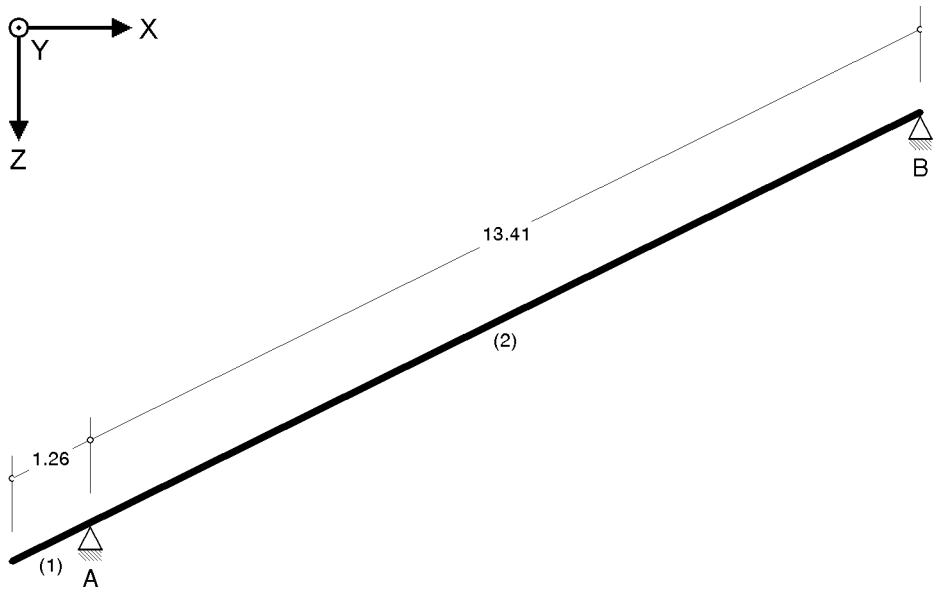
POSITION 5: VALLEY RAFTER

system: valley rafter



system parameters

overall length:	14.68 m
angle of slope:	26.34°
material:	coniferous timber: C24 with E = 11000 N/mm²
cross-section:	b=24.0 cm, h=28.0 cm
design codes:	Eurocode: EN 1990 (load factors), EN 1991 (wind and snow loads), EN 1995 (timber constr.)
nat. annex:	NA-DE (Deutschland)

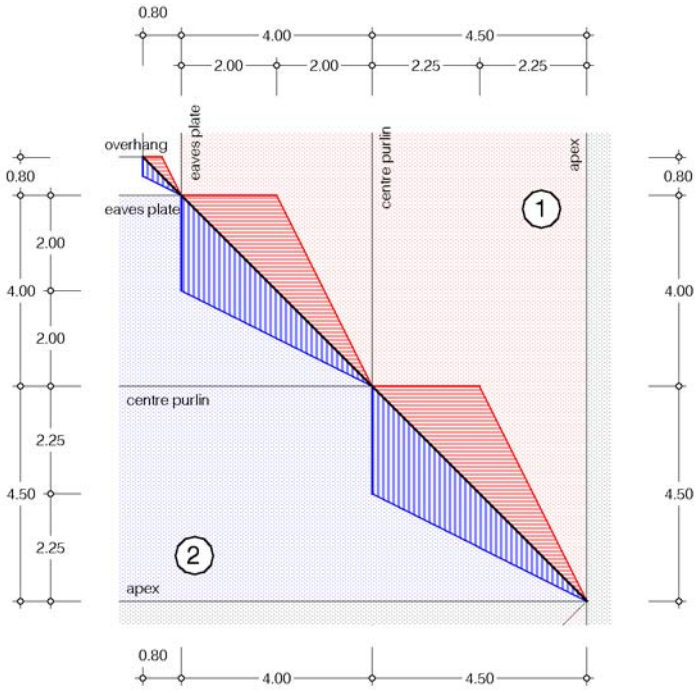
support, hinges, notches

ξ runs in bar direction from bottom to top beam end.
column c indicates the notch depth perpendicular to the bar centre-line.

node	at ξ	support direction			hinge	c
		X	Y	Z		
-	m	-	-	-	-	cm
A	1.26	fix	fix	fix	-	0.0
B	14.68	fix	fix	fix	-	0.0

