



HPKM Column Shoe

For bolted column connections

Version: Peikko Group 8/2012



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System benefits

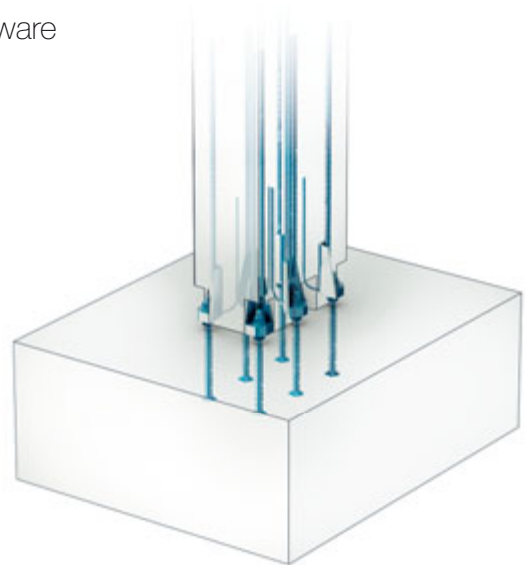
- Easy and fast erection of the column with good adjustment possibilities
- No need for temporary bracing during erection work
- Doesn't require in-situ welding
- Easy to design with free Peikko Designer[®] software

HPKM Column Shoe is a building product used to create cost-effective moment resisting connections between:

- precast concrete columns and foundations
- two precast concrete columns

The system consists of column shoes and anchor bolts. Column shoes are cast into precast concrete column whereas anchor bolts are cast into foundation or another column. On construction site the columns are erected on the anchor bolts, adjusted on the correct level and vertical position and fixed to the bolts. Finally the joint between column and base structure is grouted.

The column does not require any temporary bracing during erection stage. In final stage the grouted connection will act as a traditional reinforced concrete cross section. Typically four column shoes are enough to create a moment resisting connection. The product range includes also accessories for easy installation of the products.



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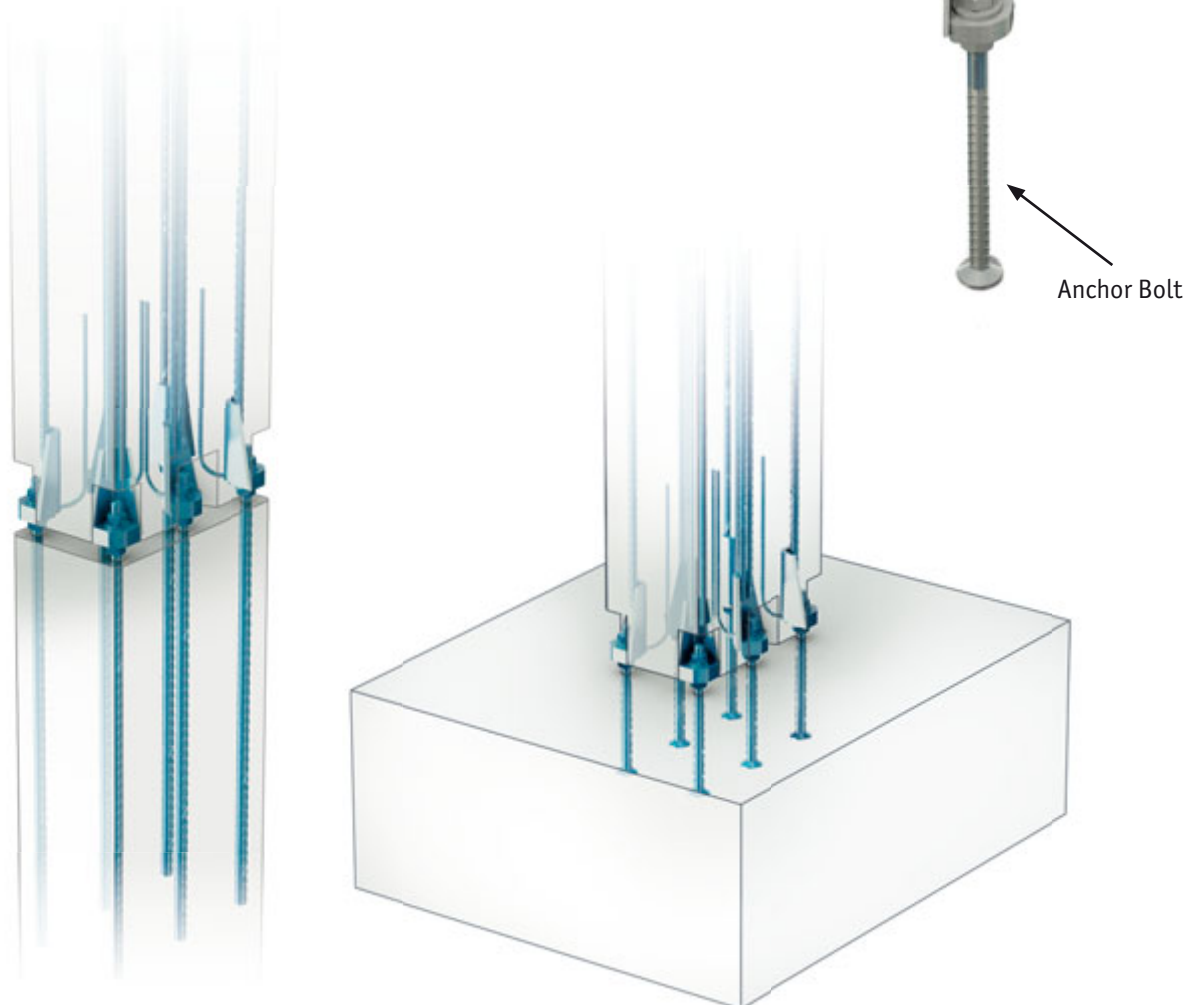
1. Product properties

HPKM Column Shoes are available in several standard models to solve the most of precast concrete column connections. The system consists of:

- Column shoe
- Anchor bolt
- Accessories: recess formers and installation templates

HPKM Column Shoes are used with HPM Anchor Bolts to create moment resisting precast concrete column connections. Column Shoes are cast into the bottom part of the column together with main and supplementary reinforcement, detailed in Annex A of this manual. HPM Anchor Bolts are either cast into foundation (column-foundation connection) or in the top part of lower column (column-column connection). Column shoe has a round hole that fits with the corresponding anchor bolt. The column connection is developed by fastening the anchor bolts to column shoes by using nuts and washers. The bolted connection offers sufficient assembly tolerances to adjust the column at the correct level and vertical position. To finalize the connection, the joint underneath the column and recesses are grouted with non-shrink grout material.

