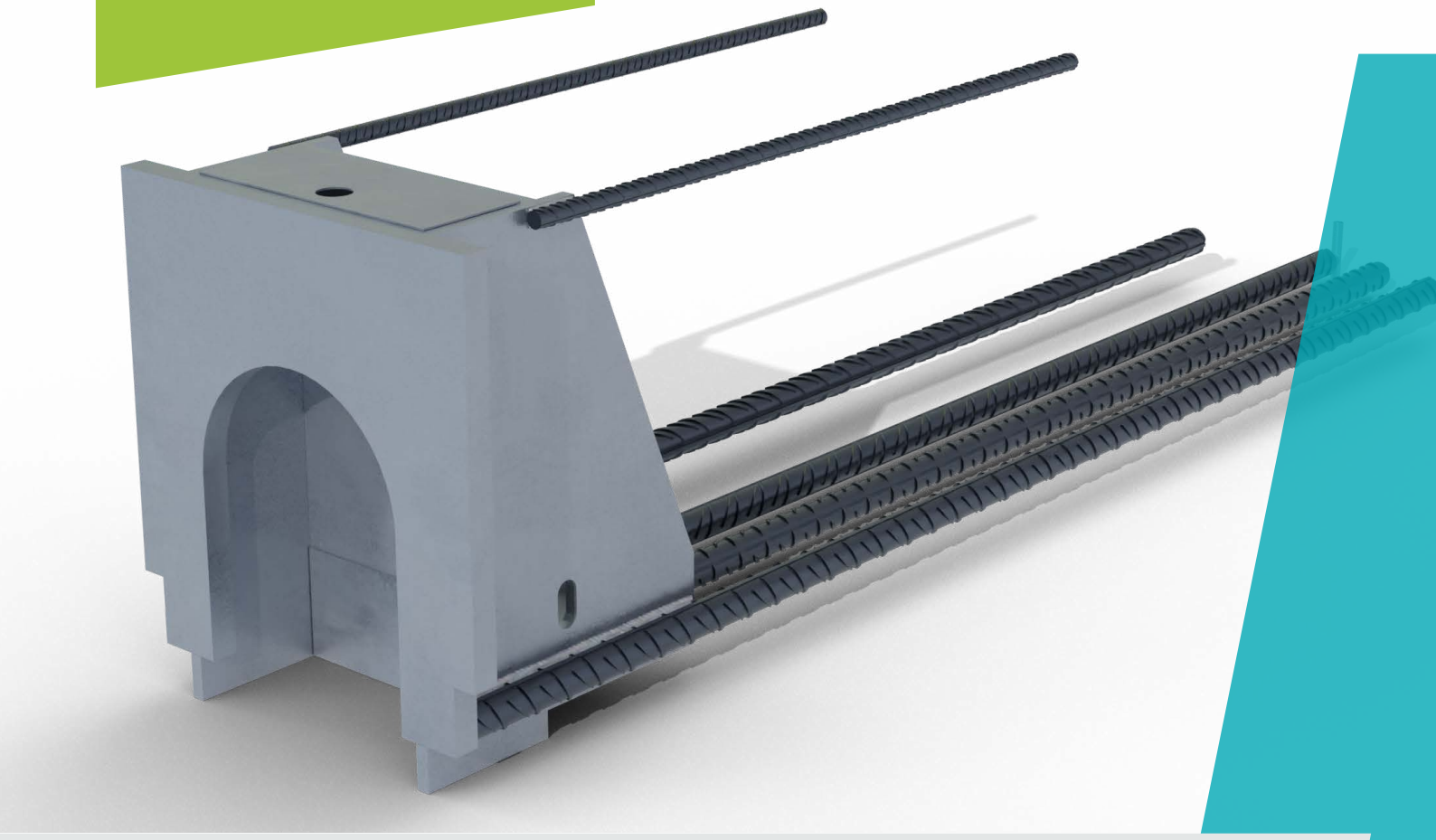
TECHNICAL MANUAL



PC® Beam Shoe

Hidden beam shoe for corbel system

Version PEIKKO GROUP 05/2022

peikko®

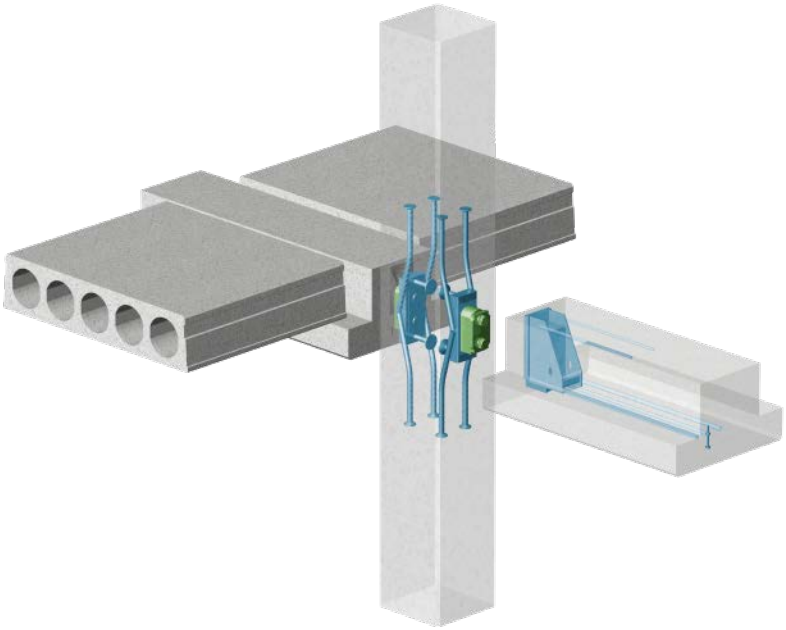
PC® Beam Shoe

Hidden beam shoe for corbel system

- Easy and fast beam installation.
- Fits into low beams and slabs.
- Hidden and esthetic connection.

PC® Beam Shoe is a building product used with PCs® Corbel as vertical support between reinforced or prestressed concrete beams and reinforced concrete columns or walls. It consists of steel plates that form a pocket for the corbel and reinforcing bars that anchor forces into the beam. PC® Beam Shoe is cast to the beam, where all parts of the beam shoe are hidden.

PC® Beam Shoe is dimensioned to be used with PCs® Corbel so that the final position of the beam installed on the corbel can be adjusted. After the corbel plate of PCs® Corbel is bolted to the column plate, the PCs® Corbel system may be used without any other additional actions in the factory or on-site (wedging, welding, etc). The standard models of PC® Beam Shoes are designed to withstand vertical and horizontal loads with a maximum design value of vertical load to 1500kN.



peikko®

www.peikko.com

CONTENTS

About PC® Beam Shoe

1. Product properties

Standard PC® Beam Shoes are always composed of steel plates creating a pocket for PCs® Corbel and bearing parts for a concrete beam.

PC® Beam Shoe is cast into beam together with the main reinforcement of the beam; supplementary reinforcement to ensure the interaction between the PC® Beam Shoe and the rest of the beam has to be provided. This supplementary reinforcement is detailed in this Technical Manual (Annex A).

Opening in PC® Beam Shoe end plate fits the shape of PCs® Corbel plate. This ensures the transfer of vertical load to the column or wall. Horizontal forces are transferred through the contact of beam shoe end plate and washer plate of PCs® Corbel.

The joint of PCs® Corbel and PC® Beam Shoe is not visible in the final construction. Some of the steel parts of the PC® Beam Shoe can be visible when the PC® Beam Shoe is placed at the bottom of the beam. However, no part of the joint stands out from the final construction!

