

# From Forest to Skyline

Exploring the Future of wood  
engineering and High-Rise  
Wooden Buildings

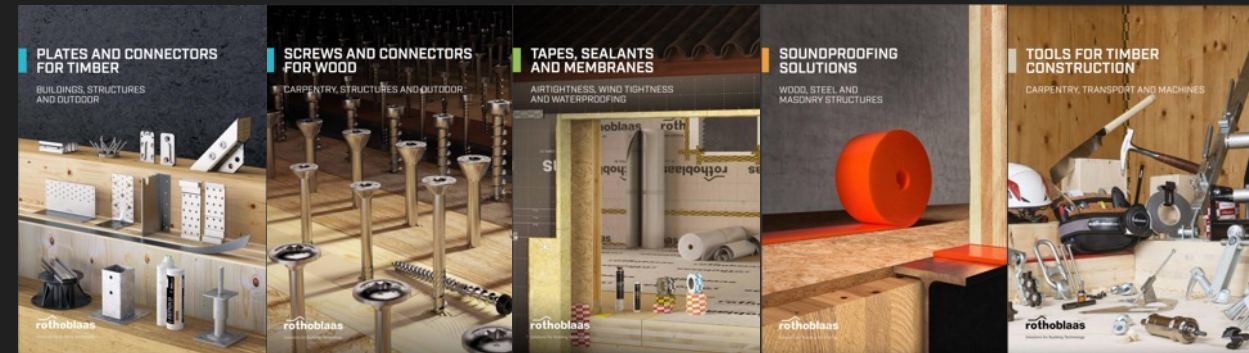
**MEng. Sivert Knutsen**  
Technical consultant - Rothoblaas



# Rothoblaas

## ALPINE HEART INTERNATIONAL SPIRIT

- Full-service provider of construction materials.
- The cutting edge of construction materials and technology



# Build in wood

“ We want to make wood a natural choice of building material for the construction of multi-storey buildings



*Build-in-Wood Consortium*

We are part of a European project « Build In Wood ». We are an active partner in many projects.

Check them out on the website: <https://www.build-in-wood.eu/>



Join the Build-in-Wood Community



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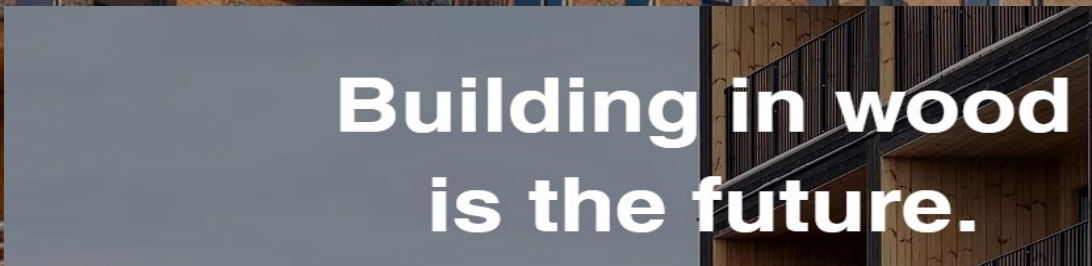
The Build-in-Wood Community



The Project Consortium



Project News



Building in wood is the future.

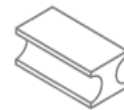


## USE OF WOOD

The construction industry is targeted as a big polluter – in forms of resource extraction, processing and landfill waste. However, building with timber, especially when it's locally sourced, immediately **lowers the carbon footprint** of the building and actually **captures carbon** in the processed wood materials – which in turn results in positive forestry practices to grow more material. **A truly renewable resource.**



**more wood**  
less CO<sub>2</sub>



**STEEL**  
12200 KG CO<sub>2</sub>/m<sup>3</sup>



**CONCRETE**  
385 KG CO<sub>2</sub>/m<sup>3</sup>



**BRICK**  
375 KG CO<sub>2</sub>/m<sup>3</sup>

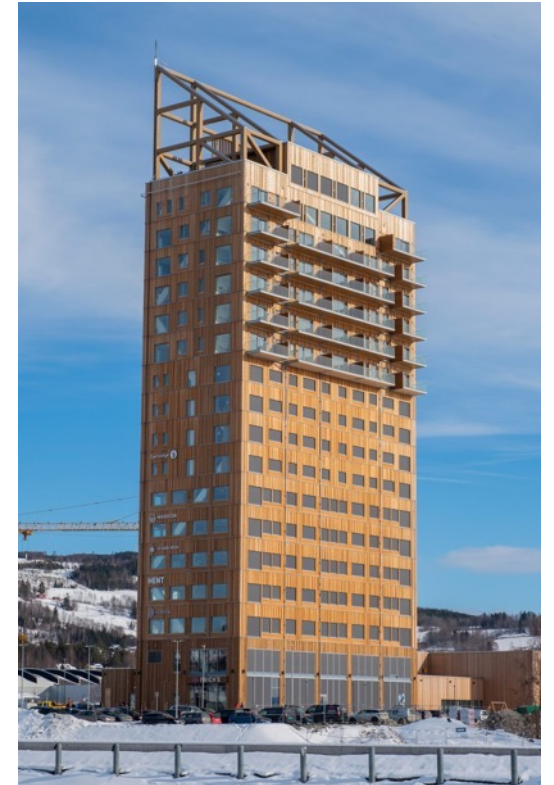


**TIMBER**  
-800 KG CO<sub>2</sub>/m<sup>3</sup>

## USE OF WOOD IN HIGH RISE BUILDINGS

- The edge of engineering craftsmanship
- New demands on connection.
- Problems relates to:
  - Comfort
  - Outdated Regulation
  - Lack of standardisations

Sara Kulturhus Sweden (2021)  
72.8m  
CLT Construction

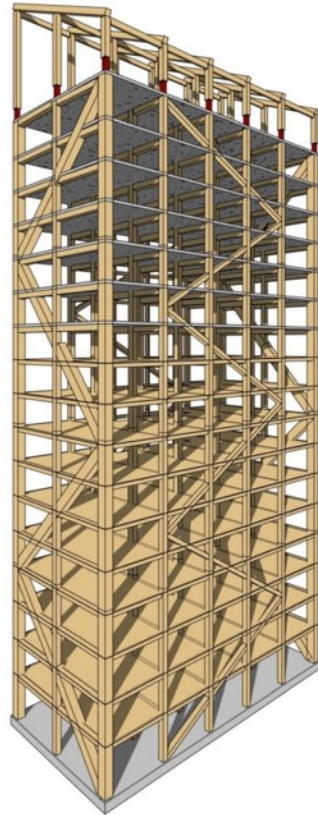


Mjøstårnet Norway (2019)  
85.4m  
Frame construction

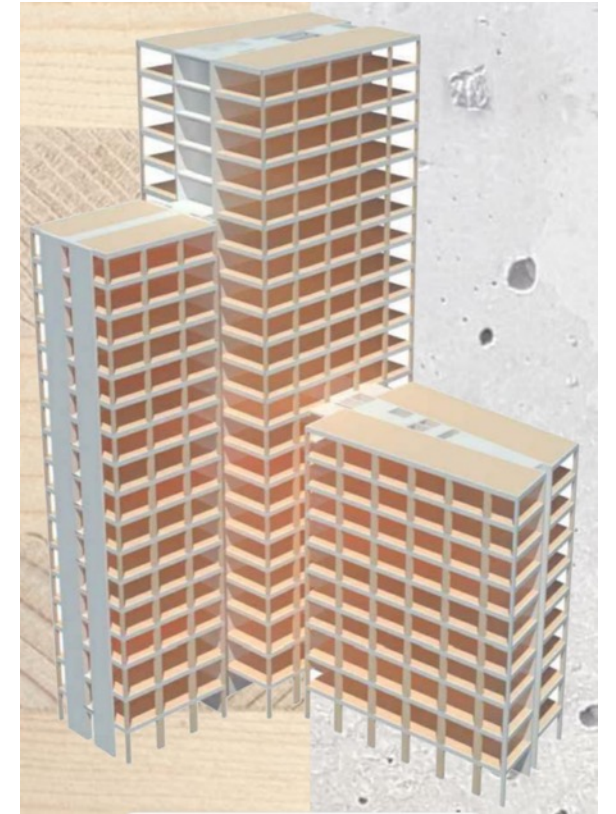
# Construction types



- Platform/shell structure



- Frame construction



- hybrid structure

# Construction types fastening

## Platform/shell structure

- Wood-Wood
- Stiff connections
- Angular brackets
- Screws

## Frame construction

- Wood-Wood
- Force transmission
- Steel plates with dowels
- Brackets
- Screws

## Hybrid structure

- Wood-Steel
- Wood-concrete
- Composite action
- Brackets
- Special connections





**HBS**  
 Diameter:  
 3.5, 4, 4.5, 5, 6, 8, 10, 12  
 Längd upp till 600mm



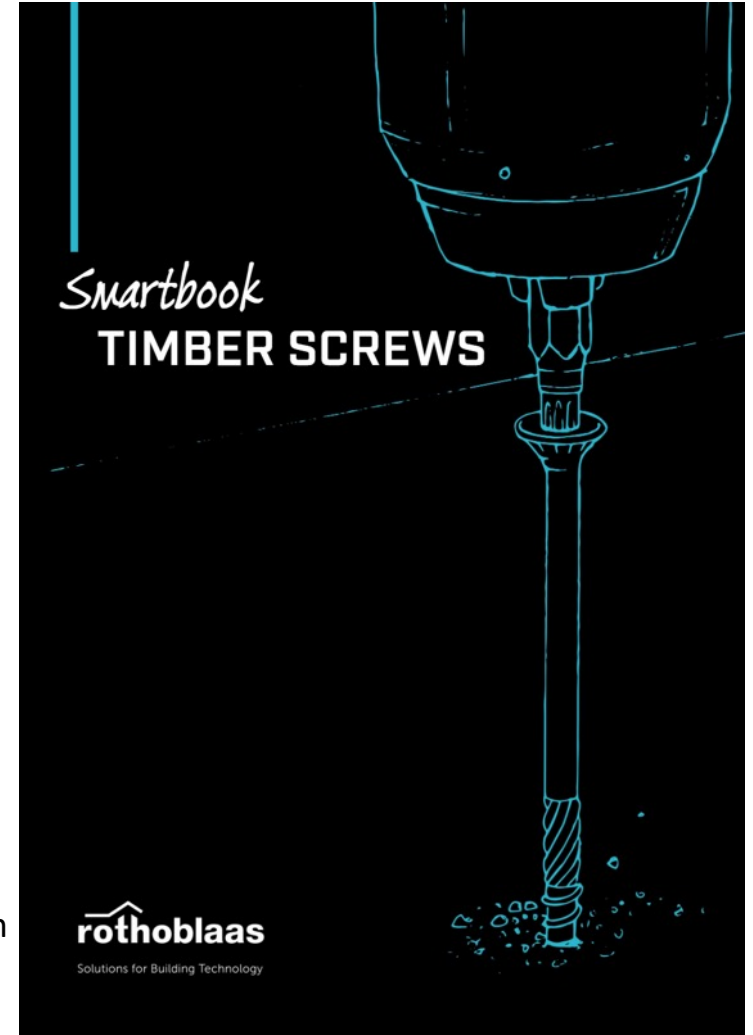
**TBS**  
 Diameter:  
 6, 8, 10,  
 Längd upp till 520mm



**VGZ**  
 Diameter:  
 7, 9, 11,  
 Längd upp till 600mm



**VGS**  
 Diameter:  
 9, 11, 13  
 Längd upp till 1200mm





## Smartbook

### CORROSION

#### ATMOSPHERIC CORROSION CLASSES

C

#### INFLUENCING FACTORS

Corrosion caused by the atmosphere depends on relative humidity, air pollution, chloride content and whether the connection is internal, external protected or external. Exposure is described by the C<sub>1</sub> category which is based on category C as defined in EN ISO 9223.

