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BUILDING CONTROL CALCULATION PACKAGE

BIRCH COTTAGE, BROCKWEIR

PROJECT TITLE:	RAISED TIE ROOF TRUSS DESIGN
CLIENT:	JOE PAWSON
DOC REF:	JAC_21_051
DATE:	05/03/2021

CONTENTS

1.0 BRIEF

To undertake the structural design calculations of the proposed 'raised tie' roof truss for the property at Birch Cottage, Brockweir as advised by the client.

An inspection of the property was carried out on the 23rd September 2019 by Richard Jackson, Director of JAC Structural Engineering Ltd. A 'Structural Inspection Report' was subsequently prepared for the barn to assess its condition and suitability for conversion in line with the client's plans.

Figure 1; Front elevation of the barn.

1.1 BUILDING DESCRIPTION

The barn is a single storey, stone structure, approximately 13m long x 5m wide.

The barn is situated to the north west of Birch Cottage and is bounded on the west side of the building by a public highway.

The barn is constructed from traditional stone walls, most of which remain plumb and without significant cracking or deterioration. No damp proof course was observed at the base of the stone walls.

A small section to the south of the existing building retains a corrugated iron roof supported on timbers. The rest of the building has no roof. There is evidence that a mezzanine floor once existed towards the southern end of the barn, however this floor has since been removed.

2.0 PROPOSED WORKS

The calculations included in Section 3.0 provide the design for the timber 'raised tie' attic truss structure. The calculations have been provided for submission and approval by the Forest of Dean District Council Building Control Officer.

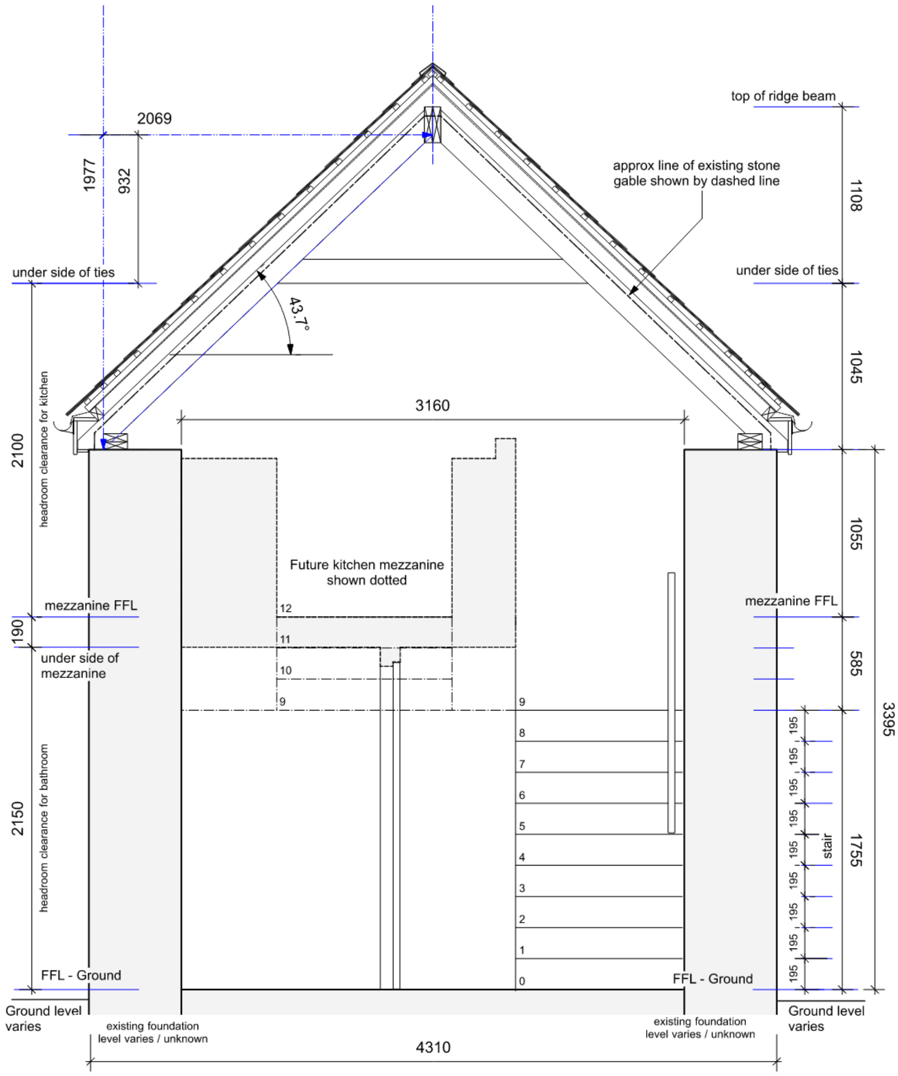


Figure 2 – Extract from drawing 001_'Birch Cottage Barn / Cross Section' illustrating geometry of raised tie truss.

Calculations and sketches to support the proposed works are included in Section 3.0.