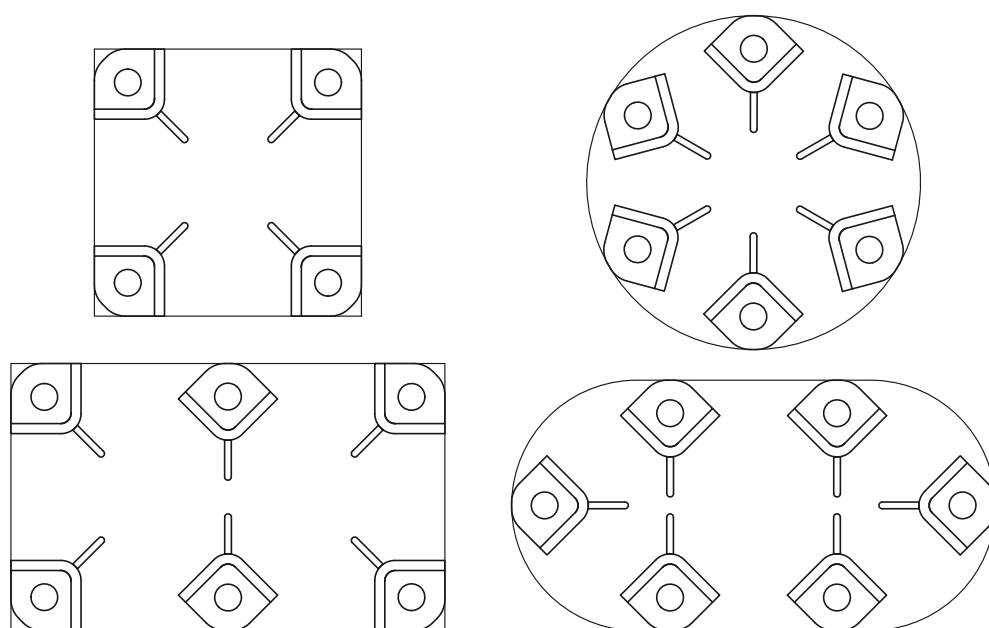
Figure 1 HPKM Column Shoes and HPM anchor bolts in column connection



The design values of resistances of HPKM Column Shoes are equal as the design values of resistances of corresponding HPM Anchor Bolts. For more information about anchor bolts, see the Technical Manual of HPM Anchor Bolts.

Column connections can be designed to resist normal forces, bending moments, shear forces and their combinations. The appropriate type of column shoe and anchor bolt to be used in connection may be selected and the resistance of the connection verified by using Peikko Designer® software (download from www.peikko.com). 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 2 Arrangement of HPKM Column Shoes in different column cross sections



1.1 Structural behavior

HPKM Column Shoes are pre-designed so that they have sufficient resistance against maximal design values of tensile and compressive forces from the corresponding HPM Anchor Bolts.

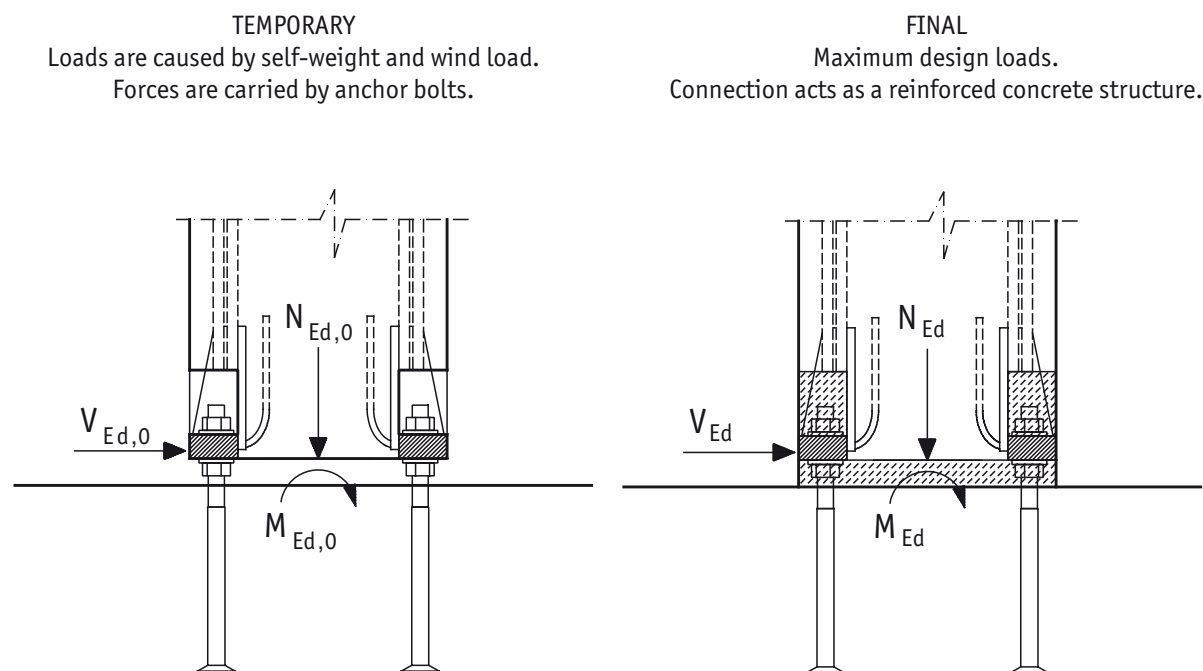
1.1.1 Temporary conditions

At erection stage the forces loading column shoes are caused principally by self-weight of the column and bending moment and shear force from wind load. Since the joint between the column and the base structure is not grouted, all the forces from the column shoes are carried solely by anchor bolts. The bolts must be designed for buckling and bending. If the size of the bolt is not sufficient for the load, size or quantity of bolts and column shoes should be increased. The gap underneath the column and recesses has to be grouted and grout has to be hardened before the column is loaded by other structures.

1.1.2 Final conditions

At final stage, after the grout has reached the designed strength, the connection acts as a reinforced-concrete structure. Column shoes in interaction with anchor bolts and grout material are able to resist bending moments and forces designed for final conditions.

Figure 3 Structural behavior of the column connection under temporary and final conditions.



1.2 Limitations for application

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

1.2.1 Loading and environmental conditions

HPKM Column Shoes are designed to carry static loads. In the case of dynamic and/or fatigue loads, individual design has to be made.

Column Shoes are designed to be used in indoors and dry conditions. When using HPKM Column Shoes in other conditions, the surface treatment, concrete cover or raw materials must be adequate according to environmental exposure class and intended operating life.

1.2.2 Interaction with column

HPKM Columns Shoes are pre-designed to be used in reinforced concrete columns with minimum dimensions summarized in Table 1. If column shoes must be placed in the column with smaller dimensions, please contact Peikko Technical Support.

Table 1 The minimum sizes [mm] of column cross sections for standard HPKM Column Shoes

		HPKM 16	HPKM 20	HPKM 24	HPKM 30	HPKM 39
	A1	115	120	125	140	180
	b_{min}	230	240	250	280	360

	HPKM 16	HPKM 20	HPKM 24	HPKM 30	HPKM 39
A2	135	145	150	175	225
d _{min}	270	290	300	350	450

$$c/c = \frac{d - 2E}{\sqrt{2}}, \text{ where } E \text{ is taken from dimensions table – Table 3}$$

The standard properties of HPKM Column Shoes are guaranteed in reinforced concrete columns made of concrete grade C30/37 or higher. The strength of grout material in the joint must be equivalent or higher than the designed concrete grade of the column. For minimum concrete grade for anchor bolts, see Technical Manual of HPM Anchor Bolts.