Atmospheric corrosivity only affects the exposed part of the connector.

- presence of chlorides
- pollution

#### SERVICE CLASSES

SC

#### INFLUENCING FACTORS

The service classes are related to the thermo-hygrometric conditions of the environment in which a timber structural element is installed. They relate the temperature and humidity of the surroundings to the water content within the material.

- exposure
- level of humidity

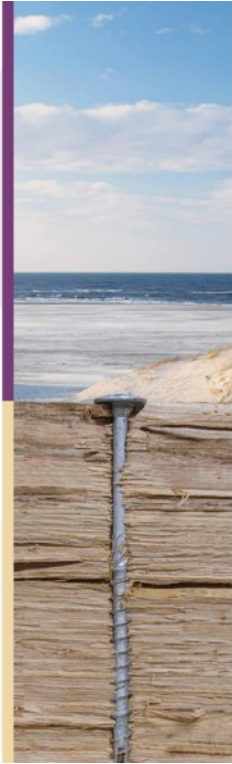
#### WOOD CORROSION CLASSES

T

#### INFLUENCING FACTORS

Corrosion caused by wood depends on the wood species, wood treatment and moisture content. Exposure is defined by the T<sub>1</sub> category as indicated. The corrosivity of wood only affects the connector part inserted in the wooden element.

- pH of the wood
- moisture content of the wood



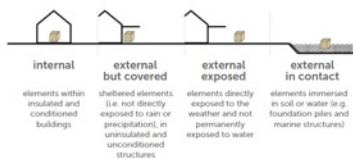
### SERVICE CLASSES - SC

Defined according to the new generation of Eurocode 5 (prEN 1995-1-1)<sup>2)</sup>



#### EXPOSURE

most common cases



### RELATIVE HUMIDITY AND EQUILIBRIUM MOISTURE CONTENT OF THE WOOD

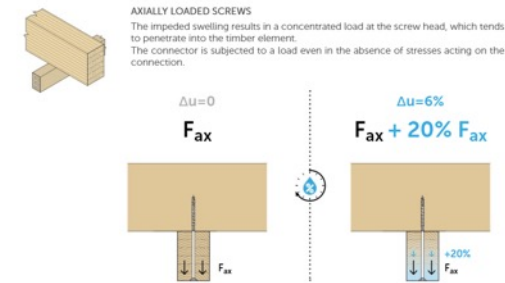
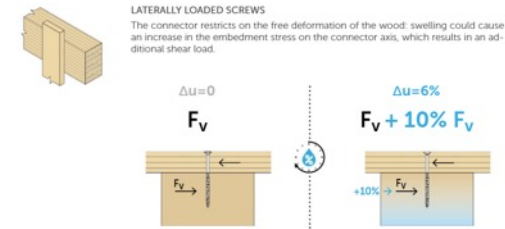
Annual average <sup>2)</sup> relative atmospheric humidity of the surrounding air	50%	75%	85%	(3)
corresponding wood moisture content <sup>4)</sup>	(10%)	(16%)	(18%)	saturated
Maximum <sup>3)</sup> relative atmospheric humidity of the surrounding air	65%	85%	95%	(3)
corresponding wood moisture content <sup>4)</sup>	(12%)	(20%)	(24%)	saturated

<sup>2)</sup> The upper limit of relative humidity must not be exceeded for more than a several consecutive weeks per year.  
<sup>3)</sup> The average annual relative humidity over a ten-year period is used to assign wood elements to the corrosivity categories for (dowel type fasteners).  
<sup>4)</sup> The moisture content of members in SC4 (primarily fully saturated) is affected by the surrounding element (e.g. soil or water).  
<sup>5)</sup> The moisture content may not apply to engineered wood products, LVL or wood-based panel products.  
<sup>6)</sup> Corresponding representative moisture of SMO (Solid Wood Based) elements.  
<sup>7)</sup> prEN 1995-1-1 (in d.) Basis of design and materials - Final draft (22.01.2023) - Project team SC5.T3 & SC5/WG10, CEN.

### SWELLING: STRESS INCREMENTS

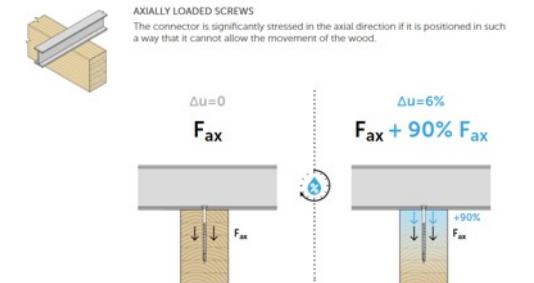
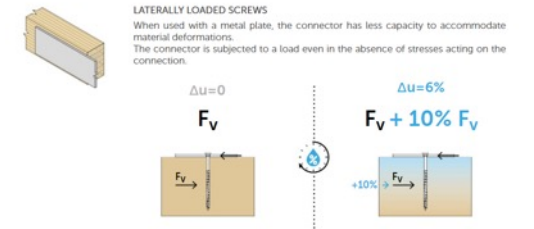
#### TIMBER-TO-TIMBER

A change in moisture within a timber element causes additional stress on the connector<sup>1)</sup>.



#### STEEL-TO-TIMBER

A metal plate creates a rigid confinement of the wood and prevents its deformation induced by changes in moisture content.



*Moisture variations affect the strength of connections*

<sup>1)</sup> DIN EN 1995-1-1/NA:2013-08 and DIN EN 1995-1-1:2010-12

Wide range of certification

- Wood-Wood
- Wood-panel
- Wood-steel

Calculation help

**My Project**

Download for free at  
Rothoblaas website



geometry	SHEAR				TENSION	
	timber-to-timber	panel-timber <sup>(1)</sup>	thin steel-timber plate <sup>(2)</sup>	thick steel-timber plate <sup>(3)</sup>	thread withdrawal <sup>(4)</sup>	head pull-through <sup>(5)</sup>
$d_1$ [mm] $L$ [mm] $b$ [mm] $A$ [mm]	$R_{V,k}$ [kN]	$R_{V,k}$ [kN]	$R_{V,k}$ [kN]	$R_{V,k}$ [kN]	$R_{ax,k}$ [kN]	$R_{Tred,k}$ [kN]

geometry	SHEAR					
	CLT - CLT lateral face		panel - CLT <sup>(1)</sup> lateral face		CLT - panel - CLT <sup>(1)</sup> lateral face	
$d_1$ [mm] $L$ [mm] $b$ [mm] $A$ [mm]	$R_{V,k}$ [kN]	$R_{V,k}$ [kN]	$R_{V,k}$ [kN]	$t$ [mm]	$R_{V,k}$ [kN]	$t$ [mm] $R_{V,k}$ [kN]

geometry	SHEAR			
	LVL - LVL	LVL - LVL - LVL		timber - LVL
$d_1$ [mm] $L$ [mm] $b$ [mm] $A$ [mm]	$R_{V,k}$ [kN]	$t_1$ [mm]	$t_2$ [mm]	$R_{V,k}$ [kN]



## ETA Certification

- End grain capacity
- Reinforcement
- Stiffness calculation

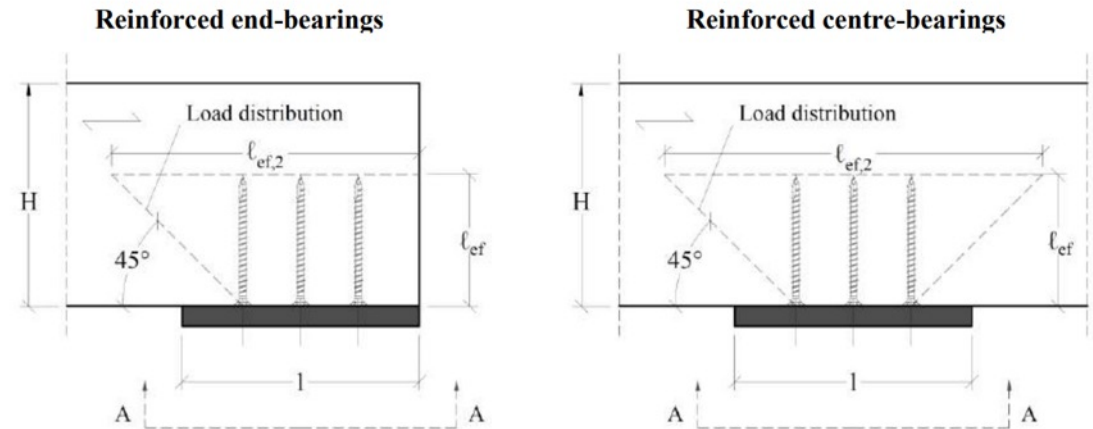


Members at an angle of  $0^\circ \leq \alpha \leq 90^\circ$  to the grain shall be calculated according to EN 1995-1-1:2008 from:

$$F_{ax,\alpha,Rk} = \frac{n_{ef} \cdot k_{ax} \cdot f_{ax,k} \cdot d \cdot \ell_{ef}}{k_\beta} \left( \frac{\rho_k}{\rho_a} \right)^{0,8} \quad [N]$$

## Annex C Compression reinforcement

“VGS”, “VGZ”, “VGZH” and “VGSB” screws with a full thread or “RTR” threaded rods may be used for reinforcement of timber members with compression stresses at an angle  $\alpha$  to the grain of  $45^\circ < \alpha < 90^\circ$ . The compression force must be evenly distributed over all screws or threaded rods.