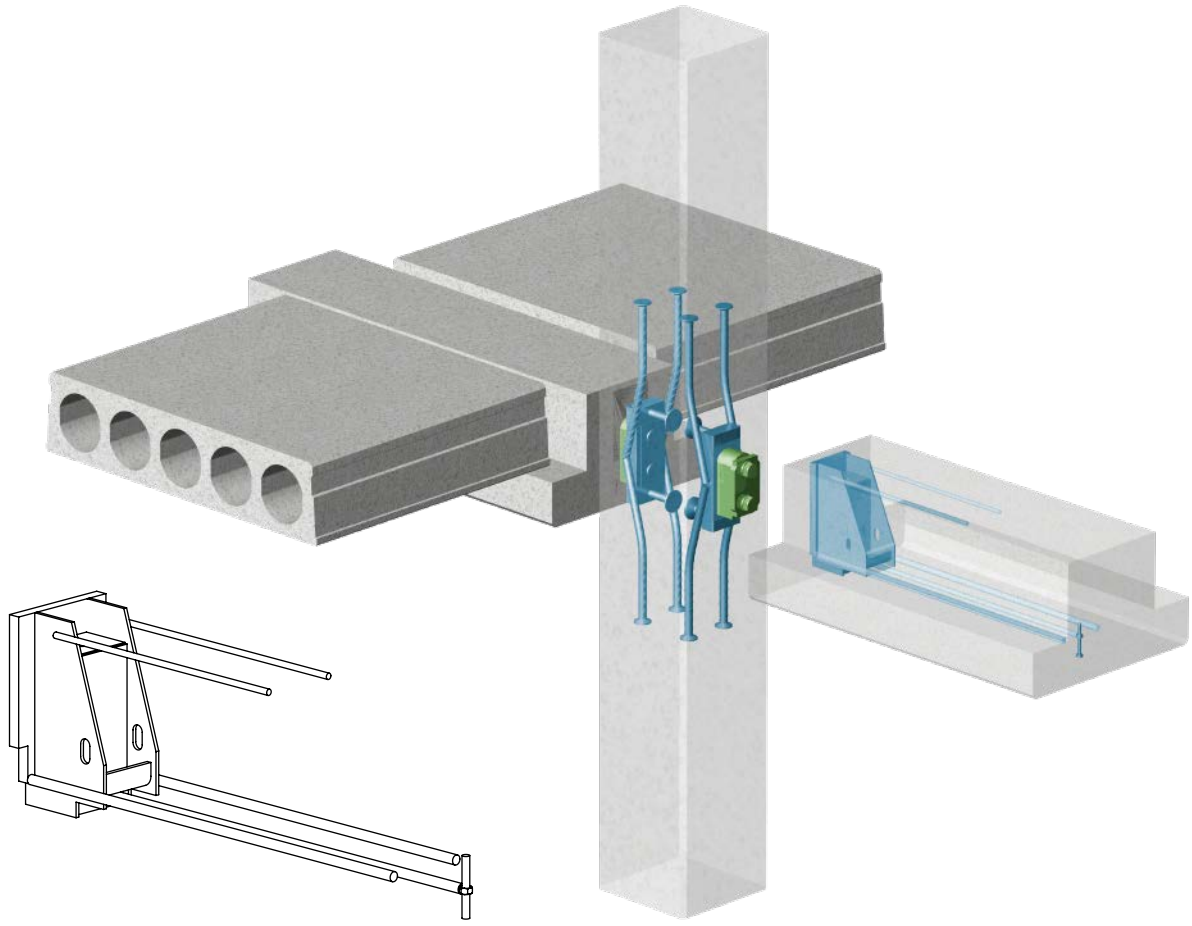
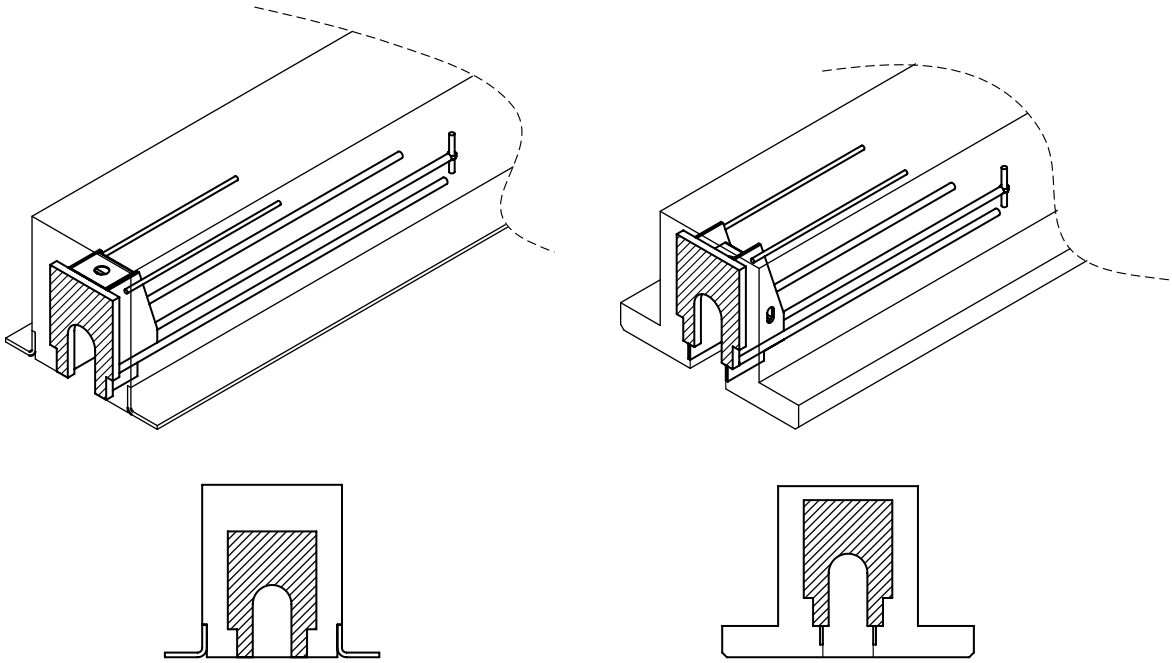


Figure 1. PCs® Corbel system (PCs® Corbel + PC® Beam Shoe) with a reinforced concrete beam.

After the hardening of the beam concrete, formwork is removed, and the beam is ready to be installed on PCs® Corbel. PCs® system is able to carry vertical and horizontal loads at assembly time, normal use, and fire situation (see *Table 6* and *Table 7* of this Technical Manual for maximum design values).

PC® Beam Shoe is available in two standardized models for each load class (*Figure 2*):

- for a beam with a low flange (for example PC 3-L)
- for a beam with a high flange (for example PC 3-H).



PC® Beam Shoe in a beam with low flange – type L

PC® Beam Shoe in a beam with high flange – type H

Figure 2. Standard PC® Beam Shoe models – type L and type H.

The beam shoe types differ in height. Type –L fits low beams with steel flange and type –H fits beams with concrete flange. In the case of a beam without a flange, the shoe type and its location must be considered separately.

1.1 Structural behavior

PC® Beam Shoe consists of a box made of steel plates with anchoring bars that transfer loads from the beam to the corbel. Transfer of loads between the beam and the corbel are provided by the bearing end plate of the PC® Beam Shoe to the corbel plate (vertical loads) or the washer plate (horizontal loads) of PCs®. For this reason, beams supported by PCs® Corbel must have an end plate with an opening of a shape that corresponds to the shape of the corbel plate.

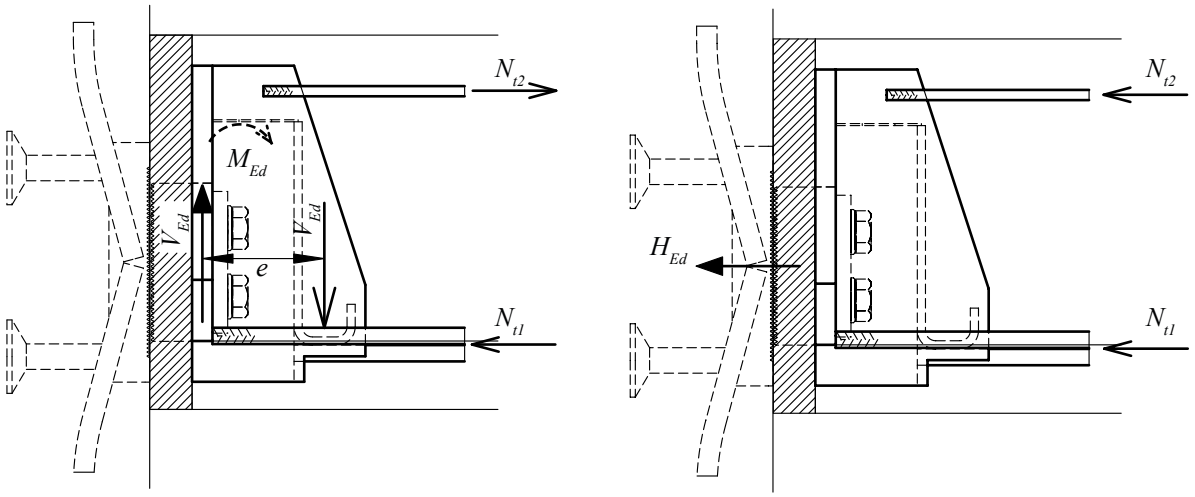


Figure 3. Transfer of forces in PC® Beam Shoe under vertical and horizontal loading.

The load transfer mechanism of PC® Beam Shoe under vertical and horizontal loading is shown in *Figure 3*. PC® Beam Shoes are pre-designed so that all components of the system have sufficient resistance against actions caused by external loads.

1.2 Limitations for application

The standard models of PC® Beam Shoes are pre-designed to be used under conditions mentioned hereafter in this paragraph. In the case when these conditions may not be satisfied, please contact Peikko Technical Support for an individual design of PC® Beam Shoe.

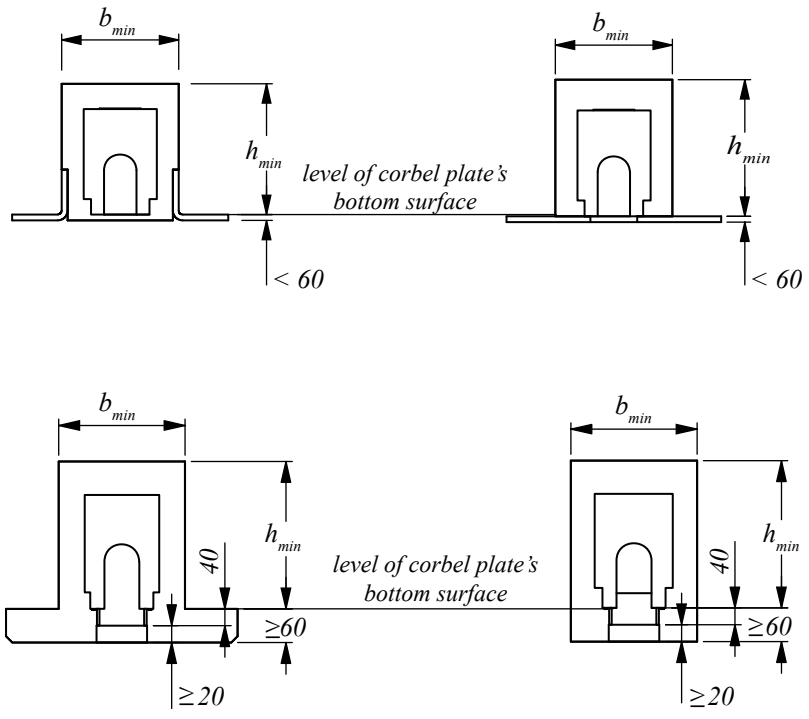
1.2.1 Loading and environmental conditions

PC® Beam Shoes are designed to carry static loads. In the case of dynamic and/or fatigue loads, individual design has to be made. PC® beam Shoe is designed to be used in indoors and dry conditions. When using PC® Beam Shoe in other conditions, the surface treatment or raw materials must be adequate according to environmental exposure class and intended operating life.

