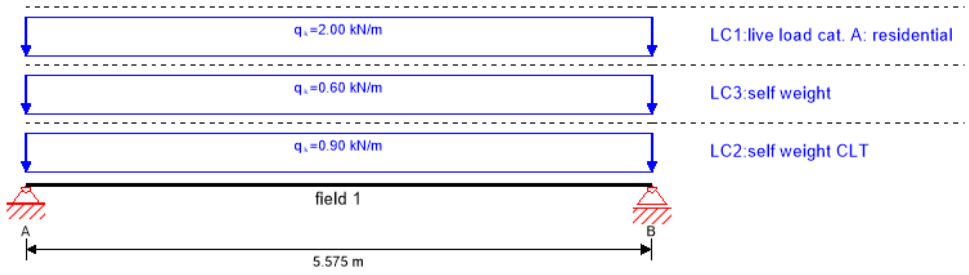
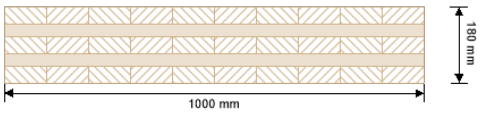
system



global utilization ratio 106 %

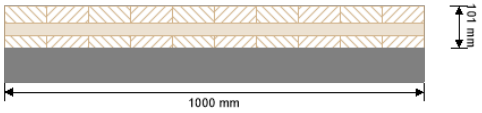
ULS	ULS fire	SLS	SLS vibration	support
25 %	17 %	54 %	106 %	-1 %

section: CLT 180 L5s



layer	thickness	orientation	material
1	40.0 mm	0°	C24 spruce ETA (2019)
2	30.0 mm	90°	C24 spruce ETA (2019)
3	40.0 mm	0°	C24 spruce ETA (2019)
4	30.0 mm	90°	C24 spruce ETA (2019)
5	40.0 mm	0°	C24 spruce ETA (2019)
t_{CLT}	**180.0 mm**		

section fire: CLT 180 L5s



layer	thickness	orientation	material
1	40.0 mm	0°	C24 spruce ETA (2019)
2	30.0 mm	90°	C24 spruce ETA (2019)
3	31.0 mm	0°	C24 spruce ETA (2019)
t_{CLT}	**101.0 mm**		
time	**90 min**		

fire resistance class:R 90

fire protection layering : no additional fire protection

k_0	d_0	$d_{char,0,h}$	$d_{ef,h}$	$d_{char,0,v}$	$d_{ef,v}$
[-]	[mm]	[mm]	[mm]	[mm]	[mm]
1	7	72.0	79.0	0.0	0.0

material values

material	$f_{m,k}$	$f_{t,0,k}$	$f_{t,90,k}$	$f_{c,0,k}$	$f_{c,90,k}$	$f_{v,k}$	$f_{r,k\ min}$	$E_{0,mean}$	G_{mean}	$G_{r,mean}$
	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[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
LC2 LC2	self weight CLT self weight CLT	G G	permanent permanent	0.6	1	1.35	1	1	1
LC3 LC3	self weight self weight	G G	permanent permanent	0.6	1	1.35	1	1	1

load case groups

	load case category	Typ	duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1	live load cat. A: residential	Q	medium term	0.8	0	1.5	0.7	0.5	0.3
LC1	live load cat. A: residential	Q	medium term						

LC2:self weight CLT

continuous load

field	load at start
	[kN/m]
1 1	0.90

LC3:self weight

continuous load

field	load at start
	[kN/m]
1 1	0.60

LC1:live load cat. A: residential

continuous load

field	load at start
	[kN/m]
1 1	2.00

ULS combinations

	combination rule
LCO1	1.35/1.00 * LC2 + 1.35/1.00 * LC3
LCO1	1.35/1.00 * LC2 + 1.35/1.00 * LC3
LCO2	1.35/1.00 * LC2 + 1.35/1.00 * LC3 + 1.50/0.00 * LC1
LCO2	1.35/1.00 * LC2 + 1.35/1.00 * LC3 + 1.50/0.00 * LC1

