Structural Calculation ltd

Mobbs Wood Farm,
Coventry, CV7 9JN

02476 709222

10/01/2020

Site Address	Brook House, Cockshutt, Ellesmere SY12 0JR
Structural Engineer	Eng Alessia Masini, PhD
Checking Engineer	Jason Pritchard BEng

Description of Works

JP1524 Structural steelwork details relating to proposed house remodelling.

Standards

BS 5268:part 2: 1996 Structural use of timber
BS 6399 part 2 - 1995 Wind loads
BS 5950 part 1 – 2000 Structural use of steelwork in building
BS 8110 part 1 - 1997 Structural use of concrete
BS 5628 part 1 - 1992 Code of practice for use of masonry
BS 6399 part 1 - 1996 Loading for buildings: dead and imposed
BS 6399 part 3 - 1988 Loading for buildings: imposed roof load
Wind loads

Notes

The contractor is responsible for all temporary works involved with the project. Advice may be requested from the engineer, but additional fees may be involved for further designs.

Any and all structural steelwork is now required by law to be CE Marked and must be supplied by an execution class 2 capable fabricator with an externally assessed and approved FPC.

Only the work requested and as contained within this report has been undertaken, no checks on other observations or information gained either on site or from the drawing have been made. Further checks can be carried out but again additional fees may be involved.

In the absence of detailed ground condition information the foundations are assumed satisfactory for ground bearing. This must be verified on site and agreed with L.A. Officer. Further consideration to detail may have to be undertaken at a design stage however written instruction will be required and additional fees may be involved.

These drawings are not architectural and are provided only to indicate the position of the calculated structural elements. Further advice should be sort from a suitably qualified architect to ensure compliance with current building regulations and best practices.

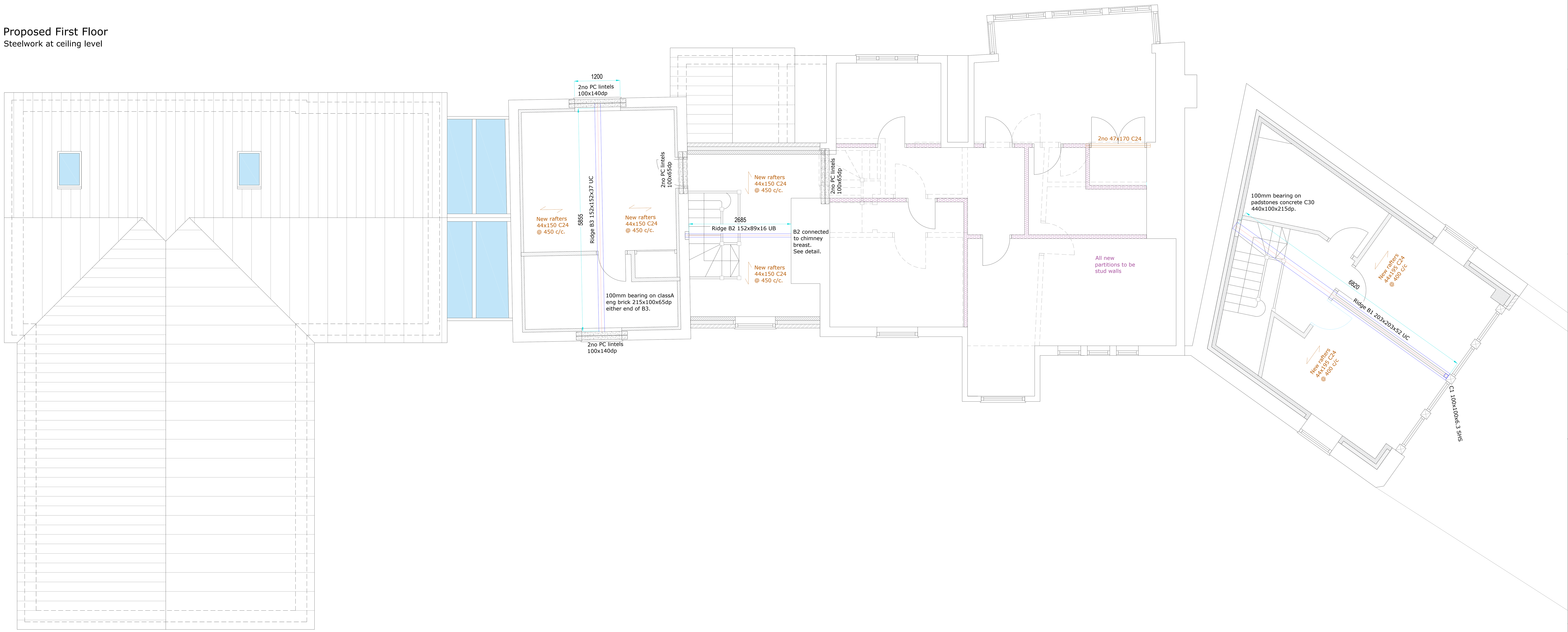
If something is missing from the report or an item is left unresolved or unclear please contact the engineer for clarification prior to carrying out the work.

IF IN DOUBT - ASK
ALL DIMS TO BE CHECKED ON SITE.

ALL DIMS IN MM

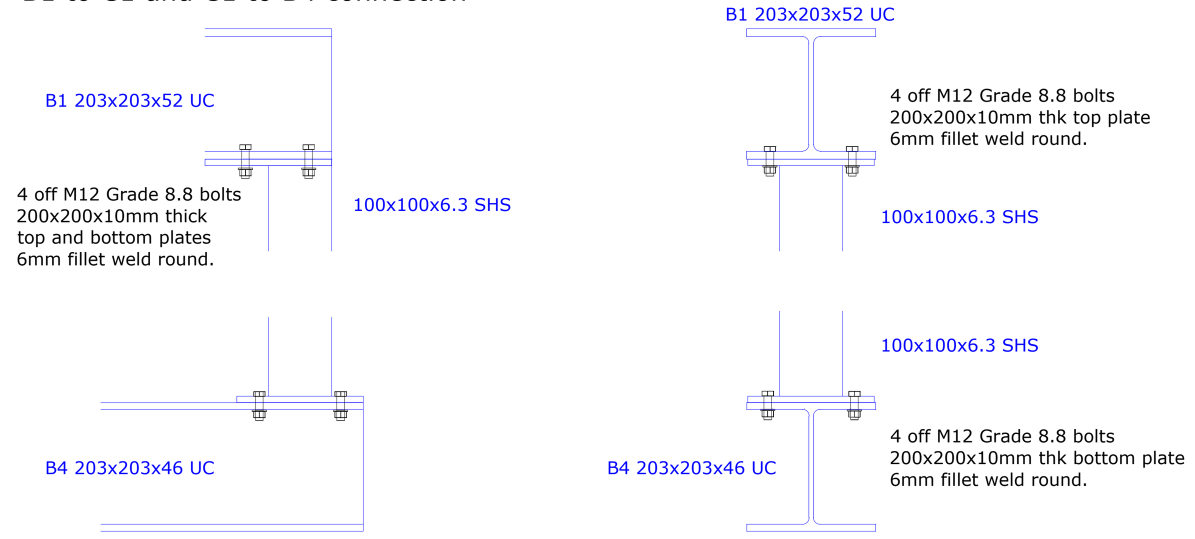
IF IN DOUBT - ASK

Proposed First Floor
Steelwork at ceiling level

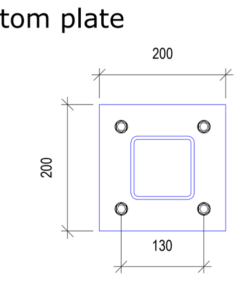


Details
Scale 1:10 @ A1

B1 to C1 and C1 to B4 connection

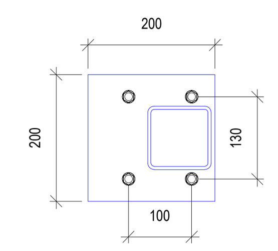


C1 bottom plate



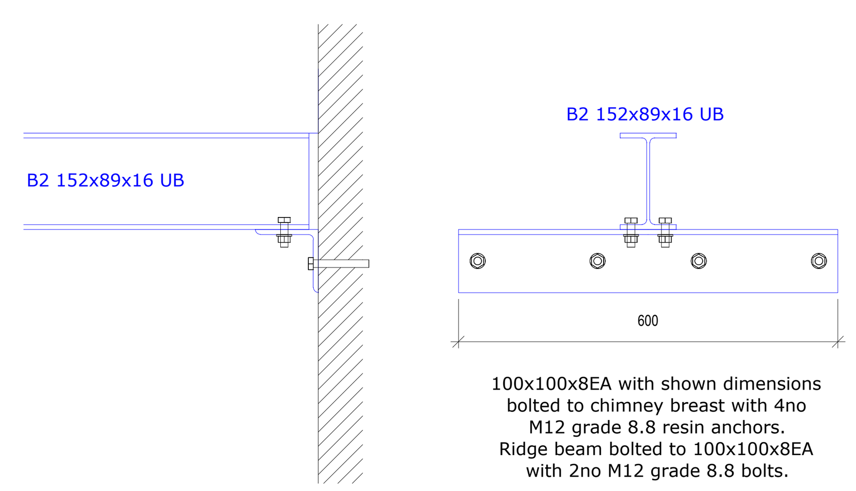
4 off M12 Grade 8.8 resin anchors bolted
down to B4 top flange. 200x200x10mm thick
base plate 6mm fillet weld round.

C1 top plate



4 off M12 Grade 8.8 resin anchors bolted
to B1 bottom flange. 200x200x10mm thick
base plate 6mm fillet weld round.

B2 to chimney breast connection



100x100x8EA with shown dimensions
bolted to chimney breast with 4no
M12 grade 8.8 resin anchors.
Ridge beam bolted to 100x100x8EA
with 2no M12 grade 8.8 bolts.

Structural Calculations Ltd
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www.structuralcalculation.co.uk

Project	Brook House			Job no.	JP1524
Drawing	Proposed First Floor			Sheet no.	A
Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	Scale nts @A1	revision rev B

IF IN DOUBT - ASK
ALL DIMS TO BE CHECKED ON SITE.

ALL DIMS IN MM

IF IN DOUBT - ASK

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Project	Brook House			Job no.	JP1524
Drawing	Proposed Ground Floor			Sheet no.	B
Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	Scale nts @A1	revision rev B

Structural Calculation ltd

Mobbs Wood Farm,
Coventry, CV7 9JN

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10/01/2020

Start of supporting Calculations

General Imposed Load Values		extracts from BS6399 Part 1
	UDL	Point
Domestic and residential	1.5	1.4
Offices	2.5	2.7
Factories workshops etc.	5	4.5
Roof super imposed	0.6	0.9
Balconies	same as room to which they give access.	

General Dead Load Values	
	UDL
Timber Joist suspended floor	0.5
Timber Joist with ceiling underneath	0.7
Concrete slab 150mm thick	3.7
Concrete slab 200mm thick	4.8
Mezzanine floor joists + boards	0.4
Ceiling only	0.2
Ceiling plus loft storage	1.3
5mm thick steel sheet	0.4

General Dead Load Values	
	kN/m3
Stud wall plasterboard	5.48
Brick/block solid	19.6
Brick/block solid + finishes	18.4
Brick/block 2 skin + sml cavity + finishes	16.6
Brick/block 2 skin + 100mm cavity + finishes	13.1
Lght weight block solid	7.9
Lght weight block inner Brick outer + finishes	10.2

General Roof Load Values				
		kN/m2		
Roof Tiles	Concrete	0.69	Slate	0.39
Roof Battens & Felt		0.05		
Roof Rafters		0.09		
Roof Insulation		0.10		
Roof Plasterboard lining		0.05		
Roof Services		0.10		
Roof and Ceiling Superimposed Load		0.60		
Roof Snow load		0.50		

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project: Brook House				Job no.: JP1524	
	Section: Beam B1				Sheet no./rev: 1	
	Calcs by: AM	date: 10/01/2020	Chk'd by: JP	date: 10/01/2020	App'd by: JP	date: 10/01/2020

Beam B1 **UC** **203x203x52 UC**

SUMMARY OF RESULTS

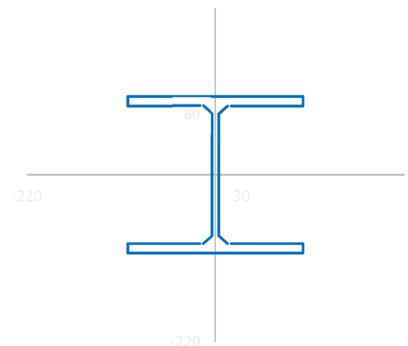
Max Applied Moment =	49.3 kNm	< 140.25 kNm	**OK**
Max Applied Shear =	28.2 kN	< 268.78 kN	**OK**
Max Deflection LL =	2.4 mm	< 19.44 mm	**OK**
Max Buckling =	49.3 kNm	< 64.5 kNm	**OK**

Span = **7** meters

Support positions

Distance from end Support A 0.00 m Support B 7.000 m

Support conditions Bottom flange to supports



Loading

Roof Super load both sides, spaning 2.8 m & 2.8 m

Imposed: Critical case udl load, 0.3 x 5.6 / 2 = 0.84 kN/m

45 degree Pitched roof Concrete Marley either side

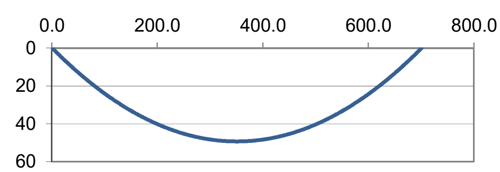
Dead: udl load, 1.08 / cos(45) x 5.6 / 2 = 4.276 kN/m

unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
19.69 kN	28.16 kN		19.69 kN	28.16 kN

Class 1 Plastic

Bending Moment (ULS)

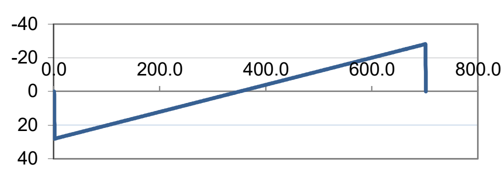
Actual moment =	49.27	*kNm*
Allowable moment =	140.25	*kNm*
Capacity	**35%**	
	LTB (ULS)	
Actual Buckling resistance =	64.51	*kNm*
Capacity	**76%**	



Bending moment diagram

Shear (ULS)

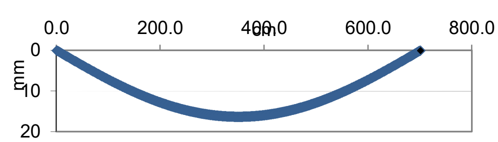
Actual shear =	28.16	*kN*
Allowable shear =	268.78	*kN*
Low shear present		
Capacity	**10%**	



Shear force diagram

Deflection (SLS)

Total deflection =	16.31	*mm*	*(L/429)*
Actual deflection LL =	2.44	*mm*	*(L/2869)*
Allowable deflection LL =	*19.44*	*mm*	*(L/360)*
Capacity	**58%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = **28.16** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**3.6N Blockwork**			
Characteristic strength of masonry =	**2.6**	N/mm²		
Width of beam end bearing =	**204.3**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	1.38	N/mm²	
Capacity	**127%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**440**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	1.38	N/mm²	
Capacity	**25%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.64	N/mm²	
Capacity	**59%**		**OK**

Structural Calculation Ltd, Mobbs Wood Farm, Coventry, CV7 9JN	Project: Brook House			Job no: JP1524	
	Section: Column C1			Sheet no./rev: 3	
	Calcs by: AM	date: 10/01/2020	Chk'd by: JP / date: 10/01/2020	App'd by: JP	date: 10/01/2020

Column C1 **SHS** **100x100x6.3**

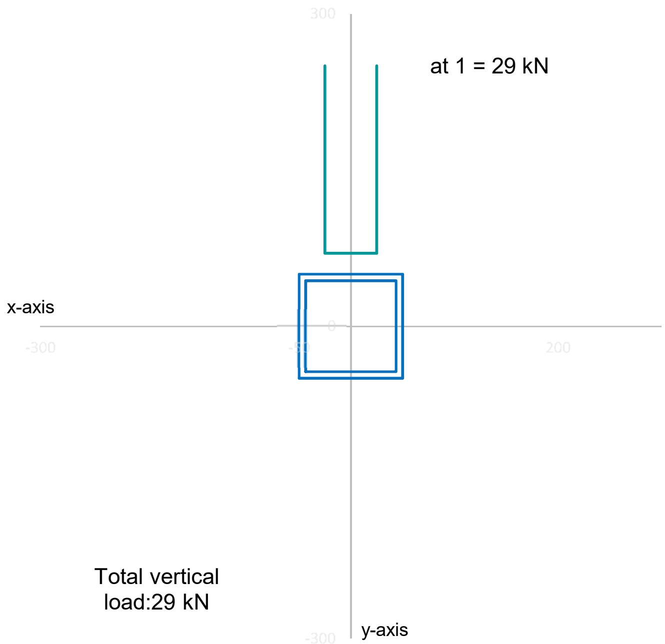
Height = **3.650** meters

SUMMARY OF RESULTS

Nominal effective length 'L_{Ex} / L_{Ey}' *[mm]* =	4380 / 4380	
Compression resistance:	295 kN > 29 kN	**OK**
Buckling resistance:	20 kNm > 9 kNm	**OK**
Overall check:	0.80 < 1.00	**OK**

End restraint

Top x-x:	Not held in position but restrained in direction
Top y-y:	Not held in position but restrained in direction
Btm. x-x:	Effectively held in position and restrained in direction
Btm. y-y:	Effectively held in position and restrained in direction



Effecting length factors

For x-x axis 'L_{Fx-x}' = 1.20

For y-y axis 'L_{Fy-y}' = 1.20

Loading

Imposed Direct compression 'PL' [kN] =

Dead Direct compression 'PL' *[kN]* =

	at 1	*at 2*	*at 3*	*at 4*
Eccentricity	**100**			
LL Reaction	**2.9**			
DL Reaction	**16.8**			

Applied moment about x-x axis 'M_{xx}' *[kNm]* = **4.15**

Applied moment about y-y axis 'M_{yy}' *[kNm]* =

Section is class 1 plastic

NOTE: Loads are factored.

Steel Grade:	**S275**
Resultant moment about x-x axis 'M_{xx}' *[kNm]* =	8.37
Resultant moment about y-y axis 'M_{yy}' *[kNm]* =	5.14

Compression resistance

Reduced design strength 'p_{yr}' *[MPa]* =	N/A
Slenderness for x-x axis 'λ_x' =	115.3
Slenderness for y-y axis 'λ_y' =	115.3
Strut curve for x-x axis:	a)
Strut curve for y-y axis:	a)
Parameter 'p_E' =	152.3
Robertson constant 'α' =	2.0
Limiting slenderness 'λ_0' =	17.2
Perry factor 'η' =	0.20
Parameter 'Ø' =	228.6
Compressive strength 'p_c' *[N/mm^2]* =	126.7
Based on y-y axis calculations	
Compression resistance 'P_c' *[kN]* =	294.0
Applied total vertical load 'F_c' *[kN]* =	28.2
Capacity	**10%**

Buckling resistance moment

Equivalent slenderness 'λ_{LT}':	48.0
Parameter 'p_E' =	877.2
Robertson constant α_{LT} =	7.0
Limiting equivalent slenderness 'λ_{L0}' =	34.3
Perry factor η_{LT} =	0.1
Parameter $Ø_{LT}$ =	618.2
Bending strength 'p_b' *[N/mm^2]* =	242.8
Member buckling resistance 'M_{bs}' *[kNm]* =	19.7
Applied moment about x-x 'M_{xx}' *[kNm]* =	8.4
Capacity	**43%**

Bending about Y-Y

Moment of resistance 'M_{Ry}' *[kNm]* =	18.4
Applied moment about y-y 'M_{yy}' *[kNm]* =	5.1
Capacity	**28%**

Overall check based on equation for 'simple structures'

F_c / Pc + M_x / M_{bs} + M_y / (p_y * Z_y) = 29 / 295 + 9 / 20 + 6 / (275 * 67) = 0.10 + 0.43 + 0.28 = **80%**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House			Job no. JP1524	
	Section Beam B2			Sheet no./rev 4	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B2 **UB** **152x89x16 UB**

SUMMARY OF RESULTS

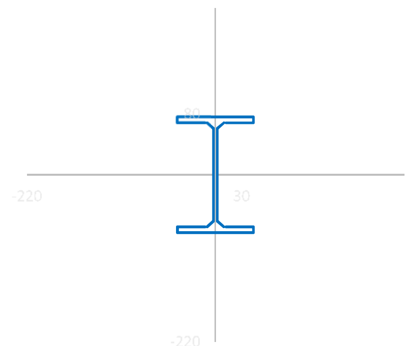
Max Applied Moment =	5.1 kNm	< 29.98 kNm	**OK**
Max Applied Shear =	6.9 kN	< 113.16 kN	**OK**
Max Deflection LL =	0.2 mm	< 7.5 mm	**OK**
Max Buckling =	5.1 kNm	< 14 kNm	**OK**

