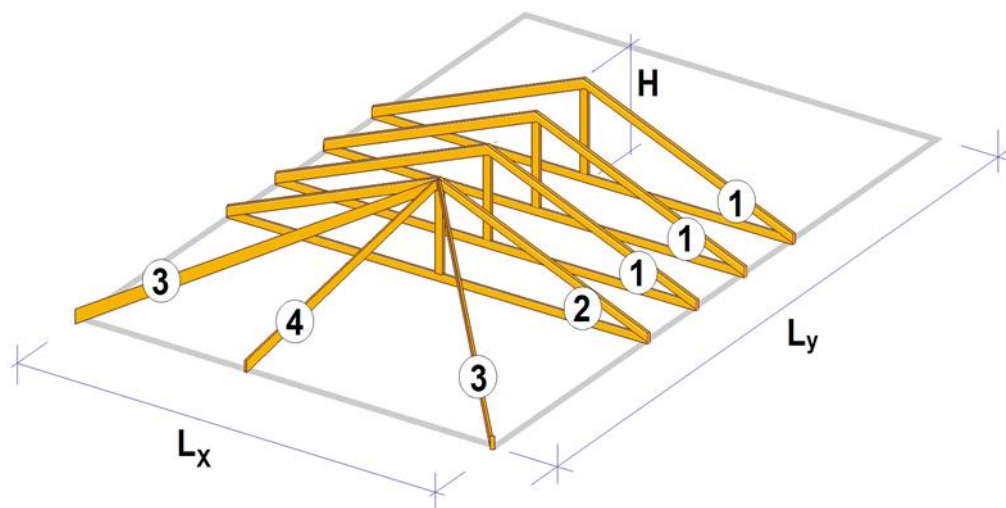


CÁLCULOS JUSTIFICATIVOS



1.1. General description, assumptions, materials, loads

1.1.1. Construction type

Hipped roof $L_x=8.690$ m, $L_y=9.840$ m, $H=1.730$ m

Timber roof, from trusses with timber GL24h. The truss type as sketch above.

Truss span 8.690 m, height 1.730 m, roof pitch 21.71° , truss spacing 5.670m

Finishing (rafter) from timber GL24h, of thickness 20 mm

Purlins from timber GL24h, with dimensions 100x240 mm, in spacing 1.250 m

Truss element cross sections BxH [mm]

Elements rafters, cross section 100x220 [mm]

Elements bottom chord, cross section 100x220 [mm]

Elements other elements, cross section 100x100 [mm]

1.1.2. Design codes

EN1990-1-1:2002, Eurocode 0 Part 1-1, Basis of structural design
EN1991-1-1:2002, Eurocode 1 Part 1-1, Actions on structures
EN1991-1-3:2003, Eurocode 1 Part 1-3, Snow loads
EN1991-1-4:2005, Eurocode 1 Part 1-4, Wind actions
EN1995-1-1:2009, Eurocode 5 Part 1-1, Design of timber structures

1.1.3. Design methodology

The internal forces of the roof trusses are computed with finite element analysis. The truss is considered as a two dimensional frame. The stiffness of the connections is adjusted according to the selected degree of stiffness. In order to compute the design values for internal forces in various loading conditions, the internal forces are first computed in unit loading, and then from their combination the internal forces in various loading conditions are obtained. All the load combinations according to Eurocode 1 and Eurocode 5 are taken into account, and the checks are performed in the most unfavourable loading conditions, for combined action, in ultimate limit state, according to EC5 EN1995-1-1:2009, §6. The connections are designed as bolted connections with metal plates according to EC5 EN1995-1-1:2009, §8. The deflections are checked in serviceability limit condition, according to EC5 EN1995-1-1:2009, §7.

1.1.4. Material properties (truss, purlins, finishing)

(EC5 EN1995-1-1:2009, §3)

Timber class : GL24h

Service classes : Class 1, moisture content $\leq$ 12% (EC5 §2.3.1.3)

Material factor $\gamma_M=1.25$ (EC5 Table 2.3)

Characteristic material properties for timber

$f_{mk} = 24.0$ MPa, $f_{t0k} = 16.5$ MPa, $f_{t90k} = 0.4$ MPa

$f_{c0k} = 24.0$ MPa, $f_{c90k} = 2.7$ MPa, $f_{vk} = 2.7$ MPa

$E_{0m} = 11600$ MPa, $E_{005} = 9400$ MPa, $E_{90m} = 390$ MPa

$G_m = 720$ MPa, $\rho_k = 380$ Kg/m³

1.1.5. Distributed roof loads

Permanent load of roof covering

$G_e = 0.400$ kN/m² (Tiles from clay)