The structural properties of HPKM Column Shoes are guaranteed only if supplementary reinforcement is provided in the column in accordance with rules of Annex A of this Technical Manual. It is notable that the supplementary reinforcement is used in addition to the main reinforcement designed to resist internal forces in the column.

1.2.3 Positioning of the column shoe

The concrete cover of main anchor bars of column shoe is 40 - 46 mm when HPKM Column Shoe is located at the corner of column. If the HPKM Column Shoe is in the middle position, the concrete cover thickness is more than in corner position (see Figure 4 and Table 2).

Figure 4 Concrete cover of main anchor bars – corner and middle position of column shoe

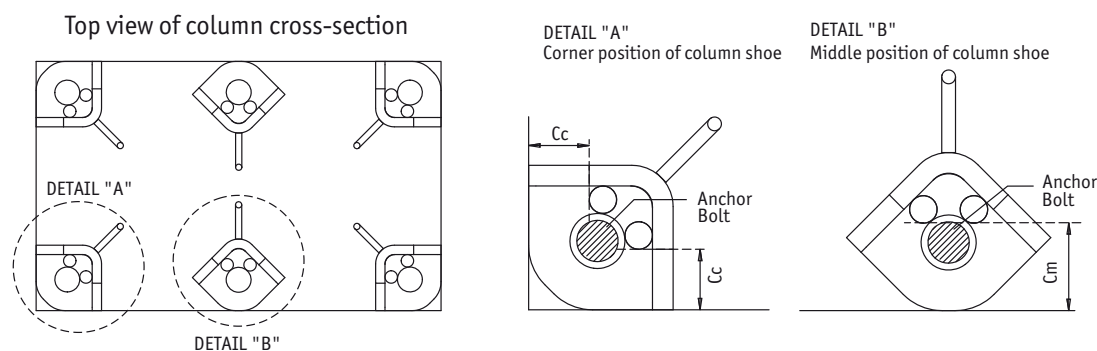


Table 2 Concrete cover of main anchor bars in corner or middle position of column shoe

	HPKM 16	HPKM 20	HPKM 24	HPKM 30	HPKM 39
Corner concrete cover C_c [mm]	40	42	42	44	46
Middle concrete cover C_m [mm]	55	58	60	63	72

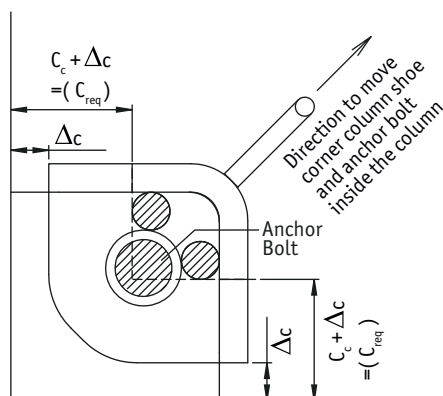
If higher values of concrete cover are required ($c_{req} > c_c$ or $c_{req} > c_m$), HPKM Column Shoes need to be placed toward the column centre (see Figure 5). To prevent concrete to fill up the pocket during casting, the recess boxes may be used. When column shoes are located away from column surface, there are special request to prevent the concrete to fill up the the gap of Δ_c size. For detailed information see the installation chapter of HPKM Column Shoes.



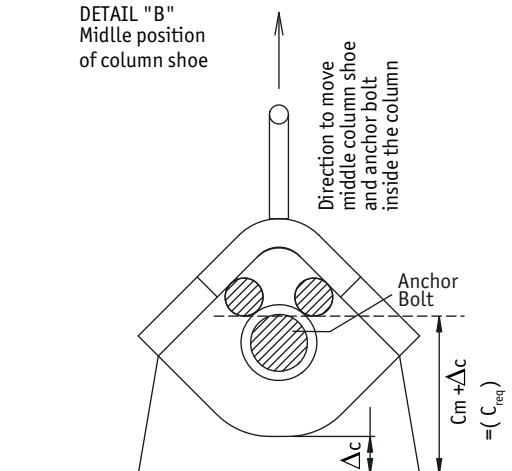
NOTE! When column shoes are moved towards centre of the column, the anchor bolts should be moved accordingly in the bolt arrangement drawings.

Figure 5 Concrete cover of main anchor bars – determination of required concrete cover thickness c_{req}

DETAIL "A"
Corner position of column shoe



DETAIL "B"
Middle position of column shoe



1.3 Other properties

HPKM Column Shoes are fabricated of steel plates and reinforcing bars with the following material properties:

Steel plates	S355J2+N	EN 10025-2
Ribbed bars	B500B	EN 10080
	BSt500S/B500B	DIN 488

Peikko Group's production units are externally controlled and periodically audited on the basis of production certifications and product approvals by various organizations, including Inspecta Certification, VTT Expert Services, Nordcert, SLV, TSUS and SPSC among others.

Products are marked with the mark of Inspecta, the emblem of Peikko Group, the type of product and year and week of manufacturing.

Table 3 Dimensions [mm], weights [kg] and color codes of HPKM Column Shoes

		HPKM 16	HPKM 20	HPKM 24	HPKM 30	HPKM 39	manuf. tolerances
	B	85	95	105	120	150	+3, -0
	C	75	80	85	90	110	+2, -0
	D	115	120	125	140	180	
	E	50	50	50	50	60	± 1
	H	725	875	1105	1430	1885	± 10
	K	135	145	150	175	225	
	t	15	20	30	45	50	
	X	30	30	30	30	37	
	Ø	28	31	35	40	55	+2, -0
	weight	2,0	3,5	6,1	12,6	25,0	
color code							

Lap lengths of anchor bars are defined according to concrete grade C30/37 in poor bond conditions.

2. Resistances

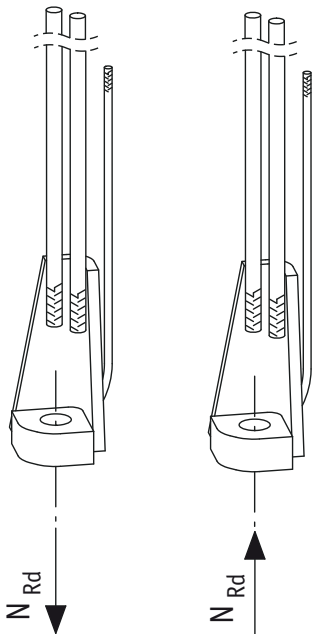
The resistances of HPKM Column Shoes are determined by a design concept that makes reference to the following standards:

- EN 1992-1-1:2004/AC:2010
- EN 1993-1-1:2005/AC:2009
- EN 1993-1-8:2005/AC:2005
- ETAG 001, Annex C:2010

HPKM Column Shoes are designed to withstand tensile or compressive forces corresponding to the design values of resistances of HPM Anchor Bolts. The maximum design values of resistances of individual HPKM Column Shoes are given in Table 4.

