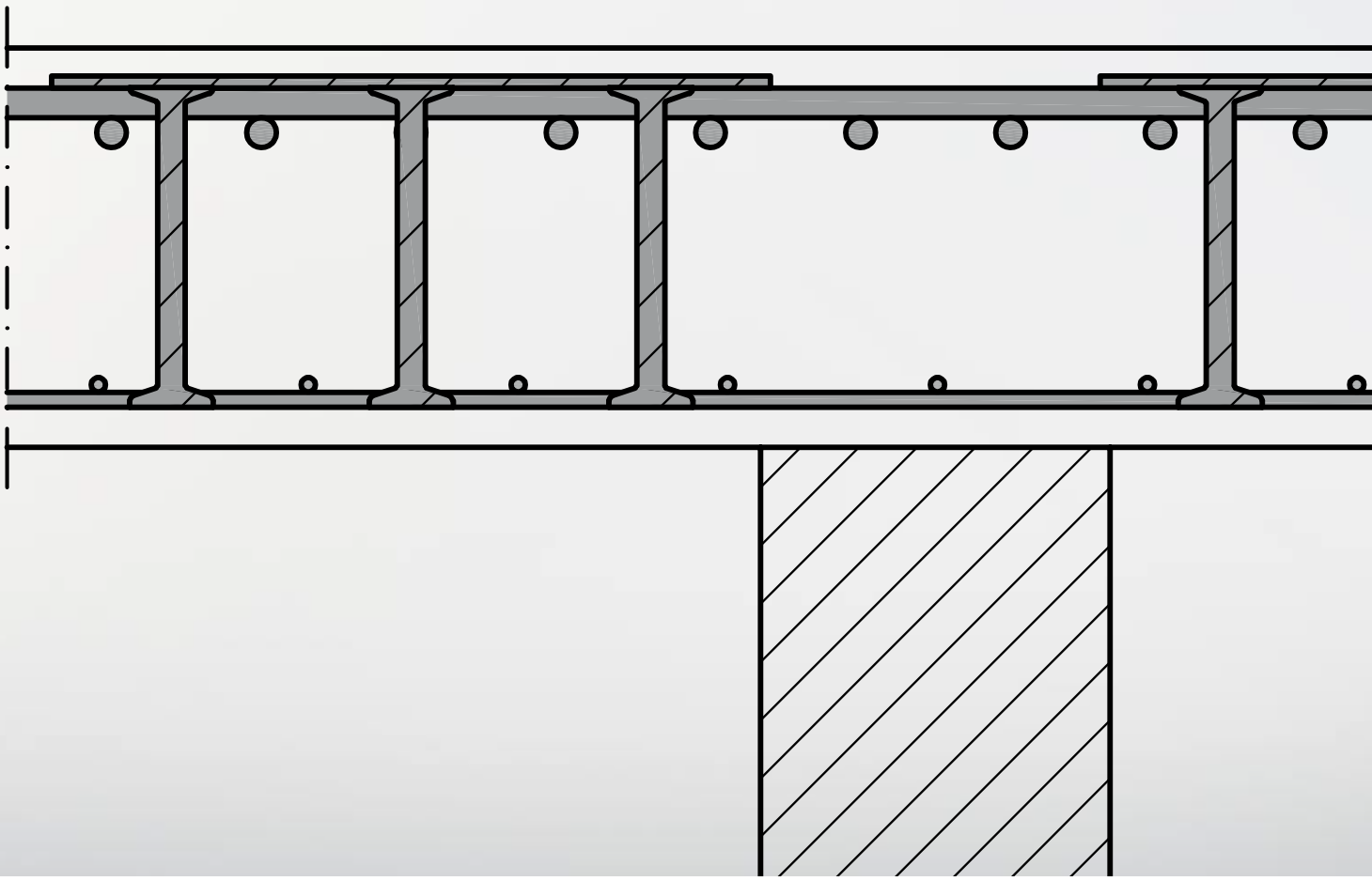
SCHÖCK
Dependable by design



TECHNICAL INFORMATION – JANUARY 2023

Bole®
Punching shear reinforcement

Efficient punching shear reinforcement for reliable load bearing capacity in the column area of flat slabs and foundation slabs.

Planning and consulting service

The engineers of Schöck's application engineering department would be very happy to advise you on static, structural and building-physics questions and will produce for you proposals for your solution with calculations and detailed drawings.
For this please send your planning documentation (general arrangements, sections, static data) with the address of the building project to:

Schöck Ltd
Staniford House
4 Wedgwood Road
Bicester
Oxfordshire
OX26 4UL

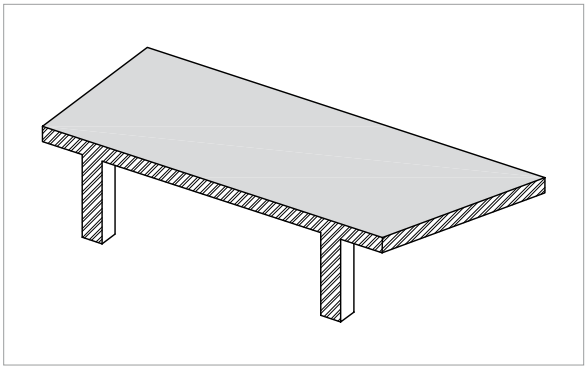
Telephone hotline for design support services
Tel.: 01865 290 890
Fax: 01865 290 899
E-Mail: design-uk@schoeck.com

Planning tools - downloads and requests
Tel.: 01865 290 890
Fax: 01865 290 899
E-Mail: design-uk@schoeck.com
Web: www.schoeck.com

CPD Seminars and on-site consultation
Tel.: 01865 290 890
Fax: 01865 290 899
Web: www.schoeck.com

