

# 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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Job Ref. 2024-07-SW2 5AE

## Structural Engineer

MM

Date 19/07/2024

Sheet No./Rev. 2

#### **Document Control:**

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

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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 TE. THEY ARE TO BE CHECKED ON SITE BY
THE CONTRACTOR AND BUILDING CONTROL OFFICE REGION TO THE START OF THE WORKS. ANY DIFFERENCES ARE
TO BE REPORTED TO PEPP IMMEDIATELY

- 1. The existing masonry is assumed to be minimus 3.6N/mm<sup>2</sup> blockwork in a 1:2:8 mortar
- 2. Floor joists are assumed to pan as indicated on the drawings.
- 3. The external walls are assumed be avity brickwork.

#### **NOTES**

Contracto chick and imensions before ordering any steel.

All materia and whemanship must fully comply with all relevant current British Standard and Codes of practice.



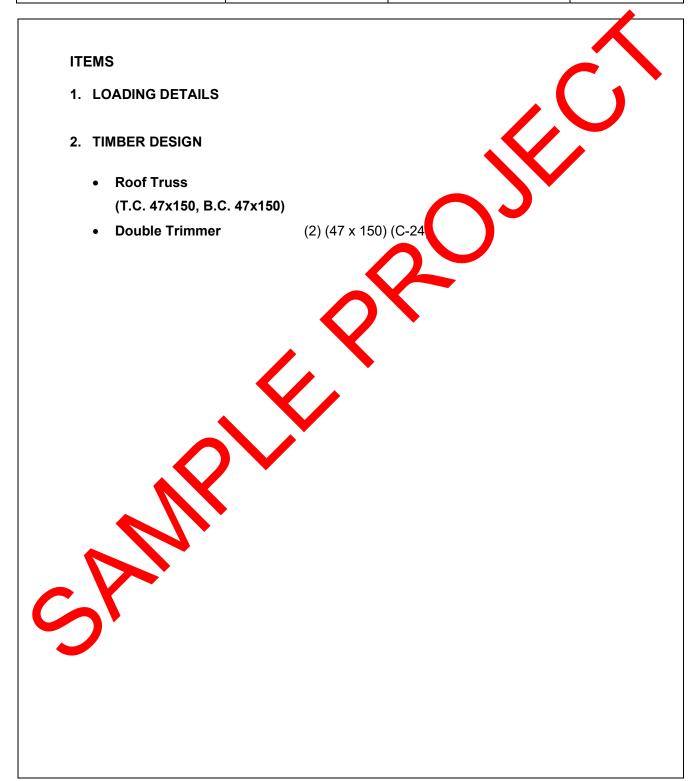
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#### 1. LOADING DETAILS

PITCHED ROOF			
Clay Tiles	=	0.65	KN/m <sup>2</sup>
Felt and battens	=	0.05	KN/m <sup>2</sup>
Timber rafters	=	0.1	KN/n²
Insulations and other membranes	=	0.1	1 Vm²
Ceiling and services	=	0.2	KN).
Total dead load on the slope	=	1.1	K. (m²
Live Load	=	0.6	KN/ <sup>2</sup>
LOFT FLOOR			
Plywood Flooring	-	0.1	KN/m <sup>2</sup>
Timber Joists	=	.2	KN/m <sup>2</sup>
Insulation	=		KN/m <sup>2</sup>
Ceiling and services		0.2	KN/m <sup>2</sup>
Partitions	=	0.5	KN/m <sup>2</sup>
Total dead load	=	1.10	KN/m <sup>2</sup>
Live Load	=	1.5	KN/m <sup>2</sup>
FIRST FLOOR	<u>,                                      </u>		
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 <sup>2</sup>
Total dead loa	=	1.10	KN/m²
Live Load	=	1.5	KN/m²
WALL L. N.			
Brick wall (192 mm)	=	2	KN/m <sup>2</sup>
Block will with plaster	=	1.9	KN/m <sup>2</sup>
Glairs	=	0.5	KN/m <sup>2</sup>



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#### 2. TIMBER DESIGN

#### Roof Truss

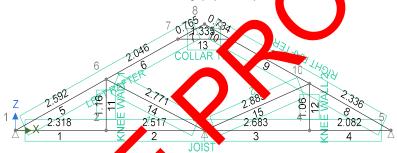
#### TIMBER MEMBER ANALYSIS & DESIGN (EN1995-1-1:2004)

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	ns v	Youngs Modulus	Shear Modulus	Thermal Coefficient
	(kg/m³)	kN/mm²	kN/mm²	°C-1
C24 (EC5)	420	11	0.69	0

#### Section

Nam	Area	Moment	of inertia	Shear are	•
	(cm²)	Major (cm⁴)	Minor (cm⁴)	Minor (cm²)	Major (cm²)
4 x150	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-ord	linates		Freedom	1		dinate tem	Spring		
	(m)	(m)	X	Z	Rot.	Name	Angle (°)	X (kN/m)	Z N/m)	Rot. k lm/°
1	0	0	Fixed	Fixed	Free		0			0
2	2.318	0	Free	Free	Free		0	0	0	0
3	4.835	0	Fixed	Fixed	Free		0	O.	U	0
4	7.518	0	Free	Free	Free		0	9	0	0
5	9.6	0	Fixed	Fixed	Free				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
9	5.485	2.07	Free	Free	Free		0	0	0	0
10	7.518	1.06	Free	Free	FIC		0	0	0	0

#### **Elements**

Eleme nt	Length	No	des	Section	Material		Releases	;	Rotate d
	(m)	Start	Er			Start momen t	End momen t	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	2.0	4	5	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
5	2.59		6	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
6	_046	6	7	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
7	765	7	8	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
3	2.3.8	5	10	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
Š	2.27	10	9	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
10	0.734	9	8	47x150	C24 (EC5)	Fixed	Fixed	Fixed	
	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	



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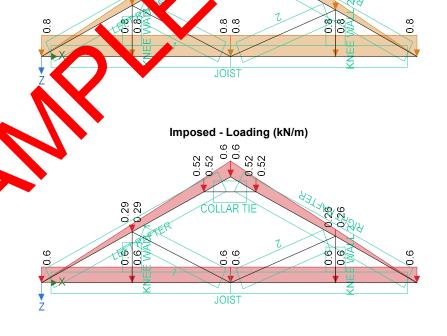
#### Members

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 - Load (KN/m)





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#### Load combination factors

Load combination	Self Weight	Permanen t	lmposed
LoadCombination1 (Service)	1.00	1.00	1.00
LoadCombination2 (Strength)	1.00	1.35	1.50

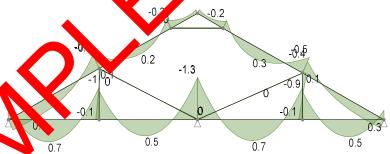
#### **Member Loads**

Member	Load case	Load Type	Orientatio	Description
			n	
JOIST	Permanent	UDL	Global	0.8 k Vm
LEFT RAFTER	Permanent	VDL	Globalz	0 kN/n to 0.75 kN/m
RIGHT RAFTER	Permanent	VDL	Glob IZ	○ MV/m to 0.75 kN/m
JOIST	Imposed	UDL	Glesan	<b>→</b> 0.6 kN/m
LEFT RAFTER	Imposed	VDL	∪ balZ	0 kN/m to 0.6 kN/m
RIGHT RAFTER	Imposed	Vi	GlobalZ	0 kN/m to 0.6 kN/m

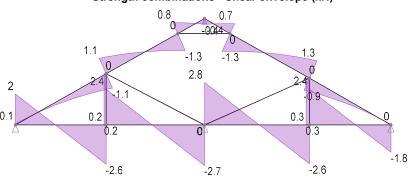
#### Results

#### **Forces**

### Strength combinations - Moment envelope (kNm)



#### Strength combinations - Shear envelope (kN)





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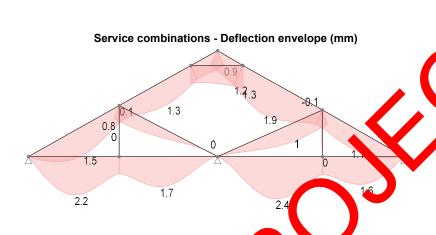
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#### JOIST - Span 1

#### Partial factor for material properties and restances

Partial factor for material properties - Table 2.3; = 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 it member;

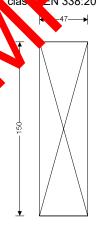
N = **1** b = **47** mm

Breadth of sections

h = **150** mm

Depth of sections
Timber streng clas N 338:2016 Table 1;

