TECHNICAL MANUAL

ROOCO® Column Shoe

Reliable Bolted Column Connections

Version PEIKKO GROUP 06/2024

ROOCO® Column Shoe

Reliable Bolted Column Connections

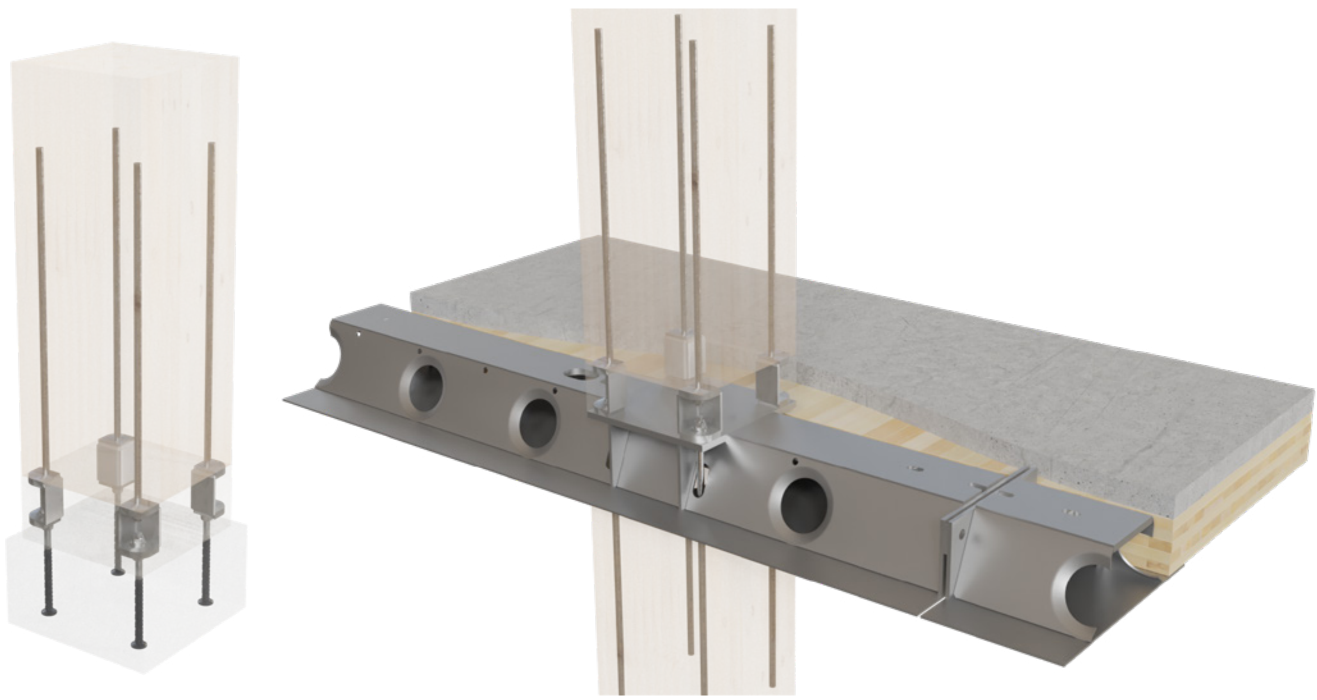
- Moment-resisting timber column connection in the erection and final stage
- Quick and easy erection of columns with minimal crane time
- No bracing during the erection stage
- Vertical and horizontal tolerance adjustment
- Standardized connection with precalculated resistances

ROOCO® Column Shoes are construction products that create cost-effective and moment-resisting connections between timber columns and foundations or between timber columns.

The column connection is made using column shoes and glued-in rods. Rods are glued inside a timber column bottom, and column shoes are attached to the bars with nuts. At the top of the timber column, rods are glued inside to facilitate a connection with another column. For connection with the foundation, anchor bolts are cast into the foundation.

On the construction site, the columns are erected onto anchor bolts or glue-in rods and adjusted to the correct position. Fixing is achieved by tightening nuts on the anchor bolts or glue-in rods. The joint between the column and the supporting structure can be grouted for a full load capacity of timber column connection or made as a dry connection.

The ROOCO® Column Shoe is designed according to Eurocodes or relevant local regulations as a steel part attached to the column.



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About ROOCO® Column Shoe

1. Product properties

ROOCO® Column Shoes are available in four standard models to suit different types of timber column connections. The Peikko column connection system, using ROOCO®, consists of the following:

- ROOCO® Column shoes
- Special washers
- Threaded bars with nuts

ROOCO® Column Shoes are used with HPM® Rebar Anchor Bolts to make moment-resisting timber column connections with a foundation. ROOCO® Column Shoes are used with glued-in rods when connecting timber columns.

The column shoe has a round hole that fits with the corresponding HPM® Rebar Anchor Bolts or threaded bars. The column connection is achieved by fastening the column shoes to anchor bolts using nuts and washers. The bolted connection offers assembly tolerances to adjust the column to the correct vertical and horizontal position. The horizontal tolerance for ROOCO® Column Shoe giving ±6mm tolerance in the erection stage.

Based on the arrangement of the nuts and washer used with columns shoe, two different joints can be created.

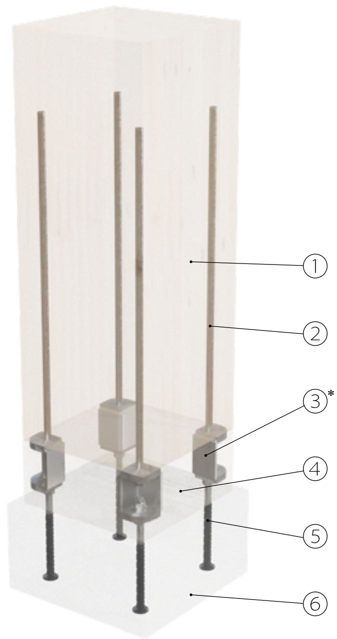


Figure 1. ROOCO® Column Shoe and HPM® Rebar Anchor Bolts in a column-to-foundation connection.

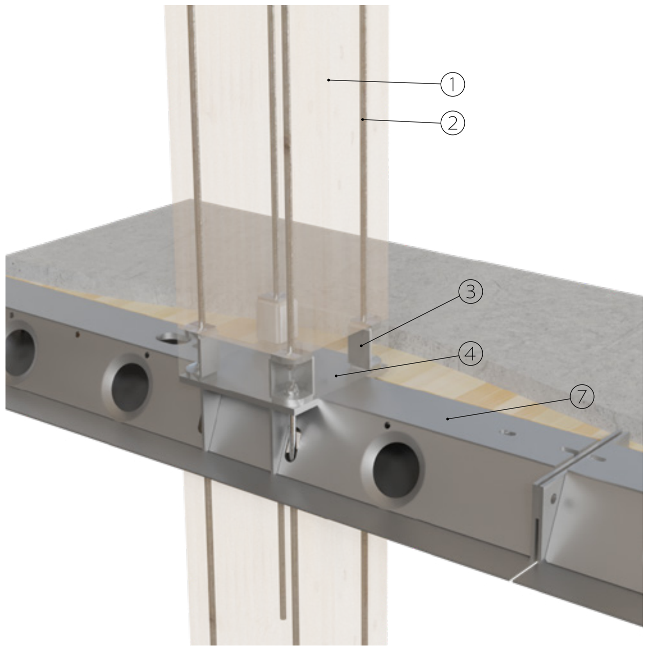


Figure 2. ROOCO® Column Shoe and threaded bars in a column-beam-column connection.

Legend:
① – Timber column
② – Glued-in rod
③ – ROOCO® Column shoe (* with vertical adjustment option)
④ – Grouting
⑤ – HPM® Rebar Anchor Bolt
⑥ – Concrete foundation
⑦ – DELTABEAM® Composite Beam

Vertically adjustable connection is mainly intended with connection to foundation (*Figure 1*), but can also be used with column-beam-column connections (*Figure 25*, Annex B). Arrangement of the two bottom nuts at column shoe allows vertical tolerances at the anchor bolts. The joint between the column and the foundation is grouted with non-shrinkable grouting mortar to finalize the connection.

The vertically non-adjustable option is mainly intended for column-beam-column connections (*Figure 2*). ROOCO® Column Shoes can also be used in a dry connection (*Figure 26*, Annex B). In such cases, the connecting surfaces shall be flat and parallel, and the responsible structural engineer shall evaluate suitability for such connection.

ROOCO® Column Shoes are available in various standard models that are suitable for different applications.

a) ROOCO® XX-1 Column Shoe with one special washer
b) ROOCO® XX-2 Column Shoe with two special washers
c) ROOCO® XX-3 Column Shoe with three special washers

Table 1. ROOCO® Column Shoe standard models.

a) ROOCO® XX-1 used with HPM® Rebar Anchor Bolts where two special washers and nuts are part of HPM® Rebar Anchor Bolt assembly.	**b) ROOCO® XX-2 used in connection with columns or beams without a height adjustment option.**	**c) ROOCO® XX-3 used in connection with columns or beams with height adjustment option.**
Note: XX → M thread size of anchor and glued-in rod.		

ROOCO® Column Shoe in connections with concrete foundations needs one threaded bar with nut and one HPM® Rebar Anchor Bolt per column shoe.

Peikko can supply threaded bars and nuts for timber parts as part of delivery.

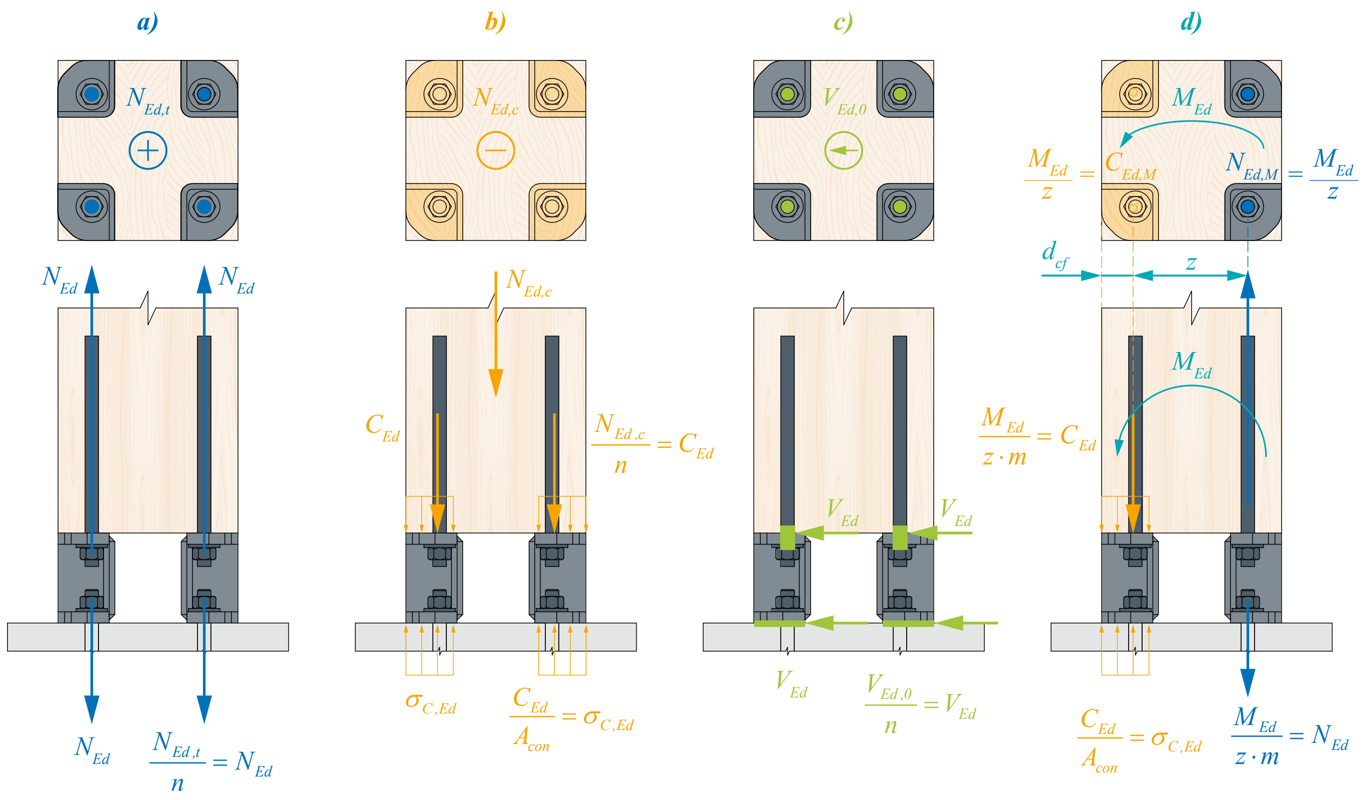
ROOCO® Column Shoe connection is designed to resist axial forces, bending moments, shear forces, and interactions of these forces. It is possible to use four or more column shoes in one column cross-section depending on the dimensions of the columns and the magnitude of forces to be transmitted.

Figure 3. Arrangement of ROOCO® Column Shoes in different column cross-sections.

1.1 Structural behavior

ROOCO® Column Shoes are designed to transfer axial forces and shear forces, and a column connection composed of several ROOCO® Column Shoes can transfer bending moments as well.

During the erection stage (or dry installation) – tension and shear forces from the timber column are transferred through glued-in rods into the top plates of ROOCO® Column Shoes and then into the base construction via bottom plates and anchor bolts. Compression forces are transferred only by ROOCO® Column Shoes' top plate's contact area with timber.



a) *Tension force is transferred only through glued-in rods and HPM® rebar anchor bolts.*

b) *Compression force is transferred only through the ROOCO® Column Shoe top and bottom plate contact area.*

c) *Shear force is transferred through glued-in rods and HPM® rebar anchor bolts on both sides (top and bottom) of the ROOCO® Column Shoe.*

d) *The bending moment is transferred by a combination of tensioned glued-in rods and compressed areas above the top plates of ROOCO® Column Shoes.*

Options a – d shall be combined in case of interaction of forces.

$N_{Ed,t}$ – *Design tension force in the column.*

$N_{Ed,c}$ – *Design compression force in the column.*

$V_{Ed,0}$ – *Design shear force in the column.*

M_{Ed} – *Design bending moment in the column.*

N_{Ed} – *Design tension force acting on one ROOCO® Column Shoe, glued-in rod and HPM® rebar anchor bolt.*

C_{Ed} – *Design compression force acting on one ROOCO® Column Shoe and HPM® rebar anchor bolt.*

V_{Ed} – *Design shear force acting on one ROOCO® Column Shoe, glued-in rod and HPM® rebar anchor bolt.*

$\sigma_{C,Ed}$ – *Stress on ROOCO® Column Shoe top and bottom plate resulting from design compression force* C_{Ed}.

