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PEARL ENGINEERS, PLANNERS & PROJECT MANAGERS

STRUCTURAL CALCULATION REPORT

Client Name

Client Address 25 Sudbourne Rd

Project Reference: 2024-07-SW2 5AE

02 TOWERFIELDS WESTERHAM ROAD
BROMLEY, BR2 6HF

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Document Control:

Purpose/Status	Date	Rev.	Comments	Structural Engineer
Approval Issue	19/07/2024		B'Regs Issue	MM

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Project Information

Design Codes – Eurocodes and their respective National Annexes:

BS EN 1990. Eurocode 0: 'Basis of structural design'

BS EN 1991. Eurocode 1: 'Actions on structures'

BS EN 1992. Eurocode 2: 'Design of concrete structures'

BS EN 1993. Eurocode 3: 'Design of steel structures'

BS EN 1995. Eurocode 5: 'Design of timber structures'

BS EN 1996. Eurocode 6: 'Design of masonry structures' BS EN

1997. Eurocode 7: 'Geotechnical Design'

ASSUMPTIONS

THE FOLLOWING ASSUMPTIONS ARE MADE ABOUT THE SITE. THEY ARE TO BE CHECKED ON SITE BY THE CONTRACTOR AND BUILDING CONTROL OFFICER PRIOR TO THE START OF THE WORKS. ANY DIFFERENCES ARE TO BE REPORTED TO PEPP IMMEDIATELY.

1. The existing masonry is assumed to be minimum 3.6N/mm^2 blockwork in a 1:2:8 mortar
2. Floor joists are assumed to span as indicated on the drawings.
3. The external walls are assumed to be cavity brickwork.

NOTES

Contractor to check all dimensions before ordering any steel.

All materials and workmanship must fully comply with all relevant current British Standard and Codes of practice.

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Project: 25 Sudbourne Rd SW2 5AE UK			**Sheet No./Rev.** 4
Job Ref. 2024-07-SW2 5AE	**Structural Engineer** **MM**		**Date 19/07/2024**

ITEMS

1. **LOADING DETAILS**

2. **TIMBER DESIGN**

- **Roof Truss**
  (T.C. 47x150, B.C. 47x150)
- **Double Trimmer** (2) (47 x 150) (C-24)

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	Job Ref. 2024-07-SW2 5AE | **Structural Engineer** **MM**	**Date** **19/07/2024**

1. LOADING DETAILS

PITCHED ROOF			
Clay Tiles	=	0.65	KN/m^2
Felt and battens	=	0.05	KN/m^2
Timber rafters	=	0.1	KN/m^2
Insulations and other membranes	=	0.1	KN/m^2
Ceiling and services	=	0.2	KN/m^2
Total dead load on the slope	**=**	**1.1**	$\mathbf{KN/m^2}$
Live Load	**=**	**0.6**	$\mathbf{KN/m^2}$
LOFT FLOOR			
Plywood Flooring	=	0.15	KN/m^2
Timber Joists	=	0.2	KN/m^2
Insulation	=	0.05	KN/m^2
Ceiling and services	=	0.2	KN/m^2
Partitions	=	0.5	KN/m^2
Total dead load	**=**	**1.10**	$\mathbf{KN/m^2}$
Live Load	**=**	**1.5**	$\mathbf{KN/m^2}$
FIRST FLOOR			
Plywood Flooring	=	0.15	KN/m2
Timber Joists	=	0.2	KN/m2
Insulation	=	0.05	KN/m2
Ceiling and services	=	0.2	KN/m2
Partitions	=	0.5	KN/m^2
Total dead load	=	1.10	$\mathbf{KN/m^2}$
Live Load	=	1.5	$\mathbf{KN/m^2}$
WALL LOADS			
Brick wall (102 mm)	=	2	KN/m^2
Brick wall with plaster	=	1.9	KN/m^2
Glazing	=	0.5	KN/m^2

2. TIMBER DESIGN

- **Roof Truss**

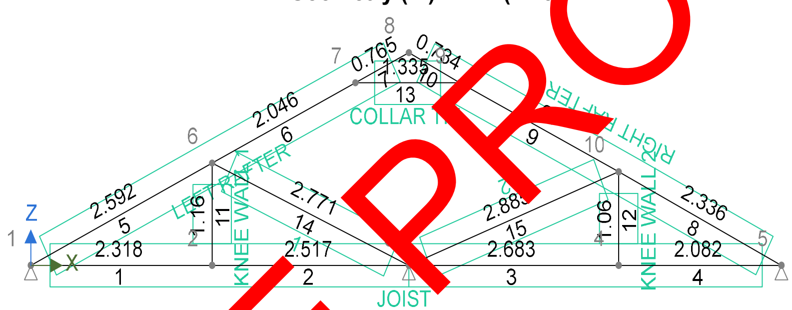
TIMBER MEMBER ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the recommended values

ANALYSIS

Geometry

Geometry (m) - C24 (EC5)



Materials

Name	Density (kg/m³)	Youngs Modulus kN/mm²	Shear Modulus kN/mm²	Thermal Coefficient °C⁻¹
C24 (EC5)	420	11	0.69	0

Sections

Name	Area (cm²)	Moment of inertia Major (cm⁴)	Moment of inertia Minor (cm⁴)	Shear area parallel to Minor (cm²)	Shear area parallel to Major (cm²)
47x150	71	1322	130	59	59
35x100	35	292	36	29	29
47x150 5	71	1322	130	59	59
55x65	36	126	90	30	30

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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	2.318	0	Free	Free	Free		0	0	0	0
3	4.835	0	Fixed	Fixed	Free		0	0	0	0
4	7.518	0	Free	Free	Free		0	0	0	0
5	9.6	0	Fixed	Fixed	Free		0	0	0	0
6	2.318	1.16	Free	Free	Free		0	0	0	0
7	4.15	2.07	Free	Free	Free		0	0	0	0
8	4.835	2.41	Free	Free	Free		0	0	0	0
9	5.485	2.07	Free	Free	Free		0	0	0	0
10	7.518	1.06	Free	Free	Free		0	0	0	0

Elements

Element	Length (m)	Nodes		Section	Material	Releases			Rotated
		Start	End			Start moment	End moment	Axial	
1	2.318	1	2	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
2	2.517	2	3	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
3	2.683	3	4	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
4	2.082	4	5	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
5	2.592	1	6	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
6	2.046	6	7	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
7	0.765	7	8	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
8	2.336	5	10	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
9	2.27	10	9	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
10	0.734	9	8	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
11	1.16	2	6	47x150 5	C24 (EC5)	Fixed	Fixed	Fixed	
12	1.06	4	10	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
13	1.335	7	9	35x100	C24 (EC5)	Fixed	Fixed	Fixed	
14	2.771	6	3	55x65	C24 (EC5)	Fixed	Fixed	Fixed	
15	2.885	10	3	55x65	C24 (EC5)	Fixed	Fixed	Fixed	

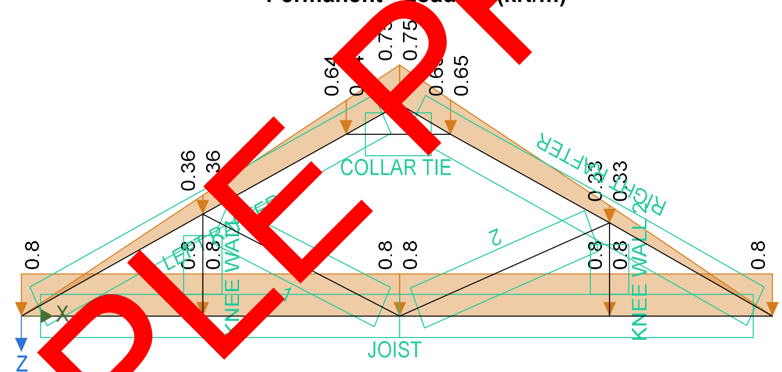
Members

Name	Elements	
	Start	End
JOIST	1	4
LEFT RAFTER	5	7
RIGHT RAFTER	8	10
KNEE WALL 1	11	11
KNEE WALL 2	12	12
COLLAR TIE	13	13
1	14	14
2	15	15

