

MR & MRS McCORMICK

NETHERBY COTTAGE, BOX

LOFT CONVERSION FEASIBILITY CALCULATIONS



Netherby Cottage, Box	Project No:	SKEL_0201
Loft Conversion Calculations	Date started:	15/08/2024
Calc by: TC	Checked by:	PB

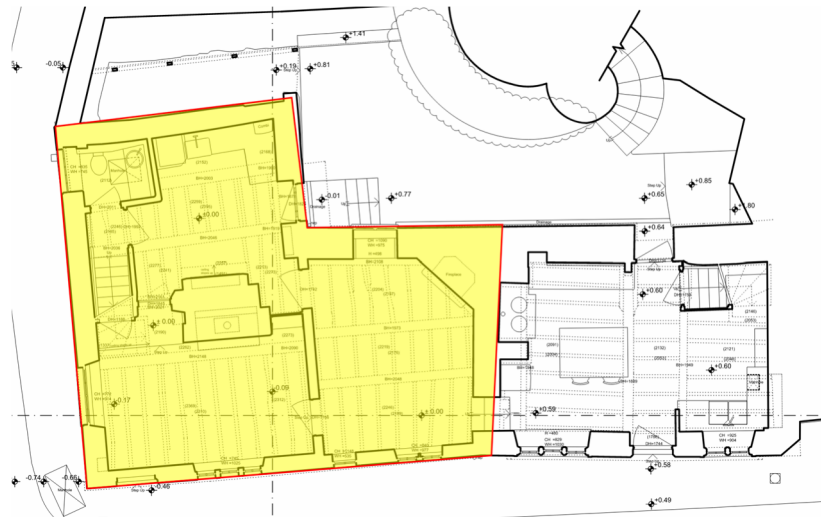
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1.0 INTRODUCTION

Skeletal Consulting Engineers Limited (SCE) has been appointed by Mr and Mrs McCormick (the client) to carry out structural feasibility design works related to the possible conversion of part of their attic space into an additional bedroom within their Grade II listed property at Netherby Cottage in Box. The property is split into two parts; what we will refer to as the 'Eastern wing' and the 'L-shaped wing'. In this report, we will be analysing the L-shaped wing only (as highlighted below).



Peter Bone of SCE conducted a visual 'walkaround' survey of the property on 09/08/2024 to measure up some of the critical structural elements such as size and spacing of ceiling joists, rafters and purlins. The client provided SCE with a measured survey of the property which gives accurate measurements to rooms.

This calculation pack will analyse the existing structural elements within the attic, checking those elements are acceptable for the increased load associated with a habitable space.

- Existing timber ceiling joists.
- Existing downstand beams (supporting ceiling joists).
- Existing rafters to span without propping at third points by purlins.
- Strengthening of existing rafters (if required).

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SUMMARY OF FINDINGS

Existing ceiling joists to act as new loft floor joists

These were measured on site as being 100mm deep typically down to the top of the ceiling below x 75mm wide at typically around 400mm centres. It was not clear if this is the actual full depth of the joists; the only area where joists are exposed below is in the bathroom; based on the survey drawings provided the joists may be 125mm deep. This needs to be checked on site prior to moving forward with the design of a new loft space.

We have therefore checked the joists as 100mm and 125mm deep. All the timber in the loft looked like it is oak but this needs to be confirmed by a timber specialist along with the grade of timber. We have assessed the joists for the minimum grades of softwood (C16) and oak (D18). The results are summarised below:

	C16	D18 (Oak)
100 x 75 @ 400 centres	X	X
125 x 75 @ 400 centres	X (needs to be min C24)	X (needs to be min D27)

Existing bottom chords (beams) to main trusses that support existing ceiling joists and will need to support new loft floor loads

The bottom chords (beams) of the 3 main trusses forming the roof were measured on site as being 150mm deep typically down to the top of the ceiling below x 220mm wide at typically. All these beams protrude/downstand below the first floor ceiling below. Based on the survey drawings and site measurements we have assessed the beams to be 250mm deep but as above, this needs to be confirmed precisely on site as does the type and grade of timber.

