ZÜBLIN Timber
www.zueblin-timber.com

LENO®

Cross Laminated Timber (CLT)

ZÜBLIN
WORK ON PROGRESS

1 Wine hotel, Gengenbach (DE); © Pfeffer & Salz

LENO® Cross Laminated Timber (CLT)

LENO®. For 30 years, this name has been a synonym for large-format mass timber building components – factory-engineered wall, floor and roof elements made by cross-laminating spruce boards cut to millimetre precision.

The CLT panels can be manufactured in dimensions up to 4.80m wide and 20.00m long, with a thickness varying from 60mm to 320mm to ensure the most cost-effective option under different load conditions.

The cross-laminated structure, with each layer of board oriented perpendicular to the adjacent layers and glued together with a strong and durable adhesive bond, creates components that are rigid and resistant to warping. As standard floor, roof or wall panels, or as custom-designed, precision-prefabricated and ready-to-install modular building systems, the relatively simple structural design from a construction physics point of view guarantees cost-effective applications in all areas of the construction process. More information can be found on our homepage. Also try our new design program, free of charge in our download area: **www.zueblin-timber.com/downloads.**

1 Residential house, Rickenbach (DE); © Markus Guhl Fotografie/ **2** University Witten/ Herdecke (DE); © Johannes Buldmann

Material Properties

Dimensions
- Length up to 14.80m (up to 20m on request)
- Width up to 4.80m
- Thickness from 60mm to 320mm
- All elements are individually made to measure. The grain direction of the outer layers can either run along the length or the width of the panels.

Timber species
- Softwood

Surfaces
- Industrial, industrial visual, nordic visual
- Special surfaces (see pages 20/21)
- Drywall, insulation

Panel types
- Wall, floor and roof elements
- Party walls
- Curved shell structures
- Bridges
- Lift shafts
- Stairs

Processing
- Format cut
- Window and door openings, recesses
- Milling, cut-outs for joints
- Cut-outs for lifting loops
- Special trims
- 3D trims

Gluing
- Polyurethane adhesive bond in E1 emission class

Moisture content
- 12% ± 2%

Movement
- In the panel plane ~ 0.01% per % moisture content change
- Perpendicular to the panel plane ~ 0.2% per % moisture content change

Weight
- Characteristic density ρ_k = 350kg/m³ (for connector/fastener design)
- Specific weight approx. 5kN/m³ (for design load)

1 Stroud Chapel (UK); © Fernando Mañoso

Cross sections

Cross section values for standard LENO® panels

Description	Number of layers	Composition bold = parallel to outer layers	Thickness	Self weight	A_{tot}	W_{tot}	I_{tot}
LENO®		mm	mm	kN/m²	cm²	cm³	cm⁴
60	3	**20**-20-**20**	60	0.30	600	600	1,800
70	3	**20**-30-**20**	70	0.35	700	817	2,858
80	3	**20**-40-**20**	80	0.40	800	1,067	4,267
80	4	**20**-20-20-**20**	80	0.40	800	1,067	4,267
90	3	**30**-30-**30**	90	0.45	900	1,350	6,075
90	4	**20**-30-20-**20**	90	0.45	900	1,350	6,075
100	3	**30**-40-**30**	100	0.50	1,000	1,667	8,333
100	4	**30**-20-20-**30**	100	0.50	1,000	1,667	8,333
100	5	**20**-20-**20**-20-**20**	100	0.50	1,000	1,667	8,333
120	3	**40**-40-**40**	120	0.60	1,200	2,400	14,400
120	5	**30**-20-**20**-20-**30**	120	0.60	1,200	2,400	14,400
130	5	**30**-20-**30**-20-**30**	130	0.65	1,300	2,817	18,308
140	5	**40**-20-**20**-20-**40**	140	0.70	1,400	3,267	22,867
150	5	**40**-20-**30**-20-**40**	150	0.75	1,500	3,750	28,125
160	5	**40**-20-**40**-20-**40**	160	0.80	1,600	4,267	34,133
170	5	**40**-30-**30**-30-**40**	170	0.85	1,700	4,817	40,942
180	5	**40**-30-**40**-30-**40**	180	0.90	1,800	5,400	48,600
190	5	**40**-40-**30**-40-**40**	190	0.95	1,900	6,017	57,158
200	5	**40**-40-**40**-40-**40**	200	1.00	2,000	6,667	66,667
210	7	**30**-**30**-30-**30**-30-**30**-**30**	210	1.05	2,100	7,350	77,175
220	7	**40**-**40**-20-**20**-20-**40**-**40**	220	1.10	2,200	8,067	88,733
230	7	**30**-**40**-30-**30**-30-**40**-**30**	230	1.15	2,300	8,817	101,392
240	7	**40**-**40**-20-**40**-20-**40**-**40**	240	1.20	2,400	9,600	115,200
250	7	**40**-**40**-30-**30**-30-**40**-**40**	250	1.25	2,500	10,417	130,208
260	7	**40**-**40**-40-**20**-40-**40**-**40**	260	1.30	2,600	11,267	146,467
270	7	**40**-**40**-40-**30**-40-**40**-**40**	270	1.35	2,700	12,150	164,025
280	7	**40**-**40**-40-**40**-40-**40**-**40**	280	1.40	2,800	13,067	182,933
290	9	**40**-**30**-30-**30**-30-**30**-30-**30**-**40**	290	1.45	2,900	14,017	203,242
300	9	**40**-**40**-20-**40**-20-**40**-20-**40**-**40**	300	1.50	3,000	15,000	225,000
320	9	**40**-**40**-20-**40**-40-**40**-20-**40**-**40**	320	1.60	3,200	17,067	273,067

Notes:

- Values based on 1m panel width, with cross sections optimised for one directional load transfer.
- Manufacture and pre-dimension of special cross sections, especially for bi-directional load transfer, is possible and available on request.

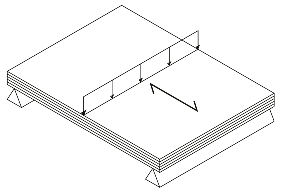
1 House by the lake (DE); © Florian Holzherr

Structural Parameters

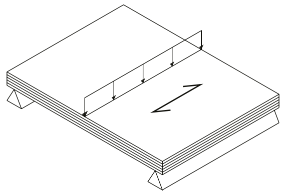
LENO® standard cross sections for design according to simplified design method (based on gross cross-section)

Load perpendicular to the panel plane
DIN EN 1995-1-1: 2010-12

Grain direction of outer layer parallel to span



Grain direction of outer layer perpendicular to span



Value[1]		E_{mean}	Rigidity[1] E x I	$f_{m,k}$	$f_{v,k}$	E_{mean}	Rigidity[1] E x I	$f_{m,k}$	$f_{v,k}$
LENO®	Layers	N/mm²	E+12 Nmm²	N/mm²	N/mm²	N/mm²	E+12 Nmm²	N/mm²	N/mm²
60	3	10,590	0.191	23.11	0.76	410	0.007	8.00	1.90
70	3	10,130	0.290	22.11	0.79	870	0.025	10.29	1.63
80	3	9,620	0.411	21.00	0.82	1,380	0.059	12.00	1.43
90	3	10,590	0.644	23.11	0.76	410	0.025	8.00	1.27
100	3	10,300	0.858	22.46	0.78	700	0.059	9.60	1.14
100	5	8,710	0.726	19.01	0.87	2,290	0.191	9.60	2.28
120	3	10,590	1.525	23.11	0.76	410	0.059	8.00	0.95
120	5	9,680	1.393	21.11	0.82	1,320	0.191	8.00	1.90
130	5	9,420	1.724	20.55	0.84	1,580	0.290	7.38	1.76
140	5	10,170	2.325	22.18	0.79	830	0.191	6.86	1.63
150	5	9,970	2.804	21.75	0.81	1,030	0.290	6.40	1.52
160	5	9,800	3.344	21.38	0.83	1,200	0.411	6.00	1.43
170	5	9,430	3.860	20.57	0.83	1,570	0.644	8.47	1.34
180	5	9,230	4.488	20.15	0.85	1,770	0.858	8.00	1.27
190	5	8,910	5.092	19.44	0.85	2,090	1.195	10.11	1.20
200	5	8,710	5.808	19.01	0.87	2,290	1.525	9.60	1.14
210	7	10,170	7.846	22.18	0.79	830	0.644	6.86	1.09
220	7	10,790	9.570	23.53	0.74	210	0.191	4.36	1.04
230	7	10,370	10.510	22.62	0.78	630	0.644	6.26	0.99
240	7	10,640	12.261	23.22	0.76	360	0.411	4.00	0.95
250	7	10,510	13.679	22.92	0.77	490	0.644	5.76	0.91
260	7	10,380	15.202	22.65	0.78	620	0.909	7.38	0.88
270	7	10,270	16.847	22.41	0.78	730	1.195	7.11	0.85
280	7	10,170	18.597	22.18	0.79	830	1.525	6.86	0.81
290	9	9,790	19.906	21.37	0.76	1,210	2.450	7.45	1.18
300	9	10,290	23.144	22.44	0.74	710	1.606	4.80	1.14
320	9	10,180	27.808	22.22	0.74	820	2.229	6.00	1.07