3.0 CALCULATIONS

The following pages include detailed calculations for the proposed works;

- Loading (Page 4)
- 2D Raised Tie Truss Analysis (Page 5)
- Diagonal member, timber element design (Page 13)
- Tie member, timber element design (Page 16)

3.1 CALCULATION SUMMARY

The 'raised tie' timber truss is formed from the following timber elements;

- Right and Left Rafter timber members to be 195x47 C24 timbers, supported at the ridge beam and wall plate.
- Rafters to be laterally braced by the ridge beam, and 145x44 C16 timbers (noggins) spanning between trusses at the midspan of both rafters (at the approximate position of the tie beam).
- Raised Tie timber member to be 145x44 C16 timbers, bolted to the left and right rafters using 2no. M12 grade 8.8 bolts at each end.
- Raised tie trusses to be spaced at 600mm centres along the length of the roof.
- Trusses to be mechanically fixed to timber wall-plate. Wall-plate to be secured using 'Simpson Strong Tie' engineering restraint straps along length of wall to prevent uplift.

LOADING

Roof

Dead

Roof pitch;	$\theta = 45°$
Roof tiles;	$VRoof_{d1} = 0.65$ kN/m^2
Battens;	$VRoof_{d2} = 0.05$ kN/m^2
Truss rafters;	$VRoof_{d3} = 0.15$ kN/m^2
Ceiling;	$VRoof_{d4} = 0.15$ kN/m^2
Adjusted dead load on plan;	$VRoof_{dp}$ = sum($VRoof_{d1}$, to $VRoof_{d4}$)/cos (θ) = 1.41 kN/m^2

Imposed

Snow;	$VRoof_{im1} = 0.60$ kN/m^2
Imposed load on plan;	$VRoof_{im}$ = sum($VRoof_{im1}$) = 0.60 kN/m^2

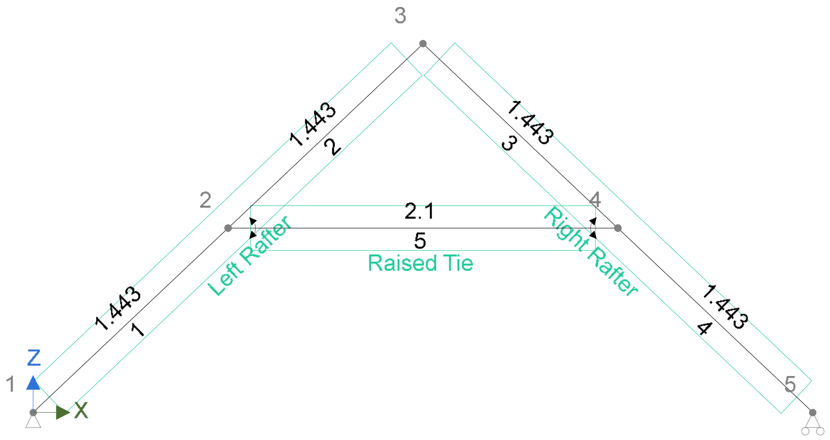
2D RAISED TIE TRUSS ANALYSIS

ANALYSIS

Tedds calculation version 1.0.33

Geometry

Geometry (m) - C16 (EC5)



Materials

Name	Density (kg/m³)	Youngs Modulus kN/mm²	Shear Modulus kN/mm²	Thermal Coefficient °C⁻¹
C16 (EC5)	310	8	0.5	0

Sections

Name	Area	Moment of inertia		Shear area parallel to	
		Major	Minor	Minor	Major
	(cm²)	(cm⁴)	(cm⁴)	(cm²)	(cm²)
47x195	91.7	2904.2	168.7	76.4	76.4
44x145	63.8	1117.8	102.9	53.2	53.2

Nodes

Node	Co-ordinates		Freedom			Coordinate system		Spring		
	X (m)	Z (m)	X	Z	Rot.	Name	Angle (°)	X (kN/m)	Z (kN/m)	Rot. kNm/°
1	0	0	Fixed	Fixed	Free		0	0	0	0
2	1.05	0.99	Free	Free	Free		0	0	0	0
3	2.1	1.98	Free	Free	Free		0	0	0	0

Node	Co-ordinates		Freedom			Coordinate system		Spring		
	X (m)	Z (m)	X	Z	Rot.	Name	Angle (°)	X (kN/m)	Z (kN/m)	Rot. kNm/°
4	3.15	0.99	Free	Free	Free		0	0	0	0
5	4.2	0	Free	Fixed	Free		0	0	0	0

Elements

Element	Length (m)	Nodes		Section	Material	Releases			Rotated
		Start	End			Start moment	End moment	Axial	
1	1.443	1	2	47x195	C16 (EC5)	Fixed	Fixed	Fixed	
2	1.443	2	3	47x195	C16 (EC5)	Fixed	Fixed	Fixed	
3	1.443	3	4	47x195	C16 (EC5)	Fixed	Fixed	Fixed	
4	1.443	4	5	47x195	C16 (EC5)	Fixed	Fixed	Fixed	
5	2.1	2	4	44x145	C16 (EC5)	Free	Free	Fixed	

