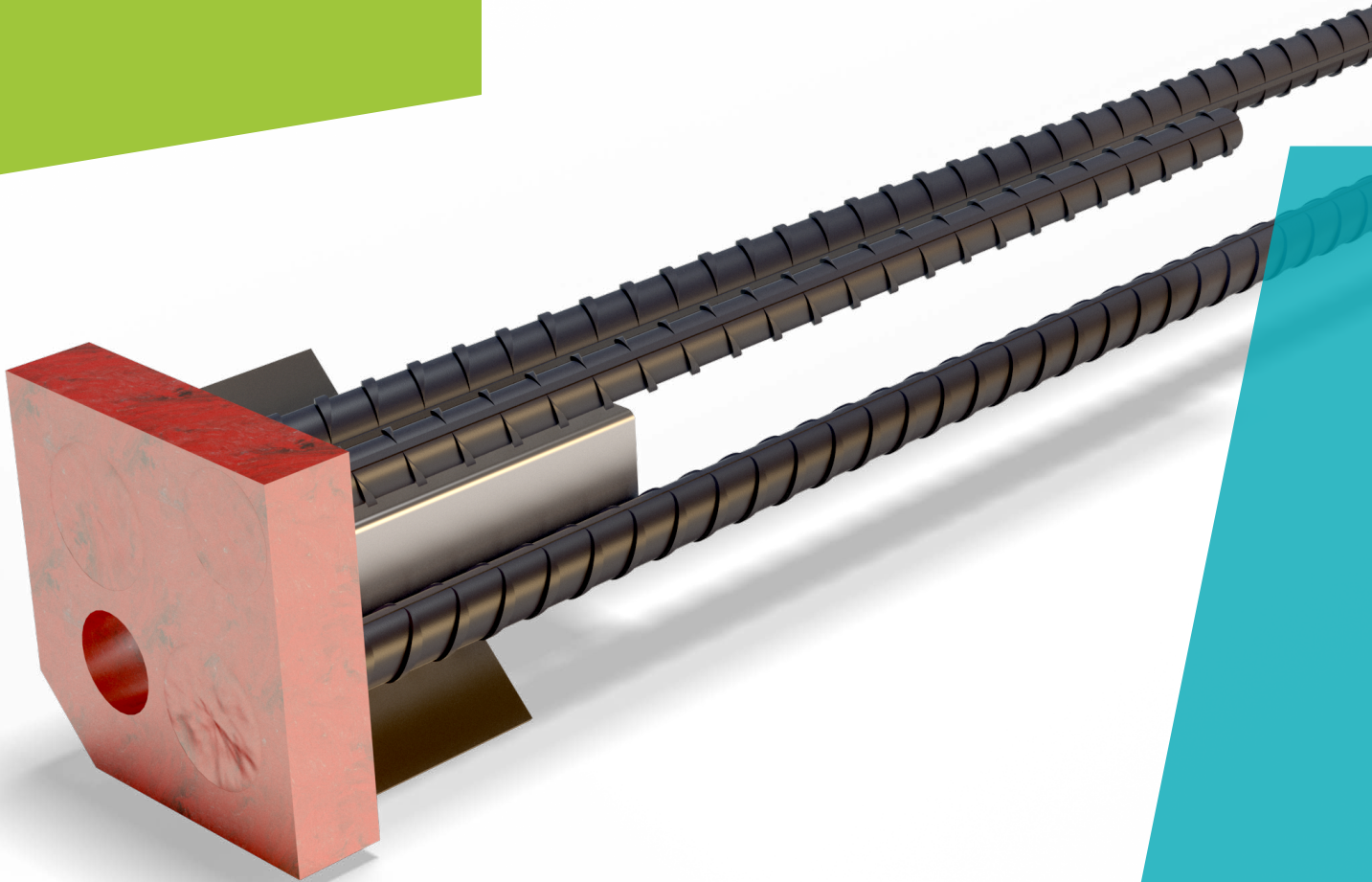


TECHNICAL MANUAL



BECO[®] Beam Shoe

Effective Bolted Beam-to Column Connections

Version PEIKKO GROUP 09/2022



BECO® Beam Shoe

For bolted beam-to-column connections

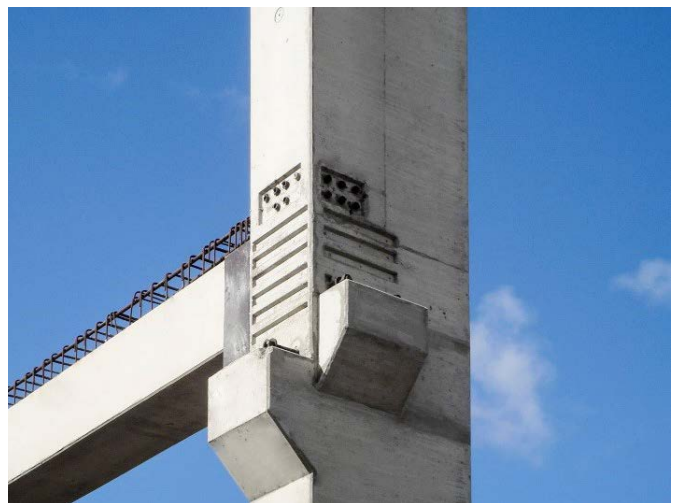
- Enables to create continuous precast beam system
- Quick, easy and cost-efficient erection of the beam
- No welding during assembly stage

BECO® Beam Shoes are construction products used to create cost-effective, moment-resisting connections between precast concrete columns and precast concrete beams.

The Beam-to-column Connection is made by Beam Shoes and Coupler Systems. The Beam Shoes are casted into precast concrete beams, while Anchoring Couplers are casted into columns. On the construction site the beams are erected on corbels, adjusted to the correct positions and fixed to the Anchoring Couplers with the help of threaded bars. The joint between beam and column should be grouted before loading the beam. After grout is hardened, the joint works as reinforced concrete structure.

BECO® Beam Shoes are used together with COPRA® Anchoring Couplers.

The BECO® Beam Shoe is designed according to Eurocode 2 and Eurocode 3.



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About BECO® Beam Shoe

1. Product properties

BECO® Beam Shoes are available in several standard models for most precast concrete column-beam connections. The system consists of:

- Beam Shoes
- Anchoring Couplers
- Accessories

BECO® Beam Shoes are used with COPRA® Anchoring Couplers to create precast concrete column-beam connections. Beam Shoes are cast into the end part of the concrete beam together with main and supplementary reinforcement, detailed in Appendix A to this manual. COPRA® Anchoring Couplers are cast into the column. The beam is usually attached to the column through beam shoes with threaded bars screwed into anchoring couplers (*Figure 1*). When using half precast concrete slabs, the beams are only coupled to the lower beam shoes and the upper connection is realized using Peikko MODIX® Rebar Couplers (*Figure 2*).

Figure 1. Precast concrete connection.

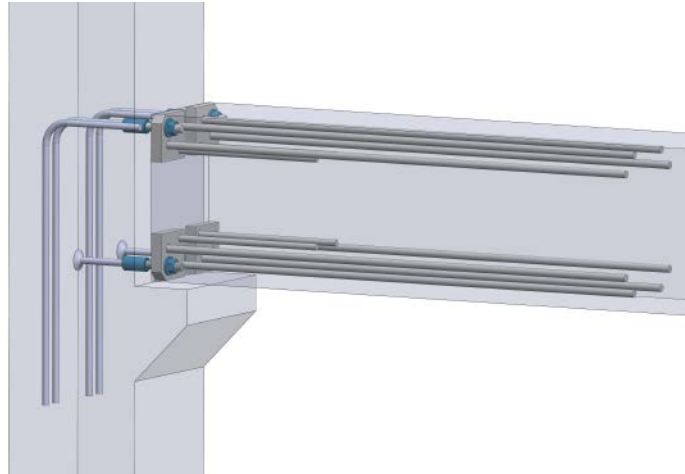
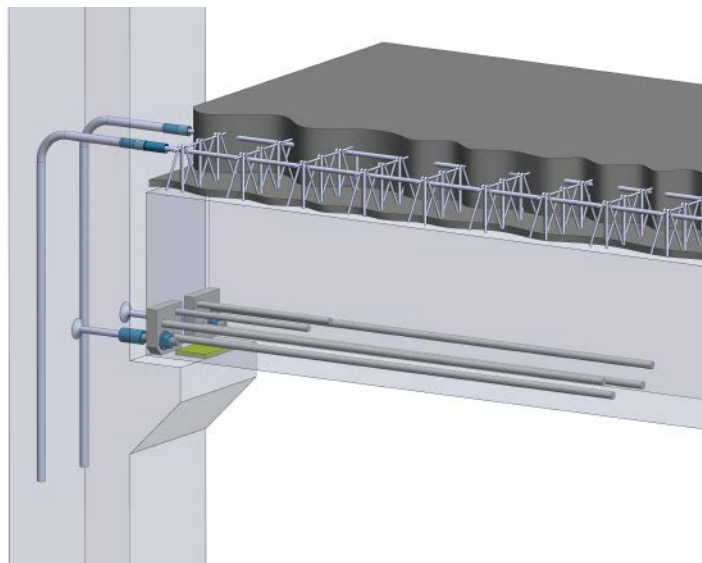
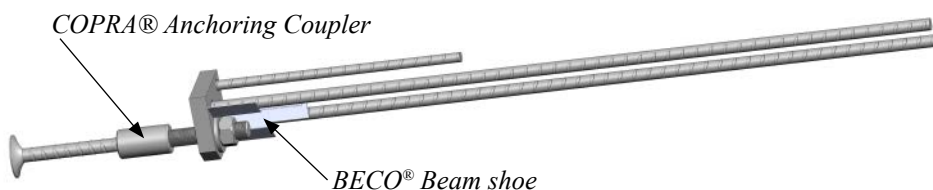


Figure 2. Half precast concrete connection.



