COLUMN SHOES

TECHNICAL MANUAL

EXMET
PRECAST ACCESSORIES

Version 1.0

Replaces EXM- BAS -DC-1002 R3
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1. PRODUCT PROPERTIES

GENERAL

Exmet manufactures anchor bolts in two capacity categories: Normal Capacity Bolts (NKP) and High Strength Bolts (SKP). NKK type column shoes are designed to match NKP anchor bolts. There are currently no high capacity column shoes available that match SKP bolts.

Use of bolted column connection offers following benefits:

- Simple connecting process for elements through bolting.
- Immediate initial tensile force transfer once nuts are tightened.
- Reduced need for temporary supports.
- Faster and easier adjustment of columns in installation in vertical direction and lining.
- Once the gap between the elements is filled with grout and hardened, connection is considered to be close to rigid connection.
- A bolted connection offers enhanced potential for reusing elements in a circular economy.

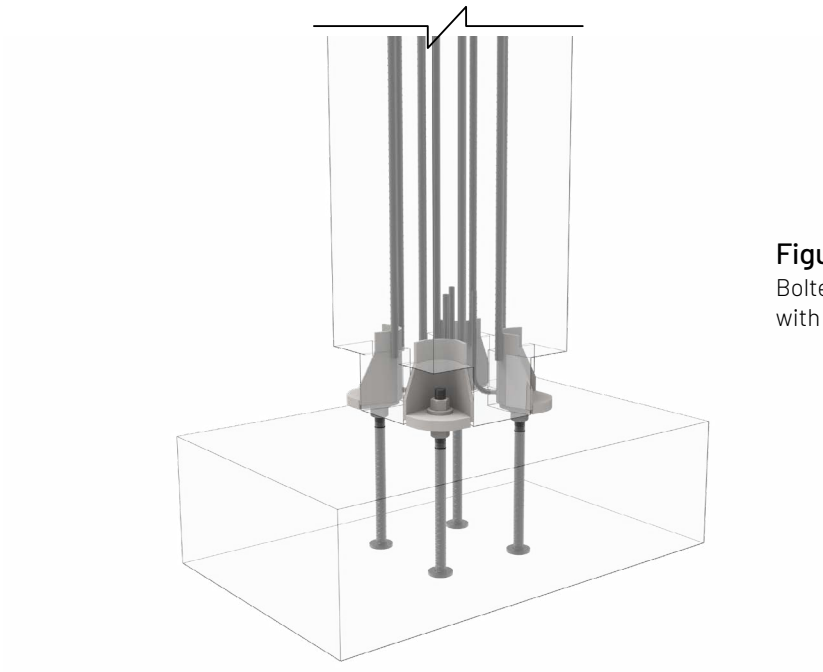


Figure 1
Bolted column – foundation connection
with 4 × NKP/L anchor bolts and 4 × NKK column shoes

A bolted connection with column shoes and anchor bolts provides a stiff connection capable of handling both bending moment and axial forces. For torsion moments and lateral forces, a traditional bolted connection allows for minimal lateral movement until the gap between the bolt hole and the bolt is closed. Once the gap is closed, direct force transfer begins, in addition to shear transfer occurring under the column below. Adding the shear keys to contact surface improves shear transfer in connection.

Bolted connection with NKP anchor bolts and NKK shoes (Fig.1) is designed for connecting structural concrete elements or concrete elements and cast in situ structures in quasi-static loading. NKK Column shoe consist of base plate, bended steel plate and anchor bars. All connections between NKK shoe parts are welded.

Figure 2
Column shoe type NKK

The resistance of a single NKK column shoe matches the capacity of an NKP anchor bolt. For additional details on anchor bolts, please refer to the NKP anchor bolts user manual.

The required number of bolt and shoe pairs for a column connection depends on the internal forces in the connection. For a rigid flexural connection, a minimum of 2 pairs of bolts and shoes (2 in each direction within the plane) is necessary. For a hinged connection, at least two shoes and bolts are required. Using 4 suitably sized shoes and bolts in a hinged connection simplifies the adjustment of level and alignment.

The placement and sizing of anchor bolts and column shoes should be determined based on design loads and structural geometry. To streamline the connection, it is highly recommended to use symmetric placement of bolts and shoes and to ensure that all bolts are of the same size. For circular columns, it is advisable to use 6 anchor bolts for rigid connections to facilitate proper overlap with the main reinforcement.

The placement and sizing of anchor bolts and shoes must align with the designed main reinforcement of the concrete structure. Proper overlap of the anchor bars with the main reinforcement is essential to ensure a safe and effective final connection.