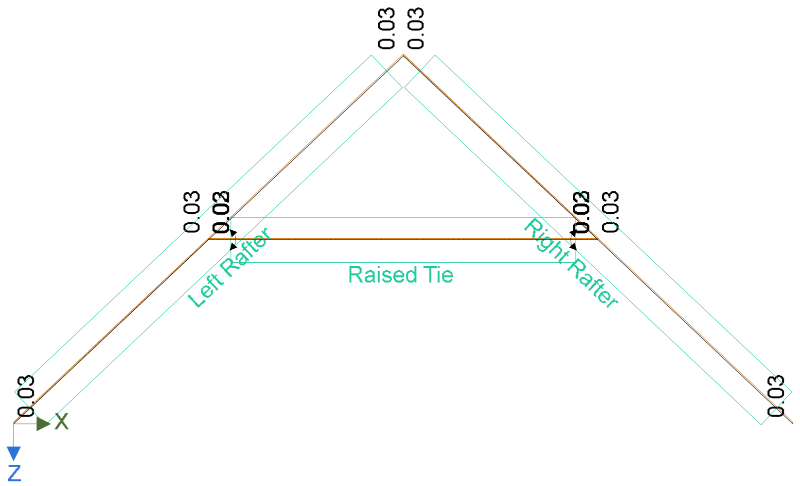
Members

Name	Elements	
	Start	End
Left Rafter	1	2
Right Rafter	3	4
Raised Tie	5	5

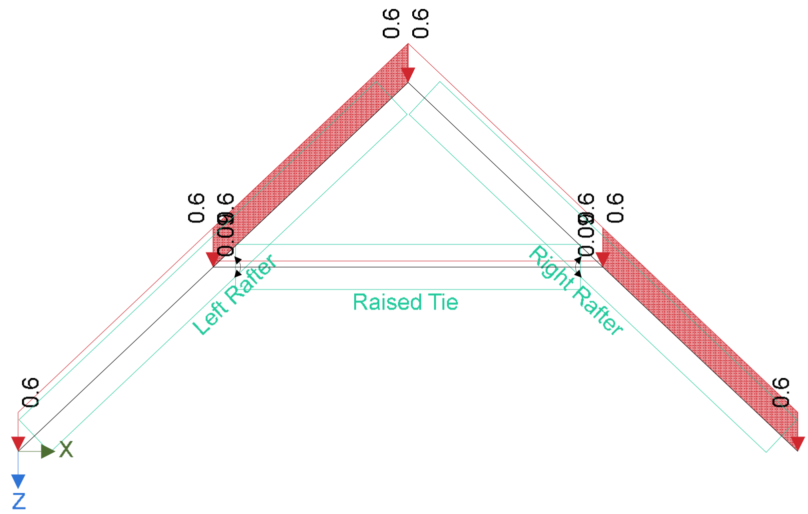
Loading

Self weight included (Self weight x 1)

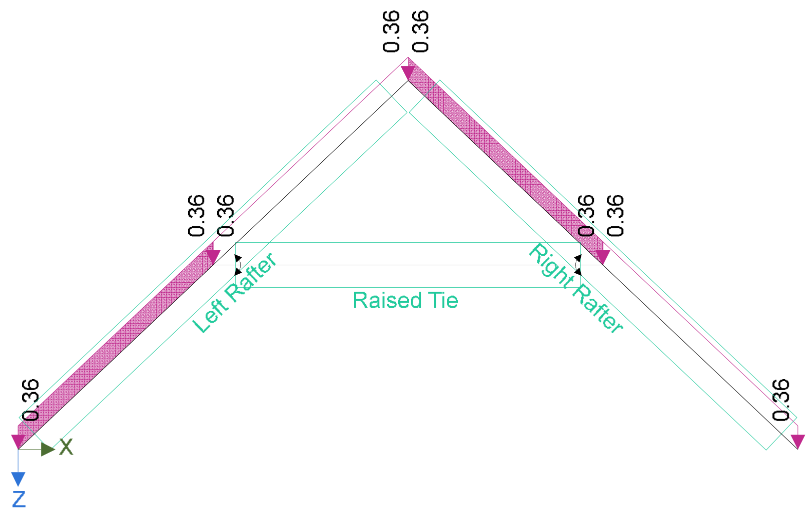
Self weight - Loading (kN/m)



Permanent - Loading (kN/m)



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

Load combination	Self weight	Permanent	Imposed
1.0G + 1.0Q + 1.0RQ (Service)	1.00	1.00	1.00

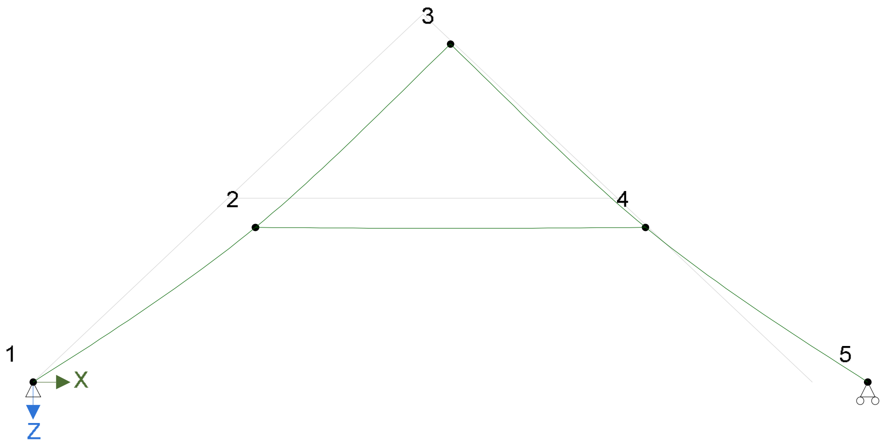
Member Loads

Member	Load case	Load Type	Orientation	Description
Left Rafter	Permanent	UDL	GlobalZ	0.6 kN/m
Right Rafter	Permanent	UDL	GlobalZ	0.6 kN/m
Raised Tie	Permanent	UDL	GlobalZ	0.09 kN/m
Left Rafter	Imposed	UDL	GlobalZ	0.36 kN/m
Right Rafter	Imposed	UDL	GlobalZ	0.36 kN/m