ULS combinations fire

	combination rule
LCO3	1.00/1.00 * LC2 + 1.00/1.00 * LC3
LCO3	1.00/1.00 * LC2 + 1.00/1.00 * LC3
LCO4	1.00/1.00 * LC2 + 1.00/1.00 * LC3 + 1.00/0.00 * 0.30 * LC1
LCO4	1.00/1.00 * LC2 + 1.00/1.00 * LC3 + 1.00/0.00 * 0.30 * LC1

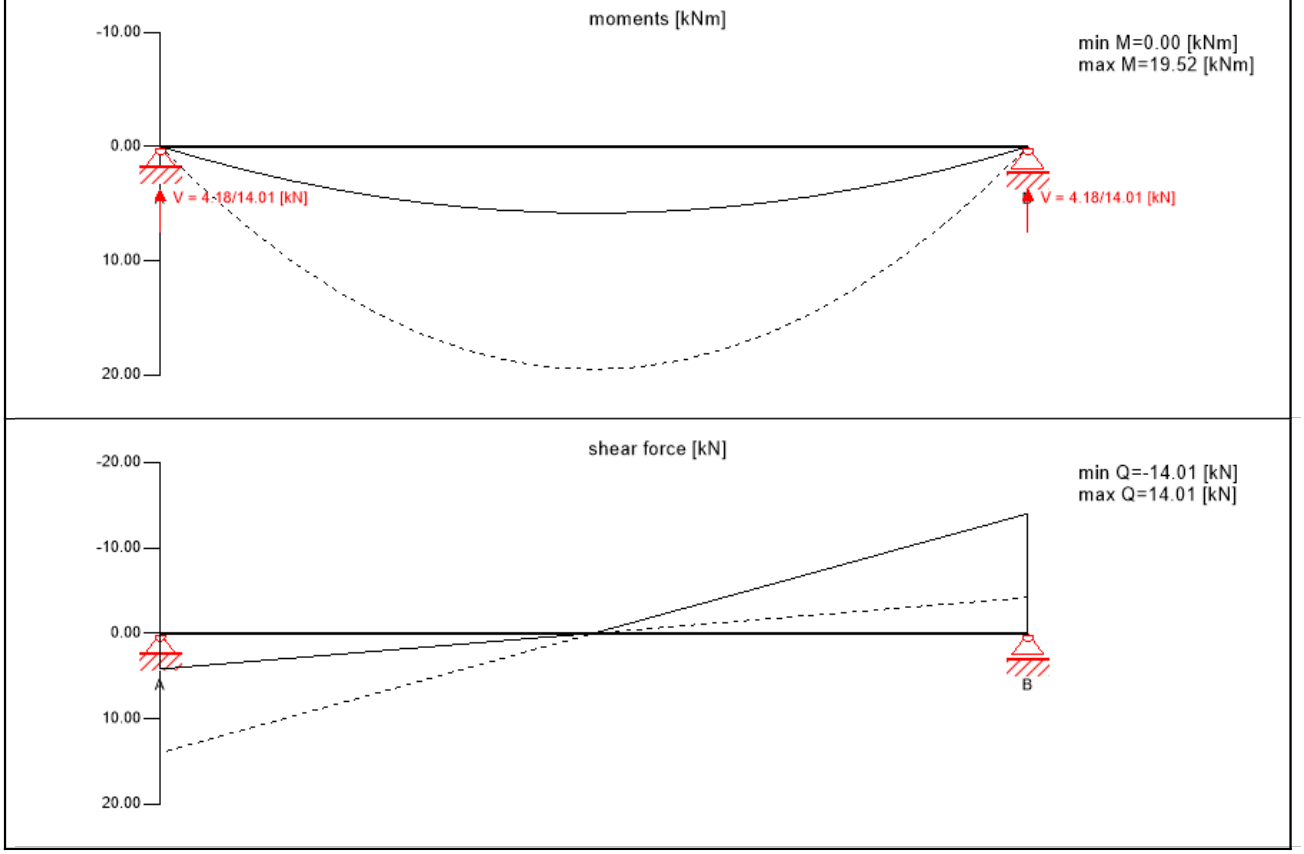
SLS characteristic combination

	combination rule
LCO5	1.00/1.00 * LC2 + 1.00/1.00 * LC3
LCO5	1.00/1.00 * LC2 + 1.00/1.00 * LC3
LCO6	1.00/1.00 * LC2 + 1.00/1.00 * LC3 + 1.00/0.00 * LC1
LCO6	1.00/1.00 * LC2 + 1.00/1.00 * LC3 + 1.00/0.00 * LC1

SLS quasi-permanent combination

	combination rule
LCO7	1.00/1.00 * LC2 + 1.00/1.00 * LC3
LCO7	1.00/1.00 * LC2 + 1.00/1.00 * LC3
LCO8	1.00/1.00 * LC2 + 1.00/1.00 * LC3 + 1.00/0.00 * 0.30 * LC1
LCO8	1.00/1.00 * LC2 + 1.00/1.00 * LC3 + 1.00/0.00 * 0.30 * LC1