C24



#### 47x150 timber section

Cross-sectional area, A, 7050 mm²
Section modulus, W<sub>y</sub>, 176250 mm³
Section modulus, W<sub>L</sub>, 55225 mm³
Second moment of area, I<sub>y</sub>, 13218750 mm²
Second moment of area, I<sub>L</sub>, 1297787 mm²
Radius of gyration, I<sub>z</sub>, 43.9 mm
Radius of gyration, I<sub>z</sub>, 13.6 mm

#### Timber strength class C24

Mean density, pmean, 420 kg/m3

Characteristic bending strength,  $f_{\rm m.k.}$ , 24 N/mm² Characteristic shear strength,  $f_{\rm v.k.}$  4 N/mm² Characteristic compression strength parallel to grain,  $f_{\rm o.0.k.}$  21 N/mm² Characteristic compression strength perpendicular to grain,  $f_{\rm o.0.k.}$  2.5 N/mm² Characteristic tension strength parallel to grain,  $f_{\rm o.0.k.}$  14.5 N/mm² Mean modulus of elasticity,  $F_{\rm o.mean}$  11000 N/mm² Fifth percentile modulus of elasticity,  $F_{\rm o.mean}$  990 N/mm² Characteristic density,  $F_{\rm o.mean}$  990 N/mm² Characteristic density,  $F_{\rm o.mean}$  350 kg/m³ Characteristic density,  $F_{\rm o.mean}$  990 N/mm² Characteristic density,  $F_{\rm o.mean}$  350 kg/m³



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#### Span details

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

#### 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);  $k_{c,90} = 1.5$ 

#### Check tension parallel to the grain - Section 6.1.2

Axial tension;  $P_d = 0.078 \text{ kN}$ 

Design tensile stress;  $\sigma_{t,0,d} = (h_{ef} - h_{ef} - 2) = 0.009 \text{ N/mm}^2$ 

Design tensile strength;  $f_{t,0} = k_{h,t} + k_{h,t} + k_{mod} + f_{t,0,k} + k_{h,t} + k_{mod} + k_{h,t} + k_{h,t}$ 

= 0.001

PASS Des in ten ile strength exceeds design tensile stress

#### Check design at end of span

#### Check shear force - Section 6.1.7

Design shear force;

Design shear stress - exp.6.60;

Design shear strength;

 $F_{y,d} = 2.693 \text{ kN}$ 

 $\tau_{y,d} = 1.5 f_{y,d} / (k_{cr} b h) = 0.855 \text{ N/mm}^2$ 

 $f_{v,y,d} = k_{mod} - f_{v,k} / \gamma_M = 2.462 \text{ N/mm}^2$ 

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

PASS - Design shear strength exceeds design shear stress

#### Check bending Section 6.1.6

Design bendimmon t;  $M_{v,d} = 1.305 \text{ kNm}$ 

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

Design ading trench;  $f_{m,y,d} = k_{mod} f_{m,k} / \gamma_M = 14.769 \text{ N/mm}^2$ 

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

PASS - Design bending strength exceeds design bending stress

#### Cer combined bending and axial compression - Section 6.2.4

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

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

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;  $L_{e,y} = 0.9$  4835 mm = 4352 mm

Slenderness ratio;  $\lambda_{y} = L_{e,y} / i_{y} = 100.494$ 

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

Effective length for z-axis bending;  $L_{e,z} = \mathbf{0}$  mm Slenderness ratio;  $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

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



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

Straightness factor;  $\beta_c = 0.2$ 

Instability factors - exp.6.25, 6.26, 6.27 & 6.28;  $k_y = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,y} - 0.3$ ) +  $\lambda_{rel,y}^2$ ) = 2.003

 $k_z = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,z} - 0.3$ ) +  $\lambda_{rel,z}^2$ ) 3.470

 $k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) = 0.302$ 

 $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.06$ 

Column stability checks - exp.6.23 & 6.24;  $\sigma_{c,0,d} / (k_{c,y} - f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y} = 1.0$ 

 $\sigma_{c,0,d} / (k_{c,z} - f_{c,0,d}) + k_m - v_{d} / v_{d} = 0$ 

PASS - Column stab. is acceptable

Consider Combination 1 - LoadCombination1 (Service)

Check design 1187 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;  $\delta_y = 1.2$  mm

Final deflection;  $\delta_{V,Final}$   $\delta$  (1 - .def) = **3.9** mm

Allowable deflection;  $\delta_{y,A-wable} = \frac{1}{250} = 19.3 \text{ mm}$ 

 $\delta_{y}$  hal /  $\delta_{y}$ , Allowable = **0.202** 

ASS - Allowable deflection exceeds final deflection

JOIST - Span 2

Partial factor for material properties au resistances

Partial factor for material properties - tole 2.7  $\gamma_M = 1.300$ 

Member details

Load duration - cl.2.2 Medium-term

Service class - cl. 3.1.3;

Timber section detail

Number of time a vection in member; N = 1Bread's of sections; b = 47 mmDepth of eccurs, h = 150 mm

ber street, th class - EN 338:2016 Table 1; C24



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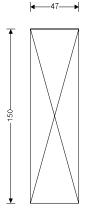
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#### 47x150 timber section

Cross-sectional area, A, 7050 mm²
Section modulus, W<sub>.,</sub> 176250 mm³
Section modulus, W<sub>.,</sub> 55225 mm³
Second moment of area, I<sub>.,</sub> 13218750 mm²
Second moment of area, I<sub>.,</sub> 1297787 mm²
Radius of gyration, I<sub>.,</sub> 13.6 mm
Timber strength class C24

Characteristic bending strength,  $f_{\rm mix}$ , 24 N/mm² Characteristic shear strength,  $f_{\rm tot}$  4 N/mm² Characteristic compression strength parallel to grain,  $f_{\rm cole}$ , 21 N/mm, Characteristic compression strength perpendicular to grain,  $f_{\rm cole}$ , 2.5 Nr.  $^{\circ}$  Characteristic tension strength parallel to grain,  $f_{\rm cole}$ , 4.5 N/mm² Mean modulus of elasticity,  $F_{\rm cole}$ , 1000 N/mm² Fifth percentile modulus of elasticity,  $F_{\rm cole}$ , 400 N/mm²

Shear modulus of elasticity,  $G_{\text{mean}}$ , 690 N Characteristic density,  $\rho_{\text{le}}$ , 350 kg/m³ Mean density,  $\rho_{\text{mean}}$ , 420 kg/m³

#### Span details

Bearing length;

Lb 100 x x

#### Consider Combination 2 - LoadCombination2 Strongth)

#### **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-distributing factor - cl.6.25(2);  $k_{cr} = 0.67$  Crack factor for shear moistance - cl.6.27(2);  $k_{cr} = 0.67$  Load configuration actor - 1.6.1;  $\frac{1}{2}$   $\frac{1}{2}$   $\frac{1}{2}$  System strength factor - 2.6.6;  $k_{sys} = 1.1$ 

#### Check tension aralle to the grain - Section 6.1.2

Axial tension; P<sub>d</sub> = **0.113** kN

Design Processing Strates;  $\sigma_{t,0,d} = P_d / (b \text{ min}(h_{ef\_e1}, h_{ef\_e2})) = \textbf{0.012 N/mm}^2$  Design term by strength;  $f_{t,0,d} = k_{h,t} \text{ k}_{mod} \text{ k}_{sys} \text{ f}_{t,0,k} / \gamma_M = \textbf{9.815 N/mm}^2$ 

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

PASS - Design tensile strength exceeds design tensile stress

#### She k design at start of span

#### neck shear force - Section 6.1.7

Design shear force; F<sub>y,d</sub> = **2.811** kN

 $\begin{array}{ll} \text{Design shear stress - exp.6.60;} & \tau_{y,d} = 1.5 \quad \text{F}_{y,d} \, / \, (k_{cr} \quad b \quad h) = \textbf{0.893} \, \, \text{N/mm}^2 \\ \text{Design shear strength;} & f_{v,y,d} = k_{mod} \quad k_{sys} \quad f_{v,k} \, / \, \gamma_{M} = \textbf{2.708} \, \, \text{N/mm}^2 \\ \end{array}$ 

 $\tau_{y,d} / f_{v,y,d} = 0.330$ 

PASS - Design shear strength exceeds design shear stress

#### Check bending moment - Section 6.1.6

Design bending moment;