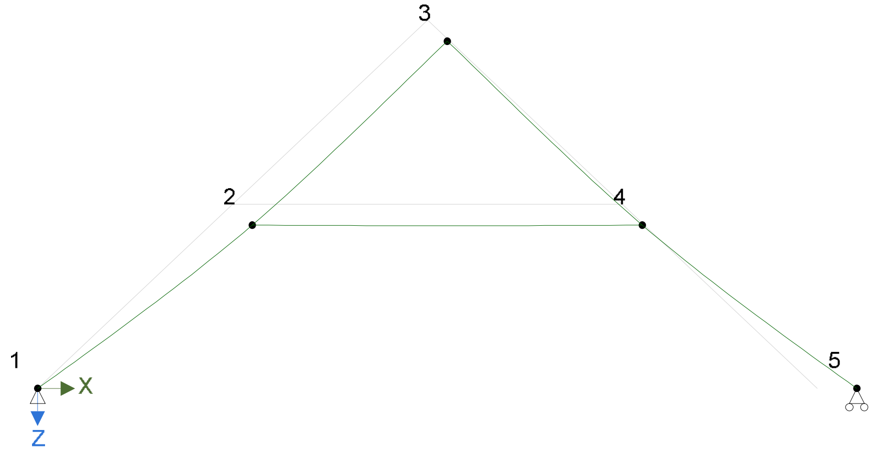
Results

Total deflection

1.35G + 1.5Q + 1.5RQ (Strength) - Total deflection

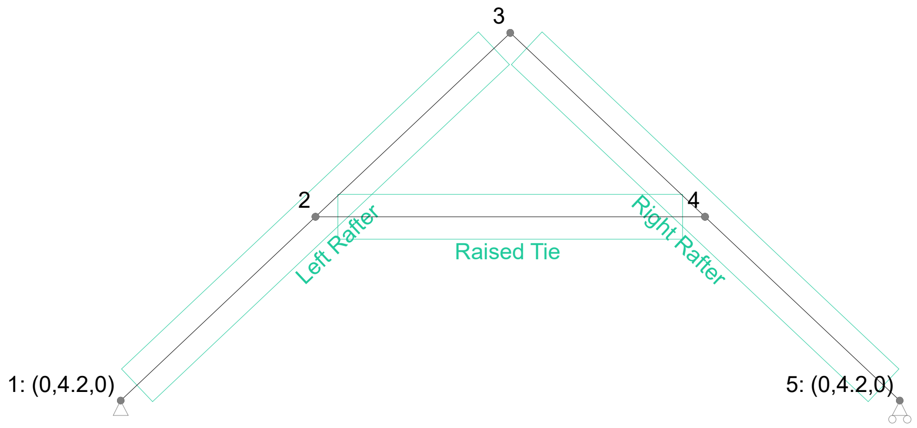


1.0G + 1.0Q + 1.0RQ (Service) - Total deflection

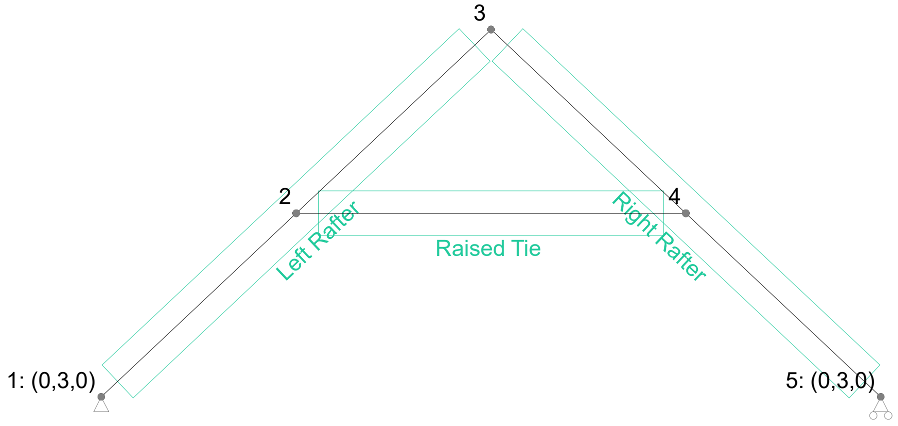


Reactions

1.35G + 1.5Q + 1.5RQ (Strength) - Local node reactions - Node: (Horiz (kN), Vert (kN), Mom (kNm))



1.0G + 1.0Q + 1.0RQ (Service) - Local node reactions - Node: (Horiz (kN), Vert (kN), Mom (kNm))



