European Technical Assessment

ETA-24/0782 of 11 September 2024

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR
Product family to which the construction product belongs	Mechanical fasteners for use in concrete
Manufacturer	pgb - Polska Sp. z o.o. ul. Fryderyka Wilhelma Redena 3 41-807 ZABRZE POLEN
Manufacturing plant	pgb-Polska plant 4
This European Technical Assessment contains	24 pages including 3 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 330232-01-0601-v05, Edition 01/2024

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Specific Part

1 Technical description of the product

The Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR is a fastener made of zinc plated steel, stainless steel or high corrosion resistant steel which is placed into a drilled hole and anchored by torque-controlled expansion.

The product description is given in Annex A.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The performances given in Section 3 are only valid if the fastener is used in compliance with the specifications and conditions given in Annex B.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the fastener of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	Performance
Characteristic resistance to tension load (static and quasi-static loading)	see Annex B3, C1, C2
Characteristic resistance to shear load (static and quasi-static loading)	see Annex C3
Characteristic resistance for seismic performance categories C1 and C2	see Annex C4, C5
Displacements	see Annex C8, C9, C10

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1
Resistance to fire	see Annex C6, C7

3.3 Aspects of durability

Essential characteristic	Performance
Durability	See Annex B1

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with the European Assessment Document EAD 330232-01-0601-v05 the applicable European legal act is: 1996/582/EC.

The system to be applied is: 1

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable European Assessment Document

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

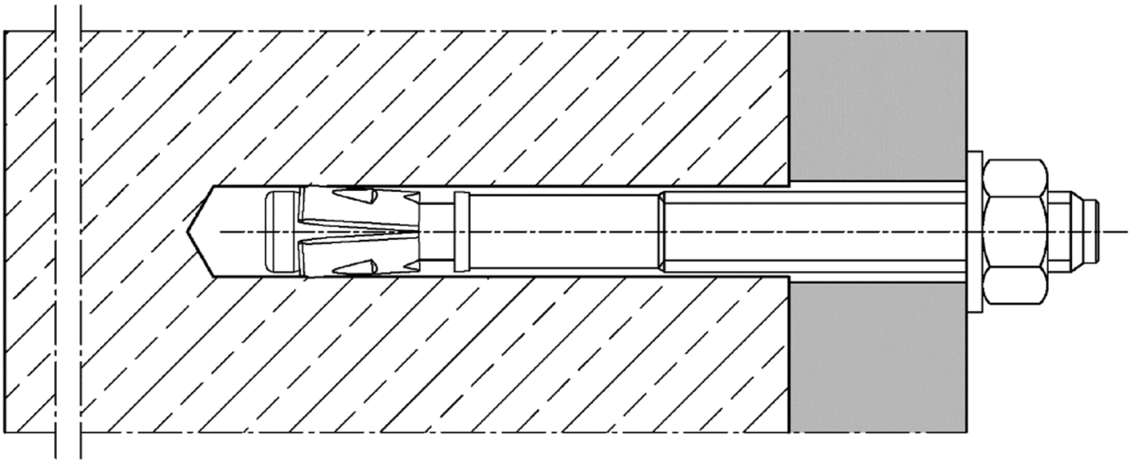
Issued in Berlin on 11 September 2024 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock
Head of Section

