TECHNICAL MANUAL

HPKM® Column Shoe

Reliable Bolted Column Connections

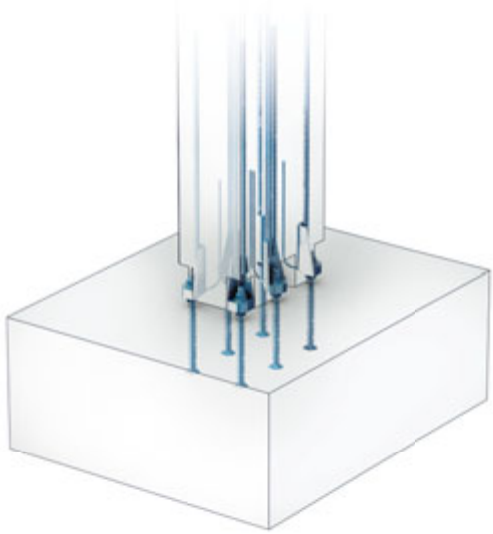
Version: PEIKKO GROUP ACI-M 01/2017
Designed according to ACI 318M-11

peikko®

HPKM® Column Shoe

For bolted column connections

- Full-Scale tested & approved connection
- Quick, easy and cost-efficient erection of the column with minimal crane time
- No bracing & welding during assembly stage
- Easy to design with Peikko Designer® software



The bolted column shoes' connection was originally invented by Peikko Group. The current generation of Column Shoes was introduced in the late 1980s.

HPKM® Column Shoes are construction products used to create cost-effective, moment-resisting, stiff connections between precast concrete columns and foundations, or between precast concrete columns. The bolted column shoes' connection is at least as rigid as a continuously reinforced cast-in-situ column connection. HPKM® Column Shoes are used together with HPM Rebar Anchor Bolts.

The Column Connection is made by the Column Shoes and the Anchor Bolts. The Column Shoes are casted into precast concrete columns, while Anchor Bolts are casted into the foundation or another column (columns' splice). On the construction site the columns are erected on the Anchor Bolts, adjusted to the correct level and vertical position. Fixing is achieved by tightening nuts on the Anchor Bolts. The joint between column and structure below should be grouted before loading the column. After grout is hardened, the joint works as reinforced concrete structure.

Peikko Group's HPKM® Column Shoes' connection has been ETA approved (ETA-13/0603). It can also be designed according to ACI 318M-11. The HPKM® Column Shoe as steel part casted into concrete is designed according to Eurocodes or ACI 318M-11.

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Revision: 003*

1. Product properties

HPKM® Column Shoes are available in several standard models to enable most types of precast concrete column connection. The original Peikko column connection system consists of:

- Column shoes
- Anchor bolts
- Accessories: recess formers and installation templates

HPKM® Column Shoes are used with HPM Rebar Anchor Bolts to make moment-resisting precast concrete column connections. The connection can be designed to be at least as stiff as a continuously reinforced cast-in-situ connection. The column shoes are cast into the bottom part of the column together with the main and supplementary reinforcement as detailed in Annex A of this manual. HPM Rebar Anchor Bolts are either cast into the foundations (column-to-foundation connection) or in the top part of the lower column (column-to-column connection). Column shoes have a round hole that fits with the corresponding anchor bolt. The column connection is achieved by fastening the anchor bolts to column shoes using nuts and washers. The bolted connection offers sufficient assembly tolerances to adjust the column to the correct height and vertical position. To finalize the connection, the joint underneath the column is grouted with non-shrink grout material, as are the recesses.

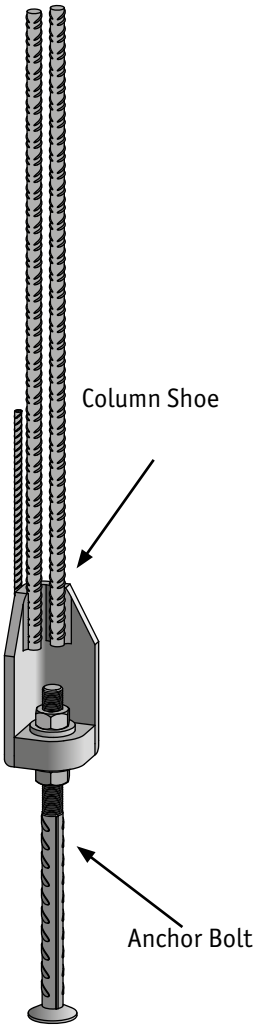
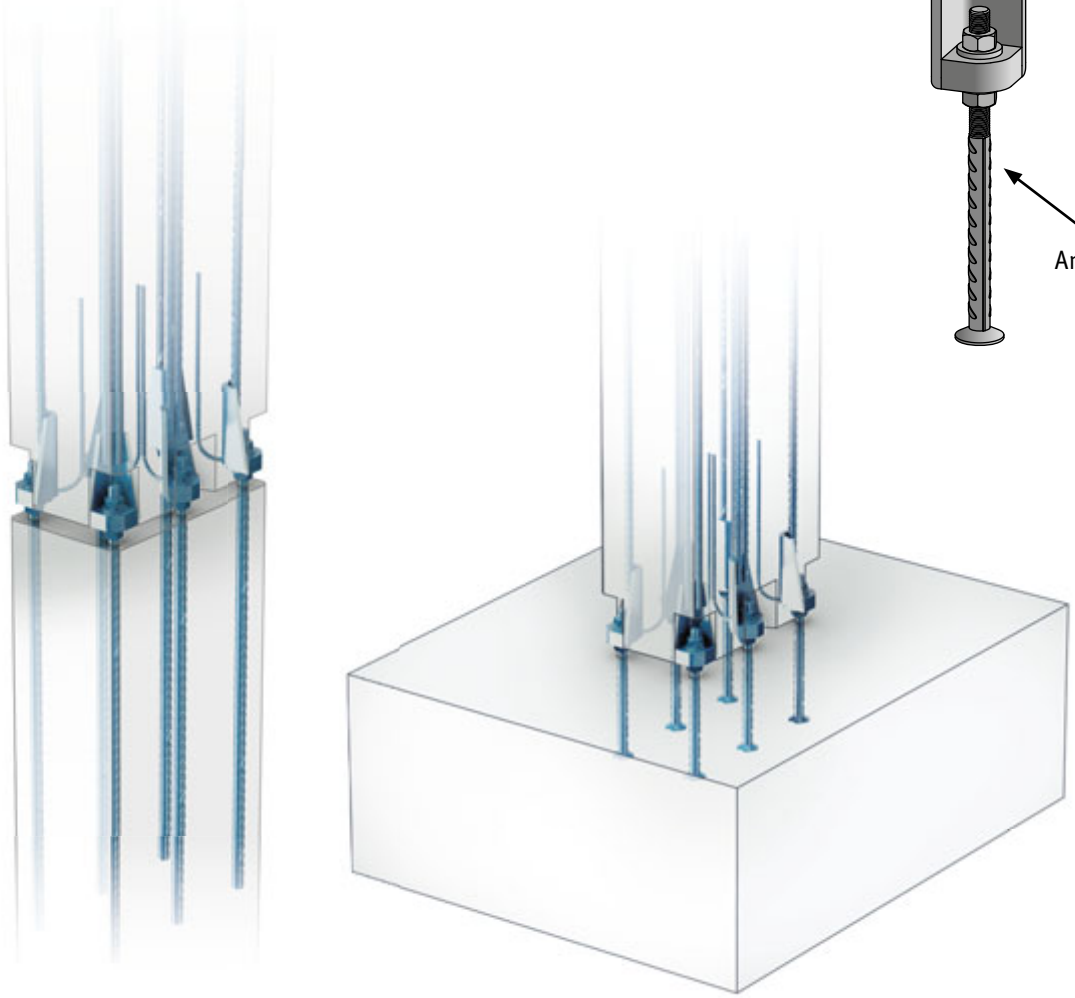