Span = **2.7** meters

Support positions

Distance from end Support A 0.00 m Support B 2.700 m

Support conditions Bottom flange to supports



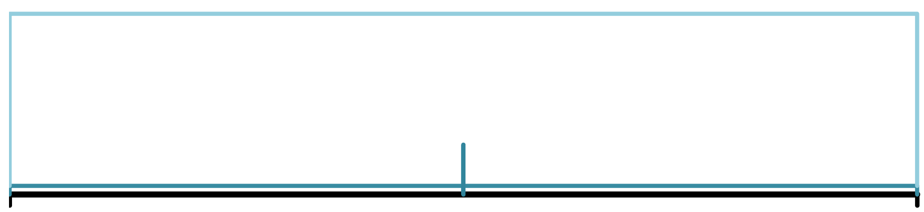
Loading

Roof Super load both sides, spaning 2.2 m & 2.2 m

Imposed: Critical case point load, 0.9 kN acting at centre span

40 degree Pitched roof Concrete Marley either side

Dead: udl load, 1.08 / cos(40) x 4.4 / 2 = 3.102 kN/m

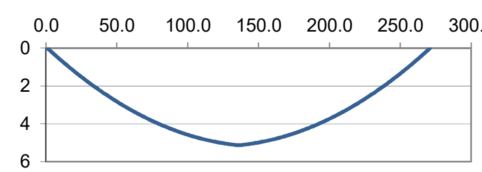


unfactorec	factored	**LOADING DIAGRAM &**	unfactored	*factored*
4.85 kN	6.88 kN	**REACTIONS**	4.85 kN	6.88 kN

Class 1 Plastic

Bending Moment (ULS)

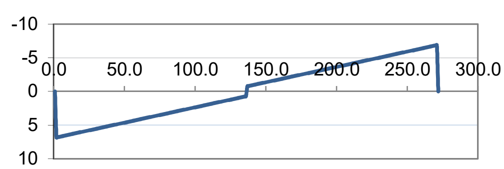
Actual moment =	5.13	*kNm*
Allowable moment =	29.98	*kNm*
Capacity	**17%**	
	LTB (ULS)	
Actual Buckling resistance =	14.00	*kNm*
Capacity	**37%**	



Bending moment diagram

Shear (ULS)

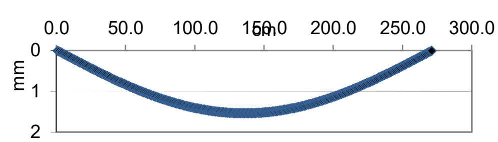
Actual shear =	6.88	*kN*
Allowable shear =	113.16	*kN*
Low shear present		
Capacity	**6%**	



Shear force diagram

Deflection (SLS)

Total deflection =	1.53	*mm*	*(L/1765)*
Actual deflection LL =	0.22	*mm*	*(L/12273)*
Allowable deflection LL =	*7.50*	*mm*	*(L/360)*
Capacity	**14%**		



Deflection

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Bearing Beam B2				Sheet no./rev 5	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam End Reaction = **6.88** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**Weak Brickwork**			
Characteristic strength of masonry =	**2.8**	N/mm²		
Width of beam end bearing =	**88.7**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.17	N/mm²
Actual Bearing Stress =	0.78	N/mm²

Capacity **66%** **Padstone Not Required**

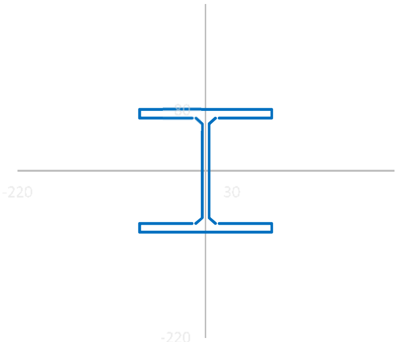
Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B3				Sheet no./rev 6	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B3 **UC** **152x152x37 UC**

SUMMARY OF RESULTS

Max Applied Moment =	26.1 kNm	< 75.08 kNm	**OK**
Max Applied Shear =	17.7 kN	< 213.58 kN	**OK**
Max Deflection LL =	2.9 mm	< 16.39 mm	**OK**
	26.1 kNm		

Span = **5.9** meters



Support positions

Distance from end Support A 0.00 m Support B 5.900 m

Support conditions Bottom flange to supports

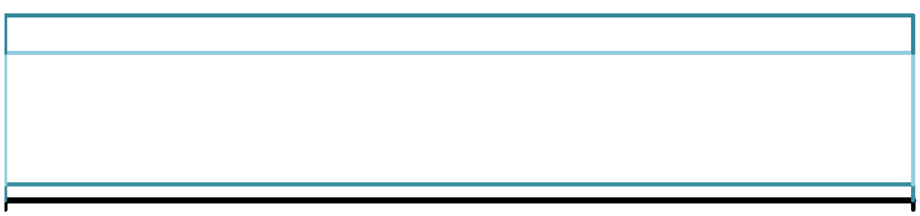
Loading

Roof Super load both sides, spaning 2.1 m & 2.1 m

Imposed: Critical case udl load, 0.4 x 4.2 / 2 = 0.84 kN/m

40 degree Pitched roof Concrete Marley either side

Dead: udl load, 1.08 / cos(40) x 4.2 / 2 = 2.961 kN/m

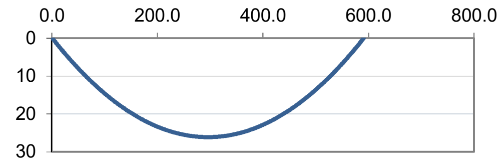


unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
12.28 kN	17.69 kN		12.28 kN	17.69 kN

Class 1 Plastic

Bending Moment (ULS)

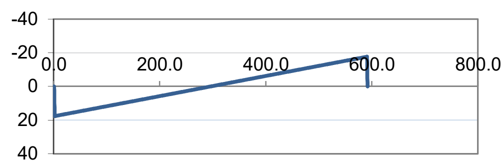
Actual moment =	26.10	*kNm*
Allowable moment =	75.08	*kNm*
Capacity	**35%**	
	LTB (ULS)	
Actual Buckling resistance =		*Fully restrained*
Capacity	**0%**	



Bending moment diagram

Shear (ULS)

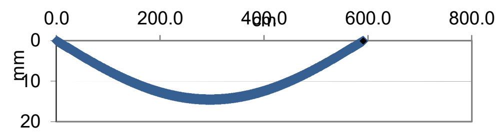
Actual shear =	17.69	*kN*
Allowable shear =	213.58	*kN*
Low shear present		
Capacity	**8%**	



Shear force diagram

Deflection (SLS)

Total deflection =	14.50	*mm*	*(L/407)*
Actual deflection LL =	2.93	*mm*	*(L/2014)*
Allowable deflection LL =	*16.39*	*mm*	*(L/360)*
Capacity	**61%**		



Deflection

Beam End Reaction = 17.69 kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**Weak Brickwork**			
Characteristic strength of masonry =	**2.8**	N/mm²		
Width of beam end bearing =	**154.4**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress = 1.17 N/mm²

Actual Bearing Stress = 1.15 N/mm²

Capacity **98%** **Padstone Not Required**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B4				Sheet no./rev 8	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B4 **UC** **203x203x46 UC**

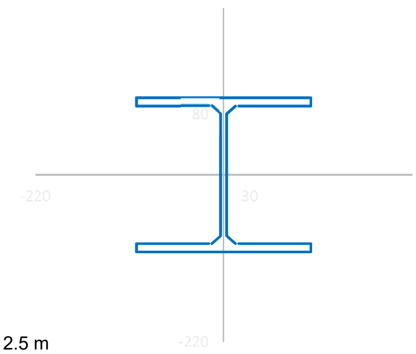
SUMMARY OF RESULTS

Max Applied Moment =	77.3 kNm	< 123.75 kNm	**OK**
Max Applied Shear =	50.3 kN	< 241.4 kN	**OK**
Max Deflection LL =	2.8 mm	< 13.33 mm	**OK**
	77.3 kNm		

Span = **4.8** meters

Support positions

Distance from end Support A 0.00 m Support B 4.800 m



Support conditions Bottom flange to supports

Loading

Domestic and residential load one side, spaning 3.8 m

Imposed: Critical case udl load, 1.5 x 3.8 / 2 = 2.85 kN/m

Timber Joist with ceiling underneath one side

Dead: udl load, 0.7 x 3.8 / 2 = 1.33 kN/m

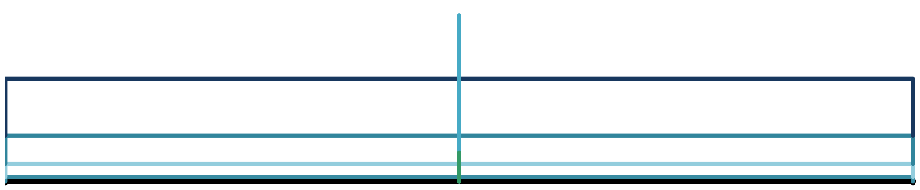
125 mm thick Brick/block solid + finishes wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 4.8 m, with a cross sectional area of 0.313 m2

Dead: Brick/block solid + finishes (18.4) x 0.313 = 5.75 kN/m

Dead: Point load, Load from C2 16.8 kN acting at 2.4 m from the support

Imposed: Point load, Load from C2 2.9 kN acting at 2.4 m from the support

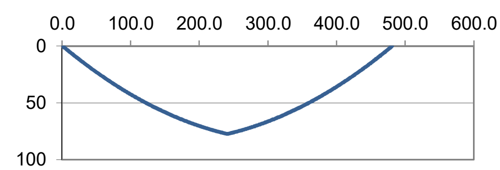


unfactored	factored		unfactored	*factored*
34.77 kN	50.33 kN	**LOADING DIAGRAM & REACTIONS**	34.77 kN	50.33 kN

Class 2 Compact

Bending Moment (ULS)

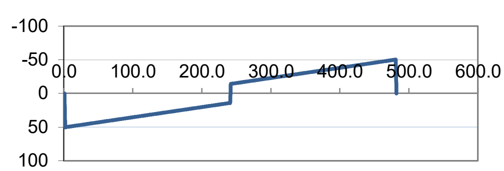
Actual moment =	77.29	*kNm*
Allowable moment =	123.75	*kNm*
Capacity	**62%**	
	LTB (ULS)	
Actual Buckling resistance =		*Fully restrained*
Capacity	**0%**	



Bending moment diagram

Shear (ULS)

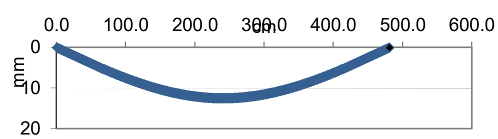
Actual shear =	50.33	*kN*
Allowable shear =	241.40	*kN*
Low shear present		
Capacity	**21%**	



Shear force diagram

Deflection (SLS)

Total deflection =	12.50	*mm*	*(L/384)*
Actual deflection LL =	2.82	*mm*	*(L/1702)*
Allowable deflection LL =	*13.33*	*mm*	*(L/360)*
Capacity	**65%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = 50.33 kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type = 3.6N Blockwork
Characteristic strength of masonry = 2.6 N/mm²

Width of beam end bearing = 203.6 mm
Length of beam end bearing = 150 mm

Bearing factor = 1.25
γm = 3.00

Stress

Maximum Bearing Stress = 1.08 N/mm²

Actual Bearing Stress = 1.65 N/mm²

Capacity **152%** **Padstone Required**

Padstone

A Engineering Brick
Characteristic strength of padstone = 13.2 N/mm²

Width of padstone = 200 mm
Length of padstone = 300 mm

Maximum bearing stress padstone = 5.50 N/mm²
Stress under beam = 1.65 N/mm²
Capacity **30%** **OK**

Maximum bearing stress masonry 1.08 N/mm²
Stress under padstone = 0.84 N/mm²
Capacity **77%** **OK**

Beam End Reaction =	50.33	kN (factored)	Variable Load Safety Factor = 1.6 Permanent Load Safety Factor = 1.4	

Masonry

Masonry type =	3.6N Blockwork			
Characteristic strength of masonry =	2.6	N/mm²		
Width of beam end bearing =	203.6	mm	Bearing factor =	1.25
Length of beam end bearing =	100	mm	γm =	3.00

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	2.47	N/mm²	
Capacity	**228%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	13.2	N/mm²	
Width of padstone =	100	mm	
Length of padstone =	640	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	2.47	N/mm²	
Capacity	**45%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.79	N/mm²	
Capacity	**73%**		**OK**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B5				Sheet no./rev 11	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B5 **UC** **203x203x46 UC**

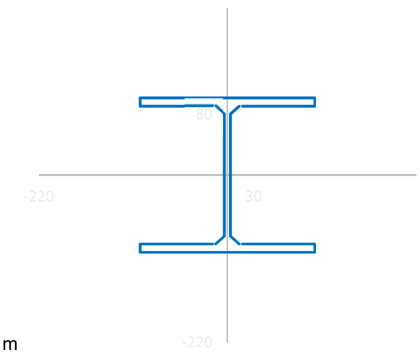
SUMMARY OF RESULTS

Max Applied Moment =	41.8 kNm	< 123.75 kNm	**OK**
Max Applied Shear =	31 kN	< 241.4 kN	**OK**
Max Deflection LL =	4.4 mm	< 15 mm	**OK**
	41.8 kNm		

Span = **5.4** meters

Support positions

Distance from end Support A 0.00 m Support B 5.400 m



Support conditions Bottom flange to supports

Loading

Domestic and residential load both sides, spaning 2.5 m & 2.5 m

Imposed: Critical case udl load, 1.5 x 5 / 2 = 3.75 kN/m

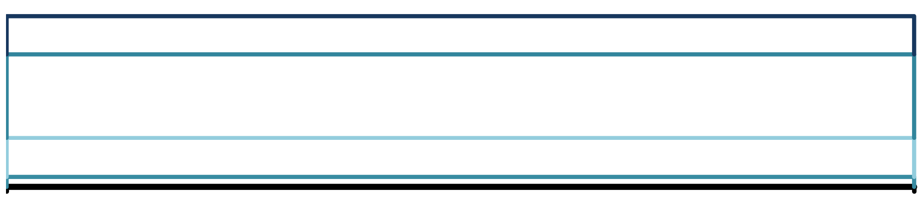
Timber Joist with ceiling underneath either side

Dead: udl load, 0.7 x 5 / 2 = 1.75 kN/m

125 mm thick Stud wall plasterboard wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 5.4 m, with a cross sectional area of 0.313 m2

Dead: Stud wall plasterboard (5.48) x 0.313 = 1.7125 kN/m

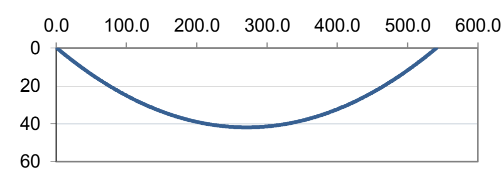


unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
20.69 kN	31 kN		20.69 kN	31 kN

Class 2 Compact

Bending Moment (ULS)

Actual moment =	41.84	*kNm*
Allowable moment =	123.75	*kNm*
Capacity	**34%**	



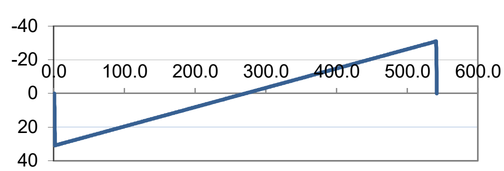
Bending moment diagram

LTB (ULS)

Actual Buckling resistance =		*Fully restrained*
Capacity	**0%**	

Shear (ULS)

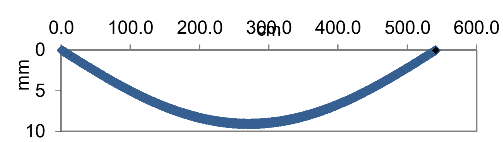
Actual shear =	31.00	*kN*
Allowable shear =	241.40	*kN*
Low shear present		
Capacity	**13%**	



Shear force diagram

Deflection (SLS)

Total deflection =	9.06	*mm*	*(L/596)*
Actual deflection LL =	4.43	*mm*	*(L/1219)*
Allowable deflection LL =	*15.00*	*mm*	*(L/360)*
Capacity	**42%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = **31.00** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type = **Weak Brickwork**
Characteristic strength of masonry = **2.8** N/mm²

Width of beam end bearing = **203.6** mm   Bearing factor = **1.25**
Length of beam end bearing = **100** mm   γm = **3.00**

Stress

Maximum Bearing Stress = 1.17 N/mm²

Actual Bearing Stress = 1.52 N/mm²

Capacity **130%** **Padstone Required**

Padstone

Concrete C30

Characteristic strength of padstone = **30** N/mm²

Width of padstone = **100** mm
Length of padstone = **440** mm

Maximum bearing stress padstone = 12.50 N/mm²
Stress under beam = 1.52 N/mm²
Capacity **12%** **OK**

Maximum bearing stress masonry 1.17 N/mm²
Stress under padstone = 0.70 N/mm²
Capacity **60%** **OK**

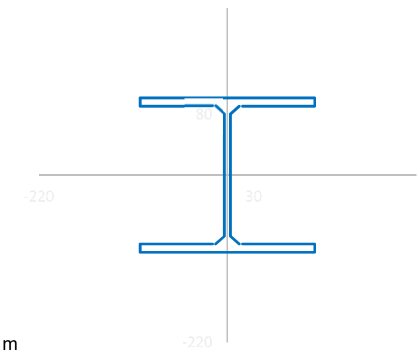
Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B6				Sheet no./rev 13	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B6 **UC** **203x203x46 UC**

SUMMARY OF RESULTS

Max Applied Moment =	60.1 kNm	< 123.75 kNm	**OK**
Max Applied Shear =	38.5 kN	< 241.4 kN	**OK**
Max Deflection LL =	4.1 mm	< 13.06 mm	**OK**
	60.1 kNm		

Span = **4.7** meters



Support positions

Distance from end Support A 0.00 m Support B 4.700 m

Support conditions Bottom flange to supports

Loading

Domestic and residential load one side, spaning 3.5 m

Imposed: Critical case udl load, 1.5 x 3.5 / 2 = 2.625 kN/m

Timber Joist with ceiling underneath one side

Dead: udl load, 0.7 x 3.5 / 2 = 1.225 kN/m

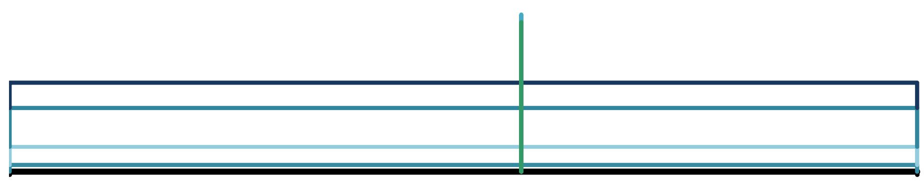
125 mm thick Stud wall plasterboard wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 4.7 m, with a cross sectional area of 0.313 m2

Dead: Stud wall plasterboard (5.48) x 0.313 = 1.7125 kN/m

Dead: Point load, Load from B5 10.6 kN acting at 2.65 m from the support

Imposed: Point load, Load from B5 10.1 kN acting at 2.65 m from the support



unfactored	factored		unfactored	*factored*
23.16 kN	34.54 kN	**LOADING DIAGRAM & REACTIONS**	25.8 kN	38.5 kN

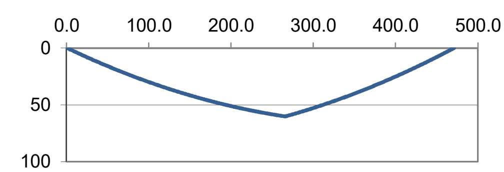
Class 2 Compact

Bending Moment (ULS)

Actual moment =	60.13	*kNm*
Allowable moment =	123.75	*kNm*
Capacity	**49%**	

LTB (ULS)

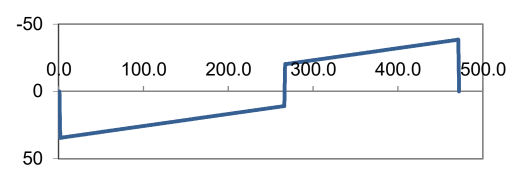
Actual Buckling resistance =		*Fully restrained*
Capacity	**0%**	



Bending moment diagram

Shear (ULS)

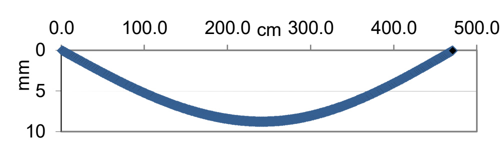
Actual shear =	38.50	*kN*
Allowable shear =	241.40	*kN*
Low shear present		
Capacity	**16%**	



Shear force diagram

Deflection (SLS)

Total deflection =	8.75	*mm*	*(L/537)*
Actual deflection LL =	4.06	*mm*	*(L/1158)*
Allowable deflection LL =	*13.06*	*mm*	*(L/360)*
Capacity	**47%**		



Deflection

calculations are based on **BS5950**:1-2000

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Bearing Beam B6				Sheet no./rev 14	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam End Reaction = 38.50 kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	Weak Brickwork			
Characteristic strength of masonry =	2.8	N/mm²		
Width of beam end bearing =	203.6	mm	Bearing factor =	**1.25**
Length of beam end bearing =	100	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.17	N/mm²	
Actual Bearing Stress =	1.89	N/mm²	
Capacity	**162%**		**Padstone Required**

Padstone

Concrete C30

Characteristic strength of padstone =	30	N/mm²	
Width of padstone =	100	mm	
Length of padstone =	660	mm	
Maximum bearing stress padstone =	12.50	N/mm²	
Stress under beam =	1.89	N/mm²	
Capacity	**15%**		**OK**
Maximum bearing stress masonry	1.17	N/mm²	
Stress under padstone =	0.58	N/mm²	
Capacity	**50%**		**OK**

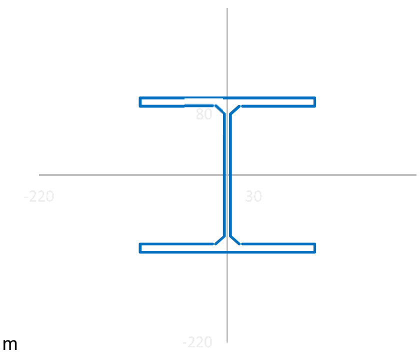
Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House			Job no. JP1524	
	Section Beam B7			Sheet no./rev 15	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B7 **UC** **203x203x46 UC**