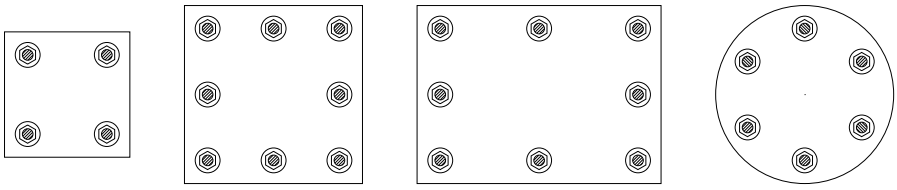


Figure 3
Typical layouts for bolt locations, bolts transfer N, M_y, M_z, V_y, V_z forces

MATERIALS

Type NKK column shoes are manufactured from following materials:

Table 1

Part	Material quality	Standard
Ribbed reinforcement bars	B500B	EN10080:2006
Anchor plates	S355J2+N	EN10025-2:2019

Anchor plates are welded to the rebars and the execution of production is performed according to EN1090-2:2018.

MARKINGS

Shoes are equipped with an identification tag that contains the following information: Shoe type (NKK), thread Size, year of the manufacturing, and batch number.

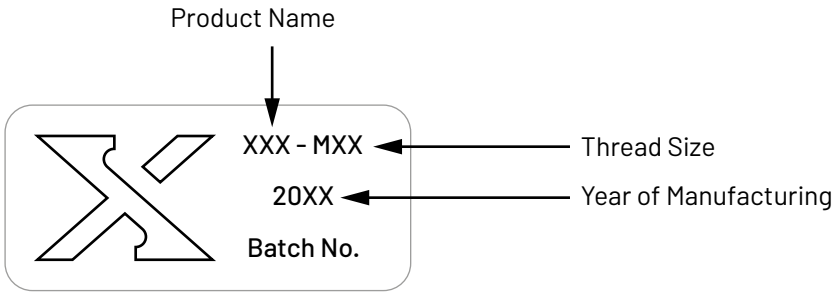


Figure 4 Identification tag for column shoe

In addition to the identification tags, all shoes are marked with a color code to facilitate the identification of the shoe type after it has been cast into concrete.

Table 2

Normal capacity column shoe	Product	Color code
NKK	NKK M16	Yellow
	NKK M20	Blue
	NKK M24	Grey
	NKK M30	Green
	NKK M39	Orange

NKK column shoes are primarily designed to be compatible with Exmet NKP L/P anchor bolts. The placement rules for bolts and shoes, the height of the bolt head from the base level, and the need for additional reinforcement in both the base structure and the column for effective force transfer are based on using Exmet products at their declared capacities for the entire structural connection.

However, NKK shoes can also be used with any bolted connections where the bolt capacity and material align with the capacities listed in Table 8. In such cases, the final structure's designer must ensure that the placement of the bolts, the height of the bolt head in the base structure, and the size of the bolt holes in the additional structure are compatible with the size and type of Exmet NKK column shoes used.

PRODUCTION TOLERANCES

Allowed deviation for column shoe total lengths for all sizes in manufacturing is ±10mm.
Base plate dimensions and hole size +2, - 1mm

ENVIRONMENTAL CONDITIONS

The default design of the column shoe is carried out for dry indoor environmental conditions. The lowest operational temperature for standard column shoe is -20°C.

When column shoe is used in other conditions, the surface treatment, concrete cover or material of column shoe must be adequate to environmental exposure class and intended operating life. Column shoes are typically casted into concrete before installation of structures. Geometry of connection is after that providing resistance to corrosion if concrete cover is sufficient according to environmental exposure class and intended operating class.

In addition to protecting with casting Exmet offers bolts and shoes in hot dip galvanized versions (EN ISO 1461:2022) or with protective paint for more demanding conditions. In case of hot dip galvanized bolts and shoes, galvanized nuts and washers are used instead of standard set. Additional protecting painting on site by installation team after installation could improve protection of bolts and shoes against corrosion. Covering of bolts and side plates of column shoe with cast in situ concrete is needed as well for ensuring fire safety of connection. Standard location of bolt and shoe ensures R60 fire resistance of connection after casting. For higher fire resistance ratings, bolts and shoes must be repositioned during the design phase according to structural calculations and the utilization rate of the connection.

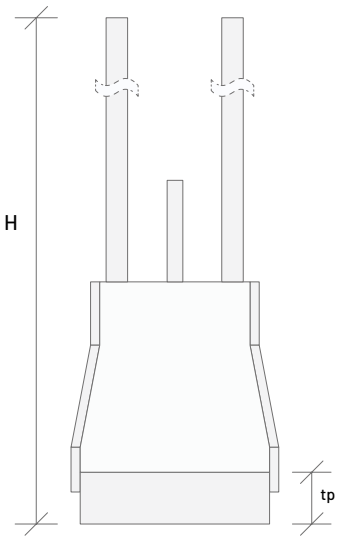
The allowable deviation of concrete cover (cdev=±10mm) and the required concrete covers for column shoe plates (cnom) are detailed in the following table.