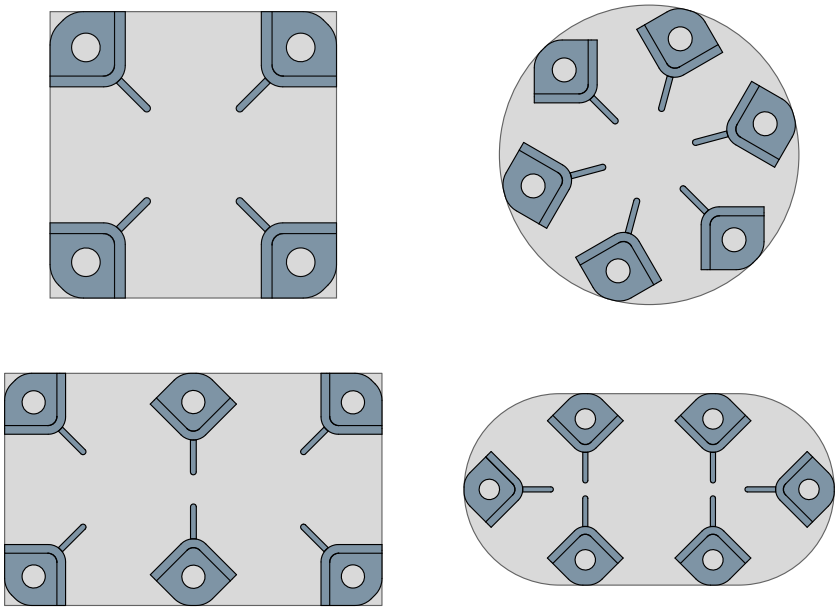
Figure 1. HPKM® Column Shoes and HPM Rebar Anchor Bolts in column connection.



The resistances of individual HPKM® Column Shoes are equal to the resistances of corresponding HPM Rebar Anchor bolts. For more information about anchor bolts, see the Technical Manual of HPM Rebar Anchor Bolts.

Peikko's column connection can be designed to resist axial forces, bending moments, shear forces, and combinations of the aforementioned forces, as well as fire exposure. The appropriate type of column shoe and anchor bolt to be used in a connection may be selected and the resistance of the connection verified using the 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® Colum Shoes in different column cross-sections.



1.1 Structural behavior

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

1.1.1 Temporary conditions

During the erection stage, the forces acting on the column shoes are caused principally by the weight of the column itself and the bending moment and shear force due to wind load. Since the joint between the column and the base structure is not grouted, all of the forces from the column shoes are carried solely by the anchor bolts. The bolts must be designed for buckling and bending. If the size of the bolt is not sufficient for the load, the size or number of bolts and column shoes should be increased. The open joint underneath the column and recesses must be grouted with non-shrink grout and the grout must harden before the column is loaded by other structures.

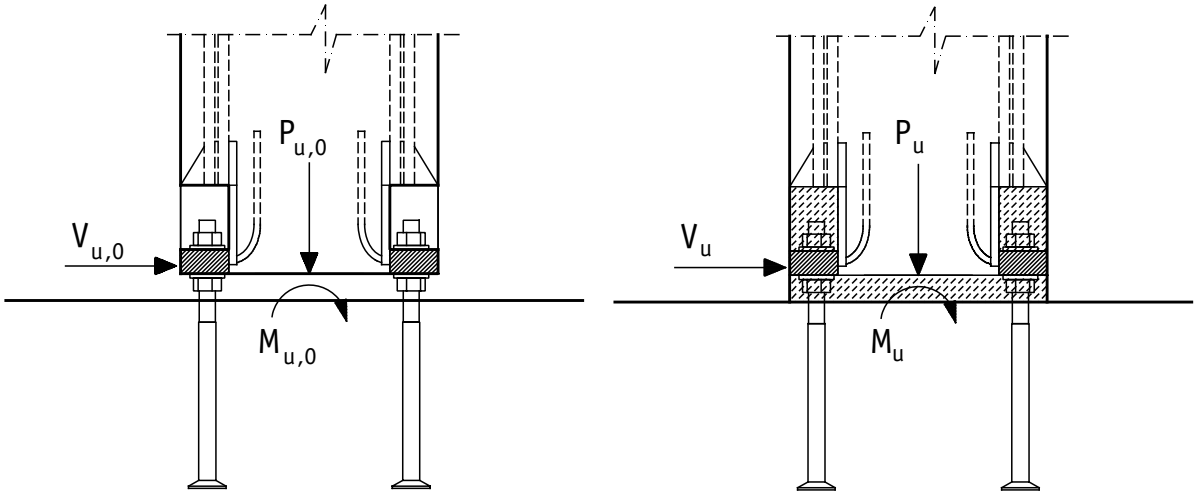
1.1.2 Final conditions

In the 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 are able to resist actions designed for final conditions.

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

TEMPORARY
Loads are caused by the weight of the column itself and wind load. Forces are carried by anchor bolts.

FINAL
Maximum design loads.
The connection acts as a reinforced concrete structure.



1.2 Application conditions

The standard models of HPKM® Column Shoes are pre-designed for use under the conditions mentioned in this section. If these conditions may not be satisfied, please contact Peikko Customer Engineering Service for individually designed HPKM® Column Shoes.

1.2.1 Loading and environmental conditions

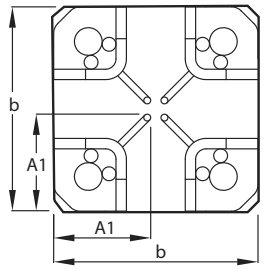
The HPKM® Column Shoe resistances given in chapter 2 are for static loads. Individual designs are required for dynamic fatigue or seismic loads.

Column shoes are designed for use indoors and in dry conditions. When using HPKM® Column Shoes in other conditions, the surface treatment, concrete cover, or raw materials must be adequate according to the environmental exposure class and intended operating life. The required concrete cover is defined by the column designer.

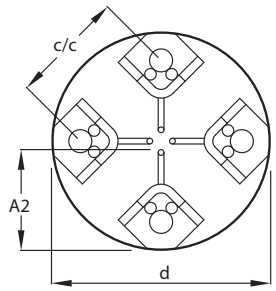
1.2.2 Interaction with column

HPKM® Columns Shoes are pre-designed for use in reinforced concrete columns with the minimum dimensions summarized in *Table 1*. If the column shoes are to be placed in a column with smaller dimensions, please contact Peikko Customer Engineering Service.

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



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



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

$c/c = \frac{d - 2E}{\sqrt{2}}$, where E is taken from dimensions table (*Table 3*).

The standard properties of HPKM® Column Shoes are guaranteed in reinforced concrete columns made of concrete grade 30 MPa cylinder strength or higher. The strength of non-shrink grout in the joint must be at least equivalent to or higher than the designed concrete grade of the column. For the minimum concrete grade for anchor bolts, see the Technical Manual of HPM Rebar Anchor Bolts.

The structural properties of HPKM® Column Shoes are guaranteed only if supplementary reinforcement is provided in the column in accordance with the rules in Annex A of this Technical Manual. It should be noted that 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 the column shoe is 40–46 mm when the HPKM® Column Shoe is located at the corner of the column. If the HPKM® Column Shoe is in the middle position, the concrete cover should be thicker than in the corner position (see *Figure 4* and *Table 2*).