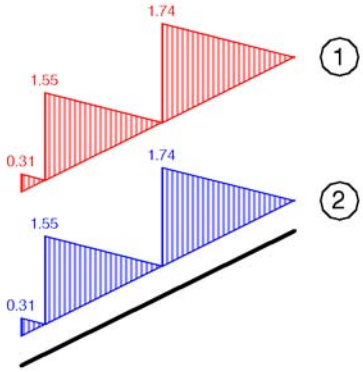
load weighting factors

the distributed loads assigned to the adjacent roof areas - multiplied with the load weighting factors - are placed as line loads on the rafter.



top view

proj.	factor	value
0.40	0.7736	0.31
2.00	0.7736	1.55
2.25	0.7736	1.74
0.40	0.7736	0.31
2.00	0.7736	1.55
2.25	0.7736	1.74



load weighting factors

loading structure

On the left-hand side, the relationship between the actions effects and load cases are shown in a tree structure. The right-hand side shows the characteristics of the superposition to the associated objects on the left-hand.

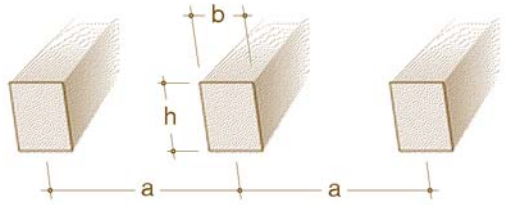
used symbols: action effect load case

permanent loads	**permanent**
1: dead load	additive (dead load of supporting structure)
2: outer skin	additive (dead load of outer skin)
3: interior finish work	additive (dead load of interior finish work)
man loads	**category H: roofs**
4: man load(1)	alternative (on protruding roof (bottom, left side))
5: man load(2)	alternative (midspan (span 1))
wind loads	**wind loads**
6: wind diagonal	alternative
7: wind from left side	alternative
8: wind from top	alternative
snow loads	**snow loads (locations up to NN+1000m)**
9: snow fully	alternative

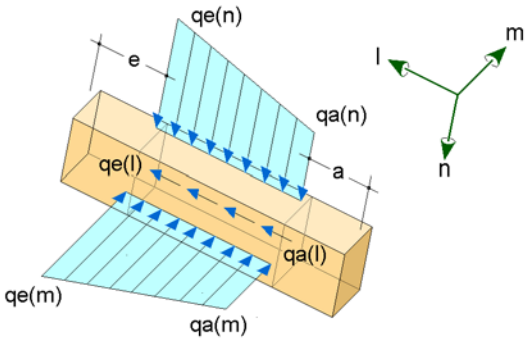
load case 1: dead load

dead load of supporting structure

valley rafter:	densitiy γ = 5.00 kN/m³	⇒ unif.distr. l.load:	0.28 * 0.24 * 5.00 =	**0.34 kN/m**
jack rafter:	densitiy γ = 5.00 kN/m³	⇒ distributed load:	0.20 * 0.14 * 5.00 / 0.80 =	**0.17 kN/m²**



h = 20.00 cm
b = 14.00 cm
a = 0.80 m



direction:	
vertical	vertical from top to bottom
wind1	perpendicular to roof area 1)[1]
wind2	perpendicular to roof area 2)[1]

)[1] positive = pressure

section partitioning see system sketch

trapezoidal loads (sectionally) of load case 1: dead load

section	direct.	a	qa	qa(l)	qa(m)	qa(n)	e	qe	qe(l)	qe(m)	qe(n)	from
-	-	m	kN/m	kN/m	kN/m	kN/m	m	kN/m	kN/m	kN/m	kN/m	
1	**vertical**	0.00	**0.336**	-0.149	0.000	0.301	0.00	**0.336**	-0.149	0.000	0.301	dead load
1	**vertical**	0.00	**0.054**	-0.024	0.000	0.049	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	**vertical**	0.00	**0.054**	-0.024	0.000	0.049	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	0.00	**0.336**	-0.149	0.000	0.301	0.00	**0.336**	-0.149	0.000	0.301	dead load
2	**vertical**	0.00	**0.271**	-0.120	0.000	0.243	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	6.31	**0.305**	-0.135	0.000	0.273	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	0.00	**0.271**	-0.120	0.000	0.243	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	6.31	**0.305**	-0.135	0.000	0.273	0.00	**0.000**	0.000	0.000	0.000	roof area 2

load case 2: outer skin

dead load of outer skin

description	value
interlocking clay tile acc. to DIN 456 incl. lathing	0.550 kN/m²
vapour barrier made of plastic sheeting	0.020 kN/m²
6 cm fiber insulating material acc. to DIN 18 165	0.060 kN/m²
load sum :	**0.630 kN/m²**