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	2.79	24.00	1.25	0.80	1.10	16.90	19.52	-4.31	25 %	LCO2 LCO2

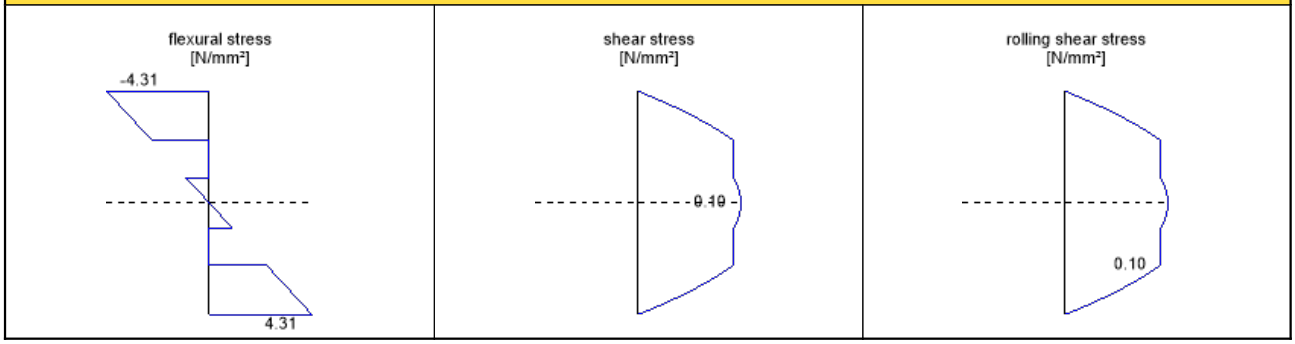
ULS shear analysis

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	5.58	4.00	1.25	0.80	2.56	-14.01	0.10	4 %	LCO2 LCO2

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	5.58	1.15	1.25	0.80	0.74	-14.01	0.10	13 %	LCO2 LCO2

stress diagram



flexural stress analysis

$M_{y,d}$ =	19.52	kNm		$f_{m,k}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.80	-	
				$k_{sys,y}$ =	1.10	-	
				k_{hm} =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,d}$ =	8.96	N/mm²	
$\sigma_{m,y,d}$ =	-4.31	N/mm²	<	$f_{m,y,d}$ =	16.90	N/mm²	✓

utilization ratio 25 %

shear stress analysis

V_d =	- 14.01	kN		$f_{v,k}$ =	4.00	N/mm²	
				γ_m =	1.25		
				k_{mod} =	0.80		
$\tau_{v,d}$ =	0.10	N/mm²	<	$f_{v,d}$ =	2.56	N/mm²	✓

