LIGNOLOC®
WOODEN NAILS

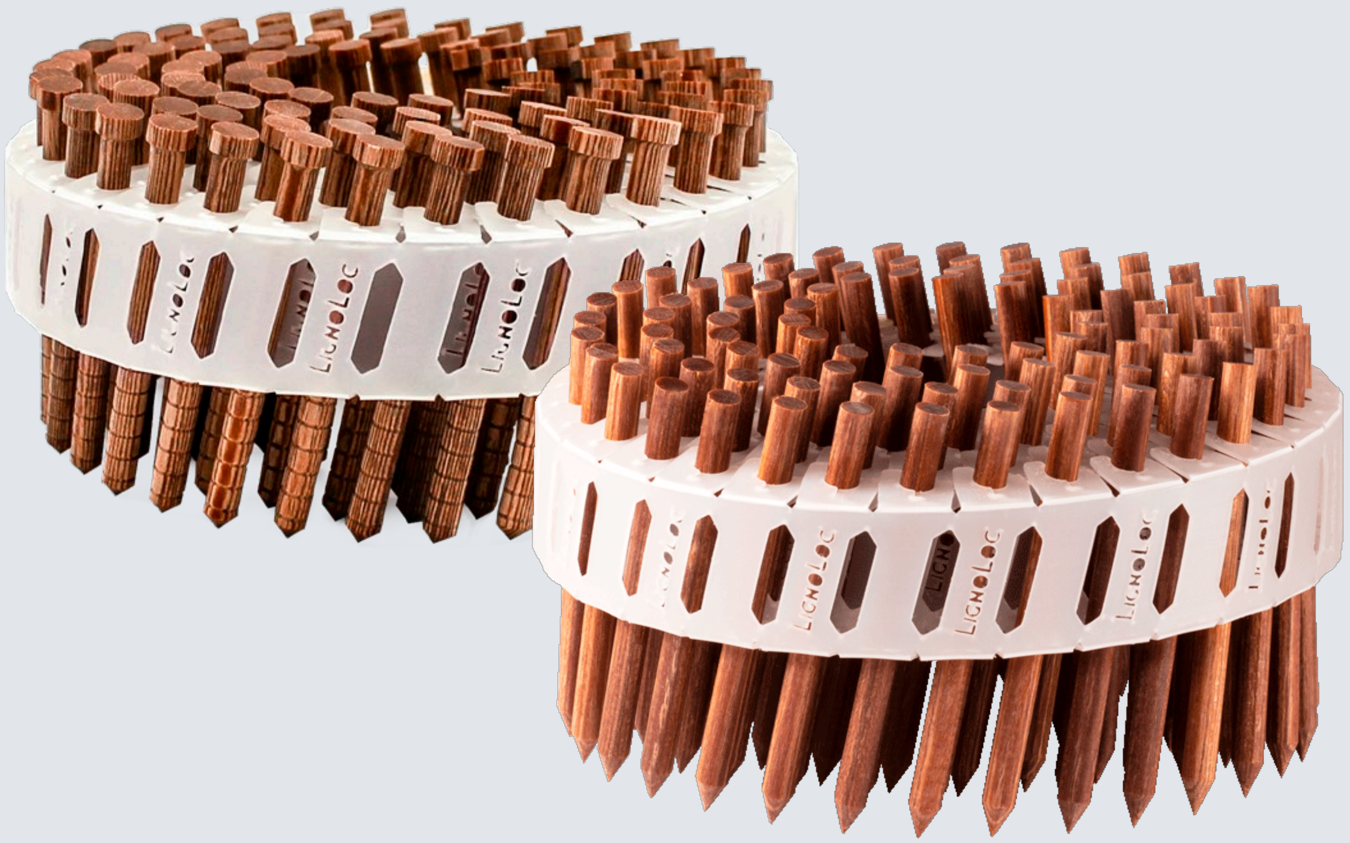
Technical Manual

2025

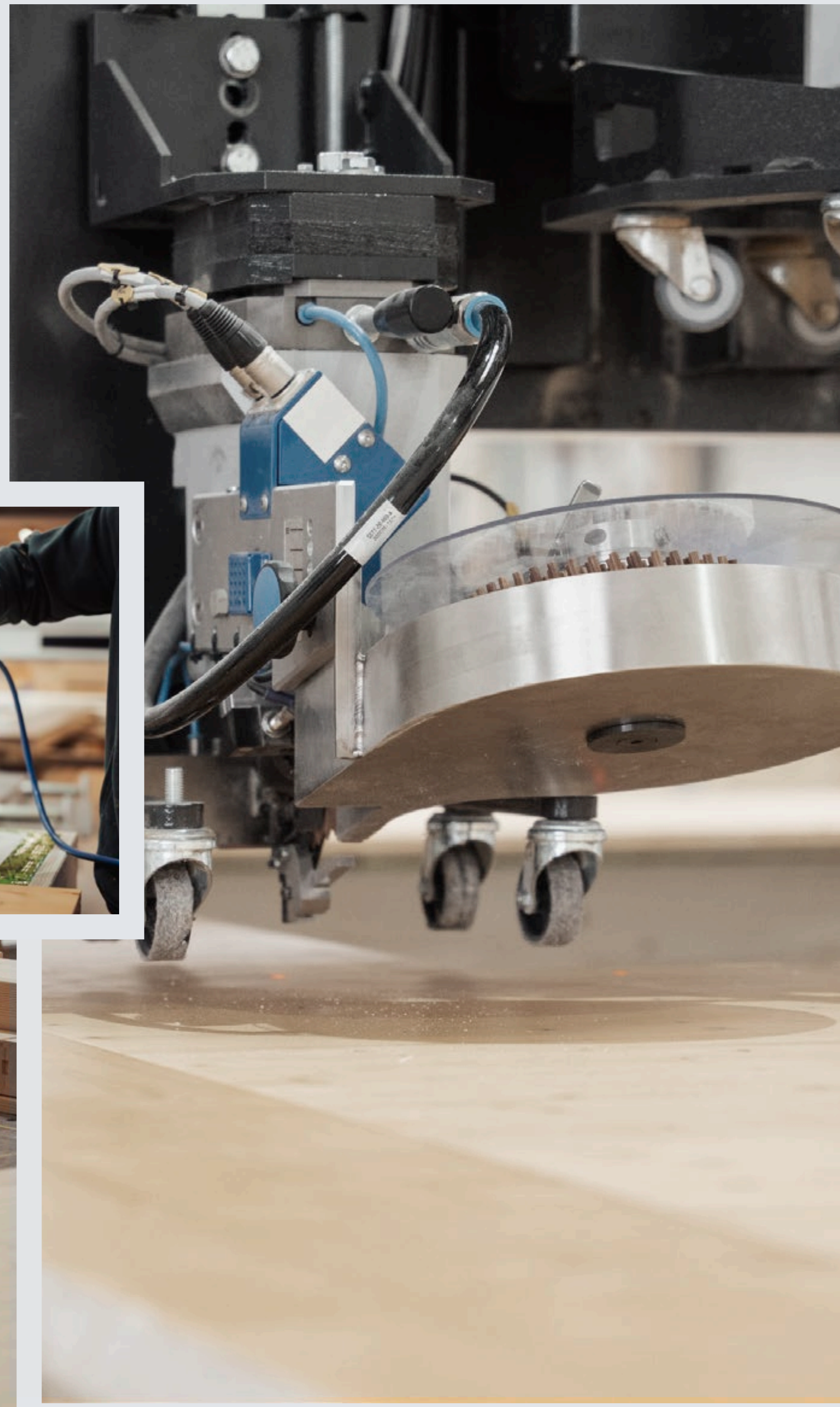
LIGNOLOC®

beck-fastening.com

We do not wait for the solution – we create it.



LIGNOLOC® wooden nails enable all-timber, monomaterial construction systems – metal-free by design.



Contents

About BECK

Founded in 1904, BECK is a fourth-generation family-owned company based in Mauerkirchen, Upper Austria. As a pioneer in fastening technology, the brand stands for sustainable innovation and uncompromising quality.
With LIGNOLOC® – the world's first shootable wooden nail – BECK continues to set new standards. This system enables monomaterial wood connections without metal and reduces CO_2 emissions by up to 66% compared to conventional fastening methods.
With SCRAIL® nail screw fasteners and other innovative fastening solutions, BECK has been paving the way for greater efficiency and sustainability in construction for more than 120 years.

"Our mission is to advance timber construction – making it greener, cleaner, and better. LIGNOLOC® unites performance, efficiency, and sustainability in perfect harmony."

Christian Beck,
General Manager & CEO, BECK

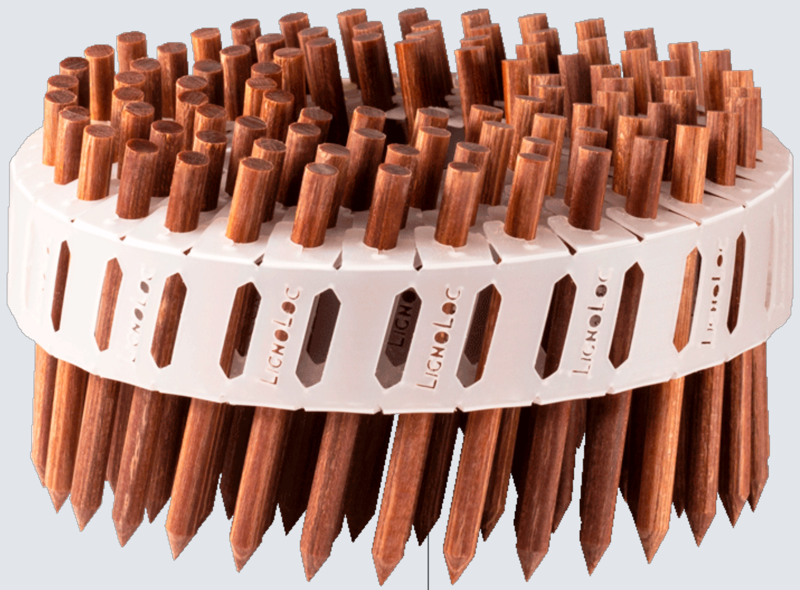
> “**LIGNOLOC**® makes it possible to join wood to wood – using wood. This creates the most natural and sustainable connection imaginable.”
>
> **Michaela Beck,**
> **Marketing Director, BECK**

LIGNOLOC® wooden nails

LIGNOLOC® wooden nails are the world’s first shootable wooden nails, enabling fast and efficient installation. They are pneumatically driven into wood using hand tools or fully automated nailing heads mounted on multifunctional bridges. No pre-drilling or adhesive is required, which significantly accelerates the construction process. Unlike metal nails, LIGNOLOC® wooden nails cause virtually no tool wear, extending the service life of saws and other cutting tools. In solid timber construction, the technical performance of these wooden nails makes a crucial difference – especially their high tensile and shear strengths, which are key to the stability of solid wood structures. A unique feature of LIGNOLOC® is its lignin adhesion: during the driving process, the heat generated by friction creates a natural bond between the nail and the wood. The resulting connection is so strong that removing the nails is virtually impossible.

Scan the QR-code for more information

Technical advantages and sustainable construction



Ecological and sustainable

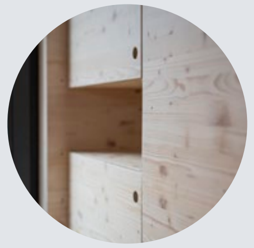
LIGNOLOC® represents the most sustainable fastening system on the market, with up to 66% lower CO_2 emissions compared to conventional metal fasteners.

Efficient and time-saving

LIGNOLOC® wooden nails are pneumatically driven into wood, eliminating the need for pre-drilling and gluing typically required for wooden dowels.

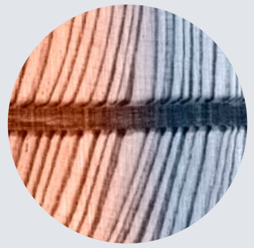
Enhanced fire resistance

Unlike steel nails, LIGNOLOC® wooden nails do not fail suddenly in the event of fire – instead, they perform like mass timber.



Naturally beautiful

LIGNOLOC® wooden nails offer a natural appearance and touch, with no chemical interaction that could affect the wood's aesthetics over time.



Thermal performance without compromise

With a thermal conductivity of just 0.64 W/mK, LIGNOLOC® wooden nails effectively prevent thermal bridging – a key factor in energy-efficient construction.

Resistant to corrosion and chemicals

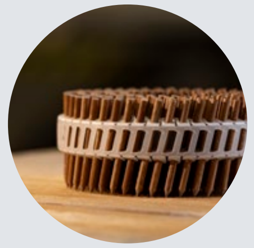
LIGNOLOC® wooden nails are resistant to corrosion, chemicals, swelling, and fungal decay, making them ideal for outdoor use and aggressive environments.

Post-processing without tool wear

LIGNOLOC® wooden nails are gentle on tools and saw blades during the post-processing of timber components.

Patented technology

Our patented LIGNOLOC® wooden nail technology provides a distinct competitive edge for our partners.



Lignin adhesion

The term lignin adhesion refers to a natural bonding process. It occurs when two or more pieces of wood – or other materials rich in lignin – are briefly heated to approximately 180 °C and then pressed together.

Under the influence of heat, the lignin contained in the material changes its state, becoming soft and tacky. Upon cooling, the lignin re-solidifies. The lignin-rich layers that were pressed together during this phase remain bonded through adhesion forces.

This process of lignin adhesion occurs particularly when wooden nails are driven into wood. The surface friction generated between the nail and the wood matrix raises the temperature at the contact zone above 180 °C. As the nail displaces the wood material, the matrix pushes back against the nail, increasing pressure and enhancing the adhesive effect.

When LIGNOLOC® wooden nails are driven into wood, the combination of high temperature and lateral pressure creates ideal conditions for initiating the adhesion of lignin. As a result, the withdrawal resistance of the wooden nail is twice as high as that of a geometrically comparable steel nail.

The ecological advantages are obvious: LIGNOLOC® wooden nails represent an especially environmentally friendly approach to building – in both material and application. Compared to the production of steel nails, the manufacturing of our wooden nails generates up to 66% less CO_2 emissions – a significant difference that makes LIGNOLOC® the preferred choice for sustainable construction projects. The wooden nails by BECK are made from European beech wood – a renewable raw material that promotes resource-efficient forestry and helps minimize environmental impact.

Structural design for planners and carpenters

ETA-23/0041 | ETA-23/0330

LIGNOLOC® wooden nails

Edge distances – LIGNOLOC® wooden nails

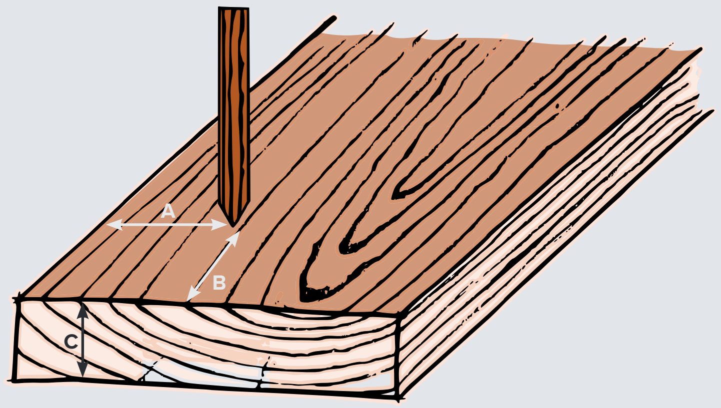
in accordance with DIN EN 1995-1-1:2010-12

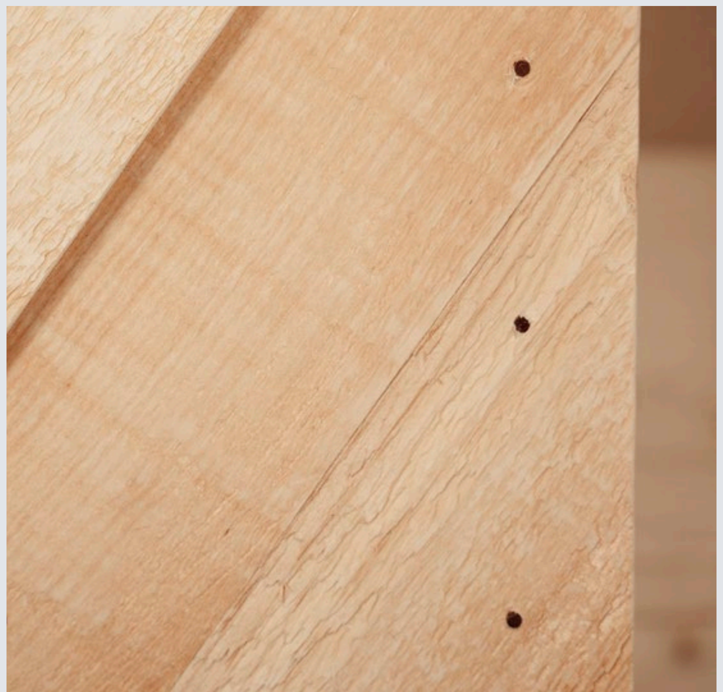
	Wood Density	
	≤ 420 kg/m^3	420 kg/m^3 - 500 kg/m^3
A	5*d	7*d[1]
B	10*d	15*d[1]
C	7*d	7*d[1]
D	When nails are driven in a row, an offset of 1*d should be maintained between them.	

	Wood density ≤ 420 kg/m^3		
	ø 3.7	ø 4.7	ø 5.3
A	18.5	23.5	26.5
B	37.0	47.0	53.0
C	25.9	32.9	37.1

	Wood density ≤ 420 kg/m^3 - 500 kg/m^3		
	ø 3.7	ø 4.7	ø 5.3
A	25.9	32.9	37.1
B	55.5	70.5	79.5
C	25.9	32.9	37.1

d = nail diameter
[1] = values also apply to wood species classified as prone to splitting (e.g. silver fir)
Wood moisture content should be below 18%.