 $M_{y,d} = 1.317 \text{ kNm}$ 



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

5AE

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

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

PASS - Design bending strength exceeds design bending stress

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Check combined bending and axial compression - Section 6.2.4

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

 $\sigma_{t,0,d} / f_{t,0,d} + k_m - \sigma_{m,y,d} / f_{m,y,d}$  323

PASS - Combined bending and axial tension utilitation is acceptable

Check design 2683 mm along span

Check shear force - Section 6.1.7

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

Design shear stress - exp.6.60;  $\tau_{y,d} = 1.5$  Fy,d (kcr b h) = **0.819** N/mm<sup>2</sup> Design shear strength;  $f_{v,y,d} = \chi_{mod} = \chi_{mod}$ 

τy,d / y,d =

PASS signshear strength exceeds design shear stress

Check bending moment - Section 6.1.6

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

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

ASF Design bending strength exceeds design bending stress

Check combined bending and axial compression - Section 6.2.4

Combined loading of ecks exp. 19 6.20;  $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} = 0.375$ 

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

PASS - Combined bending and axial compression utilisation is acceptable

Check column state of the compression or combined compression and bending - cl.6.3.2

Slenderne ratio,  $\lambda_y = L_{e,y} / i_y = 99.039$ 

ela.. slend rness ratio - exp. 6.21;  $\lambda_{\text{rel},y} = \lambda_y / \pi = \sqrt{(f_{\text{c.0.k}} / E_{0.05})} = 1.679$ 

Example 2. Every definition of the second s

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

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

Straightness factor;  $\beta_c = 0.2$ 

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

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

 $k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) = 0.311$  $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.064$ 

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



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

PASS - Column stability is accustable

#### Consider Combination 1 - LoadCombination1 (Service)

#### Check design 1497 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;  $\delta_y = 2.4 \text{ mm}$ 

Final deflection;  $\delta_{y,Final} = \delta_y (1 + k_{def}) = 4.2 \text{ mm}$ 

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

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

PASS - Allowage deflection

#### **LEFT RAFTER - Span 1**

#### Partial factor for material properties and resistances

Partial factor for material properties - Table 2.3; ym 1.300

Member details

Load duration - cl.2.3.1.2; Short-term

Service class - cl.2.3.1.3; Timber section details

Number of timber sections in member, N = 1Breadth of sections; b = 47 mmDepth of sections; h = 150 mm

Timber strength class - EN 338:2016 Tab., C24



#### 47x150 timber section

Cross-sectional area, A, 7050 mm²
Section modulus, W<sub>y</sub>, 176250 mm³
Section modulus, W<sub>y</sub>, 55225 mm³
Second moment of area, I<sub>y</sub>, 13218750 mm²
Second moment of area, I<sub>z</sub>, 1297787 mm²
Radius of gyration, I<sub>y</sub>, 43,3 mm
Radius of gyration, I<sub>z</sub>, 13,6 mm
Timber strength class C24

Characteristic bending strength,  $f_{\rm m,k}$ , 24 N/mm² Characteristic shear strength,  $f_{\rm w,k}$ , 4 N/mm² Characteristic compression strength parallel to grain,  $f_{\rm c,0,k}$ , 21 N/mm²

Characteristic compression strength perpendicular to grain,  $f_{c, oole}$ , 2.5 N/mm<sup>2</sup> Characteristic tension strength parallel to grain,  $f_{c, oole}$ , 14.5 N/mm<sup>2</sup>

Mean modulus of elasticity, E<sub>0.mean</sub>, 11000 N/mm<sup>2</sup>

Fifth percentile modulus of elasticity, E<sub>0.09</sub> 7400 N/mm<sup>2</sup>

Shear modulus of elasticity, G<sub>mean</sub>, 690 N/mm<sup>2</sup>

Characteristic density,  $\rho_{kr}$  350 kg/m<sup>3</sup>

Mean density, ρ<sub>mean</sub>, 420 kg/m<sup>3</sup>

#### Span details

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



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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;  $k_{def} = 0.8$  $k_{h,t} = 1$ Depth factor for tension - exp.3.1; 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

P<sub>d</sub> = **15.093** kN Design axial compression;

Design compressive stress;  $\sigma_{c,0,d} = P_d / A = 2.141 \text{ N/mm}^2$ 

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Design compressive strength;  $f_{c,0,d} = k_{mod} f_{c,0,d}$ 

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

PASS - Design parallel compression strength eed design arallel compression stress

#### Check design 2592 mm along span

#### Check shear force - Section 6.1.7

Design shear force;

 $F_{v,d} / (k_{cr} f b f h) = 0.363 \text{ N/mm}^2$ Design shear stress - exp.6.60;

=  $k_{mod}$  f<sub>v.k</sub> /  $\gamma_{M}$  = **2.769** N/mm<sup>2</sup> Design shear strength;

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

PASS - Design shear strength exceeds design shear stress

#### Check bending moment - Section 6.

Design bending moment;  $M_{v,d} = 0.484 \text{ kNm}$ 

Design bending stress  $\sigma_{m,y,d} = M_{y,d} / W_y = 2.747 \text{ N/mm}^2$ 

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

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

PASS - Design bending strength exceeds design bending stress

#### Checkmbined beiding and axial compression - Section 6.2.4

Combine load hecks - exp.6.19 & 6.20;  $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} = 0.187$ 

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

#### PASS - Combined bending and axial compression utilisation is acceptable

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

ferive length for y-axis bending;  $L_{e,y} = 0.9$  5402 mm = **4862** mm

 $\lambda_{v} = L_{e,v} / i_{v} = 112.278$ enderness ratio;

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

Effective length for z-axis bending;  $L_{e,z} = 0 \text{ mm}$ Slenderness ratio;  $\lambda_z = L_{e,z} / i_z = 0$ 

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

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

Straightness factor;  $\beta_{c} = 0.2$ 

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



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

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

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

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

 $\sigma_{c,0,d} / (k_{c,z} - f_{c,0,d}) + k_m - \sigma_{m,y,d} / f_{m,y,d} = 254$ 

PASS - Column ability is scen able

#### Check design 4638 mm along span

Check shear force - Section 6.1.7

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

Design shear strength;  $f_{v,y,d} = k_{mod} f_{v,y,d} = 2.7$  N/mm<sup>2</sup>

 $\tau_{y,d} / f_{v,y,d} = 0.14$ 

PASS - Design shear stress exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment;

Design bending stress;

Design bending strength;

1VI) = **0. 26** kNm

 $\sigma_{\rm m} = M_{\rm y,a} W_{\rm y} = 1.849 \text{ N/mm}^2$ 

 $f_{m,y,d} = k_{mod} \int f_{m,k} / \gamma_M = 16.615 \text{ N/mm}^2$ 

 $d / f_{m,y,d} = 0.111$ 

PASS - Design bending strength exceeds design bending stress

Check combined bending and axis compression - Section 6.2.4

Combined loading checks - exp.6.19 & 20

 $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} = 0.133$ 

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

Pres - ombined bending and axial compression utilisation is acceptable

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

Effective length for y-1 is bending;  $L_{e,y} = 0.9$  5402 mm = **4862** mm

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

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

Effective length length set z-axis bending;  $L_{e,z} = \mathbf{0} \text{ mm}$   $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

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

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

raightness factor;  $\beta_c = 0.2$ 

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

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

 $k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) = 0.247$  $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.064$ 

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

 $\sigma_{c,0,d}$  / ( $k_{c,z}$  f<sub>c,0,d</sub>) +  $k_m$   $\sigma_{m,y,d}$  /  $f_{m,y,d}$  = 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;  $\delta_{\rm Y}$  = **1.5** mm

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

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

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

PASS - Allowable deflection xcee s nal deflection

#### **RIGHT RAFTER - Span 1**

#### Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Shorterm

Service class - cl.2.3.1.3;

**Timber section details** 

Number of timber sections in member;

Breadth of sections;

Depth of sections;

Timber strength class - EN 338:2 Tab 1

= 1

47 mm

h = 150 mm

C24

C24



#### 47x150 timber section

Cross-sectional area, A, 7050 mm²
Section modulus, W<sub>y</sub>, 176250 mm³
Section modulus, W<sub>y</sub>, 55225 mm³
Second moment of area, I<sub>y</sub>, 13218750 mm⁴
Second moment of area, I<sub>z</sub>, 1297787 mm⁴
Radius of gyration, I<sub>y</sub> 43.3 mm
Radius of gyration, I<sub>y</sub> 13.6 mm

