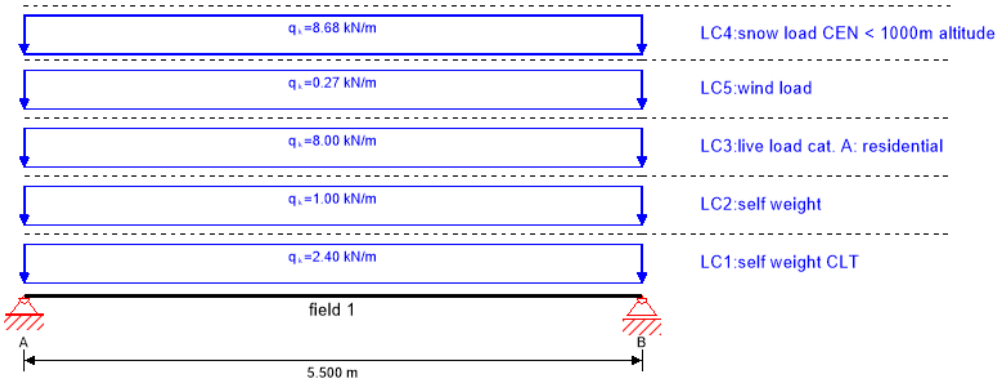
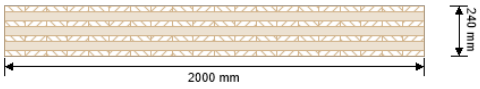
system



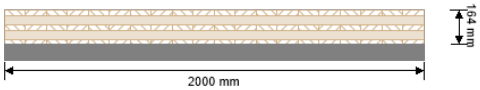
global utilization ratio										77 %
ULS	42 %	ULS fire	12 %	SLS	77 %	SLS vibration	68 %	support	-1 %	

section: CLT 240 L7s



layer	thickness	orientation	material
1	30.0 mm	0°	C24 spruce ETA (2019)
2	40.0 mm	90°	C24 spruce ETA (2019)
3	30.0 mm	0°	C24 spruce ETA (2019)
4	40.0 mm	90°	C24 spruce ETA (2019)
5	30.0 mm	0°	C24 spruce ETA (2019)
6	40.0 mm	90°	C24 spruce ETA (2019)
7	30.0 mm	0°	C24 spruce ETA (2019)
t_{CLT}	**240.0 mm**		

section fire: CLT 240 L7s



layer	thickness	orientation	material
1	30.0 mm	0°	C24 spruce ETA (2019)
2	40.0 mm	90°	C24 spruce ETA (2019)
3	30.0 mm	0°	C24 spruce ETA (2019)
4	40.0 mm	90°	C24 spruce ETA (2019)
5	24.0 mm	0°	C24 spruce ETA (2019)
t_{CLT}	**164.0 mm**		
time	**90 min**		

fire resistance class:R 90

fire protection layering : 12.5 mm gypsum plasterboard Type F
gypsum plasterboard Type A (acc. to EN 520)gypsum plasterboard Type F (acc. to EN 520)

$t_{ch,h}$ [min]	$t_{f,h}$ [min]	$t_{a,h}$ [min]	$d_{ta,h}$ [mm]	k_0 [-]	d_0 [mm]	$d_{char,0,h}$ [mm]	$d_{ef,h}$ [mm]
21	24	42	25	1	7	69.0	76.0

material values

material	$f_{m,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$f_{t,90,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{v,k}$ [N/mm²]	$f_{r,k\ min}$ [N/mm²]	$E_{0,mean}$ [N/mm²]	G_{mean} [N/mm²]	$G_{r,mean}$ [N/mm²]
C24 spruce ETA (2019) C24 spruce ETA (2019)	24.00	14.00	0.12	21.00	2.50	4.00	1.25	12,000.00	690.00	50.00

load

load case groups

	load case category	Typ	duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1 LC1	self weight CLT self weight CLT	G G	permanent permanent	0.6	1	1.35	1	1	1
LC2 LC2	self weight self weight	G G	permanent permanent	0.6	1	1.35	1	1	1
LC3 LC3	live load cat. A: residential live load cat. A: residential	Q Q	medium term medium term	0.8	0	1.5	0.7	0.5	0.3
LC4 LC4	snow load CEN < 1000m altitude snow load CEN < 1000m altitude	Q Q	short term short term	0.9	0	1.5	0.5	0.2	0
LC5 LC5	wind load wind load	Q Q	short term short term	0.9	0	1.5	0.6	0.2	0