Purlins, finishing, insulation

$G_t = 0.200$ kN/m² $G_e + G_t = 0.600$ kN/m²

Load of ceiling under the roof

$G_c = 0.300$ kN/m²

Snow load on the ground

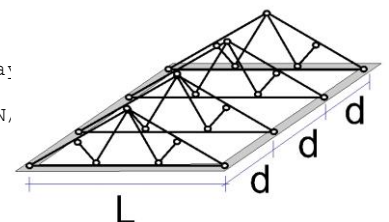
$S_k = 0.000$ kN/m²

Wind pressure on vertical surface

$Q_w = 1.250$ kN/m²

Imposed load (category H)

$Q_i = 0.400$ kN/m²



1.2. Snow load (EC1 EN1991-1-3:2003, §5)

Characteristic value of snow load on the ground: $s_k=0.000 \text{ kN/m}^2$

Snow load on the roof (EC1 EN1991-1-3:2003, §5)

Angle of pitch of roof : $\alpha=21.710^\circ$

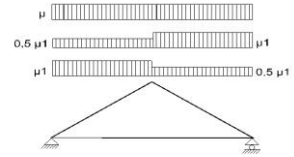
Exposure coefficient : $C_e=1.000$ (EC1-1-3 §5.2(7))

Thermal coefficient : $C_t=1.000$ (EC1-1-3 §5.2(8))

Shape coefficients, $\alpha_1=\alpha_2=21.71^\circ$, $\mu_1(\alpha_1)=\mu_1(\alpha_2)=0.800$ (Table 5.2)

$S(\alpha_1)=\mu_1(\alpha_1) \cdot C_e \cdot C_t \cdot S_k=0.800 \times 1.00 \times 1.00 \times 0.000=0.000 \text{ kN/m}^2$ (§5.2)

$S(\alpha_2)=\mu_1(\alpha_2) \cdot C_e \cdot C_t \cdot S_k=0.800 \times 1.00 \times 1.00 \times 0.000=0.000 \text{ kN/m}^2$



Snow load (EC1 EN1991-1-3:2003, §5.2(5.1), §5.3.3)

Load case (I), $S(\text{Left})=S(\alpha_1)=0.000 \text{ kN/m}^2$, $S(\text{Right})=S(\alpha_2)=0.000 \text{ kN/m}^2$

Load case (II), $S(\text{Left})=0.5 \times S(\alpha_1)=0.000 \text{ kN/m}^2$, $S(\text{Right})=S(\alpha_2)=0.000 \text{ kN/m}^2$

Load case (III), $S(\text{Left})=S(\alpha_1)=0.000 \text{ kN/m}^2$, $S(\text{Right})=0.5 \times S(\alpha_2)=0.000 \text{ kN/m}^2$

1.3. Wind loading (EC1 EN1991-1-4:2005 §5)

Pick velocity pressure $Q(z)=Q_{ref} \cdot C_e(z)$, $Q_{ref}=V_{ref}^2/1.6$ (EC1 EN1991-1-4:2005 §4.5)

Wind pressure on vertical surface $Q_{ref} \cdot C_e(z)=1.250 \text{ kN/m}^2$

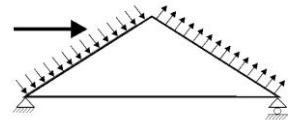
Wind pressure on roof $w_e=Q_{ref} \cdot C_e(z) \cdot C_{pe}$ (EC1 EN1991-1-4:2005, §5.2)

External pressure coefficients (EC1 EN1991-1-4:2005 Table 7.3)

For pitch angle $\alpha=21.71^\circ$, $C_{pe}(+)=0.36$, $C_{pe}(-)=-0.56$

Wind pressure $w_e(\text{Left})=0.446 \text{ kN/m}^2$

Wind pressure $w_e(\text{Right})=-0.694 \text{ kN/m}^2$



1.4. Roof timber finishing (rafter)

Timber finishing (rafter) structural system

The timber finishing (rafter) is designed as simply supported beam with span spacing of purlins $L=1.250\text{m}$, and width 1.00m .

