NJW Building Design Ltd

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Site: 4 St Johns Close, Brinsley, Nottingham NG16 5BH	**Made by NJW**
Job: Loft conversion	**Page 1**
Job number: 25-2977	**File copy**

ProSteel 5.41g 532221 — mr and Mrs I Smith Roof rooms job.PS5 — Printed 21 Mar 2025 14:12

Beam: **Beam 1** — **Span: 4.1 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	D	o.w.	0.3	0		L	0.62	0.62
U	D	Floor dl	1x1.5	0		L	3.07	3.07
U	L	Floor ll	1x0.75	0		L	1.54	1.54
U	D	stud	1	0		L	2.05	2.05
U	D	Roof dl	2.6x1.5	0		L	7.99	7.99
U	L	Roof ll	2.6x0.75	0		L	4.00	4.00
				Unfactored reactions (kN)		**Total:**	**19.27**	**19.27**
						Dead:	*13.73*	*13.73*
						Live:	*5.53*	*5.53*
Total load: 38.54/56.17 kN		*Unfactored/Factored*				**Factored reactions:**	**28.08**	**28.08**

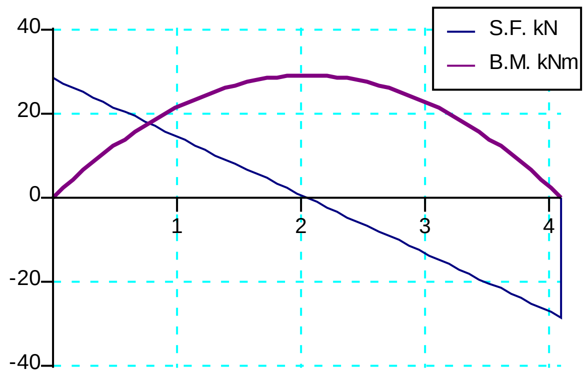
Load types: U:UDL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 28.8 kNm at 2.05 m. from R1

Maximum S.F. (factored) = 28.1 kN at R1

Live load deflection = 9.93×10^8/EI at 2.05 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 34.6×10^8/EI at 2.05 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **152 x 152 x 30 UC S275 (compact)**

D=157.6 mm B=152.9 mm t=6.5 mm T=9.4 mm I_x=1,750 cm^4 r_y=3.83 cm S_x=248 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 6.5 x 157.6/1000 = 169 kN (>=28.1) OK

Maximum moment = 28.79 kNm at 2.05 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 248/1000 = 68.20 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 5.24m

Buckling parameter (u) = 0.849

β_w = 1.000 (Class 1/2 compact)

Bending strength, p_b = 167.0 N/mm²

Slenderness, l (L_E/r_y) = 5.24 x 100/3.83 = 136.7

Slenderness factor (v) = 0.681 (x = 16.0; λ/x = 8.54)

Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 79.03

Maximum moment within segment, M_x = 28.79 kNm

Equivalent uniform moment factor, m_{LT} = 0.925 (M_2=21.6, M_3=28.8, M_4=21.6)

Equivalent uniform moment = 0.925 x 28.79 = 26.63 kNm

Buckling resistance moment, M_b = p_b.S_x = 167.0 x 248/1000 = 41.43 kNm OK

Check unstiffened web capacity with load of 28.08 kN
C1 = 60.8 kN; C2 = 1.79 kN/mm; C4 = 382; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, P_x = K√(C4.P_w)
Unstiffened web bearing capacity, P_w = 60.8 kN: no minimum stiff bearing length required

LL deflection = 9.933 x 1e8/205,000 x 1750.000 = 2.8 mm (L/1481) OK
TL deflection = 34.58 x 1e8/205,000 x 1750 = 9.6 mm (L/425)

Bearing details

152x152x30 UC stiff bearing length, b_1 = t + 1.6r + 2T = 37.5 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 153 x 100 mm padstone

Factored reaction = 13.73 x 1.4 + 5.53 x 1.6 = 28.08 kN

Factored stress under padstone = 28.08 x 1000/153 x 100 = 1.84 N/mm^2

R2 as R1

Beam: Beam 2 **Span: 2.9 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.25	0		L	0.36	0.36
R	D	Stud	1.5	1.2		L	0.75	1.80
R	D	Flat roof dl	1.5x1.5	1.2		L	1.12	2.70
R	L	Flat roof ll	0.75x1.5	1.2		L	0.56	1.35
P	D	Beam 3 dl	11	1.2			6.45	4.55
P	L	Beam 2 ll	5	1.2			2.93	2.07
P	D	Flat roof dl	1.5x1.5x0.6	1.2			0.79	0.56
P	L	Flat roof ll	1.5x0.75x0.6	1.2			0.40	0.28
				Unfactored reactions (kN)		**Total:**	**13.36**	**13.68**
						Dead:	*9.47*	*9.98*
						Live:	*3.89*	*3.70*
Total load: 27.04/39.37 kN		*Unfactored/Factored*				**Factored reactions:**	**19.48**	**19.89**