### CONNECTION STIFFNESS

The sliding module can be calculated according to ETA-19/0706, with the following expressions:

$$K_{ax,ser} = 150 \text{ kN/mm}$$

$$K_{v,ser} = K_{lat,ser} = \frac{\rho_m^{1.5} \cdot d}{23} \text{ kN/mm}$$

For shear stressed connectors in timber-to-timber joints

$$K_{v,ser} = K_{lat,ser} = 70 \cdot d^2 \text{ kN/mm}$$

For shear stressed connectors in steel-to-timber joints

where:

- d is the bolt diameter in mm;
- $\rho_m$  is the average density of the main element, in  $\text{kg/m}^3$ .

## QUALITY AND DESIGN

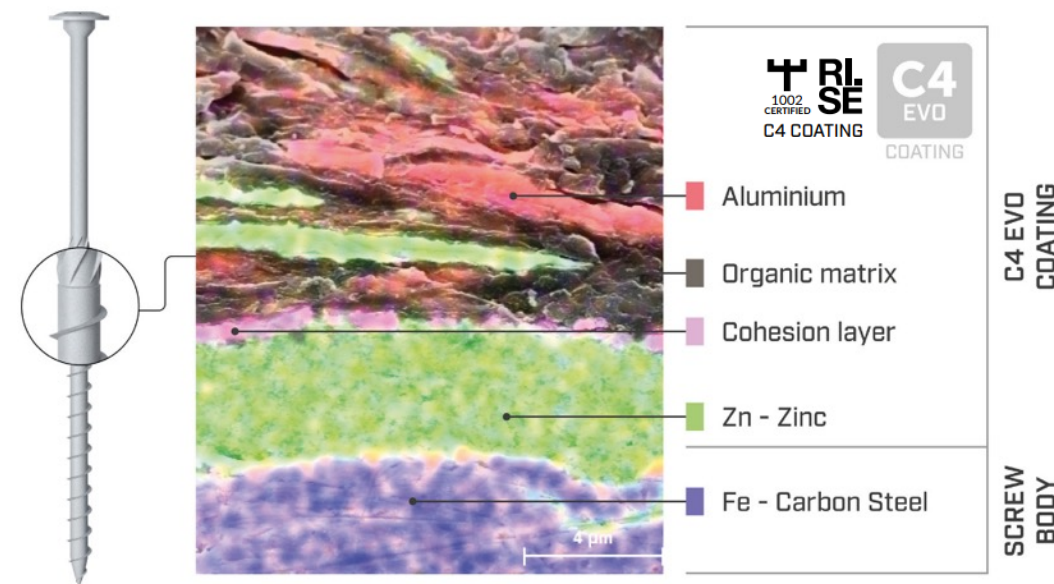
Fine balance between strength and ductility  
 $f_{yk} = 1000\text{N/mm}^2$



A screw should never snap



EVO = C4 coating  
 Coating is tested for 1440 hours of salt spray



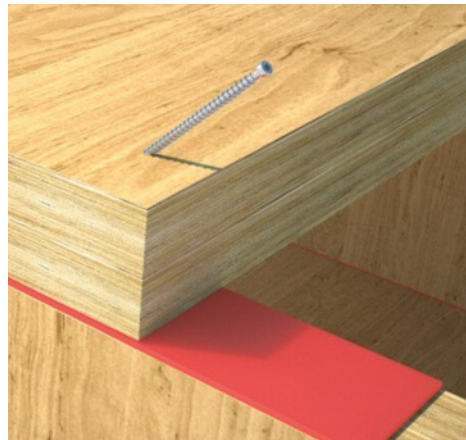


## VGZ



Why use full threaded screws compared to partial threaded screws

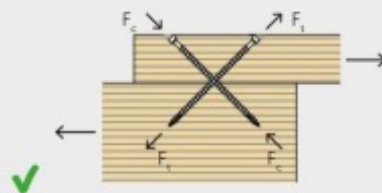
- Up to 125% better vibration reduction ( $K_{ij}$  acoustics) than partial threaded connections
- Reduces the risk of assembly errors
- Perfect for most joints and reinforcements.
- Increased strength



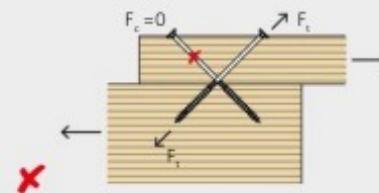
### APPLICATION EXAMPLE

TIMBER-TO-TIMBER SHEAR CONNECTION

Connection with VGZ total thread connectors



Connection with HBS partially thread screws

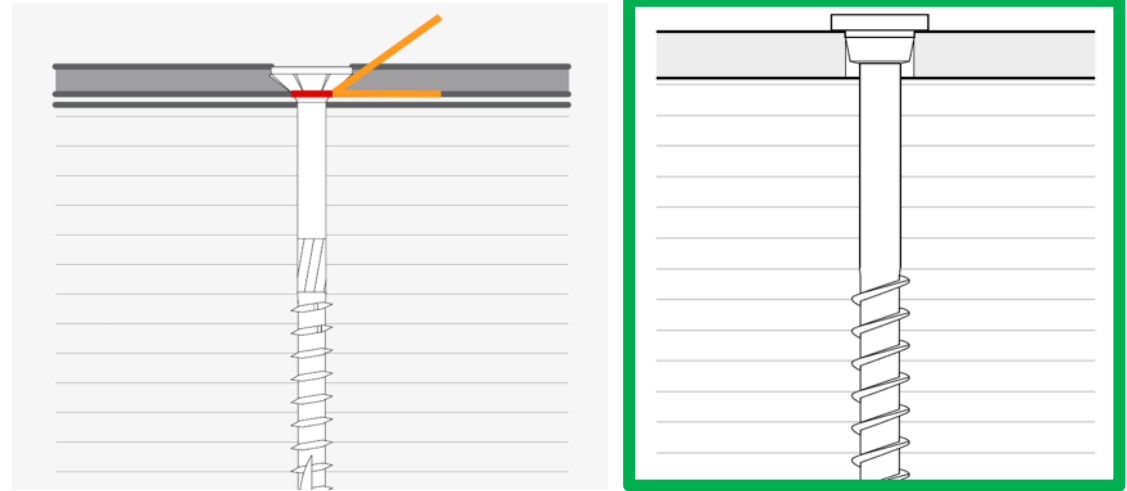


## HBS PLATE

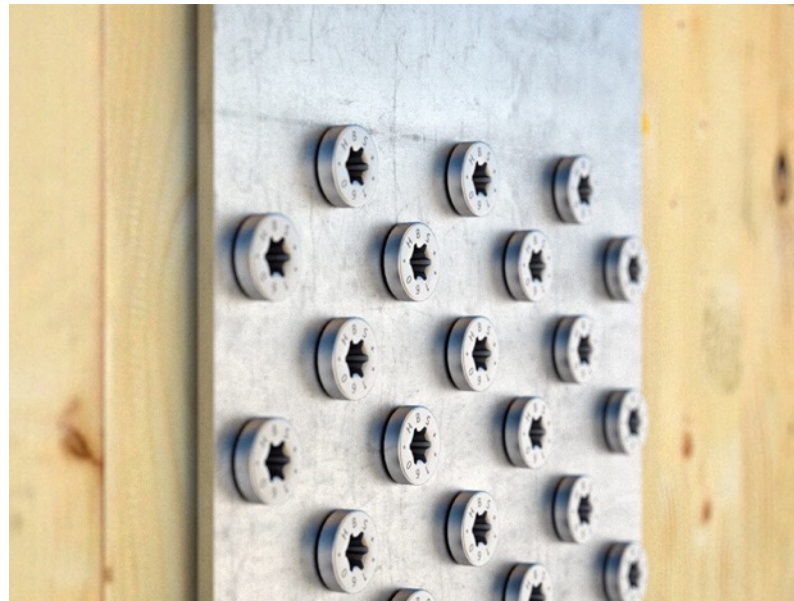


## Steel-wood application

- Risk construction
- Special design fasteners
- High capacity
- Hybrid structures



**NOTE!** Always specify torque for timber-steel connections with screws. Can be found in datasheets and ETA





**VGU + VGS= Hybrid structures**

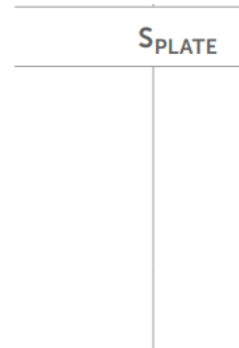


**NOTE!** Always specify torque for timber-steel connections with screws. Can be found in datasheets and ETA



**Example**

6 x VGU 11 + VGS11300



$$3^{0,9} = 2,68$$

$$2,68 * 2 * 26,52 = 142 \text{ kN}$$

$$R_{v,d} = \frac{0,8 * 142}{1,3} = 87,4 \text{ kN}$$

6,88
9,33
11,79
14,24
16,70
19,15

$$R_{v,d} = \min \left\{ \begin{array}{l} \frac{R_{V,k} \cdot k_{mod}}{\gamma_M} \\ \frac{R_{tens,k 45^\circ}}{\gamma_{M2}} \end{array} \right\} * \frac{26,87 * 6}{1,2} = 124 \text{ kN}$$



**NOTE!** Always specify torque for timber-steel connections with screws. Can be found in datasheets and ETA

**TIMBER-TO-STEEL APPLICATION**

RECOMMENDED INSERTION MOMENT:  $M_{ins}$

VGS Ø9

VGS Ø11 L < 400 mm

VGS Ø11 L ≥ 400 mm

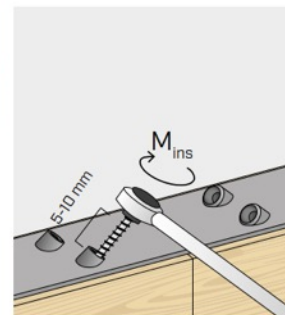
VGS Ø13

$M_{ins} = 20 \text{ Nm}$

$M_{ins} = 30 \text{ Nm}$

$M_{ins} = 40 \text{ Nm}$

$M_{ins} = 50 \text{ Nm}$



# Building high rise construction

- The difficulties ?
- Lack of knowledge ?
- Lack of solutions?
- Price ?