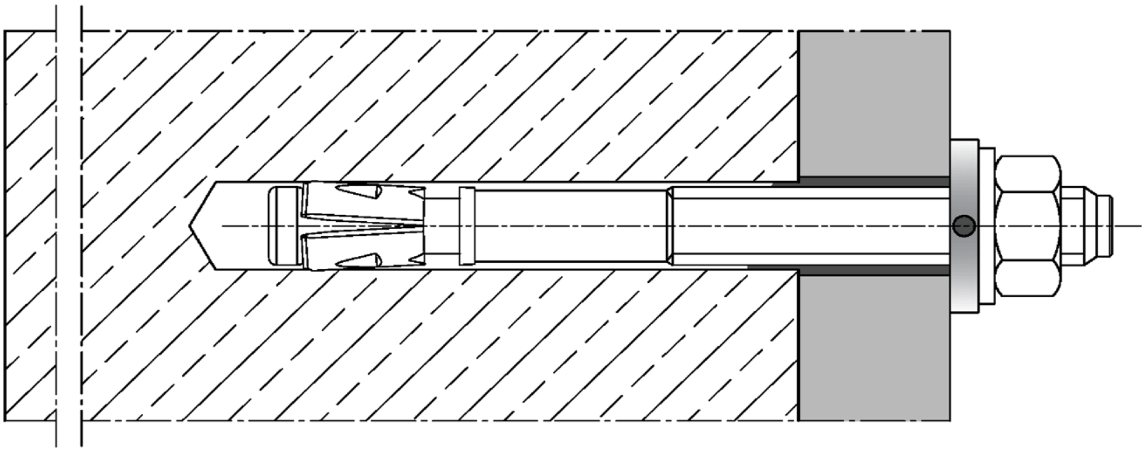
beglaubigt:
Baderschneider

Smart Through Bolt S-BZ3, S-BZ3 A4 and S-BZ3 HCR

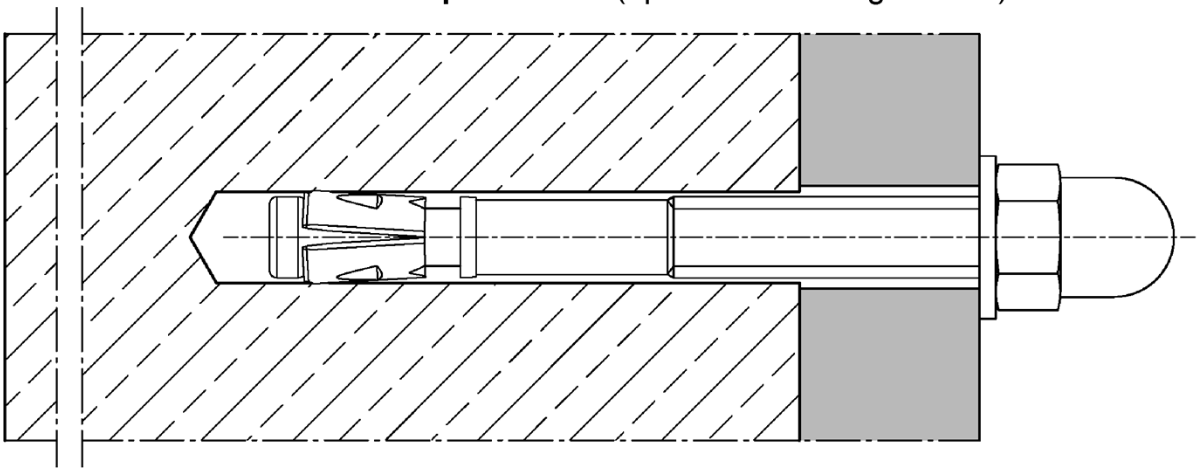
Installation condition



Installation condition with filling washer (optional with cap nut)



Installation condition with cap nut S-CN (optional with filling washer)



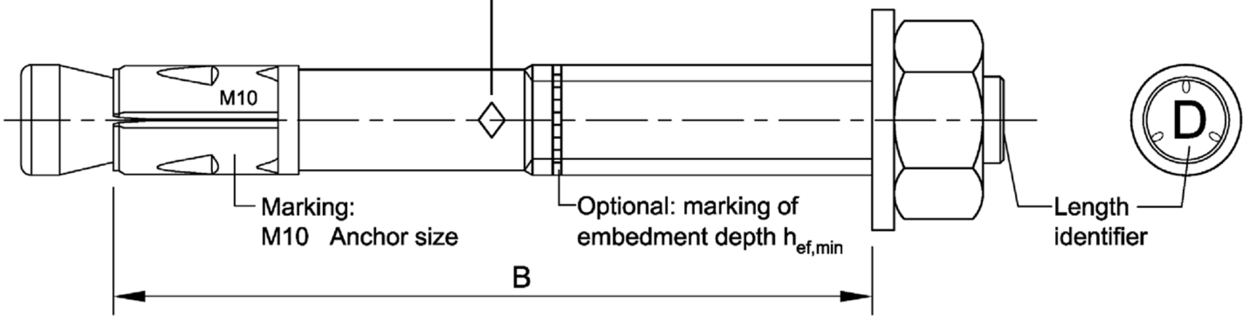
Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR	**Annex A1**
Product description Product types and installation conditions	