Dimensions of timber finishing (rafter)

Timber of finishing (rafter): GL24h, service class: Class 1, moisture content $\leq 12\%$

Spacing of purlins $L=1.250\text{m}$, roof pitch $\alpha=21.71^\circ$, thickness of finishing 20mm

Loading on timber finishing (rafter)

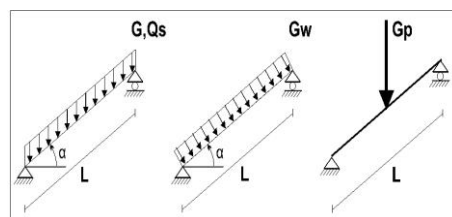
Roof covering $G_e=0.400\text{ kN/m}^2$

Self weight $G_l=0.075\text{ kN/m}^2$

Snow load $Q_s=0.000\text{ kN/m}^2$

Wind load $Q_w=0.446\text{ kN/m}^2$

Concentrated $Q_p=1.000\text{ kN}$



Internal forces of timber finishing (span $L=1.250\text{ m}$, width $=1.00\text{ m}$)

Loading			action	γ_g	γ_q	ψ_0	maxN [kN]	maxQ [kN]	maxM [kNm]
(Gk)	Permanent	Gk =0.475 [kN/m]	Permanent	1.35	0.00	1.00	0.220	0.276	0.086
(Qk1)	Snow	Qks=0.000 [kN/m]	Short-term	0.00	1.50	0.70	0.000	0.000	0.000
(Qk2)	Wind	Qkw=0.446 [kN/m]	Short-term	0.00	1.50	0.60	0.000	0.279	0.087
(Qk3)	Concentr.	Qkp=1.000 [kN]	Instantaneous	0.00	1.00	0.00	0.370	0.465	0.290

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1.4.1. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)

Control of deflection (EC5 §7.2)

Loading	$[\text{kN/m}]$	$u [\text{mm}]$	action	ψ_0	ψ_1	ψ_2	K_{def}
(Gk)	Permanent $G_k=0.475 [\text{kN/m}]$	0.753	Permanent	1.00	1.00	1.00	0.60
(Qk1)	Snow $Q_{ks}=0.000 [\text{kN/m}]$	0.000	Short-term	0.70	0.50	0.20	0.60
(Qk2)	Wind $Q_{kw}=0.446 [\text{kN/m}]$	0.761	Short-term	0.60	0.20	0.00	0.60

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Load combination	w.inst	w.fin [mm]
1 Gk	0.753	1.205
2 Gk + Qk1	0.753	1.205
3 Gk + Qk2	1.514	1.966
4 Gk + Qk1 + $\psi_0 \cdot Qk2$	1.209	1.661
5 Gk + Qk2 + $\psi_0 \cdot Qk1$	1.514	1.966

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$w_{fin}, g = w_{inst}, g(1+k_{def}), w_{fin}, q = w_{inst}, q(1+\psi_2 \cdot k_{def})$ (EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

$w_{inst} = 1.514 \text{ mm}, w_{fin} = 1.966 \text{ mm}$

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2

Final deflections

$w_{inst} = 1.514 \text{ mm} < L/300 = 1250/300 = 4.167 \text{ mm}$

$w_{net, fin} = 1.966 \text{ mm} < L/250 = 1250/250 = 5.000 \text{ mm}$

$w_{fin} = 1.966 \text{ mm} < L/150 = 1250/150 = 8.333 \text{ mm}$

The check is satisfied

1.4.2. Check of finishing, Ultimate limit state of design (EC5 EN1995-1-1:2009, §6)

L.C.	Load combination	duration class	kmod	N/Kmod	V/Kmod	M/Kmod
1	$\gamma_g \cdot Gk$	Permanent	0.60	-0.494	0.621	0.194
2	$\gamma_g \cdot Gk + \gamma_q \cdot Qk1$	Short-term	0.90	-0.329	0.414	0.129
3	$\gamma_g \cdot Gk + \gamma_q \cdot Qk2$	Short-term	0.90	-0.329	0.878	0.274
4	$\gamma_g \cdot Gk + \gamma_q \cdot Qk3$	Instantaneous	1.10	-0.606	0.761	0.370
5	$\gamma_g \cdot Gk + \gamma_q \cdot Qk1 + \gamma_q \cdot \psi_0 \cdot Qk2$	Short-term	0.90	-0.329	0.692	0.216
6	$\gamma_g \cdot Gk + \gamma_q \cdot Qk2 + \gamma_q \cdot \psi_0 \cdot Qk1$	Short-term	0.90	-0.329	0.878	0.274
	Maximum values			-0.606	0.878	0.370

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Finishing, load combination No 4

Compression parallel to the grain, $F_{c0d} = -0.666 \text{ kN}$ (EC5 §6.1.4)

