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Authorised and notified according to Article 29 of the Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011

MEMBER OF EOTA

European Technical Assessment ETA-22/0806 of 2023/05/26

I GENERAL PART

Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011: ETA-Danmark A/S	
Trade name of the construction product:	Rotho Blaas TIMBER-CONCRETE FUSION System TC FUSION
Product family to which the above construction product belongs:	Screws and threaded rods for use as a connecting element in wood-concrete composite constructions
Manufacturer:	Rotho Blaas s.r.l Via dell'Adige 2/1 IT-39040 Cortaccia (BZ) Tel. + 39 0471 818400 Fax + 39 0471 818484 Internet www.rothoblaas.com
Manufacturing plant:	Rotho Blaas s.r.l. - Held on file by ETA-Danmark AS
This European Technical Assessment contains:	27 pages including 20 Annexes which forms an integral part of the document
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of:	European Assessment document № EAD 130090-00-0303 »Wood-concrete composite slab with dowel-type fasteners«
This version replaces:	

CONTENT

II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of the product

This ETA is an assessment for the use of screws and threaded rods in timber-concrete composite connections.

This ETA covers the use of fully threaded screws (e.g. Rotho Blaas VGS, VGZ) according to ETA-11/0030 with a nominal diameter of 9, 11 and 13 mm, as well as the use of threaded rods (Rotho Blaas RTR) according to ETA-11/0030 with a nominal diameter of 16 mm.

The structural design of the Timber-Concrete FUSION System (TC FUSION) must be done in detail to ensure requirements of the load-bearing capacity (ultimate limit state) as well the serviceability (serviceability limit states) of the structural parts.

Rotho Blaas delivers the Rotho Blaas screws and Rotho Blaas threaded rods for the composite action to be used as connection components. The composite members may be partially prefabricated at the factory, or they may be composed at the building site. The proper function of the timber-concrete composite connection provides for the following components to be added in the factory or at the building site:

Base Material:

- Structural timber elements in softwood and hardwood, like solid timber (ST), glued laminated timber (GL), cross laminated timber (CLT) and laminated veneer lumber (LVL), similar glued members, wood based-panels according to a harmonized national standard (hEN) or an European Technical Assessment (ETA)

Moulding:

- It is recommended to cover the timber elements with an intermediate layer to avoid moisture penetration and/or a reduction of the water-cement content of the concrete. The friction between concrete and wood is therefore negligible.

- No other essential characteristics are assessed for the moulding.

Additional requirements on the timber-concrete composite:

- Concrete according to EN 206-1, and reinforcement according to EN 10080 and national regulations for cast at construction site according to EN 1992-1-1.
- Minimum strength class of the concrete should be C 25/30.
- The usage of a shrinkage-reduced concrete is highly recommended. Shrinkage effects in general must be considered.

Information about the products »Screw« and »Threaded rod« which are not explicit given within that ETA are given in the ETA-11/0030. Information about the geometry are also given with the Annex A.

Specifications of the product itself are given in Annex B. The connection has to fulfil the minimum geometric requirements as given in Annex C.

The intended use and exemplary applications are also detailed in the Annex F.

2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter EAD)

The screws and threaded rods are intended to be used in structural timber concrete composite connections in service class 1 and 2 as defined in EN 1995-1-1 subject to static or quasi static loading. In addition, use class 3.1 as defined in EN 335-1 (exterior, above ground, protected) is possible depending on national provisions.

The fire design of the timber part should be done in accordance to the EN 1995-1-2 and for the concrete element in accordance to EN 1992-1-2.

The performances given in Section 3 are only valid if the screws and threaded rods are used in compliance with the specifications and conditions given in Annex B.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the screws of 50 years.

The indications given on the working life cannot be interpreted as a guarantee given by the producer or Assessment Body, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the products.

3 Performance of the product and references to the methods used for its assessment

Characteristic (Basic Work Requirments	Assessment of characteristic
3.1 Mechanical resistance and stability (BWR1)	
Material and geometry	See annex A
Mechanical strength	See annex B
Mechanical stiffness and shear resistance	Timber-concrete composite slabs including Rotho Blaas self-tapping screws are used and manufactured according to an individual design made by a structural engineer responsible for the design of works on a case by case basis. Timber-concrete composite structures may function as directly load bearing and structural bracing members. The structural performance of them shall be considered in accordance with the limit state design principles specified in Eurocodes. The performance of the composite slab is outside of this ETA. Mechanical and shear resistance of Rotho Blaas Timber-Concrete FUSION System, TC FUSION are given in Annex B1, E9 and E10.
Corrosion protection	The Rotho Blaas screws or threaded rods are produced from steel wire. Screws or threaded rods made from carbon steel are electrogalvanised and yellow or blue chromate or could be coated with organic coating. The thickness of the zinc coating is minimum 5 µm.
3.2 Safety in case of fire (BWR2)	
Reaction to fire	The screws are considered to satisfy **Euroclass A1** in accordance with EN 13501-1 and Delegated Regulation 2016/364, according to EC Decision 96/603/EC.
3.3 Safety and accessibility in use (BWR4)	See aspects covered by BWR1

3.4 General aspects related to the performance of the product

The screws and threaded rods have been assessed as having satisfactory durability and serviceability when used in timber structures using the timber species described in EN 1995-1-1 and subjected to the conditions defined by service classes 1 and 2.

The screws and threaded rods are manufactured in accordance with the provisions of the European Technical Assessment using the automated manufacturing process as identified during the inspection of the plant by the assessment body issuing the ETA and the notified body and laid down in the technical documentation. The installation shall be carried out in accordance with EN 1995-1-1 or an appropriate national code unless, otherwise defined in this document.

3.5 Method of assessment

The assessment of the performance of the screws and threaded rods or the intended use in relation to the requirements for mechanical resistance and stability and safety in use in the sense of the Basic Works Requirements 1 and 4 has been made in accordance to the rules given in »*EAD 130090-00-0303: wood-concrete composite slab with dowel-type fasteners*«.

4 Attestation and verification of constancy of performance (AVCP)

4.1 AVCP system

According to the decision 2000/447/EC of the European Commission, as amended, the system of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 1.

5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE-marking.