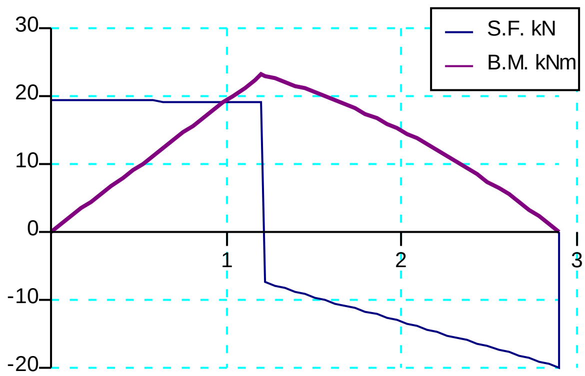
Load types: U:UDL R:Part UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 23.1 kNm at 1.20 m. from R1

Maximum S.F. (factored) = -19.9 kN at R2

Live load deflection = 3.43 x 10^8/EI at 1.40 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 11.9 x 10^8/EI at 1.40 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : 152 x 152 x 23 UC S275 (semi-compact)

D=152.4 mm B=152.2 mm t=5.8 mm T=6.8 mm I_x=1,250 cm^4 r_y=3.70 cm S_x=182 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 5.8 x 152.4/1000 = 146 kN (>=19.9) OK

Maximum moment = 23.12 kNm at 1.20 m. from R1

Moment capacity, M_c = p_y.$S_{x, eff}$ = 275 x 176/1000 = 48.47 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 3.78m
Buckling parameter (u) = 0.840
β_w = 0.968 ($S_{x,eff}/S_x$)
Bending strength, p_b = 190.2 N/mm²

Slenderness, λ (L_E/r_y) = 3.78 x 100/3.70 = 102.3
Slenderness factor (v) = 0.819 (x = 20.7; λ/x = 4.94)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 69.27

Maximum moment within segment, M_x = 23.12 kNm
Equivalent uniform moment factor, m_{LT} = 0.827 (M_2=14.0, M_3=21.1, M_4=12.5)
Equivalent uniform moment = 0.827 x 23.12 = 19.13 kNm
Buckling resistance moment, M_b = p_b.$S_{x,eff}$ = 190.2 x 176/1000 = 33.53 kNm OK

Check unstiffened web capacities with loads of 19.48 kN and 19.89 kN
C1 = 45.9 kN; C2 = 1.60 kN/mm; C4 = 271; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, P_x = K√(C4.P_w)
R1: Unstiffened web bearing capacity, P_w = 45.9 kN: no minimum stiff bearing length required
R2: Unstiffened web bearing capacity, P_w = 45.9 kN: no minimum stiff bearing length required

LL deflection = 3.425 x 1e8/205,000 x 1250.000 = 1.3 mm (L/2170) OK
TL deflection = 11.87 x 1e8/205,000 x 1250 = 4.6 mm (L/626)

Bearing details

152x152x23 UC stiff bearing length, b_1 = t + 1.6r + 2T = 31.6 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 153 x 100 mm padstone

Factored reaction = 9.47 x 1.4 + 3.89 x 1.6 = 19.48 kN

Factored stress under padstone = 19.48 x 1000/153 x 100 = 1.27 N/mm^2

R2: 153 x 100 mm padstone

Factored reaction = 9.98 x 1.4 + 3.70 x 1.6 = 19.89 kN

Factored stress under padstone = 19.89 x 1000/153 x 100 = 1.30 N/mm^2

Beam: **Beam 3** **Span: 3.0 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	D	o.w.	0.2	0		L	0.30	0.30
U	D	Stud	1.5	0		L	2.25	2.25
U	D	Roof dl	2.6x1.5	0		L	5.85	5.85
U	L	Roof ll	2.6x0.75	0		L	2.93	2.93
U	D	Floor dl	1x1.5	0		L	2.25	2.25
U	L	Floor ll	1x1	0		L	1.50	1.50
				Unfactored reactions (kN)		**Total:**	**15.08**	**15.08**
						Dead:	*10.65*	*10.65*
						Live:	*4.43*	*4.43*
Total load: 30.15/43.98 kN		*Unfactored/Factored*				**Factored reactions:**	**21.99**	**21.99**

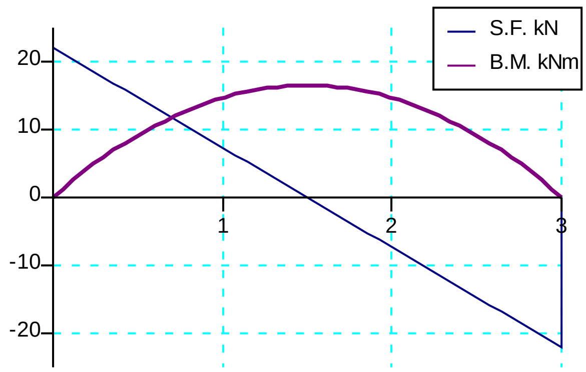
Load types: U:UDL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 16.5 kNm at 1.50 m. from R1