1.2.2 Interaction with beam and column

PC® Beam Shoes are pre-designed to be used in reinforced or prestressed concrete beams. The minimum dimensions are summarized in *Table 1*. Please note that the values in *Table 1* are valid for the case when the PC® Beam Shoe is placed in the middle of the beam. In the case when the beam shoe is not placed in the middle of the beam, the minimum edge distance of the beam shoe corresponds to $b_{min}/2$, where dimension b_{min} is taken from *Table 1*.

Table 1. The minimum beam sizes [mm] depend on the type of PC® Beam Shoes.



	h_{min} / b_{min}
PC 2-L	250/250
PC 3-L	280/280
PC 5-L	320/280
PC 7-L	380/380
PC 10-L	450/380
PC 15-L	520/520
PC 2-H	250/250
PC 3-H	280/280
PC 5-H	320/280
PC 7-H	380/380
PC 10-H	450/380
PC 15-H	520/520

The standard properties of PC® Beam Shoes are guaranteed for reinforced or prestressed beams made of concrete with a class at least C40/50. In case when PC® Beam Shoes are used in beams made of concrete with lower concrete class, the resistances have to be reduced using factors given in *Table 2*.

Table 2. Reduction factors for the lower concrete classes.

Concrete grade	C35/45	C30/37
PC 2 – PC 10	0.96	0.81
PC 15	0.91	0.75

The structural properties of PC® Beam Shoe may be guaranteed only if the supplementary reinforcement is provided to the beam following rules of Annex A of this Technical Manual. Please note that this supplementary reinforcement is used in addition to normal and shear reinforcement designed to resist internal forces in the beam.

PC® Beam Shoe carries a vertical reaction through the PCs® Corbel which is eccentric to the center of gravity of the column or wall. This eccentricity generates a bending moment $M_{Ed,1}$ that can be determined as follows:

$$M_{Ed,1} = V_{Ed} \cdot (B/2 + e)$$

where the eccentricity e is given in *Table 3*.

Before the structure is taken into use, the joint between the beam and the column has to be filled with grout. When a load is applied to the beam, the rotation of the end of the beam causes a load transfer mechanism shown in *Figure 4*. The exact value of bending moment transferred by PCs® Corbel due to restricted rotation of the beam may be estimated only case by case with regards to moment-rotation properties of the beam.

Conservative estimates of bending moment $M_{Ed,2}$ transferred due to restricted rotation at the ends of the beam are given in *Table 3*. The bending moments in *Table 3* are determined considering that horizontal tensile load H_{Ed} (see paragraph 2 for more information) develops in PCs® Corbel. If PCs® Corbel is in a higher position than indicated in *Table 3* ($xb > 50\ mm$), it is recommended to fill the joint between the end plate and the column with deformable insulation below the corbel. By this way, bending moment values presented in *Table 3* are still valid.

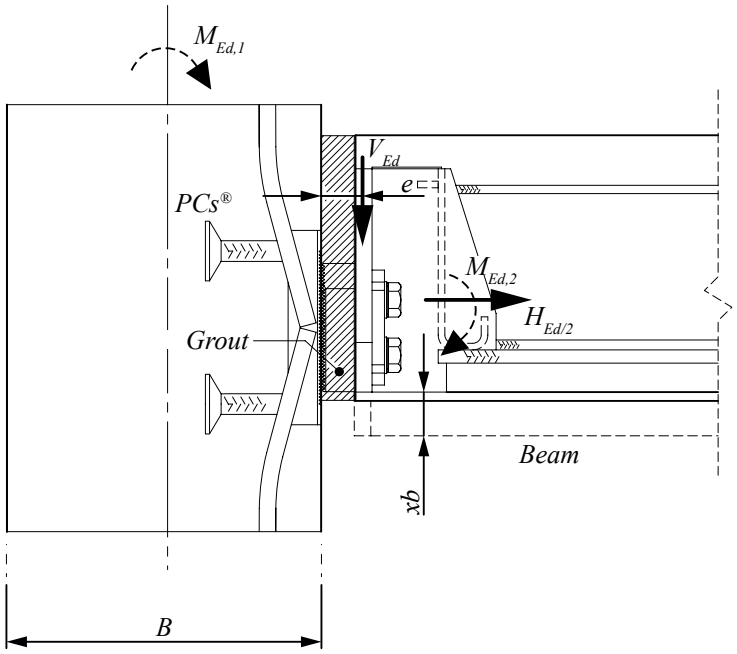


Figure 4. Moment $M_{Ed,2}$ transferred from the corbel to the column.

Table 3. The bending moment transferred to the column ($M_{Ed,2}$).

	e [mm]	$M_{Ed,2}$ (xb = 0mm) [kNm]	$M_{Ed,2}$ (xb = 10mm) [kNm]	$M_{Ed,2}$ (xb = 50mm) [kNm]
PC 2-L, H	43	2.7	2.9	3.8
PC 3-L, H	48	3.7	4.0	5.5
PC 5-L, H	56	7.7	8.2	10.3
PC 7-L, H	56	11.9	12.6	15.5
PC 10-L, H	56	20.8	21.8	25.6
PC 15-L, H	56	27.2	28.7	34.7

The total value of bending moment generated in the column by PCs® Corbel system is:

$$M_{Ed} = M_{Ed,1} + M_{Ed,2}$$

The bending moment M_{Ed} has to be taken into account in the design of the main reinforcement of the column or wall. Please note that in any case, it is recommended to consider PCs® Corbel as a simple support of the beam.

1.2.3 Positioning of the beam shoe

Position of the PC® beam shoe bottom surface in the beam may vary independetly to the slab bottom surface (e.g. due to fire resistance requirements or different beam flanges thicknesses). Adequate height of plywood boards must be applied to determinate height of the PC® beam shoe in the concrete beam.

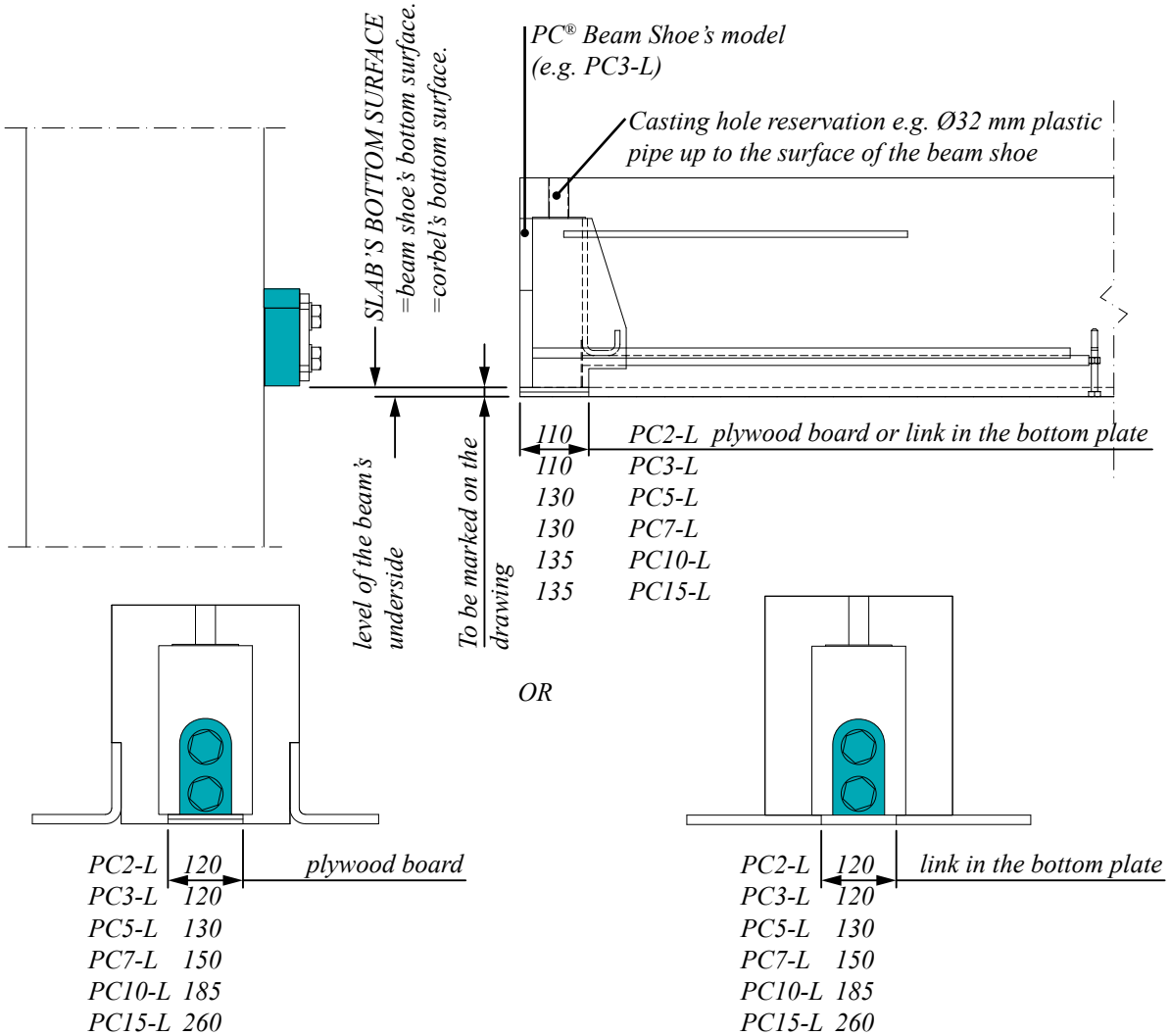


Figure 5. Things to be marked on the drawing of the beam when using PC® L beam shoe (The same level of beam shoe's bottom surface and slab's bottom surface).