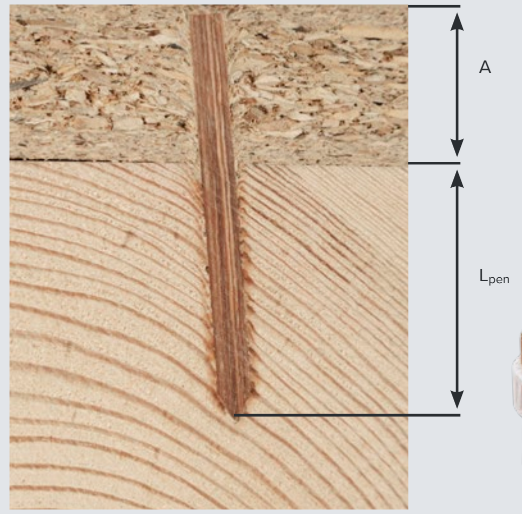




Penetration depth – LIGNOLOC® wooden nails

Minimum penetration depth – LIGNOLOC® wooden nails		
Diameter	**Top Layer**	**Substructure**
[mm]	[mm]	[mm]
ø 3.7	14.8	29.6
ø 4.7	18.8	37.6
ø 5.3	21.2	42.4

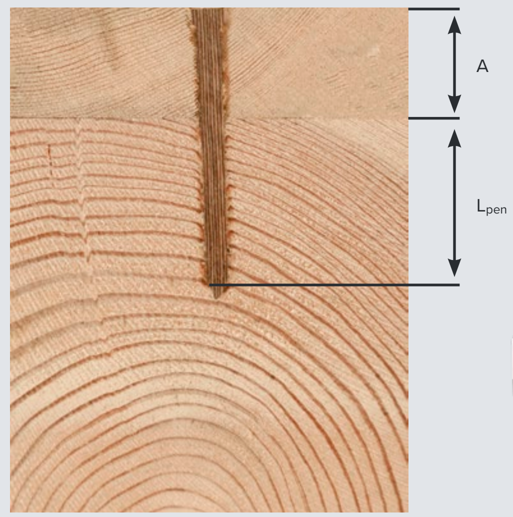
The top layer (A) should be at least 4 times the nail diameter in thickness. LIGNOLOC® wooden nails should penetrate the substructure to a depth of at least 8 times the nail diameter (L_{pen}).

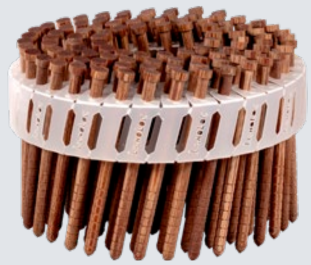


LIGNOLOC® wooden nails with head – penetration depth

Minimum penetration depth – LIGNOLOC® wooden nails		
Diameter	**Top layer**	**Substructure**
[mm]	[mm]	[mm]
ø 4.7	18.8	37.6

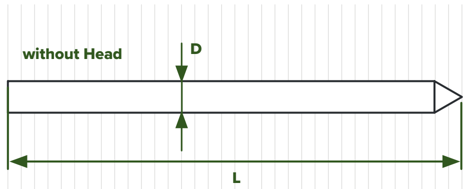
The top layer (A) should be at least 4 times the nail diameter in thickness. LIGNOLOC® wooden nails should penetrate the substructure to a depth of at least 8 times the nail diameter (L_{pen}).

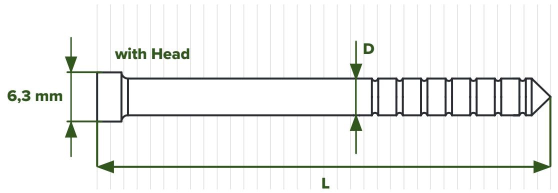




Structural design for planners

Product range





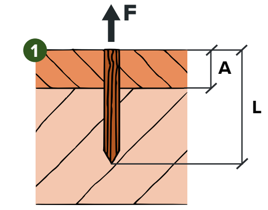
	ITEM	D DIAMETER [mm]	L LENGTH [mm]	ITEM-NO.
	LIGNOLOC® wooden nails 3.7	3.7	38	CN37AGWON.1
			50	CN37AGWON.2
			55	CN37AGWON.3
			60	CN37AGWON.4
	LIGNOLOC® wooden nails 4.7	4.7	65	CN47AGWO.2
			75	CN47AGWO.3
			90	CN47AGWO.4
	LIGNOLOC® wooden nails 5.3	5.3	65	CN53AGWO.1
			75	CN53AGWO.2
			90	CN53AGWO.3
	LIGNOLOC® wooden nails 4.7 with head	4.7	58	CN47AGWO-H.6
			64	CN47AGWO-H.10
			78	CN47AGWO-H.9

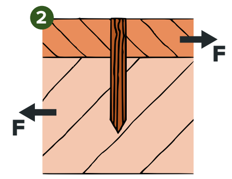
Mechanical properties

ITEM	DIAMETER [mm]	CHARACTERISTIC WITHDRAWAL PARAMETER $F_{ax,k}$ [N/mm²]	CHARACTERISTIC TENSILE CAPACITY $F_{tens,k}$ [kN]	CHARACTERISTIC YIELD MOMENT $M_{u,k}$ [Nmm]	CHARACTERISTIC HEAD PULL-THROUGH PARAMETER $F_{head,k}$ [Nmm²]
LIGNOLOC® wooden nails 3.7	3.7	7	1.2	1200	
LIGNOLOC® wooden nails 4.7	4.7	7	1.4	2200	
LIGNOLOC® wooden nails 5.3	5.3	7	2	3600	
LIGNOLOC® wooden nails 4.7 with head	4.7	7	1.4	1800	12

LIGNOLOC® wooden nails 3.7

CHARACTERISTIC WITHDRAWAL CAPACITY ❶			$F_{ax,k}$ [N]		$F_{ax,k\text{-Top layer}}$ [N]
Top layer	A	L	C16	C24	
	[mm]				
Solid wood	24	55	729	803	504
Plywood	15	50	823	907	241
	18	50	752	829	347
	20	55	823	907	428
OSB3/4	15	50	823	907	303
	18	50	752	829	436
1-layer / 3-layer	16	50	799	881	224
	18-20	50	705	777	284
Gypsum fibre board	15	50	823	907	456



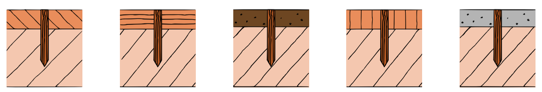


WITHDRAWAL CAPACITY ❶			$F_{ax,Rd}$ [N]						$F_{ax,Rd\text{-Top layer}}$ [N]		
Top layer	A	L	Medium		Short		Very short		Medium	Short	Very short
	[mm]		C16	C24	C16	C24	C16	C24			
Solid wood	24	55	224	247	280	309	449	494	155	194	310
Plywood	15	50	253	279	317	349	506	558	80	100	161
	18	50	231	255	289	319	463	510	116	145	231
	20	55	253	279	317	349	506	558	143	178	285
OSB3/4	15	50	253	279	317	349	506	558	101	126	202
	18	50	231	255	289	319	463	510	145	182	291
1-layer / 3-layer	16	50	246	271	307	339	492	542	69	86	138
	18-20	50	217	239	271	299	434	478	87	109	175
Gypsum fibre board	15	50	253	279	317	349	506	558	140	175	281

Load duration considered (inkl. k_{mod} and γ_M)

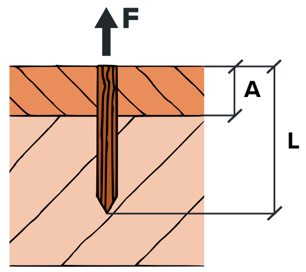
SHEAR VALUE ❷			$F_{v,Rd}$ [N]									
Top layer	A	L	Permanent		Long-term		Medium-term		Short-term		Very short-term	
	[mm]		C16	C24	C16	C24	C16	C24	C16	C24	C16	C24
Solid wood	24	55	104	107	120	123	143	147	166	171	225	232
Plywood	15	50	109	113	126	131	151	156	175	182	238	246
	18	50	109	113	126	131	151	156	175	182	238	246
	20	55	109	113	126	131	151	156	175	182	238	246
OSB3/4	15	50	109	112	127	132	158	164	188	195	254	264
	18	50	109	112	127	132	158	164	188	195	254	264
1-layer / 3-layer	16	50	104	107	120	123	143	147	166	171	211	215
	18-20	50	104	107	120	123	143	147	166	171	225	232
Gypsum fibre board	15	50	124	130	132	137	165	172	196	205	270	282

Load duration considered (inkl. k_{mod} and γ_M)



LIGNOLOC® wooden nails 4.7

CHARACTERISTIC WITHDRAWAL CAPACITY			$F_{ax,k}$ [N]		$F_{ax,k\text{-}Top\ layer}$ [N]
Top layer	A	L	C16	C24	
	[mm]				
Solid wood	24	65	1,224	1,349	504
	28	75	1,403	1,546	686
	35	90	1,642	1,810	1,072
Plywood	20/21	65	1,314	1,448	428
	24/25	65	1,194	1,316	616
	27	75	1,433	1,579	780
	35	90	1,642	1,810	1,311
OSB3/4	22	65	1,284	1,415	652
	25	65	194	1,316	842
	30	75	1,344	1,481	1,212
1-layer / 3-layer	20	65	1,344	1,481	350
	23/24	65	1,224	1,349	463
	26	65	1,164	1,283	592
	27	75	1,433	1,579	638
	32	75	1,284	1,415	896
	40	90	1,493	1,645	1,316

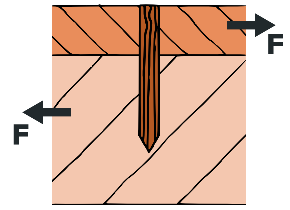


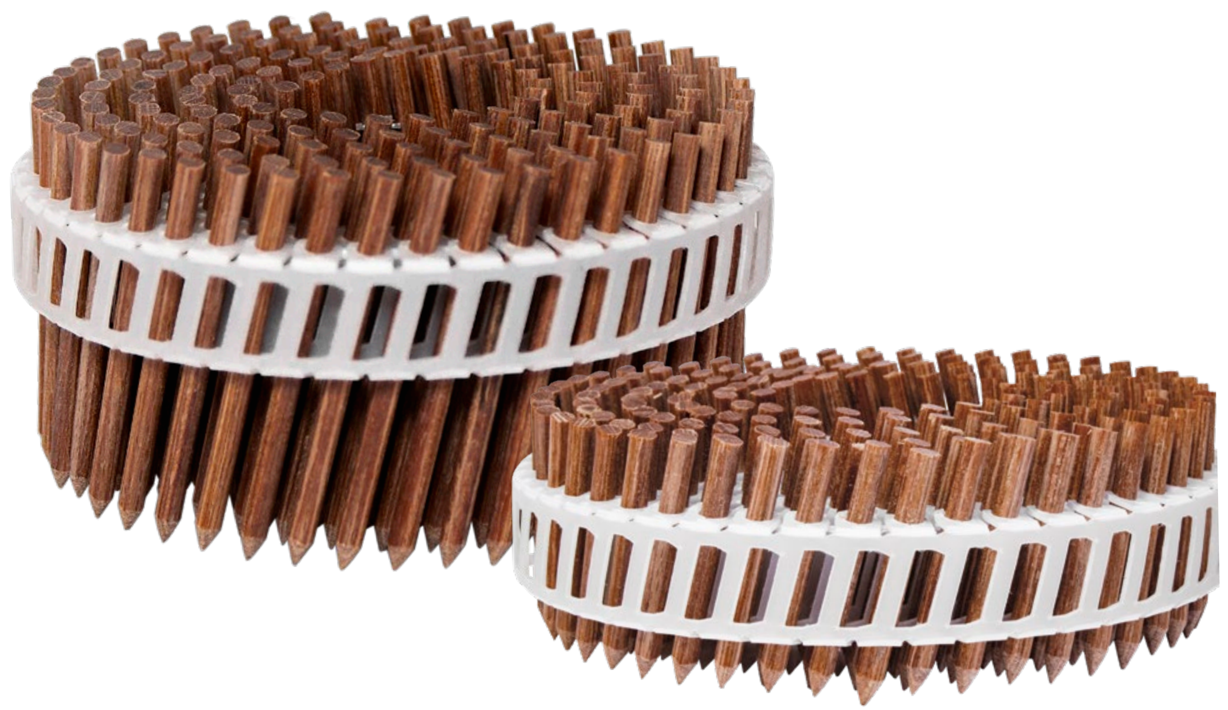
WITHDRAWAL CAPACITY			$F_{ax,Rd}$ [N]						$F_{ax,Rd\text{-}Top\ layer}$ [N]		
Top Layer	A	L	Medium		Short		Very short		Medium	Short	Very short
	[mm]		C16	C24	C16	C24	C16	C24			
Solid wood	24	65	377	415	471	519	753	830	155	194	310
	28	75	432	476	540	595	863	951	211	264	422
	35	90	505	557	632	696	1,010	1,114	330	412	660
Plywood	20/21	65	404	446	505	557	809	891	132	165	263
	24/25	65	367	405	459	506	735	810	190	237	379
	27	75	441	486	551	607	882	972	240	300	480
	35	90	505	557	632	696	1,010	1,114	403	504	807
OSB3/4	22	65	395	435	494	544	790	871	217	272	435
	25	65	60	405	75	506	119	810	281	351	561
	30	75	414	456	517	570	827	911	404	505	808
1-layer / 3-layer	20	65	414	456	517	570	827	911	108	135	215
	23/24	65	377	415	471	519	753	830	142	178	285
	26	65	358	395	448	493	716	790	182	228	364
	27	75	441	486	551	607	882	972	196	245	393
	32	75	395	435	494	544	790	871	276	345	551
	40	90	459	506	574	633	919	1,012	405	506	810

Load duration considered (incl. k_{mod} and γ_M)

SHEAR VALUE			$F_{v,Rd}$ [N]									
Top layer	A	L	Permanent		Long-term		Medium-term		Short-term		Very short-term	
	[mm]		C16	C24	C16	C24	C16	C24	C16	C24	C16	C24
Solid wood	24	65	152	156	175	181	209	216	243	251	329	340
	28	75	152	156	175	181	209	216	243	251	329	340
	35	90	152	156	175	181	209	216	243	251	329	340
Plywood	20/21	65	160	166	185	192	221	229	257	266	348	360
	24/25	65	160	166	185	192	221	229	257	266	348	360
	27	75	160	166	185	192	221	229	257	266	348	360
	35	90	160	166	185	192	221	229	257	266	348	360
OSB3/4	22	65	159	165	186	193	231	240	275	286	372	387
	25	65	159	165	186	193	231	240	275	286	372	387
	30	75	159	165	186	193	231	240	275	286	372	387
1-layer / 3-layer	20	65	152	156	175	181	209	216	243	251	308	318
	23/24	65	152	156	175	181	209	216	243	251	329	340
	26	65	152	156	175	181	209	216	243	251	329	340
	27	75	152	156	175	181	209	216	243	251	329	340
	32	75	152	156	175	181	209	216	243	251	329	340
	40	90	152	156	175	181	209	216	243	251	329	340

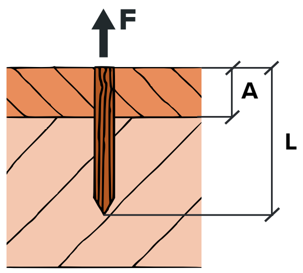
Load duration considered (incl. k_{mod} and γ_M)





LIGNOLOC® wooden nails 5.3

CHARACTERISTIC WITHDRAWAL CAPACITY			$F_{ax,k}$ [N]		$F_{ax,k\text{-Top layer}}$ [N]
Top layer	A	L	C16	C24	
	[mm]				
Solid wood	24	75	1,717	1,892	504
	28	75	1,582	1,744	686
	35	90	1,852	2,041	1,072
Plywood	20/21	65	1,481	1,632	428
	24/25	75	1,683	1,855	616
	27	75	1,616	1,781	780
	35	90	1,852	2,041	1,311
OSB3/4	22	65	1,448	1,595	652
	25	75	1,683	1,855	842
	30	90	2,020	2,226	1,212
1-layer / 3-layer	20	65	1,515	1,670	350
	23/24	75	1,717	1,892	463
	26/27	75	1,616	1,781	592
	32	90	1,953	2,152	896
	40	90	1,683	1,855	1,400

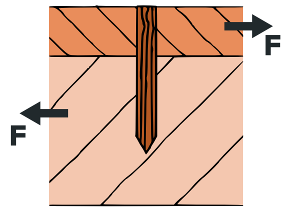


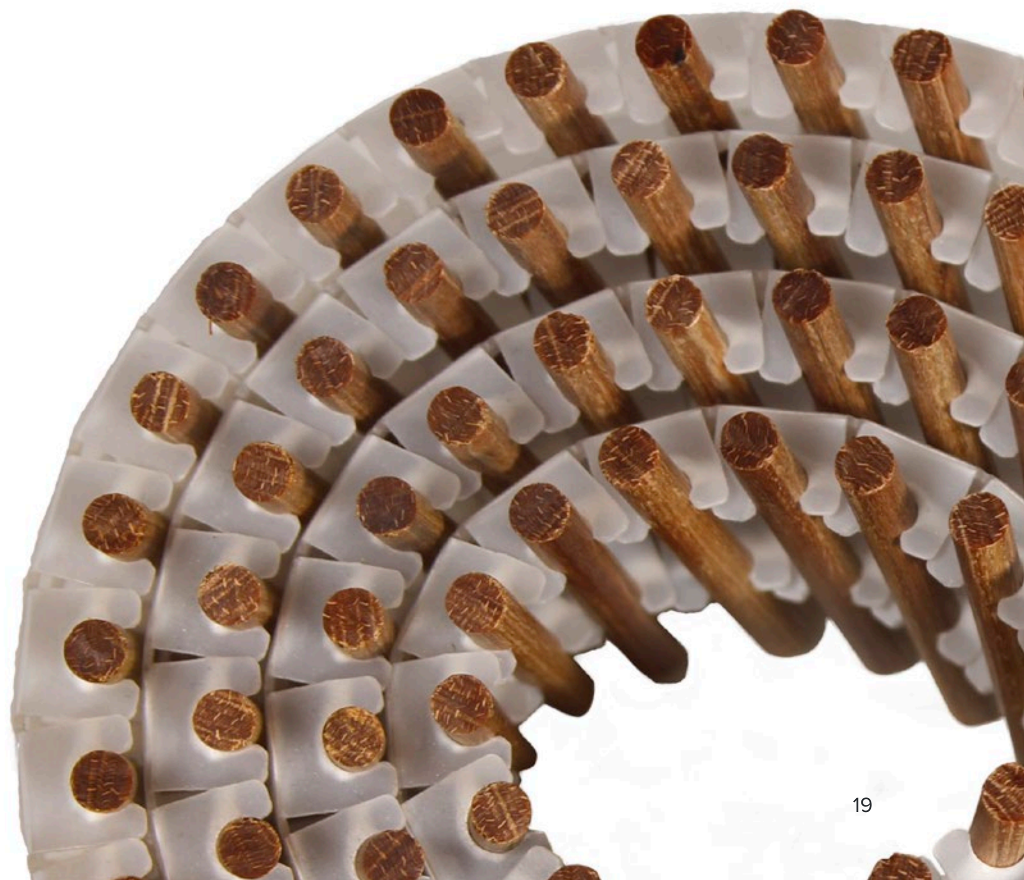
WITHDRAWAL CAPACITY			$F_{ax,Rd}$ [N]						$F_{ax,Rd\text{-Top layer}}$ [N]		
Top layer	A	L	Medium		Short		Very short		Medium	Short	Very short
	[mm]		C16	C24	C16	C24	C16	C24			
Solid wood	24	75	528	582	660	728	1,057	1,164	155	194	310
	28	75	487	537	608	671	974	1,073	211	264	422
	35	90	570	628	712	785	1,140	1,256	330	412	660
Plywood	20/21	65	456	502	570	628	911	1,004	132	165	263
	24/25	65	518	571	647	713	1,036	1,142	190	237	379
	27	75	497	548	622	685	994	1,096	240	300	480
	35	90	570	628	712	785	1,140	1,256	403	504	807
OSB3/4	22	65	446	491	557	613	891	982	217	272	435
	25	75	518	571	647	713	1,036	1,142	281	351	561
	30	90	622	685	777	856	1,243	1,370	404	505	808
1-layer / 3-layer	20	65	466	514	583	642	932	1,028	108	135	215
	23/24	75	528	582	660	728	1,057	1,164	142	178	285
	26/27	75	497	548	622	685	994	1,096	182	228	364
	32	90	601	662	751	828	1,202	1,324	276	345	551
	40	90	518	571	647	713	1,036	1,142	431	538	862

