Summary of Outcome of Calculations on Capacity of Existing Roofs

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- With ballasting, the joists and frame beams are compliant, provided the equivalent "footprint" of the panels in sedum or paving is removed.
- Where the sedum/paving is not removed, the existing structure is marginally non-compliant.

Calculations

Timber sizes taken from original drawings – Grade C24 timber throughout. Calculations to BS5268-2:2002

Original Building

Check on Joists and Main (Frame) Beams – roof finishes include paving slabs

Dead Load: Say 1.6kN/m^2 (either layer of sedum or paving slabs)
Live Load: 0.75+0.4 (solar panels plus ballast): say 1.2kN/m^2

Where sedum/paving is removed, net dead load is say 0.7kN/m^2

From drawing 685/S/03:

Joists are 50 x 250 Grade C24 at 600 centres

For loading above:

JOISTS FROM ORIGINAL DRAWINGS

TIMBER JOIST DESIGN (BS5268-2:2002)

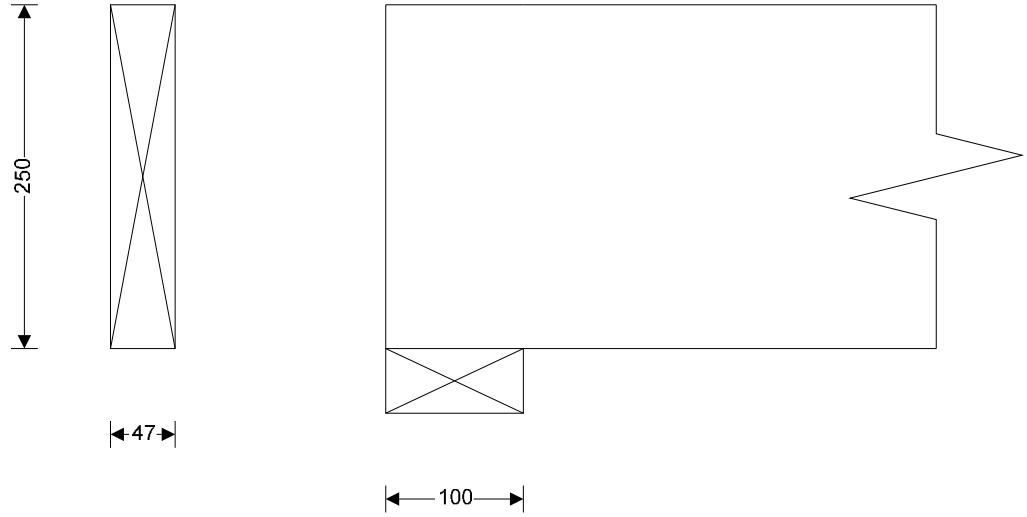
Tedds calculation version 1.1.04

Joist details

Joist breadth	b = 47 mm	Joist depth	h = 250 mm
Joist spacing	s = 600 mm	Service class of timber	1
Timber strength class	C24		

Span details

Number of spans	N_{span} = 1	Length of bearing	L_b = 100 mm
Clear length of span	L_{s1} = 4550 mm		



Section properties

Second moment of area	I = 61197917 mm^4	Section modulus	Z = 489583 mm^3

Loading details

Joist self weight	F_{swt} = 0.04 kN/m	Dead load	F_{d_udl} = 0.70 kN/m^2
Imposed UDL(Long term)	F_{i_udl} = 1.20 kN/m^2		
Imposed point load (Medium)	F_{i_pt} = 1.40 kN		

Consider long term loads

Design bending moment	M = 3.054 kNm	Design shear force	V = 2.685 kN
Design support reaction	R = 2.685 kN	Design deflection	δ = 10.428 mm