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

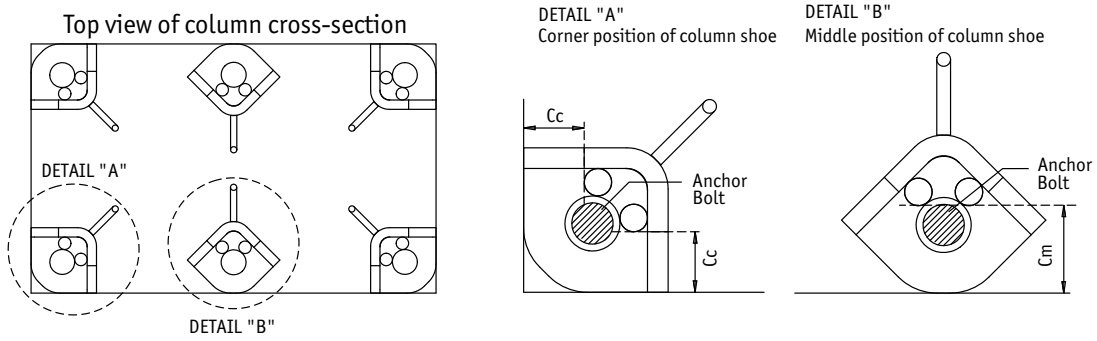


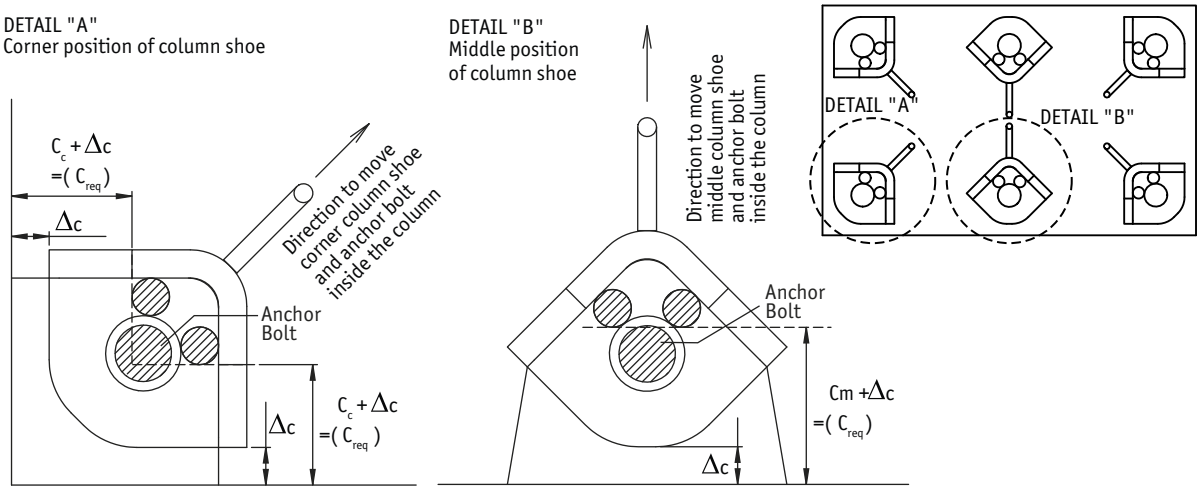
Table 2. Concrete cover of main anchor bars in corner or middle position of column shoe.

	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI
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 concrete must be prevented from filling up a gap of Δ_c size. For detailed information, see the chapter on installation of HPKM® Column Shoes.

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

Figure 5. Concrete cover of main anchor bars – determination of required concrete cover thickness creq.



1.3 Other properties

HPKM® Column Shoes are fabricated of steel plates and reinforcement steel with the following material properties:

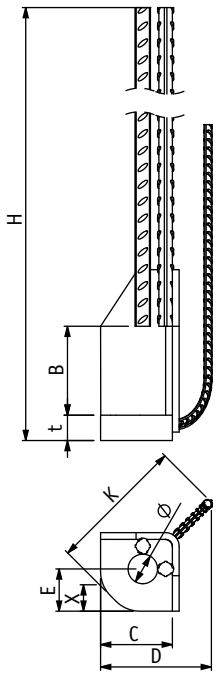
Steel plates	Grade 50	ASTM A572M
	S355J2+N	EN 10025-2
	Q345	GB/T 1591
Ribbed bars	Grade 75	ASTM A615M
	B500B	EN 10080
	HRB 500	GB 1499

To order column shoes made of specific materials, please see the chapter entitled 'Selecting HPKM® Column Shoes'.

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

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

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



	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI	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	+1, -0
X	30	30	30	30	37	
Ø	28	31	35	40	55	+2, -0
Weight	2.3	3.9	6.5	13.8	26.4	
Color code	Yellow	Blue	Gray	Green	Orange	

Lap lengths of anchor bars are defined according to concrete grade 30 MPa cylinder strength.

2. Resistances

The design concept for precast concrete column connections is according to ACI 318M-11.

When calculating the action effects of a column, the rigidity of the end connections must be estimated. It was verified during the demanding initial type testing with concrete column connections that rectangular cross-sections with at least four column shoes behave rigidly in bending or are at least as stiff as continuously reinforced cast-in-situ columns.

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

- ACI 318M-11
- ANSI/AISC 360-10
- AWS D1.1/D1.1M 2006

The calculated resistances of HPKM® Column Shoes in this manual do not include any national requirements.

2.1 Axial resistances

HPKM® Column Shoes are designed to withstand tensile and compressive forces corresponding to the design values of resistances of HPM Rebar Anchor Bolts.

It is recommended that the resistances of the column connection be calculated using the Peikko Designer® software, which makes the column connection design procedure quick and easy. The software includes a design code selection, which is required for each design case and which contains several options. By selecting a valid design code, it is possible to check the resistances of each column connection easily. It is also possible to check the erection stage resistances of a column connection before the joint is grouted.

Table 4. Design values of tensile or compressive resistances ϕN_{sa} of individual HPKM® Column Shoes for concrete grade 30 MPa cylinder strength. Anchor bolt material grade 60 according to standard ASTM A615M.

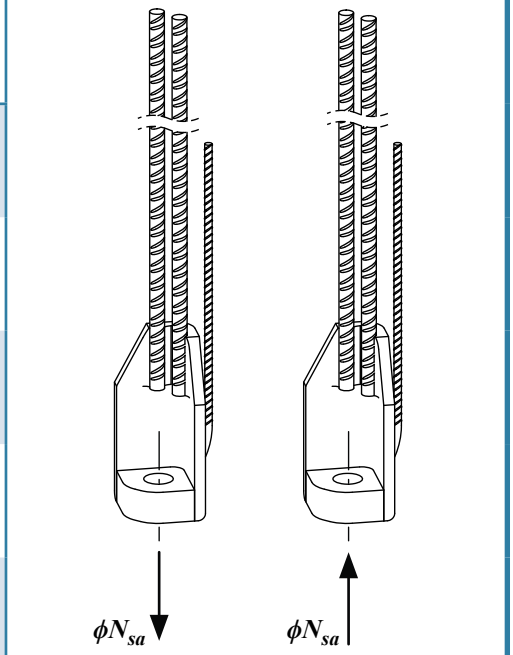
Column Shoe	Rebar Anchor Bolt	ϕN_{sa} [kN]	
HPKM 16 ACI	HPM 16 ACI ASTM	63	
HPKM 20 ACI	HPM 20 ACI ASTM	97	
HPKM 24 ACI	HPM 24 ACI ASTM	141	
HPKM 30 ACI	HPM 30 ACI ASTM	224	
HPKM 39 ACI	HPM 39 ACI ASTM	390	

Table 5. Design values of tensile or compressive resistances ϕN_{sa} of individual HPKM® Column Shoes for concrete grade 30 MPa cylinder strength. Anchor bolt material B500B according to standard EN 10080.

