Structural calculations

For

Proposed Extension and alterations

Field Farm, Dilhorne

For

Cornerstone Builders

Note: Actual beam lengths to be measured on site DO NOT use span lengths quoted in design calculations. Ensure length includes for bearings as specified on drawings.

Where long span beams are installed to support existing masonry walls the deflection, although within tolerance and cannot be avoided, can be moderate and minor cracking can show in the decoration above. This would tend to occur when props are removed and should be made good

CALCULATIONS REVIEW

Project Title: Field Farm	**Job No:** AC4066
Calculations Prepared by: Jamie Ikin	Position: Civil Engineer
Signature:	Date: 10/04/2017

Calculations Sheets and Sketches Reviewed:

Reviewed by: STEVE CLARKSON	Job Title: Associate Director
Signature:	Date: 10/04/17

1.0 DESIGN PHILOSOPHY STATEMENT.

1.0 Aspin Consulting were appointed by Cornerstone Builders to carry out a part structural appraisal of this property. The survey was carried out on 21st February 2017. It was identified that the existing timber joists and supporting timber beams may not have sufficient capacity for domestic load and require checking.

STRUCTURAL SPECIFICATION

Ensure a copy of these calculations and supporting drawings and details are forwarded to Building Control and the Builder in advance of the works commencing.

It is recommended that full approval is obtained from Building Control for the structural proposals prior to ordering materials.

1 General

The contractor shall notify the Engineer should there be any information contained within these calculations and details that are unclear or conflicts with the existing construction.

Traditional construction assumed with solid load bearing inner blockwork/ outer brickwork walls and timber floors

The condition of supporting brickwork and blockwork walls to be verified on site before ordering of materials. Any discrepancies are to be reported to the Engineer.

The structural design and enclosed calculations are based on the drawings and information provided by the Architect.

The structural information provided in the enclosed specification is in addition to that provided by the Architect.

2 Dimensions:

Prior to ordering materials all dimensions to be checked on site.

3 Building Regulation Approval:

It is recommended that full approval is obtained from Building Control for the structural proposals prior to ordering materials.

Where necessary existing foundations to be exposed and inspected by the Building Inspector.

4 Steel Fabrication:

All dimension to be checked / determined on site.

Where necessary all connections to be designed by the steel fabricator in accordance with BS 5950 to the loadings specified.

Load bearing site welding is to be avoided, bolted connections to be provided where possible. However non load bearing locating welds would be acceptable.

5 Proprietary Products:

All propriety manufacturers items [lintels, precast floors, trussed rafters, etc] to be installed in accordance with manufacturer's requirements.

6 Materials:

All materials and installation to comply with current British Standards, Building Regulations and Codes of Practice.

7 CDM 2015 Regulations:

Designer's risks have been considered during the preparation of the structural design and where possible risks have been designed out. Where residual risks remain these are highlighted on the supporting drawings and details.

Temporary works and propping of the existing structure shall consider the existing building loads and ensure stability is maintained at all times.

Installation of steel beams and heavy materials shall use mechanical handling [manual handling regulations].

The contractor is to have a co-ordinated construction plan and method statement for non-traditional works.

The contractor is to inform the designer should there be any changes to the construction that may impact on the design and CDM regulations.

8 Party Wall Act

Where works are being undertaken adjacent to an adjoining property in some cases the PARTY WALL ACT may apply.

In such instances the Architect should be consulted for advice and the correct procedure for notifying the owner of the adjoining property. Approval can take several weeks especially if agreement cannot be reached therefore the notice should be submitted well in advance of the works commencing on site.

If no Architect involved then refer to www.gov.uk/guidance/party-wall-etc-act-1996-guidance for example template notices.

2.0 BUILDING LOADS

ROOF LOADING (PITCHED TILED ROOF)

; Roof slope; θ = 30.0 °

Dead load

; Tiles; $Roof_{D1}$ = 0.65 kN/m^2

; Battens & Rafters; $Roof_{D2}$ = 0.12 kN/m^2

; Felt & Ins; $Roof_{D3}$ = 0.04 kN/m^2

; Plaster board & Services; $Roof_{D4}$ = 0.00 kN/m^2

Dead load on slope

$Roof_{DL\_sroof}$ = sum($Roof_{D1}$,$Roof_{D2}$,$Roof_{D3}$,$Roof_{D4}$) = **0.81** kN/m^2

; Ceiling joists; $Roof_{D5}$ = 0.05 kN/m^2

; Insulation; $Roof_{D6}$ = 0.03 kN/m^2

; Plasterboard and skim; $Roof_{D7}$ = 0.15 kN/m^2

; Services; $Roof_{D8}$ = 0.05 kN/m^2

Dead load on plan

$Roof_{DL\_proof}$ = sum($Roof_{D5}$,$Roof_{D6}$,$Roof_{D7}$,$Roof_{D8}$) = **0.28** kN/m^2

Total dead load on plan

$Roof_{DL} = Roof_{DL\_sroof} / \cos(\theta) + Roof_{DL\_proof}$= **1.22** kN/$m^2$

Imposed load

; Roof imposed load;; $Roof_{IL\_proof}$ = 0.75 kN/m^2 ; on plan

; Ceiling imposed load; $Ceiling_{IL}$ = 0.25kN/m^2 ; on plan

; Total imposed load on plan; $Roof_{IL} = Roof_{IL\_proof} + Ceiling_{IL}$ = **1.000**kN/m^2