[1] for 1m of panel

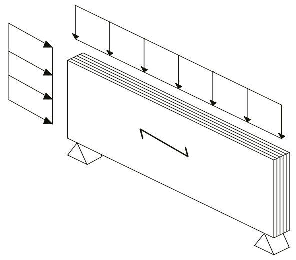
Modicication factors

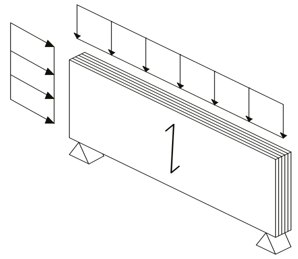
Load duration	Service Class 1	Service Class 2
Permanent	0.60	0.60
Long term	0.70	0.70
Medium term	0.80	0.80
Short term	0.90	0.90
Instantaneous	1.10	1.10

Notes:
- The characteristic value of the E-modulus is $E_{05} = \frac{5}{6} \cdot E_{mean}$
- Shear deflection only needs to be calculated if the ratio of element length (L) and element thickness (T) is less than 30 (L/T < 30). The shear modulus is then G = 60 N/mm² and the shear rigidity is calculated using the full element thickness.

LENO® standard cross-sections for design according to simplified design method (based on gross cross-section)

Load within the panel plane
DIN EN 1995-1-1: 2010-12





Value[1]		$E_{0,mean}$	$f_{m,0,k}$	$f_{t,0,k}$	$f_{c,0,k}$ [2]	i_0	$E_{90,mean}$	$f_{m,90,k}$	$f_{t,90,k}$	$f_{c,90,k}$ [2]	i_{90}	$f_{v,k}$
LENO®	Layers	N/mm²	N/mm²	N/mm²	N/mm²	mm	N/mm²	N/mm²	N/mm²	N/mm²	mm	N/mm²
60	3	7,330	16.00	9.33	14.00	20.8	3,670	8.00	4.67	7.00	5.8	1.90
70	3	6,290	13.71	8.00	12.00	25.7	4,710	10.29	6.00	9.00	8.7	1.63
80	3	5,500	12.00	7.00	10.50	30.6	5,500	12.00	7.00	10.50	11.5	1.43
80	4	5,500	12.00	7.00	10.50	30.6	5,500	12.00	7.00	10.50	11.5	1.43
90	3	7,330	16.00	9.33	14.00	31.2	3,670	8.00	4.67	7.00	8.7	1.27
90	4	4,890	10.67	6.22	9.33	35.5	6,110	13.33	7.78	11.67	14.4	1.27
100	3	6,600	14.40	8.40	12.60	36.1	4,400	9.60	5.60	8.40	11.5	1.14
100	4	6,600	14.40	8.40	12.60	36.1	4,400	9.60	5.60	8.40	11.5	1.14
100	5	6,600	14.40	8.40	12.60	33.2	4,400	9.60	5.60	8.40	20.8	2.28
120	3	7,330	16.00	9.33	14.00	41.6	3,670	8.00	4.67	7.00	11.5	0.95
120	5	7,330	16.00	9.33	14.00	39.8	3,670	8.00	4.67	7.00	20.8	1.90
130	5	7,620	16.62	9.69	14.54	41.7	3,380	7.38	4.31	6.46	25.7	1.76
140	5	7,860	17.14	10.00	15.00	46.0	3,140	6.86	4.00	6.00	20.8	1.63
150	5	8,070	17.60	10.27	15.40	48.1	2,930	6.40	3.73	5.60	25.7	1.52
160	5	8,250	18.00	10.50	15.75	50.3	2,750	6.00	3.50	5.25	30.6	1.43
170	5	7,120	15.53	9.06	13.59	56.5	3,880	8.47	4.94	7.41	31.2	1.34
180	5	7,330	16.00	9.33	14.00	58.3	3,670	8.00	4.67	7.00	36.1	1.27
190	5	6,370	13.89	8.11	12.16	64.9	4,630	10.11	5.89	8.84	36.9	1.20
200	5	6,600	14.40	8.40	12.60	66.3	4,400	9.60	5.60	8.40	41.6	1.14
210	7	7,860	17.14	10.00	15.00	69.0	3,140	6.86	4.00	6.00	31.2	1.09
220	7	9,000	19.64	11.45	17.18	69.5	2,000	4.36	2.55	3.82	20.8	1.04
230	7	8,130	17.74	10.35	15.52	75.0	2,870	6.26	3.65	5.48	31.2	0.99
240	7	9,170	20.00	11.67	17.50	74.7	1,830	4.00	2.33	3.50	30.6	0.95
250	7	8,360	18.24	10.64	15.96	80.9	2,640	5.76	3.36	5.04	31.2	0.91
260	7	7,620	16.62	9.69	14.54	87.6	3,380	7.38	4.31	6.46	32.1	0.88
270	7	7,740	16.89	9.85	14.78	89.8	3,260	7.11	4.15	6.22	36.9	0.85
280	7	7,860	17.14	10.00	15.00	91.9	3,140	6.86	4.00	6.00	41.6	0.81
290	9	7,590	16.55	9.66	14.48	95.1	3,410	7.45	4.34	6.52	49.7	1.18
300	9	8,800	19.20	11.20	16.80	93.6	2,200	4.80	2.80	4.20	49.3	1.14
320	9	2,750	6.00	3.5	5.25	50.3	8,250	18.00	10.5	15.75	102.6	1.07

[1] The values of 0 or 90 relate to the direction of the outer layer; [2] Compression factor kc,90 = 1.0 for both load directions

Deformation factors

Deformation factor		
Service Class	1	2
k_{def}	0.60	0.80
Partial factor for material properties		
γ_M according to DIN EN 1995-1-1/NA		1.30*

* For other countries please refer to the local National Annex to EN 1995-1-1

Buckling factor table Values for GL 24c

λ	k_c	λ	k_c	λ	k_c
0-20	1.00	70	0.74	120	0.30
30	0.98	80	0.61	130	0.25
40	0.96	90	0.50	140	0.22
50	0.92	100	0.42	150	0.19
60	0.85	110	0.35	160	0.17

Structural Design – Span Table

These tables can be used for the initial design of LENO® floor and roof elements. The load is considered to be a uniformly distributed area load perpendicular to the plate with the grain direction of the outer surfaces parallel to the span direction. Load cases for floor construction and variable loads are according to EN 1991-1. The self weight of LENO® is already taken into account.

