

Structural Calculations

Stroudwood Farmhouse Roof



Document Information

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Issue Status

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NOTES

Document Register

The following drawings should be viewed in conjunction with this document.

Document Register			
Originator	Document Number	Revision	Description
JP	14184-001	C1	Repair Plan

NOTES

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1. NOTES

If in doubt - ASK! Read the following carefully.

This report has been prepared by Andrew Waring Associates Ltd., with all reasonable skill, care, and diligence within the terms of the contract with the Client and within the limitations of the resources devoted to it by agreement with the Client.

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These calculations should be approved by the Local Authority Building Department or other Authorised Authority, before work commences. Work undertaken before Local Authority approval is granted is at the executor's own risk.

All dimensions used in these calculations MUST be checked on site and any significant discrepancies reported to the Engineer.

Andrew Waring Associates accept no responsibility regarding errors in the scaling of dimensions from drawings supplied by others or errors in dimensional information provided by others. Any discrepancies found must be highlighted to Andrew Waring Associates and all other applicable parties.

The lengths and spans used in these calculations are for design purposes only and should not be used as a basis for ordering materials. The Contractor should complete his own measured survey for ordering materials. Do not scale from the Engineer's drawings.

Design responsibility is limited only to those elements of the structure specifically referred to in these calculations.

It is strongly recommended that a competent and careful Contractor carries out the work and as such will be fully responsible for the design, installation, and execution of all temporary works necessary to support the structure during the works, in accordance with HSE recommendations and BRE Good Practice Guidelines.

The Contractor will be fully responsible for the design of all construction details. This includes for all setting out of structural items i.e. placement, position and levels (finished levels or otherwise). All steelwork connections are to be completed by the Main Contractor/Steel Fabricator unless otherwise noted or details are provided.

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The Contractor will be responsible for the stability of the structure during the construction phase of the Works.

Where new structural supports are to be provided to an existing structure, cracking to the existing structure may occur and require repair work to the existing finishes. To minimise cracking adequate temporary supports must be provided, to be installed in accordance with the HSE recommendations and BRE Good Practice Guidelines.

These calculations are to be read in conjunction with; the latest relevant Drawings and/or Specification(s) from the Architect, Client, other Engineering and Specialist Suppliers or Subcontractors or any other applicable third party. If any discrepancies are found these should be raised with the relevant parties.

If any conditions on site are found to conflict with or change the design contained in these calculations, these conditions should be brought to the attention of the Engineer as soon as possible.

Any deviations from the materials specified in these calculations must be brought to the attention of the Engineer prior to ordering or construction.

NOTES

2. SCHEDULE OF DESIGN STANDARDS

Eurocode: Basis of Structural Design

BS EN 1990:2002-1-A1:2005 Eurocode - Basis of structural design; with UK National Annex to BS EN 1990:2002 + A1:2005.

Eurocode 1: Actions on Structures

BS EN 1991-1-1:2002 Eurocode 1: Actions on structures - Part 1.1: General actions - Densities, self weight, imposed loads for buildings; with UK National Annex to BS EN 1991-1-1:2002.

BS EN 1991-1-3:2003 Eurocode 1: Actions on structures - Part 1.3: General actions - Snow loads; with UK National Annex to BS EN 1991-1-3:2003.

BS EN 1991-1A:2005 + A1:2010 Eurocode 1: Actions on structures - Part 1.4: General actions - Wind actions; with UK National Annex to BS EN 1991-1-4:2005 + A1:2010.

BS EN 1991-1-6:2005 Eurocode 1: Actions on structures - Part 1.6: General actions - Actions during execution; with UK National Annex to BS EN 1991-1-6:2005.

BS EN 1991-1-7:2006 Eurocode 1: Actions on structures - Part 1.7: General actions - Accidental actions; with UK National Annex to BS EN 1991-1-7:2006.

Eurocode 2: Design of Concrete Structures

BS EN 1992-1-1:2004 Eurocode 2: Design of concrete structures Part 1.1: General rules and rules for buildings; with UK National Annex to BS EN 1992-1-1:2004.

BSI PD 6681-1:2010 Published Document - Background paper to the UK National Annexes to BS EN 1992-1 and BS EN 1992-3.

BS EN 13670:2009 Execution of concrete structures.

Eurocode 3: Design of Steel Structures

BS EN 1993-1-1:2005 Eurocode 3: Design of steel structures - Part 1.1: General rules and rules for buildings; with UK National Annex to BS EN 1993-1-1:2005.

BS EN 1993-1-3:2006 Eurocode 3: Design of steel structures - Part 1.3: General rules - Supplementary rules for cold-formed members and sheeting; with UK National Annex to BS EN 1993-1-3:2006.

BS EN 1993-1-4:2006 Eurocode 3: Design of steel structures - Part 1.4: General rules - Supplementary rules for stainless steels; with UK National Annex to BS EN 1993-1-4:2006.

BS EN 1993-1-5:2006 Eurocode 3: Design of steel structures - Part 1.5: Plated structural elements; with UK National Annex to BS EN 1993-1-5:2006.

BS EN 1993-1-6:2007 Eurocode 3: Design of steel structures - Part 1.6: Strength and stability of shell structures.

BS EN 1993-1-7:2007 Eurocode 3: Design of steel structures - Part 1.7: Plated structures subject to out of plane loading.

BS EN 1993-1-8:2005 Eurocode 3: Design of steel structures - Part 1.8: Design of joints; with UK National Annex to BS EN 1993-1-8:2005.

BS EN 1993-5:2007 Eurocode 3: Design of steel structures - Part 5: Piling; with UK National Annex to BS EN 1993-5:2007+A1:2012.

BS EN 1090-2:2008 +A1:2011 Execution of steel structures and aluminium structures Part 2: Technical requirements for the execution of steel structures.

BRE Digest 437 Industrial platform floors: mezzanine and raised storage.

Eurocode 5: Design of Timber Structures

BS EN 1995-1-1:2004+A1:2008 Eurocode 5: Design of timber structures - Part 1.1: General - Common rules and rules for buildings; with UK National Annex to BS EN 1995-1-1:2004+A1:2008.

BSI PD 6593-1:2012 Published Document - Recommendations for the design of timber structures to Eurocode 5: Design of timber structures Part 1: General - Common rules and rules for buildings.

BS 8103-3:2009 Structural design of low-rise buildings - Part 3: Code of practice for timber floors and roofs for housing.

Eurocode 6: Design of Masonry Structures

BS EN 1996-1-1:2005-A1:2012 Eurocode 6: Design of masonry structures - Part 1.1: General rules for reinforced and unreinforced masonry structures; with UK National Annex to BS EN 1996-1-1:2005+A1:2012.

BS EN 1996-2:2006 Eurocode 6: Design of masonry structures - Part 2: Design considerations, selection of materials and execution of masonry; with UK National Annex to BS EN 1996-2:2006.

BS EN 1996-3:2006 Eurocode 6 Design of masonry structures - Part 3: Simplified calculation methods for unreinforced masonry structures; with UK National Annex to BS EN 1996-3:2006.

BS 8103-1:2011 Structural design of low-rise buildings - Part 1: Code of Practice for stability, site investigation, foundations, precast concrete floors and ground floor slabs for housing.

BS 8103-2:2005 Structural design of low-rise buildings - Part 2: Code of practice for masonry walls for housing.

Eurocode 7: Geotechnical Design

BS EN 1997-1:2004 Eurocode 7: Geotechnical design - Part 1; General rules; with UK National Annex to BS EN 1997-1:2004.

BS EN 1997-2:2007 Eurocode 7: Geotechnical design - Part 2; Ground investigation and testing; with UK National Annex to BS EN 1997-2:2007.

SCHEDULE OF DESIGN STANDARDS

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3. DESIGNERS RESIDUAL HEALTH AND SAFETY RISK ASSESSMENT – CDM

Under the CDM Regulations, Designers are required to avoid foreseeable risks to those involved in the pre-construction, construction, maintenance, or use of a structure throughout its service life.

Designers must eliminate or minimise risk to acceptable levels; wherever it is reasonably practicable to do so, while also taking account of other design, constructability, or practicality considerations.

This requires designers to assess the risks associated with their design and/or specification decisions. Where risks have been reduced so far as is reasonably practicable, but significant risks remain, these risks need to be highlighted to the CDM-Coordinator.

This Designers Residual Health and Safety Risk Assessment (DRA) highlights risks or concerns specifically related to the installation and construction of the building structure, foundations and below ground drainage. Health and Safety risks or concerns relating to any other aspect of the building are not considered within this DRA.

The risks of regular, day-to-day routine activities in construction are expected to be known by an experienced and competent contractor. They should be familiar with the current industry standards of health and safety methods for avoidance and/or mitigation of these risks and their implementation. This DRA will therefore consider only those tasks and associated risks that would be irregular to an experienced and competent contractor and require special risk management and mitigation.

Risk	Action with risk At Risk Parties (AR)	Initial Risk			Mitigating Action(s)	Residual Risks			Additional Comments
		P	S	RR		P	S	RR	
Damage to existing structure or finishes.	Removal of part of existing structure to form new opening(s). AR: Persons in immediate area to or above opening(s).	2	3	6	Main Contractor to assess, design and provide all appropriate temporary works including but not limited to propping and shoring of existing wall(s), adjacent floor(s) and any other structure(s) supported by the structure or part of structure to be removed.	1	3	3	N/A
Movement or collapse of structure in temporary condition. Damage to constructed works. Risk of injury.	Installation of new structural members / openings to existing structure(s). AR: Construction personnel on site. Site visitors.	4	3	12	Provide appropriate and adequate temporary propping to structures and excavations in the temporary condition. Allow sufficient time for constructed elements to cure/develop full load bearing strength before removing temporary supports.	2	3	6	N/A
Falling heavy objects with high impact force. Risk of injury.	Installation / Craning of precast concrete items / beams / columns / trusses / other heavy items. AR: Construction personnel on site. Site visitors.	4	3	12	Where heavy items are to be craned / lifted into position, site access to be strictly limited to the installation personnel only. No other trades, construction personnel or site visitors to be allowed in or in the vicinity of the working area, materials storage area, materials delivery area/access routes.	2	3	6	N/A
Falling tools or materials with risk of injury to persons below. Risk of falling from height.	Working at height generally. AR: Construction personnel at height and personnel below. Site visitors adjacent to or below working area.	3	2	6	Provide sufficient temporary access platforms i.e., scaffolding / mobile towers. Provide adequate debris netting, hand rails toe boards etc. to prevent loss of material or personnel from access platforms.	1	2	2	N/A
Probability (P)	1 – Very Low, 2 – Low, 3 – Medium, 4 – High, 5 – Very High								
Severity (S)	1 – Very Low, 2 – Low, 3 – Medium, 4 – High, 5 – Very High								
Risk Score (RR = P x S)	1 – 5 Very Low, 6 – 10 Low, 11 – 15 Medium, 16 – 20 High, 21 – 25 Very High								

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4. DOCUMENT SUMMARY

This document contains structural calculations for structural alterations to facilitate the repair of the timber roof structure at the address *"Stroudwood Farmhouse"*.

Items for which structural design calculations are to be produced by Andrew Waring Associates within this document;

- a. Design of primary superstructure elements relating to the roof only.

This document must be read in conjunction with any appendices and relevant drawing sheets, together with any architectural or third-party drawings.

This document does not specify methods of construction for the proposed works and should not be used as such.

Use of this document, information or designs therein does not absolve the Contractor of their duties under the Builder Regulations and Construction (Design and Management) Regulations. All construction and building works should be carried out in accordance with current good practice guidelines, compliance and building codes whether explicitly referred to or not.

Building Regulations apply to all works of a structural nature. This document and any other supporting documentation provided should be submitted to the Local Authority Building Control department for approval prior to commencement of any works. Commencement of works prior to obtaining Local Authority Building Control approval is at the executor's own risk.

5. MATERIAL STRENGTH, PROTECTION AND PREPARATION REQUIREMENTS

MATERIAL STRENGTHS

Unless otherwise noted:

TIMBER

- a. All timber softwood grade C24 to BS EN 1995.
- b. All particleboard decking flooring grade P5 to BS EN 312.
- c. All plywood sheathing board Class 3 / WBP to BS EN 636, BS EN 314.
- d. All oriented strand board (OSB) to be structural grade OSB3 to BS EN 300.
- e. All board thicknesses when used as flooring to be in accordance with below.

Floor decking	400mm joist centres	450mm joist centres	600mm joist centres	Standard
Softwood boarding	16	16	19	BS EN 13353
Moisture resistant chipboard	18	18	22	BS EN 312 – type P5
Plywood	15	15	18/19	BS EN 636
Oriented strand board	15	15	18/19	BS EN 300 – type OSB3

MATERIAL PROTECTION & PREPARATION

TIMBER

- a. Unless otherwise noted, all timber elements are to be pressure preservative treated suitable for the following use classes to BS 8417 / BS EN 335-2:
 - i. All roofing timbers Class 2

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FIRE PROTECTION REQUIREMENTS (PRIMARY STRUCTURE ONLY)

ALL ELEMENTS

- Protection of all elements to Architect's details and in accordance with Building Regulations Part B 2022.
- All elements must be suitably fire protected for a minimum resistance period of 30 minutes to the applicable codes of practice and good building guidelines current at the time of construction.
- Additional or increased fire protection requirements may be required subject to the size and use of the building or structure – the Architect's details take precedence in all instances.
- DO NOT ASSUME 30 MINUTES RESISTANCE IS SUFFICIENT – CONFIRM WITH THE PROJECT ARCHITECT.
- Protection of all secondary elements to Architect's/Supplier's/Specialists details.

MATERIAL STRENGTH, PROTECTION AND PREPARATION REQUIREMENTS

6. LOADINGS BRIEF

ROOF, PITCHED 42°, CLAY TILE

	(Degrees)	(kN/m ²)	DEAD	IMPOSED	SLS	ULS
Pitch	42	On slope	0.94	0.60	1.75	2.48
SUM LOADS		On plan	1.26	0.81	1.30	1.84

Load Components

PLAIN CLAY TILES	0.80
BATTENS & FELT	0.05
VCL VAPOUR CONTROL LAYER	0.01
TIMBER JOIST/RAFTER 100 x 47 @ 400	0.08
IMPOSED, ROOF, PITCH ON SLOPE	0.60

ATTIC FLOOR, TIMBER JOIST, PB+SKIM

	(kN/m ²)	DEAD	IMPOSED	SLS	ULS
SUM LOADS	On plan	0.32	0.25	0.57	0.81

Load Components

ROCKWOOL INSULATION 100mm	0.04
ROCKWOOL INSULATION 100mm	0.04
TIMBER JOIST/RAFTER 150 x 47 @ 400	0.10
VCL VAPOUR CONTROL LAYER	0.01
PLASTERBOARD + SKIM 3mm	0.13
IMPOSED, ATTIC/CEILING - ACCESS/LIGHT STORAGE	0.25

LOADINGS BRIEF

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7. DESIGN PHILOSOPHY

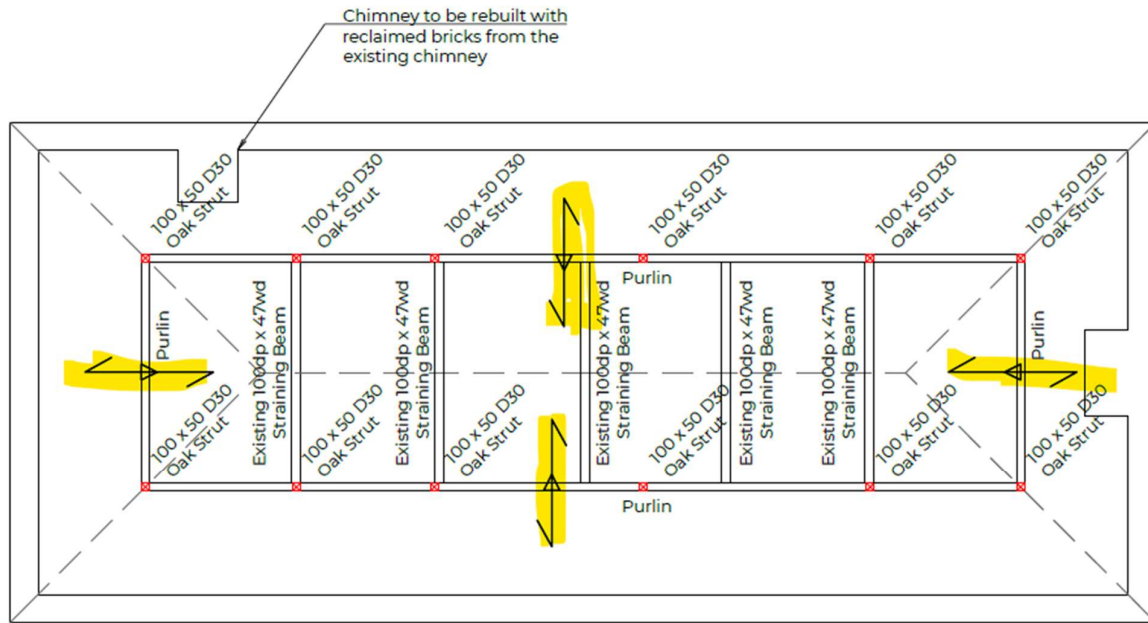
The following calculations are for repairs to a timber cut roof where the ceiling joists, purlins, rafters and beams are failing.