Marking

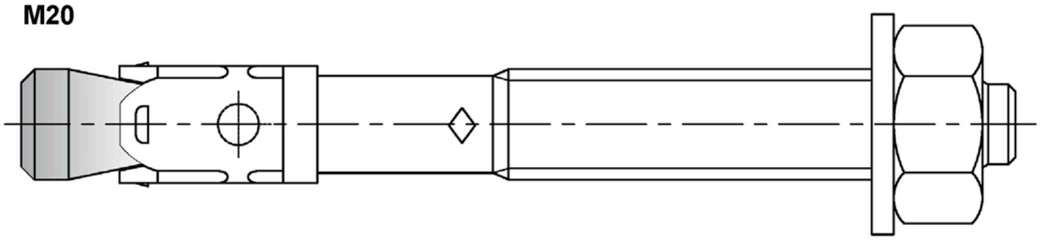
e.g.: ◇ BZ3 15

◇ Identifying mark of manufacturing plant
BZ3 fastener identity
15 max. thickness of fixture $t_{fix,max}$ for $h_{ef,min}$
A4 additional marking for stainless steel
HCR additional marking for high corrosion resistant steel

M8 – M16



M20



Usable length: $\mathbf{B = h_{ef} + t_{fix}}$

h_{ef}: (existing) effective anchorage depth
t_{fix}: fixture thickness (including e.g. levelling layers or other non-load-bearing layers or additional filling washer)

Table A1: Length identification

Length identifier		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Usable length B	≥	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105

Length identifier		P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD
Usable length B	≥	110	115	120	125	130	135	140	145	150	160	170	180	190	200	210

Length identifier		EE	FF	GG	HH	II	JJ	KK	LL
Usable length B	≥	220	230	240	250	260	270	280	290

Dimensions in mm

Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR

Product description
Marking

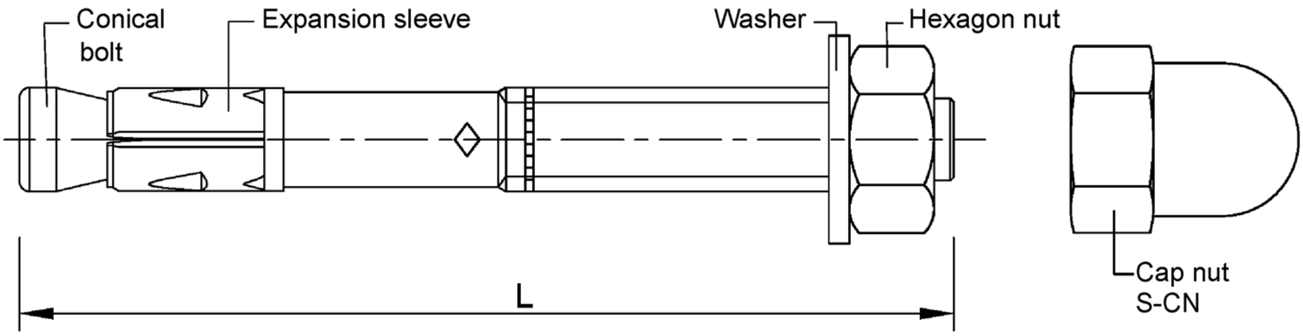
Annex A2

Table A2: Material

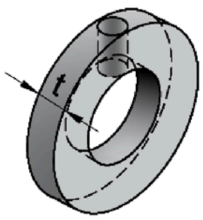
Part	S-BZ3	S-BZ3 A4	S-BZ3 HCR
	Steel, zinc plated	Stainless steel CRC III	High corrosion resistant steel CRC V
Conical bolt	Steel, galvanized ≥ 5 µm fracture elongation $A_5 \geq 8\%$	Stainless steel fracture elongation $A_5 \geq 8\%$	High corrosion resistant steel fracture elongation $A_5 \geq 8\%$
Expansion sleeve	Stainless steel	Stainless steel	Stainless steel
Washer	Steel, galvanized ≥ 5 µm	Stainless steel	High corrosion resistant steel
Filling washer S-FW			
Hexagon nut			
Cap nut S-CN			

Table A3: Fastener dimensions

Fastener size			M8	M10	M12	M16	M20
			S-BZ3 / S-BZ3 A4 / S-BZ3 HCR				
Width across hexagon nut / cap nut S-CN	s	[mm]	13	17	19	24	30
Length of fastener	L	[mm]	$h_{ef} + t_{fix} +$ 18,0	$h_{ef} + t_{fix} +$ 21,5	$h_{ef} + t_{fix} +$ 26,0	$h_{ef} + t_{fix} +$ 33,0	$h_{ef} + t_{fix} +$ 37,0
Thickness of filling washer S-FW	t	[mm]	5				



Filling washer S-FW



Reducing adapter for S-FW

Specifications of intended use

Wedge Anchor	**S-BZ3 / S-BZ3 A4 / S-BZ3 HCR**				
	M8	**M10**	**M12**	**M16**	**M20**
Static or quasi-static action	✓				
Seismic performance categories C1 and C2	✓				
Fire exposure	R30 / R60 / R90 / R120				
Variable, effective anchorage depth	35 mm to 90 mm	40 mm to 100 mm	50 mm to 125 mm	65 mm to 160 mm	90 mm to 140 mm

