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STATISCHE BEREKENING

NIEUWBOUW WONINGEN BLOK J

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INHOUD

HOOFDSTUK 1 ALGEMEEN

1.1 INLEIDING

Dit rapport betreft de statische berekening ten behoeve van de nieuw te bouwen COA woningen te Middelburg. In dit rapport de berekening voor blok J.
Uitgangsput van de rapportage is het principe van het verticaal bouwen. Bij het verticaal bouwen is de ideologie dat één woning in één dag wind- en waterdicht wordt opgeleverd.
Dit rapport is geen hoofdberekening, of enige andere uitwerking van een constructief element. Definitieve uitwerking van de verschillende onderdelen conform opgave leverancier.

1.2 TE HANTEREN NORMEN

Uitgangspunt voor de berekening vormen de documenten van de Eurocode.

NEN-EN 1990	Grondslagen van het constructief ontwerp
NEN-EN 1991	Belastingen op constructies
NEN-EN 1992	Betonconstructies
NEN-EN 1993	Staalconstructies
NEN-EN 1994	Staal - betonconstructies
NEN-EN 1995	Houtconstructies
NEN-EN 1996	Constructies van Metselwerk
NEN-EN 1997	Geotechnisch Ontwerp
NEN-EN 1999	Aluminiumconstructies

1.3 ONTWERPLEVENSDUUR EN GEVOLGKLASSE

Ontwerplevensduur	**50 jaar**		
Gebouwtype	**Eengezinswoning**		
Gevolgklasse	**CC1**	Gevolgklasse Bijzonder	**CC1**
Gebouwhoogte	**9,53**	Aantal Bouwlagen	**3**
Gebruiksklasse*	**A - Woon of verblijfsfunctie**	ψ_0=0,4 | ψ_1=0,5 | ψ_2=0,3	

Woningconfiguratie:

Woningdiepte:	**9,20 m¹**	
Beukmaat:	**5,1 m¹**	
Aantal woningen/rij:	**3**	(waaronder 1 MIVA)

* Er kunnen meerdere gebruiksklasse voorkomen in een gebouw. De meest voorkomende bepaalt de algemene gebruiksklasse

1.3.1 Extreem en Momentaan

Bij belasting moet de extreme waarde van de gebruiksbelasting in rekening zijn gebracht. Indien er meer dan twee verschillende gebruiksbelastingen aanwezig zijn dienen slechts twee van deze gebruiksbelastingen extreem te worden gerekend. De overige gebruiksbelastingen mogen momentaan worden gerekend. Om dit in rekenprogrammatuur te verdisconteren wordt er een $\psi_{0;f}$ berekend en gebruikt als ψ_0 in onze rekenprogrammatuur.

1.3.2 Verdiscontering van afwijkingen in de standaard gevolgklasse CC2

Vermenigvuldiging van de partiële veiligheidsfactoren met een factor K_{FI} conform NEN - EN 1990 - Bijlage A1.3.1 tabel NB5

$$K_{FI} = 0,9$$

1.3.3 Verdiscontering van afwijkingen in de standaard levensduur van 50 jaar

Vermenigvuldigingsfactor voor de extreme waarde van de veranderlijke belasting t.g.v. levensduur. Bepaald conform NEN - EN 1990 - Bijlage A1.1 lid (2)

$$F_t = F_{t0}\left\{1 + \frac{1-\psi_0}{9}\, ln\left(\frac{t}{t_0}\right)\right\} = \quad 1,00$$

*De tijdsafhankelijke factor F_t wordt verdisconteerd in de belastingscombinaties

1.4 CONSTRUCTIEF ONTWERP

1.4.1 Beschrijving van de hoofddraagconstructie

Bouwsysteem	**Houtbouw met HSB en CLT**
Fundering	**Prefab fundering conform opgave IJB**

1.4.2 Beschrijving van de onderdelen

Begane grondvloer	**Geïsoleerde kanaalplaatvloer met 60mm cementdekvloer**	
Verdiepingsvloer	**Dekvloer**	**80 mm**
	CLT-vloer	**200mm L5s**
Zoldervloer	**Dekvloer**	**80 mm**
	CLT-vloer	**200mm L5s**
Dakconstructie	**Prefab sporenkap volgens opgave CIBIS zonder dragend knieschot**	
Voor-achtergevels	**Hsb-elementen volgens opgave CIBIS**	
Kopgevels	**Hsb-elementen volgens opgave CIBIS**	
Bouwmuren	**CLT-wanden 100mm**	

1.4.3 Overige constructieve gegevens

Dakhelling	**37 °**

Wind:

Windgebied:	**II**
Bebouwd/onbebouwd	**Onbebouwd**
Afstand tot windgebied III	**>5 Km**

HOOFDSTUK 2 BELASTINGEN

2.1 BLIJVENDE EN OPGELEGDE BELASTINGEN

2.1.1 Kap

Algemeen

ID: Kap

Opgelegde veranderlijke belasting

Gebruiksklasse : H - daken (niet toegankelijk)

Sneeuwbelasting			0,43 kN/m²
			-------------------- +
	ψ_0=0 | ψ_1=0 | ψ_2=0	$p_{q,rep}$	0,43 kN/m²

Blijvende belasting

Pannen	1 / cos (37) × 0,45kN/m³ =		0,56 kN/m²
Tengel en panlatten incl. isolatie	1 / cos (37) × 0,06kN/m³ =		0,08 kN/m²
Sporen	1 / cos (37) × 0,08kN/m³ =		0,10 kN/m²
Onderplaat	1 / cos (37) × 0,08kN/m³ =		0,10 kN/m²
Zonnepanelen	1 / cos (37) × 0,15kN/m³ =		0,19 kN/m²
			-------------------- +
		$p_{g,rep}$	1,03 kN/m²

2.1.2 Zoldervloer *(Zie bijlage 3.1.)*

Algemeen

ID: Zolder

Opgelegde veranderlijke belasting

Gebruiksklasse : A-niet-gemeenschappelijke vloeren

Belasting door personen en goederen			1,75 kN/m²
Separatie			0,50 kN/m²
			-------------------- +
	ψ_0=0,4 | ψ_1=0,5 | ψ_2=0,3	$p_{q,rep}$	2,25 kN/m²

Blijvende belasting

Dekvloer80	0,08m × 20kN/m³ =		1,60 kN/m²
CLT-vloer200mm L5s	0,2m × 5kN/m³ =		1,00 kN/m²
			-------------------- +
		$p_{g,rep}$	2,60 kN/m²

2.1.3 Verdiepingsvloer *(Zie bijlage 3.1.)*

Algemeen

ID: Verdieping

Opgelegde veranderlijke belasting

Gebruiksklasse : A-niet-gemeenschappelijke vloeren

Belasting door personen en goederen			1,75 kN/m²
Separatie			0,50 kN/m²
			-------------------- +
	ψ_0=0,4 | ψ_1=0,5 | ψ_2=0,3	$p_{q,rep}$	2,25 kN/m²

Blijvende belasting

Dekvloer80	0,08m × 20kN/m³ =		1,60 kN/m²
CLT-vloer200mm L5s	0,2m × 5kN/m³ =		1,00 kN/m²
			-------------------- +
		$p_{g,rep}$	2,60 kN/m²

2.1.4 Begane Grondvloer

Algemeen

ID: BG

Opgelegde veranderlijke belasting

Gebruiksklasse : A-niet-gemeenschappelijke vloeren

Belasting door personen en goederen			1,75 kN/m²
Separatie			0,80 kN/m²
			-------------------- +
	ψ_0=0,4 | ψ_1=0,5 | ψ_2=0,3	$p_{q,rep}$	2,55 kN/m²

Blijvende belasting

Dekvloer	0,06m × 20kN/m³ =		1,20 kN/m²
Geïsoleerde kanaalplaatvloer met 60mm cementdekvloer			3,08 kN/m²
			-------------------- +
		$p_{g,rep}$	4,28 kN/m²

2.2 GEVELS, WANDEN, PUIEN E.D.

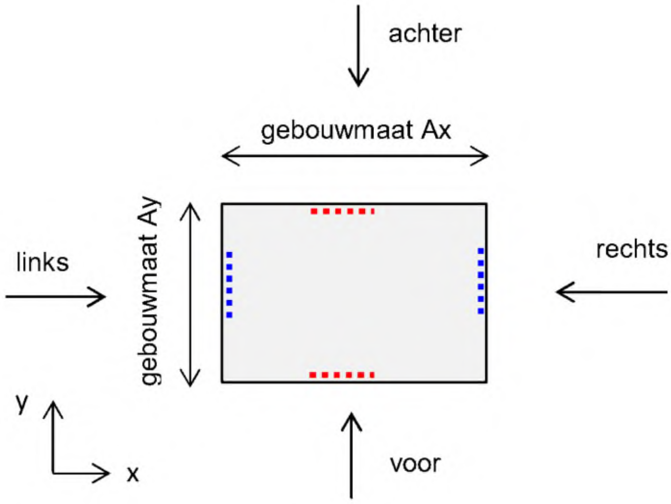
ID	*Omschrijving*	
Voor/achter	HSB-wand met steenstrips	1,33 kN/m²
Kopgevels	HSB-wand met steenstrips	1,33 kN/m²
Bouwmuur	2* CLT-wand 100mm	1,30 kN/m²

2.3 VOLUMIEKE GEWICHTEN

ID	***Omschrijving***	
Water	Water	10,0 kN/m³
Beton	Normaal beton (gewapend)	25,0 kN/m³
Kzs	Kalkzandsteen	20,0 kN/m³
Kzs+	Kalkzandsteen met hoge dichtheid	22,5 kN/m³
Metselwerk	Baksteen metselwerk	20,0 kN/m³
Hout	Naald-/loofhout	5,0 kN/m³
Grond	Natte Grond	20,0 kN/m³

2.4 WINDBELASTING

Gebouwhoogte	**9,53 m**		
Windgebied	**II**	Bebouwd/Onbebouwd	**Onbebouwd**
Orografiefactor $c_o(z)$ =	**1,00**	Referentiehoogte z_s	**5,718 m**
Afstand tot windgebied III	**>5 Km**	Extreme Stuwdruk $q_p(z)$	**0,84 kN/m²**



2.4.1 CsCd-Factor

Voor $c_s c_d$ mag 1,00 worden aangehouden indien voldaan is aan voorwaarde:

Gebouwhoogte < 15m óf gebouwhoogte < 4 * gebouwdiepte bij een hoogte tot 100m.

Type gebouw	Houtconstructie	δ_s =	0,05	
Wind in x-richting				
Gebouwmaat Ay	9,203 m	h/Ay =	1,04	
Piekfactor		k_p =	3,76	
Achtergrondresponsfactor		B^2 =	0,65	
Resonantieresponsfactor		R^2 =	0,03	
Factor $c_s c_d$ volgens formule 6.1 NEN-EN-1991-1-4		**$c_s c_d$ =**	**0,92**	
Resulterende stuwdruk $c_s c_d q_p(z)$		$c_s c_d q_p(z)$ =	0,78	kN/m²
Wind in y-richting				
Gebouwmaat Ax	15,3 m	h/Ax =	0,62	
Piekfactor		k_p =	3,71	
Achtergrondresponsfactor		B^2 =	0,57	
Resonantieresponsfactor		R^2 =	0,02	
Factor $c_s c_d$ volgens formule 6.1 NEN-EN-1991-1-4		**$c_s c_d$ =**	**0,88**	
Resulterende stuwdruk		$c_s c_d q_p(z)$ =	0,74	kN/m²

2.4.2 Windvormfactoren

	loefzijde	lijzijde		
vormfactoren	D	E	$C_{pe;10;tot}$	$C_{pe;10;tot;cor}$*
x-richting	0,80	0,50	1,30	1,11
y-richting	0,80	0,50	1,30	1,11

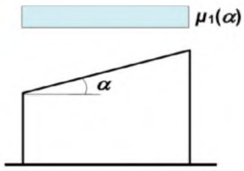
wrijving dak	$C_{fr;dak}$ =	**0,04**
wrijving gevel	$C_{fr;gvl}$ =	**0,02**

*$C_{pe;10;tot;cor}$ = (druk + zuiging) x 0,85 [conform NEN-EN 1991-1-4 / 7.2.2 (4) N.B]

2.5 SNEEUWBELASTING

Sneeuwbelasting op de grond (s_k) 0,70 kN/m² ψ_0=0 | ψ_1=0,2 | ψ_2=0

2.5.1 Schuindak



Dakhelling **37,0 °** μ_1 = 0,61

Sneeuwbelasting ($s = \mu_1 s_k$) 0,43 kN/m²

ψ_0=0 | ψ_1=0,2 | ψ_2=0

2.6 BUITENGEWONE BELASTING

2.6.1 Ontploffingen in bouwwerken

Wij gaan er vanuit dat er gasloos gebouwd wordt. Er is derhalve geen rekening gehouden met ontploffingen in bouwwerken.

HOOFDSTUK 3 BELASTINGCOMBINATIES

3.1 UITERSTE GRENSTOESTANDEN

Tabel A1.2(B) - Rekenwaarden van belastingen (STR/GEO) (Groep B)

Blijvende en tijdelijke ontwerpsituaties		Blijvende belastingen		Overheersende opgelegde belasting	Opgelegde belasting gelijktijdig met overheersende	
		Ongunstig	Gunstig		Belangrijkste	Andere
CC1	Vgl. 6.10a	1,22*G	0,9*G		1,35*Ψ_0Qk	1,35*Ψ_0Qk
	Vgl. 6.10b	1,08*G	0,9*G	1,35*Qk		1,35*Ψ_0Qk

Bij vloeistofdrukken met een fysiek beperkte waarde mag zijn volstaan met 1,2*G
Deze waarde is berekend met ξ = 0,89.

Tabel A1.3 - Rekenwaarden van belastingen voor het gebruik in buitengewone en aardbevingsbelastingscombinaties

Blijvende en tijdelijke ontwerpsituaties		Blijvende belastingen		Overheersende opgelegde belasting	Opgelegde belasting gelijktijdig met overheersende	
		Ongunstig	Gunstig		Belangrijkste	Andere
CC1	Vgl. 6.11a/b	1,0*G	1,0*G	1,0*A_d	1,0*Ψ_1Qk[a]	1,0*Ψ_2Qk
	Vgl. 6.12a/b	1,0*G	1,0*G	1,0*A_{ek} of A_{ed}	1,0*Ψ_2Qk	1,0*Ψ_2Qk

[a] Uitsluitend voor wind in combinatie met brand bij het beoordelen van disproportionele schade volgens NEN-EN 1991-1-7; voor overige gevallen ψ_2

3.2 BRUIKBAARHEIDSGRENSTOESTANDEN

Tabel A1.4 - Rekenwaarden van belastingen voor gebruik in belastingscombinaties

Combinatie	Blijvende belastingen		Overheersende opgelegde belasting	Opgelegde belasting gelijktijdig met overheersende	
	Ongunstig	Gunstig		Belangrijkste	Andere
Karakteristiek	1,0*G	1,0*G	1,0*Qk		1,0*Ψ_0Qk
Frequent	1,0*G	1,0*G	1,0*Ψ_1Qk		1,0*Ψ_2Qk
Quasi-Blijvend	1,0*G	1,0*G	1,0*Ψ_2Qk		1,0*Ψ_2Qk

HOOFDSTUK 4 FUNDERING

4.1 ALGEMEEN

4.1.1 Beschrijving van de fundering

De fundering bestaat uit een prefab fundering volgens opgave IJB. Onderstaand worden de lijnlasten op funderingsniveau berekend.

4.1.2 Grondonderzoek, grondwaterstand en terreingegevens

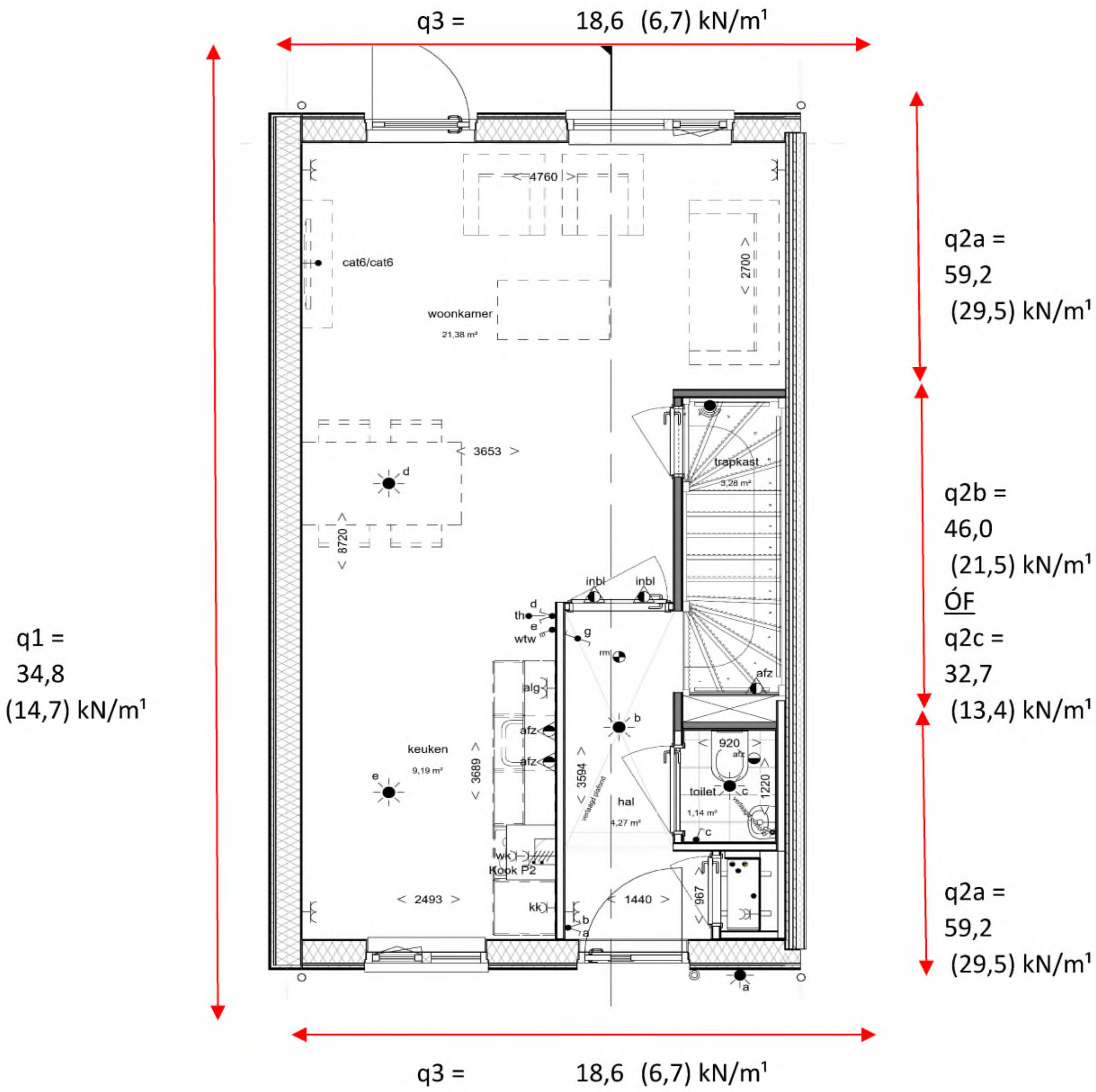
Onderzoek uitgevoerd door	Socotec		
Rapport nr.	R2502687-01	datum	4-11-2025
Funderingsadvies door	Socotec		
Rapport nr.	25SP1698-adv-01	datum	3-12-2025

Peil	0,85/0,90	m+NAP
Gemiddeld maaiveldniveau	0,53	m+NAP
Hoogste maaiveldniveau	0,58	m+NAP
Laagste maaiveldniveau	0,48	m+NAP
Gemiddeld gemeten grondwaterstand	1,30	m-NAP
Gemiddeld hoogste grondwaterstand	0,80	m-NAP
Gemiddeld laagste grondwaterstand	1,80	m-NAP

Er worden nog aanvullende sonderingen gemaakt.

4.2 OVERZICHT LIJNLASTEN 'EENGEZINSWONING'

Hieronder worden de lijnlasten visueel weergegeven.
De weergegeven lijnlast ter plaatse van de bouwmuur is hierbij berekend voor beide woningen.
q2b is in het geval van een niet-gespiegelde woning; q2c indien de woningen gespiegeld zijn.