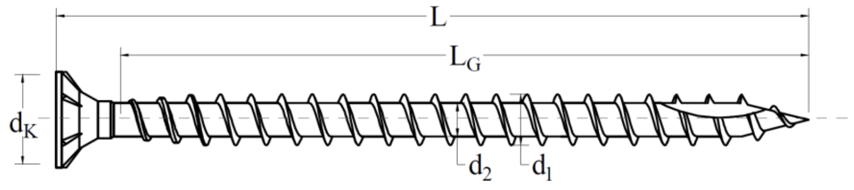
Issued in Copenhagen on 2023-05-26 by

Thomas Bruun
Managing Director, ETA-Danmark

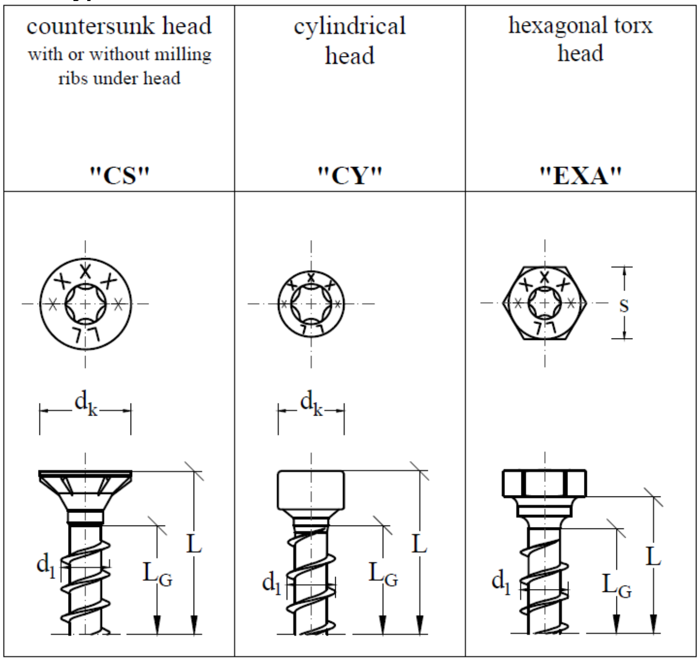
Rotho Blaas VGS, VGZ – Self-tapping screws with Countersunk, cylindrical or hexagonal head with full thread (acc. ETA-11/0030)

Table A1.1: Screw Dimensions and Materials

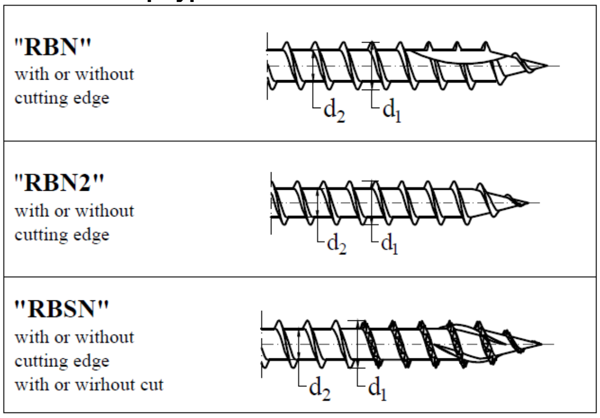
Drawing



Head types:



Alternative tip types:



[not in scale]

Materials and coatings

- acc. to ETA-11/0030

Nominal diameter		**9,0**	**11,0**		**13,00**	
d_1	Outer thread diameter	9,00	11,00		13,00	
d_2	Inner thread diameter	5,90	6,60		8,00	
d_K	Head diameter, CS	16,00	19,30		22,00	
	Head diameter, CY	11,50	13,50		15,50	
s	Heads diameter, EXA				17,00	19,00
Drive		TX 40	TX50	SW17	TX50	SW19

Nominal length and thread length of the screws

- acc. to ETA-11/0030

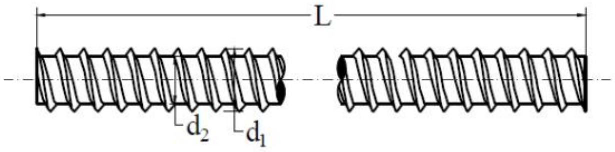
All dimensions in [mm]

Tolerances acc. ETA-11/0030

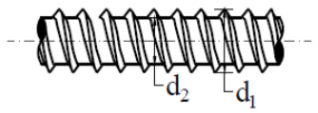
Rotho Blaas RTR – threaded rods (acc. ETA-11/0030)

Table A2.1: Threaded Rod – Dimensions and Materials

Drawing



Alternative thread types:



Materials and coatings

- acc. to ETA-11/0030

Nominal diameter		**16,0**
d_1	Outer thread diameter	16,00
d_2	Inner thread diameter	12,00

Nominal length of the threaded rods

- acc. to ETA-11/0030

All dimensions in [mm]

Tolerances acc. ETA-11/0030

Performance of the product and references to the methods used for its assessment

Performance of the Rotho Blaas VGS, VGZ screws itself (single product)

Table B1.1: Characteristic values of the load-carrying capacities of the fasteners acc. ETA-11/0030

Nominal thread diameter	d	[mm]	VGS, VGZ 9,0	VGS, VGZ 11,0	VGS, VGZ 13,0	RTR 16,0
Tensile strength [1]	$f_{tens,k}$	[kN]	25,4	38,0	53,0	100,0
Torsional strength [1]	$f_{tor,k}$	[Nm]	see ETA-11/0030			
Yield moment [1]	$M_{y,Rk}$	[Nm]	27,2	45,9	70,9	200,0
Yield strength [1]	$f_{y,k}$	[N/mm²]	1000			650
Characteristic Stiffness Parameters						
Modulus of Elasticity	E_s	[N/mm²]	210.000			
Assessed Performances						
Bending angle [1]		[°]	No breaking has been observed at a bending angle of $\alpha \leq 45°/d^{0,7}+20°$			
Safety factor insertion moment [1]		[-]	Ratio of the characteristic torsional strength to the mean insertion moment: $f_{tor,k} / R_{tor,mean} \geq 1,5$			
[1] Assessments of the product are done in accordance to the EAD 130118-01-0603, more information see ETA-11/0030						

Performance of the screws in timber products

The performance of Rothoblaas VGS, VGZ and RTR are given in the ETA-11/0030.

Performance of screws and threaded rods in concrete

The shear resistance (= withdrawal capacity and bond strength in concrete elements respectively) of the Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods in the concrete element can be calculated with the help of the charactersitic values given with the tables below.

Table B1.2: Characteristic values of the load-carrying capacities of the screws

Nominal thread diameter	d	[mm]	9,0	11,0	13,0
Bond strength in C25/30	$f_{b,k}$	*[N/mm²]*	12,50	12,50	12,50

Performance of the Rotho Blaas RTR threaded rods itself (single product)

Table B1.3: Characteristic values of the load-carrying capacities of the threaded rods

Nominal thread diameter	d	[mm]	16,0
Bond strength in C25/30	$f_{b,k}$	[N/mm²]	9,00

The conversion of the bond strength to other concrete strengths can be done in a linear way via the characteristic cylinder compression strength $f_{c,k}$. Only the use of normal concrete strength classes (up to C 50/60) is permitted. A minimum concrete strength of C25/30 must be ensured.

To determine the design value of the bond strength for verficiations in the ultimate limit state (ULS), the partial factor for concrete γ_c, as well as the coefficient α_{ct} acc. EN 1992-1 should be taken into account.

Specifications of the intended use

Geometrical requirements for anchoring the screws and threaded rods in concrete

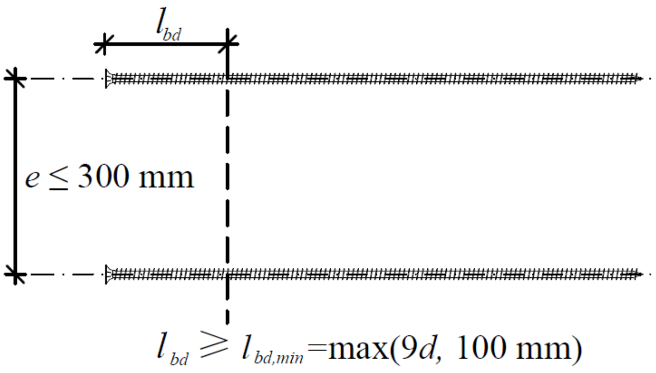


Figure C1.1: Anchoring in concrete – geometrical requirements

In the anchoring zone, supplementary reinforcement (e.g. stirrups, main bars) according to EN 1992-1-1 must be placed to transmit the resulting tensile forces. To ensure an adequate contact between the timber element and the concrete at least every 300 mm a screw or threaded rod must be arranged. This must be considered for hinge connections (one row), and if the TC-FUSION method is used for bending stiff connections screws must be arranged at least every 300 mm on the tension and also on the compression zone.