We have therefore checked the beams for the central truss (worst case span) and the truss to the east side of this roof space. The results are summarised below:

	C16	D18 (Oak)
Middle truss: 250 x 220	X (needs to be min C27)	X (needs to be min D35)
Eastern truss: 250 x 220	X (needs to be min C18)	✓

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2.0 LOADING

2.1 Roofs

2.1.1 Pitched Roof (45°) – Existing

Permanent	On pitch	On plan	
Slate tiles	0.40 kN/m ²	0.57 kN/m ²	$0.40/\cos(45)$
Battens & membrane	0.05 kN/m ²	0.07 kN/m ²	$0.05/\cos(45)$
50mm sprayed insulation	0.06 kN/m ²	0.08 kN/m ²	$0.06/\cos(45)$
Total superimposed dead	0.51 kN/m²	0.72 kN/m²	
Existing rafters	0.12 kN/m ²	0.17 kN/m ²	$0.12/\cos(45)$
Total permanent		0.89 kN/m²	
Variable			
Maintenance & Repair <i>UK NA to BS EN 1991-1-1 Table NA.7</i>		0.30 kN/m ²	$0.6 \times (60-45) / 30$
Total variable		0.30 kN/m²	

2.1.2 Pitched Roof (45°) – as existing + proposed finished (assumed)

Permanent	On pitch	On plan	
Slate tiles	0.40 kN/m ²	0.57 kN/m ²	$0.40/\cos(45)$
Battens & membrane	0.05 kN/m ²	0.07 kN/m ²	$0.05/\cos(45)$
100mm insulation	0.08 kN/m ²	0.11 kN/m ²	$0.08/\cos(45)$
Plasterboard & skim	0.15 kN/m ²	0.21 kN/m ²	$0.15/\cos(45)$
Total superimposed dead	0.68 kN/m²	0.96 kN/m²	
Existing rafters	0.12 kN/m ²	0.17 kN/m ²	$0.12/\cos(45)$
Total permanent		1.13 kN/m²	
Variable			
Maintenance & Repair <i>UK NA to BS EN 1991-1-1 Table NA.7</i>		0.30 kN/m ²	$0.6 \times (60-45) / 30$
Total variable		0.30 kN/m²	

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2.1.3 Attic – Existing (storage)

Permanent

18mm loft boards

On plan

0.14 kN/m²

100mm insulation (floor)

0.05 kN/m²

Lath and plaster (first-floor ceiling)

0.50 kN/m²

Total superimposed dead

0.69 kN/m²

Existing joists allowance

0.23 kN/m²

Total permanent

0.92 kN/m²

Variable

Attic storage allowance

0.75 kN/m²

Total variable

0.75 kN/m²

2.1.4 Attic - Proposed (assumed)

Permanent

High-quality timber or tiled floor finish

On plan

0.30 kN/m²

18mm chipboard flooring

0.14 kN/m²

100mm insulation (floor)

0.05 kN/m²

Lath and plaster (first-floor ceiling as existing)

0.50 kN/m²

Total superimposed dead

0.99 kN/m²

Existing joists allowance

0.23 kN/m²

Total permanent

1.22 kN/m²

Variable

Domestic & Residential *UK NA to BS EN 1991-1-1 Category A1*

1.50 kN/m²

Total variable

1.50 kN/m²

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2.2 Wind Loading

TEKLA TEDDS was used to calculate Wind Loading to BS EN 1991-1-4 and the associated UK National Annex. The following parameters were used in the calculation of wind loading:

Fundamental basic wind velocity	22.0 m/s
Distance upwind to shore	100 km
Altitude above sea level	56.0 m
Terrain Category	Town
Dynamic Factor	1.00