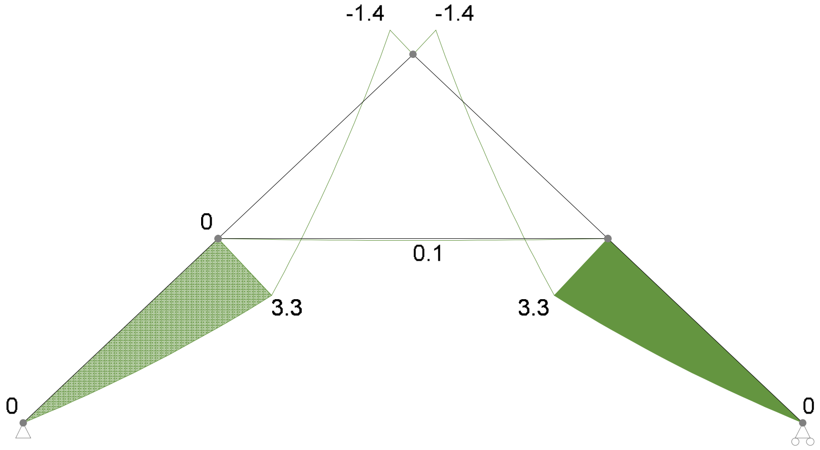
Forces

Member results

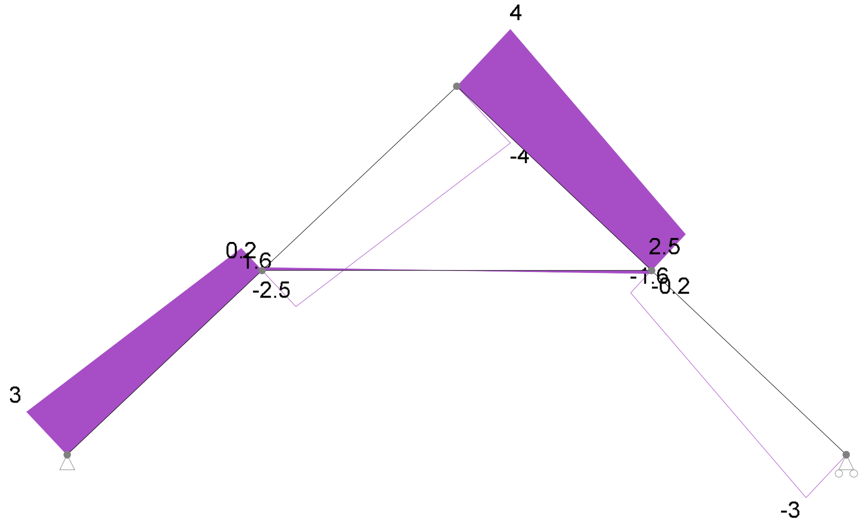
Envelope - Strength combinations

Member	Shear force		Moment			
	Pos (m)	Max abs (kN)	Pos (m)	Max (kNm)	Pos (m)	Min (kNm)
Left Rafter	2.886	-4 (max abs)	1.443	3.3 (max)	2.886	-1.4 (min)
Right Rafter	0	4	1.443	3.3 (max)	0	-1.4 (min)
Raised Tie	2.1	0.2	1.05	0.1	0	0

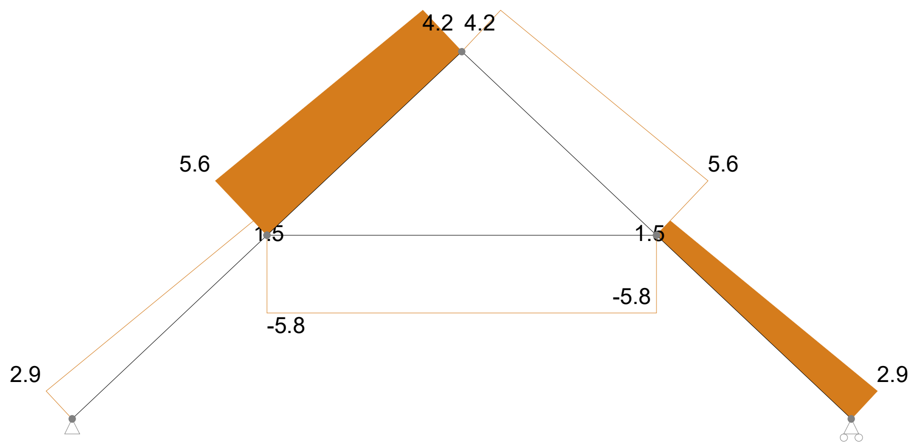
1.35G + 1.5Q + 1.5RQ (Strength) - Moment (kNm)



1.35G + 1.5Q + 1.5RQ (Strength) - Shear (kN)