Maximum S.F. (factored) = 22.0 kN at R1

Live load deflection = 3.11 x 10^8/EI at 1.50 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 10.6 x 10^8/EI at 1.50 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **178 x 102 x 19 UB S275 (compact)**

D=177.8 mm B=101.2 mm t=4.8 mm T=7.9 mm I_x=1,360 cm^4 r_y=2.37 cm S_x=171 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 4.8 x 177.8/1000 = 141 kN (>=22.0) OK

Maximum moment = 16.49 kNm at 1.50 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 171/1000 = 47.02 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 3.96m
Buckling parameter (u) = 0.886
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 114.4 N/mm^2

Slenderness, λ (L_E/r_y) = 3.96 x 100/2.37 = 166.9
Slenderness factor (v) = 0.720 (x = 22.6; λ/x = 7.39)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 106.4

Maximum moment within segment, M_x = 16.49 kNm
Equivalent uniform moment factor, m_{LT} = 0.925 (M_2=12.4, M_3=16.5, M_4=12.4)
Equivalent uniform moment = 0.925 x 16.49 = 15.26 kNm
Buckling resistance moment, M_b = p_b.S_x = 114.4 x 171/1000 = 19.56 kNm OK

Check unstiffened web capacity with load of 21.99 kN

$C1 = 40.9$ kN; $C2 = 1.32$ kN/mm; $C4 = 129$; $K = \min\{0.5+(a_e/1.4d),1.0\}$; $p_{yw} = 275\text{N/mm}^2$

(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)

Bearing capacity, $P_w = C1+b_1C2$ (b_e taken as zero) Buckling capacity, $P_x = K\sqrt{(C4.P_w)}$

With b_1=0, unstiffened web buckling capacity, P_x = 36.4 kN: no minimum stiff bearing length required

LL deflection = 3.111 x 1e8/205,000 x 1360.000 = 1.1 mm (L/2689) OK
TL deflection = 10.60 x 1e8/205,000 x 1360 = 3.8 mm (L/789)

Bearing details

178x102x19 UB stiff bearing length, $b_1 = t + 1.6r + 2T$ = 32.8 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 102 x 100 mm padstone

Factored reaction = 10.65 x 1.4 + 4.43 x 1.6 = 21.99 kN

Factored stress under padstone = 21.99 x 1000/102 x 100 = 2.16 N/mm^2

R2 as R1

Beam: **Beam 4** **Span: 2.5 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	D	o.w.	0.2	0		L	0.25	0.25
U	D	Floor dl	1.5x1.5	0		L	2.81	2.81
U	L	Floor ll	1.5x1	0		L	1.88	1.88
P	D	Beam 5 dl	5	0.9			3.20	1.80
P	L	Beam 5 ll	1	0.9			0.64	0.36
				Unfactored reactions (kN)		**Total:**	**8.78**	**7.10**
						Dead:	*6.26*	*4.86*
						Live:	*2.51*	*2.23*
Total load: 15.88/23.18 kN		*Unfactored/Factored*				**Factored reactions:**	**12.79**	**10.38**

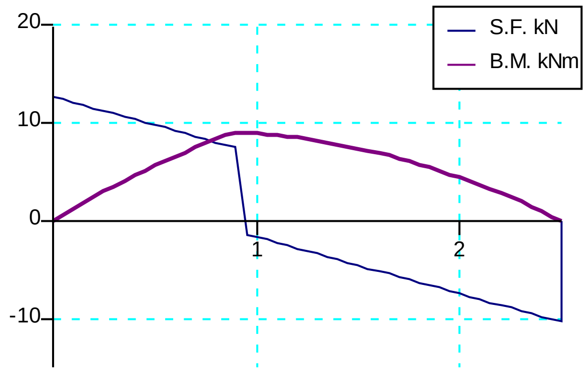
Load types: U:UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 9.15 kNm at 0.90 m. from R1

Maximum S.F. (factored) = 12.8 kN at R1

Live load deflection = 1.05 x 10^8/EI at 1.23 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 3.76 x 10^8/EI at 1.21 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **152 x 89 x 16 UB S275 (compact)**

D=152.4 mm B=88.7 mm t=4.5 mm T=7.7 mm I_x=834 cm⁴ r_y=2.10 cm S_x=123 cm³

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 4.5 x 152.4/1000 = 113 kN (>=12.8) OK

Maximum moment = 9.151 kNm at 0.90 m. from R1

Moment capacity, M_c = $p_y.S_x$ = 275 x 123/1000 = 33.83 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 3.30m
Buckling parameter (u) = 0.889
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 129.1 N/mm²