**WHT**

- Concrete to timber
- Perfect for CLT
- Easy assembly
- Characteristic load capacities up to 144,8 kN
- K1,ser available

**Angular brackets**

- Concrete to timber
- Perfect for CLT
- Easy assembly
- Characteristic load capacities up to 68,1 kN
- K1,ser available

**WHT**



**WHT PLATE C**



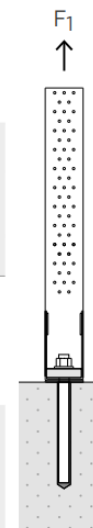
### Example WHT 620 (WHT620)

$$R_d = \min \left\{ \begin{array}{l} \frac{R_{k, \text{timber}} \cdot k_{mod}}{Y_M} \\ \frac{R_{k, \text{steel}}}{Y_{steel}} \\ R_{d, \text{concrete}} \end{array} \right.$$

$$R_d = \min \left\{ \begin{array}{l} \frac{106,2 \cdot 0,8}{1,3} = 65,35kN \\ \frac{85,2}{1,2} = 71kN \\ 78,4kN \end{array} \right.$$

WHT620 - with WHTW70 washer (M20)

configuration	R <sub>1,k</sub> TIMBER				R <sub>1,k</sub> STEEL		R <sub>1,d</sub> CONCRETE											
	holes fastening Ø5			R <sub>1,k</sub> timber [kN]	R <sub>1,k</sub> steel		R <sub>1,d</sub> uncracked		R <sub>1,d</sub> cracked		R <sub>1,d</sub> seismic							
	type	Ø x L [mm]	n <sub>v</sub> [pcs]		[kN]	[kN]	Y <sub>steel</sub>	VIN-FIX 5.8 Ø x L [mm]	[kN]	HYB-FIX 5.8 Ø x L [mm]	[kN]	HYB-FIX 8.8 Ø x L [mm]	[kN]					
<ul style="list-style-type: none"> <li>total fastening</li> <li>washer WHTW70</li> <li>M20 anchor</li> </ul>	LBA nails	Ø4,0 x 40	55	86,4	85,2	Y <sub>M2</sub>	M20 x 330	78,4	M20 x 330	81,3	M20 x 495	55,3						
		Ø4,0 x 60	55	106,2									M20 x 245	56,6	M20 x 245	69,8	M20 x 330	37,3
	screws LBS	Ø5,0 x 40	55	86,4														
	Ø5,0 x 50	55	106,2															
<ul style="list-style-type: none"> <li>partial fastening</li> <li>washer WHTW70</li> <li>M20 anchor</li> </ul>	LBA nails	Ø4,0 x 40	35	55,0	85,2	Y <sub>M2</sub>	M20 x 330	78,4	M20 x 330	81,3	M20 x 495	55,3						
		Ø4,0 x 60	35	67,6									M20 x 245	56,6	M20 x 245	69,8	M20 x 330	37,3
	screws LBS	Ø5,0 x 40	35	55,0														
	Ø5,0 x 50	35	67,6															

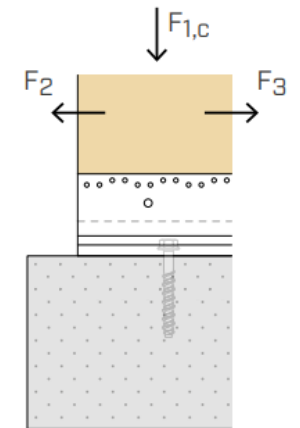
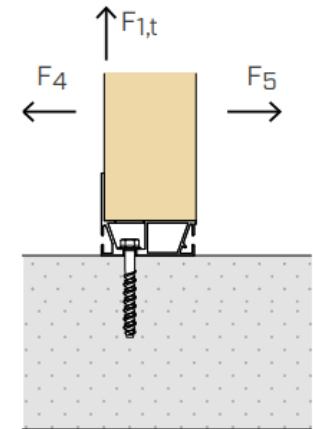


### Alu Start

- Easy assembly
- High strength
- Good thermal properties
- Industrialized way of construction
- Perfect for the building of tomorrow!



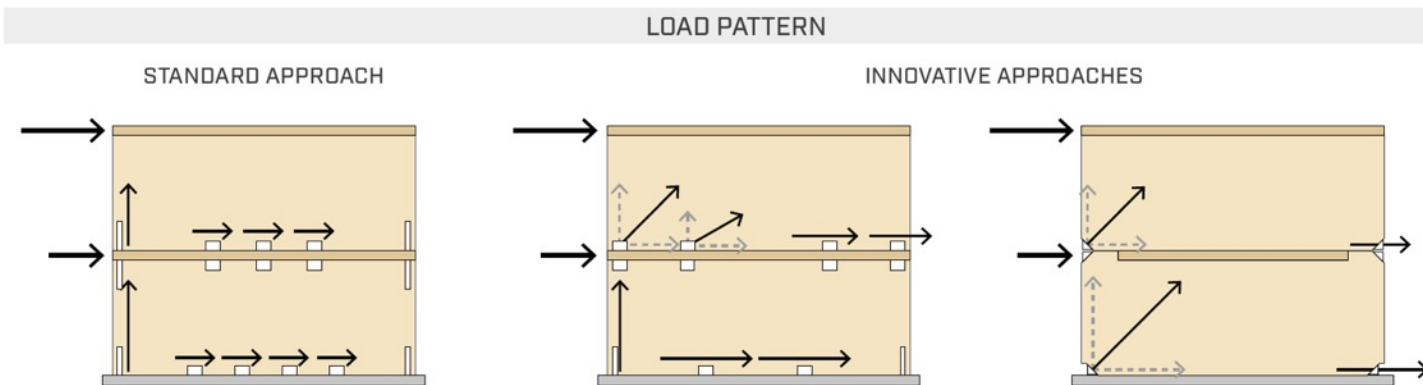
### EXTERNAL LOADS





## The basic behind construction

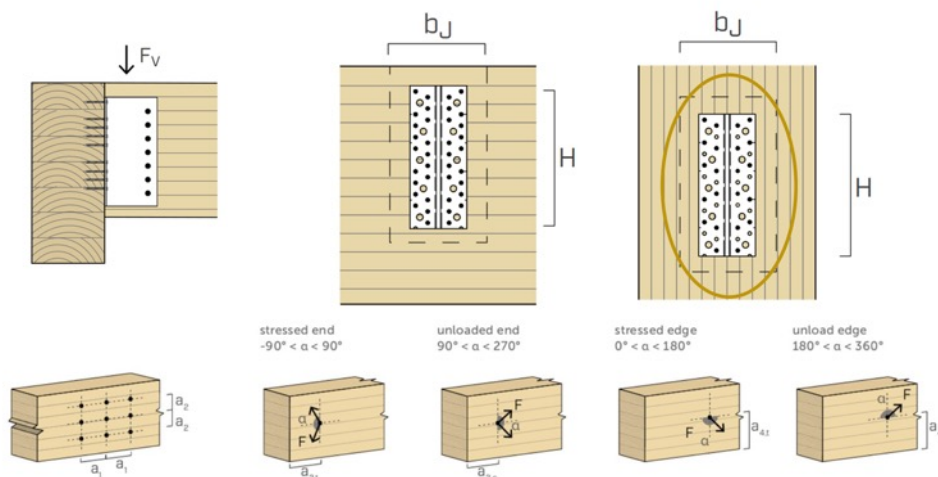
- Load path
- Force transition
- Have control over fibre directions
- Consistency is important



## Brackets for frame construction

### ALUMINI/MEDI/MAXI

- Concealed brackets
- Possible to apply on steel and concrete
- Fibre direction decide nailing pattern
- Fire safety
- Good drawing makes prefabrication possible

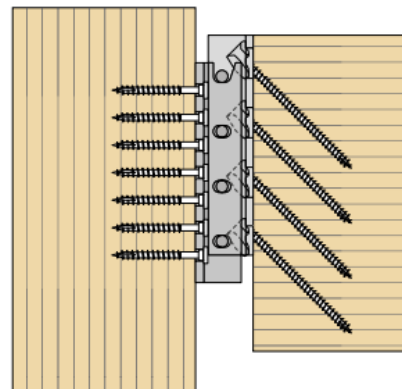
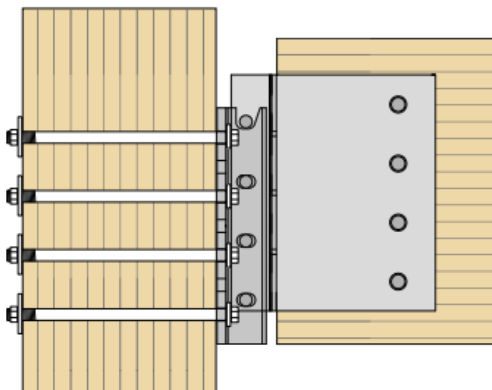




## Brackets for frame construction

### ALUMEGA

- Concealed brackets
- Possible to apply on steel and concrete
- Fire safety
- Less prefabrication needed





## Brackets for frame construction

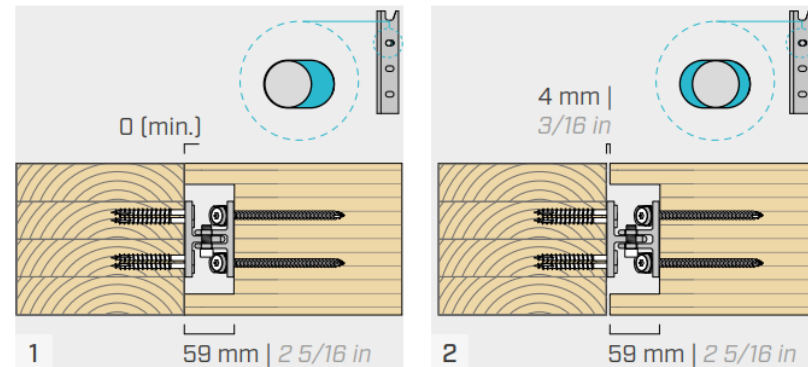
### ALUMEGA

- Concealed brackets
- Possible to apply on steel and concrete
- Fire safety
- Less prefabrication needed
- Allows rotation

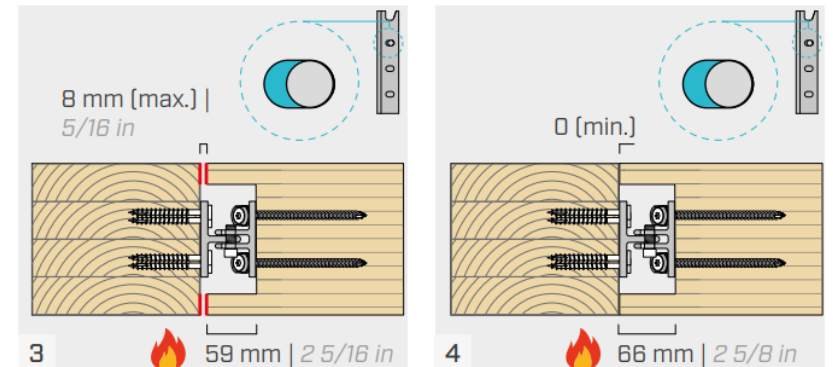
### PRELIMINARY STRUCTURAL VALUES | $F_v$