The bolted connection offers sufficient assembly tolerances to adjust the beam to the correct position. The recesses and joint must be grouted and the grout substance must harden before the structure is used.

Figure 3. *Beam Shoe and Anchoring Coupler.*

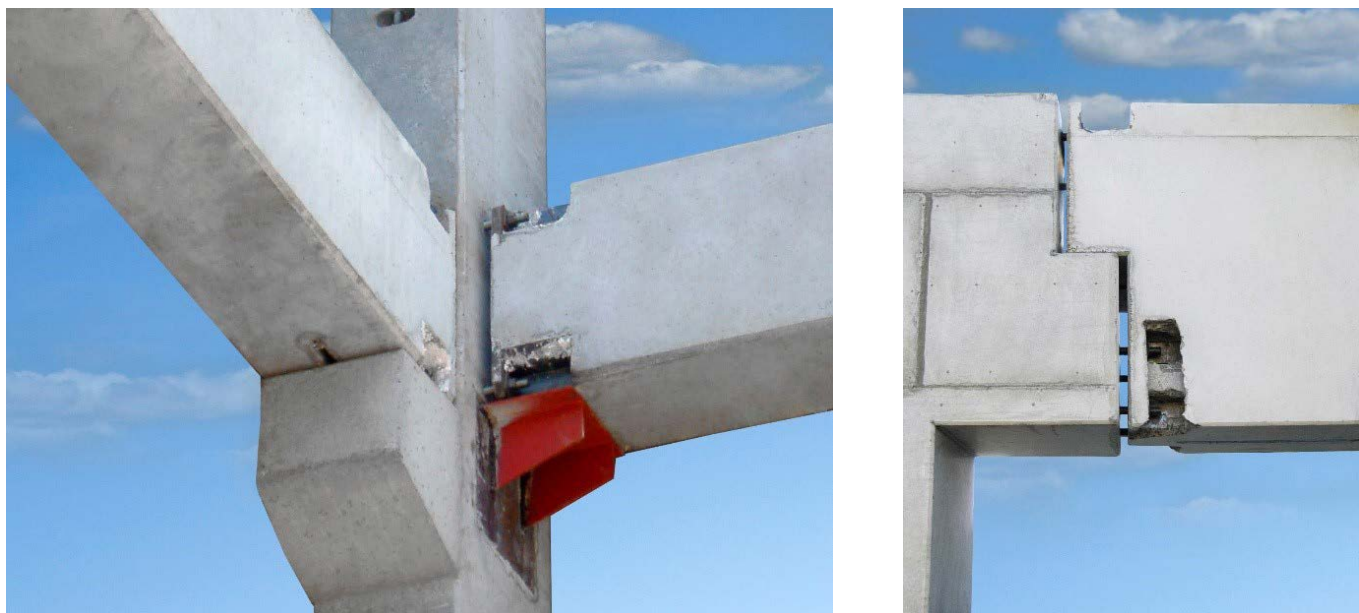


The design value resistances of BECO® Beam Shoes are equal to the design value resistances of the corresponding COPRA® Anchoring Couplers.

1.1 Structural behavior

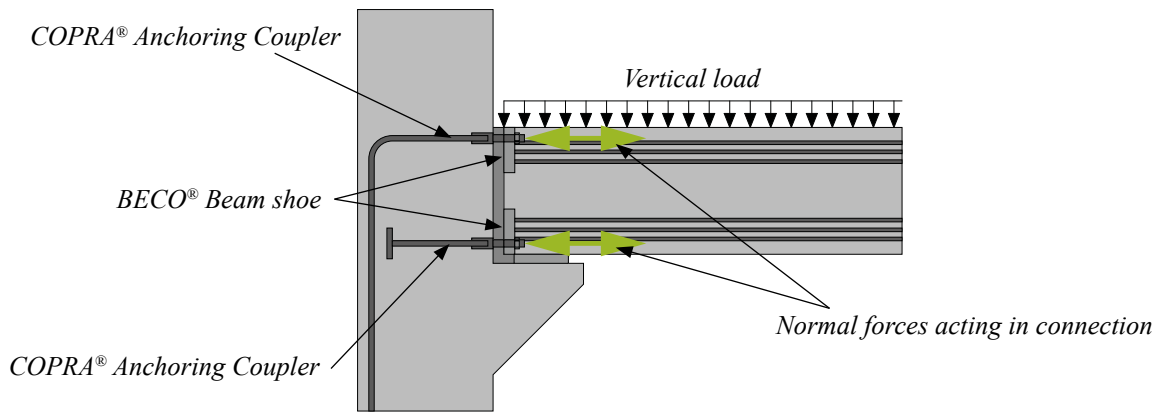
BECO® Beam Shoes are designed to carry only normal forces resulting from the bending of the beam. The vertical reactions of the beam are transferred to the column through separate supporting systems (such as corbels).

Figure 4. *Supporting systems for the beam.*



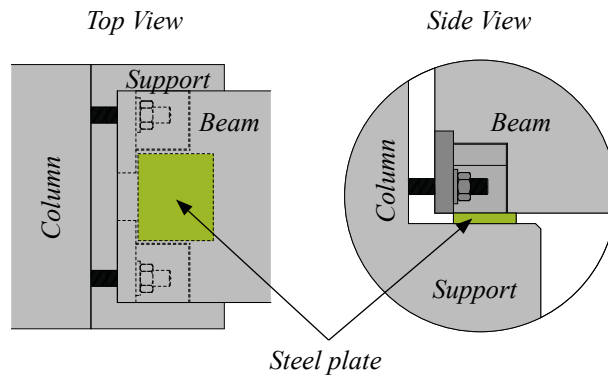
The joint between the beam end and the column should be filled with non-shrinking grout as soon as possible after installation. After the grout has hardened, the bending capacity of the joint is provided by coupling the tension force in BECO® Beam Shoes and the compressive force in the grout. The joint then behaves as a reinforced concrete section and can be designed according to the principles of EN 1992-1-1.

Figure 5. Structural behavior of the column-beam connection (example of usage).



Steel plates or shims should be used as bearings for vertical loads. These plates must be placed outside the BECO® Beam Shoe. (See Figure 6)

Figure 6. Position of steel/shim plate.



1.2 Application conditions

The standard BECO® Beam Shoe models are pre-designed to be used under the conditions mentioned in this section. If these conditions are not met, please contact Peikko’s Customer Engineering Service for custom-designed BECO® Beam Shoes.

1.2.1 Loading and environmental conditions

BECO® Beam Shoes are designed to carry static loads. Beam Shoes are designed to be used indoors and in dry conditions. When using BECO® Beam Shoes in other conditions, the surface treatment, concrete cover, or raw materials must be adequate with regard to the environmental exposure class and intended operating life.

1.2.2 Positioning of the beam shoe

The concrete cover of the beam shoe connection reinforcement is $c=30\text{mm}$ if the beam shoe is placed in the corner of the beam. A thicker concrete cover can be obtained by moving the shoe inside the cross section. The standard properties of BECO® Beam Shoes are guaranteed in reinforced concrete beams made of concrete grade C30/37 or higher. If these conditions are not met, please contact Peikko’s Customer Engineering Service for custom-designed BECO® Beam Shoes.

The structural properties of BECO® Beam Shoes are guaranteed only if supplementary reinforcement is provided in the beam in accordance with the rules set out in Appendix A to this Technical Manual. It should be noted that the supplementary reinforcement is used in addition to the main reinforcement designed to resist internal forces in the beam.

1.2.3 Application options

Figure 7. Installation of beams from the opposite sides of the column.