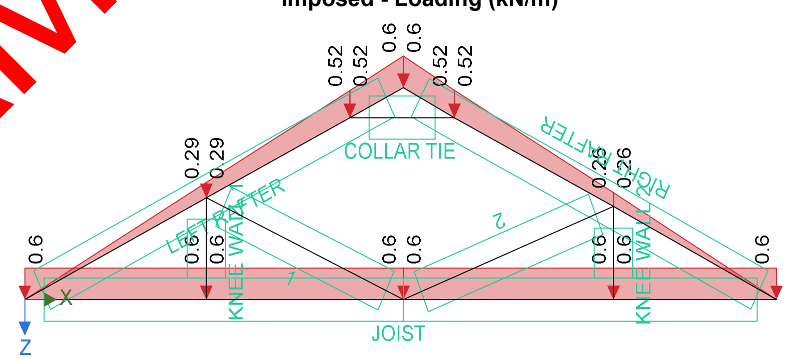
Loading

Self weight included

Permanent - Loading (kN/m)



Imposed - Loading (kN/m)



Load combination factors

Load combination	Self Weight	Permanent	Imposed
LoadCombination1 (Service)	1.00	1.00	1.00
LoadCombination2 (Strength)	1.00	1.35	1.50

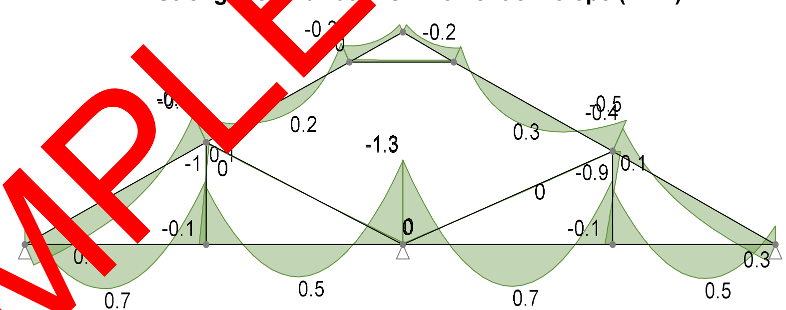
Member Loads

Member	Load case	Load Type	Orientation	Description
JOIST	Permanent	UDL	GlobalZ	0.8 kN/m
LEFT RAFTER	Permanent	VDL	GlobalZ	0 kN/m to 0.75 kN/m
RIGHT RAFTER	Permanent	VDL	GlobalZ	0 kN/m to 0.75 kN/m
JOIST	Imposed	UDL	GlobalZ	0.6 kN/m
LEFT RAFTER	Imposed	VDL	GlobalZ	0 kN/m to 0.6 kN/m
RIGHT RAFTER	Imposed	VDL	GlobalZ	0 kN/m to 0.6 kN/m

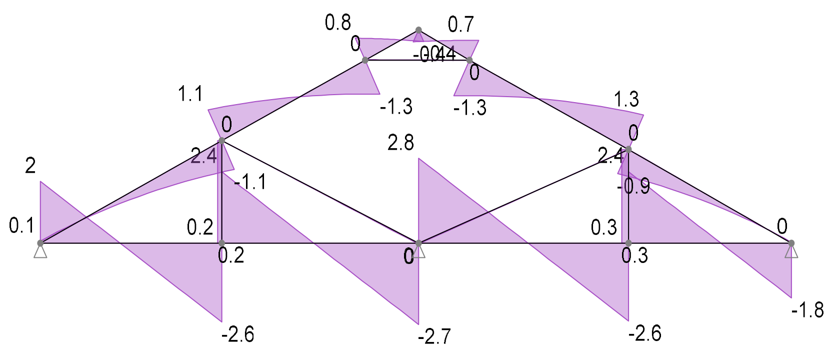
Results

Forces

Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



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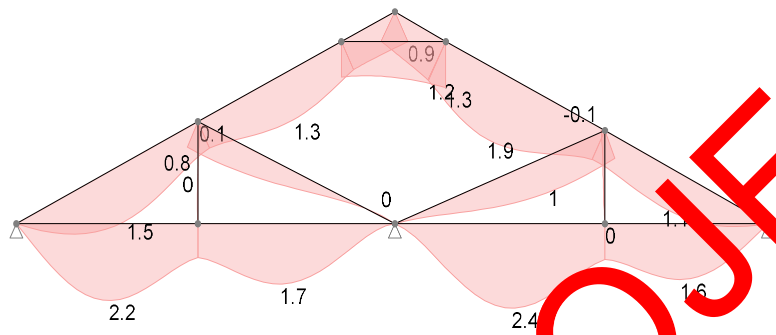
Service combinations - Deflection envelope (mm)



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JOIST - Span 1

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Medium-term

Service class - cl.2.3.1.3; 2

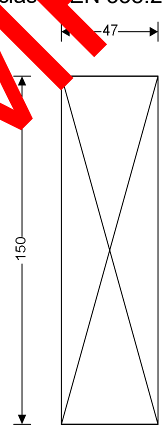
Timber section details

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

Breadth of sections; b = **47** mm

Depth of sections; h = **150** mm

Timber strength class - EN 338:2016 Table 1; **C24**



47x150 timber section

Cross-sectional area, A, 7050 mm^2

Section modulus, W_y, 176250 mm^3

Section modulus, W_z, 55225 mm^3

Second moment of area, I_y, 13218750 mm^4

Second moment of area, I_z, 1297787 mm^4

Radius of gyration, i_y, 43.3 mm

Radius of gyration, i_z, 13.6 mm

Timber strength class C24

Characteristic bending strength, $f_{m.k}$, 24 N/mm^2

Characteristic shear strength, $f_{v.k}$, 4 N/mm^2

Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2

Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2

Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2

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

Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2

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

Characteristic density, ρ_k, 350 kg/m^3

Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

<u>Consider Combination 2 - LoadCombination2 (Strength)</u>

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.8**

Deformation factor - Table 3.2; k_{def} = **0.8**

Depth factor for tension - exp.3.1; $k_{h,t}$ = **1**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Load configuration factor - cl.6.1.5(4); $k_{c,90}$ = **1.5**

Check tension parallel to the grain - Section 6.1.2

Axial tension; P_d = **0.078** kN

Design tensile stress; $\sigma_{t,0,d} = P_d / (b \times \min(h_{ef\_e1}, h_{ef\_e2}))$ = **0.009** N/mm^2

Design tensile strength; $f_{t,0,d} = k_{h,t} \times k_{mod} \times f_{t.0.k} / \gamma_M$ = **8.923** N/mm^2

$\sigma_{t,0,d} / f_{t,0,d}$ = **0.001**

PASS - Design tensile strength exceeds design tensile stress

<u>Check design at end of span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **2.693** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.855** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.462** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.347**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **1.305** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **7.401** N/mm^2

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

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.501**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.525**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.375**

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 bending; $L_{e,y} = 0.9 \times 4835$ mm = **4352** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **100.494**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{f_{c.0.k} / E_{0.05}}$ = **1.704**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

Relative slenderness ratio - exp. 6.22; $\lambda_{rel,z} = \lambda_z / \pi \times \sqrt{f_{c.0.k} / E_{0.05}}$ = **0**

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

Straightness factor;	β_c = **0.2**
Instability factors - exp.6.25, 6.26, 6.27 & 6.28;	$k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **2.0[illegible]**
	$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**
	$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.302**
	$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.0[illegible]**
Column stability checks - exp.6.23 & 6.24;	$\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **1.0[illegible]**
	$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.[illegible]7**