Base materials:

- For all anchor sizes: compacted reinforced or unreinforced normal weight concrete according to EN 206:2013+A2:2021
- For anchor sizes M8 to M10: steel fibre reinforced concrete (SFRC) according to EN 206:2013+A2:2021 including steel fibres according to EN 14889-1:2006, clause 5, group I. The maximum content of steel fibres is 80 kg/m^3.
- Cracked or uncracked concrete
- Strength classes C20/25 to C50/60 according to EN 206:2013+A2:2021

Use conditions (Environmental conditions):

- Structures subject to dry internal conditions: all materials
- For all other conditions corresponding to corrosion resistance classes CRC according to EN 1993-1-4:2006 + A1:2015: stainless steel according to Annex A3, Table A2 of this ETA

Design:

- Anchorages are designed under the responsibility of an engineer experienced in anchorages and concrete work.
- Verifiable calculation notes and drawings are prepared taking account of the loads to be anchored.
  The position of the fastener is indicated on the design drawings (e.g. position of the fastener relative to reinforcement or to supports, etc.).
- Design method EN 1992-4:2018 and Technical Report TR 055:2018

Installation:

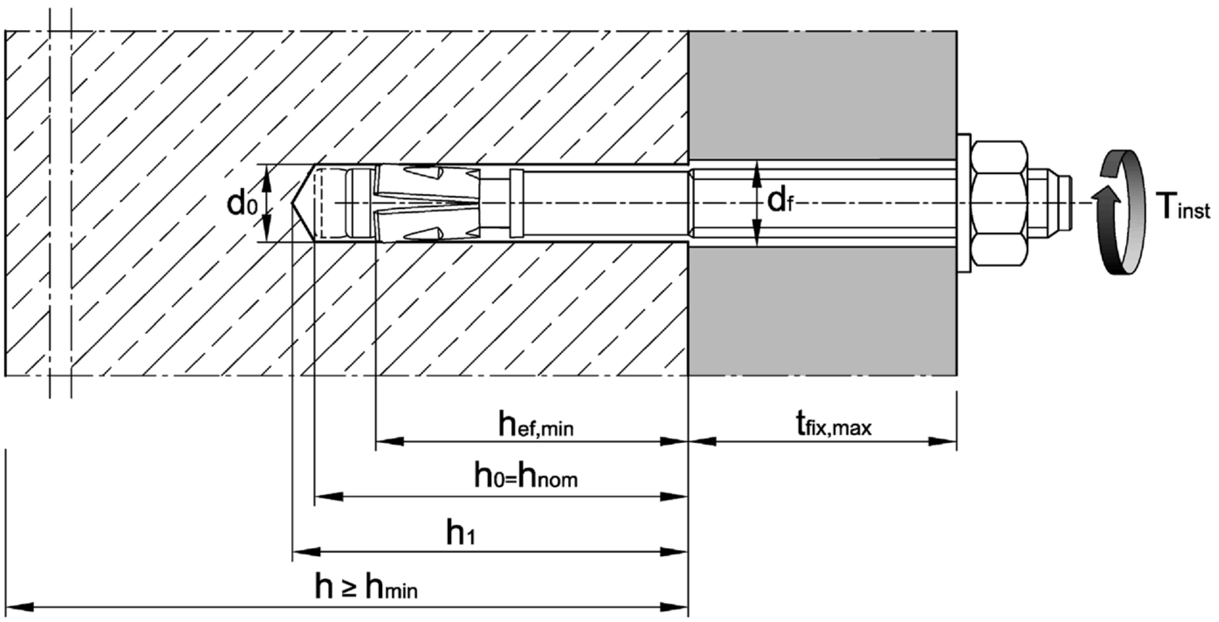
- Hole drilling by hammer drill bit or vacuum drill bit
- Use of the fastener only as supplied by the manufacturer without exchanging the components of the fastener (exception: when using the cap nut S-CN)
- The anchor can be set in pre- or through-setting installation.
- Optionally, the annular gap between fixture and stud of S-BZ3 can be filled to reduce the hole clearance. For this purpose, the filling washer (Annex A3) must be used in addition to the supplied washer. For filling use SMART chemical anchor type S-IRV or S-IRE or other high-strength injection mortar with compressive strength ≥ 40N/mm².