SUMMARY OF RESULTS

Max Applied Moment =	40.1 kNm	< 123.75 kNm	**OK**
Max Applied Shear =	45.7 kN	< 241.4 kN	**OK**
Max Deflection LL =	2.3 mm	< 12.22 mm	**OK**
	40.1 kNm		

Span = **4.4** meters



Support positions

Distance from end Support A 0.00 m Support B 4.400 m

Support conditions Bottom flange to supports

Loading

Domestic and residential load one side, spaning 2.3 m

Imposed: Critical case udl load, 1.5 x 2.3 / 2 = 1.725 kN/m

Timber Joist with ceiling underneath one side

Dead: udl load, 0.7 x 2.3 / 2 = 0.805 kN/m

125 mm thick Stud wall plasterboard wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 4.4 m, with a cross sectional area of 0.313 m2

Dead: Stud wall plasterboard (5.48) x 0.313 = 1.7125 kN/m

Dead: UDL load, Timber Joist with ceiling underneath either side 1.68 kN/m acting from 3.4 m to 4.4 m

Imposed: UDL load, Domestic and residential Critical case UDL 3.6 kN/m acting from 3.4 m to 4.4 m

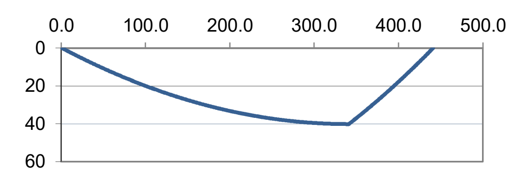
Dead: Point load, Load from B6 12.6 kN acting at 3.4 m from the support

unfactored	factored		unfactored	factored
15.91 kN	23.56 kN	**LOADING DIAGRAM & REACTIONS**	30.69 kN	45.7 kN

Class 2 Compact

Bending Moment (ULS)

Actual moment =	40.13	*kNm*
Allowable moment =	123.75	*kNm*
Capacity	**32%**	



Bending moment diagram

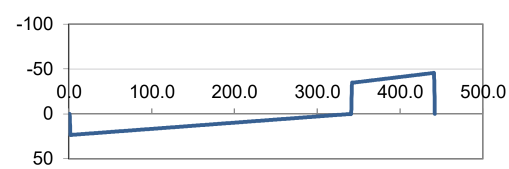
LTB (ULS)

Actual Buckling resistance = *Fully restrained*

Capacity **0%**

Shear (ULS)

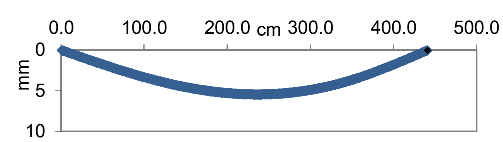
Actual shear =	45.70	*kN*
Allowable shear =	241.40	*kN*
Low shear present		
Capacity	**19%**	



Shear force diagram

Deflection (SLS)

Total deflection =	5.44	*mm*	*(L/809)*
Actual deflection LL =	2.31	*mm*	*(L/1905)*
Allowable deflection LL =	*12.22*	*mm*	*(L/360)*
Capacity	**31%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = **80.26** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**3.6N Blockwork**			
Characteristic strength of masonry =	**2.6**	N/mm²		
Width of beam end bearing =	**203.6**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	3.94	N/mm²	
Capacity	**364%**		**Padstone Required**

Padstone

Concrete C30

Characteristic strength of padstone =	**30**	N/mm²	
Width of padstone =	**215**	mm	
Length of padstone =	**440**	mm	
Maximum bearing stress padstone =	12.50	N/mm²	
Stress under beam =	3.94	N/mm²	
Capacity	**32%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.85	N/mm²	
Capacity	**78%**		**OK**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B8				Sheet no./rev 17	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B8 **UC** **152x152x23 UC**

SUMMARY OF RESULTS

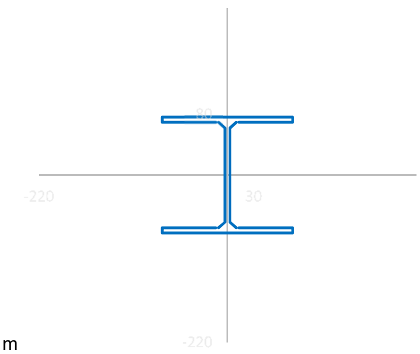
Max Applied Moment =	14.3 kNm	< 45.1 kNm	**OK**
Max Applied Shear =	17.9 kN	< 145.85 kN	**OK**
Max Deflection LL =	2 mm	< 8.89 mm	**OK**
	14.3 kNm		

Span = **3.2** meters

Support positions

Distance from end Support A 0.00 m Support B 3.200 m

Support conditions Bottom flange to supports



Loading

Domestic and residential load both sides, spaning 2.5 m & 2.5 m

Imposed: Critical case udl load, 1.5 x 5 / 2 = 3.75 kN/m

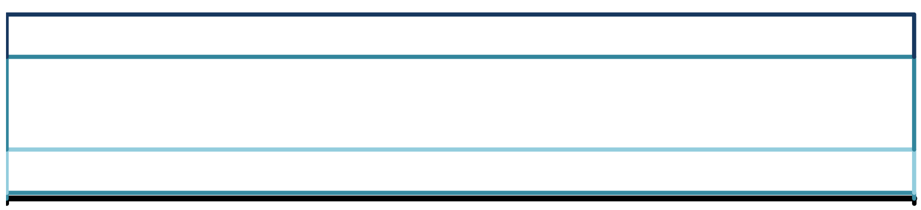
Timber Joist with ceiling underneath either side

Dead: udl load, 0.7 x 5 / 2 = 1.75 kN/m

125 mm thick Stud wall plasterboard wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 3.2 m, with a cross sectional area of 0.313 m2

Dead: Stud wall plasterboard (5.48) x 0.313 = 1.7125 kN/m

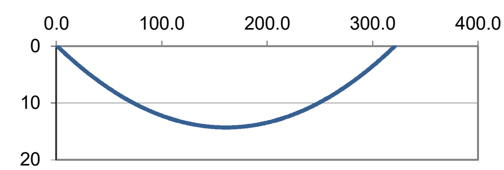


unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
11.9 kN	17.86 kN		11.9 kN	17.86 kN

Class 3 Semi-compact

Bending Moment (ULS)

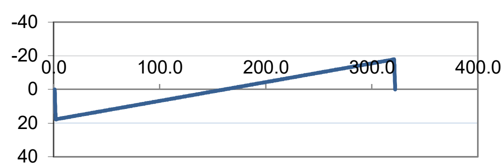
Actual moment =	14.29	*kNm*
Allowable moment =	45.10	*kNm*
Capacity	**32%**	
	LTB (ULS)	
Actual Buckling resistance =	27.30	*Fully restrained*
Capacity	**0%**	



Bending moment diagram

Shear (ULS)

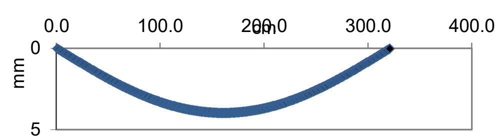
Actual shear =	17.86	*kN*
Allowable shear =	145.85	*kN*
Low shear present		
Capacity	**12%**	



Shear force diagram

Deflection (SLS)

Total deflection =	3.96	*mm*	*(L/808)*
Actual deflection LL =	2.00	*mm*	*(L/1600)*
Allowable deflection LL =	*8.89*	*mm*	*(L/360)*
Capacity	**31%**		



Deflection

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House			Job no. JP1524	
	Section Bearing Beam B8			Sheet no./rev 18	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam End Reaction =	**17.86**	kN (factored)	Variable Load Safety Factor = 1.6 Permanent Load Safety Factor = 1.4	

Masonry

Masonry type =	**Weak Brickwork**			
Characteristic strength of masonry =	**2.8**	N/mm²		
Width of beam end bearing =	**152.2**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.17	N/mm²	
Actual Bearing Stress =	1.17	N/mm²	
Capacity	**101%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**215**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	1.17	N/mm²	
Capacity	**21%**		**OK**
Maximum bearing stress masonry	1.17	N/mm²	
Stress under padstone =	0.83	N/mm²	
Capacity	**71%**		**OK**

Beam B9 **Timber beam 75x145dp (C24)**

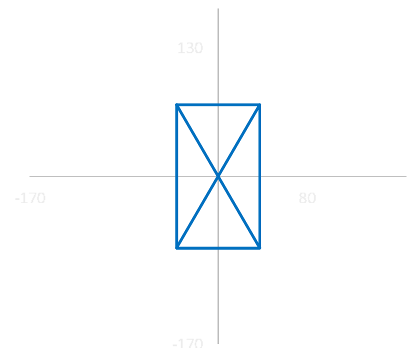
SUMMARY OF RESULTS

Max Applied Moment =	2.38 kNm < 2.96 kNm	**OK**
Max Applied Shear =	3.81 kN < 7.72 kN	**OK**
Max Deflection =	5.14 mm < 6.3 mm	**OK**

Span = **2.1** meters

Member Type Timber beam
Timber Grade = C24
Timber Class = 2 Solid Timber
E min [MPa] = 7200

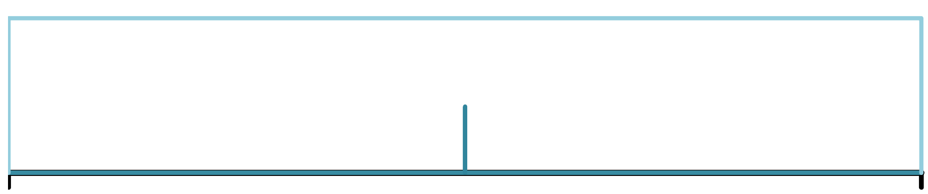
Section details
Depth 'h' [*mm*] = 145
Width 'b' [*mm*] = 75
I [*cm4*] = 1905
Z [*cm3*] = 263



K_3 Duration of Loading Short term

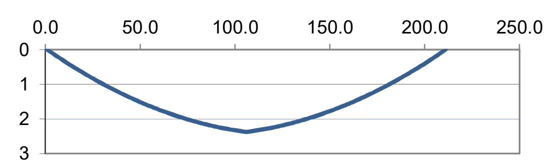
Loading
Roof Super load both sides, spaning 1.25 m & 1.25 m
Imposed: Critical case point load, 0.9 kN acting at centre span

50 degree Pitched roof Concrete Marley either side
Dead: udl load, 1.08 / cos(50) x 2.5 / 2 = 2.1 kN/m



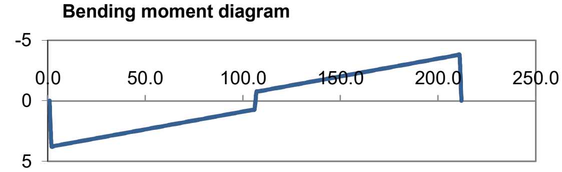
Unfactored	*Factored*		**LOADING DIAGRAM & REACTIONS**	*Unfactored*	*Factored*	
2.66	3.81	*kN*		2.66	3.81	*kN*

Bending Stress
Bending Stress = 7.50 N/mm^2
(K2 x K3 x K7 x K8) x σ
Allowable Design Bending Stress = 11.25 N/mm^2
Applied Bending Stress = 9.06 N/mm^2
Capacity **80%**



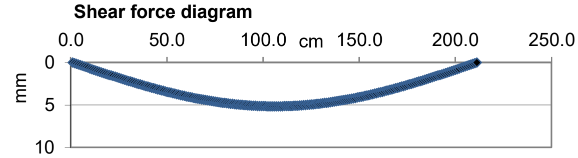
Bending moment diagram

Shear Stress
Shear Stress = 0.71 N/mm^2
(K2 x K3 x K5 x K8) x σ
Allowable Design Shear Stress = 1.07 N/mm^2
Applied Shear Stress = 0.53 N/mm^2
Capacity **49%**



Shear force diagram

Deflection
Actual deflection = 5.14 *mm*
Allowable deflection = 6.30 *mm*
Capacity **82%**



Deflection

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B10_External				Sheet no./rev 20	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B10_External **UB** **178x102x19 UB**

SUMMARY OF RESULTS

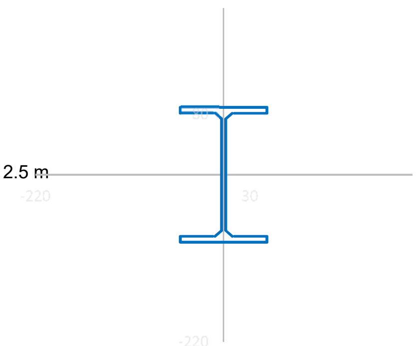
Max Applied Moment =	16 kNm	< 42.08 kNm	**OK**
Max Applied Shear =	17.6 kN	< 140.82 kN	**OK**
Max Deflection LL =	0.2 mm	< 10.06 mm	**OK**
	16 kNm		

Span = **3.62** meters

Support positions

Distance from end Support A 0.00 m Support B 3.620 m

Support conditions Bottom flange to supports



Loading

125 mm thick Brick/block solid + finishes wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 3.62 m, with a cross sectional area of 0.313 m2

Dead: Brick/block solid + finishes (18.4) x 0.313 = 5.75 kN/m

Dead: Point load, Load from B9 2.2 kN acting at 1.2 m from the support

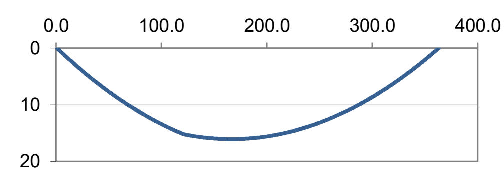
Imposed: Point load, Load from B9 0.5 kN acting at 1.2 m from the support

unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
12.55 kN	17.64 kN		11.64 kN	16.33 kN

Class 1 Plastic

Bending Moment (ULS)

Actual moment =	16.04	*kNm*
Allowable moment =	42.08	*kNm*
Capacity	**38%**	



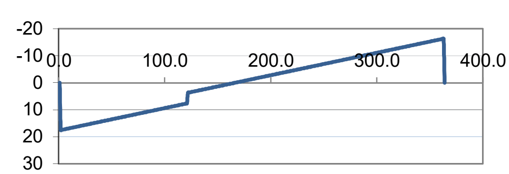
Bending moment diagram

LTB (ULS)

Actual Buckling resistance =		*Fully restrained*
Capacity	**0%**	

Shear (ULS)

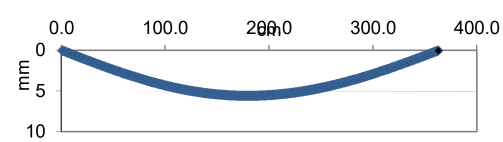
Actual shear =	17.55	*kN*
Allowable shear =	140.82	*kN*
Low shear present		
Capacity	**12%**	



Shear force diagram

Deflection (SLS)

Total deflection =	5.57	*mm*	*(L/650)*
Actual deflection LL =	0.15	*mm*	*(L/24133)*
Allowable deflection LL =	*10.06*	*mm*	*(L/360)*
Capacity	**38%**		



Deflection

calculations are based on **BS5950**:1-2000

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B5_internal				Sheet no./rev 21	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B5_internal **UB** **203x102x23 UB**

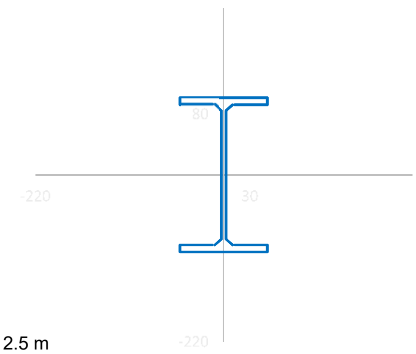
SUMMARY OF RESULTS

Max Applied Moment =	35.3 kNm	< 56.93 kNm	**OK**
Max Applied Shear =	39 kN	< 181.05 kN	**OK**
Max Deflection LL =	2.1 mm	< 10.06 mm	**OK**
	35.3 kNm		

Span = **3.62** meters

Support positions

Distance from end Support A 0.00 m Support B 3.620 m



Support conditions Bottom flange to supports

Loading

Roof Super load one side, spaning 4.4 m

Imposed: Critical case udl load, 0.3 x 4.4 / 2 = 0.66 kN/m

45 degree Pitched roof Concrete Marley one side

Dead: udl load, 1.08 / cos(45) x 4.4 / 2 = 3.359 kN/m

125 mm thick Brick/block solid + finishes wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 3.62 m, with a cross sectional area of 0.313 m2

Dead: Brick/block solid + finishes (18.4) x 0.313 = 5.75 kN/m

Dead: UDL load, Timber Joist with ceiling underneath one side 1.54 kN/m acting from 0 m to 3.62 m

Imposed: UDL load, Domestic and residential Critical case UDL 3.3 kN/m acting from 0 m to 3.62 m

unfactored	factored		unfactored	*factored*
26.85 kN	39.02 kN	**LOADING DIAGRAM & REACTIONS**	26.85 kN	39.02 kN

Class 1 Plastic

Bending Moment (ULS)

Actual moment = 35.32 *kNm*

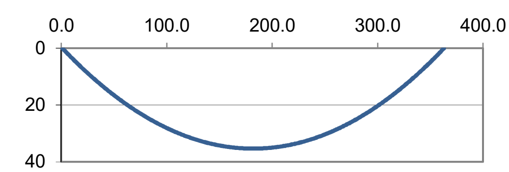
Allowable moment = 56.93 *kNm*

Capacity **62%**

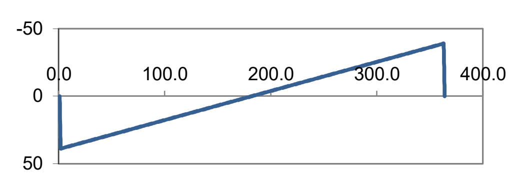
LTB (ULS)

Actual Buckling resistance = *Fully restrained*

Capacity **0%**



Bending moment diagram



Shear force diagram

Shear (ULS)

Actual shear = 39.02 *kN*

Allowable shear = 181.05 *kN*

Low shear present

Capacity **22%**

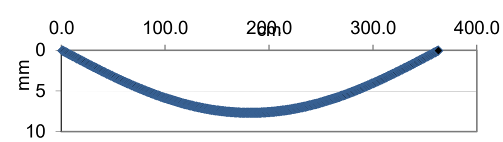
Deflection (SLS)

Total deflection = 7.67 *mm* *(L/472)*

Actual deflection LL = 2.05 *mm* *(L/1766)*

Allowable deflection LL = *10.06* *mm* *(L/360)*

Capacity **53%**



Deflection

calculations are based on **BS5950**:1-2000

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B11				Sheet no./rev 22	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B11 **UB** **152x89x16 UB**

SUMMARY OF RESULTS

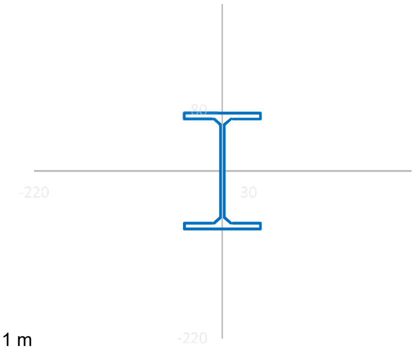
Max Applied Moment =	12.1 kNm < 29.98 kNm		**OK**
Max Applied Shear =	42.4 kN	< 113.16 kN	**OK**
Max Deflection LL =	0.1 mm	< 2.53 mm	**OK**
Max Buckling =	12.1 kNm < 33.7 kNm		**OK**

Span = **0.91** meters

Support positions

Distance from end Support A 0.00 m Support B 0.910 m

Support conditions Bottom flange to supports



Loading

Domestic and residential load one side, spaning 4.2 m

Imposed: Critical case udl load, 1.5 x 4.2 / 2 = 3.15 kN/m

Timber Joist with ceiling underneath one side

Dead: udl load, 0.7 x 4.2 / 2 = 1.47 kN/m

250 mm thick Brick/block solid + finishes wall above running In line with the beam, to a height of 1 m

Wall runs from 0 m to 0.91 m, with a cross sectional area of 0.25 m2

Dead: Brick/block solid + finishes (18.4) x 0.25 = 4.6 kN/m

Dead: Point load, Load from B10 30.4 kN acting at 0.3 m from the support

Imposed: Point load, Load from B10 7.2 kN acting at 0.3 m from the support

unfactorec	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
29.47 kN	42.51 kN		16.66 kN	24.09 kN

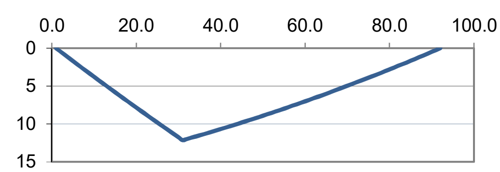
Class 1 Plastic

Bending Moment (ULS)

Actual moment =	12.13	*kNm*
Allowable moment =	29.98	*kNm*
Capacity	**40%**	

LTB (ULS)

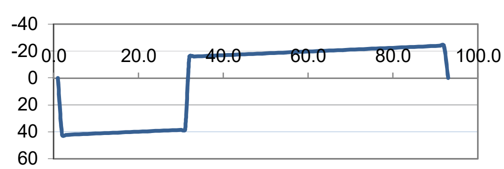
Actual Buckling resistance =	33.71	*kNm*
Capacity	**36%**	



Bending moment diagram

Shear (ULS)

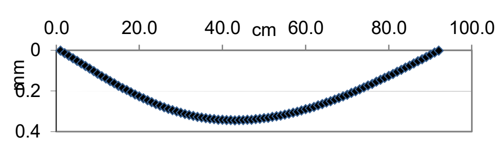
Actual shear =	42.37	*kN*
Allowable shear =	113.16	*kN*
Low shear present		
Capacity	**37%**	