Check bending stress

Permissible bending stress	σ_{m_adm} = 8.417 N/mm^2	Applied bending stress	σ_{m_max} = 6.239 N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Permissible shear stress	τ_{adm} = 0.781 N/mm^2	Applied shear stress	τ_{max} = 0.343 N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Permissible bearing stress	σ_{c_adm} = 2.640 N/mm^2	Applied bearing stress	σ_{c_max} = 0.571 N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection	δ_{adm} = 13.650 mm	Actual deflection	δ = 10.428 mm

PASS - Actual deflection within permissible limits

Consider medium term loads

Design bending moment	M = 2.784 kNm	Design shear force	V = 2.447 kN
Design support reaction	R = 2.447 kN	Design deflection	δ = 8.465 mm

Check bending stress

Permissible bending stress	σ_{m_adm} = 10.521 N/mm^2	Applied bending stress	σ_{m_max} = 5.686 N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Permissible shear stress	τ_{adm} = 0.976 N/mm^2	Applied shear stress	τ_{max} = 0.312 N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Permissible bearing stress σ_{c_adm} = 3.300 N/mm^2 Applied bearing stress σ_{c_max} = 0.521 N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection δ_{adm} = 13.650 mm Actual deflection δ = 8.465 mm

PASS - Actual deflection within permissible limits

Supporting Beams

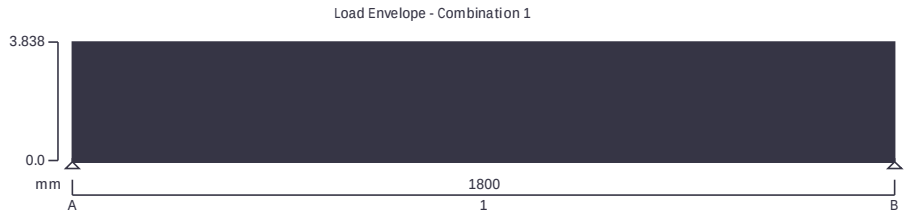
Frame A: 50 x 200 C24 spanning 2000 (Frame F similar)

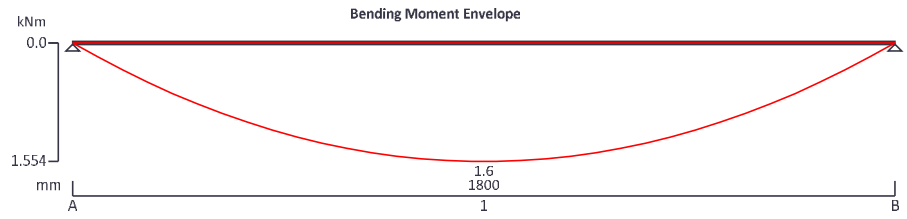
Supporting loads:
Dead Load: 0.7*2 = 1.40kN/m
Live Load: 1.2*2 = 2.4kN/m

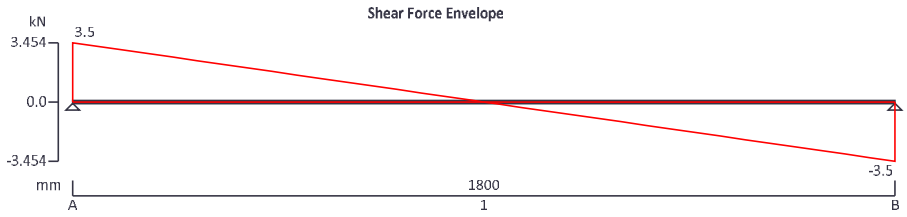
FRAME A BEAM

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.7.01







Applied loading

Beam loads

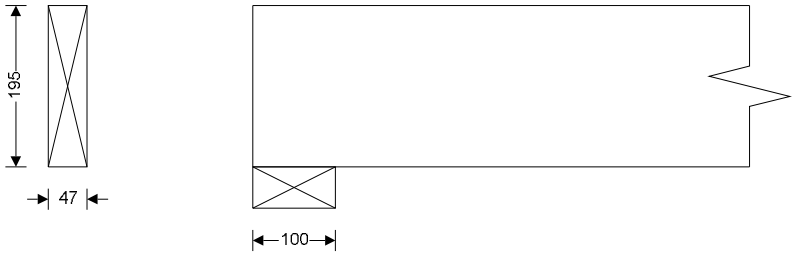
Dead self weight of beam × 1
Dead full UDL 1.400 kN/m
Imposed full UDL 2.400 kN/m