Rectangular cross section, $b = 1000 \text{ mm}, h = 20 \text{ mm}, A = 20\,000 \text{ mm}^2$

Modification factor $K_{mod} = 1.10$ (Table 3.1), material factor $\gamma_M = 1.25$ (Table 2.3)

$f_{c0k} = 24.00 \text{ N/mm}^2, f_{c0d} = K_{mod} \cdot f_{c0k} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12 \text{ N/mm}^2$ (EC5 Eq.2.14)

$F_{c0d} = -0.666 \text{ kN}, \sigma_{c0d} = F_{c0d} / A_{netto} = 1000 \times 0.666 / 20000 = 0.033 \text{ N/mm}^2 < 21.12 \text{ N/mm}^2 = f_{c0d}$ (Eq.6.2)

The check is satisfied

Finishing, load combination No 6

Shear, $F_v=0.790$ kN (EC5 §6.1.7)

Rectangular cross section, $b_{ef}=0.67 \times 1000=670$ mm, $h=20$ mm, $A=13\,400$ mm²

Modification factor $K_{mod}=0.90$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{vk}=2.70$ N/mm², $f_{vd}=K_{mod} \cdot f_{vk} / \gamma_M = 0.90 \times 2.70 / 1.25 = 1.94$ N/mm² (EC5 Eq.2.14)

$F_v=0.790$ kN, $\tau_{v0d}=1.50 F_{v0d} / A_{netto} = 1000 \times 1.50 \times 0.790 / 13400 = 0.09$ N/mm² < 1.94 N/mm² = f_{vd} (Eq.6.13)

The check is satisfied

Finishing, load combination No 4

Bending, $M_{yd}=0.407$ kNm, $M_{zd}=0.000$ kNm (EC5 §6.1.6)

Rectangular cross section, $b=1000$ mm, $h=20$ mm, $A=2.000 \times 10^4$ mm², $W_y=6.667 \times 10^4$ mm³, $W_z=3.333 \times 10^6$ mm³

Modification factor $K_{mod}=1.10$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{myk}=24.00$ N/mm², $f_{myd}=K_{mod} \cdot f_{myk} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12$ N/mm²

$f_{mzk}=24.00$ N/mm², $f_{mzd}=K_{mod} \cdot f_{mzk} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12$ N/mm²

Rectangular cross section $K_m=0.70$ (EC5 §6.1.6.(2))

$\sigma_{myd}=M_{yd} / W_{my,netto} = 1 \times 10^6 \times 0.407 / 6.667 \times 10^4 = 6.10$ N/mm²

$\sigma_{mzd}=M_{zd} / W_{mz,netto} = 1 \times 10^6 \times 0.000 / 3.333 \times 10^6 = 0.00$ N/mm²

$\sigma_{myd} / f_{myd} + K_m \cdot \sigma_{mzd} / f_{mzd} = 0.289 + 0.000 = 0.29 < 1$ (EC5 Eq.6.11)

$K_m \cdot \sigma_{myd} / f_{myd} + \sigma_{mzd} / f_{mzd} = 0.202 + 0.000 = 0.20 < 1$ (EC5 Eq.6.12)

The check is satisfied

Finishing, load combination No 4

Combined bending and axial compression, $F_{c0d}=-0.666$ kN, $M_{yd}=0.407$ kNm, $M_{zd}=0.000$ kNm (EC5 §6.2.4)

Rectangular cross section, $b=1000$ mm, $h=20$ mm, $A=2.000 \times 10^4$ mm², $W_y=6.667 \times 10^4$ mm³, $W_z=3.333 \times 10^6$ mm³

Modification factor $K_{mod}=1.10$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{c0k}=24.00$ N/mm², $f_{c0d}=K_{mod} \cdot f_{c0k} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12$ N/mm²

$f_{myk}=24.00$ N/mm², $f_{myd}=K_{mod} \cdot f_{myk} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12$ N/mm²

$f_{mzk}=24.00$ N/mm², $f_{mzd}=K_{mod} \cdot f_{mzk} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12$ N/mm²

Rectangular cross section $K_m=0.70$ (EC5 §6.1.6.(2))

$\sigma_{c0d}=F_{c0d} / A_{netto} = 1000 \times 0.666 / 20000 = 0.03$ N/mm²

$\sigma_{myd}=M_{yd} / W_{my,netto} = 1 \times 10^6 \times 0.407 / 6.667 \times 10^4 = 6.10$ N/mm²

$\sigma_{mzd}=M_{zd} / W_{mz,netto} = 1 \times 10^6 \times 0.000 / 3.333 \times 10^6 = 0.00$ N/mm²