trapezoidal loads (sectionally) of load case 2: outer skin

section	direct.	a	qa	qa(l)	qa(m)	qa(n)	e	qe	qe(l)	qe(m)	qe(n)	from
-	-	m	kN/m	kN/m	kN/m	kN/m	m	kN/m	kN/m	kN/m	kN/m	
1	**vertical**	0.00	**0.195**	-0.086	0.000	0.175	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	**vertical**	0.00	**0.195**	-0.086	0.000	0.175	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	0.00	**0.975**	-0.432	0.000	0.874	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	6.31	**1.097**	-0.487	0.000	0.983	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	0.00	**0.975**	-0.432	0.000	0.874	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	6.31	**1.097**	-0.487	0.000	0.983	0.00	**0.000**	0.000	0.000	0.000	roof area 2

load case 3: interior finish work

dead load of interior finish work

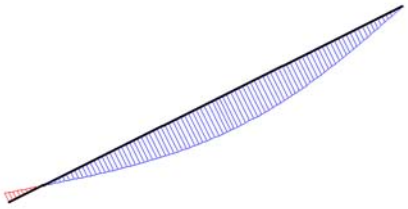
description	value
3/5 lathing	0.030 kN/m²
1,3 cm particle board DIN 68 763	0.100 kN/m²
load sum :	**0.130 kN/m²**

trapezoidal loads (sectionally) of load case 3: interior finish work

section	direct.	a	qa	qa(l)	qa(m)	qa(n)	e	qe	qe(l)	qe(m)	qe(n)	from
-	-	m	kN/m	kN/m	kN/m	kN/m	m	kN/m	kN/m	kN/m	kN/m	
1	**vertical**	0.00	**0.040**	-0.018	0.000	0.036	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	**vertical**	0.00	**0.040**	-0.018	0.000	0.036	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	0.00	**0.201**	-0.089	0.000	0.180	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	6.31	**0.226**	-0.100	0.000	0.203	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	0.00	**0.201**	-0.089	0.000	0.180	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	6.31	**0.226**	-0.100	0.000	0.203	0.00	**0.000**	0.000	0.000	0.000	roof area 2

extremal deflections

deformations perpendicular to the member centre-line
sum of all permanent loads



(max w = 150.2 mm, min w = -44.8 mm)

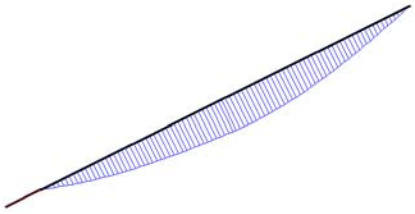
extremal support reactions

sum of all permanent loads in kN

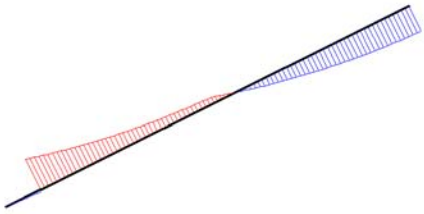
supp.	H	V
A	0.02	14.86
B	-0.02	11.13

extremal internal forces

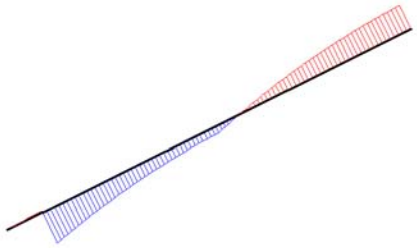
sum of all permanent loads



max Mm = 39.69 kNm, min Mm = -0.52 kNm



max N = 4.95 kN, min N = -6.23 kN

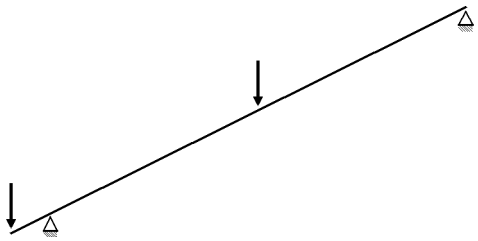


max Vn = 12.61 kN, min Vn = -9.97 kN

action effect of man loads

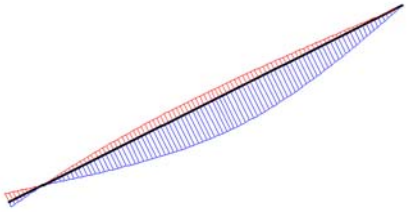
man loads are placed in each midspan
resp. at the cantilevers end. load value: P = 1.00 kN.
the following alternative load cases are analysed.