Slenderness, λ (L_E/r_y) = 3.30 x 100/2.10 = 157.4
Slenderness factor (v) = 0.698 (x = 19.6; λ/x = 8.03)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 97.59

Maximum moment within segment, M_x = 9.151 kNm
Equivalent uniform moment factor, m_{LT} = 0.860 (M_2=6.86, M_3=8.42, M_4=5.35)
Equivalent uniform moment = 0.860 x 9.151 = 7.874 kNm
Buckling resistance moment, M_b = $p_b.S_x$ = 129.1 x 123/1000 = 15.88 kNm OK

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Check unstiffened web capacities with loads of 12.79 kN and 10.38 kN
C1 = 37.9 kN; C2 = 1.24 kN/mm; C4 = 129; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, P_x = K√(C4.P_w)
R1: With b_1=0, unstiffened web buckling capacity, P_x = 34.9 kN: no minimum stiff bearing length required
R2: With b_1=0, unstiffened web buckling capacity, P_x = 34.9 kN: no minimum stiff bearing length required

LL deflection = 1.054 x 1e8/205,000 x 834.000 = 0.6 mm (L/4054) OK
TL deflection = 3.760 x 1e8/205,000 x 834 = 2.2 mm (L/1137)

Bearing details

152x89x16 UB stiff bearing length, b_1 = t + 1.6r + 2T = 32.1 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 89 x 100 mm padstone

Factored reaction = 6.26 x 1.4 + 2.51 x 1.6 = 12.79 kN

Factored stress under padstone = 12.79 x 1000/89 x 100 = 1.44 N/mm^2

R2: 89 x 100 mm padstone

Factored reaction = 4.86 x 1.4 + 2.23 x 1.6 = 10.38 kN

Factored stress under padstone = 10.38 x 1000/89 x 100 = 1.17 N/mm^2

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Beam: **Beam 5** **Span: 3.2 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.2	0		L	0.32	0.32
U	D	Stud	1.5	0		L	2.40	2.40
P	D	Stud	1.5x0.4	1.6			0.30	0.30
P	D	Floor dl	1x1.5x0.4	1.6			0.30	0.30
P	L	Floor ll	1x1x0.4	1.6			0.20	0.20
P	D	Roof dl	2.6x1.5x0.4	1.6			0.78	0.78
P	L	Roof ll	2.6x0.75x0.4	1.6			0.39	0.39
				Unfactored reactions (kN)		**Total:**	**4.69**	**4.69**
						Dead:	*4.10*	*4.10*
						Live:	*0.59*	*0.59*
Total load: 9.38/13.37 kN			*Unfactored/Factored*			**Factored reactions:**	**6.68**	**6.68**

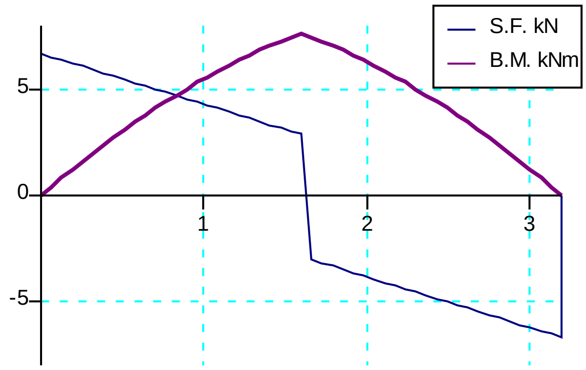
Load types: U:UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 7.65 kNm at 1.60 m. from R1

Maximum S.F. (factored) = 6.68 kN at R1

Live load deflection = 0.805 x 10^8/EI at 1.60 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 5.01 x 10^8/EI at 1.60 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **152 x 89 x 16 UB S275 (compact)**

D=152.4 mm B=88.7 mm t=4.5 mm T=7.7 mm I_x=834 cm^4 r_y=2.10 cm S_x=123 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 4.5 x 152.4/1000 = 113 kN (>=6.68) OK

Maximum moment = 7.648 kNm at 1.60 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 123/1000 = 33.83 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 4.14m

Buckling parameter (u) = 0.889

β_w = 1.000 (Class 1/2 compact)

Bending strength, p_b = 106.5 N/mm²

Slenderness, λ (L_E/r_y) = 4.14 x 100/2.10 = 197.4

Slenderness factor (v) = 0.637 (x = 19.6; λ/x = 10.1)

Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 111.8

Maximum moment within segment, M_x = 7.648 kNm

Equivalent uniform moment factor, m_{LT} = 0.880 (M_2=4.59, M_3=7.65, M_4=4.59)