$(\sigma_{c0d} / f_{c0d})^2 + \sigma_{myd} / f_{myd} + K_m \cdot \sigma_{mzd} / f_{mzd} = 0.000 + 0.289 + 0.000 = 0.29 < 1$ (EC5 Eq.6.19)

$(\sigma_{c0d} / f_{c0d})^2 + K_m \cdot \sigma_{myd} / f_{myd} + \sigma_{mzd} / f_{mzd} = 0.000 + 0.202 + 0.000 = 0.20 < 1$ (EC5 Eq.6.20)

The check is satisfied

Finishing, load combination No 4

Column stability with bending, $F_{c0d}=-0.666\text{kN}$, $M_{yd}=0.407\text{kNm}$, $M_{zd}=0.000\text{kNm}$ (EC5 §6.3.2)

Rectangular cross section, $b=1000\text{mm}$, $h=20\text{mm}$, $A=2.000\text{E}+004\text{mm}^2$, $W_y=6.667\text{E}+004\text{mm}^3$, $W_z=3.333\text{E}+006\text{mm}^3$

Modification factor $K_{mod}=1.10$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3, $E_{005}=9400\text{N/mm}^2$)

$$f_{c0k}=24.00 \text{ N/mm}^2, f_{c0d}=K_{mod} \cdot f_{c0k} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12 \text{ N/mm}^2$$

$$f_{myk}=24.00 \text{ N/mm}^2, f_{myd}=K_{mod} \cdot f_{myk} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12 \text{ N/mm}^2$$

$$f_{mk}=24.00 \text{ N/mm}^2, f_{md}=K_{mod} \cdot f_{mk} / \gamma_M = 1.10 \times 24.00 / 1.25 = 21.12 \text{ N/mm}^2$$

Rectangular cross section $K_m=0.70$ (EC5 §6.1.6.(2))

$$\sigma_{c0d}=F_{c0d}/A_{netto}=1000 \times 0.666 / 20000 = 0.03 \text{ N/mm}^2$$

$$\sigma_{myd}=M_{yd}/W_{my,netto}=1\text{E}+06 \times 0.407 / 6.667\text{E}+004 = 6.10 \text{ N/mm}^2$$

$$\sigma_{mzd}=M_{zd}/W_{mz,netto}=1\text{E}+06 \times 0.000 / 3.333\text{E}+006 = 0.00 \text{ N/mm}^2$$

Buckling length S_k

$$S_{ky}=1.00 \times 1.250 = 1.250 \text{ m} = 1250 \text{ mm}$$

$$S_{kz}=0.00 \times 1.250 = 0.000 \text{ m} = 0 \text{ mm}$$

Slenderness

$$i_y = \sqrt{I_y/A} = 0.289 \times 20 = 6 \text{ mm}, \lambda_y = 1250 / 6 = 208.33$$

$$i_z = \sqrt{I_z/A} = 0.289 \times 1000 = 289 \text{ mm}, \lambda_z = 0 / 289 = 0.00$$

Critical stresses

$$\sigma_{c,crity} = \pi^2 E_{005} / \lambda_y^2 = 2.14 \text{ N/mm}^2, \lambda_{rel,y} = \sqrt{f_{c0k} / \sigma_{c,crity}} = 3.35 \text{ (EC5 Eq.6.21)}$$

$$\sigma_{c,critz} = \pi^2 E_{005} / \lambda_z^2 = 2400.00 \text{ N/mm}^2, \lambda_{rel,z} = \sqrt{f_{c0k} / \sigma_{c,critz}} = 0.00 \text{ (EC5 Eq.6.22)}$$

$\beta_c=0.10$ (glued laminated timber)

$$k_y = 0.5 [1 + \beta_c (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2] = 6.27, K_{cy} = 1 / (k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}) = 0.086 \text{ (Eq.6.27 6.25)}$$

$$k_z = 0.5 [1 + \beta_c (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2] = 0.50, K_{cz} = 1 / (k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}) = 1.000 \text{ (Eq.6.28 6.26)}$$

$$\sigma_{c0d} / (K_{cy} \cdot f_{c0d}) + \sigma_{myd} / f_{myd} + K_m \cdot \sigma_{mzd} / f_{mzd} = 0.018 + 0.289 + 0.000 = 0.31 < 1 \text{ (EC5 Eq.6.23)}$$

$$\sigma_{c0d} / (K_{cz} \cdot f_{c0d}) + K_m \cdot \sigma_{myd} / f_{myd} + \sigma_{mzd} / f_{mzd} = 0.002 + 0.202 + 0.000 = 0.20 < 1 \text{ (EC5 Eq.6.24)}$$