Table of Contents

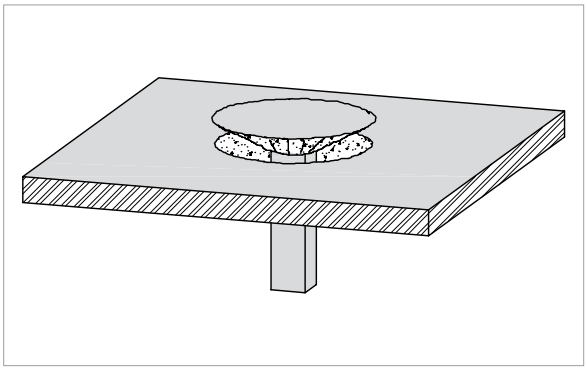
Efficient construction method with flat slabs



Efficient construction with flat slabs

The flat slab has become established in building construction due to its advantages:

- Simple panel formwork
- Simple reinforcement
- Flexible use of space without downstand beams
- Lower storey height without column heads or downstand beams
- Simple design using software

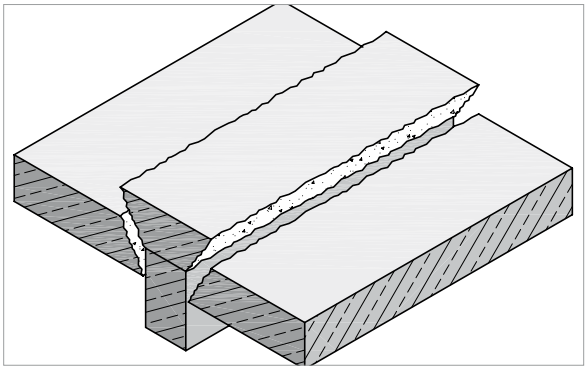


Punching shear failure

One disadvantage of slim flat slabs is the low punching shear resistance. Punching shear failure can occur as a result of concentrated loads or supporting reactions on relatively small areas. This takes place in particular in areas of:

- Columns
- Wall ends
- Wall corners

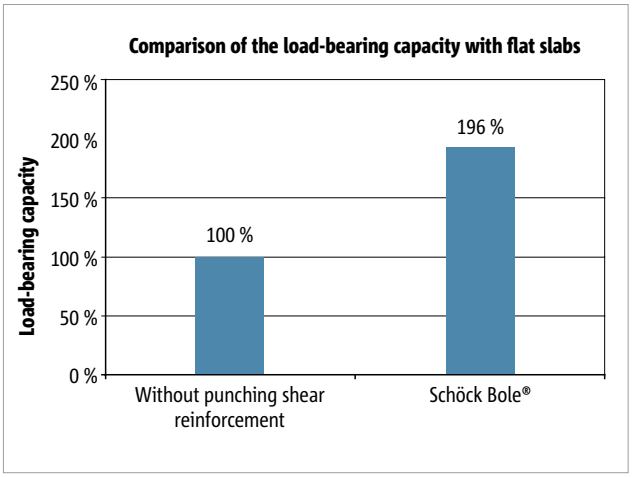
A prerequisite for punching shear resistance behaviour is a biaxial load application in the support area.



Shear force

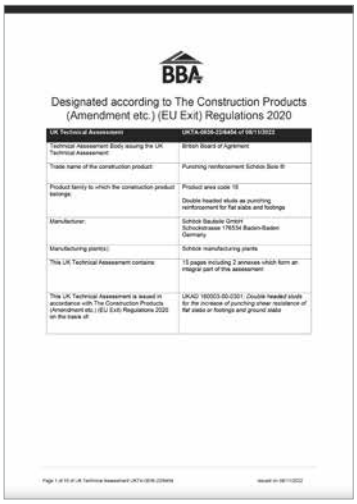
The shear force bearing capacity can also be decisive for linear supports. This can occur, for example, if the walls in the storeys are offset due to different floor plans or due to high wall loads in foundation slabs. Here, in contrast to punching shear, the load application is essentially in one direction only.

Approvals and applications



Higher load-bearing capacity

The punching shear resistance can be increased considerably through the outstanding anchorage of the double-headed studs in the concrete. Thus, for example, the load-bearing capacity of a flat slab using Schöck Bole® can be increased by 96 % compared with a slab without punching shear reinforcement. This increase in load-bearing capacity has been confirmed in numerous tests and is also contained in the British Technical Approval UKTA-0836-22/6454.

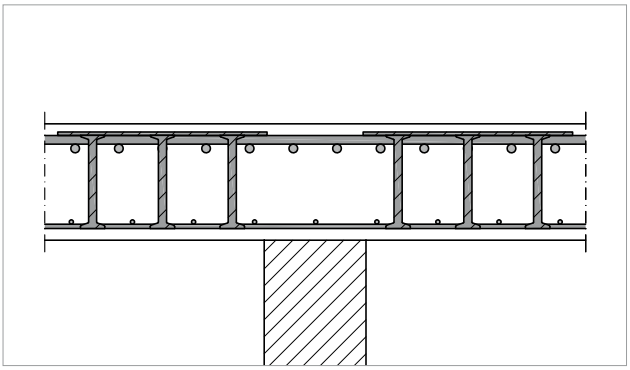

BBA

Designated according to The Construction Products (Amendment etc.) (EU Exit) Regulations 2020

Approvals and applications

The Schöck Bole® is approved for various applications:

- UKTA-0836-22/6454
  British Technical Assessment of the Schöck Bole® as punching shear reinforcement in flat slabs and foundations in accordance with BS EN 1992-1-1 (EC2). The design and utilisation of the building product is regulated in the EOTA technical report EOTA TR 060



Why Schöck Bole®?