PASS - Column stability is acceptable

<u>Consider Combination 1 - LoadCombination1 (Service)</u>

<u>Check design 1187 mm along span</u>

Check y-y axis deflection - Section 7.2

Instantaneous deflection;	δ_y = **[illegible].2** mm
Final deflection;	$\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **3.9** mm
Allowable deflection;	$\delta_{y,Allowable} = L_{m1\_s1} / 250$ = **19.3** mm
	$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.202**

PASS - Allowable deflection exceeds final deflection

<u>JOIST - Span 2</u>

Partial factor for material properties and resistances

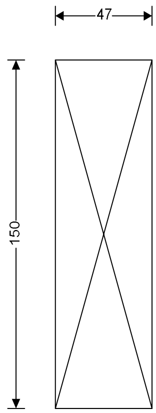
Partial factor for material properties - Table 2.3;	γ_M = **1.300**

Member details

Load duration - cl.2.3.1.2;	Medium-term
Service class - cl.2.3.1.3;	2

Timber section details

Number of timber sections in member;	N = **1**
Breadth of sections;	b = **47** mm
Depth of sections;	h = **150** mm
Timber strength class - EN 338:2016 Table 1;	**C24**



47x150 timber section
Cross-sectional area, A, 7050 mm^2
Section modulus, W_y, 176250 mm^3
Section modulus, W_z, 55225 mm^3
Second moment of area, I_y, 13218750 mm^4
Second moment of area, I_z, 1297787 mm^4
Radius of gyration, i_y, 43.3 mm
Radius of gyration, i_z, 13.6 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm^2
Characteristic shear strength, $f_{v.k}$, 4 N/mm^2
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm^2
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2
Shear modulus of elasticity, G_{mean}, 690 N/mm^2
Characteristic density, ρ_k, 350 kg/m^3
Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

Consider Combination 2 - LoadCombination2 (Strength)

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.8**
Deformation factor - Table 3.2; k_{def} = **0.8**
Depth factor for tension - exp.3.1; $k_{h,t}$ = **1**
Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**
Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**
Load configuration factor - cl.6.1.5(4); $k_{c,90}$ = **1.5**
System strength factor - cl.6.6; k_{sys} = **1.1**

Check tension parallel to the grain - Section 6.1.2

Axial tension; P_d = **0.113** kN
Design tensile stress; $\sigma_{t,0,d} = P_d / (b \times \min(h_{ef\_e1}, h_{ef\_e2}))$ = **0.012** N/mm^2
Design tensile strength; $f_{t,0,d} = k_{h,t} \times k_{mod} \times k_{sys} \times f_{t.0.k} / \gamma_M$ = **9.815** N/mm^2
$\sigma_{t,0,d} / f_{t,0,d}$ = **0.001**

PASS - Design tensile strength exceeds design tensile stress

Check design at start of span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **2.811** kN
Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.893** N/mm^2
Design shear strength; $f_{v,y,d} = k_{mod} \times k_{sys} \times f_{v.k} / \gamma_M$ = **2.708** N/mm^2
$\tau_{y,d} / f_{v,y,d}$ = **0.330**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **1.317** kNm

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Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y =$ **7.472** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times k_{sys} \times f_{m.k} / \gamma_M =$ **16.246** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d} =$ **0.46**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18; $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d} =$ **0.461**

$\sigma_{t,0,d} / f_{t,0,d} + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.323**

PASS - Combined bending and axial tension utilisation is acceptable

<u>Check design 2683 mm along span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d} =$ **2.579** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h) =$ **0.819** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times k_{sys} \times f_{v.k} / \gamma_M =$ **2.708** N/mm^2

$\tau_{y,d} / f_{v,y,d} =$ **[illegible]**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d} =$ **1.005** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y =$ **5.701** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times k_{sys} \times f_{m.k} / \gamma_M =$ **16.246** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d} =$ **0.351**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} =$ **0.375**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.270**

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 bending; $L_{e,y} = 0.9 \times 4765$ mm $=$ **4289** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y =$ **99.039**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})} =$ **1.679**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z =$ **0**

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

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

Straightness factor; $\beta_c =$ **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2) =$ **2.048**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) =$ **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) =$ **0.311**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) =$ **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} =$ **0.853**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.392**

PASS - Column stability is acceptable

<u>Consider Combination 1 - LoadCombination1 (Service)</u>

<u>Check design 1497 mm along span</u>

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **2.4** mm

Final deflection; $\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **4.3** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m1\_s2} / 250$ = **19.1** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.225**

PASS - Allowable deflection exceeds final deflection

<u>LEFT RAFTER - Span 1</u>

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Short-term

Service class - cl.2.3.1.3; 2

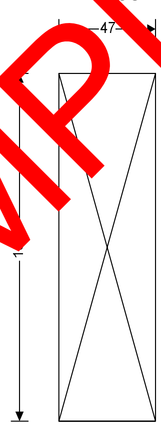
Timber section details

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

Breadth of sections; b = **47** mm

Depth of sections; h = **150** mm

Timber strength class - EN 338:2016 Table 7; **C24**



47x150 timber section
Cross-sectional area, A, 7050 mm^2
Section modulus, W_y, 176250 mm^3
Section modulus, W_z, 55225 mm^3
Second moment of area, I_y, 13218750 mm^4
Second moment of area, I_z, 1297787 mm^4
Radius of gyration, i_y, 43.3 mm
Radius of gyration, i_z, 13.6 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm^2
Characteristic shear strength, $f_{v.k}$, 4 N/mm^2
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm^2
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2
Shear modulus of elasticity, G_{mean}, 690 N/mm^2
Characteristic density, ρ_k, 350 kg/m^3
Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

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Consider Combination 2 - LoadCombination2 (Strength)

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.9**

Deformation factor - Table 3.2; k_{def} = **0.8**

Depth factor for tension - exp.3.1; $k_{h,t}$ = **1**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Check compression parallel to the grain - cl.6.1.4

Design axial compression; P_d = **15.093** kN

Design compressive stress; $\sigma_{c,0,d} = P_d / A$ = **2.141** N/mm²

Design compressive strength; $f_{c,0,d} = k_{mod} \times f_{c,0,k} / \gamma_M$ = **[illegible]** N/mm²

$\sigma_{c,0,d} / f_{c,0,d}$ = **0.[illegible]47**

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design 2592 mm along span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **1.14[illegible]** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.363** N/mm²

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.769** N/mm²

$\tau_{y,d} / f_{v,y,d}$ = **0.131**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.484** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **2.747** N/mm²

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **16.615** N/mm²

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.165**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.187**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.137**

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 bending; $L_{e,y} = 0.9 \times 5402$ mm = **4862** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **112.278**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **1.904**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **2.473**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) =$ **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) =$ **0.247**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) =$ **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} =$ **0.762**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.254**

PASS - Column stability is acceptable

Check design 4638 mm along span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d} =$ **1.255** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h) =$ **0.399** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v,k} / \gamma_M =$ **2.7[illegible]9** N/mm^2

$\tau_{y,d} / f_{v,y,d} =$ **0.14[illegible]**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d} =$ **0.[illegible]26** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y =$ **1.849** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M =$ **16.615** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d} =$ **0.111**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} =$ **0.133**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.100**

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 bending; $L_{e,y} = 0.9 \times 5402$ mm $=$ **4862** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y =$ **112.278**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})} =$ **1.904**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z =$ **0**

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

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

Straightness factor; $\beta_c =$ **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2) =$ **2.473**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) =$ **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) =$ **0.247**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) =$ **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} =$ **0.708**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.216**

PASS - Column stability is acceptable

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Consider Combination 1 - LoadCombination1 (Service)

Check design 1280 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **1.5** mm

Final deflection; $\delta_{y,Final} = \delta_y$ ´ $(1 + k_{def})$ = **2.7** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m2\_s1} / 250$ = **21.6** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.123**