The check is satisfied

1.5. Design of purlins

Structural system for purlins

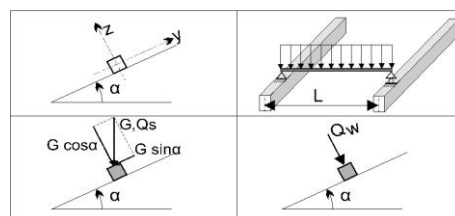
The purlins are designed as simply supported beams with span length $L=5.670\text{m}$ the distance between the trusses. They are loaded with a surface load of width $L_1=1.250\text{m}$ (purlin spacing). The purlin axis has inclination $\alpha=21.71^\circ$ with the vertical. The vertical loads (self weight, snow, concentrated load) are decomposed in two components in the directions z-z $P \cdot \cos\alpha$, and y-y $P \cdot \sin\alpha$, the wind load acts in the z-z direction.

Dimensions of purlins

Timber of purlins: GL24h, Class 1, moisture content $\leq 12\%$, cross section of purlins $B \times H: 100 \times 240\text{mm}$
Spacing of purlins $L_1=1.250\text{m}$, roof pitch $\alpha=21.71^\circ$, spacing of trusses $L=5.670\text{m}$.

Uniform loading of purlins kN/m^2

Roof covering	$G_e = 0.400 \text{ kN/m}^2$
Finishing+self weight	$G_l = 0.200 \text{ kN/m}^2$
Snow load	$Q_s = 0.000 \text{ kN/m}^2$
Wind load	$Q_w = 0.446 \text{ kN/m}^2$
Concentrated load	$Q_p = 1.000 \text{ kN}$



Line loading of purlins (kN/m) in z-z and y-y

Roof covering+self weight	$G_k = 0.750 \text{ kN/m}$, $G_{kz} = 0.697 \text{ kN/m}$, $G_{ky} = 0.277 \text{ kN/m}$
Snow load	$Q_{ks} = 0.000 \text{ kN/m}$, $Q_{ksz} = 0.000 \text{ kN/m}$, $Q_{ksy} = 0.000 \text{ kN/m}$
Wind load	$Q_{kw} = 0.557 \text{ kN/m}$, $Q_{kwz} = 0.557 \text{ kN/m}$, $Q_{kwy} = 0.000 \text{ kN/m}$
Concentrated load	$Q_{kp} = 1.000 \text{ kN}$, $Q_{kpz} = 0.929 \text{ kN}$, $Q_{kpy} = 0.370 \text{ kN}$

Internal forces of purlins (span $L=5.670 \text{ m}$, $B \times H: 100 \times 240 \text{ mm}$)

Loading	action	γ_g	γ_q	ψ_0	$Q_z [\text{kN}]$	$Q_y [\text{kN}]$	$M_y [\text{kNm}]$	$M_z [\text{kNm}]$
(Gk) Permanent	$G_k = 0.750 [\text{kN/m}]$ Permanent	1.35	0.00	1.00	1.975	0.787	2.800	0.000
(Qk1) Snow	$Q_{ks} = 0.000 [\text{kN/m}]$ Short-term	0.00	1.50	0.70	0.000	0.000	0.000	0.000
(Qk2) Wind	$Q_{kw} = 0.557 [\text{kN/m}]$ Short-term	0.00	1.50	0.60	1.580	0.000	2.239	0.000
(Qk3) Concentr.	$Q_{kp} = 1.000 [\text{kN}]$ Instantaneous	0.00	1.00	0.00	0.465	0.185	1.317	0.000

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1.5.1. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)**Control of deflection** (EC5 §7.2)

Loading [kN/m]		u[mm]	action	ψ_0	ψ_1	ψ_2	Kdef
(Gk) Permanent	$G_k = 0.697$ [kN/m]	7.017	Permanent	1.00	1.00	1.00	0.60
(Qk1) Snow	$Q_{ks} = 0.000$ [kN/m]	0.000	Short-term	0.70	0.50	0.20	0.60
(Qk2) Wind	$Q_{kw} = 0.557$ [kN/m]	5.611	Short-term	0.60	0.20	0.00	0.60

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Load combination	w.inst	w.fin [mm]
1 Gk	7.017	11.228
2 Gk + Qk1	7.017	11.228
3 Gk + Qk2	12.628	16.839
4 Gk + Qk1 + $\psi_0 \cdot Qk2$	10.384	14.594
5 Gk + Qk2 + $\psi_0 \cdot Qk1$	12.628	16.839