TYPE		single connector		double connector		triple connector	
H		ULS - $F_{v,Rk}$	ASD - $F_v$	ULS - $F_{v,Rk}$	ASD - $F_v$	ULS - $F_{v,Rk}$	ASD - $F_v$
[mm]	[in]	[kN]	[lbs]	[kN]	[lbs]	[kN]	[lbs]
240	9 1/2	90 - 140	5,500 - 9,000	180 - 280	11,000 - 18,000	270 - 420	16,500 - 27,000
360	14 1/4	140 - 210	8,500 - 13,500	280 - 420	17,000 - 27,000	420 - 630	25,500 - 40,500
480	19	180 - 280	11,500 - 18,500	360 - 560	23,000 - 37,000	540 - 840	34,500 - 55,500
600	23 5/8	230 - 350	14,500 - 23,000	460 - 700	29,000 - 46,000	690 - 1050	43,500 - 69,000
720	28 3/8	280 - 420	17,500 - 27,500	560 - 840	35,000 - 55,000	840 - 1260	52,500 - 82,500
840	33 1/16	330 - 490	20,500 - 32,000	660 - 980	41,000 - 64,000	990 - 1470	61,500 - 96,000

### INSTALLATION TOLERANCES

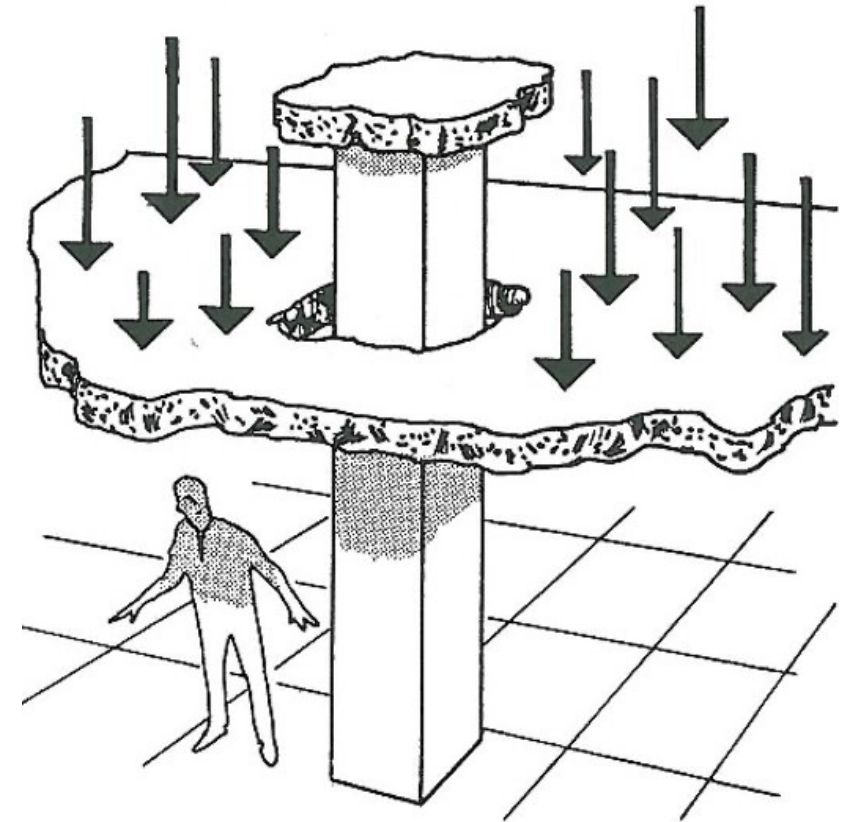
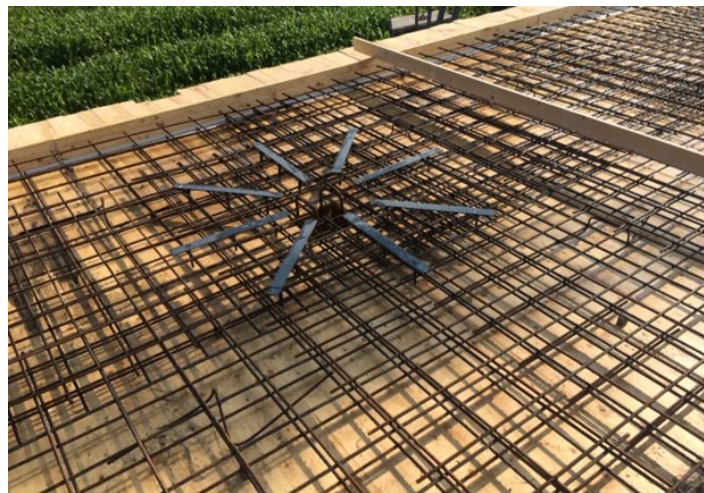
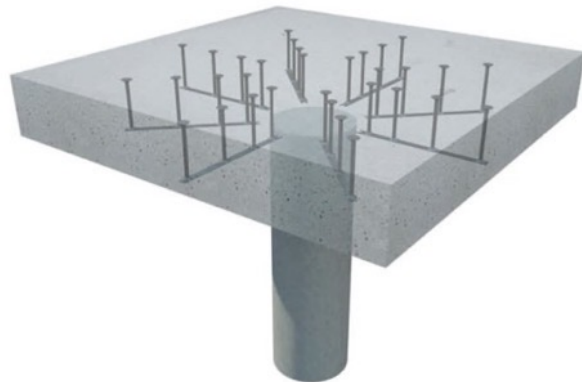


### FIRE RESISTANCE



**Brackets for frame construction**

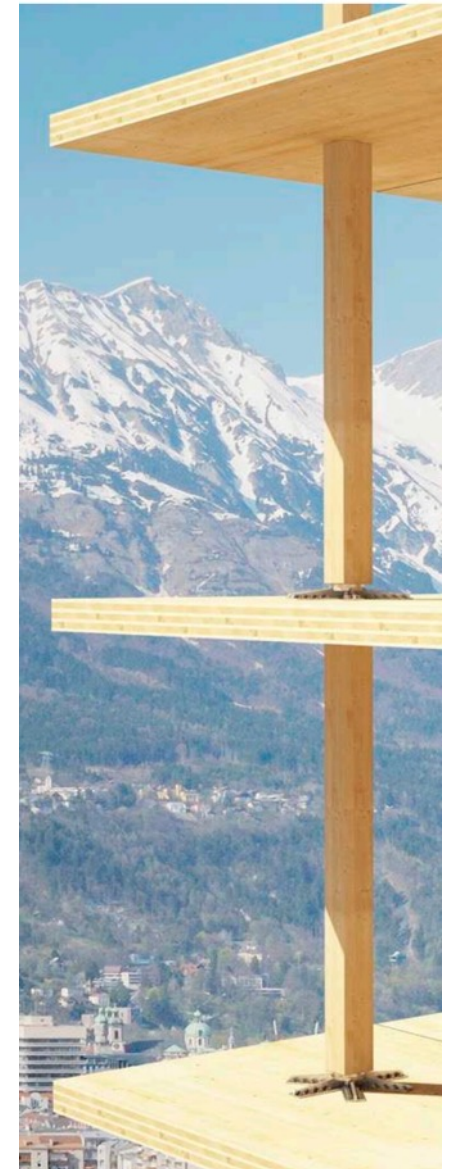
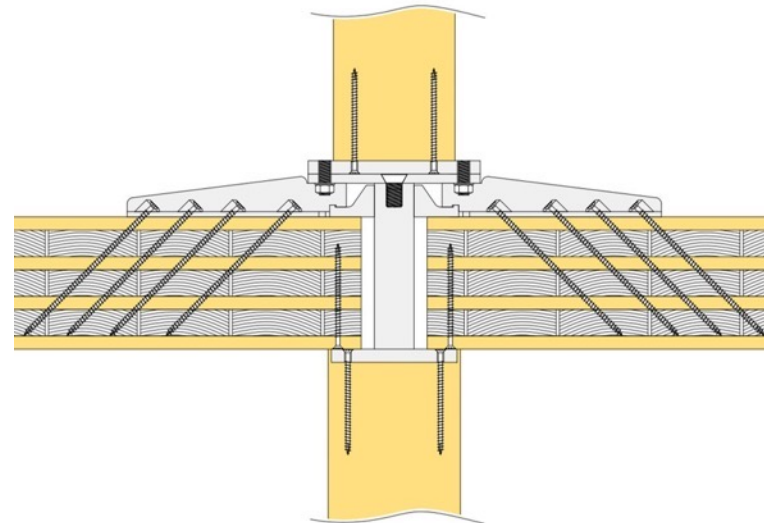
**PILLAR and SPIDER**



## Brackets for frame construction

### PILLAR and SPIDER

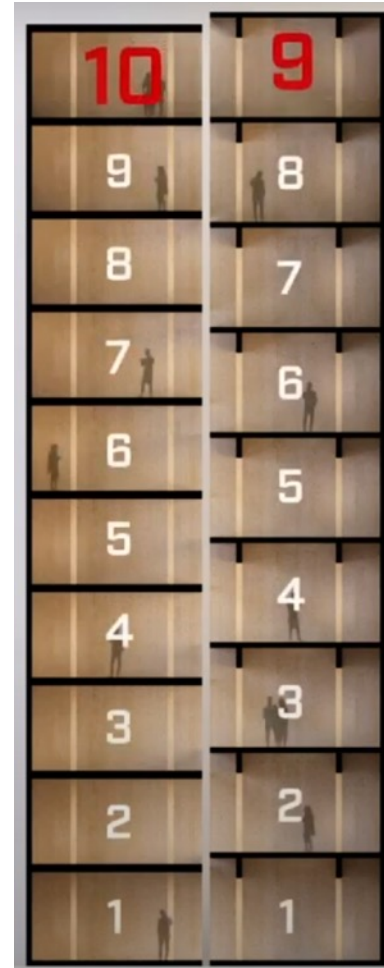
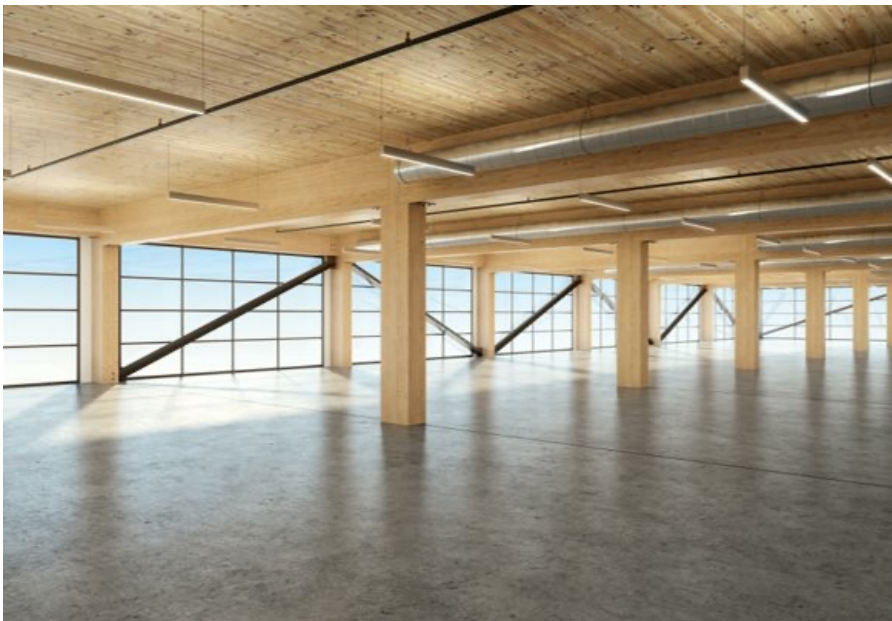
- Punching reinforcement
- Load transfer longitudinal- longitudinal
- Remove the need for beams