PASS - Allowable deflection exceeds final deflection

RIGHT RAFTER - Span 1

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Short-term

Service class - cl.2.3.1.3; 2

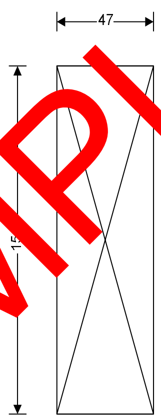
Timber section details

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

Breadth of sections; b = **47** mm

Depth of sections; h = **150** mm

Timber strength class - EN 338:2016 Table 1; **C24**



47x150 timber section
Cross-sectional area, A, 7050 mm^2
Section modulus, W_y, 176250 mm^3
Section modulus, W_z, 55225 mm^3
Second moment of area, I_y, 13218750 mm^4
Second moment of area, I_z, 1297787 mm^4
Radius of gyration, i_y, 43.3 mm
Radius of gyration, i_z, 13.6 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm^2
Characteristic shear strength, $f_{v.k}$, 4 N/mm^2
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm^2
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2
Shear modulus of elasticity, G_{mean}, 690 N/mm^2
Characteristic density, ρ_k, 350 kg/m^3
Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

Consider Combination 2 - LoadCombination2 (Strength)

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.9**

Deformation factor - Table 3.2; k_{def} = **0.8**

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	Job Ref. 2024-07-SW2 5AE	**Structural Engineer** **MM**	**Date** **19/07/2024**

Depth factor for tension - exp.3.1; $k_{h,t}$ = **1**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Check compression parallel to the grain - cl.6.1.4

Design axial compression; P_d = **15.34** kN

Design compressive stress; $\sigma_{c,0,d} = P_d / A$ = **2.176** N/mm^2

Design compressive strength; $f_{c,0,d} = k_{mod} \times f_{c.0.k} / \gamma_M$ = **14.538** N/mm^2

$\sigma_{c,0,d} / f_{c,0,d}$ = **0.150**

PASS - Design parallel compression strength exceeds design parallel compression stress

<u>Check design 2336 mm along span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **1.271** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.404** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.769** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.146**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.537** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **3.045** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **16.615** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.183**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.206**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.151**

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 bending; $L_{e,y} = 0.9 \times 5340$ mm = **4806** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **110.99**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **1.882**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **2.429**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.252**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **0.777**

$\sigma_{c,0,d}$ / ($k_{c,z}$ × $f_{c,0,d}$) + k_m × $\sigma_{m,y,d}$ / $f_{m,y,d}$ = **0.269**

PASS - Column stability is acceptable

<u>Check design 4606 mm along span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **1.315** kN

Design shear stress - exp.6.60; $\tau_{y,d}$ = 1.5 × $F_{y,d}$ / (k_{cr} × b × h) = **0.418** N/mm^2

Design shear strength; $f_{v,y,d}$ = k_{mod} × $f_{v.k}$ / γ_M = **2.769** N/mm^2

$\tau_{y,d}$ / $f_{v,y,d}$ = **0.151**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.274** kNm

Design bending stress; $\sigma_{m,y,d}$ = $M_{y,d}$ / W_y = **1.555** N/mm^2

Design bending strength; $f_{m,y,d}$ = k_{mod} × $f_{m.k}$ / γ_M = **16.615** N/mm^2

$\sigma_{m,y,d}$ / $f_{m,y,d}$ = **0.094**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; ($\sigma_{c,0,d}$ / $f_{c,0,d}$)^2 + $\sigma_{m,y,d}$ / $f_{m,y,d}$ = **0.116**

($\sigma_{c,0,d}$ / $f_{c,0,d}$)^2 + k_m × $\sigma_{m,y,d}$ / $f_{m,y,d}$ = **0.088**

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 bending; $L_{e,y}$ = 0.9 × 5340 mm = **4806** mm

Slenderness ratio; λ_y = $L_{e,y}$ / i_y = **110.99**

Relative slenderness ratio - exp.6.21; $\lambda_{rel,y}$ = λ_y / π × $\sqrt{(f_{c.0.k} / E_{0.05})}$ = **1.882**

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

Slenderness ratio; λ_z = $L_{e,z}$ / i_z = **0**

Relative slenderness ratio - exp. 6.22; $\lambda_{rel,z}$ = λ_z / π × $\sqrt{(f_{c.0.k} / E_{0.05})}$ = **0**

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; k_y = 0.5 × (1 + β_c × ($\lambda_{rel,y}$ - 0.3) + $\lambda_{rel,y}^2$) = **2.429**

k_z = 0.5 × (1 + β_c × ($\lambda_{rel,z}$ - 0.3) + $\lambda_{rel,z}^2$) = **0.470**

$k_{c,y}$ = 1 / (k_y + $\sqrt{(k_y^2 - \lambda_{rel,y}^2)}$) = **0.252**

$k_{c,z}$ = 1 / (k_z + $\sqrt{(k_z^2 - \lambda_{rel,z}^2)}$) = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d}$ / ($k_{c,y}$ × $f_{c,0,d}$) + $\sigma_{m,y,d}$ / $f_{m,y,d}$ = **0.687**

$\sigma_{c,0,d}$ / ($k_{c,z}$ × $f_{c,0,d}$) + k_m × $\sigma_{m,y,d}$ / $f_{m,y,d}$ = **0.206**

PASS - Column stability is acceptable

<u>Consider Combination 1 - LoadCombination1 (Service)</u>

<u>Check design 3644 mm along span</u>

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **1.9** mm

Final deflection; $\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **3.4** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m3\_s1} / 250$ = **21.4** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.159**

PASS - Allowable deflection exceeds final deflection

<u>KNEE WALL 1 - Span 1</u>

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Long-term

Service class - cl.2.3.1.3; 1

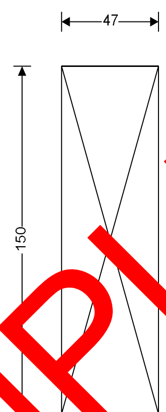
Timber section details

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

Breadth of sections; b = **47** mm

Depth of sections; h = **150** mm

Timber strength class - EN 338:2016 Table 1; **C24**



47x150 timber section
Cross-sectional area, A, 7050 mm²
Section modulus, W_y, 176250 mm³
Section modulus, W_z, 55225 mm³
Second moment of area, I_y, 13218750 mm⁴
Second moment of area, I_z, 1297787 mm⁴
Radius of gyration, i_y, 43.3 mm
Radius of gyration, i_z, 13.6 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm²
Characteristic shear strength, $f_{v.k}$, 4 N/mm²
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm²
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm²
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm²
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm²
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm²
Shear modulus of elasticity, G_{mean}, 690 N/mm²
Characteristic density, ρ_k, 350 kg/m³
Mean density, ρ_{mean}, 420 kg/m³

Span details

Bearing length; L_b = **100** mm

<u>Consider Combination 2 - LoadCombination2 (Strength)</u>

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.7**

Deformation factor - Table 3.2; k_{def} = **0.6**

Depth factor for tension - exp.3.1; $k_{h,t}$ = **1**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Check tension parallel to the grain - Section 6.1.2

Axial tension; P_d = **4.975** kN

Design tensile stress; $\sigma_{t,0,d} = P_d / (b \times \min(h_{ef\_e1}, h_{ef\_e2}))$ = **0.543** N/mm^2

Design tensile strength; $f_{t,0,d} = k_{h,t} \times k_{mod} \times f_{t.0.k} / \gamma_M$ = **7.808** N/mm^2

$\sigma_{t,0,d} / f_{t,0,d}$ = **0.070**

PASS - Design tensile strength exceeds design tensile stress

Check design at start of span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.15** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.048** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.154** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.022**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.118** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.672** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **12.923** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.052**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18; $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d}$ = **0.122**

$\sigma_{t,0,d} / f_{t,0,d} + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.106**

PASS - Combined bending and axial tension utilisation is acceptable

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

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

Beam stability check - exp.6.33; $\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d})$ = **0.052**