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$w_{fin}, g = w_{inst}, g(1 + k_{def})$, $w_{fin}, q = w_{inst}, q(1 + \psi_2 \cdot k_{def})$ (EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

$w_{inst} = 12.628$ mm, $w_{fin} = 16.839$ mm

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2Final deflections

$w_{inst} = 12.628$ mm < $L/300 = 5670/300 = 18.900$ mm

$w_{net, fin} = 16.839$ mm < $L/250 = 5670/250 = 22.680$ mm

$w_{fin} = 16.839$ mm < $L/150 = 5670/150 = 37.800$ mm

The check is satisfied

1.5.2. Check of purlins, Ultimate limit state of design (EC5 EN1995-1-1:2009, §6)

L.C.	Load combination	duration class	kmod	Q_z/K_{mod}	Q_y/K_{mod}	M_y/K_{mod}	M_z/K_{mod}
1	$\gamma_g \cdot G_k$	Permanent	0.60	4.445	1.770	6.300	0.000
2	$\gamma_g \cdot G_k + \gamma_q \cdot Q_{k1}$	Short-term	0.90	2.963	1.180	4.200	0.000
3	$\gamma_g \cdot G_k + \gamma_q \cdot Q_{k2}$	Short-term	0.90	5.596	1.180	7.932	0.000
4	$\gamma_g \cdot G_k + \gamma_q \cdot Q_{k3}$	Instantaneous	1.10	2.847	1.133	4.634	0.000
5	$\gamma_g \cdot G_k + \gamma_q \cdot Q_{k1} + \gamma_q \cdot \psi_0 \cdot Q_{k2}$	Short-term	0.90	4.543	1.180	6.439	0.000
6	$\gamma_g \cdot G_k + \gamma_q \cdot Q_{k2} + \gamma_q \cdot \psi_0 \cdot Q_{k1}$	Short-term	0.90	5.596	1.180	7.932	0.000
	Maximum values			5.596	1.770	7.932	0.000

—

Purlin, load combination No 6

Shear, $F_v=5.036$ kN (EC5 §6.1.7)

Rectangular cross section, $b_{ef}=0.67 \times 100=67$ mm, $h=240$ mm, $A=16\,080$ mm²

Modification factor $K_{mod}=0.90$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{vk}=2.70$ N/mm², $f_{vd}=K_{mod} \cdot f_{vk} / \gamma_M = 0.90 \times 2.70 / 1.25 = 1.94$ N/mm² (EC5 Eq.2.14)

$F_v=5.036$ kN, $\tau_{v0d}=1.50 F_{v0d} / A_{netto} = 1000 \times 1.50 \times 5.036 / 16080 = 0.47$ N/mm² < 1.94 N/mm² = f_{v0d} (Eq.6.13)

The check is satisfied

Purlin, load combination No 1

Shear, $F_v=1.062$ kN (EC5 §6.1.7)

Rectangular cross section, $b_{ef}=0.67 \times 240=161$ mm, $h=100$ mm, $A=16\,100$ mm²

Modification factor $K_{mod}=0.60$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{vk}=2.70$ N/mm², $f_{vd}=K_{mod} \cdot f_{vk} / \gamma_M = 0.60 \times 2.70 / 1.25 = 1.30$ N/mm² (EC5 Eq.2.14)

$F_v=1.062$ kN, $\tau_{v0d}=1.50 F_{v0d} / A_{netto} = 1000 \times 1.50 \times 1.062 / 16100 = 0.10$ N/mm² < 1.30 N/mm² = f_{v0d} (Eq.6.13)

The check is satisfied

Purlin, load combination No 6

Bending, $M_{yd}=7.139$ kNm, $M_{zd}=0.000$ kNm (EC5 §6.1.6)

Rectangular cross section, $b=100$ mm, $h=240$ mm, $A=2.400E+004$ mm², $W_y=9.600E+005$ mm³, $W_z=4.000E+005$ mm³

Modification factor $K_{mod}=0.90$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{myk}=24.00$ N/mm², $f_{myd}=K_{mod} \cdot f_{myk} / \gamma_M = 0.90 \times 24.00 / 1.25 = 17.28$ N/mm²

$f_{mzk}=24.00$ N/mm², $f_{mzd}=K_{mod} \cdot f_{mzk} / \gamma_M = 0.90 \times 24.00 / 1.25 = 17.28$ N/mm²

Rectangular cross section $K_m=0.70$ (EC5 §6.1.6.(2))