4.3 BEREKENING LIJNLASTEN 'EENGEZINSWONING'

4.3.1 q-last: q1 (kopgevels)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	0,50	1,03 | 0,43	0,5	0,2	0,0
Wand op zolder (gem.)	1,84	1,33 | 0,00	2,4	0,0	0,0
Zolder	0,50 × 5,10	2,60 | 2,25	6,6	2,3	2,3
Wand op verdieping	2,80	1,33 | 0,00	3,7	0,0	0,0
Verdieping	0,50 × 5,10	2,60 | 2,25	6,6	5,7	2,3
Wand begane grond	2,94	1,33 | 0,00	3,9	0,0	0,0
BG	0,50 × 5,10	4,28 | 2,55	10,9	6,5	2,6
			-------- +	-------- +	-------- +
			34,8	14,7	7,2

Vergelijking 6.10a E_d **= 52,0 kN/m¹** $\psi_{0;f}$ = **0,49**

Vergelijking 6.10b E_d **= 57,5 kN/m¹**

4.3.2 q-last: q2a (bouwmuur zonder trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,4	0,0
Wand op zolder (gem.)	1,84	1,30 | 0,00	2,4	0,0	0,0
Zolder	2,00 × 0,50 × 5,10	2,60 | 2,25	13,3	4,6	4,6
Wand op verdieping	2,80	1,30 | 0,00	3,6	0,0	0,0
Verdieping	2,00 × 0,50 × 5,10	2,60 | 2,25	13,3	11,5	4,6
Wand begane grond	2,94	1,30 | 0,00	3,8	0,0	0,0
BG	2,00 × 0,50 × 5,10	4,28 | 2,55	21,8	13,0	5,2
			-------- +	-------- +	-------- +
			59,2	29,5	14,4

Vergelijking 6.10a E_d **= 91,4 kN/m¹** $\psi_{0;f}$ = **0,49**

Vergelijking 6.10b E_d **= 103,8 kN/m¹**

4.3.3 q-last: q2b (bouwmuur 1x trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,4	0,0
Wand op zolder (gem.)	1,84	1,30 | 0,00	2,4	0,0	0,0
Zolder	0,50 × 5,10	2,60 | 2,25	6,6	2,3	2,3
Wand op verdieping	2,80	1,30 | 0,00	3,6	0,0	0,0
Verdieping	0,50 × 5,10	2,60 | 2,25	6,6	5,7	2,3
Wand begane grond	2,94	1,30 | 0,00	3,8	0,0	0,0
BG	2,00 × 0,50 × 5,10	4,28 | 2,55	21,8	13,0	5,2
			-------- +	-------- +	-------- +
			46,0	21,5	9,8

Vergelijking 6.10a E_d = **69,1 kN/m¹** $\psi_{0;f}$ = **0,46**

Vergelijking 6.10b E_d = **78,6 kN/m¹**

4.3.4 q-last: q2c (bouwmuur 2x trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,4	0,0
Wand op zolder (gem.)	1,84	1,30 | 0,00	2,4	0,0	0,0
Zolder	0,00	2,60 | 2,25	0,0	0,0	0,0
Wand op verdieping	2,80	1,30 | 0,00	3,6	0,0	0,0
Verdieping	0,00	2,60 | 2,25	0,0	0,0	0,0
Wand begane grond	2,94	1,30 | 0,00	3,8	0,0	0,0
BG	2,00 × 0,50 × 5,10	4,28 | 2,55	21,8	13,0	5,2
			-------- +	-------- +	-------- +
			32,7	13,4	5,2

Vergelijking 6.10a E_d = **46,8 kN/m¹** $\psi_{0;f}$ = **0,39**

Vergelijking 6.10b E_d = **53,5 kN/m¹**

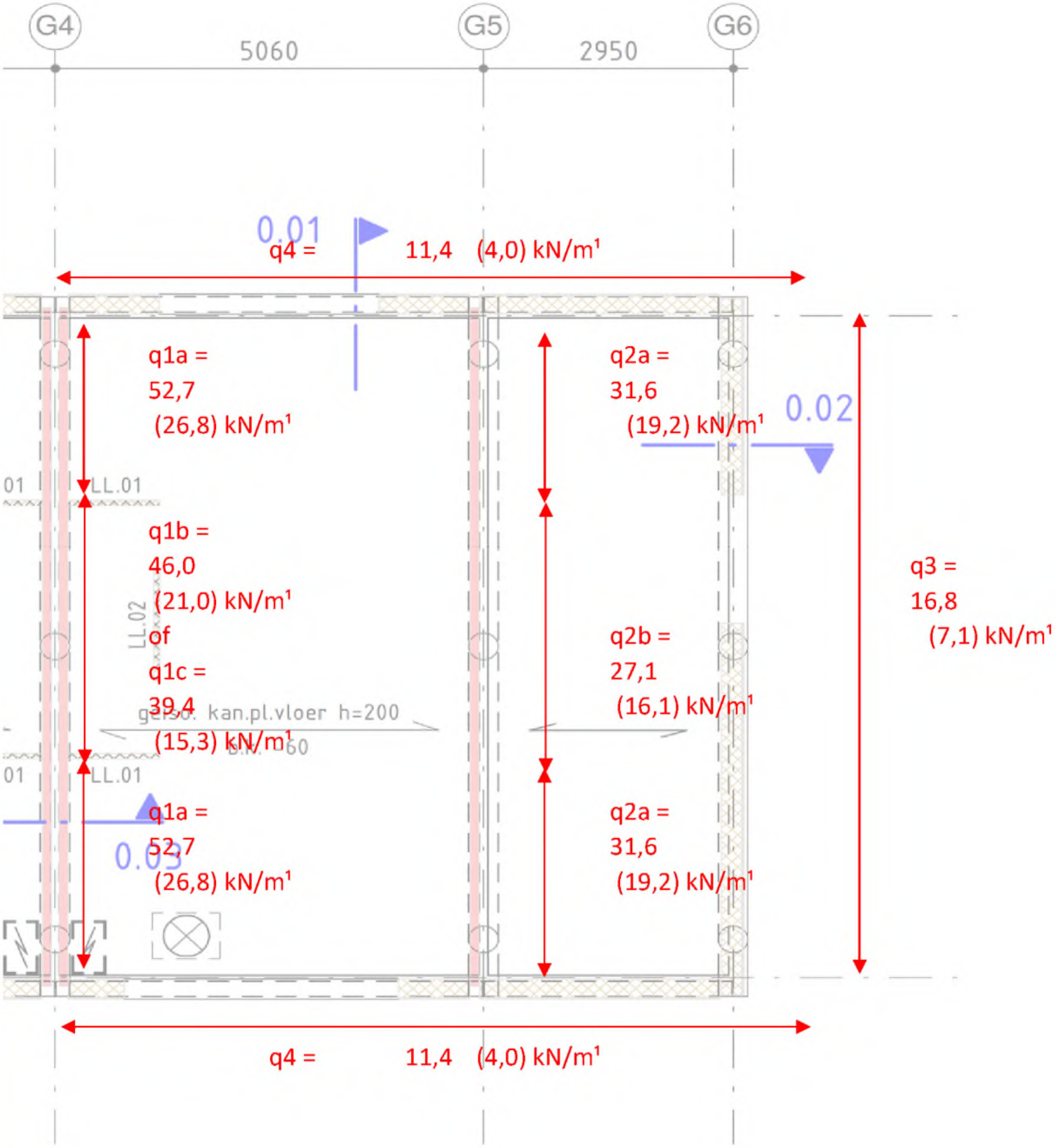
4.3.5 q-last: q3 (voor/achtergevels)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	0,50 × 9,20	1,03 | 0,43	4,7	2,0	0,0
Zolder	1,00	2,60 | 2,25	2,6	0,9	0,9
Wand op verdieping	0,88 × 2,80	1,33 | 0,00	3,3	0,0	0,0
Verdieping	1,00	2,60 | 2,25	2,6	2,3	0,9
Wand op begane grond	0,72 × 2,94	1,33 | 0,00	2,8	0,0	0,0
BG	0,50 × 1,20	4,28 | 2,55	2,6	1,5	0,6
			-------- +	-------- +	-------- +
			18,6	6,7	2,4

Vergelijking 6.10a E_d **= 25,8 kN/m¹** $\psi_{0;f}$ = **0,36**

Vergelijking 6.10b E_d **= 29,1 kN/m¹**

4.4 OVERZICHT LIJNLASTEN 'MIVA WONING'



4.5 BEREKENING LIJNLASTEN 'MIVA WONING'

4.5.1 q-last: q1a (bouwmuur zonder trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,0	0,0
Wand op zolder (gem.)	1,84	1,33 | 0,00	2,4	0,0	0,0
Zolder	0,50 × 5,10	2,60 | 2,25	6,6	2,3	2,3
Wand op verdieping	2,80	1,30 | 0,00	3,6	0,0	0,0
Verdieping	2,00 × 0,50 × 5,10	2,60 | 2,25	13,3	11,5	4,6
Wand begane grond	2,94	1,30 | 0,00	3,8	0,0	0,0
BG	2,00 × 0,50 × 5,10	4,28 | 2,55	21,8	13,0	5,2
			-------- +	-------- +	-------- +
			52,7	26,8	12,1

Vergelijking 6.10a E_d **= 80,3 kN/m¹** $\psi_{0;f}$ = **0,45**

Vergelijking 6.10b E_d **= 93,0 kN/m¹**

4.5.2 q-last: q1b (bouwmuur 1* trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,0	0,0
Wand op zolder (gem.)	1,84	1,33 | 0,00	2,4	0,0	0,0
Zolder	0,50 × 5,10	2,60 | 2,25	6,6	2,3	2,3
Wand op verdieping	2,80	1,30 | 0,00	3,6	0,0	0,0
Verdieping	0,50 × 5,10	2,60 | 2,25	6,6	5,7	2,3
Wand begane grond	2,94	1,30 | 0,00	3,8	0,0	0,0
BG	2,00 × 0,50 × 5,10	4,28 | 2,55	21,8	13,0	5,2
			-------- +	-------- +	-------- +
			46,0	21,0	9,8

Vergelijking 6.10a E_d **= 69,1 kN/m¹** $\psi_{0;f}$ = **0,47**

Vergelijking 6.10b E_d **= 78,1 kN/m¹**

4.5.3 q-last: q1c (bouwmuur 2* trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,0	0,0
Wand op zolder (gem.)	1,84	1,33 | 0,00	2,4	0,0	0,0
Zolder	0,50 × 5,10	2,60 | 2,25	6,6	2,3	2,3
Wand op verdieping	2,80	1,30 | 0,00	3,6	0,0	0,0
Verdieping	0,00	2,60 | 2,25	0,0	0,0	0,0
Wand begane grond	2,94	1,30 | 0,00	3,8	0,0	0,0
BG	2,00 × 0,50 × 5,10	4,28 | 2,55	21,8	13,0	5,2
			-------- +	-------- +	-------- +
			39,4	15,3	7,5

Vergelijking 6.10a **E_d = 58,0 kN/m¹** **$\psi_{0;f}$ = 0,49**

Vergelijking 6.10b **E_d = 63,2 kN/m¹**

4.5.4 q-last: q2a (dragende binnenas)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,0	0,0
Bouwmuur	0,50 × 4,63	1,30 | 0,00	3,0	0,0	0,0
Verdieping	0,50 × 8,01	2,60 | 2,25	10,4	9,0	3,6
BG	0,50 × 8,01	4,28 | 2,55	17,1	10,2	4,1
			-------- +	-------- +	-------- +
			31,6	19,2	7,7

Vergelijking 6.10a **E_d = 48,8 kN/m¹** **$\psi_{0;f}$ = 0,40**

Vergelijking 6.10b **E_d = 60,1 kN/m¹**

4.5.5 q-last: q2b (dragende binnenas t.p.v. trapgat)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	2,00 × 0,50	1,03 | 0,43	1,0	0,0	0,0
Bouwmuur	0,50 × 4,63	1,30 | 0,00	3,0	0,0	0,0
Verdieping	0,50 × 6,71	2,60 | 2,25	8,7	7,5	3,0
BG	0,50 × 6,71	4,28 | 2,55	14,4	8,6	3,4
			-------- +	-------- +	-------- +
			27,1	16,1	6,4

Vergelijking 6.10a **E_d = 41,6 kN/m¹** **$\psi_{0;f}$ = 0,40**

Vergelijking 6.10b **E_d = 51,0 kN/m¹**

4.5.6 q-last: q3 (kopgevel MIVA)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	0,50	1,03 | 0,43	0,5	0,0	0,0
Kopgevels	4,63	1,33 | 0,00	6,2	0,0	0,0
Verdieping	0,50 × 2,95	2,60 | 2,25	3,8	3,3	1,3
BG	0,50 × 2,95	4,28 | 2,55	6,3	3,8	1,5
			-------- +	-------- +	-------- +
			16,8	7,1	2,8

Vergelijking 6.10a **E_d = 24,3 kN/m¹** **$\psi_{0;f}$ =** **0,40**

Vergelijking 6.10b **E_d = 27,7 kN/m¹**

4.5.7 q-last: q4 (voor/achtergevel MIVA)

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Kap	0,50 × 9,20	1,03 | 0,43	4,7	2,0	0,0
Voor/achter	2,13	1,33 | 0,00	2,8	0,0	0,0
Verdieping	0,50	2,60 | 2,25	1,3	0,5	0,5
BG	0,50 × 1,20	4,28 | 2,55	2,6	1,5	0,6
			-------- +	-------- +	-------- +
			11,4	4,0	1,1

Vergelijking 6.10a **E_d = 15,3 kN/m¹** **$\psi_{0;f}$ =** **0,27**

Vergelijking 6.10b **E_d = 17,7 kN/m¹**

HOOFDSTUK 5 BEGANE GRONDVLOER

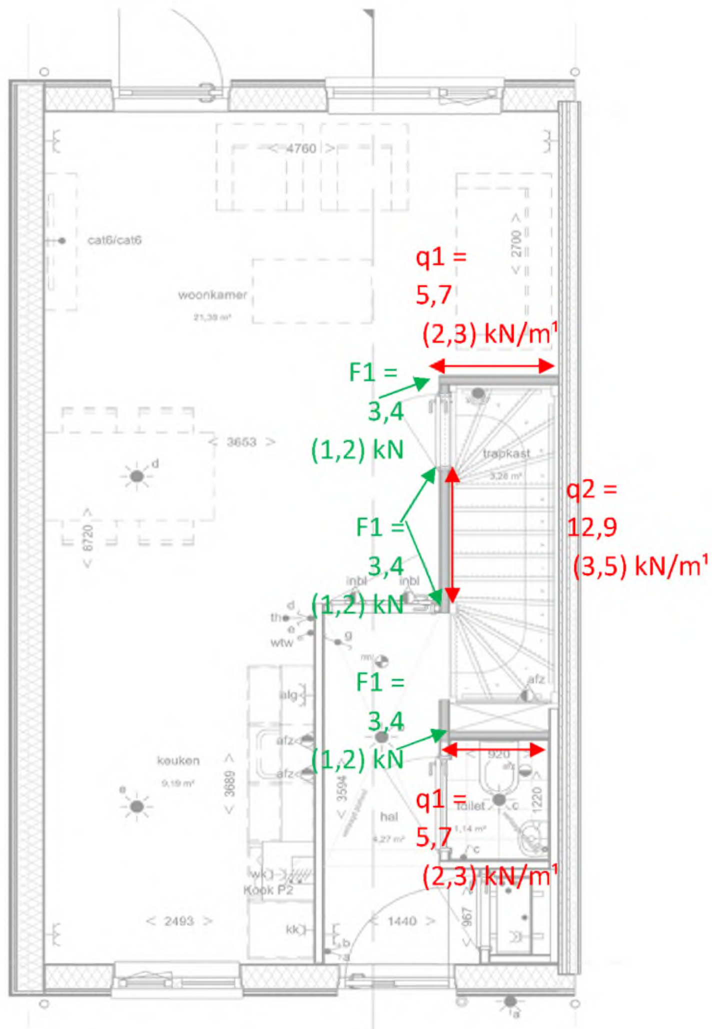
5.1 ALGEMEEN

5.1.1 Beschrijving van de begane grondvloer

De begane grondvloer wordt uitgevoerd als geïsoleerde kanaalplaatvloer volgens opgave leverancier. Deze wordt belast met lijn- en puntlasten uit de dragende wanden op de begane grond.

5.2 OVERZICHT LIJNLASTEN 'EENGEZINSWONING'

Onderstaand worden de lijn- en puntlasten visueel weergegeven.
De notatiewijze is xx(xx) betekent permanente(veranderlijke) belasting.
De belastingen zijn karakteristiek (dus zonder veiligheidsfactoren) weergegeven.



5.3 BEREKENING LIJN- EN PUNTLASTEN 'EENGEZINSWONING'

5.3.1 q-last: q1

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Wand op zolder (gem.)	0,10 × 1,00	5,00 | 0,00	0,5	0,0	0,0
Zolder	0,50	2,60 | 2,25	1,3	1,1	0,5
Wand op verdieping	0,10 × 2,65	5,00 | 0,00	1,3	0,0	0,0
Verdieping	0,50	2,60 | 2,25	1,3	1,1	0,5
Wand begane grond	0,10 × 2,63	5,00 | 0,00	1,3	0,0	0,0
			-------- +	-------- +	-------- +
			5,7	2,3	0,9

Vergelijking 6.10a **E_d = 8,2 kN/m¹** **$\psi_{0;f}$ = 0,40**

Vergelijking 6.10b **E_d = 9,2 kN/m¹**

5.3.2 q-last: q2

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Zolder	0,50 × 3,85	2,60 | 2,25	5,0	1,7	1,7
Wand op verdieping	0,10 × 2,80	5,00 | 0,00	1,4	0,0	0,0
Verdieping	0,50 × 3,85	2,60 | 2,25	5,0	1,7	1,7
Wand begane grond	0,10 × 2,94	5,00 | 0,00	1,5	0,0	0,0
			-------- +	-------- +	-------- +
			12,9	3,5	3,5

Vergelijking 6.10a **E_d = 20,3 kN/m¹** **$\psi_{0;f}$ = 0,40**

Vergelijking 6.10b **E_d = 18,6 kN/m¹**

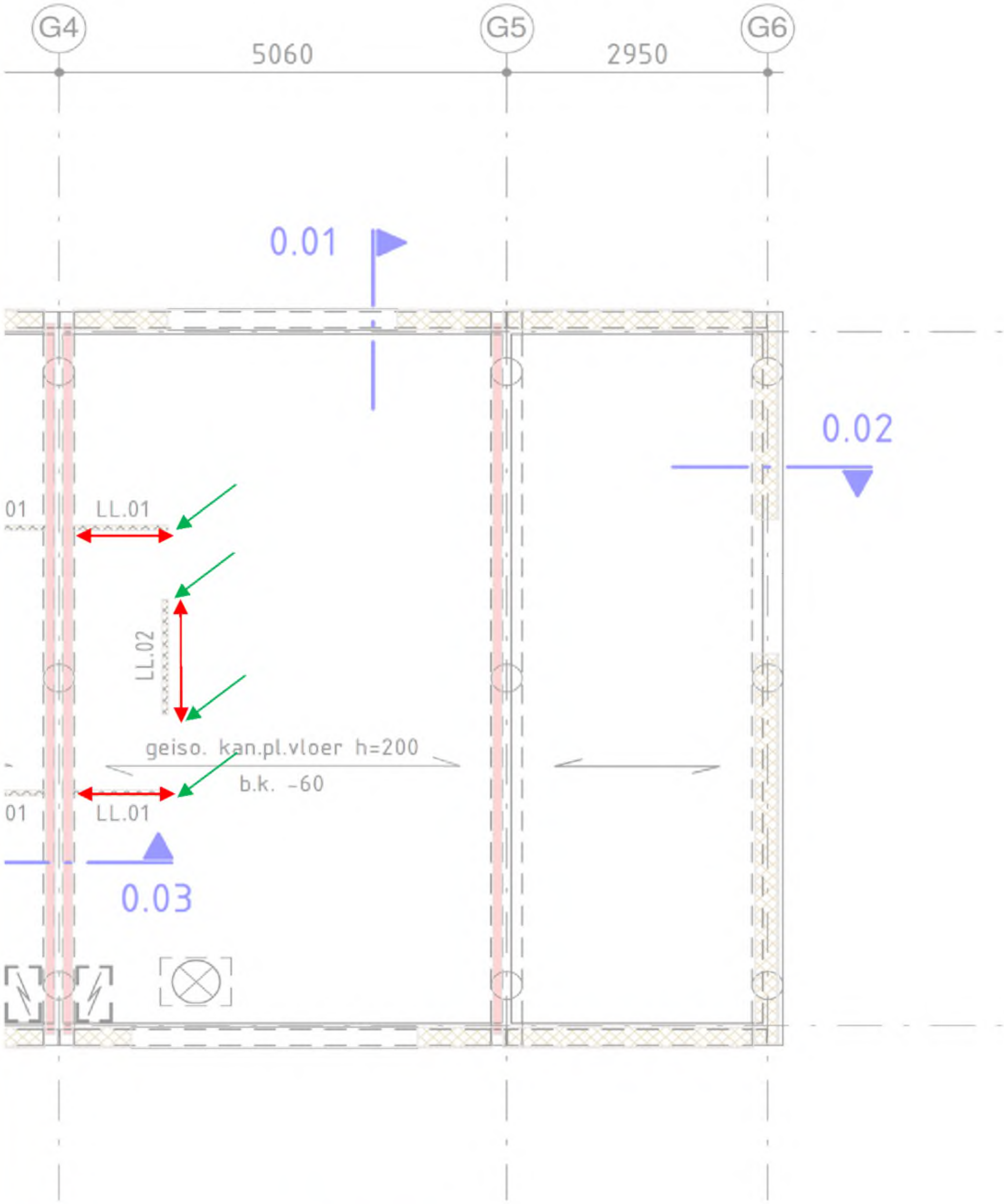
5.3.3 F-last: F1

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN]	$Q_{rep,extr}$ [kN]	$Q_{rep,mom}$ [kN]
q2	0,50 × 0,78	8,70 | 3,00	3,4	1,2	0,5
			-------- +	-------- +	-------- +
			3,4	1,2	0,5

Vergelijking 6.10a **E_d = 4,7 kN** **$\psi_{0;f}$ = 0,40**

Vergelijking 6.10b **E_d = 5,2 kN**

5.4 OVERZICHT LIJNLASTEN 'MIVA WONING'



LL.01	3,9 (1,1) kN/m¹
LL.02	6,5 (1,7) kN/m¹
F1	2,5 (0,7) kN

5.5 BEREKENING LIJN- EN PUNTLASTEN 'MIVA WONING'

5.5.1 q-last: q1

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Wand op verdieping	0,10 × 2,65	5,00 | 0,00	1,3	0,0	0,0
Verdieping	0,50	2,60 | 2,25	1,3	1,1	0,5
Wand begane grond	0,10 × 2,63	5,00 | 0,00	1,3	0,0	0,0
			-------- +	-------- +	-------- +
			3,9	1,1	0,5

Vergelijking 6.10a **E_d = 5,4 kN/m¹** $\psi_{0;f}$ = **0,40**

Vergelijking 6.10b **E_d = 5,8 kN/m¹**

5.5.2 q-last: q2

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN/m¹]	$Q_{rep,extr}$ [kN/m¹]	$Q_{rep,mom}$ [kN/m¹]
Verdieping	0,50 × 3,85	2,60 | 2,25	5,0	1,7	1,7
Wand begane grond	0,10 × 2,94	5,00 | 0,00	1,5	0,0	0,0
			-------- +	-------- +	-------- +
			6,5	1,7	1,7

Vergelijking 6.10a **E_d = 10,2 kN/m¹** $\psi_{0;f}$ = **0,40**

Vergelijking 6.10b **E_d = 9,3 kN/m¹**

5.5.3 F-last: F1

ID	[n] × afmetingen [l × b × h] in m	G_{rep} | Q_{rep} [kN/m²]	G_{rep} [kN]	$Q_{rep,extr}$ [kN]	$Q_{rep,mom}$ [kN]
q2	0,50 × 0,78	6,48 | 1,73	2,5	0,7	0,3
			-------- +	-------- +	-------- +
			2,5	0,7	0,3

Vergelijking 6.10a **E_d = 3,4 kN** $\psi_{0;f}$ = **0,40**

Vergelijking 6.10b **E_d = 3,6 kN**

HOOFDSTUK 6 STABILITEIT

6.1 ALGEMEEN

6.1.1 Beschrijving van de stabiliteit

De stabiliteit van de woningen wordt gehaald uit de stabiliteitswanden in voor- en achtergevel in combinatie met stijve vloerschijven. Hierbij zorgt de verbinding van de HSB-wanden aan de vloeren en fundering voor de opvang van de horizontale windbelasting. De leverancier van de prefab houtskeletbouw levert de berekening van de stabiliserende elementen aan.