2.2.1 Wind on Roof

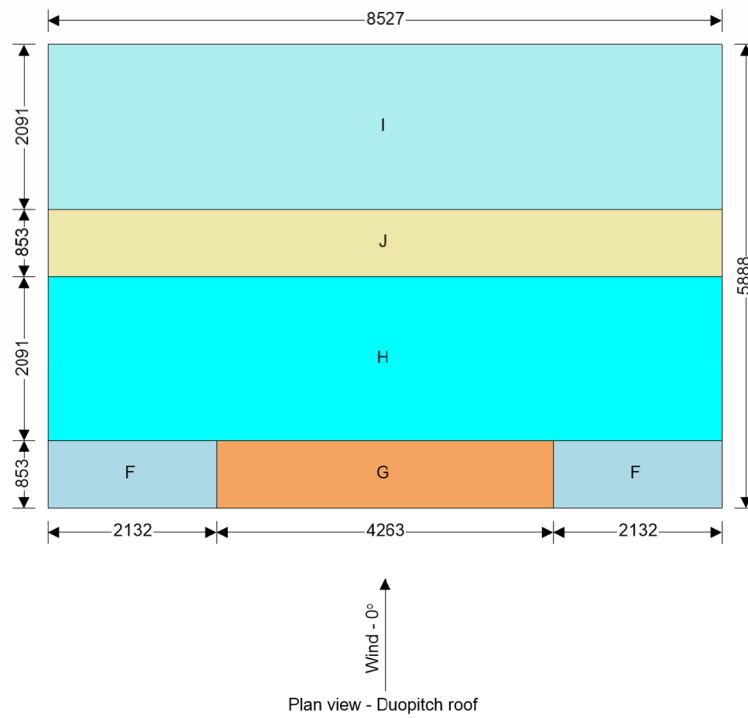
Roof load case 1 – Wind 0, c_{pi} 0.20, $-c_{pe}$

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p , (kN/m ²)	Net pressure p (kN/m ²)	Area A_{ref} (m ²)	Net force F_w (kN)
F (-ve)	0.80	0.71	0.39	5.14	1.99
G (-ve)	0.60	0.71	0.25	5.14	1.31
H (-ve)	0.70	0.71	0.32	25.22	8.08
I (-ve)	-0.50	0.71	-0.47	25.22	-11.95
J (-ve)	-0.80	0.71	-0.67	10.28	-6.91

Roof load case 2 – Wind 0, c_{pi} -0.30, $+c_{pe}$

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p , (kN/m ²)	Net pressure p (kN/m ²)	Area A_{ref} (m ²)	Net force F_w (kN)
F (+ve)	0.80	0.71	0.74	5.14	3.82
G (+ve)	0.60	0.71	0.61	5.14	3.14
H (+ve)	0.70	0.71	0.68	25.22	17.09
I (+ve)	-0.50	0.71	-0.12	25.22	-2.94
J (+ve)	-0.80	0.71	-0.31	10.28	-3.24

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3.0 ATTIC FLOOR

3.1 Existing Ceiling Joists

To assess the feasibility of the loft conversion, we must first analyse the existing ceiling joists to see if they are sufficient to accept the increased loading from the loft conversion. If they are insufficient, the floor deck would likely need strengthening with additional joists.

The ceiling joists were measured from the attic space as 75mm wide and 100mm deep to the top of the lath and plaster (at 400mm centres). It is thought that the ceiling joists may be in fact 125mm deep (the remainder of the joist hidden by the lath and plaster. The worst case joist spans 3m between a masonry wall and the bottom chord of the roof truss (which downstands into the bedrooms below).

The ceiling joists appeared to be oak, but will be analysed as both low-grade softwood (C16) and hardwood (D18) for completeness.

Loading

UDL

Permanent (less joist s/wt.)	0.99 kN/m ²
Variable	1.50 kN/m ²

Analysis & Design

- Joists have been designed using the 'timber joist analysis and design' calculation on the TEKLA TEDDS software to BS EN 1995.
- The joists have been designed as service class 1.
- Deflection criteria: Permanent + Variable to not exceed span/250
- Creep deformation has been included:
 - Variable load proportion = 0.60
 - Quasi-permanent load factor = 0.3
- Assume 50mm bearing length.

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Check 75x100mm C16 @ 400mm c/c:



Design options... Joist... Deflection criteria... Output options...

Design span

Span 1

Span details - estimated required depth is 150 mm

Solid timber 1 / 75 x 100

Softwood species C16

Display options

Details ☐

Loading ☐

Moment (kNm) ☐

Shear (kN) ☐

Deflection (mm) ☐

☒ Preview results

		Capacity	Maximum	Utilisation	
Bearing stress	N/mm ²	1.5	0.4	0.246	✓
Bending stress	N/mm ²	11.7	13.2	1.123	✗
Shear stress	N/mm ²	2.2	0.7	0.303	✓
Deflection	mm	12	29.5	2.455	✗

Joists unacceptable for proposed loading.

Check 125x75mm C16 @ 400mm c/c:



Design options... Joist... Deflection criteria... Output options...