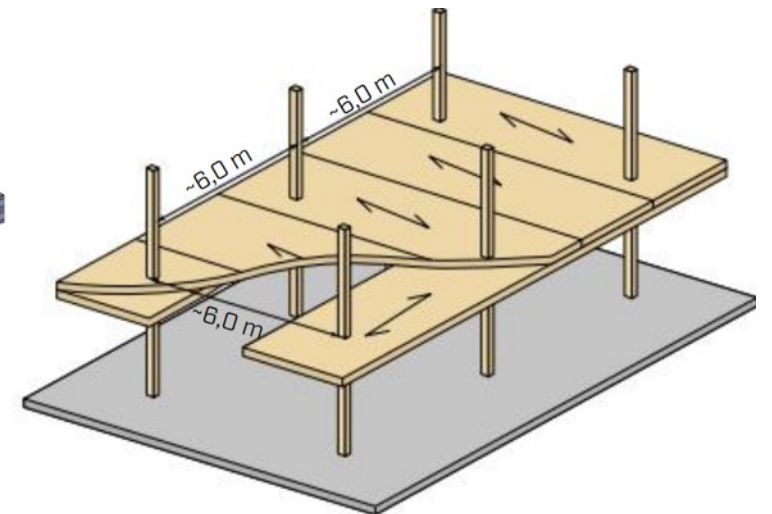
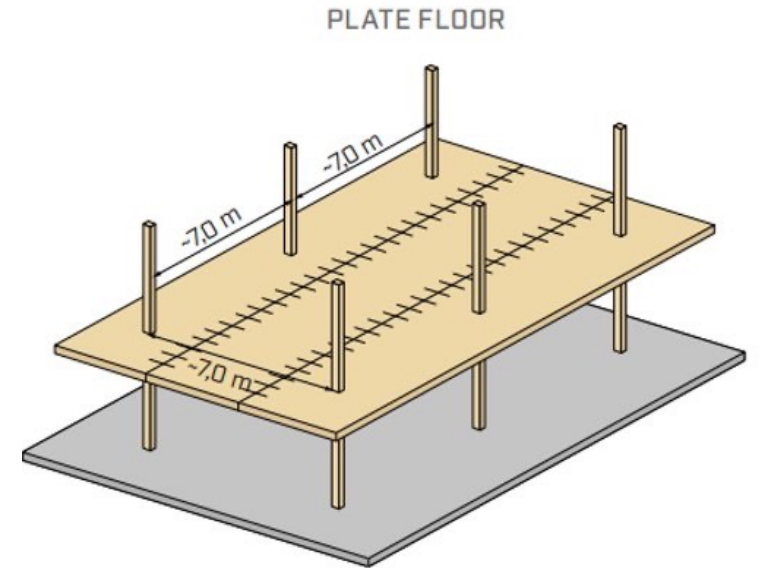
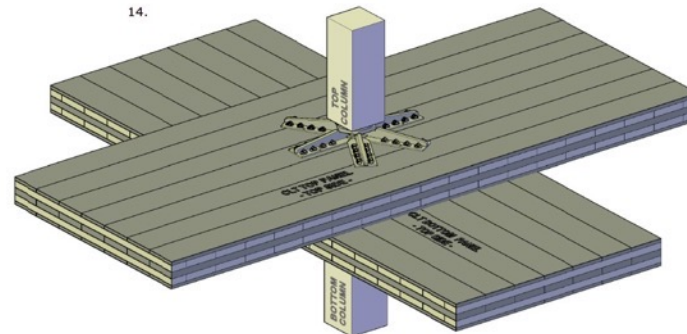
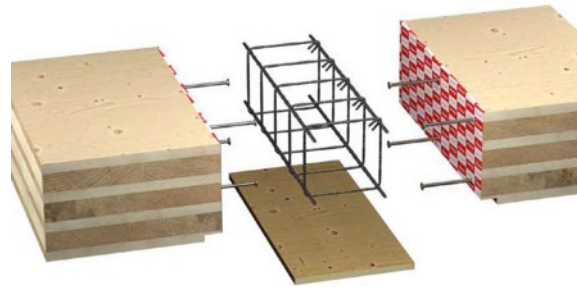
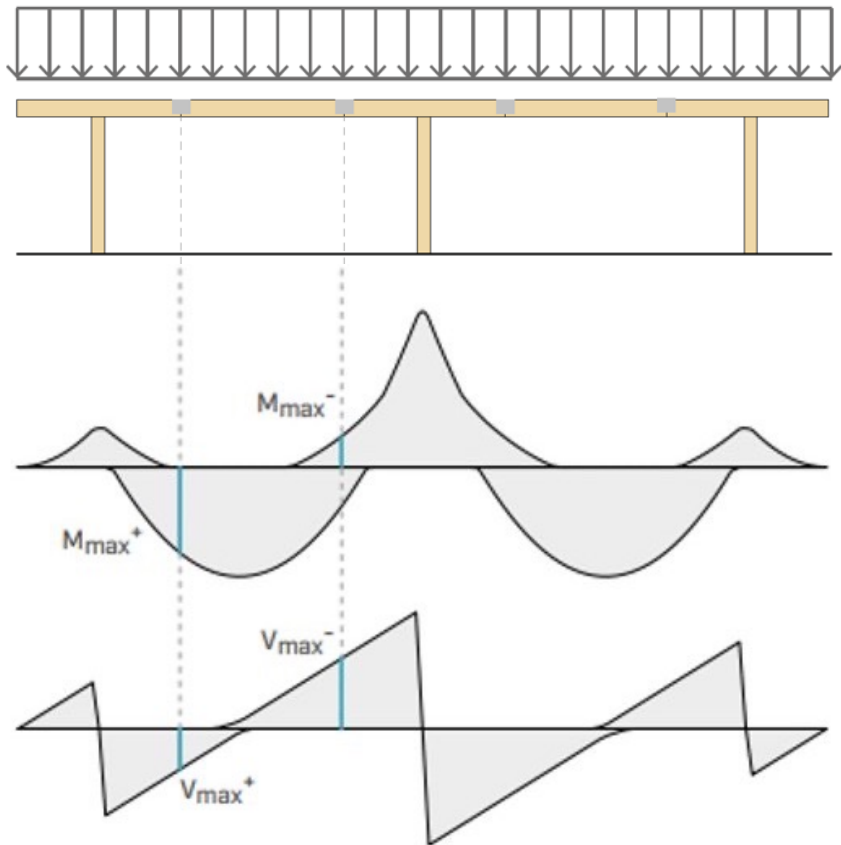
## Brackets for frame construction

### PILLAR and SPIDER



## Brackets for frame construction

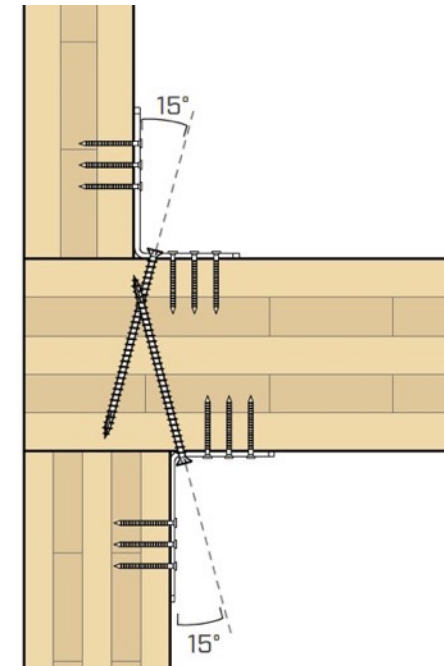
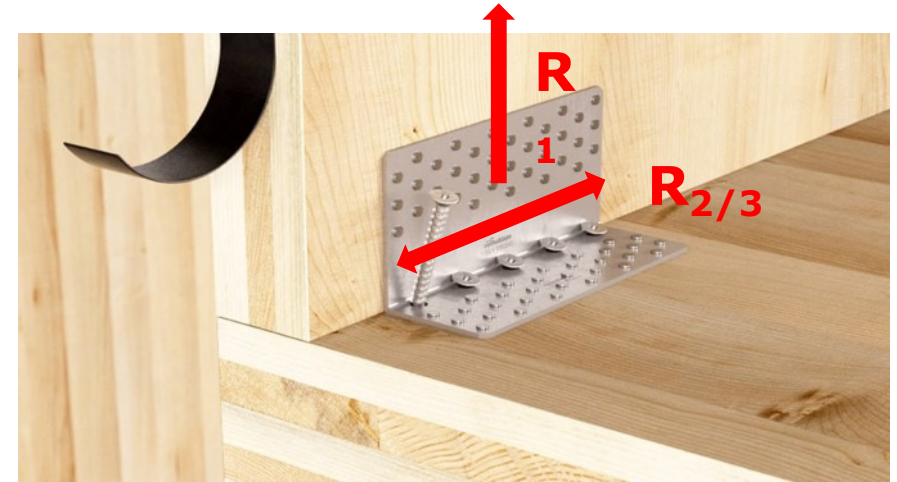
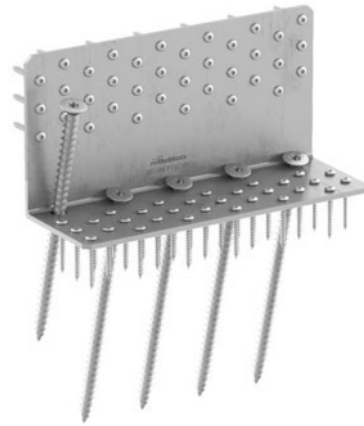
### PILLAR and SPIDER