Table B1: Installation parameters

Anchor size			S-BZ3 / S-BZ3 A4 / S-BZ3 HCR				
			M8	M10	M12	M16	M20
Nominal drill hole diameter	d_0	[mm]	8	10	12	16	20
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8,45	10,45	12,5	16,5	20,55
Minimum effective anchorage depth	$h_{ef,min}$	[mm]	35	40	50	65	90
Maximum effective anchorage depth	$h_{ef,max}$	[mm]	90	100	125	160	140
Depth of drill hole	$h_{nom} = h_0 \geq$	[mm]	h_{ef} + 8	h_{ef} + 9	h_{ef} + 10	h_{ef} + 14	h_{ef} + 14 (h_{ef} + 28)[1]
	$h_1 \geq$	[mm]	h_{ef} + 10	h_{ef} + 11	h_{ef} + 13	h_{ef} + 17	h_{ef} + 17 (h_{ef} + 31)[1]
Diameter of clearance hole in the fixture [2]	$d_f \leq$	[mm]	9	12	14	18	22
Projection after anchor has been inserted for installing with cap nut S-CN (acc. to Annex B7, Figure 3)	C	[mm]	10,5	12,5	16,0	19,5	23,0
Installation torque S-BZ3	T_{inst}	[Nm]	15	40	60	110	160
Installation torque S-BZ3 A4 / HCR	T_{inst}	[Nm]	15	40	55	100	200

[1] Increased drill hole depth for hammer drilling without borehole cleaning.

[2] For larger diameters of clearance hole in the fixture, see EN 1992-4:2018, chapter 6.2.2.2



Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR

Intended use
Installation parameters

Annex B2

Table B2: Minimum thickness of concrete member, minimum spacings, edge distances

Anchor size			**S-BZ3 / S-BZ3 A4 / S-BZ3 HCR**				
			M8	**M10**	**M12**	**M16**	**M20**
Minimum member thickness depending on h_{ef}	$h_{min} \geq$	[mm]	max (1,5·h_{ef} ; 80)		max (1,5·h_{ef};100)	max (1,5·h_{ef};120)	max (1,5·h_{ef};150)
Minimum edge distances and spacings							
Minimum edge distance	c_{min}	[mm]	40	45	55	65	90
	for s ≥	[mm]	see Table B4				
Minimum spacings	s_{min}	[mm]	35	40	50	65	95
	for c ≥	[mm]	see Table B4				

The following equation must be fulfilled for the calculation of the minimum spacing and edge distance during installation in combination with variable anchorage depth and member thickness:

$$A_{sp,rqd} \leq A_{sp,ef}$$

Required splitting area $A_{sp,rqd}$ and idealized splitting area $A_{sp,ef}$ according to Table B4.

Table B3: Applicable concrete thickness h_{sp} and area A_{sp} to determine characteristic edge distance $c_{cr,sp}$

Anchor size				**S-BZ3 / S-BZ3 A4 / S-BZ3 HCR**				
				M8	**M10**	**M12**	**M16**	**M20**
Applicable concrete thickness	S-BZ3 S-BZ3 A4 S-BZ3 HCR	h_{sp}	[mm]	$\min(h\,;\ h_{ef} + 1{,}5 \cdot c \cdot \sqrt{2})$				
Area to determine $c_{cr,sp}$ 1)	S-BZ3	A_{sp}	[mm²]	$\frac{N^0_{Rk,sp} - 2{,}573}{0{,}000436}$	$\frac{N^0_{Rk,sp} + 2{,}040}{0{,}000693}$	$\frac{N^0_{Rk,sp} + 3{,}685}{0{,}000692}$	$\frac{N^0_{Rk,sp} + 3{,}738}{0{,}000875}$	$\frac{N^0_{Rk,sp} + 2{,}423}{0{,}000453}$
	S-BZ3 A4 S-BZ3 HCR	A_{sp}	[mm²]	$\frac{N^0_{Rk,sp} + 4{,}177}{0{,}000862}$	$\frac{N^0_{Rk,sp} + 7{,}235}{0{,}000967}$	$\frac{N^0_{Rk,sp} + 7{,}847}{0{,}000951}$	$\frac{N^0_{Rk,sp} + 11{,}41}{0{,}000742}$	$\frac{N^0_{Rk,sp} + 2{,}423}{0{,}000453}$

1) With $N^0_{Rk,sp}$ in kN

Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR	**Annex B3**
Intended use Minimum spacings and edge distances Required area and applicable concrete thickness	

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Table B4: Areas to determine spacings and edge distances for installation