- User-friendly software for a simple design
- High load-bearing capacities for slim structural components
- Safety through the BBA technical assessment and numerous structural component tests
- 2 different versions for a simple and rapid installation

Punching shear reinforcement

2 Schöck Bole® types for different installation situations:

Schöck Bole® type O:
- Prefabricated rail for subsequent installation from above
- Stud diameters 10, 12, 14, 16, 20 and 25 mm
- Position indicator flag with details of the installation position

Installation: After placing of the complete reinforcement

Schöck Bole® type U:
- Free spacers are fixed on the rail on-site
- Concrete covers 20/25/30/35 mm
- Stud diameters 10, 12, 14, 16, 20 and 25 mm
- Position indicator flag with details of the installation position

Installation: Before placing the bottom reinforcement layer

Design software

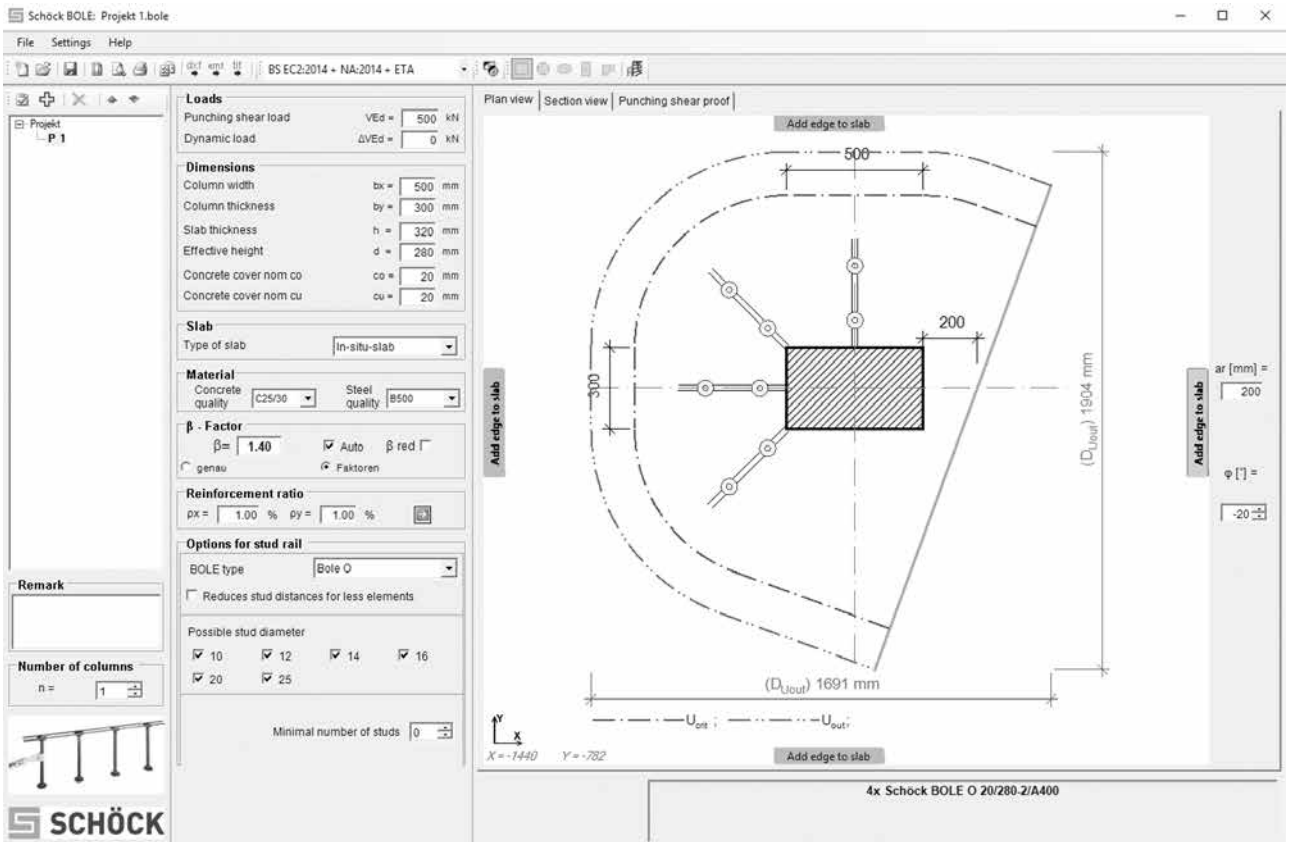
The Schöck Bole® design software enables a rapid and secure design of the punching shear reinforcement as per BS EN 1992-1-1 and other standards With this different shapes and positions of columns can be entered:

- Internal column
- Edge column
- Corner column
- Circular, rectangular and oval columns
- Wall inside corner
- Wall end

In addition, floor slabs and foundations can be dimensioned. Dynamic load components for verification against fatigue can also be taken into account in the design.

The benefits:

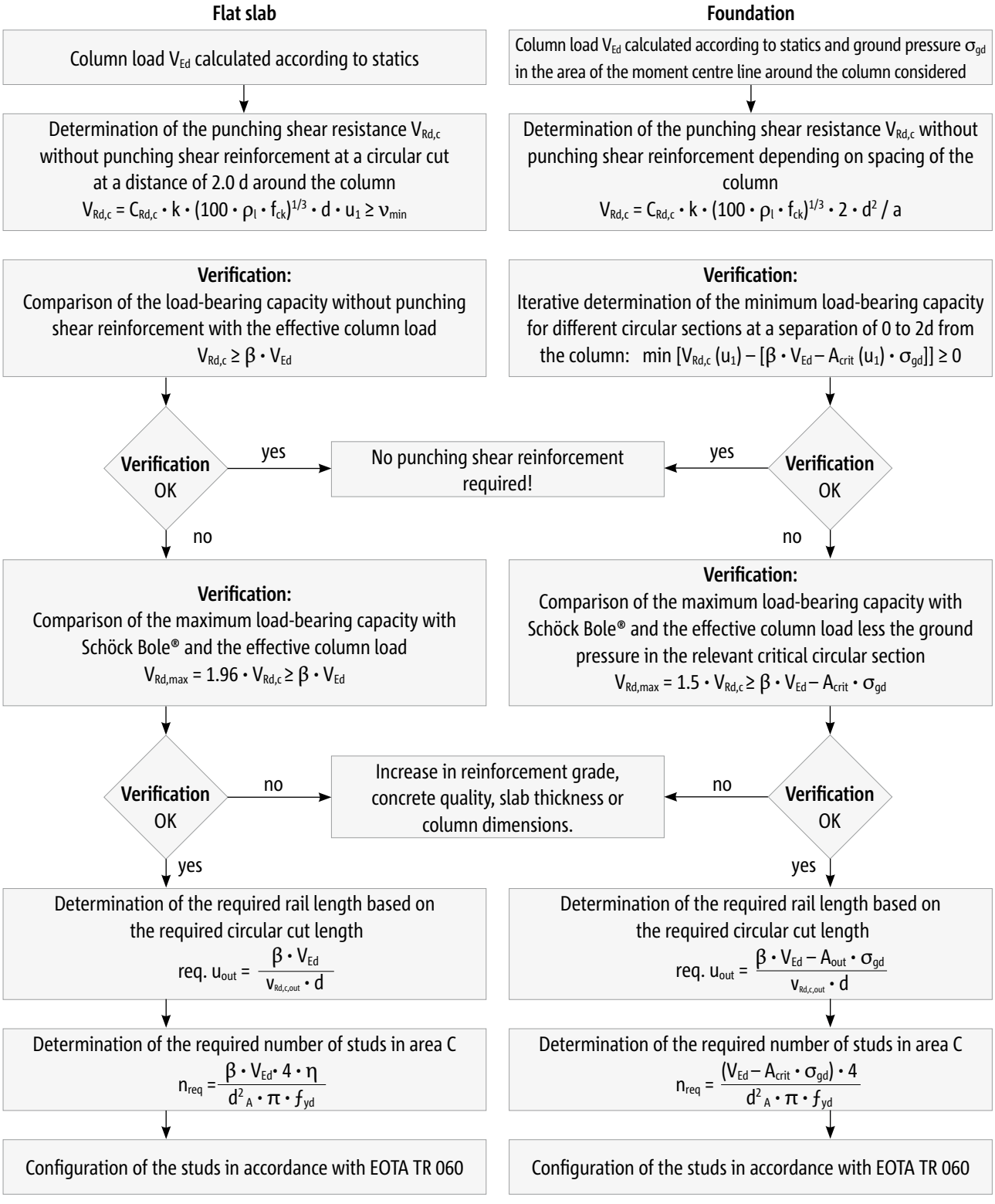
- High design reliability
- Comprehensible design report with all verifications
- Export of CAD files with the plan view of the installation, sections and labelling
- Management of several positions of a project in one file
- Error messages with information for correction
- Creation of parts lists for the complete project



Schöck Bole® design

The design of the Schöck Bole® punching shear reinforcement takes place using Approval UKTA-0836-22/6454 in conjunction with BS EN 1992-1-1:2004 and national appendix. Due to the different load-bearing behaviour of flat slabs and foundation slabs, 2 verification concepts are differentiated.

Schöck Bole® design concept



Design example of a rectangular internal column

1. Boundary conditions:

Given:

Internal column b/d = 300/450 mm
C30/37 concrete
B500 reinforcing steel
Slab thickness h = 240 mm
Concrete cover c_{nom} = 20 mm
Mean static useful height $d_{eff} \approx 200$ mm

V_{Ed} = 980 kN

Design value of the punching load V_{Ed} [kN]

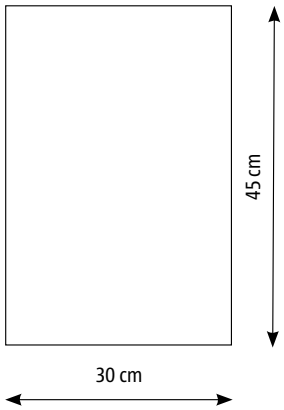
$f_{yk} = 500 \frac{N}{mm^2}$

$\rho = 0.0093$

$\rho = \sqrt{\rho_y \cdot \rho_z}$

ρ is the mean longitudinal reinforcement grade in the punching cone

Column cross-section:



2. Design:

2.1 Critical circular section

$u_{crit} = 2 \cdot 300\ mm + 2 \cdot 450\ mm + 2 \cdot \pi \cdot 2 \cdot 200\ mm = 4010\ mm$

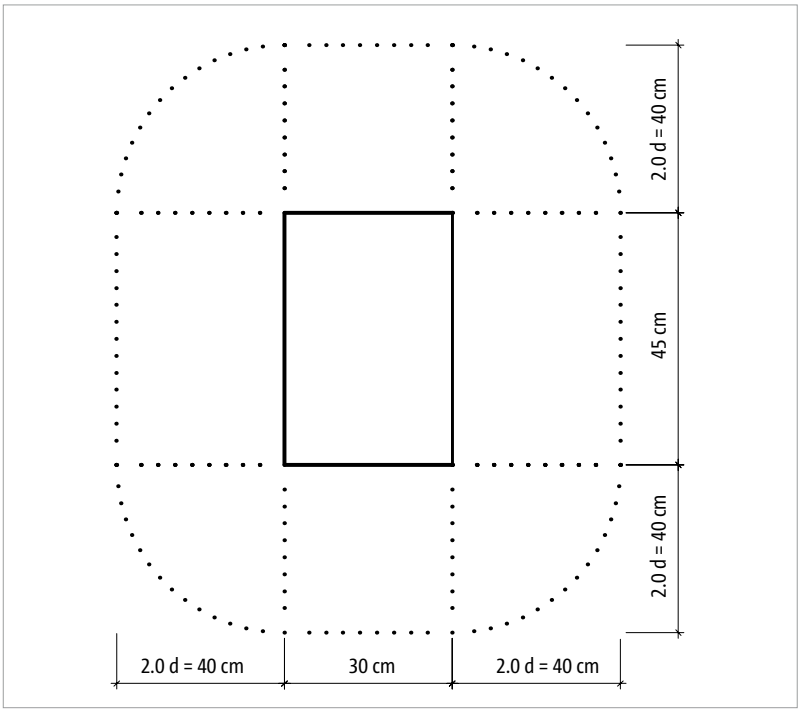
The critical circular section u_{crit} is led at a distance of 2.0 d_m from the edge of the column in accordance with BS EN 1992-1-1, section 6.4.2