Table 3

Exposure class	c_{nom} [mm] for shoe plates Structural class S4, Lifetime 50 years	Alternative additional protection for environement	c_{nom} [mm] Lifetime 100 years
X0	-	-	30
XC1	25	HDG	35
XC2/XC3	35	HDG	45
XC4	40	HDG	50
XD1/XS1	45	HDG	55
XD2/XS2	50	HDG	60
XD3/XS3	55	HDG	65

2. PRODUCT DIMENSIONS

Column shoe NKK basic dimensions:



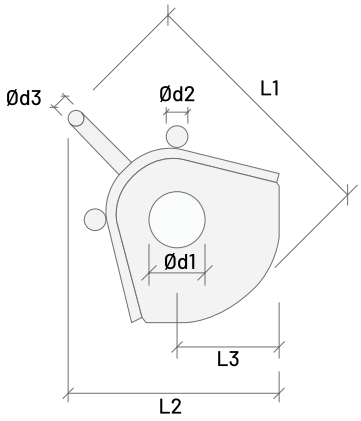


Table 4

Shoe type & weight	H [mm]	L1 and Ød3 [mm]	L2 [mm]	L3 [mm]	tp [mm]	Ød1 [mm]	Ød2 [mm]	Color code
NKK-M16 (2.3 kg)	600	124 Ø 8	104	50	15	Ø 28	2× Ø 12	Yellow
NKK-M20 (4.2 kg)	820	130 Ø 10	108	50	20	Ø 31	2× Ø 16	Blue
NKK-M24 (6.7 kg)	1185	140 Ø 12	116	50	30	Ø 35	2× Ø 16	Grey
NKK-M30 (12.2 kg)	1390	169 Ø 16	137	50	45	Ø 40	2× Ø 20	Green
NKK-M39 (26.7 kg)	1910	221 Ø 20	177	60	50	Ø 55	2× Ø 25	Orange

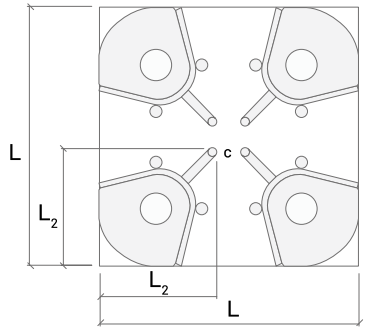
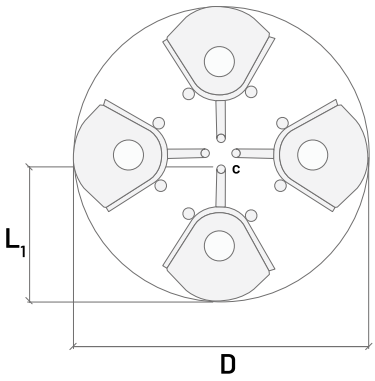
MINIMUM COLUMN DIMENSION AND CONCRETE STRENGTH FOR COLUMN

The minimum column section size required for different standard NKK column shoes is specified in Table 5. This required section size is determined based on the shoe's side dimensions and anchor bar dimensions listed in Table 4. For rectangular columns, the critical dimension is L2 (the side dimension), while for circular columns, it is L1 (the diagonal shoe size).

The minimum distance 'c' between anchoring bars is calculated as either the manufacturing tolerance of the shoe, the diameter of the anchor bar (D3), or 20 mm, whichever is greater. This value is rounded to the nearest even millimeter.

A slight reduction in the required section size may be possible if the shoes are produced on a common bottom plate. For tailored solutions, please contact Exmet for more information.

Table 5

Type of section \ type of shoe	Minimum section dimension L or D for column [mm] NKK – M16	NKK- M20	NKK – M24	NKK-M30	NKK-M39
	230	240	250	290	370
	270	280	300	360	480

The length of anchor bars for the column shoe is determined based on C30/37 concrete and the capacity of NKP anchor bolts. Increasing the concrete strength in the column does not enhance the design capacity of the connection, as the steel capacity of the bolted connection is the primary factor.
The concrete strength of the in-situ joint should be at least equal to that of the column. To achieve the full capacity of the connection, supplementary reinforcement in the anchorage area must adhere to the layout and quantities specified in Table 11.

CONCRETE COVER

If column shoes and anchor bolts are placed in connection without offsetting the bolts and shoes inside (Δ=0), then concrete cover for column shoe anchor bars must be done according to the Table 6 and Figure 5.