Design span

Span 1

Span details

Solid timber 1 / 75 x 125

Softwood species C16

Display options

Details ☐

Loading ☐

Moment (kNm) ☐

Shear (kN) ☐

Deflection (mm) ☐

☒ Preview results

		Capacity	Maximum	Utilisation	
Bearing stress	N/mm ²	1.5	0.4	0.249	✓
Bending stress	N/mm ²	11.2	8.5	0.759	✓
Shear stress	N/mm ²	2.2	0.5	0.245	✓
Deflection	mm	12	15.4	1.283	✗

Preview output...

125x75mm C16 joists @ 400mm c/c unacceptable. Joists would need to be a minimum of C24:

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Display options

Details ☐

Loading ☐

Moment (kNm) ☐

Shear (kN) ☐

Deflection (mm) ☐

Design options...

Joist...

Deflection criteria...

Output options...

Design span

Span 1

Span details

Solid timber 1 / 75 x 125

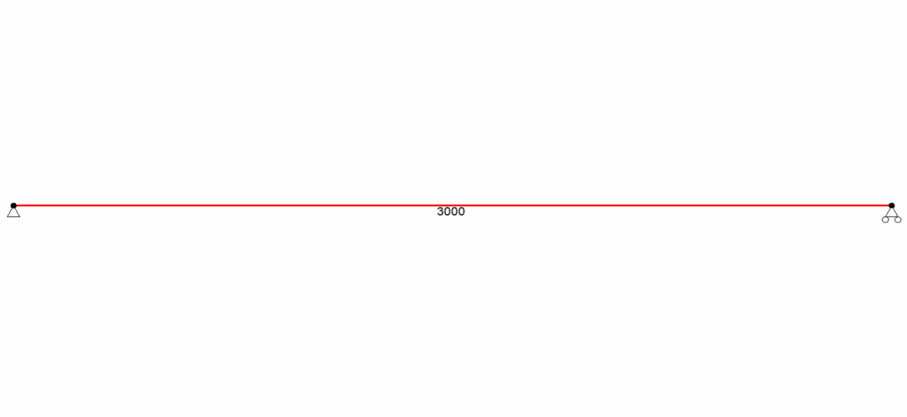
Softwood species C24 ...

☒ Preview results

		Capacity	Maximum	Utilisation	
Bearing stress	N/mm ²	1.7	0.4	0.220	✓
Bending stress	N/mm ²	16.8	8.6	0.508	✓
Shear stress	N/mm ²	2.7	0.5	0.197	✓
Deflection	mm	12	11.2	0.937	✓

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Check 75x100mm D18 @ 400mm c/c:



Display options

Details ☐

Loading ☐

Moment (kNm) ☐

Shear (kN) ☐

Deflection (mm) ☐

Design options... Joist... Deflection criteria... Output options...

Design span

Span 1

Span details - estimated required depth is 150 mm

Solid timber / x

Hardwood species

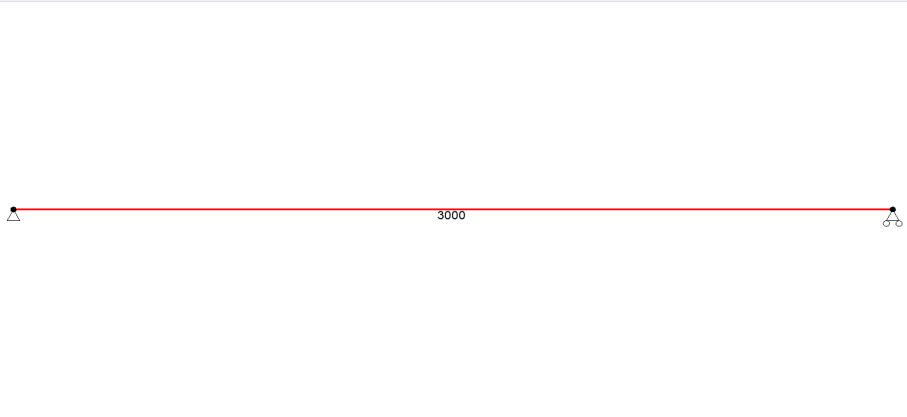
☒ Preview results

	Capacity	Maximum	Utilisation	
Bearing stress	N/mm ² 3.2	0.4	0.115	✓
Bending stress	N/mm ² 13.2	13.4	1.016	✗
Shear stress	N/mm ² 2.4	0.7	0.282	✓
Deflection	mm 12	25.3	2.107	✗

Preview output...