6.2 OPTREDENDE STABILITEITSKRACHTEN PER WONING

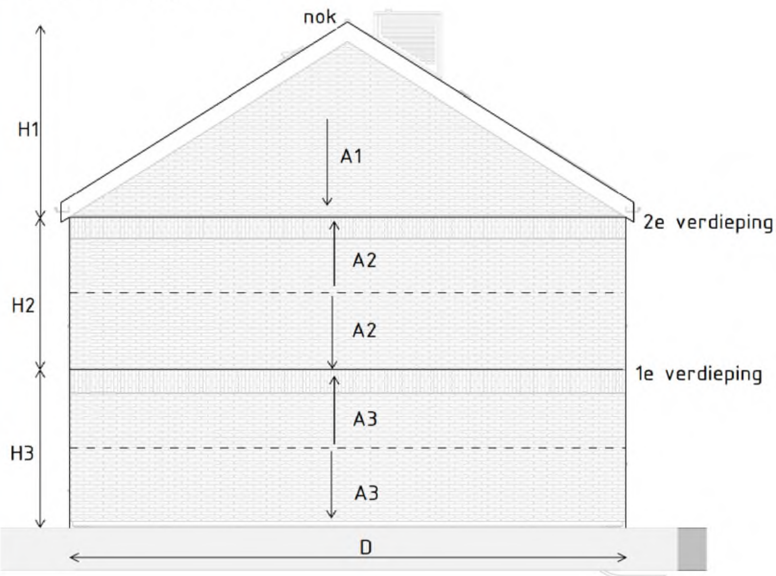
Onderstaande stabiliteitskrachten dienen te worden opgenomen door de stabiliserende voor- en achtergevels.

Aantal woningen/blok **3 stuks**

Windbelasting op kopgevels:

$qp_{(ze)}$ =	**0,84 kN/m²**
CeCi =	**1,3**
CsCd =	**0,85**
Cprob =	**1**
Fw =	**$qp_{(ze)}$*CeCi*CsCd*Cprob**
	0,84 *1,3* 0,85* 1
	0,93 kN/m²

Aanzicht kopgevels:



Diepte D =	**9,20 m^1**	
Hoogte H1 =	**3,68 m^1**	
Hoogte H2 =	**2,80 m^1**	
Hoogte H3 =	**2,94 m^1**	
Oppervlakte A1 =	**16,93 m^2**	= 0,5*3,68*8,7
Oppervlakte A2 =	**25,77 m^2**	= 2,8*9,203
Oppervlakte A3 =	**27,06 m^2**	= 2,94*9,203

$A_{tot,2e}$ =	**29,81 m^2**	= 0,5*24,36*16,00
$F_{w,2e}$ =	**27,67 kN**	= 28,18 m^2 * 0,92 kN/m^2
$A_{tot,1e}$ =	**26,41 m^2**	= 0,5*27,05682 + 0,5*25,7684
$F_{w,1e}$ =	**24,52 kN**	= 24,97 m^2 * 0,92 kN/m^2

Imperfecties/scheefstand:

$F_{imp,2e}$ = **1,00 kN/woning**

$F_{imp,1e}$ = **1,00 kN/woning**

Stabiliteitskrachten per gevel:

Aantal woningen in blok: **2 stuks**

2e verdieping:

$F_{w,2e}$ =	**27,67 kN**		
	27,67 kN/ 2	=	**13,84 kN/woning**
$F_{imp,2e}$ =	**1,00 kN/woning**		
F_{stab} =	$F_w + F_{imp}$	=	**14,84 kN/woning**

1e verdieping:

Achtergevels

Woningtype	Σpenanten/woning	Aantal/blok	Σpenanten/totaal:	%tot.
Eengezinswoning	2130	2	4260	45,5%
MIVA-woning	5093	1	5093	54,5%
			9353	100,0%

Voorgevels

Woningtype	Σpenanten/woning	Aantal/blok	Σpenanten/totaal:	%tot.
Eengezinswoning	1478	2	2956	36,7%
MIVA-woning	5093	1	5093	63,3%
			8049	100,0%

$F_{w,1e}$ = **24,52 kN**

CLT-vloer verdieping fungeert als schijf --> krachten gelijkmatig verdeeld over voor- en achtergevels.

Stabiliteitskracht per voorgevel begane grond:

$F_{w,1e,voor}$ =	24,52 kN /2 =	**12,26 kN**
$F_{w,eengezins}$ =	(12,26*36,7%)/2 =	**2,25 kN/woning**
$F_{w,MIVA}$ =	(12,26*63,3%)	**7,76 kN/woning**

Stabiliteitskracht per achtergevel begane grond

$F_{w,1e,achter}$=	24,52 kN /2 =	**12,26 kN**
$F_{w,eengezins}$ =	(12,26*45,5%)/2 =	**2,79 kN/woning**
$F_{w,MIVA}$ =	(12,26*54,5%)	**6,68 kN/woning**

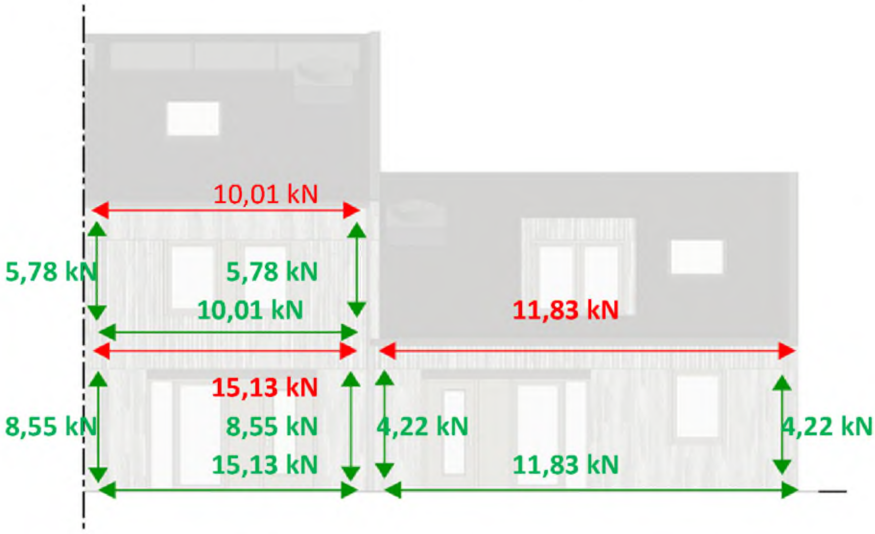
Stabiliteitskracht per gevel:

Totale stabiliteitskracht =	14,84 kN/woning		
Voorgevel verdieping =	7,42 kN	*50,0%*	**10,22kN/woning*
Achtergevel verdieping	7,42 kN	*50,0%*	**10,22kN/woning*

Stabiliteitskracht voorgevel eengezinswoning:
50% Fwe,2e/woning + Fw,eengezins voor + imperfectie =
7,42+2,85+1,00 = **10,67 kN**
Stabiliteitskracht achtergevel eengezinswoning:
50% Fwe,2e/woning + Fw,eengezins achter + imperfectie =
7,42+3,41+1,00 = **11,21 kN**

Stabiliteitskracht voorgevel MIVA woning:
Fw,MIVA,voor + imperfectie =
7,76+1,00 = **8,76 kN**
Fw,MIVA,achter+imperfectie =
6,68+1,00 = **7,68 kN**

Overzicht belastingen:
Belastingen zijn fundamenteel dus inclusief veiligheidsfactoren.



** getoond worden hier de maatgevende krachten uit voor/achtergevels. De werkelijke stabiliteitskrachten per gevel mogen daarom ook worden overgenomen uit bovenstaande opgave.*

In te leiden belasting vanuit het casco
Over te dragen belasting vanuit de HSB-wand naar het casco/ondergelegen HSB

Eengezinswoningen

$F_{hor,2e;voor}$ =	10,01 kN	$F_{vert,1e;voor}$ =	5,78 kN
$F_{hor,1e;voor}$ =	14,40 kN	$F_{vert,bgg;voor}$ =	8,14 kN
$F_{hor,bgg;voor}$ =	14,40 kN		
$F_{hor,2e;achter}$ =	10,01 kN	$F_{vert,1e;achter}$ =	5,78 kN
$F_{hor,1e;achter}$=	15,13 kN	$F_{vert,bgg;achter}$=	8,55 kN
$F_{hor,bgg;achter}$ =	15,13 kN		

MIVA woningen

$F_{hor,1e;voor}$ =	11,83 kN	$F_{vert,bgg;voor}$ =	4,22 kN
$F_{hor,bgg;voor}$ =	11,83 kN		
$F_{hor,1e;achter}$=	10,37 kN	$Fv_{ert,bgg;achter}$ =	3,70 kN
$F_{hor,bgg;achter}$ =	10,37 kN		

HOOFDSTUK 7 BRANDWERENDHEID

M.b.t. brandwerendheid kan er onderscheid gemaakt worden in de volgende onderdelen:
- Sterkte bij brand (Afdeling 4.2.2)
- Beperking van uitbreiding van brand (Afdeling 4.2.8)

Hieronder worden de geldende artikelen uit het Besluit Bouwwerken Leefomgeving (BBL) benoemd m.b.t. dit project. Aan dit hoofdstuk kunnen geen rechten worden ontleend. Er dient te allen tijde advies gevraagd te worden aan de brandadviseur. Dit hoofdstuk is slechts ter notificatie. Het niet tijdig inschakelen van een brandadviseur kan extra kosten met zich meebrengen.

7.1 UITGANGSPUNTEN

Gebruiksoppervlak	**< 500 m²**
Hoogste vloer met verblijfsfuntie t.o.v. meetniveau*	**5,80 m**
Gebruiksfuntie	**Woonfunctie; overig**
Permanente vuurbelasting vlgs. NEN6090	**> 500 mJ/m²**

* Het meetniveau is de bovenkant van het terrein ter plaatse van de toegang van een gebouw. Indien een gebouw slechts kan worden betreden via een trap of een hellingbaan, is het meetniveau de hoogte van het terrein aan de voet van de trap of de hellingbaan.

7.2 CLT

Kopse zijden CLT-elementen verlijmen ter voorkoming delaminatie.

7.3 BRANDWERENDHEID HOOFDDRAAGCONSTRUCTIE

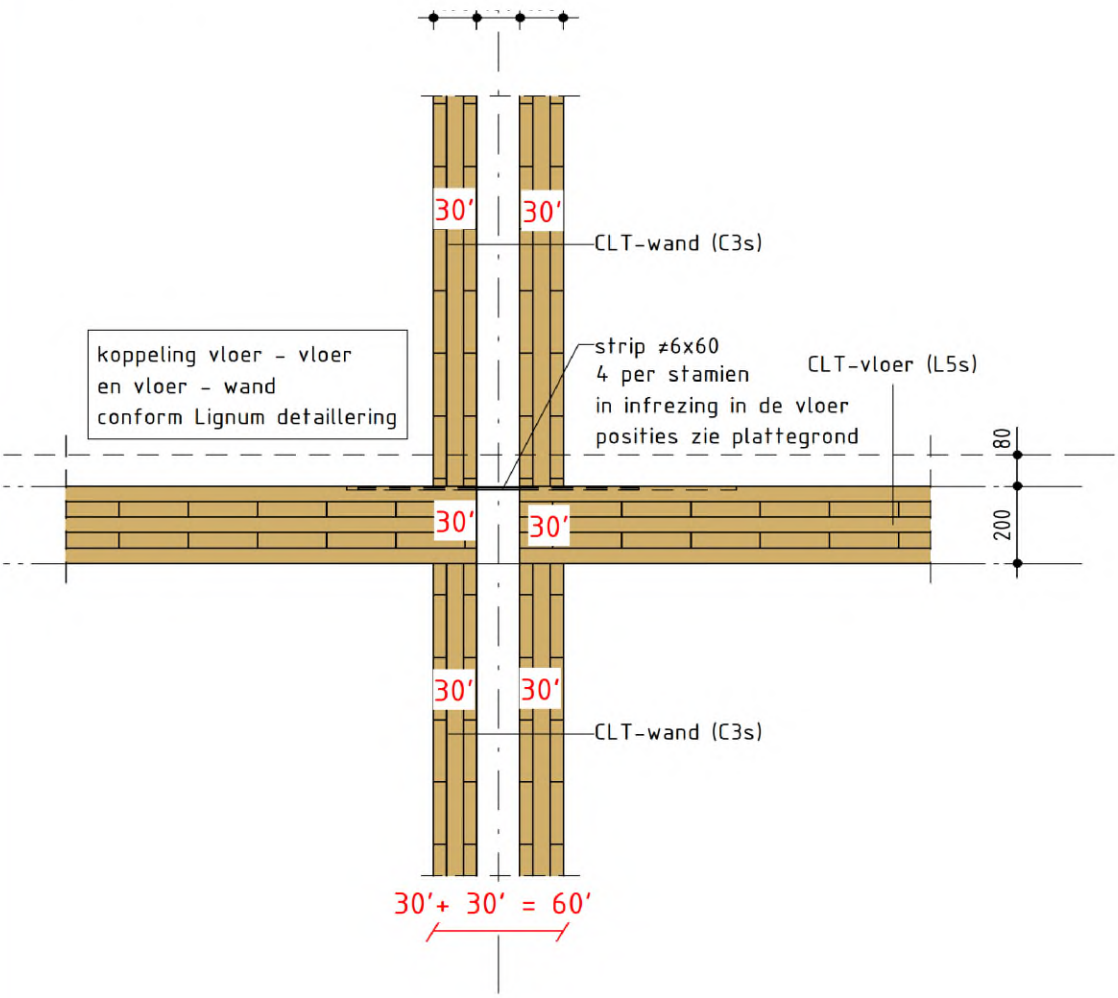
Er is geen sprake van een hoofddraagconstructie voor brand. De hoofddraagconstructie heeft daarom een brandwerendheid van **0** minuten.

7.4 BRANDDOORSLAG BOUWMUREN

De vereiste weerstand tegen branddoorslag bedraagt 60 minuten. Om hieraan te voldoen, wordt de bouwmuur uitgevoerd als een dubbele constructie bestaande uit twee CLT-wanden. Elke wand heeft een brandwerendheid van 30 minuten. Gezamenlijk zorgen deze wanden voor een totale weerstand tegen branddoorslag van 60 minuten (30 + 30).

7.4.1 Brandwerendheid verdiepingsvloeren

Voor de verdiepingsvloeren geldt dat er, zoals vermeld in paragraaf 7.4., geen brandwerendheidseis (0 minuten) van toepassing is. Desondanks zijn de vloeren getoetst op een brandwerendheid van 30 minuten, vanwege de eis met betrekking tot branddoorslag ter plaatse van de bouwmuren.



7.5 STABILITEIT BIJ BRAND

Het uitgangspunt is dat bij brand de constructieve stabiliteit gewaarborgd blijft door één afzonderlijke woning. Daarbij wordt aangenomen dat in brandsituaties de windbelasting gereduceerd mag worden tot 20% van de maatgevende windbelasting.

Conform paragraaf 6.2. bedraagt de totale windbelasting per niveau:

2e verdiepingsvloer:	**27,7 kN**
1e verdiepingsvloer:	**52,2 kN**

Gereduceerde windbelasting in geval van brand. Daarnaast geen veiligheid:

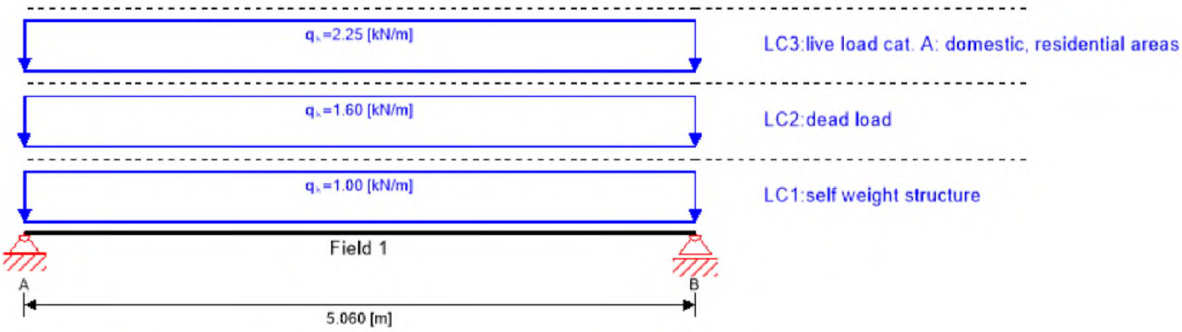
2e verdiepingsvloer:	20%*	27,7 =	**4,1 kN**
1e verdiepingsvloer:	20%*	52,2 =	**7,7 kN**

De capaciteit van per woning is hierbij ten minste gelijk aan de optredende windbelasting in normale situatie: (conform H6)

2e verdiepingsvloer rij:	**10,0 kN**	U.C. =	**0,41 AKKOORD**
1e verdiepingsvloer rij:	**14,4 kN**	U.C. =	**0,54 AKKOORD**
1e vvl MIVA	**10,4 kN**	U.C. =	**0,75 AKKOORD**

Conclusie: Uit de toetsing blijkt dat één afzonderlijke woning in staat is om de constructieve stabiliteit te waarborgen in geval van brand. Hiermee wordt voldaan aan het gestelde uitgangspunt.

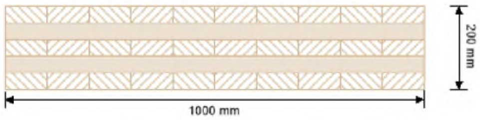
System



Global utilization ratio									85 %
ULS	23 %	ULS Fire	13 %	SLS	59 %	Vibration	85 %	Support	-1 %

Product data

Section: CLT 200 L5s



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	40.0 mm	90°	C24 spruce ETA (2022)
3	40.0 mm	0°	C24 spruce ETA (2022)
4	40.0 mm	90°	C24 spruce ETA (2022)
5	40.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**200.0 mm**		

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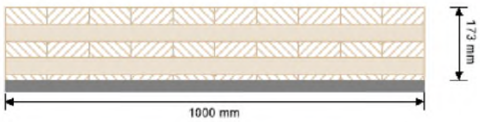
Section Fire: CLT 200 L5s



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	40.0 mm	90°	C24 spruce ETA (2022)
3	40.0 mm	0°	C24 spruce ETA (2022)
4	40.0 mm	90°	C24 spruce ETA (2022)
5	13.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**173.0 mm**		
Time	**30 min**		

Fire resistance class: R 30

Fire protection layering:
no additional fire protection

k_0 [-]	d_0 [mm]	$d_{char,0,h}$ [mm]	$d_{ef,h}$ [mm]	$d_{char,0,v}$ [mm]	$d_{ef,v}$ [mm]
1	7	20.0	27.0	0.0	0.0

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 (2022)	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	Type	Duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1	self weight structure	G	permanent	0.6	1	1.35	1	1	1
LC2	dead load	G	permanent	0.6	1	1.35	1	1	1
LC3	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.4	0.5	0.3

LC1:self weight structure

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continuous load	
Field	q_k [kN/m]
1	0.9999999

LC2:dead load

continuous load	
Field	q_k [kN/m]
1	1.6

LC3:live load cat. A: domestic, residential areas

continuous load	
Field	q_k [kN/m]
1	2.25

ULS Combinations	
	Combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC2
LCO2	1.20/1.00 * LC1 + 1.20/1.00 * LC2 + 1.50/0.00 * LC3

ULS Combinations Fire	
	Combination rule
LCO3	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO4	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3

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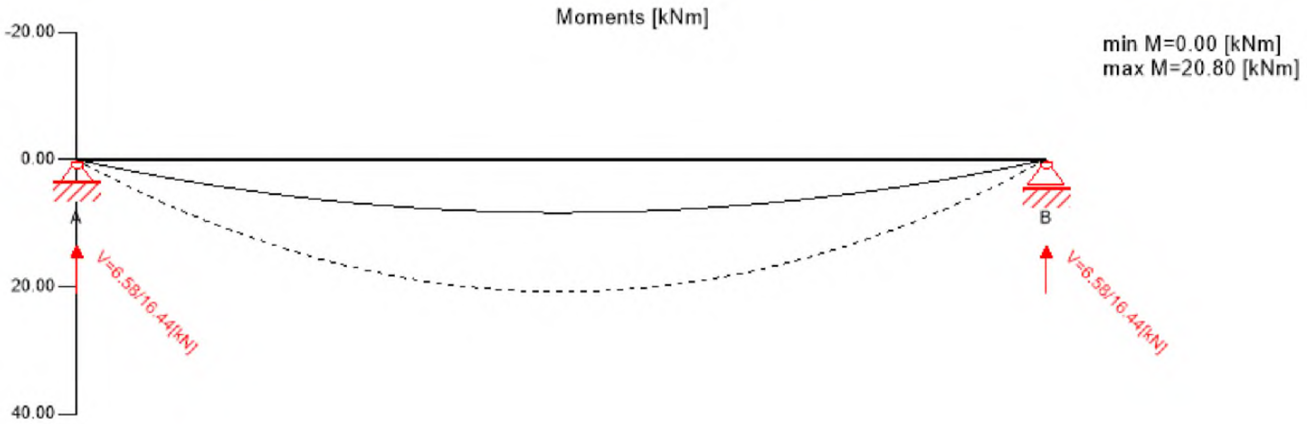
SLS Characteristic Combination