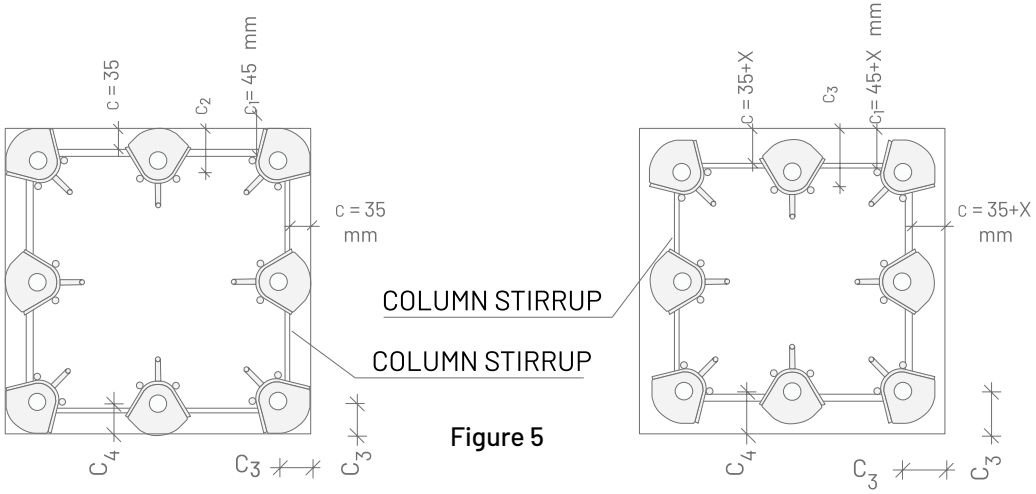


Figure 5

Table 6

Column shoe	Shoe in corner of the column		Shoe at middle of the side	
	Anchor bar cover C_1 [mm]	Bolt hole C_3 [mm]	Anchor bar cover C_2 [mm]	Bolt hole C_4 [mm]
NKK M16	45	50	73	50
NKK M20	45	50	76	50
NKK M24	45	50	82	50
NKK M30	45	50	89	50
NKK M39	45	60	109	60

Distances for increased by X mm concrete cover

Concrete cover for column stirrups (max 8mm stirrups) 35mm + X mm

Column shoe	Shoe in corner of the column		Shoe at middle of the side	
	Anchor bar cover C_1 [mm]	Bolt hole C_3 [mm]	Anchor bar cover C_2 [mm]	Bolt hole C_4 [mm]
NKK M16	45+X	50+X	73+X	50+X
NKK M20	45+X	50+X	76+X	50+X
NKK M24	45+X	50+X	82+X	50+X
NKK M30	45+X	50+X	89+X	50+X
NKK M39	45+X	60+X	109+X	60+X

If the column shoe or column reinforcement requires a greater concrete cover than can be achieved with the standard shoe placement, the concrete cover can be increased by offsetting the shoe inside. The position of the anchor bolts in the structure below must be adjusted accordingly. Note that the Exmet NKK shoe has a different opening angle (less than 90 degrees) compared to some traditional shoes. For corner shoe placements, it is crucial to ensure that the shoe is symmetrically positioned within the reinforcement cage.

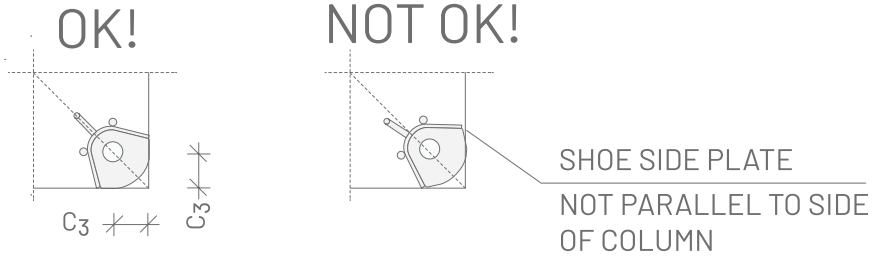


Figure 6
Placement of shoe in corner of column

NOTE! Exmet offers column shoe void formers to ease the installation process in factory.

3. RESISTANCES

Resistances of connection with NKK column shoes is calculated according to the following standards:

EN 1992-1-1: 2004

EN 1992 -4: 2018

EN 1993-1-1: 2005

EN 1993-1-8: 2005

The tensile capacity of the NKK column shoe matches the capacity of the NKP anchor bolts. To achieve the full design capacity of the connection and ensure its proper functioning, supplementary reinforcement in the concrete detail is required to effectively transfer forces from the bolted connection to the concrete. The quantities of supplementary reinforcement provided in the tables below are estimated based on the steel part capacity. Additional checks for the main reinforcement of both the column and foundation, as well as for EQV, should be conducted by the structural designer. The resistances for anchor bolt steel capacity are listed in Table 8, with capacities estimated for the following load cases:

- only Shear load applied
  or
- only Axial load applied.

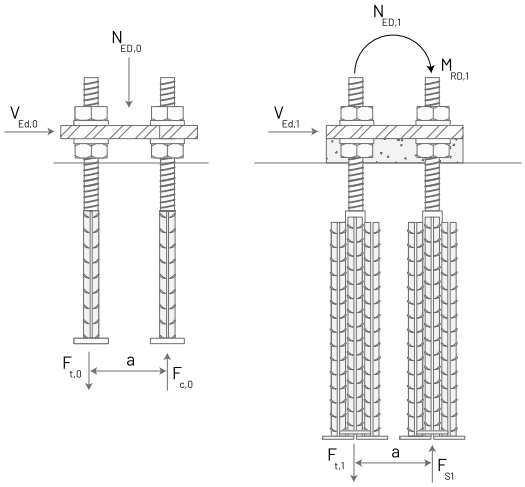
The combined application of shear and axial loads must be managed according to the rules specified in EN1992-4 for steel and concrete verifications. All capacities presented in Table 8 are valid only for quasi-static loads. For dynamic loads, the designer must account for fatigue and dynamic impact based on the type of dynamic load, and the connection capacities should be adjusted accordingly.