It is recommended to calculate the resistance of column connection with Peikko Designer® software.

Table 4 Design values of resistances of individual HPKM Column Shoes for concrete grade C30/37

Column Shoe	Anchor Bolt	N_{Rd} [kN]	
HPKM 16	HPM 16	61,7	
HPKM 20	HPM 20	96,3	
HPKM 24	HPM 24	138,7	
HPKM 30	HPM 30	220,4	
HPKM 39	HPM 39	383,4	

The resistance of HPKM Column Shoe is valid for tensile or compressive force N_{Rd}

2.1 Fire resistance

If the column shoe is exposed to action of fire, the characteristic value of resistance need to be determined. If the resistance is not sufficient, it is recommended to position the column shoe toward the centre of column – see chapter 1.2.3. The additional concrete cover will increase the fire resistance of column shoe.

The fire resistance of HPKM column shoes is 90 minutes when they are placed in the corner of the column. All types of shoes fulfill the requirements of the fire resistance class F90 according to DIN 4102-2 standard. Resistance values are based on simulation test.

Selecting HPKM Column Shoe

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

- Resistance
- Properties of the column
- Properties of the grout
- Position and arrangement of the column shoes in the column

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

- Erection stage
- Final stage
- Fire situation

Peikko Designer®

Peikko Designer is free dimensioning software which is used for designing connections with Peikko's products. It can be downloaded from www.peikko.com. It is recommended to design the column connection by using Peikko Designer software. The typical procedure is done in the following steps:

USER INPUT

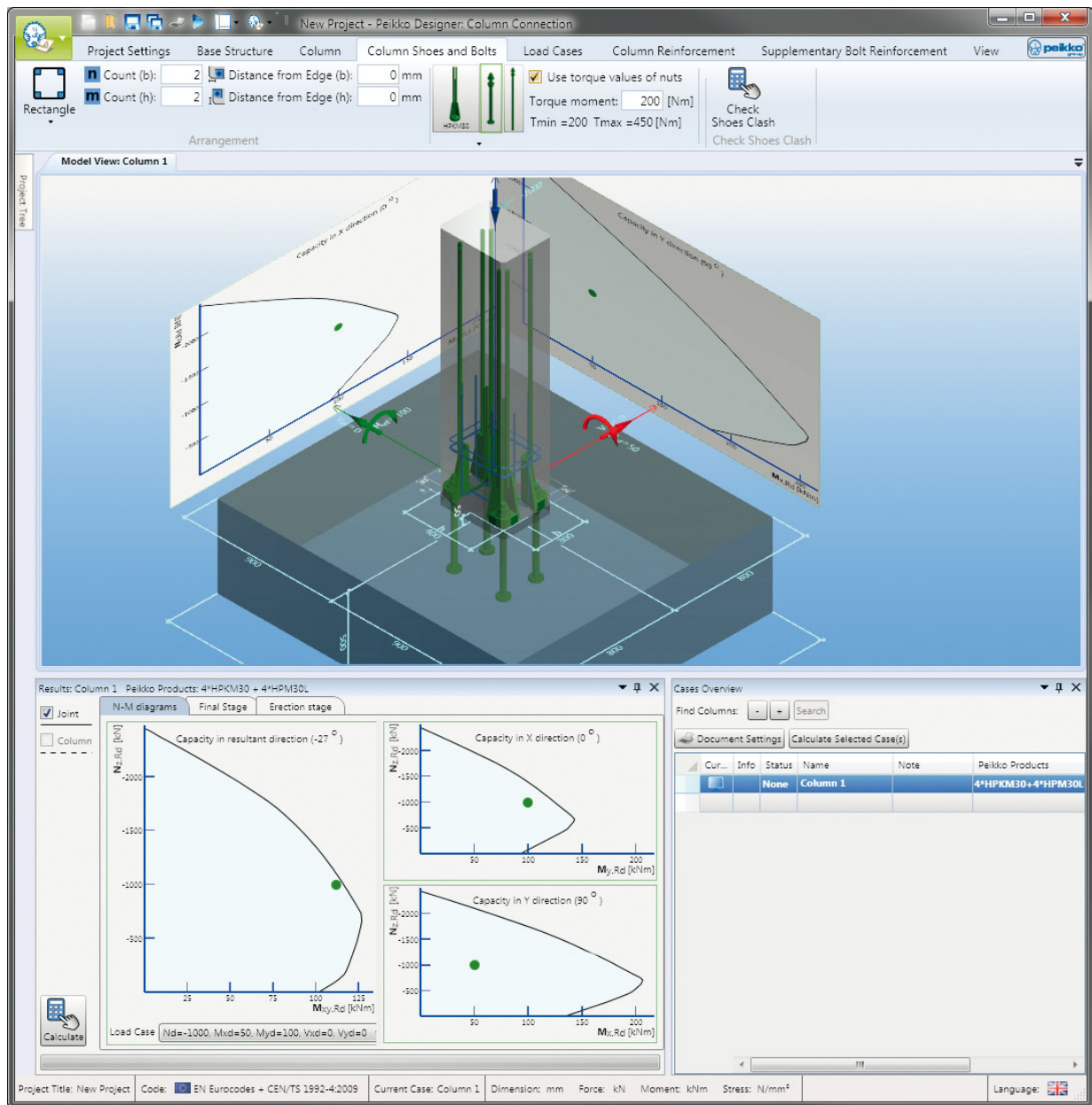
- Materials for column and grouting
- Geometry of the column
- Design values of the forces – erection and final stage
- Type of column shoe and anchor bolt
- Column shoe arrangement
- Column reinforcement (optional)

PEIKKO DESIGNER OUTPUT

- N-M diagram (axial force-bending moment diagram) of joint in final stage
- N-M diagram of reinforced column
- Calculation results for anchor bolts in final stage
- Calculation results for anchor bolts in erection stage
- Supplementary reinforcement details
- Summary of products in the project

It is easy and fast to determine the most economical design according to Peikko Designer® outputs.

Figure 6 User interface of Peikko Designer® – module of column connection



Annex A – Supplementary reinforcement

Details of supplementary reinforcement for HPKM Column Shoes are shown in following figures. Required quantities and lengths of stirrups are given in the Table 5.

Table 5 Required supplementary reinforcement (B500B)

		HPKM 16	HPKM 20	HPKM 24	HPKM 30	HPKM 39
U-stirrup	①	4 Ø 6	4 Ø 6	4 Ø 6	4 Ø 6	4 Ø 6
U-stirrup	②	2 Ø 6	2 Ø 6	2 Ø 6	2 Ø 6	2 Ø 6
Stirrup	③	2 Ø 8	2 Ø 8	3 Ø 8	3 Ø 8	3 Ø 10
Stirrup	④	2 Ø 8	2 Ø 8	3 Ø 8	3 Ø 8	3 Ø 10
Stirrup	⑤	Ø 8	Ø 8	Ø 8	Ø 8	Ø 10
a		140	165	200	250	300
l_b		300	300	300	300	300

Maximum spacing of transverse reinforcement ⑤ in the lap zone $l_0 \leq 150$ mm (EN 1992-1-1:2004, 8.7.4 and 9.5.3).