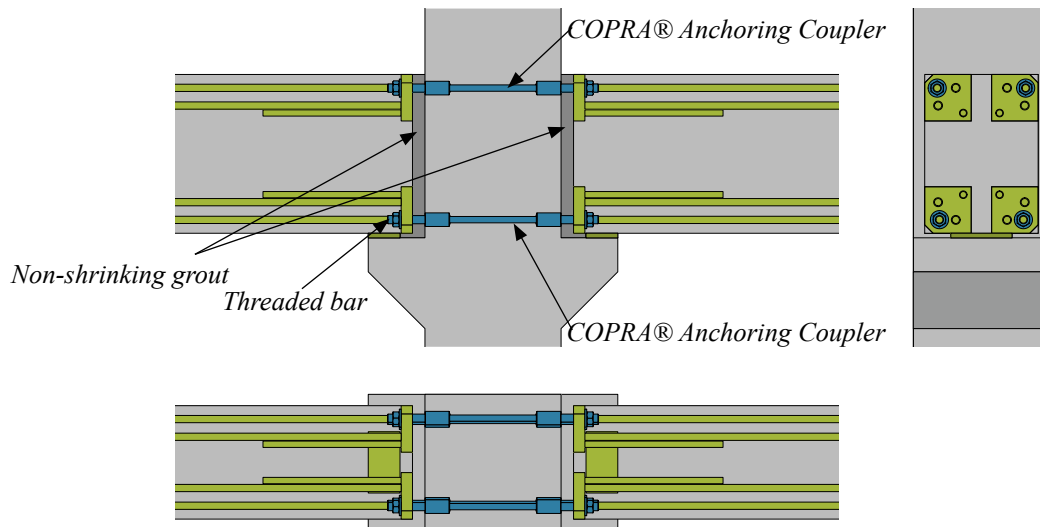


Figure 8. Installation of beams from the opposite sides of the column using a half-precast connection.

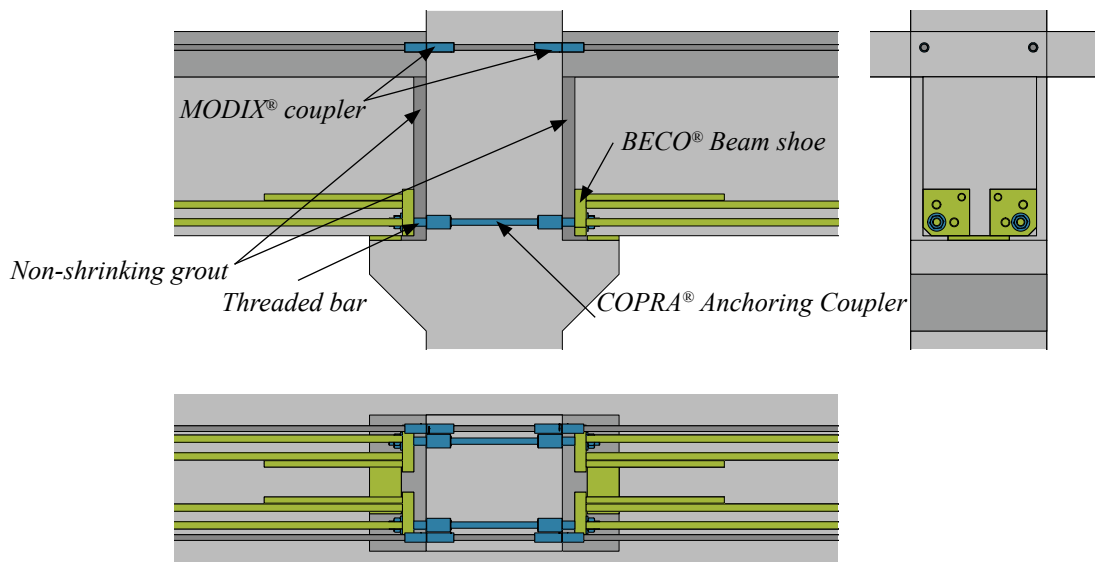
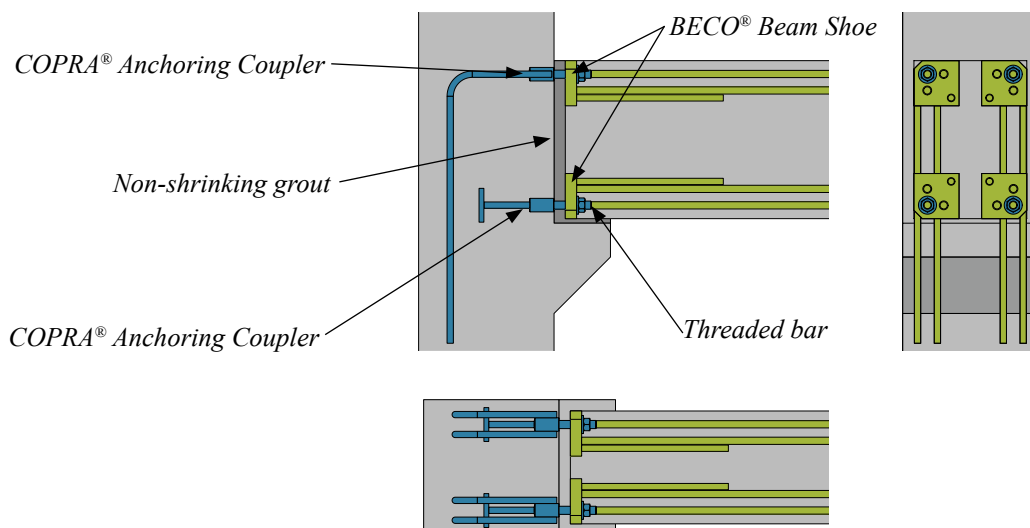


Figure 9. Installation of the beam from one side.



1.3 Other properties

BECO® Beam Shoes are made of steel plates and reinforcing bars with the following material properties:

Steel plates	S355J2+N	EN 10025-2
Ribbed bars	B500B	EN 10080

Peikko Group’s production units are externally controlled and periodically audited on the basis of production certifications and product approvals by various independent organizations.

The products bear the inspection mark, the emblem of Peikko Group, the type of product, and the year and week of manufacturing.

Figure 10. Dimension [mm] of the BECO® beam shoe.

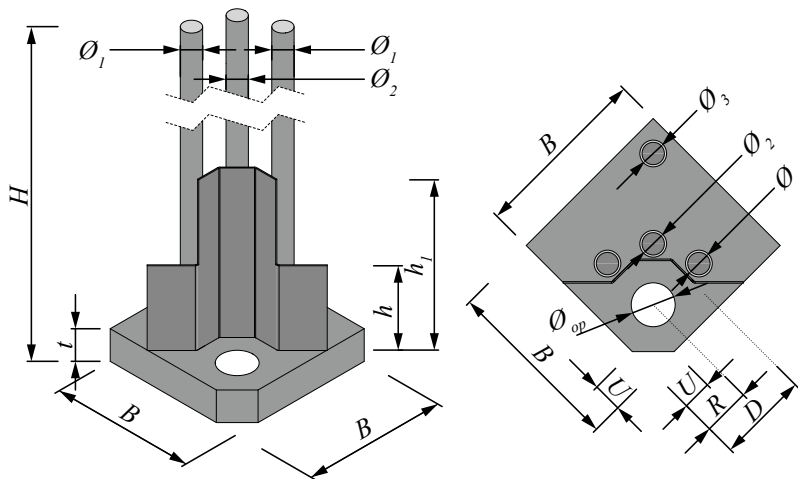


Table 1. Dimensions [mm], weights [kg], and color codes of Beam Shoes.

Beam Shoe	BECO® 16H	BECO® 20H	BECO® 24H	BECO® 30H	BECO® 39H	BECO® 30P	BECO® 36P	BECO® 39P	BECO® 45P	BECO® 52P
B	115	125	140	150	190	160	200	225	260	290
H	930	1085	1225	1625	2250	1850	2330	2105	2400	3140
t	15	20	25	35	45	40	50	50	60	80
R	50	50	50	50	60	50	60	60	60	60
U	30	30	30	30	37	30	37	37	37	37
D	80	80	85	90	115	90	110	115	125	130
h	80	90	90	100	130	100	110	130	125	150
h1	145	160	165	185	225	185	215	225	245	295
Ø1	12	16	20	25	32	28	32	28	32	40
Ø2	-	-	-	-	-	-	-	28	32	32
Ø3	10	12	16	20	28	20	28	28	32	32
Øop	27	30	35	40	55	40	50	55	60	70
Weight	3.5	6.2	10.3	19.6	43.9	27.0	47.2	52.0	79.6	133.3
Color code*	Yellow	Blue	Gray	Green	Orange	Black	Red	Brown	Purple	White

*Color code is marked on base surface of BECO® bottom plate.