LF	description	explanation
4	man load(1)	on protruding roof (bottom, left side)
5	man load(2)	midspan (span 1)



extremal deflections

deformations perpendicular to the member centre-line
Extremal from all load cases of the action effect man loads



(max w = 9.3 mm, min w = -2.7 mm)

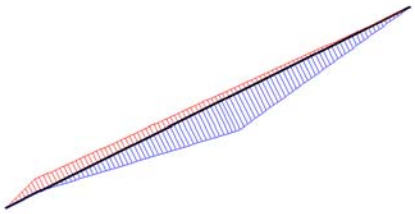
extremal support reactions

Extremal from all load cases of the action effect man loads in kN

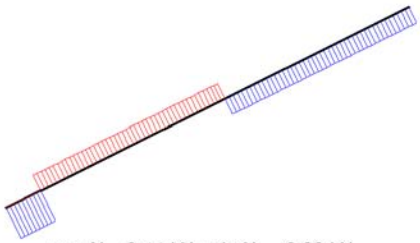
supp.	H		V	
	min	max	min	max
A	0.00	0.04	0.00	1.08
B	-0.04	0.00	-0.08	0.50

extremal internal forces

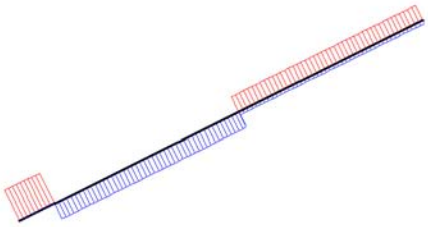
Extremal from all load cases of the action effect man loads



max Mm = 3.01 kNm, min Mm = -1.13 kNm



max N = 0.44 kN, min N = -0.22 kN

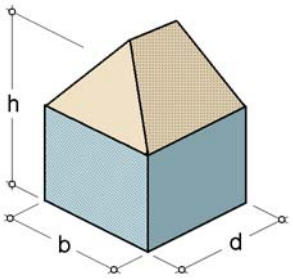


max Vn = 0.45 kN, min Vn = -0.90 kN

action effect of wind loads

ground roughness profile acc. to DIN 1055-4 resp. DIN EN 1991-1-4/NA: inland

wind zone:	2
h + NN:	60 m
factor:	1.0000
qref:	0.39 kN/m²
h:	10.25 m
b:	8.50 m
d:	12.00 m
⇒ **q(h):**	**0.67 kN/m²**



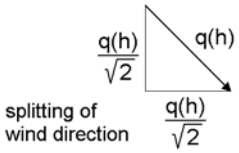
the following alternative load cases are analysed.

LF	description	explanation
6	wind diagonal	
7	wind from left side	
8	wind from top	

load case 6: wind diagonal

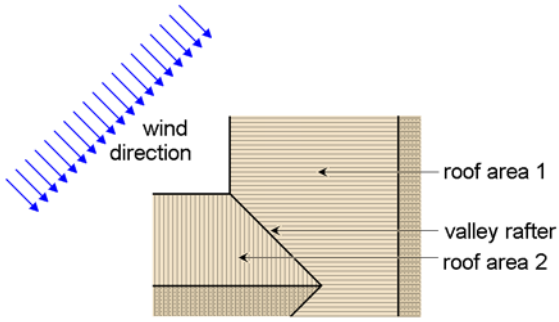
external pressure coefficients $c_{pe,10}$ in the area of the valley rafter
acc. to DIN 1055-4:2005-03 Tab. 7 resp. EN 1991-1-4 Tab. 7.5

uncertainty factor:
f_u = 1.20



(+) = pressure (-) = suction

roof area	angle	$c_{pe,10}$	$q = f_u \cdot c_{pe,10} \cdot q(h)/\sqrt{2}$
1	35°	0.70	0.40 kN/m²
2	35°	0.70	0.40 kN/m²