Equivalent uniform moment = 0.880 x 7.648 = 6.729 kNm

Buckling resistance moment, M_b = p_b.S_x = 106.5 x 123/1000 = 13.09 kNm OK

Check unstiffened web capacity with load of 6.684 kN
C1 = 37.9 kN; C2 = 1.24 kN/mm; C4 = 129; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, $P_w = C1+b_1C2$ (b_e taken as zero) Buckling capacity, $P_x = K\sqrt{(C4.P_w)}$
With b_1=0, unstiffened web buckling capacity, P_x = 34.9 kN: no minimum stiff bearing length required

LL deflection = 0.8055 x 1e8/205,000 x 834.000 = 0.5 mm (L/6792) OK
TL deflection = 5.010 x 1e8/205,000 x 834 = 2.9 mm (L/1092)

Bearing details

152x89x16 UB stiff bearing length, b_1 = t + 1.6r + 2T = 32.1 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 89 x 100 mm padstone

Factored reaction = 4.10 x 1.4 + 0.59 x 1.6 = 6.68 kN

Factored stress under padstone = 6.68 x 1000/89 x 100 = 0.75 N/mm^2

R2 as R1

Beam: **Beam 6** **Span: 2.2 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	D	o.w.	0.2	0		L	0.22	0.22
U	D	Roof dl	3.5x1.5	0		L	5.78	5.78
U	L	Roof ll	3.5x0.75	0		L	2.89	2.89
P	D	Beam 5dl	5	0.8			3.18	1.82
P	L	Beam 5 ll	1	0.8			0.64	0.36
				Unfactored reactions (kN)		**Total:**	**12.70**	**11.06**
						Dead:	*9.18*	*7.81*
						Live:	*3.52*	*3.25*
Total load: 23.76/34.63 kN			*Unfactored/Factored*			**Factored reactions:**	**18.49**	**16.14**

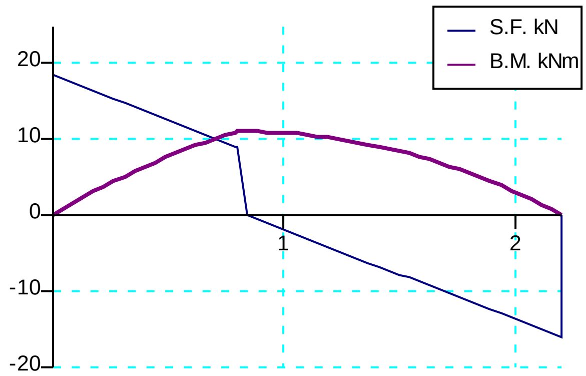
Load types: U:UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 11.0 kNm at 0.84 m. from R1

Maximum S.F. (factored) = 18.5 kN at R1

Live load deflection = 1.00 x 10^8/EI at 1.08 m. from R1 *(E in N/mm^2, I in cm^4)*

Total deflection = 3.66 x 10^8/EI at 1.06 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **152 x 89 x 16 UB S275 (compact)**

D=152.4 mm B=88.7 mm t=4.5 mm T=7.7 mm I_x=834 cm^4 r_y=2.10 cm S_x=123 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 4.5 x 152.4/1000 = 113 kN (>=18.5) OK

Maximum moment = 11.01 kNm at 0.84 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 123/1000 = 33.83 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 2.94m
Buckling parameter (u) = 0.889
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 142.0 N/mm^2

Slenderness, λ (L_E/r_y) = 2.94 x 100/2.10 = 140.2
Slenderness factor (v) = 0.728 (x = 19.6; λ/x = 7.15)
Equivalent slenderness (λ_{LT}) = u.v.$\lambda.\sqrt{\beta_w}$ = 90.76

Maximum moment within segment, M_x = 11.01 kNm
Equivalent uniform moment factor, m_{LT} = 0.892 (M_2=8.38, M_3=10.6, M_4=7.09)
Equivalent uniform moment = 0.892 x 11.01 = 9.821 kNm
Buckling resistance moment, M_b = p_b.S_x = 142.0 x 123/1000 = 17.47 kNm OK

Check unstiffened web capacities with loads of 18.49 kN and 16.14 kN
C1 = 37.9 kN; C2 = 1.24 kN/mm; C4 = 129; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, $P_x = K\sqrt{(C4.P_w)}$
R1: With b_1=0, unstiffened web buckling capacity, P_x = 34.9 kN: no minimum stiff bearing length required
R2: With b_1=0, unstiffened web buckling capacity, P_x = 34.9 kN: no minimum stiff bearing length required

LL deflection = 1.000 x 1e8/205,000 x 834.000 = 0.6 mm (L/3761) OK
TL deflection = 3.661 x 1e8/205,000 x 834 = 2.1 mm (L/1027)

Bearing details

152x89x16 UB stiff bearing length, b_1 = t + 1.6r + 2T = 32.1 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 89 x 100 mm padstone