Lap lengths of anchor bars are defined according to concrete grade C30/37 in good bond conditions. If beam shoes are used in poor bond conditions, please contact Peikko’s Customer Engineering Service for custom design.

2. Resistances

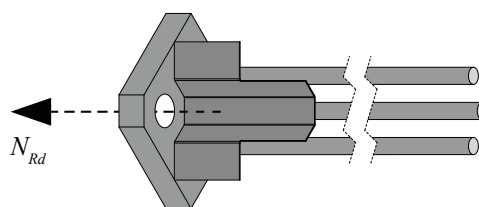
The resistances of BECO® Beam Shoes are determined by a design concept that makes reference to the following standards:

- EN 1992-1-1:2004/AC:2010
- EN 1993-1-1:2005/AC:2009
- EN 1993-1-8:2005

BECO® Beam Shoes are designed to withstand tensile forces corresponding to the design value resistances of COPRA® Anchoring Couplers. The maximum design value resistances of individual BECO® Beam Shoes are given in Table 2.

Table 2. Design value resistances of individual BECO® Beam Shoes for concrete grade C30/37.

Beam Shoe	Anchoring Coupler	N_{Rd} [kN]
BECO® 16H	COPRA® 16H-...*	62
BECO® 20H	COPRA® 20H-...*	96
BECO® 24H	COPRA® 24H-...*	139
BECO® 30H	COPRA® 30H-...*	220
BECO® 39H	COPRA® 39H-...*	383
BECO® 30P	COPRA® 30P-...*	299
BECO® 36P	COPRA® 36P-...*	436
BECO® 39P	COPRA® 39P-...*	521
BECO® 45P	COPRA® 45P-...*	697
BECO® 52P	COPRA® 52P-...*	938



* See the section entitled “Selecting connection components” for more information about product code of COPRA®

The maximum resistance of BECO® Beam Shoes is based on the tensile resistance of the COPRA® Anchoring Couplers N_{Rd} .

2.1 Fire resistance

The concrete cover of the anchoring coupler and the anchor bars of the beam shoes should be at least equivalent to the concrete cover of the reinforcement of the precast beam elements. If the fire resistance of the beam shoe connection is judged to be insufficient, the concrete cover of the beam shoe must be increased by increasing the dimensions of the precast beam or placing BECO® Beam Shoe more inside if the size of the cross section allows it.

Selecting BECO® Beam Shoe

The following aspects must be considered when designing the column-beam connection using BECO® Beam Shoes and COPRA® Anchoring Couplers:

- **Resistance**
- **Position and arrangement of the beam shoes**
- **Properties of the concrete column**

Resistance:

External forces (dead load, vertical load) acting on the precast beam generate a bending moment. Distribution of forces as shown in *Figure 5* leads to normal forces acting on the connection. The normal forces must be determined within the global analysis of the structure in accordance with relevant design standards. Appropriate models of beam shoe and anchoring coupler are selected to ensure that they have sufficient resistance compared to the design value of tensile force in the connection (see *Table 2*).

Design example:

- Tensile force in connection (per beam shoe)
 $N_{Ed} = 356.0 \text{ kN}$

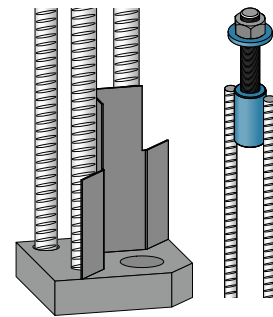
Selected anchoring coupler and beam shoe:

- Beam Shoe **BECO® 39H**
- Anchoring coupler **COPRA® 39H-...**
- Resistance element $N_{Rd} = \mathbf{383.4 \text{ kN}}$

$$N_{Ed} < N_{Rd}$$

$$356.0 \text{ kN} < 383.4 \text{ kN}$$

Figure 11. BECO® Beam Shoe and COPRA® Anchoring Coupler.



Position and arrangement of the beam shoes

The beam shoes are cast into the end part of the concrete beam and in the corners of the cross-sections of the concrete beam. At least two beam shoes need to be used in connection for half-precast concrete connections (*Figure 8*). In normal precast connections, it is recommended to use at least four beam shoes at each end of the beam.

The minimum dimensions of the concrete beam and distances between couplers are in *Table 3* and *Table 4*. Fire resistance, environmental conditions and placement of main reinforcement must be considered when defining dimensions of structures. If minimum distances are not met, please contact Peikko's Customer Engineering Service.

Table 3. Minimum dimensions of concrete beams.

Beam	BECO® 16H	BECO® 20H	BECO® 24H	BECO® 30H	BECO® 39H	BECO® 30P	BECO® 36P	BECO® 39P	BECO® 45P	BECO® 52P
$a_{b,min}$	240	260	290	310	390	330	410	460	530	590
$b_{b,min}$	240	260	290	310	390	330	410	460	530	590

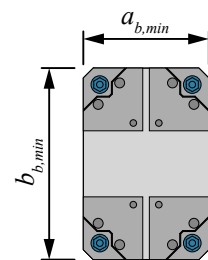
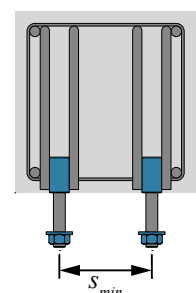


Table 4. Minimum distance between COPRA® Anchoring Couplers in column.

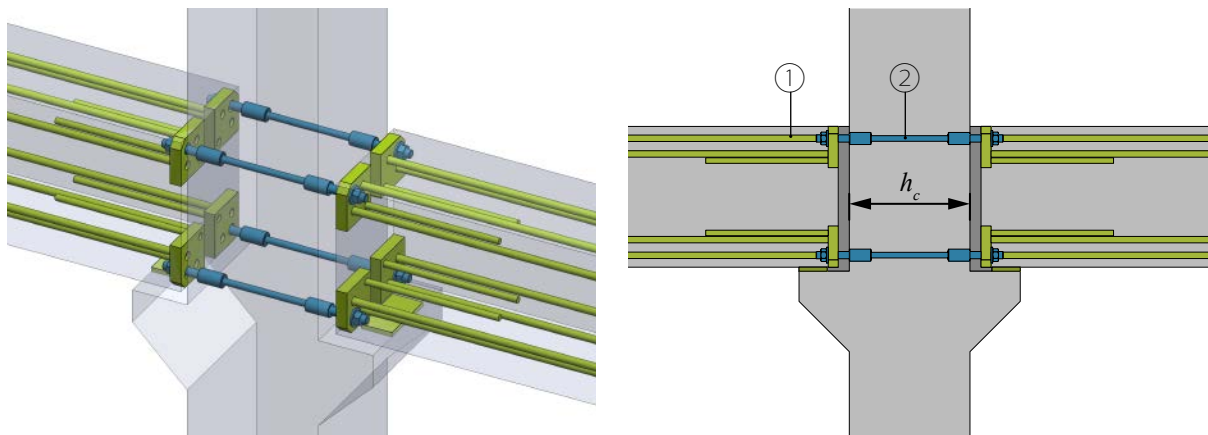
Beam	BECO® 16H	BECO® 20H	BECO® 24H	BECO® 30H	BECO® 39H	BECO® 30P	BECO® 36P	BECO® 39P	BECO® 45P	BECO® 52P
s_{min}	140	160	190	210	270	230	290	340	410	470



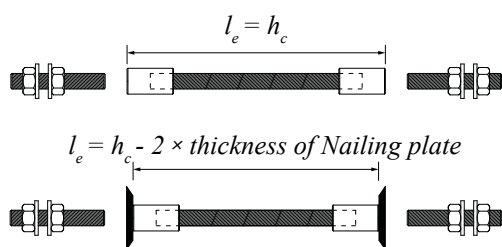
Properties of the connection

- **Double-sided solution**

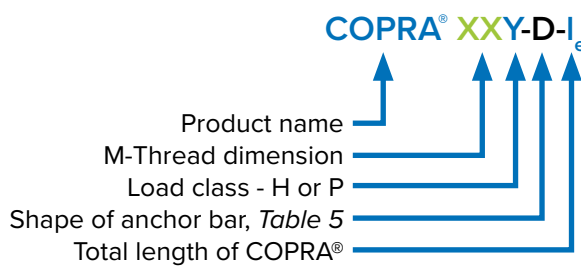
For double-sided connections, COPRA® is symmetric and consists of two threaded muffs connected with a threaded bar (see the figure below).



