SURREY HILLS CONSULTING ENGINEERS LIMITED STRUCTURAL ENGINEERING CONSULTANTS	Project **Peerglow Estate, London, EN3 4SB**				Job Ref. **AR0700**	
	Section **Second Floor and Roof Design**				Sheet no./rev. **1**	
	Calc. by **AT**	Date **Oct 2023**	Chk'd by **AC**	Date **Oct 2023**	App'd by	Date

STRUCTURAL CALCULATIONS

Second Floor and Roof Design

For

[redacted]

At

Peerglow Estate

London

EN3 4SB

October 2023

PREAMBLE

1. The calculations that follow form part only of the overall application submitted for Building Control Approval and are based upon drawings prepared by others. Dimensions used in calculations have been scaled/obtained from such drawings.

2. The purpose of the calculations is to justify the use of identified structural members as shown on plans, or to determine minimum sizes necessary to comply with relevant Standards where sizes have either not been shown on plans or have proved to be undersized. Should sizes calculated conflict with those shown on plans the most structurally beneficial shall be adopted and it is the responsibility of the drawing originator to amend plans as appropriate.

3. The calculations are in respect only of those structural elements to which they specifically refer. No responsibility or liability is therefore accepted in respect of any other element or part of the building.

4. The contractor is to take all necessary precautions to ensure the safety of the building and its stability during all stages of the proposed works.

5. Any alterations to the drawings or any on site discrepancies or changes affected on site during construction should be notified to the Structural Engineer in writing, with specific instructions to accommodate the changes made – as such changes could materially affect the sizes of the structural members that have been designed, approved and adopted on plans.

6. In any event, all work shall be made available for inspection by, and shall be to the entire satisfaction of, the Local Authority Building Control Inspector or other Approved Inspector.

7. No work appertaining to the plans should be carried out until the plans and calculations have been examined by the appropriate Local/Statutory Authority and formal written approval obtained. Any works carried before such approval is obtained, either for the original Application or revised information, is done solely at the Contractor's/Owners own risk. No works relating to these calculations should be carried out if 'Conditional Approval Subject to Calculations' is granted by the Local Authority.

8. No site visits are to be made by the Engineer during the course of construction unless specifically requested in writing.

GENERAL NOTES

1. For setting out dimensions and general construction details, see Architect's Drawings. Any Engineer's sketch or drawings must not be scaled.

2. Contractor to check all dimensions and levels prior to commencing any construction or fabrication.

3. Any sketch, drawing or specification is to be read in conjunction with all other sketches, drawings or specifications relating to the project.

4. Where site or adjoining building details are at variance with issued details the Engineer is to be informed immediately in writing.

5. The contractor is to ensure the stability of each element and the whole building until the construction is complete.

6. All designs, connections, workmanship and materials are to comply with current Building Regulations, relevant British Standards, Codes of Practice, Manufacturers recommendations and Engineer details.

7. No structural members are to be cut, notched or jointed unless specified.

8. Proprietary structural elements, fixings or admixtures may only be used with Engineer's approval and to manufacturers' recommendations.

9. Unless noted otherwise, all connections (including laps and anchorage of any reinforcement in concrete) shall mobilize the full structural capacity of the member.

10. All bolted connections of steelwork shall have a minimum of 2 bolts.

11. All structural connections of timber to be formed using double-sided timber connectors and bolts with large washers.

12. No holes of any size to be formed in structural members unless specified by the Engineer or approval by him in writing.

LOADING (kN/m^2)

The following loading is generally considered in the design of the structural elements.

PITCHED ROOF PERMANENT ACTIONS

Tiles	w_{Gtiles} = 0.55 kN/m^2
Rafters, Battens and Felt	$w_{Grafters}$ = 0.15 kN/m^2
Insulation	w_{Ginsul} = 0.10 kN/m^2
Plasterboard & Skim	$w_{Gplaster}$ = 0.20 kN/m^2

Total pitched roof permanent action = 1.00 kN/m^2

PITCHED ROOF VARIABLE ACTIONS

Pitched roof variable action $w_{Qsnow\ pitch}$ = 0.60 kN/m^2

FLAT ROOF PERMANENT ACTIONS

Chipping's and Bitumen	w_{Gchip} = 0.20 kN/m^2
Three Layers Felt	w_{Gfelt} = 0.10 kN/m^2
Boarding & Joists	$w_{Gjoists}$ = 0.30 kN/m^2
Insulation	w_{Ginsul} = 0.10 kN/m^2
Plasterboard & Skim	$w_{Gplaster}$ = 0.20 kN/m^2
Total flat roof permanent action	$w_{Gflatroof} = (w_{Gchip} + w_{Gfelt} + w_{Gjoists} + w_{Ginsul} + w_{Gplaster})$ = 0.90 kN/m^2

FLAT ROOF VARIABLE ACTIONS

Flat roof variable action $w_{Qsnow\ flat}$ = 0.75 kN/m^2

CEILING PERMANENT ACTIONS

Boarding & Joists	$w_{Gjoists}$ = 0.30 kN/m^2
Insulation	w_{Ginsul} = 0.10 kN/m^2
Plasterboard & Skim	$w_{Gplaster}$ = 0.20 kN/m^2

CEILING VARIABLE ACTIONS

Ceiling variable action $w_{Qceiling}$ = 0.25 kN/m^2

FLOORS PERMANENT ACTIONS

Boarding & Joists	$w_{Gjoists}$ = 0.30 kN/m^2
Plasterboard & Skim	$w_{Gplaster}$ = 0.20 kN/m^2
Total floor permanent action	$w_{Gfloor} = (w_{Gjoists} + w_{Gplaster})$ = 0.50 kN/m^2

FLOOR VARIABLE ACTIONS

Floor variable action w_{Qfloor} = 1.50 kN/m^2

STUDWORK PARTITIONS

Studs and Noggins w_{Gstud} = 0.10 kN/m^2

Insulation	$w_{Ginsul} = 0.10$ kN/m^2
Plasterboard & Skim	$w_{Gplaster} = 0.20$ kN/m^2
Total	$w_{Gpartitions} = (w_{Gstud} + w_{Ginsul} + w_{Gplaster}) = 0.40$ kN/m^2

BLOCKWORK PARTITIONS

100mm blockwork	$w_{Gblock} = 2.20$ kN/m^2
Plasterboard & Skim	$w_{Gplaster} = 0.20$ kN/m^2

100mm BRICK WALL

100 Bricks	$w_{Gbrick100} = 2.15$ kN/m^2
Plasterboard & Skim	$w_{Gplaster} = 0.20$ kN/m^2

215mm BRICK WALL

215 Bricks	$w_{Gbrick215} = 4.30$ kN/m^2
Render & Skim	$w_{Grender} = 0.70$ kN/m^2

CAVITY WALL

102 Brick + 140 Block	$w_{Gblock} + w_{Gbrick100} = 4.35$ kN/m^2
Insulation	$w_{Ginsul} = 0.10$ kN/m^2
Plasterboard & Skim	$w_{Gplaster} = 0.20$ kN/m^2

GLASS

15mm thick toughened laminated	$w_{Gglass} = 0.38$ kN/m^2

Members Design

The following calculations are based on the information provided by the client via email dated **19/10/23**. No site visit or surveys have been carried out for the purposes of these calculations. The calculations are to be read in conjunction with all the relevant structural engineering drawings/sketches and architectural drawings.

Floor Joists C24 50x200 @ 400C.C

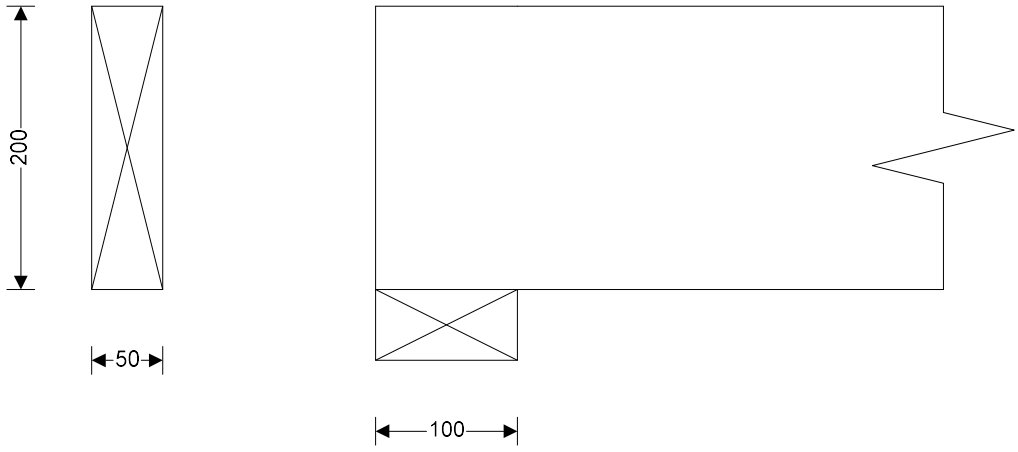
TIMBER JOIST DESIGN (BS5268-2:2002)

Joist details

Joist breadth;	b = **50** mm
Joist depth;	h = **200** mm
Joist spacing;	s = **400** mm
Timber strength class;	**C24**
Service class of timber;	**1**

Span details

Number of spans;	N_{span} = **1**
Length of bearing;	L_b = **100** mm
Effective length of span;	L_{s1} = **3600** mm



Section properties

Second moment of area;	$I = b \times h^3 / 12$ = **33333333** mm^4
Section modulus;	$Z = b \times h^2 / 6$ = **333333** mm^3

Loading details

Joist self weight;	$F_{swt} = b \times h \times \rho_{char} \times g_{acc}$ = **0.03** kN/m
Dead load;	F_{d_udl} = **0.75** kN/m^2
Imposed UDL(Long term);	F_{i_udl} = **1.50** kN/m^2

Imposed point load (Medium term); F_{i_pt} = **1.40** kN

Modification factors

Service class for bending parallel to grain K_{2m} = **1.00**
Service class for compression K_{2c} = **1.00**
Service class for shear parallel to grain K_{2s} = **1.00**
Service class for modulus of elasticity K_{2e} = **1.00**
Section depth factor; K_7 = **1.05**
Load sharing factor; K_8 = **1.10**

Consider long term loads

Load duration factor; K_3 = **1.00**
Maximum bending moment; M = **1.514** kNm
Maximum shear force; V = **1.682** kN
Maximum support reaction; R = **1.682** kN
Maximum deflection; δ = **5.945** mm

Check bending stress

Bending stress; σ_m = **7.500** N/mm^2
Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **8.626** N/mm^2
Applied bending stress; σ_{m_max} = M / Z = **4.541** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.710** N/mm^2
Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.781** N/mm^2
Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.252** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.400** N/mm^2
Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.640** N/mm^2
Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.336** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **10.800** mm
Bending deflection (based on E_{mean}); $\delta_{bending}$ = **5.676** mm
Shear deflection; δ_{shear} = **0.269** mm
Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **5.945** mm

PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor; K_3 = **1.25**
Maximum bending moment; M = **1.802** kNm
Maximum shear force; V = **2.002** kN
Maximum support reaction; R = **2.002** kN
Maximum deflection; δ = **6.131** mm

Check bending stress

Bending stress; σ_m = **7.500** N/mm^2
Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **10.783** N/mm^2
Applied bending stress; σ_{m_max} = M / Z = **5.405** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.710** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.976** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.300** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.400** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.300** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.400** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **10.800** mm

Bending deflection (based on E_{mean}); $\delta_{bending}$ = **5.811** mm

Shear deflection; δ_{shear} = **0.320** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **6.131** mm

PASS - Actual deflection within permissible limits

Gym Floor Joists C24 50x200 @ 300C.C

TIMBER JOIST DESIGN (BS5268-2:2002)