Factored reaction = 9.18 x 1.4 + 3.52 x 1.6 = 18.49 kN

Factored stress under padstone = 18.49 x 1000/89 x 100 = 2.08 N/mm^2

R2: 89 x 100 mm padstone

Factored reaction = 7.81 x 1.4 + 3.25 x 1.6 = 16.14 kN

Factored stress under padstone = 16.14 x 1000/89 x 100 = 1.81 N/mm^2

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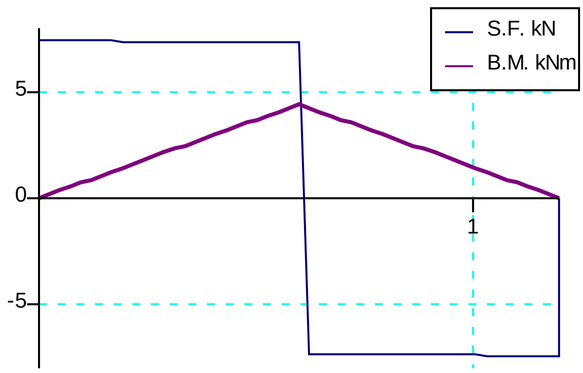
Beam: **Beam 7** **Span: 1.2 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.15	0		L	0.09	0.09
P	D	Beam 4dl	7	0.6			3.50	3.50
P	L	Beam 4 ll	3	0.6			1.50	1.50
				Unfactored reactions (kN)		**Total:**	**5.09**	**5.09**
						Dead:	*3.59*	*3.59*
						Live:	*1.50*	*1.50*
Total load: 10.18/14.85 kN *Unfactored/Factored*						**Factored reactions:**	**7.43**	**7.43**

Load types: U:UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 4.42 kNm at 0.60 m. from R1
Maximum S.F. (factored) = 7.43 kN at R1
Live load deflection = 0.108 x 10^8/EI at 0.60 m. from R1 *(E in N/mm², I in cm⁴)*
Total deflection = 0.364 x 10^8/EI at 0.60 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **127 x 76 x 13 UB S275 (compact)**

D=127.0 mm B=76.0 mm t=4.0 mm T=7.6 mm I_x=473 cm^4 r_y=1.84 cm S_x=84.0 cm^3
Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 4.0 x 127.0/1000 = 83.8 kN (>=7.43) OK
Maximum moment = 4.418 kNm at 0.60 m. from R1
Moment capacity, M_c = p_y.S_x = 275 x 84.0/1000 = 23.10 kNm OK
Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 1.69m
Buckling parameter (u) = 0.896
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 200.8 N/mm²

Slenderness, λ (L_E/r_y) = 1.69 x 100/1.84 = 92.07
Slenderness factor (v) = 0.788 (x = 16.3; λ/x = 5.65)
Equivalent slenderness (λ_{LT}) = u.v.$\lambda.\sqrt{\beta_w}$ = 64.99

Maximum moment within segment, M_x = 4.418 kNm
Equivalent uniform moment factor, m_{LT} = 0.851 (M_2=2.22, M_3=4.42, M_4=2.22)
Equivalent uniform moment = 0.851 x 4.418 = 3.758 kNm
Buckling resistance moment, M_b = p_b.S_x = 200.8 x 84.0/1000 = 16.86 kNm OK

Check unstiffened web capacity with load of 7.426 kN
C1 = 33.4 kN; C2 = 1.10 kN/mm; C4 = 114; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm²
(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)
Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero) Buckling capacity, P_x = K$\sqrt{(C4.P_w)}$
With b_1=0, unstiffened web buckling capacity, P_x = 30.9 kN: no minimum stiff bearing length required

LL deflection = 0.1080 x 1e8/205,000 x 473.000 = 0.1 mm OK
TL deflection = 0.3640 x 1e8/205,000 x 473 = 0.4 mm (L/3196)

Bearing details

127x76x13 UB stiff bearing length, b_1 = t + 1.6r + 2T = 31.4 mm

Masonry: 100mm 10.4N/mm^2 solid block (SF>2.0), class (ii) mortar, normal const/normal mfr
Local design strength (factored) = 8.4/3.5 = 2.40N/mm^2 (BS5628-1:2005 Table 2d/2e)

R1: 76 x 100 mm padstone

Factored reaction = 3.59 x 1.4 + 1.50 x 1.6 = 7.43 kN

Factored stress under padstone = 7.43 x 1000/76 x 100 = 0.98 N/mm^2

R2 as R1

Beam: **Beam 8 - Existing Beam** **Span: 3.2 m.**

		Load name	*Loading w1*	*Start x1*	*Loading w2*	*End x2*	*R1comp*	*R2comp*
U	D	o.w.	0.4	0		L	0.64	0.64
U	D	Masonry	4x1.8	0		L	11.52	11.52
P	D	Beam 1 dl	14	1.6			7.00	7.00
P	L	Beam 1 ll	6	1.6			3.00	3.00
				Unfactored reactions (kN)		**Total:**	**22.16**	**22.16**
						Dead:	*19.16*	*19.16*
						Live:	*3.00*	*3.00*
Total load: 44.32/63.25 kN		*Unfactored/Factored*			**Factored reactions:**		**31.62**	**31.62**