Used COPRA® Anchoring Couplers:



Product code:



Example: COPRA® 39H-D-600

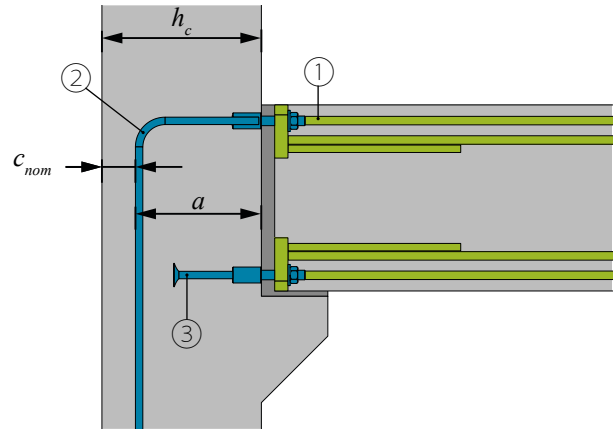
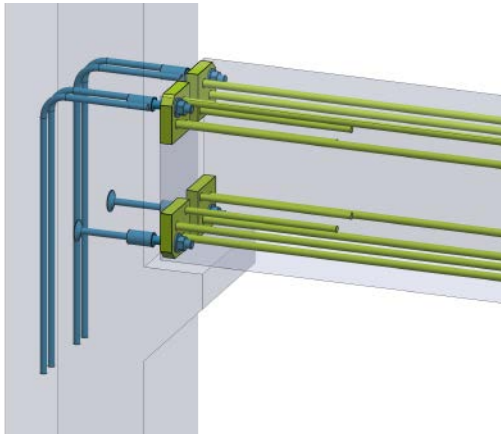
System product code:

1. BECO® 39H 2. COPRA® 39H-D-600

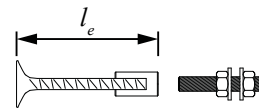
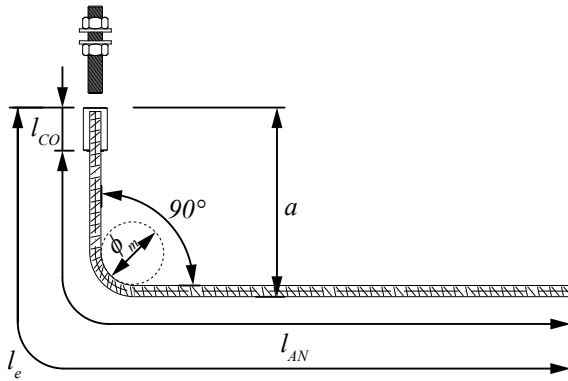
NOTE: Nailing plates should be taken into account only in cases where they are used. More information can be found in COPRA® Technical manual.

• **Single-sided solutions**

For single-sided connections, COPRA® consists of one threaded muff and an anchorage part. The standard types of single-sided COPRA® Anchoring Coupler are shown in the figure below.



Used COPRA® Anchoring Couplers:



Product code: **COPRA® XXY-P12-I (a-(dXX)*)**

Product code: **COPRA® XXY-L-I_e**

- Product Name
- M-Thread dimension
- Load class - H or P
- Shape of anchor bar, *Table 5*
- Total length of COPRA®
- Length [mm]
- Mandrel diameter ϕ_m

- Product Name
- M-Thread dimension
- Load class - H or P
- Shape of anchor bar, *Table 5*
- Total length of COPRA®

Example: COPRA® 39H-L-430

* Mandrel diameter must be defined only if value differs from minimum requirements of EN 1992-1-1 section 8.3

$$a \geq a_{min}$$

$$l_e = l_{co} + l_{AN}$$

l_{co} - length of coupler (table below)
 l_{AN} - anchor length of bar acc. EN 1992-1-1.

	a_{min}	l_{CO}		a_{min}	l_{CO}
COPRA® 16H	205	48	COPRA® 30P	315	90
COPRA® 20H	255	60	COPRA® 36P	365	108
COPRA® 24H	315	72	COPRA® 39P	375	120
COPRA® 30H	395	90	COPRA® 45P	430	135
COPRA® 39H	490	120	COPRA® 52P	570	160

Example: COPRA® 39H-P12-1050(570)



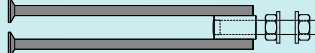
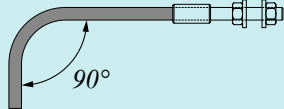
System product code:

1. BECO® 39H

2. COPRA® 39H-P12-1050(570)

3. COPRA® 39H-L-430

Table 5. End types & bending shapes of COPRA® Anchoring Coupler. Shape codes acc. to EN ISO 3766.

	P - Straight end		D - Double sided		L - Headed stud
P		D		L	
P12					

NOTE: P, D or L letters describe end type of anchor bar, but numbers after letter - bending shape.

Appendix A – Supplementary reinforcement

Supplementary reinforcement

Transverse reinforcement must be provided for the beam in the zones where the anchorage bars overlap the main reinforcement of the beam according to the principles of EN 1992-1-1. Stirrups must be provided in addition to shear reinforcement of the beam. The diameter (d_{st}), the number (n), and the position of the stirrups should be determined according to Table 6 and Figure 12.

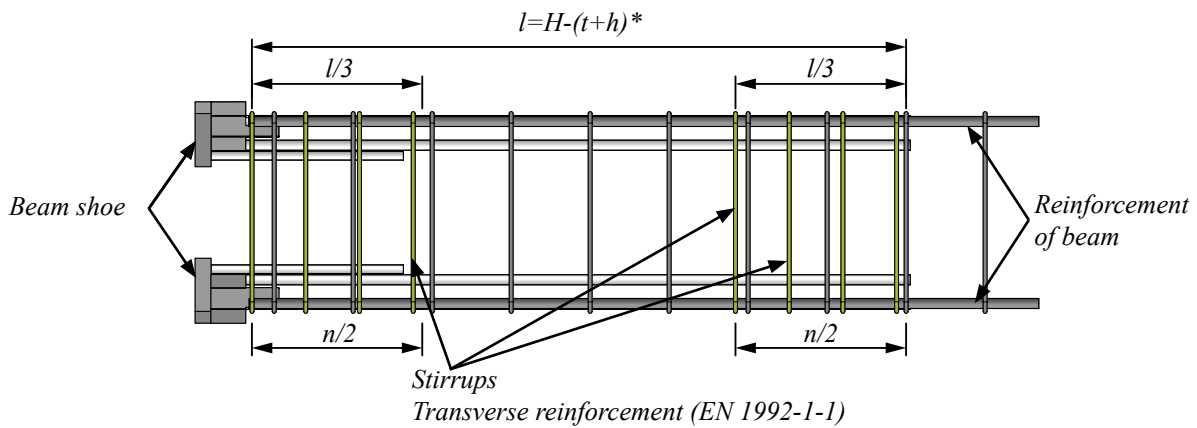
Table 6. Design of transverse reinforcement.

	BECO® 16H	BECO® 20H	BECO® 24H	BECO® 30H	BECO® 39H	BECO® 30P	BECO® 36P	BECO® 39P	BECO® 45P	BECO® 52P
d_{st} [mm]	-	-	10	12	14	12	14	14	14	16
n	-	-	8	10	12	10	12	12	16	18

Shear reinforcement according EN 1992-1-1 chapter 9 is required.

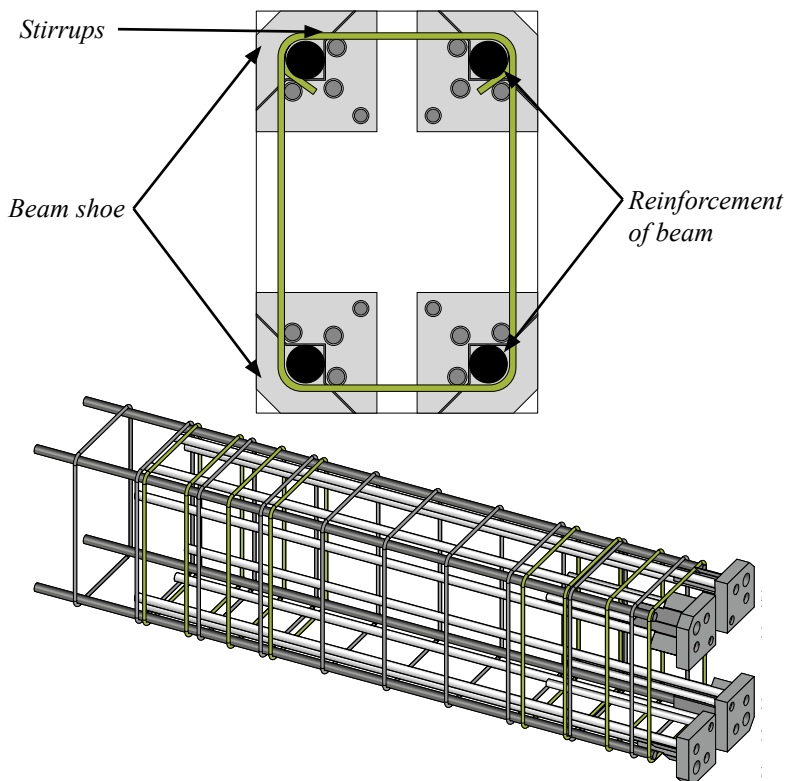
Figure 12. Transverse reinforcement in the overlap zone.