$C_{Ed,M}$ – *Design compression force in connection resulting from bending moment.*

$N_{Ed,M}$ – *Design tension force in connection resulting from bending moment.*

z – *The arm of tension a compression forces resulting from bending moment in the connection.*

d_{cf} – *Distance from the edge of the top plate of ROOCO® Column Shoe to its center of gravity. Values for each type of ROOCO® Column Shoe are defined in Table 8.*

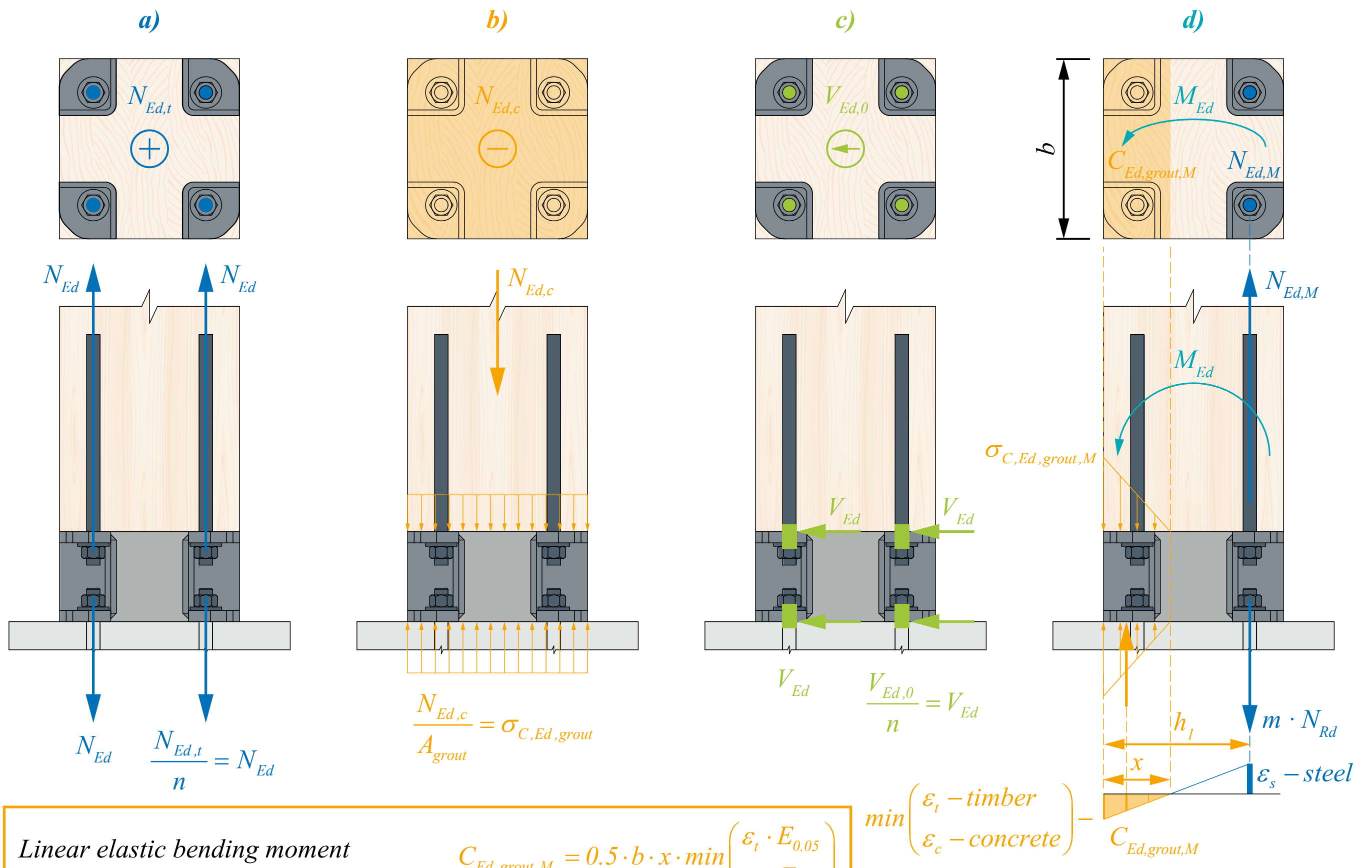
A_{con} – *Contact area of the top or bottom plates of ROOCO® Column Shoe. Values for each type of ROOCO® Column Shoe are defined in Table 7.*

n – *Number of ROOCO® Column Shoes used in the whole connection of timber column.*

m – *Number on ROOCO® Column Shoes in tension.*

Figure 4. Load transfer scheme of the connection of timber columns and ROOCO® Column Shoes without grouting in erection stage.

In the final stage (when grouting is installed between the bottom part of the column and the foundation or beam), the transfer of tension and shear forces is the same as during the erection stage or dry installation. Compression forces are transferred through ROOCO® Column Shoe top and bottom plate contact areas and the contact area between the timber column and grouting.



Linear elastic bending moment resistance of fully grouted timber column connection with four ROOCO® Column Shoes and glued-in rods:

$$C_{Ed,grout,M} = 0.5 \cdot b \cdot x \cdot min\begin{pmatrix} \varepsilon_t \cdot E_{0.05} \\ \varepsilon_c \cdot E_c \end{pmatrix}$$

$$M_{el,Rd,tc} = m.N_{Rd} \cdot h_1 = C_{Ed,grout,M} \cdot \frac{x}{3}$$

a) *Tension force is transferred only through glued-in rods and HPM® rebar anchor bolts.*
b) *Compression force is transferred through the timber column contact area with the grout and ROOCO® Column Shoe beneath.*
c) *Shear force is transferred through glued-in rods and HPM® rebar anchor bolts on both sides (top and bottom) of the ROOCO® Column Shoe.*
d) *The bending moment is transferred by a combination of tended glued-in rods and compressed areas above the top plates of ROOCO® Column Shoes and grouting under timber column.*

Options a – d shall be combined in case of interaction of forces.

$C_{Ed,grout,M}$ – *Design compression force resulting from bending moment in the column, acting on one third of dimension 'x' from the edge of the column.*

$\sigma_{C,Ed,grout}$ – *Stress on timber column area Agrout, resulting from design compression force $N_{Ed,c}$.*

$\sigma_{C,Ed,grout,M}$ – *Stress on timber column compressed area, resulting from design bending moment M_{Ed}.*

b – *Width of the column (dimension perpendicular to direction of bending moment).*

x – *Width of compressed area from compression force resulting from bending moment in the column.*

h_1 – *Distance of glued-in rods in tension from the of the column on the compressed side.*

A_{grout} – *Contact area of timber column and the grouting (including top plates of ROOCO® Column Shoes).*

m – *Number of ROOCO® Column Shoes used in one row perpendicular to bending moment direction.*

Figure 5. Load transfer scheme of the connection of timber columns and ROOCO® Column Shoes with grouting in final stage.

If the shear capacity of glued-in rod is insufficient due to reduction of the embedment strength perpendicular to grains to 10 %, the engrain of the bottom part of the column must be reinforced. The reinforcement may be provided e.g. by screws or glued-on plywood panel. Precalculated single shear resistances of glued-in rods and resistances of interaction of forces defined in Annex A of this Technical manual, are determined according to calculation procedure for glued-in rods reinforced with glued-on plywood panel of particular thickness.

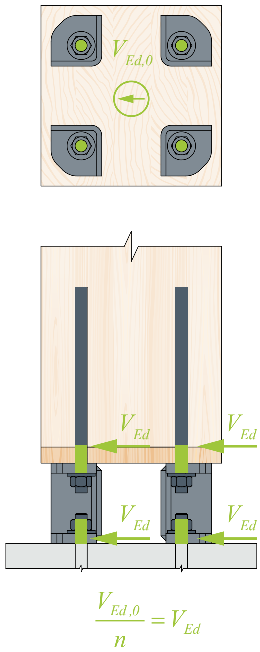


Figure 6. Shear transfer schema of connection of timber column with plywood panel and ROOCO® Column Shoe.

Design of glued-in rod joint with an end-grain reinforcement (glued-on plywood panel), is made according to "*RIGID GLULAM JOINTS TO CONCRETE ABUTMENTS WITH GLUED-IN STEEL RODS*" by Kai Simon, Simon Aicher.

For design of glued-in rod joint with end-grain reinforcement the following conditions of the lateral force resistance have to be satisfied:

$$F_{lat,Ek} \leq F_{lat,Rk} = min \begin{cases} F_{lat,reinf,Rk} \\ F_{lat,bond,Rk} \\ F_{lat,panel,t,Rk} \end{cases}$$

$F_{lat,Rk}$ = Lateral force resistance.
$F_{lat,reinf,Rk}$ = End-grain reinforcement resistance.
$F_{lat,bondRk}$ = Characteristic lateral capacity of bonded GLT-panel interface.
$F_{lat,panel,t,Rk}$ = Tension capacity of the panel net cross-section in direction of the shear force.

$$F_{lat,reinf,Rk} = \left[\left(\sqrt{\left(\frac{2 \cdot M_{y,Rk}}{f_{h1,k} \cdot d} \right) - t_p^{\,2} \cdot \left(\frac{f_{h2,k}}{f_{h1,k}} - 1 \right)} - t_p \right) \cdot f_{h1,k} + t_p \cdot f_{h2,k} \right] \cdot d$$

$M_{y,Rk}$ = Characteristic yield moment of the rod.

$$M_{y,Rk} = 0.3 \cdot f_{u,k} \cdot d_e^{\,2.6}$$

$f_{u,k}$ = Characteristic tensile strength of steel rod. $f_{u,k} = 800\ N/mm^2$ for 8.8 anchor bolt.
d_e = Equivalent tensile stress diameter for rods with metric thread.
$f_{h1,k}$ = Embedment strength of timber (rod parallel to grain and loaded laterally). Value calculated as 10 % of embedment strength according to EN 1995-1-1.

$$f_{h1,k} = 0.1 \cdot \frac{0.082 \cdot (1 - 0.01 \cdot d_{drill}) \cdot \rho_k}{k_{mat}}$$

d_{drill} = Drill diameter of the hole in the timber part.
ρ_k = Characteristic timber density. ρ_k = 385 kg/m^3 for GL24h, according to EN 14080.
k_{mat} = $k_{mat} = k_{90} \cdot sin^2\ \alpha + cos^2\ \alpha$.
α = Angle of the load to grain (α =90°).
k_{90} = $k_{90} = 1.35 + 0.015 \cdot d$ for softwood, according to EN 1995-1-1 eq. (8.33).
$f_{h2,k}$ = Embedment strength of the plywood panel.

$$f_{h2,k} = 0.11 \cdot (1 - 0.01 \cdot d_{drill}) \cdot \rho_{k,ply}$$

ρ_{kply} = Characteristic plywood density. According to used plywood technical manual.
d = Steel rod diameter.
t_p = Thickness of the plywood panel.

$$F_{lat,bond,Rk} = h_{b,eff} \cdot w_{b,eff} \cdot f_{v,b,end-grain,k}$$

$h_{b,eff}$ = Effective shearing length $h_{b,eff} = 2 \cdot a_{4,t}$.
$a_{4,t}$ = Distance to loaded edge.
$w_{b,eff}$ = Width of the effective bond area. $w_{b,eff} = 5 \cdot d_{rod}$. Which is the minimum spacing between rods.
$f_{v,b,end\text{-}grain,k}$ = Characteristic bond line shear strength of GLT vs. plywood panel, $f_{v,b,end\text{-}grain,k} = 3.5\ N/mm^2$.

$$F_{lat,panel,Rk} = t_p \cdot (w_{b,eff} - d_{drill}) \cdot f_{t,plate,k}$$

$f_{t,plate,k}$ = Characteristic tensile capacity of the plywood panel. According to used plywood technical manual.

It is possible to use only plywood panels with sanded or unsanded surfaces without any surface treatment. Plywood elements with e.g. laminated surface are not suitable for application in glued connection.

1.1.1 Temporary conditions

Temporary conditions differ depending on the chosen connection type (with or without grouting on site) and needed tolerances (with or without vertical adjustment).

In connection with vertical adjustment (*Figure 7* – a) at the erection stage, the forces acting on column shoes are caused principally by the self-weight of the column and the bending moment and shear force mainly due to wind loads. Since the joint between the column and the base structure is not grouted, all the forces from the column shoes are carried solely by the anchor bolts. The bolts must be designed for buckling and bending. If the bolt size is insufficient for the load, the size or number of bolts and ROOCO® Column Shoes shall be increased. The open joint underneath the column must be grouted using non-shrink grout with adequate strength, and the grout must harden before the column is loaded by other structures.

For connection without vertical adjustment and with grouting on site (*Figure 7* – b), since the joint between the column and the base structure is not grouted, all forces are carried solely by the column shoes in the erection stage. The open joint underneath the column must be grouted using non-shrink grout with adequate strength, and the grout must harden before the column is loaded by higher loads.

Dry connection with column shoe embedment in timber (*Figure 7 – c*) has load-bearing capacity right after finishing assembly. Assembly tolerances and chosen connection method shall be considered while calculating the dry connection's bearing capacity.