trapezoidal loads (sectionally) of load case 6: wind diagonal

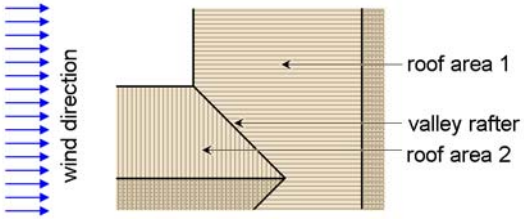
section -	direct. -	a m	qa kN/m	qa(l) kN/m	qa(m) kN/m	qa(n) kN/m	e m	qe kN/m	qe(l) kN/m	qe(m) kN/m	qe(n) kN/m	from
1	**Wind1**	0.00	**0.123**	0.000	-0.050	0.112	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	**Wind2**	0.00	**0.123**	0.000	0.050	0.112	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	**Wind1**	0.00	**0.615**	0.000	-0.249	0.562	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	**Wind1**	6.31	**0.692**	0.000	-0.281	0.632	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	**Wind2**	0.00	**0.615**	0.000	0.249	0.562	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	**Wind2**	6.31	**0.692**	0.000	0.281	0.632	0.00	**0.000**	0.000	0.000	0.000	roof area 2

load case 7: wind from left side

external pressure coefficients $c_{pe,10}$ in the area of the valley rafter
acc. to DIN 1055-4:2005-03 Tab. 7 resp. EN 1991-1-4 Tab. 7.5

(+) = pressure (-) = suction

roof area	angle	zone	$c_{pe,10}$	$q = c_{pe,10} * q(h)$
1	35°	G	0.70	0.47 kN/m²
2	35°	I	-0.37	-0.25 kN/m²



trapezoidal loads (sectionally) of load case 7: wind from left side

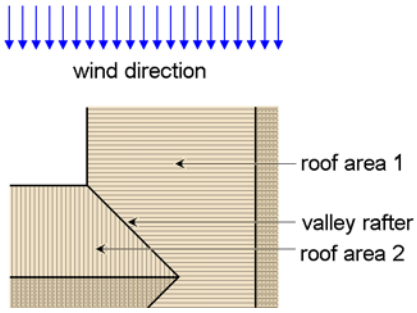
section	direct.	a	qa	qa(l)	qa(m)	qa(n)	e	qe	qe(l)	qe(m)	qe(n)	from
-	-	m	kN/m	kN/m	kN/m	kN/m	m	kN/m	kN/m	kN/m	kN/m	
1	Wind1	0.00	**0.145**	0.000	-0.059	0.132	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	Wind2	0.00	**-0.076**	0.000	-0.031	-0.069	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	Wind1	0.00	**0.725**	0.000	-0.294	0.662	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	Wind1	6.31	**0.815**	0.000	-0.331	0.745	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	Wind2	0.00	**-0.380**	0.000	-0.154	-0.347	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	Wind2	6.31	**-0.427**	0.000	-0.173	-0.390	0.00	**0.000**	0.000	0.000	0.000	roof area 2

load case 8: wind from top

external pressure coefficients $c_{pe,10}$ in the area of the valley rafter
acc. to DIN 1055-4:2005-03 Tab. 7 resp. EN 1991-1-4 Tab. 7.5

(+) = pressure (-) = suction

roof area	angle	zone	$c_{pe,10}$	$q = c_{pe,10} * q(h)$
1	35°	I	-0.37	-0.25 kN/m²
2	35°	G	0.70	0.47 kN/m²

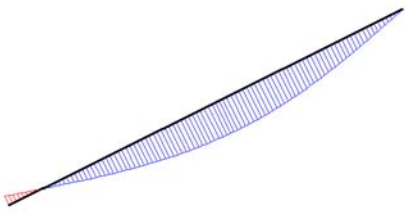


trapezoidal loads (sectionally) of load case 8: wind from top

section	direct.	a	qa	qa(l)	qa(m)	qa(n)	e	qe	qe(l)	qe(m)	qe(n)	from
-	-	m	kN/m	kN/m	kN/m	kN/m	m	kN/m	kN/m	kN/m	kN/m	
1	Wind1	0.00	**-0.076**	0.000	0.031	-0.069	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	Wind2	0.00	**0.145**	0.000	0.059	0.132	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	Wind1	0.00	**-0.380**	0.000	0.154	-0.347	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	Wind1	6.31	**-0.427**	0.000	0.173	-0.390	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	Wind2	0.00	**0.725**	0.000	0.294	0.662	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	Wind2	6.31	**0.815**	0.000	0.331	0.745	0.00	**0.000**	0.000	0.000	0.000	roof area 2

extremal deflections

deformations perpendicular to the member centre-line
Extremal from all load cases of the action effect wind loads



(max w = 54.0 mm, min w = -16.1 mm)