LC1:self weight CLT

continuous load

field	load at start
	[kN/m]
1 1	2.40

LC2:self weight

continuous load

field	load at start
	[kN/m]
1 1	1.00

LC3:live load cat. A: residential

continuous load

field	load at start
	[kN/m]
1 1	8.00

LC4:snow load CEN < 1000m altitude

continuous load

field	load at start
	[kN/m]
1 1	8.68

LC5:wind load

continuous load	
field	load at start
	[kN/m]
1 1	0.27

ULS combinations

	combination rule
LCO1 LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC2 1.35/1.00 * LC1 + 1.35/1.00 * LC2
LCO2 LCO2	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC3 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC3
LCO3 LCO3	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC3 + 1.50/0.00 * 0.50 * LC4 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC3 + 1.50/0.00 * 0.50 * LC4
LCO4 LCO4	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC3 + 1.50/0.00 * 0.50 * LC4 + 1.50/0.00 * 0.60 * LC5 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC3 + 1.50/0.00 * 0.50 * LC4 + 1.50/0.00 * 0.60 * LC5
LCO5 LCO5	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC4 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC4
LCO6 LCO6	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC4 + 1.50/0.00 * 0.70 * LC3 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC4 + 1.50/0.00 * 0.70 * LC3
LCO7 LCO7	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC4 + 1.50/0.00 * 0.70 * LC3 + 1.50/0.00 * 0.60 * LC5 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC4 + 1.50/0.00 * 0.70 * LC3 + 1.50/0.00 * 0.60 * LC5
LCO8 LCO8	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC5 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC5
LCO9 LCO9	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC5 + 1.50/0.00 * 0.70 * LC3 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC5 + 1.50/0.00 * 0.70 * LC3
LCO10 LCO10	1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC5 + 1.50/0.00 * 0.70 * LC3 + 1.50/0.00 * 0.50 * LC4 1.35/1.00 * LC1 + 1.35/1.00 * LC2 + 1.50/0.00 * LC5 + 1.50/0.00 * 0.70 * LC3 + 1.50/0.00 * 0.50 * LC4

ULS combinations fire

	combination rule
LCO11 LCO11	1.00/1.00 * LC1 + 1.00/1.00 * LC2 1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO12 LCO12	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3
LCO13 LCO13	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4
LCO14 LCO14	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.00 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.00 * LC5
LCO15 LCO15	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4
LCO16 LCO16	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.30 * LC3 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.30 * LC3
LCO17 LCO17	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC5
LCO18 LCO18	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5
LCO19 LCO19	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 + 1.00/0.00 * 0.30 * LC3 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 + 1.00/0.00 * 0.30 * LC3
LCO20 LCO20	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4

SLS characteristic combination

	combination rule
LCO21 LCO21	1.00/1.00 * LC1 + 1.00/1.00 * LC2 1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO22 LCO22	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC3 + 1.00/0.00 * 0.50 * LC4 + 1.00/0.00 * 0.60 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC3 + 1.00/0.00 * 0.50 * LC4 + 1.00/0.00 * 0.60 * LC5
LCO23 LCO23	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC4 + 1.00/0.00 * 0.70 * LC3 + 1.00/0.00 * 0.60 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC4 + 1.00/0.00 * 0.70 * LC3 + 1.00/0.00 * 0.60 * LC5
LCO24 LCO24	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC5 + 1.00/0.00 * 0.70 * LC3 + 1.00/0.00 * 0.50 * LC4 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC5 + 1.00/0.00 * 0.70 * LC3 + 1.00/0.00 * 0.50 * LC4