Load combinations

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

Analysis results

Design moment	M = 1.554 kNm	Design shear	F = 3.454 kN
Total load on beam	W_{tot} = 6.908 kN		
Reactions at support A	R_{A_max} = 3.454 kN	R_{A_min} = 3.454 kN	
Unfactored dead load reaction at support A	R_{A_Dead} = 1.294 kN		
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = 2.160 kN		
Reactions at support B	R_{B_max} = 3.454 kN	R_{B_min} = 3.454 kN	
Unfactored dead load reaction at support B	R_{B_Dead} = 1.294 kN		
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = 2.160 kN		



Timber section details

Breadth of section	b = 47 mm	Depth of section	h = 195 mm
Number of sections	N = 1	Breadth of beam	b_b = 47 mm
Timber strength class	C24		

Member details

Service class of timber	1	Load duration	Long term
Length of span	L_{s1} = 1800 mm		
Length of bearing	L_b = 100 mm		

Lateral support - cl.2.10.8

Permiss.depth-to-breadth ratio	5.00	Actual depth-to-breadth ratio	4.15

PASS - Lateral support is adequate

Check bearing stress

Permissible bearing stress	σ_{c_adm} = 2.400 N/mm^2	Applied bearing stress	σ_{c_a} = 0.735 N/mm^2

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress	σ_{m_adm} = 7.864 N/mm^2	Applied bending stress	σ_{m_a} = 5.218 N/mm^2

PASS - Applied bending stress is less than permissible bending stress

Shear parallel to grain

Permissible shear stress $\tau_{adm} = 0.710$ N/mm^2 Applied shear stress $\tau_a = 0.565$ N/mm^2

PASS - Applied shear stress is less than permissible shear stress

Deflection

Permissible deflection $\delta_{adm} = 5.400$ mm Total deflection $\delta_a = 2.961$ mm

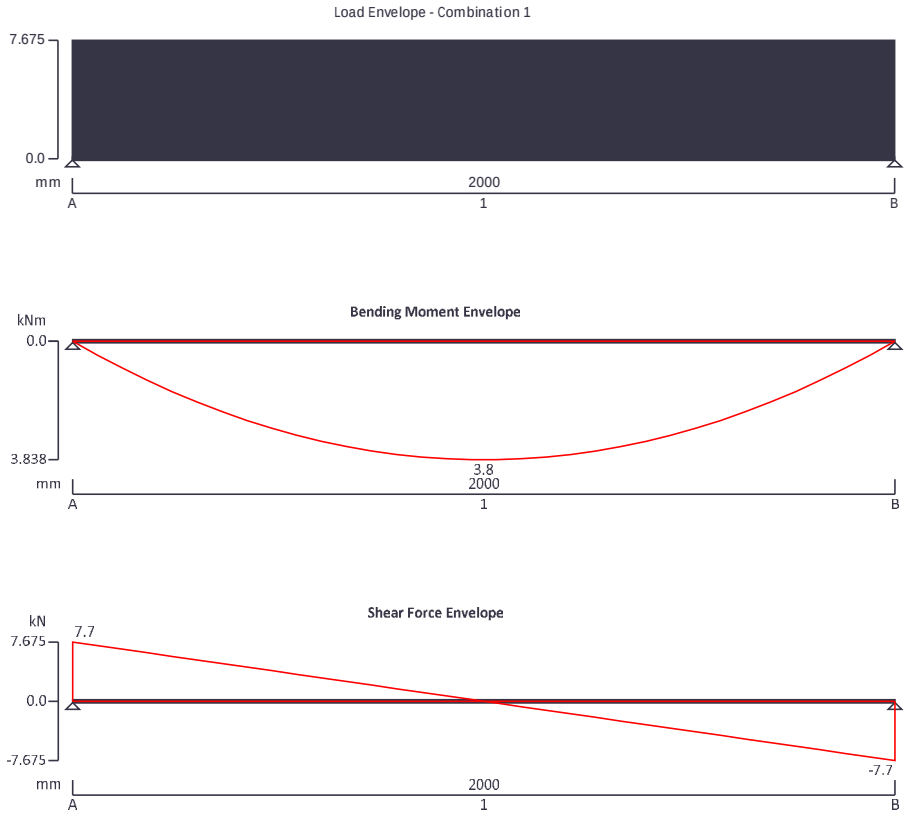
PASS - Total deflection is less than permissible deflection