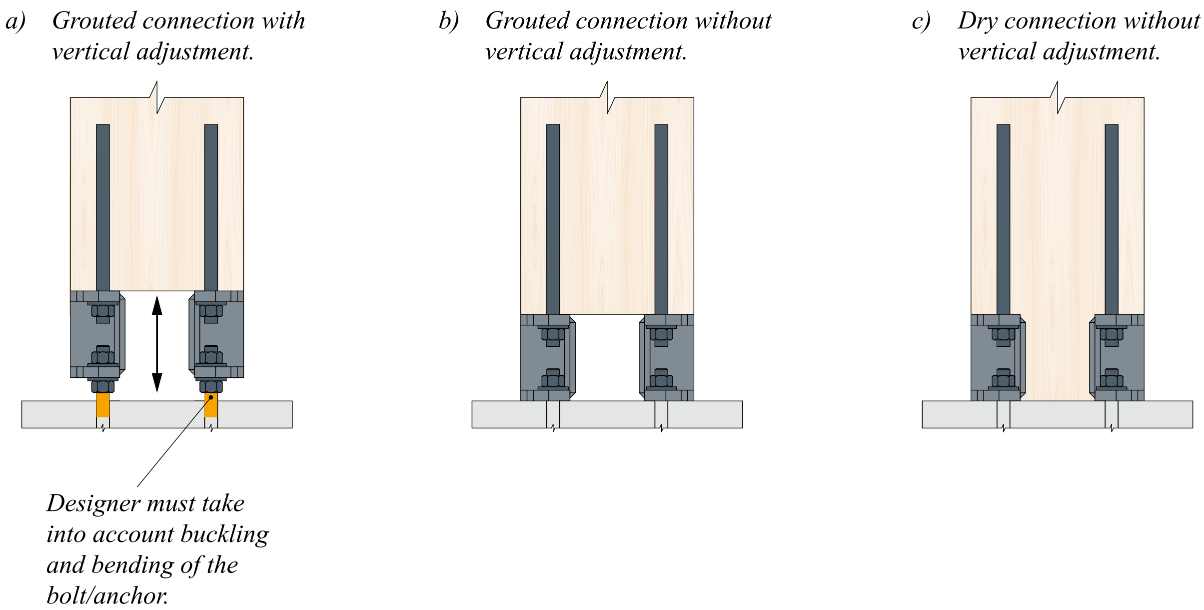


Figure 7. Connection types of ROOCO® Column Shoes.

1.1.2 Final conditions

For connections with grouting at the site, column shoes take tensile and compressive forces according to their capacities, and the grouted area takes a majority of compression force after the grout has reached the designed strength.

1.2 Application conditions

The models of ROOCO® Column Shoes are designed to be used under the conditions mentioned in this chapter. If these conditions are not satisfied, please contact Peikko Technical Support.

1.2.1 Loading and environmental conditions

ROOCO® Column Shoes are designed to transfer static loads. Custom design checks must be made according to relevant standards for dynamic, fatigue, or seismic loads. The designed lifetime for welded steel parts of ROOCO® Columns Shoes in dry internal conditions is 50 years.

Column shoes are designed for use indoors and in dry conditions. When using ROOCO® Column Shoes in other conditions, the surface treatment or concrete cover must be adequate according to the environmental exposure class and intended operating life.

The glue for threaded bars, intended for load-bearing timber structures, must not be subjected to temperatures more than 60° C over a longer time period in service classes 1 and 2, which are loaded predominantly static or quasi-static according to EN 1990 and EN 1991-1-1. Glue must be certified according to relevant standard for use in timber structures. For more information, check the glue manufacturer's specifications regards working temperature.

1.2.2 Interaction with column

ROOCO® Column Shoes are designed for timber columns with the minimum dimensions showed in *Figure 8* and summarized in *Table 2*.

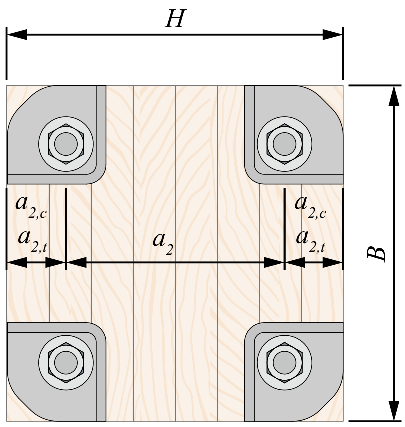


Figure 8. Minimum edge and axial distances of glued-in rods and timber column edges.

Table 2. The minimum sizes [mm] of column cross-sections for standard ROOCO® Column Shoes.

ROOCO® Column Shoes	ROOCO® 16	ROOCO® 20	ROOCO® 24	ROOCO® 30
$B \times H$ [mm] for $a_{2,c}$	160 × 160	200 × 200	240 × 240	300 × 300
$B \times H$ [mm] for $a_{2,t}$	160 × 210	200 × 260	240 × 315	300 × 390

Height of the cross-section with consideration of edge distance $a_{2,t}$ can be reduced according to direction of the shear force.

ROOCO® Column Shoes must be aligned with their top and bottom plates with timber column corner edges. Plates cannot protrude out of the cross-section. ROOCO® Column Shoes can be placed inside the timber column cross-section, but the following minimum distances in *Table 3* must be adhered to. The edge distances of glued-in rods for attachment of ROOCO® Column Shoe to timber column are presented in *Table 3*.

Table 3. The minimum edge and axial distances [mm] of glued-in rods and timber column edges.

Thread size	M16	M20	M24	M30
$a_{2,c}$ [mm]	40	50	60	75
$a_{2,t}$ [mm]	64	80	96	120
a_2 [mm]	80	100	120	150

Table 4. Minimum embedment length of the glued-in rod in timber acc. to DIN EN 1995-1-1/NA:2013-08.

Minimum embedment length of the glued-in rod in timber	M16	M20	M24	M30
$l_{a,min}$ [mm]	160	200	288	450

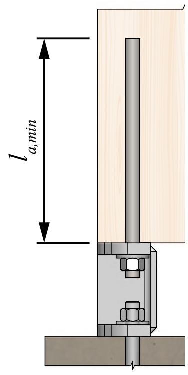


Figure 9. Minimum embedment length of the glued-in rod in timber.

1.3 Other properties

ROOCO® Column Shoes are fabricated of steel plates with the following material properties:

Steel plates and washers	S355J2 + N	EN 10025-2	Prime-painted

Threaded bars (glued-in rods) and nuts used to connect ROOCO® Column Shoes comply with the following standards:

Threaded bars	8.8	ISO 898-1	Hot-dip galvanized ISO 10684:2004
Nuts	Property class 8	ISO 898-2, EN ISO 4032	Hot-dip galvanized ISO 10684:2004

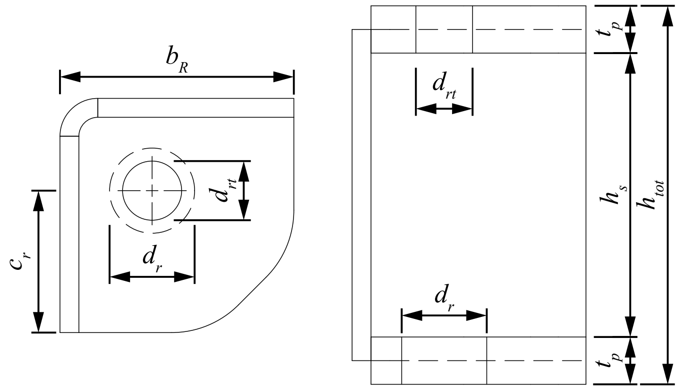
By default, column shoes are prime-painted. Contact Technical Support for other surface coatings.

Plywood properties

Minimal characteristic tension strength of birch plywood:	$f_{t,plate,k} = 30\ N/mm^2$
Minimal characteristic compression strength of birch plywood:	$f_{c,k} = 24\ N/mm^2$

Peikko Group's production units are controlled externally and audited periodically based on the production certifications and product approvals provided by various independent organizations.

Table 5. Dimensions [mm] and weights [kg] of ROOCO® Column Shoes.



ROOCO® size	b_R	c_r	d_r	d_{rt}	h_s	t_p	h_{tot}	*Weight*
	[mm]							[kg]
16	72	40	28	17	95	15	125	1.6
20	88	50	32	21	105	20	145	3.0
24	105	60	36	25	120	20	160	4.5
30	127	75	42	31	140	25	190	8.2

To secure proper installation of the ROOCO® Column Shoe, protrusion of glued-in rods or cast HPM® Rebar Anchor Bolts must be in line with minimum and maximum values according to *Table 6*. Values h_{sc} define only the length of the threaded bar as shown in *Figure 10* to secure the possibility of installation of washers and nuts for both sides. The value h_{sc} is the same in the case of the vertical adjustment type of connection.

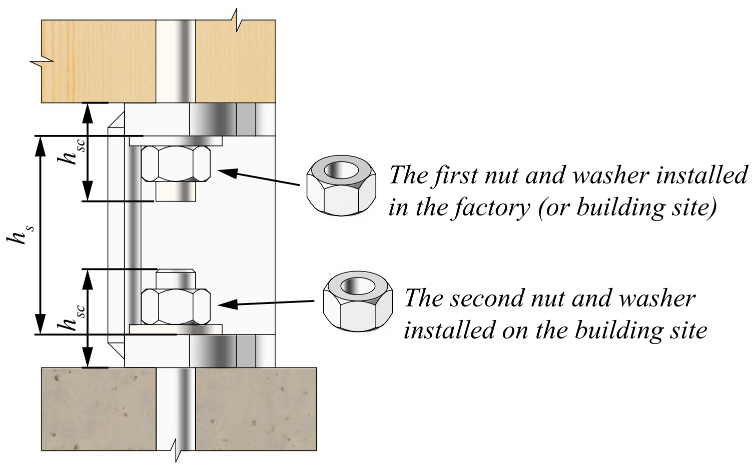


Figure 10. Maximum protruding part of threaded anchor.

Table 6. Minimum and maximum values of h_{sc}.

M / [mm]	$h_{sc,min}$	$h_{sc,max}$
16	40	51
20	49	62
24	54	69
30	66	82

2. Resistances

The resistances of ROOCO® Column Shoes are determined by a design concept that refers to the following standards and specifications:

- EN 1993-1-1:2005/AC:2009
- EN 1993-1-8:2005/AC:2005
- EN 1995-1-1:2004/A1:2008

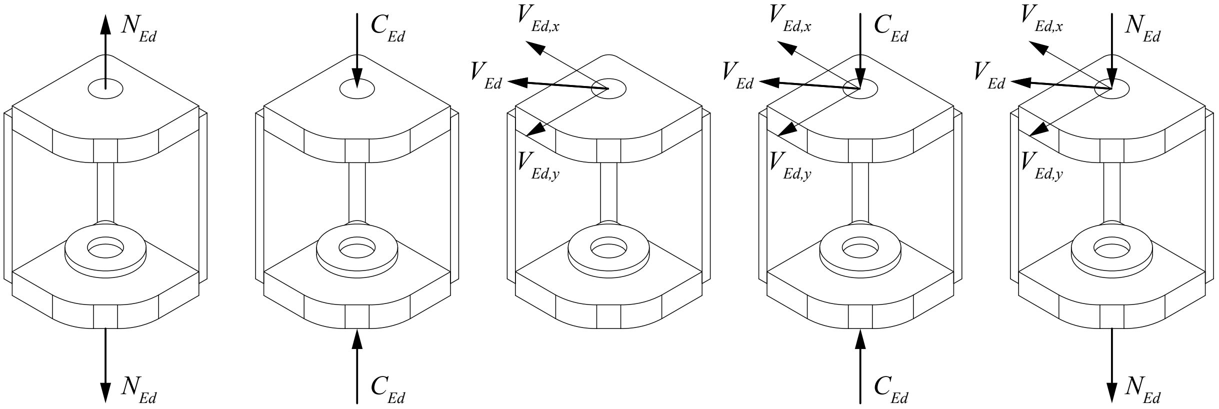


Figure 11. Directions of the loads.

Assumptions for designed resistances (*Table 7*, *Table 8*, *Table 9*, and *Figure 14*):

- Materials defined in Chapter 1.3.
- Manufacturing and installation tolerances have been considered.
- Resistances do not consider properties of supporting structure, influence of near edges of concrete, or cross-section of timber columns and its strength class or other properties. These shall be verified by responsible designer separately
- Calculations have been made for static loads according to EN 1993-1-8.

Resistances in this Technical Manual are designed for ROOCO® Column Shoes placed on the supporting timber, steel, or concrete structure without further specified properties. The supporting part of the joint (construction) must be designed and verified separately by the designer according to relevant standards. The minimum concrete grade which can be used is C25/30.

Resistances of glued-in rods in the timber column (if not selected from Annex A of this Technical Manual) have to be designed according to relevant standards, and these values shall be compared with resistances of the ROOCO® Column Shoes steel box (*Table 7*, *Table 9* and *Figure 14*), where the minimum value from both is decisive. The minimum strength class of timber which can be used is GL24h or LVL timber with equal or greater strength properties. Designed resistances are valid only if all the above assumptions and geometrical criteria are fulfilled.

Axial and shear resistance of the joint is based on decisive resistances of the ROOCO® Column Shoe steel box and selected anchor (e.g., HPM® Rebar Anchor Bolts) and timber part. For more information please follow section 'Selecting of ROOCO® Column Shoe'.

2.1 Axial resistance

Table 7. Design values of axial resistances $N_{Rd,s}$ of individual ROOCO® Column Shoe steel box and $N_{Rd,HPM}$ for HPM® Rebar Anchor Bolts

Column Shoe	$N_{Rd,s}$ [kN]	$N_{Rd,HPM}$ [kN]	Shoe contact area with a timber A_{con} [mm^2]
ROOCO 16	67	62	3806
ROOCO 20	107	96	5622
ROOCO 24	166	139	7128
ROOCO 30	223	220	11700

$N_{Rd,s}$ – axial resistances of ROOCO® Column Shoe steel box
$N_{Rd,HPM}$ – axial resistance of HPM® Rebar Anchor Bolts (for more information check HPM® Rebar Anchor Bolts Technical Manual)

Tension force is always acting on the axis of the glued-in rod.

Compression force acting on the steel box's top plate is always considered as a force acting in the center of gravity of this top plate. Values d_{cf} must always be considered while calculating the lever arm of forces from bending moment according to *Table 8*.

Table 8. Distance of center of gravity of top plate from the edge.

Column Shoe	d_{cf} [mm]
ROOCO 16	35
ROOCO 20	42
ROOCO 24	49
ROOCO 30	59

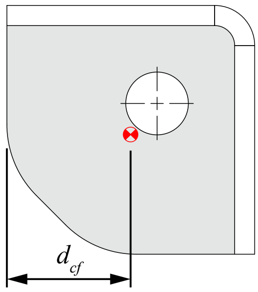


Figure 12. Distance d_{cf}.

The glue-in rod resistance (embedment length and block shear failure) shall be calculated and specified by the responsible structural engineer according to chosen calculation method and glue. Several calculation methods are available for glue-in rods, and the responsible structural engineer shall use the method accepted locally. For convenience, Annex A gives precalculated values according to DIN EN 1995-1-1/NA:2013-08.

Glue requirements shall be specified in design specification or drawings and available to the manufacturer of timber structures.