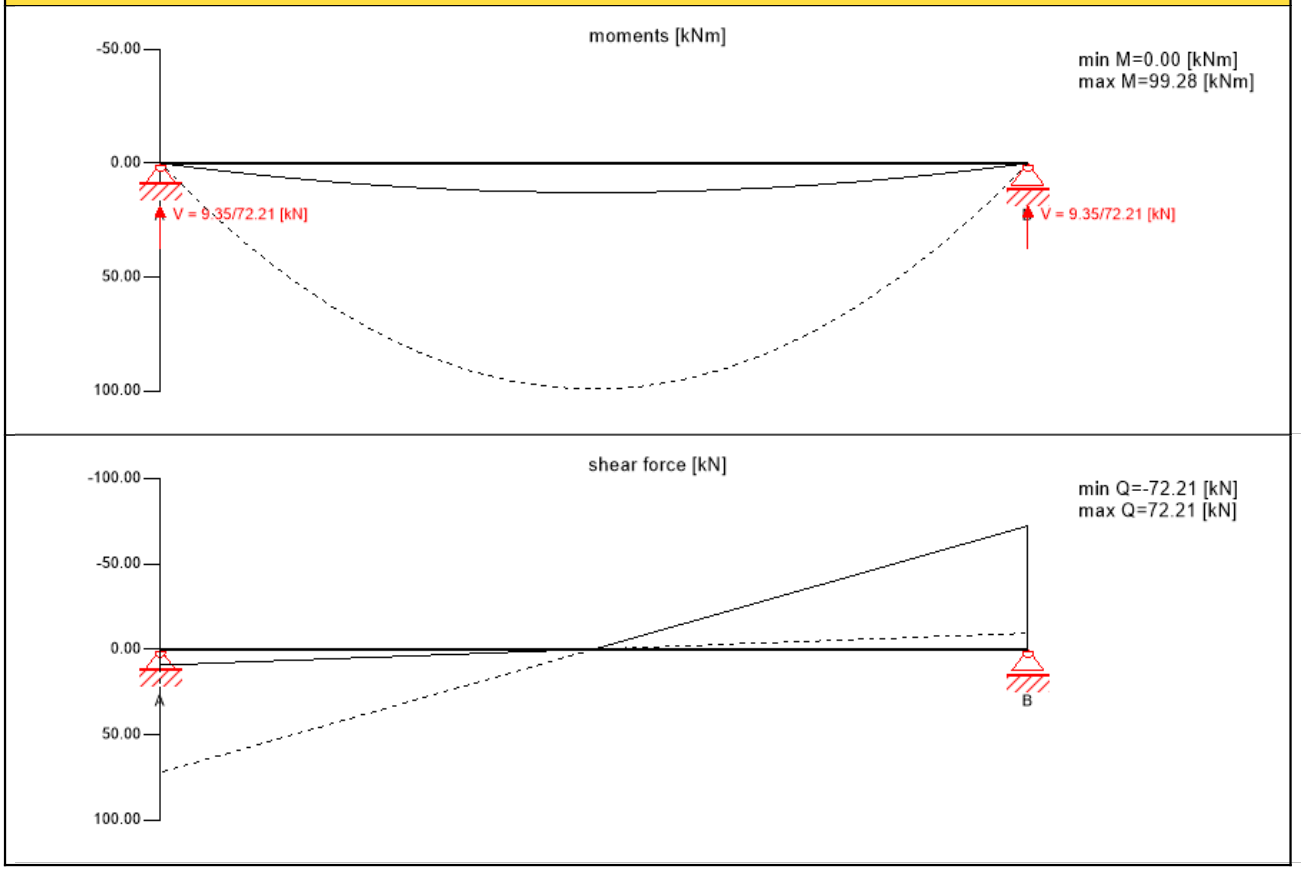
SLS quasi-permanent combination

	combination rule
LCO25 LCO25	1.00/1.00 * LC1 + 1.00/1.00 * LC2 1.00/1.00 * LC1 + 1.00/1.00 * LC2

SLS quasi-permanent combination

	combination rule
LCO26 LCO26	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.00 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.00 * LC5
LCO27 LCO27	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC5 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC4 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC5
LCO28 LCO28	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4 1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.00 * LC5 + 1.00/0.00 * 0.30 * LC3 + 1.00/0.00 * 0.00 * LC4

Ultimate limit state (ULS) - design results



ULS flexural design

field	dist.	$f_{m,k}$	γ_m	k_{mod}	$k_{sys,y}$	$f_{m,y,d}$	$M_{y,d}$	$\sigma_{m,y,d}$	ratio	
	[m]	[N/mm²]	[-]	[-]	[-]	[N/mm²]	[kNm]	[N/mm²]		
1	2.75	24.00	1.25	0.90	1.10	19.01	99.28	8.01	42 %	LCO7 LCO7

