Strength calculation of roof structure

Enzo C1 40

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1 General information

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Product:	Enzo C1 40 (Product number: EAN 4744319010812)
Description:	This report indicates only the calculations about the roof structure. This report does not include calculations about wall structures, base foundation and ground surface. All calculations are based on knowledge, that the strength of the walls, base foundations and soil is sufficient for that product.

2 Standards

- EN 338: 2016 - Timber - Strength classes.
- EN 1991-1-3: 2006 - Eurocode 1: Actions on structures - Part 1-3: General actions - Snow loads.
- EN 1991-1-4: 2005 - Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions.
- EN 1995-1-1: 2005 - Eurocode 5: Dimensioning and construction of wooden structures - Part 1-1: General - Common rules and regulations for buildings.
- EN 14080: 2013 Timber structures: Glulam and solid wood: Requirements.

3 Primary data

3.1 Product info

Cross-section width (b)	70	mm
Cross-section height (h)	138	mm
Effective cross-section height for shear(h_v)	104	mm
Bending and shear span for beam supported from both ends (L)	4720	mm
Bending and shear span for cantilever beam (L_{cant})	950	mm
Span for compression (L_c)*	3350	mm
Spacing (s)	624	mm
Support length (l)	40	mm
Quantity of support areas at one side (spa)	1	pc
Roof angle (α)	15	deg
Purlin beam position angle (β)	15	deg
Purlin beam elevation angle (Φ)	0	deg
Strength class of timber	C24	

* - Span for compression - purlin length considered for calculating the maximum load acting on 1 support in total.

3.2 Dead load

Load of the beam	$g_{k,a}$	0,080	kN/m²
Load of the load-bearing boards	$g_{k,b}$	0,095	kN/m²
Maximum allowed load of the covering material*	$\mathbf{g_{k,c}}$	**0,50**	**kN/m²**
Maximum allowed load of the covering material*	$\mathbf{g_{k,c}}$	**50**	**kg/m²**

* - Maximum weight of the material, which the roof can support. Applies only at those parameters, which are shown in this document. Not allowed to increase, if other loads, which are shown in this document, are smaller.

3.3 Normative loads that affect the roof

Dead load	g_k	0,81	kN/m²
Wind load (Wind zone 1; $v_{b,0}$ = 22,5 m/s)	$q_{wind,k}$	0,28	kN/m²
Snow load (Snow zone 2)	$q_{snow,k}$	0,60	kN/m²

3.4 Snow thickness according to the snow load

Fresh snow	0,60	m
Settled snow (several hours or days after snowfall)	0,30	m
Aged snow (several weeks or months after snowfall)	0,20	m
Wet snow	0,15	m

4 Material properties

4.1 Normative properties of the material

Bending strength	$f_{m,k}$	24	N/mm²
Shear strength	$f_{v,k}$	4	N/mm²
Compressive strength	$f_{c,90,k}$	2,5	N/mm²
Average modulus of elasticity of longitudinal fibres	$E_{m,0,mean}$	11000	N/mm²
5% value of the modulus of elasticity in longitudinal section	$E_{m,0,5,k}$	7400	N/mm²

4.2 Calculated properties

Load-duration class	Short term	
Service class	2	
Terrain factor	2	
Partial safety factor of the material	γ_m	1,3
Modification factor	k_{mod}	0,9
Cross-sectional factor	k_h	1,02
System strength factor	k_{sys}	1,1
Fraction factor	k_{cr}	0,67
Auxiliary factor	$k_{c,90}$	1
Dead load safety factor	$\gamma_{G,1}$	1,4
Partial coefficient of the variable load	γ_Q	1,45
Snow load factor	$\Psi_{0,snow}$	0,5
Wind load factor	$\Psi_{0,wind}$	0,6

4.3 Calculated properties of the material

Bending strength: $f_{m,d}= \cos(\beta)^*((k_{mod}{}^*k_h{}^*k_{sys}{}^*f_{m,k})/\gamma_m)$	$f_{m,d}$	17,95	N/mm²
Shearing strength: $f_{v,d}= (k_{mod}{}^*k_{sys}{}^*f_{v,k})/\gamma_m$	$f_{v,d}$	3,05	N/mm²
Compressive strength: $f_{c,90,d}= (k_{mod}{}^*k_{sys}{}^*f_{c,90,k})/\gamma_m$	$f_{c,90,d}$	1,90	N/mm²

5 Normative loads

5.1 Normative loads on the roof structure

Dead load: $g_k^{'}= g_k{}^*s$	$g_k^{'}$	0,51	N/mm
Wind load: $q_{wind,k}^{'}=q_{wind,k}{}^*s$	$q_{wind,k}^{'}$	0,18	N/mm
Snow load: $q_{snow,k}^{'}=q_{snow,k}{}^*s$	$q_{snow,k}^{'}$	0,37	N/mm

6 Limited load condition

6.1 Calculation of internal forces

The calculated total loads act on the beam in STR load combinations:

A. The dominant variable load is Wind

$P_d = \gamma_{G,1}{}^{*}g_k{}^{*}+\gamma_Q{}^{*}q_{wind,k}{}^{*}+\gamma_Q{}^{*}\Psi_{0,snow}{}^{*}q_{snow,k}{}^{*}$

P_d = 1,23 kN/m

Will not be decisive!