2.2 Shear resistances

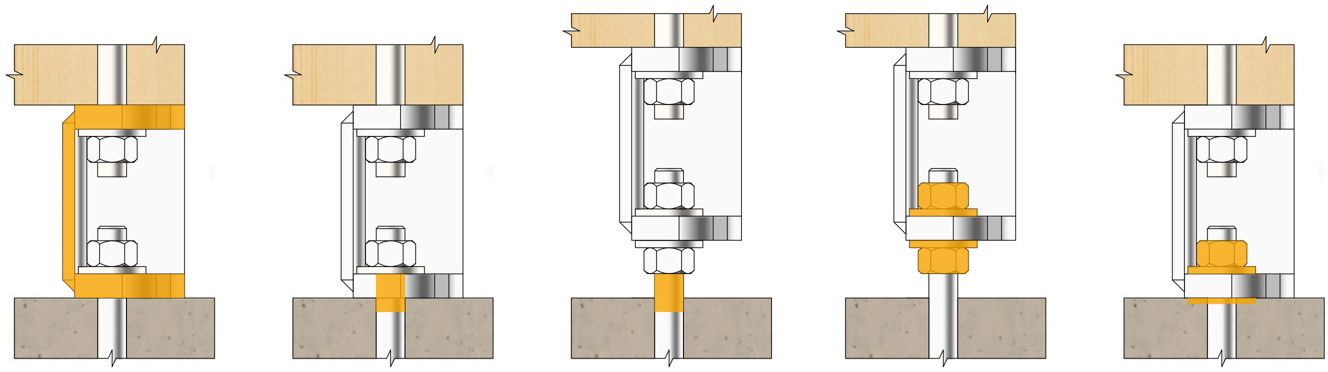


Figure 13. Illustration of shear resistances.

Table 9. Design values of shear resistances $V_{Rd,s}$ of individual ROOCO® Column Shoe steel box, $V_{Rd,HPM}$ for HPM® Rebar Anchor Bolts and $V_{Rd,friction}$ for defined torque moment T_{req}.

Column Shoe	$V_{Rd,s}$ [kN]	$V_{Rd,HPM,erection}$ [kN]	$V_{Rd,HPM,final}$ [kN]	$V_{Rd,friction}$ [kN]	T_{req} [Nm]
ROOCO 16	17	5	20	15	140
ROOCO 20	27	10	31	22	260
ROOCO 24	45	18	45	28	410
ROOCO 30	68	37	72	40	720

$V_{Rd,s}$ – shear resistances of ROOCO® Column Shoe steel box
$V_{Rd,HPM,erection}$ – shear resistances derived from HPM® Rebar Anchor Bolts in the erection stage
$V_{Rd,HPM,final}$ – shear resistances derived from HPM® Rebar Anchor Bolts in the final stage
$V_{Rd,friction}$ – shear resistance of the friction connection calculated from pretension by applied torque moment T_{req} on the nut, washer, and bottom plate of ROOCO® Column Shoe due to an oversized hole in the bottom plate. $V_{Rd,friction}$, and T_{req} values are calculated to match the shear resistance of the glued-in rod of strength class 8.8, in a glued-in length of 1000 mm in timber column of strength class GL24h with $k_{mod} = 0.9$ and with glued-on plywood panel.
If using a greater strength classes of materials, verification of torque moment and shear resistances is required according to relevant standards and regulations.
T_{req} – Required torque moment for tightening the nut on the bottom plate of ROOCO® Column Shoe to secure shear resistances $V_{Rd,friction}$. Values T_{req} are designed in accordance with VDI 2230.

Calculation assumptions for T_{req} values are as follows:

- None of the connection parts are lubricated, and surfaces are considered dry.
- The connection of surfaces between a washer, nut, and supporting structure are categorized as class C according to EN 1090-2.
- Friction coefficient $\mu = 0.3$.
- One friction plane.

The shear resistances $V_{Rd,HPM,erection}$, $V_{Rd,tb,erection}$ and $V_{Rd,friction}$ in case of vertical adjustment option shall be reduced of the value 15 % of designed compression force C_{Ed} [kN].

$$V_{Rd} - 0.15 \times C_{Ed} \geq V_{Ed}$$

$V_{Rd,tb,erection}$ = shear resistances of threaded bars in the erection stage.

Value of $V_{Rd,friction}$ is calculated according to above defined conditions. The verification of the shear resistance while taking into account value of $V_{Rd,friction}$ is under consideration of the designer. Precalculated values of shear resistance in the Annex A do not take the value of $V_{Rd,friction}$ as a condition for determination of final shear resistance.

2.3 Interaction of axial and shear forces

In case of interaction of axial (compression or tensile) force and shear force, the following graph shall be used.

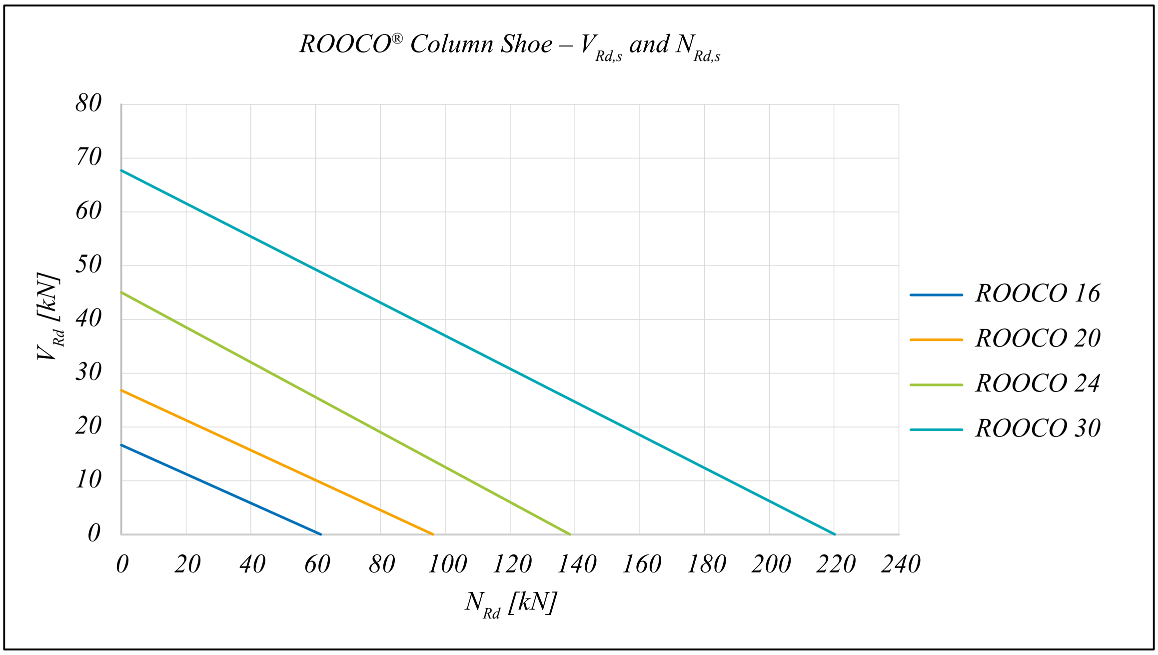


Figure 14. Design values of the interaction of shear $V_{Rd,s}$ and axial $N_{Rd,s}$ resistances of individual ROOCO® Column Shoe steel box.

2.4 Fire resistance

Fire resistance of column connections with ROOCO® Column Shoe shall be designed according to EN 1995-1-2:2004/AC:2009. Selected glue shall produce connections of such strength and durability that the integrity of the bond is maintained in the assigned fire resistance period.

Temperature development should be calculated according to EN 1995-1-2 to assess timber and glue strength and stiffness reduction, especially for bending moment and shear resistance of column connections. It depends on glue type, timber cover thickness, protective measures and fire load. Glue temperature performance should be taken according to the glue manufacturer's specification or relevant standards (EN 301). For adhesives, the softening temperature is considerably below the charring temperature of the wood.

Exposed column shoe steel parts shall be protected by grout or other suitable materials.

Technical report TR070 "*Design of glued-in rods for timber connections*" October 2019 covers glued-in rods with glues assessed according to EAD 130006-00-0304 "*Glued-in rods for timber connections*" and specifies a temperature limit of 60°C for service classes 1 and 2 with predominantly static or quasi-static loading according to EN 1990 and EN 1991-1-1.

EN 1995-1-2 does not specify analytical methods to calculate temperatures other than the charring temperature of 300°C. EN 1995-1-2 *Annex B "Advanced calculation methods"* gives timber properties to perform numerical modeling of temperature development and distribution – thermal response model.

Unprotected cover thickness according to EN 1995-1-2 Annex B numerical modeling

Table 10 and *Figure 15* specify the time to reach 60°C (glue failure) with corresponding timber cover thickness, and values are derived from numerical modeling and the following assumptions:

- Softwood values of thermal conductivity, specific heat, and the ratio of density to dry density according to EN 1995-1-2 Annex B Tables B.1 and B.2 and Figures B.1 to B.3
- Standard fire exposure according to EN 1991-1-2:2002/AC:2013 (ISO 834)
- Glue temperature limit 60°C
- Starting ambient temperature is 20°C
- Fire exposure from all four sides perpendicular to the grain
- An unprotected column with minimum dimensions of 200 × 200 mm
- The integrity of the face bonds is maintained in the assigned fire resistance period.

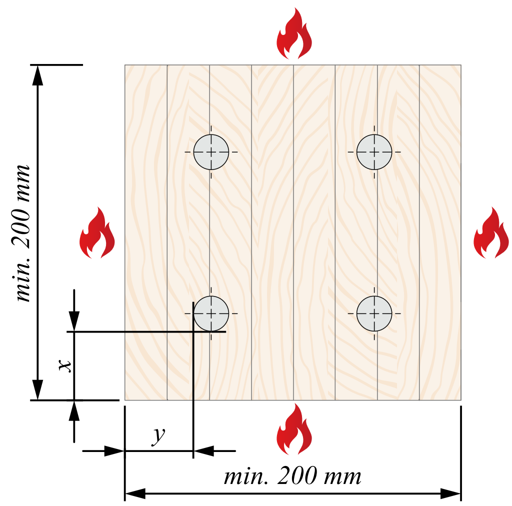


Figure 15. Column exposure to the fire and related cover for determination of the time value "t".

Table 10. Minimum cover distance for the assigned fire period with a glue temperature limit of 60°C.

t [min]	15	20	25	30	35	40	45	50	55	60	65	70	75	80
z [mm]	32	37	42	46	50	54	58	62	65	69	73	78	82	87

t – time to reach 60°C at a cover distance (z) from the edge of the column.
z – minimum cover distance of the surface of the glued-in rod.
z = min (x ; y)

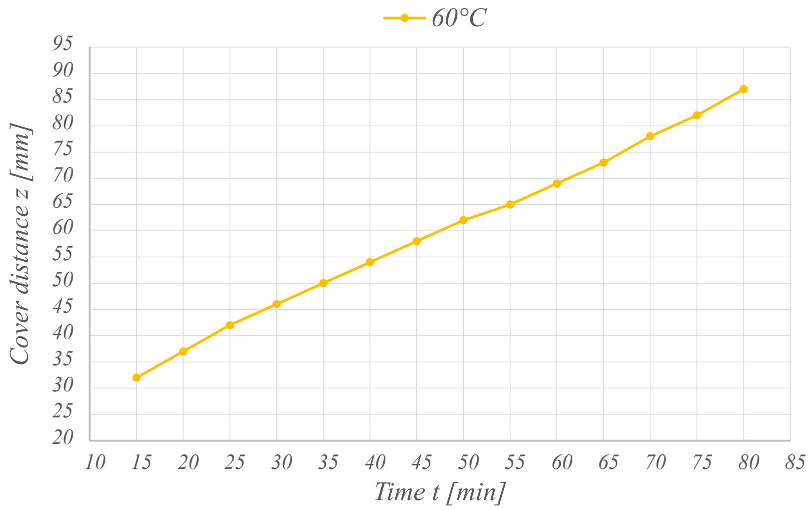


Figure 16. Minimum cover distance for assigned fire period with a glue temperature limit of 60°C

If conditions are different than defined assumptions and distances in *Table 10* are not sufficient, please contact Peikko Technical Support.

Selecting ROOCO® Column Shoe

The following aspects must be considered when selecting the appropriate type of ROOCO® Column Shoe to be used in a column connection:

- Column shoe resistance
- Properties of the timber column
- Properties of the glue and threaded bar
- HPM® Rebar Anchor bolt resistances
- Glued-in rods resistance (plywood resistance)
- Position and arrangement of the column shoes in the column
- The design value of actions

The resistance of the column connection should be verified for the following design situations:

- Erection stage
- Final stage
- Fire situation
- Environmental exposure conditions

In the case of connection types with vertical adjustment in combination with HPM® Rebar Anchor Bolts, HPM® Rebar Anchor Bolts Technical Manual shall be used to design the resistance of the connection in the erection stage.

If all of the following formulas are fulfilled, the selection of the product by code can be done:

$$N_{Rd} \geq N_{Ed}$$

$$C_{Rd} \geq C_{Ed}$$

$$V_{Rd} \geq V_{Ed}$$

Interaction of forces verified by *Figure 14* – Interaction of forces.

$$N_{Rd} = min(N_{Rd,s} \,;\, N_{Rd,g} \,;\, N_{Rd,HPM} \text{ or } N_{Rd,tb})$$

$$C_{Rd} = min(N_{Rd,s} \,;\, C_{Rd,t} \,;\, C_{Rd,ply} \,;\, C_{Rd,HPM} \text{ or } C_{Rd,tb})$$

$$V_{Rd} = min(V_{Rd,s} \,;\, V_{Rd,g} \text{ or } V_{Rd,g,ply} \,;\, V_{Rd,HPM} \text{ or } V_{Rd,tb} \,;\, V_{Rd,friction})$$

$N_{Rd,s}$	$V_{Rd,s}$	Axial and shear resistances of the ROOCO® Column Shoe steel box
$N_{Rd,g}$	$V_{Rd,g}$ and $V_{Rd,g,ply}$	Tensile and shear resistances of single glued-in rod connection or shear resistance of glued-in rod with applied plywood panel on the bottom side of the column
$N_{Rd,HPM}$	$N_{Rd,tb}$	Tensile resistance of the HPM® Rebar Anchor Bolt or threaded bar
$C_{Rd,HPM}$	$C_{Rd,tb}$	For vertical adjustment option, compression resistance of the HPM® Rebar Anchor Bolt or threaded bar taking into consideration the effects of buckling and bending
	$C_{Rd,ply}$	Compression resistance of applied plywood panel
$V_{Rd,HPM}$	$V_{Rd,tb}$	Selected value from $V_{Rd,HPM,erection}$ and $V_{Rd,HPM,final}$, according to selected stage of verification)
$V_{Rd,HPM,final}$	$V_{Rd,tb,final}$	Shear resistance of the HPM® Rebar Anchor Bolt or threaded bar in final stage
$V_{Rd,HPM,erection}$	$V_{Rd,tb,erection}$	Shear resistance of the HPM® Rebar Anchor Bolt or threaded bar in erection stage for version with vertical adjustment

Tensile, compression, and shear resistances in each stage shall be calculated by the designer in case of use of threaded bars instead of HPM® Rebar Anchor Bolts, and these values must be used in equations for $N_{Rd,tb}$, $C_{Rd,tb}$, and $V_{Rd,tb,final}$ or $V_{Rd,tb,erection}$.