Shear force diagram

Deflection (SLS)

Total deflection =	0.34	*mm*	*(L/2676)*
Actual deflection LL =	0.07	*mm*	*(L/13000)*
Allowable deflection LL =	*2.53*	*mm*	*(L/360)*
Capacity	**9%**		



Deflection

calculations are based on **BS5950**:1-2000

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Bearing Beam B11				Sheet no./rev 23	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam End Reaction = 42.51 kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	Weak Brickwork			
Characteristic strength of masonry =	2.8	N/mm²		
Width of beam end bearing =	88.7	mm	Bearing factor =	1.25
Length of beam end bearing =	150	mm	γm =	3.00

Stress

Maximum Bearing Stress =	1.17	N/mm²	
Actual Bearing Stress =	3.20	N/mm²	
Capacity	**274%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	13.2	N/mm²	
Width of padstone =	100	mm	
Length of padstone =	440	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	3.20	N/mm²	
Capacity	**58%**		**OK**
Maximum bearing stress masonry	1.17	N/mm²	
Stress under padstone =	0.97	N/mm²	
Capacity	**83%**		**OK**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project	Brook House		Job no.	JP1524
	Section	Beam B12		Sheet no./rev	24
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B12 **UC** **203x203x46 UC**

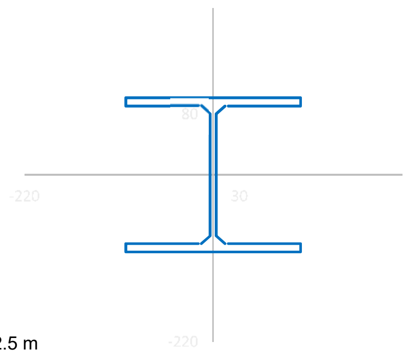
SUMMARY OF RESULTS

Max Applied Moment =	42.4 kNm < 123.75 kNm	**OK**
Max Applied Shear =	49.9 kN < 241.4 kN	**OK**
Max Deflection LL =	0.7 mm < 9.44 mm	**OK**
Max Buckling =	42.4 kNm < 91.5 kNm	**OK**

Span = **3.4** meters

Support positions

Distance from end Support A 0.00 m Support B 3.400 m



Support conditions Bottom flange to supports

Loading

Roof Super load one side, spaning 4.2 m

Imposed: Critical case udl load, 0.3 x 4.2 / 2 = 0.63 kN/m

45 degree Pitched roof Concrete Marley one side

Dead: udl load, 1.08 / cos(45) x 4.2 / 2 = 3.207 kN/m

250 mm thick Brick/block solid + finishes wall above running In line with the beam, to a height of 2.5 m

Wall runs from 0 m to 3.4 m, with a cross sectional area of 0.625 m2

Dead: Brick/block solid + finishes (18.4) x 0.625 = 11.5 kN/m

Dead: UDL load, Timber Joist with ceiling underneath one side 1.47 kN/m acting from 0 m to 3.4 m

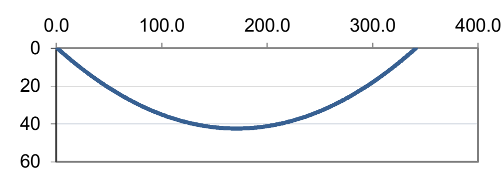
Imposed: UDL load, Domestic and residential Critical case UDL 3.15 kN/m acting from 0 m to 3.4 m

unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
34.69 kN	49.86 kN		34.69 kN	49.86 kN

Class 2 Compact

Bending Moment (ULS)

Actual moment =	42.38	*kNm*
Allowable moment =	123.75	*kNm*
Capacity	**34%**	



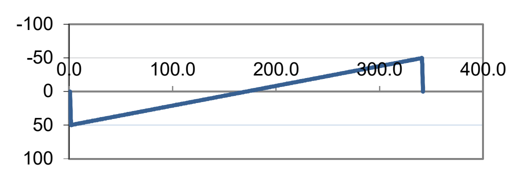
Bending moment diagram

LTB (ULS)

Actual Buckling resistance =	91.46	*kNm*
Capacity	**46%**	

Shear (ULS)

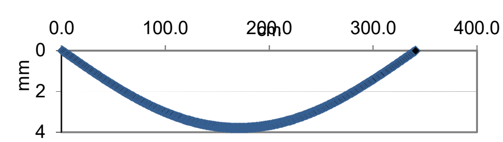
Actual shear =	49.86	*kN*
Allowable shear =	241.40	*kN*
Low shear present		
Capacity	**21%**	



Shear force diagram

Deflection (SLS)

Total deflection =	3.79	*mm*	*(L/897)*
Actual deflection LL =	0.70	*mm*	*(L/4857)*
Allowable deflection LL =	*9.44*	*mm*	*(L/360)*
Capacity	**28%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = **49.86** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**Weak Brickwork**			
Characteristic strength of masonry =	**2.8**	N/mm²		
Width of beam end bearing =	**100**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**150**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.17	N/mm²	
Actual Bearing Stress =	3.32	N/mm²	
Capacity	**285%**		**Padstone Required**

Padstone

A Engineering Brick

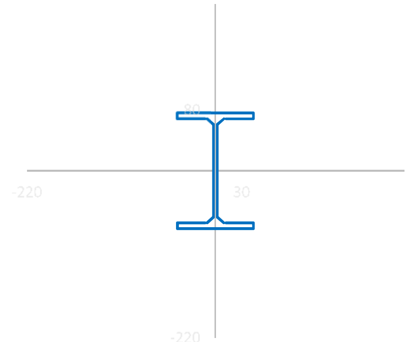
Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**660**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	3.32	N/mm²	
Capacity	**60%**		**OK**
Maximum bearing stress masonry	1.17	N/mm²	
Stress under padstone =	0.76	N/mm²	
Capacity	**65%**		**OK**

Beam B13 **UB** **152x89x16 UB**

SUMMARY OF RESULTS

Max Applied Moment =	10.2 kNm	< 29.98 kNm	**OK**
Max Applied Shear =	11.3 kN	< 113.16 kN	**OK**
Max Deflection LL =	0.4 mm	< 9.44 mm	**OK**
Max Buckling =	10.2 kNm	< 11.4 kNm	**OK**

Span = **3.4** meters



Support positions

Distance from end Support A 0.00 m Support B 3.400 m

Support conditions Bottom flange to supports

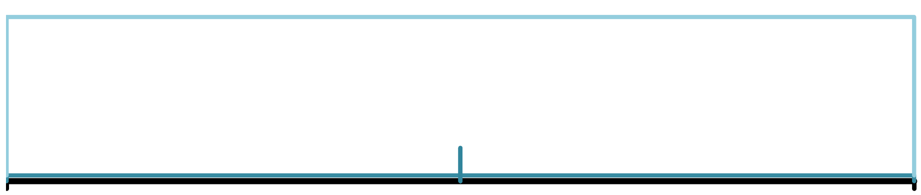
Loading

Roof Super load both sides, spaning 2.8 m & 2.8 m

Imposed: Critical case point load, 0.9 kN acting at centre span

45 degree Pitched roof Concrete Marley either side

Dead: udl load, 1.08 / cos(45) x 5.6 / 2 = 4.276 kN/m



unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
7.99 kN	11.27 kN		7.99 kN	11.27 kN

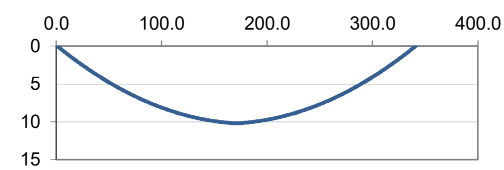
Class 1 Plastic

Bending Moment (ULS)

Actual moment =	10.19	*kNm*
Allowable moment =	29.98	*kNm*
Capacity	**34%**	

LTB (ULS)

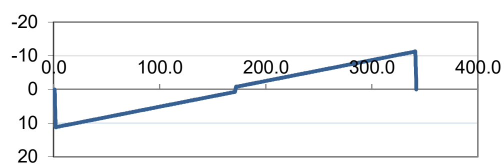
Actual Buckling resistance =	11.42	*kNm*
Capacity	**89%**	



Bending moment diagram

Shear (ULS)

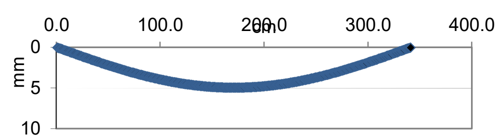
Actual shear =	11.27	*kN*
Allowable shear =	113.16	*kN*
Low shear present		
Capacity	**10%**	



Shear force diagram

Deflection (SLS)

Total deflection =	4.94	*mm*	*(L/688)*
Actual deflection LL =	0.43	*mm*	*(L/7907)*
Allowable deflection LL =	*9.44*	*mm*	*(L/360)*
Capacity	**36%**		



Deflection

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project		Brook House		Job no. JP1524	
	Section		Bearing Beam B13		Sheet no./rev 27	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam End Reaction = **11.27** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**3.6N Blockwork**			
Characteristic strength of masonry =	**2.6**	N/mm²		
Width of beam end bearing =	**88.7**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	1.27	N/mm²	
Capacity	**117%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**215**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	1.27	N/mm²	
Capacity	**23%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.52	N/mm²	
Capacity	**48%**		**OK**

STEEL MEMBER ANALYSIS & DESIGN (EN1993-1-1:2005)

In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex

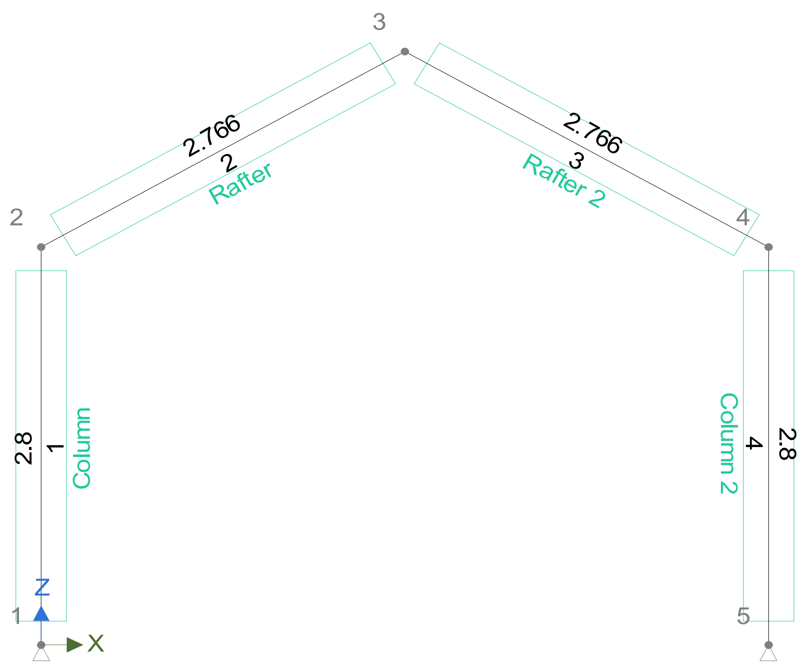
Tedds calculation version 4.3.04

ANALYSIS

Tedds calculation version 1.0.27

Geometry

Geometry (m) - Steel (EC3) - UB 152x89x16

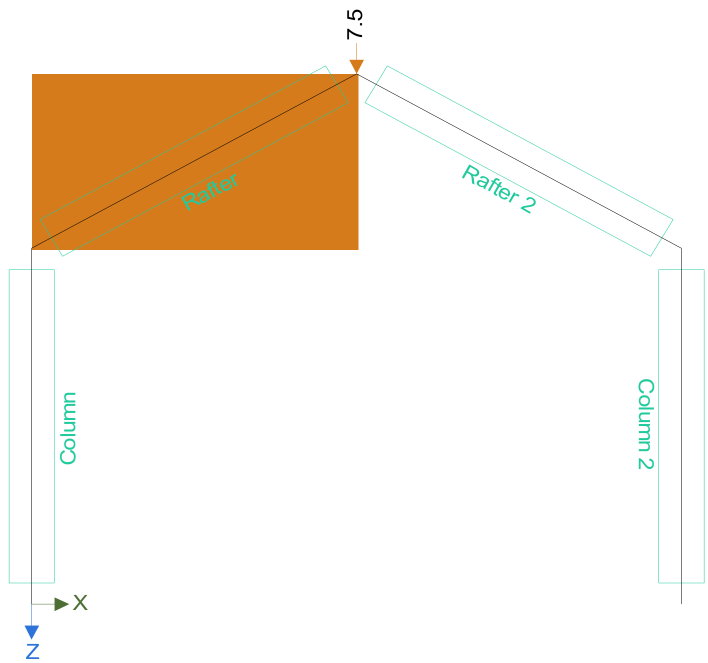


Loading

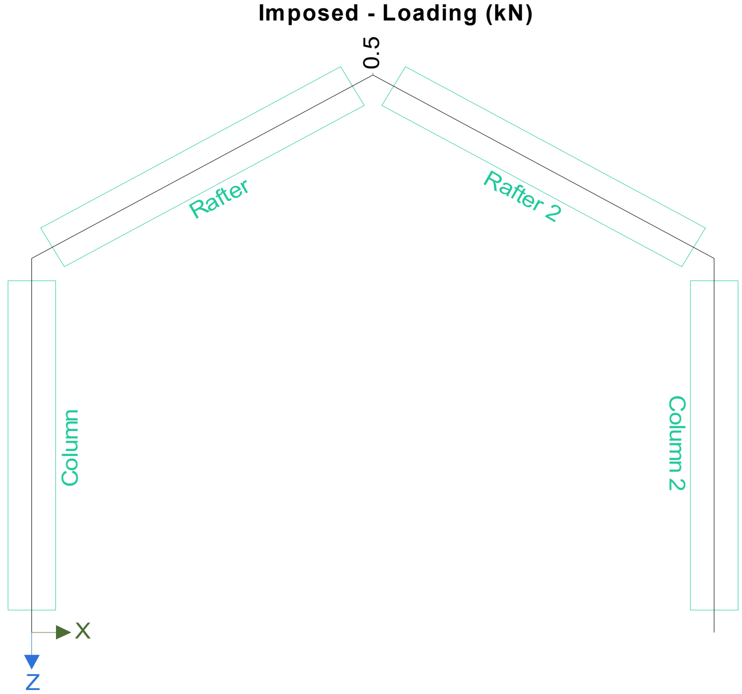
Self weight included

Structural Calculation Ltd Mobbs Wood Farm Ansty CV7 9JN	Project Brook House			Job no. JP1524	
	Calcs for Portal Frame			Start page no./Revision 29	
	Calcs by AM	Calcs date 10/01/2020	Checked by JP	Checked date 10/01/2020	Approved by JP	Approved date 10/01/2020

Permanent - Loading (kN/m,kN)



Imposed - Loading (kN)

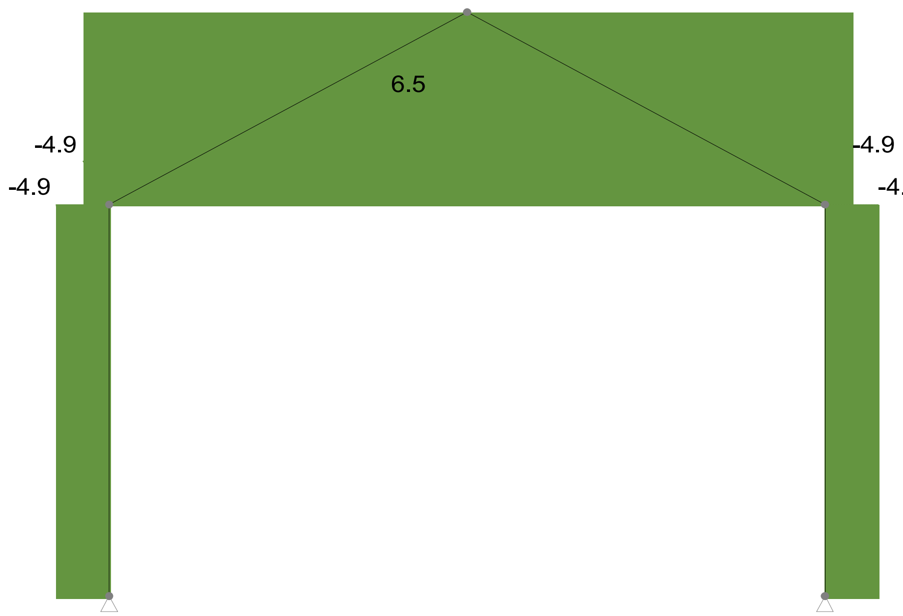


Structural Calculation Ltd Mobbs Wood Farm Ansty CV7 9JN	Project Brook House			Job no. JP1524	
	Calcs for Portal Frame			Start page no./Revision 30	
	Calcs by AM	Calcs date 10/01/2020	Checked by JP	Checked date 10/01/2020	Approved by JP	Approved date 10/01/2020

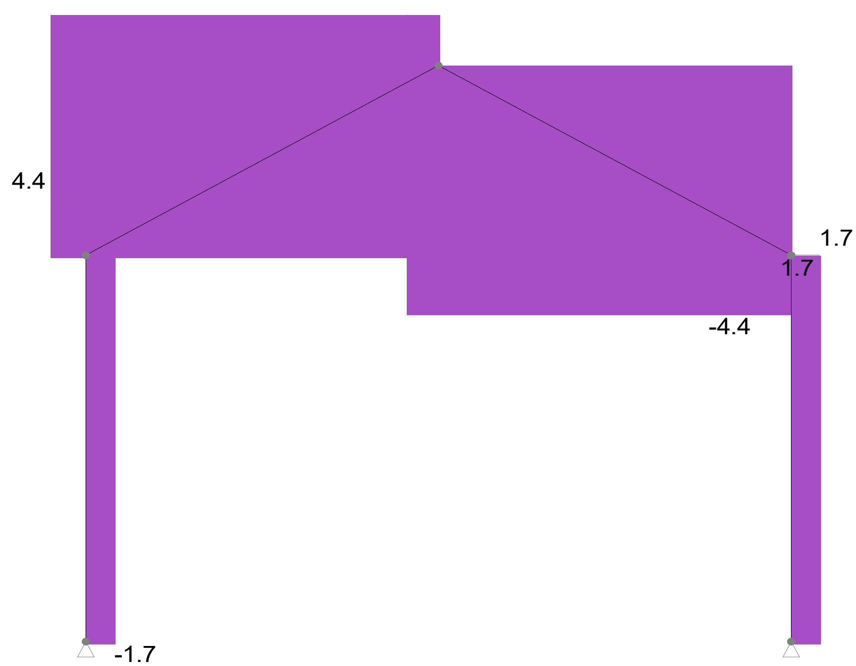
Results

Forces

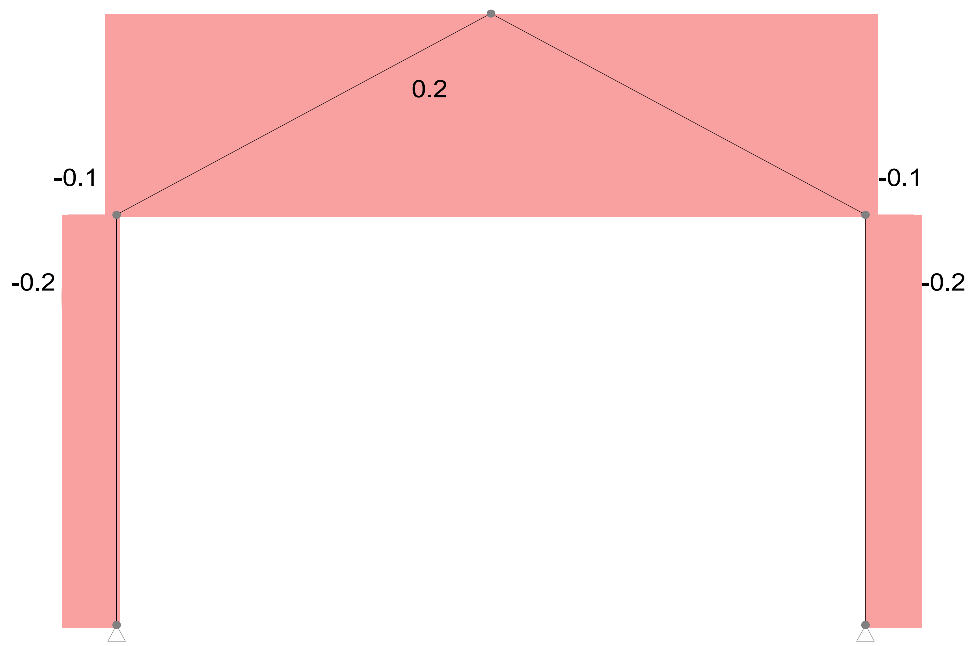
Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



Service combinations - Deflection envelope (mm)



Partial factors - Section 6.1

Resistance of cross-sections γ_{M0} = **1**

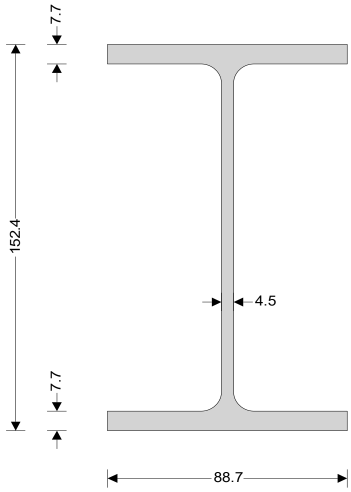
Resistance of members to instability γ_{M1} = **1**