Permanent load g_k [kN/m²]	Variable load q_k [kN/m²]	Category	Single span 3.0m	3.5m	4.0m	4.5m	5.0m	5.5m	6.0m	6.5m	7.0m
1.0	1.5	A	90	100	120	130	150	160	180	210	210
	2.0			100		140		170	190		220
	2.8				130		160	180	210		230
	3.0	C	100		140	150	170	200		220	240
	4.0		120			160	190	210	220	230	250
	5.0			140	150	170	200			240	270
1.5	1.5	A	90	120	120	140	160	180	200	210	220
	2.0				130				210		230
	2.8		100		140	150	170	200		220	240
	3.0	C				160	180	210		230	250
	4.0		120	130	150	170	190		220	240	260
	5.0			140	160	180	210		230	250	270
2.0	1.5	A	100	120	130	150	170	190	210	220	240
	2.0				140						
	2.8					160	180	200		230	250
	3.0	C	120	130		170	190	210	220	240	260
	4.0			140	150	180	200		230	250	270
	5.0				160	190	210	220	240	260	280
2.5	1.5	A	100	120	140	150	170	200	210	220	250
	2.0					160	180			230	
	2.8		120			170	190	210	220	240	260
	3.0	C		130	150		200				
	4.0			140	160	180	210	220	240	250	280
	5.0					190				270	290
3.0	1.5	A		120	140	160	180	210	210	230	260
	2.0						190		220	240	
	2.8			130	150	170	200				
	3.0	C		140		180			230	250	270
	4.0				160	190	210	220	240	260	280
	5.0			150	170	200		230	250	270	240

Permanent load g_k [kN/m²]	Variable load q_k [kN/m²]	Category	Double span ($l_2 = 0{,}8 \times l_1$ up to $l_2 = l_1$) 3.0m	3.5m	4.0m	4.5m	5.0m	5.5m	6.0m	6.5m	7.0m
1.0	1.5	A	100	120	120	130	140	150	160	190	210
	2.0										
	2.8										
	3.0	C						160	170		
	4.0					140	150	170	190	210	
	5.0				130		160	180	200		220
1.5	1.5	A			120	130	140	160	180	200	180
	2.0										190
	2.8										200
	3.0	C					150				210
	4.0					140	160	170	190	210	220
	5.0				130	150	170	190	210		230
2.0	1.5	A			120	130	150	170	190	180	200
	2.0										210
	2.8									190	
	3.0	C				140				200	
	4.0				130		160	180	200	210	220
	5.0				140	150	170	190	210	220	230
2.5	1.5	A			120	140	160	180	160	190	210
	2.0								170		
	2.8								180	200	
	3.0	C							190	210	
	4.0				130	150			200		220
	5.0				140		170	190	210	220	240
3.0	1.5	A			120	140	160	180	170	200	210
	2.0								180		
	2.8								190	210	
	3.0	C							200		220
	4.0				140	150	170	190	210		230
	5.0					160	180	200		220	240

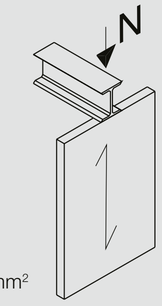
These tables show cross sections fulfilling the following criteria: **1)** Vibration design for evaluation category 1.5–2.5 [Winter/Hamm/Richter: "Schwingungstechnische Optimierung von Holz- und Holz-Beton-Verbunddecken", Final Report AiF 15283 N, 2009] / **2)** $w_{inst} \leq l/400$ [DIN EN 1995-1-1:2010-12, Tab. 7.2] / **3)** $w_{fin} \leq l/300$ [DIN EN 1995-1-1:2010-12, Tab. 7.2] / **4)** $w_{netfin} \leq l/350$ [DIN EN 1995-1-1:2010-12, Tab. 7.2]

Structural Design – Examples

LENO® panel with axial loading

Example: point load on top, narrow surface of wall element

HEB 300 on LENO® 90-3L, h = 3m,
N_d = 200 kN (short term)



Verification of compression:

- $A_{tot} = 300mm \cdot 90mm = 27{,}000mm^2$ (support area)
- Compression stress $\sigma_{c,0,d} = \frac{200{,}000}{27{,}000} = 7.41N/mm^2$
- Compression resistance $f_{c,0,d} = \frac{0.9 \cdot 14.00}{1.3} = 9.69N/mm^2$ ($f_{c,0,k}$ refer to table page 7), $k_{c,90} = 1.0$
- Verification: $\frac{\sigma_{c,0,d}}{k_{c,90} \cdot f_{c,0,d}} = \frac{7.41}{1.0 \cdot 9.69} = 0.76 \leq 1{,}0$

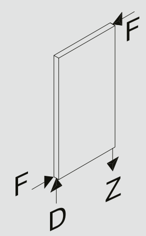
Verification of buckling:

- Effective length $l_{ef} = 3{,}000mm$
- Radius of gyration $i_0 = 31.2mm$ (refer to table page 7)
- Slenderness ratio $\lambda = \frac{l_{ef}}{i_0} = 96.1$
- Compression factor $k_c = 0.45$ (linearly interpolated)
- Assumption for $A_{tot,eff}$: load distribution under 15° both sides. Verification at half effective length (here 1.5m)
- $A_{tot,eff} = (300mm + 2 \cdot \tan 15° \cdot 1{,}500mm) \cdot 90mm = 99{,}346mm^2$
- Compression stress $\sigma_{c,0,d} = \frac{200{,}000}{99{,}346} = 2.01N/mm^2$
- Verification: $\frac{\sigma_{c,0,d}}{k_c \cdot f_{c,0,d}} = \frac{2.01}{0.45 \cdot 9.69} = 0.46 \leq 1.0$

LENO® panel with shear load

Example: shear wall

LENO® 90-4L, element width = 2,5m,
F_d = 70 kN (short term)



Verification of shear stress:

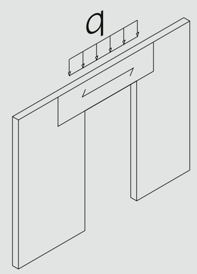
- Shear stress $\tau_d = \frac{F_d}{t \cdot b} = \frac{70{,}000}{90 \cdot 2{,}500} = 0.31N/mm^2$
- Shear resistance ($f_{v,k}$ refer to table page 7) $f_{v,d} = \frac{0.9 \cdot 1.27}{1.3} = 0.88N/mm^2$
- Verification: $\frac{\tau_d}{f_{v,d}} = \frac{0.31}{0.88} = 0.35 \leq 1.0$

LENO® panel as a beam

Example: lintel

LENO® 90-3L, horizontal surface lamellas, lintel length = 2m, lintel height = 30cm, g_k = 6kN/m, q_k = 4 kN/m (medium term)

Design and deflection values as a single span beam:



- $M_d = 7.05kNm$
- $V_d = 14.1kN$
- $w_{g,inst} = 0.84mm$, with $EI = \frac{7{,}330 \cdot 90 \cdot 300^3}{12}$ ($E_{0,mean}$ refer to table page 7)
- $w_{q,inst} = 0.56mm$, with $EI = \frac{7{,}330 \cdot 90 \cdot 300^3}{12}$ ($E_{0,mean}$ refer to table page 7)

Verification of bending stress:

- Bending stress $\sigma_{m,0,d} = \frac{M_d}{W} = \frac{7.05 \cdot 10^6 \cdot 6}{90 \cdot 300^2} = 5.22N/mm^2$
- Bending resistance $f_{m,0,d} = \frac{0.8 \cdot 16.00}{1.3} = 9.85N/mm^2$ ($f_{m,0,k}$ refer to table page 7)
- Verification: $\frac{\sigma_{m,0,d}}{f_{m,0,d}} = \frac{5.22}{9.85} = 0.53 \leq 1.0$

Verification of shear stress:

- Shear stress $\tau_d = 1.5 \cdot \frac{V_d}{(b \cdot h)} = \frac{1.5 \cdot 14.1 \cdot 10^3}{90 \cdot 300} = 0.78N/mm^2$
- Shear resistance ($f_{v,k}$ refer to table page 7) $f_{v,d} = \frac{0.8 \cdot 1.27}{1.3} = 0.78N/mm^2$
- Verification: $\frac{\tau_d}{f_{v,d}} = \frac{0.78}{0.78} = 1.0 \leq 1.0$

Verification of bearing pressure:

- Shear stress $\sigma_{c,90,d} = \frac{F_{c,d}}{(b \cdot l)} = \frac{14.1 \cdot 10^3}{(90 \cdot 150)} = 1.04N/mm^2$
- Shear resistance ($f_{c,90.k}$ refer to table page 7) $f_{c,90.k} = \frac{0.8 \cdot 7.00}{1.3} = 4.31N/mm^2$
- Verification: $\frac{\sigma_{c,90,d}}{f_{c,90,d}} = \frac{1.04}{4.31} = 0.24 \leq 1.0$

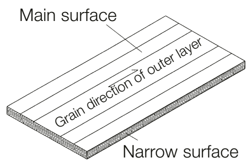
Verification of serviceability limit:

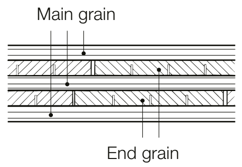
- The deflection limits need to be set, dependent on the application, and then compared with the expected deflections.