Joist details

Joist breadth; b = **50** mm

Joist depth; h = **200** mm

Joist spacing; s = **300** mm

Timber strength class; **C24**

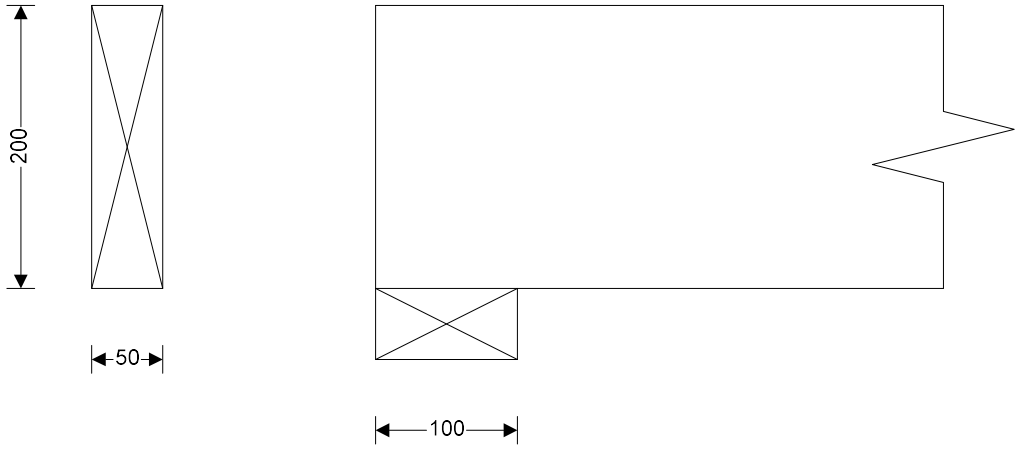
Service class of timber; **1**

Span details

Number of spans; N_{span} = **1**

Length of bearing; L_b = **100** mm

Effective length of span; L_{s1} = **3355** mm



Section properties

Second moment of area; $I = b \times h^3 / 12 =$ **33333333** mm^4

Section modulus; $Z = b \times h^2 / 6 =$ **333333** mm^3

Loading details

Joist self weight; $F_{swt} = b \times h \times \rho_{char} \times g_{acc} =$ **0.03** kN/m

Dead load; $F_{d\_udl} =$ **0.75** kN/m^2

Imposed UDL(Long term); $F_{i\_udl} =$ **2.50** kN/m^2

Imposed point load (Medium term); $F_{i\_pt} =$ **2.50** kN

Modification factors

Service class for bending parallel to grain $K_{2m} =$ **1.00**

Service class for compression $K_{2c} =$ **1.00**

Service class for shear parallel to grain $K_{2s} =$ **1.00**

Service class for modulus of elasticity $K_{2e} =$ **1.00**

Section depth factor; $K_7 =$ **1.05**

Load sharing factor; $K_8 =$ **1.10**

<u>Consider long term loads</u>

Load duration factor; $K_3 =$ **1.00**

Maximum bending moment; M = **1.420** kNm

Maximum shear force; V = **1.693** kN

Maximum support reaction; R = **1.693** kN

Maximum deflection; $\delta =$ **4.878** mm

Check bending stress

Bending stress; $\sigma_m =$ **7.500** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 =$ **8.626** N/mm^2

Applied bending stress; $\sigma_{m\_max} = M / Z =$ **4.260** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; $\tau =$ **0.710** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 =$ **0.781** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h) =$ **0.254** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); $\sigma_{cp1} =$ **2.400** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 =$ **2.640** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b) =$ **0.339** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm}) =$ **10.065** mm

Bending deflection (based on E_{mean}); $\delta_{bending} =$ **4.625** mm

Shear deflection; $\delta_{shear} =$ **0.252** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear} =$ **4.878** mm

PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor; $K_3 =$ **1.25**

Maximum bending moment; M = **2.462** kNm

Maximum shear force; V = **2.935** kN

Maximum support reaction; R = **2.935** kN

Maximum deflection; $\delta =$ **7.090** mm

Check bending stress

Bending stress; $\sigma_m =$ **7.500** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 =$ **10.783** N/mm^2

Applied bending stress; $\sigma_{m\_max} = M / Z =$ **7.385** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; $\tau =$ **0.710** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 =$ **0.976** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h) =$ **0.440** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); $\sigma_{cp1} =$ **2.400** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 =$ **3.300** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b) =$ **0.587** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm}) =$ **10.065** mm

Bending deflection (based on E_{mean}); $\delta_{bending} =$ **6.652** mm

Shear deflection; $\delta_{shear} =$ **0.438** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear} =$ **7.090** mm

PASS - Actual deflection within permissible limits

Loading for Roof Trimmer Beams UKPFC 100x50x10

Permanent

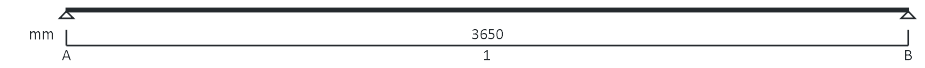
Permanent load from pitched roof = 1.0kN/m^2/cos(27) x 1.9m/2 = ***1.1kN/m***

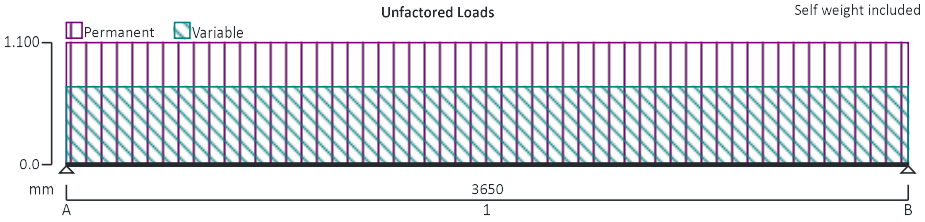
Variable

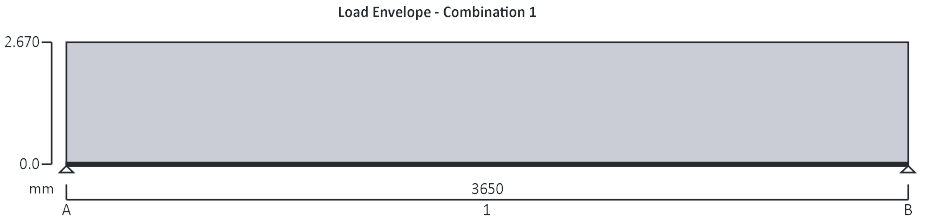
Variable load from pitched roof = 0.60kN/m^2/cos(27) x 1.9m/2 = ***0.7kN/m***

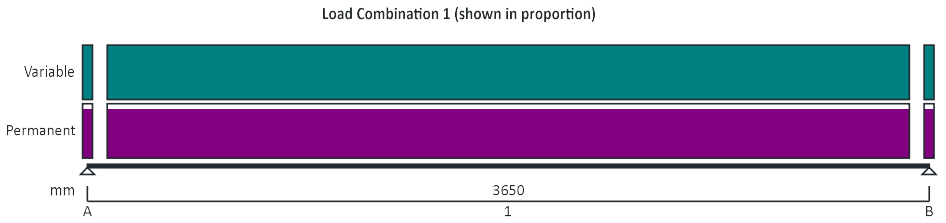
STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

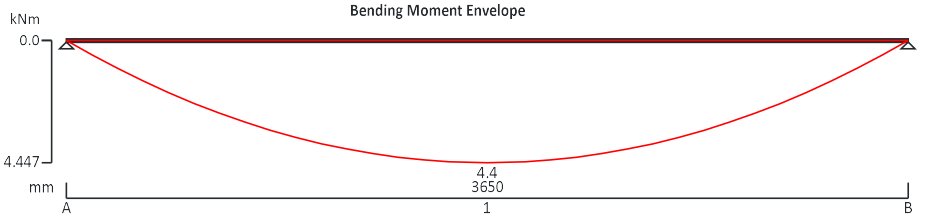
In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex

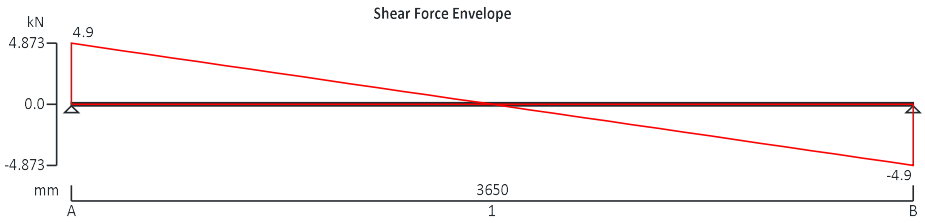












Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads	Permanent self weight of beam × 1
	Permanent full UDL 1.1 kN/m
	Variable full UDL 0.7 kN/m

Load combinations

Load combination 1	Support A	Permanent × 1.35
		Variable × 1.50
		Permanent × 1.35
		Variable × 1.50
	Support B	Permanent × 1.35
		Variable × 1.50

Analysis results

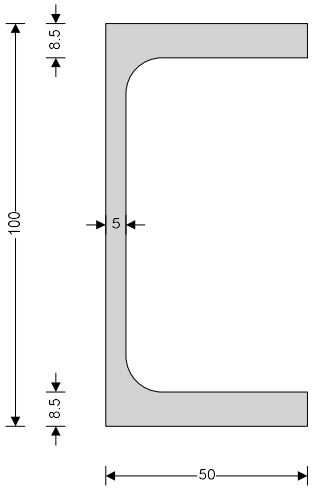
Maximum moment;	M_{max} = **4.4** kNm;	M_{min} = **0** kNm
Maximum shear;	V_{max} = **4.9** kN;	V_{min} = **-4.9** kN
Deflection;	δ_{max} = **10.1** mm;	δ_{min} = **0** mm
Maximum reaction at support A;	R_{A_max} = **4.9** kN;	R_{A_min} = **4.9** kN
Unfactored permanent load reaction at support A;	$R_{A\_Permanent}$ = **2.2** kN	
Unfactored variable load reaction at support A;	$R_{A\_Variable}$ = **1.3** kN	
Maximum reaction at support B;	R_{B_max} = **4.9** kN;	R_{B_min} = **4.9** kN
Unfactored permanent load reaction at support B;	$R_{B\_Permanent}$ = **2.2** kN	
Unfactored variable load reaction at support B;	$R_{B\_Variable}$ = **1.3** kN	

Section details

Section type;	**UKPFC 100x50x10 (Tata Steel Advance)**
Steel grade;	**S235**

EN 10025-2:2004 - Hot rolled products of structural steels

Nominal thickness of element;	$t = \max(t_f, t_w)$ = **8.5** mm
Nominal yield strength;	f_y = **235** N/mm^2
Nominal ultimate tensile strength;	f_u = **360** N/mm^2
Modulus of elasticity;	E = **210000** N/mm^2



Partial factors - Section 6.1

Resistance of cross-sections; γ_{M0} = **1.00**

Resistance of members to instability; γ_{M1} = **1.00**

Resistance of tensile members to fracture; γ_{M2} = **1.10**

Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis; K_y = **1.000**

Effective length factor in minor axis; K_z = **1.000**

Effective length factor for torsion; $K_{LT.A}$ = **1.000**;

$K_{LT.B}$ = **1.000**;

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235\ N/mm^2 / f_y]}$ = **1.00**

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

Width of section; $c = d$ = **65** mm

$c / t_w = 13.0 \times \varepsilon <= 72 \times \varepsilon$; Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section; $c = b - t_w - r_1$ = **36** mm

$c / t_f = 4.2 \times \varepsilon <= 9 \times \varepsilon$; Class 1

Section is class 1

Check shear - Section 6.2.6

Height of web; $h_w = h - 2 \times t_f$ = **83** mm

Shear area factor; η = **1.000**

$h_w / t_w < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force; $V_{Ed} = \max(abs(V_{max}), abs(V_{min}))$ = **4.9** kN

Shear area - cl 6.2.6(3); $A_v = A - 2 \times b \times t_f + (t_w + r_1) \times t_f$ = **569** mm^2

Design shear resistance - cl 6.2.6(2); $V_{c,Rd} = V_{pl,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **77.2** kN

PASS - Design shear resistance exceeds design shear force

Check bending moment major (y-y) axis - Section 6.2.5

Design bending moment; $M_{Ed} = \max(abs(M_{s1\_max}), abs(M_{s1\_min}))$ = **4.4** kNm

Design bending resistance moment - eq 6.13; $M_{c,Rd} = M_{pl,Rd} = W_{pl.y} \times f_y / \gamma_{M0}$ = **11.5** kNm