Timber strength class C24

Characteristic bending strength,  $f_{m,k}$ , 24 N/mm<sup>2</sup>

Characteristic shear strength, f<sub>v,k</sub> 4 N/mm<sup>2</sup>

Characteristic compression strength parallel to grain,  $f_{\text{c.o.ie}}$  21 N/mm<sup>2</sup>

Characteristic compression strength perpendicular to grain,  $f_{c\,90\,k}$ , 2.5 N/mm² Characteristic tension strength parallel to grain,  $f_{c\,0\,k}$ , 14.5 N/mm²

Mean modulus of elasticity, E<sub>0.mean</sub>, 11000 N/mm<sup>2</sup>

Fifth percentile modulus of elasticity,  $E_{0.09}$ , 7400 N/mm<sup>2</sup>

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

Characteristic density, Pie 350 kg/m3

Mean density,  $\rho_{mean},\,420~kg/m^3$ 

#### Span details

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

#### 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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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<sub>d</sub> = **15.34** kN

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

Design compressive strength;  $f_{c,0,d} = k_{mod} - f_{c,0,k} / \gamma_M = 14.53$  1/mm<sup>2</sup>

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

PASS - Design parallel compression strength exceeds design parallel compression stress

#### Check design 2336 mm along span

Check shear force - Section 6.1.7

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

Design shear stress - exp.6.60;  $\tau_{y,d} = 10^{-10} \text{ h}$  = **0.404** N/mm<sup>2</sup>

Design shear strength;  $f_{v,y} = k_{mog} + k_{mog} = 2.769 \text{ N/mm}^2$ 

 $f_{v,y} = 0.146$ 

P/S - Deign spar strength exceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment;

Design bending stress;

Design bending strength;

d = **0.537** kNm

 $\sigma_{m,y,d} = M_{y,d} / W_y = 3.045 \text{ N/mm}^2$ 

 $f_{m,y,d} = k_{mod} - f_{m.k} / \gamma_M = 16.615 \text{ N/mm}^2$ 

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

PS - Design bending strength exceeds design bending stress

#### Check combined boron an axial compression - Section 6.2.4

Combined loadin checks exp.6. & 6.20;

 $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} = 0.206$ 

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

PASS - Combined bending and axial compression utilisation is acceptable

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

Effective agth y-axis bending;  $L_{e,y} = 0.9$  5340 mm = **4806** mm

The terms to;  $\lambda_y = L_{e,y} / i_y = 110.99$ 

lative standerness ratio - exp. 6.21;  $\lambda_{\text{rel},y} = \lambda_y / \pi \wedge \sqrt{(f_{\text{c.0.k}} / E_{0.05})} = \textbf{1.882}$ 

Effective length for z-axis bending;  $L_{e,z} = \mathbf{0}$  mm length for z-axis bending;  $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

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

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

Straightness factor;  $\beta_c = 0.2$ 

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

 $k_z = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,z} - 0.3$ ) +  $\lambda_{rel,z}^2$ ) = **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;  $\sigma_{c,0,d} / (k_{c,y} - f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} = 0.777$ 



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

PASS - Column stability is accustable

#### Check design 4606 mm along span

Check shear force - Section 6.1.7

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

Design shear stress - exp.6.60;  $\tau_{y,d} = 1.5 + F_{y,d} / (k_{cr} + b + h) = 3.418 \text{ N/min}$ 

Design shear strength;  $f_{v,y,d} = k_{mod} \int f_{v,k} / \gamma_M = 2.769 \text{ N}_{b} \text{ m}^2$ 

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

PASS - Design shear strength exceed design shear stress

Check bending moment - Section 6.1.6

Design bending moment;  $M_{y,d} = 0.274 \text{ km}$ 

Design bending stress;  $\sigma_{m,y,d} = M_{md} / W_{p} = 1.555 \text{ N/mm}^2$ Design bending strength;  $f_{m,y,d} = M_{md} / W_{p} = 1.555 \text{ N/mm}^2$ 

 $\sigma_{m,y}$ ,  $f_{m,y}$ 

PASS - Deben ing strength exceeds design bending stress

Check combined bending and axial compression - section 62.4

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

PASS Combined bending and axial compression utilisation is acceptable

Check columns subjected to either impression 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;  $\lambda_y = L_{e,y} / i_y = 110.99$ 

Relative slendernes ratio exp. 21  $\lambda_{\text{rel,y}} = \lambda_y / \pi / \sqrt{(f_{c.0.k} / E_{0.05})} = 1.882$ 

Effective length for z-axis rending;  $L_{e,z} = \mathbf{0}$  mm Slenderness  $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

Relative slende near ratio exp. 6.22;  $\lambda_{\text{rel},z} = \lambda_z / \pi / \sqrt{(f_{\text{c.0.k}} / E_{0.05})} = \mathbf{0}$ 

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

Straightness fact  $\beta_c = 0.2$ 

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

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

 $k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) = 0.252$  $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.064$ 

folumn stability checks - exp.6.23 & 6.24;  $\sigma_{c,0,d}$  / ( $k_{c,y}$  f<sub>c,0,d</sub>) +  $\sigma_{m,y,d}$  / f<sub>m,y,d</sub> = **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

#### Consider Combination 1 - LoadCombination1 (Service)

#### Check design 3644 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;  $\delta_{V} = 1.9 \text{ mm}$ 



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Final deflection;  $\delta_{y,\text{Final}} = \delta_y \quad \text{(1 + k_{def})} = \textbf{3.4 mm}$  Allowable deflection;  $\delta_{y,\text{Allowable}} = L_{\text{m3\_s1}} / 250 = \textbf{21.4 mm}$ 

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

PASS - Allowable deflection exceeds fall deflection

#### KNEE WALL 1 - Span 1

#### Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Long-term Service class - cl.2.3.1.3;

Timber section details

Number of timber sections in member; N = 1Breadth of sections; b = 47 mmDepth of sections; h = 50 m

Timber strength class - EN 338:2016 Table 1;



#### 47x150 tin.

Cross-sections 2a, A, 7050 mm<sup>2</sup>
Section modulus, W<sub>2</sub>, 55225 mm<sup>3</sup>
Section modulus, W<sub>2</sub>, 55225 mm<sup>3</sup>
Second moment of area, I<sub>2</sub>, 13218750 mm<sup>4</sup>
Second moment of area, I<sub>3</sub>, 13218750 mm<sup>4</sup>
Radio of gyration, I<sub>2</sub>, 43.3 mm
Finds of gyration, I<sub>2</sub>, 13.6 mm
Annual of the second moment of area (Characteristic banding strength f. 24 N/m

Characteristic bending strength, f<sub>m,k</sub>, 24 N/mm<sup>2</sup>
Characteristic shear strength, f<sub>m,k</sub>, 4 N/mm<sup>2</sup>

Characteristic compression strength parallel to grain,  $f_{c,0,k}$  21 N/mm² Characteristic compression strength perpendicular to grain,  $f_{c,0,k}$  2.5 N/mm² Characteristic tension strength parallel to grain,  $f_{c,0,k}$  14.5 N/mm² Mean modulus of elasticity,  $F_{c,mean}$  11000 N/mm² Fifth percentile modulus of elasticity,  $F_{c,0,0}$  7400 N/mm² Shear modulus of elasticity,  $G_{moon}$  990 N/mm²

Characteristic density,  $\rho_{\text{Ne}}$ , 350 kg/m³ Mean density,  $\rho_{\text{mean}}$ , 420 kg/m³

#### nan eu

Being length;  $L_b = 100 \text{ mm}$ 

#### on ider Combination 2 - LoadCombination2 (Strength)

#### odification 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;  $P_d = 4.975 \text{ kN}$ 



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

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

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

PASS - Design tensile strength exceeds design ensile stress

#### Check design at start of span

Check shear force - Section 6.1.7

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

Design shear stress - exp.6.60;  $\tau_{y,d} = 1.5 + F_{y,d} / (k_{cr} + b) = 0.18 \text{ N/m}^2$ 

Design shear strength;  $f_{v,y,d} = k_{mod} \int f_{v,k} / \gamma_M = 2.154 \text{ N/N}_{color}^2$ 

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

PASS - Design shear strength a ceeds design shear stress

Check bending moment - Section 6.1.6

Design bending moment; M<sub>y,d</sub> 3.118 Nm

Design bending stress;  $\sigma_{m,y} \in M$  **9.672** N/mm<sup>2</sup> Design bending strength;  $\sigma_{m,k} / \gamma_M = 12.923$  N/mm<sup>2</sup>

5m / fm,y,d 0.052

PASS - Death bending strength exceeds design bending stress

Check combined bending and axial mpression ection 6.2.4

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

PAS - Combined bending and axial tension utilisation is acceptable

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

Lateral buckling factor - ex. 6.3 k<sub>crit</sub> = **1.000** 

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

PASS - Beam stability is acceptable

#### Check design te. of span

Check ear forte - Section 6.1.7

Posign shere force;  $F_{y,d} = 0.15 \text{ kN}$ 

esign page stress - exp.6.60;  $\tau_{y,d} = 1.5 \, \hat{f}_{y,d} \, / \, (k_{cr} \, \hat{b} \, \hat{h}) = 0.048 \, \text{N/mm}^2$ 

Due on shear strength;  $f_{v,y,d} = k_{mod} \int f_{v,k} / \gamma_M = 2.154 \text{ N/mm}^2$ 

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

PASS - Design shear strength exceeds design shear stress

Check bending moment - Section 6.1.6

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

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

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

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

PASS - Design bending strength exceeds design bending stress



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#### Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18;

 $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d} = 0.094$ 

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

PASS - Combined bending and axial tension utilisation is acceptable

Check beams subjected to either bending or combined bending and compression ▲cl.6.