Geometrical requirements for lap splice of the screws and threaded rods in concrete

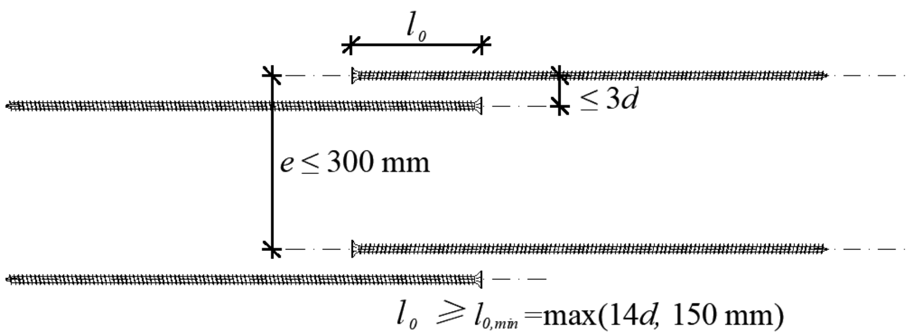


Figure C1.2: Lap splice in concrete – geometrical requirements

In the area of the lap splice, additional reinforcement (e.g stirrups, main bars) according to EN 1992-1-1 must be placed to withstand the resulting tensile forces. At least two rods must be placed at the ends of the splice.

The minimum spacing, end- and edge- distances of the screws and/or threaded rods must fulfill the requirements given with the ETA-11/0030 on the timber side. The minimum penetration length sould be chosen in accordance to Annex E8, equation (14). In the case of axial forces on the screws and if the grain direction in the lamella is perpendicular to the axis of the screw the minimum penetration length given with ETA-11/0030 should be taken into account.

Additional forces on to the screws and/or threaded rods due to eccentricities must be considered in the structural design.

Calculation of anchorage and lap length

General note: The structural design is based on the specifications of the EN 1992-1-1.

Basic anchorage length

The arrangement of anchored screws or rods should comply with figure C1.1. The basic required anchorage length $l_{b,rqd}$ for anchoring the force $F_{ax,Rd}$ assuming a constant bond stress equal to f_{bd} follows from:

$$l_{b,rqd} = \frac{F_{ax,Rd}}{d \cdot \pi \cdot f_{bd}} \quad (1)$$

Design anchorage length

The design anchorage length l_{bd} follows from:

$$l_{bd} = l_{b,rqd} \cdot \frac{F_{ax,Ed}}{F_{ax,Rd}} \geq l_{bd,\min} = \max(9 \cdot d; 100\ \mathrm{mm}) \quad (2)$$

When calculating the anchorage length the length of the screw head may also be considered with f_{bd} .

Lap length

The arrangement of lap splices with srews or threaded rods should comply with figure C1.2. The lap length l_0 follows from:

$$l_0 = 1{,}5 \cdot l_{bd} \geq l_{0,\min} = \max(14 \cdot d; 150\ \mathrm{mm}) \quad (3)$$

Where

d	Nominal diameter of fastener (outer diameter of the thread) [mm]
f_{bd}	Design values of bond strength for fastener [N/mm²]
$F_{ax,Ed}$	Design value of the axial tension force onto the fastener [N]
$F_{ax,Rd}$	Design value of the axial resistance force of the fastener (concrete) [N]
l_0	Lap length of fastener [mm]
$l_{0,min}$	Minimum lap length of fastener [mm]
l_{bd}	Design anchorage length of fastener [mm]
$l_{bd,min}$	Minimum anchorage length of fastener [mm]
$l_{b,rqd}$	Basic anchorage length of fastener [mm]

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Verification for panel to panel, panel to concrete connection

In Table E1.1 all necessary verifications (№ 1 to 7) are listed for bending rigid edge-panel connection (e.g. for slab constructions) to transfer

- bending moments m_d, shear forces v_d and normal forces n_d

like shown in Annex F1 and F3. For the applications with CLT the presented approaches and verifications for the structural design given in the Annexes E2 to E10 should be considered.

If the connection method is used to transfer only shear and normal forces (e.g. hinge connection) the verifications to consider the actions onto the screws due to axial and shear forces for applications shown in the Annex F2 and F4 are also given in Table E1.1.

Table E1.1: Structural design of connections timber-to-concrete

№	Labelling	Verification	Reference
1	Axial performance of screws or threaded rods[1)]	$\frac{F_{ax,Ed}}{F_{ax,Rd}} \leq 1,0$	ETA-11/0030
2	Lateral performance of screws or threaded rods [2)]	$\frac{F_{lat,Ed}}{F_{lat,Rd}} \leq 1,0$	ETA-11/0030
3	Combined performance of screws or threaded rods	$\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{lat,Ed}}{F_{lat,Rd}}\right)^2 \leq 1,0$	ETA-11/0030
4	Design of the lap length	$l_0 \geq l_{0,\min}$	Annex C
5	Axial performance of screws or threaded rods in concrete [3)]	$\frac{F_{ax,Ed}}{F_{ax,Rd}} \leq 1,0$	EN 1992-1-1:2015
6	Lateral performance of screws or threaded rods in concrete [3)]	$\frac{F_{lat,Ed}}{F_{lat,Rd}} \leq 1,0$	EN 1992-1-1:2015
7	Combined performance of screws or threaded rods in concrete [3)]	$\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{lat,Ed}}{F_{lat,Rd}}\right)^2 \leq 1,0$	EN 1992-1-1:2015

[1)] The calculation of the withdrawal strength shall be carried out in accordance with ETA-11/0030. The design moment $m_{x,d,s}$ to determine axial force per fastener ($F_{ax,Ed}$) should be increased by $m_{yx,d}$ acc. to Figure E2.1. Group effects must not be considered so $n_{ef}=n$.

[2)] The specifications of ETA-11/0030 must be followed for the determination of the lateral capacity. The calculation may be carried out using the European yield model according to Eurocode 5 for single shear connections with thick steel plates. If the minimum spacings of ETA-11/0030 to the loaded edge ($a_{4,t}$) are not fulfilled (see Annex E8), the load bearing capacity ($F_{v,Rd}$) must be reduced by the ratio of the spacing to the edge (a_4) and the minimum spacing acc. ETA-11/0030 ($a_{4,t}$).

$$F_{lat,z,\sup,Rd} = F_{v,\sup,Rd} \cdot \frac{a_{4,\sup}}{a_{4,t}}; \quad F_{lat,z,\inf,Rd} = F_{v,\inf,Rd} \cdot \frac{a_{4,\inf}}{a_{4,t}} \qquad (4)$$

[3)] Verifications 5 to 7 are not required if the design criteria according to Annex E8 are fulfilled.