Side view:



* Dimensions are according Table 1.

Cross section view:



Installation of BECO® Beam Shoe

INSTALL THE PRODUCT – PRECAST FACTORY

Identification of the product

BECO® Beam Shoes are available in standard models analogous to the M-thread sizes of the COPRA® Anchoring Couplers. The model of the beam shoe can be identified by the name on the product's label and also the color of the product. The color codes are shown in the table below.

Color identification of BECO® Beam Shoe with corresponding COPRA® Anchoring Coupler.

Beam Shoe	Anchoring Coupler	Color Code
BECO® 16H*	COPRA® 16H-...	Yellow
BECO® 20H*	COPRA® 20H-...	Blue
BECO® 24H*	COPRA® 24H-...	Grey
BECO® 30H*	COPRA® 30H-...	Green
BECO® 39H*	COPRA® 39H-...	Orange
BECO® 30P*	COPRA® 30P-...	Black
BECO® 36P*	COPRA® 36P-...	Red
BECO® 39P*	COPRA® 39P-...	Brown
BECO® 45P*	COPRA® 45P-...	Purple
BECO® 52P*	COPRA® 52P-...	White

* Color code is marked on base surface of BECO® bottom plate.

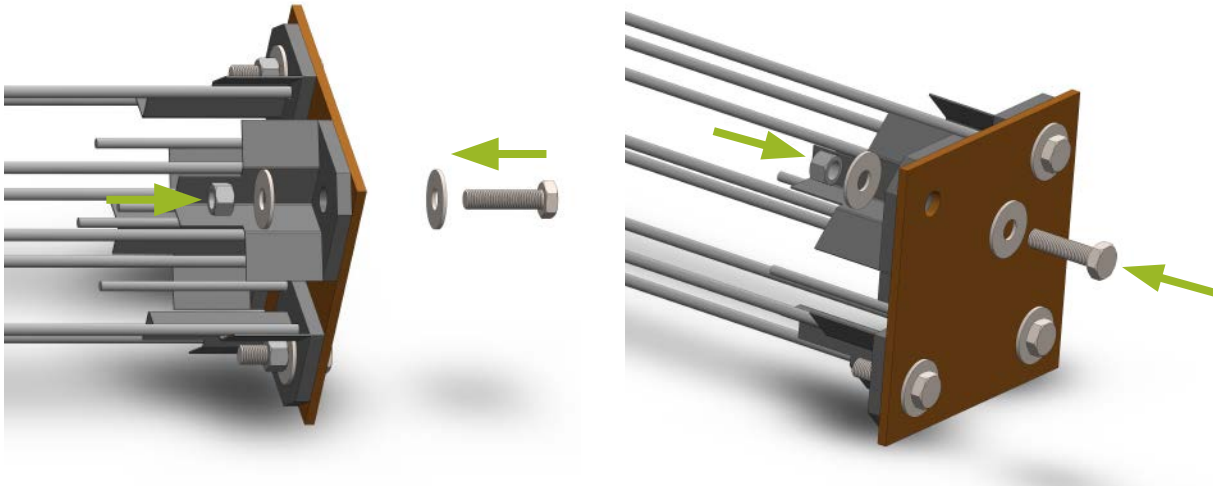


Installation of the beam shoes

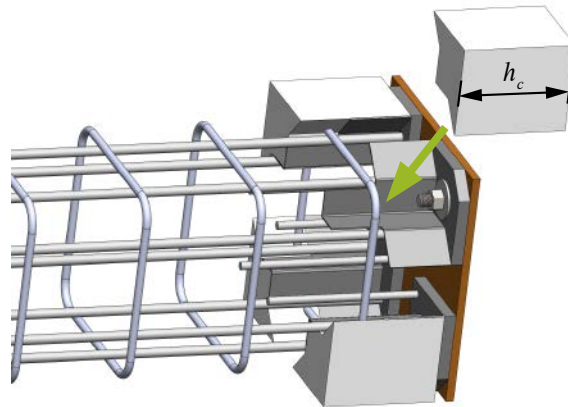
BECO® Beam Shoes are placed into the reinforcement and fixed to the mold's end plate with bolts. Before concreting, the beam recess box must be filled with an additional element (Styrofoam) to ensure that there is a sufficient cavity for the insertion of the threaded bar, and the threaded bar should then be tightened. After the concrete has hardened, the additional element should be removed. Supplementary reinforcement must be provided in accordance with Appendix A. The maximum installation tolerances of the beam shoe in the precast beam element are ± 2 mm.

INSTALLING

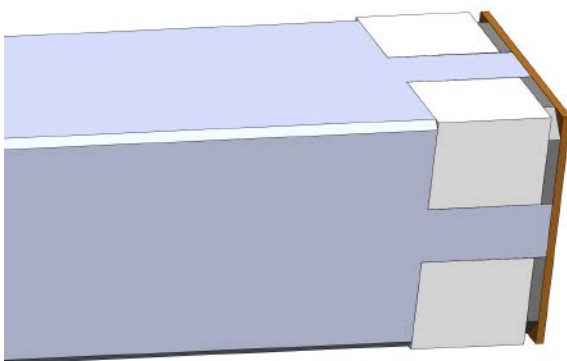
Installation of a BECO® Beam Shoe into a mold.



Installation of polystyrene recess block.



Concreting beam.



Removing additional element.

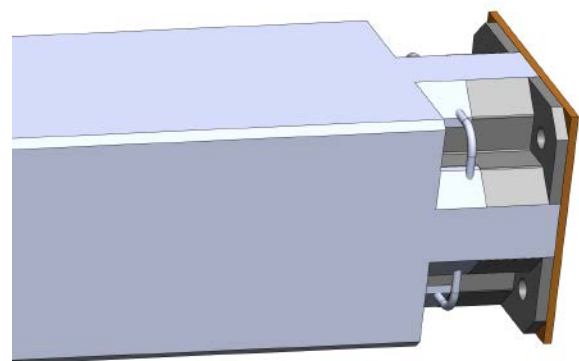


Table 7. Height of polystyrene recess block in mm.

	BECO® 16H	BECO® 20H	BECO® 24H	BECO® 30H	BECO® 39H	BECO® 30P	BECO® 36P	BECO® 39P	BECO® 45P	BECO® 52P
h_c	130	145	166	195	245	195	220	245	263	320



Please note, polystyrene recess box and installation bolts with washers are not part of the Peikko's delivery. Those must be supplied separately.

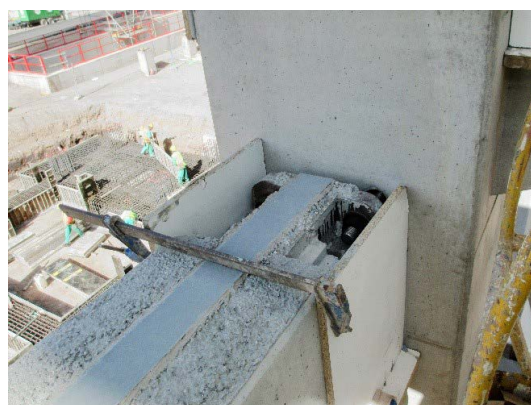
INSTALL THE PRODUCT – CONSTRUCTION SITE

Identification of the product

BECO® Beam Shoes are available in standard models analogous to the M-thread sizes of the COPRA® Anchoring Couplers. The model of the beam shoe can be identified by the name on the product's label and also the color of the product. The color codes are shown in the table below.

Color identification of BECO® Beam Shoe with corresponding COPRA® Anchoring Coupler.

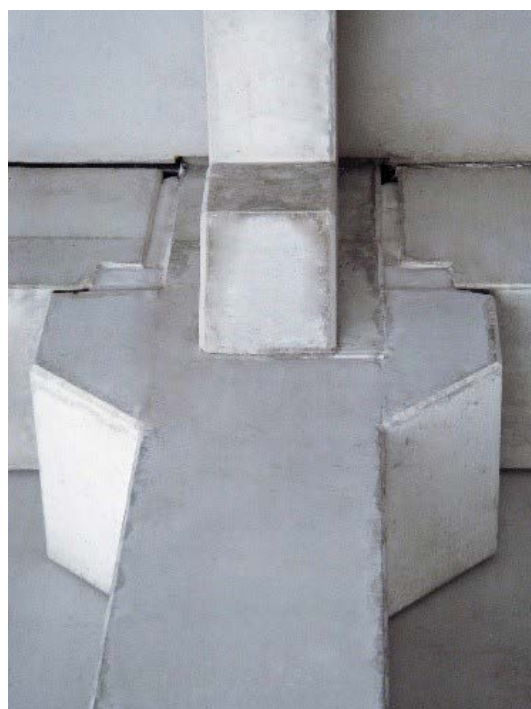
Beam Shoe	Anchoring Coupler	Color Code
BECO® 16H*	COPRA® 16H-...	Yellow
BECO® 20H*	COPRA® 20H-...	Blue
BECO® 24H*	COPRA® 24H-...	Grey
BECO® 30H*	COPRA® 30H-...	Green
BECO® 39H*	COPRA® 39H-...	Orange
BECO® 30P*	COPRA® 30P-...	Black
BECO® 36P*	COPRA® 36P-...	Red
BECO® 39P*	COPRA® 39P-...	Brown
BECO® 45P*	COPRA® 45P-...	Purple
BECO® 52P*	COPRA® 52P-...	White



* Color code is marked on base surface of BECO® bottom plate.