PASS - Beam stability is acceptable

Check design at end of span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.15** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.048** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.154** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.022**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.056** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.317** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **12.923** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.025**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18; $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d}$ = **0.094**

$\sigma_{t,0,d} / f_{t,0,d} + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.087**

PASS - Combined bending and axial tension utilisation is acceptable

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

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

Beam stability check - exp.6.33; $\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d})$ = **0.025**

PASS - Beam stability is acceptable

<u>Consider Combination 1 - LoadCombination1 (Service)</u>

<u>Check design at end of span</u>

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **0.1** mm

Final deflection; $\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **0.1** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m4\_s1} / 125$ = **9.3** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.009**

PASS - Allowable deflection exceeds final deflection

<u>KNEE WALL 2 - Span 1</u>

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Long-term

Service class - cl.2.3.1.3; 1

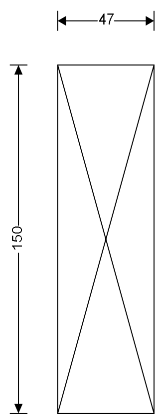
Timber section details

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

Breadth of section; b = **47** mm

Depth of section; h = **150** mm

Timber strength class - EN 338:2016 Table 1; **C24**



47x150 timber section

Cross-sectional area, A, 7050 mm^2

Section modulus, W_y, 176250 mm^3

Section modulus, W_z, 55225 mm^3

Second moment of area, I_y, 13218750 mm^4

Second moment of area, I_z, 1297787 mm^4

Radius of gyration, i_y, 43.3 mm

Radius of gyration, i_z, 13.6 mm

Timber strength class C24

Characteristic bending strength, $f_{m.k}$, 24 N/mm^2

Characteristic shear strength, $f_{v.k}$, 4 N/mm^2

Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2

Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2

Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2

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

Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2

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

Characteristic density, ρ_k, 350 kg/m^3

Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

<u>Consider Combination 2 - LoadCombination2 (Strength)</u>

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.7**

Deformation factor - Table 3.2; k_{def} = **0.6**

Depth factor for tension - exp.3.1; $k_{h,t}$ = **1**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Check tension parallel to the grain - Section 6.1.2

Axial tension; P_d = **4.948** kN

Design tensile stress; $\sigma_{t,0,d} = P_d / (b \times \min(h_{ef\_e1}, h_{ef\_e2}))$ = **0.540** N/mm^2

Design tensile strength; $f_{t,0,d} = k_{h,t} \times k_{mod} \times f_{t.0.k} / \gamma_M$ = **7.808** N/mm^2

$\sigma_{t,0,d} / f_{t,0,d}$ = **0.069**

PASS - Design tensile strength exceeds design tensile stress

<u>Check design at start of span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.258** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.082** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.154** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.038**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.136** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.77** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **12.923** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.06**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18; $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d}$ = **0.129**

$\sigma_{t,0,d} / f_{t,0,d} + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.111**

PASS - Combined bending and axial tension utilisation is acceptable

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

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

Beam stability check - exp.6.33; $\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d})$ = **0.06**

PASS - Beam stability is acceptable

__**Check design at end of span**__

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.258** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (b \times h)$ = **0.082** N/mm²

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.154** N/mm²

$\tau_{y,d} / f_{v,y,d}$ = **0.038**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.138** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.782** N/mm²

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **12.923** N/mm²

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.061**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18; $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d}$ = **0.130**

$\sigma_{t,0,d} / f_{t,0,d} + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.112**

PASS - Combined bending and axial tension utilisation is acceptable

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

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

Beam stability check - exp.6.33; $\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d})$ = **0.061**

PASS - Beam stability is acceptable

__**Consider Combination 1 - LoadCombination1 (Service)**__

__**Check design at end of span**__

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **0.1** mm

Final deflection; $\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **0.2** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m5\_s1} / 125$ = **8.5** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.023**

PASS - Allowable deflection exceeds final deflection

PEPP PEARL ENGINEERS, PLANNERS & PROJECT MANAGERS 02 TOWERFIELDS WESTERHAM ROAD BROMLEY, BR2 6HF Email: info@Pearlepp.co.uk Website: www. pearlepp.co.uk Tel no. 02035763199	**Project:** 25 Sudbourne Rd SW2 5AE UK	**Sheet No./Rev.** 26
	Job Ref. 2024-07-SW2 5AE | **Structural Engineer MM**	**Date 19/07/2024**

COLLAR TIE - Span 1

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Long-term

Service class - cl.2.3.1.3; 1

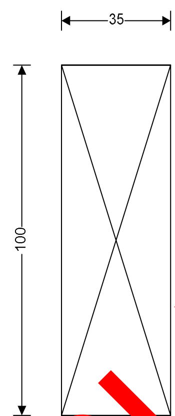
Timber section details

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

Breadth of sections; b = **35** mm

Depth of sections; h = **100** mm

Timber strength class - EN 338:2016 Table 1; **C24**



35x100 timber secti[illegible]
Cross-sectional are[illegible] 3500 m[illegible]
Section modulus, W_y, [illegible] mm^3
Section m[illegible] 204[illegible] m^3
Secon[illegible] oment of [illegible] ea, I_y, 29[illegible]67 mm^4
Se[illegible] moment o[illegible] ea, I_z, 35729[illegible] mm^4
Radius [illegible] gyrat[illegible], i_y, 28.9 mm
Radius of g[illegible] ion, i_z, 10.1 mm
Timber streng[illegible] class C24
Characteristic ben[illegible] ng strength, $f_{m.k}$, 24 N/mm^2
Characteristic shear strength, $f_{v.k}$, 4 N/mm^2
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2
Chara[illegible] eristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2
C[illegible] acteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2
[illegible] ean modulus of elasticity, $E_{0.mean}$, 11000 N/mm^2
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2
Shear modulus of elasticity, G_{mean}, 690 N/mm^2
Characteristic density, ρ_k, 350 kg/m^3
Mean density, ρ_{mean}, 420 kg/m^3

Span details

Beari[illegible] ngth; L_b = **100** mm

Consider [illegible] ombi[illegible] tion 2 - LoadCombination2 (Strength)

[illegible] odi[illegible] ion factors

D[illegible] on of load and moisture content - Table 3.1; k_{mod} = **0.7**

De[illegible] rmation factor - Table 3.2; k_{def} = **0.6**

[illegible] epth factor for bending - Major axis - exp.3.1; $k_{h,m,y}$ = min((150 mm / h)$^{0.2}$, 1.3) = **1.084**

[illegible] epth factor for tension - exp.3.1; $k_{h,t}$ = min((150 mm / max(b, h))$^{0.2}$, 1.3) = **1.084**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Check compression parallel to the grain - cl.6.1.4

Design axial compression; P_d = **4.681** kN

Design compressive stress; $\sigma_{c,0,d}$ = P_d / A = **1.338** N/mm^2

Design compressive strength; $f_{c,0,d}$ = k_{mod} ´ $f_{c.0.k}$ / γ_M = **11.308** N/mm^2

$\sigma_{c,0,d}$ / $f_{c,0,d}$ = **0.118**

PASS - Design parallel compression strength exceeds design parallel compression stress

<u>Check design at start of span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.017** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.011** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M$ = **2.154** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.005**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.037** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.637** N/mm^2

Design bending strength; $f_{m,y,d} = k_{h,m,y} \times k_{mod} \times f_{m.k} / \gamma_M$ = **14.015** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.045**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.059**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.046**

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 bending; $L_{e,y} = 0.9 \times 1335$ mm = **1202** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **41.621**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **0.706**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **0.790**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.874**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **0.181**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.143**

PASS - Column stability is acceptable

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

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

Beam stability check - exp.6.35; $(\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d}))^2 + \sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d})$ = **0.113**