Connectors and Fasteners

Fastener capacity in LENO® DIN EN 1995-1-1: 2010-12

Connection type	Main surface	Narrow surface
Special connectors		
e.g. split ring or shear plate connectors	DIN EN 1995-1-1, section 8 with $\alpha = 0°$ *	DIN EN 1995-1-1/NA, 8.11
Dowels/Bolts	DIN EN 1995-1-1, 8.5	DIN EN 1995-1-1, 8.5
	where $f_{h,\alpha,k} = \frac{32 \cdot (1 - 0{,}015 \cdot d)}{1{,}1 \cdot \sin^2\alpha + \cos^2\alpha}$ [N/mm²]	with $f_{h,k} = 9 \cdot (1 - 0{,}017 \cdot d)$ [N/mm²]
Nails	DIN EN 1995-1-1, 8.3.1	Structurally permitted
Shear		Minimum diameter d_n = 4mm
Withdrawal	Minimum diameter d_n = 4mm, profiled nails $f_{ax,k} \geq 50 \cdot 10^{-6} \cdot \rho_k^2$ und $f_{head,k} \geq 100 \cdot 10^{-6} \cdot \rho_k^2$ $t_{pen} \geq 3$ lamella layers $F_{ax,Rk} = 14 \cdot d^{0,6} \cdot l_{ef} \cdot k_d$ [N] $d < 6mm: k_d = 0{,}8$; $d \geq 6mm: k_d = 1{,}0$	Structurally permitted Minimum diameter d_n = 4mm
Screws	DIN EN 1995-1-1, 8.7	
Shear	Minimum diameter d_n = 4mm Definition $f_{h,k}$: $t_{pen} < 3$ lamella layers, ρ_k = 350kg/m³ $t_{pen} \geq 3$ lamella layers, ρ_k = 400kg/m³	Acc ETA-10/0241 A.5.3 Minimum diameter d_n = 8mm, n_{ef} solid timber $f_{hk} = 20 \cdot d^{-0,5}$ in end grain of narrow surface
Withdrawal	$F_{ax,Rk} = \frac{31 \cdot d^{0,8} \cdot l_{ef}^{0,9} \cdot k_d}{1{,}5 \cdot \cos^2\alpha + \sin^2\alpha}$ [N]	Minimum diameter d_n = 8 mm $F_{ax,Rk} = \frac{31 \cdot d^{0,8} \cdot l_{ef}^{0,9} \cdot k_d}{1{,}5 \cdot \cos^2\alpha + \sin^2\alpha}$ [N]
	$d < 6mm: k_d = 0{,}8$; $d \geq 6mm: k_d = 1{,}0$; α-angle screw axis to grain direction	

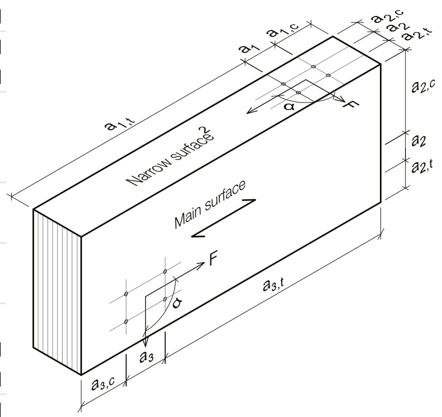




* Independent of angle between grain and load direction

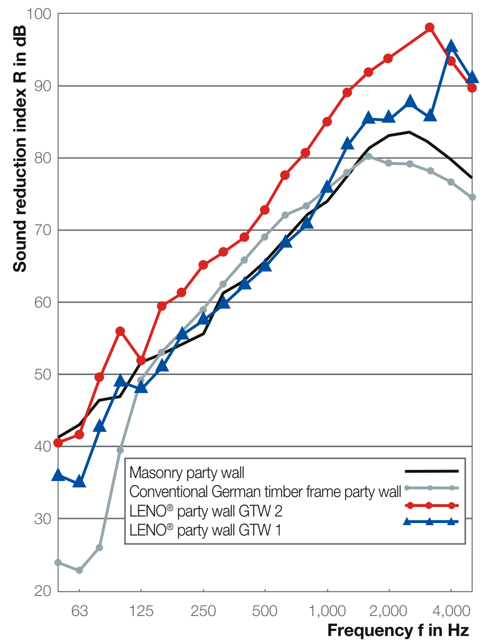
Distances for fasteners in LENO®

		Connections to the main surface	Connections to the narrow side surface
Special connectors		Minimum distances according to DIN EN 1995-1-1, 8.9 Table 8.7, 8.8, 8.9	Minimum distances according to DIN EN 1995-1-1/NA Table NA.19
Dowels/Bolts [1]			
in between	a_1	$(3 + 2 \cdot \cos\alpha) \cdot d$	4 d
	a_2	3 d	3 d
from the loaded edge	$a_{1,t}$	5 d	5 d
	$a_{2,t}$		3 d
from the unloaded edge	$a_{1,c}$	4 d · sin α (min. 3 d)	3 d
	$a_{2,c}$	3 d	3 d
Nails		not pre-drilled	
in between	a_1	$(3 + 3 \cdot \cos\alpha) \cdot d$	
	a_2	3 d	
from the loaded edge	$a_{1,t}$	$(7 + 3 \cdot \cos\alpha) \cdot d$	
	$a_{2,t}$	$(3 + 4 \cdot \cos\alpha) \cdot d$	
from the unloaded edge	$a_{1,c}$	6 d	
	$a_{2,c}$	3 d	
Screws [2, 3]			
in between	a_1	4 d	10 d
	a_2	2,5 d	3 d
from the loaded edge	$a_{1,t}$	6 · d	12 d
	$a_{2,t}$	6 · d	
from the unloaded edge	$a_{1,c}$	6 · d	7 d
	$a_{2,c}$	2,5 d	5 d



1 Connections to the narrow surface: minimum key lamella thickness: $t_i = d$; minimum LENO® thickness $t_{LENO} = 6$ d; minimum penetration depth $t_{pen} = 5$ d/ **2** Self-drilling screws without drill head/ **3** Connections to the narrow surface: minimum key lamella thickness: $d \leq 8mm$ $t_i = 2$ d, $d > 8mm$ $t_i = 3$ d; minimum penetration depth LENO® $t_{LENO} = 10$ d; minimum penetration depth $t_{pen} = 10$ d/ **4** The load-bearing capacity for initially protected LENO® components must be verified separately beta0 = 0.7mm/min, fire behaviour D-s2, d0

Party Wall – Data and Facts



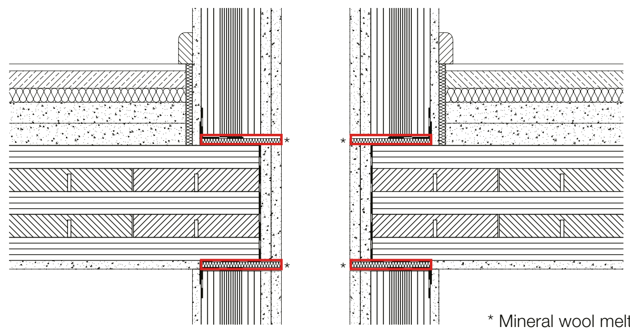
Source: Holtz, F., Hessinger, J., Rabold A., et al.: INFORMATIONSDIENST HOLZ, holzbau handbuch, R3/T3/F4, Schallschutz Wände und Dächer, Ed. Holzabsatzfonds u. DGfH, Bonn/Munich 2004

The GTW 1.1 party wall meets all the legal requirements and is perfectly suited for buildings where high sound insulation standards are required. The GTW 3 LENO® party wall also has a very high sound insulation level while being optimised with regard to overall thickness.

LENO® is used as the raw material for all party walls. Each of the three designs offers high-quality sound insulation, especially in the low frequency range. The subjective experience is confirmed by objective measurements, as can be clearly seen in the diagram on the left comparing the measured sound reduction of four different party wall designs. The higher the measurement curve, the better the sound insulation level of the wall structure.