Resistance of tensile members to fracture γ_{M2} = **1.1**

Column design

Section details

Section type	UB 152x89x16 (BS4-1)
Steel grade - EN 10025-2:2004	S275
Nominal thickness of element	t_{nom} = max(t_f, t_w) = **7.7** mm
Nominal yield strength	f_y = **275** N/mm^2
Nominal ultimate tensile strength	f_u = **410** N/mm^2
Modulus of elasticity	E = **210000** N/mm^2



UB 152x89x16 (BS4-1)
Section depth, h, 152.4 mm
Section breadth, b, 88.7 mm
Mass of section, Mass, 16 kg/m
Flange thickness, t_f, 7.7 mm
Web thickness, t_w, 4.5 mm
Root radius, r, 7.6 mm
Area of section, A, 2032 mm^2
Radius of gyration about y-axis, i_y, 64.074 mm
Radius of gyration about z-axis, i_z, 21.016 mm
Elastic section modulus about y-axis, $W_{el.y}$, 109483 mm^3
Elastic section modulus about z-axis, $W_{el.z}$, 20237 mm^3
Plastic section modulus about y-axis, $W_{pl.y}$, 123256 mm^3
Plastic section modulus about z-axis, $W_{pl.z}$, 31180 mm^3
Second moment of area about y-axis, I_y, 8342621 mm^4
Second moment of area about z-axis, I_z, 897506 mm^4

Lateral restraint

Both flanges have lateral restraint at supports only

Consider Combination 1 - 1.35G + 1.5Q + 1.5RQ (Strength)

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]} = \mathbf{0.92}$

Internal compression parts subject to bending and compression - Table 5.2 (sheet 1 of 3)

Width of section — $c = d = \mathbf{121.8}$ mm

$\alpha = \min([h / 2 + N_{Ed} / (2 \times t_w \times f_y) - (t_f + r)] / c, 1) = \mathbf{0.522}$

$c / t_w = 27.1 = 29.3 \times \varepsilon \le 396 \times \varepsilon / (13 \times \alpha - 1)$ Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section — $c = (b - t_w - 2 \times r) / 2 = \mathbf{34.5}$ mm

$c / t_f = 4.5 = 4.8 \times \varepsilon \le 9 \times \varepsilon$ Class 1

Section is class 1

Check compression - Section 6.2.4

Design compression force — $N_{Ed} = \mathbf{6.6}$ kN

Design resistance of section - eq 6.10 — $N_{c,Rd} = N_{pl,Rd} = A \times f_y / \gamma_{M0} = \mathbf{558.8}$ kN

$N_{Ed} / N_{c,Rd} = \mathbf{0.012}$

PASS - Design compression resistance exceeds design compression

Slenderness ratio for y-y axis flexural buckling - Section 6.3.1.3

Critical buckling length — $L_{cr,y} = L_{m1\_s1} = \mathbf{2800}$ mm

Critical buckling force — $N_{cr,y} = \pi^2 \times E \times I_y / L_{cr,y}^2 = \mathbf{2205.5}$ kN

Slenderness ratio for buckling - eq 6.50 — $\bar{\lambda}_y = \sqrt{(A \times f_y / N_{cr,y})} = \mathbf{0.503}$

Check y-y axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 — a

Imperfection factor - Table 6.1 — $\alpha_y = \mathbf{0.21}$

Buckling reduction determination factor — $\phi_y = 0.5 \times (1 + \alpha_y \times (\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2) = \mathbf{0.659}$

Buckling reduction factor - eq 6.49 — $\chi_y = \min(1 / (\phi_y + \sqrt{(\phi_y^2 - \bar{\lambda}_y^2)}), 1) = \mathbf{0.923}$

Design buckling resistance - eq 6.47 — $N_{b,y,Rd} = \chi_y \times A \times f_y / \gamma_{M1} = \mathbf{515.9}$ kN

$N_{Ed} / N_{b,y,Rd} = \mathbf{0.013}$

PASS - Design buckling resistance exceeds design compression

Slenderness ratio for z-z axis flexural buckling - Section 6.3.1.3

Critical buckling length $L_{cr,z} = L_{m1\_s1\_seg1} = \mathbf{2800}$ mm

Critical buckling force $N_{cr,z} = \pi^2 \times E \times I_z / L_{cr,z}^2 = \mathbf{237.3}$ kN

Slenderness ratio for buckling - eq 6.50 $\bar{\lambda}_z = \sqrt{(A \times f_y / N_{cr,z})} = \mathbf{1.535}$

Check z-z axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 b

Imperfection factor - Table 6.1 $\alpha_z = \mathbf{0.34}$

Buckling reduction determination factor $\phi_z = 0.5 \times (1 + \alpha_z \times (\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2) = \mathbf{1.904}$

Buckling reduction factor - eq 6.49 $\chi_z = \min(1 / (\phi_z + \sqrt{(\phi_z^2 - \bar{\lambda}_z^2)}), 1) = \mathbf{0.33}$

Design buckling resistance - eq 6.47 $N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1} = \mathbf{184.3}$ kN

$N_{Ed} / N_{b,z,Rd} = \mathbf{0.036}$

PASS - Design buckling resistance exceeds design compression

Check torsional and torsional-flexural buckling - Section 6.3.1.4

Torsional buckling length $L_{cr,T} = L_{m1\_s1\_seg1\_R} = \mathbf{2800}$ mm

Distance from shear centre to centroid in y axis $y_0 = \mathbf{0.0}$ mm

Distance from shear centre to centroid in z axis $z_0 = \mathbf{0.0}$ mm

Radius of gyration $i_0 = \sqrt{(i_y^2 + i_z^2)} = \mathbf{67.4}$ mm

Elastic critical torsional buckling force $N_{cr,T} = 1 / i_0^2 \times (G \times I_t + \pi^2 \times E \times I_w / L_{cr,T}^2) = \mathbf{905.6}$ kN

Torsion factor $\beta_T = 1 - (y_0 / i_0)^2 = \mathbf{1}$

Elastic critical torsional-flexural buckling force

$N_{cr,TF} = N_{cr,y} / (2 \times \beta_T) \times [1 + N_{cr,T} / N_{cr,y} - \sqrt{[(1 - N_{cr,T} / N_{cr,y})^2 + 4 \times (y_0 / i_0)^2 \times N_{cr,T} / N_{cr,y}]}] = \mathbf{905.6}$ kN

Elastic critical buckling force $N_{cr} = \min(N_{cr,T}, N_{cr,TF}) = \mathbf{905.6}$ kN

Slenderness ratio for torsional buckling - eq 6.52 $\bar{\lambda}_T = \sqrt{[A \times f_y / N_{cr}]} = \mathbf{0.786}$

Design resistance for torsional and torsional-flexural buckling - Section 6.3.1.1

Buckling curve - Table 6.2 b

Imperfection factor - Table 6.1 $\alpha_T = \mathbf{0.34}$

Buckling reduction determination factor $\phi_T = 0.5 \times (1 + \alpha_T \times (\bar{\lambda}_T - 0.2) + \bar{\lambda}_T^2) = \mathbf{0.908}$

Buckling reduction factor - eq 6.49 $\chi_T = \min(1 / (\phi_T + \sqrt{(\phi_T^2 - \bar{\lambda}_T^2)}), 1) = \mathbf{0.733}$

Design buckling resistance - eq 6.47 $N_{b,T,Rd} = \chi_T \times A \times f_y / \gamma_{M1} = \mathbf{409.8}$ kN

$N_{Ed} / N_{b,T,Rd} = \mathbf{0.016}$

PASS - Design buckling resistance exceeds design compression

<u>Check design at start of span</u>

Check shear - Section 6.2.6

Height of web $h_w = h - 2 \times t_f = \mathbf{137}$ mm $\eta = \mathbf{1.000}$

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force $V_{y,Ed} = \mathbf{1.7}$ kN

Shear area - cl 6.2.6(3) $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w) = \mathbf{818}$ mm^2

Design shear resistance - cl 6.2.6(2) $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0} = \mathbf{129.8}$ kN

$V_{y,Ed} / V_{c,y,Rd} = \mathbf{0.013}$

PASS - Design shear resistance exceeds design shear force

Check design at end of span

Check shear - Section 6.2.6

Height of web — $h_w = h - 2 \times t_f =$ **137** mm — $\eta =$ **1.000**

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force — $V_{y,Ed} =$ **1.7** kN

Shear area - cl 6.2.6(3) — $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w) =$ **818** mm^2

Design shear resistance - cl 6.2.6(2) — $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0} =$ **129.8** kN

$V_{y,Ed} / V_{c,y,Rd} =$ **0.013**

PASS - Design shear resistance exceeds design shear force

Check bending moment - Section 6.2.5

Design bending moment — $M_{y,Ed} =$ **4.9** kNm

Design bending resistance moment - eq 6.13 — $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0} =$ **33.9** kNm

$M_{y,Ed} / M_{c,y,Rd} =$ **0.143**

PASS - Design bending resistance moment exceeds design bending moment

Slenderness ratio for lateral torsional buckling

Correction factor - For cantilever beams — $k_c =$ **1**

$C_1 = 1 / k_c^2 =$ **1**

Poissons ratio — $\nu =$ **0.3**

Shear modulus — $G = E / [2 \times (1 + \nu)] =$ **80769** N/mm^2

Unrestrained effective length — $L = 1.0 \times L_{m1\_s1\_seg1\_B} =$ **2800** mm

Elastic critical buckling moment — $M_{cr} = C_1 \times \pi^2 \times E \times I_z / L^2 \times \sqrt{(I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z))} =$ **31.3** kNm

Slenderness ratio for lateral torsional buckling — $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})} =$ **1.041**

Limiting slenderness ratio — $\bar{\lambda}_{LT,0} =$ **0.4**

$\bar{\lambda}_{LT} > \bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Check buckling resistance - Section 6.3.2.1

Buckling curve - Table 6.5 — b

Imperfection factor - Table 6.3 — $\alpha_{LT} =$ **0.34**

Correction factor for rolled sections — $\beta =$ **0.75**

LTB reduction determination factor — $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2] =$ **1.016**

LTB reduction factor - eq 6.57 — $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2) =$ **0.674**

Modification factor — $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1) =$ **1.000**

Modified LTB reduction factor - eq 6.58 — $\chi_{LT,mod} = \min(\chi_{LT} / f, 1, 1 / \bar{\lambda}_{LT}^2) =$ **0.674**

Design buckling resistance moment - eq 6.55 — $M_{b,y,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1} =$ **22.9** kNm

$M_{y,Ed} / M_{b,y,Rd} =$ **0.212**

PASS - Design buckling resistance moment exceeds design bending moment

Check bending and axial force - Section 6.2.9

Bending and axial force check - eq.6.33 & eq.6.34 — $N_{y,lim} = \min(0.25 \times N_{pl,Rd}, 0.5 \times h_w \times t_w \times f_y / \gamma_{M0}) =$ **84.8** kN

$N_{Ed} / N_{y,lim} =$ **0.071**

Allowance need not be made for the effect of the axial force on the plastic resistance moment about the y-y axis

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3 — $\psi_y = 0 \text{ kNm} / -4.856 \text{ kNm} =$ **0.000**

$\alpha_y = -2.428 \text{ kNm} / -4.856 \text{ kNm} =$ **0.500**

$C_{my} = \max(0.6 + 0.4 \times \psi_y) = \mathbf{0.600}$

$\psi_{LT} = 0$ kNm / -4.856 kNm = **0.000**

$\alpha_{LT} = -2.428$ kNm / -4.856 kNm = **0.500**

$C_{mLT} = \max(0.6 + 0.4 \times \psi_{LT}) = \mathbf{0.600}$

Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance	$M_{y,Rk} = W_{pl.y} \times f_y =$ **33.9** kNm
Characteristic moment resistance	$M_{z,Rk} = W_{pl.z} \times f_y =$ **8.6** kNm
Characteristic resistance to normal force	$N_{Rk} = A \times f_y =$ **558.8** kN
Interaction factors	$k_{yy} = C_{my} \times (1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1})) = \mathbf{0.602}$
	$k_{zy} = 1 - 0.1 \times \min(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1}) = \mathbf{0.991}$
Interaction formulae - eq 6.61 & eq 6.62	$N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1}) = \mathbf{0.14}$
	$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1}) = \mathbf{0.243}$

PASS - Combined bending and compression checks are satisfied

Consider Combination 2 - 1.0G + 1.0Q + 1.0RQ (Service)

Check design 2217 mm along span

Check y-y axis deflection - Section 7.2.1

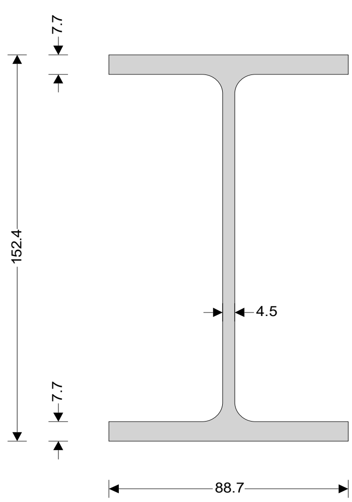
Maximum deflection	$\delta_y =$ **0.2** mm
Allowable deflection	$\delta_{y,Allowable} = L_{m1\_s1} / 180 =$ **15.6** mm
	$\delta_y / \delta_{y,Allowable} =$ **0.01**

PASS - Allowable deflection exceeds design deflection

Rafter design

Section details

Section type	UB 152x89x16 (BS4-1)
Steel grade - EN 10025-2:2004	S275
Nominal thickness of element	$t_{nom} = \max(t_f, t_w) =$ **7.7** mm
Nominal yield strength	$f_y =$ **275** N/mm^2
Nominal ultimate tensile strength	$f_u =$ **410** N/mm^2
Modulus of elasticity	$E =$ **210000** N/mm^2



UB 152x89x16 (BS4-1)
Section depth, h, 152.4 mm
Section breadth, b, 88.7 mm
Mass of section, Mass, 16 kg/m
Flange thickness, t_f, 7.7 mm
Web thickness, t_w, 4.5 mm
Root radius, r, 7.6 mm
Area of section, A, 2032 mm^2
Radius of gyration about y-axis, i_y, 64.074 mm
Radius of gyration about z-axis, i_z, 21.016 mm
Elastic section modulus about y-axis, $W_{el.y}$, 109483 mm^3
Elastic section modulus about z-axis, $W_{el.z}$, 20237 mm^3
Plastic section modulus about y-axis, $W_{pl.y}$, 123256 mm^3
Plastic section modulus about z-axis, $W_{pl.z}$, 31180 mm^3
Second moment of area about y-axis, I_y, 8342621 mm^4
Second moment of area about z-axis, I_z, 897506 mm^4

Lateral restraint

Both flanges have lateral restraint at supports only

Consider Combination 1 - 1.35G + 1.5Q + 1.5RQ (Strength)

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]}$ = **0.92**

Internal compression parts subject to bending and compression - Table 5.2 (sheet 1 of 3)

Width of section — $c = d$ = **121.8** mm

$\alpha = \min([h / 2 + N_{Ed} / (2 \times t_w \times f_y) - (t_f + r)] / c, 1)$ = **0.515**

$c / t_w = 27.1 = 29.3 \times \varepsilon <= 396 \times \varepsilon / (13 \times \alpha - 1)$ Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section — $c = (b - t_w - 2 \times r) / 2$ = **34.5** mm

$c / t_f = 4.5 = 4.8 \times \varepsilon <= 9 \times \varepsilon$ Class 1

Section is class 1

Check compression - Section 6.2.4

Design compression force — N_{Ed} = **4.5** kN

Design resistance of section - eq 6.10 — $N_{c,Rd} = N_{pl,Rd} = A \times f_y / \gamma_{M0}$ = **558.8** kN

$N_{Ed} / N_{c,Rd}$ = **0.008**

PASS - Design compression resistance exceeds design compression

Slenderness ratio for y-y axis flexural buckling - Section 6.3.1.3

Critical buckling length — $L_{cr,y} = L_{m2\_s1}$ = **2766** mm

Critical buckling force — $N_{cr,y} = \pi^2 \times E \times I_y / L_{cr,y}^2$ = **2260.1** kN

Slenderness ratio for buckling - eq 6.50 — $\bar{\lambda}_y = \sqrt{(A \times f_y / N_{cr,y})}$ = **0.497**

Check y-y axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 — a

Imperfection factor - Table 6.1 — α_y = **0.21**

Buckling reduction determination factor — $\phi_y = 0.5 \times (1 + \alpha_y \times (\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2)$ = **0.655**

Buckling reduction factor - eq 6.49 — $\chi_y = \min(1 / (\phi_y + \sqrt{(\phi_y^2 - \bar{\lambda}_y^2)}), 1)$ = **0.925**

Design buckling resistance - eq 6.47 — $N_{b,y,Rd} = \chi_y \times A \times f_y / \gamma_{M1}$ = **517** kN

$N_{Ed} / N_{b,y,Rd}$ = **0.009**

PASS - Design buckling resistance exceeds design compression

Slenderness ratio for z-z axis flexural buckling - Section 6.3.1.3

Critical buckling length — $L_{cr,z} = L_{m2\_s1\_seg1}$ = **2766** mm

Critical buckling force — $N_{cr,z} = \pi^2 \times E \times I_z / L_{cr,z}^2$ = **243.1** kN

Slenderness ratio for buckling - eq 6.50 — $\bar{\lambda}_z = \sqrt{(A \times f_y / N_{cr,z})}$ = **1.516**

Check z-z axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 — b

Imperfection factor - Table 6.1 — α_z = **0.34**

Buckling reduction determination factor — $\phi_z = 0.5 \times (1 + \alpha_z \times (\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2)$ = **1.873**

Buckling reduction factor - eq 6.49 — $\chi_z = \min(1 / (\phi_z + \sqrt{(\phi_z^2 - \bar{\lambda}_z^2)}), 1)$ = **0.336**

Design buckling resistance - eq 6.47 — $N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1}$ = **188** kN

$N_{Ed} / N_{b,z,Rd}$ = **0.024**

PASS - Design buckling resistance exceeds design compression

Check torsional and torsional-flexural buckling - Section 6.3.1.4

Torsional buckling length $L_{cr,T} = L_{m2\_s1\_seg1\_R} = \mathbf{2766}$ mm

Distance from shear centre to centroid in y axis $y_0 = \mathbf{0.0}$ mm

Distance from shear centre to centroid in z axis $z_0 = \mathbf{0.0}$ mm

Radius of gyration $i_0 = \sqrt{(i_y^2 + i_z^2)} = \mathbf{67.4}$ mm

Elastic critical torsional buckling force $N_{cr,T} = 1 / i_0^2 \times (G \times I_t + \pi^2 \times E \times I_w / L_{cr,T}^2) = \mathbf{912.3}$ kN

Torsion factor $\beta_T = 1 - (y_0 / i_0)^2 = \mathbf{1}$

Elastic critical torsional-flexural buckling force

$$N_{cr,TF} = N_{cr,y} / (2 \times \beta_T) \times [1 + N_{cr,T} / N_{cr,y} - \sqrt{[(1 - N_{cr,T} / N_{cr,y})^2 + 4 \times (y_0 / i_0)^2 \times N_{cr,T} / N_{cr,y}]}] = \mathbf{912.3} \text{ kN}$$

Elastic critical buckling force $N_{cr} = \min(N_{cr,T}, N_{cr,TF}) = \mathbf{912.3}$ kN

Slenderness ratio for torsional buckling - eq 6.52 $\bar{\lambda}_T = \sqrt{[A \times f_y / N_{cr}]} = \mathbf{0.783}$

Design resistance for torsional and torsional-flexural buckling - Section 6.3.1.1

Buckling curve - Table 6.2 b

Imperfection factor - Table 6.1 $\alpha_T = \mathbf{0.34}$

Buckling reduction determination factor $\phi_T = 0.5 \times (1 + \alpha_T \times (\bar{\lambda}_T - 0.2) + \bar{\lambda}_T^2) = \mathbf{0.905}$

Buckling reduction factor - eq 6.49 $\chi_T = \min(1 / (\phi_T + \sqrt{(\phi_T^2 - \bar{\lambda}_T^2)}), 1) = \mathbf{0.735}$

Design buckling resistance - eq 6.47 $N_{b,T,Rd} = \chi_T \times A \times f_y / \gamma_{M1} = \mathbf{410.8}$ kN

$N_{Ed} / N_{b,T,Rd} = \mathbf{0.011}$

PASS - Design buckling resistance exceeds design compression

<u>**Check design at start of span**</u>

Check shear - Section 6.2.6

Height of web $h_w = h - 2 \times t_f = \mathbf{137}$ mm $\eta = \mathbf{1.000}$

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force $V_{y,Ed} = \mathbf{4.4}$ kN

Shear area - cl 6.2.6(3) $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w) = \mathbf{818}$ mm^2

Design shear resistance - cl 6.2.6(2) $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0} = \mathbf{129.8}$ kN

$V_{y,Ed} / V_{c,y,Rd} = \mathbf{0.034}$

PASS - Design shear resistance exceeds design shear force

Check bending moment - Section 6.2.5

Design bending moment $M_{y,Ed} = \mathbf{4.9}$ kNm

Design bending resistance moment - eq 6.13 $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0} = \mathbf{33.9}$ kNm

$M_{y,Ed} / M_{c,y,Rd} = \mathbf{0.143}$

PASS - Design bending resistance moment exceeds design bending moment

Slenderness ratio for lateral torsional buckling

Correction factor - For cantilever beams $k_c = \mathbf{1}$

$C_1 = 1 / k_c^2 = \mathbf{1}$

Poissons ratio $\nu = \mathbf{0.3}$

Shear modulus $G = E / [2 \times (1 + \nu)] = \mathbf{80769}$ N/mm^2

Unrestrained effective length $L = 1.0 \times L_{m2\_s1\_seg1\_B} = \mathbf{2766}$ mm