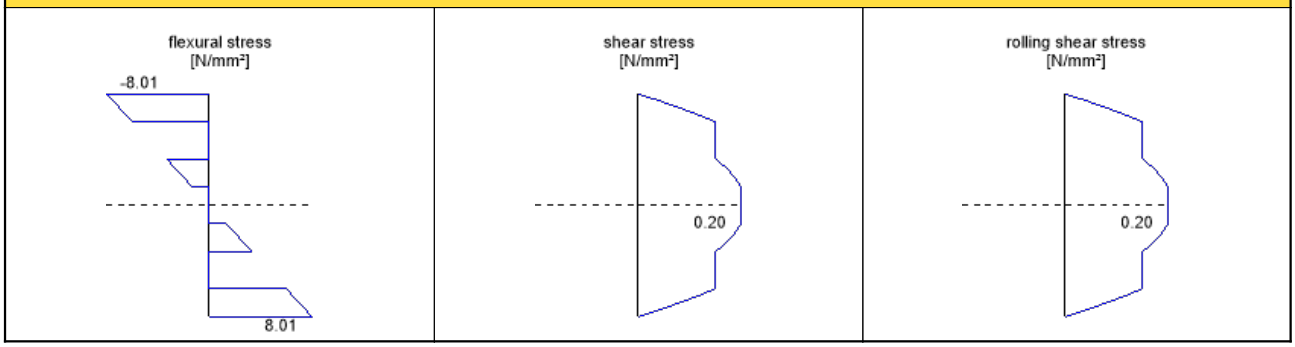
ULS shear analysis

field	dist.	$f_{v,k}$	γ_m	k_{mod}	$f_{v,d}$	V_d	$\tau_{v,d}$	ratio	
	[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kN]	[N/mm²]		
1	5.5	4.00	1.25	0.90	2.88	-72.21	0.20	7 %	LCO7 LCO7

ULS rolling shear

field	dist.	$f_{r,k}$	γ_m	k_{mod}	$f_{r,d}$	V_d	$\tau_{r,d}$	ratio	
	[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kN]	[N/mm²]		
1	5.5	1.05	1.25	0.90	0.76	-72.21	0.20	27 %	LCO7 LCO7

stress diagram



flexural stress analysis

$M_{y,d}$ =	99.28	kNm		$f_{m,k}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.90	-	
				$k_{sys,y}$ =	1.10	-	
				k_{hm} =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,d}$ =	10.08	N/mm²	
$\sigma_{m,y,d}$ =	8.01	N/mm²	<	$f_{m,y,d}$ =	19.01	N/mm²	✓

utilization ratio 42 %

shear stress analysis

V_d =	- 72.21	kN		$f_{v,k}$ =	4.00	N/mm²	
				γ_m =	1.25		
				k_{mod} =	0.90		
$\tau_{v,d}$ =	0.20	N/mm²	<	$f_{v,d}$ =	2.88	N/mm²	✓