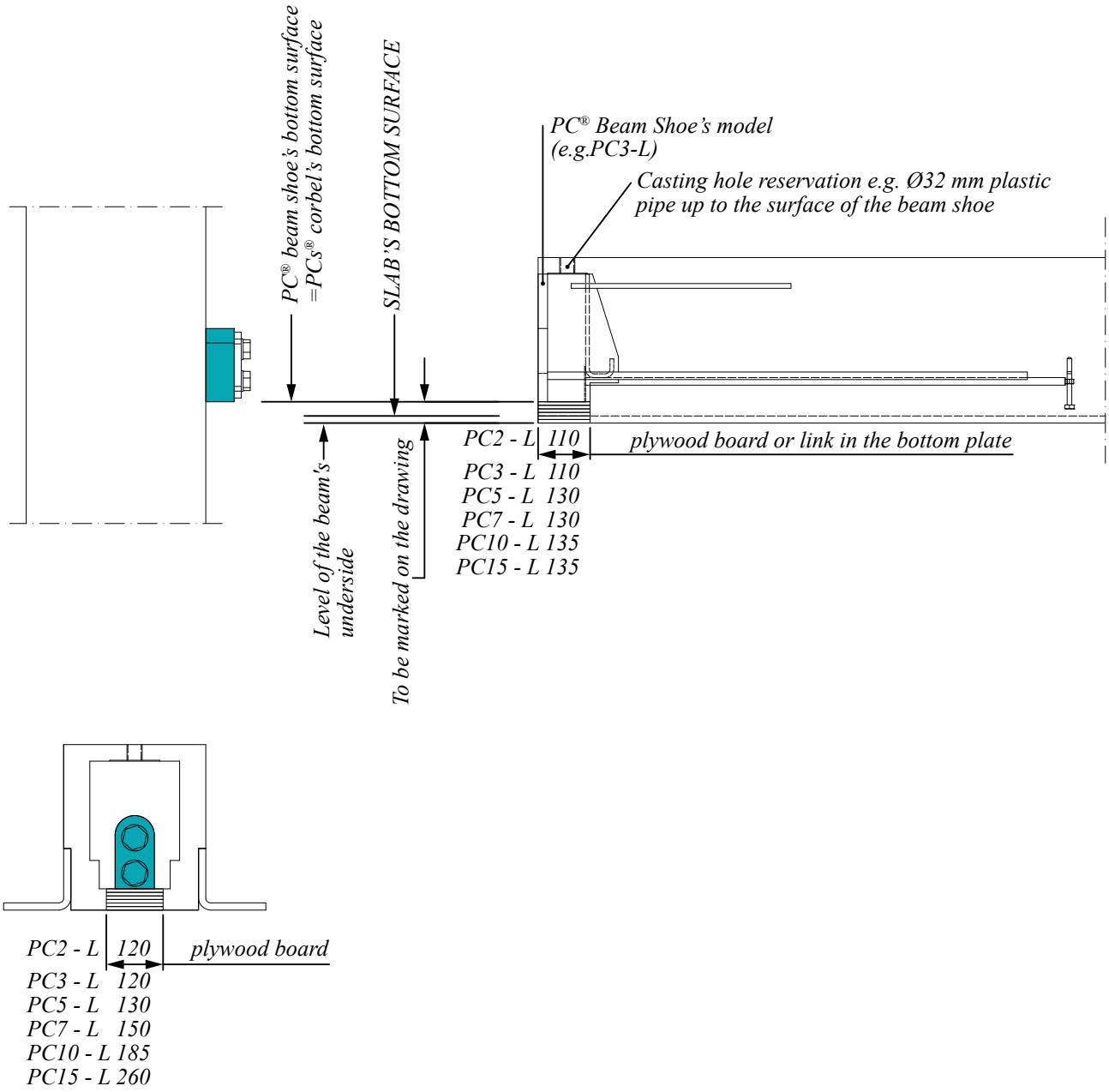


Figure 6. Things to be marked on the drawing of the beam when using PC® L beam shoe (Different level of beam shoe's bottom surface and slab's bottom surface).

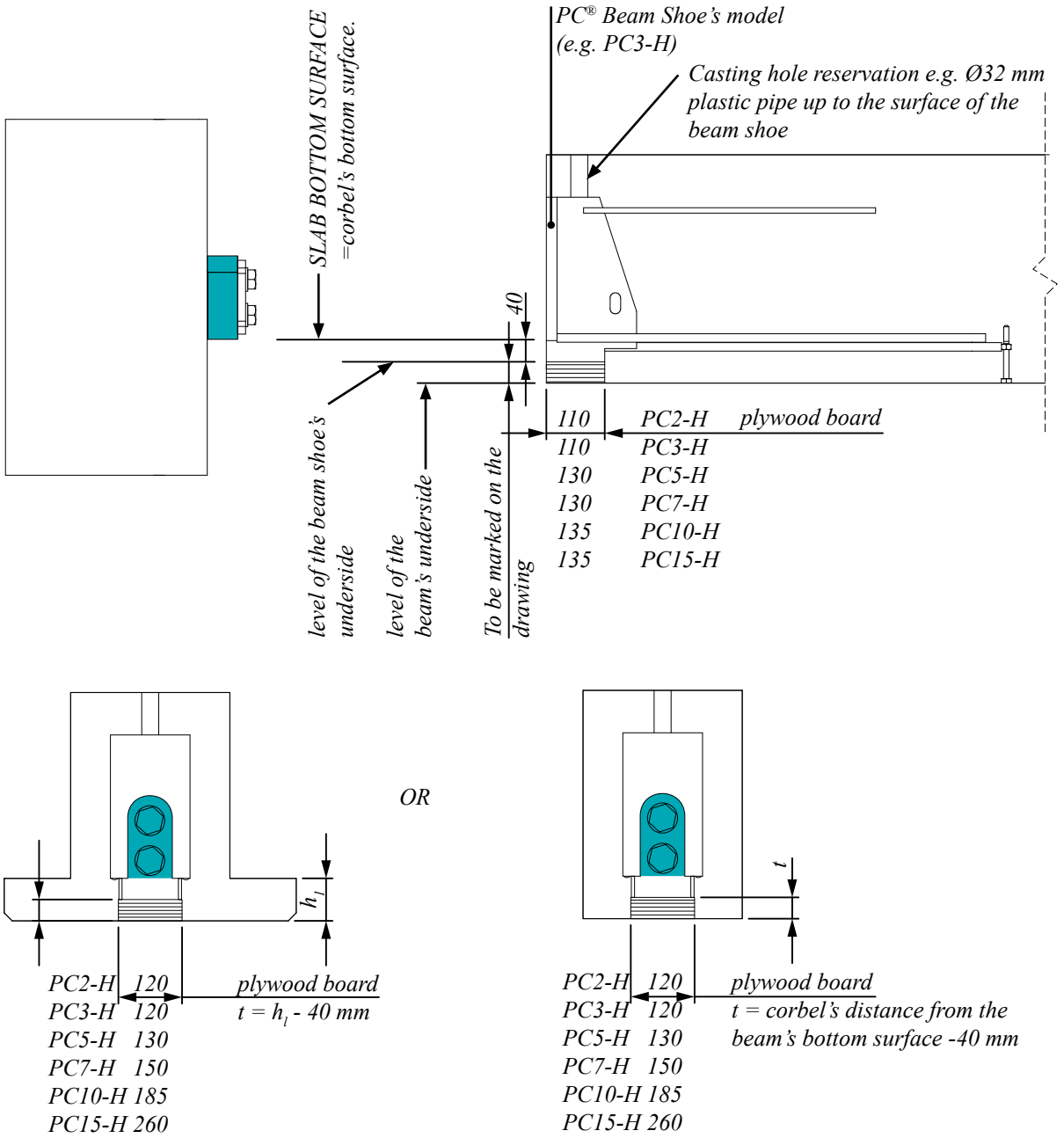


Figure 7. Things to be marked on the drawing of the beam when using PC® H beam shoe. (The same level of beam shoe's bottom surface and slab's bottom surface).