SUPERSTRUCTURE FORM AND MATERIALS

- Flitch plate strengthening to Purlins
- New rafters to replace existing damaged
- Joists fixed to existing to strengthen ceiling
- New struts and timber beams to support purlins

8. EXISTING RAFTERS

GENERAL ARRANGEMENT



ROOF PLAN

1:50

LOADS

ROOF, PITCHED 42°, CLAY TILE

	(Degrees)	(kN/m ²)	DEAD	IMPOSED	SLS	ULS
Pitch	42	On slope	0.94	0.60	1.75	2.48
SUM LOADS		On plan	1.26	0.81	1.30	1.84

Load Components

PLAIN CLAY TILES	0.80
BATTENS & FELT	0.05
VCL VAPOUR CONTROL LAYER	0.01
TIMBER JOIST/RAFTER 100 x 47 @ 400	0.08
IMPOSED, ROOF, PITCH ON SLOPE	0.60

SECTION SIZE, GRADE, PROTECTION AND DRILLING REQUIREMENTS, BEARING DETAIL

80 x 50 Timber assumed to be D18

EXISTING RAFTERS

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SECTION DESIGN

TIMBER RAFTER ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the UK national annex

Tedds calculation version 1.0.07

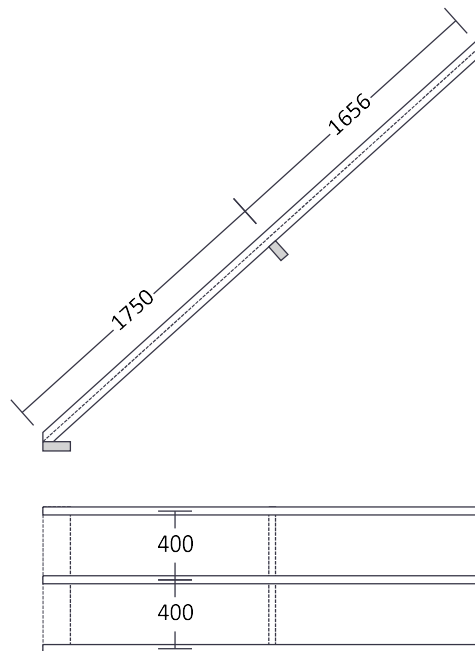
Rafter details

Rafter spacing

$S_{\text{Rafter}} = 400 \text{ mm}$

Rafter inclination

$\theta_{\text{Rafter}} = 42 \text{ deg}$



Forces input on Rafter

Permanent load on slope

$F_{G_Rafter} = 0.86 \text{ kN/m}^2$

Imposed load on plan

$F_{Q_Rafter} = 0.81 \text{ kN/m}^2$

Snow load on plan

$F_{S_Rafter} = 0.40 \text{ kN/m}^2$

Rafter loading details

Distributed loads

Permanent load on slope

$p_G = 0.34 \text{ kN/m}$

Imposed load on slope

$p_Q = 0.24 \text{ kN/m}$

Snow load on slope

$p_S = 0.12 \text{ kN/m}$

Member span 1 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	7.5	0.5	0.068	PASS
Bearing stress	N/mm ²	1.0	0.3	0.331	PASS
Bending stress	N/mm ²	8.0	4.5	0.563	PASS
Shear stress	N/mm ²	1.4	0.4	0.287	PASS
Bending and axial force				0.565	PASS

EXISTING RAFTERS

Column stability check				0.626	PASS
Deflection	mm	7	2.9	0.419	PASS
Member span 2 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	7.5	0.2	0.033	PASS
Bearing stress	N/mm ²	1.0	0.2	0.183	PASS
Bending stress	N/mm ²	8.0	4.5	0.563	PASS
Shear stress	N/mm ²	1.4	0.4	0.277	PASS
Bending and axial force				0.565	PASS
Column stability check				0.621	PASS
Deflection	mm	6.6	2.1	0.313	PASS

ANALYSIS

Tedds calculation version 1.0.37

Loading

Self weight included (Permanent x 1)

Load combination factors

Load combination	Permanent	Imposed	Snow	Wind
1.35G + 1.50Q (Strength)	1.35	1.50	0.00	0.00
1.00G + 1.00Q (Service)	1.00	1.00	0.00	0.00

Member Loads

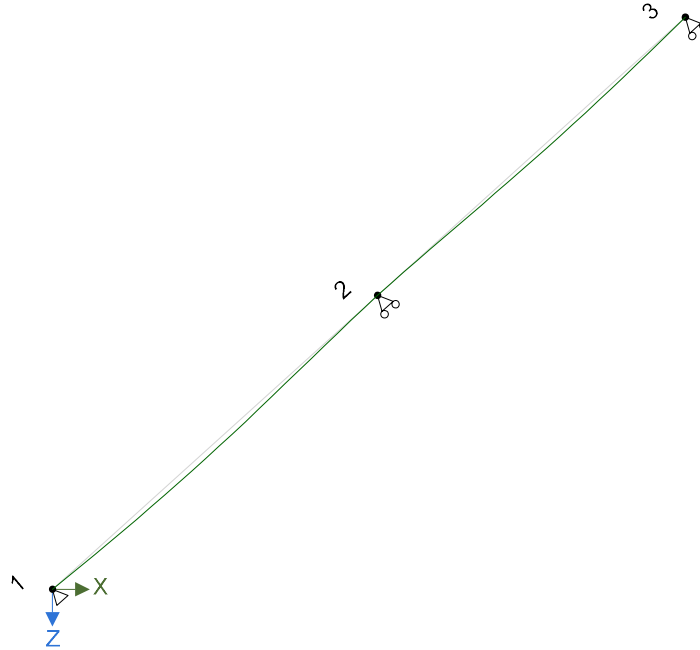
Member	Load case	Load Type	Orientation	Description
Member	Permanent	UDL	GlobalZ	0.34 kN/m at 0 m to 3.406 m
Member	Imposed	UDL	GlobalZ	0.24 kN/m at 0 m to 3.406 m
Member	Snow	UDL	GlobalZ	0.12 kN/m at 0 m to 3.406 m

EXISTING RAFTERS

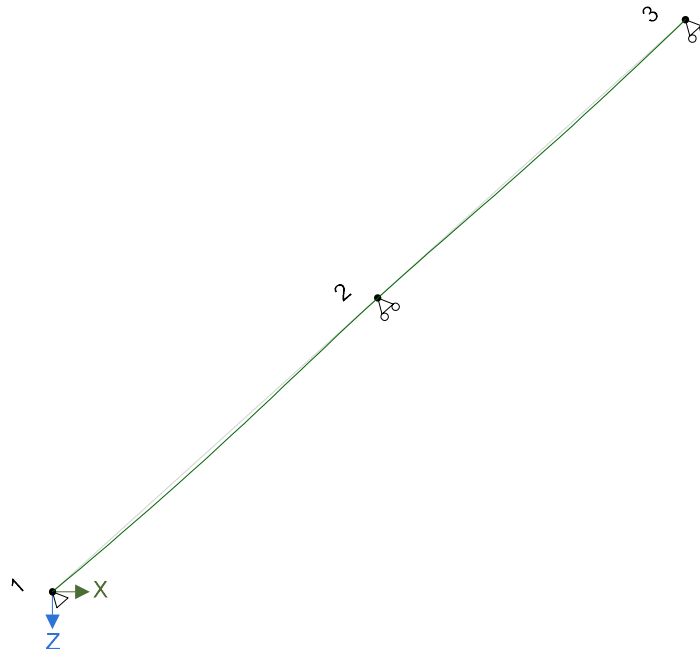
Results

Total deflection

1.35G + 1.50Q (Strength) - Total deflection



1.00G + 1.00Q (Service) - Total deflection



EXISTING RAFTERS

Node deflections

Load combination: 1.35G + 1.50Q (Strength)

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	0	0.27002	Member
2	-0.1	0	-0.02569	Member
3	-0.1	0	-0.20655	Member

Load combination: 1.00G + 1.00Q (Service)

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	0	0.19146	Member
2	-0.1	0	-0.01822	Member
3	-0.1	0	-0.14646	Member

Total base reactions

Load case/combination	Force	
	FX (kN)	FZ (kN)
1.35G + 1.50Q (Strength)	0	2.9
1.00G + 1.00Q (Service)	0	2

Reactions

Load case: Permanent

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0.8	0.2	0
2	0	0.6	0
3	0	0.2	0

Load case: Imposed

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0.5	0.1	0
2	0	0.4	0
3	0	0.1	0

Load case: Snow

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0.3	0.1	0
2	0	0.2	0
3	0	0.1	0

EXISTING RAFTERS

Load case: Wind

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0	0	0
2	0	0	0
3	0	0	0

Load combination: 1.35G + 1.50Q (Strength)

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	1.9	0.4	0
2	0	1.3	0
3	0	0.4	0

Load combination: 1.00G + 1.00Q (Service)

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	1.4	0.3	0
2	0	0.9	0
3	0	0.3	0

Element end forces

Load combination: 1.35G + 1.50Q (Strength)

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	1.75	1	-1.9	-0.4	0
		2	0.9	-0.7	-0.2
2	1.656	2	-0.9	-0.7	0.2
		3	0	-0.4	0

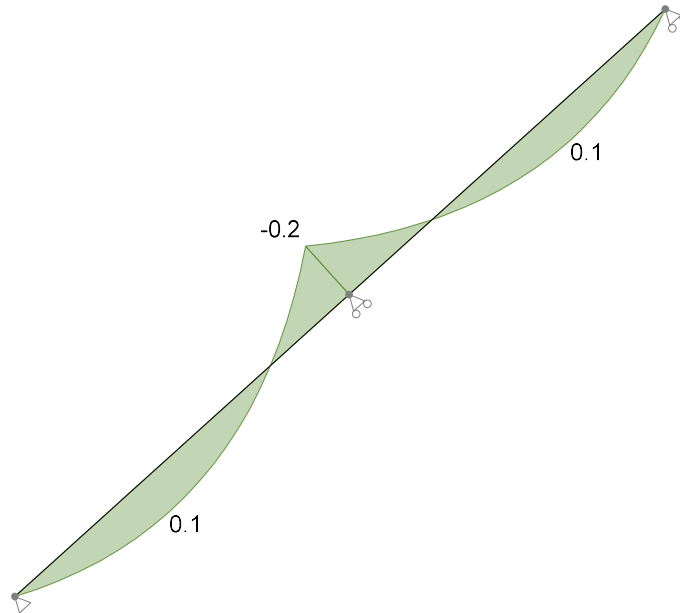
Load combination: 1.00G + 1.00Q (Service)

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	1.75	1	-1.4	-0.3	0
		2	0.7	-0.5	-0.2
2	1.656	2	-0.7	-0.5	0.2
		3	0	-0.3	0

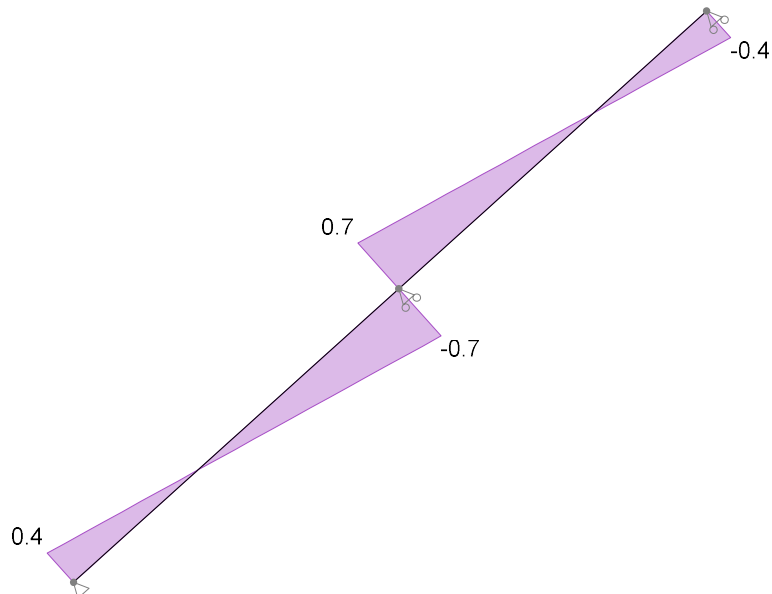
EXISTING RAFTERS

Forces

Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



EXISTING RAFTERS

Member results

Envelope - Strength combinations

Member	Position (m)	Shear force (kN)	Moment (kNm)
Member	0.67	0	0.1 (max)
	1.75	-0.7 (max abs)	-0.2 (min)

Tedds calculation version 2.2.20

Member - Span 1

Partial factor for material properties and resistances

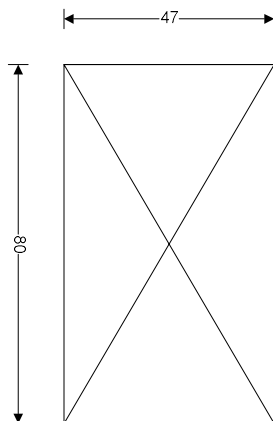
Partial factor $\gamma_M = 2.000$

Member details

Load duration Medium-term Service class 2

Timber section details

Number of timber sections $N = 1$
 Breadth of sections $b = 47$ mm Depth of sections $h = 80$ mm
 Timber strength class **C16**



47x80 timber section

Cross-sectional area, A , 3760 mm²
 Section modulus, W_y , 50133.3 mm³
 Section modulus, W_z , 29453 mm³
 Second moment of area, I_y , 2005333 mm⁴
 Second moment of area, I_z , 692153 mm⁴
 Radius of gyration, i_y , 23.1 mm
 Radius of gyration, i_z , 13.6 mm
Timber strength class D18
 Characteristic bending strength, $f_{m,k}$, 18 N/mm²
 Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²
 Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²
 Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²
 Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²
 Mean modulus of elasticity, $E_{0,mean}$, 9500 N/mm²
 Fifth percentile modulus of elasticity, $E_{0.05}$, 8000 N/mm²
 Shear modulus of elasticity, G_{mean} , 590 N/mm²
 Characteristic density, ρ_k , 475 kg/m³
 Mean density, ρ_{mean} , 570 kg/m³

Span details

Bearing length $L_b = 100$ mm

Consider Combination 1 - 1.35G + 1.50Q (Strength)

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 0.512$ N/mm² Design compressive strength $f_{c,0,d} = 7.480$ N/mm²
 Utilisation = **0.068**

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.320$ N/mm² Des.perp.comp.strength $f_{c,y,90,d} = 0.968$ N/mm²
 Utilisation = **0.331**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

EXISTING RAFTERS

Check shear force - Section 6.1.7

Design shear stress

$\tau_{y,d} = 0.250 \text{ N/mm}^2$

Design shear strength

$f_{v,y,d} = 1.408 \text{ N/mm}^2$

Utilisation = 0.178

PASS - Design shear strength exceeds design shear stress

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis

$L_{e,y} = 1575 \text{ mm}$

Relative slenderness ratio

$\lambda_{rel,y} = 1.218$

Effective length for z-axis

$L_{e,z} = 0 \text{ mm}$

Relative slenderness ratio

$\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.128

PASS - Column stability is acceptable

Check design at end of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress

$\sigma_{c,y,90,d} = 0.177 \text{ N/mm}^2$

Des.perp.comp.strength

$f_{c,y,90,d} = 0.968 \text{ N/mm}^2$

Utilisation = 0.183

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress

$\tau_{y,d} = 0.403 \text{ N/mm}^2$

Design shear strength

$f_{v,y,d} = 1.408 \text{ N/mm}^2$

Utilisation = 0.287

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress

$\sigma_{m,y,d} = 4.498 \text{ N/mm}^2$

Design bending strength

$f_{m,y,d} = 7.983 \text{ N/mm}^2$

Utilisation = 0.563

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = 0.565

PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis

$L_{e,y} = 1575 \text{ mm}$

Relative slenderness ratio

$\lambda_{rel,y} = 1.218$

Effective length for z-axis

$L_{e,z} = 0 \text{ mm}$

Relative slenderness ratio

$\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.626

PASS - Column stability is acceptable

Consider Combination 2 - 1.00G + 1.00Q (Service)

Check design 757 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep

$\delta_{y,Final} = 2.9 \text{ mm}$

Allowable deflection

$\delta_{y,Allowable} = 7 \text{ mm}$

Utilisation = 0.419

PASS - Allowable deflection exceeds final deflection

Member - Span 2

Partial factor for material properties and resistances

Partial factor

$\gamma_M = 2.000$

EXISTING RAFTERS

Member details

Load duration

Medium-term

Service class

2

Timber section details

Number of timber sections

N = 1

Breadth of sections

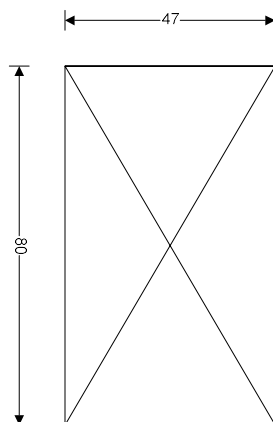
b = 47 mm

Depth of sections

h = 80 mm

Timber strength class

C16



47x80 timber section

Cross-sectional area, A, 3760 mm²

Section modulus, W_y, 50133.3 mm³

Section modulus, W_z, 29453 mm³

Second moment of area, I_y, 2005333 mm⁴

Second moment of area, I_z, 692153 mm⁴

Radius of gyration, i_y, 23.1 mm

Radius of gyration, i_z, 13.6 mm

Timber strength class D18

Characteristic bending strength, f_{m,k}, 18 N/mm²

Characteristic shear strength, f_{v,k}, 3.5 N/mm²

Characteristic compression strength parallel to grain, f_{c,0,k}, 18 N/mm²

Characteristic compression strength perpendicular to grain, f_{c,90,k}, 4.8 N/mm²

Characteristic tension strength parallel to grain, f_{t,0,k}, 11 N/mm²

Mean modulus of elasticity, E_{0,mean}, 9500 N/mm²

Fifth percentile modulus of elasticity, E_{0,05}, 8000 N/mm²

Shear modulus of elasticity, G_{mean}, 590 N/mm²

Characteristic density, ρ_k, 475 kg/m³

Mean density, ρ_{mean}, 570 kg/m³

Span details

Bearing length

L_b = 100 mm

Consider Combination 1 - 1.35G + 1.50Q (Strength)

Check compression parallel to the grain - cl.6.1.4

Design compressive stress σ_{c,0,d} = 0.249 N/mm²

Design compressive strength f_{c,0,d} = 7.480 N/mm²

Utilisation = 0.033

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress σ_{c,y,90,d} = 0.177 N/mm²

Des.perp.comp.strength f_{c,y,90,d} = 0.968 N/mm²

Utilisation = 0.183

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress τ_{y,d} = 0.390 N/mm²

Design shear strength f_{v,y,d} = 1.408 N/mm²

Utilisation = 0.277

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress σ_{m,y,d} = 4.498 N/mm²

Design bending strength f_{m,y,d} = 7.983 N/mm²

Utilisation = 0.563

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = 0.565

PASS - Combined bending and axial compression utilisation is acceptable

EXISTING RAFTERS

Contract Stroudwood Farmhouse			Job Ref. 14184
Date May 2025	By JP	Checked by BM	Revision No. A
Document Reference 14184-CALC-01			Drawing Ref. See Register

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 1490$ mm

Relative slenderness ratio $\lambda_{rel,y} = 1.153$

Effective length for z-axis $L_{e,z} = 0$ mm

Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = **0.621**

PASS - Column stability is acceptable

Consider Combination 2 - 1.00G + 1.00Q (Service)

Check design 962 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 2.1$ mm

Allowable deflection

$\delta_{y,Allowable} = 6.6$ mm

Utilisation = **0.313**

PASS - Allowable deflection exceeds final deflection

TIMBER MEMBER ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the UK national annex