STRUCTURAL BEHAVIOR

The column connection with shoes and anchor bolts is designed to handle axial forces (both tension and compression), shear forces, and their combinations. To accommodate flexural bending moments (for a rigid flexural connection), a group of connector pairs is required. For bolted column connections, two stages must be considered:

- Temporary stage – only bolts are operating, joint is not casted or has not reached design strength.
- Final stage – joint is casted, concrete has reached designed compressive strength.

Table 7



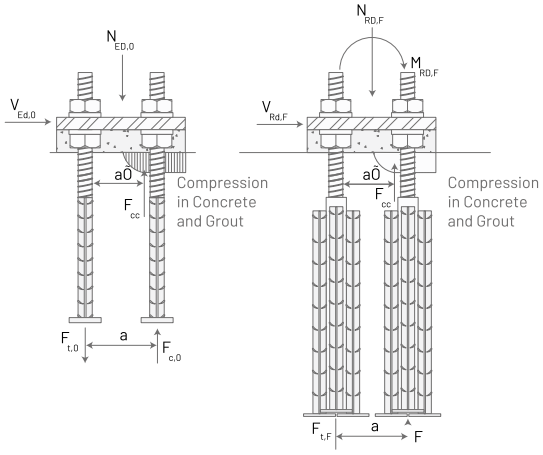
Temporary stage (installation of frame)

In this stage, only the bolts and shoes are functioning. Even if the joint is filled with concrete, the joint concrete has not yet achieved the required strength. Therefore, in cases of combined axial and shear loads, the capacity relies solely on the shear and tension/ compression capacities of the bolts. If the combined capacity of the bolts during the installation phase is insufficient, then:

The size of the bolts and shoes needs to be increased to achieve the required capacity.

Or

The frame must be braced during installation to ensure that forces in the critical connection are reduced to the required level.



Final stage

Concrete in joint has reached the design strength, assembly works as reinforced concrete structure. Tension is taken by bolts and shoes, compression with concrete and grout.
For shear transfer three different options are available:

Shear is transferred via friction on the compressed side of connection.

Shear is transferred via bolt hole edge compression and dowel effect of bolt (significant drop of capacity).

Shear is transferred with additional shear key at bottom level of connected structure.

The shear forces for the connection, as presented in Table 10, are based on the presence of sufficient friction in the connection.

TENSILE RESISTANCES

The estimation of the tensile resistance for bolted connections, based on column shoes and anchor bolts, follows the guidelines set out in EN 1993-1-8 and EN 1992-4. For a structure fixed with anchor bolts, the joint must possess sufficient local stiffness (such as adequate thickness of the fixing plate or additional stiffeners) to ensure accurate estimation of bolt capacity without accounting for additional prying forces. Exmet column shoes and wall shoes are designed to provide the necessary stiffness in the connection. However, if NKK shoes are used with anchor bolts other than Exmet NKP bolts, the structural designer must ensure that the connection maintains proper stiffness and strength.

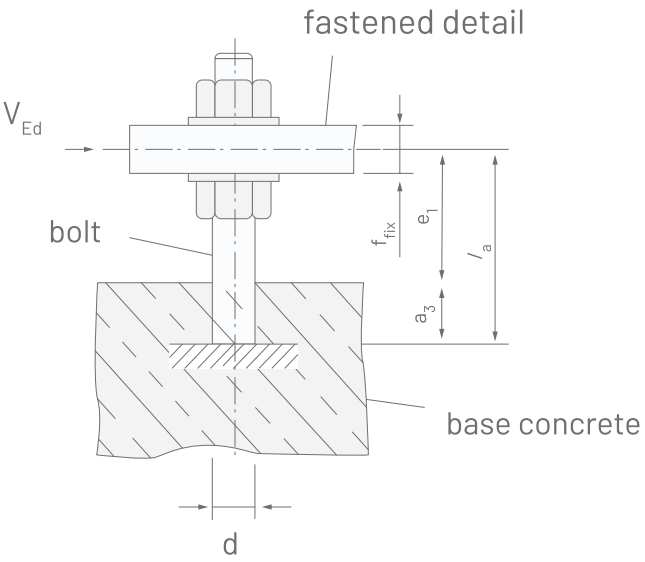
Tensile capacity of threaded bar:

$$N_{Rd0} = N_{Rd} = 0{,}9\frac{f_{ub}A_s}{\gamma_{Mb}}$$

Where A_s - minimum area of threaded bar, f_{ub} - threaded bar material tensile strength and γ_{Mb} – safety factor for bolt material (γ_{Mb} = 1,25).

SHEAR RESISTANCES

At installation the stage shear load acts with a lever arm.