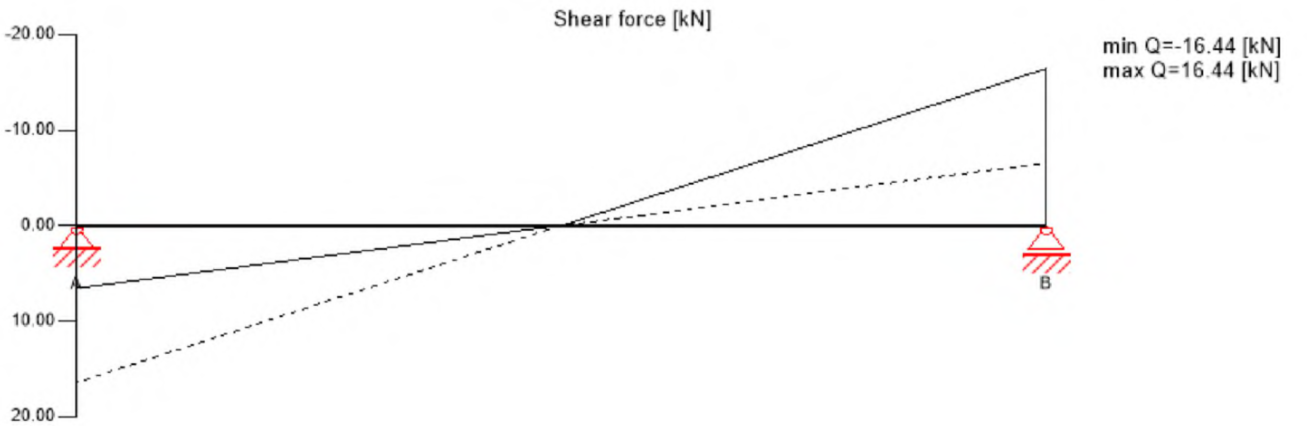
	Combination rule
LCO5	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO6	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC3

SLS Quasi-permanent Combination

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

Ultimate limit state (ULS) - design results





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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	2.53	24.00	1.25	0.80	1.10	16.90	20.80	-3.94	23%	LCO2

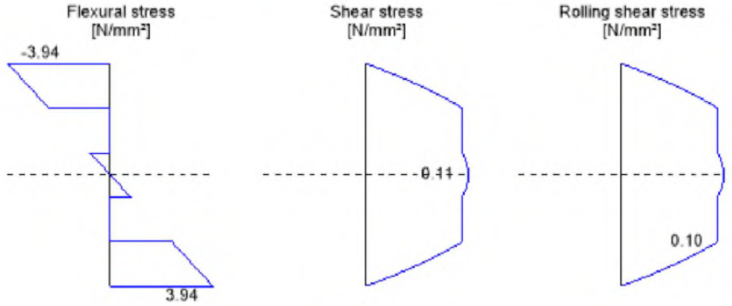
ULS Shear analysis

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	5.06	4.00	1.25	0.80	2.56	-16.44	0.11	4%	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	5.06	1.05	1.25	0.80	0.67	-16.44	0.10	15%	LCO2

Stress diagram



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Flexural stress analysis

$M_{y,d}$ =	20.80	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.80	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	8.96	N/mm²	
$\sigma_{m,y,d}$ =	-3.94	N/mm²		$f_{m,y,d}$ =	16.90	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓

Utilization ratio **23%**

Rolling shear analysis

V_d =	-16.44	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.80	-	
$\tau_{r,d}$ =	0.10	N/mm²	<	$f_{r,d}$ =	0.67	N/mm²	✓

Utilization ratio **15%**

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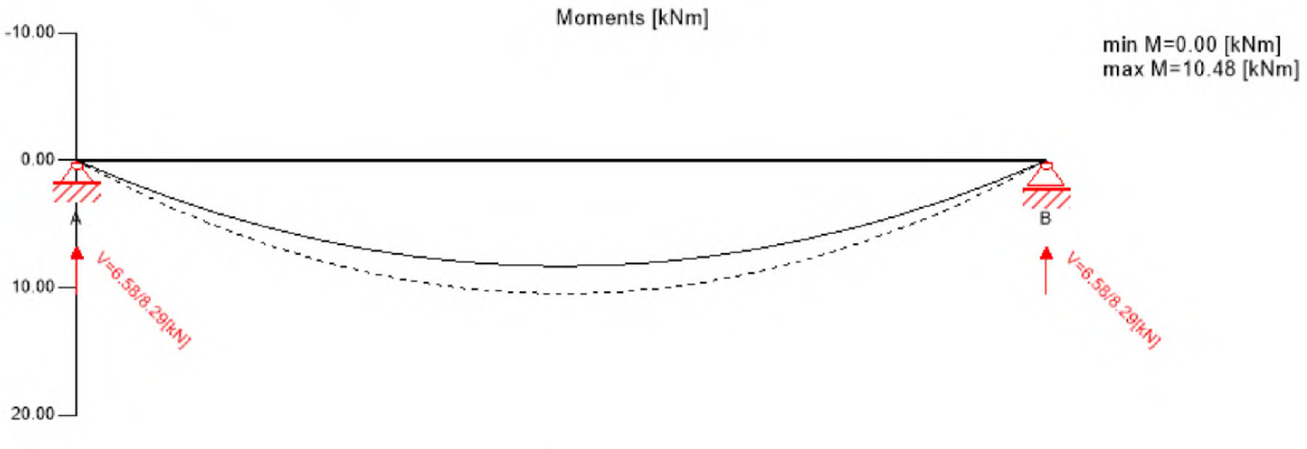
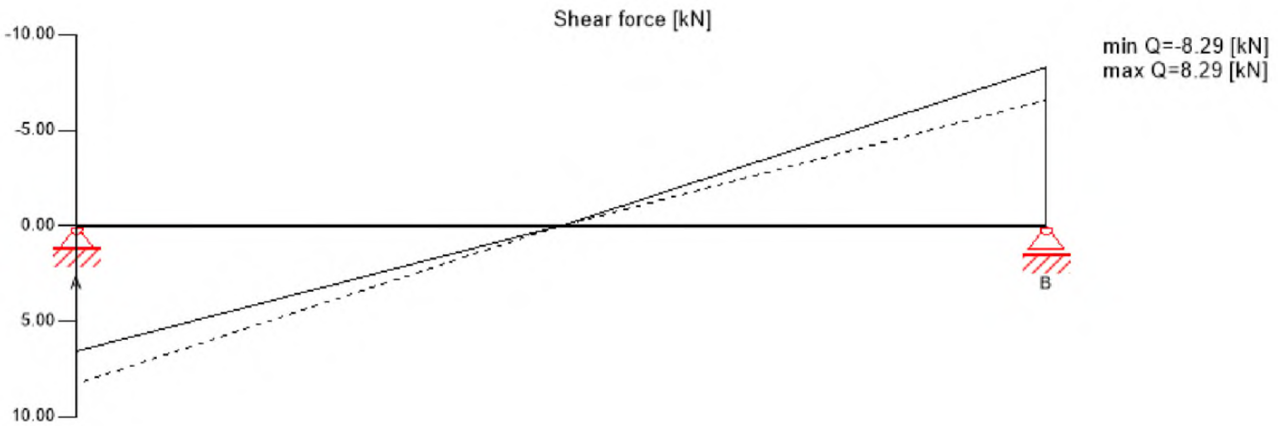
Ultimate limit state (ULS) fire design - results





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	2.53	24.00	1.00	1.00	1.10	1.15	30.36	10.48	3.87	13%	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	0.0	4.00	1.00	1.00	1.15	4.60	8.29	0.07	1%	LCO4

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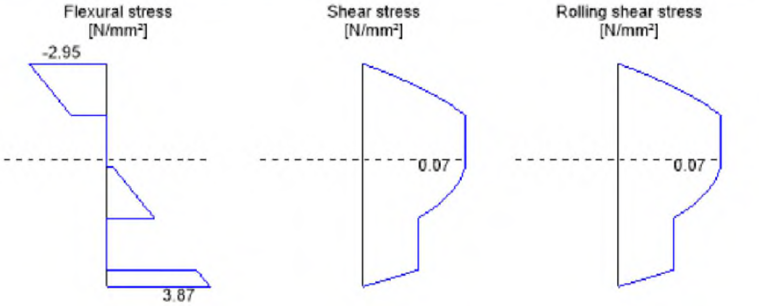
ULS Fire Rolling shear

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	0.0	1.05	1.00	1.00	1.15	1.21	8.29	0.07	6%	LCO4

Stress diagram



Flexural stress analysis Fire

$M_{y,d}$ =	10.48	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
				k_{fi} =	1.15	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	16.10	N/mm²	
$\sigma_{m,y,d}$ =	3.87	N/mm²		$f_{m,y,d}$ =	30.36	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓

Utilization ratio 13%

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Rolling shear analysis Fire

V_d =	8.29	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				k_{fi} =	1.15	-	
$\tau_{r,d}$ =	0.07	N/mm²	<	$f_{r,d}$ =	1.21	N/mm²	✓
Utilization ratio							**6%**

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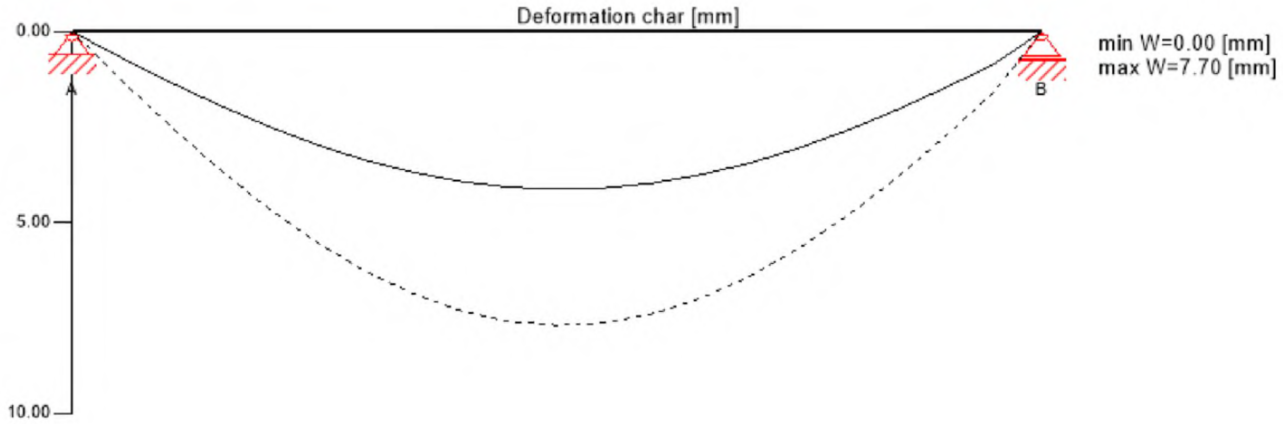
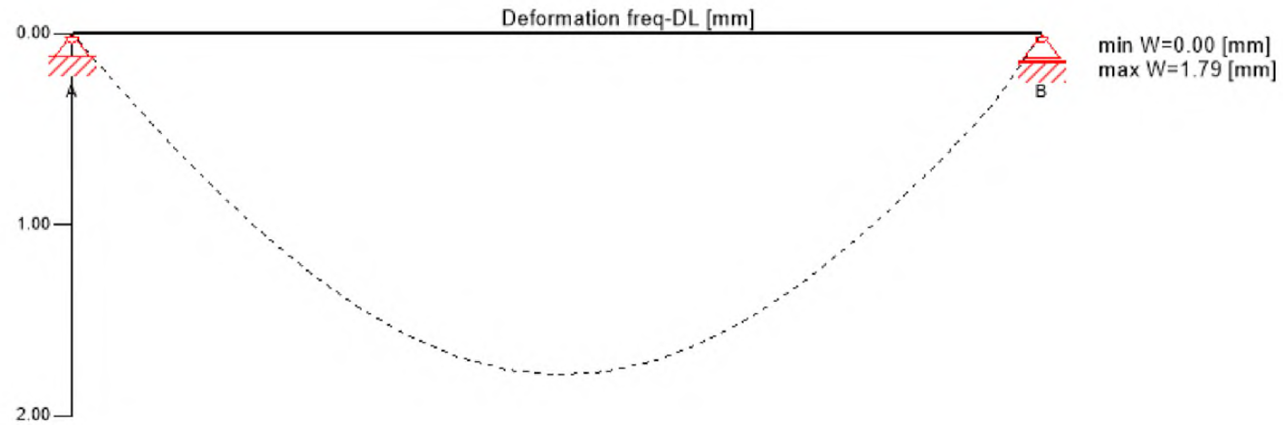
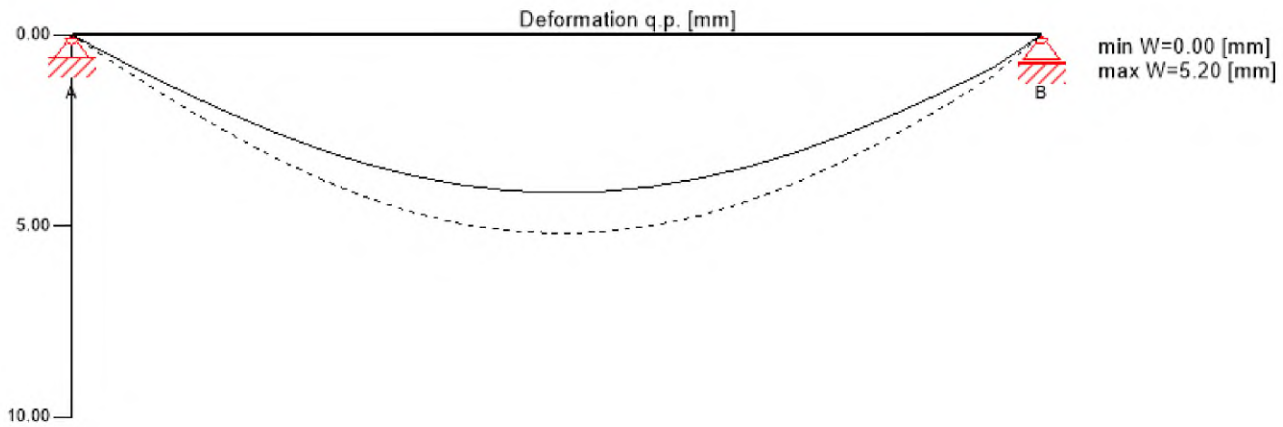
Service limit state design (SLS) - design results







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w_{inst} = w[char]					
Field	K_{def}	Limit	w_{limit}	$w_{calc.}$	Ratio
		[-]	[mm]	[mm]	
1	0.8	L/250	20.2	7.7	38%

w_{fin} = w[char] + w[q.p.]*kdef					
Field	K_{def}	Limit	w_{limit}	$w_{calc.}$	Ratio
		[-]	[mm]	[mm]	
1	0.8	L/250	20.2	11.9	59%

$w_{net,fin}$ = w[frq] - w[D.L] + w[q.p.]*kdef					
Field	K_{def}	Limit	w_{limit}	$w_{calc.}$	Ratio
		[-]	[mm]	[mm]	
1	0.8	L/333	15.2	5.9	39%

Vibration analysis

General		
Total mass	1.34	[t]
Tributary width	1.0	[m]
Stiffness Longitudinal direction	6336.0	[kNm²]
Stiffness Cross direction	1664.0	[kNm²]
Modal damping	1.0	[%]
α	0.0	[-]
Man weight	700.0	[N]
Modal mass	669.8	[kg]

Analysis				
Criterion	Calc.	Class II	Class II	Cl. II
Frequency criterion min	9.488 [Hz]	4.5 [Hz]	47 %	✓
Frequency criterion	9.488 [Hz]	6.0 [Hz]	63 %	
Acceleration criterion	0.47 [m/s²]	0.1 [m/s²]	470 %	
Stiffness criterion	0.426 [mm]	0.5 [mm]	85 %	✓

Support reaction

Load case category	k_{mod}	A_V	B_V
		[kN]	
self weight structure	0.6	2.53	2.53
		2.53	2.53
dead load	0.6	4.05	4.05
		4.05	4.05
live load cat. A: domestic, residential areas	0.8	5.69	5.69
		0.00	0.00

Reference documents for this analysis

English title	Description
EN 338	EN 338 - Structural timber ? Strength classes
EN 1995-1-1	EN 1995-1-1 - Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
ETA-14/0349	European Technical Assessment ETA-14/0349
Expertise Rolling shear - no edge gluing, [redacted]	Expertise on Rolling shear for CLT
EN 1995-1-2	EN 1995-1-2 - Eurocode 5 — Design of timber structures — Part 1-2: General — Structural fire design
Technical expertise 122/2011/02: analysis of load bearing capacity and separation performance of CLT elements	Verification of the load bearing capacity and the insulation criterion of CLT structures with Stora Enso CLT
Technical expertise 2434/2012 - BB: failure time tf of gypsum fire boards (GKF) according to ON B 3410	Expertise on failure time tf of gypsum wall fire boards according to ON B3410 and gypsum wall boards type DF according to EN 520
EN 1990	EN 1990 - Eurocode ? Basis of structural design
Fire safety in timber buildings - technical guildeline for Europe	Fire safety in timber buildings - technical guideline for Europe; publishes by SP Technical Research Institute of Sweden
National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12	ÖNORM EN 1995-1-2 - National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12
Expertise Rolling shear, [redacted]	Expertise on rolling shear strength and rolling shear modulus of CLT panels
ÖNORM EN 1995-1-1_NA, chapter 7.3	ÖNORM EN 1995-1-1 - Austria - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General- Common rules and rules for buildings; chapter 7.3

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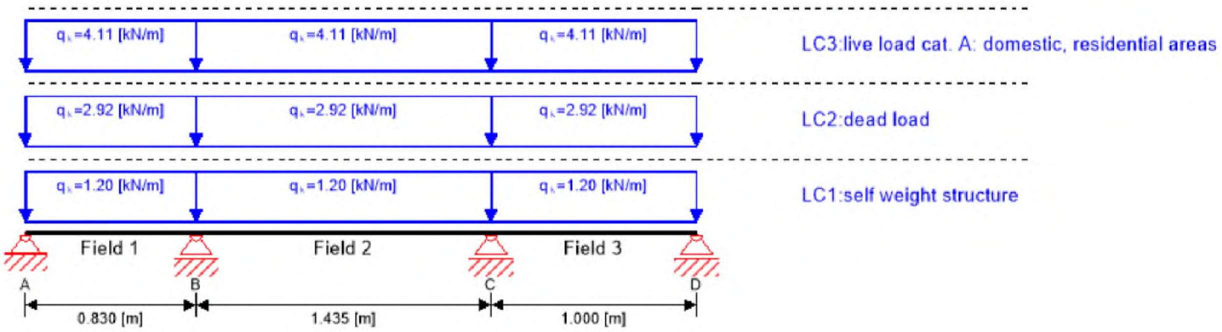
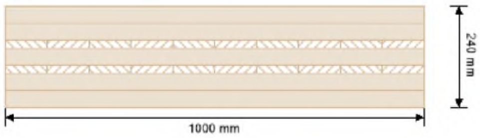
System



Global utilization ratio				55 %
ULS 20 %	ULS Fire 5 %	SLS 27 %	Vibration 55 %	Support -1 %

Product data

Section: CLT 240 L7s - 2



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	90°	C24 spruce ETA (2022)
2	40.0 mm	90°	C24 spruce ETA (2022)
3	20.0 mm	0°	C24 spruce ETA (2022)
4	40.0 mm	90°	C24 spruce ETA (2022)
5	20.0 mm	0°	C24 spruce ETA (2022)
6	40.0 mm	90°	C24 spruce ETA (2022)
7	40.0 mm	90°	C24 spruce ETA (2022)
t_{CLT}	**240.0 mm**		

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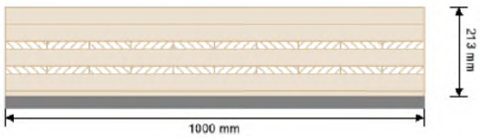
Section Fire: CLT 240 L7s - 2



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	90°	C24 spruce ETA (2022)
2	40.0 mm	90°	C24 spruce ETA (2022)
3	20.0 mm	0°	C24 spruce ETA (2022)
4	40.0 mm	90°	C24 spruce ETA (2022)
5	20.0 mm	0°	C24 spruce ETA (2022)
6	40.0 mm	90°	C24 spruce ETA (2022)
7	13.0 mm	90°	C24 spruce ETA (2022)
t_{CLT}	**213.0 mm**		

Fire resistance class: R 30

Time **30 min**

Fire protection layering:
no additional fire protection

k_0 [-]	d_0 [mm]	$d_{char,0,h}$ [mm]	$d_{ef,h}$ [mm]	$d_{char,0,v}$ [mm]	$d_{ef,v}$ [mm]
1	7	20.0	27.0	0.0	0.0

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 (2022)	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	Type	Duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1	self weight structure	G	permanent	0.6	1	1.35	1	1	1
LC2	dead load	G	permanent	0.6	1	1.35	1	1	1
LC3	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.4	0.5	0.3

LC1:self weight structure

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continuous load	
Field	**q_k** [kN/m]
1	1.2
2	1.2
3	1.2

LC2:dead load

continuous load	
Field	**q_k** [kN/m]
1	2.92
2	2.92
3	2.92

LC3:live load cat. A: domestic, residential areas

continuous load	
Field	**q_k** [kN/m]
1	4.11
2	4.11
3	4.11

ULS Combinations	
	Combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC2
LCO2	1.20/1.00 * LC1 + 1.20/1.00 * LC2 + 1.50/0.00 * LC3