Tedds calculation version 2.2.20

Member1 span 1 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	9.7	0.3	0.036	PASS
Bearing stress	N/mm ²	2.6	0.2	0.080	PASS
Bending stress	N/mm ²	11.0	4.9	0.443	PASS
Shear stress	N/mm ²	1.9	0.4	0.229	PASS
Bending and axial force				0.443	PASS
Column stability check				0.445	PASS
Beam stability check				0.197	PASS
Deflection	mm	7.2	2.6	0.364	PASS
Member1 span 2 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	9.7	0.4	0.041	PASS
Bearing stress	N/mm ²	2.6	0.2	0.073	PASS
Bending stress	N/mm ²	11.0	4.9	0.443	PASS
Shear stress	N/mm ²	1.9	0.4	0.220	PASS
Bending and axial force				0.445	PASS
Column stability check				0.500	PASS
Beam stability check				0.235	PASS
Deflection	mm	13	1.5	0.116	PASS
Member2 span 1 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	9.7	0.4	0.041	PASS
Bearing stress	N/mm ²	2.6	0.2	0.074	PASS
Bending stress	N/mm ²	11.0	5.0	0.451	PASS
Shear stress	N/mm ²	1.9	0.4	0.221	PASS
Bending and axial force				0.452	PASS
Column stability check				0.508	PASS
Beam stability check				0.242	PASS
Deflection	mm	13	1.5	0.113	PASS

EXISTING RAFTERS

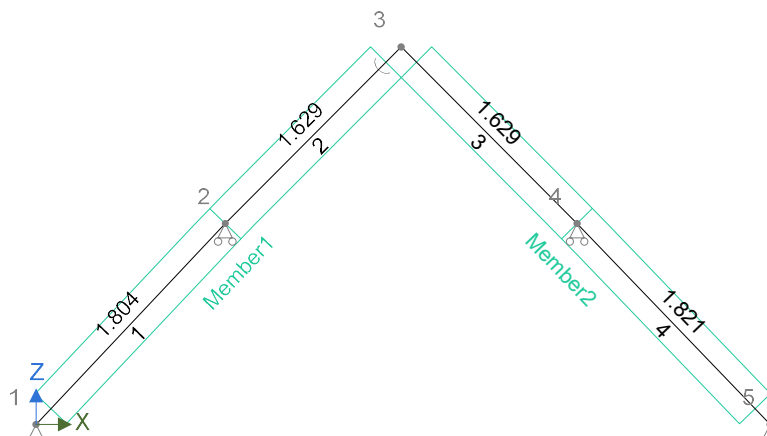
Member2 span 2 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	9.7	0.3	0.035	PASS
Bearing stress	N/mm ²	2.6	0.2	0.072	PASS
Bending stress	N/mm ²	11.0	5.0	0.451	PASS
Shear stress	N/mm ²	1.9	0.4	0.233	PASS
Bending and axial force				0.451	PASS
Column stability check				0.452	PASS
Beam stability check				0.204	PASS
Deflection	mm	7.3	2.8	0.384	PASS

ANALYSIS

Tedds calculation version 1.0.37

Geometry

Geometry (m) - D18 (EC5) - 50x80



Materials

Name	Density (kg/m ³)	Youngs Modulus kN/mm ²	Shear Modulus kN/mm ²	Thermal Coefficient °C ⁻¹
D18 (EC5)	570	9.5	0.59	0

Sections

Name	Area (cm ²)	Moment of inertia Major (cm ⁴)	Minor (cm ⁴)	Shear area parallel to Minor (cm ²)	Major (cm ²)
50x80	40	213.3	83.3	33.3	33.3

Nodes

Node	Co-ordinates X (m) Z (m)		Freedom X Z Rot.			Coordinate system Name Angle (°)		Spring X (kN/m) Z (kN/m) Rot. kNm/°		
1	0	0	Fixed	Fixed	Free		0	0	0	0
2	1.238	1.312	Free	Fixed	Free		0	0	0	0
3	2.389	2.465	Free	Free	Free		0	0	0	0
4	3.54	1.312	Free	Fixed	Free		0	0	0	0
5	4.803	0	Fixed	Fixed	Free		0	0	0	0

EXISTING RAFTERS

Elements

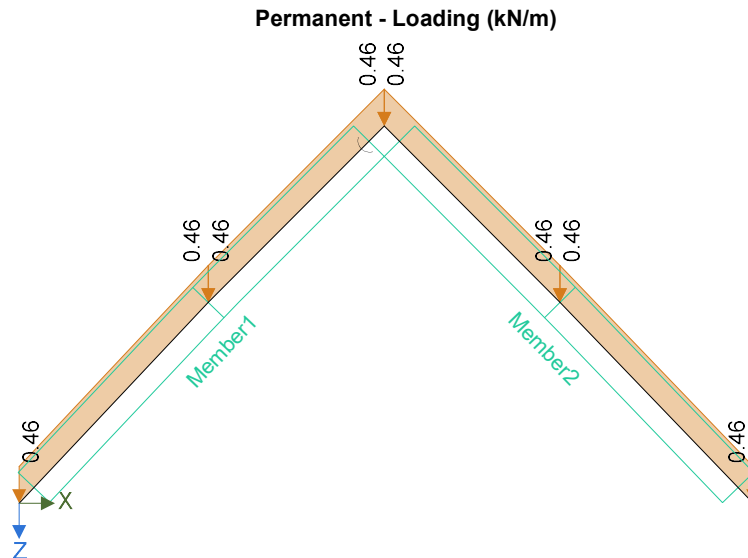
Element	Length (m)	Nodes		Section	Material	Releases		Axial	Rotated
		Start	End			Start moment	End moment		
1	1.804	1	2	50x80	D18 (EC5)	Fixed	Fixed	Fixed	
2	1.629	2	3	50x80	D18 (EC5)	Fixed	Free	Fixed	
3	1.629	3	4	50x80	D18 (EC5)	Fixed	Fixed	Fixed	
4	1.821	4	5	50x80	D18 (EC5)	Fixed	Fixed	Fixed	

Members

Name	Elements	
	Start	End
Member1	1	2
Member2	3	4

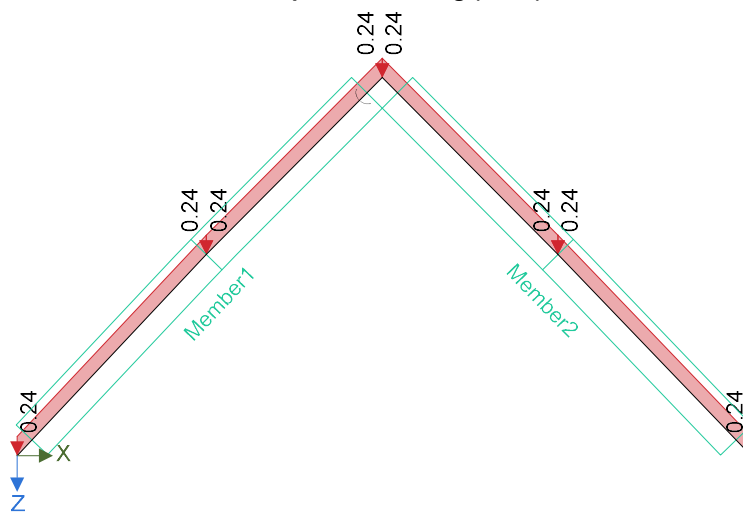
Loading

Self weight included



EXISTING RAFTERS

Imposed - Loading (kN/m)



Load combination factors

Load combination	Self Weight	Permanent	Imposed
1.35G + 1.5Q + 1.5RQ (Strength)	1.35	1.35	1.50
1.0G + 1.0Q + 1.0RQ (Service)	1.00	1.00	1.00

Member Loads

Member	Load case	Load Type	Orientation	Description
Member1	Permanent	UDL	GlobalZ	0.46 kN/m
Member2	Permanent	UDL	GlobalZ	0.46 kN/m
Member1	Imposed	UDL	GlobalZ	0.24 kN/m
Member2	Imposed	UDL	GlobalZ	0.24 kN/m

Results

Reactions

Load case: Self Weight

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	0	0
2	0	0	0
4	0	0	0
5	0	0	0

Load case: Permanent

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0.3	0.6	0

EXISTING RAFTERS

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
2	0	1	0
4	0	1	0
5	-0.3	0.6	0

Load case: Imposed

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0.1	0.3	0
2	0	0.5	0
4	0	0.5	0
5	-0.1	0.3	0

Load combination: 1.35G + 1.5Q + 1.5RQ (Strength)

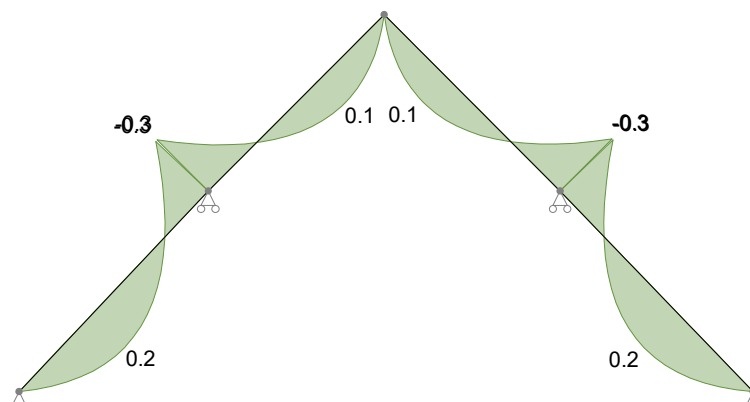
Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0.6	1.3	0
2	0	2.1	0
4	0	2.2	0
5	-0.6	1.3	0

Load combination: 1.0G + 1.0Q + 1.0RQ (Service)

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0.4	1	0
2	0	1.5	0
4	0	1.5	0
5	-0.4	0.9	0

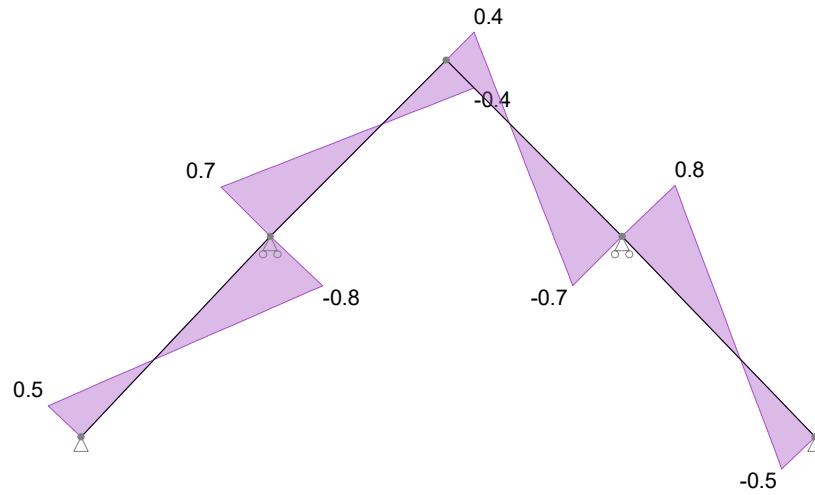
Forces

Strength combinations - Moment envelope (kNm)

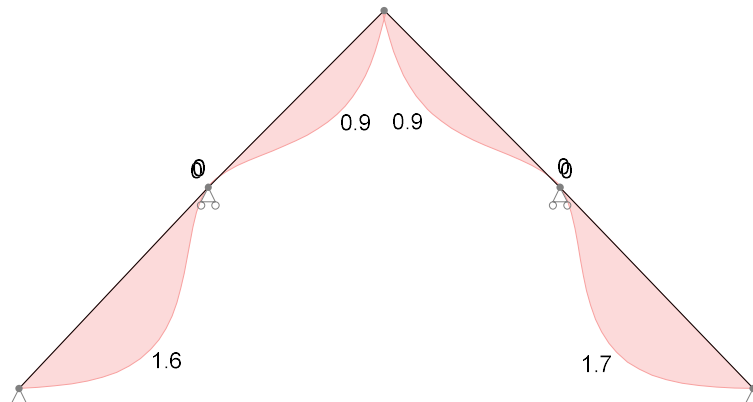


EXISTING RAFTERS

Strength combinations - Shear envelope (kN)



Service combinations - Deflection envelope (mm)



Member1 - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

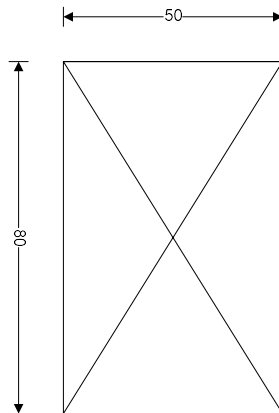
Member details

Load duration Long-term Service class 1

Timber section details

Number of timber sections $N = 1$
Breadth of sections $b = 50$ mm Depth of sections $h = 80$ mm
Timber strength class **D18**

EXISTING RAFTERS



50x80 timber section

Cross-sectional area, A , 4000 mm²

Section modulus, W_y , 53333.3 mm³

Section modulus, W_z , 33333 mm³

Second moment of area, I_y , 2133333 mm⁴

Second moment of area, I_z , 833333 mm⁴

Radius of gyration, i_y , 23.1 mm

Radius of gyration, i_z , 14.4 mm

Timber strength class D18

Characteristic bending strength, $f_{m,k}$, 18 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 9500 N/mm²

Fifth percentile modulus of elasticity, $E_{0,05}$, 8000 N/mm²

Shear modulus of elasticity, G_{mean} , 590 N/mm²

Characteristic density, ρ_k , 475 kg/m³

Mean density, ρ_{mean} , 570 kg/m³

Span details

Bearing length

$L_b = 100$ mm

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

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 0.344$ N/mm²

Design compressive strength $f_{c,0,d} = 9.692$ N/mm²

Utilisation = 0.036

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.207$ N/mm²

Des.perp.comp.strength $f_{c,y,90,d} = 2.585$ N/mm²

Utilisation = 0.080

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.270$ N/mm²

Design shear strength $f_{v,y,d} = 1.885$ N/mm²

Utilisation = 0.143

PASS - Design shear strength exceeds design shear stress

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 1624$ mm

Relative slenderness ratio $\lambda_{rel,y} = 1.062$

Effective length for z-axis $L_{e,z} = 0$ mm

Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.055

PASS - Column stability is acceptable

Check design at end of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.183$ N/mm²

Des.perp.comp.strength $f_{c,y,90,d} = 2.585$ N/mm²

Utilisation = 0.071

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

EXISTING RAFTERS

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.431 \text{ N/mm}^2$ Design shear strength $f_{v,y,d} = 1.885 \text{ N/mm}^2$
 Utilisation = **0.229**
PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 4.868 \text{ N/mm}^2$ Design bending strength $f_{m,y,d} = 10.991 \text{ N/mm}^2$
 Utilisation = **0.443**
PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = **0.443**
PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 1624 \text{ mm}$ Relative slenderness ratio $\lambda_{rel,y} = 1.062$
 Effective length for z-axis $L_{e,z} = 0 \text{ mm}$ Relative slenderness ratio $\lambda_{rel,z} = 0$
 $\lambda_{rel,y} > 0.3$ column stability check is required
 Utilisation = **0.445**
PASS - Column stability is acceptable

Check beams subjected to either bending or combined bending and compression - cl.6.3.3

Utilisation = **0.197**
PASS - Beam stability is acceptable

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

Check design 782 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 2.6 \text{ mm}$ Allowable deflection $\delta_{y,Allowable} = 7.2 \text{ mm}$
 Utilisation = **0.364**
PASS - Allowable deflection exceeds final deflection

Member1 - Span 2

Partial factor for material properties and resistances

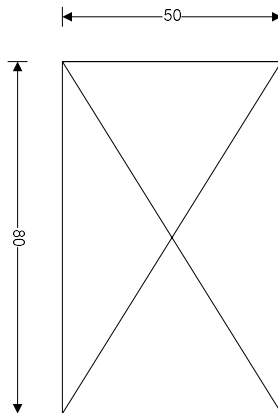
Partial factor $\gamma_M = 1.300$

Member details

Load duration Long-term Service class 1

Timber section details

Number of timber sections N = 1
 Breadth of sections b = 50 mm Depth of sections h = 80 mm
 Timber strength class D18



50x80 timber section

Cross-sectional area, A , 4000 mm²

Section modulus, W_y , 53333.3 mm³

Section modulus, W_z , 33333 mm³

Second moment of area, I_y , 2133333 mm⁴

Second moment of area, I_z , 833333 mm⁴

Radius of gyration, i_y , 23.1 mm

Radius of gyration, i_z , 14.4 mm

Timber strength class D18

Characteristic bending strength, $f_{m,k}$, 18 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 9500 N/mm²

Fifth percentile modulus of elasticity, $E_{0,05}$, 8000 N/mm²

Shear modulus of elasticity, G_{mean} , 590 N/mm²

Characteristic density, ρ_k , 475 kg/m³

Mean density, ρ_{mean} , 570 kg/m³

Span details

Bearing length

$L_b = 100$ mm

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

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 0.396$ N/mm²

Design compressive strength $f_{c,0,d} = 9.692$ N/mm²

Utilisation = **0.041**

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.189$ N/mm²

Des.perp.comp.strength $f_{c,y,90,d} = 2.585$ N/mm²

Utilisation = **0.073**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress $\tau_{v,d} = 0.415$ N/mm²

Design shear strength $f_{v,y,d} = 1.885$ N/mm²

Utilisation = **0.220**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 4.868$ N/mm²

Design bending strength $f_{m,y,d} = 10.991$ N/mm²

Utilisation = **0.443**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = **0.445**

PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 1466$ mm

Relative slenderness ratio $\lambda_{rel,y} = 0.959$

Effective length for z-axis $L_{e,z} = 0$ mm

Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = **0.5**

PASS - Column stability is acceptable

EXISTING RAFTERS

Contract Stroudwood Farmhouse			Job Ref. 14184
Date May 2025	By JP	Checked by BM	Revision No. A
Document Reference 14184-CALC-01			Drawing Ref. See Register

Check beams subjected to either bending or combined bending and compression - cl.6.3.3

Utilisation = **0.235**

PASS - Beam stability is acceptable

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

Check design 968 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 1.5$ mm

Allowable deflection

$\delta_{y,Allowable} = 13$ mm

Utilisation = **0.116**

PASS - Allowable deflection exceeds final deflection

Member2 - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

Member details

Load duration Long-term

Service class 1

Timber section details

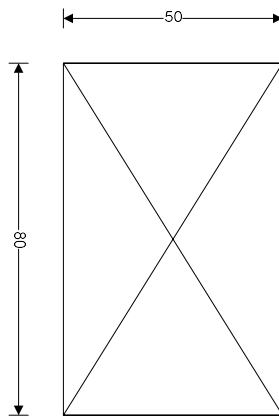
Number of timber sections $N = 1$

Breadth of sections $b = 50$ mm

Depth of sections

$h = 80$ mm

Timber strength class **D18**



50x80 timber section

Cross-sectional area, A , 4000 mm²

Section modulus, W_y , 53333.3 mm³

Section modulus, W_z , 33333 mm³

Second moment of area, I_y , 2133333 mm⁴

Second moment of area, I_z , 833333 mm⁴

Radius of gyration, i_y , 23.1 mm

Radius of gyration, i_z , 14.4 mm

Timber strength class D18

Characteristic bending strength, $f_{m,k}$, 18 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 9500 N/mm²