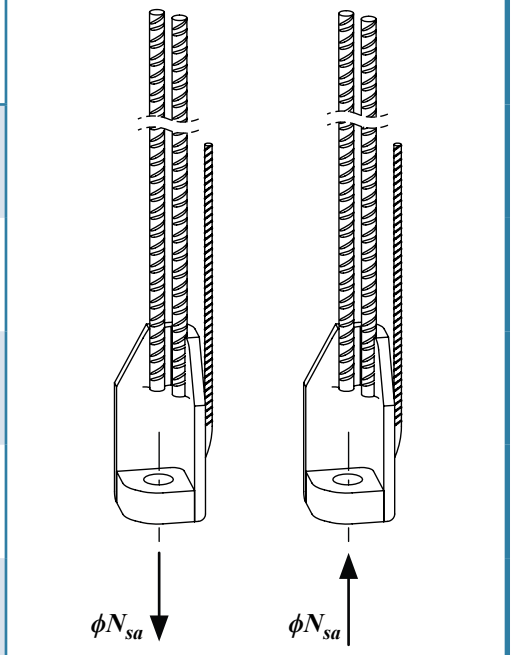
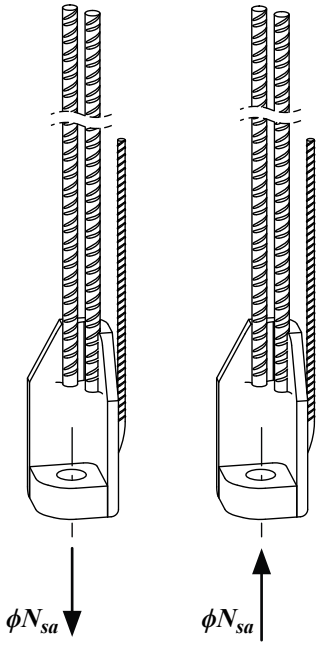
Column Shoe	Rebar Anchor Bolt	ϕN_{sa} [kN]	
HPKM 16 ACI	HPM 16 ACI EN	55	
HPKM 20 ACI	HPM 20 ACI EN	86	
HPKM 24 ACI	HPM 24 ACI EN	125	
HPKM 30 ACI	HPM 30 ACI EN	199	
HPKM 39 ACI	HPM 39 ACI EN	346	

Table 6. Design values of tensile or compressive resistances ϕN_{sa} of individual HPKM® Column Shoes for concrete grade 30 MPa cylinder strength. Anchor bolt material HRB500 according to standard GB 1499.

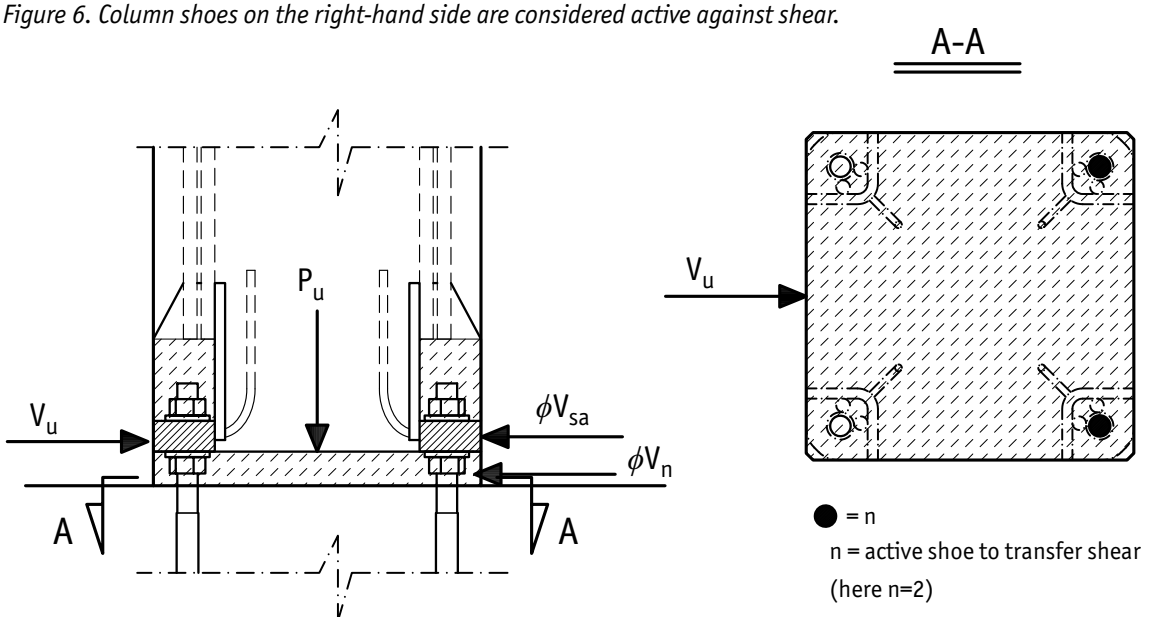
Column Shoe	Rebar Anchor Bolt	ϕN_{sa} [kN]	
HPKM 16 ACI	HPM 16 ACI GB	63	
HPKM 20 ACI	HPM 20 ACI GB	97	
HPKM 24 ACI	HPM 24 ACI GB	141	
HPKM 30 ACI	HPM 30 ACI GB	224	
HPKM 39 ACI	HPM 39 ACI GB	390	

The resistance ϕN_{sa} shown in *Tables 4–6* is the resistance of pure steel failure. For concrete failure and further information, please see the technical manual of HPM Rebar Anchor Bolt.

2.2 Shear resistances

The action effects at the connection are first divided between the individual column shoes.

Figure 6. Column shoes on the right-hand side are considered active against shear.



The design value of the shear force in the final stage for a single column shoe on the active side (see *Figure 6*) is calculated as follows:

$$V_{ua} = \frac{V_u - \phi V_n}{n}$$

$$\phi V_{n,f} = \phi \mu P_u \leq 0.2 f'_c A_c$$

where:

V_u = factored shear load
$V_{n,f}$ = shear friction strength of column connection
μ = friction coefficient = 0.55 for steel on grout and 0.7 for steel on concrete
P_u = factored compressive load in the column that is consistent with the lateral force being evaluated
ϕ = strength reduction factor
n = the number of the individual active column shoes resisting shear force
f'_c = specified compressive strength of concrete
A_c = area of concrete section resisting shear transfer

The shear resistance of a column shoe is calculated according to ACI 318M-11, section D.6.1.2, Equation (D-29).

Table 7. Design values of shear resistance ϕV_{sa} of individual HPKM® Column Shoe. Anchor bolt material grade 60 according to standard ASTM A615M.

Column Shoe	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI
Rebar Anchor Bolt	HPM 16 ACI ASTM	HPM 20 ACI ASTM	HPM 24 ACI ASTM	HPM 30 ACI ASTM	HPM 39 ACI ASTM
ϕV_{sa} [kN]	28	43	62	99	173

Table 8. Design values of shear resistance ϕV_{sa} of individual HPKM® Column Shoe. Anchor bolt material B500B according to standard EN 10080.

Column Shoe	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI
Rebar Anchor Bolt	HPM 16 ACI EN	HPM 20 ACI EN	HPM 24 ACI EN	HPM 30 ACI EN	HPM 39 ACI EN
ϕV_{sa} [kN]	25	38	55	88	153

Table 9. Design values of shear resistance ϕV_{sa} of individual HPKM® Column Shoe. Anchor bolt material HRB500 according to standard GB 1499.

Column Shoe	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI
Rebar Anchor Bolt	HPM 16 ACI GB	HPM 20 ACI GB	HPM 24 ACI GB	HPM 30 ACI GB	HPM 39 ACI GB
ϕV_{sa} [kN]	28	43	62	99	173

The resistance ϕV_{sa} shown in *Tables 7–9* is the resistance of pure steel failure. For concrete failure and further information, please see the technical manual of HPM Rebar Anchor Bolts.