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ULS Combinations Fire

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

SLS Characteristic Combination

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

SLS Quasi-permanent Combination

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

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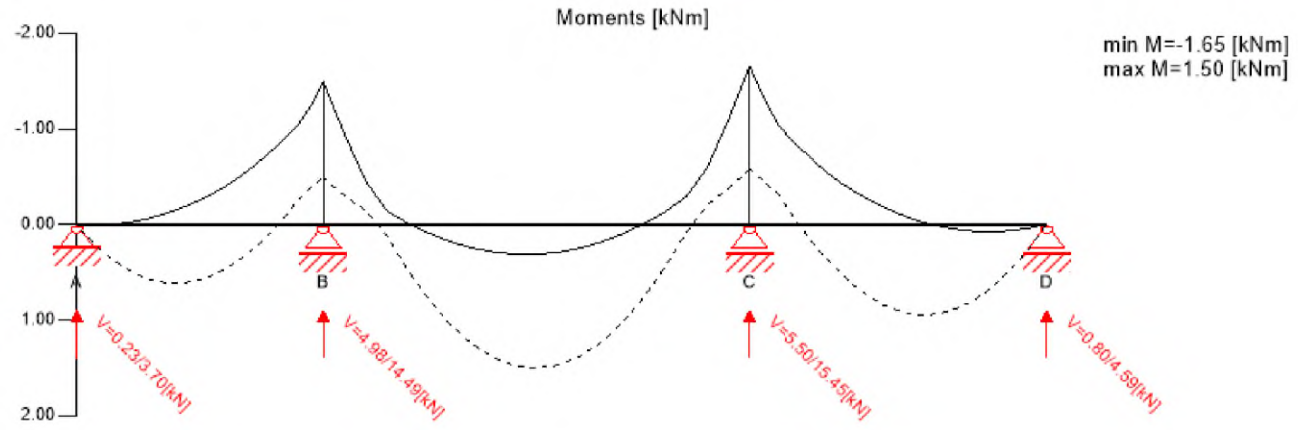
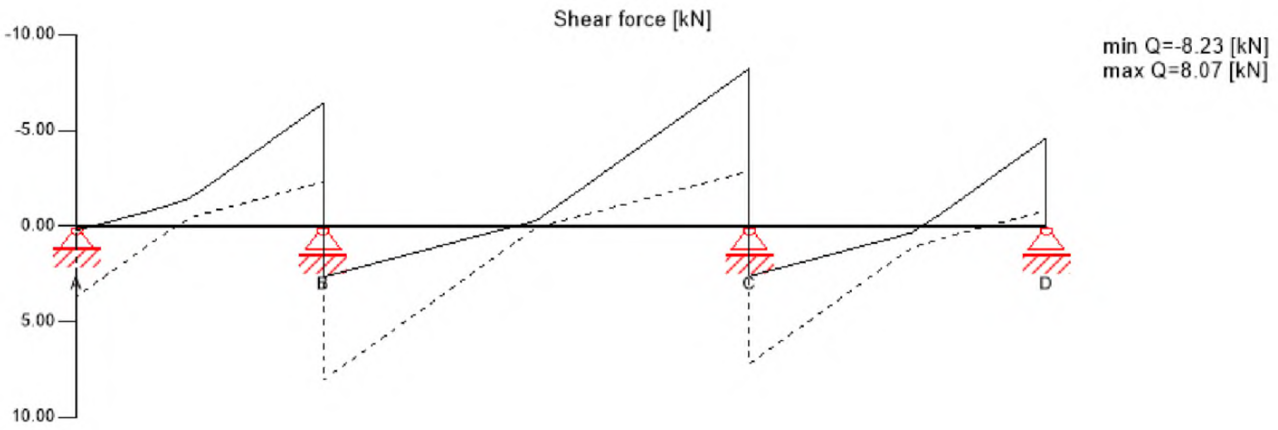
Ultimate limit state (ULS) - design results





ULS Flexural design

Field	Dist. [m]	$f_{m,k}$ [N/mm²]	γ_m [-]	k_{mod} [-]	$k_{sys,y}$ [-]	$f_{m,y,d}$ [N/mm²]	$M_{y,d}$ [kNm]	$\sigma_{m,y,d}$ [N/mm²]	Ratio	
1	0.83	24.00	1.25	0.80	1.10	16.90	-1.50	1.60	9%	LCO2
2	1.44	24.00	1.25	0.80	1.10	16.90	-1.65	1.77	10%	LCO2
3	0.0	24.00	1.25	0.80	1.10	16.90	-1.65	1.77	10%	LCO2

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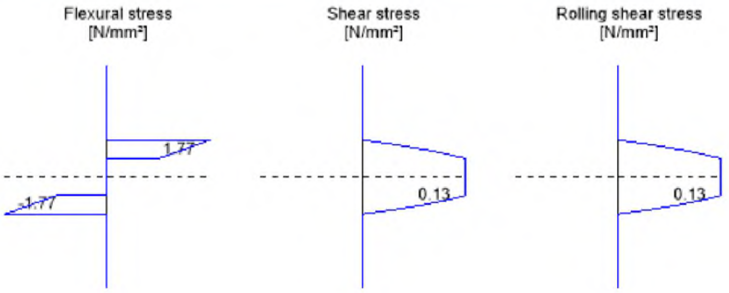
ULS Shear analysis

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	0.83	4.00	1.25	0.80	2.56	-6.41	0.10	4%	LCO2
2	1.44	4.00	1.25	0.80	2.56	-8.23	0.13	5%	LCO2
3	0.0	4.00	1.25	0.80	2.56	7.21	0.12	5%	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	0.83	1.05	1.25	0.80	0.67	-6.41	0.10	15%	LCO2
2	1.44	1.05	1.25	0.80	0.67	-8.23	0.13	20%	LCO2
3	0.0	1.05	1.25	0.80	0.67	7.21	0.12	17%	LCO2

Stress diagram



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Flexural stress analysis

$M_{y,d}$ =	-1.65	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.80	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	8.96	N/mm²	
$\sigma_{m,y,d}$ =	1.77	N/mm²		$f_{m,y,d}$ =	16.90	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓
Utilization ratio							**10%**

Rolling shear analysis

V_d =	-8.23	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.80	-	
$\tau_{r,d}$ =	0.13	N/mm²	<	$f_{r,d}$ =	0.67	N/mm²	✓
Utilization ratio							**20%**

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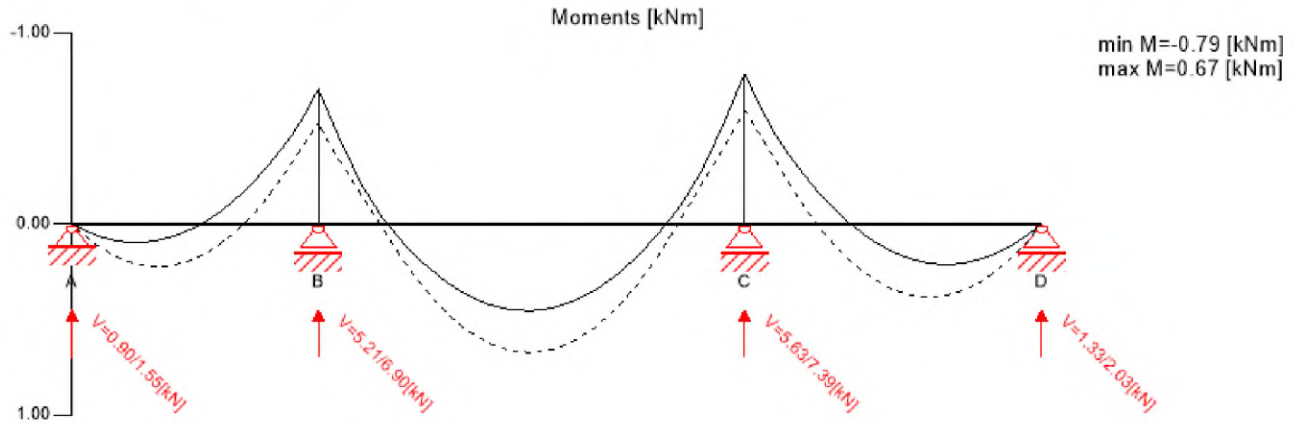
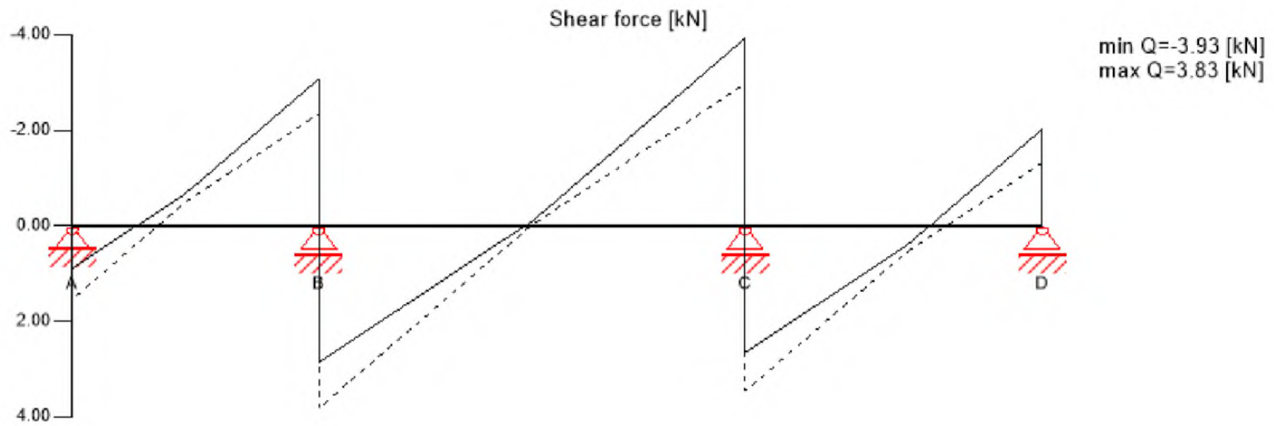
Ultimate limit state (ULS) fire design - results





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	0.83	24.00	1.00	1.00	1.10	1.15	30.36	-0.71	0.76	2%	LCO4
2	1.44	24.00	1.00	1.00	1.10	1.15	30.36	-0.79	0.84	3%	LCO4
3	0.0	24.00	1.00	1.00	1.10	1.15	30.36	-0.79	0.84	3%	LCO4

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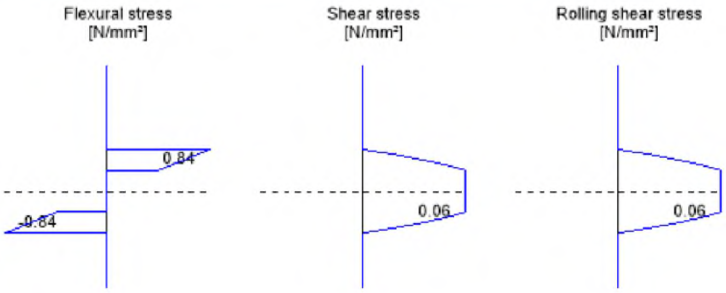
ULS Fire Shear analysis

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	0.83	4.00	1.00	1.00	1.15	4.60	-3.07	0.05	1%	LCO4
2	1.44	4.00	1.00	1.00	1.15	4.60	-3.93	0.06	1%	LCO4
3	0.0	4.00	1.00	1.00	1.15	4.60	3.47	0.06	1%	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	0.83	1.05	1.00	1.00	1.15	1.21	-3.07	0.05	4%	LCO4
2	1.44	1.05	1.00	1.00	1.15	1.21	-3.93	0.06	5%	LCO4
3	0.0	1.05	1.00	1.00	1.15	1.21	3.47	0.06	5%	LCO4

Stress diagram



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Flexural stress analysis Fire

$M_{y,d}$ =	-0.79	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
				k_{fi} =	1.15	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	16.10	N/mm²	
$\sigma_{m,y,d}$ =	0.84	N/mm²		$f_{m,y,d}$ =	30.36	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓
Utilization ratio							**3%**

Rolling shear analysis Fire

V_d =	-3.93	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%**

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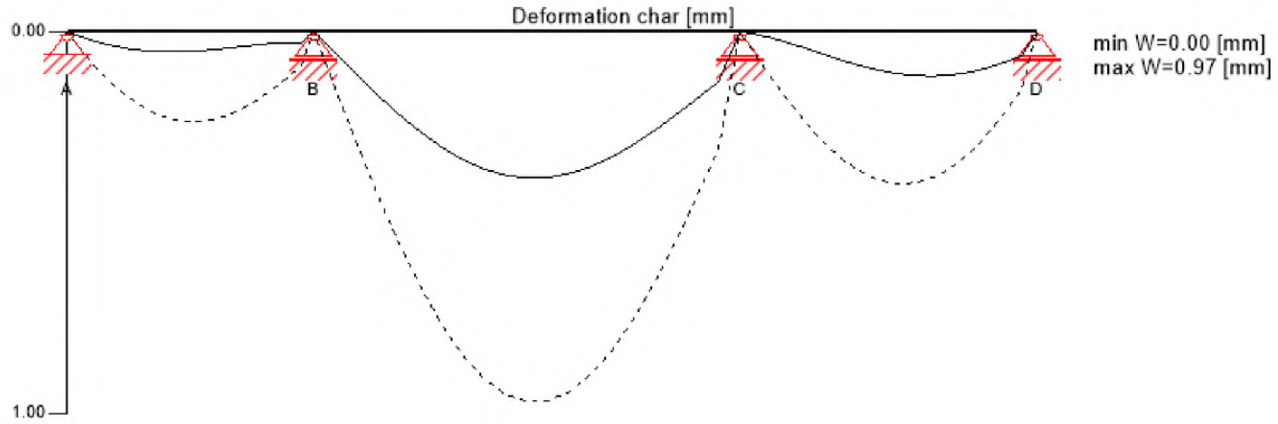
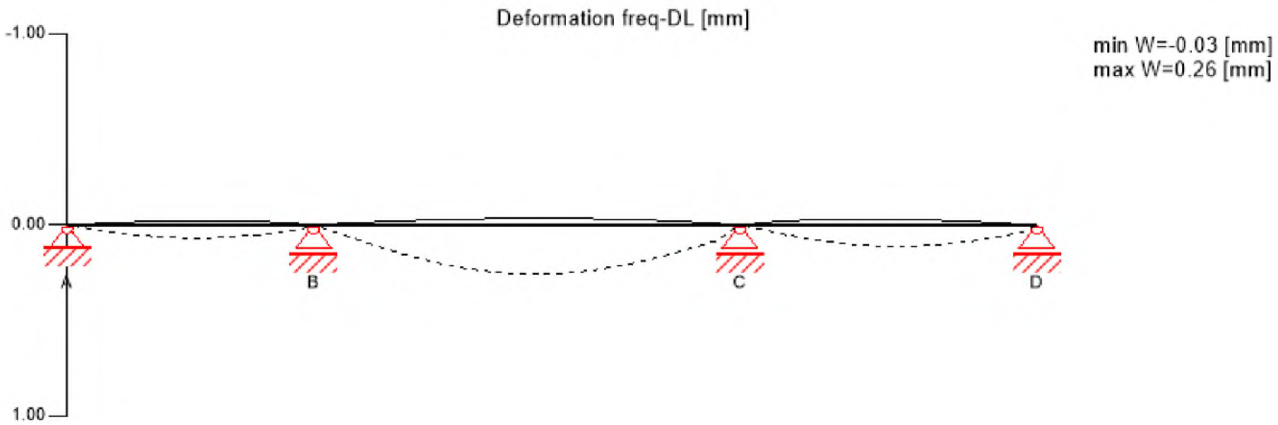
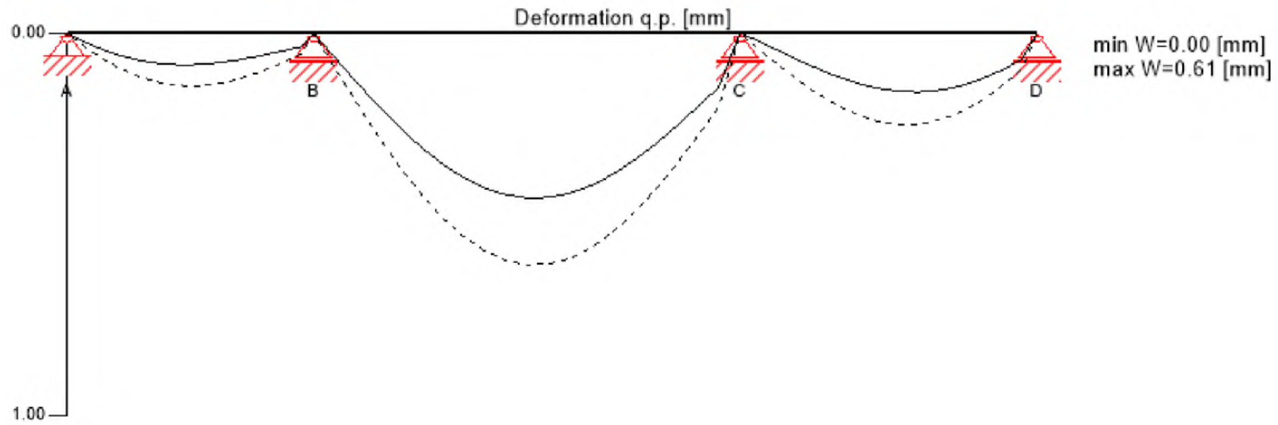
Service limit state design (SLS) - design results







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w_{inst} = w[char]					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	1	L/250	3.3	0.2	7%
2	1	L/250	5.7	1.0	17%
3	1	L/250	4.0	0.4	10%

w_{fin} = w[char] + w[q.p.]*kdef					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	1	L/250	3.3	0.4	11%
2	1	L/250	5.7	1.6	27%
3	1	L/250	4.0	0.6	16%

$w_{net,fin}$ = w[frq] - w[D.L] + w[q.p.]*kdef					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	1	L/333	2.5	0.2	8%
2	1	L/333	4.3	0.9	20%
3	1	L/333	3.0	0.4	12%

Vibration analysis

General		
Total mass	1.37	[t]
Tributary width	1.0	[m]
Stiffness Longitudinal direction	448.0	[kNm²]
Stiffness Cross direction	13376.0	[kNm²]
Modal damping	1.0	[%]
α	0.0	[-]
Man weight	700.0	[N]
Modal mass	109.7	[kg]

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Analysis							
Criterion	Calc.	Class I	Class II	Class I	Class II	Cl. I	Cl. II
Frequency criterion min	35.749 [Hz]	4.5 [Hz]	4.5 [Hz]	13 %	13 %	✓	✓
Frequency criterion	35.749 [Hz]	8.0 [Hz]	6.0 [Hz]	22 %	17 %		
Acceleration criterion	0.0 [m/s²]	0.05 [m/s²]	0.1 [m/s²]	0 %	0 %		
Stiffness criterion	0.137 [mm]	0.25 [mm]	0.5 [mm]	55 %	27 %	✓	✓

Support reaction

Load case category	k_{mod}	A_V	B_V	C_V	D_V
			[kN]		
self weight structure	0.6	0.31	1.53	1.65	0.42
		0.31	1.53	1.65	0.42
dead load	0.6	0.75	3.73	4.02	1.03
		0.75	3.73	4.02	1.03
live load cat. A: domestic, residential areas	0.8	1.62	5.44	5.76	1.89
		-0.55	-0.19	-0.11	-0.44

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Reference documents for this analysis

English title	**Description**
EN 338	EN 338 - Structural timber ? Strength classes
EN 1995-1-1	EN 1995-1-1 - Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
ETA-14/0349	European Technical Assessment ETA-14/0349
Expertise Rolling shear - no edge gluing,	Expertise on Rolling shear for CLT
EN 1995-1-2	EN 1995-1-2 - Eurocode 5 — Design of timber structures — Part 1-2: General — Structural fire design
Technical expertise 122/2011/02: analysis of load bearing capacity and separation performance of CLT elements	Verification of the load bearing capacity and the insulation criterion of CLT structures with Stora Enso CLT
Technical expertise 2434/2012 - BB: failure time tf of gypsum fire boards (GKF) according to ON B 3410	Expertise on failure time tf of gypsum wall fire boards according to ON B3410 and gypsum wall boards type DF according to EN 520
EN 1990	EN 1990 - Eurocode ? Basis of structural design
Fire safety in timber buildings - technical guildeline for Europe	Fire safety in timber buildings - technical guideline for Europe; publishes by SP Technical Research Institute of Sweden
National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12	ÖNORM EN 1995-1-2 - National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12
Expertise Rolling shear,	Expertise on rolling shear strength and rolling shear modulus of CLT panels
ÖNORM EN 1995-1-1_NA, chapter 7.3	ÖNORM EN 1995-1-1 - Austria - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General- Common rules and rules for buildings; chapter 7.3

Disclaimer

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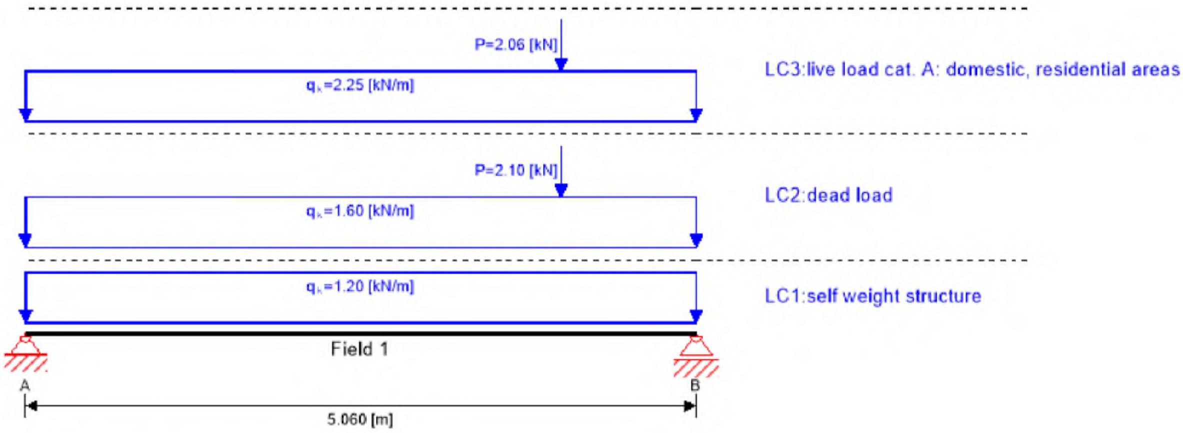
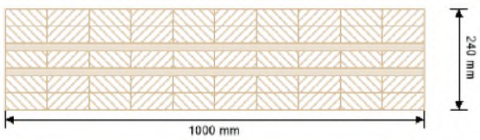
System



Global utilization ratio									81 %
ULS	16 %	ULS Fire	6 %	SLS	36 %	Vibration	81 %	Support	-1 %