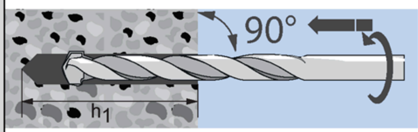
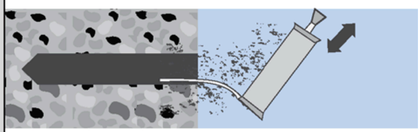
Anchor size					S-BZ3 / S-BZ3 A4 / S-BZ3 HCR				
					M8	**M10**	**M12**	**M16**	**M20**
The following equation must be fulfilled for the calculation of the minimum spacing and edge distance during installation in combination with variable anchorage depth and member thickness: $A_{sp,rqd} \leq A_{sp,ef}$									
Idealized splitting area $A_{sp,ef}$ The edge distances and spacings shall be selected or rounded in steps of 5 mm.									
Member thickness: $h > h_{ef} + 1,5 \cdot c$									
Single anchor or anchor group with $s \geq 3 \cdot c$									
Idealized splitting area			$A_{sp,ef}$	[mm²]	$(6 \cdot c) \cdot (1,5 \cdot c + h_{ef})$				
Anchor group ($s < 3 \cdot c$)									
Idealized splitting area			$A_{sp,ef}$	[mm²]	$(3 \cdot c + s) \cdot (1,5 \cdot c + h_{ef})$				
Member thickness: $h \leq h_{ef} + 1,5 \cdot c$									
Single anchor or anchor group with $s \geq 3 \cdot c$									
Idealized splitting area			$A_{sp,ef}$	[mm²]	$(6 \cdot c) \cdot h$				
Anchor group ($s < 3 \cdot c$)									
Idealized splitting area			$A_{sp,ef}$	[mm²]	$(3 \cdot c + s) \cdot h$				
Required splitting area $A_{sp,rqd}$									
S-BZ3		cracked concrete	$A_{sp,rqd}$	[mm²]	13 900	23 700	31 500	42 300	91 250
		uncracked concrete	$A_{sp,rqd}$	[mm²]	22 500	34 700	41 300	50 200	110 000
S-BZ3 A4 S-BZ3 HCR		cracked concrete	$A_{sp,rqd}$	[mm²]	16 900	25 900	29 800	44 300	91 250
		uncracked concrete	$A_{sp,rqd}$	[mm²]	19 700	35 700	35 300	54 800	110 000

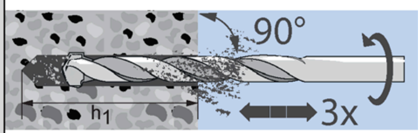
Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR

Intended use
Projected effective area to determine spacings and edge distances

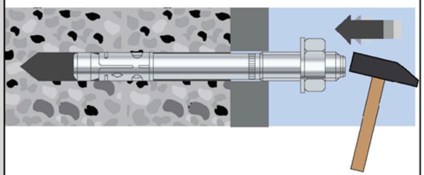
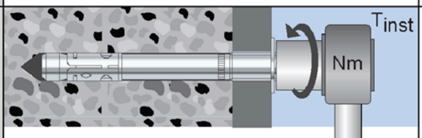
Annex B4

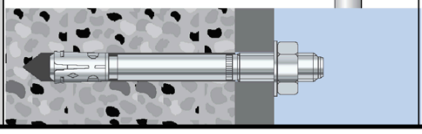
Installation instructions

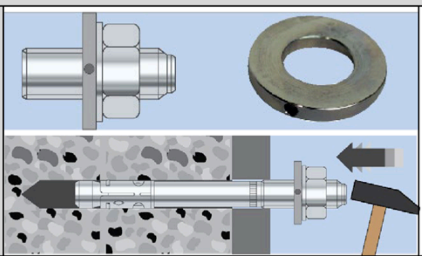
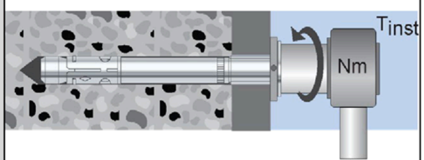
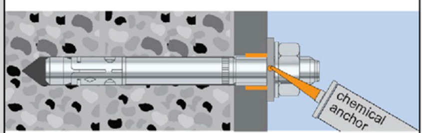
Hole drilling with cleaning		
1		**Hammer drilling or vacuum drilling:** Drill hole perpendicular to concrete surface. If using a vacuum drill bit, proceed with step 3.
2		Blow out dust. Alternatively vacuum clean down to the bottom of the hole.