Elastic critical buckling moment $M_{cr} = C_1 \times \pi^2 \times E \times I_z / L^2 \times \sqrt{(I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z))} = \mathbf{31.8}$ kNm

Slenderness ratio for lateral torsional buckling $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})} = \mathbf{1.033}$

Limiting slenderness ratio $\bar{\lambda}_{LT,0} = \mathbf{0.4}$

$\bar{\lambda}_{LT}$ > $\bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Check buckling resistance - Section 6.3.2.1

Buckling curve - Table 6.5 — b

Imperfection factor - Table 6.3 — α_{LT} = **0.34**

Correction factor for rolled sections — β = **0.75**

LTB reduction determination factor — $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2]$ = **1.008**

LTB reduction factor - eq 6.57 — $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.679**

Modification factor — $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1)$ = **1.000**

Modified LTB reduction factor - eq 6.58 — $\chi_{LT,mod} = \min(\chi_{LT} / f, 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.679**

Design buckling resistance moment - eq 6.55 — $M_{b,y,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1}$ = **23** kNm

$M_{y,Ed} / M_{b,y,Rd}$ = **0.211**

PASS - Design buckling resistance moment exceeds design bending moment

Check bending and axial force - Section 6.2.9

Bending and axial force check - eq.6.33 & eq.6.34 — $N_{y,lim} = \min(0.25 \times N_{pl,Rd}, 0.5 \times h_w \times t_w \times f_y / \gamma_{M0})$ = **84.8** kN

$N_{Ed} / N_{y,lim}$ = **0.053**

Allowance need not be made for the effect of the axial force on the plastic resistance moment about the y-y axis

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3 — ψ_y = -4.856 kNm / 6.51 kNm = **-0.746**

α_y = 1.002 kNm / 6.51 kNm = **0.154**

$C_{my} = \max(0.2 + 0.8 \times \alpha_y, 0.4)$ = **0.400**

ψ_{LT} = -4.856 kNm / 6.51 kNm = **-0.746**

α_{LT} = 1.002 kNm / 6.51 kNm = **0.154**

$C_{mLT} = \max(0.2 + 0.8 \times \alpha_{LT}, 0.4)$ = **0.400**

Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance — $M_{y,Rk} = W_{pl.y} \times f_y$ = **33.9** kNm

Characteristic moment resistance — $M_{z,Rk} = W_{pl.z} \times f_y$ = **8.6** kNm

Characteristic resistance to normal force — $N_{Rk} = A \times f_y$ = **558.8** kN

Interaction factors — $k_{yy} = C_{my} \times (1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}))$ = **0.401**

$k_{zy} = 1 - 0.1 \times \min(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1})$ = **0.984**

Interaction formulae - eq 6.61 & eq 6.62 — $N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.093**

$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.231**

PASS - Combined bending and compression checks are satisfied

Check design at end of span

Check shear - Section 6.2.6

Height of web — $h_w = h - 2 \times t_f$ = **137** mm — η = **1.000**

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force — $V_{y,Ed}$ = **3.9** kN

Shear area - cl 6.2.6(3) — $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w)$ = **818** mm^2

Design shear resistance - cl 6.2.6(2) — $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0}$ = **129.8** kN

$V_{y,Ed} / V_{c,y,Rd}$ = **0.03**

PASS - Design shear resistance exceeds design shear force

Check bending moment - Section 6.2.5

Design bending moment — $M_{y,Ed}$ = **6.5** kNm

Design bending resistance moment - eq 6.13 — $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0}$ = **33.9** kNm

$M_{y,Ed} / M_{c,y,Rd}$ = **0.192**

PASS - Design bending resistance moment exceeds design bending moment

Slenderness ratio for lateral torsional buckling

Correction factor - For cantilever beams — k_c = **1**

$C_1 = 1 / k_c^2$ = **1**

Poissons ratio — ν = **0.3**

Shear modulus — $G = E / [2 \times (1 + \nu)]$ = **80769** N/mm^2

Unrestrained effective length — $L = 1.0 \times L_{m2\_s1\_seg1\_T}$ = **2766** mm

Elastic critical buckling moment — $M_{cr} = C_1 \times \pi^2 \times E \times I_z / L^2 \times \sqrt{(I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z))}$ = **31.8** kNm

Slenderness ratio for lateral torsional buckling — $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})}$ = **1.033**

Limiting slenderness ratio — $\bar{\lambda}_{LT,0}$ = **0.4**

$\bar{\lambda}_{LT} > \bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Check buckling resistance - Section 6.3.2.1

Buckling curve - Table 6.5 — b

Imperfection factor - Table 6.3 — α_{LT} = **0.34**

Correction factor for rolled sections — β = **0.75**

LTB reduction determination factor — $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2]$ = **1.008**

LTB reduction factor - eq 6.57 — $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.679**

Modification factor — $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1)$ = **1.000**

Modified LTB reduction factor - eq 6.58 — $\chi_{LT,mod} = \min(\chi_{LT} / f, 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.679**

Design buckling resistance moment - eq 6.55 — $M_{b,y,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1}$ = **23** kNm

$M_{y,Ed} / M_{b,y,Rd}$ = **0.283**

PASS - Design buckling resistance moment exceeds design bending moment

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3 — ψ_y = -4.856 kNm / 6.51 kNm = **-0.746**

α_y = 1.002 kNm / 6.51 kNm = **0.154**

$C_{my} = \max(0.2 + 0.8 \times \alpha_y, 0.4)$ = **0.400**

ψ_{LT} = -4.856 kNm / 6.51 kNm = **-0.746**

α_{LT} = 1.002 kNm / 6.51 kNm = **0.154**

$C_{mLT} = \max(0.2 + 0.8 \times \alpha_{LT}, 0.4)$ = **0.400**

Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance — $M_{y,Rk} = W_{pl.y} \times f_y$ = **33.9** kNm

Characteristic moment resistance — $M_{z,Rk} = W_{pl.z} \times f_y$ = **8.6** kNm

Characteristic resistance to normal force — $N_{Rk} = A \times f_y$ = **558.8** kN

Interaction factors — $k_{yy} = C_{my} \times (1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}))$ = **0.401**

$k_{zy} = 1 - 0.1 \times \min(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1})$ = **0.985**

Interaction formulae - eq 6.61 & eq 6.62 — $N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.121**

$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.301**

PASS - Combined bending and compression checks are satisfied

Consider Combination 2 - 1.0G + 1.0Q + 1.0RQ (Service)

Check design at end of span

Check y-y axis deflection - Section 7.2.1

Maximum deflection δ_y = **0.2** mm

Allowable deflection $\delta_{y,Allowable} = L_{m2\_s1} / 180$ = **15.4** mm

$\delta_y / \delta_{y,Allowable}$ = **0.014**

PASS - Allowable deflection exceeds design deflection

Column 2 design

Section details

Section type UB 152x89x16 (BS4-1)

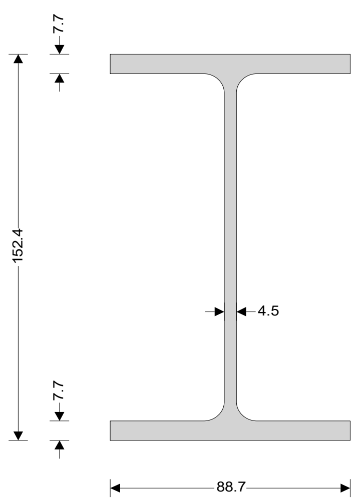
Steel grade - EN 10025-2:2004 S275

Nominal thickness of element $t_{nom} = \max(t_f, t_w)$ = **7.7** mm

Nominal yield strength f_y = **275** N/mm^2

Nominal ultimate tensile strength f_u = **410** N/mm^2

Modulus of elasticity E = **210000** N/mm^2



UB 152x89x16 (BS4-1)
Section depth, h, 152.4 mm
Section breadth, b, 88.7 mm
Mass of section, Mass, 16 kg/m
Flange thickness, t_f, 7.7 mm
Web thickness, t_w, 4.5 mm
Root radius, r, 7.6 mm
Area of section, A, 2032 mm^2
Radius of gyration about y-axis, i_y, 64.074 mm
Radius of gyration about z-axis, i_z, 21.016 mm
Elastic section modulus about y-axis, $W_{el.y}$, 109483 mm^3
Elastic section modulus about z-axis, $W_{el.z}$, 20237 mm^3
Plastic section modulus about y-axis, $W_{pl.y}$, 123256 mm^3
Plastic section modulus about z-axis, $W_{pl.z}$, 31180 mm^3
Second moment of area about y-axis, I_y, 8342621 mm^4
Second moment of area about z-axis, I_z, 897506 mm^4

Lateral restraint

Both flanges have lateral restraint at supports only

Consider Combination 1 - 1.35G + 1.5Q + 1.5RQ (Strength)

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]}$ = **0.92**

Internal compression parts subject to bending and compression - Table 5.2 (sheet 1 of 3)

Width of section c = d = **121.8** mm

$\alpha = \min([h / 2 + N_{Ed} / (2 \times t_w \times f_y) - (t_f + r)] / c, 1)$ = **0.522**

$c / t_w = 27.1 = 29.3 \times \varepsilon <= 396 \times \varepsilon / (13 \times \alpha - 1)$ Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section $c = (b - t_w - 2 \times r) / 2$ = **34.5** mm

$c / t_f = 4.5 = 4.8 \times \varepsilon <= 9 \times \varepsilon$ Class 1

Section is class 1

Check compression - Section 6.2.4

Design compression force — N_{Ed} = **6** kN

Design resistance of section - eq 6.10 — $N_{c,Rd} = N_{pl,Rd} = A \times f_y / \gamma_{M0}$ = **558.8** kN

$N_{Ed} / N_{c,Rd}$ = **0.011**

PASS - Design compression resistance exceeds design compression

Slenderness ratio for y-y axis flexural buckling - Section 6.3.1.3

Critical buckling length — $L_{cr,y} = L_{m3\_s1}$ = **2800** mm

Critical buckling force — $N_{cr,y} = \pi^2 \times E \times I_y / L_{cr,y}^2$ = **2205.5** kN

Slenderness ratio for buckling - eq 6.50 — $\bar{\lambda}_y = \sqrt{(A \times f_y / N_{cr,y})}$ = **0.503**

Check y-y axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 — a

Imperfection factor - Table 6.1 — α_y = **0.21**

Buckling reduction determination factor — $\phi_y = 0.5 \times (1 + \alpha_y \times (\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2)$ = **0.659**

Buckling reduction factor - eq 6.49 — $\chi_y = \min(1 / (\phi_y + \sqrt{(\phi_y^2 - \bar{\lambda}_y^2)}), 1)$ = **0.923**

Design buckling resistance - eq 6.47 — $N_{b,y,Rd} = \chi_y \times A \times f_y / \gamma_{M1}$ = **515.9** kN

$N_{Ed} / N_{b,y,Rd}$ = **0.012**

PASS - Design buckling resistance exceeds design compression

Slenderness ratio for z-z axis flexural buckling - Section 6.3.1.3

Critical buckling length — $L_{cr,z} = L_{m3\_s1\_seg1}$ = **2800** mm

Critical buckling force — $N_{cr,z} = \pi^2 \times E \times I_z / L_{cr,z}^2$ = **237.3** kN

Slenderness ratio for buckling - eq 6.50 — $\bar{\lambda}_z = \sqrt{(A \times f_y / N_{cr,z})}$ = **1.535**

Check z-z axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 — b

Imperfection factor - Table 6.1 — α_z = **0.34**

Buckling reduction determination factor — $\phi_z = 0.5 \times (1 + \alpha_z \times (\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2)$ = **1.904**

Buckling reduction factor - eq 6.49 — $\chi_z = \min(1 / (\phi_z + \sqrt{(\phi_z^2 - \bar{\lambda}_z^2)}), 1)$ = **0.33**

Design buckling resistance - eq 6.47 — $N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1}$ = **184.3** kN

$N_{Ed} / N_{b,z,Rd}$ = **0.033**

PASS - Design buckling resistance exceeds design compression

Check torsional and torsional-flexural buckling - Section 6.3.1.4

Torsional buckling length — $L_{cr,T} = L_{m3\_s1\_seg1\_R}$ = **2800** mm

Distance from shear centre to centroid in y axis — y_0 = **0.0** mm

Distance from shear centre to centroid in z axis — z_0 = **0.0** mm

Radius of gyration — $i_0 = \sqrt{(i_y^2 + i_z^2)}$ = **67.4** mm

Elastic critical torsional buckling force — $N_{cr,T} = 1 / i_0^2 \times (G \times I_t + \pi^2 \times E \times I_w / L_{cr,T}^2)$ = **905.6** kN

Torsion factor — $\beta_T = 1 - (y_0 / i_0)^2$ = **1**

Elastic critical torsional-flexural buckling force

$N_{cr,TF} = N_{cr,y} / (2 \times \beta_T) \times [1 + N_{cr,T} / N_{cr,y} - \sqrt{[(1 - N_{cr,T} / N_{cr,y})^2 + 4 \times (y_0 / i_0)^2 \times N_{cr,T} / N_{cr,y}]}]$ = **905.6** kN

Elastic critical buckling force — $N_{cr} = \min(N_{cr,T}, N_{cr,TF})$ = **905.6** kN

Slenderness ratio for torsional buckling - eq 6.52 — $\bar{\lambda}_T = \sqrt{[A \times f_y / N_{cr}]}$ = **0.786**

Design resistance for torsional and torsional-flexural buckling - Section 6.3.1.1

Buckling curve - Table 6.2 — b

Imperfection factor - Table 6.1 — α_T = **0.34**

Buckling reduction determination factor — $\phi_T = 0.5 \times (1 + \alpha_T \times (\bar{\lambda}_T - 0.2) + \bar{\lambda}_T^2)$ = **0.908**

Buckling reduction factor - eq 6.49 — $\chi_T = \min(1 / (\phi_T + \sqrt{(\phi_T^2 - \bar{\lambda}_T^2)}), 1) = \mathbf{0.733}$

Design buckling resistance - eq 6.47 — $N_{b,T,Rd} = \chi_T \times A \times f_y / \gamma_{M1} = \mathbf{409.8}$ kN

$N_{Ed} / N_{b,T,Rd} = \mathbf{0.015}$

PASS - Design buckling resistance exceeds design compression

Check design at start of span

Check shear - Section 6.2.6

Height of web — $h_w = h - 2 \times t_f = \mathbf{137}$ mm — $\eta = \mathbf{1.000}$

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force — $V_{y,Ed} = \mathbf{1.7}$ kN

Shear area - cl 6.2.6(3) — $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w) = \mathbf{818}$ mm^2

Design shear resistance - cl 6.2.6(2) — $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0} = \mathbf{129.8}$ kN

$V_{y,Ed} / V_{c,y,Rd} = \mathbf{0.013}$

PASS - Design shear resistance exceeds design shear force

Check bending moment - Section 6.2.5

Design bending moment — $M_{y,Ed} = \mathbf{4.9}$ kNm

Design bending resistance moment - eq 6.13 — $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0} = \mathbf{33.9}$ kNm

$M_{y,Ed} / M_{c,y,Rd} = \mathbf{0.143}$

PASS - Design bending resistance moment exceeds design bending moment

Slenderness ratio for lateral torsional buckling

Correction factor - For cantilever beams — $k_c = \mathbf{1}$

$C_1 = 1 / k_c^2 = \mathbf{1}$

Poissons ratio — $\nu = \mathbf{0.3}$

Shear modulus — $G = E / [2 \times (1 + \nu)] = \mathbf{80769}$ N/mm^2

Unrestrained effective length — $L = 1.0 \times L_{m3\_s1\_seg1\_B} = \mathbf{2800}$ mm

Elastic critical buckling moment — $M_{cr} = C_1 \times \pi^2 \times E \times I_z / L^2 \times \sqrt{(I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z))} = \mathbf{31.3}$ kNm

Slenderness ratio for lateral torsional buckling — $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})} = \mathbf{1.041}$

Limiting slenderness ratio — $\bar{\lambda}_{LT,0} = \mathbf{0.4}$

$\bar{\lambda}_{LT} > \bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Check buckling resistance - Section 6.3.2.1

Buckling curve - Table 6.5 — b

Imperfection factor - Table 6.3 — $\alpha_{LT} = \mathbf{0.34}$

Correction factor for rolled sections — $\beta = \mathbf{0.75}$

LTB reduction determination factor — $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2] = \mathbf{1.016}$

LTB reduction factor - eq 6.57 — $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2) = \mathbf{0.674}$

Modification factor — $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1) = \mathbf{1.000}$

Modified LTB reduction factor - eq 6.58 — $\chi_{LT,mod} = \min(\chi_{LT} / f, 1, 1 / \bar{\lambda}_{LT}^2) = \mathbf{0.674}$

Design buckling resistance moment - eq 6.55 — $M_{b,y,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1} = \mathbf{22.9}$ kNm

$M_{y,Ed} / M_{b,y,Rd} = \mathbf{0.212}$

PASS - Design buckling resistance moment exceeds design bending moment

Check bending and axial force - Section 6.2.9

Bending and axial force check - eq.6.33 & eq.6.34 — $N_{y,lim} = \min(0.25 \times N_{pl,Rd}, 0.5 \times h_w \times t_w \times f_y / \gamma_{M0}) = \mathbf{84.8}$ kN

$N_{Ed} / N_{y,lim} = \mathbf{0.071}$

Allowance need not be made for the effect of the axial force on the plastic resistance moment about the y-y axis

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3 — ψ_y = 0 kNm / -4.856 kNm = **0.000**

α_y = -2.428 kNm / -4.856 kNm = **0.500**

C_{my} = max(0.6 + 0.4 × ψ_y) = **0.600**

ψ_{LT} = 0 kNm / -4.856 kNm = **0.000**

α_{LT} = -2.428 kNm / -4.856 kNm = **0.500**

C_{mLT} = max(0.6 + 0.4 × ψ_{LT}) = **0.600**

Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance — $M_{y,Rk} = W_{pl.y} \times f_y$ = **33.9** kNm

Characteristic moment resistance — $M_{z,Rk} = W_{pl.z} \times f_y$ = **8.6** kNm

Characteristic resistance to normal force — $N_{Rk} = A \times f_y$ = **558.8** kN

Interaction factors — $k_{yy} = C_{my} \times (1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}))$ = **0.602**

$k_{zy} = 1 - 0.1 \times \min(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1})$ = **0.991**

Interaction formulae - eq 6.61 & eq 6.62 — $N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.14**

$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.243**

PASS - Combined bending and compression checks are satisfied

Consider Combination 2 - 1.0G + 1.0Q + 1.0RQ (Service)

Check design 583 mm along span

Check y-y axis deflection - Section 7.2.1

Maximum deflection — δ_y = **0.2** mm

Allowable deflection — $\delta_{y,Allowable} = L_{m3\_s1} / 180$ = **15.6** mm

$\delta_y / \delta_{y,Allowable}$ = **0.01**

PASS - Allowable deflection exceeds design deflection

Rafter 2 design

Section details

Section type — UB 152x89x16 (BS4-1)

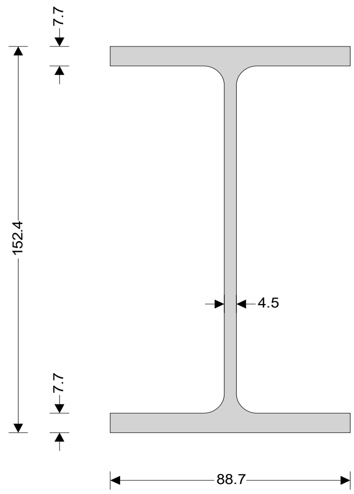
Steel grade - EN 10025-2:2004 — S275

Nominal thickness of element — $t_{nom} = \max(t_f, t_w)$ = **7.7** mm

Nominal yield strength — f_y = **275** N/mm^2

Nominal ultimate tensile strength — f_u = **410** N/mm^2

Modulus of elasticity — E = **210000** N/mm^2



UB 152x89x16 (BS4-1)
Section depth, h, 152.4 mm
Section breadth, b, 88.7 mm
Mass of section, Mass, 16 kg/m
Flange thickness, t_f, 7.7 mm
Web thickness, t_w, 4.5 mm
Root radius, r, 7.6 mm
Area of section, A, 2032 mm^2
Radius of gyration about y-axis, i_y, 64.074 mm
Radius of gyration about z-axis, i_z, 21.016 mm
Elastic section modulus about y-axis, $W_{el.y}$, 109483 mm^3
Elastic section modulus about z-axis, $W_{el.z}$, 20237 mm^3
Plastic section modulus about y-axis, $W_{pl.y}$, 123256 mm^3
Plastic section modulus about z-axis, $W_{pl.z}$, 31180 mm^3
Second moment of area about y-axis, I_y, 8342621 mm^4
Second moment of area about z-axis, I_z, 897506 mm^4

Lateral restraint

Both flanges have lateral restraint at supports only

<u>Consider Combination 1 - 1.35G + 1.5Q + 1.5RQ (Strength)</u>

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]} = \mathbf{0.92}$

Internal compression parts subject to bending and compression - Table 5.2 (sheet 1 of 3)

Width of section — $c = d = \mathbf{121.8}$ mm

$\alpha = \min([h / 2 + N_{Ed} / (2 \times t_w \times f_y) - (t_f + r)] / c, 1) = \mathbf{0.515}$

$c / t_w = 27.1 = 29.3 \times \varepsilon <= 396 \times \varepsilon / (13 \times \alpha - 1)$ Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section — $c = (b - t_w - 2 \times r) / 2 = \mathbf{34.5}$ mm

$c / t_f = 4.5 = 4.8 \times \varepsilon <= 9 \times \varepsilon$ Class 1

Section is class 1

Check compression - Section 6.2.4

Design compression force — $N_{Ed} = \mathbf{4.2}$ kN

Design resistance of section - eq 6.10 — $N_{c,Rd} = N_{pl,Rd} = A \times f_y / \gamma_{M0} = \mathbf{558.8}$ kN