Slenderness ratio for lateral torsional buckling

Correction factor - Table 6.6; k_c = **0.94**

$C_1 = 1 / k_c^2$ = **1.132**

Curvature factor; $g = \sqrt{[1 - (I_z / I_y)]}$ = **0.919**

Poissons ratio; ν = **0.3**

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

Unrestrained length; $L = 1.0 \times L_{s1}$ = **3650** mm

Elastic critical buckling moment; $M_{cr} = C_1 \times \pi^2 \times E \times I_z / (L^2 \times g) \times \sqrt{[I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z)]}$ = **12.6** kNm

Slenderness ratio for lateral torsional buckling; $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})}$ = **0.954**

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

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

Design resistance for buckling - Section 6.3.2.1

Buckling curve - Table 6.5; d

Imperfection factor - Table 6.3; α_{LT} = **0.76**

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

LTB reduction determination factor; $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2]$ = **1.051**

LTB reduction factor - eq 6.57; $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.587**

Modification factor; $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1)$ = **0.971**

Modified LTB reduction factor - eq 6.58; $\chi_{LT,mod} = \min(\chi_{LT} / f, 1)$ = **0.605**

Design buckling resistance moment - eq 6.55; $M_{b,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1}$ = **6.9** kNm

PASS - Design buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 7.2.1

Consider deflection due to permanent and variable loads

Limiting deflection; $\delta_{lim} = L_{s1} / 250$ = **14.6** mm

Maximum deflection span 1; $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min}))$ = **10.069** mm

PASS - Maximum deflection does not exceed deflection limit

Loading for Loft Floor Beam 'A' & 'B' 203 UKC 46

Permanent

Permanent load from loft floor = 0.75kN/m^2 x 7.1m/2 = ***1.3kN/m***

Variable

Variable load from loft floor = 2.5kN/m^2 x 7.1m/2 = ***4.3kN/m***

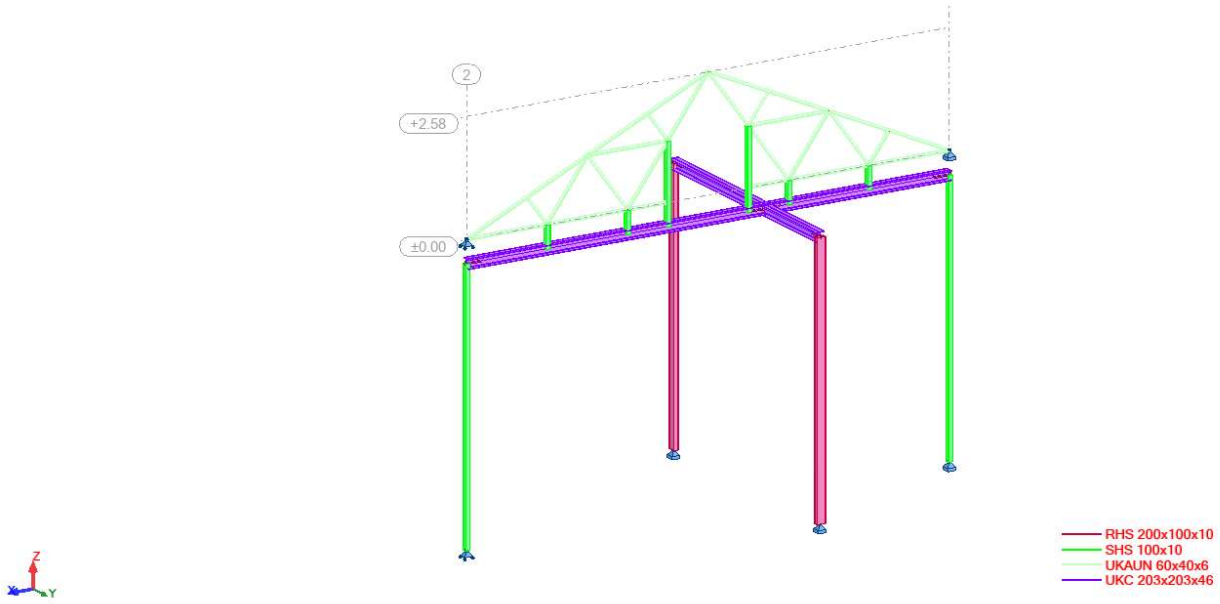
Loading for Loft Floor Beam 'C' 203 UKC 46

Permanent

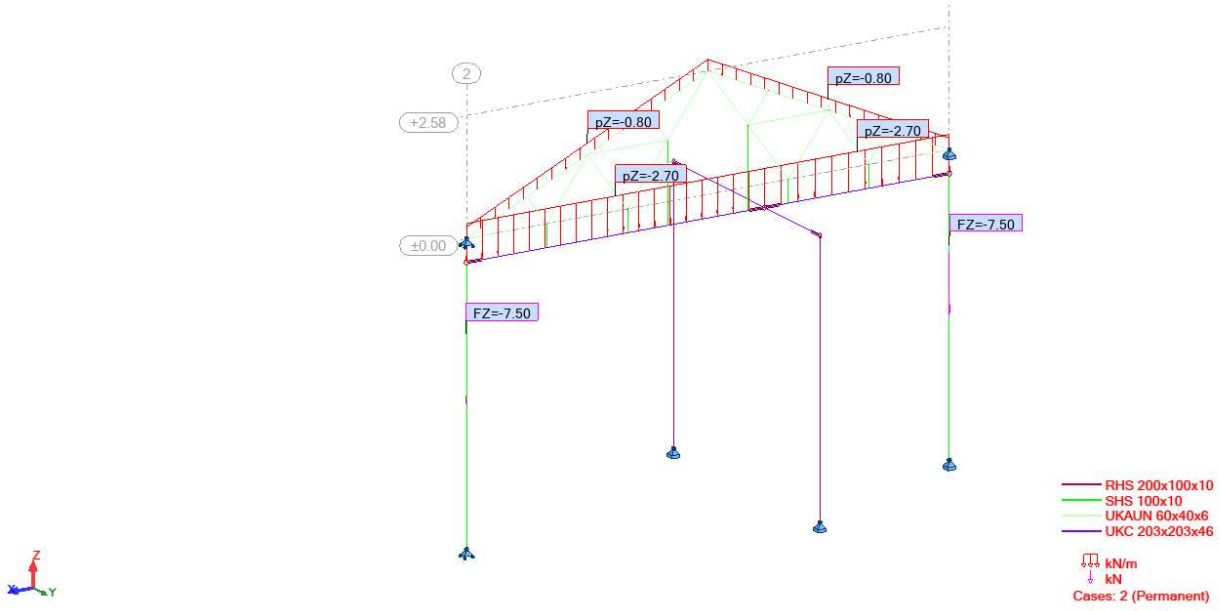
Permanent loads from Beams 'A' & 'B' are automatically calculated in the 3D analisys software

Variable

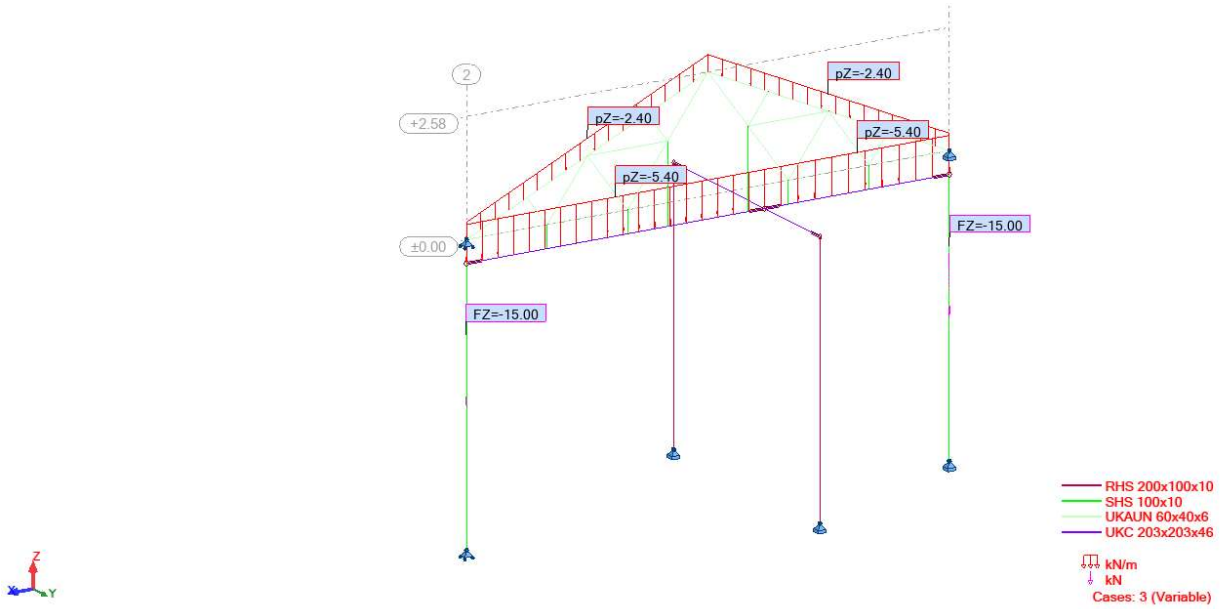
Variable loads from Beams 'A' & 'B' are automatically calculated in the 3D analisys software