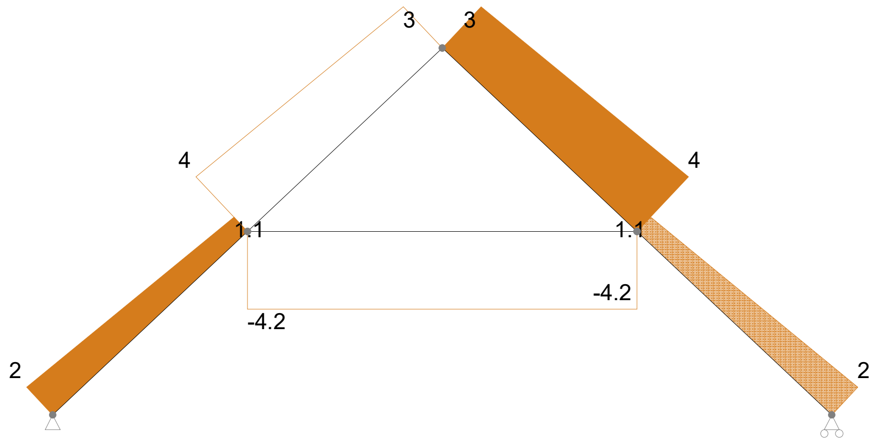


1.35G + 1.5Q + 1.5RQ (Strength) - Axial force (kN)

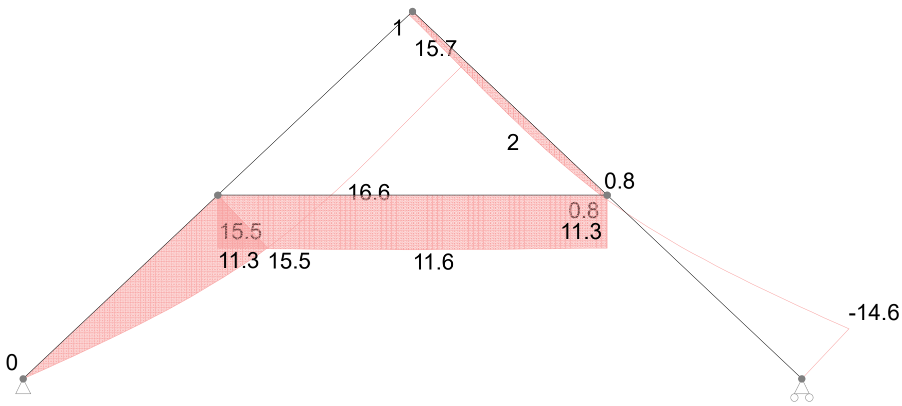


JAC Structural Engineering	Project Birch Cottage, Brockweir			Project No. JAC_21_051
	Calcs for Building Control Calculation Package			Client Joe Pawson
	Calc by JAC	Date 05/03/2021		

1.0G + 1.0Q + 1.0RQ (Service) - Axial force (kN)



1.0G + 1.0Q + 1.0RQ (Service) - Deflection (mm)



DIAGONAL MEMBER, TIMBER ELEMENT DESIGN

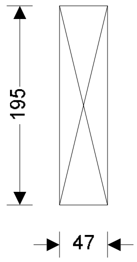
Timber member design to EN1995-1-1:2004

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 1.7.04

Analysis results

Design moment in major axis;	M_y = **3.300** kNm
Design shear;	F = **4.000** kN
Design axial compression;	P = **5.600** kN



Timber section details

Breadth of timber sections;	b = **47** mm
Depth of timber sections;	h = **195** mm
Number of timber sections in member;	N = **1**
Overall breadth of timber member;	$b_b = N \times b$ = **47** mm
Timber strength class - EN 338:2016 Table 1;	**C24**

Member details

Load duration - cl.2.3.1.2;	**Medium-term**
Service class of timber - cl.2.3.1.3;	**1**
Unbraced length in major (y-y) axis;	L_y = **1450** mm
Effective length factor in major (y-y) axis;	K_y = **1**
Effective length in major (y-y) axis;	$L_{ey} = L_y \times K_y$ = **1450** mm
Unbraced length in minor (z-z) axis;	L_z = **1450** mm
Effective length factor in minor (z-z) axis;	K_z = **1**
Effective length in minor (z-z) axis;	$L_{ez} = L_z \times K_z$ = **1450** mm

Section properties

Cross sectional area of member;	$A = N \times b \times h$ = **9165** mm^2
Section modulus;	$W_y = N \times b \times h^2 / 6$ = **297863** mm^3
	$W_z = h \times (N \times b)^2 / 6$ = **71793** mm^3
Second moment of area;	$I_y = N \times b \times h^3 / 12$ = **29041594** mm^4
	$I_z = h \times (N \times b)^3 / 12$ = **1687124** mm^4
Radius of gyration;	$r_y = \sqrt{(I_y / A)}$ = **56.3** mm
	$r_z = \sqrt{(I_z / A)}$ = **13.6** mm

Partial factor for material properties and resistances

Partial factor for material properties - Table 2.3; γ_M = **1.300**

Modification factors

Modification factor for load duration and moisture content - Table 3.1

k_{mod} = **0.800**

Deformation factor for service classes - Table 3.2; k_{def} = **0.600**

Depth factor for bending - exp.3.1; $k_{h.m}$ = **1.000**

Depth factor for tension - exp.3.1; $k_{h.t}$ = **1.000**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.700**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.670**

Load configuration factor - exp.6.4; $k_{c.90}$ = **1.000**

System strength factor - cl.6.6; k_{sys} = **1.000**

Effective length - Table 6.1; $L_{ef} = 1.0 * L_s$ = **1450** mm

Critical bending stress - exp.6.32; $\sigma_{m.crit} = 0.78 * (N * b)^2 * E_{0.05} / (h * L_{ef})$ = **45.094** N/mm^2