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

CLT edge joint connection (bending rigid connection)

<u>Design Concept</u>

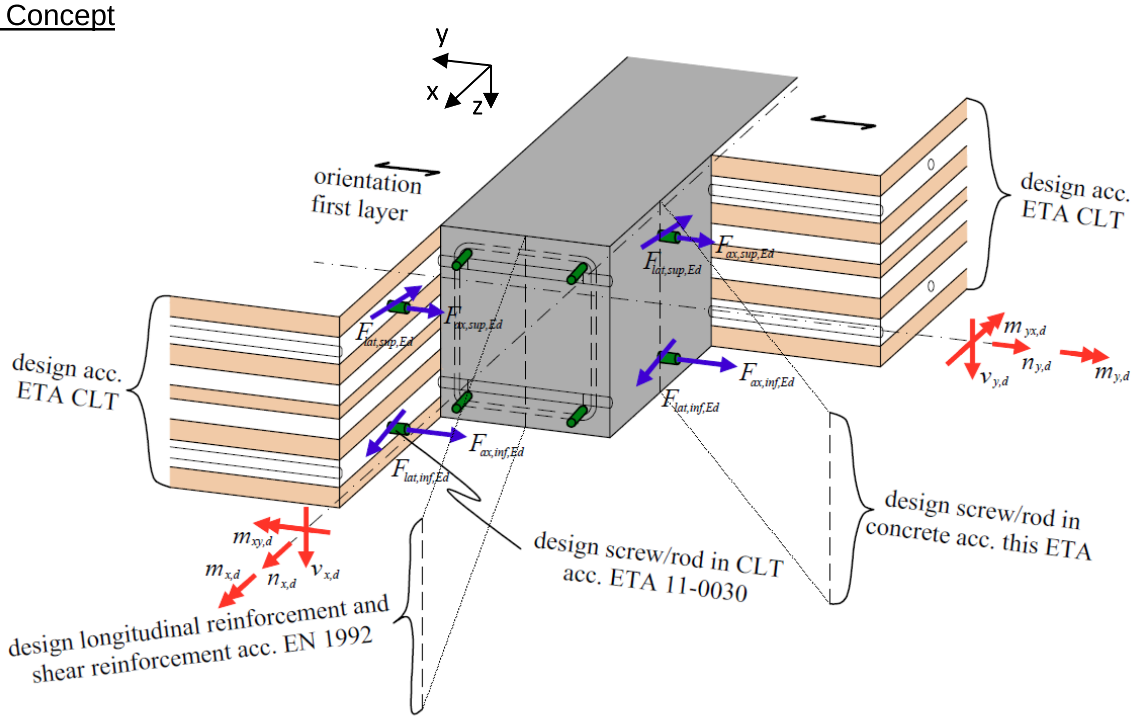


Figure E2.1: CLT panel to panel connection, design concept

A detailed list of verifications to carry out for this connection can be found in Annex E3.

The design of the concrete curb (e.g. longitudinal reinforcement, stirups) should be carried out according to the specifications of EN 1992 and the national regulations. No further information is given in this Annex.

The design of the timber elements should be carried out according to EN 1995 or according to the ETA of the products used.

The verifications for the connection shown in Figure E1.1 are given in Annex E3. For determining the load on the fasteners, due to the internal forces shown, the procedure according Annex E4 to E7 can be used. Alternative methods for the calculation of the forces based on numerical models are also applicable.

Approaches to determine the stiffness of this connection are given in Annex E9 to E10.

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

CLT edge connection (bending rigid panel joint)

Symbols for main geometric parameters

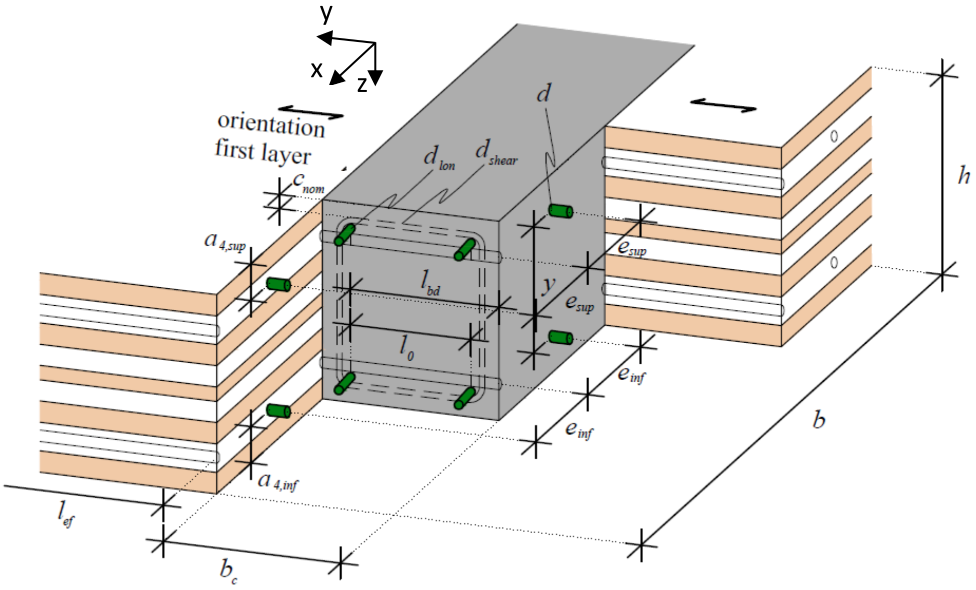


Figure E3.1 CLT panel to panel connection, symbols for main geometric parameters

Where

b	Width of the connection [mm]
b_c	Width of the concrete curb [mm]
c_{nom}	Nominal concrete cover acc. EN 1992-1-1 [mm]
d	Nominal diameter of screw or threaded rod [mm]
d_{lon}	Nominal diameter of longitudinal reinforcement [mm]
d_{shear}	Nominal diameter of shear reinforcement (stirrup) [mm]
$e_{inf/sup}$	Distance of screws or threaded rod [mm]
h	Height of the CLT Panels [mm]
l_0	Lap length of screw or threaded rod [mm]
l_{bd}	Anchorage length of screws or threaded rod [mm]
l_{ef}	Penetration length of screw or threaded rod in CLT [mm]
y	Distance between upper and lower row of screws or threaded rods [mm]

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Edge connection (bending rigid panel joint)
Materials: CLT, ST, GLT and LVL

Calculation of the inner lever arm (compression only in first longitudinal layer)

The given equations are only valid for mainly bending loads and at least a partially compressed cross-section. The given equations can be used for connections with a contact area between end grain of the timber parts and the concrete with Solid Timber (ST), Glued laminated timber (GLT) and also Laminated veneer lumber (LVL). If the cross-section is fully in tension, the forces must be carried by the fasteners only.