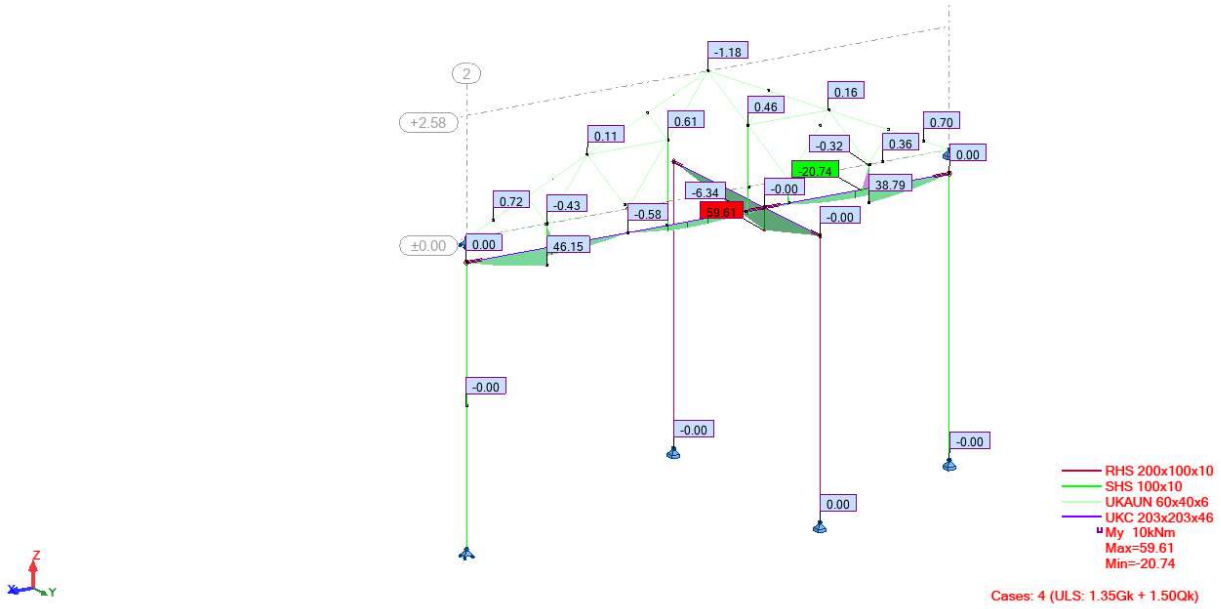
Idealised structural diagram



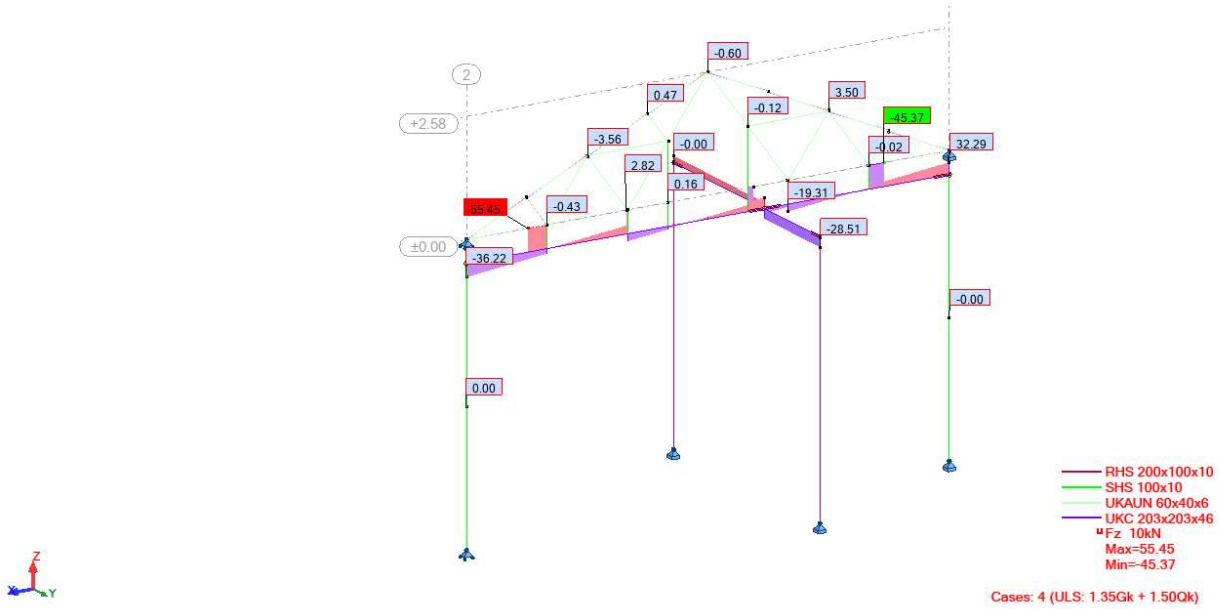
Application of permanent loads



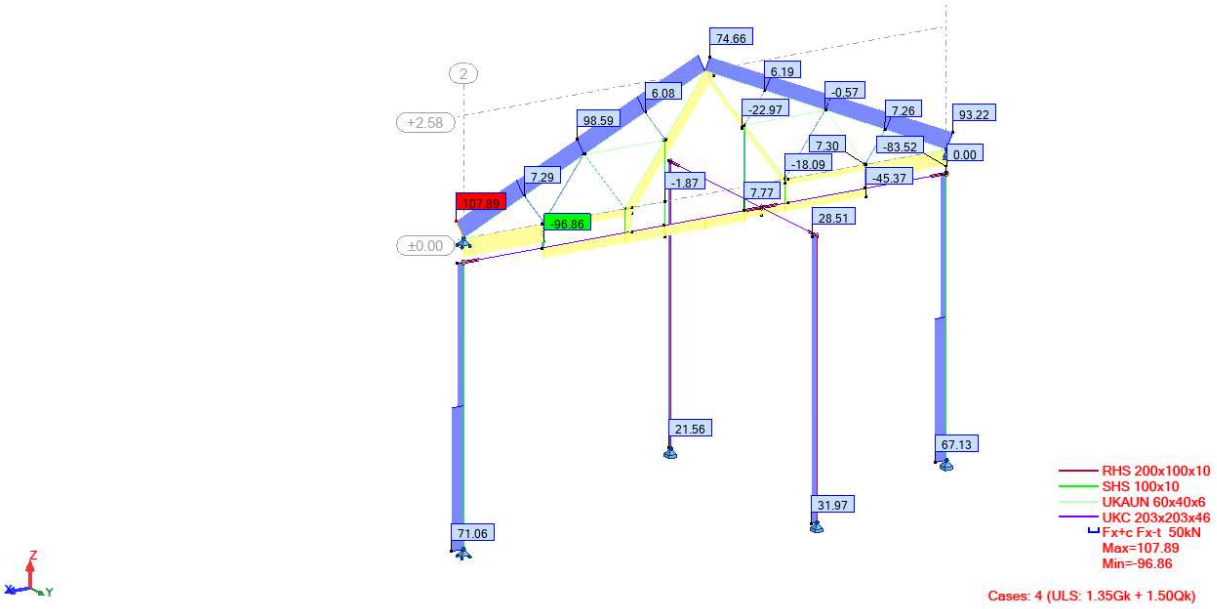
Application of variable loads



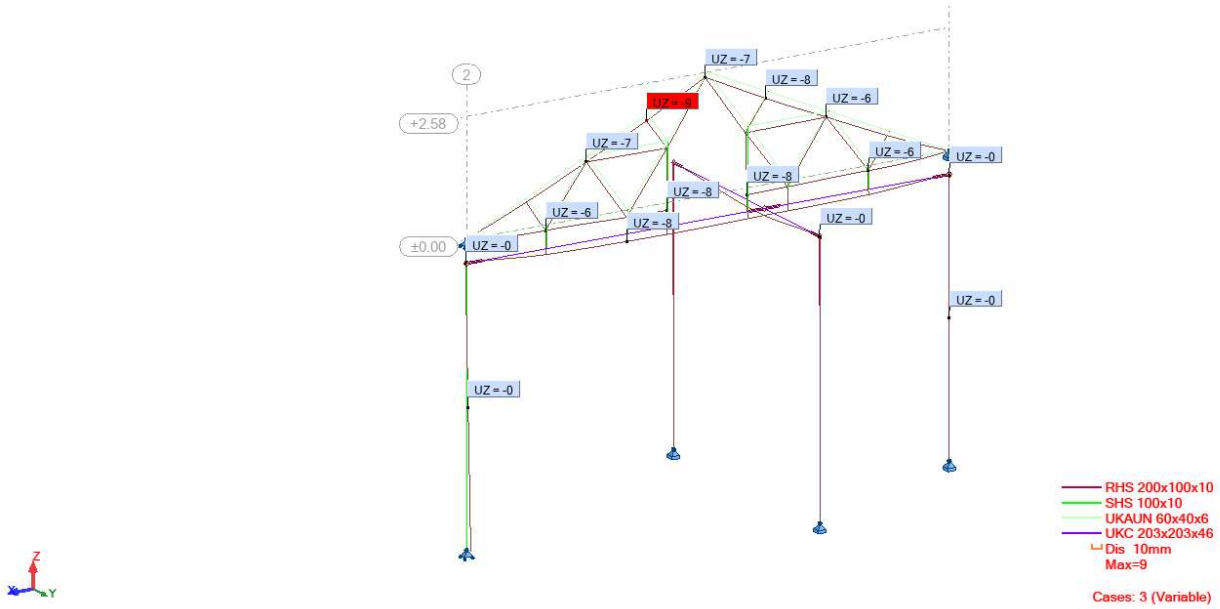
ULS Bending Moments



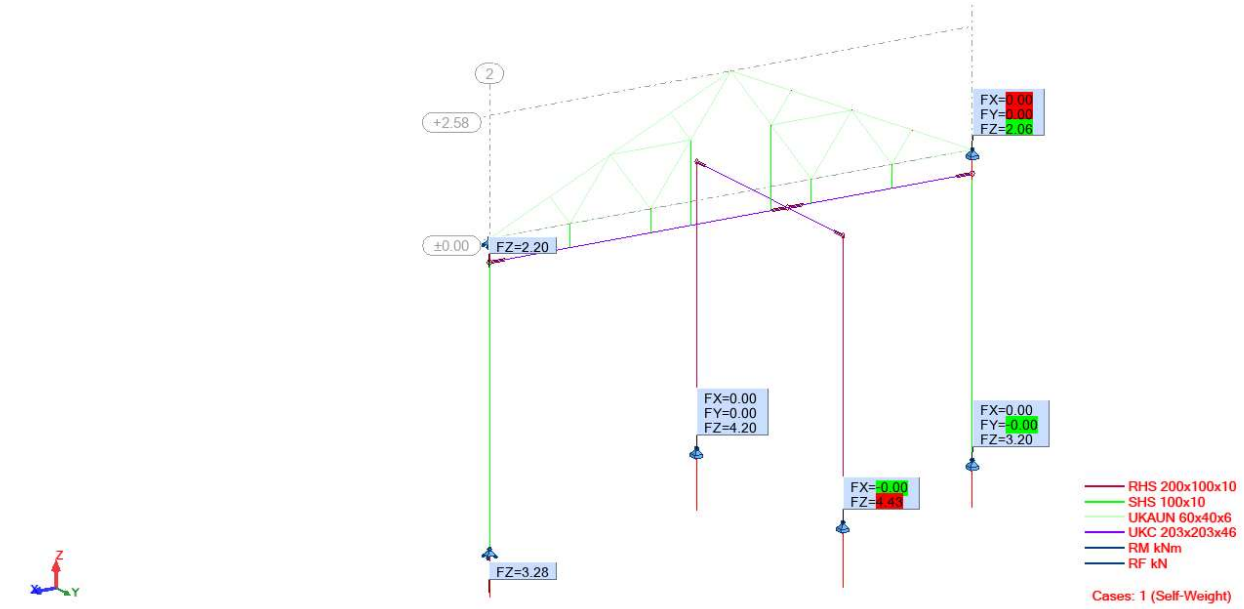
ULS Shear Force



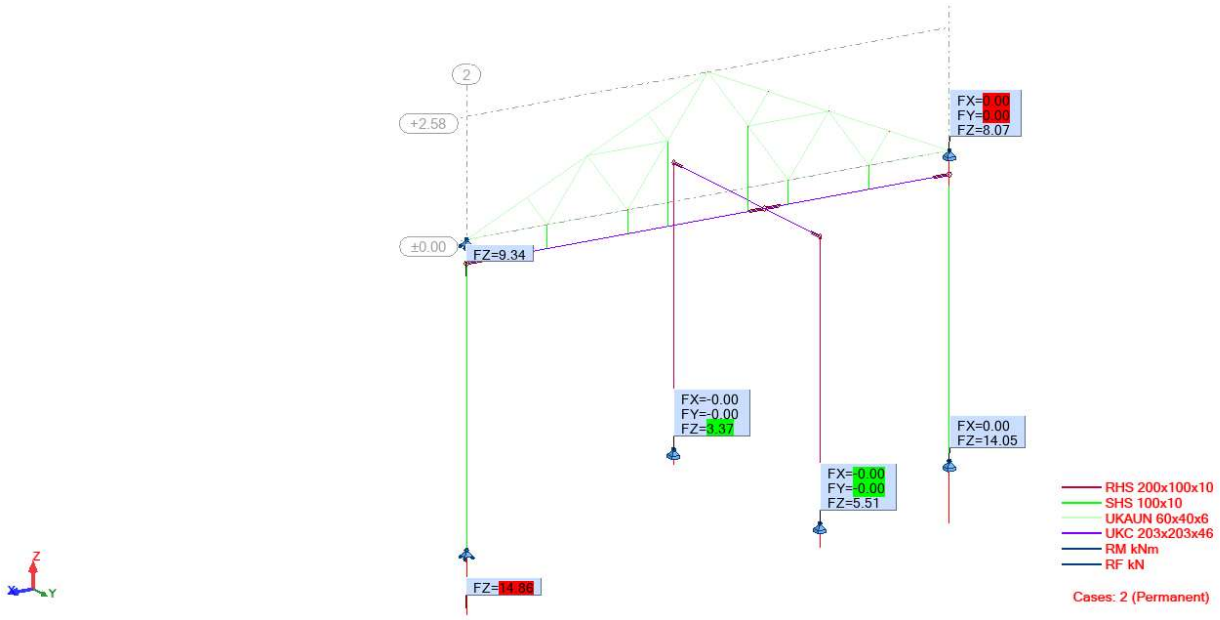
ULS Axial Forces



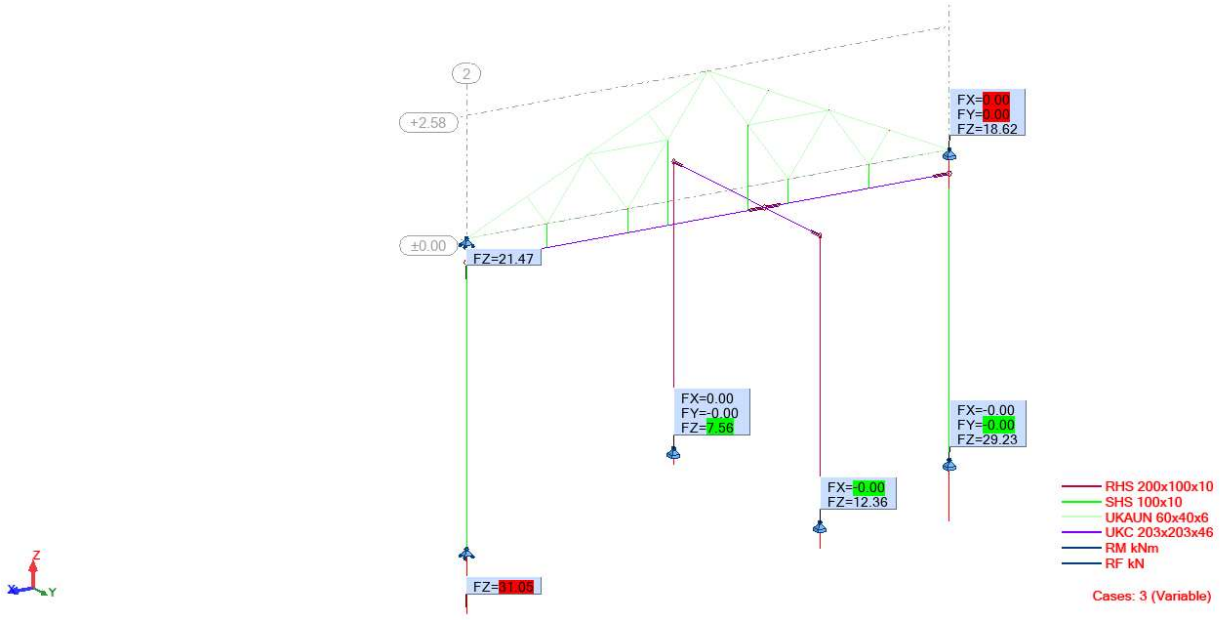
Variable load deflections



Self-weight reactions



Permanent load reactions



Variable load reactions

STEEL DESIGN

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 1 Member_1 **POINT:** 3 **COORDINATE:** x = 1.00 L = 1.79 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 7.77 kN	My,Ed = -6.34 kN*m	
Nc,Rd = 1260.25 kN	My,pl,Rd = 42.24 kN*m	
Nb,Rd = 1260.25 kN	My,c,Rd = 42.24 kN*m	Vz,Ed = -16.17 kN
	MN,y,Rd = 42.24 kN*m	Vz,c,Rd = 363.80 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

 About y axis:

 About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.01 < 1.00 (6.2.4.(1))

My,Ed/My,c,Rd = 0.15 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.04 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/250.00 = 7 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

uz = 0 mm < uz max = L/250.00 = 7 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*

ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 2 Member_2 **POINT:** 3 **COORDINATE:** x = 1.00 L = 1.79 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 2.33 kN	My,Ed = -1.92 kN*m	
Nc,Rd = 1260.25 kN	My,pl,Rd = 42.24 kN*m	
Nb,Rd = 1260.25 kN	My,c,Rd = 42.24 kN*m	Vz,Ed = -0.39 kN
	MN,y,Rd = 42.24 kN*m	Vz,c,Rd = 363.80 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))
My,Ed/My,c,Rd = 0.05 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/250.00 = 7 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 0 mm < uz max = L/250.00 = 7 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 3 Member_3 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00

b=40 mm Ay=240 mm2 Az=360 mm2 Ax=568 mm2
tw=6 mm Iy=201000 mm4 Iz=71200 mm4 Ix=6223 mm4
tf=6 mm Wely=5025 mm3 Welz=2381 mm3

INTERNAL FORCES AND CAPACITIES:

N,Ed = 7.26 kN My,Ed = -0.30 kN*m
Nc,Rd = 201.64 kN My,Ed,max = 0.90 kN*m
Nb,Rd = 127.93 kN My,c,Rd = 1.78 kN*m Vz,Ed = 1.53 kN
Vz,c,Rd = 73.79 kN
Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

Ly = 0.80 m Lam_y = 0.56 Lz = 0.80 m Lam_z = 0.94
Lcr,y = 0.80 m Xy = 0.86 Lcr,z = 0.80 m Xz = 0.63
Lamy = 42.31 kyy = 1.01 Lamz = 71.08 kzy = 1.00

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.17 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.13 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.02 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 42.31 < Lambda,max = 210.00 Lambda,z = 71.08 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.55 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.56 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 4 Member_4 **POINT:** 2 **COORDINATE:** x = 0.13 L = 0.77 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm gM0=1.00 gM1=1.00
b=40 mm Ay=240 mm2 Az=360 mm2 Ax=568 mm2
tw=6 mm Iy=201000 mm4 Iz=71200 mm4 Ix=6223 mm4
tf=6 mm Wely=5025 mm3 Welz=2381 mm3

INTERNAL FORCES AND CAPACITIES:

N,Ed = 91.70 kN My,Ed = 0.68 kN*m
Nc,Rd = 201.64 kN My,el,Rd = 1.78 kN*m
Nb,Rd = 201.64 kN My,c,Rd = 1.78 kN*m Vz,Ed = -0.40 kN

Vz,c,Rd = 73.79 kN
Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.38 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.84 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/500.00 = 12 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 7 mm < uz max = L/500.00 = 12 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 5 **POINT:** 3 **COORDINATE:** x = 0.40 L = 1.87 m

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wply=9468 mm3	Wplz=5288 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -83.52 kN	My,Ed = 0.36 kN*m	
Nt,Rd = 201.64 kN	My,pl,Rd = 3.36 kN*m	
	My,c,Rd = 3.36 kN*m	Vz,Ed = -0.02 kN
	MN,y,Rd = 2.78 kN*m	Vz,c,Rd = 73.79 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nt,Rd = 0.41 < 1.00 (6.2.3.(1))
My,Ed/My,c,Rd = 0.11 < 1.00 (6.2.5.(1))
My,Ed/MN,y,Rd = 0.13 < 1.00 (6.2.9.1.(2))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/500.00 = 9 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 5 mm < uz max = L/500.00 = 9 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 6 Member_6 **POINT:** 2 **COORDINATE:** x = 0.88 L = 5.41 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 106.37 kN	My,Ed = 0.70 kN*m	
Nc,Rd = 201.64 kN	My,el,Rd = 1.78 kN*m	
Nb,Rd = 201.64 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = 0.42 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.39 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.92 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/500.00 = 12 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 8 mm < uz max = L/500.00 = 12 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 7 Member_7 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -0.49 kN	My,Ed = -0.35 kN*m	
Nt,Rd = 201.64 kN	My,el,Rd = 1.78 kN*m	
	My,c,Rd = 1.78 kN*m	Vz,Ed = 0.35 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.20 < 1.00 (6.2.5.(1))