Fifth percentile modulus of elasticity, $E_{0,05}$, 8000 N/mm²

Shear modulus of elasticity, G_{mean} , 590 N/mm²

Characteristic density, ρ_k , 475 kg/m³

Mean density, ρ_{mean} , 570 kg/m³

Span details

Bearing length $L_b = 100$ mm

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

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 0.105$ N/mm²

Design compressive strength $f_{c,0,d} = 9.692$ N/mm²

Utilisation = **0.011**

PASS - Design parallel compression strength exceeds design parallel compression stress

EXISTING RAFTERS

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Check design at end of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.191 \text{ N/mm}^2$ Des.perp.comp.strength $f_{c,y,90,d} = 2.585 \text{ N/mm}^2$
Utilisation = **0.074**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.416 \text{ N/mm}^2$ Design shear strength $f_{v,y,d} = 1.885 \text{ N/mm}^2$
Utilisation = **0.221**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 4.953 \text{ N/mm}^2$ Design bending strength $f_{m,y,d} = 10.991 \text{ N/mm}^2$
Utilisation = **0.451**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = **0.452**

PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 1466 \text{ mm}$ Relative slenderness ratio $\lambda_{rel,y} = 0.959$
Effective length for z-axis $L_{e,z} = 0 \text{ mm}$ Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = **0.508**

PASS - Column stability is acceptable

Check beams subjected to either bending or combined bending and compression - cl.6.3.3

Utilisation = **0.242**

PASS - Beam stability is acceptable

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

Check design 656 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 1.5 \text{ mm}$ Allowable deflection $\delta_{y,Allowable} = 13 \text{ mm}$
Utilisation = **0.113**

PASS - Allowable deflection exceeds final deflection

Member2 - Span 2

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

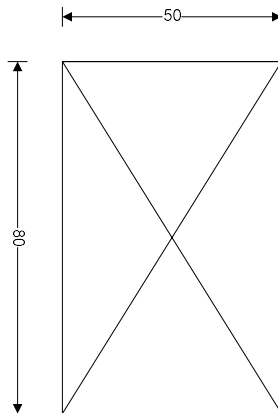
Member details

Load duration Long-term Service class 1

Timber section details

Number of timber sections $N = 1$
Breadth of sections $b = 50 \text{ mm}$ Depth of sections $h = 80 \text{ mm}$
Timber strength class **D18**

EXISTING RAFTERS



50x80 timber section
 Cross-sectional area, A , 4000 mm²
 Section modulus, W_y , 53333.3 mm³
 Section modulus, W_z , 33333 mm³
 Second moment of area, I_y , 2133333 mm⁴
 Second moment of area, I_z , 833333 mm⁴
 Radius of gyration, i_y , 23.1 mm
 Radius of gyration, i_z , 14.4 mm
Timber strength class D18
 Characteristic bending strength, $f_{m,k}$, 18 N/mm²
 Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²
 Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²
 Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²
 Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²
 Mean modulus of elasticity, $E_{0,mean}$, 9500 N/mm²
 Fifth percentile modulus of elasticity, $E_{0.05}$, 8000 N/mm²
 Shear modulus of elasticity, G_{mean} , 590 N/mm²
 Characteristic density, ρ_k , 475 kg/m³
 Mean density, ρ_{mean} , 570 kg/m³

Span details

Bearing length $L_b = 100$ mm

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

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 0.011$ N/mm² Design compressive strength $f_{c,0,d} = 9.692$ N/mm²
 Utilisation = 0.001

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.187$ N/mm² Des.perp.comp.strength $f_{c,y,90,d} = 2.585$ N/mm²
 Utilisation = 0.072

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.439$ N/mm² Design shear strength $f_{v,y,d} = 1.885$ N/mm²
 Utilisation = 0.233

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 4.953$ N/mm² Design bending strength $f_{m,y,d} = 10.991$ N/mm²
 Utilisation = 0.451

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = 0.451

PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 1639$ mm Relative slenderness ratio $\lambda_{rel,y} = 1.072$
 Effective length for z-axis $L_{e,z} = 0$ mm Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.452

PASS - Column stability is acceptable

EXISTING RAFTERS

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Check beams subjected to either bending or combined bending and compression - cl.6.3.3

Utilisation = **0.204**

PASS - Beam stability is acceptable

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

Check design 1029 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 2.8$ mm

Allowable deflection

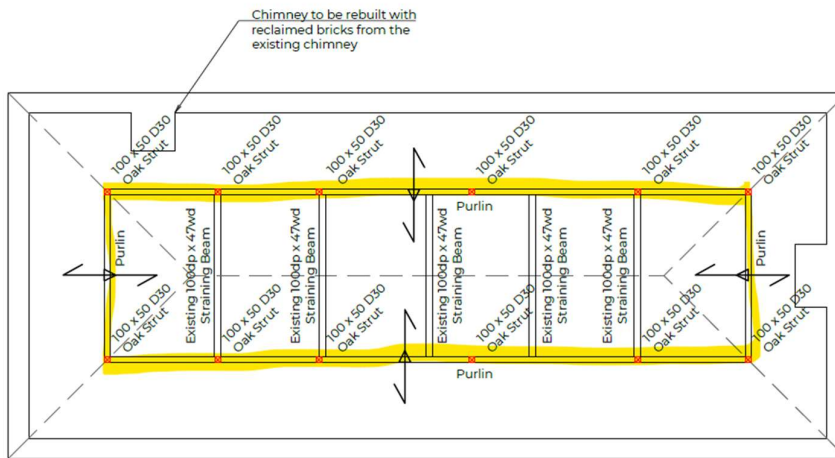
$\delta_{y,Allowable} = 7.3$ mm

Utilisation = **0.384**

PASS - Allowable deflection exceeds final deflection

9. PURLIN STRENGTHENING

GENERAL ARRANGEMENT



ROOF PLAN
1:50

LOADS

Dead: 2.45kN/m

Live: 1.25kN/m

$2.45 \times 0.743 = 1.82\text{kN/m}$

$1.25 \times 0.743 = 0.93\text{kN/m}$

SECTION SIZE, GRADE, PROTECTION AND DRILLING REQUIREMENTS, BEARING DETAIL

80 x 80 assumed D18 Purlin at 42 degrees strengthened with 8mm S275 Plate fixed at 200c/c's

SECTION DESIGN

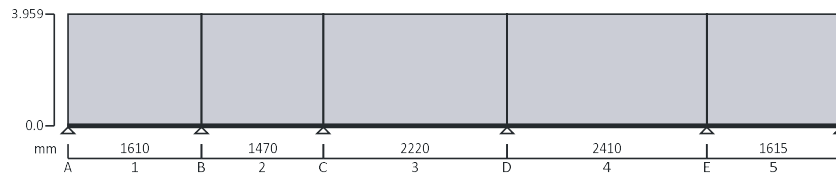
FLITCH BEAM ANALYSIS & DESIGN TO EN1995-1-1:2004

In accordance with EN1995-1-1:2004 + A2:2014 and Corrigendum No.1 and the UK National Annex incorporating National Amendment No.1

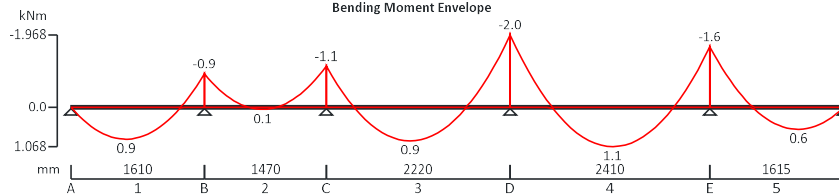
Tedds calculation version 1.7.05

PURLIN STRENGTHENING

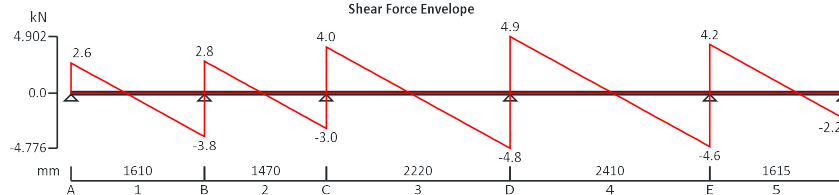
Load Envelope - Combination 1



Bending Moment Envelope



Shear Force Envelope



Applied loading

Beam loads

Permanent self weight of beam $\times 1$

Permanent full UDL 1.820 kN/m

Variable full UDL 0.930 kN/m

Load combinations

Load combination 1

Support A

Permanent $\times 1.35$

Variable $\times 1.50$

Span 1

Permanent $\times 1.35$

Variable $\times 1.50$

Support B

Permanent $\times 1.35$

Variable $\times 1.50$

Span 2

Permanent $\times 1.35$

Variable $\times 1.50$

Support C

Permanent $\times 1.35$

Variable $\times 1.50$

Span 3

Permanent $\times 1.35$

Variable $\times 1.50$

Support D

Permanent $\times 1.35$

Variable $\times 1.50$

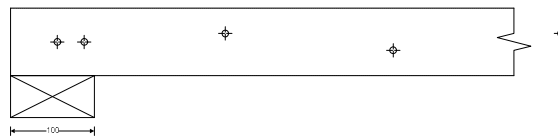
PURLIN STRENGTHENING

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Span 4	Permanent × 1.35 Variable × 1.50
Support E	Permanent × 1.35 Variable × 1.50
Span 5	Permanent × 1.35 Variable × 1.50
Support F	Permanent × 1.35 Variable × 1.50

Analysis results

Design moment	M = 1.968 kNm	Design shear	F = 4.902 kN
Total load on member	W _{tot} = 36.915 kN		
Reactions at support A	R _{A_max} = 2.619 kN	R _{A_min} = 2.619 kN	
Unfactored permanent load reaction at support A	R _{A_Permanent} = 1.257 kN		
Unfactored variable load reaction at support A	R _{A_Variable} = 0.615 kN		
Reactions at support B	R _{B_max} = 6.524 kN	R _{B_min} = 6.524 kN	
Unfactored permanent load reaction at support B	R _{B_Permanent} = 3.130 kN		
Unfactored variable load reaction at support B	R _{B_Variable} = 1.533 kN		
Reactions at support C	R _{C_max} = 7.062 kN	R _{C_min} = 7.062 kN	
Unfactored permanent load reaction at support C	R _{C_Permanent} = 3.388 kN		
Unfactored variable load reaction at support C	R _{C_Variable} = 1.659 kN		
Reactions at support D	R _{D_max} = 9.679 kN	R _{D_min} = 9.679 kN	
Unfactored permanent load reaction at support D	R _{D_Permanent} = 4.643 kN		
Unfactored variable load reaction at support D	R _{D_Variable} = 2.274 kN		
Reactions at support E	R _{E_max} = 8.857 kN	R _{E_min} = 8.857 kN	
Unfactored permanent load reaction at support E	R _{E_Permanent} = 4.249 kN		
Unfactored variable load reaction at support E	R _{E_Variable} = 2.081 kN		
Reactions at support F	R _{F_max} = 2.175 kN	R _{F_min} = 2.175 kN	
Unfactored permanent load reaction at support F	R _{F_Permanent} = 1.043 kN		
Unfactored variable load reaction at support F	R _{F_Variable} = 0.511 kN		



Timber section details

Breadth of section	b = 80 mm	Depth of section	h = 80 mm
Number of sections	N = 1		
Timber strength class	D18		

Steel section details

Breadth of steel plate	b _s = 8 mm	Depth of steel plate	h _s = 80 mm
Number of steel plates in beam	N _s = 1	nominal yield stress	f _y = 275 N/mm ²
Bolt diameter	φ _b = 8 mm		

Member details

Service class of timber	2	Load duration	Medium-term
Length of span 1	L _{s1} = 1610 mm		

PURLIN STRENGTHENING

Length of span 2 $L_{s2} = 1470$ mm
 Length of span 3 $L_{s3} = 2220$ mm
 Length of span 4 $L_{s4} = 2410$ mm
 Length of span 5 $L_{s5} = 1615$ mm
 Length of bearing $L_b = 100$ mm

Compression perpendicular to grain - cl.6.1.4

Design compressive stress $\sigma_{c,90,d} = 1.210$ N/mm² Design compressive strength $f_{c,90,d} = 2.954$ N/mm²

PASS - Design compressive strength exceeds design compressive stress at bearing

Bending - cl 6.1.6

Design timber bending stress $\sigma_{m,t,d} = 7.182$ N/mm² Design timber bending strength $f_{m,d} = 12.561$ N/mm²

PASS - Design timber bending strength exceeds design timber bending stress

Design steel bending stress $\sigma_{m,s,d} = 205.258$ N/mm² Design steel bending strength $f_{y,d} = 275.000$ N/mm²

PASS - Design steel bending strength exceeds design steel bending stress

Shear - cl.6.1.7

Applied shear stress $\tau_d = 0.534$ N/mm² Permissible shear stress $f_{v,d} = 2.154$ N/mm²

PASS - Design shear strength exceeds design shear stress

Deflection - cl.7.2

Deflection limit $\delta_{lim} = 9.640$ mm Total final deflection $\delta_{fin} = 5.198$ mm

PASS - Total final deflection is less than the deflection limit

Steel-to-timber connections - cl.8.2.3

Characteristic yield moment - exp.8.30

$$M_{y,Rk} = 0.3 \text{ mm}^{0.4} \times f_{u,k} \times \phi_b^{2.6} = 26743 \text{ Nmm}$$

Char.embed.strength par.to grain - exp.8.32

$$f_{h,0,k} = 0.082e9 \text{ m/sec}^2 \times (1 \text{ mm} - 0.01 \times \phi_b) \times \rho_k = 35.834 \text{ N/mm}^2$$

$$k_{90} = 0.9 + 0.015 \times \phi_b / 1 \text{ mm} = 1.020$$

Char.embed.strength perp.to grain - exp.8.31

$$f_{h,90,k} = f_{h,0,k} / k_{90} = 35.131 \text{ N/mm}^2$$

Thickness limit for thin steel plates

$$b_{s,thin} = \phi_b / 2 = 4 \text{ mm}$$

Thickness limit for thick steel plates

$$b_{s,thk} = \phi_b = 8 \text{ mm}$$

Characteristic load-carrying capacity for a thick plate in single shear - exp.8.10

$$F_{v,Rk,c} = f_{h,k} \times b \times \phi_b \times (\sqrt{[2 + 4 \times M_{y,Rk} / (f_{h,k} \times \phi_b \times b^2)]} - 1) = 9.783$$

kN

$$F_{v,Rk,d} = 2.3 \times \sqrt{[M_{y,Rk} \times f_{h,k} \times \phi_b]} = 6.306 \text{ kN}$$

$$F_{v,Rk,e} = f_{h,k} \times b \times \phi_b = 22.484 \text{ kN}$$

$$F_{v,Rk} = \text{Min}(F_{v,Rk,c}, F_{v,Rk,d}, F_{v,Rk,e}) = 6.306 \text{ kN}$$

Flitch plate bolting requirements

Total load on member $W_{tot} = 36.915$ kN

Total load taken by steel $W_s = 32.860$ kN

Characteristic bolt capacity $F_{v,Rk} = 6.306$ kN

Number of interfaces $N_{int} = 1$

Bolts required at supports $N_{be} = 2$

Bolts required to beam length $N_{bl} = 5.211$

Limiting bolt spacing $S_{limit} = 200$ mm

Maximum bolt spacing $S_{max} = 200$ mm

Provide a minimum of 2 No.8 mm diameter bolts at each support

Provide 8 mm diameter bolts at maximum 200 mm centres staggered 10 mm alternately above and below the centre line

Minimum bolt spacings - cl.8.5

Minimum end spacing $S_{end} = 56$ mm

Minimum edge spacing $S_{edge} = 32$ mm

Minimum bolt spacing $S_{bolt} = 32$ mm

Minimum washer diameter $\phi_w = 24$ mm

Minimum washer thickness $t_w = 2.4$ mm

PURLIN STRENGTHENING

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PURLIN ROTATED SECTION CHECK

A steel flitch plate is equivalent to a timber 20 times the thickness of the steel plate.

Steel plate dimensions: 8 mm thick × 80 mm deep

Steel grade: S275 → yield strength $f_y = 275 \text{ MPa}$

Timber: D30 → bending strength $f_b = 30 \text{ MPa}$

For steel:

$$Z_{pl,steel} = (b \times d^2) / 4 = (8 \times 80^2) / 4 = 12,800 \text{ mm}^3$$

$$M_{pl,steel} = f_y \times Z_{pl,steel} = 275 \times 12,800 = 3,520,000 \text{ N}\cdot\text{mm} = 3.52 \text{ kNm}$$

For timber (assuming elastic bending):

$$Z_{el} = (b \times d^2) / 6$$

$$\gamma_M \text{ (partial safety factor)} = 1.5$$

Set $M_{el,timber} = M_{pl,steel}$ and solve for b_{timber} :

$$M_{el,timber} = (f_b \times Z_{el}) / \gamma_M$$

$$(30 \times b_{timber} \times 80^2) / (6 \times 1.5) = 3,520,000$$

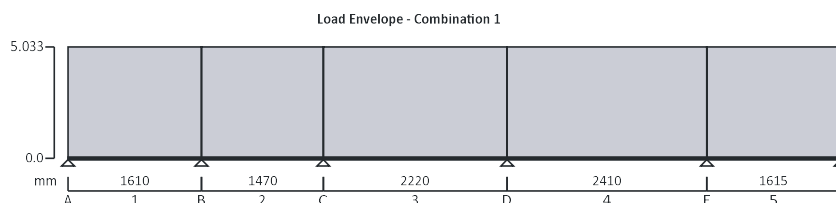
$$b_{timber} = (3,520,000 \times 9) / (30 \times 6400) = 165 \text{ mm}$$

Therefore total section of 80 x 80 D18 with 8mm S275 plate becomes 3No. 80 x 80 D18 timbers.