Erection of a precast beam

When erecting the beam on the corbel, the position of the beam in the vertical direction may be adjusted using shims or steel plates on the corbel. The element must be checked to ensure that it is in the correct position before the nuts are tightened using a slogging ring wrench (DIN 7444) and a 1.5 kg sledgehammer or equivalent. The threaded bars must be screwed to the COPRA® Anchoring Couplers. The nuts must be screwed on tightly. After the nuts have been tightened, the crane can be detached from the beam. The joint of the element can then be grouted with mortar. The grout must be of a non-shrinking type. After the grout has reached sufficient strength, the connection is finalized. The installation must be carried out according to the erection plan.



The tolerances and the thickness of the joint are shown in *Table 8*.

	M16	M20	M24	M30	M36	M39	M45	M52
d_A	42	50	56	71	85	92	110	125
s_w	24	30	36	46	55	60	70	80

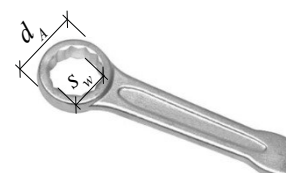
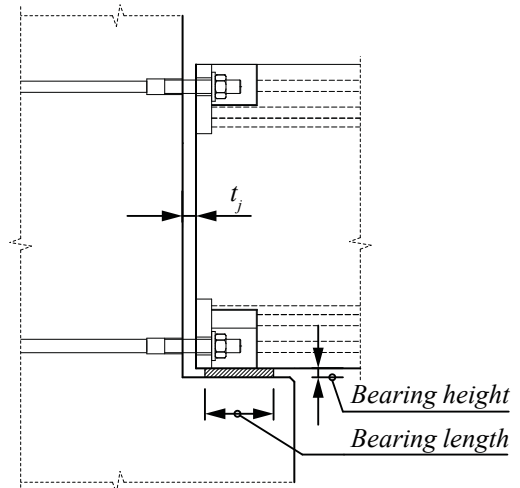


Table 8. Recommendations for tolerances.

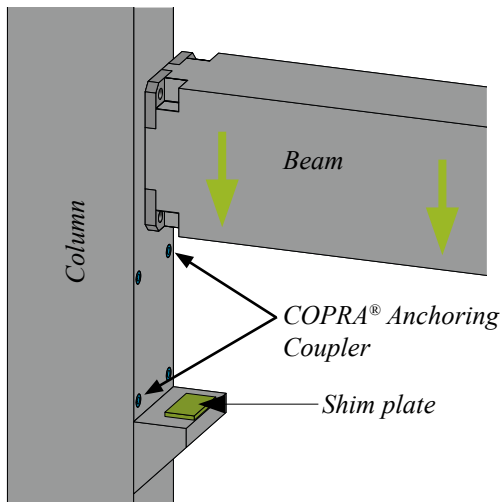
Beam Shoe	Anchoring Coupler	Joint thickness t_j [mm]	Tolerance of the joint [mm]
BECO® 16H	COPRA® 16H	20	± 5
BECO® 20H	COPRA® 20H	20	± 5
BECO® 24H	COPRA® 24H	20	± 5
BECO® 30H	COPRA® 30H	20	± 5
BECO® 39H	COPRA® 39H	20	± 8
BECO® 30P	COPRA® P30	20	± 5
BECO® 36P	COPRA® 36P	20	± 7
BECO® 39P	COPRA® 39P	20	± 8
BECO® 45P	COPRA® 45P	20	± 7
BECO® 52P	COPRA® 52P	20	± 9



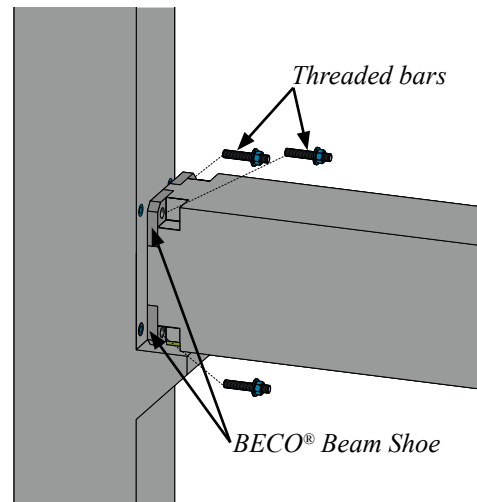
For alternative joint thickness solutions, please contact Peikko's Customer Engineering Service.

Erection of a precast concrete beam with beam shoes step by step.

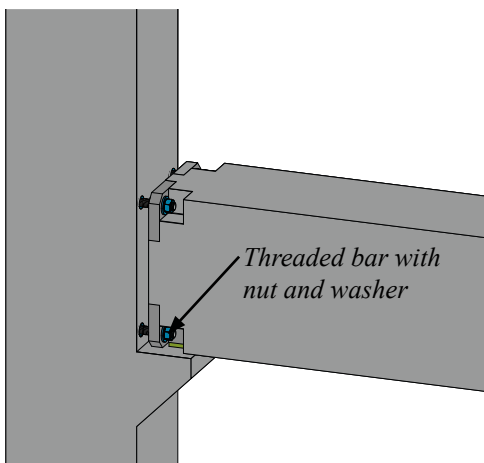
Install the beam on pre-leveled shim plates.



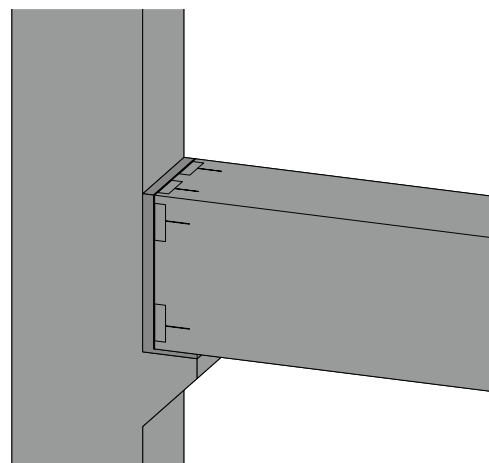
Insert the threaded bars with washers and nuts through the base plates into the coupler parts of the anchoring couplers.



Screw the nuts, washers and threaded bars on and tighten them.

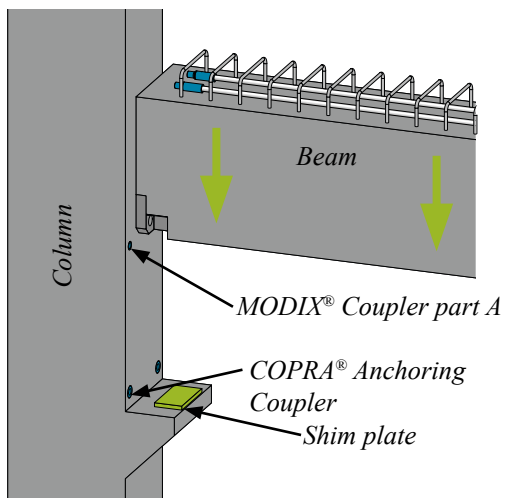


The connection is finalized after the grout has hardened.

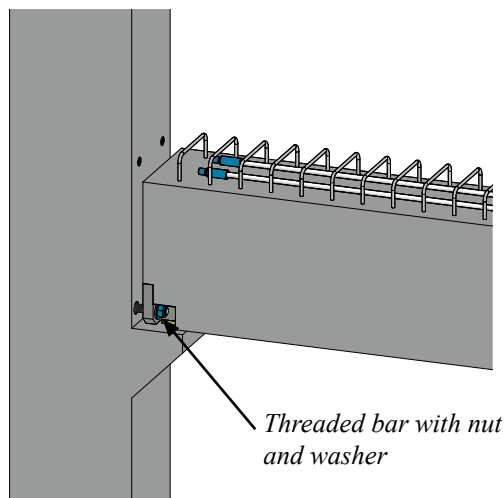


Erection of a precast concrete beam with half precast concrete slab step by step.