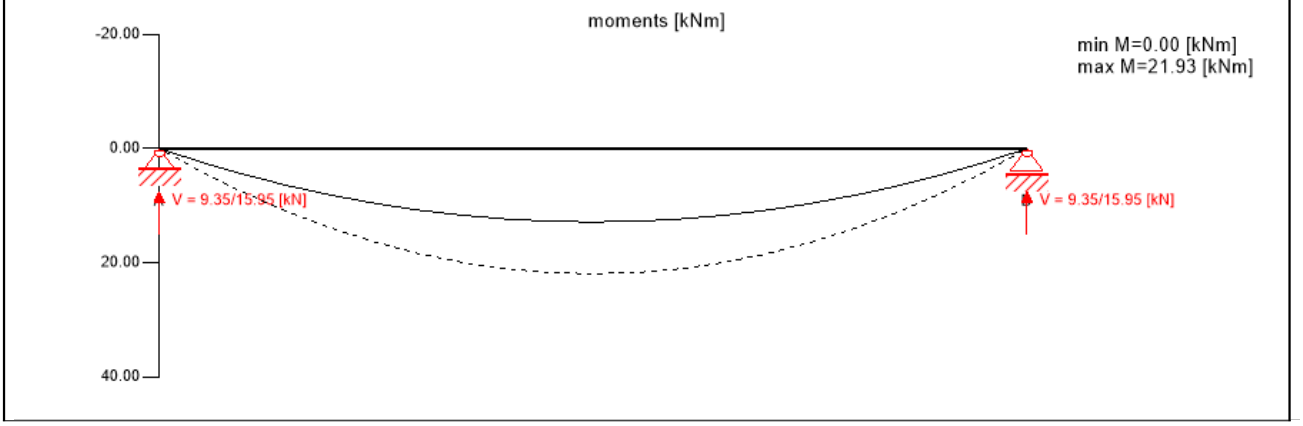
utilization ratio 7 %

rolling shear analysis

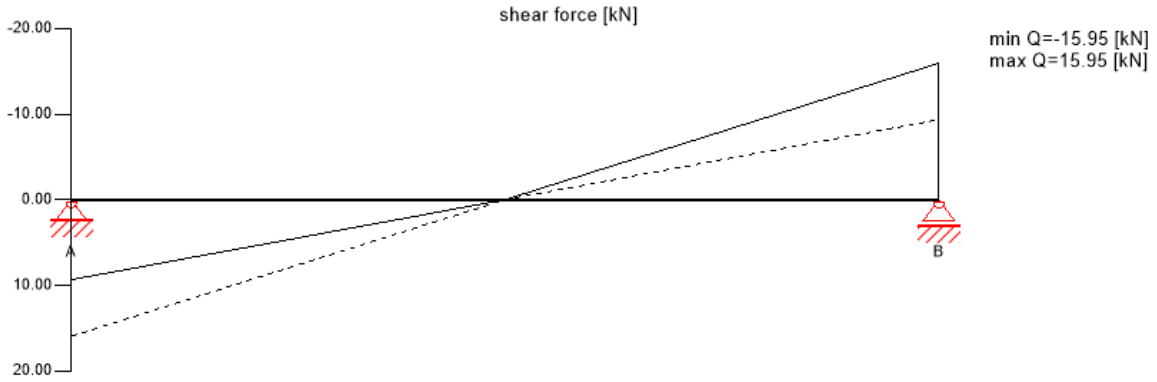
V_d =	-72.21	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.90	-	
$\tau_{r,d}$ =	0.20	N/mm²	<	$f_{r,d}$ =	0.76	N/mm²	✓

utilization ratio 27 %

Ultimate limit state (ULS) fire design - results



Ultimate limit state (ULS) fire design - results



ULS fire flexural design

field	dist.	$f_{m,k}$	γ_m	k_{mod}	$k_{sys,y}$	k_{fi}	$f_{m,y,d}$	$M_{y,d}$	$\sigma_{m,y,d}$	ratio	
	[m]	[N/mm²]	[-]	[-]	[-]	[-]	[N/mm²]	[kNm]	[N/mm²]		
1	2.75	24.00	1.00	1.00	1.10	1.15	30.36	21.93	3.61	12 %	LCO12 LCO12