Lever arm $l_a = a_3 + e_1$, where $a_3 = 0{,}5\, d_{nom}$

Distance e_1 is a distance between shear load and concrete surface, e- thickness of grouting.

Bending moment in bolt is calculated as:

$M_{Ed} = V_{Ed} \frac{l_a}{\alpha_M}$, in case of restrain α_M =2.0

In case of pure shear load bolt bending capacity is

$M_{Rd,s} = \frac{1{,}2\, W_{el} f_{uk}}{\gamma_{Ms}} = \frac{1{,}2\, \pi d_{min}^3 \quad f_{uk}}{32\, \gamma_{Ms}}$ where

γ_{Ms} = 1,25

d_{min} is minimum diameter of thread and

$f_{uk} \geq 550\ MPa$ for B500B (For NKK bolts)

$$V_{Rd,s} = \frac{1{,}2\alpha_M\, \pi d_{min}^3 \quad f_{uk}}{32\, \gamma_{Ms} l_a}$$

COMBINED SHEAR AND TENSION RESISTANCES

Without supplementary reinforcement combined tension and shear loads verification in connection must be done according to the following conditions from EN1992-4: 2018

1. Steel failure of bolt (shoe): $\left(\frac{N_{Ed}}{N_{Rd,s}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd,s}}\right)^2 \leq 1$, verification shall be done for each bolt in the group
2. Failure modes other than steel failure of bolt, verification shall be done for largest value of $\frac{N_{Ed}}{N_{Rd,i}}$ and $\frac{V_{Ed}}{V_{Rd,i}}$ for each different failure mode (failure modes are listed in Table 9):

$$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1,5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1,5} \leq 1 \qquad \text{EQ.1}$$

Or

$$\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1{,}2 \ , if \ \frac{N_{Ed}}{N_{Rd,i}} \leq 1 \ and \ \frac{V_{Ed}}{V_{Rd,i}} \leq 1 \qquad \text{EQ.2}$$

If bolt and column shoe have supplementary reinforcement for both tension and shear loads, same formulas EQ.1 and EQ.2 are valid for verifications, only instead of $\frac{N_{Ed}}{N_{Rd,i}}$ in concrete cone failure mode (in case of tension) and $\frac{V_{Ed}}{V_{Rd,i}}$ for concrete edge failure mode (in case of shear) corresponding ratios for failure of supplementary reinforcement must be used.

If supplementary reinforcement for bolt and shoe are provided for tension loads or for shear loads only, conditions for combined shear and tension verification will be done according to the following equation:

$$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{2/3} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{2/3} \leq 1 \qquad \text{EQ.3}$$

With additional limitations $\frac{N_{Ed}}{N_{Rd,i}} \leq 1 \; and \; \frac{V_{Ed}}{V_{Rd,i}} \leq 1$

If supplementary reinforcement is provided only for tension loads, $N_{Rd,i}$ and $V_{Rd,i}$ in EQ.3 represent following design resistances:

$N_{Rd,p}$ - design resistance in case of pullout failure under tension load

$N_{Rd,sp}$ - design resistance of concrete under splitting failure under tension load

$N_{Rd,cb}$ - design resistance in case of concrete blow out failure under tension load

$N_{Rd,re}$ - design resistance of steel failure of supplementary reinforcement

$N_{Rd,a}$ - design resistance associated with supplementary reinforcement anchorage failure

$V_{Rd,c}$ - design resistance in case of concrete edge failure under shear load

$V_{Rd,cp}$ - design resistance in case of concrete pry -out failure under shear load

If supplementary reinforcement is provided only for taking shear loads, $N_{Rd,i}$ and $V_{Rd,i}$ in EQ.3 represent following design resistances:

$N_{Rd,p}$ - design resistance in case of pull-out failure under tension load

$N_{Rd,sp}$ - design resistance of concrete under splitting failure under tension load

$N_{Rd,c}$ - design resistance in case of concrete cone failure under tension

$N_{Rd,cb}$ - design resistance in case of concrete blow out failure under tension load

$N_{Rd,re}$ - design resistance of steel failure of supplementary reinforcement

$N_{Rd,a}$ - design resistance associated with supplementary reinforcement anchorage

$V_{Rd,cp}$ - design resistance in case of concrete pry -out failure under shear load

For both cases N_{Ed} and V_{Ed} are actions corresponding to the specific failure modes. Calculation formulas for $N_{Rd,i}$ and $V_{Rd,i}$ are presented in EN1992-4:2018. All verification for concrete element according to EQ1, EQ2 or EQ3 shall be executed by structural designer. In table 8 steel capacities for Exmet bolts and column shoes are presented for installation stage and for ready structure.