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

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

PASS - B m st hility acceptable

#### Consider Combination 1 - LoadCombination1 (Service)

#### Check design at end of span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;  $\delta_y = 0.1$ 

Final deflection;  $\delta_{y,F} = \delta_y / (1 + k_{def}) =$ **0.1**mm Allowable deflection;  $\delta_{x,Allows} / L_{m4\_s1} / 125 =$ **9.3**mm

 $\delta_{y,F}$  I /  $\delta_{y,r}$  wable = **0.009** 

PSS - Allowable deflection exceeds final deflection

#### KNEE WALL 2 - Span 1

#### Partial factor for material properties and resistances

Partial factor for material properties. Take 2.3; γ<sub>M</sub> = **1.300** 

Member details

Load duration - cl.2.3.1.2; Long-term

Service class - cl.2,27.3,

Timber section tails

Number of time ar sections in member; N = 1Breadth of section b = 47 mmDepth spection h = 150 mm

Timber sengal sess - EN 338:2016 Table 1; C24



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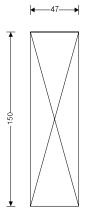
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#### 47x150 timber section

Cross-sectional area, A, 7050 mm²
Section modulus, W<sub>u</sub>, 176250 mm³
Section modulus, W<sub>u</sub>, 55225 mm³
Second moment of area, I<sub>u</sub>, 13218750 mm²
Second moment of area, I<sub>u</sub>, 1297787 mm²
Radius of gyration, I<sub>u</sub>, 43.3 mm
Radius of gyration, I<sub>u</sub> 13.6 mm
Timber strength class C24

Characteristic bending strength,  $f_{\rm mix}$ , 24 N/mm² Characteristic shear strength,  $f_{\rm cut}$  4 N/mm² Characteristic compression strength parallel to grain,  $f_{\rm cut}$ , 21 N/mm Characteristic compression strength perpendicular to grain,  $f_{\rm cut}$ , 2.5 N/m² Characteristic tension strength parallel to grain,  $f_{\rm cut}$ , 44.5 N/mm² Mean modulus of elasticity,  $E_{\rm cut}$  1000 N/m² Fifth percentile modulus of elasticity,  $E_{\rm cut}$ , 400 N/mm² Shear modulus of elasticity,  $G_{\rm mean}$  990 N/m²

Characteristic density,  $\rho_{le}$ , 350 kg/m<sup>3</sup> Mean density,  $\rho_{mean}$ , 420 kg/m

#### Span details

Bearing length;

Lb 100 N

#### Consider Combination 2 - LoadCombination2 Strongth)

#### **Modification factors**

Duration of load and moisture context - 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-distributing factor - cl.6. p(2);  $k_{cr} = 0.67$ Crack factor for shear moistance - cl.6. p(2);  $k_{cr} = 0.67$ 

#### Check tension peallel to the grant - Section 6.1.2

Axial tension: P<sub>d</sub> = **4.948** kN

Design tensile 5. ss;  $\sigma_{t,0,d} = P_d / (b \text{ min}(h_{ef\_e1}, h_{ef\_e2})) = \textbf{0.540} \text{ N/mm}^2$ 

Design tensile stens h;  $f_{t,0,d} = k_{h,t} - k_{mod} - f_{t,0,k} / \gamma_M = 7.808 \text{ N/mm}^2$ 

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

PASS - Design tensile strength exceeds design tensile stress

#### ec' de n at start of span

#### Chick shear force - Section 6.1.7

esign shear force; F<sub>y,d</sub> = **0.258** kN

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

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

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

PASS - Design shear strength exceeds design shear stress

#### Check bending moment - Section 6.1.6

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

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

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



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

PASS - Design bending strength exceeds design bending tre

Check combined bending and axial compression - Section 6.2.4

Combined loading checks - exp.6.17 & 6.18;

 $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d} = 0.129$ 

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

PASS - Combined bending and axial tension utilisation is

Lateral buckling factor - exp.6.34;

 $k_{crit} = 1.000$ 

Beam stability check - exp.6.33;

 $\sigma_{m,y,d} / (k_{crit} f_{m,y,d}) = 0.06$ 

- Beam sability is acceptable

Check design at end of span

Check shear force - Section 6.1.7

Design shear force;

Design shear stress - exp.6.60;

 $b = 0.082 \text{ N/mm}^2$ 

 $f_{v.k} / \gamma_M = 2.154 \text{ N/mm}^2$ 

Design shear strength;

Design shear strength exceeds design shear stress

Check bending moment - Section 6

Design bending moment;

 $M_{v,d} = 0.138 \text{ kNm}$ 

Design bending stress;

 $\sigma_{m,v,d} = M_{v,d} / W_v = 0.782 \text{ N/mm}^2$ 

Design bending strength;

 $f_{m,y,d}$  =  $k_{mod}$   $^{^{\prime}}$   $f_{m,k}$  /  $\gamma_M$  = 12.923 N/mm²

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

PASS - Design bending strength exceeds design bending stress

Check combined ending and axial compression - Section 6.2.4

g ch. ks - exp.6.17 & 6.18; Combined lo

 $\sigma_{t,0,d} / f_{t,0,d} + \sigma_{m,y,d} / f_{m,y,d} = 0.130$ 

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

PASS - Combined bending and axial tension utilisation is acceptable

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

ater bucklin, factor - exp.6.34;

 $k_{crit} = 1.000$ 

B ar stability check - exp.6.33;

 $\sigma_{m,y,d} / (k_{crit} - f_{m,y,d}) = 0.061$ 

PASS - Beam stability is acceptable

nsider Combination 1 - LoadCombination1 (Service)

Check design at end of span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;

 $\delta_{y} = 0.1 \text{ mm}$ 

 $\delta_{\text{y,Final}} = \delta_{\text{y}}$  (1 + k<sub>def</sub>) = **0.2** mm Final deflection:

Allowable deflection;  $\delta_{y,Allowable}$  = L<sub>m5\_s1</sub> / 125 = **8.5** mm

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

PASS - Allowable deflection exceeds final deflection



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#### **COLLAR TIE - Span 1**

#### Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Long-term

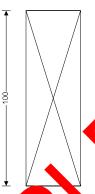
Service class - cl.2.3.1.3;

**Timber section details** 

Number of timber sections in member; N = 1Breadth of sections; b = 35 mmDepth of sections; h = 100 mm

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





#### 35x100 timber section

Cross-sectional art 1s, 3500 mm.