Product data

Section: CLT 240 L7s - 2



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	40.0 mm	0°	C24 spruce ETA (2022)
3	20.0 mm	90°	C24 spruce ETA (2022)
4	40.0 mm	0°	C24 spruce ETA (2022)
5	20.0 mm	90°	C24 spruce ETA (2022)
6	40.0 mm	0°	C24 spruce ETA (2022)
7	40.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**240.0 mm**		

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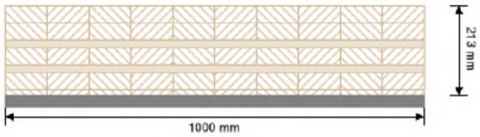
Section Fire: CLT 240 L7s - 2



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	40.0 mm	0°	C24 spruce ETA (2022)
3	20.0 mm	90°	C24 spruce ETA (2022)
4	40.0 mm	0°	C24 spruce ETA (2022)
5	20.0 mm	90°	C24 spruce ETA (2022)
6	40.0 mm	0°	C24 spruce ETA (2022)
7	13.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**213.0 mm**		
Time	**30 min**		

Fire resistance class: R 30

Fire protection layering:
no additional fire protection

k_0 [-]	d_0 [mm]	$d_{char,0,h}$ [mm]	$d_{ef,h}$ [mm]	$d_{char,0,v}$ [mm]	$d_{ef,v}$ [mm]
1	7	20.0	27.0	0.0	0.0

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 (2022)	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	Type	Duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1	self weight structure	G	permanent	0.6	1	1.35	1	1	1
LC2	dead load	G	permanent	0.6	1	1.35	1	1	1
LC3	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.4	0.5	0.3

LC1:self weight structure

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continuous load	
Field	**q_k**
	[kN/m]
1	1.2

LC2:dead load

continuous load	
Field	**q_k**
	[kN/m]
1	1.6

point load		
Field	**Distance from start**	**P_k**
	[m]	[kN]
1	4.040	2.1

LC3:live load cat. A: domestic, residential areas

continuous load	
Field	**q_k**
	[kN/m]
1	2.25

point load		
Field	**Distance from start**	**P_k**
	[m]	[kN]
1	4.040	2.06

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ULS Combinations	
	Combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC2
LCO2	1.20/1.00 * LC1 + 1.20/1.00 * LC2 + 1.50/0.00 * LC3

ULS Combinations Fire	
	Combination rule
LCO3	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO4	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3

SLS Characteristic Combination	
	Combination rule
LCO5	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO6	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC3

SLS Quasi-permanent Combination	
	Combination rule
LCO7	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO8	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3

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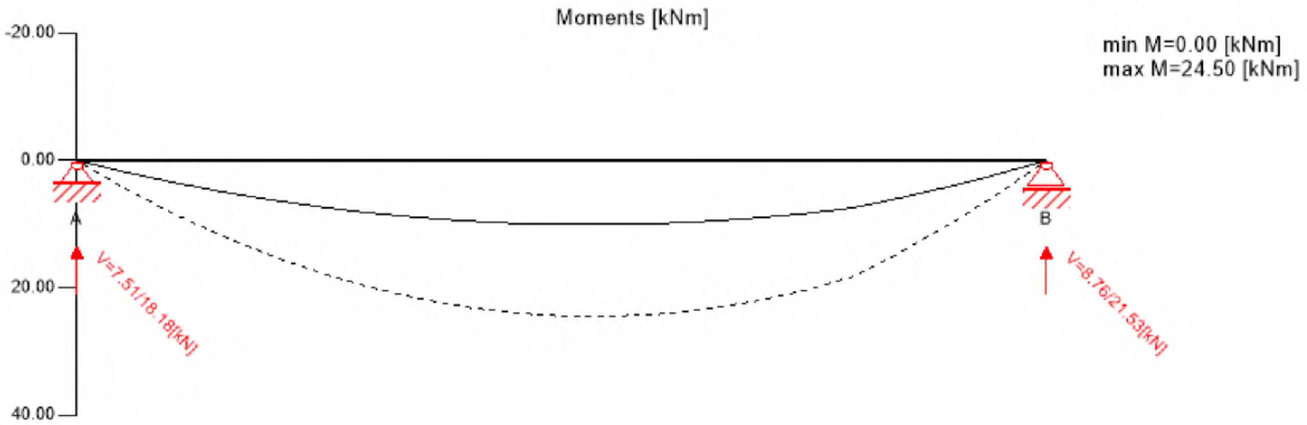
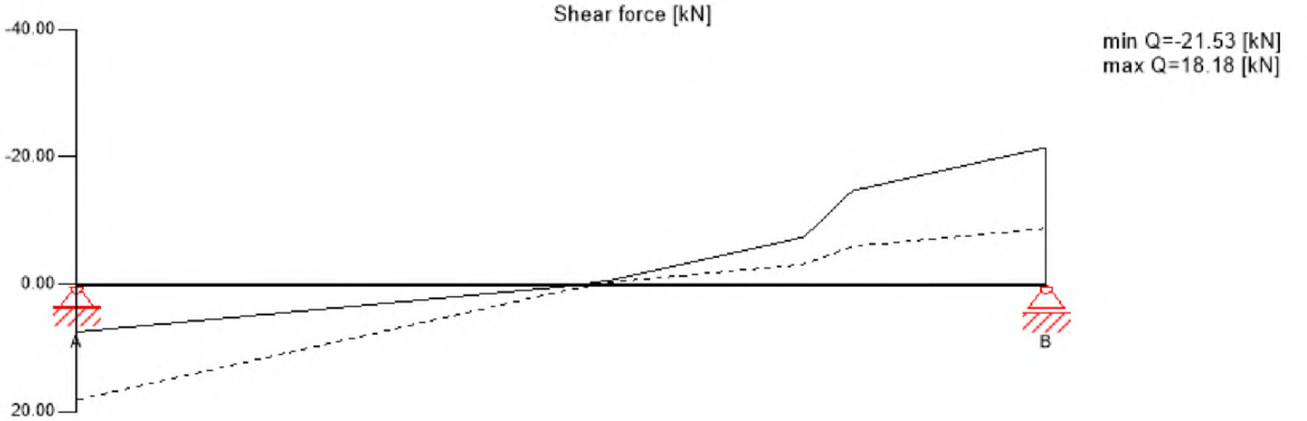
Ultimate limit state (ULS) - design results





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	2.78	24.00	1.25	0.80	1.10	16.90	24.50	-2.64	16%	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	5.06	4.00	1.25	0.80	2.56	-21.53	0.13	5%	LCO2

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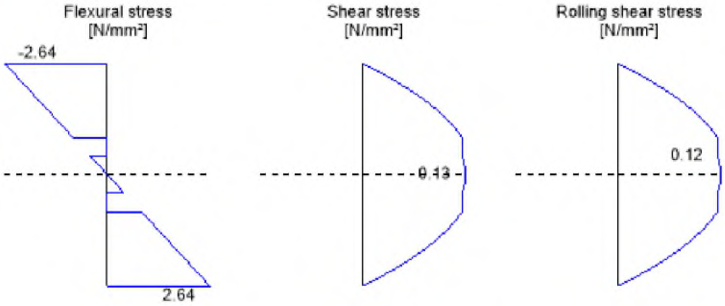
ULS Rolling shear

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	5.06	1.25	1.25	0.80	0.80	-21.53	0.12	15%	LCO2

Stress diagram



Flexural stress analysis

$M_{y,d}$ =	24.50	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.80	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	8.96	N/mm²	
$\sigma_{m,y,d}$ =	-2.64	N/mm²		$f_{m,y,d}$ =	16.90	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓
Utilization ratio							16%

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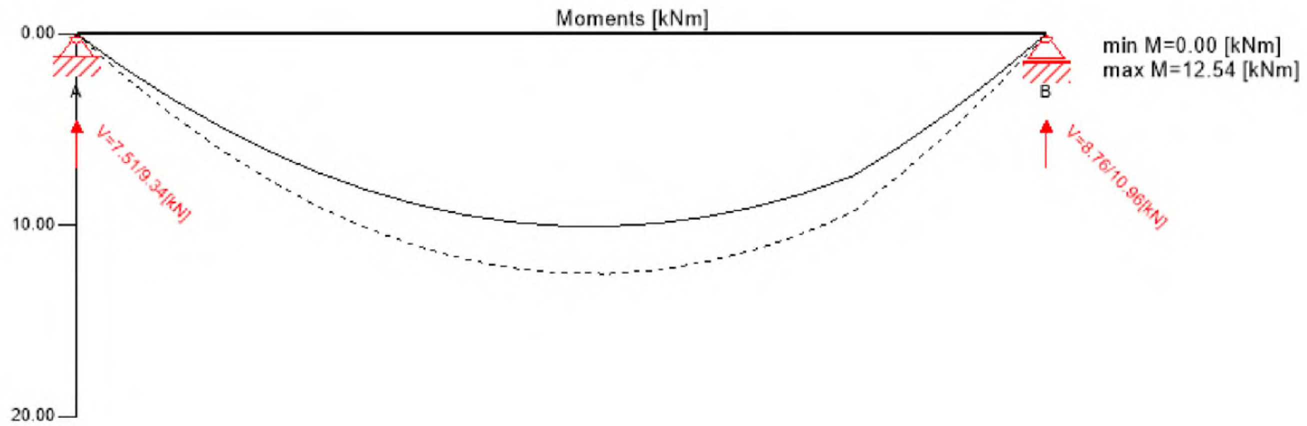
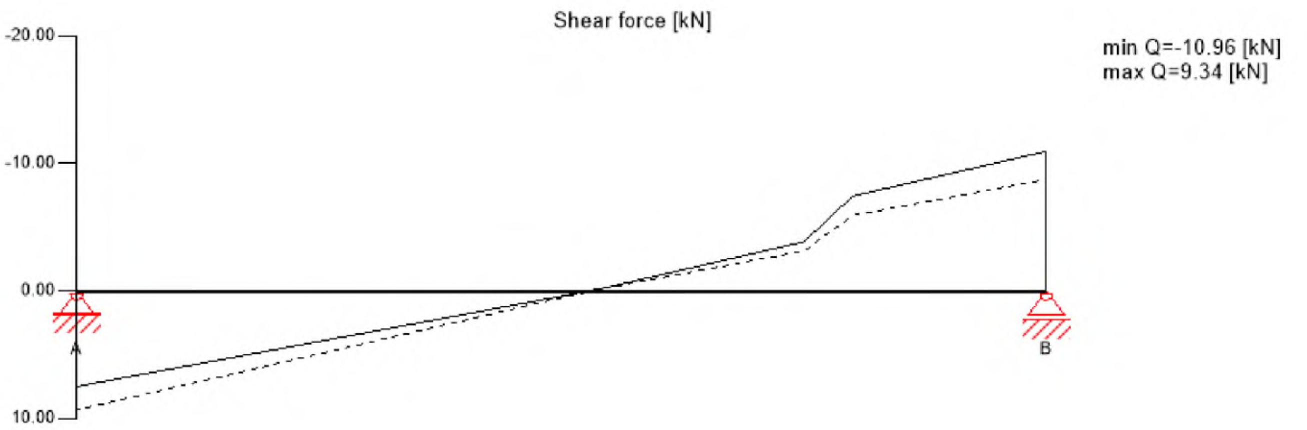
Rolling shear analysis

V_d =	-21.53	kN		$f_{r,k}$ =	1.25	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.80	-	
$\tau_{r,d}$ =	0.12	N/mm²	<	$f_{r,d}$ =	0.80	N/mm²	✓
Utilization ratio							15%

Ultimate limit state (ULS) fire design - results





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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	2.78	24.00	1.00	1.00	1.10	1.15	30.36	12.54	1.81	6%	LCO4

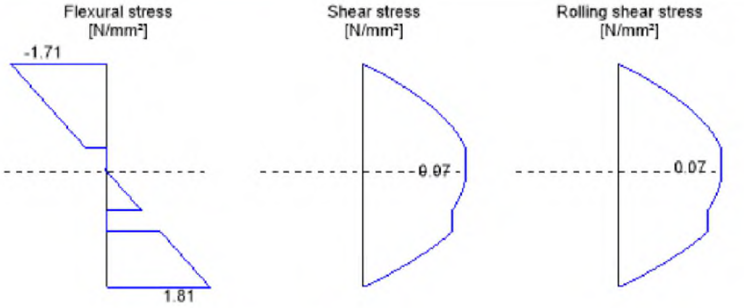
ULS Fire Shear analysis

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	5.06	4.00	1.00	1.00	1.15	4.60	-10.96	0.07	2%	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	5.06	1.25	1.00	1.00	1.15	1.44	-10.96	0.07	5%	LCO4

Stress diagram



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Flexural stress analysis Fire

$M_{y,d}$ =	12.54	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
				k_{fi} =	1.15	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	16.10	N/mm²	
$\sigma_{m,y,d}$ =	1.81	N/mm²		$f_{m,y,d}$ =	30.36	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓

Utilization ratio **6%**

Rolling shear analysis Fire

V_d =	-10.96	kN		$f_{r,k}$ =	1.25	N/mm²	
				γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				k_{fi} =	1.15	-	
$\tau_{r,d}$ =	0.07	N/mm²	<	$f_{r,d}$ =	1.44	N/mm²	✓

Utilization ratio **5%**

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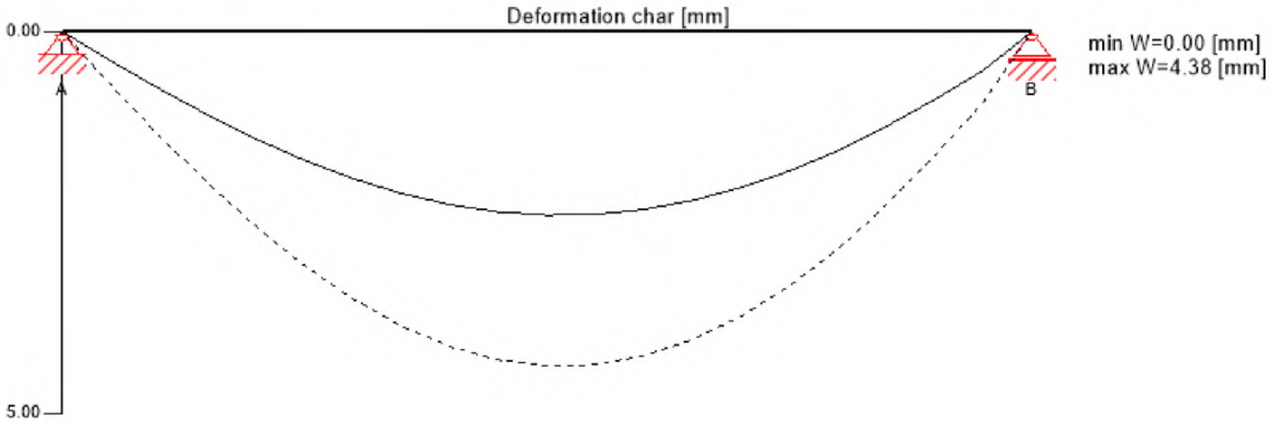
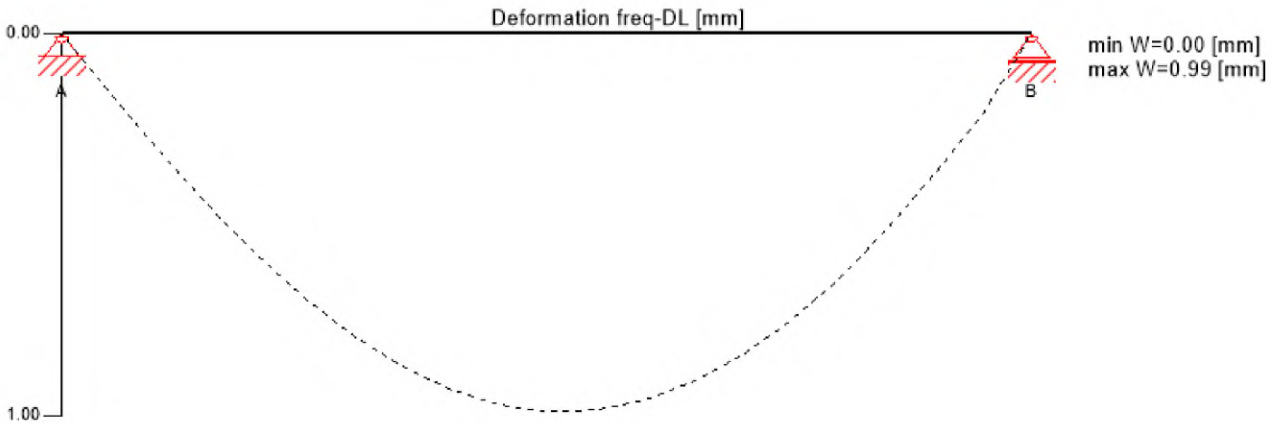
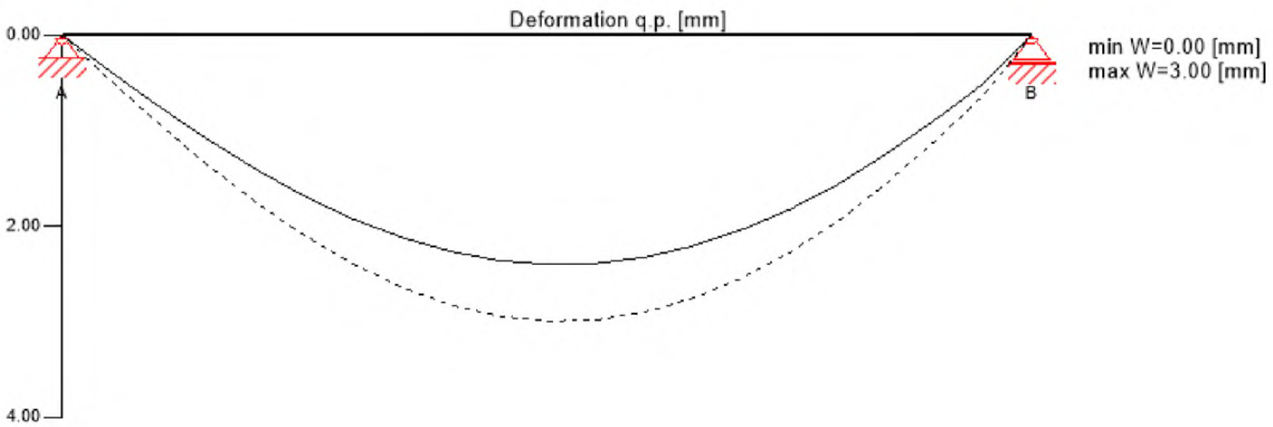
Service limit state design (SLS) - design results







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w_{inst} = w[char]

Field	K_{def}	Limit	w_{limit}	$w_{calc.}$	Ratio
		[-]	[mm]	[mm]	
1	1	L/250	20.2	4.4	22%

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

Field	K_{def}	Limit	w_{limit}	$w_{calc.}$	Ratio
		[-]	[mm]	[mm]	
1	1	L/250	20.2	7.4	36%

$w_{net,fin}$ = w[frq] - w[D.L] + w[q.p.]*kdef

Field	K_{def}	Limit	w_{limit}	$w_{calc.}$	Ratio
		[-]	[mm]	[mm]	
1	1	L/333	15.2	4.0	26%

Vibration analysis

General		
Total mass	1.66	[t]
Tributary width	1.0	[m]
Stiffness Longitudinal direction	13376.0	[kNm²]
Stiffness Cross direction	448.0	[kNm²]
Modal damping	4.0	[%]
α	0.0	[-]
Man weight	700.0	[N]
Modal mass	828.3	[kg]

Analysis							
Criterion	Calc.	Class I	Class II	Class I	Class II	Cl. I	Cl. II
Frequency criterion min	12.398 [Hz]	4.5 [Hz]	4.5 [Hz]	36 %	36 %	✓	✓
Frequency criterion	12.398 [Hz]	8.0 [Hz]	6.0 [Hz]	65 %	48 %		
Acceleration criterion	0.03 [m/s²]	0.05 [m/s²]	0.1 [m/s²]	59 %	30 %		
Stiffness criterion	0.202 [mm]	0.25 [mm]	0.5 [mm]	81 %	40 %	✓	✓

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Support reaction

Load case category	k_{mod}	A_V	B_V
		[kN]	
self weight structure	0.6	3.04	3.04
		3.04	3.04
dead load	0.6	4.47	5.72
		4.47	5.72
live load cat. A: domestic, residential areas	0.8	6.11	7.34
		0.00	0.00

Reference documents for this analysis

English title	Description
EN 338	EN 338 - Structural timber ? Strength classes
EN 1995-1-1	EN 1995-1-1 - Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
ETA-14/0349	European Technical Assessment ETA-14/0349
Expertise Rolling shear - no edge gluing, [redacted]	Expertise on Rolling shear for CLT
EN 1995-1-2	EN 1995-1-2 - Eurocode 5 — Design of timber structures — Part 1-2: General — Structural fire design
Technical expertise 122/2011/02: analysis of load bearing capacity and separation performance of CLT elements	Verification of the load bearing capacity and the insulation criterion of CLT structures with Stora Enso CLT
Technical expertise 2434/2012 - BB: failure time tf of gypsum fire boards (GKF) according to ON B 3410	Expertise on failure time tf of gypsum wall fire boards according to ON B3410 and gypsum wall boards type DF according to EN 520
EN 1990	EN 1990 - Eurocode ? Basis of structural design
Fire safety in timber buildings - technical guildeline for Europe	Fire safety in timber buildings - technical guideline for Europe; publishes by SP Technical Research Institute of Sweden
National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12	ÖNORM EN 1995-1-2 - National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12
Expertise Rolling shear, [redacted]	Expertise on rolling shear strength and rolling shear modulus of CLT panels
ÖNORM EN 1995-1-1_NA, chapter 7.3	ÖNORM EN 1995-1-1 - Austria - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General- Common rules and rules for buildings; chapter 7.3