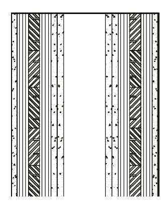
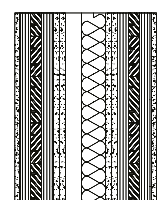
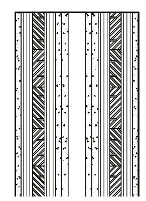
Several simple and practical details help to simplify and speed up the installation process while also taking the relevant fire protection requirements into account. To further minimise the construction time on site, the components are pre-bonded with plasterboard ex works and easily achieve the F 90-B/F 30-B requirements.

Example: party wall – floor detail



* Mineral wool melting point > 1,000°C

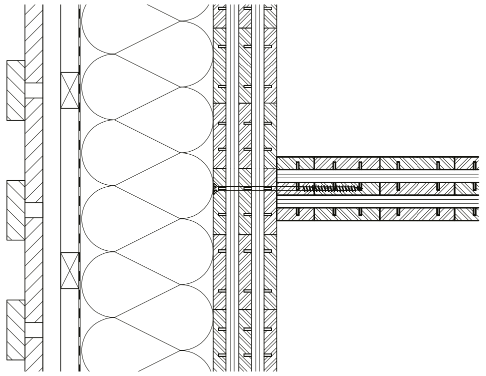
Technical data

	GTW 1	GTW 1.1	GTW 3
Sketch			
Wall construction from left to right	GKF plasterboard 12.5mm LENO® 90.0mm Fermacell 2 x 18.0mm Cavity 100.0mm Fermacell 2 x 18.0mm LENO® 90.0mm GKF plasterboard 12.5mm	GKF plasterboard 12.5mm LENO® 90.0mm Fermacell 2 x 18.0mm Mineral wool/Luftraum 60.0mm Fermacell 2 x 18.0mm LENO® 90.0mm GKF plasterboard 12.5mm	GKF plasterboard 12.5mm LENO® 90.0mm Fermacell 2 x 18.0mm Luftraum 40.0mm Fermacell 2 x 18.0mm LENO® 90.0mm GKF plasterboard 12.5mm
Total width	377.0mm	337.0mm	317.0mm
Sound insulation	R_w 68dB	R_w 73dB	R_w 65dB
Fire resistance [4] **Designed to DIN 4102-4**	F 90-B from cavity side F 30-B from inside	F 90-B from cavity side F 30-B from inside	F 90-B from cavity side F 30-B from inside

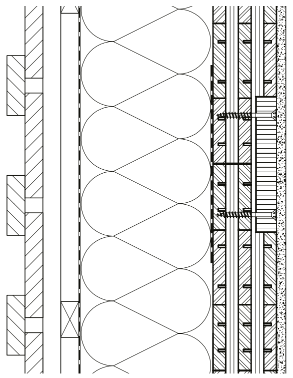
Construction Details

Wall

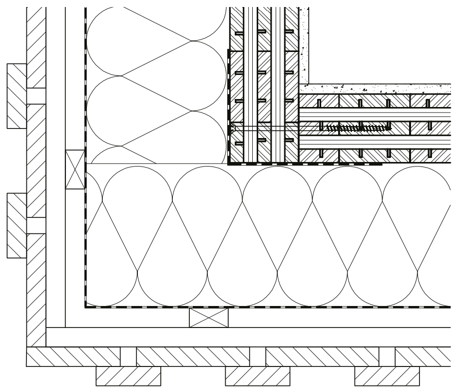
Example: external/internal wall junction



Example: wall panel to panel connection

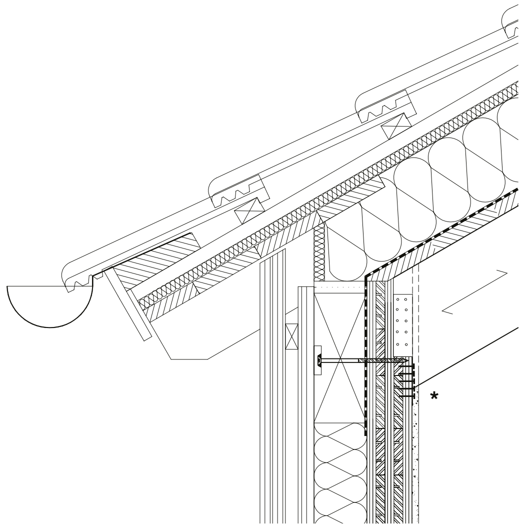


Example: external corner detail



Roof

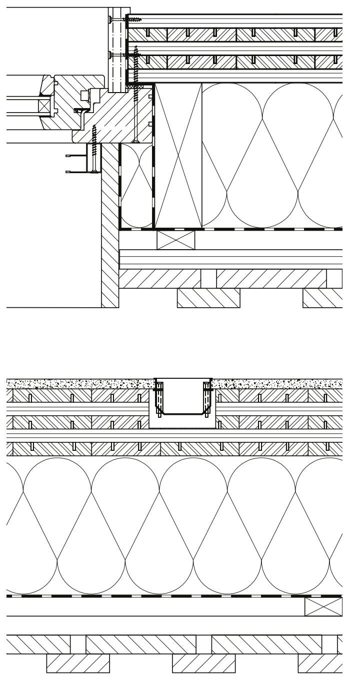
Example: eaves detail with visible rafters



* Tip: purlin only required for gable end.

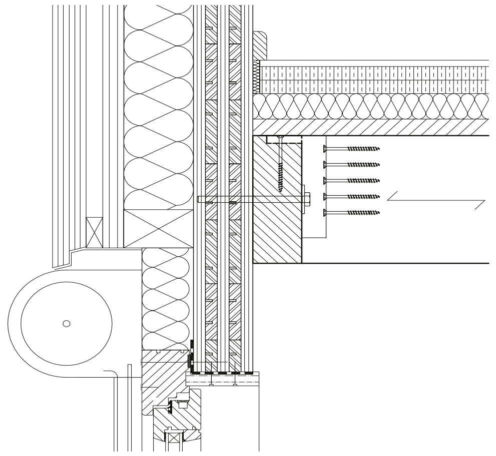
Windows/Services

Example: window side detail + wall socket

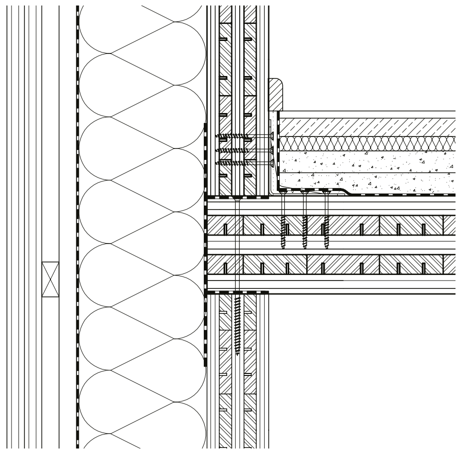


Floor

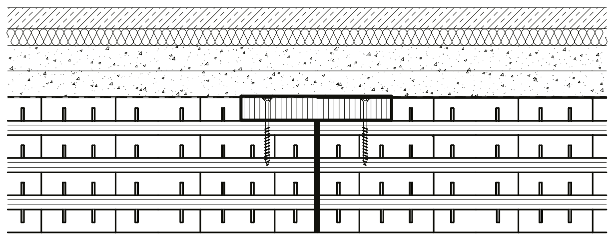
Example: external wall and floor beam connection detail, balloon construction



Example: external wall and LENO® floor connection detail, platform construction

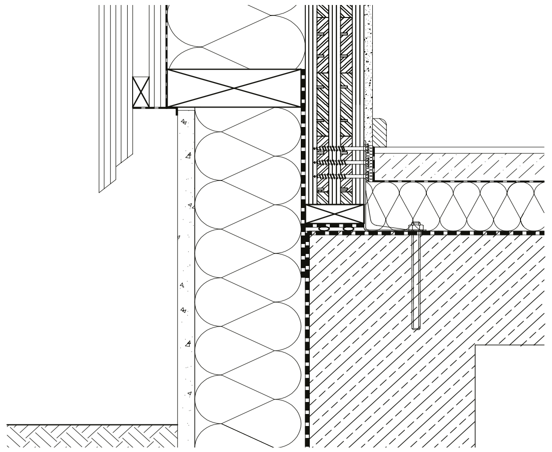


Example: floor panel-to-panel connection detail with LVL cover strip

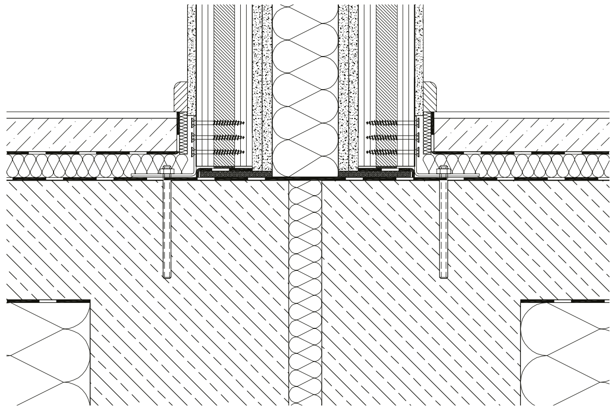


Ground floor

Example: ground floor detail with perimeter insulation above sole plate



Example: ground floor party wall detail



Note

All suggested details for guidance only.