Relative slenderness for bending - exp.6.30; $\lambda_{rel.m} = \sqrt{[f_{m.k} / \sigma_{m.crit}]}$ = **0.730**

Lateral buckling factor - exp.6.34; k_{crit} = **1.000**

Bending - cl 6.1.6

Design bending stress; $\sigma_{m.d} = M_y / W_y$ = **11.079** N/mm^2

Design bending strength; $f_{m.d} = k_{h.m} * k_{mod} * k_{sys} * k_{crit} * f_{m.k} / \gamma_M$ = **14.769** N/mm^2

$\sigma_{m.d} / f_{m.d}$ = **0.750**

PASS - Design bending strength exceeds design bending stress

Compression parallel to the grain - cl.6.1.4

Design compressive stress; $\sigma_{c.0.d} = P / A$ = **0.611** N/mm^2

Design compressive strength; $f_{c.0.d} = k_{mod} * k_{sys} * f_{c.0.k} / \gamma_M$ = **12.923** N/mm^2

$\sigma_{c.0.d} / f_{c.0.d}$ = **0.047**

PASS - Design compressive strength exceeds design compressive stress

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

Slenderness ratio in major (y-y) axis; $\lambda_y = L_{ey} / r_y$ = **25.759**

Relative slenderness ratio - eq.6.21; $\lambda_{rel.y} = \lambda_y * \sqrt{(f_{c.0.k} / E_{0.05})} / \pi$ = **0.437**

Slenderness ratio in minor (z-z) axis; $\lambda_z = L_{ez} / r_z$ = **106.871**

Relative slenderness ratio - eq.6.22; $\lambda_{rel.z} = \lambda_z * \sqrt{(f_{c.0.k} / E_{0.05})} / \pi$ = **1.812**

Instability factors - eq.6.25 to eq.6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel.y} - 0.3) + \lambda_{rel.y}^2)$ = **0.609**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel.z} - 0.3) + \lambda_{rel.z}^2)$ = **2.293**

$k_{c.y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel.y}^2)})$ = **0.968**

$k_{c.z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel.z}^2)})$ = **0.270**

Column stability checks - eq.6.23 & eq.6.24; $\sigma_{c.0.d} / (k_{c.y} * f_{c.0.d}) + \sigma_{m.d} / f_{m.d}$ = **0.799**

$\sigma_{c.0.d} / (k_{c.z} * f_{c.0.d}) + k_m * \sigma_{m.d} / f_{m.d}$ = **0.700**

PASS - Member stability meets design criteria

Combined bending and axial compression - cl.6.2.4

Combined loading checks - eq.6.19 & 6.20; $(\sigma_{c.0.d} / f_{c.0.d})^2 + \sigma_{m.d} / f_{m.d}$ = **0.752**

$(\sigma_{c.0.d} / f_{c.0.d})^2 + k_m * \sigma_{m.d} / f_{m.d}$ = **0.527**

PASS - Member design meets combined bending and axial compression criteria

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

Lateral torsional stability check - eq.6.35; $(\sigma_{m.d} / (k_{crit} * f_{m.d}))^2 + \sigma_{c.0.d} / (k_{c.z} * f_{c.0.d})$ = **0.738**

PASS - Member design meets lateral torsional stability criteria

Shear - cl.6.1.7

Applied shear stress; $\tau_d = 3 * F / (2 * k_{cr} * A)$ = **0.977** N/mm^2

Permissible shear stress; $f_{v.d} = k_{mod} * k_{sys} * f_{v.k} / \gamma_M$ = **2.462** N/mm^2

$\tau_d / f_{v.d}$ = **0.397**

PASS - Design shear strength exceeds design shear stress

TIE MEMBER, TIMBER ELEMENT DESIGN

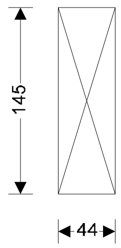
Timber member design to EN1995-1-1:2004

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 1.7.04

Analysis results

Design axial tension; P = **6.000** kN



Timber section details

Breadth of timber sections; b = **44** mm

Depth of timber sections; h = **145** mm

Number of timber sections in member; N = **1**

Overall breadth of timber member; $b_b = N \times b =$ **44** mm

Timber strength class - EN 338:2016 Table 1; **C16**

Member details

Load duration - cl.2.3.1.2; **Medium-term**

Service class of timber - cl.2.3.1.3; **1**

Section properties

Cross sectional area of member; $A = N \times b \times h =$ **6380** mm^2

Section modulus; $W_y = N \times b \times h^2 / 6 =$ **154183** mm^3

$W_z = h \times (N \times b)^2 / 6 =$ **46787** mm^3

Second moment of area; $I_y = N \times b \times h^3 / 12 =$ **11178292** mm^4

$I_z = h \times (N \times b)^3 / 12 =$ **1029307** mm^4

Radius of gyration; $r_y = \sqrt{(I_y / A)} =$ **41.9** mm

$r_z = \sqrt{(I_z / A)} =$ **12.7** mm

Partial factor for material properties and resistances

Partial factor for material properties - Table 2.3; $\gamma_M =$ **1.300**

Modification factors

Modification factor for load duration and moisture content - Table 3.1

$k_{mod} =$ **0.800**

Deformation factor for service classes - Table 3.2; $k_{def} =$ **0.600**

Depth factor for bending - exp.3.1; $k_{h.m} = \min((150 \text{ mm} / h)^{0.2}, 1.3) =$ **1.007**