B. The dominant variable load is Snow

$P_d = \gamma_{G,1}{}^{*}g_k{}^{*}+\gamma_Q{}^{*}q_{snow,k}{}^{*}+\gamma_Q{}^{*}\Psi_{0,wind}{}^{*}q_{wind,k}{}^{*}$

P_d = 1,40 kN/m

Becomes decisive!

C. Only the load due to dead weight is considered

$P_d = \gamma_{G,1}{}^{*}g_k{}^{*}$

P_d = 0,71 kN/m

Will not be decisive!

6.2 Maximum internal forces:

Bending moment for beam supported from both ends:

$M_d = [P_d * \cos(\Phi)] * [L / \cos(\Phi)]^2 / 8$

$M_d = 3{,}91$ kNm

Bending moment for cantilever beam:

$M_{dk} = [P_d * \cos(\Phi)] * [L_{cant} / \cos(\Phi)]^2 / 2$

$M_{dk} = 0{,}63$ kNm

Shear force for beam supported from both ends:

$V_d = (P_d * L) / 2$

$V_d = 3{,}31$ kN

Shear force for cantilever beam:

$V_{dk} = P_d * L_{cant}$

$V_{dk} = 1{,}33$ kN

Compression force:

$V_c = (P_d * L_C)$

$V_c = 4{,}70$ kN

6.3 Bending check for beam supported from both ends

Strength condition: $\sigma_{m,d} < f_{m,d}$

Section modulus moment of resistance:

$W=(b*h^2)/6$

$W = 222180\ mm^3$

Calculated bending stress:

$\sigma_{m,d}= M_d/W$

$\sigma_{m,d} = 17{,}60\ N/mm^2$

$\sigma_{m,d}= 17{,}60\ N/mm^2$	<	$f_{m,d}= 17{,}95\ N/mm^2$
OK!		

6.4 Shear check for beam supported from both ends

Strength condition: $\tau_d < f_{v,d}$

Cross-sectional area:

$A=b*h_v$

$A= 7280\ mm^2$

Calculated shear stress:

$\tau_d=(3/2)*(V_d/A)*(1/k_{cr})$

$\tau_d = 1{,}02\ N/mm^2$

$\tau_d= 1{,}02\ N/mm^2$	<	$f_{v,d}= 3{,}05\ N/mm^2$
OK!		

6.5 Compression check (in the support area)

Strength condition: $\sigma_{c,90,d} < k_{c,90}{}^{*}f_{c,90,d}$

Effective cross-section area for compression:

A_{ef}= b*l*spa

A_{ef} = 2800 mm²

Calculated compressive stress:

$\sigma_{c,90,d}$= V_c/A_{ef}

$\sigma_{c,90,d}$ = 1,68 N/mm²

$\sigma_{c,90,d}$ = 1,68 N/mm²	<	$k_{c,90}\cdot f_{c,90,d}$ = 1,90 N/mm²
OK!		

6.6 Bending check for cantilever beam

Strength condition: $\sigma_{m,d} < f_{m,d}$

Section modulus moment of resistance:

W=(b*h²)/6

W = 222180 mm³

Calculated bending stress:

$\sigma_{m,d}$= M_{dk}/W

$\sigma_{m,d}$ = 2,85 N/mm²

$\sigma_{m,d}$= 2,85 N/mm²	<	$f_{m,d}$= 17,95 N/mm²
OK!		

6.7 Shear check for cantilever beam

Strength condition: $\tau_d < f_{v,d}$

Cross-sectional area:

$A=b*h_v$

$A= 7280\ mm^2$

Calculated shear stress:

$\tau_d=(3/2)*(V_{dk}/A)*(1/k_{cr})$

$\tau_d = 0{,}41\ N/mm^2$

τ_d= 0,41 N/mm^2	<	$f_{v,d}$= 3,05 N/mm^2
OK!		

7 Summary

Force type	**Fulfilment of requirements (%)**
Bend for beam supported from both ends	102
Shear for beam supported from both ends	299
Compression	113
Bend for cantilever beam	630
Shear for cantilever beam	743

The strength of the roof structure is sufficient in the case of the given conditions and loads.