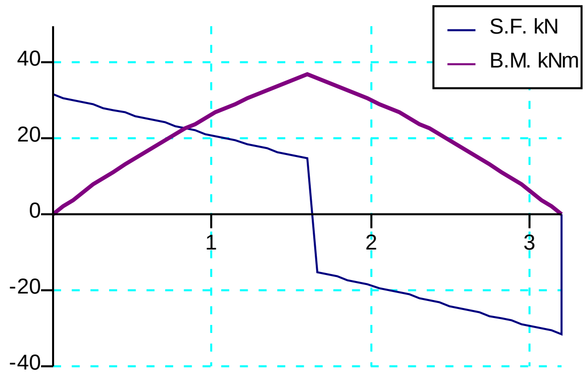
Load types: U:UDL P:PL D: Dead; L: Live (positions in m. from R1)

Maximum B.M. (factored) = 37.0 kNm at 1.60 m. from R1

Maximum S.F. (factored) = 31.6 kN at R1

Live load deflection = 4.10 x 10^8/EI at 1.60 m. from R1 *(E in N/mm², I in cm⁴)*

Total deflection = 24.0 x 10^8/EI at 1.60 m. from R1



Shear force and bending moment

Beam calculation to BS5950-1:2000 using S275 steel

SECTION SIZE : **2No 178 x 102 x 19 UB S275 (compact)**

D=177.8 mm B=101.2 mm t=4.8 mm T=7.9 mm I_x=1,360 cm^4 r_y=2.37 cm S_x=171 cm^3

Shear capacity = 0.6 p_y.t.D = 0.6 x 275 x 2 x 4.8 x 177.8/1000 = 282 kN (>=31.6) OK

Maximum moment = 36.98 kNm at 1.60 m. from R1

Moment capacity, M_c = p_y.S_x = 275 x 171 x 2/1000 = 94.05 kNm OK

Beam is laterally restrained at supports only: effective length = 1.2L+2D

Effective length (L_E) = 4.20m
Buckling parameter (u) = 0.886
β_w = 1.000 (Class 1/2 compact)
Bending strength, p_b = 108.4 N/mm²

Slenderness, λ (L_E/r_y) = 4.20 x 100/2.37 = 177.0
Slenderness factor (v) = 0.704 (x = 22.6; λ/x = 7.83)
Equivalent slenderness (λ_{LT}) = u.v.λ.$\sqrt{\beta_w}$ = 110.4

Maximum moment within segment, M_x = 36.98 kNm
Equivalent uniform moment factor, m_{LT} = 0.878 (M_2=21.9, M_3=37.0, M_4=21.9)
Equivalent uniform moment = 0.878 x 36.98 = 32.45 kNm
Buckling resistance moment, M_b = p_b.S_x = 108.4 x 171 x 2/1000 = 37.06 kNm OK

Check unstiffened web capacity with load of 31.62/2 = 15.81 kN

C1 = 40.9 kN; C2 = 1.32 kN/mm; C4 = 129; K = min{0.5+(a_e/1.4d),1.0}; p_{yw} = 275N/mm^2

(for derivation of C factors see Steelwork Design Guide to BS5950-1:2000 6th ed.)

Bearing capacity, P_w = C1+b_1C2 (b_e taken as zero)   Buckling capacity, P_x = K√(C4.P_w)

With b_1=0, unstiffened web buckling capacity, P_x = 36.4 kN: no minimum stiff bearing length required

LL deflection = 4.096 x 1e8/2 x 205,000 x 1360.000 = 0.7 mm (L/4357) OK

TL deflection = 24.03 x 1e8/2 x 205,000 x 1360 = 4.3 mm (L/743)

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Beam: Trimmer 9 **Span: 2.0 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	T	o.w.	0.15	0		L	0.15	0.15
U	T	Roof dl	3x1.5	0		L	4.50	4.50
U	T	Roof ll	3x0.75	0		L	2.25	2.25
							6.90	6.90

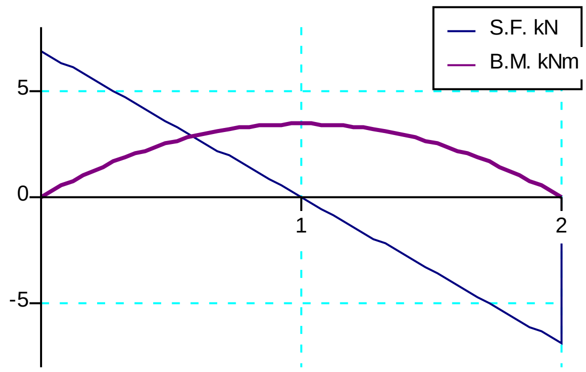
Total load: 13.80 kN

Load types: U:UDL T: Total (positions in m. from R1)