The shear resistance of a column shoe subjected to shear and compression shall meet the requirement:

$$V_{ua} \leq \phi V_{sa}$$

It is recommended that the shear resistances of column connections be calculated using the Peikko Designer® software, which makes column connection shear design quick and easy, both in the final and erection stage.

2.3 Fire resistances

The required concrete cover thickness is defined by the column designer.

Selecting HPKM® Column Shoe

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

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

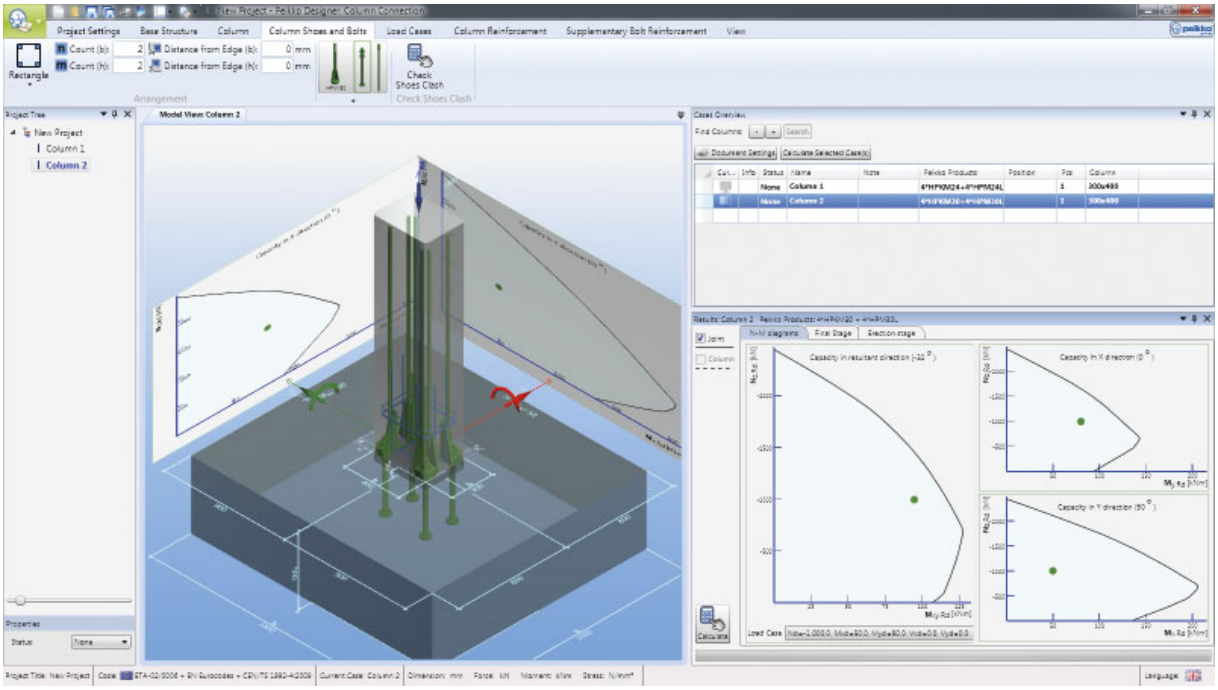
Examples of ordering column shoes from specific materials:

- HPKM ACI ASTM = shoe manufactured from plates according to standard ASTM A572M and rebars according to standard ASTM A615M
- HPKM ACI EN = shoe manufactured from plates according to standard EN 10025-2 and rebars according to standard EN 10080
- HPKM ACI GB = shoe manufactured from plates according to standard GB-2008 and rebars according to standard GB 1499

Peikko Designer® Column Connection software

Peikko Designer® is software to be used for designing column connections with Peikko's products. It can be downloaded free of charge from www.peikko.com. The Column Connection module enables the user to design connections to resist actual loadings and optimize the connections to meet the requirements of the project as a whole. The output reports of the software can be used to further verify the design and output drawings as details of the connection. A summary of the products in the project helps to plan material flow during construction.

Figure 7. User interface of Peikko Designer® Column Connection.



The typical selection procedure is done in the following steps:

USER INPUT

- Materials for column, structure under column, and grouting
- Geometries of the column and structure under the column
- Design values of the actions – erection, final, and fire stages
- Type of column shoes and anchor bolts
- Column shoe arrangement
- Column reinforcement (optional)

PEIKKO DESIGNER OUTPUT

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

Annex A – Supplementary reinforcement

Details of supplementary reinforcement for HPKM® Column Shoes are shown in the following figures. The required quantities of stirrups are given in the *Table 10*.

Table 10. Supplementary reinforcement (yield strength 420 MPa or higher).

	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI
Stirrup ①	1 Ø 10	1 Ø 10	1 Ø 10	2 Ø 10	2 Ø 10
Stirrup ②	1 Ø 10	1 Ø 10	1 Ø 10	2 Ø 10	2 Ø 10
a	140	165	200	250	300