Joists unacceptable for proposed loading.

Check 125x75mm D18 @ 400mm c/c:



Display options

Details ☐

Loading ☐

Moment (kNm) ☐

Shear (kN) ☐

Deflection (mm) ☐

Design options... Joist... Deflection criteria... Output options...

Design span

Span 1

Span details

Solid timber / x

Hardwood species

☒ Preview results

	Capacity	Maximum	Utilisation	
Bearing stress	N/mm ² 3.2	0.4	0.116	✓
Bending stress	N/mm ² 12.6	8.7	0.686	✓
Shear stress	N/mm ² 2.4	0.5	0.228	✓
Deflection	mm 12	13.2	1.100	✗

Preview output...

125x75mm D18 joists @ 400mm c/c unacceptable. Joists would need to be a minimum of D27:

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Display options

Details ☐

Loading ☐

Moment (kNm) ☐

Shear (kN) ☐

Deflection (mm) ☐

Design options...

Joist...

Deflection criteria...

Output options...

Design span

Span 1

Span details

Solid timber / x

Hardwood species

☒ Preview results

		Capacity	Maximum	Utilisation	
Bearing stress	N/mm ²	3.5	0.4	0.109	✓
Bending stress	N/mm ²	19.0	8.7	0.459	✓
Shear stress	N/mm ²	2.6	0.5	0.210	✓
Deflection	mm	12	12.0	0.998	✓

Preview output...

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3.2 Existing Downstand Beams

The increased load on the existing attic joists will be transferred onto the bottom chord of the three triangular trusses at roof level. The bottom chord downstands from the ceiling below and was measured as approximately 220mm wide and 250mm deep.

These existing beams also appeared to be oak, but will be analysed as both low-grade softwood (C16) and hardwood (D18) for completeness.

3.2.1 Truss south of chimney

The worst-case span (5.00m) is located south of the large chimney breast, spanning between the external wall and internal loadbearing partition.

Loading

Full UDL (left and right)

Permanent	2.99 kN/m	$(1.22\text{kN/m}^2 \times 4.90\text{m} / 2)$
Variable	3.68 kN/m	$(1.50\text{kN/m}^2 \times 4.90\text{m} / 2)$

Full UDL (central)

Permanent	1.94 kN/m	$(1.22\text{kN/m}^2 \times 3.18\text{m} / 2)$
Variable	2.39 kN/m	$(1.50\text{kN/m}^2 \times 3.18\text{m} / 2)$

Analysis & Design

- Joists have been designed using the 'timber beam analysis and design' calculation on the TEKLA TEDDS software to BS EN 1995.
- The beam has been designed as service class 1.
- Deflection criteria: Permanent + Variable to not exceed span/250
- Assume built into existing walls. Therefore, 100mm bearing length.

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Check softwood (C16):



Show beam sketch for: Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam: Timber

Member details...

- 220 x 250 C16 timber section

Design options

Duration of loading: Medium-term

- Maximum deflection is 0.004 x span

Deflection criteria...

Preview results

	Capacity	Maximum	Utilisation	
Compressive stress	N/mm ² 1.354	0.986	0.728	✓
Bending stress	N/mm ² 9.846	10.589	1.075	✗
Shear stress	N/mm ² 1.969	0.883	0.448	✓
Total deflection	mm 20	27.932	1.397	✗

Output options

Output options...

220x250mm C16 unacceptable. Beam would need to be a minimum of C27:



Show beam sketch for: Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam: Timber

Member details...

- 220 x 250 C27 timber section

Design options

Duration of loading: Medium-term

- Maximum deflection is 0.004 x span

Deflection criteria...

Preview results

	Capacity	Maximum	Utilisation	
Compressive stress	N/mm ² 1.538	0.99	0.644	✓
Bending stress	N/mm ² 16.615	10.639	0.640	✓
Shear stress	N/mm ² 2.462	0.887	0.360	✓
Total deflection	mm 20	19.541	0.977	✓

Output options

Output options...

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Check D18:

mm 5000 1 A B

Show beam sketch for Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam Timber

Member details...

- 220 x 250 D18 timber section

Design options

i Duration of loading Medium-term

- Maximum deflection is 0.004 x span Deflection criteria...