Section modulus, W<sub>1</sub>, 3513 3 mm<sup>3</sup>

Section modulus, W<sub>2</sub>, 3513 3 mm<sup>3</sup>

Section modulus, W<sub>3</sub> 2513 3 mm<sup>3</sup>

Second doment of the L<sub>1</sub>, 2515 5 mm<sup>4</sup>

Section moment of the L<sub>2</sub>, 35725 mm<sup>4</sup>

Radius chayrath of L<sub>2</sub>, 28.9 mm

Radius of the Control of the Co

Characteristic bending strength, f<sub>mik</sub> 24 N/mm<sup>2</sup>
Characteristic shear strength, f<sub>vik</sub> 4 N/mm<sup>2</sup>

Characteristic compression strength parallel to grain,  $f_{c.o.k}$ , 21 N/mm² Characteristic compression strength perpendicular to grain,  $f_{c.o.o.k}$ , 2.5 N/mm² Characteristic tension strength parallel to grain,  $f_{c.o.k}$ , 14.5 N/mm²

rean modulus of elasticity, E<sub>0.mearr</sub> 11000 N/mm<sup>2</sup>
Fifth percentile modulus of elasticity, E<sub>0.05</sub>, 7400 N/mm<sup>2</sup>

Fifth percentile modulus of elasticity,  $E_{0.05}$ , 7400 N Shear modulus of elasticity,  $G_{\text{mean}}$ , 690 N/mm² Characteristic density,  $\rho_{\text{lk}}$ , 350 kg/m³ Mean density,  $\rho_{\text{mean}}$ , 420 kg/m³

#### Span details

Bearing th;  $L_b = 100 \text{ mm}$ 

#### Consider combination 2 - LoadCombination2 (Strength)

#### loan, tion actors

Degree of load and moisture content - Table 3.1;  $k_{mod} = 0.7$ Degree of load and moisture content - Table 3.1;  $k_{def} = 0.6$ 

epin factor for bending - Major axis - exp.3.1;  $k_{h,m,y} = min((150 \text{ mm / h})^{0.2}, 1.3) = 1.084$ 

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

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<sub>d</sub> = **4.681** kN

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

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

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



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PASS - Design parallel compression strength exceeds design parallel compression stress

#### Check design at start of span

Check shear force - Section 6.1.7

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

Design shear stress - exp.6.60;  $\tau_{y,d} = 1.5 + F_{y,d} / (k_{cr} + b + h) = 0.641 \text{ N} \text{ m}^2$ 

Design shear strength;  $f_{v,y,d} = k_{mod} f_{v,k} / \gamma_M = 2.154 \text{ N/m}^2$ 

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

PASS - Design shear strength exceeds signs hear stress

Check bending moment - Section 6.1.6

Design bending moment;  $M_{y,d} = 0.037 \text{ kN}_{y}$ 

Design bending stress;  $\sigma_{m,y,d} = M_{y,d} / V = 0.637 \text{ N} \text{ nm}^2$ 

Design bending strength;  $f_{m,y,d} = k_{h,m,v} = 14.015 \text{ N/mm}^2$ 

 $\sigma_{m,y,d}$   $m_{,y,d}$  0.045

PASS - Design and ending stress

Check combined bending and axial compression action 6.2.4

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

 $\int_{c,0,d} / f_{c,0,d})^2 + k_m \int_{c,0,d} / f_{m,y,d} = 0.046$ 

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;

Slenderness ratio;

Relative slenderness ratio - 0. 6.21;

Effective length for axis and a

Slenderness ration

Relative slen ness 10 - exp. 6.22;

 $L_{e,y} = 0.9$  1335 mm = **1202** mm

 $\lambda_y = L_{e,y} / i_y = 41.621$ 

 $\lambda_{\text{rel,y}} = \lambda_y / \pi$   $\sqrt{(f_{c.0.k} / E_{0.05})} = 0.706$ 

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

 $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

 $\lambda_{\text{rel,z}} = \lambda_z / \pi$   $\sqrt{(f_{c.0.k} / E_{0.05})} = 0$ 

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

Straight s factor;  $\beta_c = 0.2$ 

pc - **U.Z** 

Instability ctors xp.6.25, 6.26, 6.27 & 6.28;

umn stability checks - exp.6.23 & 6.24;

 $k_y = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,y}$  - 0.3) +  $\lambda_{rel,y}^2$ ) = **0.790** 

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

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

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

 $\sigma_{c,0,d} / (k_{c,y} - f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} = 0.181$ 

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

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;  $(\sigma_{m,y,d} / (k_{crit} - f_{m,y,d}))^2 + \sigma_{c,0,d} / (k_{c,z} - f_{c,0,d}) = 0.113$ 

PASS - Beam stability is acceptable



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#### Check design 1154 mm along span

Check bending moment - Section 6.1.6

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

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

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 $f_{m,y,d} = k_{h,m,y} - k_{mod} - f_{m,k} / \gamma_M = 14 / 5 N$ Design bending strength;

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

PASS - Design bending strength exceeds lesion bending stress

Check combined bending and axial compression - Section 6.2.4

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

> $(\sigma_{c,0,d} / f_{c,0,d})^2 +$ .038

PASS - Combined bending and axia compress n utilisation is acceptable

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

J.9 ´ 335 mm = **1202** mm Effective length for y-axis bending;

Slenderness ratio;

Relative slenderness ratio - exp. 6.21;  $\sqrt{(f_{c.0.k} / E_{0.05})} = 0.706$ 

- 0 mm Effective length for z-axis bending;  $z = L_{e,z} / i_z = 0$ Slenderness ratio;

Relative slenderness ratio - exp. 6.22;  $_{\rm L} = \lambda_{\rm z} / \pi ~ (f_{\rm c.0.k} / E_{0.05}) = 0$ 

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

Straightness factor;  $\beta_c = 0.2$ 

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

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

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

 $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.064$ chec Column stab - exp.6.23 & 6.24;

 $\sigma_{c,0,d} / (k_{c,y} - f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} = 0.169$ 

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

PASS - Column stability is acceptable

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

ater bucklin, factor - exp.6.34;  $k_{crit} = 1.000$ 

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

PASS - Beam stability is acceptable

#### nsider Combination 1 - LoadCombination1 (Service)

#### Check design at end of span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;  $\delta_{y}$  = **1.3** mm

 $\delta_{y,Final} = \delta_y$  (1 + k<sub>def</sub>) = **2.1** mm Final deflection:

Allowable deflection;  $\delta_{y,Allowable}$  = L<sub>m6\_s1</sub> / 250 = **5.3** mm

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

PASS - Allowable deflection exceeds final deflection



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#### 1 - Span 1

#### Partial factor for material properties and resistances

Partial factor for material properties - Table 2.3;  $\gamma_{\rm M} = 1.300$ 

Member details

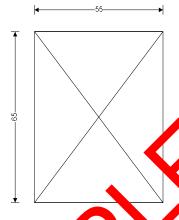
Load duration - cl.2.3.1.2; Short-term

Service class - cl.2.3.1.3; 2

Timber section details

Number of timber sections in member; N = 1Breadth of sections; b = **55** mm Depth of sections: h = **65** mm C24

Timber strength class - EN 338:2016 Table 1;



#### timber: ss-sectio

Mean density,  $\,\rho_{mean}\,$  420 kg/m³

.2 mm<sup>3</sup> dulus, W\_, 32771 mm<sup>3</sup> ot of area, I,, 1258698 mm<sup>4</sup> cond m of area, Í<u>.,</u> 901198 mm⁴ cond mome Radius of gyration, i<sub>y</sub>, 18.8 mm Radius of gyration, i2, 15.9 mm Timber strength class C24 haracteristic bending strength, f m.k 24 N/mm² Characteristic shear strength, f vk 4 N/mm² Characteristic compression strength parallel to grain, f cold 21 N/mm<sup>2</sup> Characteristic compression strength perpendicular to grain, f c 90 kg 2.5 N/mm<sup>2</sup> Characteristic tension strength parallel to grain, f , nk, 14.5 N/mm² Mean modulus of elasticity, E <sub>0.mean</sub>, 11000 N/mm<sup>2</sup> Fifth percentile modulus of elasticity, E nos, 7400 N/mm<sup>2</sup> Shear modulus of elasticity, G mean, 690 N/mm<sup>2</sup> Characteristic density, pp. 350 kg/m3

#### Span details

Bearin length;  $L_b = 100 \text{ mm}$ 

#### Com. Conside. tion 2 - LoadCombination2 (Strength)

#### ctors

praton or and and moisture content - Table 3.1; kmod = 0.9 Dermation factor - Table 3.2;  $k_{def} = 0.8$ 

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

epth 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<sub>d</sub> = **8.458** kN

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

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



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

PASS - Design parallel compression strength exceeds design parallel compression tree

#### Check design at end of span

Check shear force - Section 6.1.7

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

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

Design shear strength;  $f_{V,y,d} = k_{mod} - k_{sys} - f_{V,k} / \gamma_{M} = 3.146 \text{ mm}^2$ 

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

PASS - Design shear strength exceed design shear stress

Check bending moment - Section 6.1.6

Design bending moment;  $M_{y,d} = 0.029 \text{ km}$ 

Design bending stress;  $\sigma_{m,y,d} = M_{vd} / W_{e} = 0.756 \text{ N} \text{ nm}^2$ 

Design bending strength;  $f_{m,y,d} = \frac{1.604 \text{ N/mm}^2}{\text{kmod}} = \frac{1.604 \text{ N/mm}^2}{\text{kmod}}$ 