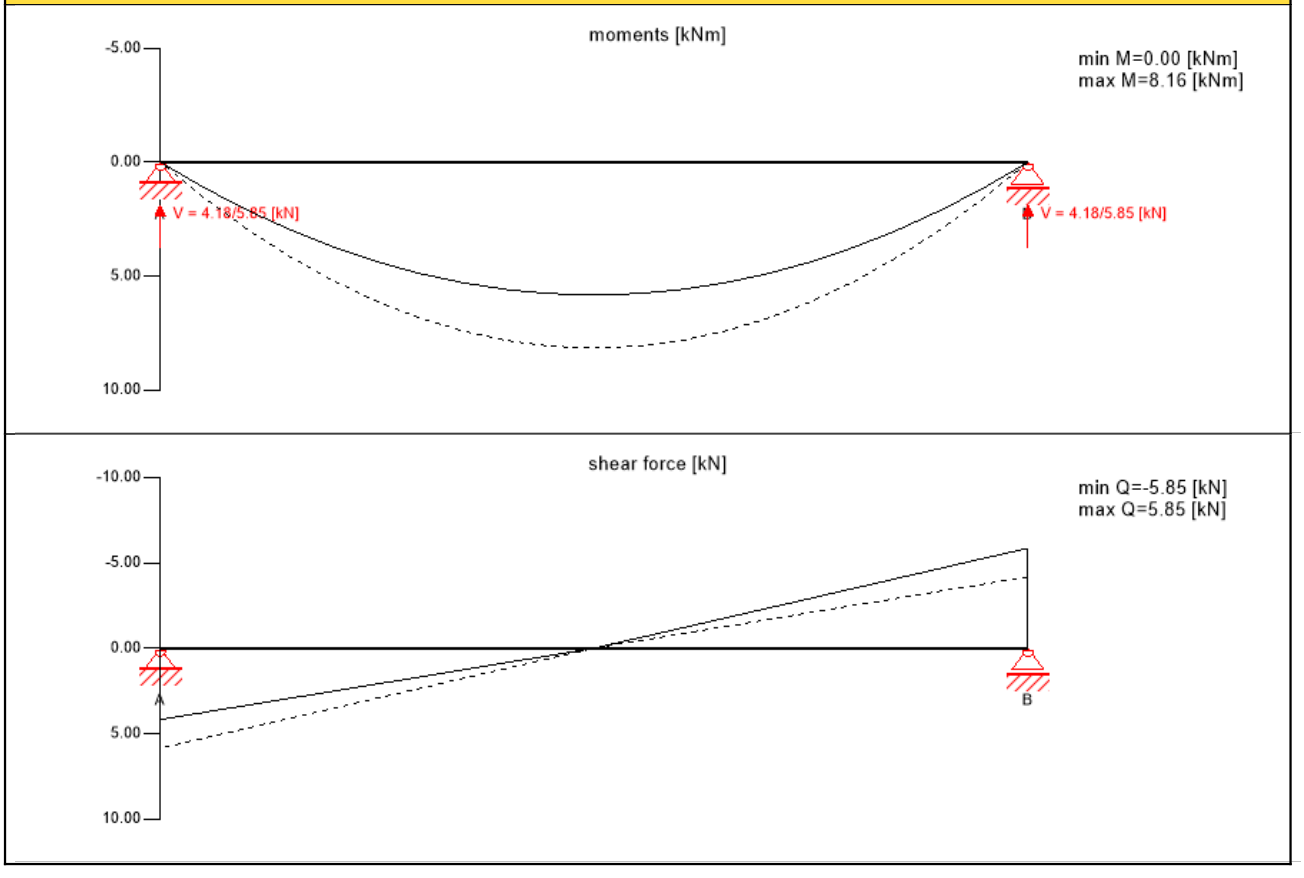
utilization ratio 4 %

rolling shear analysis

V_d =	-14.01	kN		$f_{r,k}$ =	1.15	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.80	-	
$\tau_{r,d}$ =	0.10	N/mm²	<	$f_{r,d}$ =	0.74	N/mm²	✓

utilization ratio 13 %

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	2.79	24.00	1.00	1.00	1.10	1.15	30.36	8.16	5.17	17 %	LCO4 LCO4