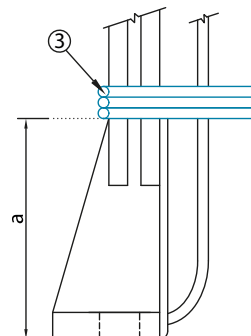
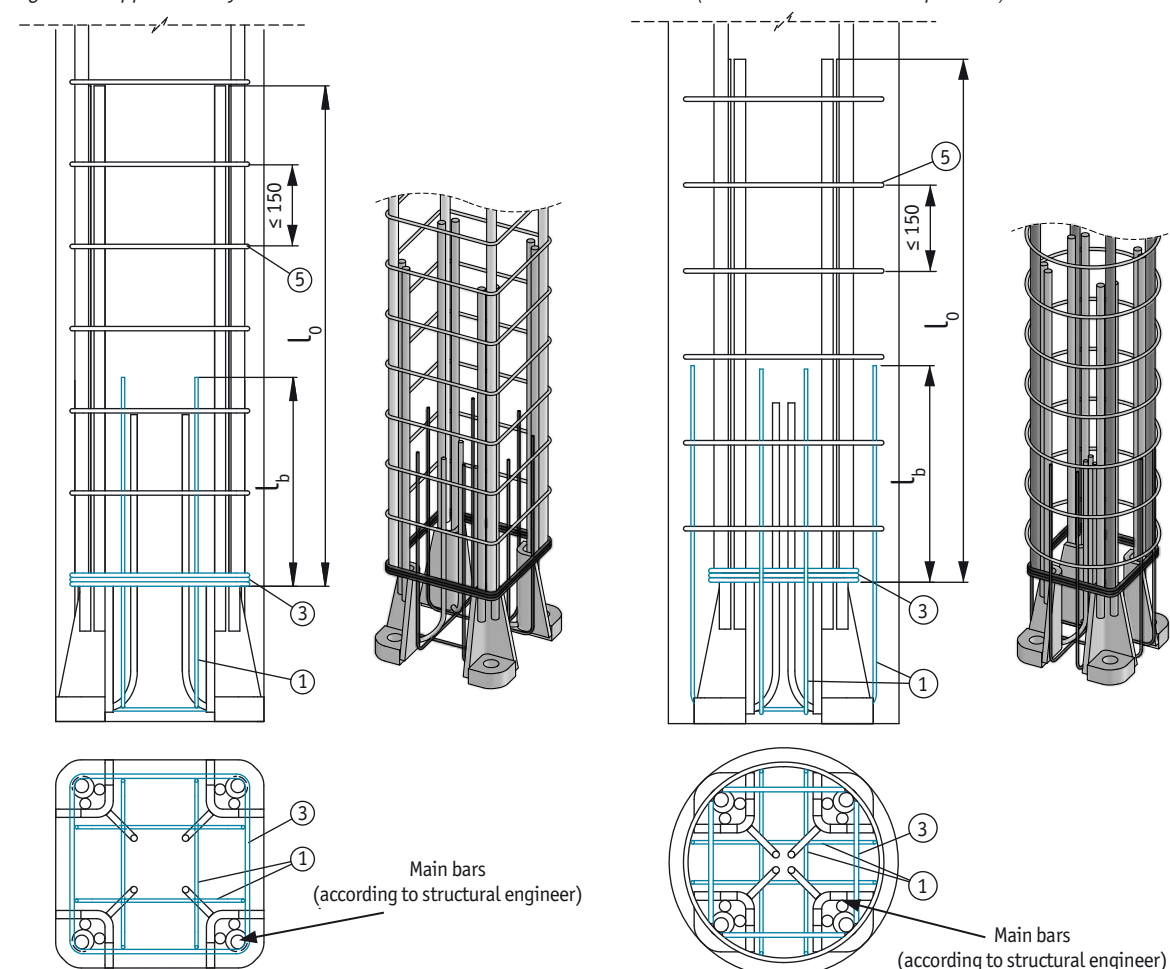
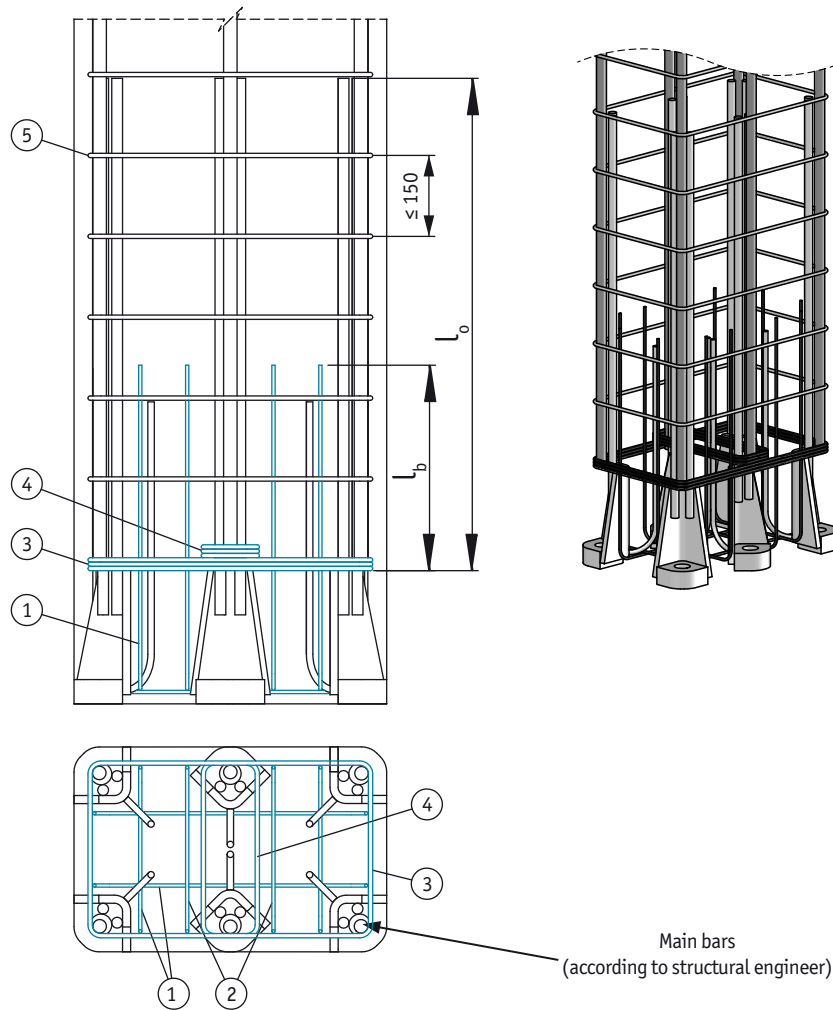


Figure 7 Supplementary reinforcement needed for HPKM Column Shoes (HPKM 30 shown in the pictures)





Column shoes in short columns

Short columns are typically one storey high columns. HPKM Column Shoes are designed to be used with reinforcing bars of the column, where splices of bars are needed to ensure the transfer of forces from column to the column shoe. By using HPKM Column Shoes with column height HPM Bolts, the number of splices can be reduced as well as reinforcement material. The bolts act as the main reinforcement of the column which can be fully replaced by HPM Bolts. The anchor bolts are manufactured to the required length L (max. 6 m).