$v_{Ed} = \beta \cdot V_{Ed} / u_{crit} = 1.15 \cdot 980\ kN / 4.01\ m = 281.0\ kN/m$

β = 1.15 for internal columns

β Load increase factor for horizontal non-displaceable slab systems according to BS EN 1992-1-1, section 6.4.3

Design example of a rectangular internal column



2.2 Punching shear resistance:

$$v_{Rd,c} = [\frac{0.18}{\gamma_c} \cdot k \cdot (100 \cdot \rho_l \cdot f_{ck})^{1/3}] \cdot d_{eff}\ [kN/m] \geq v_{Ed}$$

$v_{Rd,c}$ in accordance with BS EN1992-1-1/NA, section 6.4.4

$$k = 1 + \sqrt{\frac{200}{d_{eff}}} = 1 + \sqrt{\frac{200}{200}} = 2.0 \leq 2.0$$

Scale factor k in accordance with BS EN 1992-1-1, section 6.4.4

$$\rho = 0.0093 \leq \rho_{max} = 2\ \%$$

Maximum reinforcement content according to BS EN 1992-1-1, section 6.4.4

$$_{Rd,c} = [0.12 \cdot 2.0 \cdot (100 \cdot 0.0093 \cdot 30)^{1/3}] \cdot 200\ mm$$

$$= 145.6\ kN/m < v_{Ed} = 281.0\ kN/m$$

⇒ Schöck Bole® is required!

$$v_{Rd,max} = 1.96 \cdot v_{Rd,c} \geq v_{Ed}$$

$$v_{Rd,max} = 1.96 \cdot 145.6\ kN/m = 285.4\ kN/m > v_{Ed} = 281.0\ kN/m$$

$v_{Rd,max}$ in accordance with UKTA-0836-22/6454 with a preliminary factor of 1.96 with flat slabs

⇒ The maximum load-bearing capacity of the Schöck Bole® is sufficient!

Design example of a rectangular internal column

2.3 Design of studs in first punching cone

Selected stud diameter ⌀ 14

Number of rails with 2 double-headed studs per rail in the first punching cone

$$\beta \cdot V_{Ed} \le V_{Rd,sy} = \frac{\sum A_{s,req} \cdot f_{yd}}{\eta}$$

$$\eta = \begin{cases} 1.0 \text{ for } d_m \le 200 \text{ mm} \\ \\ 1.6 \text{ for } d_m \ge 800 \text{ mm.} \end{cases} ; \eta = 1.0$$

$$\Rightarrow \sum A_{s,req} = (\eta \cdot \beta \cdot V_{Ed}) / f_{yd} = \frac{1.0 \cdot 1.15 \cdot 980}{\frac{500}{1.15}} = 2592 \text{ mm}^2$$

$$\text{No. of rails } n = \sum A_{s,req} / (2 \cdot A_{s,studs}) = \frac{2592 \text{ mm}^2}{2 \cdot 154 \text{ mm}^2} = 8.41 \Rightarrow 12 \text{ rails}$$

The number of rails is rounded up, based on the maximum permitted spacings between the studs.

Factor η to take into account the slab thickness as a function of the static useful height

3. Schöck Bole® design:

the design rules according to the British technical assessment of Schöck Bole® UKTA-0836-22/6454 with regard to the spacing rule for the studs.

The Schöck Bole® approval requires a geometric tangential distance of the studs at the outer edge C of ≤ 1.7 • d_{eff} and of ≤ 3.5 • d_{eff} on the circular section of the outermost studs.

3.1 Required length of the Bole®

Shear force load-bearing capacity at the outer circular section

Determination of the required length of the outer circular section according to BS EN 1992-1-1, section 6.4.4

$$k = 1 + \sqrt{\frac{200}{d_{eff}}} = 2 \le 2$$

$$v_{R,c,out} = 0.12 \cdot k \cdot (100 \cdot \rho \cdot f_{ck})^{1/3} \cdot d_{eff}$$

$$v_{R,c,out} = 0.12 \cdot 2 \cdot (100 \cdot 0.0093 \cdot 30)^{1/3} \cdot 200 \text{ mm} = 145.6 \text{ kN/m}$$

required length of the outer circular section

$$\text{req. } u_{out} = \frac{\beta \cdot v_{Ed}}{v_{R,c,out}} = \frac{1.15 \cdot 980 \text{ kN}}{145.6 \text{ kN/m}} \cdot 10^3 = 7741 \text{ mm}$$

required length of the Bole®

$$\text{req. } l_s = \frac{\text{req. } u_{out} - 2 \cdot 300 - 2 \cdot 450}{2 \cdot \pi} - 1.5 \cdot d_{eff}$$

$$\text{req. } l_s = \frac{7741 - 2 \cdot 300 - 2 \cdot 450}{2 \cdot \pi} - 1.5 \cdot 200 = 693 \text{ mm}$$

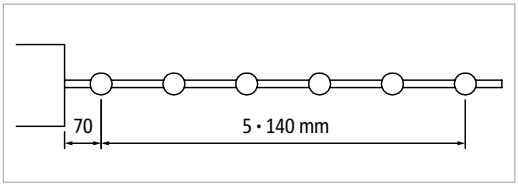
Design example of a rectangular internal column

3.2 Required number of studs of the Bole®

$s_{w,1}$ = 0.375 • d_{eff} = 0.375 • 200 = 75 mm
The first stud spacing is set at 70 mm.