Maximum B.M. = 3.45 kNm at 1.00 m. from R1

Maximum S.F. = 6.90 kN at R1

Total deflection = 1.44 x 10^8/EI at 1.00 m. from R1 *(E in N/mm^2, I in cm^4)*



Shear force and bending moment

Timber beam calculation to BS5268 Part 2: 2002 using C24 timber

Use 2no 50 x 170 C24 *7.1 kg/m approx*

z = 481.7 cm^3 I = 4,094 cm^4

Timber grade: C24 2 members acting together: K_8 = 1.1

K_3 (loading duration factor) = 1.00 K_7 (depth factor) = 1.064 K_8 (load sharing factor) = 1.1

E = 7,200 x 1.14 = 8,208 N/mm^2 ($E_{min}.K_9$)

Bending

Permissible bending stress, $\sigma_{m,adm} = \sigma_{m,g}.K_3.K_7.K_8$ = 7.5 x 1.00 x 1.064 x 1.1 = 8.78 N/mm^2

Applied bending stress, $\sigma_{m,a}$ = 3.45 x 1000/481.7 = 7.16 N/mm^2 OK

Shear

Permissible shear stress, $\tau_{adm,//} = \tau_{g,//}.K_3.K_8$ = 0.71 x 1.00 x 1.1 = 0.78 N/mm^2

Applied shear stress, τ_a = 6.90 x 1000 x 3/2 x 100 x 170 = 0.61 N/mm^2 OK

Deflection

Bending deflection = 1.44 x 10^8/8,208 x 4,094 = 4.28 mm

Mid-span shear deflection = 1.2 x 3.45 x 10^6/((E/16) x 100 x 170) = 0.47 mm

Total deflection = 4.28 + 0.47 = 4.75 mm (0.0024 L) <=0.003L OK

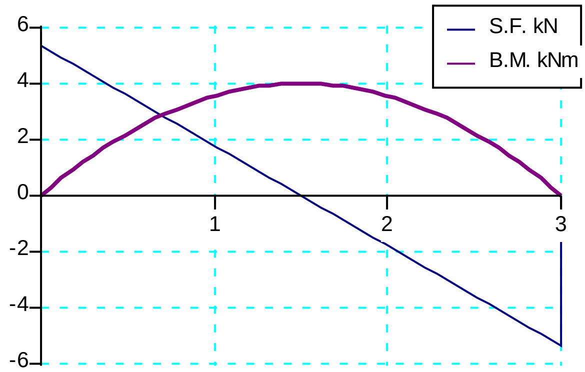
Beam: **Trimmer 10** **Span: 3.0 m.**

		Load name	Loading w1	Start x1	Loading w2	End x2	R1comp	R2comp
U	T	o.w.	0.15	0		L	0.23	0.23
U	T	Roof dl	1.5x1.5	0		L	3.38	3.38
U	T	Roof ll	1.5x0.75	0		L	1.69	1.69
							5.29	5.29

Total load: 10.57 kN

Load types: U:UDL T: Total (positions in m. from R1)

Maximum B.M. = 3.97 kNm at 1.50 m. from R1
Maximum S.F. = 5.29 kN at R1
Total deflection = 3.72×10^8/EI at 1.50 m. from R1 *(E in N/mm^2, I in cm^4)*



Shear force and bending moment

Timber beam calculation to BS5268 Part 2: 2002 using C24 timber
Use 2no 75 x 170 C24 *10.7 kg/m approx*
z = 722.5 cm^3 I = 6,141 cm^4
Timber grade: C24 2 members acting together: K_8 = 1.1
K_3 (loading duration factor) = 1.00 K_7 (depth factor) = 1.064 K_8 (load sharing factor) = 1.1
E = 7,200 x 1.14 = 8,208 N/mm^2 ($E_{min}.K_9$)

Bending
Permissible bending stress, $\sigma_{m,adm} = \sigma_{m,g}.K_3.K_7.K_8$ = 7.5 x 1.00 x 1.064 x 1.1 = 8.78 N/mm^2
Applied bending stress, $\sigma_{m,a}$ = 3.97 x 1000/722.5 = 5.49 N/mm^2 OK

Shear
Permissible shear stress, $\tau_{adm,//} = \tau_{g,//}.K_3.K_8$ = 0.71 x 1.00 x 1.1 = 0.78 N/mm^2
Applied shear stress, τ_a = 5.29 x 1000 x 3/2 x 150 x 170 = 0.31 N/mm^2 OK

Deflection
Bending deflection = 3.72×10^8/8,208 x 6,141 = 7.37 mm
Mid-span shear deflection = 1.2 x 3.97 x 10^6/((E/16) x 150 x 170) = 0.36 mm
Total deflection = 7.37 + 0.36 = 7.74 mm (0.0026 L) <=0.003L OK