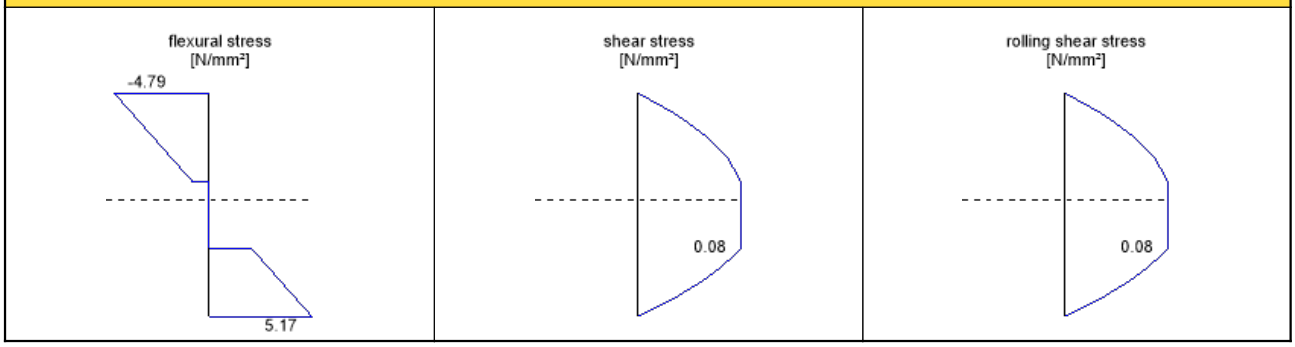
ULS fire shear analysis

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	5.58	4.00	1.00	1.00	1.15	4.60	-5.85	0.08	2 %	LCO4 LCO4

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	5.58	1.15	1.00	1.00	1.15	1.32	-5.85	0.08	6 %	LCO4 LCO4

stress diagram



flexural stress analysis fire

$M_{y,d}$ =	8.16	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	
$\sigma_{m,y,d}$ =	5.17	N/mm²	<	$f_{m,y,d}$ =	30.36	N/mm²	✓

utilization ratio 17 %

shear stress analysis fire

V_d =	-5.85	kN		$f_{v,k}$ =	4.00	N/mm²	
				γ_m =	1.00		
				k_{mod} =	1.00		
				k_{fi} =	1.15		
$\tau_{v,d}$ =	0.08	N/mm²	<	$f_{v,d}$ =	4.60	N/mm²	✓