SHEAR AND TENSION DESIGN VALUES

Shear and tension resistances for bolted connections (steel resistance) based on NKP bolts and NKK shoes

Table 8

Column shoe / (Anchor bolt)	Grout thickness	Lever arm	Installation stage (only one force acting)		Final stage (only one force acting)	
	e	l_a	$N_{Rd0,s}$	$V_{Rd0,s}$	$N_{Rd,s}$	$V_{Rd,s}$
	[mm]	[mm]	[kN]	[kN]	[kN]	[kN]
NKK- M16 (bolt NKP L/P – M16)	50	66	62	4	62	20
NKK -M20 (bolt NKP L/P – M20)	50	70	97	8	97	31
NKK -M24 (bolt NKP L/P – M24)	50	74	140	12,5	140	45
NKK -M30 (bolt NKP L/P – M30)	50	80	220	24	220	71
NKK – M39 (bolt NKP L/P – M39)	60	100	385	39	385	125

Note: The NKK column shoe is designed to be compatible with NKP anchor bolts. If SKP anchor bolts are used with the NKK column shoe, the capacity will be limited to that of the NKK shoe, and the higher capacity of the SKP anchor bolts will not be fully utilized.

FIRE RESISTANCE

The fire resistance of bolted connections should be verified in accordance with EN1992-1-2. If the fire resistance of the connection is insufficient, either increase the concrete cover or implement other fire protection measures, such as using external fireproof covers. If the column section is adequate, the simplest solution for enhancing fire resistance is to increase the concrete cover around the reinforcement cage and column shoe. For removable structures, using fireproof covers can provide easier future access to bolts.

4. INSTALLATION OF COLUMN SHOES

Installation of shoes in the factory must be done according to the production drawings. Column shoes should be placed into the column reinforcement and secured to the column's bottom formwork using installation bolts. The installation tolerance for column shoes in the plane is ±2 mm. The position of the column shoes in the formwork must be stabilized to prevent movement. For bolt recesses, it is advisable to use standard void boxes, which can be requested from Exmet.

If an NKK shoe is installed at the bottom of a column or a column below, the required bolt height to achieve a proper connection is detailed in Table 10 and Figure 7. For easier design, TEKLA components are available to ensure accurate positioning of bolts and shoes during the design stage.

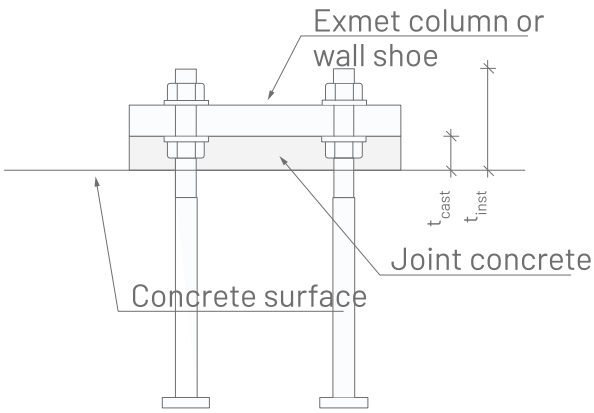


Figure 7 Installation heights for Exmet bolts if shoe is located at the bottom of the column

Table 10

Column shoe NKK (mm)

Bolt type	Height from casting t_{inst}	Thickness of joint t_{cast}
NKP L/P – M16	105	50
NKP L/P – M20	115	50
NKP L/P – M24	130	50
NKP L/P – M30	150	50
NKP L/P – M39	180	60

After installing the column, all bolts should be tightened once the vertical alignment of the element is confirmed. A torque wrench should be used to ensure that the torque is at least equal to the minimum specified in the table below and does not exceed the maximum allowed torque, $T_{max.}$

Table 11

Bolt	T_{min} [Nm]	T_{max} [Nm]
NKP L/P – M16	120	200
NKP L/P – M20	150	250
NKP L/P – M24	200	350
NKP L/P – M30	250	450
NKP L/P – M39	350	1000

WELDING OF SHOE ANCHOR BARS TO MAIN REINFORCEMENT

As a rule, welding of anchor bars of shoe or anchor bolts to main reinforcement of concrete element is not recommended and not needed. However, materials used in shoe anchor bars are weldable and welding has been used in the production of shoes. If there will be need to weld anchor bars of shoe to main reinforcement cage (e.g due to product geometry or handling of cage in production), requirements and instructions of standard EN 17660 -1 Welding of reinforcing steel, must be followed during work planning, execution and supervision.

BENDING OF COLUMN SHOE ANCHOR BARS

Rebar anchors of NKK column shoes are made from B500B reinforcement steel. If the standard column shoe cannot be installed due to product geometry, the anchor bar geometry may be adjusted by bending to fit the prefab product. Bending must comply with the requirements of EN1992-1-1, with a minimum straight section of 300 mm before the bend begins. The mandrel diameter for bending should follow Table 8.1N of EN1992-1-1. Since there are typically at least two rebars connected to the shoe, bending the final product can be complex. Therefore, it is advisable to order a custom product based on the required bent shape drawing. The connection capacities listed in Table 8 are for the unmodified product and cannot be directly applied to modified products.

The capacity for modified connections, as well as the appropriate shoe and bolt sizes, must be assessed by a structural designer based on the modified connection shape and the actual geometry and reinforcement of the prefab element.