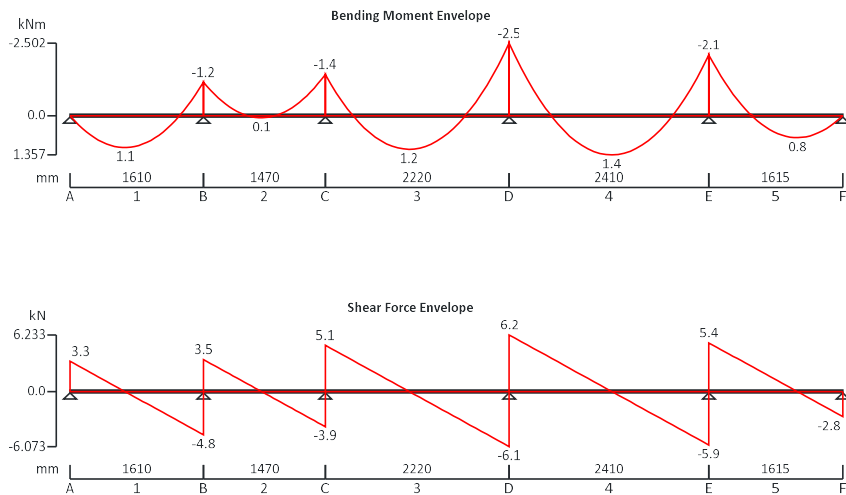
TIMBER BEAM ANALYSIS & DESIGN TO EN1995-1-1:2004

In accordance with EN1995-1-1:2004 + A2:2014 and Corrigendum No.1 and the UK National Annex incorporating National Amendment No.1

Tedds calculation version 1.7.05



PURLIN STRENGTHENING



Applied loading

Beam loads

Permanent self weight of beam $\times 1$

Permanent full UDL 2.250 kN/m

Variable full UDL 1.250 kN/m

Load combinations

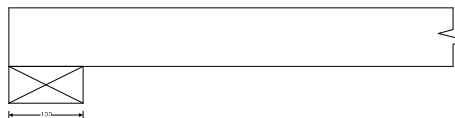
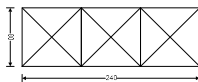
Load combination 1

Support A	Permanent $\times 1.35$ Variable $\times 1.50$
Span 1	Permanent $\times 1.35$ Variable $\times 1.50$
Support B	Permanent $\times 1.35$ Variable $\times 1.50$
Span 2	Permanent $\times 1.35$ Variable $\times 1.50$
Support C	Permanent $\times 1.35$ Variable $\times 1.50$
Span 3	Permanent $\times 1.35$ Variable $\times 1.50$
Support D	Permanent $\times 1.35$ Variable $\times 1.50$
Span 4	Permanent $\times 1.35$ Variable $\times 1.50$
Support E	Permanent $\times 1.35$ Variable $\times 1.50$
Span 5	Permanent $\times 1.35$ Variable $\times 1.50$
Support F	Permanent $\times 1.35$ Variable $\times 1.50$

PURLIN STRENGTHENING

Analysis results

Design moment	$M = 2.502 \text{ kNm}$	Design shear	$F = 6.233 \text{ kN}$
Total load on member	$W_{\text{tot}} = 46.935 \text{ kN}$		
Reactions at support A	$R_{A_{\text{max}}} = 3.330 \text{ kN}$	$R_{A_{\text{min}}} = 3.330 \text{ kN}$	
Unfactored permanent load reaction at support A	$R_{A_{\text{Permanent}}} = 1.548 \text{ kN}$		
Unfactored variable load reaction at support A	$R_{A_{\text{Variable}}} = 0.827 \text{ kN}$		
Reactions at support B	$R_{B_{\text{max}}} = 8.295 \text{ kN}$	$R_{B_{\text{min}}} = 8.295 \text{ kN}$	
Unfactored permanent load reaction at support B	$R_{B_{\text{Permanent}}} = 3.855 \text{ kN}$		
Unfactored variable load reaction at support B	$R_{B_{\text{Variable}}} = 2.060 \text{ kN}$		
Reactions at support C	$R_{C_{\text{max}}} = 8.978 \text{ kN}$	$R_{C_{\text{min}}} = 8.978 \text{ kN}$	
Unfactored permanent load reaction at support C	$R_{C_{\text{Permanent}}} = 4.173 \text{ kN}$		
Unfactored variable load reaction at support C	$R_{C_{\text{Variable}}} = 2.230 \text{ kN}$		
Reactions at support D	$R_{D_{\text{max}}} = 12.306 \text{ kN}$	$R_{D_{\text{min}}} = 12.306 \text{ kN}$	
Unfactored permanent load reaction at support D	$R_{D_{\text{Permanent}}} = 5.720 \text{ kN}$		
Unfactored variable load reaction at support D	$R_{D_{\text{Variable}}} = 3.056 \text{ kN}$		
Reactions at support E	$R_{E_{\text{max}}} = 11.260 \text{ kN}$	$R_{E_{\text{min}}} = 11.260 \text{ kN}$	
Unfactored permanent load reaction at support E	$R_{E_{\text{Permanent}}} = 5.234 \text{ kN}$		
Unfactored variable load reaction at support E	$R_{E_{\text{Variable}}} = 2.796 \text{ kN}$		
Reactions at support F	$R_{F_{\text{max}}} = 2.766 \text{ kN}$	$R_{F_{\text{min}}} = 2.766 \text{ kN}$	
Unfactored permanent load reaction at support F	$R_{F_{\text{Permanent}}} = 1.285 \text{ kN}$		
Unfactored variable load reaction at support F	$R_{F_{\text{Variable}}} = 0.687 \text{ kN}$		



Timber section details

Breadth of section	$b = 80 \text{ mm}$	Depth of section	$h = 80 \text{ mm}$
Number of sections	$N = 3$	Breadth of member	$b_b = 240 \text{ mm}$
Inclination of section	$\theta = 42.0 \text{ deg}$		
Timber strength class	D18		

Member details

Service class of timber	2	Load duration	Medium-term
Length of span 1	$L_{s1} = 1610 \text{ mm}$		
Length of span 2	$L_{s2} = 1470 \text{ mm}$		
Length of span 3	$L_{s3} = 2220 \text{ mm}$		
Length of span 4	$L_{s4} = 2410 \text{ mm}$		
Length of span 5	$L_{s5} = 1615 \text{ mm}$		
Length of bearing	$L_b = 100 \text{ mm}$		

Compression perpendicular to grain - cl.6.1.4

Design compressive stress	$\sigma_{c,90,d} = 0.513 \text{ N/mm}^2$	Design compressive strength	$f_{c,90,d} = 2.954 \text{ N/mm}^2$
---------------------------	--	-----------------------------	-------------------------------------

PASS - Design compressive strength exceeds design compressive stress at bearing

Biaxial bending - cl 6.1.6

Des.bend.stress in maj.axis	$\sigma_{m,y,d} = 7.262 \text{ N/mm}^2$	Des.bend.stress in min.axis	$\sigma_{m,z,d} = 2.180 \text{ N/mm}^2$
Design bending strength	$f_{m,d} = 12.561 \text{ N/mm}^2$		

PASS - Design bending strength exceeds design bending stress

PURLIN STRENGTHENING

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Shear - cl.6.1.7

Applied shear stress

$$\tau_d = 0.727 \text{ N/mm}^2$$

Permissible shear stress

$$f_{v,d} = 2.154 \text{ N/mm}^2$$

PASS - Design shear strength exceeds design shear stress

Deflection - cl.7.2

Deflection limit

$$\delta_{lim} = 9.640 \text{ mm}$$

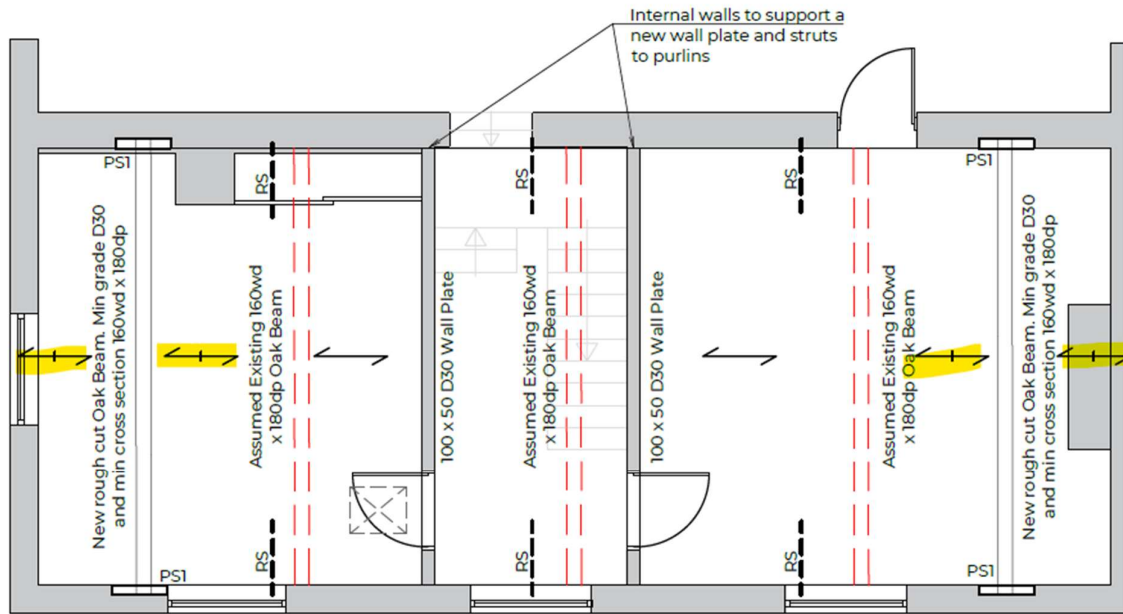
Total final deflection

$$\delta_{fin} = 1.556 \text{ mm}$$

PASS - Total final deflection is less than the deflection limit

10. EXISTING CEILING JOISTS

GENERAL ARRANGEMENT



ATTIC PLAN
1:50

LOADS

ATTIC FLOOR, TIMBER JOIST, PB+SKIM

	(kN/m ²)	DEAD	IMPOSED	SLS	ULS
SUM LOADS	On plan	0.32	0.25	0.57	0.81
<u>Load Components</u>					
ROCKWOOL INSULATION 100mm		0.04			
ROCKWOOL INSULATION 100mm		0.04			
TIMBER JOIST/RAFTER 150 x 47 @ 400		0.10			
VCL VAPOUR CONTROL LAYER		0.01			
PLASTERBOARD + SKIM 3mm		0.13			
IMPOSED, ATTIC/CEILING - ACCESS/LIGHT STORAGE			0.25		

SECTION SIZE, GRADE, PROTECTION AND DRILLING REQUIREMENTS, BEARING DETAIL

40dp x 50wd (Assumed D18) Joists @ 300c/c's

EXISTING CEILING JOISTS

SECTION DESIGN

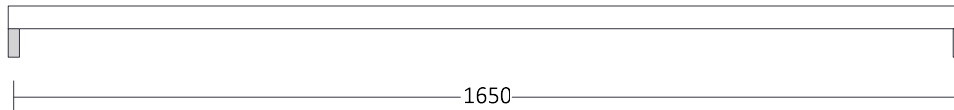
TIMBER JOIST ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the UK national annex

Tedds calculation version 1.0.07

Joist details

Joist spacing $s_{Joist} = 300 \text{ mm}$



Forces input on Joist

Vertical permanent load on joist $F_{G_Joist} = 0.22 \text{ kN/m}^2$

Vertical imposed load on joist $F_{Q_Joist} = 0.25 \text{ kN/m}^2$

Joist loading details

Distributed loads

Vertical permanent load on joist $p_G = 0.07 \text{ kN/m}$

Vertical imposed load on joist $p_Q = 0.08 \text{ kN/m}$

Member results summary	Unit	Capacity	Maximum	Utilisation	Result
Bearing stress	N/mm ²	1.3	0.1	0.066	PASS
Bending stress	N/mm ²	12.3	5.4	0.435	PASS
Shear stress	N/mm ²	1.9	0.4	0.204	PASS
Deflection	mm	6.6	12.1	1.831	FAIL

ANALYSIS

Tedds calculation version 1.0.37

Loading

Self weight included (Permanent x 1)

Load combination factors

Load combination	Permanent	Imposed	Snow	Wind
1.35G + 1.50Q (Strength)	1.35	1.50	0.00	0.00
1.00G + 1.00Q (Service)	1.00	1.00	0.00	0.00

Member Loads

Member	Load case	Load Type	Orientation	Description
Member	Permanent	UDL	GlobalZ	0.07 kN/m at 0 m to 1.65 m
Member	Imposed	UDL	GlobalZ	0.08 kN/m at 0 m to 1.65 m

EXISTING CEILING JOISTS

Results

Total deflection

1.35G + 1.50Q (Strength) - Total deflection



1.00G + 1.00Q (Service) - Total deflection



Node deflections

Load combination: 1.35G + 1.50Q (Strength)

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	0	1.0547	
2	0	0	-1.0547	

Load combination: 1.00G + 1.00Q (Service)

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	0	0.73936	
2	0	0	-0.73936	

Total base reactions

Load case/combination	Force	
	FX (kN)	FZ (kN)
1.35G + 1.50Q (Strength)	0	0.3
1.00G + 1.00Q (Service)	0	0.2

Element end forces

Load combination: 1.35G + 1.50Q (Strength)

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	1.65	1	0	-0.2	0
		2	0	-0.2	0

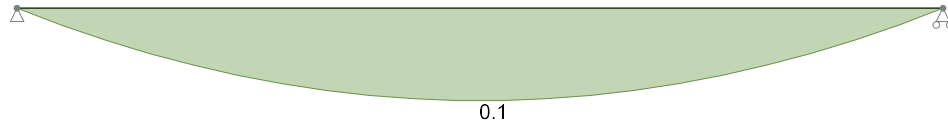
Load combination: 1.00G + 1.00Q (Service)

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	1.65	1	0	-0.1	0
		2	0	-0.1	0

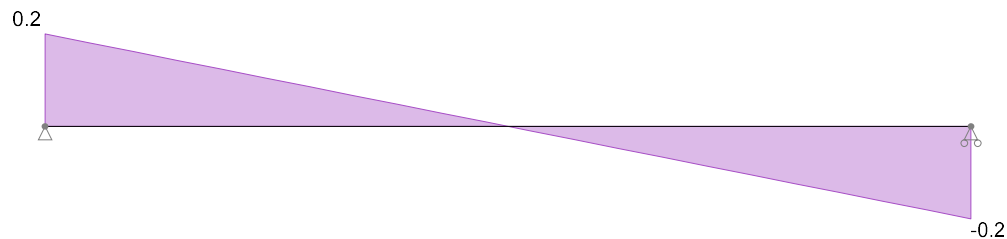
EXISTING CEILING JOISTS

Forces

Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



Member results

Envelope - Strength combinations

Member	Position (m)	Shear force (kN)		Moment (kNm)	
Member	0	0.2 (max abs)		0	
	0.825	0		0.1 (max)	
	1.65	-0.2		0	

Tedds calculation version 2.2.20

Member - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

Member details

Load duration Long-term

Service class 2

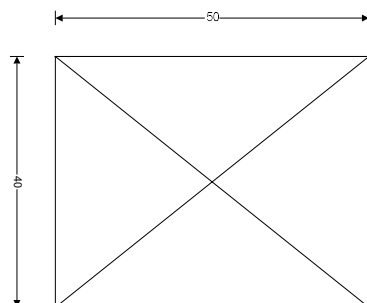
Timber section details

Number of timber sections $N = 1$

Breadth of sections $b = 50 \text{ mm}$

Depth of sections $h = 40 \text{ mm}$

Timber strength class **C16**



50x40 timber section

Cross-sectional area, A , 2000 mm²

Section modulus, W_y , 13333.3 mm³

Section modulus, W_z , 16667 mm³

Second moment of area, I_y , 266667 mm⁴

Second moment of area, I_z , 416667 mm⁴

Radius of gyration, i_y , 11.5 mm

Radius of gyration, i_z , 14.4 mm

Timber strength class D18

Characteristic bending strength, $f_{m,k}$, 18 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²

Mean modulus of elasticity, $E_{0.05,mean}$, 9500 N/mm²

Fifth percentile modulus of elasticity, $E_{0.05}$, 8000 N/mm²

Shear modulus of elasticity, $G_{0.05}$, 550 N/mm²

Characteristic density, ρ_k , 475 kg/m³

Mean density, ρ_{mean} , 570 kg/m³

EXISTING CEILING JOISTS

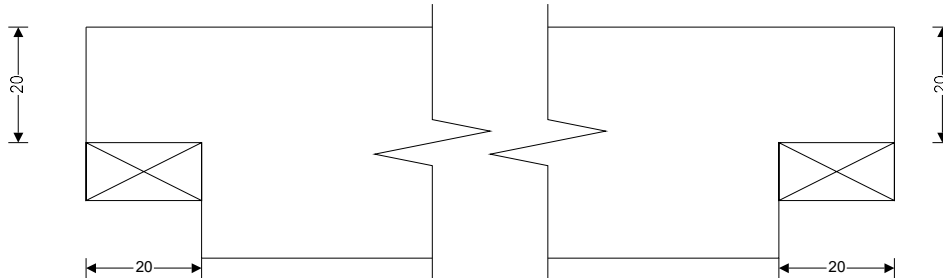
Span details

Bearing length

$L_b = 20 \text{ mm}$

Depth at notched end

$h_{ef} = 20 \text{ mm}$



Consider Combination 1 - 1.35G + 1.50Q (Strength)

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress

$\sigma_{c,y,90,d} = 0.087 \text{ N/mm}^2$

Des.perp.comp.strength

$f_{c,y,90,d} = 1.303 \text{ N/mm}^2$

Utilisation = 0.066

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress

$\tau_{v,d} = 0.388 \text{ N/mm}^2$

Design shear strength

$f_{v,y,d} = 1.895 \text{ N/mm}^2$

Utilisation = 0.204

PASS - Design shear strength exceeds design shear stress

Check design 825 mm along span

Check bending moment - Section 6.1.6

Design bending stress

$\sigma_{m,y,d} = 5.355 \text{ N/mm}^2$

Design bending strength

$f_{m,y,d} = 12.32 \text{ N/mm}^2$

Utilisation = 0.435

PASS - Design bending strength exceeds design bending stress

Consider Combination 2 - 1.00G + 1.00Q (Service)