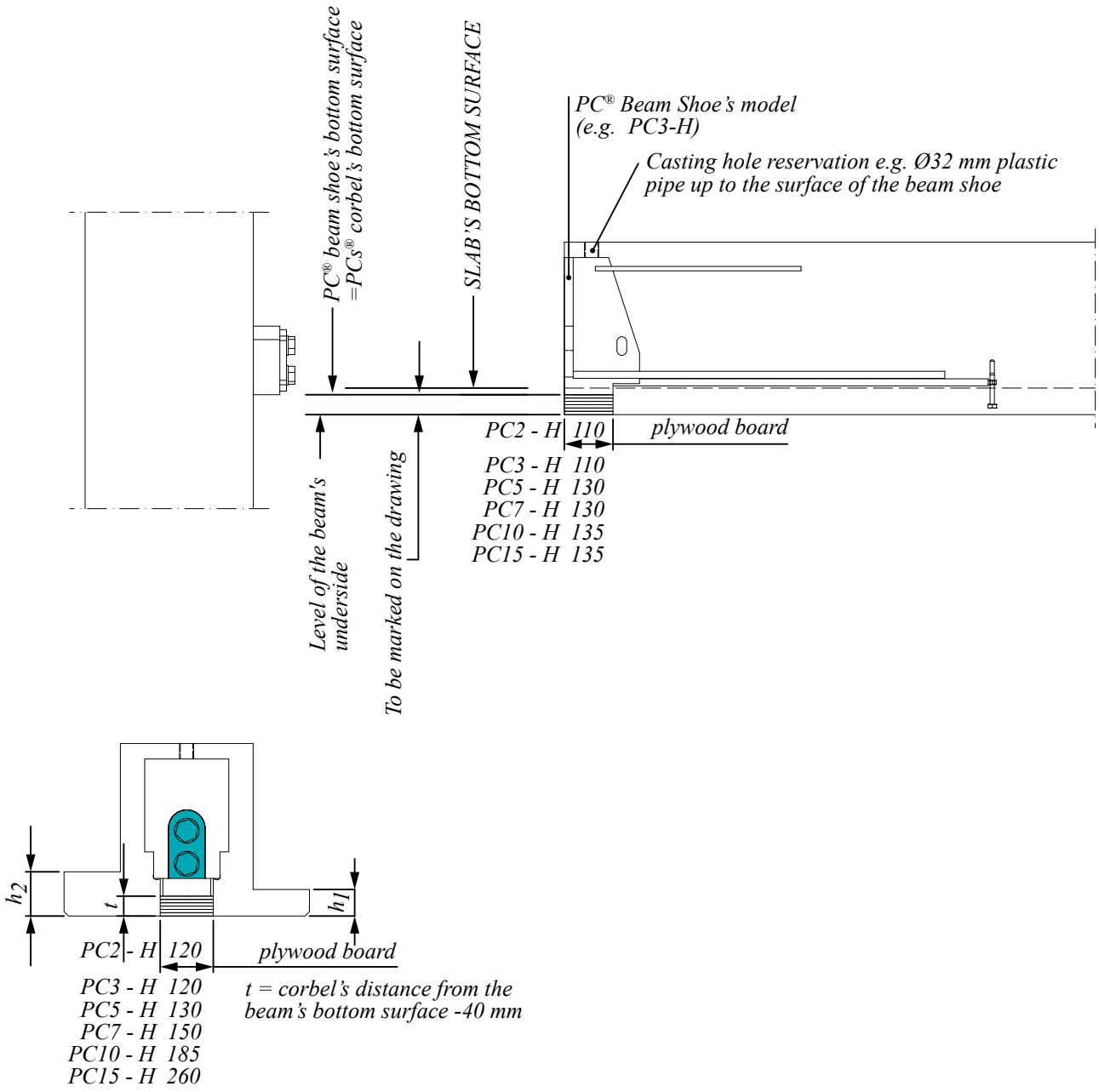


Figure 8. Things to be marked on the drawing of the beam when using PC® H beam shoe. (Different level of beam shoe's bottom surface and slab's bottom surface).

1.2.4 Positioning of the beam

The length of the beam is chosen so that the space between the beam and square column or wall is 20 mm according to *Figure 7*. The tolerance for the beam length is ±20 mm in the connection. The tolerance of the beam length is smaller with beams connected to the circular column. The length of the beam is chosen so that the space between the beam and the column or wall surface is about 10 mm. Then the tolerance for the beam length is approximately ±10 mm in the connection.

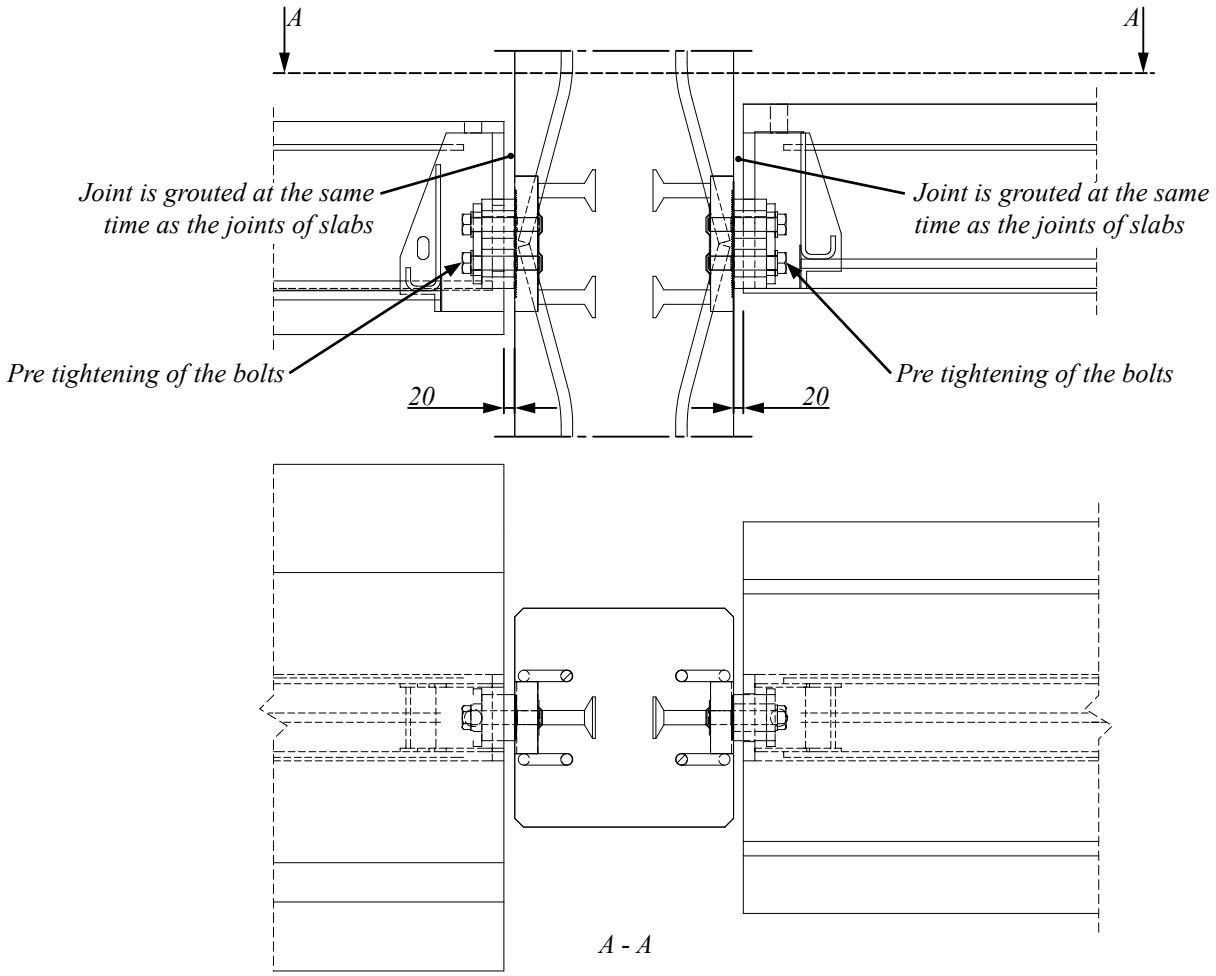


Figure 9. Beam connection to a square column.

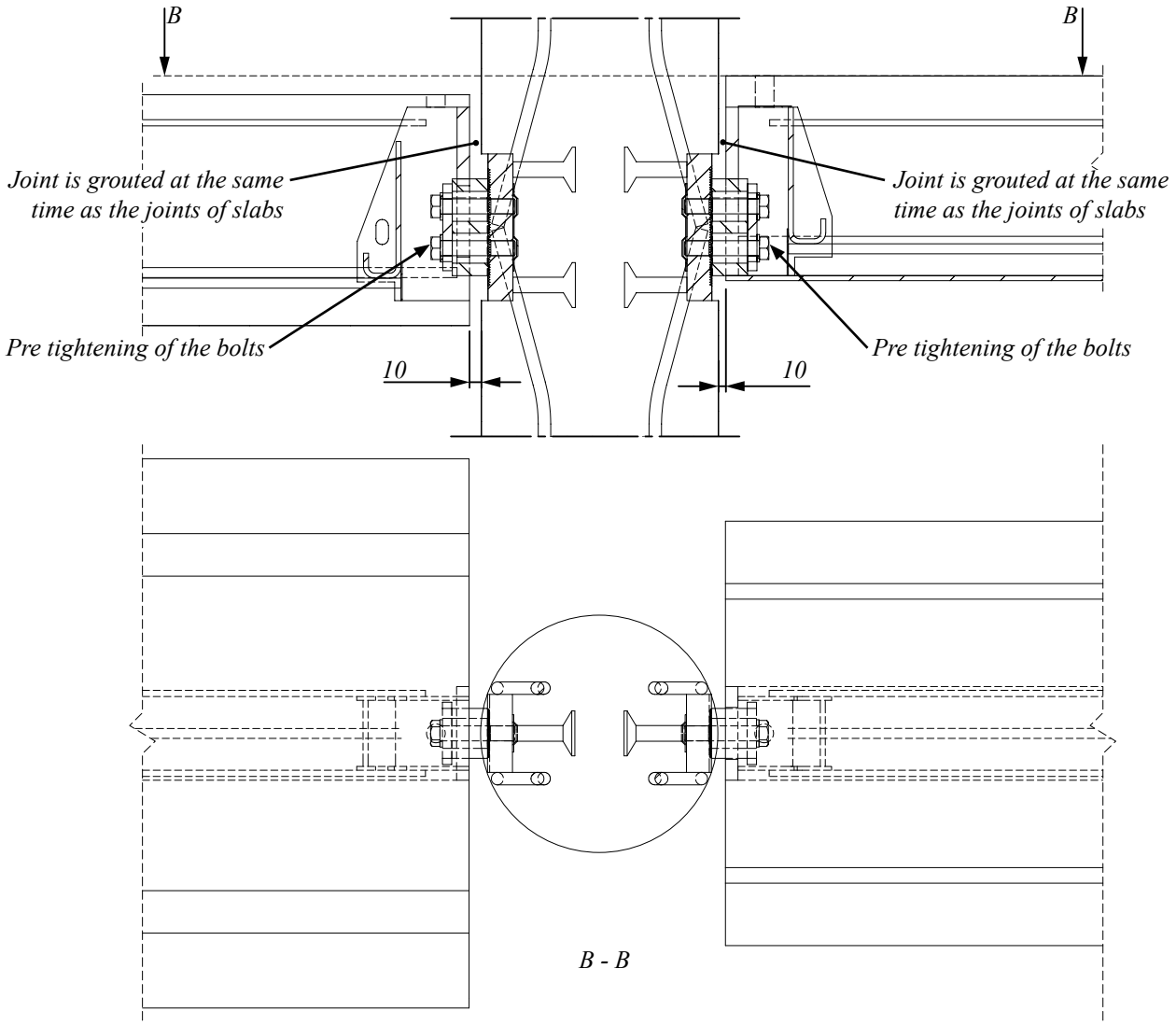


Figure 10. Beam connection to the circular column.