$C_{Rd,t}$	Compression resistance of timber transferring force through the ROOCO® Column Shoe top plate
$V_{Rd,friction}$	Shear resistances values derived from applied torque moment T_{req}

The shear resistances $V_{Rd,HPM,erection}$, $V_{Rd,tb,erection}$ and $V_{Rd,friction}$ in case of vertical adjustment option shall be reduced of the value 15 % of designed compression force C_{Ed} [kN].

$$V_{Rd} - 0.15 \times C_{Ed} \geq V_{Ed}$$

Process of calculation of resistances

Layout of ROOCO® Column Shoes, thread size, and embedment length of glued-in rods

Internal forces – C_{Ed}, N_{Ed}, V_{Ed}, $N_{Ed,t}$, $N_{Ed,c}$, $N_{Ed,M}$, $\sigma_{C,Ed,grout}$, $\sigma_{C,Ed,grout,M}$

Option 1. Detailed resistances:

ROOCO® Column Shoe steel box:

$N_{Rd,s}$ (*Table 7*), $V_{Rd,s}$ (*Table 9*)

Interaction of forces (Figure 14)

For glued-in rod calculate:

$N_{Rd,g}$, $V_{Rd,g}$ or $V_{Rd,g,ply}$ *and interaction of forces*

For HPM® Rebar Anchor Bolt select or calculate:

$N_{Rd,HPM}$ (*Table 7*), $V_{Rd,HPM,erection}$ *and* $V_{Rd,HPM,final}$ (*Table 9*)

$C_{Rd,HPM}$, $V_{Rd,friction}$ (or *Table 9*) *and interaction of forces*

For threaded bar select or calculate:

$N_{Rd,tb}$, $C_{Rd,tb}$, $V_{Rd,tb,erection}$, $V_{Rd,tb,final}$, $V_{Rd,friction}$ *(or Table 9)* *and interaction of forces*

For connection calculate:

$C_{Rd,t}$, $R_{ax,block}$, $C_{Rd,ply}$

Define: N_{Rd}, C_{Rd}, V_{Rd}

Option 2. Simplified method according to Annex A:

ROOCO® Column Shoe steel box, glued-in rod with applied plywood panel and HPM® Rebar Anchor Bolt:

$N_{Rd,r}$, $C_{Rd,r}$, $V_{Rd,r}$ *(Table 10) and interaction of forces (Annex A)*

For HPM® Rebar Anchor Bolt select or calculate:

$V_{Rd,HPM,erection}$ *(Table 9)*, $C_{Rd,HPM}$ *and interaction of forces*

For threaded bar calculate:

$N_{Rd,tb}$, $C_{Rd,tb}$, $V_{Rd,tb,erection}$, $V_{Rd,tb,final}$ *and interaction of forces*, $V_{Rd,friction}$ *(or Table 9)*

For connection calculate:

$R_{ax,block}$

Define: N_{Rd}, C_{Rd}, V_{Rd}

ROOCO® Column Shoe connection to timber column verification

$$C_{Rd} \geq C_{Ed}$$

$$N_{Rd} \geq N_{Ed}$$

$$V_{Rd} \geq V_{Ed}$$

If not fulfilled → back to layout

Verification of timber in the joint

$$f_{c,0,d} \geq (\sigma_{C,Ed,grout}, \sigma_{C,Ed,grout,M}, \sigma_{C,Ed,grout} + \sigma_{C,Ed,grout,M})$$

$$R_{ax,block} \geq (N_{Ed,t}, N_{Ed,M}, \text{interaction } (N_{Ed,t} \text{ or } N_{Ed,c}, N_{Ed,M}))$$

$R_{ax,block}$	*Axial resistance of timber block shear failure for the group of connectors (example of calculation procedure is explained in Annex A)*
$f_{c,0,d}$	*Compression resistance of timber in direction parallel to the grains*
$f_{c,90,d,ply}$	*Compression resistance of plywood perpendicular to grain*

Product code

After selecting the correct ROOCO® Column Shoe, a product code describing the product may be defined according to the description. Please use this code in drawings and when ordering the product from Technical Support.

ROOCO XX-Y+L_1+L_2-Z

XX	– Column shoe size	}	Required basic information
Y	– Number of special washers		
Z	– Number of nuts		
L_1	– Length of threaded bar	}	Additional information about threaded bars
L_2	– Length of threaded bar		

The number of threaded bars is defined by additional information about the lengths of threaded bars.

Product code examples:	Description
ROOCO 16-1-1	ROOCO® Column Shoe size 16 with one special washer and one nut. Intended for connection with HPM® Rebar Anchor Bolts where two additional special washers are part of the HPM® Rebar Anchor Bolt assembly.
ROOCO 16-3+850-1	ROOCO® Column Shoe size 16 with three special washers, one nut and one M16 threaded bar 850 mm long.
ROOCO 16-3+850+1200-3	ROOCO® Column Shoe size 16 with three special washers and three nuts, one M16 threaded bar 850 mm long, and one M16 threaded bar 1200 mm long.

Note: HPM® Rebar Anchor Bolts must be ordered separately.

Example of selection

This example describes the verification of the connection in the erection stage while there is no grouting under the column. The resistance in bending moment and compression will increase after the space between the bottom side of the column and the top of the foundation is filled with grout. The plywood panel is used in this assembly.

Assumptions:

- Heated interior conditions – Class 1.
- Dominant wind loads in design combination
- Timber class GL24h, $k_{mod} = 0.9$
- Threaded bars of class 8.8
- Glue with properties according to EN 301 with CE certification based on ETA
- Anchors HPM® Rebar Anchor Bolts HPM 24
- Plywood panel of thickness 35 mm
- Timber column, concrete base structure and anchors are verified and sufficient for transfer of design loads
- Design case without grouting

$z = B - a_{2,t} - a_{2,c} + (c_r - d_{cf}) = 360\ mm - 96\ mm - 85\ mm = 360\ mm - 96\ mm - 96\ mm + (60\ mm - 49\ mm) = 179\ mm$

$C_{Ed,1} = (N_{Ed,c}/n) = 150\ kN / 4 = 37.5\ kN$ $\quad n = 4$

$C_{Ed,M} = (M_{Ed}/z) = 20\ kNm / 179\ mm = 111.7\ kN$

$C_{Ed,2} = C_{Ed,M} / m = 111.7\ kN / 2 = 55.9\ kN$ $\quad m = 2$

$N_{Ed,M} = C_{Ed,M} = 111.7\ kN$

$N_{Ed,1} = C_{Ed,2} = 59.9\ kN$

$C_{Ed} = C_{Ed,1} + C_{Ed,2} = 37.5\ kN + 59.9\ kN = 93.4\ kN$

$N_{Ed} = N_{Ed,1} - C_{Ed,1} = 55.9\ kN - 37.5\ kN = 18.4\ kN$

$V_{Ed} = V_{Ed,0} / n = 50\ kN / 4 = 12.5\ kN$

Combination for ROOCO® under compression: $C_{Ed} = 93.4\ kN$

$V_{Ed} = 12.5\ kN$

Combination for ROOCO® under tension: $N_{Ed} = 18.4\ kN$

$V_{Ed} = 12.5\ kN$

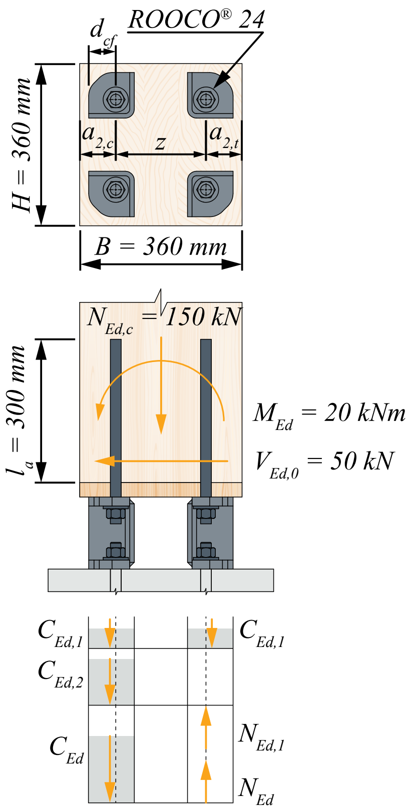


Figure 17. Internal forces of the connection of the selection example.

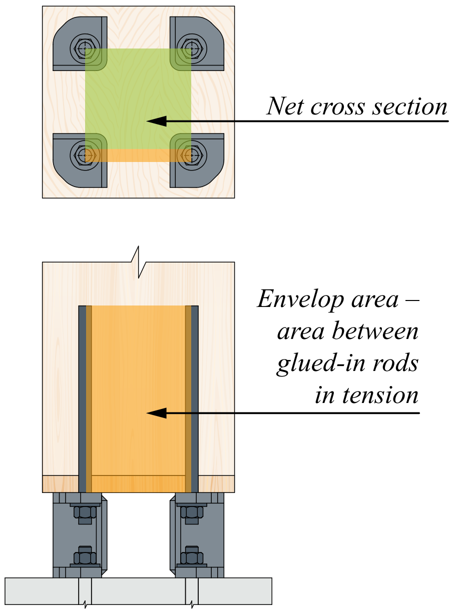


Figure 18. Areas for verification of the block shear failure from tensile force.

Verification of block shear failure from tensile force $m \times N_{Ed} = 2 \times 18.4\ kN = 36.8\ kN$ for a group of axially loaded rods (EOTA TR 070:2019-10 (Chapter 4.1.7):

Envelope area: $A_{env} = (H\text{-}2 \times a_{2,c}) \times l_a = (360\ mm - 2 \times 96\ mm) \times 300^{*}\ mm = 50{,}400\ mm^2$

* Minimum embedment length of the glued-in rod in timber acc. to DIN EN 1995-1-1/NA:2013-08 for M24 is 288 mm.

Shear strength of GL24h: $f_{v,d} = (f_{v,k} \times k_{mod}) / \gamma_M = (3.5\ MPa \times 0.9) / 1.25 = 2.52\ MPa$

$R_{ax,env} = A_{env} \times f_{v,d} = 50{,}400\ mm^2 \times 2.52\ MPa = 127.0\ kN$

Net cross section: $A_{net} = 0\ mm^2$ – This verification is relevant only for pure tension load acting on the column or combination of tension load and bending moment!

Tensile strength of GL24h: $f_{t,0,d} = (f_{t,0,k} \times k_{mod}) / \gamma_M = (19.2\ MPa \times 0.9) / 1.25 = 13.8\ MPa$

$R_{ax,net} = A_{net} \times f_{t,0,d}$

$R_{ax,block} = min(R_{ax,env}; R_{ax,net})$

$R_{ax,block} > [N_{Ed}, M - m \times C_{Ed,1}]$

$127.0\ kN > [111.7\ kN - 2 \times 37.5\ kN] \Rightarrow 127.0\ kN > 36.8\ kN$ OK

m – number of glued-in rods in tension

Verification of compression force $C_{Ed} = 93.4\ kN$ and shear force $V_{Ed} = 12.5\ kN$

1. Verification of resistance of glued-in rod according to Annex A – *Table 11.*

M24		$N_{Rd,r}$ [kN] Length of glued-in rod l_a			$V_{Rd,g}$ [kN] Length of glued-in rod l_a			$V_{Rd,r}$ [kN]	$C_{Rd,r}$ [kN]
		300 [1]	500	1000	250	500	1000	t_{ply} = 35 mm	
k_{mod}	0.7	44.6 [1]	54.5	79.3	2.50	3.91	6.95	24.4	97.4
	0.8	51.3 [1]	62.7	91.2	2.85	4.47	7.95	27.8	111.3
	0.9	57.9 [1]	70.8	103.0	3.21	5.03	8.94	31.3	125.2
	1.1	71.1 [1]	86.9	126.4	3.92	6.14	10.93	38.3	153.0

$C_{Ed} = 93.4\ kN < C_{Rd,r} = 125.2\ kN$ $V_{Ed} = 12.5\ kN < V_{Rd,r} = 31.3\ kN$ OK

[1] Length min. l_a = 290 mm ⇨ min. allowed embedment length for thread size M24 according to DIN EN 1995-1-1/NA:2013-08.

2. Verification of resistance of ROOCO® Column Shoe

Compression force is transferred by the top steel plate of the ROOCO® Column Shoe, while the shear is transferred only by the threaded bar and ROOCO® Column Shoe. Each force is verified separately. Cross-check must be made with *Figure 14* to verify steel box resistance.