PASS - Beam stability is acceptable

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02 TOWERFIELDS WESTERHAM ROAD BROMLEY, BR2 6HF Email: info@Pearlepp.co.uk Website: www. pearlepp.co.uk Tel no. 02035763199	**Job Ref. 2024-07-SW2 5AE**	**Structural Engineer** **MM**	**Date** **19/07/2024**

Check design 1154 mm along span

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.028** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.473** N/mm^2

Design bending strength; $f_{m,y,d} = k_{h,m,y} \times k_{mod} \times f_{m.k} / \gamma_M$ = **14.[illegible]15** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.034**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.04[illegible]**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.038**

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 bending; $L_{e,y} = 0.9 \times$ [illegible]335 mm = **1202** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **41.[illegible]**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **0.706**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **0.790**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.874**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **0.169**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.135**

PASS - Column stability is acceptable

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

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

Beam stability check - exp.6.35; $(\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d}))^2 + \sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d})$ = **0.112**

PASS - Beam stability is acceptable

Consider Combination 1 - LoadCombination1 (Service)

Check design at end of span

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **1.3** mm

Final deflection; $\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **2.1** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m6\_s1} / 250$ = **5.3** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.39**

PASS - Allowable deflection exceeds final deflection

<u>1 - Span 1</u>

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Short-term

Service class - cl.2.3.1.3; 2

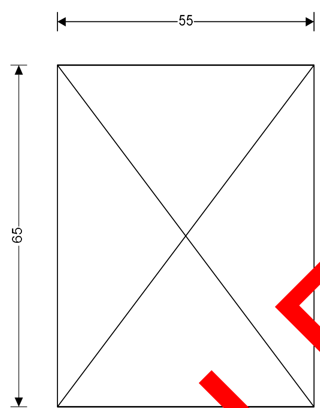
Timber section details

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

Breadth of sections; b = **55** mm

Depth of sections; h = **65** mm

Timber strength class - EN 338:2016 Table 1; **C24**



55x65 timber section
Cross-sectional area, A, 3575 mm^2
Section modulus, W_y, 38729.2 mm^3
Section modulus, W_z, 32771 mm^3
Second moment of area, I_y, 1258698 mm^4
Second moment of area, I_z, 901198 mm^4
Radius of gyration, i_y, 18.8 mm
Radius of gyration, i_z, 15.9 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm^2
Characteristic shear strength, $f_{v.k}$, 4 N/mm^2
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm^2
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2
Shear modulus of elasticity, G_{mean}, 690 N/mm^2
Characteristic density, ρ_k, 350 kg/m^3
Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

<u>Consider Combination 2 - LoadCombination2 (Strength)</u>

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.9**

Deformation factor - Table 3.2; k_{def} = **0.8**

Depth factor for bending - Major axis - exp.3.1; $k_{h,m,y}$ = min((150 mm / h)$^{0.2}$, 1.3) = **1.182**

Depth factor for tension - exp.3.1; $k_{h,t}$ = min((150 mm / max(b, h))$^{0.2}$, 1.3) = **1.182**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

System strength factor - cl.6.6; k_{sys} = **1.1**

Check compression parallel to the grain - cl.6.1.4

Design axial compression; P_d = **8.458** kN

Design compressive stress; $\sigma_{c,0,d} = P_d / A$ = **2.366** N/mm^2

Design compressive strength; $f_{c,0,d} = k_{mod} \times k_{sys} \times f_{c.0.k} / \gamma_M$ = **15.992** N/mm^2

$\sigma_{c,0,d}$ / $f_{c,0,d}$ = **0.148**

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design at end of span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.032** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h)$ = **0.020** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times k_{sys} \times f_{v.k} / \gamma_M$ = **3.[illegible]46** N/mm^2

$\tau_{y,d} / f_{v,y,d}$ = **0.007**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.029** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **0.756** N/mm^2

Design bending strength; $f_{m,y,d} = k_{h,m,y} \times k_{mod} \times k_{sys} \times f_{m.k} / \gamma_M$ = **21.604** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.035**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.057**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.046**

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 bending; $L_{e,y} = 0.9 \times 2771$ mm = **2494** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **132.91**

Relative slenderness ratio - exp.6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **2.254**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **3.235**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.180**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **0.857**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.164**

PASS - Column stability is acceptable

Consider Combination 1 - LoadCombination1 (Service)

Check design 101 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **0.8** mm

Final deflection; $\delta_{y,Final} = \delta_y$ ´ $(1 + k_{def})$ = **1.4** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m7\_s1} / 250$ = **11.1** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.13**

PASS - Allowable deflection exceeds final deflection

2 - Span 1

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Short-term

Service class - cl.2.3.1.3; 1

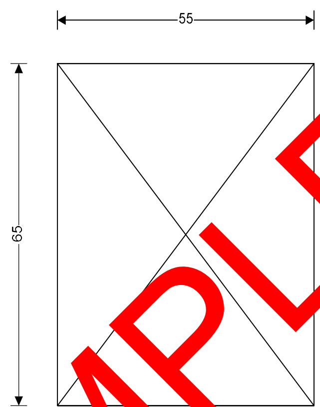
Timber section details

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

Breadth of sections; b = **55** mm

Depth of sections; h = **65** mm

Timber strength class - EN 338:2016 Table 1; **C24**



55x65 timber section
Cross-sectional area, A, 3575 mm²
Section modulus, W_y, 38729.2 mm³
Section modulus, W_z, 32771 mm³
Second moment of area, I_y, 1258698 mm⁴
Second moment of area, I_z, 901198 mm⁴
Radius of gyration, i_y, 18.8 mm
Radius of gyration, i_z, 15.9 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm²
Characteristic shear strength, $f_{v.k}$, 4 N/mm²
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm²
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm²
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm²
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm²
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm²
Shear modulus of elasticity, G_{mean}, 690 N/mm²
Characteristic density, ρ_k, 350 kg/m³
Mean density, ρ_{mean}, 420 kg/m³

Span details

Bearing length; L_b = **100** mm

Consider Combination 2 - LoadCombination2 (Strength)

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.9**

Deformation factor - Table 3.2; k_{def} = **0.6**

Depth factor for bending - Major axis - exp.3.1; $k_{h,m,y} = \min((150 \text{ mm} / h)^{0.2}, 1.3)$ = **1.182**

Depth factor for tension - exp.3.1; $k_{h,t} = \min((150 \text{ mm} / \max(b, h))^{0.2}, 1.3)$ = **1.182**

Bending stress re-distribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

System strength factor - cl.6.6; k_{sys} = **1.1**

Check compression parallel to the grain - cl.6.1.4

Design axial compression; P_d = **8.898** kN

Design compressive stress; $\sigma_{c,0,d} = P_d / A =$ **2.489** N/mm^2

Design compressive strength; $f_{c,0,d} = k_{mod} \times k_{sys} \times f_{c.0.k} / \gamma_M =$ **15.992** N/mm^2

$\sigma_{c,0,d} / f_{c,0,d} =$ **0.156**

PASS - Design parallel compression strength exceeds design parallel compression stress

<u>Check design at end of span</u>

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **0.028** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times b \times h) =$ **0.017** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times k_{sys} \times f_{v.k} / \gamma_M =$ **3.046** N/mm^2

$\tau_{y,d} / f_{v,y,d} =$ **0.006**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **0.017** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y =$ **0.436** N/mm^2

Design bending strength; $f_{m,y,d} = k_{h,m,y} \times k_{mod} \times k_{sys} \times f_{m.k} / \gamma_M =$ **21.604** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d} =$ **0.02**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} =$ **0.044**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.038**

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 bending; $L_{e,y} = 0.9 \times 2885$ mm = **2597** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y =$ **138.378**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})} =$ **2.346**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z =$ **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2) =$ **3.458**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) =$ **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) =$ **0.167**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) =$ **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} =$ **0.954**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d} =$ **0.160**

PASS - Column stability is acceptable

Consider Combination 1 - LoadCombination1 (Service)