Load duration considered (incl. k_{mod} and γ_M)

SHEAR VALUE			$F_{v,Rd}$ [N]									
Top layer	A	L	Permanent		Long-term		Medium-term		Short-term		Very short-term	
	[mm]		C16	C24	C16	C24	C16	C24	C16	C24	C16	C24
Solid wood	24	75	202	208	233	240	278	287	323	334	400	412
	28	75	202	208	233	240	278	287	323	334	438	452
	35	90	202	208	233	240	278	287	323	334	438	452
Plywood	20/21	65	213	221	246	255	294	305	336	348	410	425
	24/25	75	213	221	246	255	294	305	342	354	463	479
	27	75	213	221	246	255	294	305	342	354	463	479
	35	90	213	221	246	255	294	305	342	354	463	479
OSB3/4	22	65	211	219	248	257	307	320	365	380	495	515
	25	75	211	219	248	257	307	320	365	380	495	515
	30	90	211	219	248	257	307	320	365	380	495	515
1-layer / 3-layer	20	65	182	187	212	219	242	250	272	281	333	344
	23/24	75	202	208	233	240	278	287	313	323	383	395
	26/27	75	202	208	233	240	278	287	323	334	433	447
	32	90	202	208	233	240	278	287	323	334	438	452
	40	90	202	208	233	240	278	287	323	334	438	452

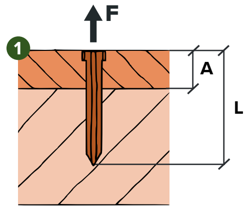
Load duration considered (incl. k_{mod} and γ_M)

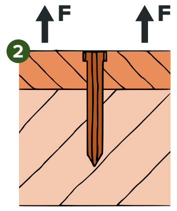


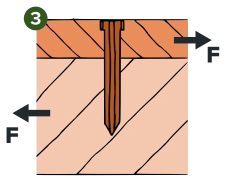


LIGNOLOC® wooden nails 4.7 with head

CHARACTERISTIC WITHDRAWAL CAPACITY (1)			$F_{ax,k}$ [N]		$F_{ax,k\text{-Top layer}}$ [N]
Top layer	A	L	C16	C24	
	[mm]				
Solid wood (55 mm length)	18	58	1,194	1,316	476
	20	58	1,135	1,250	476
	25	64	1,164	1,283	476
	25	78	1,582	1,744	476







WITHDRAWAL VALUE (1)			$F_{ax,Rd}$[1] [N]					
Top layer	A	L	Medium		Short		Very Short	
	[mm]		C16	C24	C16	C24	C16	C24
Solid wood (55 mm length)	18	58	367	405	459	506	735	810
	20	58	349	385	437	481	698	769
	25	64	358	395	448	494	717	790
	25	78	487	537	608	671	974	1,073

HEAD PULL-THROUGH VALUE (2)			$F_{head,Rd}$[1] [N]					$F_{head,Rd}$[2] [N]				
Top layer	A	L	Perma-nent	Long-term	Medium-term	Short-term	Very short-term	Perma-nent	Long-term	Medium-term	Short-term	Very short-term
	[mm]											
Solid wood (55 mm length)	18	58	128	146	183	220	330	128	146	146	183	220
	20	58	128	146	183	220	330	128	146	146	183	220
	25	64	0	146	183	220	330	128	146	146	183	220
	25	78	128	146	183	220	330	128	146	146	183	220

Load duration considered (incl. k_{mod} and γ_M)

SHEAR VALUE (3)			$F_{v,Rd}$[1] [N]									
Top layer	A	L	Permanent		Long-term		Medium-term		Short-term		Very short-term	
	[mm]		C16	C24	C16	C24	C16	C24	C16	C24	C16	C24
Solid wood (55 mm length)	18	58	137	142	158	163	189	195	220	227	277	286
	20	58	137	142	158	163	189	195	220	227	298	307
	25	64	137	142	158	163	189	195	220	227	298	307
	25	78	137	142	158	163	189	195	220	227	298	307

SHEAR VALUE (3)			$F_{v,Rd}$[2] [N]									
Top layer	A	L	Permanent		Long-term		Medium-term		Short-term		Very short-term	
	[mm]		C16	C24	C16	C24	C16	C24	C16	C24	C16	C24
Solid wood (55 mm length)	18	58	137	142	158	163	196	175	201	207	243	251
	20	58	137	142	158	163	196	175	201	207	243	251
	25	64	137	142	158	163	196	175	201	207	243	251
	25	78	137	142	158	163	169	175	201	207	243	251

[1] Service class 1 & 2
[2] Service class 3

Load duration considered (incl. k_{mod} and γ_M)

General principles

The characteristic values, including the mechanical strengths and geometric parameters of LIGNOLOC® wooden nails, are determined and presented based on EN 1995-1-1 and in accordance with the specifications of ETA-23/0041 and ETA-23/0330.

The design values are derived from the characteristic values as follows:

$$F_{ax,t,d} = F_{ax,t,k} \cdot k_{mod,ax} / \gamma_M$$
$$F_{head,d} = F_{max,k} \cdot k_{mod} / \gamma_M$$

The coefficients $k_{mod,ax}$ and γ_M are taken from the relevant standard.

The calculations are based on a characteristic mean density of 350 kg/m³ and a penetration depth of t = 8d.

LOAD DURATION CLASS	$k_{mod,M}$	$k_{mod,ax}$	$k_{mod,M}$	$k_{mod,M}$		
	Service class 1 and 2		Service class 1 and 3*	Solid wood, 3-layer, plywood	OSB3/4	Gypsum fibre board
Permanent	0.35	-	0.35	0.6	0.4	0.2
Long-term	0.4	-	0.4	0.7	0.5	0.4
Medium-term	0.5	0.4	0.4	0.8	0.7	0.6
Short-term	0.6	0.5	0.5	0.9	0.9	0.8
Very Short-term	0.9	0.8	0.6	1.1	1.1	1.1

* for LIGNOLOC® wooden nails 4,7 with head

For nails under combined loading both perpendicular and axial to the nail direction, the following design rules apply:

$$\frac{F_{ax,Ed}}{F_{ax,Rd}} + \frac{F_{v,Ed}}{F_{v,Rd}} \leq 1$$

For shear resistance, the fibre orientation resulting in the lowest value is assumed (a = 90°).

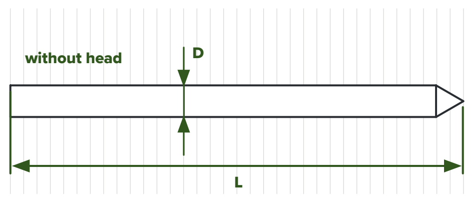
The characteristic density and partial safety factor γ_M used in the calculations can be taken from the following table:

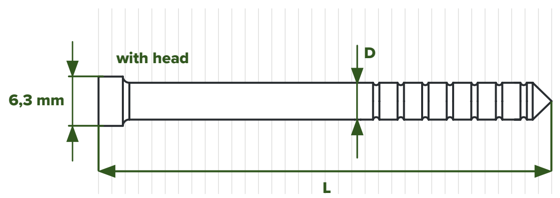
	rk [kg/m³]	gM
Solid wood	350	1.3
Plywood	450	1.3
OSB3/4	600	1.2
1-layer / 3-layer	350	1.3
Gypsum fibre board	1000	1.3

Spacing between fasteners and distances to edges are in accordance with EN 1995-1-1.
The design and verification of timber components and panels must be carried out separately.

Structural design for carpenters

Product range





	ITEM	D DIAMETER [mm]	L LENGTH [mm]	ITEM NO.
	LIGNOLOC® wooden nails 3.7	3.7	38	CN37AGWON.1
			50	CN37AGWON.2
			55	CN37AGWON.3
			60	CN37AGWON.4
	LIGNOLOC® wooden nails 4.7	4.7	65	CN47AGWO.2
			75	CN47AGWO.3
			90	CN47AGWO.4
	LIGNOLOC® wooden nails 5.3	5.3	65	CN53AGWO.1
			75	CN53AGWO.2
			90	CN53AGWO.3
	LIGNOLOC® wooden nails 4.7 with head	4.7	58	CN47AGWO-H.6
			64	CN47AGWO-H.10
			78	CN47AGWO-H.9

Mechanical properties

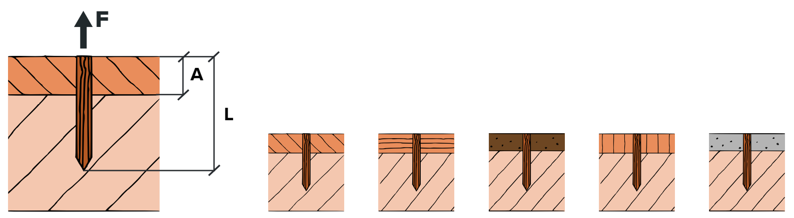
ITEM	DIAMETER [mm]	CHARACTERISTIC WITHDRAWAL PARAMETER $F_{ax,k}$ [N/mm^2]	CHARACTERISTIC TENSILE CAPACITY $Ft_{ens,k}$ [kN]	CHARACTERISTIC YIELD MOMENT $M_{u,k}$ [Nmm]	CHARACTERISTIC HEAD PULL-THROUGH PARAMETER $F_{head,k}$ [Nmm^2]
LIGNOLOC® wooden nails 3.7	3.7	7	1.2	1200	
LIGNOLOC® wooden nails 4.7	4.7	7	1.4	2200	
LIGNOLOC® wooden nails 5.3	5.3	7	2	3600	
LIGNOLOC® wooden nails 4.7 with head	4.7	7	1.4	1800	12

LIGNOLOC® wooden nails 3.7

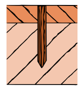
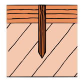
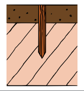
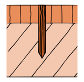
LIGNOLOC® WOODEN NAILS 3.7			Withdrawal capacity			Shear value	
			$F_{ax,d}$ [kg] Medium		$F_{ax,k\text{-Top layer}}$ [kg] Medium	$F_{v,Rd}$ [kg] Permanent	
Top layer	A [mm]	L [mm]	C16	C24		C16	C24
Solid wood	24	55	22.9	25.2	15.8	10.6	10.9
Plywood	15	50	25.8	28.4	8.2	11.1	11.5
	18	50	23.6	26.0	11.8	11.1	11.5
	20	55	25.8	28.4	14.5	11.1	11.5
OSB3/4	15	50	25.8	28.4	10.3	11.1	11.4
	18	50	23.6	26.0	14.8	11.1	11.4
1-layer / 3-layer	16	50	25.1	27.6	7.0	10.6	10.9
	18-20	50	22.1	24.4	8.9	10.6	10.9
Gypsum fibre board	15	50	25.8	28.4	14.3	12.6	13.3

LIGNOLOC® wooden nails 4.7

LIGNOLOC® WOODEN NAILS 4.7			Withdrawal capacity			Shear value	
			$F_{ax,k}$ [kg] Medium		$F_{ax,k\text{-Top layer}}$ [kg] Medium	$F_{v,Rd}$ [kg] Permanent	
Top layer	A [mm]	L [mm]	C16	C24		C16	C24
Solid wood	24	65	38.4	42.3	15.8	15.5	15.9
	28	75	44.0	48.5	21.5	15.5	15.9
	35	90	51.5	56.8	33.6	15.5	15.9
Plywood	20/21	65	41.2	45.4	13.4	16.3	16.9
	24/25	65	37.5	41.3	19.3	16.3	16.9
	27	75	44.9	49.5	24.5	16.3	16.9
	35	90	51.5	56.8	41.1	16.3	16.9
OSB3/4	22	65	40.3	44.4	22.2	16.2	16.8
	25	65	6.1	41.3	28.6	16.2	16.8
	30	75	42.2	46.5	41.2	16.2	16.8
1-layer / 3-layer	20	65	42.2	46.5	11.0	15.5	15.9
	23/24	65	38.4	42.3	14.5	15.5	15.9
	26	65	36.5	40.2	18.6	15.5	15.9
	27	75	44.9	49.5	20.0	15.5	15.9
	32	75	40.3	44.4	28.1	15.5	15.9
	40	90	46.8	51.6	41.3	15.5	15.9

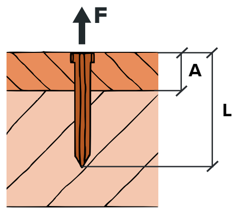


LIGNOLOC® wooden nails 5.3

LIGNOLOC® WOODEN NAILS 5.3			Withdrawal capacity			Shear value	
			$F_{ax,k}$ [kg]		$F_{ax,k\text{-Top-layer}}$ [kg]	$F_{v,Rd}$ [kg]	
			medium-term			permanent	
Top layer	A [mm]	L [mm]	C16	C24		C16	C24
 Solid wood	24	75	1,717	1,892	504	20.6	21.2
	28	75	1,582	1,744	686	20.6	21.2
	35	90	1,852	2,041	1,072	20.6	21.2
 Plywood	20/21	65	1,481	1,632	428	21.7	22.5
	24/25	75	1,683	1,855	616	21.7	22.5
	27	75	1,616	1,781	780	21.7	22.5
	35	90	1,852	2,041	1,311	21.7	22.5
 OSB3/4	22	65	1,448	1,595	652	21.5	22.3
	25	75	1,683	1,855	842	21.5	22.3
	30	90	2,020	2,226	1,212	21.5	22.3
1-layer / 3-layer 	20	65	1,515	1,670	350	18.6	19.1
	23/24	75	1,717	1,892	463	20.6	21.2
	26/27	75	1,616	1,781	592	20.6	21.2
	32	90	1,953	2,152	896	20.6	21.2
	40	90	1,683	1,855	1,400	20.6	21.2

LIGNOLOC® wooden nails 4.7 with head

LIGNOLOC® WOODEN NAILS 4.7 WITH HEAD			Withdrawal capacity			Shear value	
			$F_{ax,k}$ [kg]		$F_{head,k\text{-Top-layer}}$ [kg]	$F_{v,Rd}$ [kg]	
			medium-term	medium-term	permanent	permanent	
Top layer	A [mm]	L [mm]	C16	C24		C16	C24
Solid wood	18	58	37	41	13.1	14.0	14.5
	20	58	36	39	13.1	14.0	14.5
	25	64	37	40	13,1	14,0	14,5
	25	78	50	55	13.1	14.0	14.5



General principles

To simplify practical application for carpenters, only the most unfavourable load duration classes – medium-term and permanent – have been considered. Therefore, the values provided represent conservative minimum values and are universally applicable. For more detailed structural verifications, values for other load duration classes can be taken from ETA-compliant calculations.

The characteristic values, including the mechanical properties and geometric parameters of LIGNOLOC® wooden nails, are determined and presented in accordance with EN 1995-1-1 and the specifications of ETA-23/0041 and ETA-23/0330.

The design values are derived from the characteristic values as follows:

$$F_{ax,t,d} = F_{ax,t,k} \cdot k_{mod,ax} / \gamma_M$$
$$F_{head,d} = F_{max,k} \cdot k_{mod} / \gamma_M$$

The coefficients $k_{mod,ax}$ and γ_M are taken from the relevant standard.

The calculations are based on a characteristic density of 350 kg/m³ and a penetration depth of t = 8d.

LOAD DURATION CLASS	$k_{mod,M}$	$k_{mod,ax}$	$k_{mod,M}$	$k_{mod,M}$		
	Service class 1 and 2		Service class 1 and 3*	Solid wood, 3-layer, plywood	OSB3/4	Gypsum fibre board
Permanent	0.35	-	0.35	0.6	0.4	0.2
Long-term	0.4	-	0.4	0.7	0.5	0.4
Medium-term	0.5	0.4	0.4	0.8	0.7	0.6
Short-term	0.6	0.5	0.5	0.9	0.9	0.8
Very short-term	0.9	0.8	0.6	1.1	1.1	1.1

* for LIGNOLOC® wooden nails 4,7 with head

For nails subjected to combined loading perpendicular and parallel to the nail axis, the following applies:

$$\frac{F_{ax,Ed}}{F_{ax,Rd}} + \frac{F_{v,Ed}}{F_{v,Rd}} \leq 1$$

For shear resistance, the fibre orientation resulting in the lowest value is assumed (a = 90°).