Unfactored foundation design loads; $w_{roof\_u} = Roof_{DL} + Roof_{IL}$ = **2.215** kN/m^2

Factored design loads; $w_{roof\_f} = 1.4 \times Roof_{DL} + 1.6 \times Roof_{IL}$ = **3.301** kN/m^2

TIMBER FLOOR LOADING (1ST FLOOR)

Dead load

; Boards; $Floor_{1\_D1}$ = 0.18 kN/m^2

; Joists; $Floor_{1\_D2}$ = 0.20 kN/m^2 ;

; Ceiling; $Floor_{1\_D3}$ = 0.18 kN/m^2

Total dead load;$Floor_{1\_DL}$ = sum($Floor_{1\_D1}$,$Floor_{1\_D2}$,$Floor_{1\_D3}$) = **0.56** kN/m^2

Imposed load

; Imposed load; $Floor_{1\_I1}$ = 1.50 kN/m^2

; Partitions; $Floor_{1\_I2}$ = 0.50 kN/m^2

Total imposed load; $Floor_{1\_IL}$ = sum($Floor_{1\_I1}$,$Floor_{1\_I2}$) = **2.00** kN/m^2

Total 1st floor loads

Unfactored foundation design loads; $w_{floor1\_u} = Floor_{1\_DL} + Floor_{1\_IL}$ = **2.56** kN/m^2

Factored design loads; $w_{floor1\_f} = 1.4 \times Floor_{1\_DL} + 1.6 \times Floor_{1\_IL} = \mathbf{3.98}$ kN/m^2

CAVITY WALL LOADING

Dead load

; Masonry (outer leaf); $CW_{D1} = 2.10$ kN/m^2

; Masonry (inner leaf); $CW_{D2} = 1.80$ kN/m^2

; Plaster; $CW_{D3} = 0.18$ kN/m^2

Total dead load;$CW_{DL} = sum(CW_{D1},CW_{D2},CW_{D3}) = \mathbf{4.08}$ kN/m^2

Total cavity wall load

Unfactored foundation design loads; $w_{cw\_u} = CW_{DL} = \mathbf{4.08}$ kN/m^2

Factored design loads; $w_{cw\_f} = 1.4 \times CW_{DL} = \mathbf{5.71}$ kN/m^2

INTERNAL WALL LOADING

Dead load

; Masonry; $IW_{D1} = 1.80$ kN/m^2

; Plaster (2 sides); $IW_{D2} = 0.36$ kN/m^2

Total dead load;$IW_{DL} = sum(IW_{D1},IW_{D2}) = \mathbf{2.16}$ kN/m^2

Total internal wall load

Unfactored foundation design loads; $w_{iw\_u} = IW_{DL} = \mathbf{2.16}$ kN/m^2

Factored design loads; $w_{iw\_f} = 1.4 \times IW_{DL} = \mathbf{3.02}$ kN/m^2

3.0 STRUCTURAL CALCULATIONS

3.1 Joist Check

Consider 175x75 @ 400mm C/C

TIMBER JOIST DESIGN (BS5268)

TIMBER JOIST DESIGN (BS5268-2:2002)

TEDDS calculation version 1.1.02

Joist details

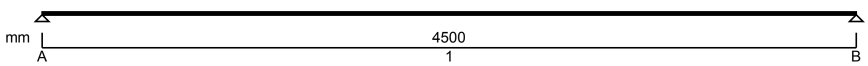
Joist breadth; b = **75** mm

Joist depth; h = **175** mm

Joist spacing; s = **400** mm

Timber strength class; **C16**

Service class of timber; **2**

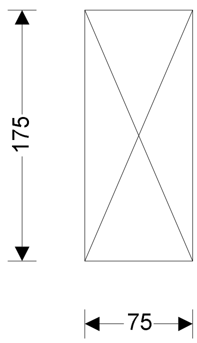


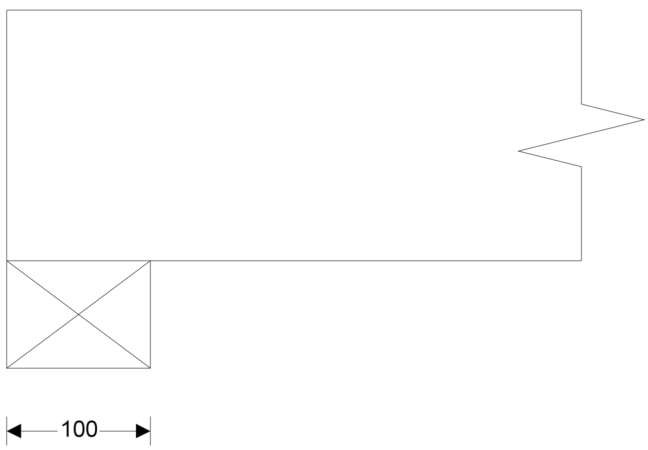
Span details

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

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

Effective length of span; L_{s1} = **4500** mm





Section properties

Second moment of area; $I = b \times h^3 / 12$ = **33496094** mm^4

Section modulus; $Z = b \times h^2 / 6$ = **382813** mm^3

Loading details

Joist self weight;	$F_{swt} = b \times h \times \rho_{char} \times g_{acc}$ = **0.04** 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 = **1.06**
Load sharing factor;	K_8 = **1.10**