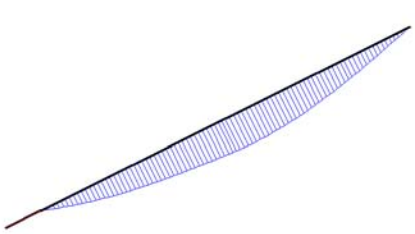
extremal support reactions

Extremal from all load cases of the action effect wind loads in kN

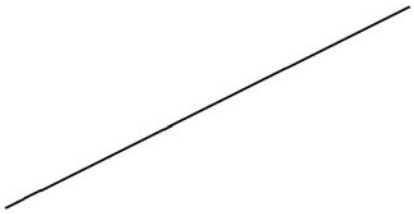
support	Hx		V		Hy	
	min	max	min	max	min	max
A	0.00	2.10	0.00	4.24	-1.88	1.88
B	0.00	1.53	0.00	3.09	-1.38	1.38

extremal internal forces

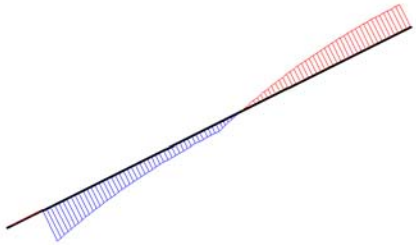
Extremal from vertical load components from all load cases of action effect wind loads



max Mm = 14.33 kNm, min Mm = -0.12 kNm



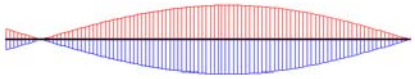
max N = 0.00 kN, min N = 0.00 kN



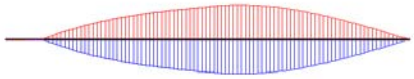
max Vn = 4.58 kN, min Vn = -3.45 kN

extremal internal forces

Extremal from horizontal load components from load cases of action effect



(max w = 29.3 mm, min w = -29.3 mm)



max Mn = 5.71 kNm, min Mn = -5.71 kNm

max Vm = 1.83 kN, min Vm = -1.83 kN

action effect of snow loads

snow load zone:	1
h + NN:	60 m
⇒ s_k:	0.65 kN/m²

the following load case is analysed.

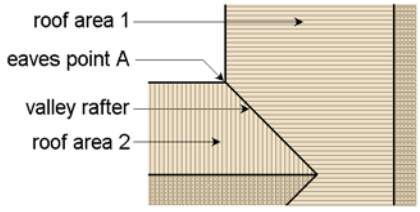
LF	description
9	snow fully

load case 9: snow fully

load determination acc. to EN 1991-1-3

If snow sliding is prevented by snowguards or the like the shape coefficient μ_1 is specified to 0.8 regardless of the roof pitch.

roof area	pitch	μ_1	$q = \mu_1 s_k \cos \alpha$
1	35	0.67	0.35 kN/m²
2	35	0.67	0.35 kN/m²

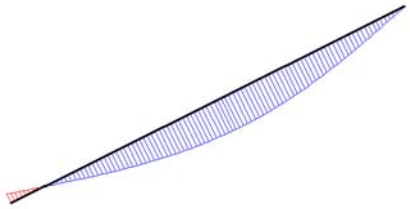


trapezoidal loads (sectionally) of load case 9: snow fully

section	direct.	a	qa	qa(l)	qa(m)	qa(n)	e	qe	qe(l)	qe(m)	qe(n)	from
-	-	m	kN/m	kN/m	kN/m	kN/m	m	kN/m	kN/m	kN/m	kN/m	
1	**vertical**	0.00	**0.110**	-0.049	0.000	0.098	0.00	**0.000**	0.000	0.000	0.000	roof area 1
1	**vertical**	0.00	**0.110**	-0.049	0.000	0.098	0.00	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	0.00	**0.549**	-0.244	0.000	0.492	7.10	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	6.31	**0.618**	-0.274	0.000	0.554	0.00	**0.000**	0.000	0.000	0.000	roof area 1
2	**vertical**	0.00	**0.549**	-0.244	0.000	0.492	7.10	**0.000**	0.000	0.000	0.000	roof area 2
2	**vertical**	6.31	**0.618**	-0.274	0.000	0.554	0.00	**0.000**	0.000	0.000	0.000	roof area 2

extremal deflections

deformations perpendicular to the member centre-line
Extremal from all load cases of the action effect snow loads



(max w = 47.3 mm, min w = -14.1 mm)