APPENDIX 1, SPECIAL REINFORCEMENT DESIGN QUESTIONS IN BOLTED CONNECTIONS

Reinforcement design for connections with anchor bolts and column shoes follows concrete design rules according to EN1992-1-1 and due to transfer of load via connectors some additional rules from EN 1992-4:2018 will apply for neighborhood of bolt. If pull out concrete cone or break out concrete cone conditions are not fulfilled for full development of cone according to EN1992-4:2018, supplementary reinforcement for anchor bolt neighborhood must be designed as per EN1992-4:2018 supplementary reinforcement design rules. Rules for bolts are presented in Exmet anchor bolts manual. To achieve equal capacity with bolt, column shoe anchor bars will need additional reinforcement according to Table 12 and Figures 8-1, 8-2.

The bolted connection functions as a lapping joint, beginning with the shoe and bolt and extending to the overlap of the anchor bars with the main reinforcement of the column. All reinforcement lapping rules from EC2 apply to the overlap between the shoe anchor bars and the main reinforcement. To achieve the full capacity of the lapping joint, the number of stirrups in the lapping zone should comply with the requirements specified in EN1992-1-1, section 8.7.

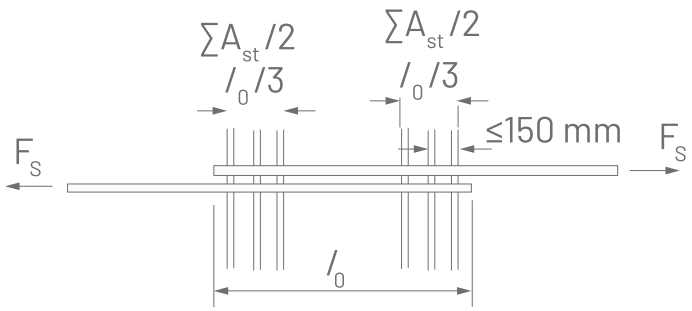


Figure 8-1 General reinforcement demand in shoe / reinforcement cage overlap according to EC2.

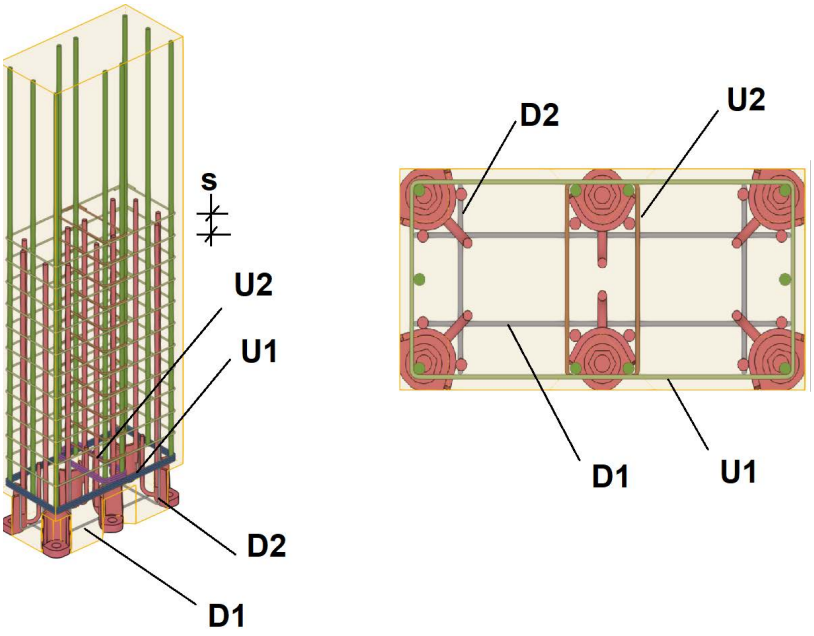


Figure 8-2 Column shoes and reinforcement overlap for layout with intermediate shoes

Table 12
Lapping bar reinforcement for column shoes

Shoe	D1 (per pair of shoes)	D2 (per pair of shoes)	U1 (in bottom)	U2 (in bottom (for medium Shoe only))	**U3 (Overlap stirrups)**	**Ast in Column shoe anchors**
NKK-M16	1Ø8	1Ø8 /pair	2Ø8 stirrups in bundle	2Ø8 stirrups in bundle	Ø8	226 mm²
NKK-M20	1Ø8	1Ø8 /pair	2Ø8 stirrups in bundle	2Ø8 stirrups in bundle	Ø8	400 mm²
NKK-M24	1Ø8	1Ø8 /pair	3Ø8 stirrups in bundle	3Ø8 stirrups in bundle	Ø8	400 mm²
NKK-M30	1Ø8	1Ø8 /pair	3Ø8 stirrups in bundle	3Ø8 stirrups in bundle	Ø8	628 mm²
NKK-M39	1Ø8	1Ø8 /pair	3Ø10 stirrups in bundle	3Ø10 stirrups in bundle	Ø10	980 mm²

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