Check design 736 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **1** mm

Final deflection; $\delta_{y,Final} = \delta_y$ ´ $(1 + k_{def})$ = **1.6** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m8\_s1} / 250$ = **11.5** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.136**

PASS - Allowable deflection exceeds final deflection

PEPP 02 TOWERFIELDS WESTERHAM ROAD BROMLEY, BR2 6HF Email: info@Pearlepp.co.uk Website: www. pearlepp.co.uk Tel no. 02035763199	**Project:** 25 Sudbourne Rd SW2 5AE UK		**Sheet No./Rev.** 34
	Job Ref. 2024-07-SW2 5AE	**Structural Engineer** **MM**	**Date** **19/07/2024**

- **Double Trimmer** (2) (47 x 150) (C-24)

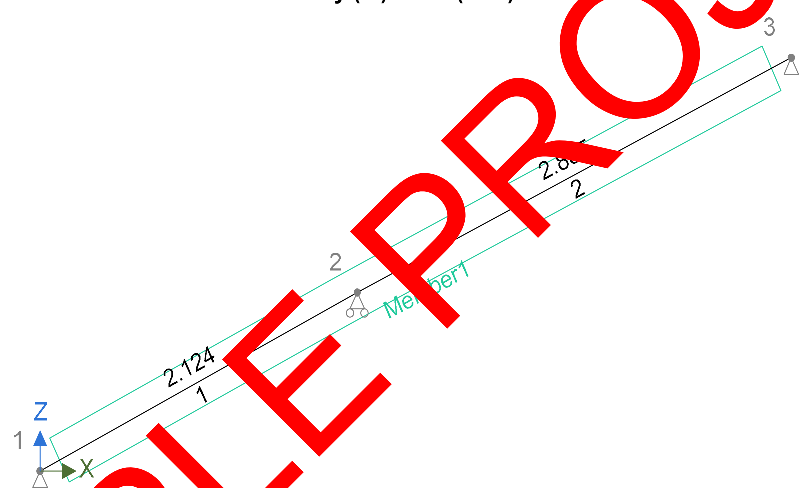
TIMBER MEMBER ANALYSIS & DESIGN (EN1995-1-1:2004)

In accordance with EN1995-1-1:2004 + A2:2014 incorporating corrigendum June 2006 and the recommended values

ANALYSIS

Geometry

Geometry (m) - C24 (EC5) - 2/47x150



Materials

Name	Density (kg/m³)	Youngs Modulus kN/mm²	Shear Modulus kN/mm²	Thermal Coefficient °C⁻¹
C24 (EC5)	420	11	0.69	0

Sections

Name	Area (cm²)	Moment of inertia Major (cm⁴)	Moment of inertia Minor (cm⁴)	Shear area parallel to Minor (cm²)	Shear area parallel to Major (cm²)
2/47x150	141	2644	1038	118	118

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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	1.9	0.95	Free	Fixed	Free		0	0	0	0
3	4.5	2.2	Fixed	Fixed	Free		0	0	0	0

Elements

Element	Length (m)	Nodes		Section	Material	Releases			Rotated
		Start	End			Start moment	End moment	Axial	
1	2.124	1	2	2/47x150	C24 (EC5)	Fixed	Fixed	Fixed	
2	2.885	2	3	2/47x150	C24 (EC5)	Fixed	Fixed	Fixed	

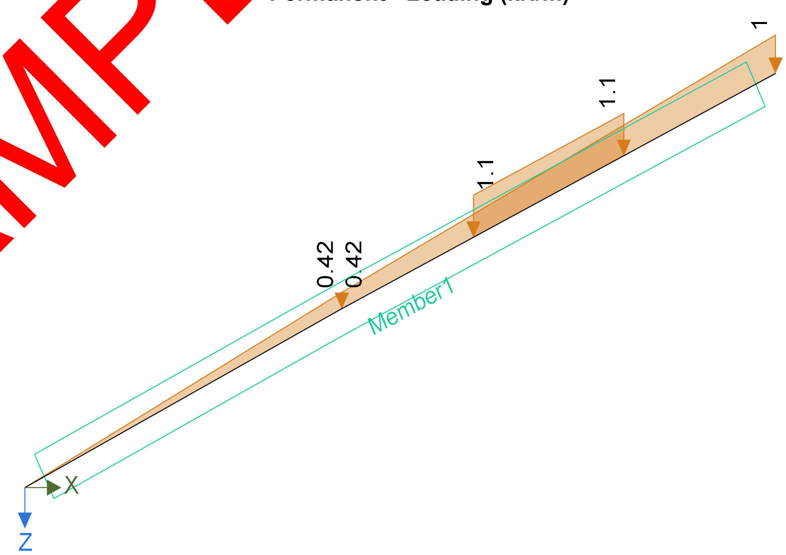
Members

Name	Elements	
	Start	End
Member1	1	2

Loading

Self weight included

Permanent - Loading (kN/m)



Load combination factors

Load combination	Self Weight	Permanent	Imposed
LoadCombination1 (Service)	**1.00**	**1.00**	**1.00**
LoadCombination2 (Strength)	**1.00**	**1.40**	**1.60**

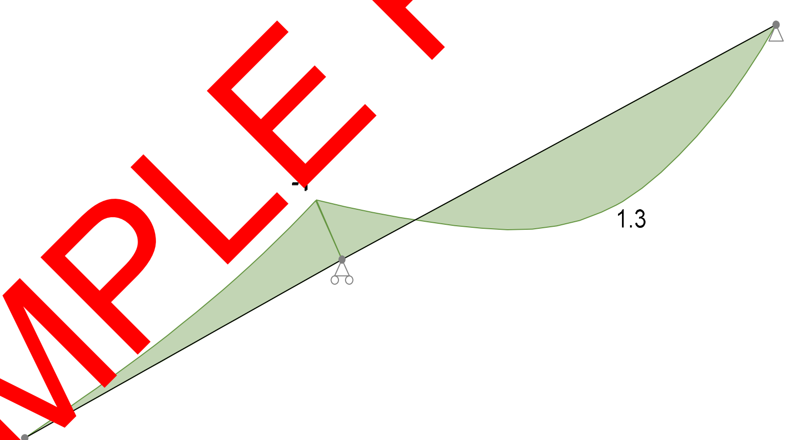
Member Loads

Member	Load case	Load Type	Orientation	Description
Member1	Permanent	UDL	GlobalZ	1.1 kN/m at 3 m to 4 m
Member1	Permanent	VDL	GlobalZ	0 kN/m to 1 kN/m