Consider long term loads

Load duration factor;	K_3 = **1.00**
;;Maximum bending moment;	M = **2.379** kNm
;Maximum shear force;	V = **2.115** kN
;;Maximum support reaction;	R = **2.115** kN
;Maximum deflection;	δ = **17.421** mm

Check bending stress

Bending stress;	σ_m = **5.300** N/mm^2
Permissible bending stress;	$\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **6.186** N/mm^2
Applied bending stress;	σ_{m_max} = M / Z = **6.215** N/mm^2

FAIL - Applied bending stress exceeds permissible bending stress

Check shear stress

Shear stress;	τ = **0.670** N/mm^2
Permissible shear stress;	$\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.737** N/mm^2
Applied shear stress;	$\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.242** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane);	σ_{cp1} = **2.200** N/mm^2
Permissible bearing stress;	$\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.420** N/mm^2
Applied bearing stress;	$\sigma_{c\_max} = R / (b \times L_b)$ = **0.282** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection;	$\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **13.500** mm
Bending deflection (based on E_{mean});	$\delta_{bending}$ = **17.025** mm
Shear deflection;	δ_{shear} = **0.395** mm
Total deflection;	$\delta = \delta_{bending} + \delta_{shear}$ = **17.421** mm

FAIL - Actual deflection exceeds permissible deflection

Consider medium term loads

Load duration factor;	K_3 = **1.25**
;;Maximum bending moment;	M = **2.435** kNm
;Maximum shear force;	V = **2.165** kN
;;Maximum support reaction;	R = **2.165** kN
;Maximum deflection;	δ = **15.578** mm

Check bending stress

Bending stress; σ_m = **5.300** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **7.733** N/mm^2

Applied bending stress; σ_{m_max} = M / Z = **6.362** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.670** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.921** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.247** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.200** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.025** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.289** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **13.500** mm

Bending deflection (based on E_{mean}); $\delta_{bending}$ = **15.174** mm

Shear deflection; δ_{shear} = **0.405** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **15.578** mm

FAIL - Actual deflection exceeds permissible deflection

Existing Timber Joist has Insufficient Capacity – Fails

Consider 175x75 at alternating centres of originals

TIMBER JOIST DESIGN (BS5268)

TIMBER JOIST DESIGN (BS5268-2:2002)

TEDDS calculation version 1.1.02

Joist details

Joist breadth; b = **75** mm

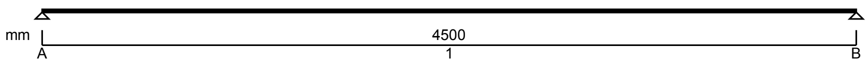
Joist depth; h = **175** mm

Joist spacing; s = **300** mm

Timber strength class; **C16**

Service class of timber; **1**

Aspin Consulting Genesis Centre, Suite F13 North Staffs Business Centre Innovation Way, ST6 4BF	Project Field Farm				Job Ref. AC4066	
	Section Design Calculations				Sheet no./rev. 11	
	Calc. by JCI	Date 10/04/17	Chk'd by SC	Date 10/04/17	App'd by	Date

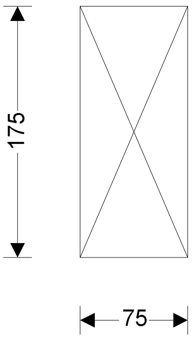


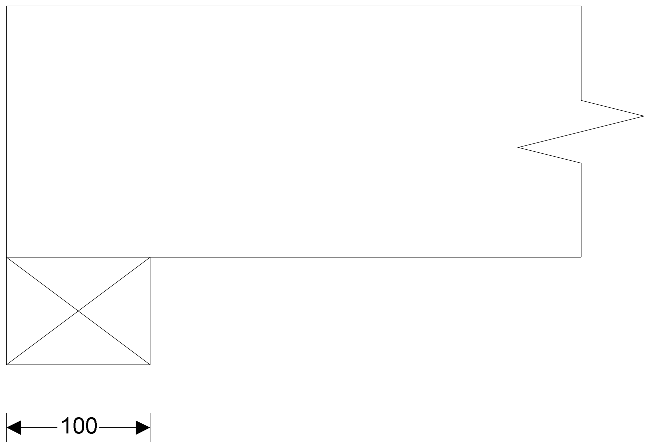
Span details

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

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

Effective length of span; L_{s1} = **4500** mm





Section properties

Second moment of area; $I = b \times h^3 / 12$ = **33496094** mm^4

Section modulus; $Z = b \times h^2 / 6$ = **382813** mm^3

Loading details

Joist self weight; $F_{swt} = b \times h \times \rho_{char} \times g_{acc}$ = **0.04** kN/m

Dead load; F_{d_udl} = **0.35** 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 = **1.06**

Load sharing factor; K_8 = **1.10**

Consider long term loads

Load duration factor; K_3 = **1.00**

;;Maximum bending moment; M = **1.506** kNm

;Maximum shear force; V = **1.339** kN

;;Maximum support reaction; R = **1.339** kN

;Maximum deflection; δ = **11.026** mm

Check bending stress

Bending stress; σ_m = **5.300** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **6.186** N/mm^2