Thermal Insulation

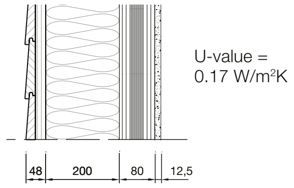
The thermal conductivity of LENO® is λ = 0.13W/mK, which is the same as solid spruce. Any thermal insulation material available on the market (wood fibre board, mineral fibre, PS, PUR, hemp, etc.) can be used to insulate a LENO® structure. The diagram below shows the u-values of an 80mm thick external LENO® wall, calculated according to DIN 4108, depending on the thickness of the insulation material.

Thermal properties

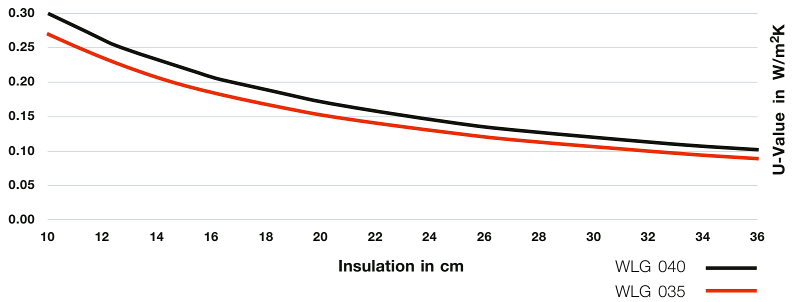
Thermal conductivity	λ	0.13W/mK
Heat capacity	c	~ 1.6kJ/kgK
Density	ρ	~ 500kg/m³

Example construction

Plasterboard	12.5mm
LENO®	80mm
Wood fibre board λ = 0.040W/mK	200mm
Ventilated cavity and cladding	48mm



LENO® U-values with insulation material Λ = 0.040 AND Λ = 0.035



1 Residential house, Hamburg (DE);
© Tobias Münch Architekt BDA

Certification/Building Physics

LENO® panels are manufactured from PEFC-certified wood sourced from sustainably managed forests. Our vacuum pressing process, patented in 1994 and a sustainability award-winner, enables us to achieve high pressures in an extremely energy-saving process. Any waste material produced during sorting or cutting is used in a carbon-neutral biomass heating system at the factory to heat the drying kiln and production facilities. The result is a closed carbon cycle with a minimum use of energy for production. Continuous production control both in-house and through external monitoring ensures the high quality of our LENO® products.

Moisture protection

All LENO® building products are breathable. When using a breathable external insulation, cavity and rain screen, vapour barriers are not required.

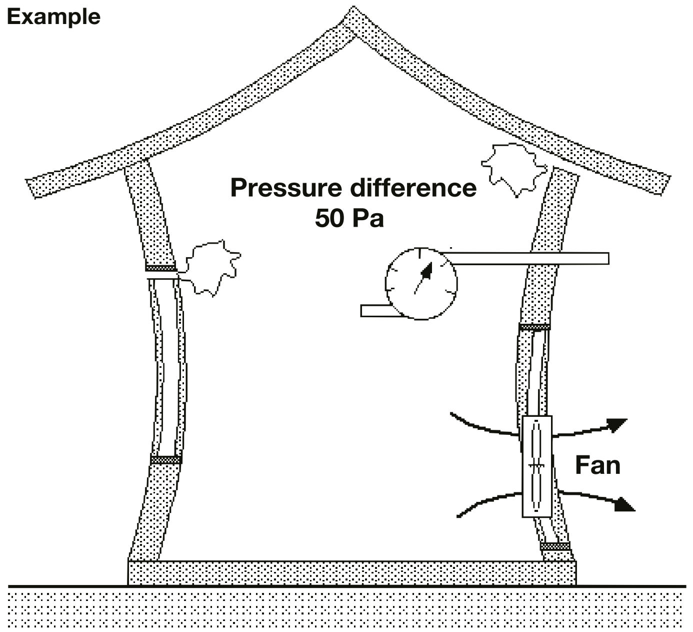
Moisture resistance properties

Water vapour resistance	μ	20-50
sD value (90mm)	sD	1.8-4.5m
sD value (120mm)	sD	2.4-6.0m

Airtightness

LENO® panels can be defined as airtight when they have a minimum of 4 layers. Additional sealing layers are not required. Connection details (plinth, door, window, panel to panel connection, etc.) must be made airtight with suitable sealants. Where stricter airtightness standards apply (Passive house, mechanical ventilation and heat recovery), we recommend masking off all end surfaces. Suggestions regarding implementation as well as an airtightness test report from ift Rosenheim are available on request.

Example



Construction Physics – Fire resistance

The general type approval Z-9.1-501 for LENO® cross laminated timber components describes the reduced cross-section method, defines the requirements for the integrity and indicates and shows the possibilities for joint design.

Coverings on the side facing the fire: minimum thickness of fire resistant layer (GKF) or plasterboard (GF) in mm	**Wall – minimum thickness LENO® cross laminated timber in mm**	**Fire resistance class [a]**
-	70	F 30-B
12.5	60	F 30-B
-	90	F 60-B
12.5	80	F 60-B
18	70	F 60-B
-	120	F 90-B
15	110	F 90-B
18	100	F 90-B

[a] The specified classification only applies with regard to the assessment of integrity; proof of the load-bearing capacity must be provided separately!

Coverings on the side facing the fire: minimum thickness of fire resistant layer (GKF) or plasterboard (GF) in mm	**Wall – minimum thickness LENO® cross laminated timber in mm**	**Fire resistance class [a]**
-	70	F 30-B
12.5	60	F 30-B
-	110	F 60-B
12.5	90	F 60-B
18	80	F 60-B
-	140	F 90-B
12.5	130	F 90-B
18	120	F 90-B

[a] The specified classification only applies with regard to the assessment of integrity; proof of the load-bearing capacity must be provided separately!

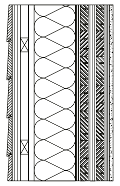
In general, the fire-separating function can be assumed to be fulfilled if the remaining cross-section has a minimum dimension of 40mm and consists of at least two layers of boards glued together perpendicular to each other. The minimum thickness of the last board layer exposed to fire must be at least 10mm.

1 Building community, Würzburg (DE); © Christoph Naumann-Zimmer

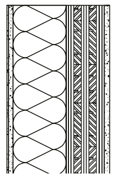
Building Physics – Sound insulation

The solid LENO® cross sections make it possible to achieve excellent sound reduction levels in both walls and floors. The following example constructions have been tested, and additional test results and suggestions for construction can be requested from ZÜBLIN Timber.