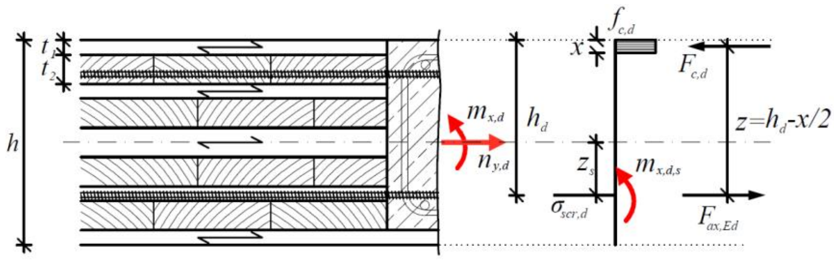


Figure E4.1: CLT panel to panel connection, calculation of the inner lever arm

$$m_{x,d,s} = m_{x,d} + n_{y,d} \cdot z_s$$

$$x = h_d - \sqrt{\frac{f_{c,d} \cdot h_d^2 - 2 \cdot m_{x,d,s}}{f_{c,d}}} \qquad (5)$$

$$z = h_d - x/2$$

Where

$f_{c,d}$	Minimum of design values of concrete compressive strength and compressive strength parallel to grain of the CLT panel [N/mm²]
h_d	Distance between the upper compressed longitudinal fibre and the centre of gravity of the pulled row of fasteners [mm]
$m_{x,d}$	Design bending moment [Nmm/mm]
$m_{x,d,s}$	Design bending moment referred to the axis of the pulled row of fasteners [Nmm/mm]
$n_{y,d}$	Design normal force [N/mm]
x	Height of the compression zone [mm]
z	Inner lever arm [mm]
z_s	Distance between the centre of gravity of the CLT panel and the pulled row of fasteners [mm]

If x is greater than the thickness of the first compressed longitudinal layer, the equations given in Annex E5 shall be used.

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Edge joint connection (bending rigid panel joint)
Material: CLT

Calculation of the inner lever arm (compression out of the first longitudinal layer)

The given equations are only valid for mainly bending loads and at least a partially compressed cross-section. If the cross-section is fully in tension, the forces must be carried by the fasteners only.

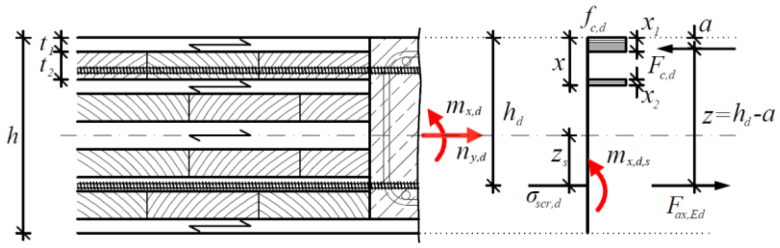


Figure E5.1: CLT panel to panel connection, calculation of the inner lever arm

$$m_{x,d,s} = m_{x,d} + n_{y,d} \cdot z_s$$
$$x = h_d - \sqrt{t_2^2 + 2 \cdot t_1 \cdot t_2 - 2 \cdot h_d \cdot t_2 + h_d^2 - \frac{2 \cdot m_{x,d,s}}{f_{c,d}}}$$
$$x_1 = t_1 \qquad (6)$$
$$x_2 = x - x_1 - t_2$$
$$a = \frac{1}{2} \cdot \frac{x_2^2 + 2 \cdot x_2 \cdot (t_2 + x_1) + x_1^2}{x_1 + x_2}$$
$$z = h_d - a$$

Where

t_1	Thickness of the first layer
t_2	Thickness of the second layer
$f_{c,d}$	Minimum of design values of concrete compressive strength and compressive strength parallel to grain of the CLT panel [N/mm²]
h_d	Distance between the upper compressed longitudinal fibre and the centre of gravity of the row of fasteners under tension [mm]
$m_{x,d}$	Design bending moment [Nmm/mm]
$m_{x,d,s}$	Design bending moment referred to the axis of the pulled row of fasteners [Nmm/mm]
$n_{y,d}$	Design normal force [N/mm]
x	Height of the compression zone [mm]
z	Inner lever arm [mm]
z_s	Distance between the centre of gravity of the CLT panel and the row of fasteners under tension [mm]

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Edge joint connection
Materials: CLT, ST, GLT and LVL

Calculation of the force per fastener in axial direction

The axial tension force in a row of fasteners with a spacing *e* may be calculated from the bending moment and the normal force perpendicular to the connection to:

$$F_{ax,Ed} = \left(\frac{m_{x,d}}{z} + n_{y,d} \right) \cdot e \qquad (7)$$

Where

$F_{ax,Ed}$	Design value of the axial tension forces onto the screw [N]
$m_{x,d}$	Design bending moment perpendicular to the connection [Nmm/mm]
$n_{y,d}$	Design normal force perpendicular to the connection [N/mm]
e	Distance between the fasteners in a row [mm]
z	Inner lever arm [mm]

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Edge joint connection (bending rigid panel joint)
Materials: CLT, ST, GLT and LVL

Calculation of the force per fastener in lateral direction

The formulas given below apply to connections with two rows of fasteners. Whereby the load is distributed in equal parts to each fastener. It is also possible to transfer the lateral forces only with one row of fasteners. *Note: The self-weight of the concrete element must also be considered.*

The lateral load of a screw in the x-direction of the connection is given by:

$$F_{lat,\sup,x,Ed} = \left(\frac{|m_{xy,d}|}{y} + \frac{n_{\sup}}{n} \cdot |n_{x,d}| \right) \cdot e_{\sup} \tag{8}$$

$$F_{lat,\inf,x,Ed} = \left(\frac{|m_{xy,d}|}{y} + \frac{n_{\inf}}{n} \cdot |n_{x,d}| \right) \cdot e_{\inf} \tag{9}$$

The lateral load of a screw perpendicular to the panel plane (z-direction) is given by:

$$F_{lat,\sup,z,Ed} = \frac{n_{\sup}}{n} \cdot v_{y,d} \cdot e_{\sup} \tag{10}$$

$$F_{lat,\inf,z,Ed} = \frac{n_{\inf}}{n} \cdot v_{y,d} \cdot e_{\inf} \tag{11}$$

The total lateral load of a fastener is then given by:

$$F_{lat,\sup,Ed} = \sqrt{F_{lat,\sup,x,Ed}{}^2 + F_{lat,\sup,z,Ed}{}^2} \tag{12}$$

$$F_{lat,\inf,Ed} = \sqrt{F_{lat,\inf,x,Ed}{}^2 + F_{lat,\inf,z,Ed}{}^2} \tag{13}$$

Where

$F_{\mathrm{lat,Ed}}$	Design value of the total lateral forces onto the screw in z direction [N]
$F_{\mathrm{lat,x,Ed}}$	Design value of the lateral forces onto the screw in x direction [N]
$F_{\mathrm{lat,z,Ed}}$	Design value of the lateral forces onto the screw in z direction [N]
$m_{\mathrm{x,d}}$	Design bending moment parallel to the connection [Nmm/mm]
$n_{\mathrm{x,d}}$	Design normal force parallel to the connection [N/mm]
$v_{\mathrm{x,d}}$	Design shear load perpendicular to the connection, x-direction [N/mm]
$v_{\mathrm{y,d}}$	Design shear load perpendicular to the connection, y-direction [N/mm]
e_{sup}	Distance between fasteners (upper row) [mm]
e_{inf}	Distance between fasteners (lower row) [mm]
n	Number of fasteners per running meter [-]
n_{sup}	Number of fasteners per running meter (upper row) [-]
n_{inf}	Number of fasteners per running meter (lower row) [-]
y	Distance between upper and lower row of fasteners [mm]

It is also possible to assign the transversal and normal force to only one row of screws.