Applied bending stress; σ_{m_max} = M / Z = **3.934** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.670** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.737** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.153** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.200** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.420** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.178** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **13.500** mm

Bending deflection (based on E_{mean}); $\delta_{bending}$ = **10.776** mm

Shear deflection; δ_{shear} = **0.250** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **11.026** mm

PASS - Actual deflection within permissible limits

<u>Consider medium term loads</u>

Load duration factor; K_3 = **1.25**

;;Maximum bending moment; M = **1.942** kNm

;Maximum shear force; V = **1.726** kN

;;Maximum support reaction; R = **1.726** kN

;Maximum deflection; δ = **11.964** mm

Check bending stress

Bending stress; σ_m = **5.300** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **7.733** N/mm^2

Applied bending stress; σ_{m_max} = M / Z = **5.072** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.670** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.921** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.197** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.200** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.025** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.230** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **13.500** mm

Bending deflection (based on E_{mean}); $\delta_{bending}$ = **11.641** mm

Shear deflection; δ_{shear} = **0.323** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **11.964** mm

PASS - Actual deflection within permissible limits

Provide additional 175x75 C16 Timber Joist between every other space of existing joists, providing 800mm centres between new.

3.2 Consider existing 125x75 @ 400mm C/C

TIMBER JOIST DESIGN (BS5268)

TIMBER JOIST DESIGN (BS5268-2:2002)

TEDDS calculation version 1.1.02

Joist details

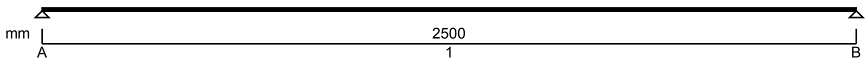
Joist breadth; b = **75** mm

Joist depth; h = **125** mm

Joist spacing; s = **400** mm

Timber strength class; **C16**

Service class of timber; **2**

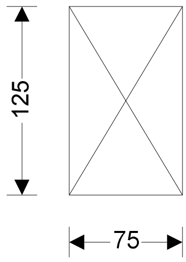


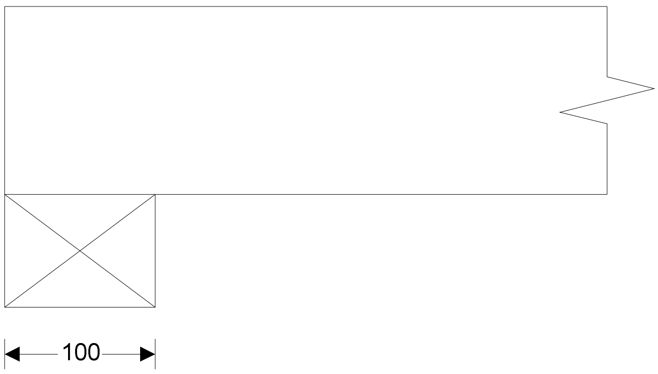
Span details

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

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

Effective length of span; L_{s1} = **2500** mm





Section properties

Second moment of area; $I = b \times h^3 / 12$ = **12207031** mm^4

Section modulus; $Z = b \times h^2 / 6$ = **195312** 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} = **0.35** 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 = **1.10**

Load sharing factor; K_8 = **1.10**

Consider long term loads

Load duration factor; K_3 = **1.00**

;;Maximum bending moment; M = **0.600** kNm

;Maximum shear force; V = **0.961** kN

;;Maximum support reaction; R = **0.961** kN

;Maximum deflection; δ = **3.778** mm

Check bending stress

Bending stress; σ_m = **5.300** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **6.419** N/mm^2

Applied bending stress; σ_{m_max} = M / Z = **3.074** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.670** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.737** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.154** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.200** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.420** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.128** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\text{ mm})$ = **7.500** mm

Bending deflection (based on E_{mean}); $\delta_{bending}$ = **3.639** mm

Shear deflection; δ_{shear} = **0.140** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **3.778** mm

PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor; K_3 = **1.25**

;;Maximum bending moment; M = **1.007** kNm

;Maximum shear force; V = **1.611** kN

;;Maximum support reaction; R = **1.611** kN

;Maximum deflection; δ = **5.275** mm

Check bending stress

Bending stress; σ_m = **5.300** N/mm^2

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **8.024** N/mm^2

Applied bending stress; σ_{m_max} = M / Z = **5.154** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress; τ = **0.670** N/mm^2

Permissible shear stress; $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.921** N/mm^2

Applied shear stress; $\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.258** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane); σ_{cp1} = **2.200** N/mm^2

Permissible bearing stress; $\sigma_{c\_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **3.025** N/mm^2

Applied bearing stress; $\sigma_{c\_max} = R / (b \times L_b)$ = **0.215** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection; $\delta_{adm} = \min(L_{s1} \times 0.003, 14\ mm)$ = **7.500** mm

Bending deflection (based on E_{mean}); $\delta_{bending}$ = **5.040** mm

Shear deflection; δ_{shear} = **0.234** mm

Total deflection; $\delta = \delta_{bending} + \delta_{shear}$ = **5.275** mm

PASS - Actual deflection within permissible limits

Existing Timber Joist has Capacity – Pass

3.3 Consider Existing Timber beam – 225x200mm

Width of pitch roof load carried ; **R_w = 4.0m** ;;
Unfactored Dead load udl ; $wroof_{dead}$= $R_w \times Roof_{DL}$ =**4.861**kN/m
Unfactored Imposed load udl ; $wroof_{imposed}$= $R_w \times Roof_{IL}$ =**4.000**kN/m