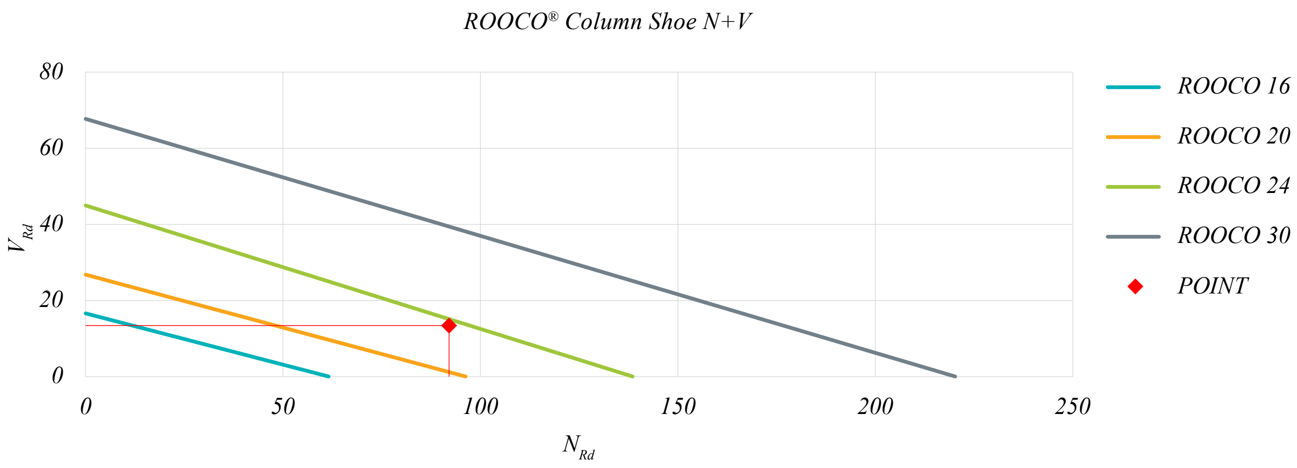


Figure 19. Verification of resistance of ROOCO® Column Shoe example of selection.

Verification of tension force $N_{Ed} = 18.4\ kN$ and shear force $V_{Ed} = 12.5\ kN$

1. Verification of resistance of the connection according to Annex A.

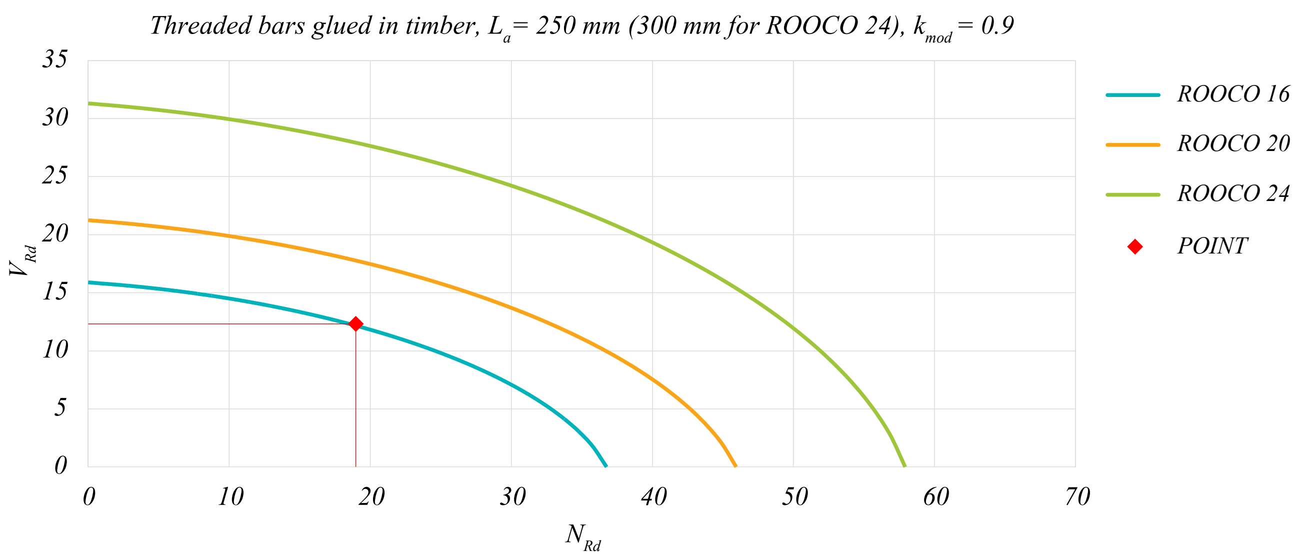


Figure 20. Verification of resistance of the connection for example of selection.

In case of not using end-grain reinforcement like plywood, for laterally loaded glued-in rods inserted parallel to the grain, the embedding strength should be taken as 10 % of the embedding strength perpendicular to grain. For ROOCO 24 characteristic embedment strength perpendicular to grain is 1.40 N/mm^2 and design shear load-carrying capacity is only 3.21 kN.

2. Verification of resistance of the HPM® Rebar Anchor Bolts for interaction of forces according to HPM® Rebar Anchor Bolt Technical Manual (Chapter 2.2) and *Table 7* and *Table 9*:

$$N_{Ed} / (1.4 \times N_{Rd,HPM}) + V_{Ed} / V_{Rd,HPM,final} \leq 1$$

$$18.4\ kN / (1.4 \times 139\ kN) + 12.5\ kN / 45\ kN = 0.37 < 1$$ OK

Column Shoe	$N_{Rd,s}$ [kN]	$N_{Rd,HPM}$ [kN]	Shoe contact area with a timber A_{con} [mm^2]
ROOCO 16	67	62	3806
ROOCO 20	107	96	5622
ROOCO 24	166	139	7128
ROOCO 30	223	220	11700

Column Shoe	$V_{Rd,s}$ [kN]	$V_{Rd,HPM,erection}$ [kN]	$V_{Rd,HPM,final}$ [kN]	$V_{Rd,friction}$ [kN]	T_{req} [Nm]
ROOCO 16	17	5	20	15	140
ROOCO 20	27	10	31	22	260
ROOCO 24	45	18	45	28	410
ROOCO 30	68	37	72	40	720

Verification of torque moment for transferring the shear force $V_{Ed} = 12.5\ kN$:

Design shear force: $V_{Ed} = 12.5\ kN$

Required torque moment according to *Table 9*: $T_{req,24} = 410\ Nm$

$V_{Ed} = 12.5\ kN < V_{Rd,friction,24} = 28\ kN$ OK

Column Shoe	$V_{Rd,s}$ [kN]	$V_{Rd,HPM,erection}$ [kN]	$V_{Rd,HPM,final}$ [kN]	$V_{Rd,friction}$ [kN]	T_{req} [Nm]
ROOCO 16	17	5	20	15	140
ROOCO 20	27	10	31	22	260
ROOCO 24	45	18	45	28	410
ROOCO 30	68	37	72	40	720

Note: Verification according to *Table 9* (T_{req}), *Table 11*, and Annex A – Design values of resistances in an interaction of tension and shear forces of the joint with glued-in rods of strength class 8.8 and timber of grade GL24h according to EN 1995-1-1 and DIN EN 1995-1-1/NA:2013-08 is possible only when timber strength GL24h and threaded bars of strength class of at least 8.8 are selected, with minimum strengths of plywood according to Chapter 1.3.

If these assumptions are not true, the designer has to design the resistance of the glued-in rods separately. Verification of resistance of the ROOCO® Column Shoe is always the same (design load shall be verified with resistances in *Table 7*, *Table 9*, and *Figure 14*).

Selection and ordering:

$l_a = 300\ mm,\ L_{tot} = l_a + h_{sc} = 300\ mm + 54\ mm + 35\ mm = 389\ mm$ h_{sc} – *Table 6*

ROOCO 20-2+389-2 ⇨ This product code does not include the bottom anchor

ANNEX A – Glued-in rod calculation according to DIN EN 1995-1-1/ NA:2013-08

Annex A gives precalculated values according to DIN EN 1995-1-1/NA:2013-08 and ”*RIGID GLULAM JOINTS TO CONCRETE ABUTMENTS WITH GLUED-IN STEEL RODS*” by Kai Simon, Simon Aicher. The glue shall be tested and comply with EN 1995-1-1/NA:2013-08 Table NA.12 requirements. The presented values are for guidance only. The length of the glue-in rod shall be calculated and specified by the responsible structural engineer according to chosen calculation method and glue. Influence of plywood panels on the shear capacity defined in this chapter is explained in Chapter 1.1 and *Figure 6*. Installation of plywood panels is illustrated in Chapter "Installation of ROOCO® Column Shoes" on page 33.

The following resistances are considered for materials with minimum grade:

- Glued-in rod property class minimum 8.8 according to ISO 898-1 (drilled hole is equal to the nominal diameter of the thread + 2 mm)
- Timber grade GL24h according to EN 14080:2013
- Birch plywood (unsanded)

Characteristic compression strength of plywood	$f_{ck,\perp}$	27 MPa
Characteristic tensile strength of plywood	$f_{tk,\square}$	30 MPa
Mean modulus of elasticity of plywood	$E_{\perp}$	7500 MPa
Characteristic bondline shear strength	$f_{v,b,end.grain,k}$	3.5 MPa

Explanation of resistances markings:

$N_{Rd,r}$ – The smallest value of tension resistance of glued-in rod connection at a particular length and kmod factor, and tension resistance of the ROOCO® Column Shoe steel box. Axial HPM® Rebar Anchor Bolt resistance is always greater.

$V_{Rd,r}$ – The smallest value of shear resistance of glued-in rod with applied plywood panel of particular diameter and length for several k_{mod} factors, and shear resistance of the ROOCO® Column Shoe steel box. Shear HPM® Rebar Anchor Bolt resistance is always greater.

$C_{Rd,r}$ – The smaller value of compression resistance of timber GL24h parallel to the grains and plywood panel in perpendicular direction, acting on the area of the top plate of the ROOCO® Column Shoe (*Table 7*) for several k_{mod} factors, and compression resistance of the ROOCO® Column Shoe steel box. Axial HPM® Rebar Anchor Bolt resistance without consideration of buckling and bending is always greater.

Note: All below-defined resistances correspond to glued-in rods, plywood, and timber resistances. ROOCO® Column Shoe steel box resistances are always greater in this precalculated example.

$$N_{Rd,r} = min(N_{Rd,s}; N_{Rd,g}; N_{Rd,HPM})$$

$$C_{Rd,r} = min(N_{Rd,s}; C_{Rd,t}; C_{Rd,ply})$$

$$V_{Rd,r} = min(V_{Rd,s}; V_{Rd,g,ply}; V_{Rd,HPM,final})$$

Table 11. Design values of tensile resistances $N_{Rd,r}$, shear resistances $V_{Rd,g}$ or $V_{Rd,ply}$ of individual glued-in rods of strength class 8.8 and plywood of several thicknesses t_{ply}, and compression resistances $C_{Rd,r}$ for timber grade GL24h according to EN 1995-1-1 and DIN EN 1995-1-1/NA:2013-08 and plywood.

M16		$N_{Rd,r}$ [kN] Length of glued-in rod l_a			$V_{Rd,g}$ [kN] - 10 % of f_{hk} Length of glued-in rod l_a			$V_{Rd,r}$ [kN]	$C_{Rd,r}$ [kN]
		250	500	1000	250	500	1000	t_{ply} = 24 mm	
k_{mod}	0.7	28.3	36.1	52.6	1.59	3.03	3.66	12.4	49.1
	0.8	32.5	41.6	60.2	1.82	3.47	4.18	14.1	56.2
	0.9	36.8	47.0	60.5	2.05	3.90	4.70	15.9	63.2
	1.1	45.2	57.8	60.8	2.50	4.77	5.75	19.4	77.2

M20		$N_{Rd,r}$ [kN] Length of glued-in rod l_a			$V_{Rd,g}$ [kN] - 10 % of f_{hk} Length of glued-in rod l_a			$V_{Rd,r}$ [kN]	$C_{Rd,r}$ [kN]
		250	500	1000	250	500	1000	t_{ply} = 27 mm	
k_{mod}	0.7	35.3	45.2	65.7	1.89	3.51	5.23	16.5	67.6
	0.8	40.6	52.0	75.6	2.16	4.02	5.98	18.9	77.3
	0.9	45.9	58.8	85.5	2.43	4.52	6.73	21.3	86.9
	1.1	56.5	72.2	95.0	2.97	5.52	8.22	26.0	106.2

M24		$N_{Rd,r}$ [kN] Length of glued-in rod l_a			$V_{Rd,g}$ [kN] - 10 % of f_{hk} Length of glued-in rod l_a			$V_{Rd,r}$ [kN]	$C_{Rd,r}$ [kN]
		300 [1]	500	1000	250	500	1000	t_{ply} = 35 mm	
k_{mod}	0.7	44.6 [1]	54.5	79.3	2.50	3.91	6.95	24.4	97.4
	0.8	51.3 [1]	62.7	91.2	2.85	4.47	7.95	27.8	111.3
	0.9	57.9 [1]	70.8	103.0	3.21	5.03	8.94	31.3	125.2
	1.1	71.1 [1]	86.9	126.4	3.92	6.14	10.93	38.3	153.0

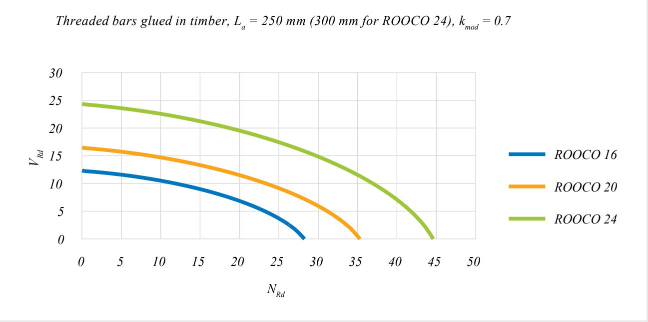
M30		$N_{Rd,r}$ [kN] Length of glued-in rod l_a		$V_{Rd,g}$ [kN] - 10 % of f_{hk} Length of glued-in rod l_a			$V_{Rd,r}$ [kN]	$C_{Rd,r}$ [kN]
		500 [2]	1000	250	500	1000	t_{ply} = 40 mm	
k_{mod}	0.7	68.1 [2]	99.1	2.56	4.38	8.37	31.9	143.6
	0.8	78.3 [2]	113.9	2.92	5.00	9.56	36.5	164.1
	0.9	88.4 [2]	128.6	3.29	5.63	10.76	41.0	184.6
	1.1	108.6 [2]	158.0	4.02	6.88	13.15	50.1	225.6

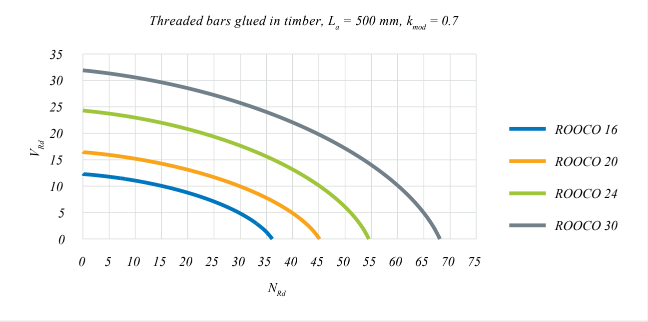
[1] Length min. l_a = 290 mm ⇨ min. allowed embedment length for thread size M24 according to DIN EN 1995-1-1/NA:2013-08.
[2] Length min. l_a = 490 mm ⇨ min. allowed embedment length for thread size M30 according to DIN EN 1995-1-1/NA:2013-08.