1.3 Other properties

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

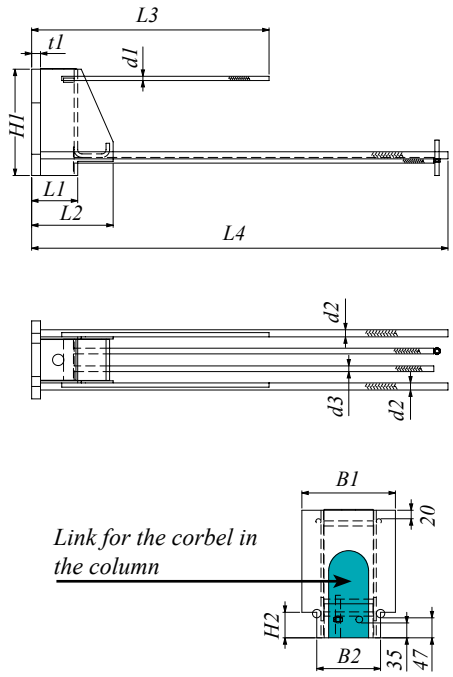
Plates	S355J2 + N	EN 10025-2
	S355J0	EN 10025-2
Ribbed bars	B500B	EN 10080

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

Please note that the guaranteed manufacturing tolerances for different dimensions of PC® Beam Shoes are as follows:

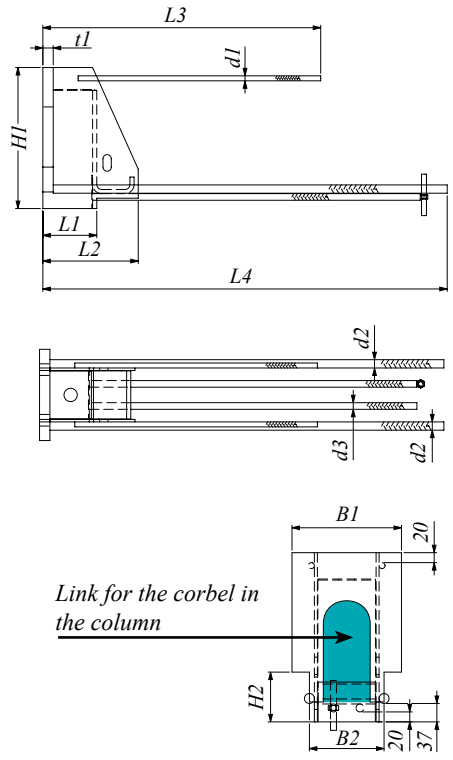
Beam Shoe parts	Width, height and thickness ±3 mm
	Total length ±20 mm

Table 4. Dimensions [mm], weights [kg] and color codes of the beam shoes for low flange beams (PC® L).



	PC® Beam Shoe model					
	PC 2-L	PC 3-L	PC 5-L	PC 7-L	PC 10-L	PC 15-L
H1	240	270	300	340	410	410
H2	60	60	60	60	60	60
B1	180	190	220	240	270	389
B2	150	150	150	154	220	343
L1	95	110	130	130	135	135
L2	155	170	230	235	315	315
L3	530	535	670	670	915	835
L4	755	1115	1175	1270	1290	1810
t1	15	20	25	25	25	25
d1	10	10	12	12	16	16
d2	16	16	20	20	25	25
d3	16	16	16	20	25	25
Weight	12.6	17.4	28.3	35.5	58.5	89.3
Color	Red	Gray	Yellow	Green	Blue	Black

Table 5. Dimensions [mm], weights [kg] and color codes of the beam shoes for high flange beams (PC® H).



	PC® Beam Shoe model					
	PC2-H	PC3-H	PC5-H	PC7-H	PC10-H	PC 15-H
H1	280	310	340	380	450	450
H2	100	100	100	100	100	100
B1	180	190	220	240	270	389
B2	150	150	150	154	220	343
L1	95	110	130	130	135	135
L2	155	170	230	235	315	315
L3	530	535	670	670	915	835
L4	655	940	975	1120	1125	1610
t1	15	20	25	25	25	25
d1	10	10	12	12	16	16
d2	16	16	20	20	25	25
d3	16	16	16	20	25	25
Weight	12.3	16.5	26.8	34.3	59.0	91.8
Color	Red	Gray	Yellow	Green	Blue	Black

2. Resistances

The resistances of PC® 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/AC:2005

PC® Beam Shoe is designed to take vertical and horizontal loads. The maximum resistances of PC® Beam Shoes against these two types of loads are given in *Table 6* and *Table 7* and are according to corresponding PCs® Corbel.

The load transfer mechanism illustrated on *Figure 4* shows that usually a horizontal tensile load will be associated to the vertical load acting on the corbel. The value of the horizontal tensile load considered to beam shoe is usually estimated to be $H_{Ed} = 0.2 \times V_{Rd}$ for concrete corbels. For PC® Beam Shoe, the resistance against vertical load is determined for the following load combinations:

- Vertical load acting together with horizontal tensile load H_{Ed} that corresponds to 20% of V_{Rd}
- Vertical load without any horizontal tensile load.

The characteristic values of resistances of PC® Beam Shoes determined for fire exposure classes R60 and R90 are identical to values given in *Table 6* and *Table 7* for normal use situation.

Table 6. Design values of resistances of PC® Beam Shoe (without horizontal tensile load).

Load	Notations	Units	PC 2	PC 3	PC 5	PC 7	PC 10	PC 15
Vertical load	V_{Rd}	kN	230	355	575	785	1010	1500
Horizontal load	H_{Ed}	kN	0	0	0	0	0	0

Table 7. Design values of resistances of PC® Beam Shoe (with horizontal tensile load $H_{Ed} = 0.2 \times V_{Rd}$).

Load	Notations	Units	PC 2	PC 3	PC 5	PC 7	PC 10	PC 15
Vertical load	V_{Rd}	kN	210	355	520	710	960	1500
Horizontal load	H_{Ed}	kN	42	71	104	142	192	300

PC® Beam Shoe has no torsion resistance. Torsion in the connection can be prevented during installation by supporting the beam and during the final stage by good cooperation between beam and slab. Both supports and the beam's connection to the slab must be designed and defined in plans before they can be taken into account. Supporting high beams against torsion might require additional options designed by the responsible structural engineer.

Selecting PC® Beam Shoe

The following aspects have to be considered when selecting the appropriate model of PC® Beam Shoe to be used in a project:

- Load bearing capacity
- Properties of the beam and column or wall
- Position of the beam shoe in the beam.

The load bearing capacity of PC® Beam Shoe should be verified for the following design situations:

- Assembly time
- Normal use
- Fire situation.

If the beam shoe is to be used in an environment with higher fire exposure class, it is recommended to lift the beam shoe higher than the bottom level of the slabs, if the beam is thick enough. Then the concrete cover will act as fire protection.

Annex A – Supplementary reinforcement

Ribbed bars on the bottom of the shoe anchor to the main reinforcement of the beam according to their capacity, when the distance between shoe anchors and the main reinforcement is ≤ 100 mm. The designer has to check is there a need for supplementary reinforcement anchoring the main reinforcement. Stirrups against splitting are needed at both ends of the shoe (*Figures 11 and 12*).