Preview results

	Capacity	Maximum	Utilisation	
Compressive stress	N/mm ² 2.954	1	0.338	✓
Bending stress	N/mm ² 11.077	10.753	0.971	✓
Shear stress	N/mm ² 2.154	0.895	0.416	✓
Total deflection	mm 20	23.969	1.198	✗

Output options

Output options...

220x250mm D18 unacceptable. Beam would need to be a minimum of D35:

mm 5000 1 A B

Show beam sketch for Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam Timber

Member details...

- 220 x 250 D35 timber section

Design options

i Duration of loading Medium-term

- Maximum deflection is 0.004 x span Deflection criteria...

Preview results

	Capacity	Maximum	Utilisation	
Compressive stress	N/mm ² 3.323	1.005	0.302	✓
Bending stress	N/mm ² 21.538	10.817	0.502	✓
Shear stress	N/mm ² 2.523	0.9	0.357	✓
Total deflection	mm 20	19.109	0.955	✓

Output options

Output options...

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3.2.2 Eastern Truss

The truss located to the east of the chimney will also be analysed. This downstand beam spans 4.65m between external walls.

Loading

Full UDL (left and right)

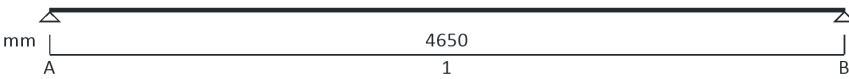
Permanent	2.36 kN/m	$(1.22\text{kN/m}^2 \times 3.87\text{m} / 2)$
Variable	2.90 kN/m	$(1.50\text{kN/m}^2 \times 3.87\text{m} / 2)$

Analysis & Design

- Joists have been designed using the 'timber beam analysis and design' calculation on the TEKLA TEDDS software to BS EN 1995.
- The beam has been designed as service class 1.
- Deflection criteria: Permanent + Variable to not exceed span/250
- Assume built into existing walls. Therefore, 100mm bearing length.

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Check softwood (C16):



mm 4650 1 A B

Show beam sketch for Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam Timber

Member details...

- 220 x 250 C16 timber section

Design options

i Duration of loading Medium-term

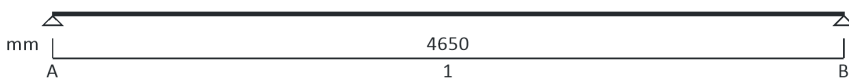
- Maximum deflection is 0.004 x span Deflection criteria...

Preview results

		Capacity	Maximum	Utilisation	
Compressive stress	N/mm ²	1.354	0.82	0.606	✓
Bending stress	N/mm ²	9.846	9.154	0.930	✓
Shear stress	N/mm ²	1.969	0.735	0.373	✓
Total deflection	mm	18.6	20.712	1.114	✗

Output options Output options...

220x260mm C16 unacceptable. Beam would need to be a minimum of C18:



mm 4650 1 A B

Show beam sketch for Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam Timber

Member details...

- 220 x 250 C18 timber section

Design options

i Duration of loading Medium-term

- Maximum deflection is 0.004 x span Deflection criteria...

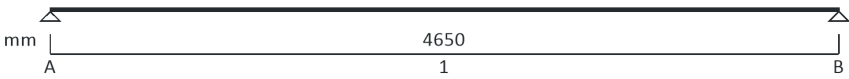
Preview results

		Capacity	Maximum	Utilisation	
Compressive stress	N/mm ²	1.354	0.821	0.606	✓
Bending stress	N/mm ²	11.077	9.163	0.827	✓
Shear stress	N/mm ²	2.092	0.735	0.351	✓
Total deflection	mm	18.6	18.436	0.991	✓

Output options Output options...

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Check D18:



Show beam sketch for Geometry

Beam analysis

Geometry...

Loading...

Combinations...

Member details

Type of beam Timber

Member details...

- 220 x 250 D18 timber section

Design options

i Duration of loading Medium-term

- Maximum deflection is 0.004 x span Deflection criteria...

Preview results

	Capacity	Maximum	Utilisation	
Compressive stress	N/mm ² 2.954	0.833	0.282	✓
Bending stress	N/mm ² 11.077	9.296	0.839	✓
Shear stress	N/mm ² 2.154	0.746	0.346	✓
Total deflection	mm 18.6	17.779	0.956	✓

Output options

Output options...