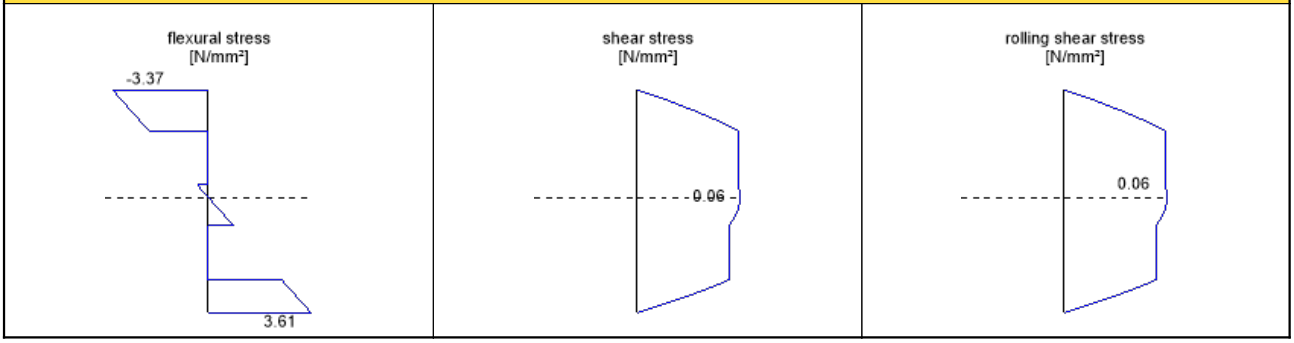
ULS fire shear analysis

field	dist.	$f_{v,k}$	γ_m	k_{mod}	k_{fi}	$f_{v,d}$	V_d	$\tau_{v,d}$	ratio	
	[m]	[N/mm²]	[-]	[-]	[-]	[N/mm²]	[kN]	[N/mm²]		
1	5.5	4.00	1.00	1.00	1.15	4.60	-15.95	0.06	1 %	LCO12 LCO12

ULS fire rolling shear

field	dist.	$f_{r,k}$	γ_m	k_{mod}	k_{fi}	$f_{r,d}$	V_d	$\tau_{r,d}$	ratio	
	[m]	[N/mm²]	[-]	[-]	[-]	[N/mm²]	[kN]	[N/mm²]		
1	5.5	1.05	1.00	1.00	1.15	1.21	-15.95	0.06	5 %	LCO12 LCO12

stress diagram



flexural stress analysis fire

$M_{y,d}$ =	21.93	kNm		$f_{m,k}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				$k_{sys,y}$ =	1.10	-	
				k_{hm} =	1.00	-	
				k_l =	1.00	-	
				k_{fi} =	1.15	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,d}$ =	16.10	N/mm²	
$\sigma_{m,y,d}$ =	3.61	N/mm²	<	$f_{m,y,d}$ =	30.36	N/mm²	✓

utilization ratio 12 %

shear stress analysis fire

V_d =	15.95	- kN		$f_{v,k}$ =	4.00	N/mm²	
				γ_m =	1.00		
				k_{mod} =	1.00		
				k_{fi} =	1.15		
$\tau_{v,d}$ =	0.06	N/mm²	<	$f_{v,d}$ =	4.60	N/mm²	✓