The characteristic density and partial safety factor γ_M used in the calculations can be taken from the following table:

	rk [kg/m³]	gM
Solid wood	350	1.3
Plywood	450	1.3
OSB3/4	600	1.2
1-layer / 3-layer	350	1.3
Gypsum fibre board	1000	1.3

Spacing between fasteners and distances to edges are in accordance with EN 1995-1-1.
The design and verification of timber components and panels must be carried out separately.

Structural analysis of a shear wall in wood panel construction

According to DIN EN 1995-1-1:2010-12 with LIGNOLOC® wooden nails

Calculation performed by:
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Structural Engineers
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01 // System

A single-family home constructed using timber panel construction is considered. The exterior wall element presented below was identified as the most critical and will be used for the subsequent structural design.

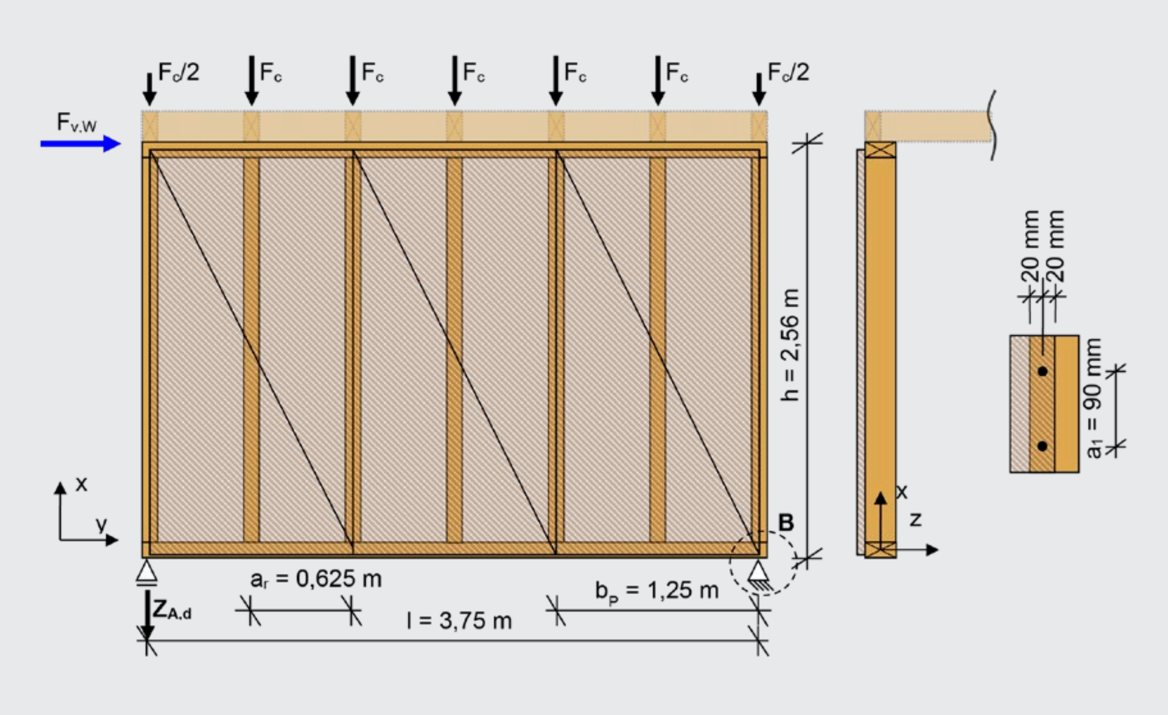
Edge studs: Softwood C24, b_{Ri} x h_{Ri} = 80 x 120 mm², NKL 1

Inner studs: Softwood C24, b_{Ri} x h_{Ri} = 80 x 120 mm², NKL 1, a_r = 0,625 m (stud spacing)

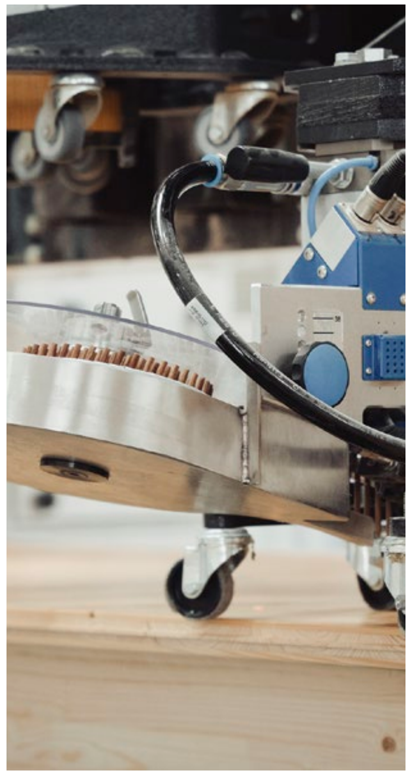
Bottom/Top plates: Softwood C24, b_S x h_S = 60 x 120 mm², NKL 1

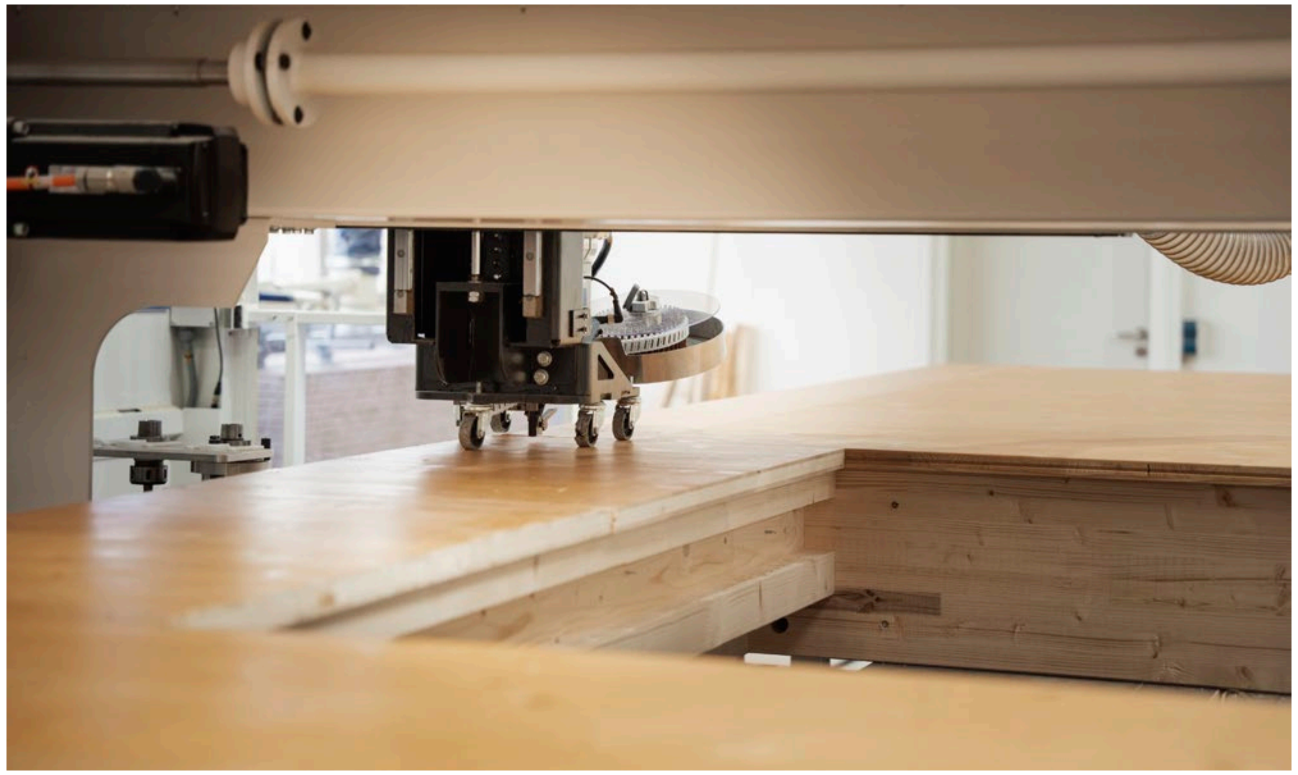
Sheathing: OSB/4, t_P = 18 mm, applied on one side according to DIN EN 12369-1:2001

Fasteners: LIGNOLOC® wooden nails, d = 3.7 mm, l = 50 mm, a_1 = 90 mm



LOAD TYPE	CHARACTERISTIC VALUE	LOAD DURATION CLASS	Ψ_0
Permanent load	$F_{c,G,k}$ = 2.0 kN	Permanent	-
Imposed load	$F_{c,Q,k}$ = 5.0 kN	Medium-term	0.7
Snow load < 1000 m	$F_{c,S,k}$ = 3.0 kN	Short-term	0.5
Wind load (in plane)	$F_{v,W,k}$ = 5.0 kN	Short/very short-term	0.6
Wind load (out-of-plane)	w_k = 0.4 kN/m²	Short/very short-term	0.6





02 // Application requirement

For the simplified design of shear walls according to method A of DIN EN 1995-1-1:2010-12

Anchorage

Is end anchorage provided? ✓ — 9.2.4.2 (1)

Sheathing

Is the width of each panel at least h/4? — 9.2.4.2 (2)

$b_p = 1{,}25\,m \geq \frac{h}{4} = \frac{2{,}56}{4} = 0{,}64\,m$ ✓

Is there a maximum of one horizontal panel joint? ✓ — 9.2.4.2 (NA.20)

Are the panel edges rigidly connected in shear? ✓

Fasteners as per ETA-23/0041, analogous to unpre-drilled nails per EN 1995-1-1:2010-12

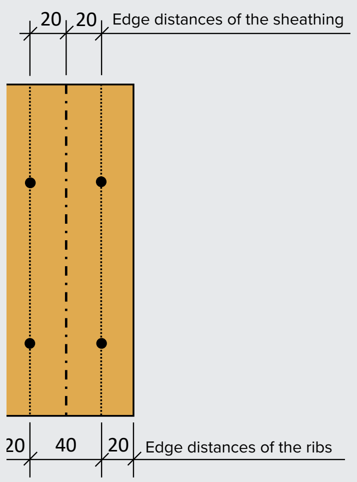
Is a consistent fastener spacing provided along all edges? — 9.2.4.2 (2)

$a_1 = 90$ mm ✓

Fastener Spacing Verification

$a_1 = 90$ mm ≤ 150 mm (Nails) ✓ — 10.8.2 (1)

$a_1 = 90$ mm ≤ 80 · d = 80 · 3,7 = 296 mm ✓ — 8.3.1.3 (NA.12)



Have the minimum fastener spacing requirements in the studs been met? — Table 8.2

$a_{1,min,VH} = (5 + 5/\cos\alpha) \cdot d = (5 + 5(\cos 0^\circ)) \cdot 3{,}7 = 37\,mm \leq 90\,mm$ ✓

$a_{2,min,VH} = 5 \cdot d = 5 \cdot 3{,}7 = 18{,}5\,mm \leq 40\,mm$ ✓

$a_{4,c,min,VH} = 5 \cdot d = 5 \cdot 3{,}7 = 18{,}5\,mm \leq 20\,mm$ ✓

Have the minimum fastener spacings in the OSB panel been met?

$a_{4,c,min} = 3 \cdot d = 3 \cdot 3{,}7 = 11{,}1\,mm \leq 20\,mm$ ✓ — 8.3.1.3 (NA.13

03 // Load on the edge rib

Characteristic axial forces in the edge stud

From permanent load: $F_{Ri,G,k} = 0{,}5 \cdot F_{c,G,k} = 0{,}5 \cdot 2{,}0\,kN = 1{,}0\,kN$

From imposed load: $F_{Ri,Q,k} = 0{,}5 \cdot F_{c,Q,k} = 0{,}5 \cdot 5{,}0\,kN = 2{,}5\,kN$

From snow load: $F_{Ri,S,k} = 0{,}5 \cdot F_{c,S,k} = 0{,}5 \cdot 3{,}0\,kN = 1{,}5\,kN$

From wind load: $F_{Ri,W,k} = F_{v,W,i,k} \cdot h/l = 5{,}0\,kN \cdot 2{,}56\,m/3{,}75\,m = 3{,}41\,kN$

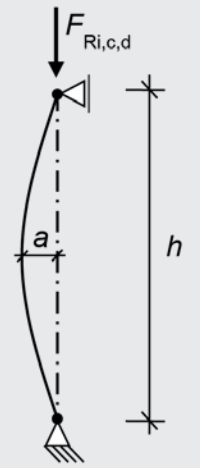
Design verification based on the following load case (wind as leading action)

$$E_d = E\left\{\sum_{j\geq1}\gamma_{G,j} \cdot G_{k,j} \oplus \gamma_{Q,1} \cdot Q_{k,1} \oplus \sum_{i>1}\gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}\right\}$$

$$F_{Ri,c,d} = 1{,}35 \cdot F_{Ri,G,k} + 1{,}5 \cdot F_{Ri,W,k} + 1{,}5 \cdot 0{,}7 \cdot F_{Ri,Q,k} + 1{,}5 \cdot 0{,}5 \cdot F_{Ri,S,k}$$

$$F_{Ri,c,d} = 1{,}35 \cdot 1{,}0\,kN + 1{,}5 \cdot 3{,}41\,kN + 1{,}5 \cdot (0{,}7 \cdot 2{,}5\,kN + 0{,}5 \cdot 1{,}5\,kN) = 10{,}21\,kN$$

NOTE: According to DIN EN 1990/NA:2010-12, all possible combinations of actions must be considered. In the design of timber structures, different kmod values must be applied depending on the load duration class. To maintain clarity in this example, only a single load combination is considered. However, for practical structural verification, all relevant load cases must be analysed in full.



Design value of the bending moment due to imperfection

10.2 (1)

$M_d = F_{Ri,c,d} \cdot a = F_{Ri,c,d} \cdot \frac{h}{300} = 10{,}21\,kN \cdot \frac{2{,}56}{300} = 0{,}09\,kNm$

Design value of the bending moment due to wind

$M_{d,Wind} = \left(1{,}5 \cdot 0{,}4\,kN/m^2 \cdot 0{,}625\,m/2\right) \cdot 2{,}56^2 m^2/8 = 0{,}154\,kNm$

$M_{d,ges} = M_d + M_{d,Wind} = 0{,}09\,kNm + 0{,}154\,kNm = 0{,}24\,kNm$

04 // Shear flow in the composite and sheathing layers

Design value of horizontal action

$$F_{v,d} = \gamma_Q \cdot F_{v,W,k} = 1{,}5 \cdot 5{,}0\,kN = 7{,}5\,kN$$

Design value of shear

$$s_{v,0,d} = \frac{F_{v,d}}{l} = \frac{7{,}5\,kN}{3{,}75\,m} = 2{,}0\,\frac{kN}{m}$$

05 // Calculation of the governing anchorage forces

Note: The maximum uplift force can be determined for the load cases “permanent load” and “wind”. Since the effect of “permanent load” is stabilising, it must be multiplied by the partial safety factor γG,stb = 0.9 in accordance with DIN EN 1990/NA:2010-12, Table NA.A.1.2(A).

Force equilibrium about point B

$$Z_{A,d} = \frac{1}{l} \cdot \left[\gamma_Q \cdot F_{v,W} \cdot h - \gamma_{G,stb} \cdot F_{c,G,k} \cdot \left(a_r + 2 \cdot a_r + 3 \cdot a_r + 4 \cdot a_r + 5 \cdot a_r + 6 \cdot a_r \cdot 1/2\right)\right]$$

$$Z_{A,d} = \frac{1}{3{,}75} \cdot \left[1{,}5 \cdot 5{,}0\,kN \cdot 2{,}56 - 0{,}9 \cdot 2{,}0\,kN \cdot \left(0{,}625 + 2 \cdot 0{,}625 + 3 \cdot 0{,}625 + 4 \cdot 0{,}625 + 5 \cdot 0{,}625 + 6/2 \cdot 0{,}6252\right)\right]$$

$$Z_{A,d} = -\,0{,}28\,kN$$

Due to the acting overpressure, no mechanical fasteners are needed to resist uplift in this case.