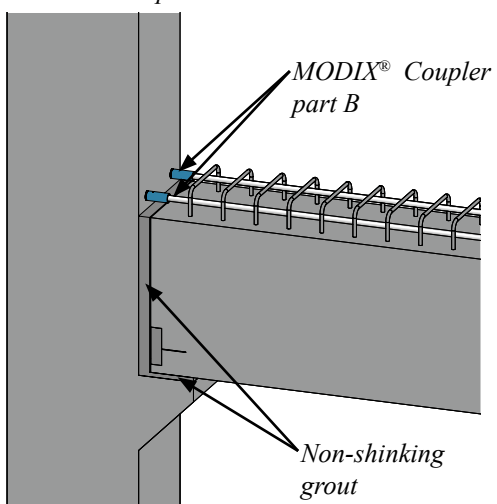
Installed the beam on pre-leveled shim plates.



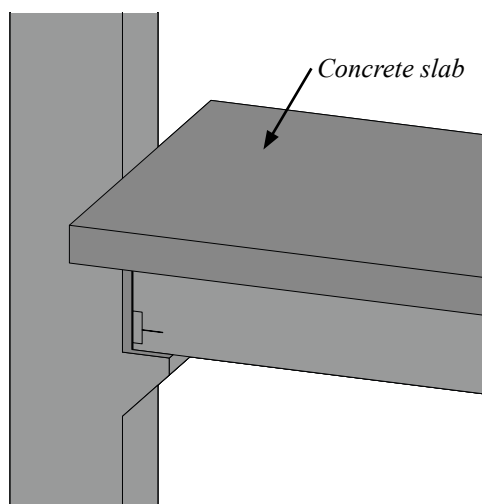
Screw the nuts, washers and threaded bars on and tighten them.



Fill the connection with grout and screw on the MODIX® Rebar Couplers.

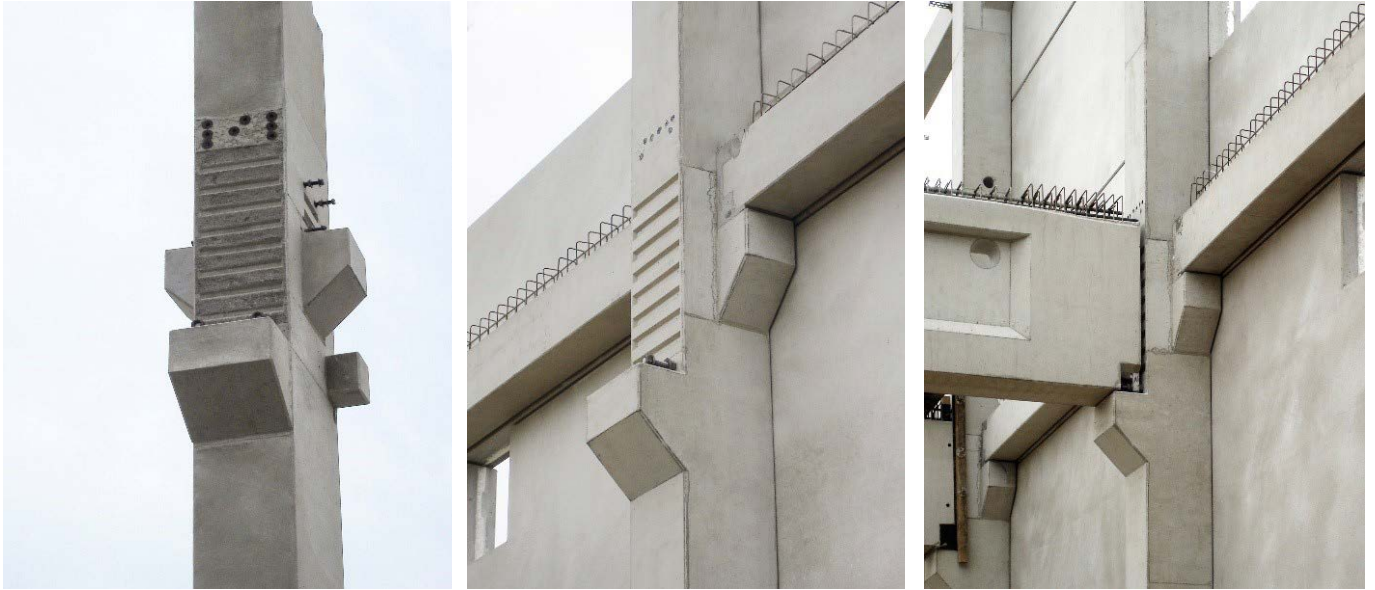


Finalize construction with the concrete slab.

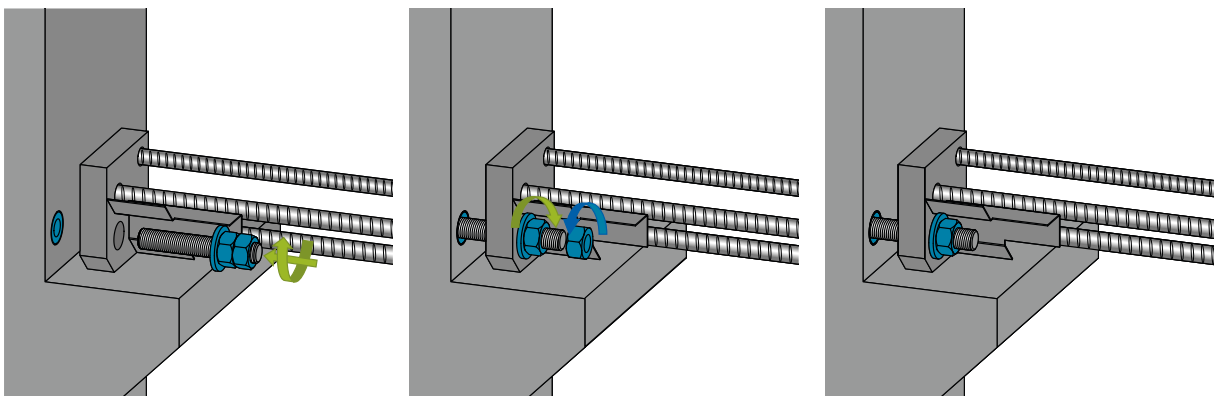
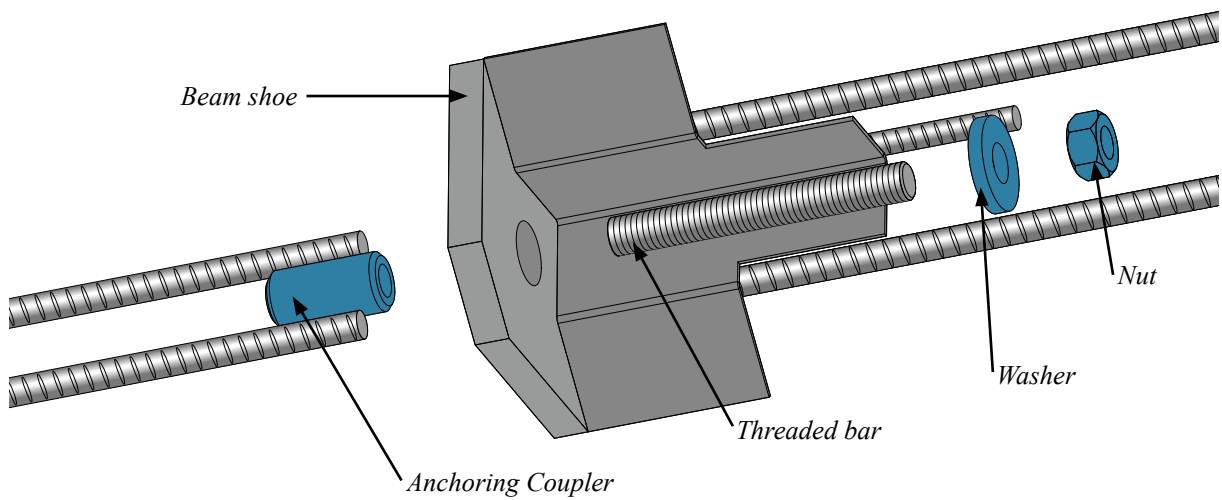


INSTALLING

Erection of a precast concrete beam.



Connecting a COPRA® Anchoing Coupler with a BECO® Beam Shoe with the help of a threaded bar step by step.



Technical Manual Revisions

Version: PEIKKO GROUP 09/2022. Revision: 003

- Update to Table 1.

Version: PEIKKO GROUP 03/2019. Revision: 002

- Revision of installation figures
- Branding brought up to 2018 styles.

Version: PEIKKO GROUP 11/2015. Revision: 001*

- New cover design for 2018 added.

Resources

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Use our powerful software every day to make your work faster, easier and more reliable. Peikko design tools include design software, 3D components for modeling programs, installation instructions, technical manuals and product approvals of Peikko's products.

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