$N_{Ed} / N_{c,Rd} = \mathbf{0.008}$

PASS - Design compression resistance exceeds design compression

Slenderness ratio for y-y axis flexural buckling - Section 6.3.1.3

Critical buckling length — $L_{cr,y} = L_{m4\_s1} = \mathbf{2766}$ mm

Critical buckling force — $N_{cr,y} = \pi^2 \times E \times I_y / L_{cr,y}^2 = \mathbf{2260.1}$ kN

Slenderness ratio for buckling - eq 6.50 — $\bar{\lambda}_y = \sqrt{(A \times f_y / N_{cr,y})} = \mathbf{0.497}$

Check y-y axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 — a

Imperfection factor - Table 6.1 — $\alpha_y = \mathbf{0.21}$

Buckling reduction determination factor — $\phi_y = 0.5 \times (1 + \alpha_y \times (\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2) = \mathbf{0.655}$

Buckling reduction factor - eq 6.49 — $\chi_y = \min(1 / (\phi_y + \sqrt{(\phi_y^2 - \bar{\lambda}_y^2)}), 1) = \mathbf{0.925}$

Design buckling resistance - eq 6.47 — $N_{b,y,Rd} = \chi_y \times A \times f_y / \gamma_{M1} = \mathbf{517}$ kN

$N_{Ed} / N_{b,y,Rd} = \mathbf{0.008}$

PASS - Design buckling resistance exceeds design compression

Slenderness ratio for z-z axis flexural buckling - Section 6.3.1.3

Critical buckling length $L_{cr,z} = L_{m4\_s1\_seg1} = \mathbf{2766}$ mm

Critical buckling force $N_{cr,z} = \pi^2 \times E \times I_z / L_{cr,z}^2 = \mathbf{243.1}$ kN

Slenderness ratio for buckling - eq 6.50 $\bar{\lambda}_z = \sqrt{(A \times f_y / N_{cr,z})} = \mathbf{1.516}$

Check z-z axis flexural buckling resistance - Section 6.3.1.1

Buckling curve - Table 6.2 b

Imperfection factor - Table 6.1 $\alpha_z = \mathbf{0.34}$

Buckling reduction determination factor $\phi_z = 0.5 \times (1 + \alpha_z \times (\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2) = \mathbf{1.873}$

Buckling reduction factor - eq 6.49 $\chi_z = \min(1 / (\phi_z + \sqrt{(\phi_z^2 - \bar{\lambda}_z^2)}), 1) = \mathbf{0.336}$

Design buckling resistance - eq 6.47 $N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1} = \mathbf{188}$ kN

$N_{Ed} / N_{b,z,Rd} = \mathbf{0.022}$

PASS - Design buckling resistance exceeds design compression

Check torsional and torsional-flexural buckling - Section 6.3.1.4

Torsional buckling length $L_{cr,T} = L_{m4\_s1\_seg1\_R} = \mathbf{2766}$ mm

Distance from shear centre to centroid in y axis $y_0 = \mathbf{0.0}$ mm

Distance from shear centre to centroid in z axis $z_0 = \mathbf{0.0}$ mm

Radius of gyration $i_0 = \sqrt{(i_y^2 + i_z^2)} = \mathbf{67.4}$ mm

Elastic critical torsional buckling force $N_{cr,T} = 1 / i_0^2 \times (G \times I_t + \pi^2 \times E \times I_w / L_{cr,T}^2) = \mathbf{912.3}$ kN

Torsion factor $\beta_T = 1 - (y_0 / i_0)^2 = \mathbf{1}$

Elastic critical torsional-flexural buckling force

$N_{cr,TF} = N_{cr,y} / (2 \times \beta_T) \times [1 + N_{cr,T} / N_{cr,y} - \sqrt{[(1 - N_{cr,T} / N_{cr,y})^2 + 4 \times (y_0 / i_0)^2 \times N_{cr,T} / N_{cr,y}]}] = \mathbf{912.3}$ kN

Elastic critical buckling force $N_{cr} = \min(N_{cr,T}, N_{cr,TF}) = \mathbf{912.3}$ kN

Slenderness ratio for torsional buckling - eq 6.52 $\bar{\lambda}_T = \sqrt{[A \times f_y / N_{cr}]} = \mathbf{0.783}$

Design resistance for torsional and torsional-flexural buckling - Section 6.3.1.1

Buckling curve - Table 6.2 b

Imperfection factor - Table 6.1 $\alpha_T = \mathbf{0.34}$

Buckling reduction determination factor $\phi_T = 0.5 \times (1 + \alpha_T \times (\bar{\lambda}_T - 0.2) + \bar{\lambda}_T^2) = \mathbf{0.905}$

Buckling reduction factor - eq 6.49 $\chi_T = \min(1 / (\phi_T + \sqrt{(\phi_T^2 - \bar{\lambda}_T^2)}), 1) = \mathbf{0.735}$

Design buckling resistance - eq 6.47 $N_{b,T,Rd} = \chi_T \times A \times f_y / \gamma_{M1} = \mathbf{410.8}$ kN

$N_{Ed} / N_{b,T,Rd} = \mathbf{0.01}$

PASS - Design buckling resistance exceeds design compression

<u>**Check design at start of span**</u>

Check shear - Section 6.2.6

Height of web $h_w = h - 2 \times t_f = \mathbf{137}$ mm $\eta = \mathbf{1.000}$

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force $V_{y,Ed} = \mathbf{3.9}$ kN

Shear area - cl 6.2.6(3) $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w) = \mathbf{818}$ mm^2

Design shear resistance - cl 6.2.6(2) $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0} = \mathbf{129.8}$ kN

$V_{y,Ed} / V_{c,y,Rd} = \mathbf{0.03}$

PASS - Design shear resistance exceeds design shear force

Check bending moment - Section 6.2.5

Design bending moment $M_{y,Ed} = \mathbf{6.5}$ kNm

Design bending resistance moment - eq 6.13 — $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0} = \mathbf{33.9}$ kNm

$M_{y,Ed} / M_{c,y,Rd} = \mathbf{0.192}$

PASS - Design bending resistance moment exceeds design bending moment

Slenderness ratio for lateral torsional buckling

Correction factor - For cantilever beams — $k_c = \mathbf{1}$

$C_1 = 1 / k_c^2 = \mathbf{1}$

Poissons ratio — $\nu = \mathbf{0.3}$

Shear modulus — $G = E / [2 \times (1 + \nu)] = \mathbf{80769}$ N/mm^2

Unrestrained effective length — $L = 1.0 \times L_{m4\_s1\_seg1\_T} = \mathbf{2766}$ mm

Elastic critical buckling moment — $M_{cr} = C_1 \times \pi^2 \times E \times I_z / L^2 \times \sqrt{(I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z))} = \mathbf{31.8}$ kNm

Slenderness ratio for lateral torsional buckling — $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})} = \mathbf{1.033}$

Limiting slenderness ratio — $\bar{\lambda}_{LT,0} = \mathbf{0.4}$

$\bar{\lambda}_{LT}$ > $\bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Check buckling resistance - Section 6.3.2.1

Buckling curve - Table 6.5 — b

Imperfection factor - Table 6.3 — $\alpha_{LT} = \mathbf{0.34}$

Correction factor for rolled sections — $\beta = \mathbf{0.75}$

LTB reduction determination factor — $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2] = \mathbf{1.008}$

LTB reduction factor - eq 6.57 — $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2) = \mathbf{0.679}$

Modification factor — $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1) = \mathbf{1.000}$

Modified LTB reduction factor - eq 6.58 — $\chi_{LT,mod} = \min(\chi_{LT} / f, 1, 1 / \bar{\lambda}_{LT}^2) = \mathbf{0.679}$

Design buckling resistance moment - eq 6.55 — $M_{b,y,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1} = \mathbf{23}$ kNm

$M_{y,Ed} / M_{b,y,Rd} = \mathbf{0.283}$

PASS - Design buckling resistance moment exceeds design bending moment

Check bending and axial force - Section 6.2.9

Bending and axial force check - eq.6.33 & eq.6.34 — $N_{y,lim} = \min(0.25 \times N_{pl,Rd}, 0.5 \times h_w \times t_w \times f_y / \gamma_{M0}) = \mathbf{84.8}$ kN

$N_{Ed} / N_{y,lim} = \mathbf{0.05}$

Allowance need not be made for the effect of the axial force on the plastic resistance moment about the y-y axis

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3 — $\psi_y = -4.856$ kNm / 6.51 kNm = $\mathbf{-0.746}$

$\alpha_y = 1.002$ kNm / 6.51 kNm = $\mathbf{0.154}$

$C_{my} = \max(0.2 + 0.8 \times \alpha_y, 0.4) = \mathbf{0.400}$

$\psi_{LT} = -4.856$ kNm / 6.51 kNm = $\mathbf{-0.746}$

$\alpha_{LT} = 1.002$ kNm / 6.51 kNm = $\mathbf{0.154}$

$C_{mLT} = \max(0.2 + 0.8 \times \alpha_{LT}, 0.4) = \mathbf{0.400}$

Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance — $M_{y,Rk} = W_{pl.y} \times f_y = \mathbf{33.9}$ kNm

Characteristic moment resistance — $M_{z,Rk} = W_{pl.z} \times f_y = \mathbf{8.6}$ kNm

Characteristic resistance to normal force — $N_{Rk} = A \times f_y = \mathbf{558.8}$ kN

Interaction factors — $k_{yy} = C_{my} \times (1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1})) = \mathbf{0.401}$

$k_{zy} = 1 - 0.1 \times \min(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1}) = \mathbf{0.985}$

Interaction formulae - eq 6.61 & eq 6.62 — $N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1}) = \mathbf{0.121}$

$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1}) = \mathbf{0.301}$

PASS - Combined bending and compression checks are satisfied

Check design at end of span

Check shear - Section 6.2.6

Height of web $h_w = h - 2 \times t_f = \mathbf{137}$ mm $\eta = \mathbf{1.000}$

$h_w / t_w = 30.4 = 32.9 \times \varepsilon / \eta < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force $V_{y,Ed} = \mathbf{4.4}$ kN

Shear area - cl 6.2.6(3) $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w) = \mathbf{818}$ mm^2

Design shear resistance - cl 6.2.6(2) $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{(3)}) / \gamma_{M0} = \mathbf{129.8}$ kN

$V_{y,Ed} / V_{c,y,Rd} = \mathbf{0.034}$

PASS - Design shear resistance exceeds design shear force

Check bending moment - Section 6.2.5

Design bending moment $M_{y,Ed} = \mathbf{4.9}$ kNm

Design bending resistance moment - eq 6.13 $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0} = \mathbf{33.9}$ kNm

$M_{y,Ed} / M_{c,y,Rd} = \mathbf{0.143}$

PASS - Design bending resistance moment exceeds design bending moment

Slenderness ratio for lateral torsional buckling

Correction factor - For cantilever beams $k_c = \mathbf{1}$

$C_1 = 1 / k_c^2 = \mathbf{1}$

Poissons ratio $\nu = \mathbf{0.3}$

Shear modulus $G = E / [2 \times (1 + \nu)] = \mathbf{80769}$ N/mm^2

Unrestrained effective length $L = 1.0 \times L_{m4\_s1\_seg1\_B} = \mathbf{2766}$ mm

Elastic critical buckling moment $M_{cr} = C_1 \times \pi^2 \times E \times I_z / L^2 \times \sqrt{(I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z))} = \mathbf{31.8}$ kNm

Slenderness ratio for lateral torsional buckling $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})} = \mathbf{1.033}$

Limiting slenderness ratio $\bar{\lambda}_{LT,0} = \mathbf{0.4}$

$\bar{\lambda}_{LT} > \bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Check buckling resistance - Section 6.3.2.1

Buckling curve - Table 6.5 b

Imperfection factor - Table 6.3 $\alpha_{LT} = \mathbf{0.34}$

Correction factor for rolled sections $\beta = \mathbf{0.75}$

LTB reduction determination factor $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2] = \mathbf{1.008}$

LTB reduction factor - eq 6.57 $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2) = \mathbf{0.679}$

Modification factor $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1) = \mathbf{1.000}$

Modified LTB reduction factor - eq 6.58 $\chi_{LT,mod} = \min(\chi_{LT} / f, 1, 1 / \bar{\lambda}_{LT}^2) = \mathbf{0.679}$

Design buckling resistance moment - eq 6.55 $M_{b,y,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1} = \mathbf{23}$ kNm

$M_{y,Ed} / M_{b,y,Rd} = \mathbf{0.211}$

PASS - Design buckling resistance moment exceeds design bending moment

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3 $\psi_y = -4.856$ kNm / 6.51 kNm = $\mathbf{-0.746}$

$\alpha_y = 1.002$ kNm / 6.51 kNm = $\mathbf{0.154}$

$C_{my} = \max(0.2 + 0.8 \times \alpha_y, 0.4) = \mathbf{0.400}$

$\psi_{LT} = -4.856$ kNm / 6.51 kNm = $\mathbf{-0.746}$

α_{LT} = 1.002 kNm / 6.51 kNm = **0.154**

C_{mLT} = max(0.2 + 0.8 × α_{LT}, 0.4) = **0.400**

Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance — $M_{y,Rk} = W_{pl.y} \times f_y$ = **33.9** kNm

Characteristic moment resistance — $M_{z,Rk} = W_{pl.z} \times f_y$ = **8.6** kNm

Characteristic resistance to normal force — $N_{Rk} = A \times f_y$ = **558.8** kN

Interaction factors — $k_{yy} = C_{my} \times (1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}))$ = **0.401**

$k_{zy} = 1 - 0.1 \times \min(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1})$ = **0.984**

Interaction formulae - eq 6.61 & eq 6.62 — $N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.093**

$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1})$ = **0.231**

PASS - Combined bending and compression checks are satisfied

Consider Combination 2 - 1.0G + 1.0Q + 1.0RQ (Service)

Check design at start of span

Check y-y axis deflection - Section 7.2.1

Maximum deflection — δ_y = **0.2** mm

Allowable deflection — $\delta_{y,Allowable} = L_{m4\_s1} / 180$ = **15.4** mm

$\delta_y / \delta_{y,Allowable}$ = **0.014**

PASS - Allowable deflection exceeds design deflection

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House			Job no. JP1524	
	Section Beam B16			Sheet no./rev 49	
	Calcs by AM	date 10/01/2020	Chk'd by JP date 10/01/2020	App'd by JP	date 10/01/2020

Beam B16 **UC** **203x203x52 UC**

SUMMARY OF RESULTS

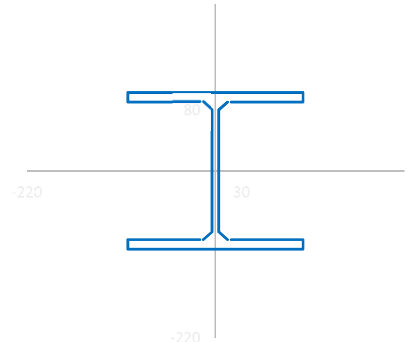
Max Applied Moment =	52.1 kNm	< 140.25 kNm	**OK**
Max Applied Shear =	29 kN	< 268.78 kN	**OK**
Max Deflection LL =	2.7 mm	< 20 mm	**OK**
Max Buckling =	52.1 kNm	< 64.5 kNm	**OK**

Span = 7.2 meters

Support positions

Distance from end Support A 0.00 m Support B 7.200 m

Support conditions Bottom flange to supports



Loading

Roof Super load both sides, spaning 2.8 m & 2.8 m

Imposed: Critical case udl load, 0.3 x 5.6 / 2 = 0.84 kN/m

45 degree Pitched roof Concrete Marley either side

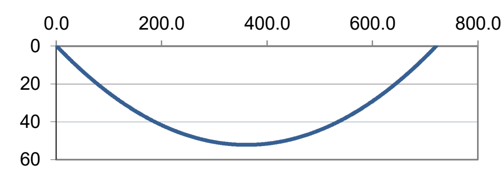
Dead: udl load, 1.08 / cos(45) x 5.6 / 2 = 4.276 kN/m

unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
20.25 kN	28.96 kN		20.25 kN	28.96 kN

Class 1 Plastic

Bending Moment (ULS)

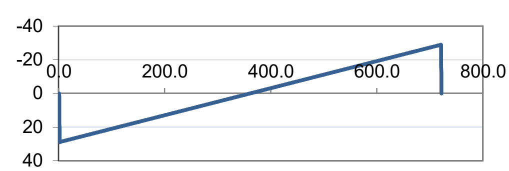
Actual moment =	52.13	*kNm*
Allowable moment =	140.25	*kNm*
Capacity	**37%**	
	LTB (ULS)	
Actual Buckling resistance =	64.51	*kNm*
Capacity	**81%**	



Bending moment diagram

Shear (ULS)

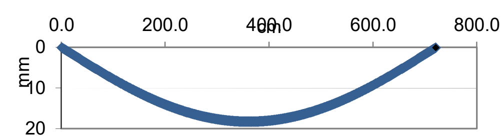
Actual shear =	28.96	*kN*
Allowable shear =	268.78	*kN*
Low shear present		
Capacity	**11%**	



Shear force diagram

Deflection (SLS)

Total deflection =	18.26	*mm*	*(L/394)*
Actual deflection LL =	2.73	*mm*	*(L/2637)*
Allowable deflection LL =	*20.00*	*mm*	*(L/360)*
Capacity	**63%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = **28.96** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**3.6N Blockwork**			
Characteristic strength of masonry =	**2.6**	N/mm²		
Width of beam end bearing =	**204.3**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	1.42	N/mm²	
Capacity	**131%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**440**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	1.42	N/mm²	
Capacity	**26%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.66	N/mm²	
Capacity	**61%**		**OK**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House				Job no. JP1524	
	Section Beam B17				Sheet no./rev 51	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam B17 **UC** **152x152x30 UC**

Span = **4.2** meters

Support positions

Distance from end Support A 0.00 m Support B 4.200 m

Support conditions Bottom flange to supports

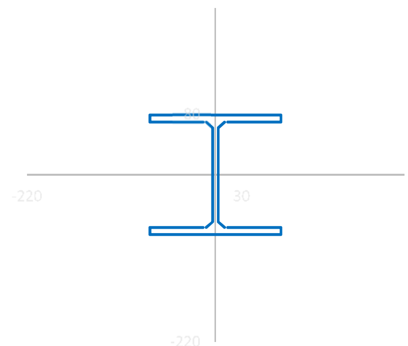
Loading

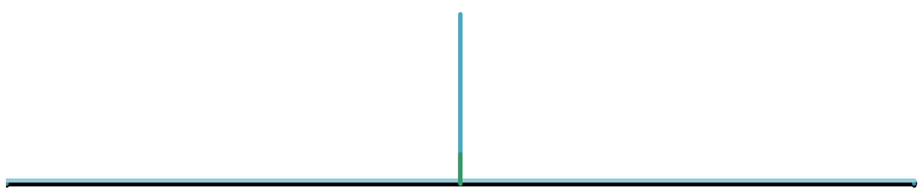
Dead: Point load, Load from C5 17.2 kN acting at 2.1 m from the support

Imposed: Point load, Load from C5 3 kN acting at 2.1 m from the support

SUMMARY OF RESULTS

Max Applied Moment =	31.2 kNm	< 61.05 kNm	**OK**
Max Applied Shear =	15.3 kN	< 169.03 kN	**OK**
Max Deflection LL =	1.3 mm	< 11.67 mm	**OK**
Max Buckling =	31.2 kNm	< 37.5 kNm	**OK**





unfactored	factored	LOADING DIAGRAM & REACTIONS	unfactored	factored
10.72 kN	15.31 kN		10.72 kN	15.31 kN

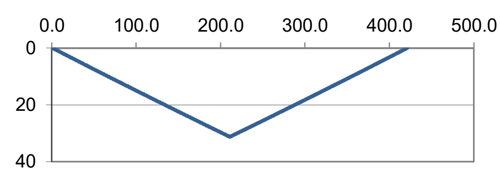
Class 1 Plastic

Bending Moment (ULS)

Actual moment =	31.23	*kNm*
Allowable moment =	61.05	*kNm*
Capacity	**51%**	

LTB (ULS)

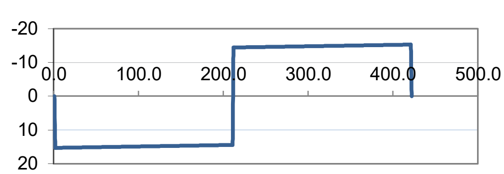
Actual Buckling resistance =	37.51	*kNm*
Capacity	**83%**	



Bending moment diagram

Shear (ULS)

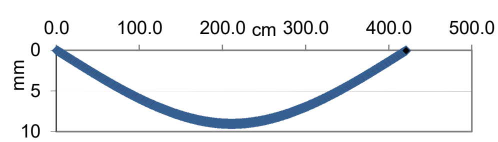
Actual shear =	15.31	*kN*
Allowable shear =	169.03	*kN*
Low shear present		
Capacity	**9%**	



Shear force diagram

Deflection (SLS)

Total deflection =	9.02	*mm*	*(L/466)*
Actual deflection LL =	1.29	*mm*	*(L/3256)*
Allowable deflection LL =	*11.67*	*mm*	*(L/360)*
Capacity	**54%**		



Deflection

calculations are based on **BS5950**:1-2000

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project Brook House			Job no. JP1524	
	Section Bearing Beam B17			Sheet no./rev 52	
	Calcs by AM	date 10/01/2020	Chk'd by JP	date 10/01/2020	App'd by JP	date 10/01/2020