06 // Verification of the edge stud

In-plane buckling

6.3.1 (NA.5)

$$a_r = 62{,}5\,cm \leq 50 \cdot t_P = 50 \cdot 1{,}8\,cm = 90\,cm$$

$$h_{Ri}/b_{Ri} = 120/80 = 1{,}5 \leq 4$$

No Buckling

Out-of-plane buckling

6.3.2

$$\sigma_{c,0,d} = \frac{F_{Ri,c,d}}{A} = \frac{10{,}21\,kN \cdot 10^{-3}}{0{,}12 \cdot 0{,}08\,m^2} = 1{,}06\,MN/m^2$$

$$\sigma_{m,d} = \frac{M_{d,ges}}{W} = \frac{0{,}24\,kNm \cdot 10^{-3} \cdot 6}{0{,}12^2 \cdot 0{,}08\,m^3} = 1{,}25\,MN/m^2$$

$$f_{c,o,d} = k_{mod} \cdot \frac{f_{c,0,k}}{\gamma_M} = \frac{1{,}0 \cdot 21\,MN/m^2}{1{,}3} = 16{,}15\,MN/m^2$$

$$f_{m,d} = k_{mod} \cdot \frac{f_{m,k}}{\gamma_M} = \frac{1{,}0 \cdot 24\,MN/m^2}{1{,}3} = 18{,}46\,MN/m^2$$

Buckling coefficient

according to Schneider (24th ed.), table 9.29a or equation (6.25)

$$\lambda_y = \frac{l_{ef}}{i_y} = \frac{2{,}56}{0{,}289 \cdot 0{,}12} = 73{,}8$$

Interpolation of table values: $k_{c,y} = 0{,}51$

Lateral-torsional buckling coefficient

according to Schneider (24th ed.), table 9.32 or equation (6.34)

$$\frac{l_{ef} \cdot h}{b^2} = \frac{2{,}56 \cdot 0{,}12}{0{,}08^2} = 48 \leq 135$$

$$k_{crit} = 1{,}0$$

Verification

equation (NA.60)

$$\eta = \frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,o,d}} + \frac{\sigma_{m,d}}{k_{crit} \cdot f_{m,d}} = \frac{1{,}06 MN/m^2}{0{,}51 \cdot 16{,}15} + \frac{1{,}25 MN/m^2}{1{,}0 \cdot 18{,}46} = 0{,}20 \leq 1{,}0\ \checkmark$$

07 // Verification of bottom plate compression

Overhangs

$$\ddot{u}_{li} = Min\begin{Bmatrix} 30\,mm \\ a \\ l \\ l_1/2 \end{Bmatrix} = Min\begin{Bmatrix} 30\,mm \\ - \\ 80\,mm \\ (625-80)/2=272{,}5\,mm \end{Bmatrix} = 30\,mm$$

$$\sigma_{c,90,d} = \frac{F_{Ri,c,d}}{A_{ef}} = \frac{10{,}21 \cdot 10^{-3}}{0{,}12 \cdot (0{,}08+0{,}03)} = 0{,}77\,MN/m^2$$

Perpendicular-to-grain bearing coefficient

Continuous support, sole plate made of softwood (VH)

$$l_1 = (0{,}625 - 0{,}08) = 0{,}545\,m \geq 2 \cdot h_{Ri} = 2 \cdot 0{,}08\,m = 0{,}16\,m$$

$$\Rightarrow k_{c,90} = 1{,}25$$

6.1.5 (3)

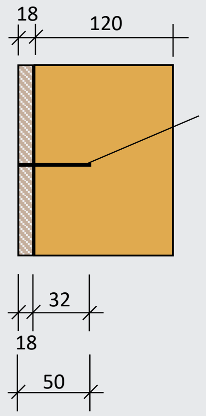
$$f_{c,90,d} = k_{mod} \cdot \frac{f_{c,90,k}}{\gamma_M} = 1{,}0 \cdot \frac{1{,}2 \cdot 2{,}5\,MN/m^2}{1{,}3} = 2{,}31\,\frac{MN}{m^2}$$

9.2.4.2 (NA.21)
(20% increase in load-bearing capacity)

Verification

$$\eta = \frac{\sigma_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} = \frac{0{,}77\,MN/m2}{1{,}25 \cdot 2{,}31\,MN/m^2} = 0{,}27 \leq 1{,}0\,\checkmark$$

08 // Verification of the LIGNOLOC® fasteners



Embedment strength of the OSB board

Gl. (8.22)

$$f_{h,1,k} = 65 \cdot d^{-0,7} \cdot t_P^{0,1} = 65 \cdot 3{,}7^{-0,7} \cdot 18^{0,1} = 34{,}73\,N/mm^2$$

$$f_{h,1,d} = f_{h,1,k} \cdot \frac{k_{mod,1}}{\gamma_M} = 34{,}73\,N/mm^2 \cdot \frac{1{,}0}{1{,}3} = 26{,}7\,N/mm^2$$

Embedment strength of solid wood (α=0°)

according to the ETA

$$f_{h,2,k} = 0{,}082 \cdot \rho_k \cdot d^{-0,3} = 0{,}082 \cdot 350\,kg/m^3 \cdot 3{,}7^{-0,3} = 19{,}38\,N/mm^2$$

$$f_{h,2,d} = f_{h,2,k} \cdot \frac{k_{mod,1}}{\gamma_M} = 19{,}38\,N/mm^2 \cdot \frac{1{,}0}{1{,}3} = 14{,}91\,N/mm^2$$

$$\beta = \frac{f_{h,2,d}}{f_{h,1,d}} = \frac{14{,}91\,N/mm^2}{26{,}7\,N/mm^2} = 0{,}56 \leq 1{,}0$$

Design value of the yield moment

ETA table B.1

$$M_{u,k} = 1200\,Nmm$$

$$M_{u,d} = M_{u,k} \cdot \frac{k_{mod,M}}{\gamma_M} = 1200\,Nmm \cdot \frac{0{,}9}{1{,}3} = 830{,}77\,Nmm$$

Required minimum embedment depth 1 (OSB/4)

according to the ETA

$$t_{1,req} = \sqrt{\frac{\beta}{1+\beta}} + 1 \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,1,d} \cdot d}} = \sqrt{\frac{0{,}56}{1+0{,}56}} + 1 \cdot \sqrt{\frac{4 \cdot 830{,}77\,Nmm}{0{,}75 \cdot 26{,}7\,\frac{N}{mm^2} \cdot 3{,}7}} = 7{,}81\,mm$$

$$t_{1,req} = 7{,}81\,mm \leq t_{vorh} = 18{,}0\,mm\,\checkmark$$

Required minimum embedment depth 2 (VH)

according to the ETA

$$t_{2,req} = \sqrt{\frac{1}{1+\beta}} + 1 \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,2,d} \cdot d}} = \sqrt{\frac{1}{1+0{,}56}} + 1 \cdot \sqrt{\frac{4 \cdot 830{,}77\,Nmm}{0{,}75 \cdot 14{,}91\,\frac{N}{mm^2} \cdot 3{,}7}} = 11{,}48\,mm$$

$$t_{2,req} = 11{,}48\,mm \leq t_{vorh} = 32{,}0\,mm$$

Design of the load-bearing capacity per nail

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot \beta}{1+\beta}} \cdot \sqrt{1{,}5 \cdot M_{u,d} \cdot f_{h,1,d} \cdot d}$$

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot 0{,}56}{1+0{,}56}} \cdot \sqrt{1{,}5 \cdot 830{,}77\,Nmm \cdot 26{,}7\,N/mm^2 \cdot 3{,}7\,mm}$$

$$F_{v,Rd,Na} = 297{,}30\,N$$

Shear resistance of the sheathing

$$S_{v,0,R,d} = \frac{F_{v,Rd}}{a_1} = \frac{297{,}30 \cdot 10^{-3}\,kN}{0{,}09\,m} = 3{,}30 kN/m$$

Verification the shear action

$$\eta = \frac{S_{v,0,d}}{S_{v,0,R,d}} = \frac{2{,}0\,kN/m}{3{,}30\,kN/m} = 0{,}61 \leq 1{,}0 \checkmark$$

Verification of the sheathing

Load-bearing capacity of the sheathing considering the arrangement

9.2.4.2 (NA.16)

$$f_{v,0,d} = \frac{k_{mod} \cdot 0{,}33 \cdot f_{v,k,OSB}}{\gamma_M} = \frac{1{,}0 \cdot 0{,}33 \cdot 6{,}9}{1{,}3} = 1{,}75\,kN/m^2$$

Buckling of the sheathing

$$\frac{a_r}{35} = \frac{625}{35} = 17{,}86\,mm < t_P = 18\,mm$$

Buckling of the sheathing

Verification of the sheathing

$$\eta = \frac{F_{v,Rd,Na}/(t_P \cdot a_1)}{f_{v,d}} = \frac{297{,}30\,N/(18\,mm \cdot 90\,mm)}{1{,}75\,N/mm^2} = 0{,}10 \leq 1{,}0 \checkmark$$

09 // Horizontal deformation

Conditions

panel length $l = 3{,}75\,m \geq h/3 = 2{,}56/3 = 0{,}85\,m$

panel width $b_p = 1{,}25\,m \geq h/4 = 2{,}56/4 = 0{,}64\,m$

+ Panel supported by a rigid substructure
+ no increase in the fastener load-bearing capacity according to EC 9.2.4.2 (5) considered

⟶ no verification required

Fastening of a Clapboard

with LIGNOLOC® wooden nails | ETA-23/0330

Calculation performed by:
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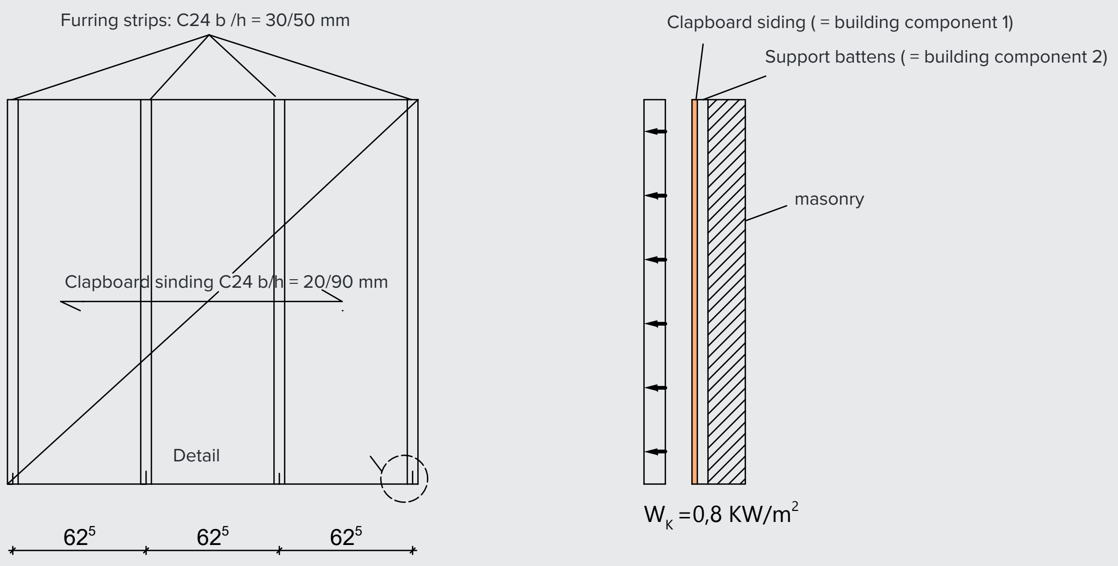
01 // System

A clapboard siding installed on a structural framework made of spruce timber is considered. Based on the local conditions, the façade can be assigned to Service Class 2.

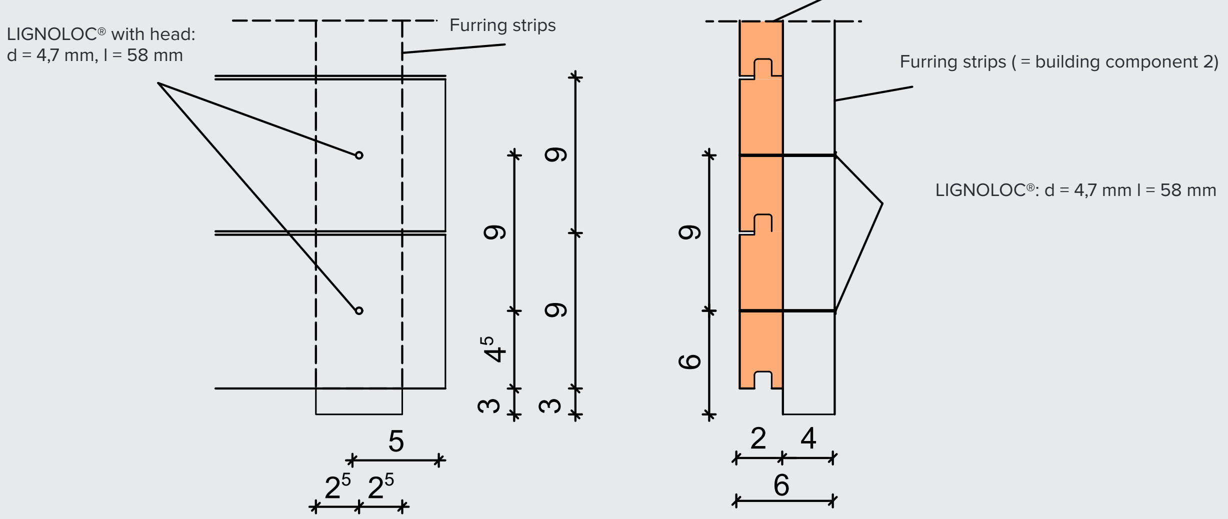
Support battens: Softwood C24, b_{Ri} x h_{Ri} = 40 x 50 mm, e= 625mm, NKL 2

Clapboard sinding: Softwood C24, b_S x h_S = 20 x 90 mm, NKL 2

Connection: LIGNOLOC® wooden nail with head, d=4,7mm, l=58 mm, a_1 = 90 mm



Detail



An analysis of the entire building resulted in a governing characteristic wind uplift load of 0.8 kN/m². For the clapboard siding, an average unit weight of $\rho_{\text{mean, Timber}} = 4{,}2\ \text{kN}/\text{m}^2$ can be assumed.

02 // Verification of the Minimum Spacings

Fasteners according to ETA-23/0330, analogous to non-pre-drilled nails in DIN EN 1995-1-1:2010-12

Are the minimum spacings in the clapboard siding (Component 1) met?

table 8.2

$$a_{1,\min,VH} = (5 + 5 \cdot (\cos\alpha)) \cdot d = (5 + 5 \cdot (\cos 90^\circ)) \cdot 4{,}7 = 23{,}5\ \text{mm} \leq 625\ \text{mm}\ \checkmark$$

$$a_{3,c,\min,VH} = 10 \cdot d = 10 \cdot 4{,}7 = 47{,}0\ \text{mm} \leq 50\ \text{mm}\ \checkmark$$

$$a_{4,t,\min,VH} = (5 + 2 \cdot \sin\alpha) \cdot d = (5 + 2 \cdot (\sin 90^\circ)) \cdot 4{,}7 = 32{,}9\ \text{mm} \leq 45\ \text{mm}\ \checkmark$$

$$a_{4,c,\min,VH} = 5 \cdot d = 5 \cdot 4{,}7 = 23{,}5\ \text{mm} \leq 45\ \text{mm}\ \checkmark$$

Are the minimum spacings in the furring strips (Component 2) met?

table 8.2

$$a_{1,\min,VH} = (5 + 5 \cdot (\cos\alpha)) \cdot d = (5 + 5 \cdot (\cos 0^\circ)) \cdot 4{,}7 = 47\ \text{mm} \leq 90\ \text{mm}\ \checkmark$$

$$a_{3,t,\min,VH} = (10 + 5 \cdot (\cos\alpha\ )) \cdot d = (10 + 5 \cdot (\cos 0^\circ)) \cdot 4{,}7 = 70{,}5\ \text{mm} \leq 60\ \text{mm}\ \checkmark$$

$$a_{4,c,\min,VH} = 5 \cdot d = 5 \cdot 4{,}7 = 23{,}5\ \text{mm} \leq 25\ \text{mm}\ \checkmark$$

03 // Loads per Nail

From permanent load

$$F_{V,G,k} = \rho_{\text{mean,Timber}} \cdot b_S \cdot h_S \cdot e = 4{,}2\tfrac{\text{kN}}{\text{m}^3} \cdot 0{,}020\text{m} \cdot 0{,}090\text{m} \cdot 0{,}625\text{m} = 4{,}7 \cdot 10^{-3}\text{kN} = 4{,}7\ \text{N}$$

Design level

$$F_{V,G,d} = F_{V,G,k} \cdot \gamma_G = 5{,}9\ \text{N} \cdot 1{,}35 = 6{,}3\ \text{N}$$

Wind load

$$F_{ax,W,k} = \underbrace{1{,}25}_{\text{continuity factor}} \cdot w_k \cdot h_S \cdot e = 1{,}25 \cdot 0{,}8\tfrac{\text{kN}}{\text{m}^2} \cdot 0{,}090\ \text{m} \cdot 0{,}625\ \text{m} = 0{,}056\ \text{kN} = 56{,}2\ \text{N}$$

At the design level

$$F_{ax,W,d} = F_{ax,W,k} \cdot \gamma_Q = 56{,}2\ N \cdot 1{,}5 = 84{,}3\ N$$

04 // Verification of Permanent Load

Embedding strength of solid timber – nail head side (α_1=90°)

according to ETA

$$f_{h,1,k} = \frac{0{,}082 \cdot \rho_{k,1} \cdot d^{-0,3}}{(1{,}35 + 0{,}015 \cdot d) \cdot \sin^2\alpha_1 + \cos^2\alpha_1}$$

$$f_{h,1,k} = \frac{0{,}082 \cdot 350\,kg/m^3 \cdot 4{,}7^{-0,3}}{(1{,}35 + 0{,}015 \cdot 4{,}7) \cdot (\sin 90^\circ)^2 + (\cos 90^\circ)^2} = 12{,}70\,N/mm^2$$

nach DIN EN 1995-1-1, Tab. 3.1

$$k_{mod,1} = 0{,}6$$

$$f_{h,1,d} = \frac{f_{h,1,k} \cdot k_{mod,1}}{\gamma_{M,1}} = \frac{12{,}70 \cdot 0{,}6}{1{,}3} = 5{,}86\,N/mm^2$$

Embedding strength of solid timber – nail tip side (α_2 = 0°)

according to ETA

$$f_{h,2,k} = \frac{0{,}082 \cdot \rho_{k,2} \cdot d^{-0,3}}{(1{,}35 + 0{,}015 \cdot d) \cdot \sin^2\alpha_2 + \cos^2\alpha_2} =$$

$$f_{h,2,k} = \frac{0{,}082 \cdot 350\,kg/m^3 \cdot 4{,}7^{-0,3}}{(1{,}35 + 0{,}015 \cdot 4{,}7) \cdot (\sin 0^\circ)^2 + (\cos 0^\circ)^2} = 18{,}04\,N/mm^2$$

according to DIN EN 1995-1-1, Tab. 3.1

$$k_{mod,2} = 0{,}6$$

$$f_{h,2,d} = \frac{f_{h,2,k} \cdot k_{mod,2}}{\gamma_{M,2}} = \frac{18{,}04 \cdot 0{,}6}{1{,}3} = 8{,}33\,N/mm^2$$

$$\beta = \frac{f_{h,2,d}}{f_{h,1,d}} = \frac{8{,}33\,N/mm^2}{5{,}86\,N/mm^2} = 1{,}42$$

Design value of the yield moment

ETA-table B.1

$$M_{u,k} = 1800\,Nmm$$

$$M_{u,d} = M_{u,k} \cdot \frac{k_{mod,M}}{\gamma_M} = 1800\,Nmm \cdot \frac{0{,}35}{1{,}3} = 485\,Nmm$$

Required minimum embedment depth 1 – nail head side

according to ETA

$$t_{1,req} = \left(\sqrt{\frac{\beta}{1+\beta}} + 1\right) \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,1,d} \cdot d}} = \left(\sqrt{\frac{1{,}42}{1+1{,}42}} + 1\right) \cdot \sqrt{\frac{4 \cdot 485\,Nmm}{0{,}75 \cdot 5{,}86 \cdot \frac{N}{mm^2} \cdot 4{,}7}} = 17{,}11\,mm$$

$$t_{1,req} = 17{,}11\,mm \leq t_{1,vorh} = 20{,}0\,mm\ \checkmark$$

Required minimum embedment depth 2 – nail tip side

according to ETA

$$t_{2,req} = \left(\sqrt{\frac{1}{1+\beta}} + 1\right) \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,2\,d} \cdot d}} = \left(\sqrt{\frac{1}{1+1{,}42}} + 1\right) \cdot \sqrt{\frac{4 \cdot 485\,Nmm}{0{,}75 \cdot 8{,}33 \frac{N}{mm^2} \cdot 4{,}7}} = 13{,}35\,mm$$

$$t_{2,req} = 13{,}35\,mm \leq t_{2,vorh} = 40{,}0\,mm\ \checkmark$$

Design of the load-bearing capacity in shear per nail

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot \beta}{1+\beta}} \cdot \sqrt{1{,}5 \cdot M_{u,d} \cdot f_{h,1,d} \cdot d}$$