Wall UDL; **height=2.4 m; udl=4.08kN/m^2**;
$Wall_{unfact}$= udl×height=**9.792**kN/m;

Total unfactored imposed UDL; $Imp_{udlunfact}$= $wroof_{imposed}$ =**4.000**kN/m
Total unfactored dead UDL; $Dead_{udlunfact}$= $wroof_{dead}$ + $Wall_{unfact}$ =**14.653**kN/m

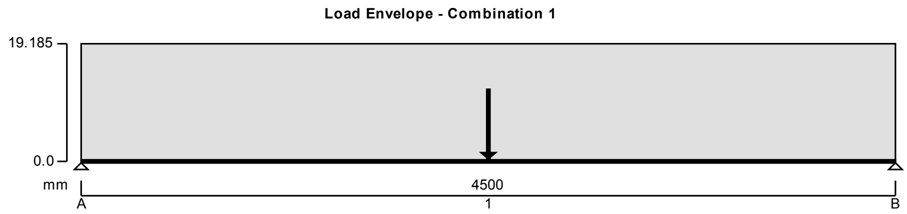
Width of first floor load carried ; **F_w= 2.5m ;**
Unfactored Floor dead ; $wufloor1_{dead}$= 3.7m × F_w × $Floor_{1\_DL}$ = **5.180**kN
Unfactored Floor imposed; $wufloor1_{imposed}$= 3.7m × F_w × $Floor_{1\_IL}$ = **18.500**kN

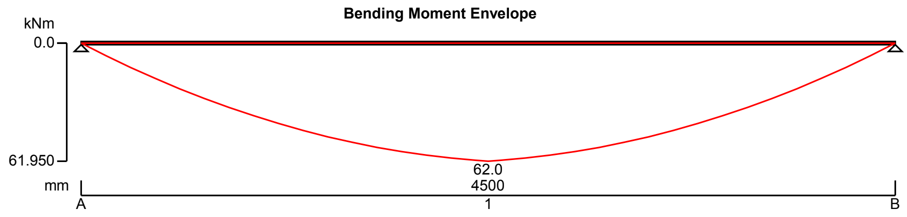
End Reaction acting on beam;
Unfactored Dead; R_{ad} = $wufloor1_{dead}$ /2 = **2.590**kN
Unfactored Imposed; R_{ai} = $wufloor1_{imposed}$ /2 = **9.250**kN

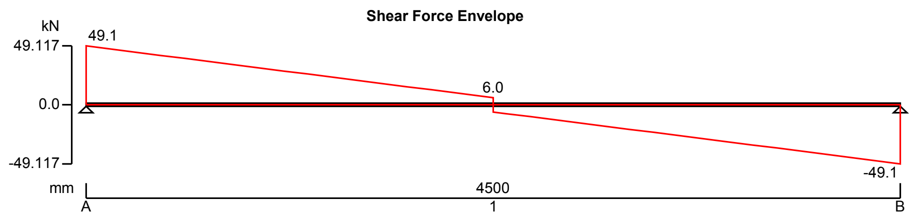
TIMBER BEAM ANALYSIS & DESIGN (BS5268)

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.5.07







Applied loading

Beam loads

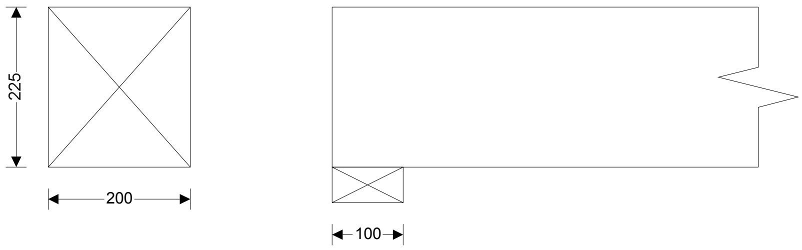
Dead self weight of beam × 1
Dead full UDL 15.000 kN/m
Imposed full UDL 4.000 kN/m
Dead point load 2.600 kN at 2250 mm
Imposed point load 9.300 kN at 2250 mm

Load combinations

Load combination 1	Support A	Dead × 1.00
		Imposed × 1.00
	Span 1	Dead × 1.00
		Imposed × 1.00
	Support B	Dead × 1.00
		Imposed × 1.00

Analysis results

Maximum moment;	M_{max} = **61.950** kNm;	M_{min} = **0.000** kNm
Design moment;	M = max(abs(M_{max}),abs(M_{min})) = **61.950** kNm	
Maximum shear;	F_{max} = **49.117** kN;	F_{min} = **-49.117** kN
Design shear;	F = max(abs(F_{max}),abs(F_{min})) = **49.117** kN	
Total load on beam;	W_{tot} = **98.234** kN	
Reactions at support A;	R_{A_max} = **49.117** kN;	R_{A_min} = **49.117** kN
Unfactored dead load reaction at support A;	R_{A_Dead} = **35.467** kN	
Unfactored imposed load reaction at support A;	$R_{A\_Imposed}$ = **13.650** kN	
Reactions at support B;	R_{B_max} = **49.117** kN;	R_{B_min} = **49.117** kN
Unfactored dead load reaction at support B;	R_{B_Dead} = **35.467** kN	
Unfactored imposed load reaction at support B;	$R_{B\_Imposed}$ = **13.650** kN	