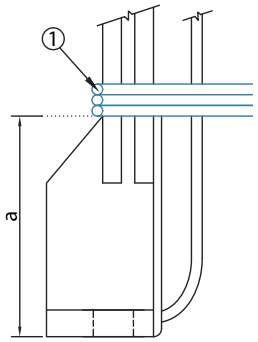
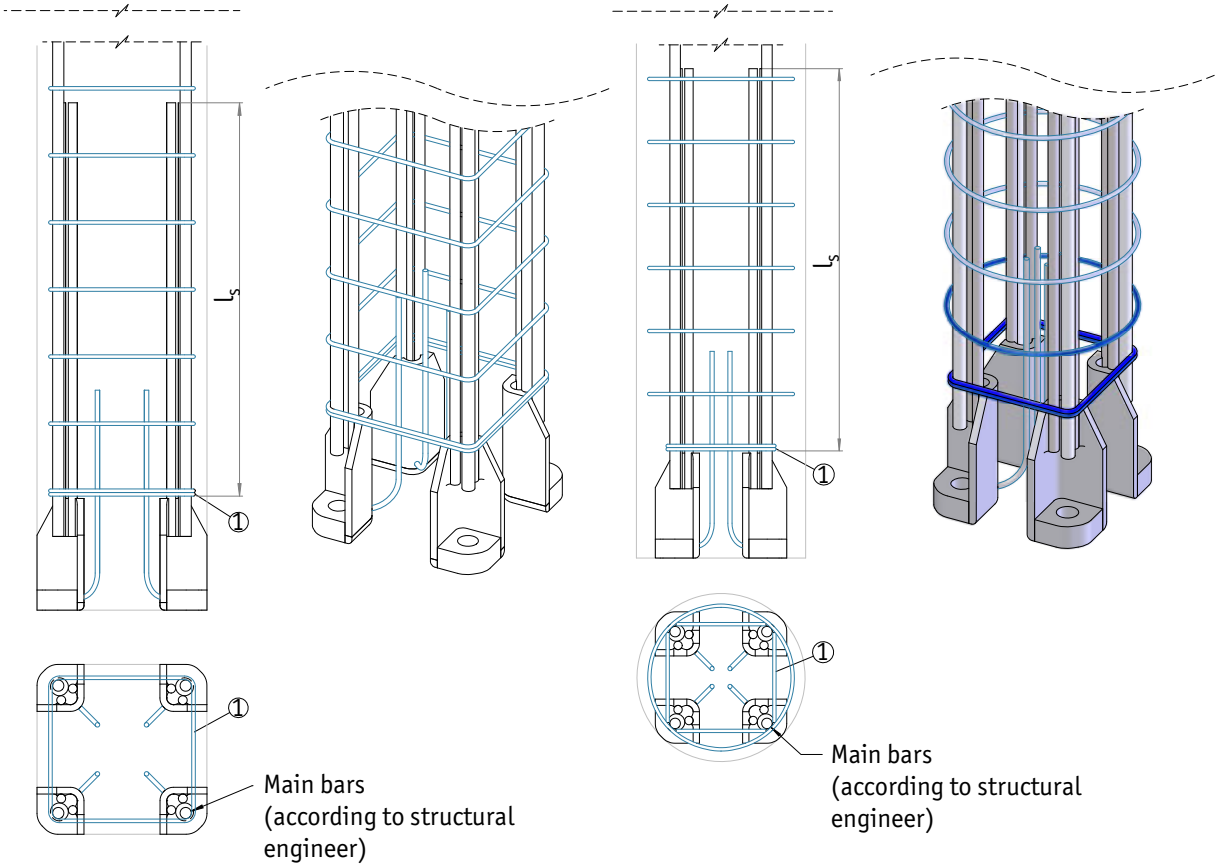
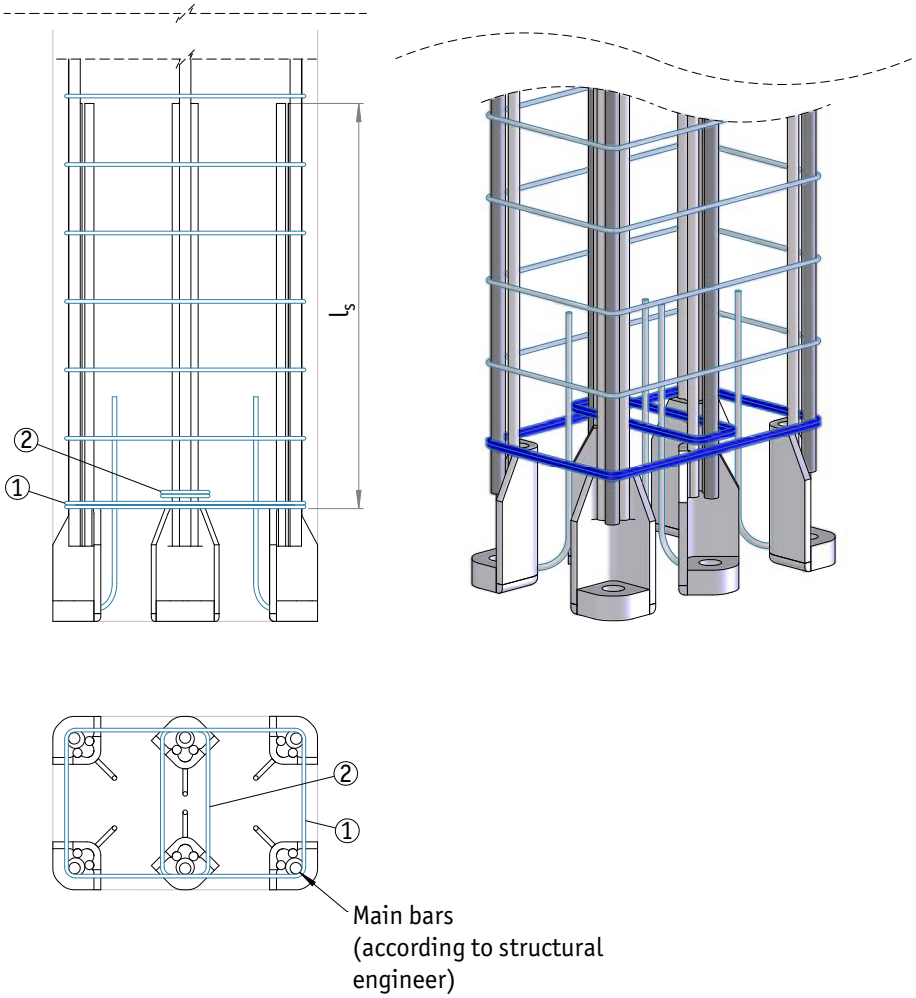


Figure 8. Supplementary reinforcement needed for HPKM® Column Shoes (HPKM® 30 shown in the pictures).



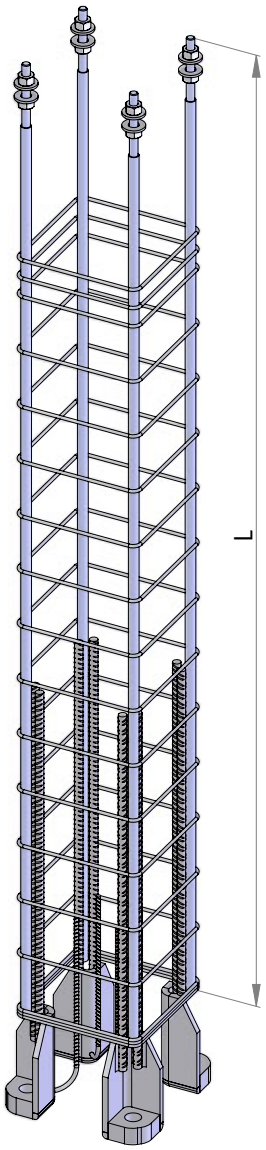

L_s
②
①
②
①
Main bars
(according to structural
engineer)

Annex B – Alternative use of HPKM® Column Shoe

Column shoes in short columns

Short columns are typically single-story columns. HPKM® Column Shoes are designed for use with the column's reinforcing bars, where splices of bars are needed to ensure the transfer of forces from the column to the column shoe. By using HPKM® Column Shoes with column-height HPM Rebar Anchor Bolts, the number of splices can be reduced, as well as the amount of reinforcement material. The bolts act as the main reinforcement of the column, which can be fully replaced by HPM Rebar Anchor Bolts. The anchor bolts are manufactured to the required length L (max. 6 m).

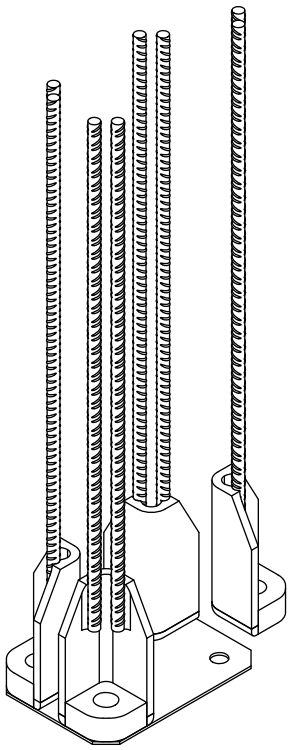
Figure 9. Column height anchor bolts.



Column shoes on an integrated steel plate

If the column shoes collide in the column (the column cross-section is too small for the column shoes designed for the column), an integrated steel plate may be used to connect the shoes together. By welding column shoes onto the plate, the rear anchor bars may be removed, reducing the required space. The steel plate may also be used as an end plate of the mold. The minimum clear distance between anchor bars and side plates of column shoes should be not less than the distance requirements according to ACI318M-11, section 7.6. Shoes on integrated steel plates are manufactured according to the customer's specifications. Please consult Peikko Customer Engineering Service for more instructions.

Figure 10. Column shoes on an integrated steel plate.



Self-made recess formers

Recess formers can be alternatively made by customers themselves according to the required dimensions shown in *Table 11* and *Table 12*. They can be made of wood, polystyrene, or similar materials. Column shoes should be fixed into the formwork properly, either by bolting them to the end plate of the mold or by welding all of the shoes together.

Table 11. Dimensions of corner recess boxes to use with HPKM® Column Shoe.