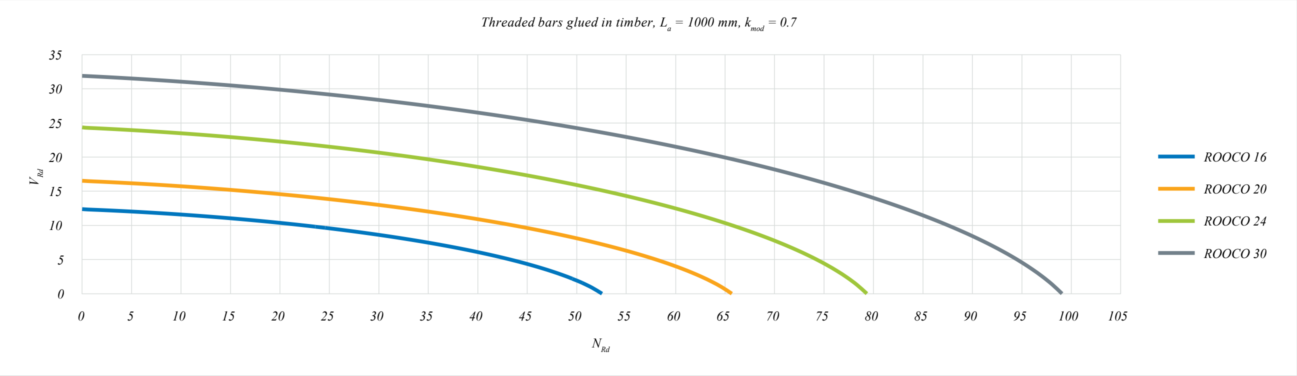
In case of an interaction of tension and shear forces, resistances of the glued-in rod and timber with the above predefined threaded bar and timber properties can be determined according to the following interaction charts. In this precalculated example, an interaction of axial and shear force resistance of the ROOCO® Column Shoe steel box is always greater than timber.

Design values of resistances in an interaction of tension and shear forces of the joint with glued-in rods of strength class 8.8 and timber of grade GL24h according to EN 1995-1-1 and DIN EN 1995-1-1/NA:2013-08.

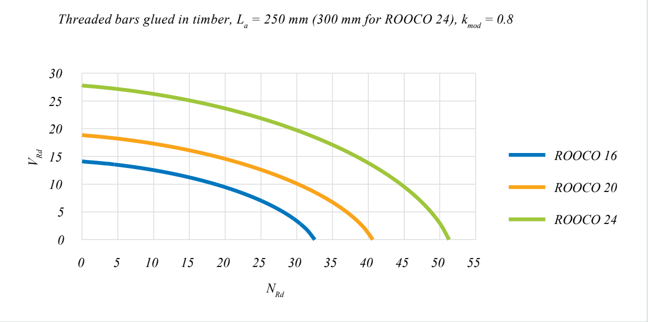
a) $k_{mod} = 0.7$

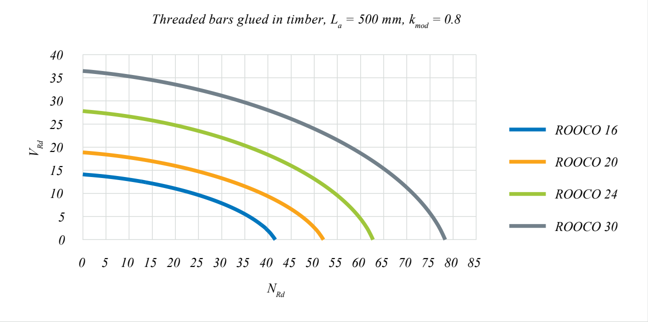


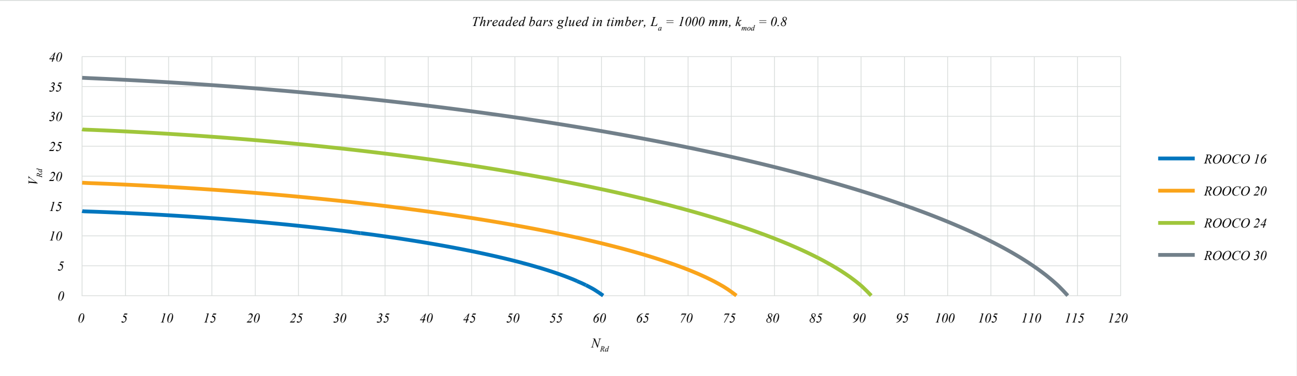




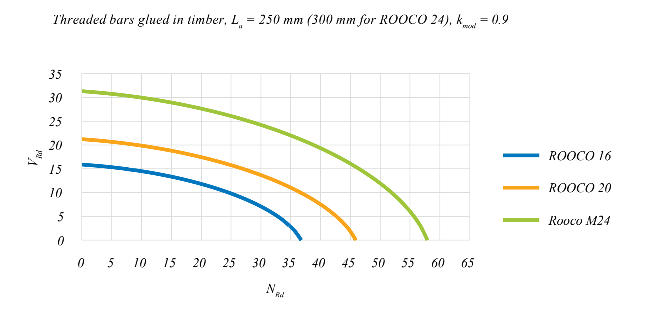
b) $k_{mod} = 0.8$

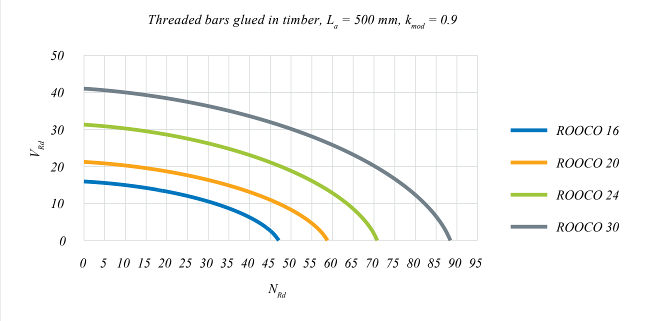


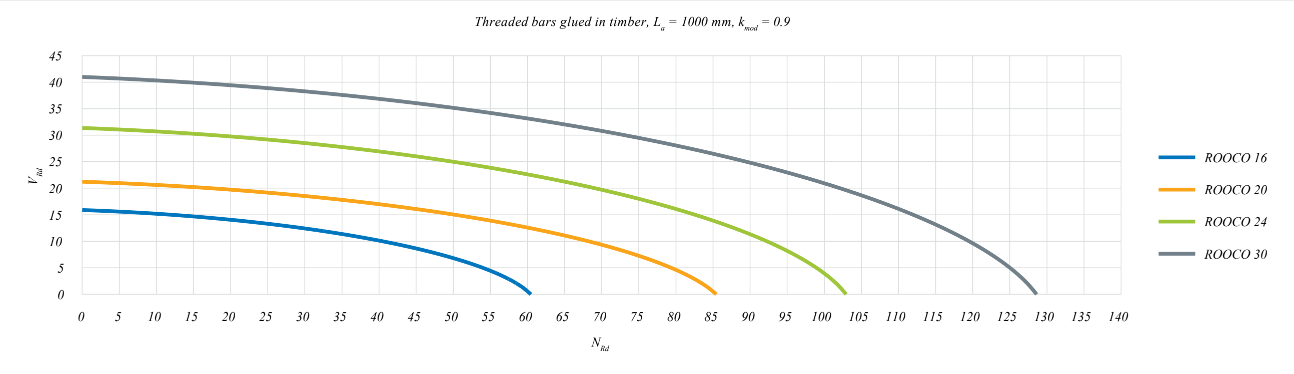




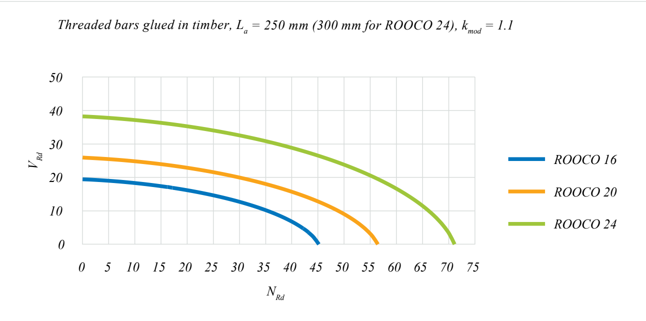
c) $k_{mod} = 0.9$

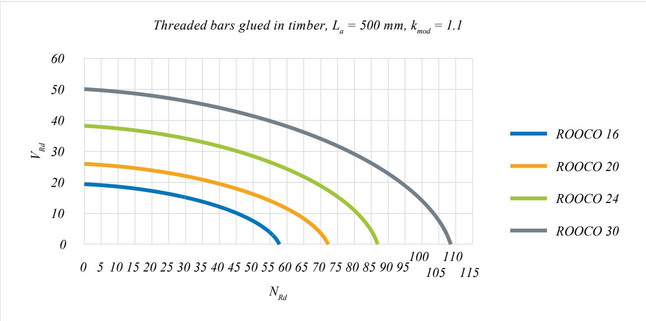


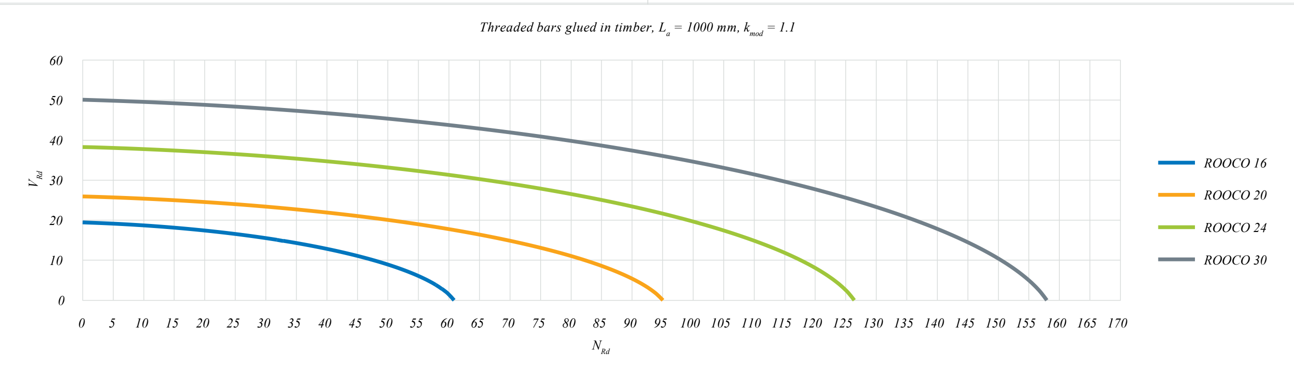




d) $k_{mod} = 1.1$







For interaction of forces without use of plywood panel, use verification from EN 1995-1-1, Chapter 8.3.3.

ANNEX B – Product application and different options

All types of connections mentioned above are shown in figures in this annex, and other options in different modifications and with additional elements such as steel baseplate, shear dowels or plywood panel.

ROOCO® Column Shoes can be used together with steel base plates for timber columns to increase the contact area and compression capacity as well. Base plates are not part of the delivery and are not standard items.

ROOCO® Column Shoes can be used with additional shear dowels installed in timber columns if the structural design requires higher shear resistance. Shear dowels are not part of the delivery and are not standard items. Peikko can supply base plates and shear dowels according to the customer's specifications under the agreement.

ROOCO® Column Shoes are designed to work with DELTABEAM® Slim Floor Structure in different combinations and ROOCO® Column Shoes configurations.

Connections with foundation

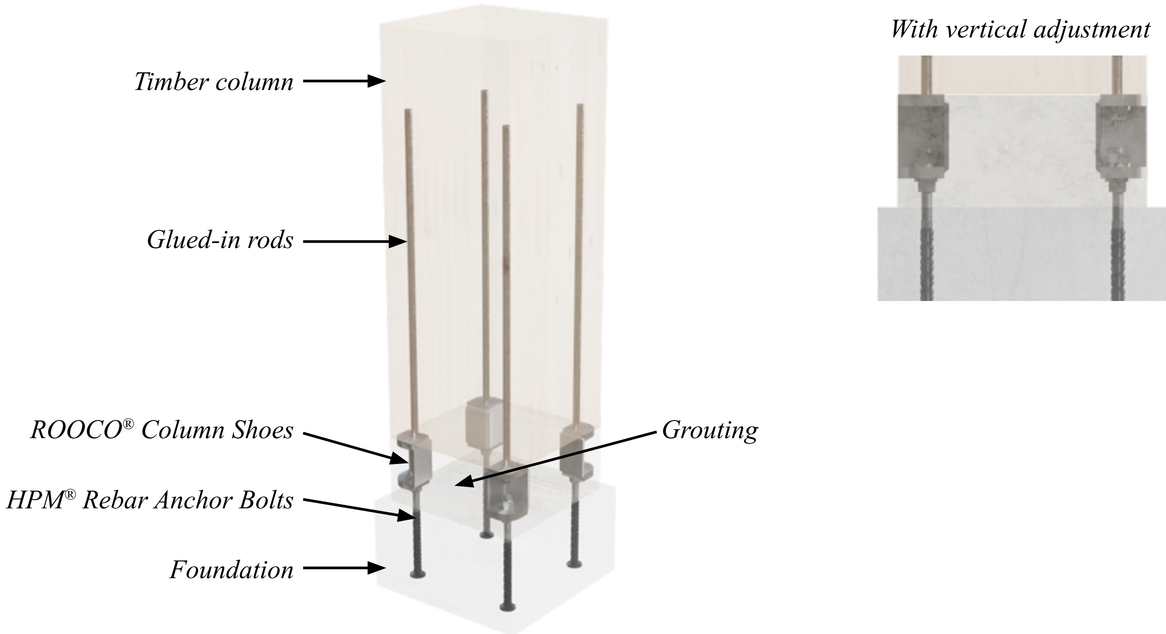


Figure 21. Foundation and timber column connection with ROOCO® Column Shoes.