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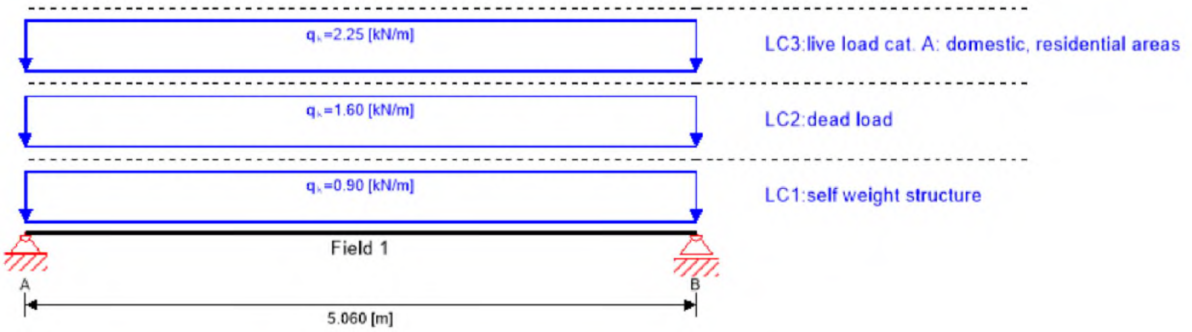
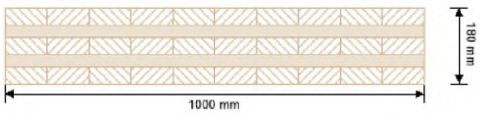
System



Global utilization ratio									78 %
ULS	27 %	ULS Fire	14 %	SLS	78 %	Vibration	0 %	Support	-1 %

Product data

Section: CLT 180 L5s



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	30.0 mm	90°	C24 spruce ETA (2022)
3	40.0 mm	0°	C24 spruce ETA (2022)
4	30.0 mm	90°	C24 spruce ETA (2022)
5	40.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**180.0 mm**		

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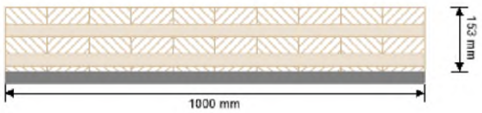
Section Fire: CLT 180 L5s



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	30.0 mm	90°	C24 spruce ETA (2022)
3	40.0 mm	0°	C24 spruce ETA (2022)
4	30.0 mm	90°	C24 spruce ETA (2022)
5	13.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**153.0 mm**		
Time	**30 min**		

Fire resistance class: R 30

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	20.0	27.0	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 (2022)	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	Type	Duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1	self weight structure	G	permanent	0.6	1	1.35	1	1	1
LC2	dead load	G	permanent	0.6	1	1.35	1	1	1
LC3	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.4	0.5	0.3

LC1:self weight structure

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continuous load	
Field	q_k [kN/m]
1	0.9

LC2:dead load

continuous load	
Field	q_k [kN/m]
1	1.6

LC3:live load cat. A: domestic, residential areas

continuous load	
Field	q_k [kN/m]
1	2.25

ULS Combinations

	Combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC2
LCO2	1.20/1.00 * LC1 + 1.20/1.00 * LC2 + 1.50/0.00 * LC3

ULS Combinations Fire

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

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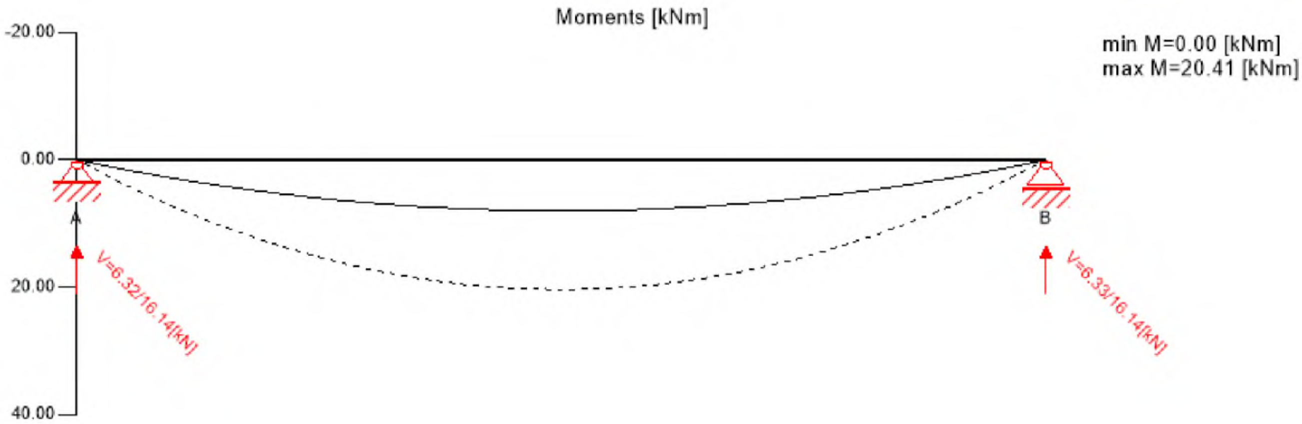
SLS Characteristic Combination

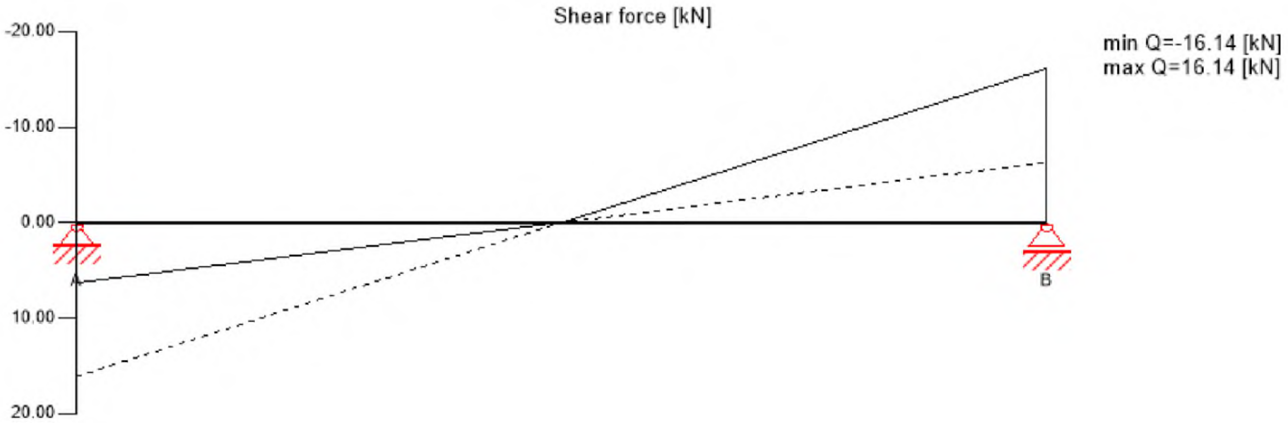
	Combination rule
LCO5	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO6	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC3

SLS Quasi-permanent Combination

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

Ultimate limit state (ULS) - design results





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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	2.53	24.00	1.25	0.80	1.10	16.90	20.41	-4.50	27%	LCO2

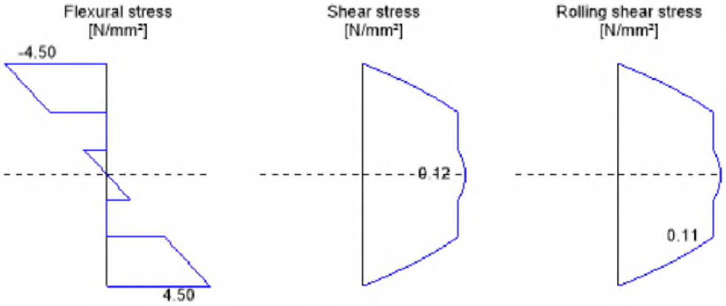
ULS Shear analysis

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	5.06	4.00	1.25	0.80	2.56	-16.14	0.12	5%	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	5.06	1.15	1.25	0.80	0.74	-16.14	0.11	15%	LCO2

Stress diagram



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Flexural stress analysis

$M_{y,d}$ =	20.41	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.80	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	8.96	N/mm²	
$\sigma_{m,y,d}$ =	-4.50	N/mm²		$f_{m,y,d}$ =	16.90	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓

Utilization ratio 27%

Rolling shear analysis

V_d =	-16.14	kN		$f_{r,k}$ =	1.15	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.80	-	
$\tau_{r,d}$ =	0.11	N/mm²	<	$f_{r,d}$ =	0.74	N/mm²	✓

Utilization ratio 15%

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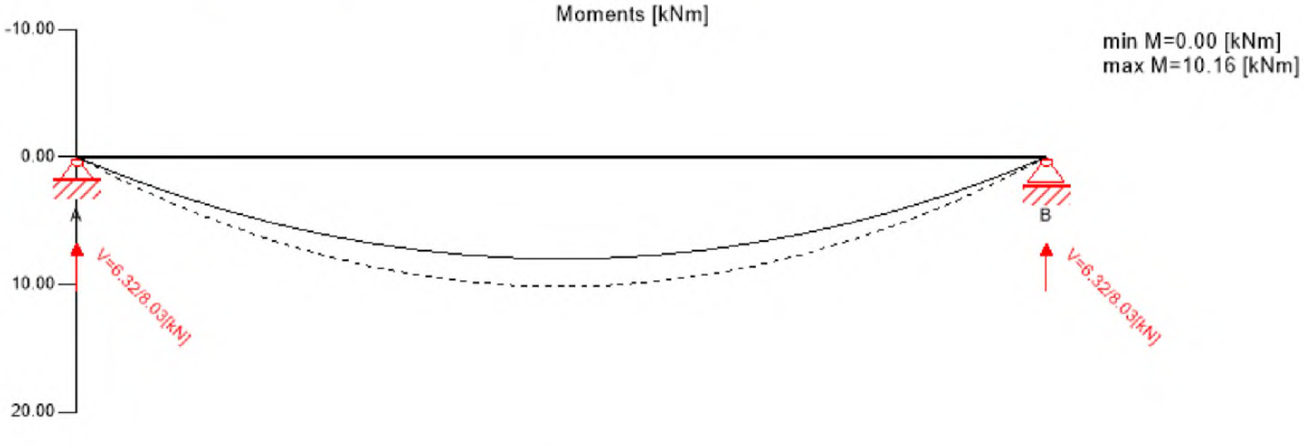
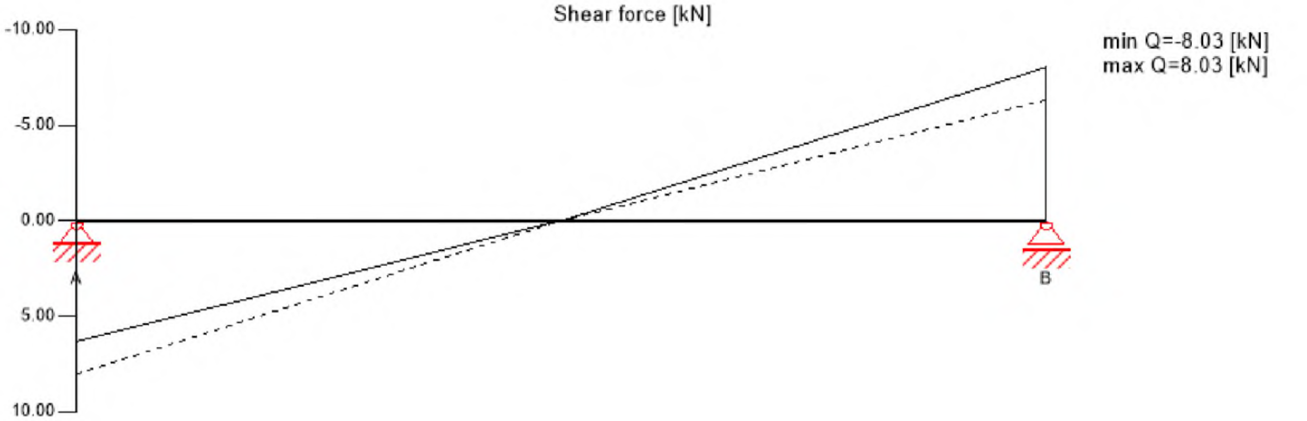
Ultimate limit state (ULS) fire design - results





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	2.53	24.00	1.00	1.00	1.10	1.15	30.36	10.16	4.28	14%	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	5.06	4.00	1.00	1.00	1.15	4.60	-8.03	0.08	2%	LCO4

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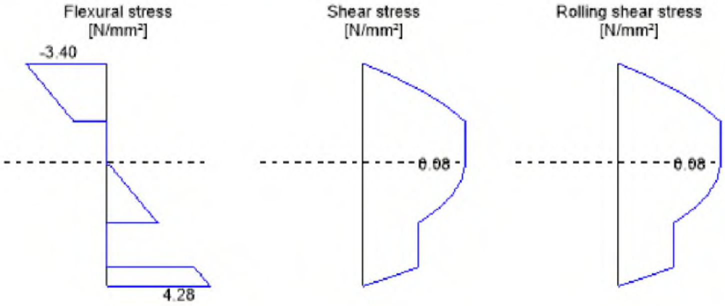
ULS Fire Rolling shear

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	5.06	1.15	1.00	1.00	1.15	1.32	-8.03	0.08	6%	LCO4

Stress diagram



Flexural stress analysis Fire

$M_{y,d}$ =	10.16	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
				k_{fi} =	1.15	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	16.10	N/mm²	
$\sigma_{m,y,d}$ =	4.28	N/mm²		$f_{m,y,d}$ =	30.36	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓

Utilization ratio 14%

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Rolling shear analysis Fire

V_d =	-8.03	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%**

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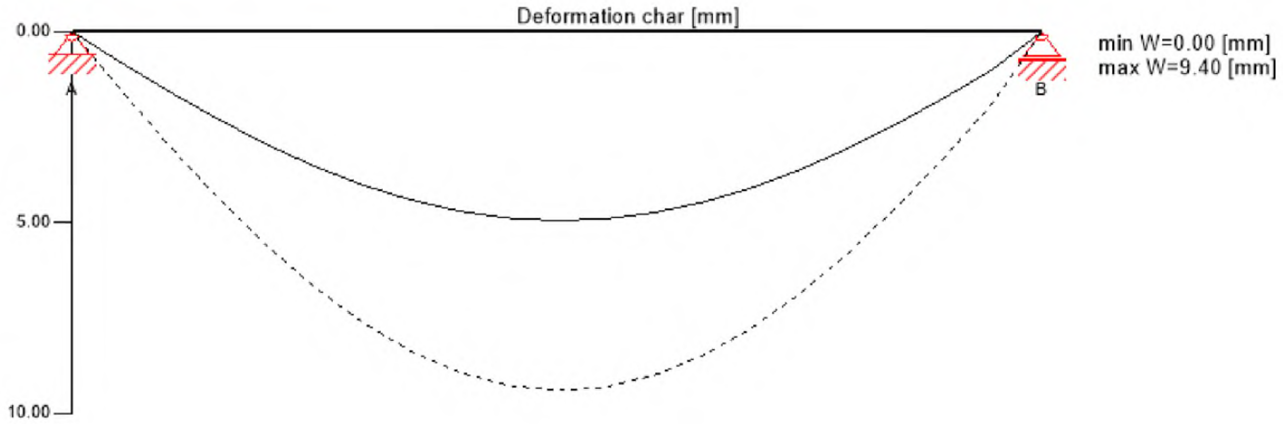
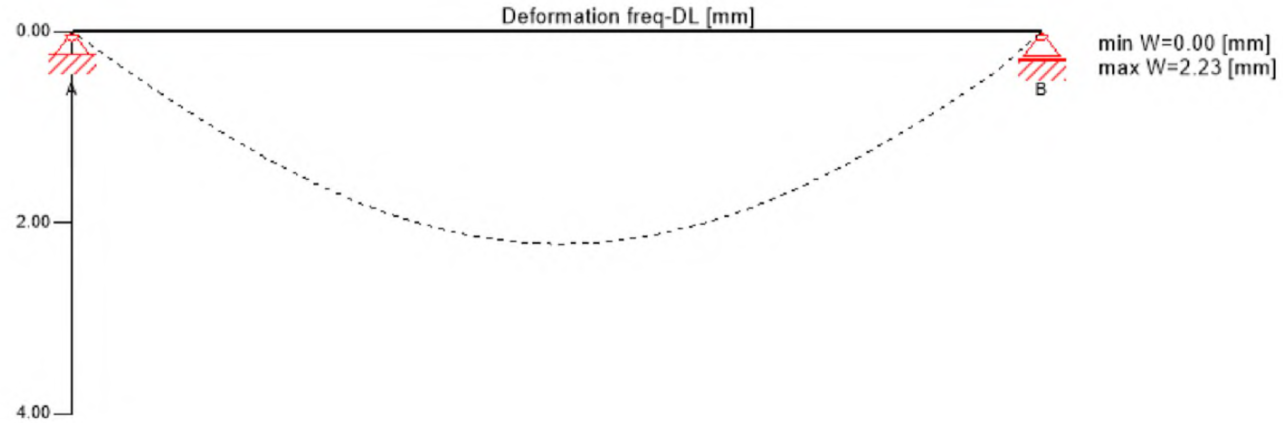
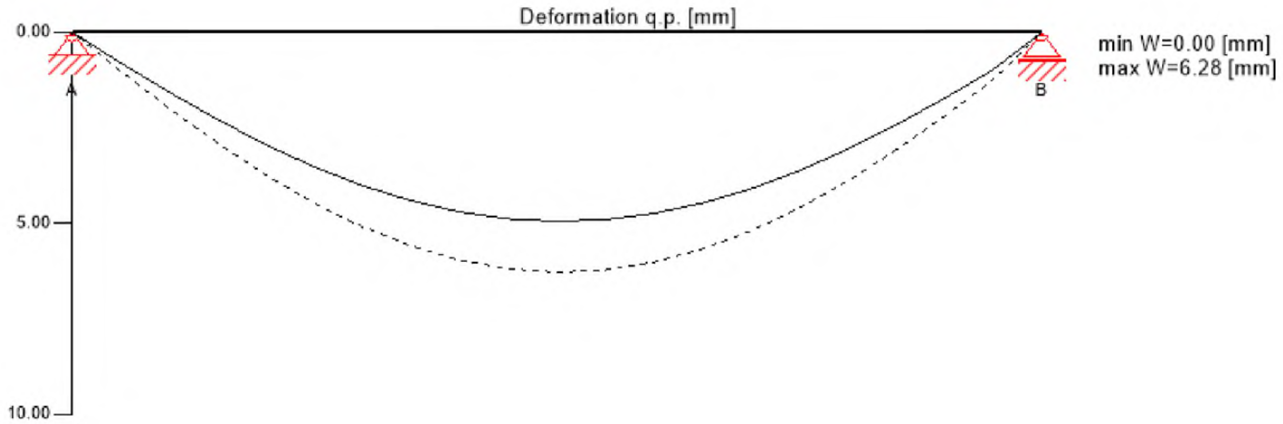
Service limit state design (SLS) - design results







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w_{inst} = w[char]					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	1	L/250	20.2	9.4	46%

w_{fin} = w[char] + w[q.p.]*kdef					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	1	L/250	20.2	15.7	78%

$w_{net,fin}$ = w[frq] - w[D.L] + w[q.p.]*kdef					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	1	L/333	15.2	8.5	56%

Support reaction			
Load case category	k_{mod}	A_V	B_V
		[kN]	
self weight structure	0.6	2.28	2.28
		2.28	2.28
dead load	0.6	4.05	4.05
		4.05	4.05
live load cat. A: domestic, residential areas	0.8	5.69	5.69
		0.00	0.00

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Reference documents for this analysis

English title	Description
EN 338	EN 338 - Structural timber ? Strength classes
EN 1995-1-1	EN 1995-1-1 - Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
ETA-14/0349	European Technical Assessment ETA-14/0349
Expertise Rolling shear - no edge gluing, [redacted]	Expertise on Rolling shear for CLT
EN 1995-1-2	EN 1995-1-2 - Eurocode 5 — Design of timber structures — Part 1-2: General — Structural fire design
Technical expertise 122/2011/02: analysis of load bearing capacity and separation performance of CLT elements	Verification of the load bearing capacity and the insulation criterion of CLT structures with Stora Enso CLT
Technical expertise 2434/2012 - BB: failure time tf of gypsum fire boards (GKF) according to ON B 3410	Expertise on failure time tf of gypsum wall fire boards according to ON B3410 and gypsum wall boards type DF according to EN 520
EN 1990	EN 1990 - Eurocode ? Basis of structural design
Fire safety in timber buildings - technical guildeline for Europe	Fire safety in timber buildings - technical guideline for Europe; publishes by SP Technical Research Institute of Sweden
National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12	ÖNORM EN 1995-1-2 - National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12
Expertise Rolling shear, [redacted]	Expertise on rolling shear strength and rolling shear modulus of CLT panels
ÖNORM EN 1995-1-1_NA, chapter 7.3	ÖNORM EN 1995-1-1 - Austria - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General- Common rules and rules for buildings; chapter 7.3

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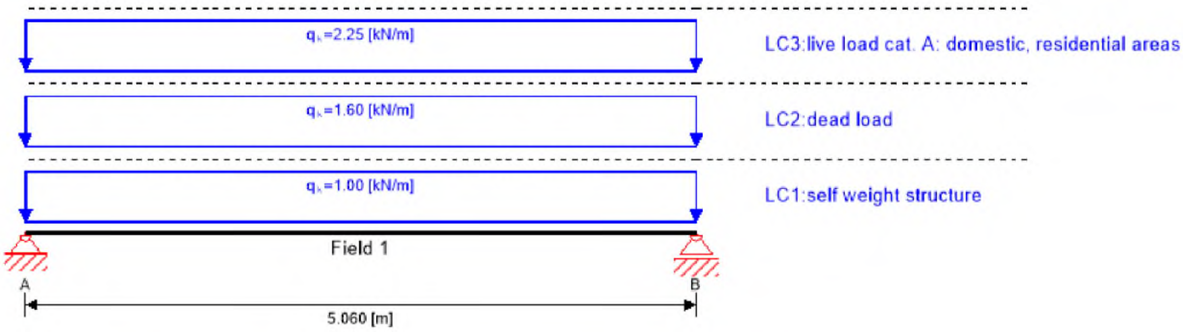
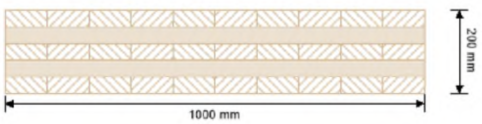
System



Global utilization ratio									**85 %**
ULS	23 %	ULS Fire	13 %	SLS	59 %	Vibration	85 %	Support	-1 %