Figure 8 Column height anchor bolts

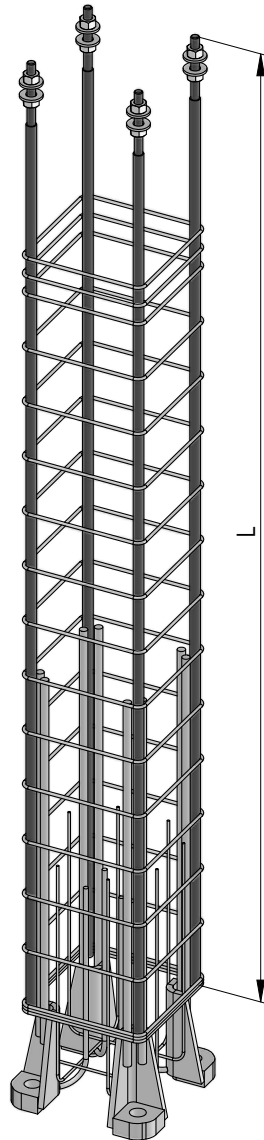
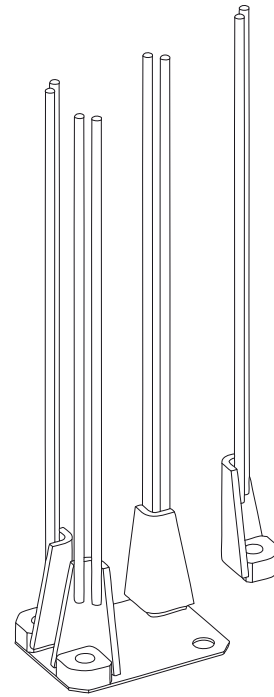


Figure 9 Column shoes on an integrated steel plate



Column shoes on an integrated steel plate

In the case when column shoes are colliding in the column (column cross section is too small for the column shoes designed for the column) an integrated steel plate may be used to connect shoes together. By welding column shoes on the plate, the rear anchor bars may be removed when less space for column shoes is needed. The steel plate may be used as an end plate of the mould as well. The minimum clear distance between anchor bars should be not less than distance requirements according to EN 1992-1-1, chapter 8.2. Shoes on integrated steel plates are manufactured according to customer's specifications. Please ask more instructions from Peikko Technical Support.

Self-made recess formers

Recess formers can be alternatively made by customers themselves, according to required dimensions shown in Table 6 and Table 7. They can be made of wood, polystyrene or similar material. Column shoes should be fixed into the formwork properly either by bolting them to end plate of the mould or welding all shoes together.

Table 6 Dimensions of corner recess boxes to use with HPKM Column Shoe

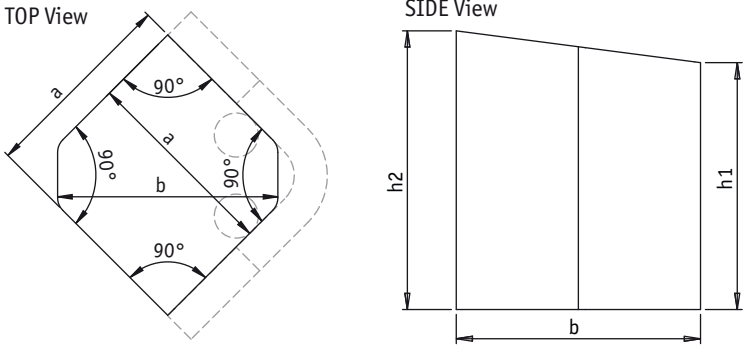
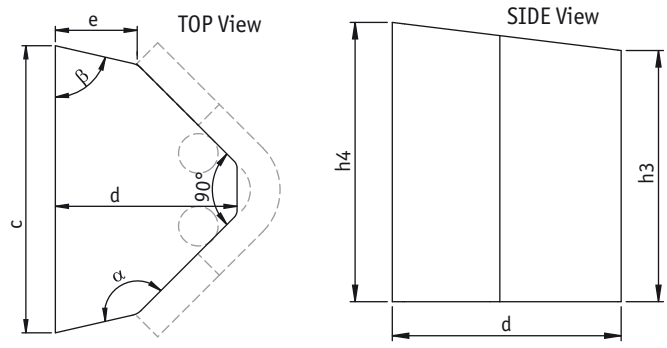
Corner recess box – dimension [mm]		a	b	h1	h2
	HPKM 16	75	83	77	87
	HPKM 20	80	88	87	97
	HPKM 24	85	94	97	107
	HPKM 30	90	99	109	122
	HPKM 39	110	127	124	136

Table 7 Dimensions of middle recess boxes to use with HPKM Column Shoe






Middle recess box – dimension [mm, °]		c	d	e	h3	h4	α	β
	HPKM 16	110	73	33	77	87	140	85
	HPKM 20	117	79	34	87	96	139	85
	HPKM 24	128	87	38	97	107	141	83
	HPKM 30	145	92	41	109	120	148	77
	HPKM 39	175	115	51	136	150	147	78

INSTALL THE PRODUCT – PRECAST FACTORY

Identification of the product

HPKM Column Shoes are available in standard models (16, 20, 24, 30 and 39) analogous to M-thread sizes of the HPM Anchor Bolts. The model of column shoe can be identified by the name in the label on the product and also according to the color of the product. Color codes are shown in the table hereafter. Color codes of recess boxes are corresponding to the color codes of HPKM Column Shoes.

HPKM Column Shoe with corresponding recess box

Column Shoe	Anchor Bolt	Corner Recess	Middle Recess	Color code
HPKM 16	HPM 16	HPKM 16 CBOX	HPKM 16 MBOX	 yellow
HPKM 20	HPM 20	HPKM 20 CBOX	HPKM 20 MBOX	 blue
HPKM 24	HPM 24	HPKM 24 CBOX	HPKM 24 MBOX	 gray
HPKM 30	HPM 30	HPKM 30 CBOX	HPKM 30 MBOX	 green
HPKM 39	HPM 39	HPKM 39 CBOX	HPKM 39 MBOX	 orange