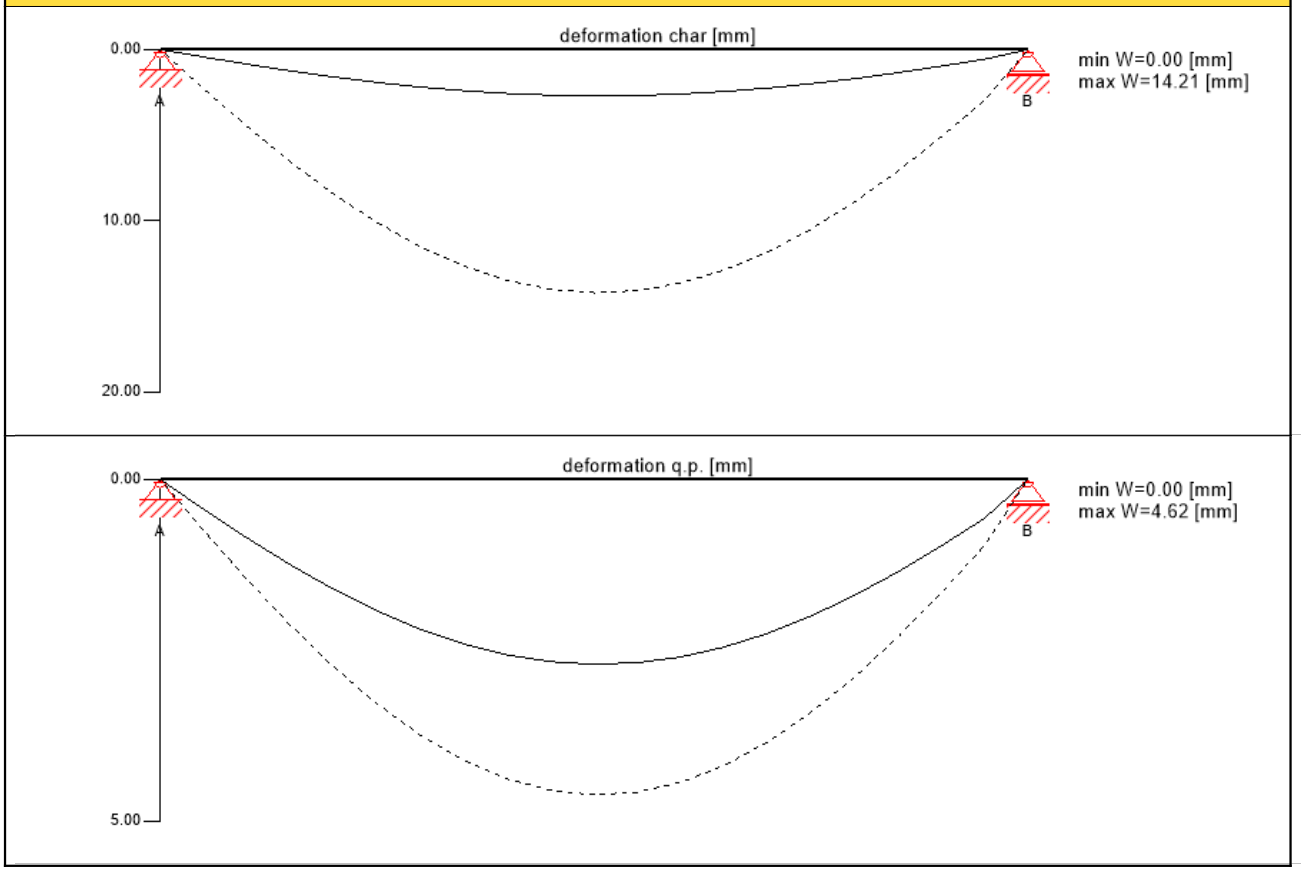
utilization ratio 1 %

rolling shear analysis fire

V_d =	-15.95	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				k_{fi} =	1.15	-	
$\tau_{r,d}$ =	0.06	N/mm²	<	$f_{r,d}$ =	1.21	N/mm²	✓

utilization ratio 5 %

Service limit state design (SLS) - design results



w_{inst} = w[char]

field	K_{def}	limit	w_{limit}	$w_{calc.}$	ratio
		[-]	[mm]	[mm]	
1	0.8	L/300	18.3	14.2	77 %

w_{fin} = w[char] + w[q.p.]*kdef

field	K_{def}	limit	w_{limit}	$w_{calc.}$	ratio
		[-]	[mm]	[mm]	
1	0.8	L/150	36.7	17.9	49 %

$w_{net,fin}$ = w[q.p.] + w[q.p.]*kdef					
field	K_{def}	limit	w_{limit}	$w_{calc.}$	ratio
		[-]	[mm]	[mm]	
1	0.8	L/250 L/250	22.0	8.3	38 %

vibration analysis

general		
total mass	2.62	[t]
tributary width	2.8	[m]
stiffness longitudinal direction	17856.0	[kNm²]
stiffness cross direction	9792.0	[kNm²]
modal damping	1.0	[%]
α	0.0	[-]
man weight	700.0	[N]
modal mass	1309.2	[kg]

analysis							
criterion	calc.	class I	class II	class I	class II	cl. I	cl. II
frequency criterion min	11.789 [Hz]	4.5 [Hz]	4.5 [Hz]	38 %	38 %	✓	✓
frequency criterion	11.789 [Hz]	8.0 [Hz]	6.0 [Hz]	68 %	51 %	✓	✓
acceleration criterion	0.096 [m/s²]	0.05 [m/s²]	0.1 [m/s²]	191 %	96 %	×	✓
stiffness criterion	0.071 [mm]	0.25 [mm]	0.5 [mm]	28 %	14 %	✓	✓

support reaction

load case category	k_{mod}	A_V	B_V
		[kN]	
self weight CLT	0.6	6.60	6.60
		6.60	6.60
self weight	0.6	2.75	2.75
		2.75	2.75
live load cat. A: residential	0.8	22.00	22.00
		0.00	0.00
snow load CEN < 1000m altitude	0.9	23.87	23.87
		0.00	0.00
wind load	0.9	0.75	0.75
		0.00	0.00

Disclaimer