N,Ed/Nt,Rd + My,Ed/My,c,Rd = 0.20 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 8 Member_8 **POINT:** 3 **COORDINATE:** x = 1.00 L = 1.59 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 7.09 kN	My,Ed = 0.01 kN*m	
Nc,Rd = 201.64 kN	My,Ed,max = 0.03 kN*m	
Nb,Rd = 46.98 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = -0.04 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 1.59 m	Lam_y = 1.12	Lz = 1.59 m	Lam_z = 1.88
Lcr,y = 1.59 m	Xy = 0.52	Lcr,z = 1.59 m	Xz = 0.23
Lamy = 84.61	kyy = 1.02	Lamz = 142.16	kzy = 0.94

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.00 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.04 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 84.61 < Lambda,max = 210.00 Lambda,z = 142.16 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.09 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.17 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 9 Member_9 **POINT:** 3 **COORDINATE:** x = 1.00 L = 3.18 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -20.41 kN	My,Ed = -0.45 kN*m	
Nt,Rd = 201.64 kN	My,el,Rd = 1.78 kN*m	
	My,c,Rd = 1.78 kN*m	Vz,Ed = -0.60 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

VERIFICATION FORMULAS:
Section strength check:
My,Ed/My,c,Rd = 0.25 < 1.00 (6.2.5.(1))
N,Ed/Nt,Rd + My,Ed/My,c,Rd = 0.35 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
uy = 0 mm < uy max = L/250.00 = 13 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 2 mm < uz max = L/250.00 = 13 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 10 Member_10 **POINT:** 3 **COORDINATE:** x = 1.00 L = 1.87 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.50 kN	My,Ed = -0.07 kN*m	
Nc,Rd = 201.64 kN	My,Ed,max = -0.07 kN*m	
Nb,Rd = 35.17 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = -0.12 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 1.87 m	Lam_y = 1.32	Lz = 1.87 m	Lam_z = 2.21
Lcr,y = 1.87 m	Xy = 0.42	Lcr,z = 1.87 m	Xz = 0.17
Lamy = 99.50	kyy = 1.00	Lamz = 167.17	kzy = 0.99

VERIFICATION FORMULAS:
Section strength check:
My,Ed/My,c,Rd = 0.04 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.04 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))
Global stability check of member:
Lambda,y = 99.50 < Lambda,max = 210.00 Lambda,z = 167.17 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.03 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.03 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 11 Member_11 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 6.23 kN	My,Ed = -0.24 kN*m	
Nc,Rd = 201.64 kN	My,Ed,max = -0.24 kN*m	
Nb,Rd = 127.93 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = 0.31 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 0.80 m	Lam_y = 0.56	Lz = 0.80 m	Lam_z = 0.94
Lcr,y = 0.80 m	Xy = 0.86	Lcr,z = 0.80 m	Xz = 0.63
Lamy = 42.31	kyy = 1.01	Lamz = 71.08	kzy = 1.00

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.14 < 1.00 (6.2.5.(1))

N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.10 < 1.00 (6.2.1(7))

Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 42.31 < Lambda,max = 210.00 Lambda,z = 71.08 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.10 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.12 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*

ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 12 Member_12 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm gM0=1.00 gM1=1.00
b=40 mm Ay=240 mm2 Az=360 mm2 Ax=568 mm2
tw=6 mm Iy=201000 mm4 Iz=71200 mm4 Ix=6223 mm4
tf=6 mm Wply=9468 mm3 Wplz=5288 mm3

INTERNAL FORCES AND CAPACITIES:

N,Ed = -60.66 kN My,Ed = -0.47 kN*m
Nt,Rd = 201.64 kN My,pl,Rd = 3.36 kN*m
My,c,Rd = 3.36 kN*m Vz,Ed = 0.71 kN
MN,y,Rd = 3.06 kN*m Vz,c,Rd = 73.79 kN
Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nt,Rd = 0.30 < 1.00 (6.2.3.(1))
My,Ed/My,c,Rd = 0.14 < 1.00 (6.2.5.(1))
My,Ed/MN,y,Rd = 0.15 < 1.00 (6.2.9.1.(2))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/250.00 = 13 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 3 mm < uz max = L/250.00 = 13 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 13 Member_13 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm gM0=1.00 gM1=1.00
b=40 mm Ay=240 mm2 Az=360 mm2 Ax=568 mm2
tw=6 mm Iy=201000 mm4 Iz=71200 mm4 Ix=6223 mm4

tf=6 mm Wely=5025 mm3 Welz=2381 mm3

INTERNAL FORCES AND CAPACITIES:

N,Ed = 6.11 kN My,Ed = -0.37 kN*m
Nc,Rd = 201.64 kN My,Ed,max = -0.37 kN*m
Nb,Rd = 127.93 kN My,c,Rd = 1.78 kN*m
Vz,Ed = 0.50 kN
Vz,c,Rd = 73.79 kN
Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

Ly = 0.80 m Lam_y = 0.56 Lz = 0.80 m Lam_z = 0.94
Lcr,y = 0.80 m Xy = 0.86 Lcr,z = 0.80 m Xz = 0.63
Lamy = 42.31 kyy = 1.01 Lamz = 71.08 kzy = 1.00

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.21 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.18 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 42.31 < Lambda,max = 210.00 Lambda,z = 71.08 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.17 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.16 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 14 Member_14 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm gM0=1.00 gM1=1.00
b=40 mm Ay=240 mm2 Az=360 mm2 Ax=568 mm2
tw=6 mm Iy=201000 mm4 Iz=71200 mm4 Ix=6223 mm4
tf=6 mm Wely=5025 mm3 Welz=2381 mm3

INTERNAL FORCES AND CAPACITIES:

N,Ed = -2.95 kN My,Ed = -0.11 kN*m
Nt,Rd = 201.64 kN My,el,Rd = 1.78 kN*m
My,c,Rd = 1.78 kN*m
Vz,Ed = 0.17 kN
Vz,c,Rd = 73.79 kN
Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.06 < 1.00 (6.2.5.(1))
N,Ed/Nt,Rd + My,Ed/My,c,Rd = 0.08 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 15 Member_15 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 4.13 kN	My,Ed = 0.05 kN*m	
Nc,Rd = 201.64 kN	My,Ed,max = 0.05 kN*m	
Nb,Rd = 46.98 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = 0.01 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

Ly = 1.59 m	Lam_y = 1.12	Lz = 1.59 m	Lam_z = 1.88
Lcr,y = 1.59 m	Xy = 0.52	Lcr,z = 1.59 m	Xz = 0.23
Lamy = 84.61	kyy = 1.01	Lamz = 142.16	kzy = 0.97

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.03 < 1.00 (6.2.5.(1))

N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.05 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))
Global stability check of member:
Lambda,y = 84.61 < Lambda,max = 210.00 Lambda,z = 142.16 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.07 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.12 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 16 Member_16 **POINT:** 3 **COORDINATE:** x = 1.00 L = 1.59 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 8.31 kN	My,Ed = -0.45 kN*m	
Nc,Rd = 201.64 kN	My,Ed,max = -0.45 kN*m	
Nb,Rd = 46.98 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = -0.44 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 1.59 m	Lam_y = 1.12	Lz = 1.59 m	Lam_z = 1.88
Lcr,y = 1.59 m	Xy = 0.52	Lcr,z = 1.59 m	Xz = 0.23
Lamy = 84.61	kyy = 1.03	Lamz = 142.16	kzy = 0.93

VERIFICATION FORMULAS:
Section strength check:
My,Ed/My,c,Rd = 0.25 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.21 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))
Global stability check of member:
Lambda,y = 84.61 < Lambda,max = 210.00 Lambda,z = 142.16 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.21 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.29 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 17 Member_17 **POINT:** 3 **COORDINATE:** x = 1.00 L = 0.80 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wely=5025 mm3	Welz=2381 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 7.29 kN	My,Ed = -0.34 kN*m	
Nc,Rd = 201.64 kN	My,Ed,max = 1.09 kN*m	
Nb,Rd = 127.93 kN	My,c,Rd = 1.78 kN*m	Vz,Ed = -1.80 kN
		Vz,c,Rd = 73.79 kN
		Class of section = 3

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 0.80 m	Lam_y = 0.56	Lz = 0.80 m	Lam_z = 0.94
Lcr,y = 0.80 m	Xy = 0.86	Lcr,z = 0.80 m	Xz = 0.63
Lamy = 42.31	kyy = 1.01	Lamz = 71.08	kzy = 1.00

VERIFICATION FORMULAS:
Section strength check:
My,Ed/My,c,Rd = 0.19 < 1.00 (6.2.5.(1))
N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.15 < 1.00 (6.2.1(7))
Vz,Ed/Vz,c,Rd = 0.02 < 1.00 (6.2.6.(1))
Global stability check of member:
Lambda,y = 42.31 < Lambda,max = 210.00 Lambda,z = 71.08 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.66 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.67 < 1.00 (6.3.3.(4))

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 18 **POINT:** 1 **COORDINATE:** x = 0.60 L = 2.81 m

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKAUN 60x40x6

h=60 mm	gM0=1.00	gM1=1.00	
b=40 mm	Ay=240 mm2	Az=360 mm2	Ax=568 mm2
tw=6 mm	Iy=201000 mm4	Iz=71200 mm4	Ix=6223 mm4
tf=6 mm	Wply=9468 mm3	Wplz=5288 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -96.86 kN	My,Ed = 0.47 kN*m	
Nt,Rd = 201.64 kN	My,pl,Rd = 3.36 kN*m	
	My,c,Rd = 3.36 kN*m	Vz,Ed = -0.06 kN
	MN,y,Rd = 2.59 kN*m	Vz,c,Rd = 73.79 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nt,Rd = 0.48 < 1.00 (6.2.3.(1))
My,Ed/My,c,Rd = 0.14 < 1.00 (6.2.5.(1))
My,Ed/MN,y,Rd = 0.18 < 1.00 (6.2.9.1.(2))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
uy = 0 mm < uy max = L/500.00 = 9 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 6 mm < uz max = L/500.00 = 9 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 19 Column_19 **POINT:** 3 **COORDINATE:** x = 1.00 L = 6.00 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:
N,Ed = 67.13 kN
Nc,Rd = 1260.25 kN
Nb,Rd = 240.36 kN

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:



About y axis:

Ly = 6.00 m	Lam_y = 2.18	Lz = 6.00 m	Lam_z = 2.18
Lcr,y = 6.00 m	Xy = 0.19	Lcr,z = 6.00 m	Xz = 0.19
Lamy = 164.20		Lamz = 164.20	



About z axis:

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nc,Rd = 0.05 < 1.00 (6.2.4.(1))
Global stability check of member:
Lambda,y = 164.20 < Lambda,max = 210.00 Lambda,z = 164.20 < Lambda,max = 210.00 STABLE
N,Ed/Nb,Rd = 0.28 < 1.00 (6.3.1.1.(1))

LIMIT DISPLACEMENTS


Deflections (LOCAL SYSTEM): *Not analyzed*


Displacements (GLOBAL SYSTEM):
vx = 1 mm < vx max = L/300.00 = 20 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
vy = 1 mm < vy max = L/300.00 = 20 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 20 Column_20 **POINT:** 3 **COORDINATE:** x = 1.00 L = 6.00 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 71.06 kN

Nc,Rd = 1260.25 kN

Nb,Rd = 240.36 kN

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 6.00 m	Lam_y = 2.18	Lz = 6.00 m	Lam_z = 2.18
Lcr,y = 6.00 m	Xy = 0.19	Lcr,z = 6.00 m	Xz = 0.19
Lamy = 164.20		Lamz = 164.20	

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.06 < 1.00 (6.2.4.(1))

Global stability check of member:

Lambda,y = 164.20 < Lambda,max = 210.00 Lambda,z = 164.20 < Lambda,max = 210.00 STABLE

N,Ed/Nb,Rd = 0.30 < 1.00 (6.3.1.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 3 mm < vx max = L/300.00 = 20 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

vy = 12 mm < vy max = L/300.00 = 20 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*

ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 21 Column_21 **POINT:** 3 **COORDINATE:** x = 1.00 L = 0.50 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 5.35 kN	My,Ed = -20.74 kN*m	
Nc,Rd = 1260.25 kN	My,Ed,max = -20.74 kN*m	
Nb,Rd = 1260.25 kN	My,c,Rd = 42.24 kN*m	Vz,Ed = -45.37 kN
	MN,y,Rd = 42.24 kN*m	Vz,c,Rd = 363.80 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:



About y axis:



About z axis:

Ly = 0.50 m	Lam_y = 0.18	Lz = 0.50 m	Lam_z = 0.18
Lcr,y = 0.50 m	Xy = 1.00	Lcr,z = 0.50 m	Xz = 1.00
Lamy = 13.68	kyy = 0.77	Lamz = 13.68	kzy = 0.46

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))

My,Ed/My,c,Rd = 0.49 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.12 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 13.68 < Lambda,max = 210.00 Lambda,z = 13.68 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.38 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.23 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 0 mm < vx max = L/300.00 = 2 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

vy = 1 mm < vy max = L/300.00 = 2 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*

ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 22 Column_22 **POINT:** 3 **COORDINATE:** x = 1.00 L = 0.50 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -12.65 kN	My,Ed = 2.08 kN*m	
Nt,Rd = 1260.25 kN	My,pl,Rd = 42.24 kN*m	
	My,c,Rd = 42.24 kN*m	Vz,Ed = 3.65 kN
	MN,y,Rd = 42.24 kN*m	Vz,c,Rd = 363.80 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nt,Rd = 0.01 < 1.00 (6.2.3.(1))

My,Ed/My,c,Rd = 0.05 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 0 mm < vx max = L/300.00 = 2 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

vy = 1 mm < vy max = L/300.00 = 2 mm Verified

Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*

ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 23 Column_23 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -42.48 kN	My,Ed = -0.35 kN*m	
Nt,Rd = 1260.25 kN	My,pl,Rd = 42.24 kN*m	
	My,c,Rd = 42.24 kN*m	Vz,Ed = 2.82 kN
	MN,y,Rd = 42.24 kN*m	Vz,c,Rd = 363.80 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nt,Rd = 0.03 < 1.00 (6.2.3.(1))
My,Ed/My,c,Rd = 0.01 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 0 mm < vx max = L/300.00 = 2 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
vy = 1 mm < vy max = L/300.00 = 2 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 24 Column_24 **POINT:** 3 **COORDINATE:** x = 1.00 L = 0.50 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: SHS 100x10

h=100 mm	gM0=1.00	gM1=1.00

b=100 mm	Ay=1775 mm2	Az=1775 mm2	Ax=3550 mm2
tw=10 mm	Iy=4740000 mm4	Iz=4740000 mm4	Ix=7410000 mm4
tf=10 mm	Wply=119000 mm3	Wplz=119000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 12.42 kN	My,Ed = 25.28 kN*m	
Nc,Rd = 1260.25 kN	My,Ed,max = 25.28 kN*m	
Nb,Rd = 1260.25 kN	My,c,Rd = 42.24 kN*m	Vz,Ed = 55.45 kN
	MN,y,Rd = 42.24 kN*m	Vz,c,Rd = 363.80 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis: About z axis:

Ly = 0.50 m	Lam_y = 0.18	Lz = 0.50 m	Lam_z = 0.18
Lcr,y = 0.50 m	Xy = 1.00	Lcr,z = 0.50 m	Xz = 1.00
Lamy = 13.68	kyy = 0.77	Lamz = 13.68	kzy = 0.46

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.01 < 1.00 (6.2.4.(1))
My,Ed/My,c,Rd = 0.60 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.15 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 13.68 < Lambda,max = 210.00 Lambda,z = 13.68 < Lambda,max = 210.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.47 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.28 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 0 mm < vx max = L/300.00 = 2 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
vy = 1 mm < vy max = L/300.00 = 2 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 25 Column_25 **POINT:** 3 **COORDINATE:** x = 1.00 L = 6.00 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:
S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: RHS 200x100x10

h=200 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1850 mm2	Az=3700 mm2	Ax=5550 mm2
tw=10 mm	Iy=27180000 mm4	Iz=8810000 mm4	Ix=21073095 mm4
tf=10 mm	Wply=346000 mm3	Wplz=209000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 31.97 kN
Nc,Rd = 1970.25 kN
Nb,Rd = 441.28 kN

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:


About y axis:

Ly = 6.00 m	Lam_y = 1.14	Lz = 6.00 m	Lam_z = 1.99
Lcr,y = 6.00 m	Xy = 0.57	Lcr,z = 6.00 m	Xz = 0.22
Lamy = 85.74		Lamz = 150.59	


About z axis:

VERIFICATION FORMULAS:

Section strength check:
N,Ed/Nc,Rd = 0.02 < 1.00 (6.2.4.(1))
Global stability check of member:
Lambda,y = 85.74 < Lambda,max = 210.00 Lambda,z = 150.59 < Lambda,max = 210.00 STABLE
N,Ed/Nb,Rd = 0.07 < 1.00 (6.3.1.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):
vx = 1 mm < vx max = L/300.00 = 20 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
vy = 0 mm < vy max = L/300.00 = 20 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 26 Column_26 **POINT:** 3 **COORDINATE:** x = 1.00 L = 6.00 m

---

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: RHS 200x100x10

h=200 mm	gM0=1.00	gM1=1.00	
b=100 mm	Ay=1850 mm2	Az=3700 mm2	Ax=5550 mm2
tw=10 mm	Iy=27180000 mm4	Iz=8810000 mm4	Ix=21073095 mm4
tf=10 mm	Wply=346000 mm3	Wplz=209000 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 21.56 kN
Nc,Rd = 1970.25 kN
Nb,Rd = 441.28 kN

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:


About y axis:

Ly = 6.00 m	Lam_y = 1.14	Lz = 6.00 m	Lam_z = 1.99
Lcr,y = 6.00 m	Xy = 0.57	Lcr,z = 6.00 m	Xz = 0.22
Lamy = 85.74		Lamz = 150.59	


About z axis:

VERIFICATION FORMULAS:

Section strength check:
N,Ed/Nc,Rd = 0.01 < 1.00 (6.2.4.(1))
Global stability check of member:
Lambda,y = 85.74 < Lambda,max = 210.00 Lambda,z = 150.59 < Lambda,max = 210.00 STABLE
N,Ed/Nb,Rd = 0.05 < 1.00 (6.3.1.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):
vx = 1 mm < vx max = L/300.00 = 20 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
vy = 0 mm < vy max = L/300.00 = 20 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 27 **POINT:** 3 **COORDINATE:** x = 0.44 L = 1.87 m

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SURREY HILLS CONSULTING ENGINEERS LIMITED STRUCTURAL ENGINEERING CONSULTANTS	Project **Peerglow Estate, London, EN3 4SB**			Job Ref. **AR0700**	
	Section **Second Floor and Roof Design**			Sheet no./rev. **44**	
	Calc. by **AT**	Date **Oct 2023**	Chk'd by **AC**	Date **Oct 2023**	App'd by Date

SECTION PARAMETERS: UKC 203x203x46

h=203 mm	gM0=1.00	gM1=1.00	
b=204 mm	Ay=4712 mm2	Az=1694 mm2	Ax=5870 mm2
tw=7 mm	Iy=45680000 mm4	Iz=15480000 mm4	Ix=222000 mm4
tf=11 mm	Wply=497000 mm3	Wplz=231000 mm3	

INTERNAL FORCES AND CAPACITIES:

My,Ed = 38.79 kN*m
My,pl,Rd = 176.44 kN*m
My,c,Rd = 176.44 kN*m

Vz,Ed = 9.16 kN
Vz,c,Rd = 347.28 kN

Mb,Rd = 124.57 kN*m

Class of section = 2


LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 169.64 kN*m	Curve,LT - b	XLT = 0.69
Lcr,upp=5.16 m	Lam_LT = 1.02	fi,LT = 1.00	XLT,mod = 0.71

BUCKLING PARAMETERS:

 About y axis:

 About z axis:

VERIFICATION FORMULAS:

Section strength check:
My,Ed/My,c,Rd = 0.22 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.03 < 1.00 (6.2.6.(1))
Global stability check of member:
My,Ed/Mb,Rd = 0.31 < 1.00 (6.3.2.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/250.00 = 17 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 4 mm < uz max = L/250.00 = 17 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
u inst,y = 0 mm < u inst,max,y = L/360.00 = 12 mm Verified
Governing Load Case: 1*3
u inst,z = 2 mm < u inst,max,z = L/360.00 = 12 mm Verified
Governing Load Case: 1*3

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 28 Beam FDM SS_28 **POINT:** 3 **COORDINATE:** x = 0.62 L = 3.50 m

---

LOADS:
Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKC 203x203x46

h=203 mm	gM0=1.00	gM1=1.00	
b=204 mm	Ay=4712 mm2	Az=1694 mm2	Ax=5870 mm2
tw=7 mm	Iy=45680000 mm4	Iz=15480000 mm4	Ix=222000 mm4
tf=11 mm	Wply=497000 mm3	Wplz=231000 mm3	

INTERNAL FORCES AND CAPACITIES:

My,Ed = 59.61 kN*m
My,pl,Rd = 176.44 kN*m
My,c,Rd = 176.44 kN*m
Vz,Ed = 15.96 kN
Vz,c,Rd = 347.28 kN
Mb,Rd = 103.18 kN*m
Class of section = 2


LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 120.54 kN*m	Curve,LT - b	XLT = 0.57
Lcr,upp=6.77 m	Lam_LT = 1.21	fi,LT = 1.19	XLT,mod = 0.58

BUCKLING PARAMETERS:


About y axis:


About z axis:

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.34 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.05 < 1.00 (6.2.6.(1))

Global stability check of member:

My,Ed/Mb,Rd = 0.58 < 1.00 (6.3.2.1.(1))

LIMIT DISPLACEMENTS


Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/250.00 = 23 mm Verified
Governing Load Case: 3 Variable
uz = 12 mm < uz max = L/250.00 = 23 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
u inst,y = 0 mm < u inst,max,y = L/360.00 = 16 mm Verified
Governing Load Case: 1*3
u inst,z = 7 mm < u inst,max,z = L/360.00 = 16 mm Verified
Governing Load Case: 1*3


Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 29 **POINT:** 1 **COORDINATE:** x = 0.73 L = 5.06 m

LOADS:

Governing Load Case: 4 ULS: 1.35Gk + 1.50Qk (1+2)*1.35+3*1.50

MATERIAL:

S355 (S355) fy = 355.00 MPa

SECTION PARAMETERS: UKC 203x203x46

h=203 mm	gM0=1.00	gM1=1.00	
b=204 mm	Ay=4712 mm2	Az=1694 mm2	Ax=5870 mm2
tw=7 mm	Iy=45680000 mm4	Iz=15480000 mm4	Ix=222000 mm4
tf=11 mm	Wply=497000 mm3	Wplz=231000 mm3	

INTERNAL FORCES AND CAPACITIES:

My,Ed = 46.15 kN*m
My,pl,Rd = 176.44 kN*m
My,c,Rd = 176.44 kN*m
Vz,Ed = -13.09 kN
Vz,c,Rd = 347.28 kN
Mb,Rd = 87.68 kN*m
Class of section = 2


LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 95.15 kN*m	Curve,LT - b	XLT = 0.49
Lcr,upp=8.32 m	Lam_LT = 1.36	fi,LT = 1.36	XLT,mod = 0.50

BUCKLING PARAMETERS:

 About y axis:

 About z axis:

VERIFICATION FORMULAS:

Section strength check:

My,Ed/My,c,Rd = 0.26 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.04 < 1.00 (6.2.6.(1))

Global stability check of member:

My,Ed/Mb,Rd = 0.53 < 1.00 (6.3.2.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0 mm < uy max = L/250.00 = 28 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
uz = 7 mm < uz max = L/250.00 = 28 mm Verified
Governing Load Case: 5 SLS: 1.00Gk + 1.00Qk (1+2+3)*1.00
u inst,y = 0 mm < u inst,max,y = L/360.00 = 19 mm Verified
Governing Load Case: 1*3
u inst,z = 5 mm < u inst,max,z = L/360.00 = 19 mm Verified
Governing Load Case: 1*3

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

Loading for Beam 'D' UKB 203x133x30

Permanent

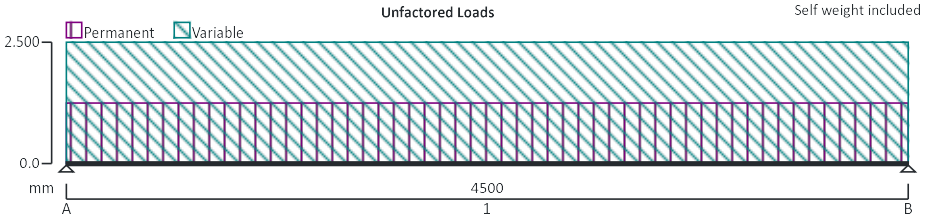
Permanent load from loft floor = 0.75kN/m² x 3.25m/2 = ***1.25kN/m***

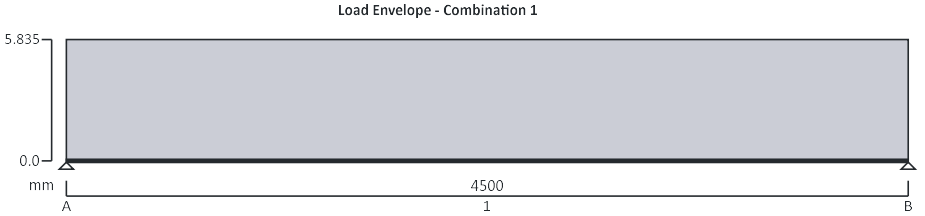
Variable

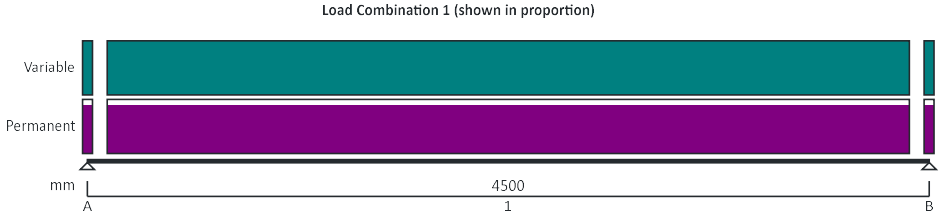
Variable load from loft floor = 1.5kN/m² x 3.25m/2 = ***2.5kN/m***

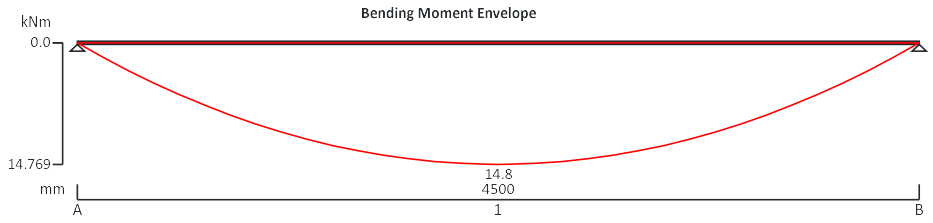
STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

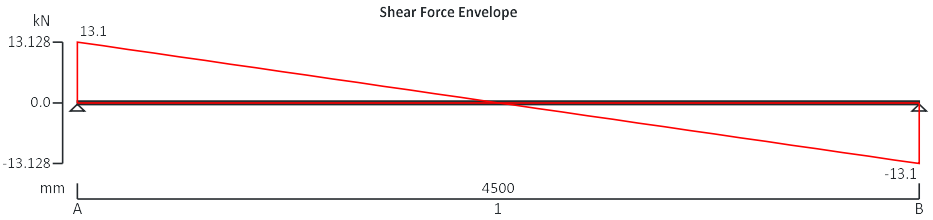
In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex











Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads	Permanent self weight of beam × 1
	Permanent full UDL 1.25 kN/m
	Variable full UDL 2.5 kN/m

Load combinations

Load combination 1	Support A	Permanent × 1.35
		Variable × 1.50
		Permanent × 1.35
		Variable × 1.50
	Support B	Permanent × 1.35
		Variable × 1.50

Analysis results

Maximum moment;	M_{max} = **14.8** kNm;	M_{min} = **0** kNm
Maximum shear;	V_{max} = **13.1** kN;	V_{min} = **-13.1** kN
Deflection;	δ_{max} = **3.6** mm;	δ_{min} = **0** mm
Maximum reaction at support A;	R_{A_max} = **13.1** kN;	R_{A_min} = **13.1** kN
Unfactored permanent load reaction at support A;	$R_{A\_Permanent}$ = **3.5** kN	
Unfactored variable load reaction at support A;	$R_{A\_Variable}$ = **5.6** kN	
Maximum reaction at support B;	R_{B_max} = **13.1** kN;	R_{B_min} = **13.1** kN
Unfactored permanent load reaction at support B;	$R_{B\_Permanent}$ = **3.5** kN	
Unfactored variable load reaction at support B;	$R_{B\_Variable}$ = **5.6** kN	

Section details

Section type;	**UKB 203x133x30 (Tata Steel Advance)**
Steel grade;	**S355**

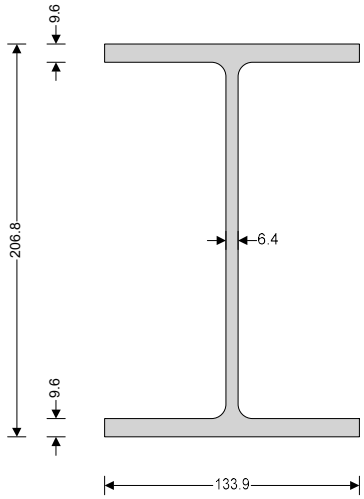
EN 10025-2:2004 - Hot rolled products of structural steels