Check design 825 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep

$\delta_{y,Final} = 12.1 \text{ mm}$

Allowable deflection

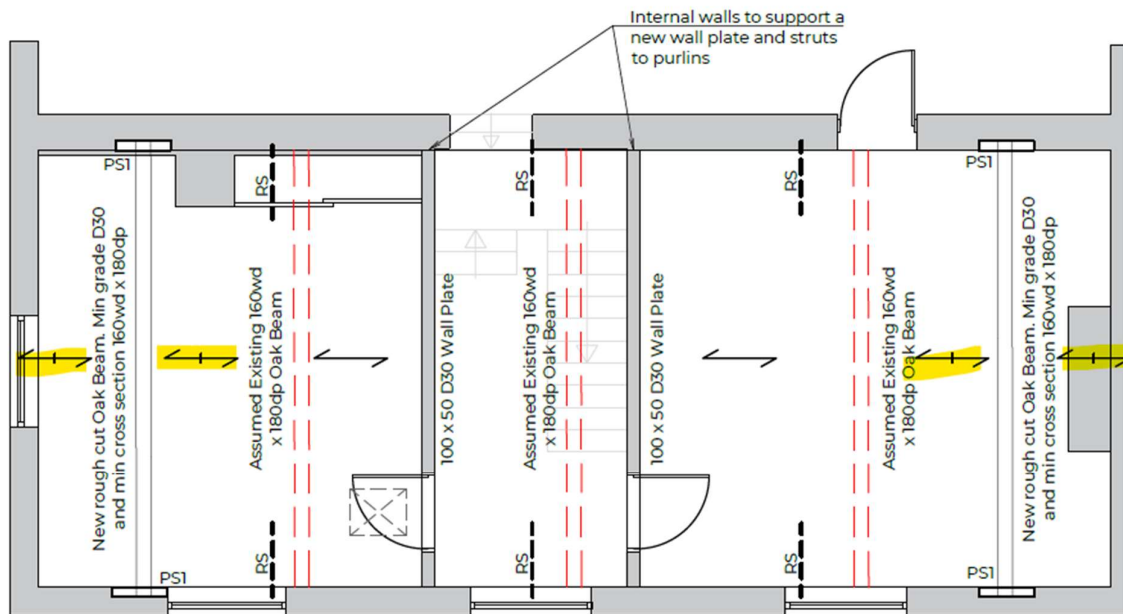
$\delta_{y,Allowable} = 6.6 \text{ mm}$

Utilisation = 1.831

FAIL - Final deflection exceeds allowable deflection

11. NEW CEILING JOISTS

GENERAL ARRANGEMENT



ATTIC PLAN

1:50

LOADS

ATTIC FLOOR, TIMBER JOIST, PB+SKIM

	(kN/m ²)	DEAD	IMPOSED	SLS	ULS
SUM LOADS	On plan	0.32	0.25	0.57	0.81
<u>Load Components</u>					
ROCKWOOL INSULATION 100mm		0.04			
ROCKWOOL INSULATION 100mm		0.04			
TIMBER JOIST/RAFTER 150 x 47 @ 400		0.10			
VCL VAPOUR CONTROL LAYER		0.01			
PLASTERBOARD + SKIM 3mm		0.13			
IMPOSED, ATTIC/CEILING - ACCESS/LIGHT STORAGE			0.25		

SECTION SIZE, GRADE, PROTECTION AND DRILLING REQUIREMENTS, BEARING DETAIL

100dp x 50wd D30 Joists @ 300c/c's

NEW CEILING JOISTS

SECTION DESIGN

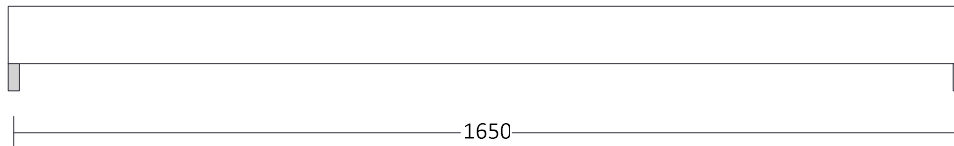
TIMBER JOIST ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the UK national annex

Tedds calculation version 1.0.07

Joist details

Joist spacing $s_{Joist} = 300 \text{ mm}$



Forces input on Joist

Vertical permanent load on joist $F_{G_Joist} = 0.22 \text{ kN/m}^2$

Vertical imposed load on joist $F_{Q_Joist} = 0.25 \text{ kN/m}^2$

Joist loading details

Distributed loads

Vertical permanent load on joist $p_G = 0.07 \text{ kN/m}$

Vertical imposed load on joist $p_Q = 0.08 \text{ kN/m}$

Member results summary	Unit	Capacity	Maximum	Utilisation	Result
Bearing stress	N/mm ²	3.1	0.1	0.034	PASS
Bending stress	N/mm ²	19.3	1.0	0.054	PASS
Shear stress	N/mm ²	2.0	0.5	0.237	PASS
Deflection	mm	6.6	0.7	0.110	PASS

ANALYSIS

Tedds calculation version 1.0.37

Loading

Self weight included (Permanent x 1)

Load combination factors

Load combination	Permanent	Imposed	Snow	Wind
1.35G + 1.50Q (Strength)	1.35	1.50	0.00	0.00
1.00G + 1.00Q (Service)	1.00	1.00	0.00	0.00

Member Loads

Member	Load case	Load Type	Orientation	Description
Member	Permanent	UDL	GlobalZ	0.07 kN/m at 0 m to 1.65 m
Member	Imposed	UDL	GlobalZ	0.08 kN/m at 0 m to 1.65 m

NEW CEILING JOISTS

Results

Total deflection

1.35G + 1.50Q (Strength) - Total deflection



1.00G + 1.00Q (Service) - Total deflection



Node deflections

Load combination: 1.35G + 1.50Q (Strength)

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	0	0.06009	
2	0	0	-0.06009	

Load combination: 1.00G + 1.00Q (Service)

Node	Deflection		Rotation (°)	Co-ordinate system
	X (mm)	Z (mm)		
1	0	0	0.04244	
2	0	0	-0.04244	

Total base reactions

Load case/combination	Force	
	FX (kN)	FZ (kN)
1.35G + 1.50Q (Strength)	0	0.4
1.00G + 1.00Q (Service)	0	0.3

Element end forces

Load combination: 1.35G + 1.50Q (Strength)

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	1.65	1	0	-0.2	0
		2	0	-0.2	0

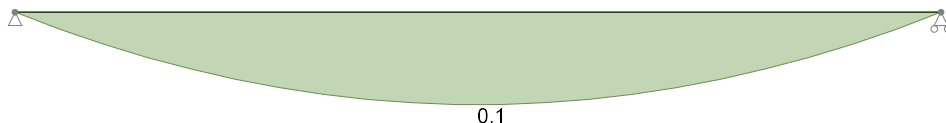
Load combination: 1.00G + 1.00Q (Service)

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	1.65	1	0	-0.1	0
		2	0	-0.1	0

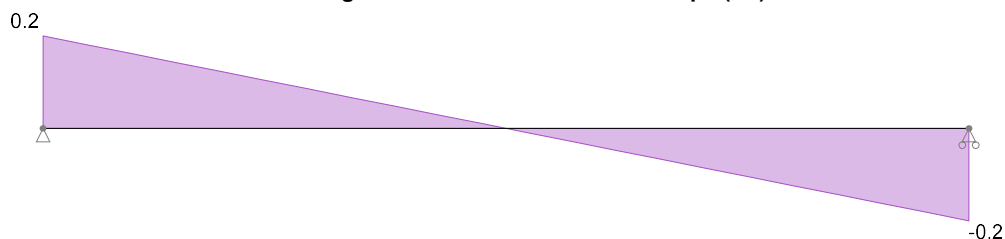
NEW CEILING JOISTS

Forces

Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



Member results

Envelope - Strength combinations

Member	Position (m)	Shear force (kN)		Moment (kNm)	
Member	0	0.2 (max abs)		0	
	0.825	0		0.1 (max)	
	1.65	-0.2		0	

Tedds calculation version 2.2.20

Member - Span 1

Partial factor for material properties and resistances

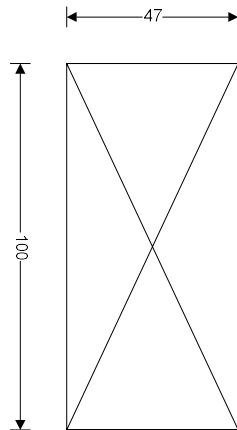
Partial factor $\gamma_M = 1.300$

Member details

Load duration Long-term Service class 2

Timber section details

Number of timber sections $N = 1$
 Breadth of sections $b = 47$ mm Depth of sections $h = 100$ mm
 Timber strength class **D30**



47x100 timber section

Cross-sectional area, A , 4700 mm²

Section modulus, W_y , 78333.3 mm³

Section modulus, W_z , 36817 mm³

Second moment of area, I_y , 3916667 mm⁴

Second moment of area, I_z , 865192 mm⁴

Radius of gyration, i_y , 28.9 mm

Radius of gyration, i_z , 13.6 mm

Timber strength class D30

Characteristic bending strength, $f_{m,k}$, 30 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.9 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 24 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 5.3 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 18 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 11000 N/mm²

Fifth percentile modulus of elasticity, $E_{0.05}$, 9200 N/mm²

Shear modulus of elasticity, G_{mean} , 690 N/mm²

Characteristic density, ρ_k , 530 kg/m³

Mean density, ρ_{mean} , 640 kg/m³

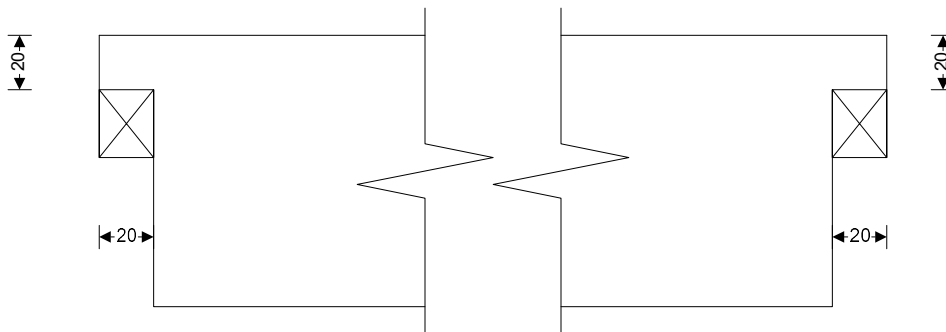
Span details

Bearing length

$L_b = 20$ mm

Depth at notched end

$h_{ef} = 20$ mm



Consider Combination 1 - 1.35G + 1.50Q (Strength)

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress

$\sigma_{c,y,90,d} = 0.106$ N/mm²

Des.perp.comp.strength

$f_{c,y,90,d} = 3.139$ N/mm²

Utilisation = **0.034**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress

$\tau_{y,d} = 0.474$ N/mm²

Design shear strength

$f_{v,y,d} = 2.310$ N/mm²

Utilisation = **0.237**

PASS - Design shear strength exceeds design shear stress

Check design 825 mm along span

Check bending moment - Section 6.1.6

Design bending stress

$\sigma_{m,y,d} = 1.049$ N/mm²

Design bending strength

$f_{m,y,d} = 19.27$ N/mm²

Utilisation = **0.054**

PASS - Design bending strength exceeds design bending stress

NEW CEILING JOISTS

Contract Stroudwood Farmhouse			Job Ref. 14184
Date May 2025	By JP	Checked by BM	Revision No. A
Document Reference 14184-CALC-01			Drawing Ref. See Register

Check design at end of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.106 \text{ N/mm}^2$ Des.perp.comp.strength $f_{c,y,90,d} = 3.139 \text{ N/mm}^2$
 Utilisation = **0.034**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.474 \text{ N/mm}^2$ Design shear strength $f_{v,y,d} = 2.310 \text{ N/mm}^2$
 Utilisation = **0.237**

PASS - Design shear strength exceeds design shear stress

Consider Combination 2 - 1.00G + 1.00Q (Service)

Check design 825 mm along span

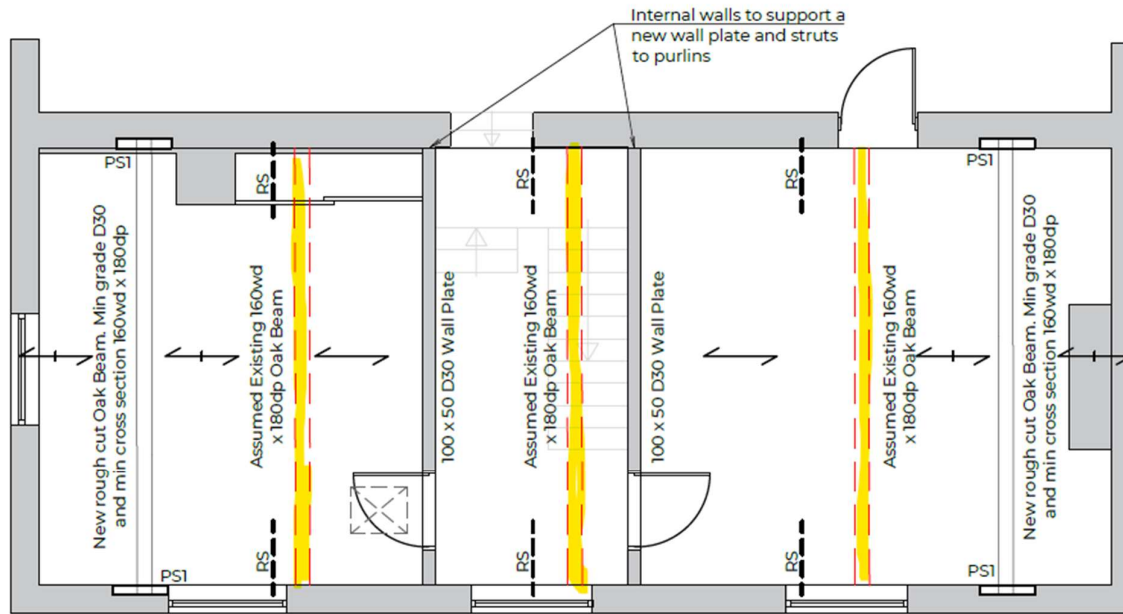
Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 0.7 \text{ mm}$ Allowable deflection $\delta_{y,Allowable} = 6.6 \text{ mm}$
 Utilisation = **0.11**

PASS - Allowable deflection exceeds final deflection

12. NEW TRUSSES

GENERAL ARRANGEMENT



ATTIC PLAN
1:50

LOADS

EXISTING TIMBER BEAM								
						L=	4.86	m
Uniformly Distributed Loads (UDL)								
Load Type	Load Case	Area Load (kN/m ²)	Zone (m)	Portion	Dead	Live	Unit	
Dead	ATTIC FLOOR, TIMBER JOIST, PB+SKIM	0.320	4.0	0.500	0.640		kN/m	
Live	IMPOSED, ATTIC/CEILING - ACCESS/LIGHT STORAGE	0.250	4.0	0.500		0.5	kN/m	
SUM					0.640	0.500	kN/m	

SECTION DESIGN

TIMBER MEMBER ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the UK national annex

Tedds calculation version 2.2.20

Member3 results summary	Unit	Capacity	Maximum	Utilisation	Result
Tensile stress	N/mm ²	11.1	0.6	0.058	PASS
Bearing stress	N/mm ²	3.3	1.1	0.344	PASS

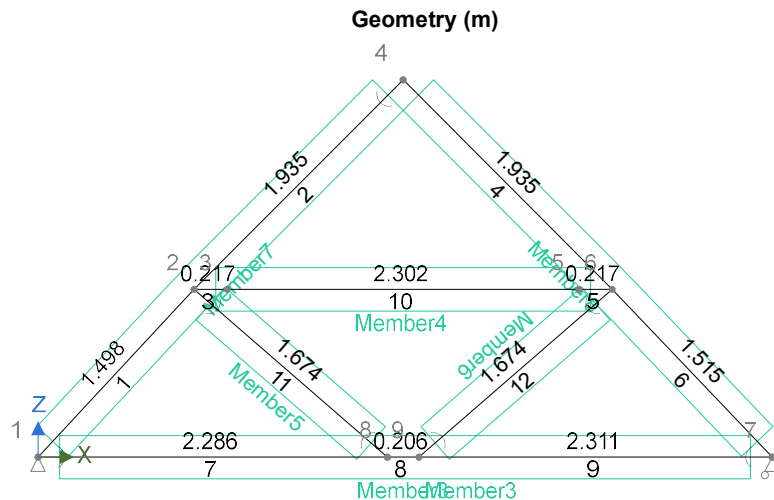
NEW TRUSSES

Bending stress	N/mm ²	18.5	0.5	0.025	PASS
Shear stress	N/mm ²	2.4	0.2	0.075	PASS
Bending and axial force				0.083	PASS
Deflection	mm	19.2	2.7	0.140	PASS
Member4 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	14.8	4.1	0.277	PASS
Bending stress	N/mm ²	20.0	0.5	0.024	PASS
Shear stress	N/mm ²	2.4	0.0	0.011	PASS
Bending and axial force				0.100	PASS
Column stability check				0.662	PASS
Deflection	mm	10.9	2.5	0.226	PASS
Member5 results summary	Unit	Capacity	Maximum	Utilisation	Result
Tensile stress	N/mm ²	10.5	0.1	0.009	PASS
Bending stress	N/mm ²	17.5	0.1	0.008	PASS
Shear stress	N/mm ²	2.1	0.0	0.006	PASS
Bending and axial force				0.017	PASS
Beam stability check				0.008	PASS
Deflection	mm	6.7	1.6	0.244	PASS
Member6 results summary	Unit	Capacity	Maximum	Utilisation	Result
Tensile stress	N/mm ²	10.5	0.7	0.069	PASS
Bending stress	N/mm ²	17.5	0.1	0.008	PASS
Shear stress	N/mm ²	2.1	0.0	0.006	PASS
Bending and axial force				0.076	PASS
Beam stability check				0.008	PASS
Deflection	mm	6.7	1.8	0.269	PASS
Member7 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	18.3	3.5	0.189	PASS
Bearing stress	N/mm ²	4.0	1.2	0.309	PASS
Bending stress	N/mm ²	25.9	2.0	0.079	PASS
Shear stress	N/mm ²	3.0	0.2	0.069	PASS
Bending and axial force				0.105	PASS
Column stability check				0.857	PASS
Deflection	mm	27.5	3.4	0.125	PASS
Member8 results summary	Unit	Capacity	Maximum	Utilisation	Result
Compressive stress	N/mm ²	13.7	2.7	0.200	PASS
Bearing stress	N/mm ²	3.7	1.0	0.267	PASS
Bending stress	N/mm ²	15.5	2.0	0.126	PASS
Shear stress	N/mm ²	2.7	0.2	0.077	PASS
Bending and axial force				0.163	PASS
Column stability check				0.999	PASS
Deflection	mm	27.6	3.2	0.117	PASS

ANALYSIS

Tedds calculation version 1.0.37

Geometry



Materials

Name	Density (kg/m ³)	Youngs Modulus kN/mm ²	Shear Modulus kN/mm ²	Thermal Coefficient °C ⁻¹
D30 (EC5)	640	11	0.69	0
D18 (EC5)	570	9.5	0.59	0
D30 (EC5) 1	640	11	0.69	0

Sections

Name	Area (cm ²)	Moment of inertia Major (cm ⁴)	Minor (cm ⁴)	Shear area parallel to Minor (cm ²)	Major (cm ²)
47x100	47	391.7	86.5	39.2	39.2
160x180	288	7776	6144	240	240
2/50x80	80	426.7	666.7	66.7	66.7