$s_{w,2}$ = 0.75 • d_{eff} = 0.75 • 20 = 150 mm
All other stud spacing is set at 140 mm.

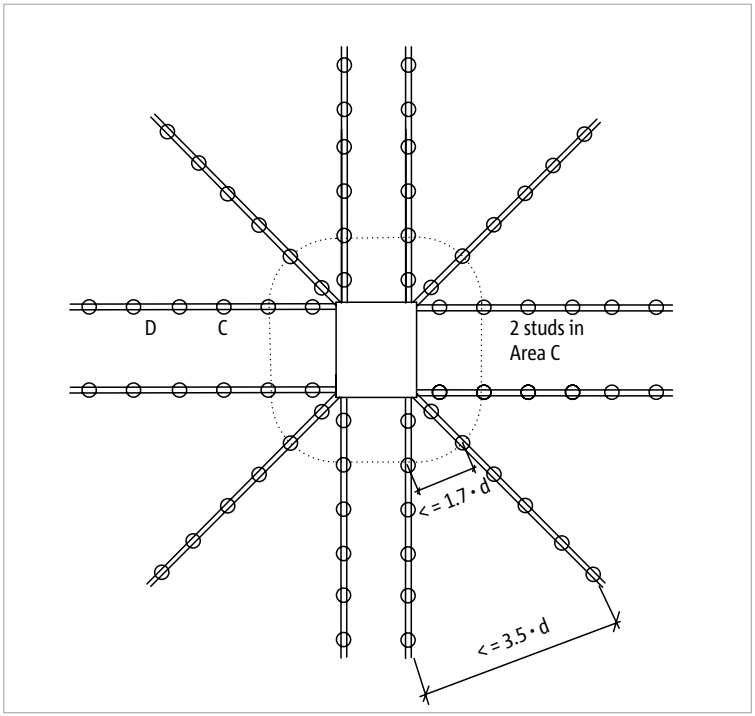
Selected: 6 studs per rail
available l_s = 70 mm + 5 • 140 mm = 770 mm ≥ 693 mm = reqd. l_s



3.3 Required height of studs of the Bole®

$h_B = h - c_u - c_o$ = 240 mm – 20 mm – 20 mm = 200 mm

Bole® selected:
Bole® U 14/200-6/A840-20



1: 12 rails are required due to the geometrical spacing rules

Standardised distances are used due to the product, whereby the maximum stud spacings must not exceed 0.75d

Explanation of the product name
see page 14

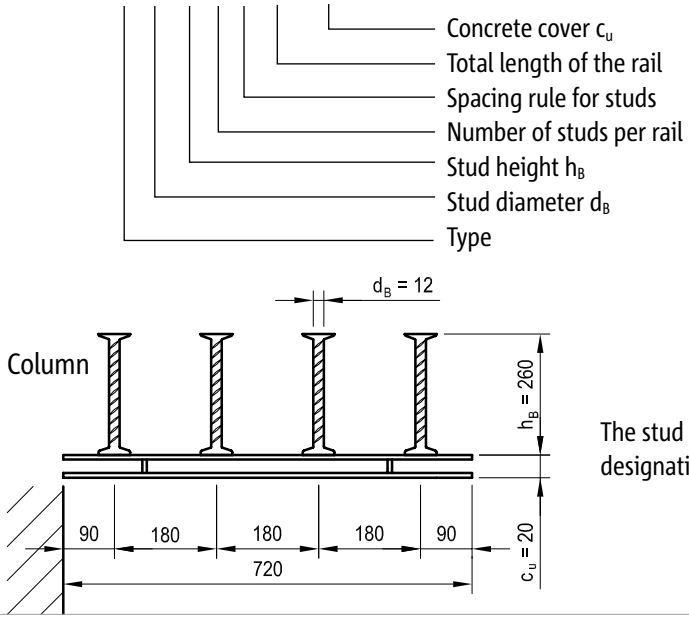
Configuration of the Schöck Bole® in accordance with application document EOTA TR 060

Order options/scope of delivery

Order options:

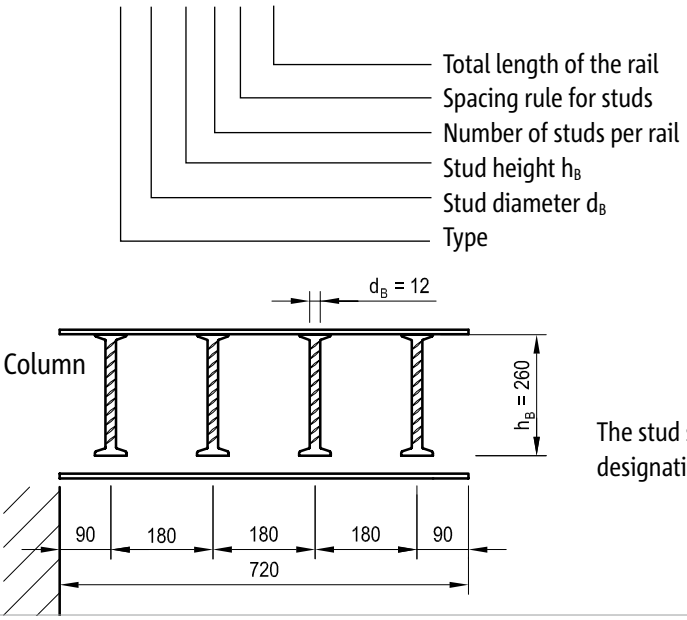
- Using the parts list from the Schöck Bole® design software
- Or informally but with correct product designation

Schöck Bole® U 12-260-4/A 720-CV20



The stud spacings can be determined by the complete designation according to the rules listed below.