External Walls

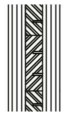


AW (D) 7	**R_w = 49dB**
Rain screen cladding	25.0mm
Counter batten	28.0mm
Batten	28.0mm
Fibre board	18.0mm
Mineral wool insulation λ = 0.035 with vertical support channel b = 60mm at e = 0.625m centres	140.0mm
LENO®	90.0mm
Plasterboard	15.0mm

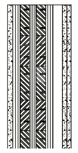


AW (D) 8	**R_w = 52dB**
Render	3.5mm
Mortar with lath	10.0mm
Mineral wool insulation λ = 0.040	120.0mm
LENO®	90.0mm
Plasterboard	15.0mm

Internal Walls

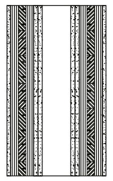


IW (D) 8	**R_w = 37dB**
LENO®	80.0mm

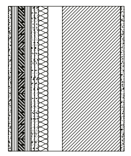


IW (D) 9	**R'_w = 52 dB**
Plasterboard	2 x 12.5mm
Resilient bar	27.0mm
LENO®	120.0mm
Plasterboard	15.0mm

Party Walls

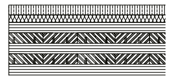


GTW (D) 1	**$R_w \geq 68dB$**
Plasterboard	12.5mm
LENO®	90.0mm
Fermacell 2 x 15mm	30.0mm
Cavity	100.0mm
Fermacell 2 x 15mm	30.0mm
LENO®	90.0mm
Plasterboard	12.5mm

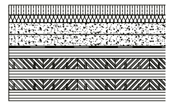


GTW (D) 4	**$R'_w \geq 67dB$**
Plasterboard	12.5mm
LENO®	90.0mm
Fermacell 2 x 15mm	30.0mm
Insulation MW DIN EN 13162	40.0mm
Cavity	60.0mm
Brickwall 1.400kg/m^3	240.0mm
Render 1.000kg/m^3	15.0mm

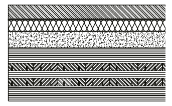
Floors



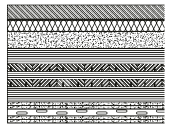
DE (D) 1	**R_w = 53dB**	**$L_{n,w}$ = 61dB**
Fermacell-dry screed elements		25.0mm
Impact sound insulation Isover Acoustic EP3		20.0mm
LENO®		140.0mm



DE (D) 2	**R_w = 62dB**	**$L_{n,w}$ = 51dB**
Fermacell dry screed elements		25.0mm
Impact sound insulation Isover Acoustic EP3		20.0mm
Fermacell honeycomb system		60.0mm
Trickling protection with Kraft paper		
LENO®		140.0 mm



DE (D) 5	**R_w = 73dB**	**$L_{n,w}$ = 40dB**
Cement screed		50.0mm
Slip membrane seperating layer		
Impact sound insulation Isover Acoustic EP1		40.0mm
Fermacell honeycomb system		60.0mm
LENO®		190.0mm

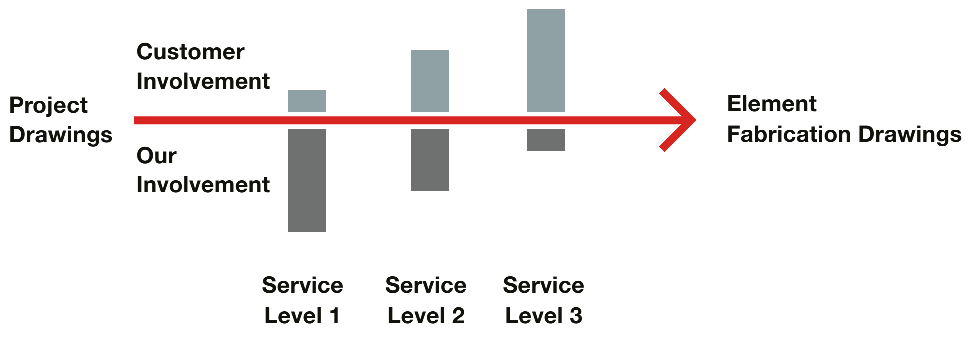


DE (D) 7	**R_w = 84dB**	**$L_{n,w}$ = 25dB**
Cement screed		50.0mm
Slip membrane seperating layer		
Impact sound insulation Isover Acoustic EP1		40.0mm
Fermacell honeycomb system		60.0mm
LENO®		190.0mm
Fermacell 2 x 15mm		30.0mm
Resilient bar with ceiling cavity		27.0mm
Acoustic SSP1		
Fermacell 2 x 15mm		30.0mm

Element Planning/ Fabrication Drawings

To guarantee the smooth running of a project, all architectural and structural drawings have to be converted into element drawings for production. All required machining has to be clearly shown on these element drawings. As a necessary consequence of this, the further a project progresses, the more in depth details will be required. Within our service offer we can adapt the amount of detailing we do, dependent on your requirements. Once we become involved, we divide the element planning phase into 3 service levels. You can control our involvement in the planning process depending on the amount of input you, the customer, wishes to contribute.

Planning process



Level 1

We need to receive the following from you:
- Architect's drawing
- Structural design and dimensions
- Details of wall construction and construction details

You receive from us:
- Element drawings overview
- Individual element drawings
- Timely clarification should any questions arise
- Pre-production documentation for site logistics and for approval

Level 2

We need to receive the following from you:
- Architect's drawings with all wall, floor and roof elevations on a scale of 1:50 wherever LENO® elements are used
- Structural design and dimensions
- Fully dimensioned plans of all floors
- Fully dimensioned section drawings with level indications

You receive from us:
- Element drawings overview
- Individual element drawings
- Timely clarification should any questions arise
- Pre-production documentation for site logistics and for approval

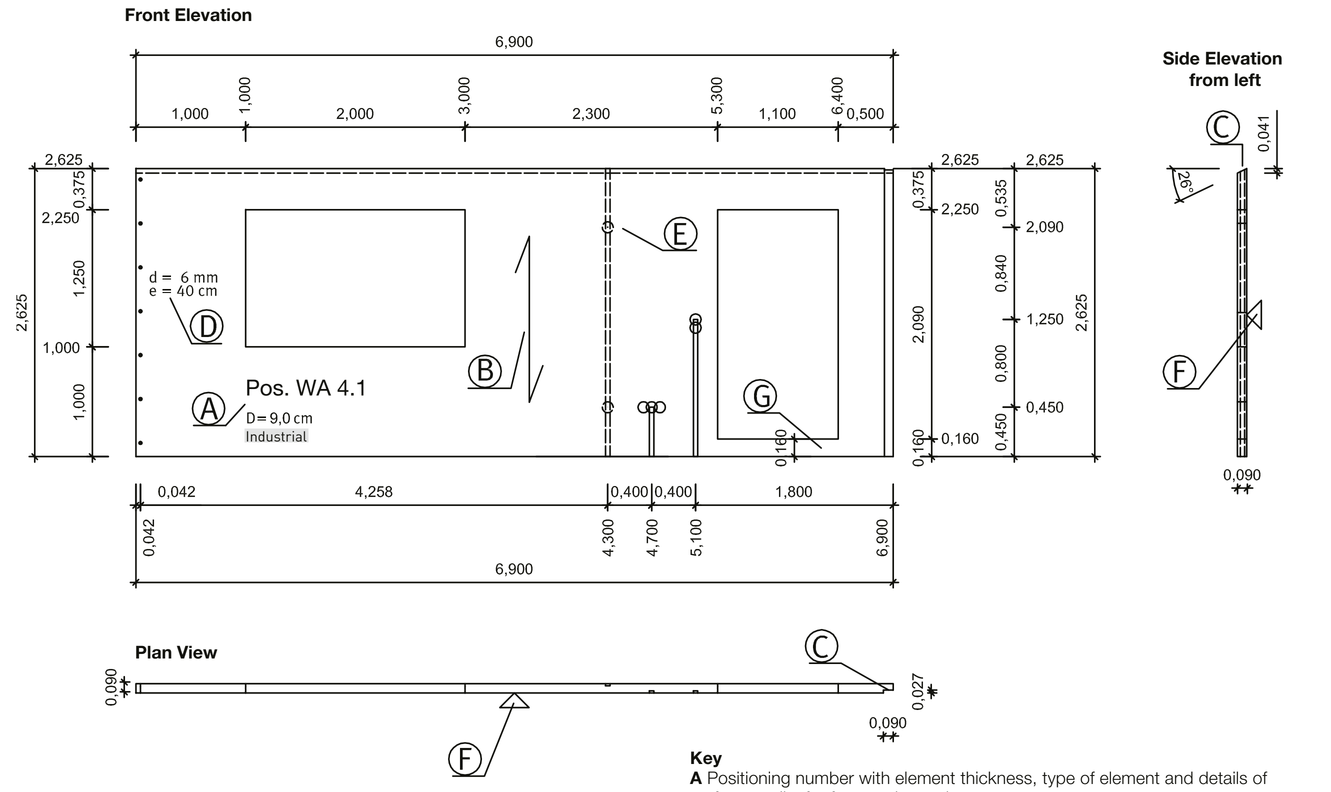
Level 3

We need to receive the following from you:
- Full set of element drawings on A3 paper
- Optional: DXF or DWG files for all elements

You receive from us:
- No further information, as we produce the elements according to your drawings

As the panels for each project are individually designed and produced, the designer only needs to consider transport width and element size. Due to the waste it would otherwise produce, we are only able to manufacture right angled LENO® panels. It is possible to optimise wastage by nesting rectangular panels in a 4.80m x 14.80m panel (4.80m x 20.00m on request). Upon request, we can provide information on permitted transport widths and lengths for standard and special sized transport within Germany and the rest of Europe. If using visible surfaces, please request detailed planning instructions.