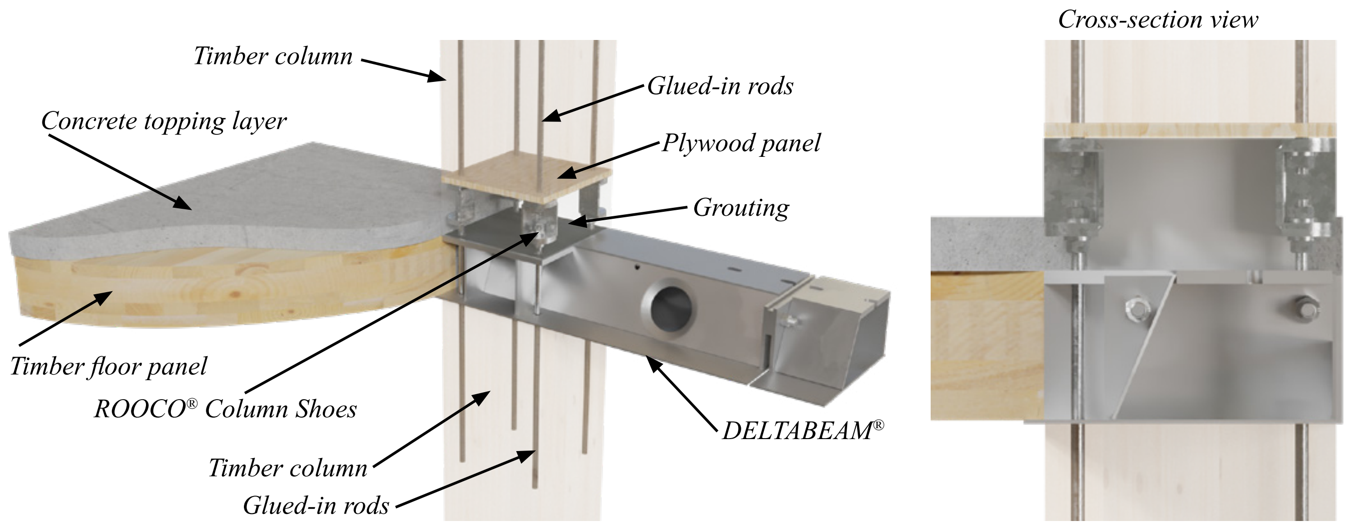


Figure 22. Column-beam-column connection with ROOCO® Column Shoes, edge DELTABEAM® and plywood plate.

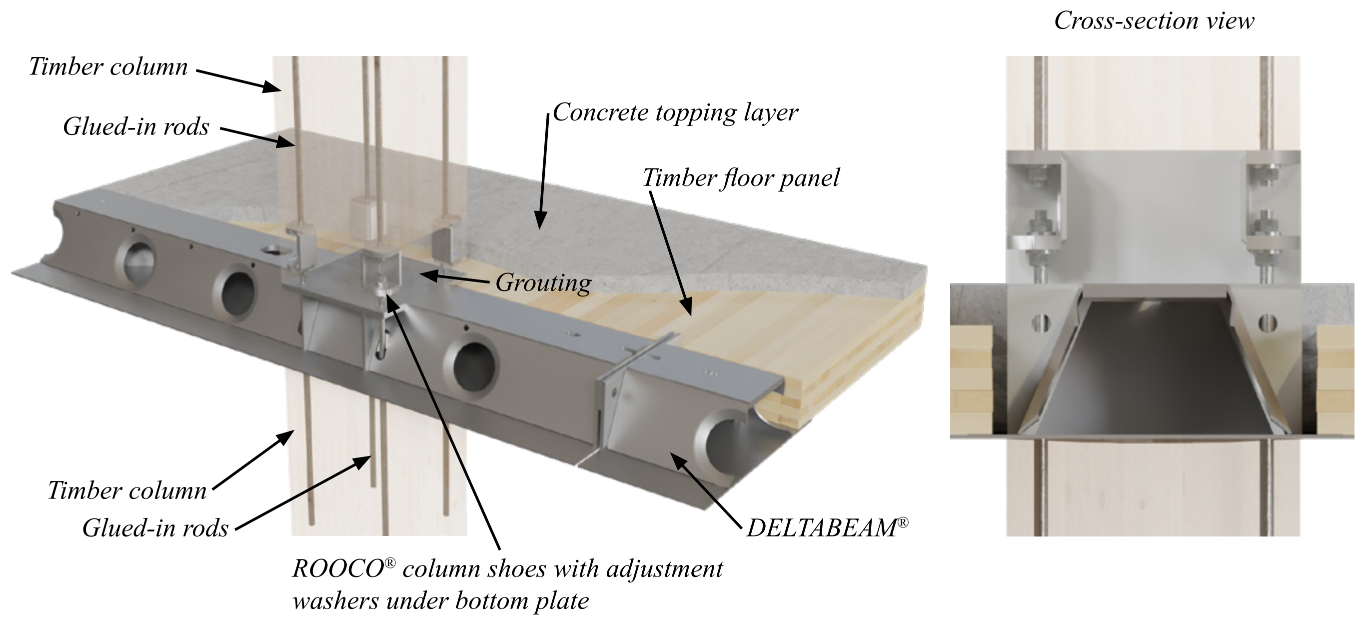


Figure 23. Column-beam-column connection with ROOCO® Column Shoes, continuous DELTABEAM®, and vertical adjustment option.

Installation of ROOCO® Column Shoe

Identification of the product

ROOCO® Column Shoes are available in standard models (16, 20, 24, and 30) analogous to the M-thread sizes of HPM® Rebar Anchor Bolts. The model of the column shoe can be identified by the name on the product's label and the color on the bottom side of the bottom plate of the ROOCO® Column Shoe. The color codes are shown in *Table 12*.

Table 12. ROOCO® Column Shoe color codes.

Column Shoe	Color code
ROOCO 16	Yellow
ROOCO 20	Blue
ROOCO 24	Gray
ROOCO 30	Green

Installation of glued-in rods

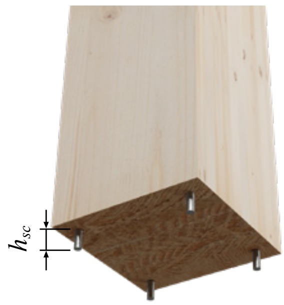
1. Holes shall be drilled in the timber column to install glue and bars. Hole diameter and length according to the design drawings.

   The installation tolerance of glued-in rod in the crosswise direction of the column is ±2 mm.

   In the context of installing laminated veneer lumber (LVL), it is imperative to exercise particular caution or special care. It is essential to incorporate insulation between the grout and the LVL material, so no moisture is able to interact with LVL.

2. Glue-in rod protrusion h_{sc} from the column bottom shall be according to *Table 6*.

   Protrusion from the column top shall be according to design drawings and it is derived from the thickness of the structure above and a needed protrusion for the column shoe.



3. Gluing shall be executed according to the glue manufacturer's technical specification and local regulations.

4. In case of plywood panel application, prior to points 1 – 3, the plywood panel itself shall be glued on the bottom surface of the column. The glue between surface of the timber column and plywood panel, shall be applied on the whole contact area, correspondingly to glue manufacturer's technical specification and local regulations. Both surfaces must fulfill the requirement of flatness to secure complete adhesion between materials. After gluing the plywood panel, the procedure of drilling and gluing the rods inside the holes, which is defined above, shall be applied.

Installation of column shoes

After glued-in rod installation and glue curing, column shoes can be installed. Installation is done by placing column shoes on the glued-in rods, followed by installation of special washers and nuts (*Figure 24*).

Figure 24. Installation of ROOCO® Column Shoes on the column

Special washers are part of the ROOCO® Column Shoe delivery, and nuts shall be part of the threaded bar assembly. Nuts placed on the bottom side of the top plate of the ROOCO® Column Shoe shall be snug-tightened. The contact surface between the column shoe and timber shall be flat and clean from the glue residue that would prevent the full contact area.

Installation in special situations with base plates, shear dowels, or dry connections shall be done according to design drawings and are outside of this manual's scope.

Erection of timber column on base structure (with vertical adjustment)

1. To level a timber column

Before erecting a column, the upper nuts and washers are removed from the anchor bolts. The lower nuts and washers are adjusted to the correct level. The column is erected directly onto the pre-leveled washers and nuts.

2. To align timber columns

The upper nuts and washers are screwed onto the bolts, and the column is aligned in the vertical position using leveling nuts. It is practical to use two theodolites from different directions to ensure verticality. The nuts can be tightened to the torque given in *Table 9* (Chapter 2 – Resistances) and *Table 13*. Greater values of T_{req} shall be specified by designer.

Table 13. T_{req} torque values of nuts connecting ROOCO® Column Shoe to a concrete foundation or steel flange of DELTABEAM®.

	ROOCO 16	ROOCO 20	ROOCO 24	ROOCO 30
T_{req} [Nm]	140	260	410	720

3. To grout joint and recesses

Before loading the column with any other structures, such as beams or columns, the joint underneath the column and bolt recesses should be grouted by following the instructions provided by the grout supplier. The grout must be non-shrink grade and with strength according to the design. To avoid air being trapped in the joint, it is recommended that grout is poured from one side of the column only. Grouting formwork is made to ensure adequate concrete cover for column shoes and anchor bolts (*Figure 25*).

After the grout has reached sufficient strength, the connection is finalized, and joining structures may be erected on the column.

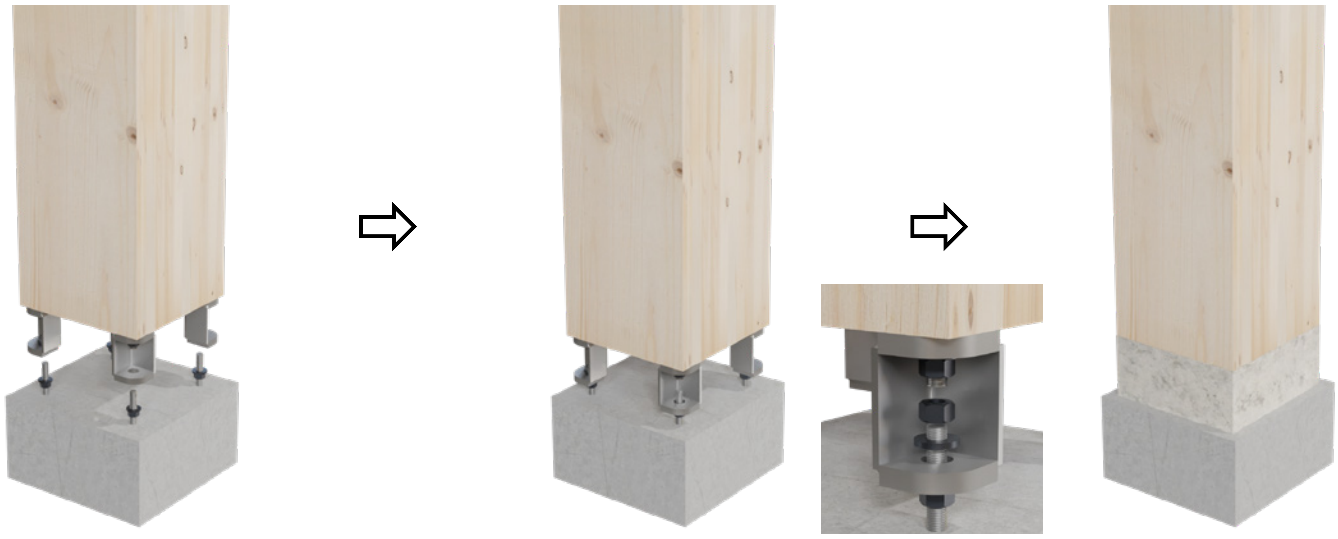


Figure 25. Installation of ROOCO® Column Shoes on foundation with vertical adjustment.

Erection of timber column on base structure (without vertical adjustment)

1. To install a timber column

Before erecting a column, the upper nuts and washers are removed from the threaded bars. Check the surface flatness of the support surface and column bottom to confirm compliance with design requirements. The column is erected directly onto the support surface.

The upper nuts and washers are screwed onto the threaded bars. The nuts are tightened to the torque given in *Table 13*. Greater values of T_{req} shall be specified by designer.

2. To grout joint and recesses

A column before grouting can take axial force and bending moment as specified in the design, and loading with other structures before grouting is only allowed if specified and allowed by the responsible structural engineer.

In all other cases, before loading the column with any other structures, such as beams or columns, the joint underneath the column and bolt recesses should be grouted by following the instructions provided by the grout supplier. The grout must be non-shrink grade and with strength according to the design. To avoid air being trapped in the joint, it is recommended that grout is poured from one side of the column only.

Grouting formwork is made to ensure adequate concrete cover for column shoes and threaded bars (*Figure 26*). After the grout has reached sufficient strength, the connection is finalized, and joining structures may be erected on the column.

Figure 26. Installation of ROOCO® Column Shoe on foundation without vertical adjustment.

Erection of timber column with dry connection

For dry connections, there can be different solutions that require different installation instructions. Thus, if a dry connection is chosen, then the designer and manufacturer should specify the installation procedure. ROOCO® Column Shoes installation requirements are the same as defined above.

Note:
Moisture protection of timber column is not part of this manual and shall be considered separately.

NOTES

Revisions

Version: PEIKKO GROUP 06/2024. Revision: 04

- Updated values and tables in Selection example.
- Defined plywood thicknesses in Annex A.

Version: PEIKKO GROUP 04/2024. Revision: 03

- Update of shear resistances of glued in rods with plywood panel.
- Updated Selection example.
- Updated Annex A.

Version: PEIKKO GROUP 08/2023. Revision: 02

- Correction to Figure 7.
- Updated Table 2 and Table 10.
- Temporary removal of selection example.
- Temporary removal of Annex A.

Version: PEIKKO GROUP 03/2023. Revision: 01

- First publication.

Resources

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