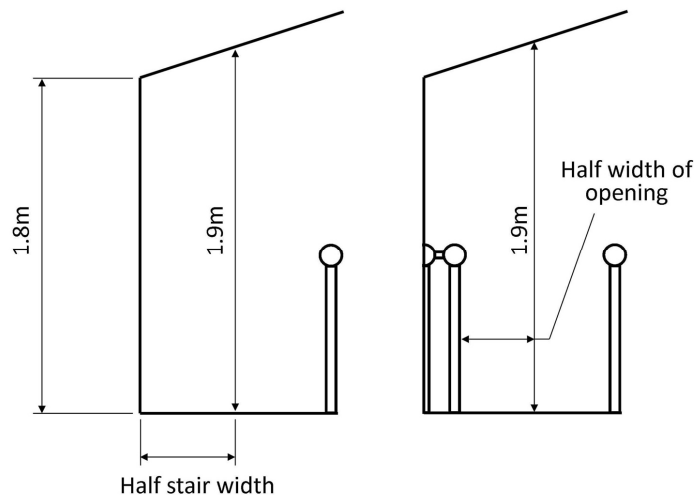
220x250mm D18 acceptable.

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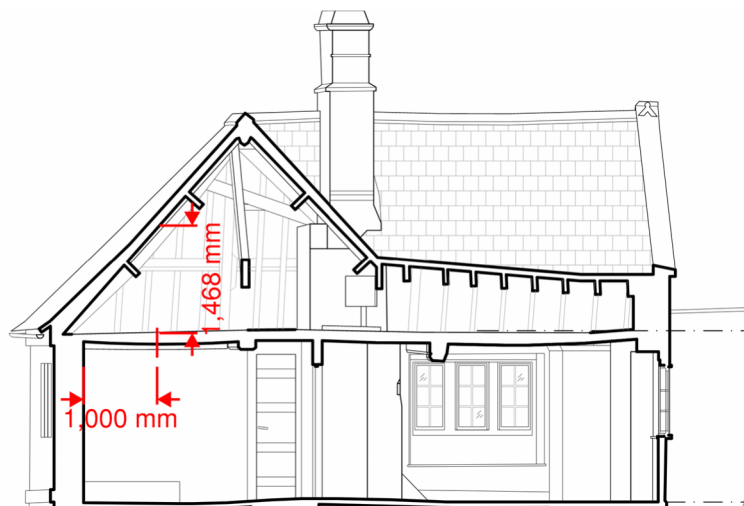
4.0 ROOF STRUCTURE

4.1 Existing Rafters

The existing stair into the loft space has very limited headroom above. The UK Building Regulations allow a reduced head height over a stair when part of a loft conversion. At the lowest point, the head height must be at least 1.8m. At the centre of the stair, the minimum head height must be 1.9m.



Looking at Section A-A provided on the 3D Building Survey Ltd drawing (sheet 7), it currently looks unlikely that a conforming head height is achievable over the current staircase (see markup below). However, we will look at the feasibility of removing the two purlins to increase the head height which will require the rafters to span the full length, unpropped. Based on the sketch below, it is unlikely that the purlin removal will increase the head height to acceptable levels. The levels over staircase should be checked with an architect before proceeding with any loft conversion works.



If the purlins are removed, the rafters will be required to span 3.7m between the external wall and the ridge. The rafters were measured as 75x75mm and are spaced at 400mm c/c.