Nodes

Node	Co-ordinates X (m)	Z (m)	Freedom X	Z	Rot.	Coordinate system Name	Angle (°)	Spring X (kN/m)	Z (kN/m)	Rot. kNm/°
1	0	0	Fixed	Fixed	Free		0	0	0	0
2	1.021	1.096	Free	Free	Free		0	0	0	0
3	1.238	1.096	Free	Free	Free		0	0	0	0
4	2.389	2.465	Free	Free	Free		0	0	0	0
5	3.54	1.096	Free	Free	Free		0	0	0	0
6	3.757	1.096	Free	Free	Free		0	0	0	0
7	4.803	0	Free	Fixed	Free		0	0	0	0
8	2.286	0	Free	Free	Free		0	0	0	0
9	2.492	0	Free	Free	Free		0	0	0	0

Elements

Element	Length (m)	Nodes		Section	Material	Releases		Axial	Rotated
		Start	End			Start moment	End moment		
1	1.498	1	2	2/50x80	D30 (EC5) 1	Fixed	Fixed	Fixed	
2	1.935	2	4	2/50x80	D30 (EC5) 1	Fixed	Free	Fixed	
3	0.217	2	3	47x100	D30 (EC5)	Free	Fixed	Fixed	
4	1.935	4	6	2/50x80	D18 (EC5)	Fixed	Fixed	Fixed	
5	0.217	5	6	47x100	D30 (EC5)	Fixed	Free	Fixed	
6	1.515	6	7	2/50x80	D18 (EC5)	Fixed	Fixed	Fixed	
7	2.286	1	8	160x180	D30 (EC5)	Free	Fixed	Fixed	
8	0.206	8	9	160x180	D30 (EC5)	Fixed	Fixed	Fixed	
9	2.311	9	7	160x180	D30 (EC5)	Fixed	Free	Fixed	
10	2.302	3	5	47x100	D30 (EC5)	Fixed	Fixed	Fixed	
11	1.674	2	8	47x100	D30 (EC5)	Free	Free	Fixed	
12	1.674	6	9	47x100	D30 (EC5)	Free	Free	Fixed	

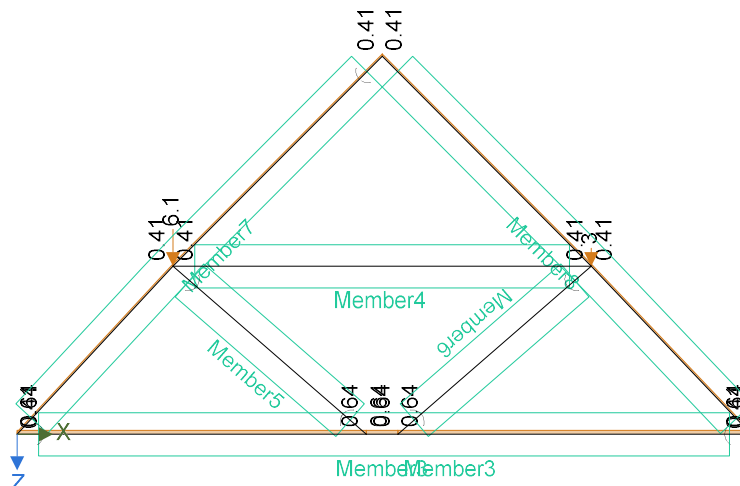
Members

Name	Elements	
	Start	End
Member3	7	9
Member4	3	5
Member5	11	11
Member6	12	12
Member7	1	2
Member8	4	6

Loading

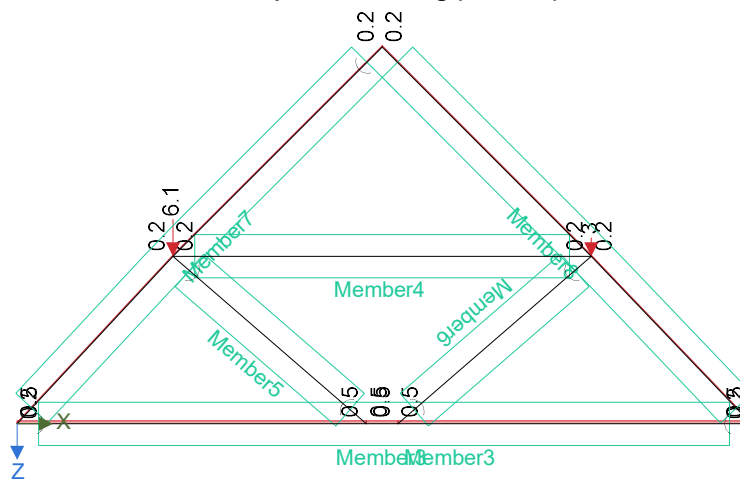
Self weight included

Permanent - Loading (kN/m,kN)



NEW TRUSSES

Imposed - Loading (kN/m,kN)



Load combination factors

Load combination	Self Weight	Permanent	Imposed
1.35G + 1.5Q + 1.5RQ (Strength)	1.35	1.35	1.50
1.0G + 1.0Q + 1.0RQ (Service)	1.00	1.00	1.00

Node loads

Node	Load case	Force		Moment (kNm)
		X (kN)	Z (kN)	
2	Permanent	0	6.1	0
6	Permanent	0	3	0
2	Imposed	0	6.1	0
6	Imposed	0	3	0

Member Loads

Member	Load case	Load Type	Orientation	Description
Member3	Permanent	UDL	GlobalZ	0.64 kN/m
Member7	Permanent	UDL	GlobalZ	0.41 kN/m
Member8	Permanent	UDL	GlobalZ	0.41 kN/m
Member3	Imposed	UDL	GlobalZ	0.5 kN/m
Member7	Imposed	UDL	GlobalZ	0.2 kN/m
Member8	Imposed	UDL	GlobalZ	0.2 kN/m

Results

Reactions

Load case: Self Weight

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0	0.7	0
7	0	0.7	0

Load case: Permanent

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0	8.4	0
7	0	6.6	0

Load case: Imposed

Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0	7.3	0
7	0	5.5	0

Load combination: 1.35G + 1.5Q + 1.5RQ (Strength)

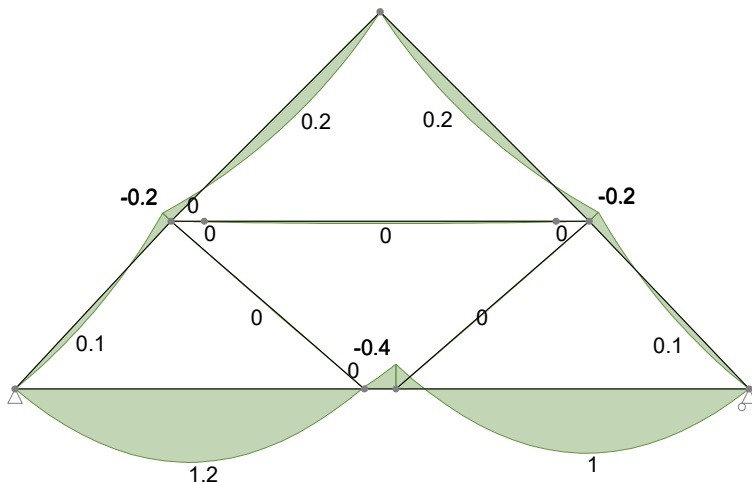
Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0	23.3	0
7	0	18.1	0

Load combination: 1.0G + 1.0Q + 1.0RQ (Service)

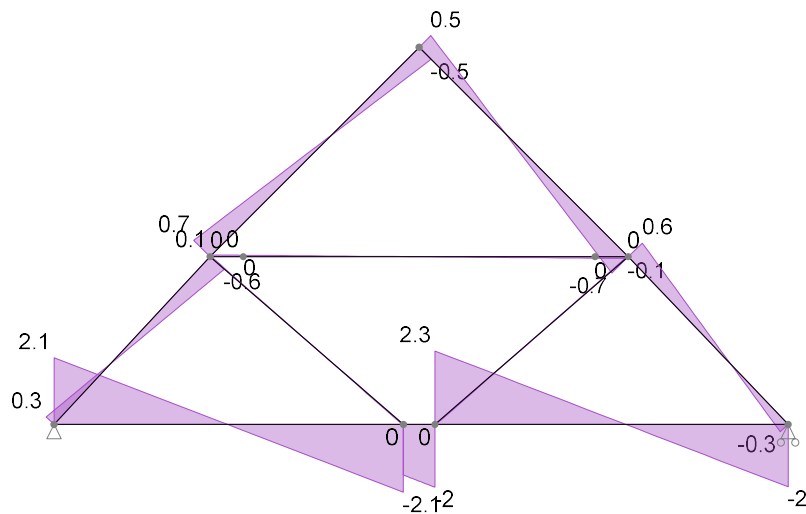
Node	Force		Moment My (kNm)
	Fx (kN)	Fz (kN)	
1	0	16.4	0
7	0	12.8	0

Forces

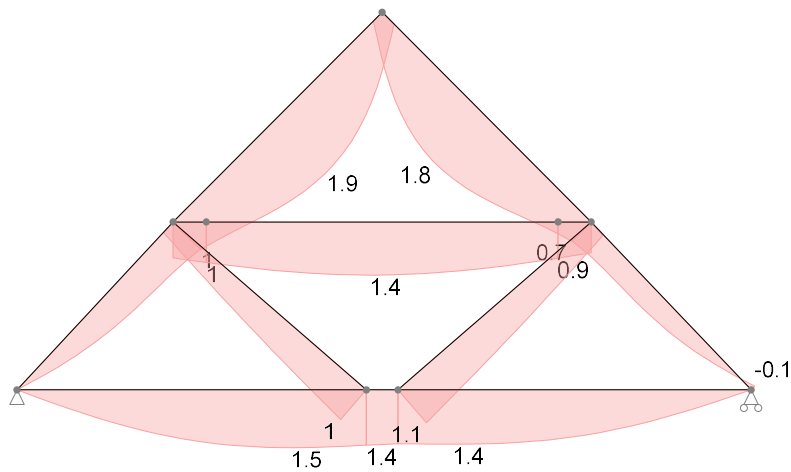
Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



Service combinations - Deflection envelope (mm)



Member results

Envelope - Strength combinations

Member	Pos (m)	Axial force		
		Max (kN)	Pos (m)	Min (kN)
Member3	2.492	-14.9	2.286	-19.9 (min)
Member4	0.217	19.2	0	19.2
Member5	1.674	-0.9	0	-0.9
Member6	1.674	-6.6	0	-6.6
Member7	0	28.7 (max)	3.433	0.5
Member8	3.45	22	0	0.5

Member3 - Span 1

Partial factor for material properties and resistances

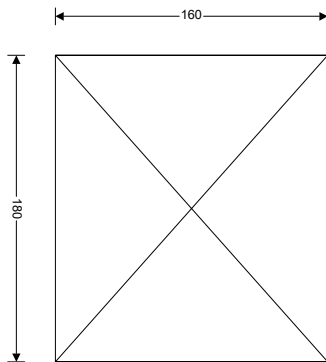
Partial factor $\gamma_M = 1.300$

Member details

Load duration Medium-term Service class 2

Timber section details

Number of timber sections N = 1
 Breadth of sections b = 160 mm Depth of sections h = 180 mm
 Timber strength class D30



160x180 timber section

Cross-sectional area, A , 28800 mm²

Section modulus, W_y , 864000 mm³

Section modulus, W_z , 768000 mm³

Second moment of area, I_y , 77760000 mm⁴

Second moment of area, I_z , 61440000 mm⁴

Radius of gyration, i_y , 52 mm

Radius of gyration, i_z , 46.2 mm

Timber strength class D30

Characteristic bending strength, $f_{m,k}$, 30 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.9 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 24 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 5.3 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 18 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 11000 N/mm²

Fifth percentile modulus of elasticity, $E_{0.05}$, 9200 N/mm²

Shear modulus of elasticity, G_{mean} , 690 N/mm²

Characteristic density, ρ_k , 530 kg/m³

Mean density, ρ_{mean} , 640 kg/m³

Span details

Bearing length

$L_b = 100$ mm

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

Check tension parallel to the grain - Section 6.1.2

Design tensile stress

$\sigma_{t,0,d} = 0.618$ N/mm²

Design tensile strength

$f_{t,0,d} = 11.077$ N/mm²

Utilisation = **0.056**

PASS - Design tensile strength exceeds design tensile stress

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress

$\sigma_{c,y,90,d} = 1.120$ N/mm²

Des.perp.comp.strength

$f_{c,y,90,d} = 3.262$ N/mm²

Utilisation = **0.344**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress

$\tau_{y,d} = 0.164$ N/mm²

Design shear strength

$f_{v,y,d} = 2.400$ N/mm²

Utilisation = **0.068**

PASS - Design shear strength exceeds design shear stress

Check design 2492 mm along span

Check shear force - Section 6.1.7

Design shear stress

$\tau_{y,d} = 0.180$ N/mm²

Design shear strength

$f_{v,y,d} = 2.400$ N/mm²

Utilisation = **0.075**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress

$\sigma_{m,y,d} = 0.466$ N/mm²

Design bending strength

$f_{m,y,d} = 18.462$ N/mm²

Utilisation = **0.025**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = **0.083**

PASS - Combined bending and axial tension utilisation is acceptable

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

Check design 1795 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 2.7$ mm

Allowable deflection

$\delta_{y,Allowable} = 19.2$ mm

Utilisation = 0.14

PASS - Allowable deflection exceeds final deflection

Member4 - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

Member details

Load duration Medium-term

Service class

2

Timber section details

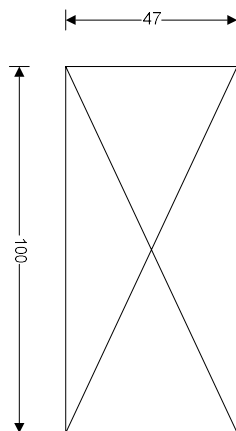
Number of timber sections $N = 1$

Breadth of sections $b = 47$ mm

Depth of sections

$h = 100$ mm

Timber strength class **D30**



47x100 timber section

Cross-sectional area, A , 4700 mm²

Section modulus, W_y , 78333.3 mm³

Section modulus, W_z , 36817 mm³

Second moment of area, I_y , 3916667 mm⁴

Second moment of area, I_z , 865192 mm⁴

Radius of gyration, i_y , 28.9 mm

Radius of gyration, i_z , 13.6 mm

Timber strength class D30

Characteristic bending strength, $f_{m,k}$, 30 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.9 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 24 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 5.3 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 18 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 11000 N/mm²

Fifth percentile modulus of elasticity, $E_{0,05}$, 9200 N/mm²

Shear modulus of elasticity, G_{mean} , 690 N/mm²

Characteristic density, ρ_k , 530 kg/m³

Mean density, ρ_{mean} , 640 kg/m³

Span details

Bearing length $L_b = 100$ mm

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

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 4.084$ N/mm²

Design compressive strength $f_{c,0,d} = 14.769$ N/mm²

Utilisation = 0.277

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.026$ N/mm²

Design shear strength

$f_{v,y,d} = 2.400$ N/mm²

Utilisation = 0.011

PASS - Design shear strength exceeds design shear stress

NEW TRUSSES

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Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis	$L_{e,y} = 2462$ mm	Relative slenderness ratio	$\lambda_{rel,y} = 1.387$
Effective length for z-axis	$L_{e,z} = 0$ mm	Relative slenderness ratio	$\lambda_{rel,z} = 0$
$\lambda_{rel,y} > 0.3$ column stability check is required			
Utilisation = 0.638			
PASS - Column stability is acceptable			

Check design 1368 mm along span

Check bending moment - Section 6.1.6

Design bending stress	$\sigma_{m,y,d} = 0.476$ N/mm ²	Design bending strength	$f_{m,y,d} = 20.021$ N/mm ²
Utilisation = 0.024			
PASS - Design bending strength exceeds design bending stress			

Check combined bending and axial compression - Section 6.2.4

Utilisation = **0.1**

PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis	$L_{e,y} = 2462$ mm	Relative slenderness ratio	$\lambda_{rel,y} = 1.387$
Effective length for z-axis	$L_{e,z} = 0$ mm	Relative slenderness ratio	$\lambda_{rel,z} = 0$
$\lambda_{rel,y} > 0.3$ column stability check is required			
Utilisation = 0.662			
PASS - Column stability is acceptable			

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

Check design 1292 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep	$\delta_{y,Final} = 2.5$ mm	Allowable deflection	$\delta_{y,Allowable} = 10.9$ mm
Utilisation = 0.226			
PASS - Allowable deflection exceeds final deflection			

Member5 - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

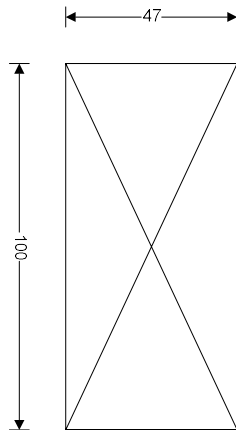
Member details

Load duration	Long-term	Service class	1
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Timber section details

Number of timber sections	N = 1		
Breadth of sections	b = 47 mm	Depth of sections	h = 100 mm
Timber strength class	D30		

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47x100 timber section

Cross-sectional area, A , 4700 mm²
 Section modulus, W_y , 78333.3 mm³
 Section modulus, W_z , 36817 mm³
 Second moment of area, I_y , 3916667 mm⁴
 Second moment of area, I_z , 865192 mm⁴
 Radius of gyration, i_y , 28.9 mm
 Radius of gyration, i_z , 13.6 mm
Timber strength class D30
 Characteristic bending strength, $f_{m,k}$, 30 N/mm²
 Characteristic shear strength, $f_{v,k}$, 3.9 N/mm²
 Characteristic compression strength parallel to grain, $f_{c,0,k}$, 24 N/mm²
 Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 5.3 N/mm²
 Characteristic tension strength parallel to grain, $f_{t,0,k}$, 18 N/mm²
 Mean modulus of elasticity, $E_{0,mean}$, 11000 N/mm²
 Fifth percentile modulus of elasticity, $E_{0.05}$, 9200 N/mm²
 Shear modulus of elasticity, G_{mean} , 690 N/mm²
 Characteristic density, ρ_k , 530 kg/m³
 Mean density, ρ_{mean} , 640 kg/m³

Span details

Bearing length $L_b = 100$ mm

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

Check tension parallel to the grain - Section 6.1.2

Design tensile stress $\sigma_{t,0,d} = 0.098$ N/mm² Design tensile strength $f_{t,0,d} = 10.511$ N/mm²
 Utilisation = 0.009

PASS - Design tensile strength exceeds design tensile stress

Check design at start of span

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.012$ N/mm² Design shear strength $f_{v,y,d} = 2.100$ N/mm²
 Utilisation = 0.006