Product data

Section: CLT 200 L5s



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	40.0 mm	90°	C24 spruce ETA (2022)
3	40.0 mm	0°	C24 spruce ETA (2022)
4	40.0 mm	90°	C24 spruce ETA (2022)
5	40.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**200.0 mm**		

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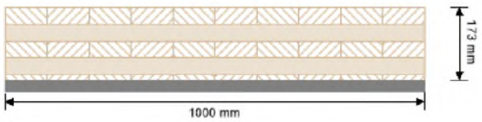
Section Fire: CLT 200 L5s



Layer	Thickness [mm]	Orientation	Material
1	40.0 mm	0°	C24 spruce ETA (2022)
2	40.0 mm	90°	C24 spruce ETA (2022)
3	40.0 mm	0°	C24 spruce ETA (2022)
4	40.0 mm	90°	C24 spruce ETA (2022)
5	13.0 mm	0°	C24 spruce ETA (2022)
t_{CLT}	**173.0 mm**		
Time	**30 min**		

Fire resistance class: R 30

Fire protection layering:
no additional fire protection

k_0 [-]	d_0 [mm]	$d_{char,0,h}$ [mm]	$d_{ef,h}$ [mm]	$d_{char,0,v}$ [mm]	$d_{ef,v}$ [mm]
1	7	20.0	27.0	0.0	0.0

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 (2022)	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	Type	Duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC1	self weight structure	G	permanent	0.6	1	1.35	1	1	1
LC2	dead load	G	permanent	0.6	1	1.35	1	1	1
LC3	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.4	0.5	0.3

LC1:self weight structure

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continuous load	
Field	q_k [kN/m]
1	0.9999999

LC2:dead load

continuous load	
Field	q_k [kN/m]
1	1.6

LC3:live load cat. A: domestic, residential areas

continuous load	
Field	q_k [kN/m]
1	2.25

ULS Combinations	
	Combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC2
LCO2	1.20/1.00 * LC1 + 1.20/1.00 * LC2 + 1.50/0.00 * LC3

ULS Combinations Fire	
	Combination rule
LCO3	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO4	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * 0.30 * LC3

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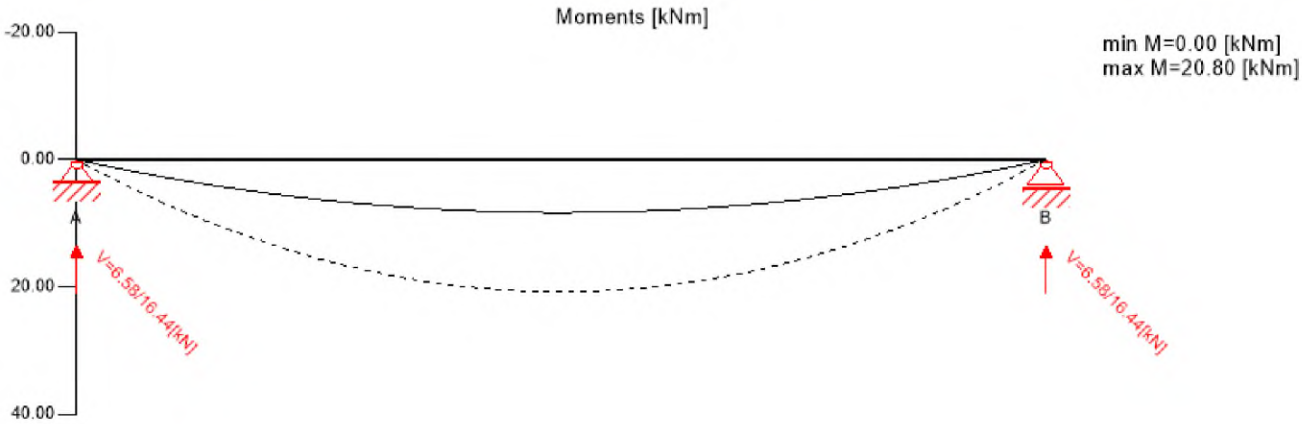
SLS Characteristic Combination

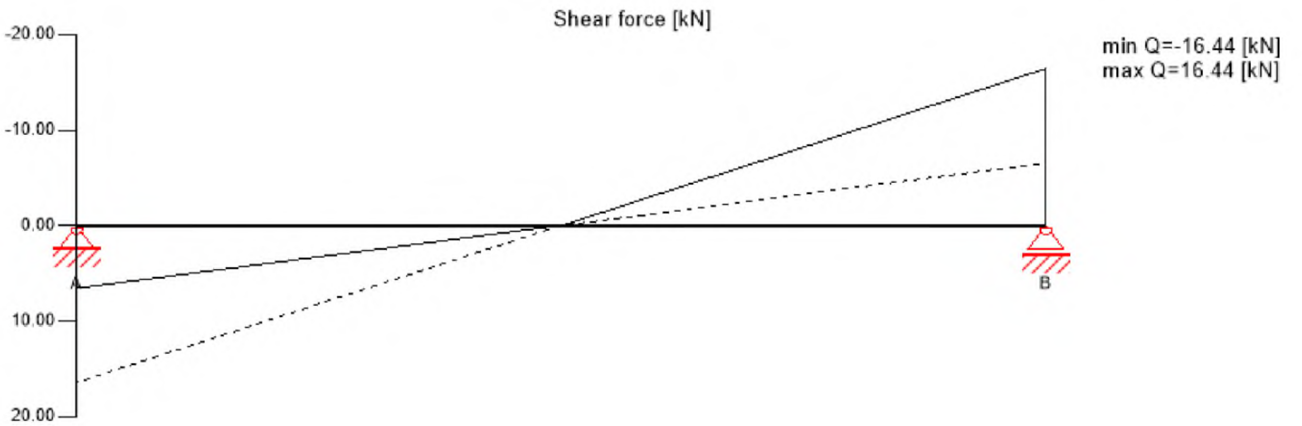
	Combination rule
LCO5	1.00/1.00 * LC1 + 1.00/1.00 * LC2
LCO6	1.00/1.00 * LC1 + 1.00/1.00 * LC2 + 1.00/0.00 * LC3

SLS Quasi-permanent Combination

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

Ultimate limit state (ULS) - design results





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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	2.53	24.00	1.25	0.80	1.10	16.90	20.80	-3.94	23%	LCO2

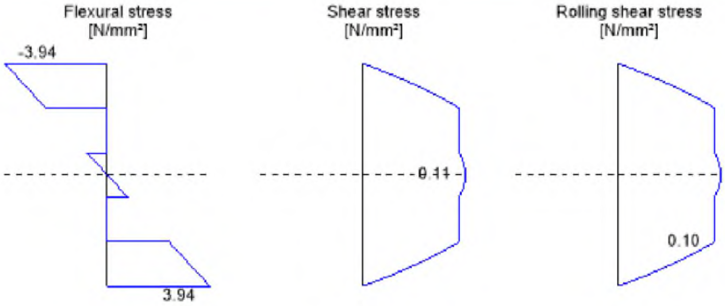
ULS Shear analysis

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	5.06	4.00	1.25	0.80	2.56	-16.44	0.11	4%	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	5.06	1.05	1.25	0.80	0.67	-16.44	0.10	15%	LCO2

Stress diagram



Flexural stress analysis

$M_{y,d}$ =	20.80	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.25	-	
				k_{mod} =	0.80	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	8.96	N/mm²	
$\sigma_{m,y,d}$ =	-3.94	N/mm²		$f_{m,y,d}$ =	16.90	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓
Utilization ratio							**23%**

Rolling shear analysis

V_d =	-16.44	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.25	-	
				k_{mod} =	0.80	-	
$\tau_{r,d}$ =	0.10	N/mm²	<	$f_{r,d}$ =	0.67	N/mm²	✓
Utilization ratio							**15%**

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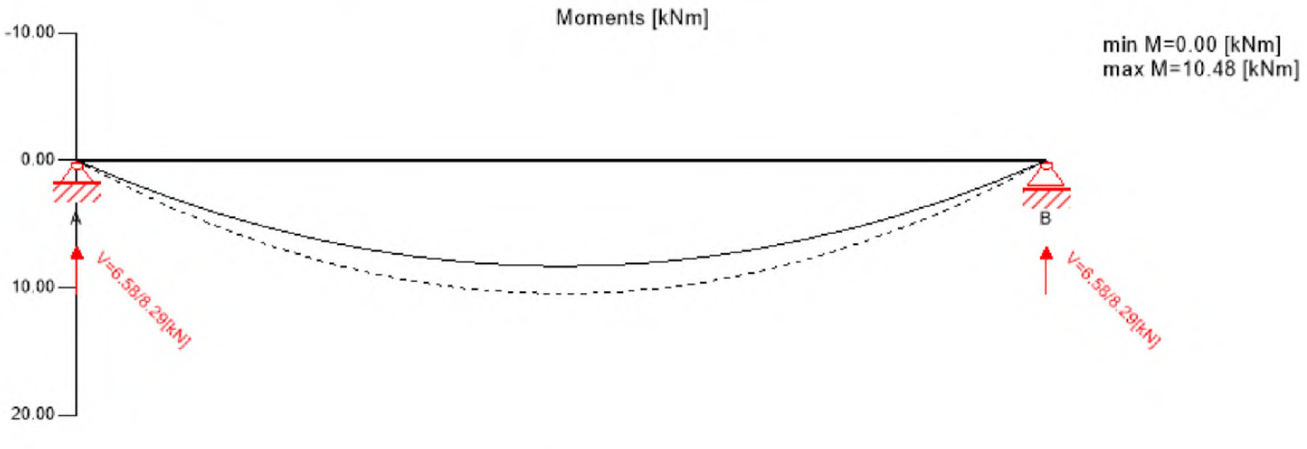
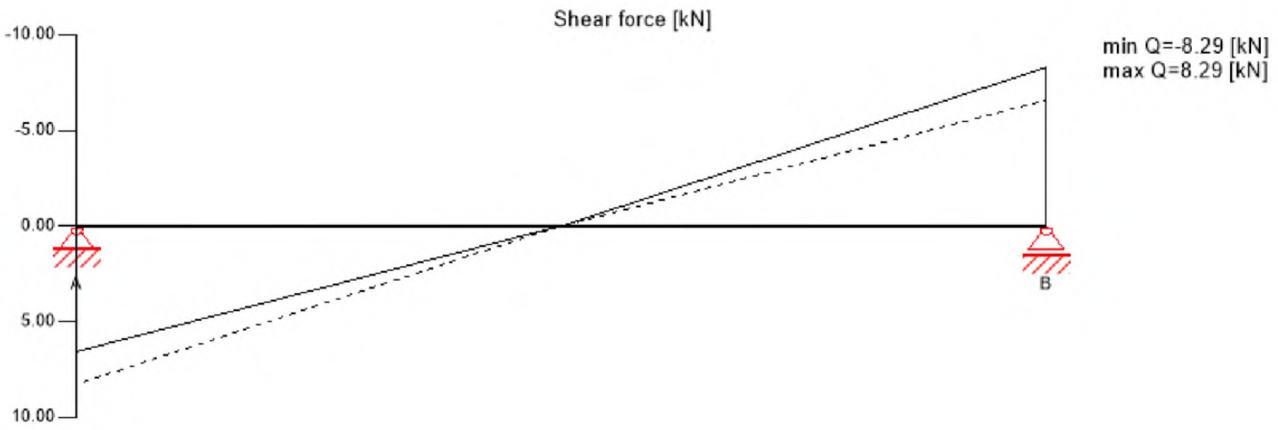
Ultimate limit state (ULS) fire design - results





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	2.53	24.00	1.00	1.00	1.10	1.15	30.36	10.48	3.87	13%	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	0.0	4.00	1.00	1.00	1.15	4.60	8.29	0.07	1%	LCO4

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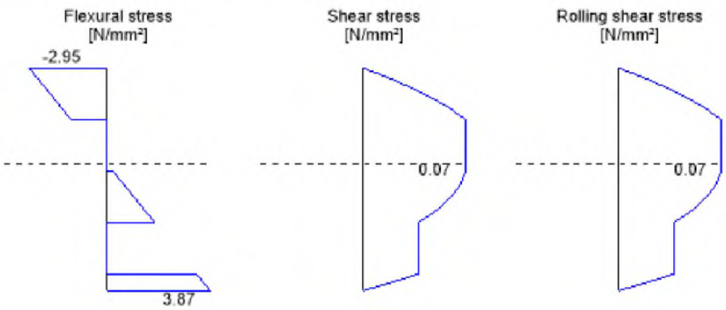
ULS Fire Rolling shear

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	0.0	1.05	1.00	1.00	1.15	1.21	8.29	0.07	6%	LCO4

Stress diagram



Flexural stress analysis Fire

$M_{y,d}$ =	10.48	kNm		$f_{m,k}$ =	24.00	N/mm²	
$M_{z,d}$ =	0.00	kNm		$f_{m,k,z}$ =	24.00	N/mm²	
$N_{t,d}$ =	0.00	kN		γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				$k_{sys,y}$ =	1.10	-	
				$k_{h,m,y}$ =	1.00	-	
				$k_{h,m,z}$ =	1.00	-	
				k_l =	1.00	-	
				k_{fi} =	1.15	-	
$\sigma_{t,d}$ =	0.00	N/mm²		$f_{t,0,d}$ =	16.10	N/mm²	
$\sigma_{m,y,d}$ =	3.87	N/mm²		$f_{m,y,d}$ =	30.36	N/mm²	
$\sigma_{m,z,d}$ =	0.00	N/mm²	<	$f_{m,z,d}$ =	0.00	N/mm²	✓

Utilization ratio 13%

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Rolling shear analysis Fire

V_d =	8.29	kN		$f_{r,k}$ =	1.05	N/mm²	
				γ_m =	1.00	-	
				k_{mod} =	1.00	-	
				k_{fi} =	1.15	-	
$\tau_{r,d}$ =	0.07	N/mm²	<	$f_{r,d}$ =	1.21	N/mm²	✓
Utilization ratio							**6%**

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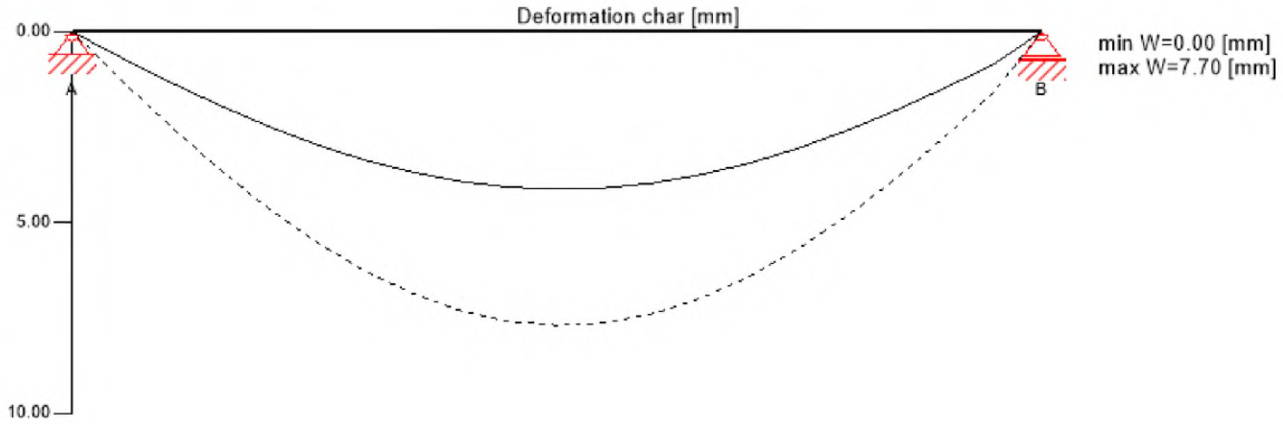
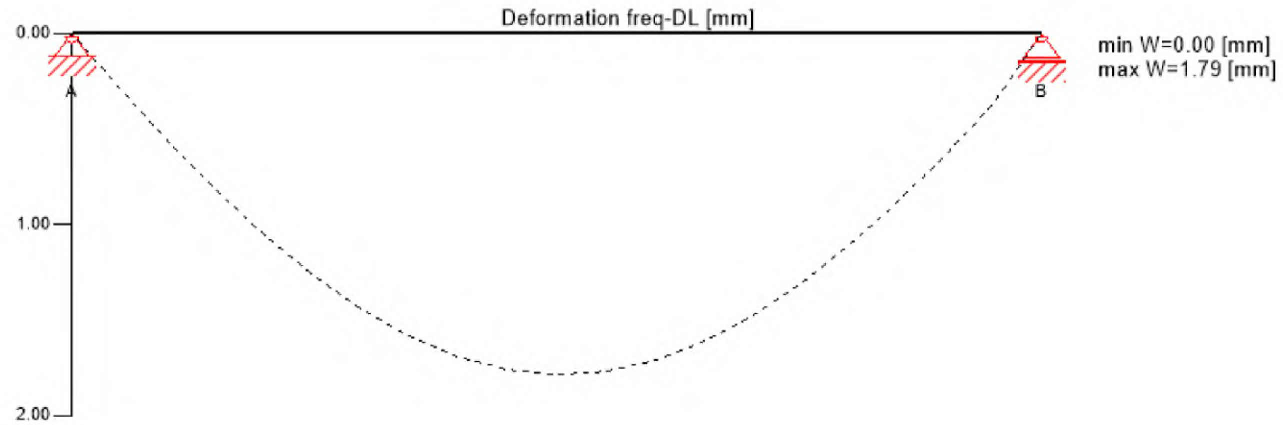
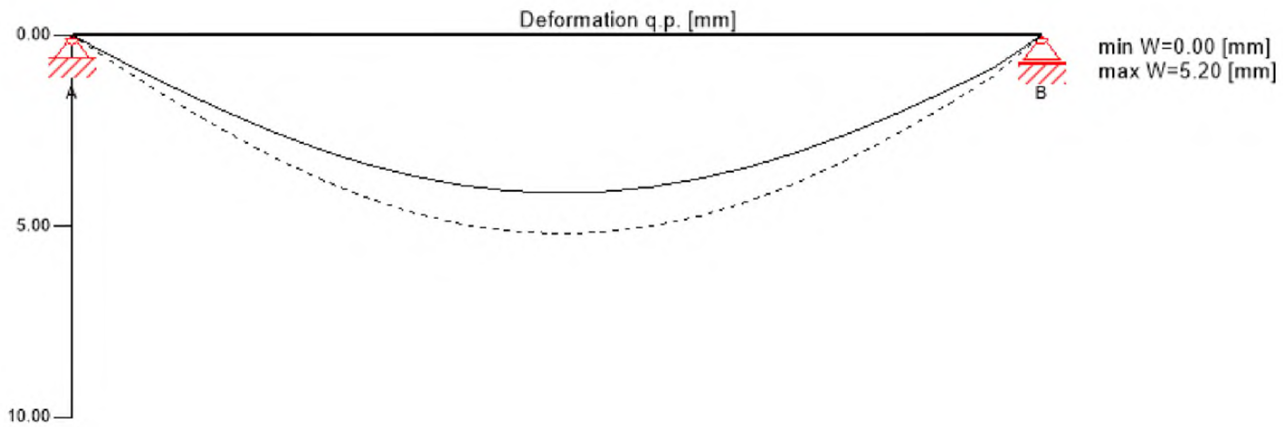
Service limit state design (SLS) - design results







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w_{inst} = w[char]					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	0.8	L/250	20.2	7.7	38%

w_{fin} = w[char] + w[q.p.]*kdef					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	0.8	L/250	20.2	11.9	59%

$w_{net,fin}$ = w[frq] - w[D.L] + w[q.p.]*kdef					
Field	**K_{def}**	**Limit**	**w_{limit}**	**$w_{calc.}$**	**Ratio**
		[-]	[mm]	[mm]	
1	0.8	L/333	15.2	5.9	39%

Vibration analysis

General		
Total mass	1.34	[t]
Tributary width	1.0	[m]
Stiffness Longitudinal direction	6336.0	[kNm²]
Stiffness Cross direction	1664.0	[kNm²]
Modal damping	1.0	[%]
α	0.0	[-]
Man weight	700.0	[N]
Modal mass	669.8	[kg]

Analysis				
Criterion	Calc.	Class II	Class II	Cl. II
Frequency criterion min	9.488 [Hz]	4.5 [Hz]	47 %	✓
Frequency criterion	9.488 [Hz]	6.0 [Hz]	63 %	
Acceleration criterion	0.47 [m/s²]	0.1 [m/s²]	470 %	
Stiffness criterion	0.426 [mm]	0.5 [mm]	85 %	✓

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Support reaction

Load case category	k_{mod}	A_V	B_V
		[kN]	
self weight structure	0.6	2.53	2.53
		2.53	2.53
dead load	0.6	4.05	4.05
		4.05	4.05
live load cat. A: domestic, residential areas	0.8	5.69	5.69
		0.00	0.00

Reference documents for this analysis

English title	Description
EN 338	EN 338 - Structural timber ? Strength classes
EN 1995-1-1	EN 1995-1-1 - Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
ETA-14/0349	European Technical Assessment ETA-14/0349
Expertise Rolling shear - no edge gluing, [redacted]	Expertise on Rolling shear for CLT
EN 1995-1-2	EN 1995-1-2 - Eurocode 5 — Design of timber structures — Part 1-2: General — Structural fire design
Technical expertise 122/2011/02: analysis of load bearing capacity and separation performance of CLT elements	Verification of the load bearing capacity and the insulation criterion of CLT structures with Stora Enso CLT
Technical expertise 2434/2012 - BB: failure time tf of gypsum fire boards (GKF) according to ON B 3410	Expertise on failure time tf of gypsum wall fire boards according to ON B3410 and gypsum wall boards type DF according to EN 520
EN 1990	EN 1990 - Eurocode ? Basis of structural design
Fire safety in timber buildings - technical guildeline for Europe	Fire safety in timber buildings - technical guideline for Europe; publishes by SP Technical Research Institute of Sweden
National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12	ÖNORM EN 1995-1-2 - National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12
Expertise Rolling shear, [redacted]	Expertise on rolling shear strength and rolling shear modulus of CLT panels
ÖNORM EN 1995-1-1_NA, chapter 7.3	ÖNORM EN 1995-1-1 - Austria - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General- Common rules and rules for buildings; chapter 7.3

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