 $\sigma_{m,v}$   $f_{m,v}$ 

PASS - Debening strength exceeds design bending stress

Check combined bending and axial compression - 9 ction 2.4

Combined loading checks - exp.6.19 & 6.20;  $\sigma_{c,0,d} / f_{c,0,d} / f_{c,0,d} = 0.057$ 

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

PASS Combined bending and axial compression utilisation is acceptable

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

Effective length for y-axis bending; Le,y = 0.9 2771 mm = 2494 mm

Slenderness ratio;  $\lambda_{v} = L_{e,v} / i_{v} = 132.91$ 

Relative slendernes ratio exp. 21  $\lambda_{\text{rel,y}} = \lambda_y / \pi \quad \sqrt{(f_{\text{c.0.k}} / E_{0.05})} = 2.254$ 

Effective length for z-axis rending;  $L_{e,z} = \mathbf{0}$  mm Slenderness  $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

Relative slendernes rate, exp. 6.22;  $\lambda_{rel,z} = \lambda_z / \pi$   $\sqrt{(f_{c.0.k} / E_{0.05})} = \mathbf{0}$ 

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

Straightness factor  $\beta_c = 0.2$ 

The first series is  $k_y = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,y} = 0.3$ ) +  $\lambda_{rel,y}^2$ ) = 3.235

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

 $k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) = 0.180$  $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.064$ 

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

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

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;  $\delta_y = 0.8 \text{ mm}$ 



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Final deflection;  $\delta_{y,\text{Final}} = \delta_y \quad \text{(1 + k_{def})} = \textbf{1.4 mm}$  Allowable deflection;  $\delta_{y,\text{Allowable}} = L_{\text{m7\_s1}} / 250 = \textbf{11.1 mm}$ 

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

PASS - Allowable deflection exceeds fall deflection

#### 2 - Span 1

#### Partial factor for material properties and resistances

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

Member details

Load duration - cl.2.3.1.2; Short-term Service class - cl.2.3.1.3; 1

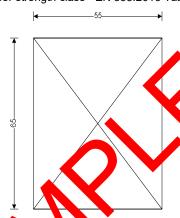
**Timber section details** 

Number of timber sections in member; N = 1

Breadth of sections; b = 55 mm

Depth of sections; h = 5 mm

Timber strength class - EN 338:2016 Table 1;



55x65 timber section

Cross-sectional area, A, 3575 mm²
Section modulus, W<sub>p</sub>, 38729.2 mm³
Section modulus, W<sub>s</sub>, 32771 mm³
Second moment of area, I<sub>p</sub>, 1258698 mm²
Second moment of area, I<sub>p</sub>, 901198 mm²
Radius of gyration, i<sub>p</sub>, 18.8 mm
Radius of gyration, i<sub>p</sub>, 15.9 mm
Timber strength class C24
Characteristic bending strength, f<sub>m k</sub> 24 N/mm²

Characteristic shear strength, f<sub>v,k</sub> 4 N/mm²
Characteristic compression strength parallel to grain, f<sub>v,0,k</sub>, 21 N/mm²
Characteristic compression strength perpendicular to grain, f<sub>v,0,k</sub>, 2.5 N/mm²
Characteristic tension strength parallel to grain, f<sub>v,0,k</sub>, 14.5 N/mm²
Mean modulus of elasticity, E<sub>0,mean</sub>, 11000 N/mm²

Fifth percentile modulus of elasticity, E  $_{0.08}$ , 7400 N/mm $^2$  Shear modulus of elasticity, G  $_{mean}$ , 690 N/mm $^2$  Characteristic density,  $p_{le}$ , 350 kg/m $^3$  Mean density,  $p_{mean}$ , 420 kg/m $^3$ 

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Burng length;  $L_b = 100 \text{ mm}$ 

#### on ider Combination 2 - LoadCombination2 (Strength)

#### odification 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;  $k_{sys} = 1.1$ 



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Check compression parallel to the grain - cl.6.1.4

Design axial compression; P<sub>d</sub> = **8.898** kN

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

Design compressive strength;  $f_{c,0,d} = k_{mod} = k_{sys} = f_{c,0,k} / \gamma_M = 15.992 \text{ N/y} \text{ m}^2$ 

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

PASS - Design parallel compression strength exceeds design parallel compression strength

Check design at end of span

Check shear force - Section 6.1.7

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

 $\tau_{y,d} / f_{v,y,d} = 0.00$ 

PASS - Design smarr stress

Check bending moment - Section 6.1.6

Design bending moment; = 17 kNm

Design bending stress;  $\sigma_{m} = M_{y} W_{y} = 0.436 \text{ N/mm}^{2}$ 

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

 $y,d / f_{m,y,d} = 0.02$ 

PASS - Design bending strength exceeds design bending stress

Check combined bending and and compression - Section 6.2.4

Combined loading checks - exp.6.19 ( $\sigma_{c,0,d} / f_{c,0,d}$ )<sup>2</sup> +  $\sigma_{m,y,d} / f_{m,y,d} = 0.044$ 

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

PSS - mbined bending and axial compression utilisation is acceptable

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

Effective lengtor y s bending;  $L_{e,y} = 0.9$  2885 mm = 2597 mm

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

Relation lender less tio - exp. 6.21;  $\lambda_{\text{rel},y} = \lambda_y / \pi / \sqrt{(f_{\text{c.0.k}} / E_{0.05})} = 2.346$ 

Effective agth z-axis bending;  $L_{e,z} = \mathbf{0}$  mm  $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

Foliative standardness ratio - exp. 6.22;  $\lambda_{\text{rel},z} = \lambda_z / \pi / \sqrt{(f_{\text{c.0.k}} / \text{E}_{0.05})} = \mathbf{0}$ 

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

rathtness factor;  $\beta_c = 0.2$ 

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

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

 $k_{c,y} = 1 / (k_y + \sqrt{(k_y^2 - \lambda_{rel,y}^2)}) = 0.167$  $k_{c,z} = 1 / (k_z + \sqrt{(k_z^2 - \lambda_{rel,z}^2)}) = 1.064$ 

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

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

PASS - Column stability is acceptable



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#### Consider Combination 1 - LoadCombination1 (Service)

#### Check design 736 mm along span

Check y-y axis deflection - Section 7.2

Instantaneous deflection;

Final deflection;

Allowable deflection;

 $\delta_y$  = 1 mm

 $\delta_{y,Final} = \delta_y$  (1 + k<sub>def</sub>) = **1.6** mm

 $\delta_{y,Allowable} = L_{m8\_s1} / 250 = 11.5$ 

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

PASS - Allowable deflection nal deflection YCe€





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• 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 at 1 the recommended values

#### **ANALYSIS**

#### Geometry

Geometry (m) - C24 (EC5) - 2/47x4



#### Materials

N	Density		Shear Modulus	Thermal Coefficient	
	(kg/m³)	kN/mm²	kN/mm²	°C <sup>-1</sup>	
24 (.50.)	420	11	0.69	0	

#### Setions

Name	Area	Moment of inertia		Shear area parallel to		
	(cm²)	Major (cm⁴)	Minor (cm <sup>4</sup> )	Minor (cm²)	Major (cm²)	
2/47x150	141	2644	1038	118	118	



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#### Nodes

Node	Co-ordinates		Freedom		Coordinate system			Spring		
	X	Z	X	Z	Rot.	Name	Angle	X	Z	Rot.
	(m)	(m)					(°)	(kN/m)	N/m)	k lm/°
1	0	0	Fixed	Fixed	Free		0			0
2	1.9	0.95	Free	Fixed	Free		0	0	0	0
3	4.5	2.2	Fixed	Fixed	Free		0	0	U	0

#### **Elements**

Eleme nt	Length	No	des	Section	М	eria		Releases	3	Rotate d
	(m)	Start	End		2		Start momen t	End momen t	Axial	
1	2.124	1	2	2/47x150	C2	4 (ÉC5)	Fixed	Fixed	Fixed	
2	2.885	2	3	2/47 (150)	C2	4 (EC5)	Fixed	Fixed	Fixed	

#### Members

Name	EI	Elements			
	Start			End	
Member1	1			<u> </u>	

#### Loading

Self weight included

#### Permanent - Loading (kN/m)



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#### Load combination factors

Load combination	Self Weight	Permanen t	pesodul
LoadCombination1 (Service)	1.00	1.00	1.00
LoadCombination2 (Strength)	1.00	1.40	1.60