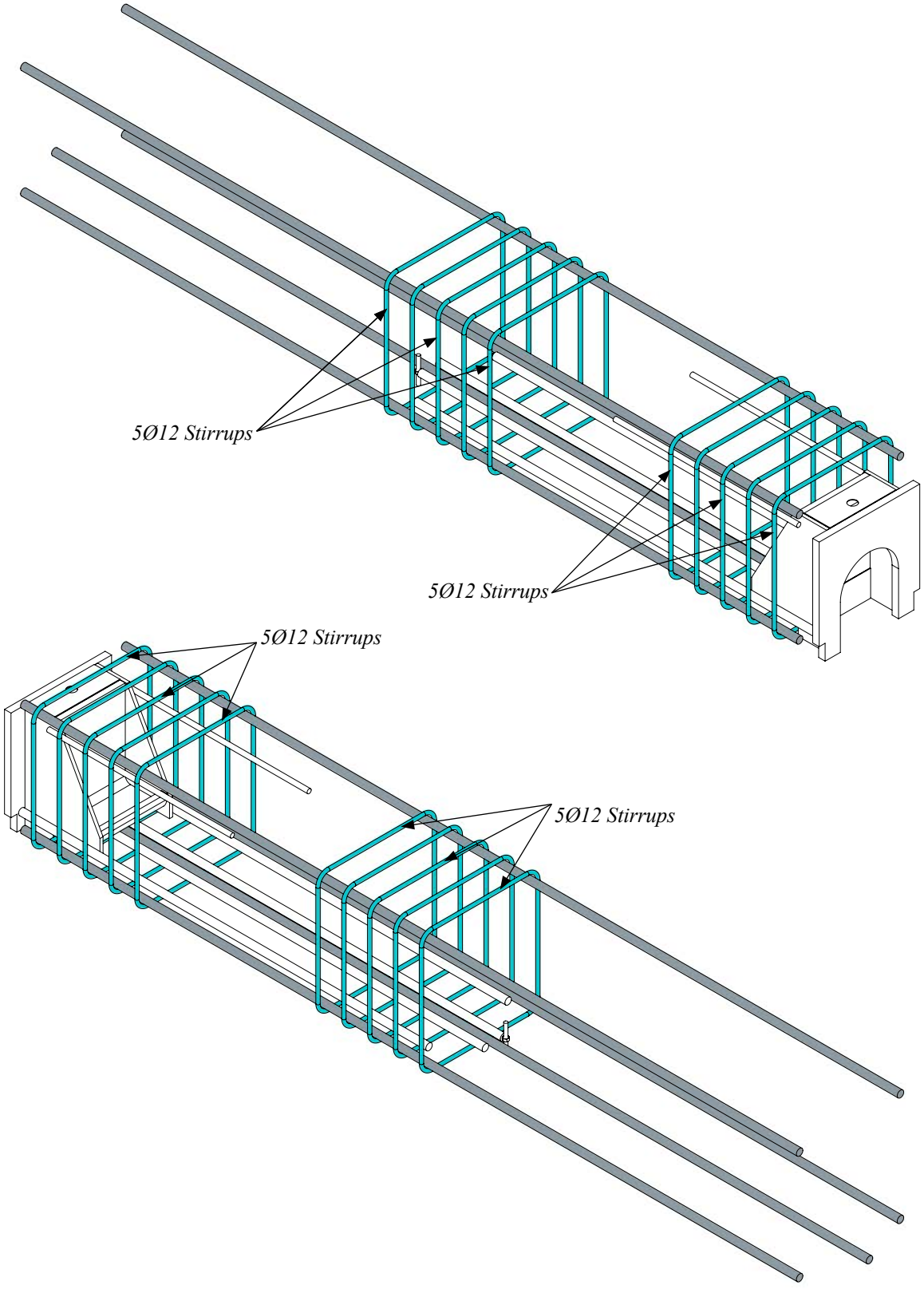


Figure 11. PC 15-L Beam Shoe Supplementary reinforcement.

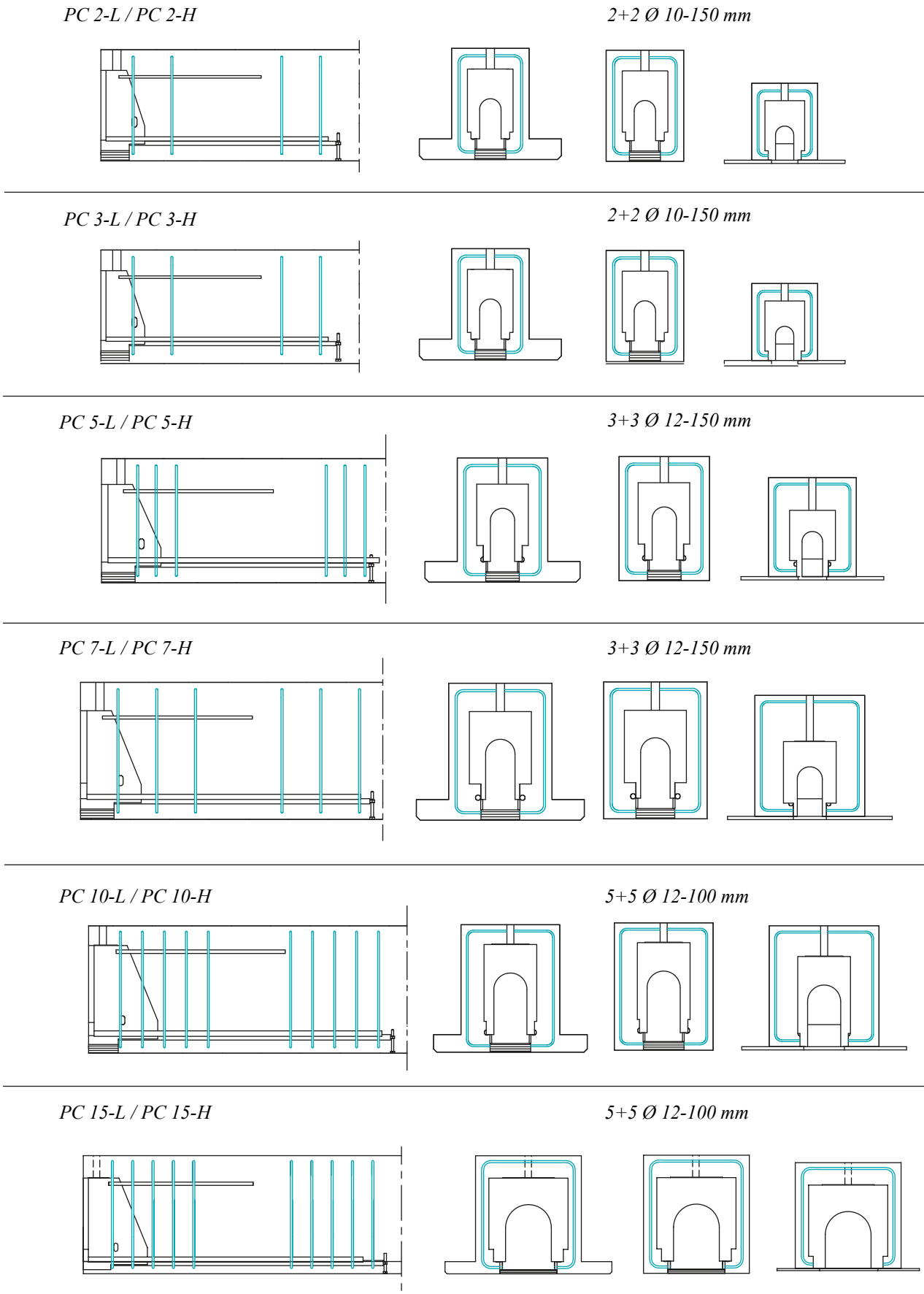


Figure 12. Supplementary reinforcement of the beam when the distance between shoe anchors and the main reinforcement is ≤ 100 mm.

When the distance between the shoe anchors and the main reinforcement is more than 100 mm, the end of the beam has to be designed as a half joint. Then hanging stirrups are needed and the main reinforcement of the beam has to be anchored by supplementary reinforcement. The supplementary reinforcement for some high beams is shown in *Figures 13 and 14*.

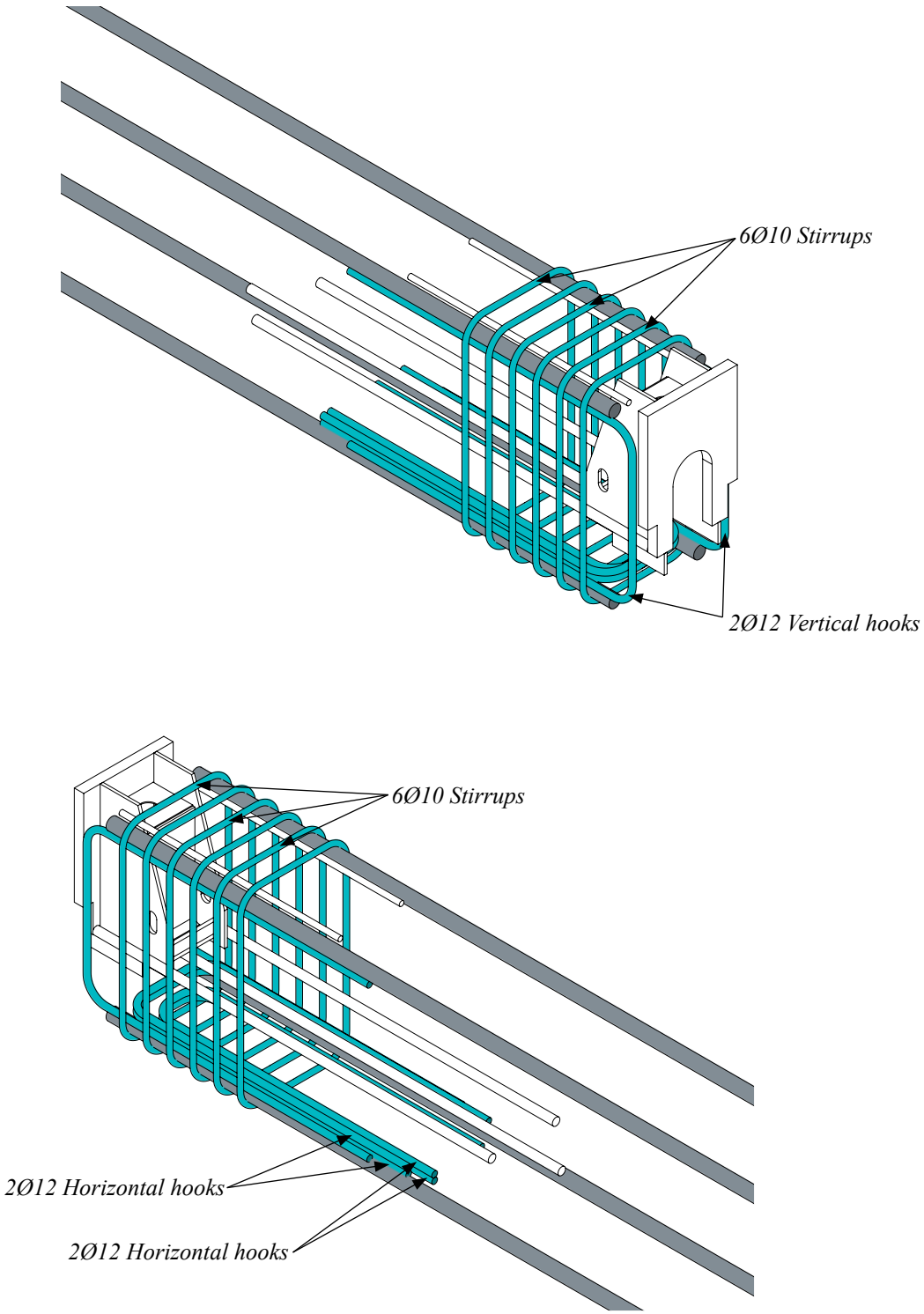


Figure 13. PC 3-H Beam Shoe Supplementary reinforcement.

