Strength calculation of roof structure
Bayern 44 ISO
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Table of contents

1 General information

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Product:	Bayern 44 ISO

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)	44	mm
Cross-section height (h)	145	mm
Effective cross-section height for shear(h_v)	100	mm
Span (L)	4212	mm
Spacing (s)	793	mm
Support length (l)	44	mm
Roof angle (α)	17,49	deg
Purlin beam position angle (β)	17,49	deg
Strength class of timber	C24	

3.2 Dead load

Load of the beam	$g_{k,a}$	0,042	kN/m²
Load of the load-bearing boards	$g_{k,b}$	0,094	kN/m²
Load of the covering material	$g_{k,c}$	0,060	kN/m²

3.3 Normative loads that affect the roof

Dead load	g_k	0,24	kN/m²
Wind load (Wind zone 1; $v_{b,0}$ = 22,5 m/s)	$q_{wind,k}$	0,33	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	1,01
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: $f_{m,d}= \cos(\beta)^*((k_{mod}{}^*k_h{}^*k_{sys}{}^*f_{m,k})/\gamma_m)$	$f_{m,d}$	17,55	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^*	0,19	N/mm
Wind load: $q_{wind,k}^*=q_{wind,k}{}^*s$	$q_{wind,k}^*$	0,26	N/mm
Snow load: $q_{snow,k}^*=q_{snow,k}{}^*s$	$q_{snow,k}^*$	0,48	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 = 0,98 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 = 1,18 kN/m

Becomes decisive!

C. Only the load due to dead weight is considered

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

P_d = 0,26 kN/m

Will not be decisive!

6.2 Maximum internal forces:

Bending moment:

$M_d = (P_d * L^2)/8$

M_d = 2,61 kNm

Shear force:

$V_d = (P_d * L)/2$

V_d = 2,48 kN

6.3 Bending check

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

Section modulus moment of resistance:

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

$W = 154183\ mm^3$

Calculated bending stress:

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

$\sigma_{m,d} = 16{,}93\ N/mm^2$

$\sigma_{m,d}= 16{,}93\ N/mm^2$	<	$f_{m,d}= 17{,}55\ N/mm^2$
OK!		

6.4 Shear check

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

Cross-sectional area:

$A=b*h_v$

$A= 4400\ mm^2$

Calculated shear stress:

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

$\tau_d = 1{,}26\ N/mm^2$

$\tau_d= 1{,}26\ N/mm^2$	<	$f_{v,d}= 3{,}05\ N/mm^2$
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:

$A_{ef} = b * l$

$A_{ef} = 1936\ mm^2$

Calculated compressive stress:

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

$\sigma_{c,90,d} = 1{,}28\ N/mm^2$

$\sigma_{c,90,d} = 1{,}28\ N/mm^2$	<	$k_{c,90} \cdot f_{c,90,d} = 1{,}90\ N/mm^2$
OK!		

7 Summary

Force type	**Fulfilment of requirements (%)**
Bend	104
Shear	241
Compression	149

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