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot 1{,}42}{1+1{,}42}} \cdot \sqrt{1{,}5 \cdot 485\,Nmm \cdot 5{,}86\,N/mm^2 \cdot 4{,}7\,mm}$$

$$F_{v,Rd,Na} = 153\,N$$

Verification

$$\eta = \frac{F_{V,G,d}}{F_{v,Rd,Na}} = \frac{6{,}3\,N}{153\,N} = 0{,}04 < 1{,}0\ (\text{utilization ratio } 4\%)$$

05 // Verification of permanent and temporary loads

Embedding strength of solid timber – nail head side (α_1 = 90°)

according to ETA

$$f_{h,1,k} = \frac{0{,}082 \cdot \rho_{k,1} \cdot d^{-0,3}}{(1{,}35 + 0{,}015 \cdot d) \cdot \sin^2\alpha_1 + \cos^2\alpha_1}$$

$$f_{h,1,k} = \frac{0{,}082 \cdot 350\,kg/m^3 \cdot 4{,}7^{-0,3}}{(1{,}35 + 0{,}015 \cdot 4{,}7) \cdot (\sin 90^\circ)^2 + (\cos 90^\circ)^2} = 12{,}70\,N/mm^2$$

$k_{mod,1} = 1{,}0$ Load duration class: medium, between short-term and very short-term

according to DIN EN 1995-1-1, Tab. 3.1

$$f_{h,1,d} = \frac{f_{h,1,k} \cdot k_{mod,1}}{\gamma_{M,1}} = \frac{13{,}79 \cdot 1{,}0}{1{,}3} = 9{,}77\,N/mm^2$$

Required minimum embedment deph 2 – Side of the nail tip (α_2=0°)

according to ETA

$$f_{h,2,k} = \frac{0{,}082 \cdot \rho_{k,2} \cdot d^{-0{,}3}}{(1{,}35 + 0{,}015 \cdot d) \cdot \sin^2\alpha_2 + \cos^2\alpha_2} =$$

$$f_{h,2,k} = \frac{0{,}082 \cdot 350\,\mathrm{kg/m^3} \cdot 4{,}7^{-0{,}3}}{(1{,}35 + 0{,}015 \cdot 4{,}7) \cdot (\sin 0^\circ)^2 + (\cos 0^\circ)^2} = 18{,}04\,\mathrm{N/mm^2}$$

$k_{mod,2} = 1{,}0$ (Load duration class: medium, between short-term and very short-term)

according to DIN EN 1995-1-1, Tab. 3.1

$$f_{h,2,d} = \frac{f_{h,2,k} \cdot k_{mod,2}}{\gamma_{M,2}} = \frac{18{,}04 \cdot 1{,}0}{1{,}3} = 13{,}88\,\mathrm{N/mm^2}$$

$$\beta = \frac{f_{h,2,d}}{f_{h,1,d}} = \frac{13{,}88\,\mathrm{N/mm^2}}{9{,}77\,\mathrm{N/mm^2}} = 1{,}42$$

Design value of the yield moment

ETA-table B.1

$$M_{u,k} = 1800\ \mathrm{Nmm}$$

To remain on the safe side, the load duration class “short-term” is assumed for the wind action.

$$M_{u,d} = M_{u,k} \cdot \frac{k_{mod,M}}{\gamma_M} = 1800\,\mathrm{Nmm} \cdot \frac{0{,}60}{1{,}3} = 831\ \mathrm{Nmm}$$

Required minimum embedment depth 1 – nail head side

according to ETA

$$t_{1,req} = \left(\sqrt{\frac{\beta}{1+\beta}} + 1\right) \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,1,d} \cdot d}} = \left(\sqrt{\frac{1{,}42}{1+1{,}42}} + 1\right) \cdot \sqrt{\frac{4 \cdot 831\ \mathrm{Nmm}}{0{,}75 \cdot 9{,}77 \cdot \frac{N}{mm^2} \cdot 4{,}7}} = 17{,}35\ \mathrm{mm}$$

$$t_{1,req} = 17{,}35\ \mathrm{mm} \leq\ t_{1,vorh} = 20{,}0\ \mathrm{mm}\ ✓$$

Required minimum embedment depth 2 – nail tip side

according to ETA

$$t_{2,req} = \left(\sqrt{\frac{1}{1+\beta}}\ +\ 1\right) \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,2,d} \cdot d}} = \left(\sqrt{\frac{1}{1+1{,}42}} + 1\right) \cdot \sqrt{\frac{4 \cdot 831\ \mathrm{Nmm}}{0{,}75 \cdot 13{,}88 \frac{N}{mm^2} \cdot 4{,}7}} = 13{,}54\ \mathrm{mm}$$

$$t_{2,req} = 13{,}54\ \mathrm{mm} \leq\ t_{2,vorh} = 40{,}0\ \mathrm{mm}\ ✓$$

Design of the load-bearing capacity in shear per nail

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot \beta}{1+\beta}} \cdot \sqrt{1{,}5 \cdot M_{u,d} \cdot f_{h,1,d} \cdot d}$$

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot 1{,}42}{1+1{,}42}} \cdot \sqrt{1{,}5 \cdot 831\ \mathrm{Nmm} \cdot 12{,}70\ \mathrm{N/mm^2}\ \cdot\ 4{,}7\ \mathrm{mm}}$$

$$F_{v,Rd,Na} = 259\ \mathrm{N}$$

Determination of the withdrawal capacity

Verification of the minimum penetration depth in component 2 – nail tip side:

$$t_{pen,min,2} = 8 \cdot d = 8 \cdot 4{,}7\ \mathrm{mm} = 37{,}6\ \mathrm{mm}$$

$$t_{pen,min,2} = 37{,}6\ \mathrm{mm} \leq t_{pen,vorh,2} = 38{,}0\ \ \mathrm{mm}\ ✓$$

Withdrawal capacity on the nail head side – component 1

$$F_{ax,Rd,1} = \min\begin{Bmatrix} 1 \\ \frac{t_{pen,1}}{8 \cdot d} \end{Bmatrix} \cdot \frac{f_{ax,k} \cdot k_{mod,ax}}{\gamma_{M,1}} \cdot d \cdot t_{pen,1} \cdot \left(\frac{\rho_{k,1}}{350}\right)^{0{,}8} =$$

$$F_{ax,l,Rd,1} = \min\begin{Bmatrix} 1 \\ \frac{20}{8 \cdot 4{,}7} \end{Bmatrix} \cdot \frac{7{,}0\ \frac{N}{mm^2} \cdot 0{,}5}{1{,}3} \cdot 4{,}7 \cdot 20\ \mathrm{mm} \cdot \left(\frac{350}{350}\right)^{0{,}8} =$$

$$F_{ax,l,Rd,1} = 0{,}53 \cdot \frac{7{,}0\ \frac{N}{mm^2} \cdot 0{,}5}{1{,}3} \cdot 4{,}7 \cdot 20\ \mathrm{mm} \cdot 1{,}0 = 135\ \mathrm{N}$$

Head pull-through capacity – component 1:

$$F_{ax,\alpha,Rd,1} = \frac{f_{head} \cdot k_{mod,M}}{\gamma_{M,1}} \cdot d_h^2 \cdot \left(\frac{\rho_{k,1}}{350}\right)^{0{,}8}$$

$$F_{ax,\alpha,Rd,1} = \frac{12\ \mathrm{N/mm^2} \cdot 0,6}{1,3} \cdot (6,3\ \mathrm{mm})^2 \cdot \left(\frac{350}{350}\right)^{0{,}8} = 220\ \mathrm{N}$$

Withdrawal capacity on the nail head side – component 1:

$$F_{ax,Rd,1} = \max\begin{Bmatrix} F_{a_x,l,R_d,1} \\ F_{a_x,\alpha,R_d,1} \end{Bmatrix} = \max\begin{Bmatrix} 135\ \mathrm{N} \\ 220\ \mathrm{N} \end{Bmatrix} = 220\ \mathrm{N}$$

Withdrawal capacity on the nail tip side – component 2

$$F_{ax,Rd,2} = \min\begin{Bmatrix} 1 \\ \frac{t_{pen,2}}{8 \cdot d} \end{Bmatrix} \cdot \frac{f_{ax,k} \cdot k_{mod,ax}}{\gamma_{M,2}} \cdot d \cdot t_{pen,2} \cdot \left(\frac{\rho_{k,2}}{350}\right)^{0{,}8} =$$

$$F_{ax,Rd,2} = \min\begin{Bmatrix} 1 \\ \frac{38}{8 \cdot 4{,}7} \end{Bmatrix} \cdot \frac{7{,}0\ \frac{N}{mm^2} \cdot 0{,}5}{1{,}3} \cdot 4{,}7 \cdot 38\ \mathrm{mm} \cdot \left(\frac{350}{350}\right)^{0{,}8} =$$

$$F_{ax,Rd,2} = 1{,}0 \cdot \frac{7{,}0\ \frac{N}{mm^2} \cdot 0{,}5}{1{,}3} \cdot 4{,}7 \cdot 38\ \mathrm{mm} \cdot 1{,}0 = 481\ \mathrm{N}$$

Withdrawal resistance:

$$F_{ax,Rd} = \min\begin{Bmatrix} F_{ax,Rd,1} \\ F_{ax,Rd,2} \end{Bmatrix} = \min\begin{Bmatrix} 220\ \mathrm{N} \\ 481\ \mathrm{N} \end{Bmatrix} = 220\ \mathrm{N}$$

Verification (combined verification)

$$\eta = \frac{F_{V,G,d}}{F_{v,Rd,Na}} + \frac{F_{ax,W,d}}{F_{ax,Rd}} = \frac{6{,}3\ \mathrm{N}}{259\ \mathrm{N}} + \frac{84{,}3\ \mathrm{N}}{220\ \mathrm{N}} = 0{,}41 < 1{,}0\ \left(\text{utilization ratio } 41\%\right)$$

Fastening of a Rhombus Façade

with LIGNOLOC® wooden nails according to ETA-23/0330

Calculation performed by:
BIGA
Structural Engineers
Prof. Dr. Ing. Patrik Aondio
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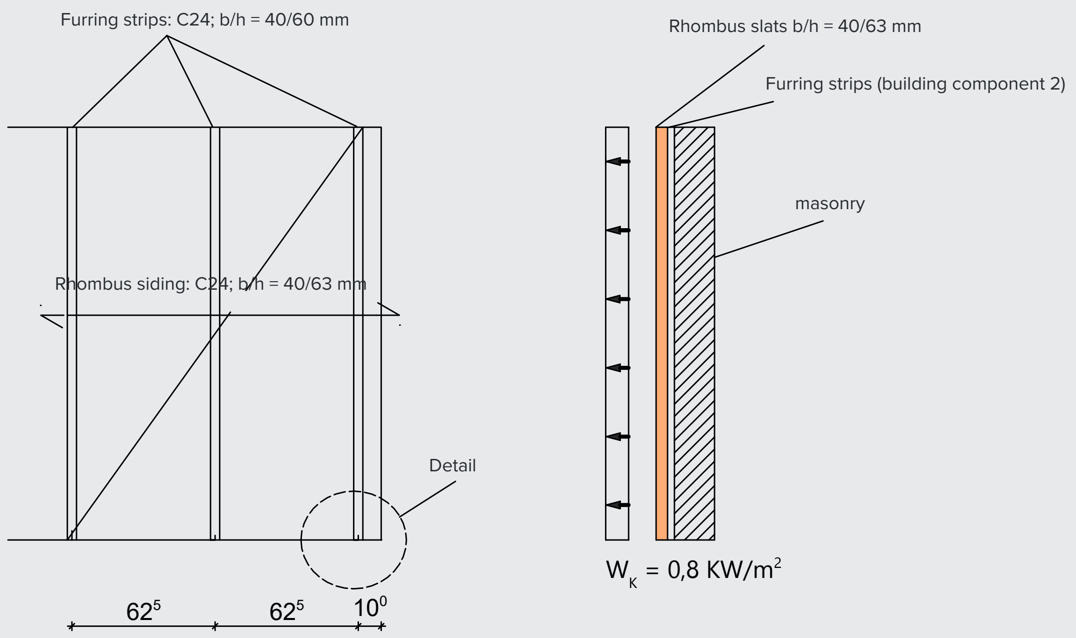
01 // System

A rhombus façade installed on a structural framework made of spruce timber is considered. Based on the local conditions, the façade can be assigned to Service Class 2.

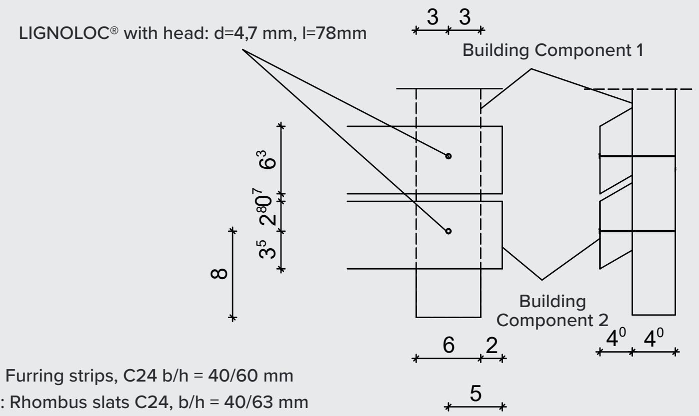
Furring strips: Softwood C24, $b_{Ri} \times h_{Ri}$ = 40 x 60 mm, e = 625mm, NKL 2

Rhombus Façade: Softwood C24, $b_S \times h_S$ = 40 x 63 mm, NKL 2

Fastening: LIGNOLOC® wooden nail with head, d = 4,7 mm, L = 78 mm



Detail



Building Component 1: Furring strips, C24 b/h = 40/60 mm
Building Component 2: Rhombus slats C24, b/h = 40/63 mm

An analysis of the entire building resulted in a governing characteristic wind uplift action of 0.8 kN/m². For the rhombus profile slats, an average density of $\rho_{\text{mean, Timber}} = 4{,}2\ \text{kN/m}^2$ can be assumed.

02 // Verification of Minimum Clearances

Fasteners according to ETA-23/0330, analogous to non-pre-drilled nails in DIN EN 1995-1-1:2010-12

Are the minimum spacings in the rhombus slats (Component 2) met?

table 8.2

$$a_{1,min,VH} = (5 + 5 \cdot (\cos\alpha)) \cdot d = (5 + 5 \cdot (\cos 90^\circ)) \cdot 4{,}7 = 23{,}5\ \text{mm} \leq 625\ \text{mm}\ \checkmark$$

$$a_{3,c,min,VH} = 10 \cdot d = 10 \cdot 4{,}7 = 47{,}0\ \text{mm} \leq 50\ \text{mm}\ \checkmark$$

$$a_{4,t,min,VH} = (5 + 2 \cdot \sin\alpha) \cdot d = (5 + 2 \cdot (\sin 90^\circ)) \cdot 4{,}7 = 32{,}9\ \text{mm} \leq 35\ \text{mm}\ \checkmark$$

$$a_{4,c,min,VH} = 5 \cdot d = 5 \cdot 4{,}7 = 23{,}5\ \text{mm} \leq 28\ \text{mm}\ \checkmark$$

Are the minimum spacings in the furring strips (Component 2) met?

table 8.2

$$a_{1,min,VH} = (5 + 5 \cdot (\cos\alpha)) \cdot d = (5 + 5 \cdot (\cos 0^\circ)) \cdot 4{,}7 = 47\ \text{mm} \leq 70\ \text{mm}\ \checkmark$$

$$a_{3,t,min,VH} = (10 + 5 \cdot (\cos\alpha)) \cdot d = (10 + 5 \cdot (\cos 0^\circ)) \cdot 4{,}7 = 70{,}5\ \text{mm} \leq 80\ \text{mm}\ \checkmark$$

$$a_{4,c,min,VH} = 5 \cdot d = 5 \cdot 4{,}7 = 23{,}5\ \text{mm} \leq 30\ \text{mm}\ \checkmark$$

03 // Loads per Nail

From permanent load

$$F_{V,G,k} = \rho_{\text{mean, Timber}} \cdot b_S \cdot h_S \cdot e = 4{,}2\frac{\text{kN}}{\text{m}^3} \cdot 0{,}04\ \text{m} \cdot 0{,}063\ \text{m} \cdot 0{,}625\ \text{m} = 6{,}6 \cdot 10^{-3}\text{kN} = 6{,}6\ \text{N}$$

Design level

$$F_{V,G,d} = F_{V,G,k} \cdot \gamma_G = 6{,}6\ \text{N} \cdot 1{,}35 = 8{,}9\ \text{N}$$

Wind load

$$F_{ax,W,k} = \underbrace{1{,}25}_{\text{continuity factor}} \cdot w_k \cdot h_S \cdot e = 1{,}25 \cdot 0{,}8\frac{\text{kN}}{\text{m}^2} \cdot 0{,}063\ \text{m} \cdot 0{,}625\ \text{m} = 0{,}039\ \text{kN} = 39{,}4\ \text{N}$$

At the design level

$$F_{ax,W,d} = F_{ax,W,k} \cdot \gamma_Q = 39{,}4\ \text{N} \cdot 1{,}5 = 59{,}1\ \text{N}$$