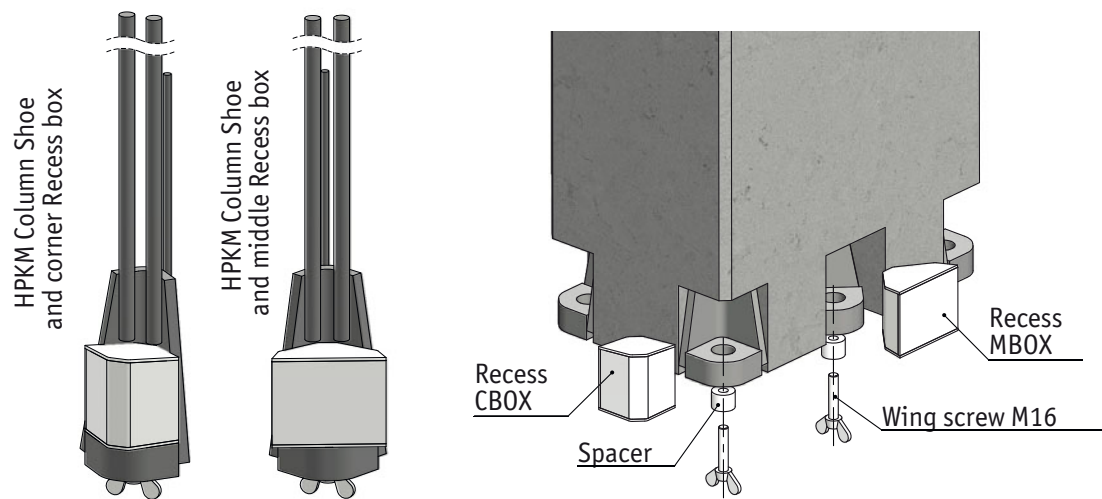
Installation of the Column Shoes

The HPKM Column Shoes are placed into the reinforcement of the column and fixed through their base plates to the end plate of the mould with recess boxes. Installation tolerance of column shoe in crosswise direction of the column is ± 2 mm. Supplementary reinforcement must be placed at the area of column base, according to drawings (Annex A). After casting the column, boxes are removed from shoes and voids are checked that they are clean from concrete.

Recess boxes are fixing accessories used to form pockets in concrete column for anchor bolts. There are separate recess boxes available for all types of column shoes and depending on the column shoe position in column’s cross section:

- CBOX is used with column shoes fixed in corner of the column
- MBOX is used with column shoes fixed in middle of the column

Recess boxes enable the shoes to be fastened and positioned to the end plate of the mould. The wing screw M16, which comes with a spacer equal to the size of the column shoe’s bolt hole, is used for fixing. With the help of the spacer, the shoe can be fixed to the correct place in the end plate. Environmental friendly formers are very durable and re-usable. It is recommended to maintain them to achieve long operating life.

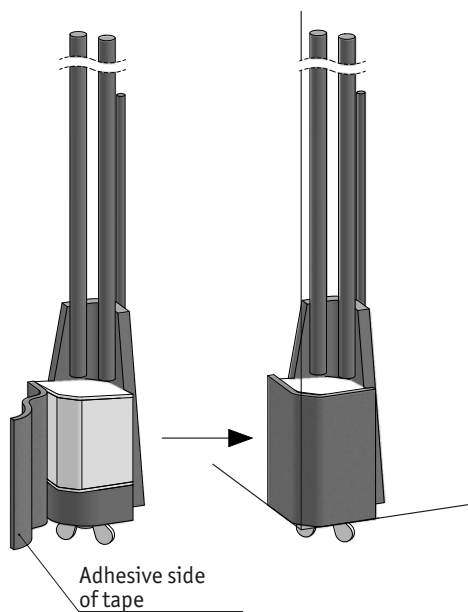


Recess boxes for corner and middle position of HPKM Column Shoe

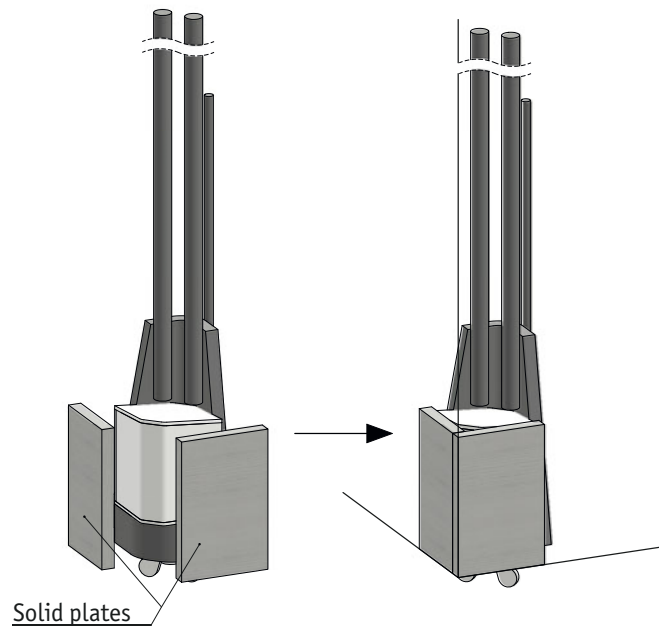
To ensure higher values of concrete cover thicknesses of main anchor bars, in accordance with chapter 1.2.3 of the technical manual, follow these instructions for increased values Δ_c of concrete cover:

- $\Delta_c < 5\text{mm}$, there is no special request for recess boxes; instructions are same as for standard concrete cover of column shoes. The gap is too small to be filled up with concrete. However if the gap is filled or partially filled, the concrete shell can be easily crushed after removing mould.
- $5\text{ mm} \leq \Delta_c \leq 15\text{mm}$, self-adhesive foam tape or equivalent can be used to prevent the fill up of the gap. Foam tape of corresponding thickness Δ_c is fixed on two sides of the recess box.
- $\Delta_c > 15\text{mm}$, to prevent the concrete to fill up the gap, it is recommended to use some kind of solid plate – e.g. plywood or hardened polystyrene of corresponding thickness Δ_c . These plates can be fixed to the surface of the mould.

Use of **self-adhesive foam tape** to prevent the fill up the gap with concrete



Use of **solid plates** to prevent the fill up the gap with concrete



Ensure of thicker concrete cover by self-adhesive foam tape or solid plates

HPKM Column Shoes before and after casting








INSTALL THE PRODUCT – CONSTRUCTION SITE

Identification of the product

HPKM Column Shoes are available in standard models (16, 20, 24, 30 and 39) analogous to HPM Anchor Bolts M-thread sizes. The model of column shoe can be identified by the name in the label on the product and also according to the color of the product. Color codes are shown in the table hereafter.