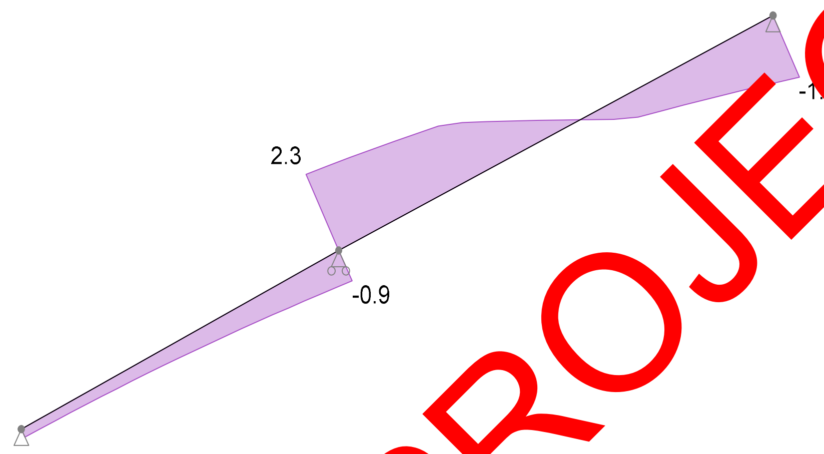
Results

Forces

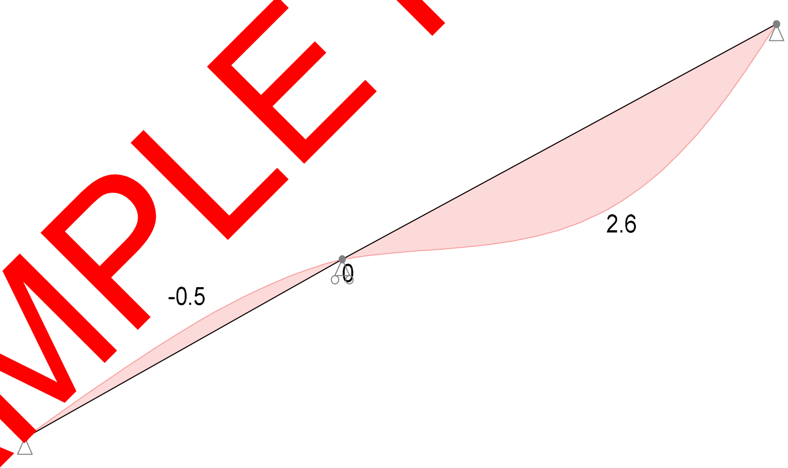
Strength combinations - Moment envelope (kNm)



Strength combinations - Shear envelope (kN)



Service combinations - Deflection envelope (mm)



<u>Member1 - Span 1</u>

Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Long-term

Service class - cl.2.3.1.3; 1

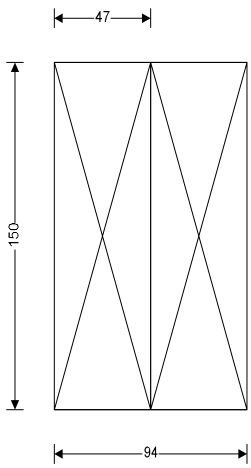
Timber section details

Number of timber sections in member; N = **2**

Breadth of sections; b = **47** mm

Depth of sections; h = **150** mm

Timber strength class - EN 338:2016 Table 1; **C24**



2/47x150 timber sections
Cross-sectional area, A, 14100 mm ^{2}
Section modulus, W_y, 352500 mm^3
Section modulus, W_z, 110450 mm^3
Second moment of area, I_y, 26437500 mm^4
Second moment of area, I_z, 2595575 mm^4
Radius of gyration, i_y, 43.3 mm
Radius of gyration, i_z, 13.6 mm
Timber strength class C24
Characteristic bending strength, $f_{m.k}$, 24 N/mm^2
Characteristic shear strength, $f_{v.k}$, 4 N/mm^2
Characteristic compression strength parallel to grain, $f_{c.0.k}$, 21 N/mm^2
Characteristic compression strength perpendicular to grain, $f_{c.90.k}$, 2.5 N/mm^2
Characteristic tension strength parallel to grain, $f_{t.0.k}$, 14.5 N/mm^2
Mean modulus of elasticity, $E_{0.mean}$, 11000 N/mm^2
Fifth percentile modulus of elasticity, $E_{0.05}$, 7400 N/mm^2
Shear modulus of elasticity, G_{mean}, 690 N/mm^2
Characteristic density, ρ_k, 350 kg/m^3
Mean density, ρ_{mean}, 420 kg/m^3

Span details

Bearing length; L_b = **100** mm

Consider Combination 2 - LoadCombination2 (Strength)

Modification factors

Duration of load and moisture content - Table 3.1; k_{mod} = **0.7**

Deformation factor - Table 3.2; k_{def} = **0.6**

Bending stress redistribution factor - cl.6.1.6(2); k_m = **0.7**

Crack factor for shear resistance - cl.6.1.7(2); k_{cr} = **0.67**

Check compression parallel to the grain - cl.6.1.4

Design axial compression; P_d = **1.102** kN

Design compressive stress; $\sigma_{c,0,d} = P_d / A =$ **0.078** N/mm^2

Design compressive strength; $f_{c,0,d} = k_{mod} \times f_{c.0.k} / \gamma_M =$ **11.308** N/mm^2

$\sigma_{c,0,d} / f_{c,0,d} =$ **0.007**

PASS - Design parallel compression strength exceeds design parallel compression stress

Check design 2124 mm along span

Check shear force - Section 6.1.7

Design shear force; $F_{y,d}$ = **2.282** kN

Design shear stress - exp.6.60; $\tau_{y,d} = 1.5 \times F_{y,d} / (k_{cr} \times N \times b \times h) =$ **0.362** N/mm^2

Design shear strength; $f_{v,y,d} = k_{mod} \times f_{v.k} / \gamma_M =$ **2.154** N/mm^2

$\tau_{y,d} / f_{v,y,d} =$ **0.168**

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **1.037** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **2.941** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **12.923** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.228**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial tension - Section 6.2.3

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.228**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.1[illegible]**

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 bending; $L_{e,y} = 0.9 \times 50[illegible]$ mm = **4[illegible]08** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **104.1[illegible]**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **1.765**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **2.205**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.284**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **0.252**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.166**

PASS - Column stability is acceptable

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

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

Beam stability check - exp.6.35; $(\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d}))^2 + \sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d})$ = **0.058**

PASS - Beam stability is acceptable

<u>Check design 3730 mm along span</u>

Check bending moment - Section 6.1.6

Design bending moment; $M_{y,d}$ = **1.327** kNm

Design bending stress; $\sigma_{m,y,d} = M_{y,d} / W_y$ = **3.764** N/mm^2

Design bending strength; $f_{m,y,d} = k_{mod} \times f_{m.k} / \gamma_M$ = **12.923** N/mm^2

$\sigma_{m,y,d} / f_{m,y,d}$ = **0.291**

PASS - Design bending strength exceeds design bending stress

Check combined bending and axial tension - Section 6.2.3

Combined loading checks - exp.6.19 & 6.20; $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$ = **0.291**

$(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.204**

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 bending; $L_{e,y} = 0.9 \times 5009$ mm = **4508** mm

Slenderness ratio; $\lambda_y = L_{e,y} / i_y$ = **104.11**

Relative slenderness ratio - exp. 6.21; $\lambda_{rel,y} = \lambda_y / \pi \times \sqrt{(f_{c.0.k} / E_{0.05})}$ = **1.765**

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

Slenderness ratio; $\lambda_z = L_{e,z} / i_z$ = **0**

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

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

Straightness factor; β_c = **0.2**

Instability factors - exp.6.25, 6.26, 6.27 & 6.28; $k_y = 0.5 \times (1 + \beta_c \times (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2)$ = **2.205**

$k_z = 0.5 \times (1 + \beta_c \times (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2)$ = **0.470**

$k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)})$ = **0.284**

$k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)})$ = **1.064**

Column stability checks - exp.6.23 & 6.24; $\sigma_{c,0,d} / (k_{c,y} \times f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d}$ = **0.316**

$\sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d}) + k_m \times \sigma_{m,y,d} / f_{m,y,d}$ = **0.210**

PASS - Column stability is acceptable

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

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

Beam stability check - exp.6.35; $(\sigma_{m,y,d} / (k_{crit} \times f_{m,y,d}))^2 + \sigma_{c,0,d} / (k_{c,z} \times f_{c,0,d})$ = **0.091**

PASS - Beam stability is acceptable

<u>Consider Combination 1 - LoadCombination1 (Service)</u>

<u>Check design 36[illegible] mm along span</u>

Check y-y axis deflection - Section 7.2

Instantaneous deflection; δ_y = **2.6** mm

Final deflection; $\delta_{y,Final} = \delta_y \times (1 + k_{def})$ = **4.1** mm

Allowable deflection; $\delta_{y,Allowable} = L_{m1\_s1} / 250$ = **20** mm

$\delta_{y,Final} / \delta_{y,Allowable}$ = **0.207**

PASS - Allowable deflection exceeds final deflection