Timber section details

Breadth of sections;	b = **200** mm
Depth of sections;	h = **225** mm
Number of sections in member;	N = **1**

Overall breadth of member; $b_b = N \times b = \mathbf{200}$ mm

Timber strength class; **C24**

Member details

Service class of timber; **1**

Load duration; **Long term**

Length of bearing; $L_b = \mathbf{100}$ mm

Section properties

Cross sectional area of member; $A = N \times b \times h = \mathbf{45000}$ mm^2

Section modulus; $Z_x = N \times b \times h^2 / 6 = \mathbf{1687500}$ mm^3

$Z_y = h \times (N \times b)^2 / 6 = \mathbf{1500000}$ mm^3

Second moment of area; $I_x = N \times b \times h^3 / 12 = \mathbf{189843750}$ mm^4

$I_y = h \times (N \times b)^3 / 12 = \mathbf{150000000}$ mm^4

Radius of gyration; $i_x = \sqrt{(I_x / A)} = \mathbf{65.0}$ mm

$i_y = \sqrt{(I_y / A)} = \mathbf{57.7}$ mm

Modification factors

Duration of loading - Table 17; $K_3 = \mathbf{1.00}$

Bearing stress - Table 18; $K_4 = \mathbf{1.00}$

Total depth of member - cl.2.10.6; $K_7 = (300 \text{ mm} / h)^{0.11} = \mathbf{1.03}$

Load sharing - cl.2.9; $K_8 = \mathbf{1.00}$

Lateral support - cl.2.10.8

No lateral support

Permissible depth-to-breadth ratio - Table 19; **2.00**

Actual depth-to-breadth ratio; $h / (N \times b) = \mathbf{1.13}$

PASS - Lateral support is adequate

Compression perpendicular to grain

Permissible bearing stress (no wane); $\sigma_{c\_adm} = \sigma_{cp1} \times K_3 \times K_4 \times K_8 = \mathbf{2.400}$ N/mm^2

Applied bearing stress; $\sigma_{c\_a} = R_{A\_max} / (N \times b \times L_b) = \mathbf{2.456}$ N/mm^2

$\sigma_{c\_a} / \sigma_{c\_adm} = \mathbf{1.023}$

FAIL - Applied compressive stress exceeds permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = \mathbf{7.741}$ N/mm^2

Applied bending stress; $\sigma_{m\_a} = M / Z_x = \mathbf{36.711}$ N/mm^2

$\sigma_{m\_a} / \sigma_{m\_adm} = \mathbf{4.742}$

FAIL - Applied bending stress exceeds permissible bending stress

Shear parallel to grain

Permissible shear stress; $\tau_{adm} = \tau \times K_3 \times K_8 = \mathbf{0.710}$ N/mm^2

Applied shear stress; $\tau_a = 3 \times F / (2 \times A) = \mathbf{1.637}$ N/mm^2

$\tau_a / \tau_{adm} = \mathbf{2.306}$

FAIL - Applied shear stress exceeds permissible shear stress

Deflection

Modulus of elasticity for deflection; $E = E_{min} = \mathbf{7200}$ N/mm^2

Permissible deflection; $\delta_{adm} = \min(14 \text{ mm}, 0.003 \times L_{s1}) = \mathbf{13.500}$ mm

Bending deflection; $\delta_{b\_s1} = \mathbf{91.471}$ mm

Shear deflection; $\delta_{v\_s1} = \mathbf{3.671}$ mm

Total deflection; $\delta_a = \delta_{b\_s1} + \delta_{v\_s1}$ = **95.142** mm

δ_a / δ_{adm} = **7.048**

FAIL - Total deflection exceeds permissible deflection

Existing Timber Beam has Insufficient Capacity – Fails

Consider Steel Beam to Strengthen – Consider 2no 200x75 PFC to either side of beam

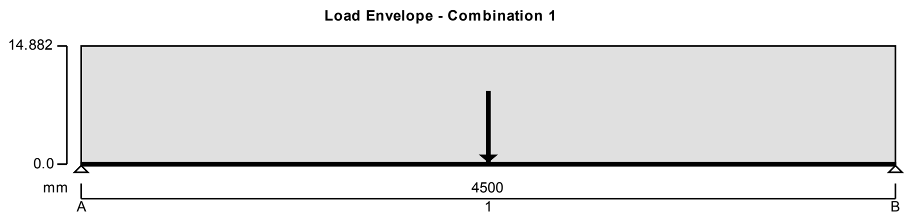
Assumed load values from existing shared evenly between both beams

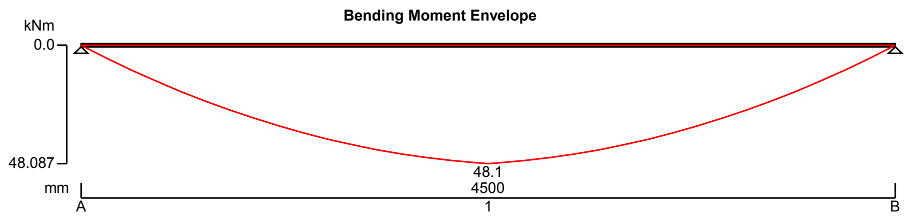
STEEL BEAM ANALYSIS & DESIGN (BS5950)