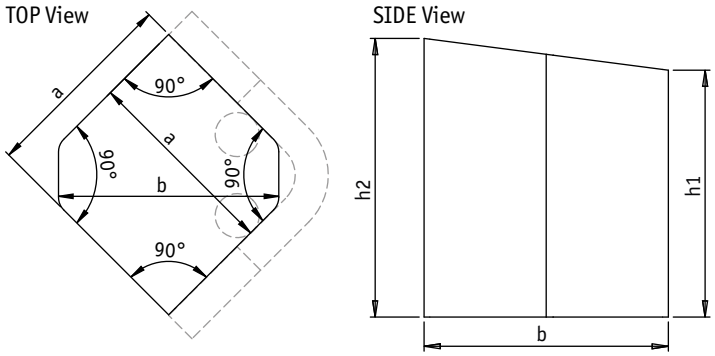
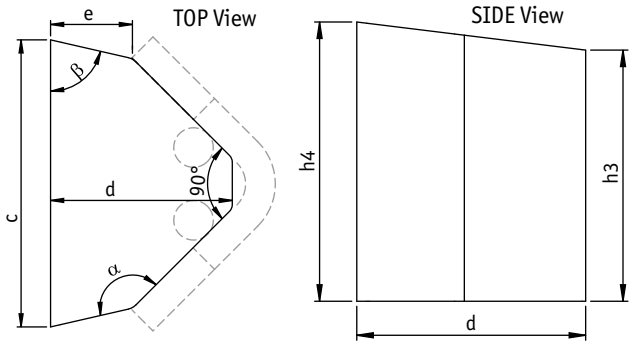
Corner recess box – dimension [mm]	a	b	h1	h2
				
HPKM 16 ACI	75	83	77	87
HPKM 20 ACI	80	88	87	97
HPKM 24 ACI	85	94	97	107
HPKM 30 ACI	90	99	109	122
HPKM 39 ACI	110	127	124	136

Table 12. 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 ACI	110	73	33	77	87	140	85
HPKM 20 ACI	117	79	34	87	96	139	85
HPKM 24 ACI	128	87	38	97	107	141	83
HPKM 30 ACI	145	92	41	109	120	148	77
HPKM 39 ACI	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 Rebar Anchor Bolts. The model of column shoe can be identified by the name on the label on the product and also according to the color of the product. The color codes are shown in the table below. The color codes of recess boxes correspond to the color codes of HPKM® Column Shoes.

HPKM® Column Shoe with corresponding recess box.

Column Shoe	Rebar Anchor Bolt	Corner recess	Middle recess	Color code
HPKM 16 ACI	HPM 16 ACI	HPKM 16 CBOX	HPKM 16 MBOX	Yellow
HPKM 20 ACI	HPM 20 ACI	HPKM 20 CBOX	HPKM 20 MBOX	Blue
HPKM 24 ACI	HPM 24 ACI	HPKM 24 CBOX	HPKM 24 MBOX	Gray
HPKM 30 ACI	HPM 30 ACI	HPKM 30 CBOX	HPKM 30 MBOX	Green
HPKM 39 ACI	HPM 39 ACI	HPKM 39 CBOX	HPKM 39 MBOX	Orange

Installation of the column choes

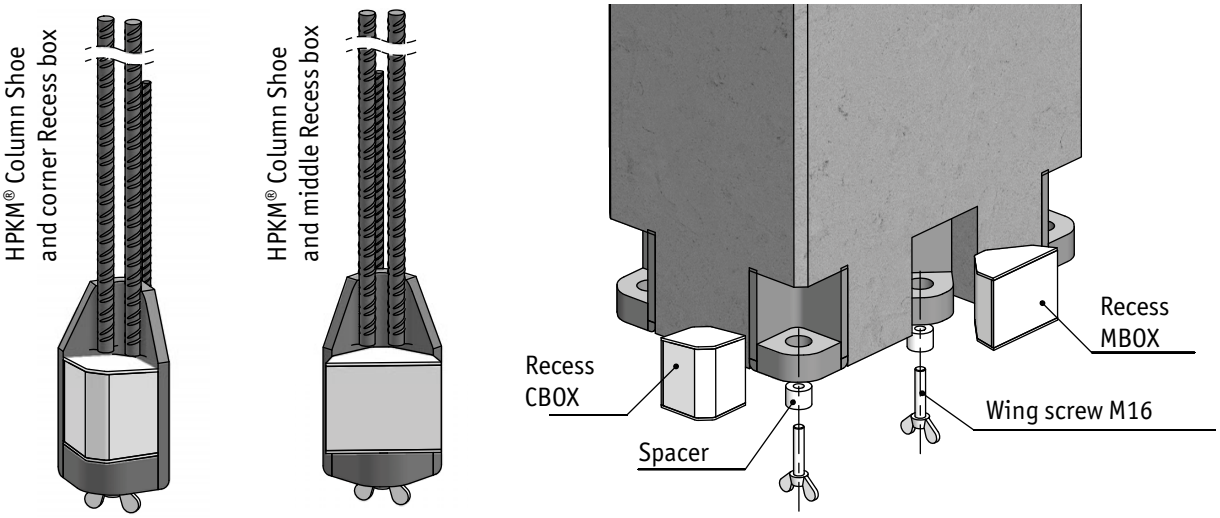
The HPKM® Column Shoes are placed into the reinforcement of the column and fixed through their base plates to the end plate of the mold with recess boxes. The installation tolerance of column shoes in the crosswise direction of the column is ± 2mm. Supplementary reinforcement must be placed in the area of the column base according to drawings (Technical Manual Annex A). After casting the column, the boxes are removed from the shoes and the voids are checked to ensure that they are free of 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, depending on the position of the column shoe in the 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 mold. The M16 wing screw, 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. Environmentally friendly formers are very durable and re-usable. It is recommended that they be maintained to achieve a long operating life.

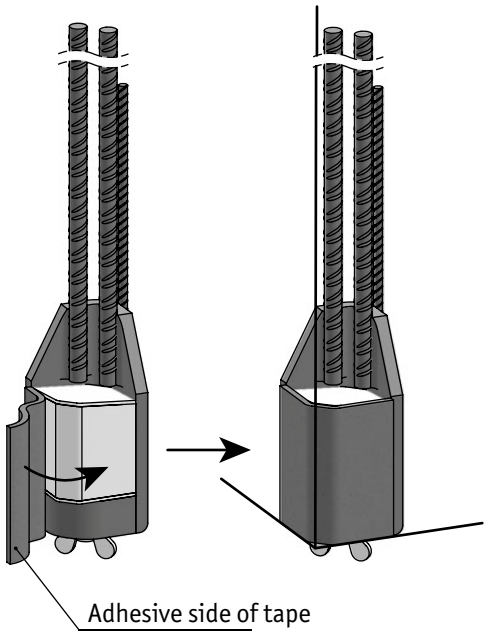
Recess boxes for corner and middle position of HPKM® Column Shoe.



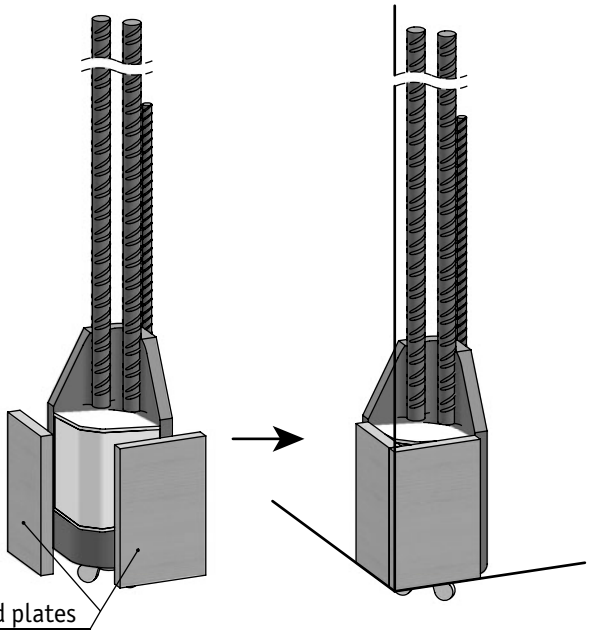
To ensure higher values of concrete cover thicknesses of main anchor bars in accordance with section 1.2.3 of the technical manual, follow these instructions for increased values Δ_c of concrete cover:

- **Δ_c < 5 mm**, there is no special requirement for recess boxes; instructions are the 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 the mold.
- **5 mm ≤ Δ_c ≤ 10 mm**, self-adhesive foam tape or equivalent can be used to prevent the gap from filling up. Foam tape of corresponding thickness Δ_c is fixed on two sides of the recess box.
- **Δ_c > 10 mm**, to prevent concrete from filling up the gap, it is recommended that a solid plate be used such as plywood or hardened polystyrene of corresponding thickness Δ_c. These plates can be fixed to the surface of the mold.