04 // Verification of Permanent Load

Embedding strength of solid timber – nail head side (α_1=90°)

according to ETA

$$f_{h,1,k} = \frac{0{,}082 \cdot \rho_{k,1} \cdot d^{-0{,}3}}{(1{,}35+0{,}015 \cdot d) \cdot \sin^2\alpha_1 + \cos^2\alpha_1}$$

$$f_{h,1,k} = \frac{0{,}082 \cdot 350\ \mathrm{kg/m^3} \cdot 4{,}7^{-0{,}3}}{(1{,}35+0{,}015 \cdot 4{,}7) \cdot (\sin 90^\circ)^2 + (\cos 90^\circ)^2} = 12{,}70\ \mathrm{N/mm^2}$$

according to DIN EN 1995-1-1, Tab. 3.1

$$k_{mod,1} = 0{,}6$$

$$f_{h,1,d} = \frac{f_{h,1,k} \cdot k_{mod,1}}{\gamma_{M,1}} = \frac{12{,}70 \cdot 0{,}6}{1{,}3} = 5{,}86\ \mathrm{N/mm^2}$$

Embedding strength of solid timber – nail tip side (α_2 = 0°)

according to ETA

$$f_{h,2,k} = \frac{0{,}082 \cdot \rho_{k,2} \cdot d^{-0{,}3}}{(1{,}35+0{,}015 \cdot d) \cdot \sin^2\alpha_2 + \cos^2\alpha_2} =$$

$$f_{h,2,k} = \frac{0{,}082 \cdot 350\ \mathrm{kg/m^3} \cdot 4{,}7^{-0{,}3}}{(1{,}35+0{,}015 \cdot 4{,}7) \cdot (\sin 0^\circ)^2 + (\cos 0^\circ)^2} = 18{,}04\ \mathrm{N/mm^2}$$

according to DIN EN 1995-1-1, Tab. 3.1

$$k_{mod,2} = 0{,}6$$

$$f_{h,2,d} = \frac{f_{h,2,k} \cdot k_{mod,2}}{\gamma_{M,2}} = \frac{18{,}04 \cdot 0{,}6}{1{,}3} = 8{,}33\ \mathrm{N/mm^2}$$

$$\beta = \frac{f_{h,2,d}}{f_{h,1,d}} = \frac{8{,}33\ \mathrm{N/mm^2}}{5{,}86\ \mathrm{N/mm^2}} = 1{,}42$$

Design value of the yield moment

ETA-table B.1

$$M_{u,k} = 1800\ \mathrm{Nmm}$$

$$M_{u,d} = M_{u,k} \cdot \frac{k_{mod,M}}{\gamma_M} = 1800\ \mathrm{Nmm} \cdot \frac{0{,}35}{1{,}3} = 485\ \mathrm{Nmm}$$

Required minimum embedment depth 1 – nail head side

according to ETA

$$t_{1,req} = \left(\sqrt{\frac{\beta}{1+\beta}} + 1\right) \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,1,d} \cdot d}} = \left(\sqrt{\frac{1{,}42}{1+1{,}42}} + 1\right) \cdot \sqrt{\frac{4 \cdot 485\ \mathrm{Nmm}}{0{,}75 \cdot 5{,}86\ \frac{\mathrm{N}}{\mathrm{mm^2}} \cdot 4{,}7}} = 17{,}11\ \mathrm{mm}$$

$$t_{1,req} = 17{,}11\ \mathrm{mm} \leq t_{1,vorh} = 40{,}0\ \mathrm{mm}\ \checkmark$$

Required minimum embedment depth 2 – nail tip side

according to ETA

$$t_{2,req} = \left(\sqrt{\frac{1}{1+\beta}} + 1\right) \cdot \sqrt{\frac{4 \cdot M_{u,d}}{0{,}75 \cdot f_{h,2,d} \cdot d}} = \left(\sqrt{\frac{1}{1+1{,}42}} + 1\right) \cdot \sqrt{\frac{4 \cdot 485\ \mathrm{Nmm}}{0{,}75 \cdot 8{,}33\ \frac{\mathrm{N}}{\mathrm{mm^2}} \cdot 4{,}7}} = 13{,}35\ \mathrm{mm}$$

$$t_{1,req} = 13{,}35\ \mathrm{mm} \leq t_{1,vorh} = 40{,}0\ \mathrm{mm}\ \checkmark$$

Design of the load-bearing capacity in shear per nail

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot \beta}{1+\beta}} \cdot \sqrt{1{,}5 \cdot M_{u,d} \cdot f_{h,1,d} \cdot d}$$

$$F_{v,Rd,Na} = \sqrt{\frac{2 \cdot 1{,}42}{1+1{,}42}} \cdot \sqrt{1{,}5 \cdot 485\ \mathrm{Nmm} \cdot 5{,}86\ \mathrm{N/mm}^2 \cdot 4{,}7\ \mathrm{mm}}$$

$$F_{v,Rd,Na} = 153{,}32\ \mathrm{N}$$

Nachweis:

$$\eta = \frac{F_{V,G,d}}{F_{v,Rd,Na}} = \frac{8{,}9\ \mathrm{N}}{153{,}32\ \mathrm{N}} = 0{,}06 < 1{,}0\ \text{(utilization ratio 6 \%)}$$

05 // Verification of permanent and temporary loads

Embedding strength of solid timber – nail head side (α_1 = 90°)

according to ETA

$$f_{h,1,k} = \frac{0{,}082 \cdot \rho_{k,1} \cdot d^{-0{,}3}}{(1{,}35+0{,}015 \cdot d) \cdot \sin^2\alpha_1 + \cos^2\alpha_1}$$

$$f_{h,1,k} = \frac{0{,}082 \cdot 350\ \mathrm{kg/m^3} \cdot 4{,}7^{-0{,}3}}{(1{,}35+0{,}015 \cdot 4{,}7) \cdot (\sin 90^\circ)^2 + (\cos 90^\circ)^2} = 12{,}70\ \mathrm{N/mm^2}$$

$$k_{mod,1} = 1{,}0$$

$$f_{h,1,d} = \frac{f_{h,1,k} \cdot k_{mod,1}}{\gamma_{M,1}} = \frac{12{,}70 \cdot 1{,}0}{1{,}3} = 9{,}77\ \frac{\mathrm{N}}{\mathrm{mm^2}}$$

Embedding strength of solid timber – nail tip side (α_2=0°)

according to ETA

$$f_{h,2,k} = \frac{0{,}082 \cdot \rho_{k,2} \cdot d^{-0{,}3}}{(1{,}35+0{,}015 \cdot d) \cdot \sin^2\alpha_2 + \cos^2\alpha_2} =$$

$$f_{h,2,k} = \frac{0{,}082 \cdot 350\ \mathrm{kg/m^3} \cdot 4{,}7^{-0{,}3}}{(1{,}35+0{,}015 \cdot 4{,}7) \cdot (\sin 0^\circ)^2 + (\cos 0^\circ)^2} = 18{,}04\ \mathrm{N/mm^2}$$

$k_{mod,2} = 1{,}0$ (Load duration class: medium, between short-term and very short-term)

according to DIN EN 1995-1-1, Tab. 3.1

$$f_{h,2,d} = \frac{f_{h,2,k} \cdot k_{mod,2}}{\gamma_{M,2}} = \frac{18{,}04 \cdot 1{,}0}{1{,}3} = 13{,}88\ \mathrm{N/mm^2}$$

$$\beta = \frac{f_{h,2,d}}{f_{h,1,d}} = \frac{13{,}88\ \mathrm{Nmm^2}}{9{,}77\ \mathrm{Nmm^2}} = 1{,}42$$

Design value of the yield moment

ETA-table B.1

$$M_{u,k} = 1800\ \text{Nmm}$$

To remain on the safe side, the load duration class “short-term” is assumed for the wind action.

$$M_{u,d} = M_{u,k} \cdot \frac{k_{mod,M}}{\gamma_M} = 1800\,Nmm \cdot \frac{0{,}60}{1{,}3} = 831\,Nmm$$

Required minimum embedment deph 1 – nail head side

according to ETA

$$t_{1,req} = \left(\sqrt{\frac{\beta}{1+\beta}}+1\right) \cdot \sqrt{\frac{4\cdot M_{u,d}}{0{,}75\cdot f_{h,1,d}\cdot d}} = \left(\sqrt{\frac{1{,}42}{1+1{,}42}}+1\right) \cdot \sqrt{\frac{4\cdot 831\,\text{Nmm}}{0{,}75\cdot 9{,}77\,\frac{N}{mm^2}\cdot 4{,}7}} = 17{,}35\,\text{mm}$$

$$t_{1,req} = 17{,}35\,\text{mm} \le t_{1,vorh} = 40{,}0\,\text{mm}\ ✓$$

Required minimum embedment deph 2 – nail tip side

according to ETA

$$t_{2,req} = \left(\sqrt{\frac{1}{1+\beta}}+1\right) \cdot \sqrt{\frac{4\cdot M_{u,d}}{0{,}75\cdot f_{h,2,d}\cdot d}} = \left(\sqrt{\frac{1}{1+1{,}42}}+1\right) \cdot \sqrt{\frac{4\cdot 831\,\text{Nmm}}{0{,}75\cdot 13{,}88\,\frac{N}{mm^2}\cdot 4{,}7}} = 13{,}54\,\text{mm}$$

$$t_{2,req} = 13{,}54\,\text{mm} \le t_{2,vorh} = 40{,}0\,\text{mm}\ ✓$$

Design of the load-bearing capacity in shear per nail

$$F_{v,Rd,Na} = \sqrt{\frac{2\cdot\beta}{1+\beta}} \cdot \sqrt{1{,}5\cdot M_{u,d}\cdot f_{h,1,d}\cdot d}$$

$$F_{v,Rd,Na} = \sqrt{\frac{2\cdot 1{,}42}{1+1{,}42}} \cdot \sqrt{1{,}5\cdot 831\ \text{Nmm}\cdot 9{,}77\ \text{N/mm}^2\cdot 4{,}7\ \text{mm}}$$

$$F_{v,Rd,Na} = 259\ \text{N}$$

Determination of the withdrawal capacity

Verification of the minimum penetration depth in component 2 – nail tip side:

$$t_{pen,min,2} = 8\cdot d = 8\cdot 4{,}7 = 37{,}6\ \text{mm}$$

$$t_{pen,min,2} = 37{,}6\ \text{mm} \le t_{pen,vorh,2} = 38{,}0\ \text{mm}\ ✓$$

Withdrawal capacity on the nail head side – component 1:

$$F_{ax,l,Rd,1} = \min\begin{Bmatrix}1\\ \frac{t_{pen,1}}{8\cdot d}\end{Bmatrix} \cdot \frac{f_{ax,k}\cdot k_{mod,ax}}{\gamma_{M,1}} \cdot d\cdot t_{pen,1}\cdot\left(\frac{\rho_{k,1}}{350}\right)^{0.8} =$$

$$F_{ax,l,Rd,1} = \min\begin{Bmatrix}1\\ \frac{40}{8\cdot 4{,}7}\end{Bmatrix} \cdot \frac{7{,}0\frac{N}{mm^2}\cdot 0{,}5}{1{,}3} \cdot 4{,}7\cdot 40\text{mm}\cdot\left(\frac{350}{350}\right)^{0{,}8} =$$

$$F_{ax,l,Rd,1} = 1{,}0\cdot\frac{7{,}0\frac{N}{mm^2}\cdot 0{,}5}{1{,}3}\cdot 4{,}7\cdot 40\ \text{mm}\cdot 1{,}0 = 506\text{N}$$

Head pull-through capacity – component 1:

$$F_{ax,\alpha,Rd,1} = \frac{f_{head}\cdot k_{mod,M}}{\gamma_{M,1}} \cdot d_h^2 \cdot \left(\frac{\rho_{k,1}}{350}\right)^{0{,}8}$$

$$F_{ax,\alpha,Rd,1} = \frac{12\ \text{N/mm}^2\cdot 0{,}6}{1{,}3} \cdot (6{,}3\text{mm})^2 \cdot \left(\frac{350}{350}\right)^{0{,}8} = 220\text{N}$$

Withdrawal capacity on the nail head side – component 1:

$$F_{ax,Rd,1} = \max\begin{Bmatrix}F_{ax,l,Rd,1}\\ F_{ax,\alpha,Rd,1}\end{Bmatrix} = \max\begin{Bmatrix}506\ \text{N}\\ 220\ \text{N}\end{Bmatrix} = 506\ \text{N}$$

Withdrawal capacity on the nail tip side – component 2:

$$F_{ax,Rd,2} = \min\begin{Bmatrix}1\\ \frac{t_{pen,2}}{8\cdot d}\end{Bmatrix} \cdot \frac{f_{ax,k}\cdot k_{mod,ax}}{\gamma_{M,2}} \cdot d\cdot t_{pen,2}\cdot\left(\frac{\rho_{k,2}}{350}\right)^{0{,}8}$$

$$F_{ax,Rd,2} = \min\begin{Bmatrix}1\\ \frac{38}{8\cdot 4{,}7}\end{Bmatrix} \cdot \frac{7{,}0\cdot\frac{N}{mm^2}\cdot 0{,}5}{1{,}3} \cdot 3{,}7\cdot 38\text{mm}\cdot\left(\frac{350}{350}\right)^{0{,}8} =$$

$$F_{ax,Rd,2} = 1{,}0\cdot\frac{7{,}0\ \frac{N}{mm^2}\cdot 0{,}5}{1{,}3}\cdot 4{,}7\cdot 38\ \text{mm}\cdot 1{,}0 = 481\ \text{N}$$

Withdrawal resistance:

$$F_{ax,Rd} = \min\begin{Bmatrix}F_{ax,Rd,1}\\ F_{ax,Rd,2}\end{Bmatrix} = \min\begin{Bmatrix}506\ \text{N}\\ 481\ \text{N}\end{Bmatrix} = 481\ \text{N}$$

Verification (combined verification)

$$\eta = \frac{F_{V,G,d}}{F_{v,Rd,Na}} + \frac{F_{ax,W,d}}{F_{ax,Rd}} = \frac{8{,}9\ \text{N}}{259\ \text{N}} + \frac{59{,}1\ \text{N}}{481\ \text{N}} = 0{,}16 < 1{,}0\ \left(\text{utilization ratio } 16\ \%\right)$$

Approvals // Certifications

EUROPEAN TECHNICAL ASSESSMENT
ETA-23/0041
The ETA-23/0041 includes all the required characteristic values for the structural design of LIGNOLOC® wooden nails without head for timber frame construction in accordance with Eurocode 5.

EUROPEAN TECHNICAL ASSESSMENT
ETA-23/0330
The ETA-23/0330 contains all the necessary characteristic values for the structural design of LIGNOLOC® wooden nails with head for load-bearing wood-to-wood and wood-based panel connections in outdoor applications.

EPD - Environmental Product Declaration according to
ISO 14025 and EN 15804+A2
The Environmental Product Declaration (EPD) for LIGNOLOC® confirms the sustainable material selection and documents the product's environmental footprint over its entire life cycle.

IAPMO Report
#UEL5065
LIGNOLOC® has received official IAPMO approval (IAPMO Group). This certification confirms the use of LIGNOLOC® wooden nails for wood-to-wood or panel-to-wood connections in the United States.

Design calculation solutions

EXCEL TOOL FOR STRUCTURAL DESIGN ACCORDING TO ETA

The Excel-based design tool by BECK is a free application for the structural design of load-bearing timber connections using LIGNOLOC® wooden nails. It is based on the ETA and systematically reflects the design rules defined therein.

The tool supports you in the configuration of the LIGNOLOC® system for various timber construction applications – particularly in the production of timber walls using solid wood panels or wood-based materials as sheathing components.

Key features include:

+ Calculation of the required number of LIGNOLOC® wooden nails in accordance with ETA-compliant specifications
+ Selection of approved materials such as OSB, plywood, MDF, and solid wood
+ Automatic consideration of material-specific characteristic values
+ Calculation of the total load-bearing capacity of complete wall assemblies

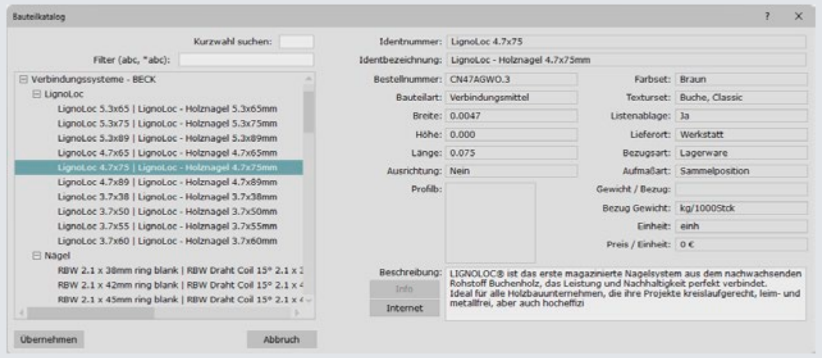
To the calculation tool

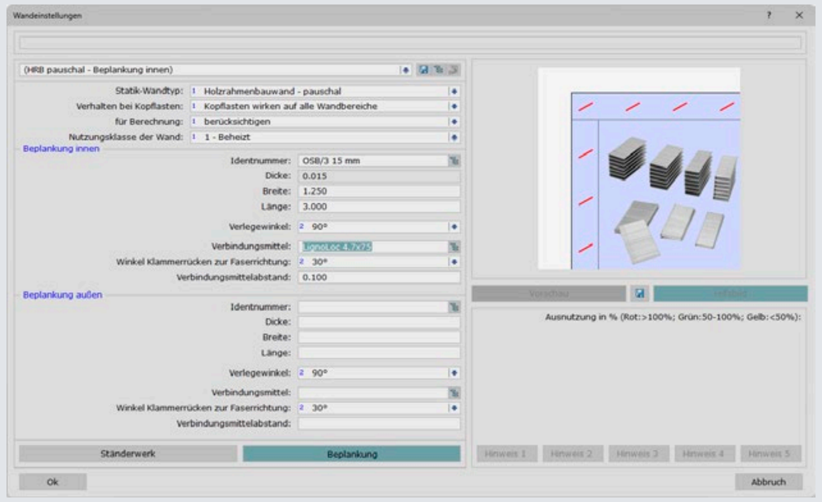
Please note: The Excel file is not available for public download. You can request the tool using our contact form. It will be sent to you by email. The tool runs locally in Microsoft Excel and does not require any cloud connection or additional software.

DC STATICS FROM DIETRICH'S

The structural analysis software DC-Statik by Dietrich's (from version 25 onwards) enables the calculation and load distribution of LIGNOLOC® wooden nails directly within the building model.
The integration is based on the design values from the ETA approvals (ETA-23/0041, ETA-23/0330) and allows code-compliant verification of load-bearing timber connections. Designers can thus dimension timber frame walls without metal fasteners – efficiently and directly within the digital workflow, without any additional software customization.