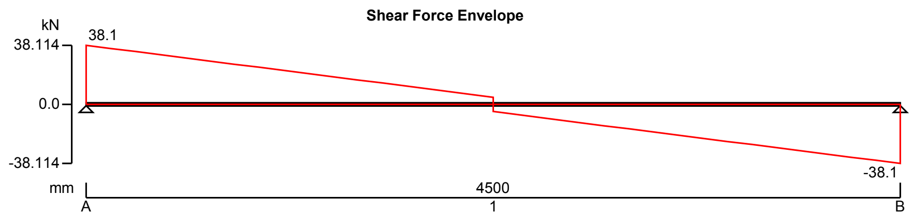
STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.05







Support conditions

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

Applied loading

Beam loads	Dead self weight of beam × 1	
	Dead full UDL 2 kN/m	
	Imposed full UDL 7.35 kN/m	
	Dead point load 1.3 kN at 2250 mm	
	Imposed point load 4.65 kN at 2250 mm	

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

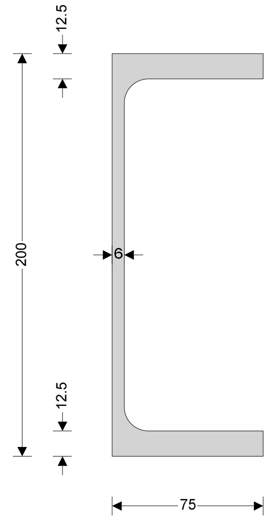
Maximum moment;	M_{max} = **48.1** kNm;	M_{min} = **0** kNm
Maximum shear;	V_{max} = **38.1** kN;	V_{min} = **-38.1** kN
Deflection;	δ_{max} = **11.9** mm;	δ_{min} = **0** mm
Maximum reaction at support A;	R_{A_max} = **38.1** kN;	R_{A_min} = **38.1** kN
Unfactored dead load reaction at support A;	R_{A_Dead} = **5.7** kN	
Unfactored imposed load reaction at support A;	$R_{A\_Imposed}$ = **18.9** kN	
Maximum reaction at support B;	R_{B_max} = **38.1** kN;	R_{B_min} = **38.1** kN
Unfactored dead load reaction at support B;	R_{B_Dead} = **5.7** kN	
Unfactored imposed load reaction at support B;	$R_{B\_Imposed}$ = **18.9** kN	

Section details

Section type;	**PFC 200x75x23 (BS4-1)**
Steel grade;	**S355**

From table 9: Design strength p_y

Thickness of element;	max(T, t) = **12.5** mm
Design strength;	p_y = **355** N/mm^2
Modulus of elasticity;	E = **205000** N/mm^2



Lateral restraint

Span 1 has full lateral restraint

Effective length factors

Effective length factor in major axis; K_x = **1.00**

Effective length factor in minor axis; K_y = **1.00**

Effective length factor for lateral-torsional buckling; $K_{LT.A}$ = **0.85**;

$K_{LT.B}$ = **0.85**;

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **0.88**

Internal compression parts - Table 11

Depth of section; d = **151** mm

$d / t = 28.6 \times \varepsilon <= 80 \times \varepsilon$; Class 1 plastic

Outstand flanges - Table 11

Width of section; b = B = **75** mm

$b / T = 6.8 \times \varepsilon <= 9 \times \varepsilon$; Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force; $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **38.1** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area; $A_v = t \times D$ = **1200** mm^2

Design shear resistance; $P_v = 0.6 \times p_y \times A_v$ = **255.6** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment; $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min}))$ = **48.1** kNm

Moment capacity low shear - cl.4.2.5.2; $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **80.6** kNm

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection; $\delta_{lim} = \min(14 \text{ mm}, L_{s1} / 360)$ = **12.5** mm

Maximum deflection span 1; $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min}))$ = **11.947** mm

PASS - Maximum deflection does not exceed deflection limit

Provide 2no 200x75 23mm PFC either side of existing 225x200mm timber beam.

Fix 360x 200x 8mm plates at 500mm C/C to the bottom flanges of PFC with timber packers to underside of timber beam.

Locate PFC with suitable coach screws.

Aspin Consulting Genesis Centre, Suite F13 North Staffs Business Centre Innovation Way, ST6 4BF	Project Field Farm			Job Ref. AC4066	
	Section Design Calculations			Sheet no./rev. 24	
	Calc. by JCI	Date 10/04/17	Chk'd by SC	Date 10/04/17	App'd by	Date

3.4 Consider New Purlin beam – 152x89 UB16 S355

Width of pitch roof load carried ; **R_w = 1.2m** ;;

Unfactored Dead load udl ; $wroof_{dead} = R_w \times Roof_{DL}$ =**1.458**kN/m

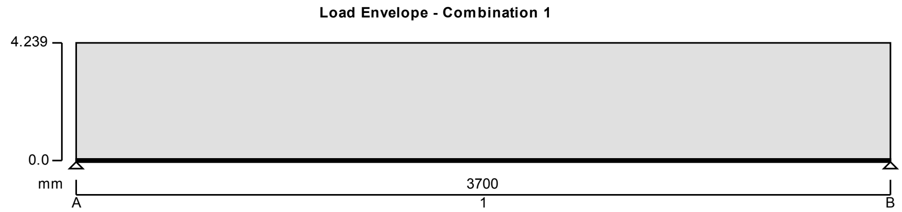
Unfactored Imposed load udl ; $wroof_{imposed} = R_w \times Roof_{IL}$ =**1.200**kN/m