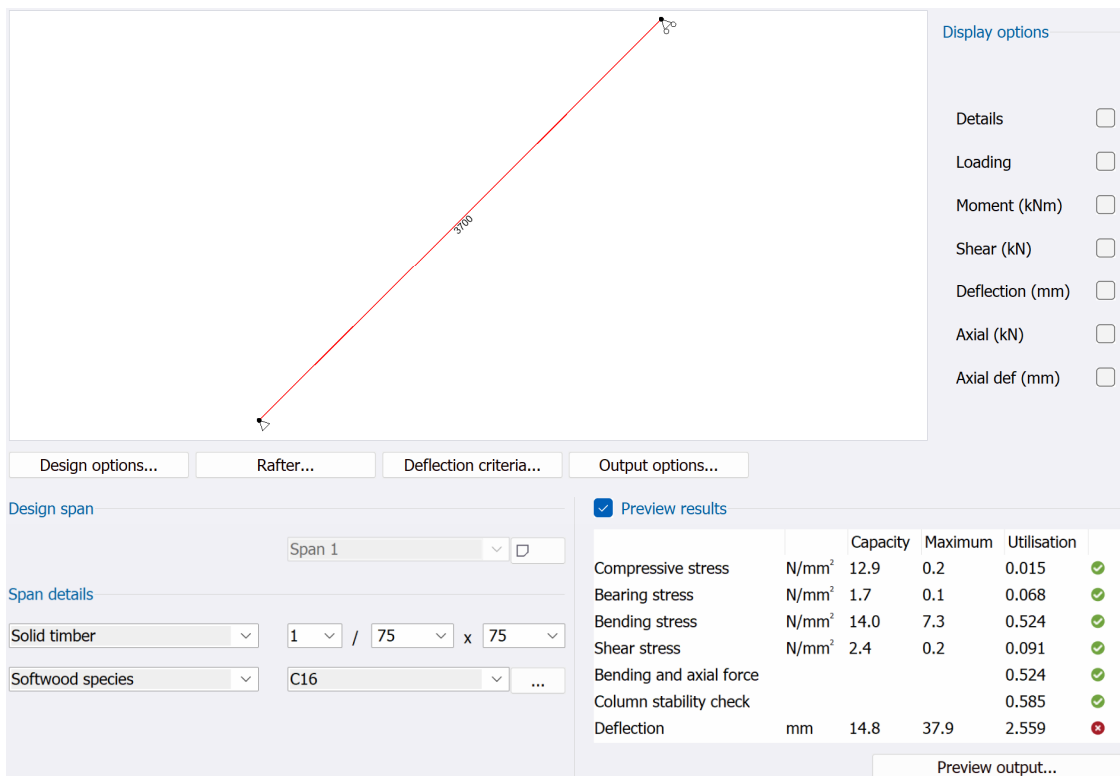
Netherby Cottage, Box	Project No:	SKEL_0201
Loft Conversion Calculations	Date started:	15/08/2024
Calc by: TC	Checked by:	PB

Loading

Permanent existing (on pitch)		0.51 kN/m ²
Variable (on plan)		0.30 kN/m ²
Wind	Lower zone	0.74 kN/m ²
	Upper zone	0.68 kN/m ²

Analysis & Design

- Rafters have been designed using the timber rafter designer calculation on the TEKLA TEDDS software to BS EN 1995.
- The rafters have been designed as service class 2.
- Deflection criteria: Permanent + Variable to not exceed span/250
- Variable load proportion = 0.37
- Quasi-permanent variable load factor = 0
- Assume supported on wall plate, therefore 100mm bearing length.



The screenshot shows the TEKLA TEDDS software interface. On the left, a 3D model of a rafter is displayed, with a red line indicating the span. The span is labeled 'Span 1' and '5700'. On the right, a 'Display options' panel is visible with checkboxes for Details, Loading, Moment (kNm), Shear (kN), Deflection (mm), Axial (kN), and Axial def (mm). Below the 3D model, there are buttons for 'Design options...', 'Rafter...', 'Deflection criteria...', and 'Output options...'. The 'Design span' section shows 'Span 1' selected. The 'Span details' section shows 'Solid timber' selected, with dimensions '1 / 75 x 75'. The 'Softwood species' section shows 'C16' selected. The 'Preview results' table is shown below, with columns for Capacity, Maximum, and Utilisation. The table contains the following data:

	Capacity	Maximum	Utilisation	
Compressive stress	N/mm ² 12.9	0.2	0.015	✓
Bearing stress	N/mm ² 1.7	0.1	0.068	✓
Bending stress	N/mm ² 14.0	7.3	0.524	✓
Shear stress	N/mm ² 2.4	0.2	0.091	✓
Bending and axial force			0.524	✓
Column stability check			0.585	✓
Deflection	mm 14.8	37.9	2.559	✗

Below the table, there is a button labeled 'Preview output...'.

C16 75x75 rafters @ 400mm c/c not acceptable. The calculation analyses the current loading condition on the roof and doesn't consider the added weight of insulation and plasterboard. Strengthening works will be required to remove the purlins and add finishes.