Hammer drilling without cleaning (M20)		
1		When the drill hole depth ($h_1 = h_{ef}$ +31mm) is reached, move the drill back and forth at least three times with the machine switched on to remove the dust in the drill hole (venting the drill hole). Continue with step 3.

Installation instructions - continuation

<table>
<tr><th colspan="3">Insert fastener</th></tr>
<tr><td>3</td><td></td><td>Drive in fastener.</td></tr>
<tr><td>4</td><td>

</td><td>Apply installation torque T_{inst}.
The fastener is set.</td></tr>
</table>

<table>
<tr><th colspan="3">Insert fastener with filling of annular gap</th></tr>
<tr><td>3</td><td></td><td>Drive in fastener with additionally mounted filling washer.</td></tr>
<tr><td>4</td><td>
</td><td>Apply installation torque T_{inst}.</td></tr>
<tr><td>5</td><td>
</td><td>Fill the annular gap between anchor and fixture with injection adhesive (see Annex B1).
Use enclosed reducing adapter.
The annular gap is completely filled, when excess mortar seeps out.</td></tr>
</table>

Installation instruction – continuation

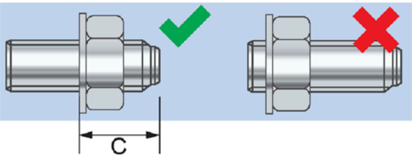
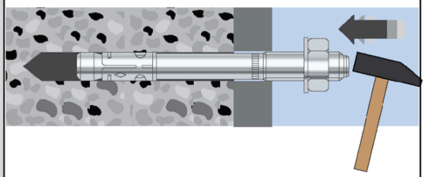
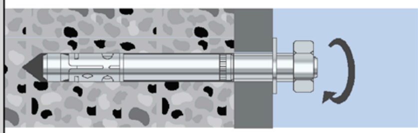
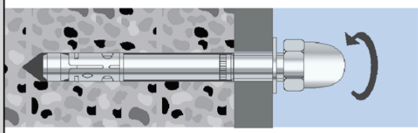
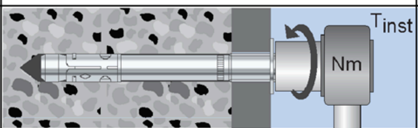
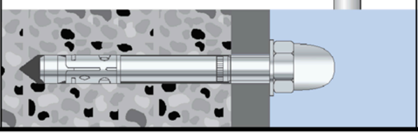
Install fastener with cap nut S-CN		
3		Check position of nut. Projection C after anchor has been inserted see Annex B2, Table B1.
4		Drive in fastener.
5		Remove nut.
6		Screw on cap nut S-CN.
7		Apply installation torque T_{inst}.
		Fastener is set.

Table C1: Characteristic values for **tension loads** under static and quasi-static action, **S-BZ3** (steel, zinc plated)

Fastener size			S-BZ3				
			M8	M10	M12	M16	M20
Installation factor	γ_{inst}	[-]	1,0				
Steel failure							
Characteristic resistance	$N_{Rk,s}$	[kN]	19,8	30,4	44,9	79,3	126,2
Partial factor [4]	γ_{Ms}	[-]	1,5				
Pull-out							
Characteristic resistance in cracked concrete C20/25	$N_{Rk,p,cr}$	[kN]	9,5	15	22	30	45
Increasing factor $N_{Rk,p,cr} = \psi_C \cdot N_{Rk,p,cr}$ (C20/25)	ψ_C	[-]	$\left(\frac{f_{ck}}{20}\right)^{0,439}$	$\left(\frac{f_{ck}}{20}\right)^{0,265}$	$\left(\frac{f_{ck}}{20}\right)^{0,5}$	$\left(\frac{f_{ck}}{20}\right)^{0,339}$	$\left(\frac{f_{ck}}{20}\right)^{0,338}$
Characteristic resistance in uncracked concrete C20/25	$N_{Rk,p,ucr}$	[kN]	14	24	30	50	55
Increasing factor $N_{Rk,p,ucr} = \psi_C \cdot N_{Rk,p,ucr}$ (C20/25)	ψ_C	[-]	$\left(\frac{f_{ck}}{20}\right)^{0,489}$	$\left(\frac{f_{ck}}{20}\right)^{0,448}$	$\left(\frac{f_{ck}}{20}\right)^{0,5}$	$\left(\frac{f_{ck}}{20}\right)^{0,203}$	$\left(\frac{f_{ck}}{20}\right)^{0,5}$
Splitting							
Characteristic resistance	$N^0_{Rk,sp}$	[kN]	min ($N_{Rk,p}$; $N^0_{Rk,c}$ [3])				
Characteristic edge distance [2]	$c_{cr,sp}$	[mm]	$min\left(\frac{A_{sp}+0{,}8\cdot(h_{sp}-h_{ef})^2}{(3{,}41\cdot h_{sp}-0{,}59\cdot h_{ef})};\frac{A_{sp}}{h_{sp}\cdot\sqrt{8}}\right) \geq 1{,}5\cdot h_{ef}$				
Characteristic spacing	$s_{cr,sp}$	[mm]	$2 \cdot c_{cr,sp}$				
Factor	$\psi_{h,sp}$	[-]	1,0				
Concrete cone failure							
Minimum, effective anchorage depth	$h_{ef,min}$	[mm]	35 [1]	40	50	65	90
Maximum, effective anchorage depth	$h_{ef,max}$	[mm]	90	100	125	160	140
Characteristic edge distance	$c_{cr,N}$	[mm]	$1{,}5 \cdot h_{ef}$				
Characteristic spacing	$s_{cr,N}$	[mm]	$2 \cdot c_{cr,N}$				
Factor — cracked concrete	$k_{cr,N}$	[-]	7,7				
Factor — uncracked concrete	$k_{ucr,N}$	[-]	11,0				