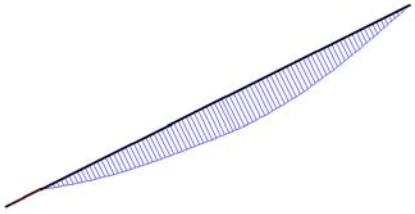
extremal support reactions

Extremal from all load cases of the action effect snow loads in kN

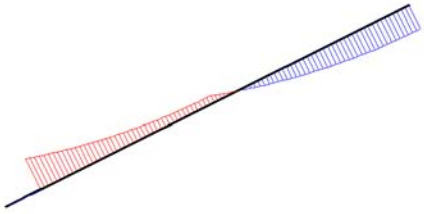
supp.	H		V	
	min	max	min	max
A	0.00	0.00	0.00	4.62
B	0.00	0.00	0.00	3.38

extremal internal forces

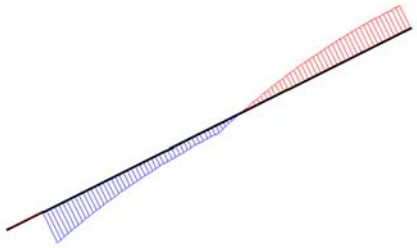
Extremal from all load cases of the action effect snow loads



max Mm = 12.55 kNm, min Mm = -0.10 kNm



max N = 1.50 kN, min N = -1.98 kN



max Vn = 4.01 kN, min Vn = -3.02 kN

main verification

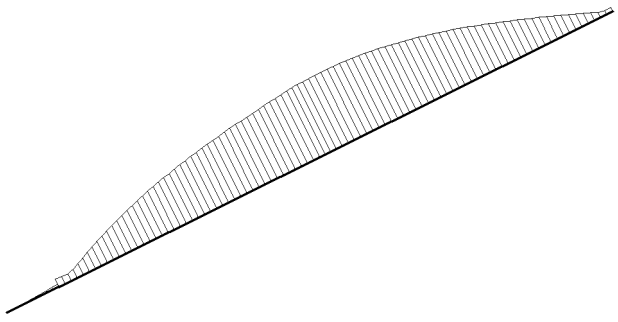
verification of load-carrying capacity for permanent and transient design situations

service class of building	1
material safety factor	1.30
combination of internal forces	acc.to EN 1990

safety and combination coefficients, classes of duration of load

action effect	γ_{sup}	γ_{inf}	Ψ_{dom}	Ψ_{sub}	KLED	k_{mod}
permanent loads	1.35	1.00	1.00	1.00	permanent	0.60
man loads	1.50	0.00	1.00	0.00	sh.-term	0.90
wind loads	1.50	0.00	1.00	0.60	sh.-v.sh.	1.00
snow loads	1.50	0.00	1.00	0.50	sh.-term	0.90

maximal degree of utilization
max U = 1.54



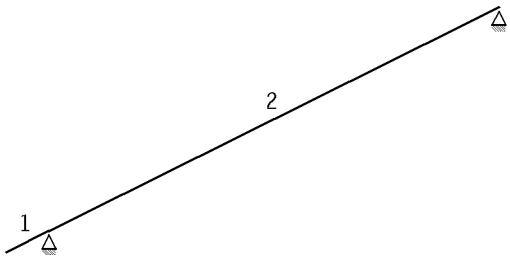
verifications of serviceability limit states

comparative lengths

for calculation of degree of utilization

section	true length	l_v vert.	l_v hor.
-	m	m	m
1	1.26	1.26	1.26
2	13.41	13.41	13.41

sections



limit values

deformation	in span	at cantilever
Winst	l_v/300	l_v/150
Wfin	l_v/200	l_v/100

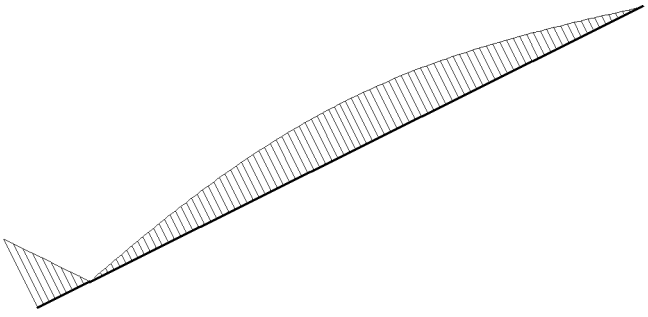
verification of serviceability limit state w_{inst}