HPKM Column Shoe color identification

Column Shoe	Color Code	Anchor Bolt	Installation Template
HPKM 16	 yellow	HPM 16	PPL 16
HPKM 20	 blue	HPM 20	PPL 20
HPKM 24	 gray	HPM 24	PPL 24
HPKM 30	 green	HPM 30	PPL 30
HPKM 39	 orange	HPM 39	PPL 39

Erection of precast column

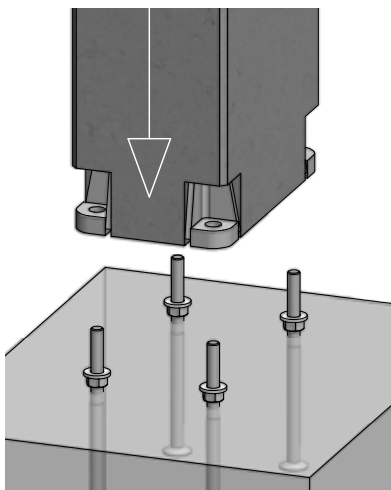
The lower nuts and washers of the anchor bolts are adjusted on the correct level. The column is installed directly on the pre-leveled washers and nuts. Additional shim plates under the column can be used if needed. Upper nuts and washers are screwed on the bolts and tightened at least to a snug-tight condition, e.g. with slogging spanner acc. to DIN 7444 or open ended slogging spanner acc. to DIN 133 and small sledgehammer. At the same time column is positioned on the correct level and vertical position by adjusting nuts. After the nuts are tightened, the crane can be released from the column. Normally there is no need for temporary bracing. The erection must be done according to the approved erection plan. Installation instructions for anchor bolts can be found in Technical Manual of HPM Anchor Bolts.



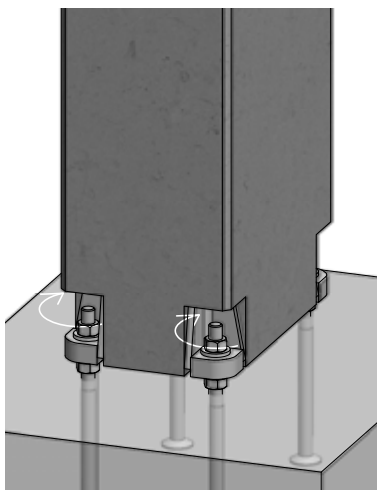
Before loading the column by any other structures e.g. beams, columns, the joint underneath the column and bolt recesses should be grouted by following instructions from grout material provider. The grout must be non-shrinking type and strength according to plans. After grouting has reached sufficient strength, the connection is finalized and the joining structures may be erected on the column.



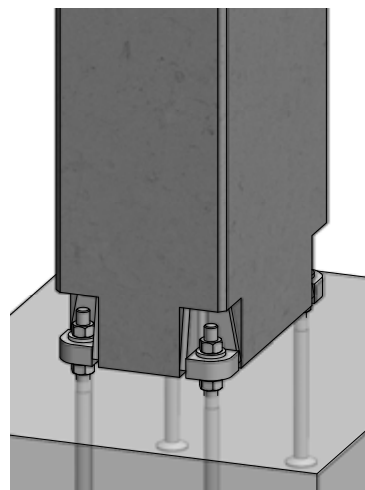
Column is installed directly on the pre-leveled washers and nuts



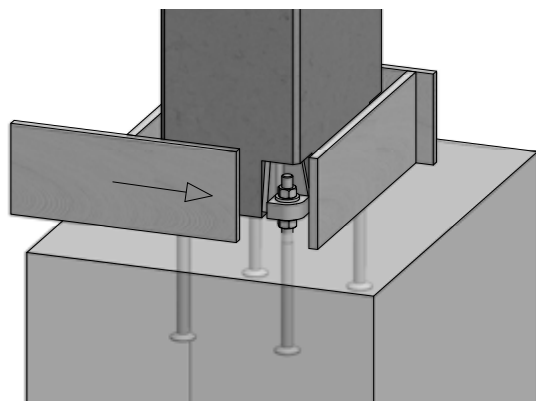
Upper nuts and washers are screwed on the bolts



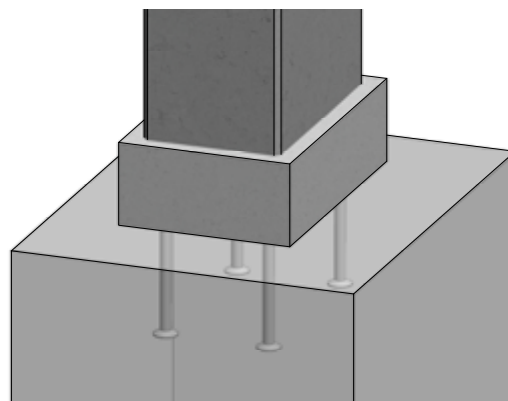
After the nuts are tightened, the crane can be released



Formwork for grouting joint and recesses



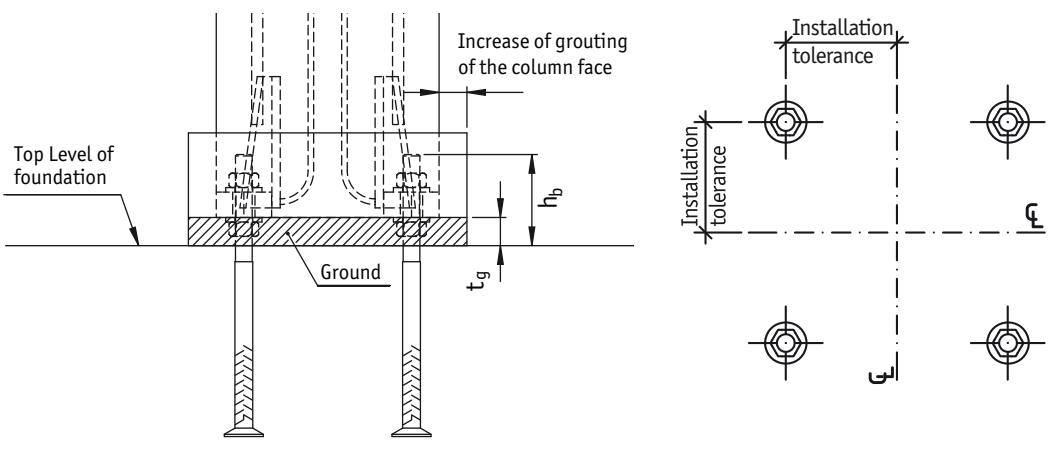
Finalized connection after grouting has hardened



Erection of precast concrete column step by step.

In column to foundation connections wider grouting can be provided to ensure higher concrete cover if it is required. It is recommended to use it in aggressive environment.

Installation tolerances and the anchor bolt's protrusion from the surface of concrete when HPKM Column Shoes are used

					
Column Shoe	HPKM 16	HPKM 20	HPKM 24	HPKM 30	HPKM 39
Anchor Bolt	HPM 16	HPM 20	HPM 24	HPM 30	HPM 39
Thickness of grouting t_g [mm]	50	50	50	50	60
Protrusion of the bolt h_b [mm]	105	115	130	150	180
Installation tolerance for the bolt [mm]	±3	±3	±3	±3	±3



PEIKKO GROUP CORPORATION

Peikko Group, founded in 1965, is a family owned company specializing in composite beams and fastening products for concrete connections. Peikko provides innovative solutions to help customers make their building process faster, easier and more reliable. Precasters, builders, constructors, developers, flooring specialists, machine manufactures, power plant designers, architects and structural designers can all enjoy and take advantage of the Peikko solutions.

Peikko Group has offices in 30 and factories in 9 countries in Europe, North America and Middle East. Peikko Group, with headquarters in Lahti, Finland, employs more than 800 persons.