$\sigma_{myd}=M_{yd}/W_{my,netto}=1E+06 \times 7.139 / 9.600E+005 = 7.44$ N/mm²

$\sigma_{mzd}=M_{zd}/W_{mz,netto}=1E+06 \times 0.000 / 4.000E+005 = 0.00$ N/mm²

$\sigma_{myd}/f_{myd} + K_m \cdot \sigma_{mzd}/f_{mzd} = 0.430 + 0.000 = 0.43 < 1$ (EC5 Eq.6.11)

$K_m \cdot \sigma_{myd}/f_{myd} + \sigma_{mzd}/f_{mzd} = 0.301 + 0.000 = 0.30 < 1$ (EC5 Eq.6.12)

The check is satisfied

Purlin, load combination No 6

Lateral torsional stability of beams, $M_{yd}=7.139$ kNm, $M_{zd}=0.000$ kNm (EC5 §6.3.3)

Rectangular cross section, $b=100$ mm, $h=240$ mm, $A=2.400E+004$ mm², $W_y=9.600E+005$ mm³, $W_z=4.000E+005$ mm³

Modification factor $K_{mod}=0.90$ (Table 3.1), material factor $\gamma_M=1.25$ (Table 2.3)

$f_{c0k}=24.00$ N/mm², $f_{c0d}=K_{mod} \cdot f_{c0k} / \gamma_M = 0.90 \times 24.00 / 1.25 = 17.28$ N/mm²

$f_{myk}=24.00$ N/mm², $f_{myd}=K_{mod} \cdot f_{myk} / \gamma_M = 0.90 \times 24.00 / 1.25 = 17.28$ N/mm²

$f_{mzk}=24.00$ N/mm², $f_{mzd}=K_{mod} \cdot f_{mzk} / \gamma_M = 0.90 \times 24.00 / 1.25 = 17.28$ N/mm²

Rectangular cross section $K_m=0.70$ (EC5 §6.1.6.(2))

$\sigma_{myd} = M_{yd}/W_{my, netto} = 1E+06 \times 7.139 / 9.600E+005 = 7.44 \text{ N/mm}^2$

$\sigma_{mzd} = M_{zd}/W_{mz, netto} = 1E+06 \times 0.000 / 4.000E+005 = 0.00 \text{ N/mm}^2$

Buckling length S_k

$S_{ky} = 1.00 \times 5.670 = 5.670 \text{ m} = 5670 \text{ mm}$

$S_{kz} = 0.00 \times 5.670 = 0.000 \text{ m} = 0 \text{ mm}$

Slenderness

$i_y = \sqrt{I_y/A} = 0.289 \times 240 = 69 \text{ mm}, \lambda_y = 5670 / 69 = 82.17$

$i_z = \sqrt{I_z/A} = 0.289 \times 100 = 29 \text{ mm}, \lambda_z = 0 / 29 = 0.00$

$\sigma_{m, crit} = M_{ycrit}/W_y = \pi \sqrt{(E/0.05 \cdot I_z \cdot G/0.05 \cdot I_{tor}) / (L_{ef}/W_y)} = 51.79 \text{ N/mm}^2$ (EC5 Eq.6.31)

Critical stresses

$\sigma_{m, crit y} = 51.79 \text{ N/mm}^2, \lambda_{rel, my} = \sqrt{f_{yk}/\sigma_{m, crit y}} = 0.68$ (EC5 Eq.6.30)

$\sigma_{m, crit z} = 240.00 \text{ N/mm}^2, \lambda_{rel, mz} = \sqrt{f_{mk}/\sigma_{m, crit z}} = 0.00$ (EC5 Eq.6.30)

$\lambda_{rel, my} = 0.68, (\lambda_{rel} \leq 0.75), K_{crit y} = 1.00$ (EC5 Eq.6.34)

$\lambda_{rel, mz} = 0.00, (\lambda_{rel} \leq 0.75), K_{crit z} = 1.00$ (EC5 Eq.6.34)

$\sigma_{myd} / (K_{crit y} \cdot f_{myd}) + K_m \cdot \sigma_{mzd} / (K_{crit z} \cdot f_{mzd}) = 0.430 + 0.000 = 0.43 < 1$ (EC5 Eq.6.33)

$K_m \cdot \sigma_{myd} / (K_{crit y} \cdot f_{myd}) + \sigma_{mzd} / (K_{crit z} \cdot f_{mzd}) = 0.301 + 0.000 = 0.30 < 1$ (EC5 Eq.6.33)

The check is satisfied