## Brackets for CLT construction

### TITAN and NINO

- High capacity up to 100kN wood-wood
- K1,ser available
- Price worthy





**Brackets for CLT construction**

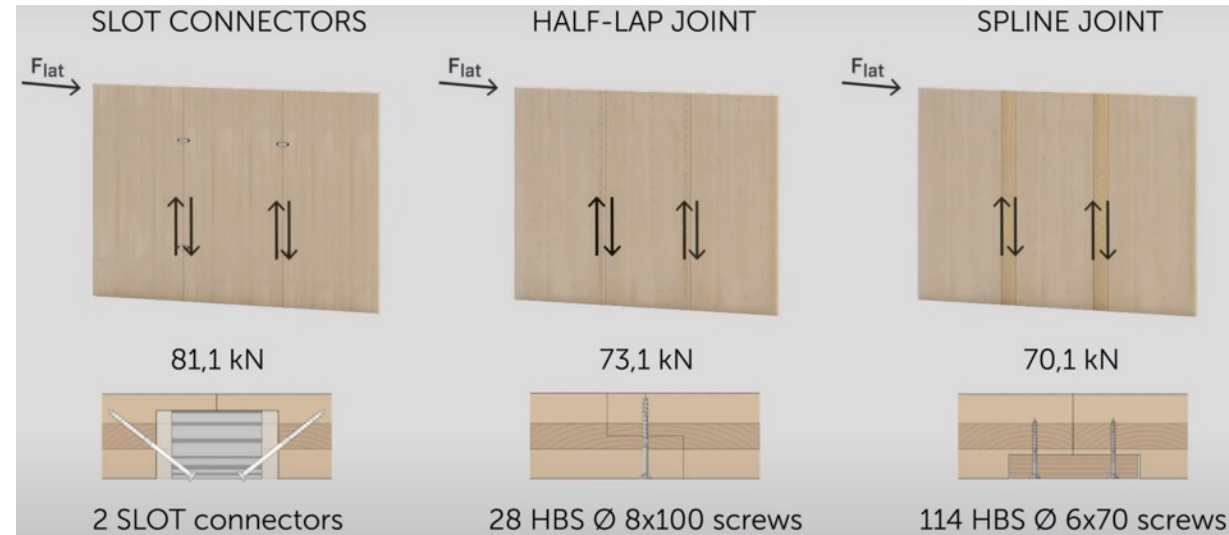
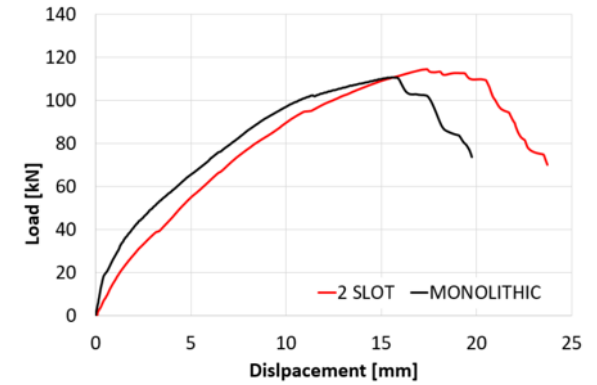
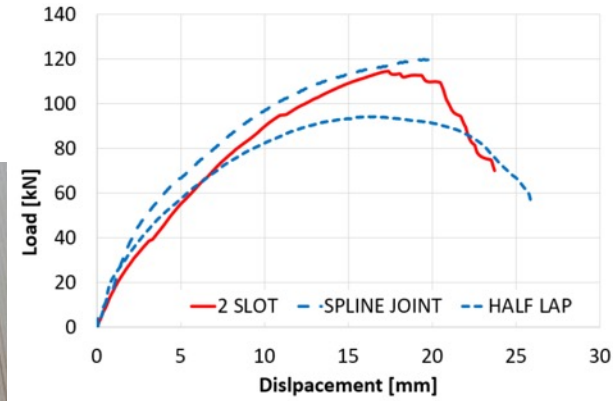
**SLOT**

- New opportunities
- Increased prefabrication
- Reduced assembly time
- Maximum strength



# Brackets for CLT construction

## SLOT

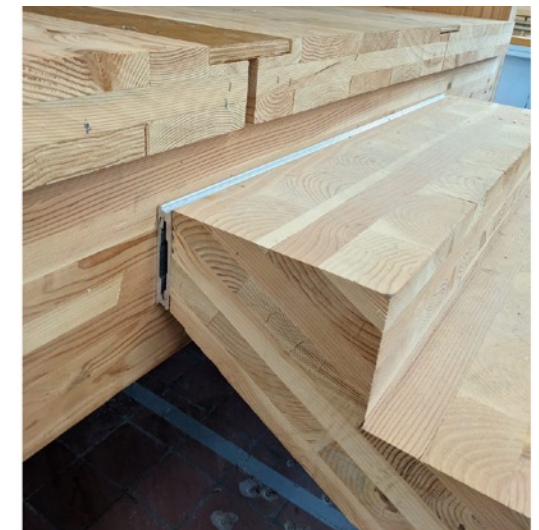
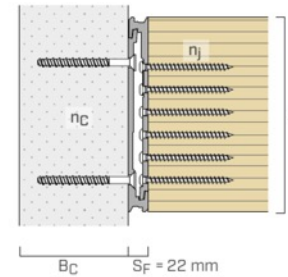
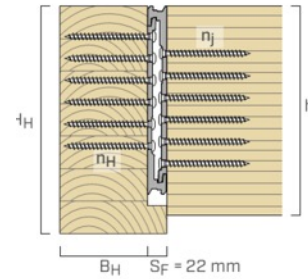




## Brackets for CLT construction

### LOCK – LOCKFLOOR

- Easy installation
- High strength
- Available in EVO
- Easy to disassemble
- Perfect for tomorrow's construction!

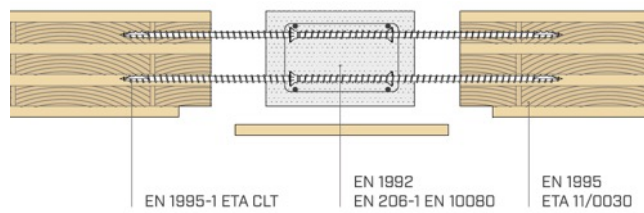
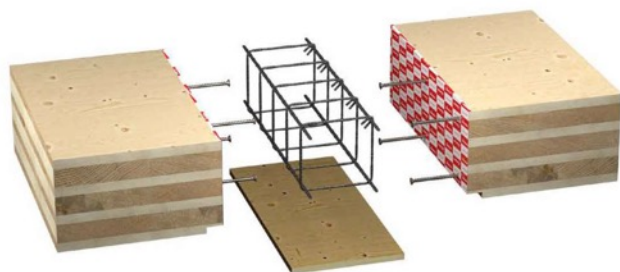




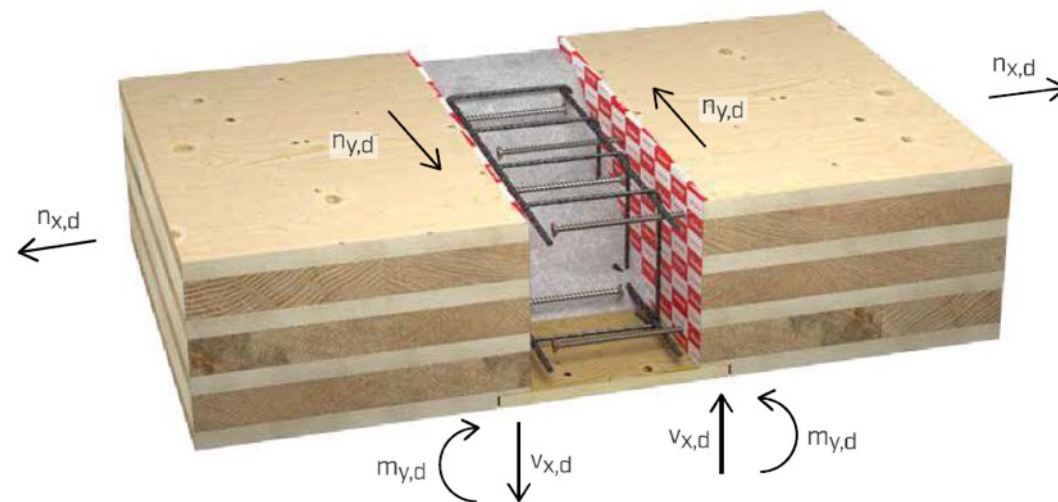
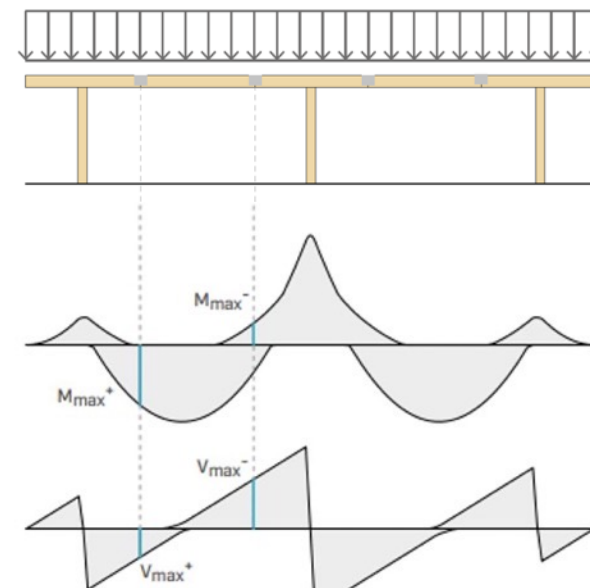
## Solutions for hybrid structures

### TC-FUSION

- Makes concrete-wood reinforced connections
- Open up a new area for hybrid structures
- ETA certified
- Wide span of applications