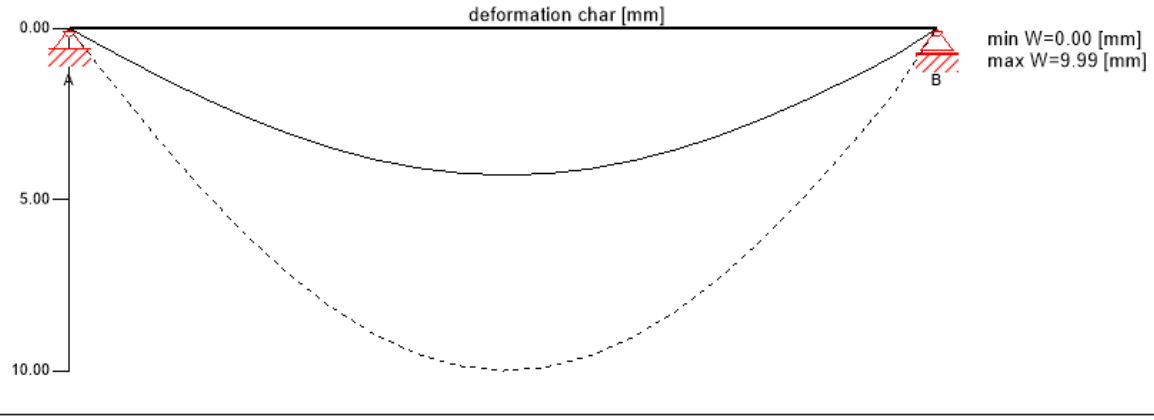
utilization ratio 2 %

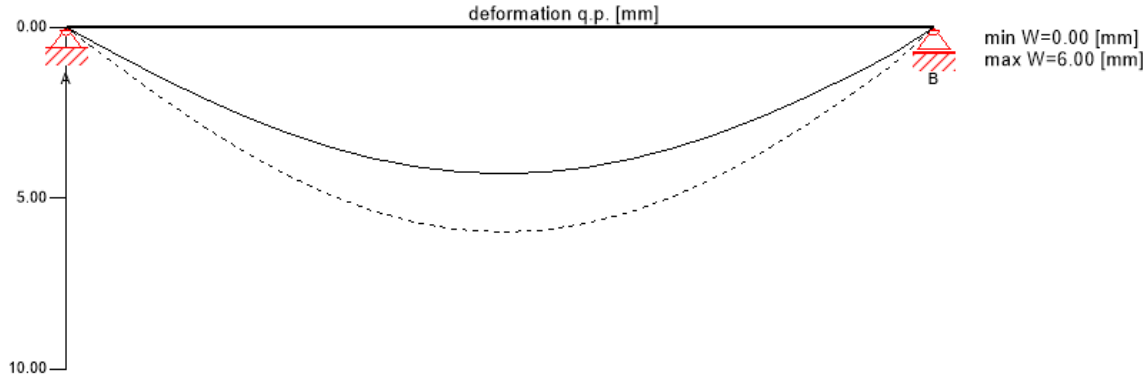
rolling shear analysis fire

V_d =	-5.85	kN		$f_{r,k}$ =	1.15	N/mm²	
				γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				k_{fi} =	1.15	-	
$\tau_{r,d}$ =	0.08	N/mm²	<	$f_{r,d}$ =	1.32	N/mm²	✓

utilization ratio 6 %

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	18.6	10.0	54 %

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

field	K_{def}	limit	w_{limit}	$w_{calc.}$	ratio
		[-]	[mm]	[mm]	
1	0.8	L/150	37.2	14.8	40 %

$w_{net,fin}$ = 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	22.3	10.8	48 %

vibration analysis

general		
total mass	2.37	[t]
tributary width	2.8	[m]
stiffness longitudinal direction	4896.0	[kNm²]
stiffness cross direction	936.0	[kNm²]
modal damping	1.0	[%]
α	0.0	[-]
man weight	700.0	[N]
modal mass	1183.7	[kg]

vibration analysis

analysis							
criterion	calc.	class I	class II	class I	class II	cl. I	cl. II
frequency criterion min	9.046 [Hz]	4.5 [Hz]	4.5 [Hz]	50 %	50 %	✓	✓
frequency criterion	9.046 [Hz]	8.0 [Hz]	6.0 [Hz]	88 %	66 %	✓	✓
acceleration criterion	0.317 [m/s²]	0.05 [m/s²]	0.1 [m/s²]	635 %	317 %	×	×
stiffness criterion	0.265 [mm]	0.25 [mm]	0.5 [mm]	106 %	53 %	×	✓

support reaction

load case category	k_{mod}	A_V	B_V
		[kN]	
self weight CLT	0.6	2.51	2.51
		2.51	2.51
self weight	0.6	1.67	1.67
		1.67	1.67
live load cat. A: residential	0.8	5.57	5.57
		0.00	0.00

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