combination coefficients

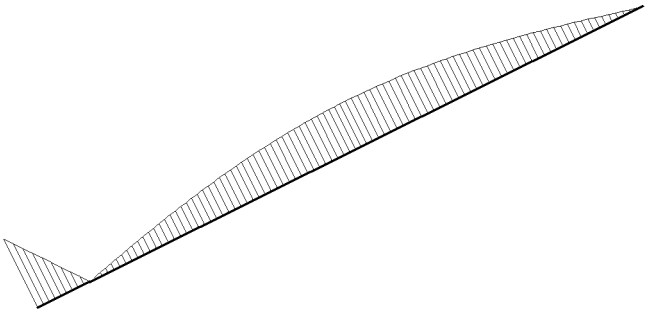
action effect	Ψ_0
man loads	0.00
wind loads	0.60
snow loads	0.50

service class 1
$\Rightarrow k_{def} = 0.60$

maximal degree of utilization
from vertical load components
max U = 8.15



maximal degree of utilization
from horizontal load components
max U = 1.04



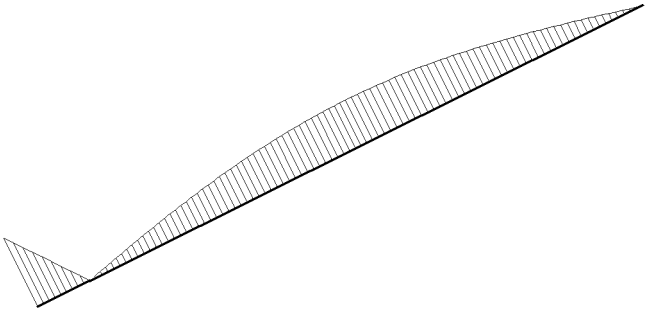
verification of serviceability limit state w_{fin}

combination coefficients

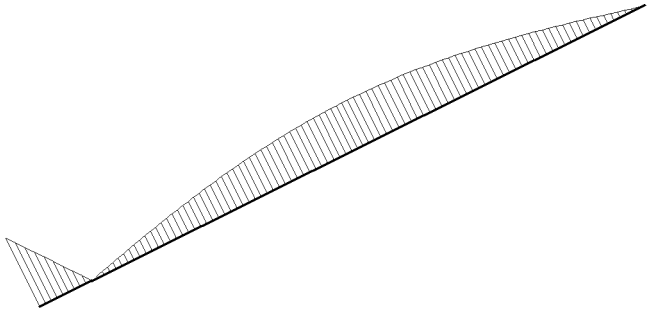
action effect	Ψ_0	Ψ_2
man loads	0.00	0.00
wind loads	0.60	0.00
snow loads	0.50	0.00

service class 1
$\Rightarrow k_{def} = 0.60$

maximal degree of utilization
from vertical load components
max U = 7.56



maximal degree of utilization
from horizontal load components
max U = 0.69



extremal support reactions

on characteristic load level

Positive vertical reaction forces (V) are acting from bottom to top. Positive horizontal reaction forces (Hx) are acting from right to left side. Man loads and snow loads are never acting at the same time. If the result of the analysed man loads is max Av < 1.0, it is set to max Av = 1.0. Hereby the case of man load directly on the support is considered.

	G	Q			G+Q			
		Hx	V	Hy	Hx	V	Hy	from
	kN	kN	kN	kN	kN	kN	kN	
support A								
min A_{Hx}	0.02	0.00	0.00	0.00	0.02	14.86	0.00	G
max A_{Hx}	0.02	2.13	4.24	0.00	2.15	19.09	0.00	G+M+W
min A_V	14.86	0.00	0.00	0.00	0.02	14.86	0.00	G
max A_V	14.86	2.10	8.85	0.00	2.11	23.71	0.00	G+W+S
min A_{Hy}	0.00	0.59	1.19	-1.88	0.61	16.04	-1.88	G+W
max A_{Hy}	0.00	0.59	1.19	1.88	0.61	16.04	1.88	G+W
support B								
min B_{Hx}	-0.02	-0.04	-0.08	0.00	-0.05	11.05	0.00	G+M
max B_{Hx}	-0.02	1.53	3.59	0.00	1.52	14.72	0.00	G+M+W
min B_V	11.13	-0.04	-0.08	0.00	-0.05	11.05	0.00	G+M
max B_V	11.13	1.53	6.47	0.00	1.52	17.60	0.00	G+W+S
min B_{Hy}	0.00	0.43	0.87	-1.38	0.41	12.00	-1.38	G+W
max B_{Hy}	0.00	0.43	0.87	1.38	0.41	12.00	1.38	G+W