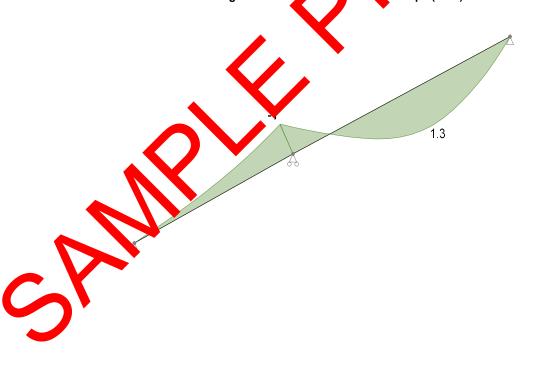
#### **Member Loads**

Member	Load case	Load Type	Orientatio n	Description
Member1	Permanent	UDL	Global	1.1 k Vm at 3 m to 4 m
Member1	Permanent	VDL	Global	0 kN/h to 1 kN/m

#### Results

#### **Forces**

#### Strength combinations - Nomen envelope (kNm)





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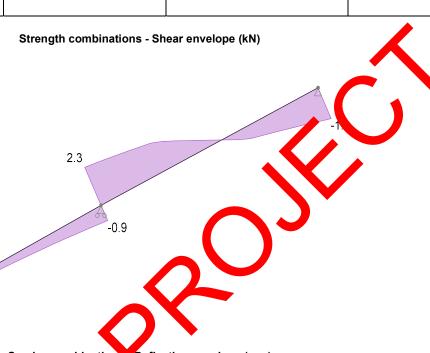
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#### Member1 - Span 1

#### Partial factor for material properties and resistances

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

#### Member details

Load duration - cl.2.3.1.2; Long-term

Service class - cl.2.3.1.3;

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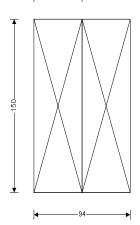
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#### **Timber section details**

Number of timber sections in member; N = 2Breadth of sections; b = 47 mmDepth of sections; h = 150 mm

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

**|**←──47──**→**|



#### 2/47x150 timber sections

Cross-sectional area, A, 14100 mm 2

Section modulus, W ,, 352500 mm<sup>3</sup> Section modulus, W., 110450 mm3 Second moment of area, I , 26437500 mm<sup>4</sup> Second moment of area, I\_, 2595575 Radius of gyration, i , 43.3 mm Radius of gyration, i \_ 13.6 mm Timber strength class C24 24 N/mm<sup>2</sup> Characteristic bending strength, f Characteristic shear gth paraller to grain, f c.o.k 21 N/mm² Characteristic co noth perpendicular to grain, f o.so k, 2.5 N/mm² Characteristi Characteristic t ain, f 14.5 N/mm<sup>2</sup> ty, E <sub>0.mean</sub>, 11000 N/mm<sup>2</sup> lasticity, E 0.05, 7400 N/mm<sup>2</sup> nodulus shear modu of elasticity, 690 N/mm² density, Page 350 kg/m<sup>3</sup> density, Pmean, 420 kg/m<sup>3</sup>

#### Span details

Bearing length; L<sub>b</sub> = **100** mm

#### Consider Combination 2 LoadCombin on2 (Strength)

#### Modification factors

#### Check mp ss on parallel to the grain - cl.6.1.4

Pesign axia compression;  $P_d = 1.102 \text{ kN}$ 

esign empressive stress;  $\sigma_{c,0,d} = P_d / A = 0.078 \text{ N/mm}^2$ 

Degn compressive strength;  $f_{c,0,d} = k_{mod} \int f_{c,0,k} / \gamma_M = 11.308 \text{ N/mm}^2$ 

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

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;  $F_{y,d} = 2.282 \text{ kN}$ 

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

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

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

PASS - Design shear strength exceeds design shear stress



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Check bending moment - Section 6.1.6

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

$$\begin{split} \text{Design bending stress;} & \sigma_{\text{m,y,d}} = M_{\text{y,d}} \, / \, \text{W}_{\text{y}} = \text{2.941 N/mm}^2 \\ \text{Design bending strength;} & f_{\text{m,y,d}} = k_{\text{mod}} \, \stackrel{'}{\sim} \, f_{\text{m,k}} \, / \, \gamma_{\text{M}} = 12.923 \, \text{N/mm}^2 \end{split}$$

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

PASS - Design bending strength exceeds a sign bending a ess

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Check combined bending and axial tension - Section 6.2.3

Combined loading checks - exp.6.19 & 6.20;  $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d}$  228

 $(\sigma_{c,0,d} / f_{c,0,d})^2 + k_m = \sigma_{m,y,d} / f_{m,y,t} = 0.1$ 

PASS - Combined bending and axial composion utilitation is acceptable

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

Effective length for y-axis bending;  $L_{e,y} = 0.9 \le 50$  mm = 408 mm

Slenderness ratio;  $\lambda_y = \sqrt{|i_y|^2} = 104.1$ 

Relative slenderness ratio - exp. 6.21;  $\lambda_{rel} = \lambda_y / E_{0.05} = 1.765$ 

Effective length for z-axis bending; = 0 mSlenderness ratio;  $\lambda_z = 0 \text{ m}$ 

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

Straightness factor;  $\beta_c = 0.2$ 

Instability factors - exp.6.25, 6.26, 27 85.28;  $k_y = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,y}$  - 0.3) +  $\lambda_{rel,y}$  = 2.205

 $k_z = 0.5$  (1 +  $\beta_c$  ( $\lambda_{rel,z}$  - 0.3) +  $\lambda_{rel,z}$ <sup>2</sup>) = **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 ecks - p.6.23 6.24;  $\sigma_{c,0,d} / (k_{c,y} - f_{c,0,d}) + \sigma_{m,y,d} / f_{m,y,d} = 0.252$ 

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

PASS - Column stability is acceptable

Checking s bjeked to either bending or combined bending and compression - cl.6.3.3

Lateral by kling for - exp.6.34;  $k_{crit} = 1.000$ 

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

PASS - Beam stability is acceptable

Chek design 3730 mm along span

heck bending moment - Section 6.1.6

besign bending moment;  $M_{y,d} = 1.327 \text{ kNm}$ 

Design bending stress;  $\sigma_{m,y,d} = M_{y,d} / W_y = 3.764 \text{ N/mm}^2$  Design bending strength;  $f_{m,y,d} = k_{mod} - f_{m,k} / \gamma_M = 12.923 \text{ N/mm}^2$ 

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

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;  $(\sigma_{c,0,d} / f_{c,0,d})^2 + \sigma_{m,y,d} / f_{m,y,d} = 0.291$ 



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MM

Date 19/07/2024

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

PASS - Combined bending and axial compression utilisation is accurate

Check columns subjected to either compression or combined compression and bending

Effective length for y-axis bending;  $L_{e,y} = 0.9$  5009 mm = **4508** mm

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

Relative slenderness ratio - exp. 6.21;  $\lambda_{\text{rel},y} = \lambda_y / \pi = \sqrt{(f_{\text{c.0.k}} / E_{0.05})} = 1.75$ 

Effective length for z-axis bending;  $L_{e,z} = \mathbf{0}$  mm Slenderness ratio;  $\lambda_z = L_{e,z} / i_z = \mathbf{0}$ 

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

 $\lambda_{rel,y} > 0$  type stabilly check is required

Straightness factor;  $\beta_c = 0.2$ 

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

 $k_z = 0$  +  $\beta c$  (2.2 - 0.3) +  $\lambda_{rel,z}^2$ ) = **0.470** 

 $k_{c,y} = 1 / (k_y - \lambda/(k_y)^2 - \lambda_{rel,y}^2)) = 0.284$  $k_z = \lambda/(k_z)^2 - \lambda_{rel,z}^2 = 1.064$ 

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

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

PASS - Column stability is acceptable

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

Lateral buckling factor - exp.6.34; k<sub>crit</sub> = **1.000** 

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

PASS - Beam stability is acceptable

Consider Combination Los (Consider Combinati

Check design 36 mm along span

Check y-y ax eflecton - Section 7.2

Instantaneous defletion;  $\delta_y = 2.6 \text{ mm}$ 

Final du Pecus p:  $\delta_{y, \text{Final}} = \delta_y \quad \text{(1 + k_{def}) = 4.1 mm}$  Nowable of flection;  $\delta_{y, \text{Allowable}} = L_{\text{m1\_s1}} / 250 = 20 \text{ mm}$ 

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

PASS - Allowable deflection exceeds final deflection