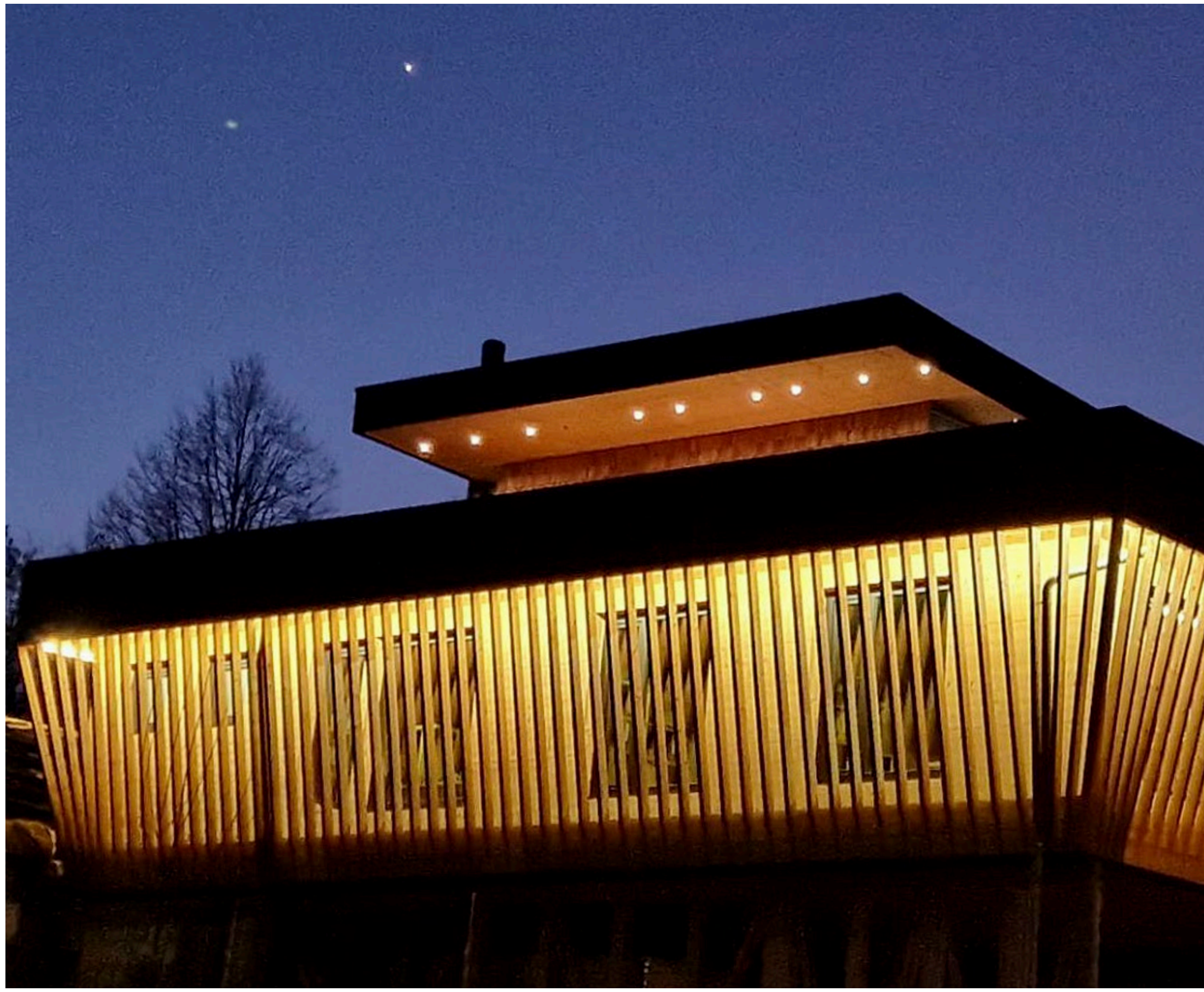
Scan the QR code
to learn more

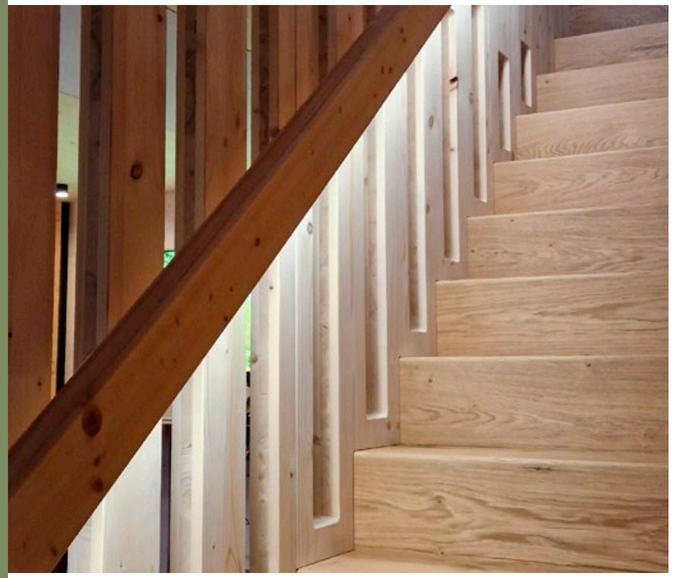




Timber frame construction with LIGNOLOC®

Selected project references





OFFICE COMPLEX – WISSEL TIMBER CONSTRUCTION

For its own company headquarters, Wissel timber construction constructed a sustainable office complex featuring a modern timber frame structure – entirely planned and executed in-house. The interior walls were clad on both sides with three-layer spruce panels, fastened exclusively with LIGNOLOC® wooden nails – resulting in a homogeneous and completely metal-free wall construction. LIGNOLOC® nails were also used in the acoustic partition wall: visible spruce battens were installed as single-type wooden elements, contributing to both the acoustic performance and architectural quality of the interior space. A particular highlight of the design and craftsmanship is the folded oak staircase: its steps are precisely milled into the wall structure – a visible expression of precision joinery, innovation, and the potential of modern timber construction.

SENIOR CARE FACILITY – MÜNCHENSTIFT

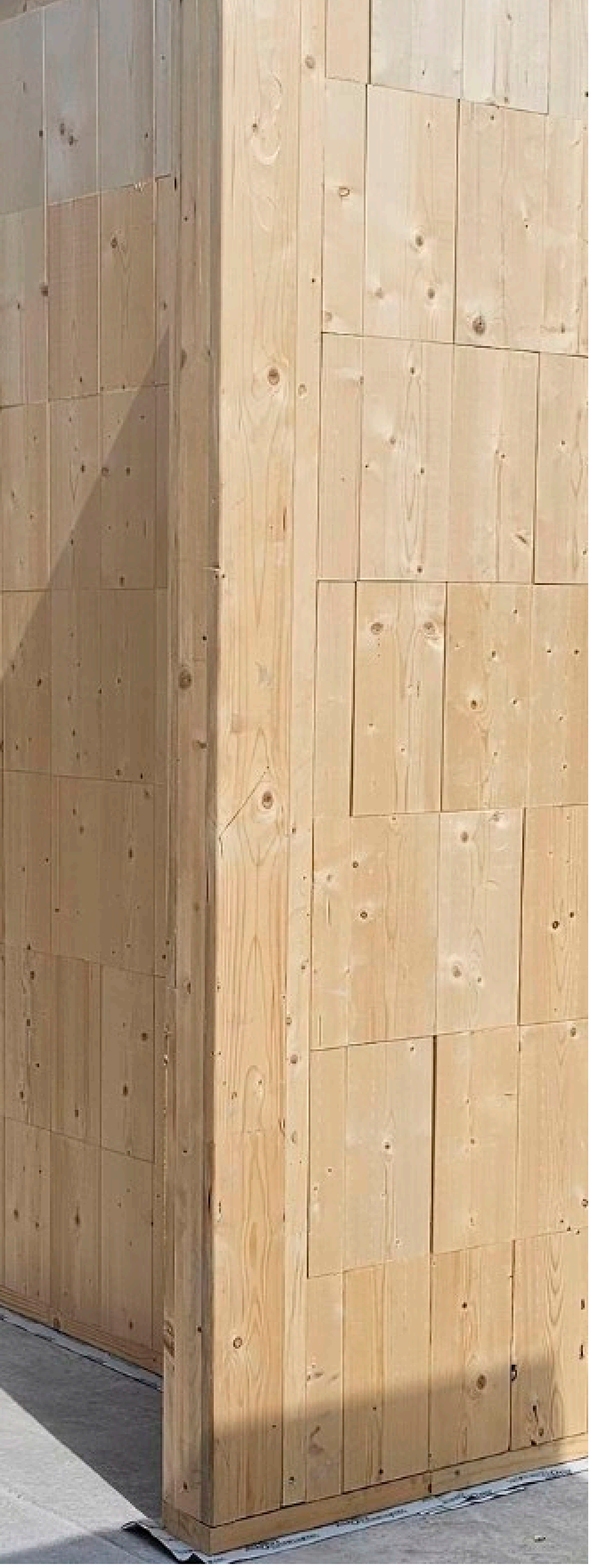
A sustainably planned senior care facility with 261 residential units was built using modern timber frame construction with exposed timber surfaces, executed by Höfle Timber Construction. The wall elements were manufactured using a WEINMANN® WALLTEQ M-300 and assembled entirely metal-free with LIGNOLOC® wooden nails by BECK. The visible connections give the wall surfaces a distinctive appearance and enable easy, tool-friendly reworking. This project stands as a prime example of the successful combination of precision, efficiency, and sustainable timber construction technology.

SINGLE-FAMILY HOME – ASCHAFFENBURG

In Aschaffenburg, a single-family home for six people was constructed using sustainable building methods, with a high proportion of owner participation. The shell construction, including floors, ceilings, and stairs, was built entirely from spruce wood. The building envelope features a continuous metal façade, while all interior walls were constructed using timber frame methods with three-layer spruce panels, fastened on both sides exclusively with LIGNOLOC® wooden nails – resulting in a single-material, completely metal-free solution. The walls were finished by the owners using clay plaster sourced directly from their own excavation site, creating a diffusion-open and pollutant-free indoor climate. Heating is provided by a masonry heater in combination with infrared ceiling panels, powered by a photovoltaic system. Domestic hot water is supplied via decentralized electric water heaters – an efficient and low-maintenance solution. This project brings together sustainable material selection, well-planned building technology, and precise craftsmanship – executed by Wissel Timber Construction in collaboration with Ewich Interior Architecture.

Alternative wall assemblies

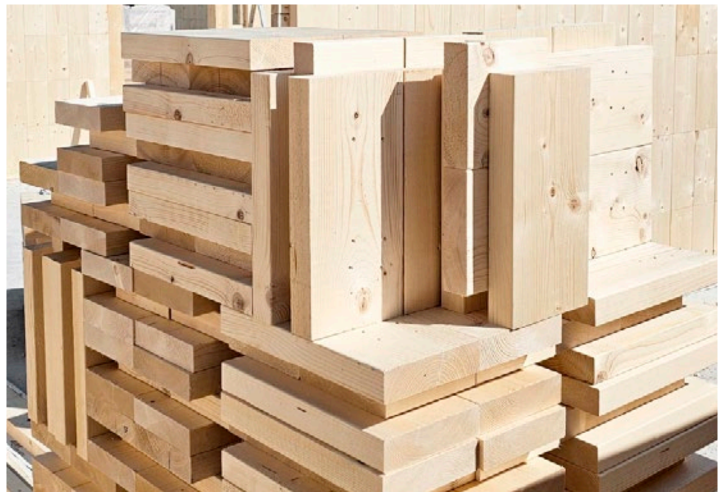
Project references



Haus Paradies Bitterfeld

NiTO® SOLID WOOD BLOCKS

In Bitterfeld, Haus Paradies was realised as a sustainable single-storey home in mass timber construction, implemented using the modular NiTO® building block system. The load-bearing walls are made from NiTO® solid wood blocks approved by the DIBt (approval number Z-9.1-909), each consisting of six laminated timber segments. These are joined exclusively with LIGNOLOC® wooden nails, forming dimensionally stable solid blocks made entirely of wood – enabling a single-material construction suitable for circular economy principles. Thanks to the precise tongue-and-groove system, the blocks allow for fast and simple assembly with excellent dimensional accuracy. In total, 57,000 LIGNOLOC® wooden nails were used. The single-material construction supports a fully ecological building approach and aligns with the principles of circular economy.



Woodbloc®

LIGNOLOC® CLT MASS TIMBER WALLS

Penzkofer Bau, based in Regen in the Bavarian Forest, has developed Woodbloc®: solid timber walls and high-load dowelled timber ceilings made entirely from solid, untreated wood – without the use of foils, adhesives, or chemical additives. The various timber layers of the Woodbloc® system are securely joined using LIGNOLOC® wooden nails. The wood used for Woodbloc® is sourced from renewable forests in the Bavarian Forest region. The use of locally grown spruce supports the regional economy and promotes sustainable forestry practices. The mass timber elements are produced in a fully automated process at the factory, from laying the boards to nailing them with LIGNOLOC® wooden nails. This method ensures consistently high quality and independence from weather conditions during manufacturing. Woodbloc® has already proven itself in numerous single-family housing projects. In addition, Woodbloc® walls and ceilings are also suitable for multi-storey residential buildings, commercial properties, and public construction projects.

Apartment house – Traunstein

VERTICALLY INSTALLED SOLID LOG WALL

In Traunstein, Chiemgauer Holzhaus realised a solid timber building with six residential units, featuring wall structures that are free from construction chemicals. Structural loads are transferred via a diagonal sheathing layer, fastened entirely with LIGNOLOC® wooden nails – resulting in a single-material solid timber wall without any metal components. The building meets the *Effizienzhaus 40* standard and is certified under the QNG sustainability scheme, combining ecological construction with maximum living comfort. Low operating costs, maximum energy efficiency – photovoltaics, a heat pump, and high-performance insulation come together in a well-designed concept for sustainable living.

Single-family home Reisecker

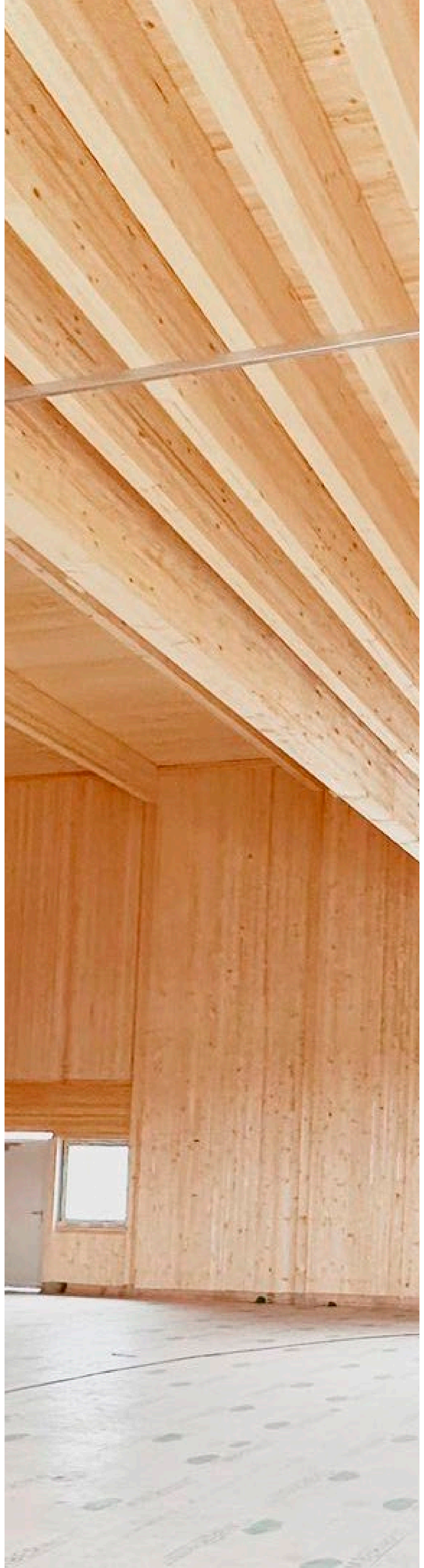
VERTICALLY INSTALLED SOLID LOG WALL

As part of the modernization of a historic four-sided farmstead in the Innviertel region of Upper Austria, this new single-family home was constructed entirely from wood, with a strong focus on ecological construction and the principles of the circular economy. For ecological reasons, the owners selected fir wood as the primary building material. All components were designed for easy disassembly and recyclability at the end of their life cycle. The load-bearing walls were built in a vertical log construction using double tongue-and-groove joints, featuring a refined exposed timber appearance. Additional bracing is provided by a diagonally installed tongue-and-groove sheathing, fastened to the log wall elements with LIGNOLOC® wooden nails. As a result, the building's entire structural system is made of solid wood, without the use of metal fasteners or full-surface adhesive layers. A particular highlight: the floor slab, storey ceilings, and the roof structure are also made entirely of solid timber elements. The exterior walls are insulated with 26 cm of cellulose and clad with a rear-ventilated, rough-sawn board-and-batten façade made of fir. The windows, also crafted from fir, were inserted from the outside into the façade.

Solid timber home – Gars

VERTICALLY INSTALLED SOLID LOG WALL

In Gars am Inn, Chiemgauer Holzhaus built a single-family home using solid timber construction, with walls that are entirely free from construction chemicals. Structural loads are transferred by a diagonal timber sheathing, fixed in place with LIGNOLOC® wooden nails – resulting in a metal-free, single-material mass timber wall with high load-bearing capacity. The construction combines natural materials, a well-planned energy concept, and a minimalist architectural design language. Large window openings create a strong connection to the surrounding landscape, while the solid timber components contribute to a balanced and comfortable indoor climate.



Building at RIO industrial park

WOODEN NAIL-LAMINATED TIMBER ELEMENTS

At RIO Industrial Park in Osterburken, prema® completed the construction of a building within just ten months, combining a high level of prefabrication with a consistently sustainable construction method. The load-bearing structure is made almost entirely of proprietary prema® panels in nail-laminated timber (NLT) construction – single-material, metal-free elements joined with LIGNOLOC® wooden nails. Solid timber components were used throughout the project – from wall elements up to nine metres in height to the solid timber floor slab. Architecture, planning, and execution were all carried out solely by prema®.

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