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Edge joint connection
Materials: CLT, ST, GLT and LVL

Construction requirements for the connection

- For the minimum concrete cover c_{nom} and minimum reinforcement the specifications of Eurocode EN 1992-1-1 must be used.

- In addition the following rules must be observed regarding the concrete element:
    - Longitudinal reinforcement (minimum diameter 8 mm) in each corner of the stirrup
    - Shear reinforcement (stirrups with minimum diameter 6 mm)
    - The screws/threaded rods must be arranged always on the inside of the stirrups

- For the fasteners in the timber, principally the rules of the ETA must be used. The following further points must be observed for this connection:
    - The minimum penetration length ($l_{ef,\min}$) of the fasteners in the timber should be

$$l_{ef,\min} = 2,3 \cdot \sqrt{\frac{M_{y,Rk}}{f_{h,k} \cdot d}} \qquad (14)$$

Where

d	Nominal diameter of the fastener [mm]
$f_{h,k}$	Embedment strength in the timber part of the connection [N/mm²] see ETA-11/0030
$l_{ef,min}$	Minimum penetration length of fastener in the timber part [mm]
$M_{,y,Rk}$	Characteristic yield moment of the fastener [Nmm]

    - Minimum spacings according to ETA-11/0030 should generally be respected. The spacing to the loaded edge ($a_{4,t}$) may be reduced in order the concrete cover complies with Eurocode 2 and the fasteners are enclosed by the stirrups and the longitudinal reinforcement. In this case, special care must be taken to ensure that the screws are inserted straight.

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Edge joint connection (bending rigid panel joint)
Materials: CLT, ST, GLT and LVL

Determination of the mechanical stiffness (slip modulus)

- Lateral Stiffness k_{ser}

  The lateral stiffness for the connection should be calculated according to equation (15).

$$k_{ser} = 2 \cdot n \cdot 60 \cdot (0,7 \cdot d)^{1,7} \quad (15)$$

Where

k_{ser}	Lateral stiffness of connection per running meter [N/mm/m]
n	Number of fasteners per running meter [-]
d	Diameter of the fastener [mm]

- Rotational stiffness k_{φ}

  The rotational stiffness is determined by applying a reference moment load (m_{ref}). This load is converted into a couple of forces (f_{ref}) with an inner lever arm (z_{SLS}). The deformations of two springs (timber under compression $u_{c,ref}$, fastener in tension $u_{t,ref}$) are determined and a rotation (φ_{ref}) is calculated from them. The rotation (φ_{ref}) and the reference moment (m_{ref}) are then used to determine the spring stiffness (k_{φ}).

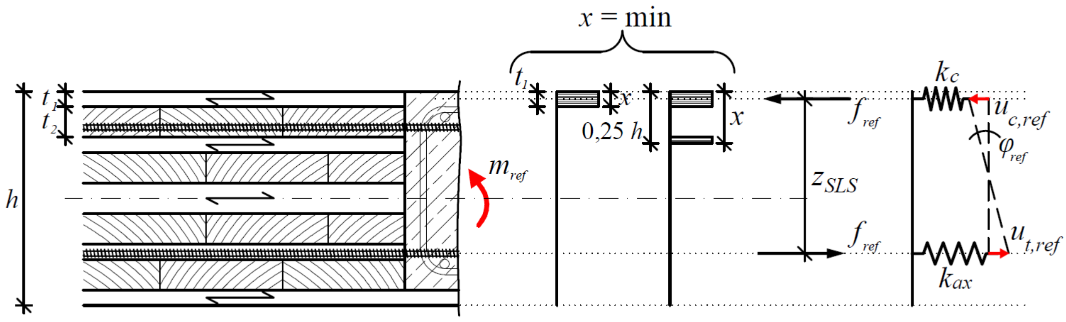


Figure E9.1: CLT panel to panel connection, determining the rotational stiffness k_{φ}

Design of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

1. Calculation of the compression zone x_{SLS} as minimum of the thickness of first compressed longitudinal layer or the thickness of all longitudinal layer parts within 25 % of the outer, compressed cross section. The given equations can be used for connections with a contact area between end grain of the timber parts and the concrete with Solid Timber (ST), Glued laminated timber (GLT) and also Laminated veneer lumber (LVL)
2. With the inner lever arm (z_{SLS} acc. Figure E9.1) the reference couple of forces is given by:

$$f_{ref} = \frac{m_{ref}}{z_{SLS}} \tag{16}$$

3. The deformation of the compression zone results in:

$$u_{c,ref} = \frac{f_{ref}}{k_c} \tag{17}$$

with

$$k_c = \frac{E_{0,lay,mean} \cdot b_{ref}}{4} \tag{18}$$

4. The deformation of the fasteners is given by:

$$u_{t,ref} = \frac{f_{ref}}{K_{ax} \cdot n_{ref}} \tag{19}$$

with

$$K_{ax} = 25 \cdot d \cdot l_{ef} \tag{20}$$

and l_{ef} has to be limited by $20 \cdot d$ for SLS (model)

5. The rotation is given by:

$$\varphi_{ref} = \tan^{-1}\left(\frac{|u_{c,ref}| + |u_{t,ref}|}{z_{SLS}}\right) \tag{21}$$

6. The total rotational mechanical stiffness results in:

$$k_{\varphi} = \frac{m_{ref}}{2 \cdot \varphi_{ref}} \tag{22}$$

Where

b_{ref}	Reference width of connection 1 m [mm]
d	Diameter of fastener [mm]
$E_{0,lay,mean}$	Modulus of elasticity CLT panel parallel to grain [N/mm²]
f_{ref}	Reference force from moment load per running meter [N/m]
K_{ax}	Axial slip modulus of the fastener [N/mm]
k_c	Spring stiffness in the compression zone [N/mm]
l_{ef}	Penetration length of the threaded part of the fastener [mm]
n_{inf}	Number of fasteners in tension zone per running meter [-]
m_{ref}	Reference moment load per running meter [N mm/m]
$u_{c,ref}$	Deformation of spring in compression zone [mm]
$u_{t,ref}$	Deformation of spring in tension zone [mm]
x_{SLS}	Height of compression zone [mm]
z_{SLS}	Inner lever arm acc. Figure E9.1 [mm]
φ_{ref}	Rotation acc. reference load [rad]

Application of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Construction method for bending stiff edge joint connections (transfer m_d, v_d, n_d) of CLT-panels

