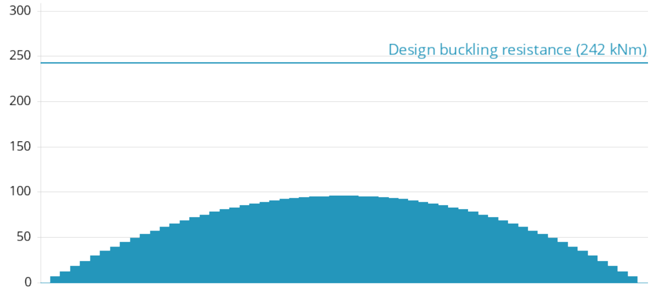
Design shear force



Shear force (kN)

Design shear force	V_{Ed} = **83.1** kN	
Design shear resistance	$V_{c,Rd}$ = **407** kN	
Utilisation	V_{Ed} / $V_{c,Rd}$ = **20** %	**OK**

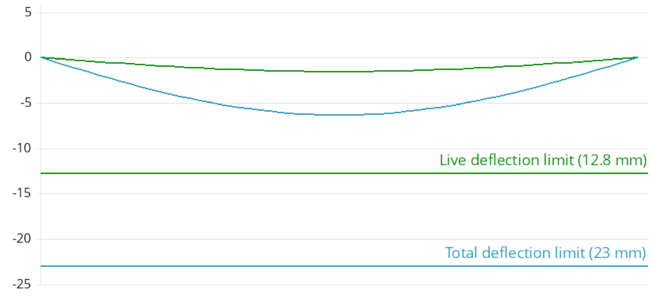
Design bending moment



Bending moments (kNm)

Design bending moment, major axis	M_{Ed} = **95.6** kNm	
Design resistance for bending	$M_{c,Rd}$ = **273** kNm	
Bending utilisation	M_{Ed} / $M_{c,Rd}$ = **35** %	**OK**
Design resistance for buckling	$M_{b,Rd}$ = **242** kNm	
Buckling utilisation	M_{Ed} / $M_{b,Rd}$ = **39** %	**OK**

Deflection



Live load deflection (green) and total load deflection (blue) in mm

Variable action deflection limit	Δ_Q = **12.8** mm	
Variable action deflection	δ_Q = **1.6** mm	**OK**
Total deflection limit	Δ_{G+Q} = **23** mm	
Total deflection	δ_{G+Q} = **6.3** mm	**OK**

Section properties

Elastic modulus - major axis, yy	W_{el} = **898** cm^3
Plastic modulus - major axis, yy	W_{pl} = **992** cm^3
Second moment of area - major axis, yy	I_y = **11,400** cm^4
Second moment of area - minor axis, zz	I_z = **3,910** cm^4
Warping constant	I_w = **0.562** dm^6

Torsional constant	I_T = **57.6** cm^4	
Area of section	A = **9,310** 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/mm²	cl.3.2.6
Poisson's ratio in elastic stage	v = **0.3**	cl.3.2.6
Shear modulus	G_s = **81,000** N/mm²	cl.3.2.6
Partial factor for resistance of cross-sections	γ_{M0} = **1**	cl.6.1(1)B / BS-EN NA
Partial factor for resistance to instability	γ_{M1} = **1**	cl.6.1(1)B / BS-EN NA
Factor for shear area	η = **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
Beta factor for buckling reduction factor calculation	β = **0.75**	cl.6.3.2.3(1) / BS-EN NA

Yield strength

Nominal yield strength for S275 grade and nominal section thickness 14.20 mm	f_y = **275** N/mm²	Tata blue book

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

Epsilon	ε = **0.924**	EN 1993-1-1:2005 Table 5.2
Flange ratio for local buckling	c_f / t_f = **7.77**	
Flange ratio limit for class 1	9 ε = **8.32**	Table 5.2 (sheet 2 of 3)
Flange class	$Class_f$ = **1**	
Web ratio for local buckling	c_w / t_w = **23.3**	
Web ratio limit for class 1	72 ε = **66.6**	Table 5.2 (sheet 1 of 3)
Web class	$Class_w$ = **1**	
Section class	Class = **1**	

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

Height of web	h_w = **226** mm	
Shear area for I and H sections	A_v = **2,560** mm²	cl.6.2.6 (3)
Design shear resistance	$V_{pl,Rd}$ = **407** 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 ε / η)

Web ratio for shear buckling	h_w / t_w = **26.2**	EN 1993-1-5:2006 cl.5.1 (2)
Shear buckling limit	72 ε / η = **66.6**	EN 1993-1-5:2006 cl.5.1 (2)

(h_w / t_w) <= (72 ε / η) therefore shear buckling calculation not required

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

The shear force (83 kN) is less than half of the plastic shear resistance (407 kN / 2 = 203 kN), therefore its effect on moment resistance may be neglected.

Class 1 section, therefore use plastic modulus	W_{pl} = **992,000** mm³	
Design bending resistance	$M_{c,Rd}$ = **273** 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** N/mm^2	cl.3.2.6 (1)
Buckling length	L_{cr} = **4,600** mm	
Critical buckling moment	M_{CR} = **624** kNm	NCCI SN003b-EN-EU
Class 1 section, therefore use plastic modulus	W_{pl} = **992,000** mm^3	cl.6.3.2.1(3)
Non-dimensional slenderness ratio	$\bar{\lambda}_{LT}$ = **0.661**	cl.6.3.2.2 (1)
Depth to width ratio for buckling curve	h / b = **0.998**	
Buckling curve for h / b ratio	Buckling curve = **b**	Table 6.5 / BS-EN NA
Imperfection factor for buckling curve b	α_{LT} = **0.34**	Table 6.3 / BS-EN NA
Intermediate factor for reduction factor calculation	Φ_{LT} = **0.708**	cl.6.3.2.3 (1)
Buckling reduction factor	χ_{LT} = **0.889**	eq (6.57)
Correction factor for moment distribution	k_c = **1**	Table 6.6
Moment distribution modification factor	f = **1**	cl.6.3.2.3 (2)
Modified buckling reduction factor	$\chi_{LT,mod}$ = **0.889**	eq (6.58)
Design buckling resistance	$M_{b,Rd}$ = **242** 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)