PASS - Design shear strength exceeds design shear stress

Check design 837 mm along span

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 0.135$ N/mm² Design bending strength $f_{m,y,d} = 17.518$ N/mm²
 Utilisation = 0.008

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = 0.017

PASS - Combined bending and axial tension utilisation is acceptable

Check beams subjected to either bending or combined bending and compression - cl.6.3.3

Utilisation = 0.008

PASS - Beam stability is acceptable

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

Check design at end of span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 1.6$ mm Allowable deflection $\delta_{y,Allowable} = 6.7$ mm

NEW TRUSSES

Utilisation = **0.244**

PASS - Allowable deflection exceeds final deflection

Member6 - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

Member details

Load duration Long-term Service class 1

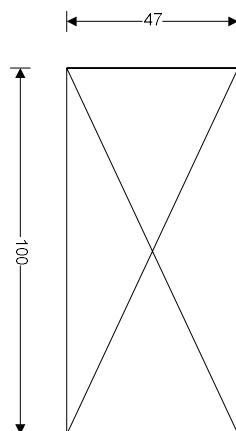
Timber section details

Number of timber sections $N = 1$

Breadth of sections $b = 47 \text{ mm}$

Depth of sections $h = 100 \text{ mm}$

Timber strength class **D30**



47x100 timber section

Cross-sectional area, $A, 4700 \text{ mm}^2$

Section modulus, $W_y, 78333.3 \text{ mm}^3$

Section modulus, $W_z, 36817 \text{ mm}^3$

Second moment of area, $I_y, 3916667 \text{ mm}^4$

Second moment of area, $I_z, 865192 \text{ mm}^4$

Radius of gyration, $i_y, 28.9 \text{ mm}$

Radius of gyration, $i_z, 13.6 \text{ mm}$

Timber strength class D30

Characteristic bending strength, $f_{m,k}, 30 \text{ N/mm}^2$

Characteristic shear strength, $f_{v,k}, 3.9 \text{ N/mm}^2$

Characteristic compression strength parallel to grain, $f_{c,0,k}, 24 \text{ N/mm}^2$

Characteristic compression strength perpendicular to grain, $f_{c,90,k}, 5.3 \text{ N/mm}^2$

Characteristic tension strength parallel to grain, $f_{t,0,k}, 18 \text{ N/mm}^2$

Mean modulus of elasticity, $E_{0,mean}, 11000 \text{ N/mm}^2$

Fifth percentile modulus of elasticity, $E_{0,05}, 9200 \text{ N/mm}^2$

Shear modulus of elasticity, $G_{mean}, 690 \text{ N/mm}^2$

Characteristic density, $\rho_k, 530 \text{ kg/m}^3$

Mean density, $\rho_{mean}, 640 \text{ kg/m}^3$

Span details

Bearing length $L_b = 100 \text{ mm}$

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

Check tension parallel to the grain - Section 6.1.2

Design tensile stress $\sigma_{t,0,d} = 0.725 \text{ N/mm}^2$

Design tensile strength $f_{t,0,d} = 10.511 \text{ N/mm}^2$

Utilisation = **0.069**

PASS - Design tensile strength exceeds design tensile stress

Check design at start of span

Check shear force - Section 6.1.7

Design shear stress $\tau_{v,d} = 0.012 \text{ N/mm}^2$

Design shear strength $f_{v,y,d} = 2.100 \text{ N/mm}^2$

Utilisation = **0.006**

PASS - Design shear strength exceeds design shear stress

Check design 837 mm along span

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 0.135 \text{ N/mm}^2$

Design bending strength $f_{m,y,d} = 17.518 \text{ N/mm}^2$

Utilisation = **0.008**

PASS - Design bending strength exceeds design bending stress

NEW TRUSSES

Check combined bending and axial compression - Section 6.2.4

Utilisation = **0.076**

PASS - Combined bending and axial tension utilisation is acceptable

Check beams subjected to either bending or combined bending and compression - cl.6.3.3

Utilisation = **0.008**

PASS - Beam stability is acceptable

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

Check design at end of span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 1.8$ mm

Allowable deflection

$\delta_{y,Allowable} = 6.7$ mm

Utilisation = **0.269**

PASS - Allowable deflection exceeds final deflection

Member7 - Span 1

Partial factor for material properties and resistances

Partial factor $\gamma_M = 1.300$

Member details

Load duration Short-term

Service class

2

Timber section details

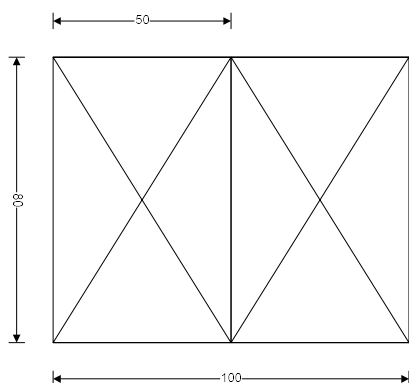
Number of timber sections $N = 2$

Breadth of sections $b = 50$ mm

Depth of sections

$h = 80$ mm

Timber strength class **D30**



2/50x80 timber sections

Cross-sectional area, $A, 8000$ mm²

Section modulus, $W_y, 106666.7$ mm³

Section modulus, $W_z, 66667$ mm³

Second moment of area, $I_y, 4266667$ mm⁴

Second moment of area, $I_z, 1886667$ mm⁴

Radius of gyration, $i_y, 23.1$ mm

Radius of gyration, $i_z, 14.4$ mm

Timber strength class D30

Characteristic bending strength, $f_{m,k}, 30$ N/mm²

Characteristic shear strength, $f_{v,k}, 3.9$ N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}, 24$ N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}, 5.3$ N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}, 18$ N/mm²

Mean modulus of elasticity, $E_{0,mean}, 11000$ N/mm²

Fifth percentile modulus of elasticity, $E_{0,05}, 9200$ N/mm²

Shear modulus of elasticity, $G_{mean}, 690$ N/mm²

Characteristic density, $\rho_k, 530$ kg/m³

Mean density, $\rho_{mean}, 640$ kg/m³

Span details

Bearing length $L_b = 100$ mm

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

Check design at start of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 1.248$ N/mm²

Des.perp.comp.strength

$f_{c,y,90,d} = 4.036$ N/mm²

Utilisation = **0.309**

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

NEW TRUSSES

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Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.096 \text{ N/mm}^2$ Design shear strength $f_{v,y,d} = 2.970 \text{ N/mm}^2$
 Utilisation = **0.032**
PASS - Design shear strength exceeds design shear stress

Check design 1498 mm along span

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.204 \text{ N/mm}^2$ Design shear strength $f_{v,y,d} = 2.970 \text{ N/mm}^2$
 Utilisation = **0.069**
PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 1.783 \text{ N/mm}^2$ Design bending strength $f_{m,y,d} = 25.907 \text{ N/mm}^2$
 Utilisation = **0.069**
PASS - Design bending strength exceeds design bending stress

Check design 2616 mm along span

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 2.036 \text{ N/mm}^2$ Design bending strength $f_{m,y,d} = 25.907 \text{ N/mm}^2$
 Utilisation = **0.079**
PASS - Design bending strength exceeds design bending stress

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

Check design 2446 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 3.4 \text{ mm}$ Allowable deflection $\delta_{y,Allowable} = 27.5 \text{ mm}$
 Utilisation = **0.125**
PASS - Allowable deflection exceeds final deflection

Member8 - Span 1

Partial factor for material properties and resistances

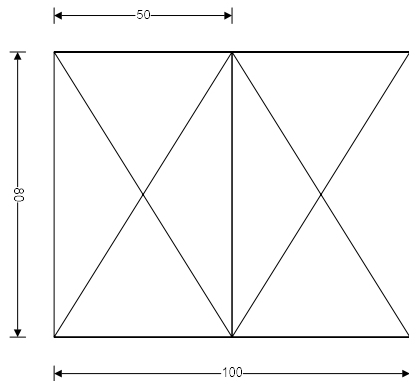
Partial factor $\gamma_M = 1.300$

Member details

Load duration Short-term Service class 2

Timber section details

Number of timber sections N = 2
 Breadth of sections b = 50 mm Depth of sections h = 80 mm
 Timber strength class D18



2/50x80 timber sections

Cross-sectional area, A , 8000 mm²

Section modulus, $W_{y,y}$, 106668.7 mm³

Section modulus, $W_{z,z}$, 66687 mm³

Second moment of area, $I_{y,y}$, 4266667 mm⁴

Second moment of area, $I_{z,z}$, 1666667 mm⁴

Radius of gyration, $i_{y,y}$, 23.1 mm

Radius of gyration, $i_{z,z}$, 14.4 mm

Timber strength class D18

Characteristic bending strength, $f_{m,k}$, 18 N/mm²

Characteristic shear strength, $f_{v,k}$, 3.5 N/mm²

Characteristic compression strength parallel to grain, $f_{c,0,k}$, 18 N/mm²

Characteristic compression strength perpendicular to grain, $f_{c,90,k}$, 4.8 N/mm²

Characteristic tension strength parallel to grain, $f_{t,0,k}$, 11 N/mm²

Mean modulus of elasticity, $E_{0,mean}$, 9500 N/mm²

Fifth percentile modulus of elasticity, $E_{0,05}$, 8000 N/mm²

Shear modulus of elasticity, G_{mean} , 590 N/mm²

Characteristic density, ρ_k , 475 kg/m³

Mean density, ρ_{mean} , 570 kg/m³

Span details

Bearing length

$L_b = 100$ mm

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

Check compression parallel to the grain - cl.6.1.4

Design compressive stress $\sigma_{c,0,d} = 0.066$ N/mm²

Design compressive strength $f_{c,0,d} = 13.708$ N/mm²

Utilisation = 0.005

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at start of span

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.145$ N/mm²

Design shear strength $f_{v,y,d} = 2.665$ N/mm²

Utilisation = 0.054

PASS - Design shear strength exceeds design shear stress

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 3105$ mm

Relative slenderness ratio $\lambda_{rel,y} = 2.03$

Effective length for z-axis $L_{e,z} = 0$ mm

Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.022

PASS - Column stability is acceptable

Check design 1935 mm along span

Check shear force - Section 6.1.7

Design shear stress $\tau_{y,d} = 0.205$ N/mm²

Design shear strength $f_{v,y,d} = 2.665$ N/mm²

Utilisation = 0.077

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 1.962$ N/mm²

Design bending strength $f_{m,y,d} = 15.544$ N/mm²

Utilisation = 0.126

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = 0.163

PASS - Combined bending and axial compression utilisation is acceptable

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Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 3105$ mm

Relative slenderness ratio $\lambda_{rel,y} = 2.03$

Effective length for z-axis $L_{e,z} = 0$ mm

Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.999

PASS - Column stability is acceptable

Check design at end of span

Check compression perpendicular to the grain - cl.6.1.5

Des.perp.comp.stress $\sigma_{c,y,90,d} = 0.975$ N/mm²

Des.perp.comp.strength $f_{c,y,90,d} = 3.655$ N/mm²

Utilisation = 0.267

PASS - Design perpendicular compression strength exceeds design perpendicular compression stress

Check shear force - Section 6.1.7

Design shear stress $\tau_{v,d} = 0.095$ N/mm²

Design shear strength $f_{v,y,d} = 2.665$ N/mm²

Utilisation = 0.036

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending stress $\sigma_{m,y,d} = 0.001$ N/mm²

Design bending strength $f_{m,y,d} = 15.544$ N/mm²

Utilisation = 0

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Utilisation = 0.04

PASS - Combined bending and axial compression utilisation is acceptable

Check columns subjected to either compression or combined compression and bending - cl.6.3.2

Effective length for y-axis $L_{e,y} = 3105$ mm

Relative slenderness ratio $\lambda_{rel,y} = 2.03$

Effective length for z-axis $L_{e,z} = 0$ mm

Relative slenderness ratio $\lambda_{rel,z} = 0$

$\lambda_{rel,y} > 0.3$ column stability check is required

Utilisation = 0.915

PASS - Column stability is acceptable

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

Check design 941 mm along span

Check y-y axis deflection - Section 7.2

Final deflection with creep $\delta_{y,Final} = 3.2$ mm

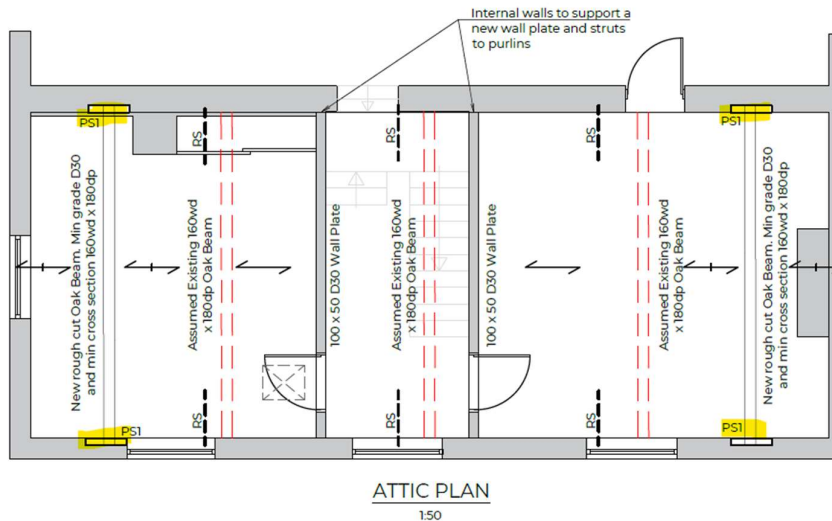
Allowable deflection $\delta_{y,Allowable} = 27.6$ mm

Utilisation = 0.117

PASS - Allowable deflection exceeds final deflection

13. PADSTONE 1

GENERAL ARRANGEMENT



LOADS

Dead: 9.1kN

Live: 7.3kN

SECTION SIZE, GRADE, PROTECTION AND DRILLING REQUIREMENTS, BEARING DETAIL

600lg x 100wd x 215dp C16 Padstone.

Wall assumed to be 5N brick with M2 Mortar

SECTION DESIGN

MASONRY BEARING DESIGN

In accordance with EN1996-1-1:2005 + A1:2012, incorporating Corrigenda February 2006 and July 2009 and the UK National Annex.

Tedds calculation version 1.0.14

Summary table

Load	Local concentration		Spreader		Utilisation	
	Design force	Resistance	Design stress	Resistance		
1	23.2 kN	11.7 kN	0.44 N/mm ²	0.73 N/mm ²	0.601	Pass

Masonry panel details

Panel length L = 1500 mm

Panel height

h = 2270 mm

Load bearing leaf thickness t = 215 mm

Effective height

h_{ef} = 1810 mm

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Effective thickness $t_{ef} = 215 \text{ mm}$

Masonry material details

Unit type **Clay - Group 1**

Mean masonry strength $f_b = 4.3 \text{ N/mm}^2$

Mortar type **M2 - General Purpose**

Characteristic strength $f_k = 1.69 \text{ N/mm}^2$

Specific weight of units $\gamma = 18 \text{ kN/m}^3$

Mortar strength $f_m = 2.0 \text{ N/mm}^2$

Design compressive strength of masonry

Category of manufacturing **Category II**

Partial factor for material $\gamma_M = 3.00$

Class of execution control **Class 2**

Design strength of masonry $f_d = 0.56 \text{ N/mm}^2$

Partial safety factors for design loads

Permanent partial factor $\gamma_{FG} = 1.35$

Variable partial factor $\gamma_{FQ} = 1.50$

Superimposed vertical loading details

Permanent UDL at top of wall $g_k = 1.57 \text{ kN/m}$

Eccent. of permanent UDL $e_{gu} = 0 \text{ mm}$

Variable UDL at top of wall $q_k = 0.75 \text{ kN/m}$

Eccent. of variable UDL $e_{qu} = 0 \text{ mm}$

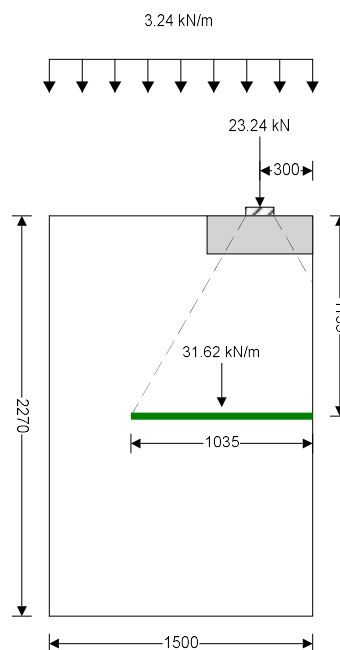
Slenderness ratio of masonry wall - Section 5.5.1.4

Slenderness ratio limit $\lambda_{lim} = 27$

Slenderness ratio $\lambda = 8.4$

PASS - Slenderness ratio is less than slenderness limit

Concentrated Load 1 details



Permanent load $G_{kc1} = 9.10 \text{ kN}$

Eccentricity of load $e_{c1} = 50 \text{ mm}$

Width of load $w_{c1} = 100 \text{ mm}$

Distance to right edge $r_{11} = 220 \text{ mm}$

Variable load $Q_{kc1} = 7.30 \text{ kN}$

Length of load $L_{c1} = 160 \text{ mm}$

Height of load $h_{c1} = 2270 \text{ mm}$

Distance to nearest edge $a_{11} = 220 \text{ mm}$

Walls subjected to concentrated loads - Section 6.1.3

Design concentrated load $N_{Edc1} = 23.24 \text{ kN}$

Design resistance $N_{Rdc1} = 11.74 \text{ kN}$

Applied concentrated load exceeds design resistance, spreader required!

PADSTONE 1

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Design of spreader beam

Type of spreader	Concrete padstone	Type of load	Point load
Length of spreader	$L_{sp1} = 600 \text{ mm}$	Width of spreader	$w_{sp1} = 108 \text{ mm}$
Height of spreader	$h_{sp1} = 215 \text{ mm}$	Eccentricity of load	$e_{sp1} = 4 \text{ mm}$
Modulus of elasticity	$E_{sp1} = 29962 \text{ N/mm}^2$	Maximum moment	$M_{Edsp1} = 1.73 \text{ kNm}$
Maximum shear	$V_{Edsp1} = 11.62 \text{ kN}$	Allowable stress	$\sigma_{Rdsp1} = 0.73 \text{ N/mm}^2$
Design stress	$\sigma_{Edsp1} = 0.44 \text{ N/mm}^2$		

PASS - Design stress under spreader is less than the allowable bearing stress

Walls subjected to mainly vertical loading - Section 6.1.2

Vertical load at mid-height	$N_{Ed1} = 31.62 \text{ kN/m}$	Design resistance	$N_{Rd1} = 91.67 \text{ kN/m}$
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PASS - Design value of vertical resistance exceeds applied vertical load