Schöck Bole® O 12-260-4/A 720



The stud spacings can be determined by the complete designation according to the rules listed below.

Order options/scope of delivery

Scope of delivery:

- Stud rails, sorted according to element type, are supplied in a carton or on pallets
- Position indicator flag on the first stud with details on the installation position and direction of installation
- Non-verbal installation instructions
- Plastic spacers are supplied free of charge with the Schöck Bole® U

Spacing rules between the studs

Due to the different spacing rules between the studs, depending on the component and the load, there are 4 product-specific definitions for the stud spacing of Schöck Bole®. The individual distances between the studs can be calculated using the spacing rule and the total length of the rail.

Spacing rules for the Schöck Bole®

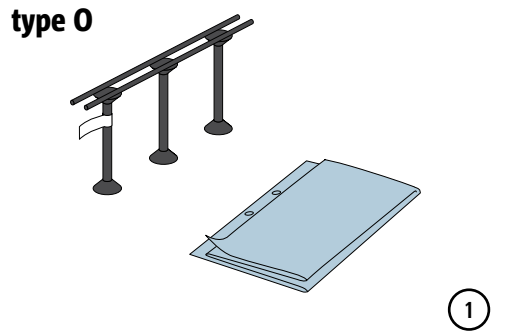
Application area	Spacing rules	Area C			Area D	
		1st stud	2nd stud	3rd stud	All other studs	Projection after the last stud
Flat slabs	A	0.35 – 0.375 d	0.7 – 0.75 d	-	0.7 – 0.75 d	0.35 – 0.375 d
Foundations	B	0.3 d	0.5 d	-	0.75 d	75 mm
Foundations	C	0.3 d	0.5 d	-	0.5 d	75 mm
Foundations	D	0.3 d	0.25 d	0.25 d	0.5 d	75 mm
Flat slabs	E	0.35 d	0.35 d	0.35 d	0.5 d	75 mm

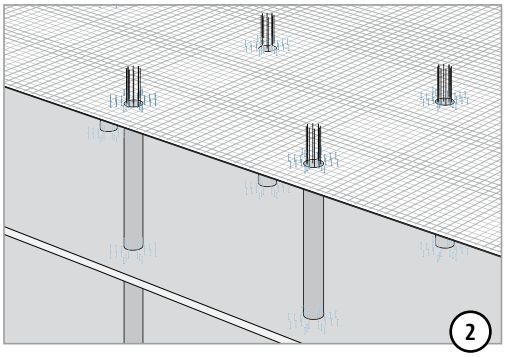
d: mean static useful height of the slab

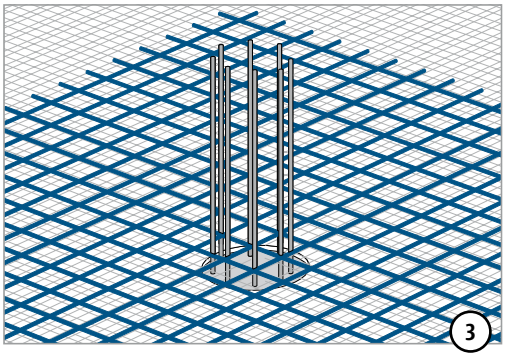
Dimensions of the double-headed studs

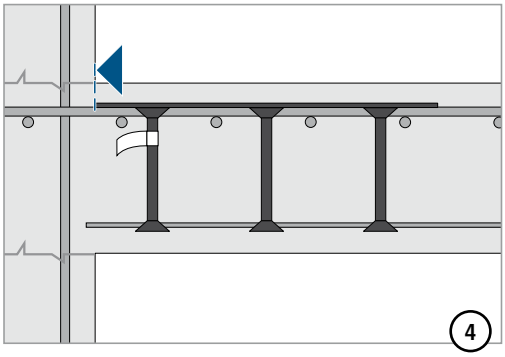
Stud diameter	minimum stud height h_B [mm]	maximum stud height h_B [mm]	head diameter [mm]	$A_{s,studs}$ [mm²]
10	130	640	30	79
12	130	630	36	113
14	140	620	42	154
16	160	1400	48	201
20	190	1400	60	314
25	220	1400	75	491