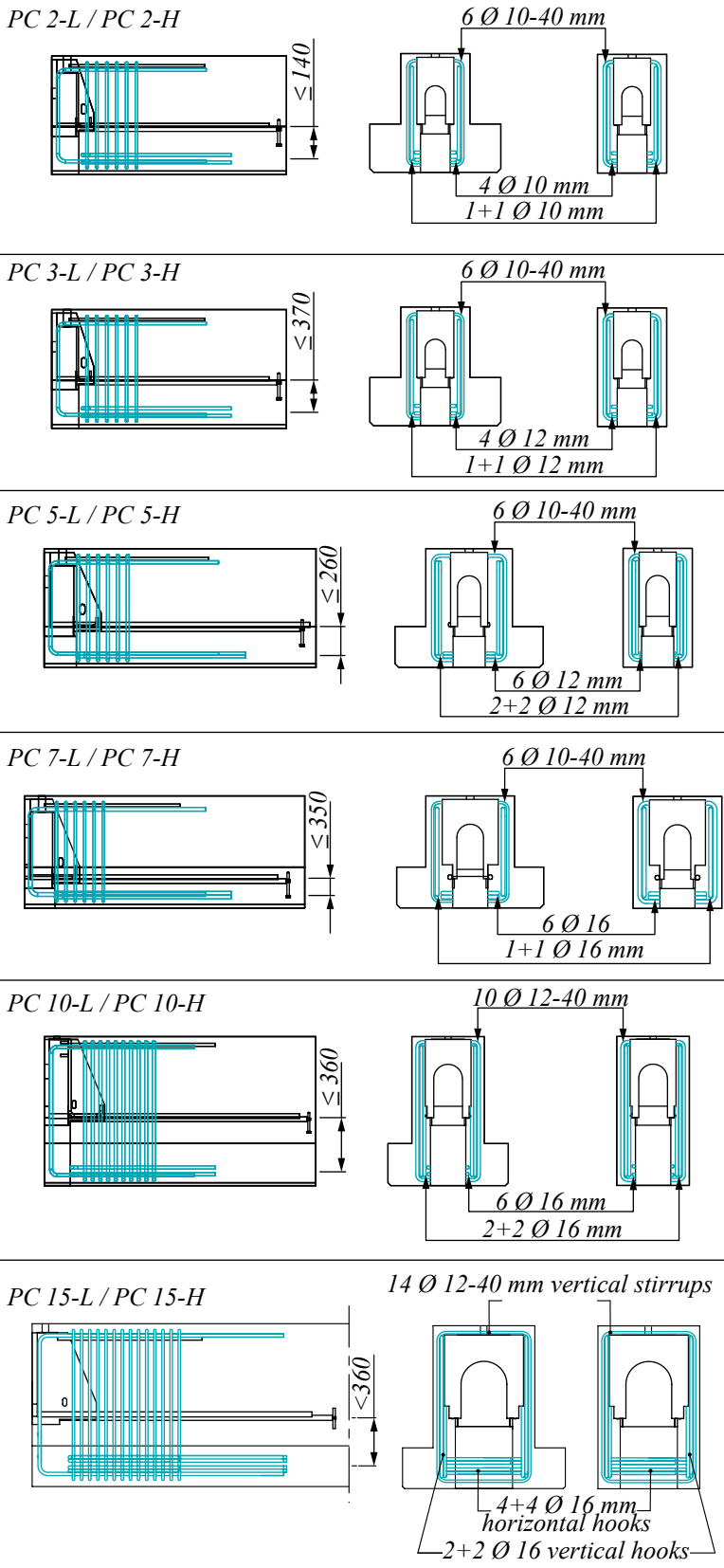


Figure 14. Supplementary reinforcement of the beam when the distance between the anchors of the shoe and the main reinforcement is more than 100 mm.

Installing PC® Beam Shoe

Identification of the product

PC® Beam Shoe is available in two different models (e.g. PC-L and PC-H) and six different sizes (2, 3, 5, 7, 10 and 15). Models and sizes can be identified by the name in the label on the product; sizes may be also identified according to color of the product. Color codes are shown in table hereafter.

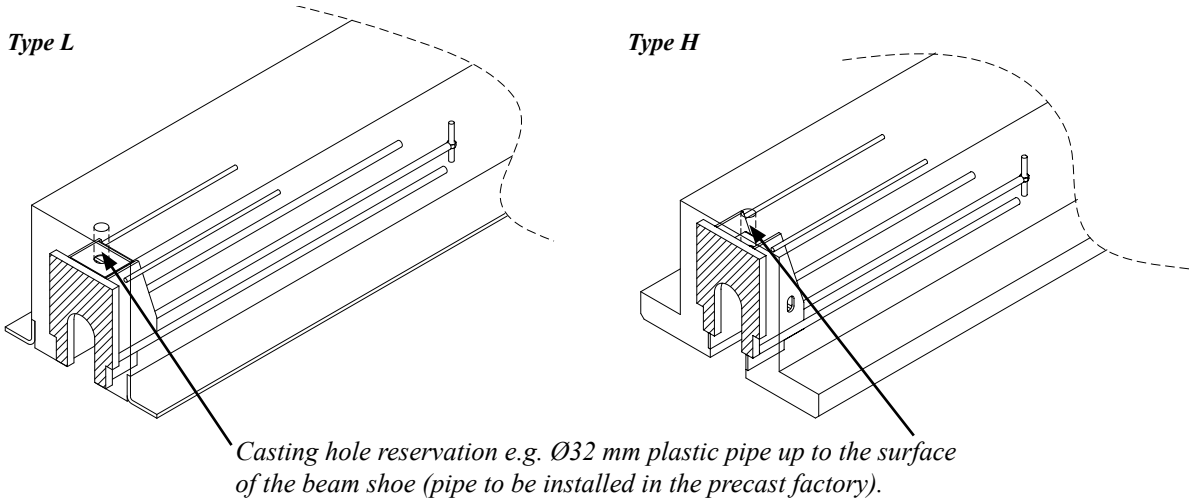


Figure 15. Standardized models for PC® Beam Shoe – type L and type H.

PC 2-L / PC 2-H	PC 3-L / PC 3-H	PC 5-L / PC 5-H	PC 7-L / PC 7-H	PC 10-L / PC 10-H	PC 15-L / PC 15-H
Red	Grey	Yellow	Green	Blue	Black

In precast factory

PC® Beam Shoe is installed in the framework according to design plans of the beam together with reinforcement of the beam. PC® Beam Shoe is installed so that it will be inside the main stirrups of the beam.

Beam shoe shall be fixed so that it will not move during casting. Pocket for PCs® Corbel is formed by steel plates of the PC® Beam Shoe, creating the required mold. It is necessary to ensure the bottom opening with plywood board or link in the bottom plate (according to *Figure 5* for PC-L or *Figure 6* for PC-H of this Technical Manual).

It is recommended to fill up the PC® Beam Shoe pocket with polystyrene or equivalent to prevent concrete to fill up the pocket.

Supplementary reinforcement must be placed at the area of beam according to design plans of the beam.

Figure 16. Example of supplementary reinforcement and fixing of PC® Beam Shoe before casting.

On construction site

Beams will be installed on the corbel so that the slot of the beam will surround the corbel and the end plate of the beam will be in contact with top surface of the corbel plate.

PC® Beam Shoes do not bear torsion loads; therefore, beams must be supported against rotation during erection and beam must have a good cooperation with slab in final construction so that slab will prevent beam's rotation.

The joint between column and beam is cast at the same time with joints of slabs.

NOTES

Revision History

Version PEIKKO GROUP 05/2022. Revision 003

- Ammendments to chapters 1.2.3 and 1.3.
- Ammendments to Tables 4 and 5.
- Added new Figures 6 and 8.

Version PEIKKO GROUP 12/2021. Revision 002

- Updated resistances of PC 2.
- Updated Figures 9 – 12 of installation instructions.

Version: PEIKKO GROUP 03/2012. Revision: 001*

- New cover design for 2018 added.

Resources

DESIGN TOOLS

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.

peikko.com/design-tools

TECHNICAL SUPPORT

Our technical support teams around the world are available to assist you with all of your questions regarding design, installation etc.

peikko.com/technical-support

APPROVALS

Approvals, certificates, and documents related to CE-marking (DoP, DoC) can be found on our websites under each products' product page.

peikko.com/products

EPDS AND MANAGEMENT SYSTEM CERTIFICATES

Environmental Product Declarations and management system certificates can be found at the quality section of our websites.

peikko.com/qehs