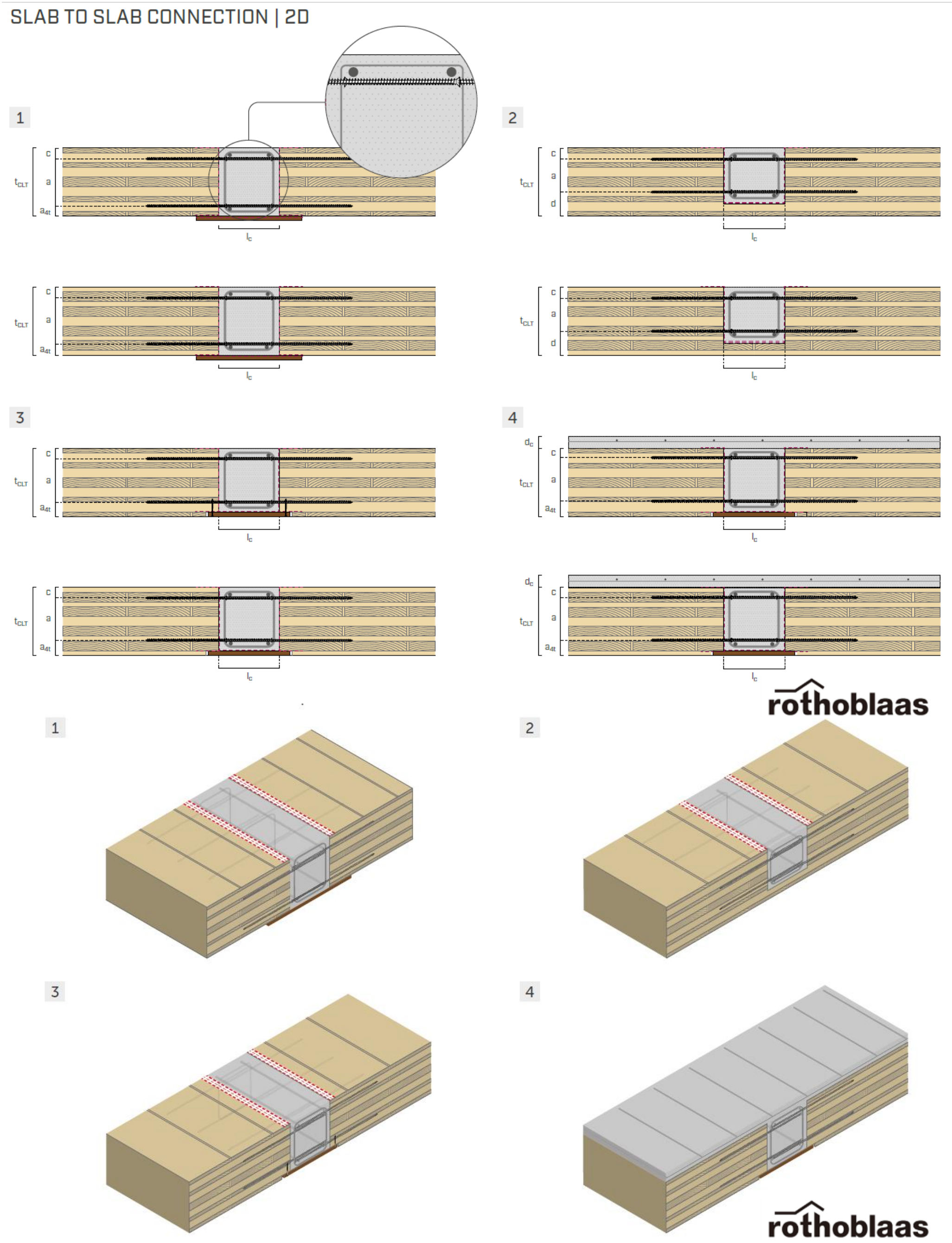


Figure F1.1: CLT edge connection, different construction methods (copyright Rothoblaas)

Application of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Construction method for wall to basement connections to transfer n_d and v_d (hinge connection)

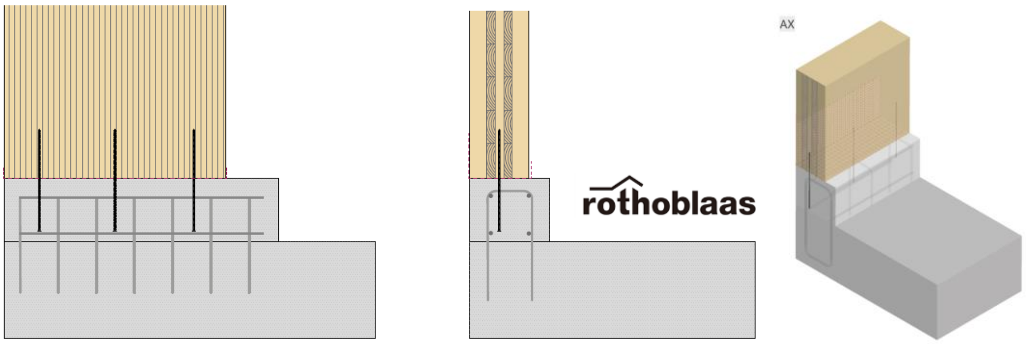


Figure F2.1: CLT wall to basement connection (copyright Rothoblaas)

Construction method for slab to concrete core connections to transfer v_d and n_d - installation steps

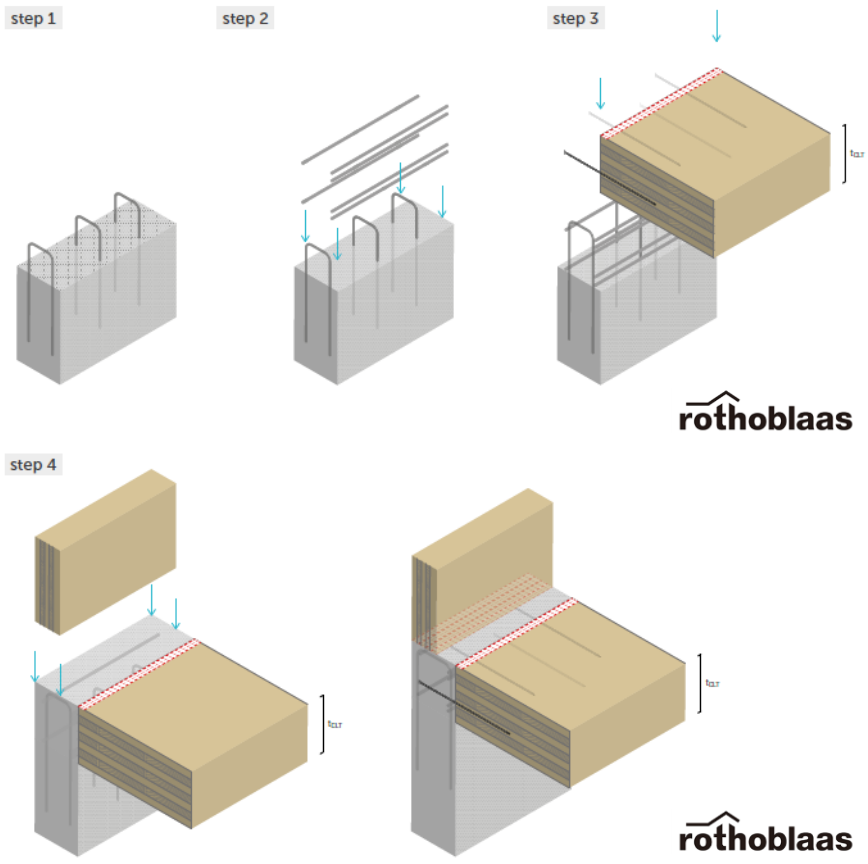


Figure F2.2: CLT slab to wall connection (copyright Rothoblaas)