Example: individuell element drawings

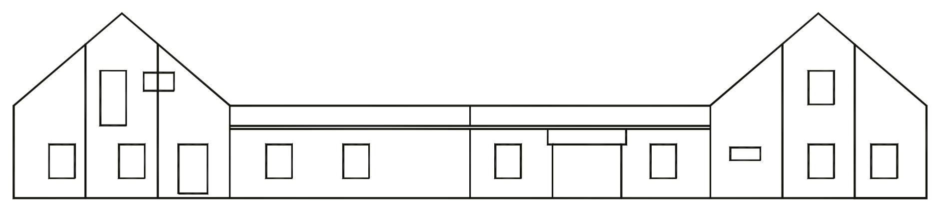


Key
A Positioning number with element thickness, type of element and details of surface quality for front and rear view
B Grain direction of element's surface layer
C Edge trimming of the elements (folds, bevels, chamfers, etc.)
D Holes or drillings (axis dimension = e, diameter = d, depth counter bore). Default d = 6mm, e = 400mm
E Routing for service runs (width = b, depth = t). Default b = 40mm, t = 30mm Socket drill hole (diameter = d, depth = t) Standard IND and Fermacell: d = 100mm, t = 55mm Sockets (diameter = d, depth = t) Standard VIS: d = 68mm, t = 55mm
F Indicator shows front elevation on both side elevation and plan view
G G Door threshold left in place, as a safety measure, during transport to site, and then removed as required on site. Minimum height h = 160mm

TIPS FOR OPTIMAL LENO® PANEL PLANNING

- Split the design of the planned building into the largest LENO® elements possible
- This guarantees a design with a minimum number of joints
- LENO® does not follow a modular grid
- LENO® allows the freedom to choose the positioning of windows and doors

Flat plan elevations showing individual elements



Surface Options

In addition to the standard industrial surface quality, various special surfaces are available on request.

STANDARD
- INDUSTRIAL

SPECIAL SURFACES
- INDUSTRIAL VISUAL
- NORDIC VISUAL
- FINELINE
- HIGH-QUALITY VENEER

SPECIAL SURFACES
- SILVER FIR
- LARCH
- TULIPWOOD
- BRUSHED
- BEECH

Industrial

For cladding on site

All lamellas are exclusively graded by strength and not by visible appearance. Knots, discolouration, and other defects are therefore, possible.

Industrial Visual

For visible surfaces in commercial buildings

The outer surface layer is manufactured using finger jointed, Nordic spruce lamellas. The surface is then sanded. All lamellas are positioned side by side without gluing the edges, allowing possible gaps between the surface lamellas to occur. Curved elements can also be produced in this surface quality.

Nordic Visual

For visible elements in residential living spaces

The outer surface layer is manufactured using finger jointed, Nordic spruce lamellas, selected for quality. The surface is then sanded. All lamellas are tightly positioned side by side without gluing the edges. By using selected Nordic raw materials, the colour and texture of the surface has a uniform and balanced appearance.

Fineline

For visible elements

One or both surfaces can be produced with Fineline for a unique, fine surface appearance. This surface type is produced using certified and quality controlled LVL panels and can be manufactured, up to a length of 19.80m. The individual boards are butt-jointed in length at a distance of approx. 6m. Curved elements can also be produced in this surface quality.

High quality oak veneer

For visible elements

The panels are overlaid with 5mm thick, sanded Oak veneers. Single, sometimes multiple knots, up to 35mm in diameter, are generally evenly distributed, giving a fine to rustic appearance. The typical growth characteristics of oak form a unique surface. The grading process ensures a predominantly uniform colour. The surface type 'Oak Veneer' can be produced up to a length of 5.90m with no visible joints. For multi spanning floor panels, any occurring joint can be hidden above or below internal walls or supporting beams.

Note

All timber and timber based products are prone to swelling and shrinking if the moisture content in the product changes. To keep the effects of such movements to a minimum, all raw materials in the production of LENO® CLT are kiln dried, and all LENO® panels are delivered with a moisture content of 12% +/– 2%. This moisture content is equivalent to the equilibrium moisture content of timber naturally occurring in a normal in-door climate. It is impossible to completely avoid the effects of moisture movement i.e. cracks or gaps) due to the natural properties of timber.

Special Applications

Point supported structures

In special applications the advantages of LENO® come into their own. Both large spanning, bi-axial plate structures and intricate point supported plates can be elegantly constructed with LENO®. Slender and wide cantilevers can be easily designed using LENO® – even for cantilevers in corners. For these special applications it is also possible to create an individually layered, specially designed LENO® pane.

1


Open questions?

We will gladly help you find the best solutions for your project. You can use our DC-Statik software to assist you in your calculations for LENO® cross laminated timber.

Visit our website

Vertical bending

LENO® can be used both as a panel and a large beam. As a result of its structural behaviour, large openings and cantilevers can easily be designed in LENO® acting as both as a lintel or a beam.

Curved panels

The specialised vacuum gluing technology enables us to produce uniaxially and biaxially axis curved components. Please contact us to find the best solution for your project.

2


1 Natuurbelevingcentrum de Oostvaarders, Almere (NL); © Roos Aldershoff photography; Architect: Drost & van Veen Architects / **2** NEXT500 Pavillon, Augsburg (DE); © Eckhart Matthäus, temporary building to celebrate the 500th anniversary of the Fuggerei; naturally weathered for several weeks

Hybrid Solutions

LENO®-PLUS

A stable and large format laminated veneer lumber (LVL) plate replaces the internal layers of the CLT elements. Both a breathable and air tight envelope is created.

Combined wood-based materials/components

CLT components individually adapted to the structural requirements, e.g. by substituting high stressed layers by LVL or beechwood in the overall cross section.

Off Site Prefabrication

LENO®-ADD

- Flexible scope of services
- Shorter construction times
- High product quality through industrial prefabrication

LENO®-Modular

- Modular systems, e.g. for hotel rooms, staircases, dormers, bath rooms
- High degree of prefabrication
- Prefabricated lift shafts

Special connectors with metal-free wood–wood connections

- Very fast installation times
- Form-fit connection ideal for visible surfaces
- No beam puller required for floor connections

Off site applied wheather protection

- Suitable for diffusion and high protection against driving rain
- Keeps building components dry thanks to non-porous moisture-active functional membrane
- Ensures good adhesion to dry and clean surfaces

1


2


1 Lift shaft, Weilheim (DE); © HOLZ|BAU|WAGEN Peiting / **2** Vertical extension of Deutsches Chorzentrum Berlin (DE); © Zimmerei Vater Lutherstadt Wittenberg

9/2023, 150

ZÜBLIN Timber GmbH
Industriestr. 2
86551 Aichach
Tel. +49 8251 908-881
timber-bauelemente@zueblin.de
www.zueblin-timber.com

Further office branches:
Leutkirch, Gaildorf, Neu-Ulm, Stuttgart, Berlin

Cover Fuggerei NEXT500 Pavillon, Augsburg (DE); © Eckhart Matthäus / **1** LENO®-element, robot cutting / **2** Ruhestein visitor information center (DE); © Achim Birnbaum

ZÜBLIN
WORK ON PROGRESS