Nominal thickness of element;	$t = \max(t_f, t_w)$ = **9.6** mm

Nominal yield strength; f_y = **355** N/mm^2

Nominal ultimate tensile strength; f_u = **470** N/mm^2

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



Partial factors - Section 6.1

Resistance of cross-sections; γ_{M0} = **1.00**

Resistance of members to instability; γ_{M1} = **1.00**

Resistance of tensile members to fracture; γ_{M2} = **1.10**

Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis; K_y = **1.000**

Effective length factor in minor axis; K_z = **1.000**

Effective length factor for torsion; $K_{LT.A}$ = **1.000**;

$K_{LT.B}$ = **1.000**;

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235\ N/mm^2 / f_y]}$ = **0.81**

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

Width of section; c = d = **172.4** mm

$c / t_w = 33.1 \times \varepsilon <= 72 \times \varepsilon$; Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section; $c = (b - t_w - 2 \times r) / 2$ = **56.2** mm

$c / t_f = 7.2 \times \varepsilon <= 9 \times \varepsilon$; Class 1

Section is class 1

Check shear - Section 6.2.6

Height of web; $h_w = h - 2 \times t_f$ = **187.6** mm

Shear area factor; η = **1.000**

$h_w / t_w < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force; $V_{Ed} = \max(abs(V_{max}), abs(V_{min}))$ = **13.1** kN

Shear area - cl 6.2.6(3); $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w)$ = **1458** mm^2

Design shear resistance - cl 6.2.6(2); $V_{c,Rd} = V_{pl,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **298.7** kN

PASS - Design shear resistance exceeds design shear force

Check bending moment major (y-y) axis - Section 6.2.5

Design bending moment; $M_{Ed} = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min})) =$ **14.8** kNm

Design bending resistance moment - eq 6.13; $M_{c,Rd} = M_{pl,Rd} = W_{pl.y} \times f_y / \gamma_{M0} =$ **111.6** kNm

Slenderness ratio for lateral torsional buckling

Correction factor - Table 6.6; $k_c =$ **0.94**

$C_1 = 1 / k_c^2 =$ **1.132**

Curvature factor; $g = \sqrt{[1 - (I_z / I_y)]} =$ **0.931**

Poissons ratio; $\nu =$ **0.3**

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

Unrestrained length; $L = 1.0 \times L_{s1} =$ **4500** mm

Elastic critical buckling moment; $M_{cr} = C_1 \times \pi^2 \times E \times I_z / (L^2 \times g) \times \sqrt{[I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z)]} =$ **84.1** kNm

Slenderness ratio for lateral torsional buckling; $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})} =$ **1.152**

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

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

Design resistance for buckling - 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; $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2] =$ **1.126**

LTB reduction factor - eq 6.57; $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2) =$ **0.607**

Modification factor; $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1) =$ **0.977**

Modified LTB reduction factor - eq 6.58; $\chi_{LT,mod} = \min(\chi_{LT} / f, 1) =$ **0.621**

Design buckling resistance moment - eq 6.55; $M_{b,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1} =$ **69.3** kNm

PASS - Design buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 7.2.1

Consider deflection due to permanent and variable loads

Limiting deflection; $\delta_{lim} = L_{s1} / 250 =$ **18** mm

Maximum deflection span 1; $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **3.551** mm

PASS - Maximum deflection does not exceed deflection limit

Padstone Design 450(l)x100x(w)x215(dp)

MASONRY BEARING DESIGN TO BS5628-1:2005

Masonry details

Masonry type; **Clay or calcium silicate bricks**

Compressive strength of unit; $p_{unit} =$ **5.0** N/mm^2

Mortar designation; **iii**

Category of masonry units; **Category II**

Category of construction control ; **Normal**

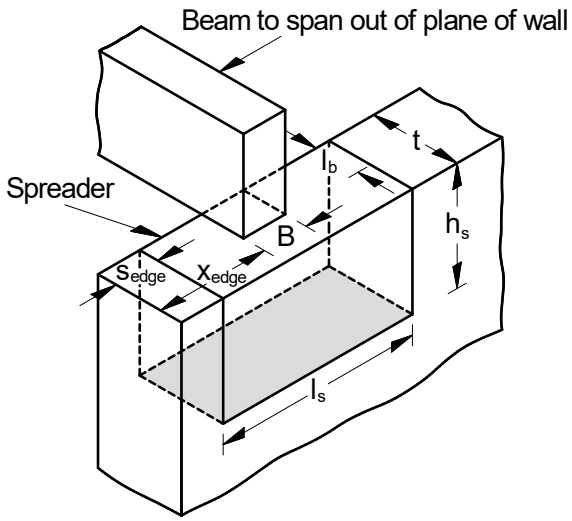
Partial safety factor for material strength; $\gamma_m =$ **3.5**

Thickness of load bearing leaf; t = **100** mm

Effective thickness of masonry wall; $t_{ef} =$ **100** mm

Height of masonry wall; h = **2700** mm

Effective height of masonry wall; h_{ef} = **2700** mm



Bearing details

Beam spanning out of plane of wall

Width of bearing; B = **133** mm

Length of bearing; l_b = **100** mm

Edge distance; x_{edge} = **10** mm

Compressive strength from Table 2 BS5628:Part 1 - Clay or calcium silicate bricks

Mortar designation; Mortar = **"iii"**

Brick compressive strength; p_{unit} = **5.0** N/mm^2

Characteristic compressive strength; f_k = **2.50** N/mm^2

Loading details

Characteristic concentrated dead load; G_k = **4** kN

Characteristic concentrated imposed load; Q_k = **6** kN

Design concentrated load; F = (G_k × 1.4) + (Q_k × 1.6) = **15.2** kN

Characteristic distributed dead load; g_k = **0.0** kN/m

Characteristic distributed imposed load; q_k = **0.0** kN/m

Design distributed load; f = (g_k × 1.4) + (q_k × 1.6) = **0.0** kN/m

Masonry bearing type

Bearing type; **Type 1**

Bearing safety factor; γ_{bear} = **1.25**

Check design bearing without a spreader

Design bearing stress; f_{ca} = F / (B × l_b) + f / t = **1.143** N/mm^2

Allowable bearing stress; f_{cp} = γ_{bear} × f_k / γ_m = **0.893** N/mm^2

FAIL - Design bearing stress exceeds allowable bearing stress, use a spreader

Spreader details

Length of spreader; l_s = **450** mm

Depth of spreader; h_s = **215** mm

Edge distance; s_{edge} = max(0 mm, x_{edge} – (l_s - B) / 2) = **0** mm

Spreader bearing type

Bearing type; **Type 3**

Bearing safety factor; γ_{bear} = **2.00**

Check design bearing with a spreader

Loading acts eccentrically outside middle third – triangular stress distribution

Offset distance; $x_{off} = x_{edge} + (B / 2)$ = **77** mm

Maximum bearing stress; $f_{ca} = 2 \times F / (3 \times x_{off} \times t) + f / t$ = **1.325** N/mm^2

Allowable bearing stress; $f_{cp} = \gamma_{bear} \times f_k / \gamma_m$ = **1.429** N/mm^2

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 × h below the bearing level

Slenderness ratio; h_{ef} / t_{ef} = **27.00**

Eccentricity at top of wall; e_x = **16.7** mm

From BS5628:1 Table 7

Capacity reduction factor; β = **0.24**

Length of bearing distributed at 0.4 × h; l_d = **1223** mm

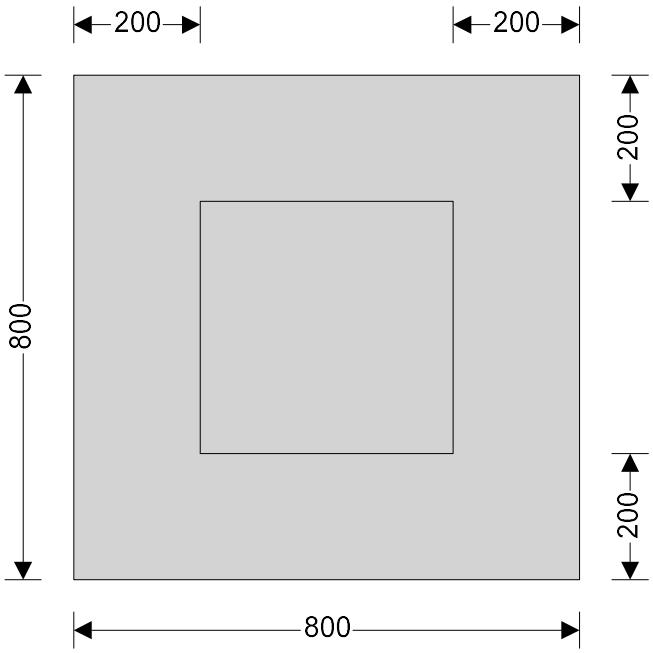
Maximum bearing stress; $f_{ca} = F / (l_d \times t) + f / t$ = **0.124** N/mm^2

Allowable bearing stress; $f_{cp} = \beta \times f_k / \gamma_m$ = **0.175** N/mm^2

PASS - Allowable bearing stress at 0.4 × h below bearing level exceeds design bearing stress

Column Pad Design 800(l)x800x(w)

PAD FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)



Pad footing details

Length of pad footing;	L = **800** mm
Width of pad footing;	B = **800** mm
Area of pad footing;	A = L × B = **0.640** m^2
Depth of pad footing;	h = **450** mm
Depth of soil over pad footing;	h_{soil} = **200** mm
Density of concrete;	ρ_{conc} = **23.6** kN/m^3

Column details

Column base length;	l_A = **400** mm
Column base width;	b_A = **400** mm
Column eccentricity in x;	e_{PxA} = **0** mm
Column eccentricity in y;	e_{PyA} = **0** mm

Soil details

Density of soil;	ρ_{soil} = **20.0** kN/m^3
Design shear strength;	ϕ' = **25.0** deg
Design base friction;	δ = **19.3** deg
Allowable bearing pressure;	$P_{bearing}$ = **100** kN/m^2

Axial loading on column

Dead axial load on column;	P_{GA} = **31.0** kN
Imposed axial load on column;	P_{QA} = **19.0** kN
Wind axial load on column;	P_{WA} = **0.0** kN
Total axial load on column;	P_A = **50.0** kN

Foundation loads

Dead surcharge load;	F_{Gsur} = **0.000** kN/m^2
Imposed surcharge load;	F_{Qsur} = **0.000** kN/m^2
Pad footing self weight;	F_{swt} = h × ρ_{conc} = **10.620** kN/m^2

Soil self weight; $F_{soil} = h_{soil} \times \rho_{soil} =$ **4.000** kN/m^2

Total foundation load; $F = A \times (F_{Gsur} + F_{Qsur} + F_{swt} + F_{soil}) =$ **9.4** kN

Calculate pad base reaction

Total base reaction; $T = F + P_A =$ **59.4** kN

Eccentricity of base reaction in x; $e_{Tx} = (P_A \times e_{PxA} + M_{xA} + H_{xA} \times h) / T =$ **0** mm

Eccentricity of base reaction in y; $e_{Ty} = (P_A \times e_{PyA} + M_{yA} + H_{yA} \times h) / T =$ **0** mm

Check pad base reaction eccentricity

$abs(e_{Tx}) / L + abs(e_{Ty}) / B =$ **0.000**

Base reaction acts within middle third of base

Calculate pad base pressures

$q_1 = T / A - 6 \times T \times e_{Tx} / (L \times A) - 6 \times T \times e_{Ty} / (B \times A) =$ **92.745** kN/m^2

$q_2 = T / A - 6 \times T \times e_{Tx} / (L \times A) + 6 \times T \times e_{Ty} / (B \times A) =$ **92.745** kN/m^2

$q_3 = T / A + 6 \times T \times e_{Tx} / (L \times A) - 6 \times T \times e_{Ty} / (B \times A) =$ **92.745** kN/m^2

$q_4 = T / A + 6 \times T \times e_{Tx} / (L \times A) + 6 \times T \times e_{Ty} / (B \times A) =$ **92.745** kN/m^2

Minimum base pressure; $q_{min} = min(q_1, q_2, q_3, q_4) =$ **92.745** kN/m^2

Maximum base pressure; $q_{max} = max(q_1, q_2, q_3, q_4) =$ **92.745** kN/m^2

PASS - Maximum base pressure is less than allowable bearing pressure