*Use of **self-adhesive foam tape** to prevent the gap from filling up with concrete.*



*Use of **solid plates** to prevent the gap from filling up with concrete.*



Ensure thicker concrete cover using 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 M-thread sizes of the HPM Rebar Anchor Bolts. Firstly precast concrete columns assembly has to be done according to project. The model of column shoe can be identified by the name on the label on the product and also according to the color of the product. The color codes are shown in the table below.

HPKM® Column Shoe color identification.

Column Shoe	Color code	Rebar Anchor Bolt	Installation template
HPKM 16 ACI	Yellow	HPM 16 ACI	PPL 16
HPKM 20 ACI	Blue	HPM 20 ACI	PPL 20
HPKM 24 ACI	Gray	HPM 24 ACI	PPL 24
HPKM 30 ACI	Green	HPM 30 ACI	PPL 30
HPKM 39 ACI	Orange	HPM 39 ACI	PPL 39

Erection of precast column

1. Leveling a precast concrete column

Before erecting the 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 on the pre-leveled washers and nuts.

Alternatively, shims are placed between the anchor bolts and adjusted to the correct level. The lower leveling nuts must be leveled to at least 5mm below the top level of the shims to ensure that the column will rest first on the shims. This method is recommended for heavier columns for easier and faster alignment of the column.

2. Aligning a precast concrete column

The upper nuts and washers are screwed onto the bolts and the attachment is aligned in the vertical position using leveling nuts. It is practical to use two theodolites from different directions to ensure verticality. After initial tightening (between 20 to 30% of verification torque), the nuts should be turned to the required nut rotation specified in the Table below. Subsequently a torque wrench should be used to verify that a torque at least equal to the T_v is required to additionally tighten the nuts. Detailed information about nut tightening procedure and sequence of the steps can be found in Steel design guide 1, 2nd edition / Base plate and anchor rod design, Appendix A, section A2.1.

Nut rotation and verification torque T_v value per bolt size.

Anchor Bolt	Nut Rotation	T_v [Nm]
HPKM 16 ACI	1/3 Turn	95
HPKM 20 ACI	1/3 Turn	165
HPKM 24 ACI	1/3 Turn	395
HPKM 30 ACI	1/3 Turn	795
HPKM 39 ACI	1/6 Turn	1365

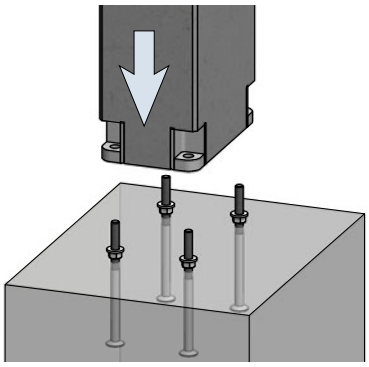
3. Grouting the joint and recesses

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

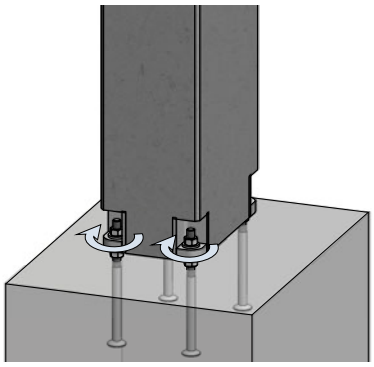
After the grout has reached the sufficient strength, the connection is finalized and joining structures may be erected onto the column.

Erection of precast concrete column step by step.

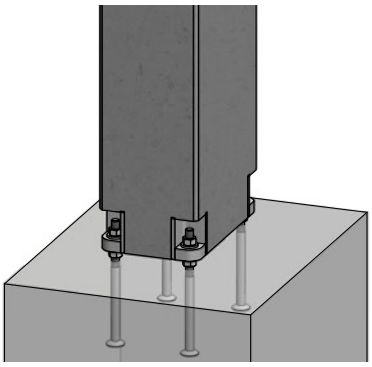
The column is installed directly on the pre-leveled washers and nuts



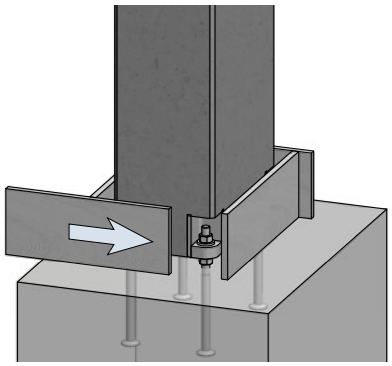
The upper nuts and washers are screwed onto the bolts



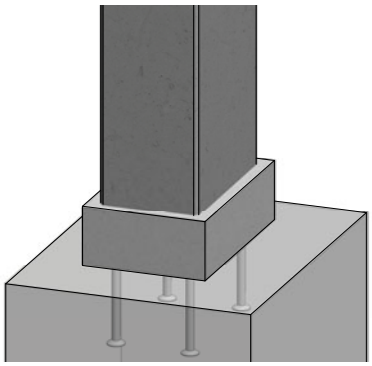
After the nuts are tightened, the crane can be released



Formwork for grouting joint and recesses

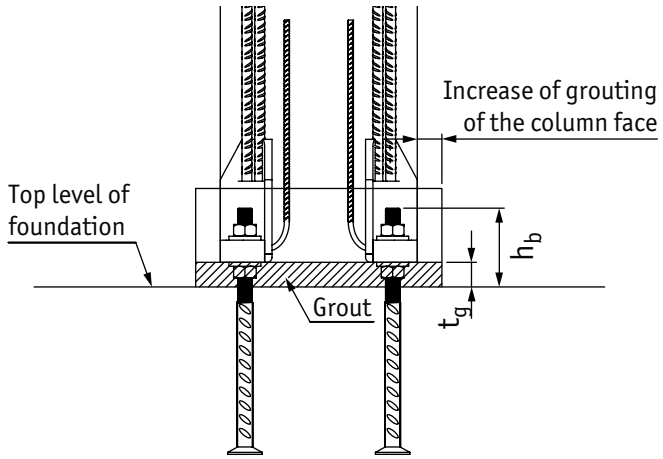


Finalized connection after grouting has hardened



In column-to-foundation connections, wider grouting can be provided to ensure higher concrete cover if it is required. It is recommended that the cover be increased in aggressive environments.

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



Column Shoe	HPKM 16 ACI	HPKM 20 ACI	HPKM 24 ACI	HPKM 30 ACI	HPKM 39 ACI
Rebar Anchor Bolt	**HPM 16 ACI**	**HPM 20 ACI**	**HPM 24 ACI**	**HPM 30 ACI**	**HPM 39 ACI**
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

Notes

Notes

Technical Manual Revisions

Version: PEIKKO GROUP ACI-M 01/2017. Revision:003*

- New cover design for 2018 added.

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