Frame B: 2 x 50 x 200 C24 spanning 2000 (Double above loads and joists). Frames C and D similar

FRAME B BEAM

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.7.01



Applied loading

Beam loads

Dead self weight of beam × 1

Dead full UDL 2.800 kN/m

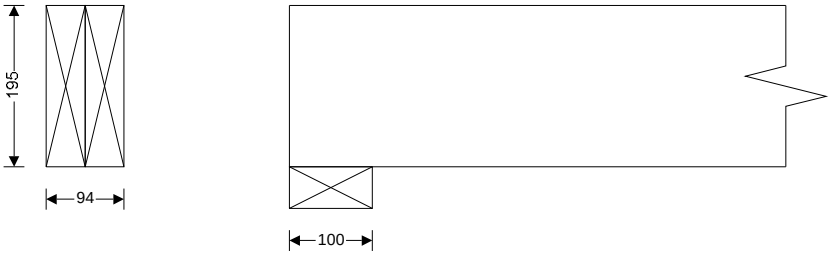
Imposed full UDL 4.800 kN/m

Load combinations

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

Analysis results

Design moment	M = 3.838 kNm	Design shear	F = 7.675 kN
Total load on beam	W_{tot} = 15.351 kN		
Reactions at support A	R_{A_max} = 7.675 kN	R_{A_min} = 7.675 kN	
Unfactored dead load reaction at support A	R_{A_Dead} = 2.875 kN		
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = 4.800 kN		
Reactions at support B	R_{B_max} = 7.675 kN	R_{B_min} = 7.675 kN	
Unfactored dead load reaction at support B	R_{B_Dead} = 2.875 kN		
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = 4.800 kN		



Timber section details

Breadth of section	b = 47 mm	Depth of section	h = 195 mm
Number of sections	N = 2	Breadth of beam	b_b = 94 mm
Timber strength class	C24		

Member details

Service class of timber	1	Load duration	Long term
Length of span	L_{s1} = 2000 mm		
Length of bearing	L_b = 100 mm		

Lateral support - cl.2.10.8

Permiss.depth-to-breadth ratio	4.00	Actual depth-to-breadth ratio	2.07

PASS - Lateral support is adequate

Check bearing stress

Permissible bearing stress	σ_{c_adm} = 2.400 N/mm^2	Applied bearing stress	σ_{c_a} = 0.817 N/mm^2

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress	σ_{m_adm} = 7.864 N/mm^2	Applied bending stress	σ_{m_a} = 6.442 N/mm^2

PASS - Applied bending stress is less than permissible bending stress

Shear parallel to grain

Permissible shear stress	τ_{adm} = 0.710 N/mm^2	Applied shear stress	τ_a = 0.628 N/mm^2

PASS - Applied shear stress is less than permissible shear stress

Deflection

Permissible deflection δ_{adm} = 6.000 mm Total deflection δ_a = 4.382 mm

PASS - Total deflection is less than permissible deflection