Application of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Construction method for slab to core connections to transfer mainly m_d, v_d and n_d

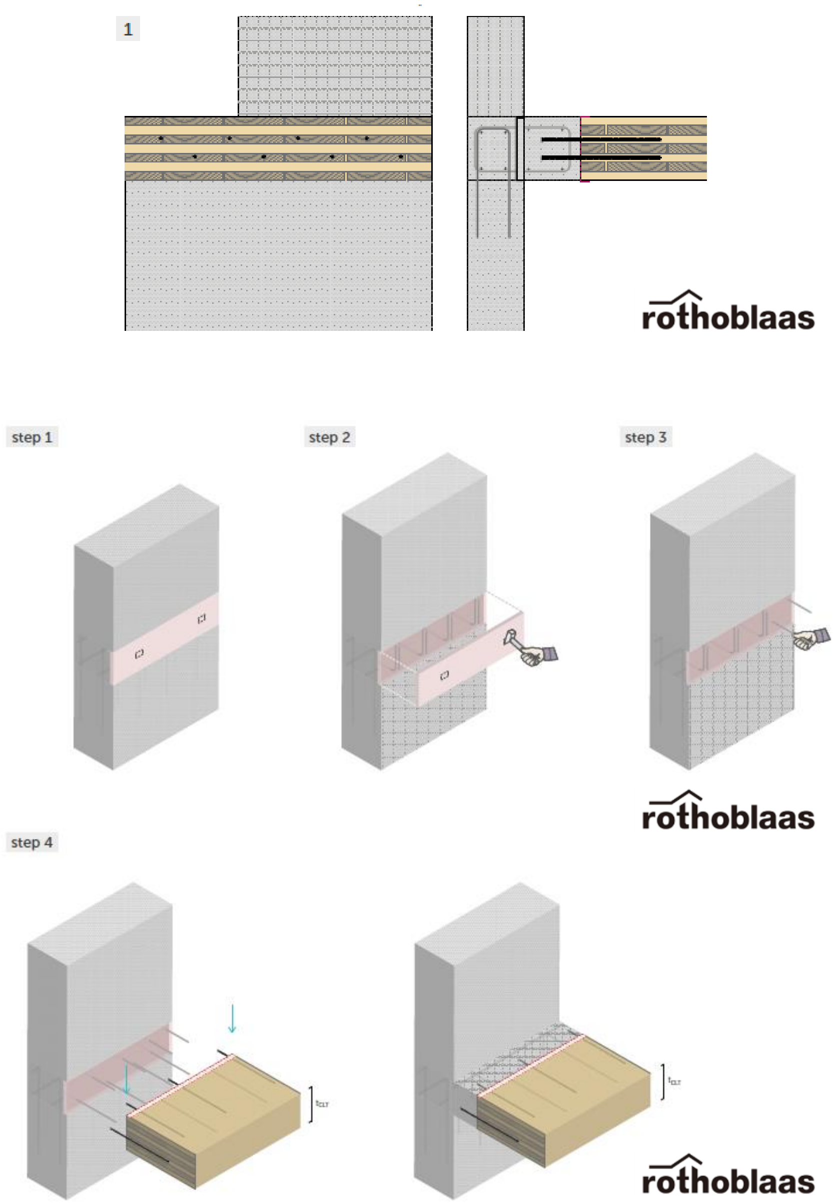


Figure F3.1: CLT slab to concrete wall connection and steps of installation (copyright Rothoblaas)

Rotho Blaas TIMBER CONCRETE FUSION (TC FUSION)	F3 (informative)
Applications and installations	

Application of Rotho Blaas VGS, VGZ screws and Rotho Blaas RTR threaded rods for the structural use in timber-concrete composite connections

Construction method for wall to wall connections to tansfer mainly v_d (hinge connection)

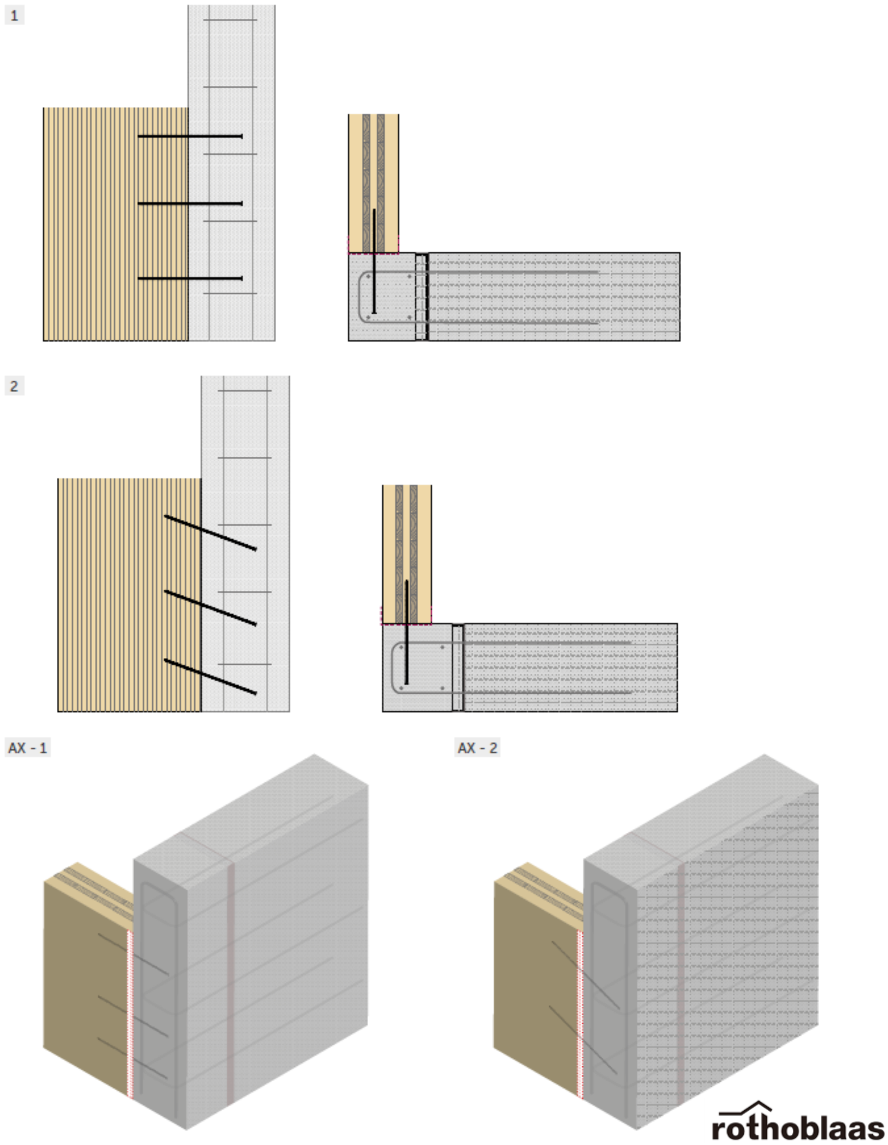


Figure F4.1: CLT wall to Concrete wall connection (copyright Rothoblaas)