NEW ETA ROTHOBLAAS FOR TIMBER - CONCRETE CONNECTION

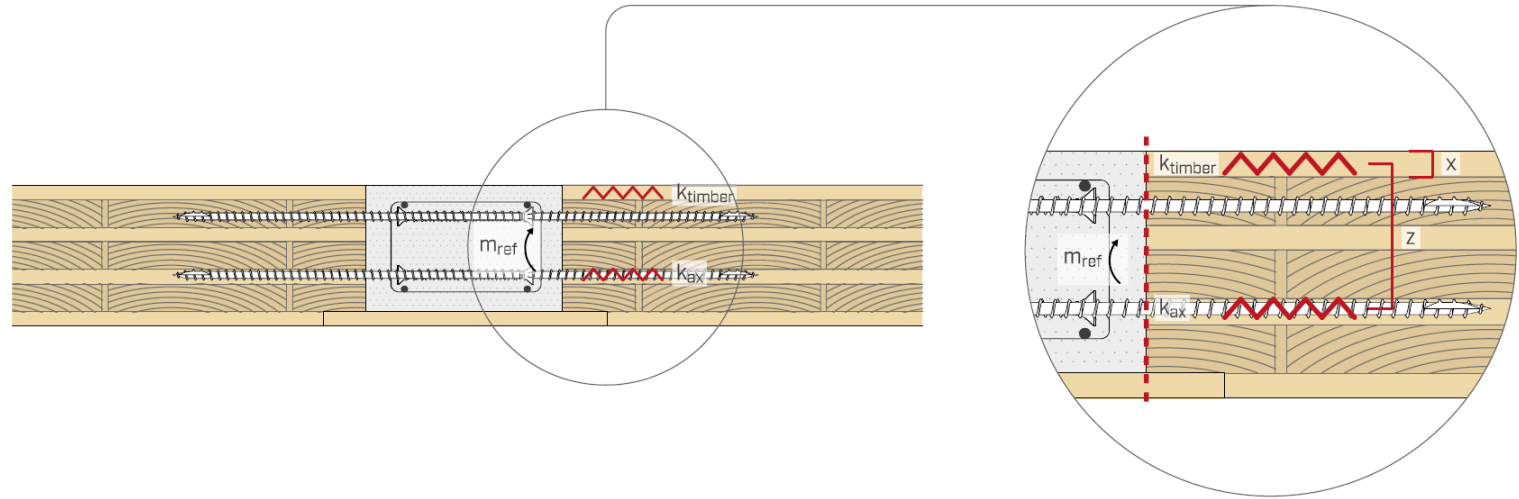


## Solutions for hybrid structures

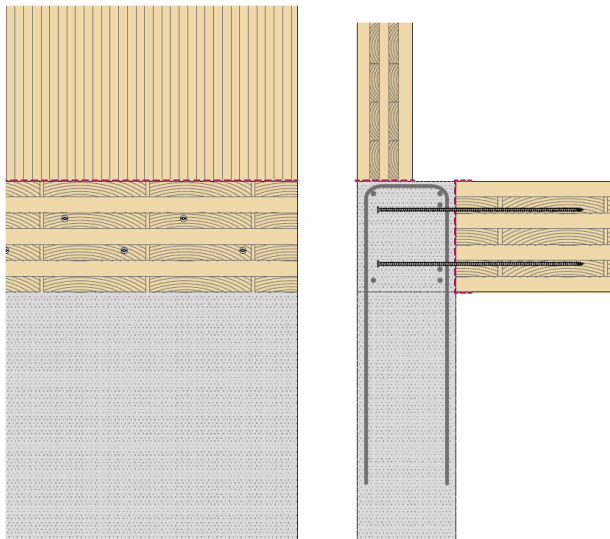
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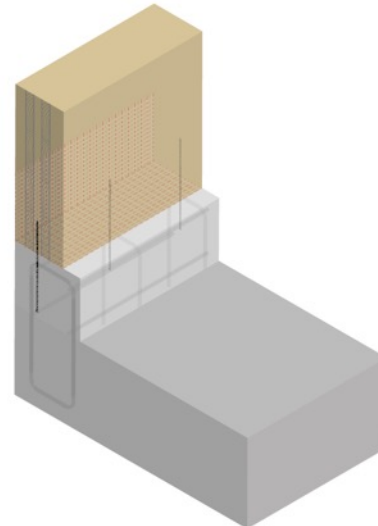
#### DESIGN CONCEPT | BENDING MOMENT STIFFNESS



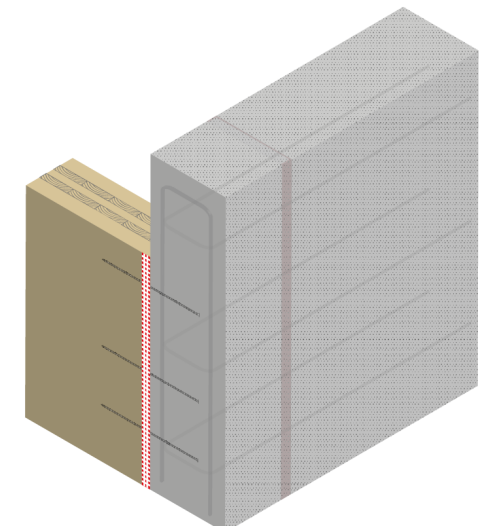
SLAB TO WALL



SLAB TO FOUNDATION

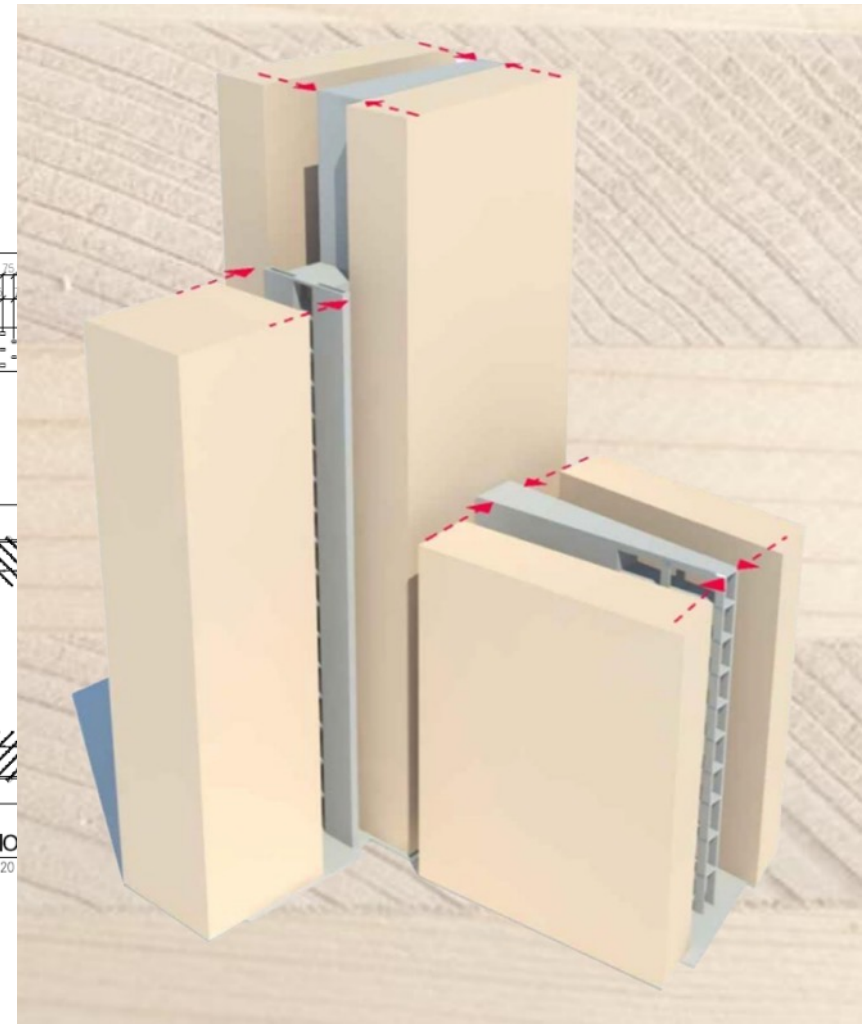
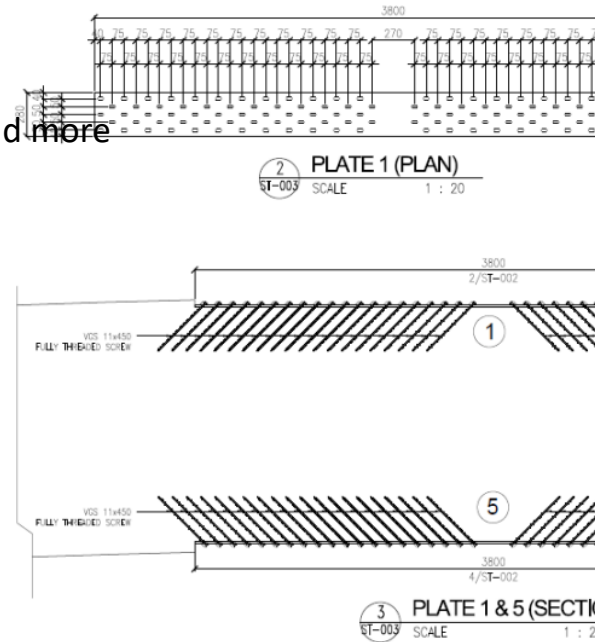
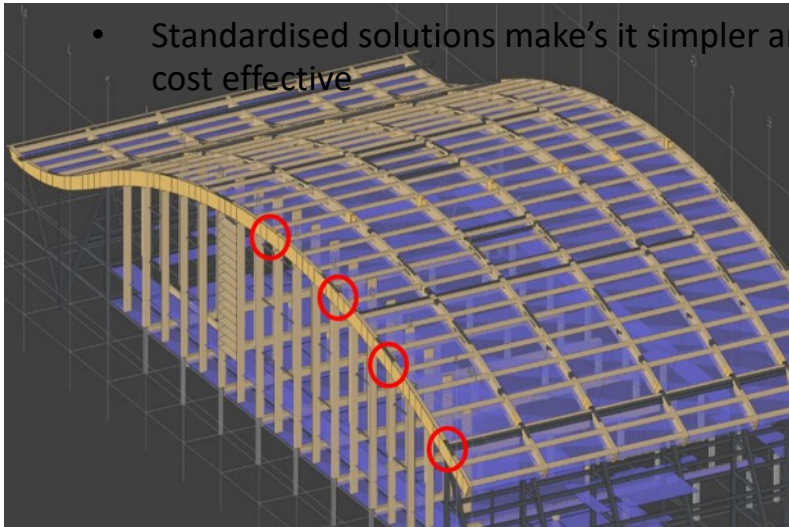


WALL TO WALL



## What can we do with these solutions?

- Stronger connection
- Combining the best from all materials
- Standardised solutions make's it simpler and more cost effective



Holzpak - Ermanno Acler

Hoho - Matthias Rinnhofer



### **Want to discuss different solutions?**

- Take contact with your local Rothoblaas agent

### **Want to explore our product?**

- Book a CPD with your Rothoblaas agent
- Check out our website

### **Want to explore mass timber?**

- Book your ticket to the next **mass timber seminar**
- Invest in your knowledge book your ticket to the **TEEW**

A large, centered version of the Rothoblaas logo, consisting of a stylized house icon above the word "rothoblaas" in a bold, lowercase sans-serif font.

Solutions for Building Technology

**Thank you for your attention**



**Timber engineer Sivert Knutsen**  
Sivert.knutsen@rothoblaas.com

**rothoblaas**

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