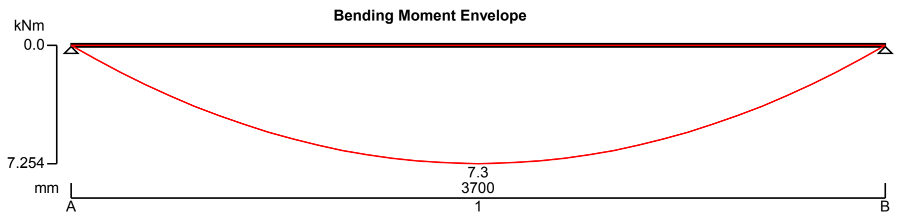
STEEL BEAM ANALYSIS & DESIGN (BS5950)

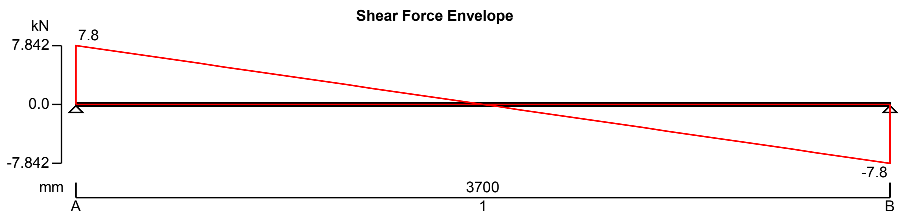
STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.05







Support conditions

Support A — Vertically restrained; Rotationally free

Support B — Vertically restrained; Rotationally free

Applied loading

Beam loads — Dead self weight of beam × 1

Dead full UDL 1.5 kN/m

Imposed full UDL 1.2 kN/m

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

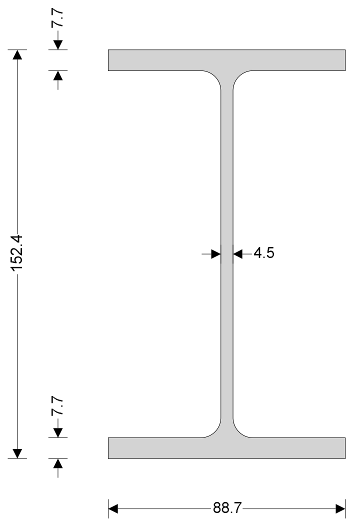
Maximum moment;	M_{max} = **7.3** kNm;	M_{min} = **0** kNm
Maximum shear;	V_{max} = **7.8** kN;	V_{min} = **-7.8** kN
Deflection;	δ_{max} = **4.1** mm;	δ_{min} = **0** mm
Maximum reaction at support A;	R_{A_max} = **7.8** kN;	R_{A_min} = **7.8** kN
Unfactored dead load reaction at support A;	R_{A_Dead} = **3.1** kN	
Unfactored imposed load reaction at support A;	$R_{A\_Imposed}$ = **2.2** kN	
Maximum reaction at support B;	R_{B_max} = **7.8** kN;	R_{B_min} = **7.8** kN
Unfactored dead load reaction at support B;	R_{B_Dead} = **3.1** kN	
Unfactored imposed load reaction at support B;	$R_{B\_Imposed}$ = **2.2** kN	

Section details

Section type;	**UB 152x89x16 (BS4-1)**
Steel grade;	**S355**

From table 9: Design strength p_y

Thickness of element;	max(T, t) = **7.7** mm
Design strength;	p_y = **355** N/mm^2
Modulus of elasticity;	E = **205000** N/mm^2



Lateral restraint

Span 1 has full lateral restraint

Effective length factors

Effective length factor in major axis;	K_x = **1.00**
Effective length factor in minor axis;	K_y = **1.00**
Effective length factor for lateral-torsional buckling;	$K_{LT.A}$ = **1.00**;
	$K_{LT.B}$ = **1.00**;

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = \mathbf{0.88}$

Internal compression parts - Table 11

Depth of section; $d = \mathbf{121.8}$ mm

$d / t = 30.8 \times \varepsilon <= 80 \times \varepsilon$; Class 1 plastic

Outstand flanges - Table 11

Width of section; $b = B / 2 = \mathbf{44.4}$ mm

$b / T = 6.5 \times \varepsilon <= 9 \times \varepsilon$; Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force; $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min})) = \mathbf{7.8}$ kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area; $A_v = t \times D = \mathbf{686}$ mm^2

Design shear resistance; $P_v = 0.6 \times p_y \times A_v = \mathbf{146.1}$ kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment; $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min})) = \mathbf{7.3}$ kNm

Moment capacity low shear - cl.4.2.5.2; $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = \mathbf{43.8}$ kNm

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection; $\delta_{lim} = L_{s1} / 360 = \mathbf{10.278}$ mm

Maximum deflection span 1; $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = \mathbf{4.076}$ mm

PASS - Maximum deflection does not exceed deflection limit