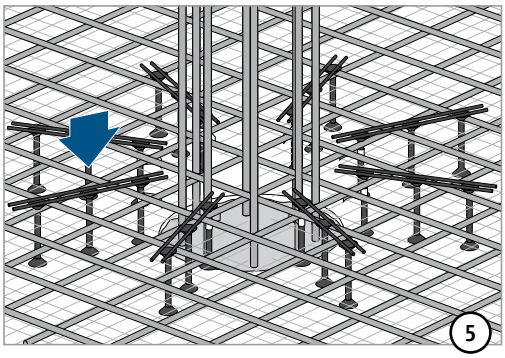
Installation instructions

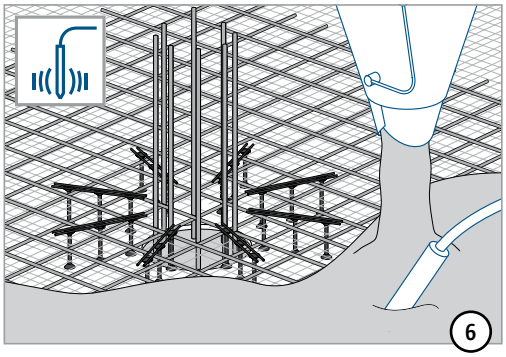






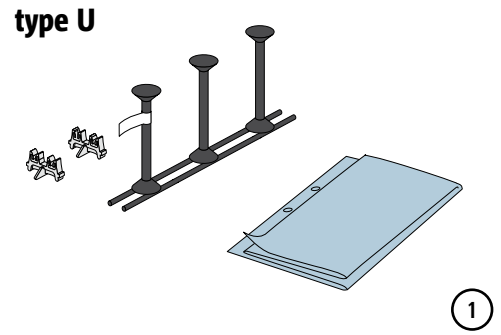


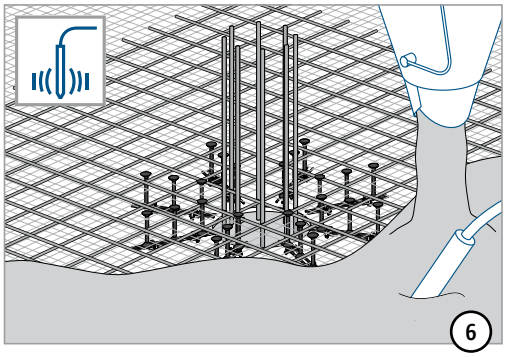


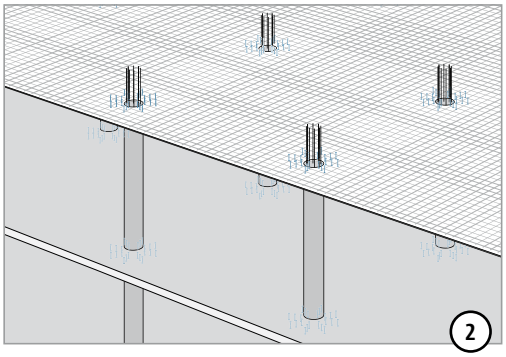


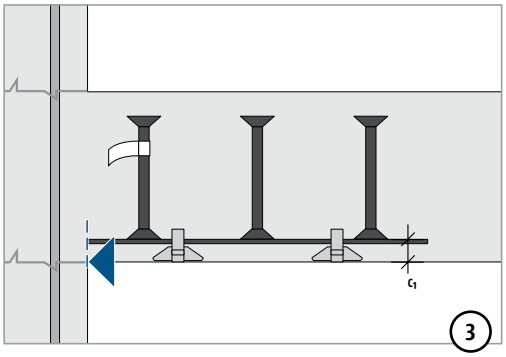
Benefit:
First, the lower and upper reinforcement is laid without considering the Schöck Bole®. Finally, the Schöck Bole® is threaded through the reinforcement layers from above Time-saving with medium reinforcement density.

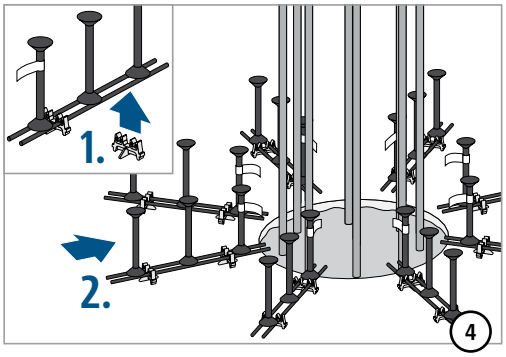
Installation instructions

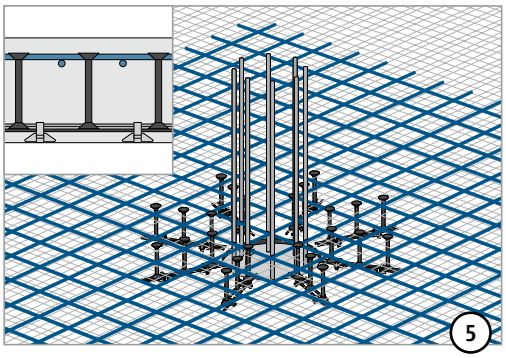












Benefit:
First, the Schöck Bole® is placed on the slab formwork and, if necessary, fixed over the plastic spacer.
Then the lower and upper reinforcement is threaded between the stud. Time-saving with very high reinforcement density.

Tender texts

Schöck Bole® type U

Supply and installation of a reinforcement element with double-headed studs to prevent punching in flat slabs or foundations.

Installation before the laying of the lower reinforcement layer. Spacers are supplied loose. The reinforcement elements consist of ... double-headed studs per element with a stud diameter of ... mm and a stud height of ... mm. The concrete cover under the studs is ... mm.

Implementation in accordance with the specifications of the structural engineer and BS EN 1992-1-1. UKTA approval or an equivalent certificate of compliance must be available for the reinforcement elements used.

The manufacturer's technical documentation must be observed.

Schöck Bole® type O

Supply and installation of a reinforcement element with double-headed studs to prevent punching in flat slabs or foundations.

Installation after laying the lower and upper reinforcement layers. The reinforcement elements consist of ... double-headed studs per element with a stud diameter of ... mm and a stud height of ... mm.

Implementation in accordance with the specifications of the structural engineer and BS EN 1992-1-1. UKTA approval or an equivalent certificate of compliance must be available for the reinforcement elements used.

The manufacturer's technical documentation must be observed.

Imprint
Published by: Schöck Ltd
Staniford House
4 Wedgwood Road
Bicester
Oxfordshire
OX26 4UL
Telephone: 01865 290 890

Subject to technical changes
Date of publication: December 2022

SCHÖCK

Dependable by design

Schöck Ltd
Staniford House
4 Wedgwood Road
Bicester
Oxfordshire, OX26 4UL
Telephone: 01865 290 890
design-uk@schoeck.com
www.schoeck.com

12.2022/GB/220542