Beam End Reaction = 15.31 kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**3.6N Blockwork**			
Characteristic strength of masonry =	**2.6**	N/mm²		
Width of beam end bearing =	**100**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	1.53	N/mm²	
Capacity	**141%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**215**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	1.53	N/mm²	
Capacity	**28%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.71	N/mm²	
Capacity	**66%**		**OK**

	Project			Job no.	
Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Brook House			JP1524	
	Section			Sheet no./rev	
	Beam B18			53	
	Calcs by	date	Chk'd by	date	App'd by	date
	AM	10/01/2020	JP	10/01/2020	JP	10/01/2020

Beam B18 **UC** **203x203x52 UC**

SUMMARY OF RESULTS

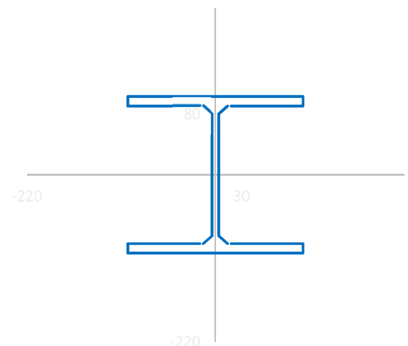
Max Applied Moment =	62.5 kNm	< 140.25 kNm	**OK**
Max Applied Shear =	34.5 kN	< 268.78 kN	**OK**
Max Deflection LL =	6.5 mm	< 20.14 mm	**OK**
	62.5 kNm		

Span = **7.25** meters

Support positions

Distance from end Support A 0.00 m Support B 7.250 m

Support conditions Bottom flange to supports



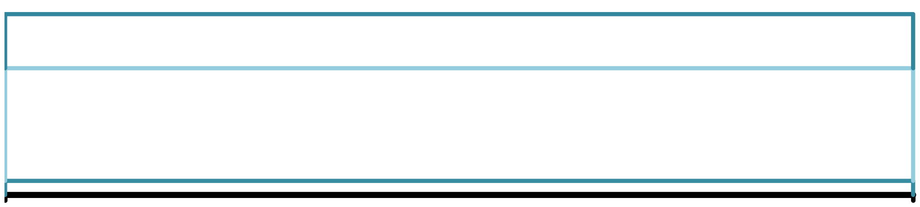
Loading

Roof Super load both sides, spaning 3.4 m & 3.1 m

Imposed: Critical case udl load, 0.6 x 6.5 / 2 = 1.95 kN/m

30 degree Pitched roof Concrete Marley either side

Dead: udl load, 1.08 / cos(30) x 6.5 / 2 = 4.053 kN/m

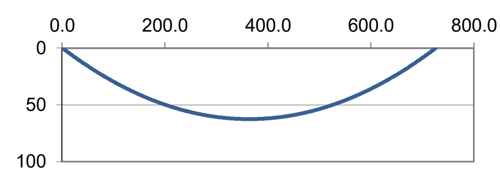


unfactored	factored	**LOADING DIAGRAM & REACTIONS**	unfactored	*factored*
23.61 kN	34.47 kN		23.61 kN	34.47 kN

Class 1 Plastic

Bending Moment (ULS)

Actual moment =	62.47	*kNm*
Allowable moment =	140.25	*kNm*
Capacity	**45%**	



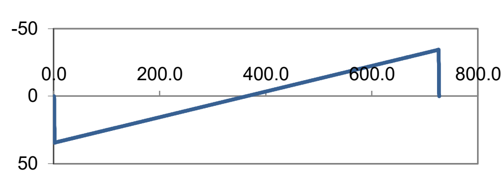
Bending moment diagram

LTB (ULS)

Actual Buckling resistance =		*Fully restrained*
Capacity	**0%**	

Shear (ULS)

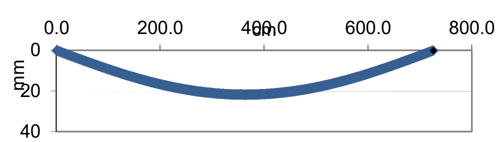
Actual shear =	34.47	*kN*
Allowable shear =	268.78	*kN*
Low shear present		
Capacity	**13%**	



Shear force diagram

Deflection (SLS)

Total deflection =	21.73	*mm*	*(L/334)*
Actual deflection LL =	6.51	*mm*	*(L/1114)*
Allowable deflection LL =	*20.14*	*mm*	*(L/360)*
Capacity	**75%**		



Deflection

calculations are based on **BS5950**:1-2000

Beam End Reaction = **34.47** kN (factored)

Variable Load Safety Factor = 1.6
Permanent Load Safety Factor = 1.4

Masonry

Masonry type =	**3.6N Blockwork**			
Characteristic strength of masonry =	**2.6**	N/mm²		
Width of beam end bearing =	**204.3**	mm	Bearing factor =	**1.25**
Length of beam end bearing =	**100**	mm	γm =	**3.00**

Stress

Maximum Bearing Stress =	1.08	N/mm²	
Actual Bearing Stress =	1.69	N/mm²	
Capacity	**156%**		**Padstone Required**

Padstone

A Engineering Brick

Characteristic strength of padstone =	**13.2**	N/mm²	
Width of padstone =	**100**	mm	
Length of padstone =	**440**	mm	
Maximum bearing stress padstone =	5.50	N/mm²	
Stress under beam =	1.69	N/mm²	
Capacity	**31%**		**OK**
Maximum bearing stress masonry	1.08	N/mm²	
Stress under padstone =	0.78	N/mm²	
Capacity	**72%**		**OK**

Structural Calculation Ltd Mobbs Wood Farm, Coventry, CV7 9JN	Project: Brook House	Job no: JP1524
	Section: Column C2	Sheet no./rev: 55
	Calcs by: AM — date: 10/01/2020 — Chk'd by: JP — date: 10/01/2020	App'd by: JP — date: 10/01/2020

Column C2 SHS 120x120x6.3

Height = 2.500 meters

SUMMARY OF RESULTS

Nominal effective length 'L_{Ex} / L_{Ey}' *[mm]* =	3000 / 3000	
Compression resistance:	655 kN > 64 kN	**OK**
Buckling resistance:	33 kNm > 5 kNm	**OK**
Overall check:	0.52 < 1.00	**OK**

End restraint

Top x-x:	Not held in position but restrained in direction
Top y-y:	Not held in position but restrained in direction
Btm. x-x:	Effectively held in position and restrained in direction
Btm. y-y:	Effectively held in position and restrained in direction

Effecice length factors

For x-x axis '$L_{Fx\text{-}x}$' = 1.20

For y-y axis '$L_{Fy\text{-}y}$' = 1.20

Loading

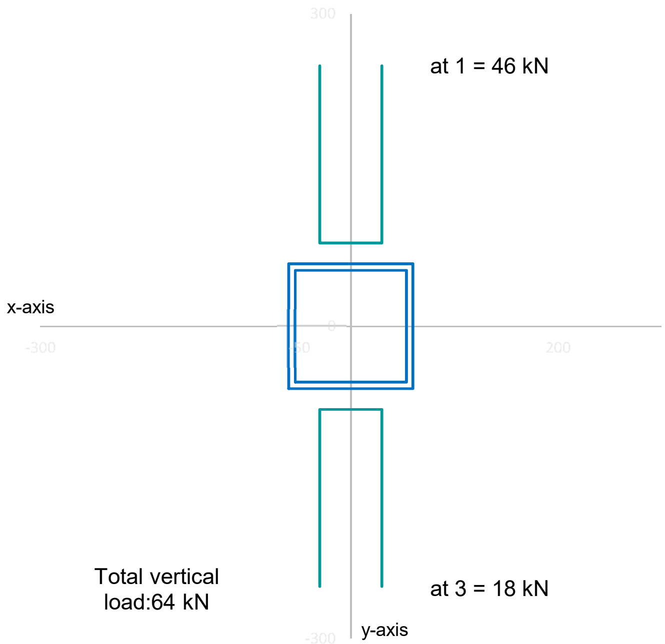
Imposed Direct compression 'PL' [kN] =

Dead Direct compression 'PL' *[kN]* =

	at 1	*at 2*	*at 3*	*at 4*
Eccentricity	100		100	
LL Reaction	13.6		6	
DL Reaction	17		5.9	

Applied moment about x-x axis 'M_{xx}' *[kNm]* =

Applied moment about y-y axis 'M_{yy}' *[kNm]* =



NOTE: Loads are factored.

Section is class 1 plastic

Steel Grade:	S275
Resultant moment about x-x axis 'M_{xx}' *[kNm]* =	4.43
Resultant moment about y-y axis 'M_{yy}' *[kNm]* =	7.93

Compression resistance

Reduced design strength 'p_{yr}' *[MPa]* =	N/A
Slenderness for x-x axis 'λ_x' =	64.9
Slenderness for y-y axis 'λ_y' =	64.9
Strut curve for x-x axis:	a)
Strut curve for y-y axis:	a)
Parameter 'p_E' =	479.8
Robertson constant 'α' =	2.0
Limiting slenderness 'λ_0' =	17.2
Perry factor 'η' =	0.10
Parameter 'Ø' =	400.3
Compressive strength 'p_c' *[N/mm²]* =	232.1
Based on y-y axis calculations	
Compression resistance 'P_c' *[kN]* =	654.4
Applied total vertical load 'F_c' *[kN]* =	63.4
Capacity	**10%**

Buckling resistance moment

Equivalent slenderness 'λ_{LT}':	27.1
Parameter 'p_E' =	2763.9
Robertson constant α_{LT} =	7.0
Limiting equivalent slenderness 'λ_{L0}' =	34.3
Perry factor η_{LT} =	0.0
Parameter $Ø_{LT}$ =	1519.4
Bending strength 'p_b' *[N/mm²]* =	275.0
Member buckling resistance 'M_{bs}' *[kNm]* =	33.0
Applied moment about x-x 'M_{xx}' *[kNm]* =	4.4
Capacity	**13%**

Bending about Y-Y

Moment of resistance 'M_{Ry}' *[kNm]* =	27.5
Applied moment about y-y 'M_{yy}' *[kNm]* =	7.9
Capacity	**29%**

Overall check based on equation for 'simple structures'

F_c / Pc + M_x / M_{bs} + M_y / (p_y * Z_y) = 64 / 655 + 5 / 33 + 8 / (275 * 100) = 0.10 + 0.13 + 0.29 = **52%**

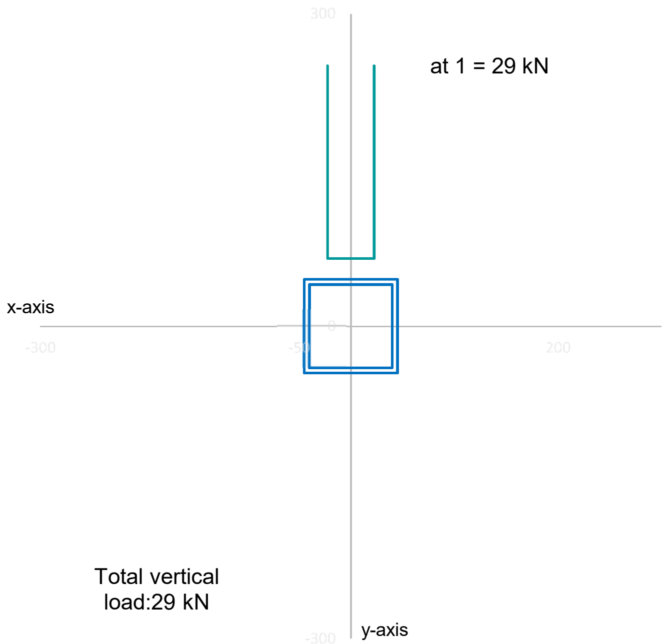
calculations are based on **BS5950**:1-2000 and SCI Steelwork Design Guide

Column C5 **SHS** **90x90x5**

Height = **1.500** meters

SUMMARY OF RESULTS

Nominal effective length 'L_{Ex} / L_{Ey}' *[mm]* =	1800 / 1800	
Compression resistance:	416 kN > 29 kN	**OK**
Buckling resistance:	15 kNm > 5 kNm	**OK**
Overall check:	0.54 < 1.00	**OK**



End restraint

Top x-x: Not held in position but restrained in direction
Top y-y: Not held in position but restrained in direction
Btm. x-x: Effectively held in position and restrained in direction
Btm. y-y: Effectively held in position and restrained in direction

Effectice length factors

For x-x axis '$L_{Fx\text{-}x}$' = 1.20
For y-y axis '$L_{Fy\text{-}y}$' = 1.20

Loading

Imposed Direct compression 'PL' [kN] =
Dead Direct compression 'PL' *[kN]* =

	at 1	*at 2*	*at 3*	*at 4*
Eccentricity	**100**			
LL Reaction	**3**			
DL Reaction	**17.2**			

Applied moment about x-x axis 'M_{xx}' *[kNm]* =
Applied moment about y-y axis 'M_{yy}' *[kNm]* =

Section is class 1 plastic

NOTE: Loads are factored.

Steel Grade:	**S275**
Resultant moment about x-x axis 'M_{xx}' *[kNm]* =	4.19
Resultant moment about y-y axis 'M_{yy}' *[kNm]* =	2.17

Compression resistance

Reduced design strength 'p_{yr}' *[MPa]* =	N/A
Slenderness for x-x axis 'λ_x' =	52.2
Slenderness for y-y axis 'λ_y' =	52.2
Strut curve for x-x axis:	a)
Strut curve for y-y axis:	a)
Parameter 'p_E' =	743.3
Robertson constant 'α' =	2.0
Limiting slenderness 'λ_0' =	17.2
Perry factor 'η' =	0.07
Parameter 'Ø' =	535.2
Compressive strength 'p_c' *[N/mm^2]* =	248.8
Based on y-y axis calculations	
Compression resistance 'P_c' *[kN]* =	415.5
Applied total vertical load 'F_c' *[kN]* =	28.9
Capacity	**7%**

Buckling resistance moment

Equivalent slenderness 'λ_{LT}':	21.7
Parameter 'p_E' =	4281.2
Robertson constant α_{LT} =	7.0
Limiting equivalent slenderness 'λ_{L0}' =	34.3
Perry factor η_{LT} =	0.0
Parameter $Ø_{LT}$ =	2278.1
Bending strength 'p_b' *[N/mm^2]* =	275.0
Member buckling resistance 'M_{bs}' *[kNm]* =	14.6
Applied moment about x-x 'M_{xx}' *[kNm]* =	4.2
Capacity	**29%**

Bending about Y-Y

Moment of resistance 'M_{Ry}' *[kNm]* =	12.1
Applied moment about y-y 'M_{yy}' *[kNm]* =	2.2
Capacity	**18%**

Overall check based on equation for 'simple structures'

F_c / Pc + M_x / M_{bs} + M_y / (p_y * Z_y) = 29 / 416 + 5 / 15 + 3 / (275 * 44) = 0.07 + 0.29 + 0.18 = **54%**

Project	Brook House	Job no.	JP1524
Section	Masonry Column under B7 & B10	Sheet no./rev	57

Structural Calculation Ltd
Mobbs Wood Farm,
Coventry,
CV7 9JN

Calcs by	date	Chk'd by	date	App'd by	date
AM	10/01/2020	JP	10/01/2020	JP	10/01/2020

SUMMARY OF RESULTS:

Slenderness check: 11.63 < 27.00	**OK**
Column design vertical load resistance: 56.7 < 88.0	**OK**

MASONRY DATA:

Masonry type: **Solid aggregate concrete blocks laid flat**
Compressive unit strength 'p_{unit}' [N/mm^2] = **7.3**
As laid height of laid flat blocks 'h_{unit}' [mm] = **100.0**
Least horizontal dimension of blocks 'l_{unit}' [mm] = N/A
Mortar strength class/designation = **M4 (iii)**
Characteristic compressive strength 'f_k' [N/mm^2] = 4.10

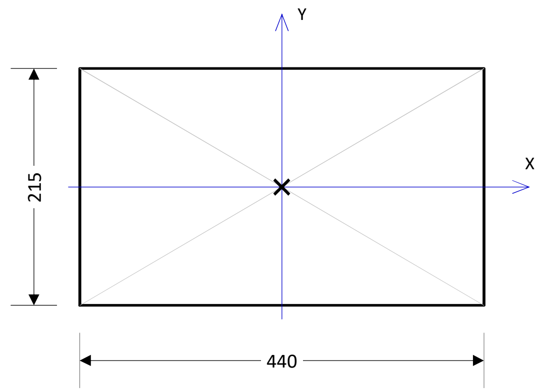
PARTIAL SAFETY FACTORS:

Category of masonry units: **Category II**
Category of construction control: **Normal**

COLUMN DATA:

Column height 'H' [m] = **2.50**
Column width 'b' [mm] = **440.0**
Column thickness 't' [mm] = **215.0**

DIAGRAM



LOADING:

Applied design vertical load on column 'PL' [kN] = **56.7**
Load eccentricity along column width '$e_{x\text{-}b}$' [mm] = **0.0**
Load eccentricity along column thickness '$e_{x\text{-}t}$' [mm] = **0.0**
Ratio $e_{x\text{-}b}$ / b = 0.00
Ratio $e_{x\text{-}t}$ / t = 0.00

SLENDERNESS CHECK

Column slenderness in minor axis 'λ_{minor}' = 11.63
Column slenderness in major axis 'λ_{major}' = 5.68
Maximum slenderness 'λ_{max}' = 11.63
Maximum allowable slenderness '$\lambda_{allowable}$' = 27.00
SLENDERNESS: OK

MINOR AXIS

Eccentricity due to slenderness 'e_{a_minor}' = 8.89
Design eccentricity in the mid-height of column 'e_{t_minor}' = 15.34
Total design eccentricity 'e_{m_minor}' = 15.34
Capacity reduction factor 'β_{minor}' = 0.94
Cap for capacity reduction factor 'β_{cap_minor}' = 1.00
Final capacity reduction factor 'β_{final_minor}' = 0.94

MAJOR AXIS

Eccentricity due to slenderness 'e_{a_major}' = 0.00
Design eccentricity in the mid-height of column 'e_{t_major}' = 13.20
Total design eccentricity 'e_{m_major}' = 13.20
Capacity reduction factor 'β_{major}' = 1.03
Cap for capacity reduction factor 'β_{cap_major}' = 1.00
Final capacity reduction factor 'β_{final_major}' = 1.00

DESIGN LOAD RESISTANCE

Characteristic compressive strength 'f_k' [N/mm^2] = 4.10
Partial safety factor for compression 'γ_m' = 3.50
Minimum capacity reduction factor 'β_{min}' = 0.94
Reduction factor for small plan area column 'γ_{area}' = 0.84
Design vertical load resistance 'R_d' [kN] = 87.98
Applied design vertical load on column 'PL' [kN] = 56.70
COLUMN DESIGN LOAD RESISTANCE: OK

NOTE: all eccentricities are in 'mm'

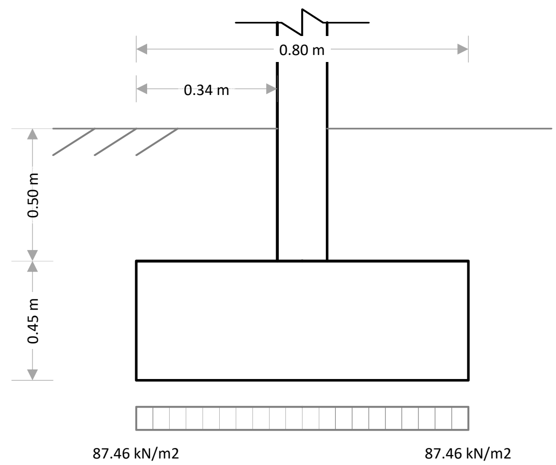
calculations are based on **BS 5628-1: 2005**

Foundation details

Pad foundation type:	unreinforced	
Foundation width =	0.8	m
Foundation thickness =	0.45	m
Soil overburden depth =	0.5	m
Load width =	0.12	m
Load eccentricity =	0	m
Concrete density =	24	kN/m³
Characteristic strength of concrete =	30	N/mm²
Soil density =	20.5	kN/m³

SUMMARY OF RESULTS

Restoring moment [kNm/m] =	N/A	
Resistance to sliding [kN/m] =	N/A	
Bearing pressure [kN/m^2] =	87.5 < 150.0	**OK**
Reinforcement =		**not required**



Allowable bearing pressure = 150 kN/m²

Loading

Loading	dead	imposed	wind
Partial safety factor 'γ_f' =	1.40	1.60	
Surcharge 'UDL' *[kN/m^2]* =	0.00	0.00	
Axial load 'N' *[kN]* =	22.90	19.60	
Horizontal load 'H' *[kN]* =	0.00	0.00	
Moment load 'M' *[kNm]* =	0.00	0.00	
Foundation s/w *[kN/m^2]* =	10.80	-	-
Soil s/w *[kN/m^2]* =	10.25	-	-

Overturning

Overall factor of safety =	1.50
Overturning moment =	N/A
Restoring moment (foundation loads) =	N/A
Restoring moment (axial loads) =	N/A
Total restoring moment =	N/A

Restoring moment: N/A

Unreinforced concrete

Average pressure on the left =	87.46	*kN/m^2*
Average pressure on the right =	87.46	*kN/m^2*
Min. unreinforced foundation depth =	0.34	*m*

Reinforcement not required

Sliding

Overall factor of safety =	1.50
Passive pressure coefficient =	N/A
Total horizontal load =	N/A
Resistance due to base friction =	N/A
Resistance due to passive force =	N/A
Total resistance to sliding =	N/A

Sliding: N/A

Bearing pressure

Total base reaction =	87.46
Effective eccentricity =	0
Maximum base pressure =	87.46
Minimum base pressure =	87.46

Base reaction acts within middle third of base
Bearing pressure: OK