Depth factor for tension - exp.3.1; $k_{h.t} = \min((150 \text{ mm} / \max(b, h))^{0.2}, 1.3) =$ **1.007**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.700**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.670**

Load configuration factor - exp.6.4; $k_{c.90}$ = **1.000**

System strength factor - cl.6.6; k_{sys} = **1.000**

Effective length - Table 6.1; $L_{ef} = 1.0 * L_s$ = **2100** mm

Critical bending stress - exp.6.32; $\sigma_{m.crit} = 0.78 * (N * b)^2 * E_{0.05} / (h * L_{ef})$ = **26.780** N/mm^2

Relative slenderness for bending - exp.6.30; $\lambda_{rel.m} = \sqrt{[f_{m.k} / \sigma_{m.crit}]}$ = **0.773**

Lateral buckling factor - exp.6.34; $k_{crit} = 1.56 - 0.75 * \lambda_{rel.m}$ = **0.980**

Tension parallel to the grain - cl.6.1.2

Design tensile stress; $\sigma_{t.0.d} = P / A$ = **0.940** N/mm^2

Design tensile strength; $f_{t.0.d} = k_{h.t} * k_{mod} * k_{sys} * f_{t.0.k} / \gamma_M$ = **5.266** N/mm^2

$\sigma_{t.0.d} / f_{t.0.d}$ = **0.179**

PASS - Design tensile strength exceeds design tensile stress

4.0 TERMS, CONDITIONS AND LIMITATIONS OF REPORT

1. GENERAL

This report is confined to an inspection of the structural elements of the property only. Therefore, the report excludes any inspection or comment on electrical and mechanical installations, decorative conditions, damp proofing, non-structural timber fixtures, fittings, mouldings, coverings, windows, finishes, etc., and all other non-structural matters.

The purpose of this report is limited to an opinion on the structural condition of the property. We shall only report upon those structural defects that may materially affect the stability of the property and provided that these defects are reasonably detectable at the time of our inspection. Whilst we will use all reasonable skill and care in preparing this report, it should be appreciated that we cannot offer any guarantee that the property will be free from future defects or that existing ones will not suffer from further deterioration.

2. ROOF STRUCTURES

It should be noted that roofs and roof timbers can be subject to deterioration and it would be necessary for you to make specific arrangements for the inspection of this area if you require confirmation about the condition.

3. UNEXPOSED PARTS

Internal inspection is made within the limits of ready accessibility and it is not normal practice to lift floor coverings or floor boards, remove panels or plaster, or move heavier items of furniture. Consequently, we have not been able to inspect woodwork or any other parts of the structure which are covered, unexposed or inaccessible and we are therefore unable to report that any such part of the property is free from defect. Such unexposed parts may contain problems and you would need to make special arrangements for these areas to be investigated (where practicably possible) if you require confirmation about their condition.

4. FOUNDATIONS

Where trial holes are excavated as part of a structural report, the condition of the footing and the founding soil relates only to the point of excavation and does not necessarily guarantee a continuation of the same conditions throughout the non-inspected areas of the structure. Whilst such trial pits will usually provide a reasonable indication as to the general state of the foundations and ground conditions, these cannot be determined with complete certainty. However, more detailed investigations could be carried out if we are so instructed.

5. MONITORING

Where the stability of a structure has been confirmed as a result of a series of monitoring readings during a given period of time, this does not guarantee the future stability of the structure beyond the monitoring period.

6. DISCLOSURE TO A THIRD PARTY

This report may not be relied upon by a third party for any purpose without the written consent of this practice. Furthermore, this report has been prepared and issued specifically for the benefit of the addressee and no responsibility will be extended to any third party for the whole or any part of its contents.

7. METHANE/RADON

Testing for or enquiry about possible Methane presence from geological or organic sources, or the presence of or susceptibility to Radon Gas, have not been carried out as part of the structural report. Whilst the presence of such gases in harmful amounts is not a common occurrence, you should consider whether you wish such a test to be carried out since this may well affect the future value of the property/site and any prospects for future development.

8. STATUTORY REQUIREMENTS

Enquiries with local or statutory authorities have not been carried out. Whilst attention may be drawn to any apparent breaches of statutory requirements relative to the building or site, the absence of any such comment does not imply compliance with such requirements.

9. METHOD OF INSPECTION

External inspection of the building has been carried out from ground level by visual and optical sighting. This method means that parts of the structure may be incapable of inspection and we cannot confirm that they are free from defect. Special arrangements (where practicably possible) would need to be made before inspection of these areas could take place.

10. CONTAMINATION

The property and site have not been tested for any form of contamination, pollution or any other environmental impairment and we are unable to make any comment in this regard. However, such matters are an important consideration and may well affect the value of the property/site and any prospects for future development. Specific environmental audits can be arranged with appropriate specialists in this field.

11. TREES AND SHRUBS

Where there are trees and shrubs in close proximity to the property then there may be a risk of possible subsidence problems in the future and advice should be sought from an Arboricultural Association approved Tree Surgeon on the need for tree and shrub reduction or removal.