[1] Fastenings with anchorage depth h_{ef} < 40mm are restricted to the use of structural components which are statically indeterminate and subject to internal exposure conditions only.

[2] Applicable concrete thickness h_{sp} and area A_{sp} to determine characteristic edge distance $c_{cr,sp}$ according to Table B3

[3] $N^0_{Rk,c}$ according to EN 1992-4:2018

[4] In absence of other national regulations

Table C2: Characteristic values for **tension loads** under static or quasi-static action, **S-BZ3 A4** and **S-BZ3 HCR**

Fastener size			S-BZ3 A4 / S-BZ3 HCR				
			M8	**M10**	**M12**	**M16**	**M20**
Installation factor	γ_{inst}	[-]	1,0				
Steel failure							
Characteristic resistance	$N_{Rk,s}$	[kN]	19,8	30,4	44,9	74,6	126,2
Partial factor 4)	γ_{Ms}	[-]	1,5				
Pull-out							
Characteristic resistance in cracked concrete C20/25	$N_{Rk,p,cr}$	[kN]	9,5	17	22	35	45
Increasing factor $N_{Rk,p,cr} = \psi_C \cdot N_{Rk,p,cr}$ (C20/25)	ψ_C	[-]	$\left(\frac{f_{ck}}{20}\right)^{0,488}$	$\left(\frac{f_{ck}}{20}\right)^{0,5}$	$\left(\frac{f_{ck}}{20}\right)^{0,435}$	$\left(\frac{f_{ck}}{20}\right)^{0,350}$	$\left(\frac{f_{ck}}{20}\right)^{0,338}$
Characteristic resistance in uncracked concrete C20/25	$N_{Rk,p,ucr}$	[kN]	20	25	42	50	55
Increasing factor $N_{Rk,p,ucr} = \psi_C \cdot N_{Rk,p,ucr}$ (C20/25)	ψ_C	[-]	$\left(\frac{f_{ck}}{20}\right)^{0,240}$	$\left(\frac{f_{ck}}{20}\right)^{0,364}$	$\left(\frac{f_{ck}}{20}\right)^{0,213}$	$\left(\frac{f_{ck}}{20}\right)^{0,196}$	$\left(\frac{f_{ck}}{20}\right)^{0,5}$
Splitting							
Characteristic resistance	$N^0_{Rk,sp}$	[kN]	min ($N_{Rk,p}$; $N^0_{Rk,c}$ 3))				
Characteristic edge distance 2)	$c_{cr,sp}$	[mm]	$min\left(\frac{A_{sp}+0{,}8\cdot(h_{sp}-h_{ef})^2}{(3{,}41\cdot h_{sp}-0{,}59\cdot h_{ef})};\frac{A_{sp}}{h_{sp}\cdot\sqrt{8}}\right) \geq 1{,}5\cdot h_{ef}$				
Characteristic spacing	$s_{cr,sp}$	[mm]	$2 \cdot c_{cr,sp}$				
Factor	$\psi_{h,sp}$	[-]	1,0				
Concrete cone failure							
Minimum, effective anchorage depth	$h_{ef,min}$	[mm]	35 1)	40	50	65	90
Maximum, effective anchorage depth	$h_{ef,max}$	[mm]	90	100	125	160	140
Characteristic edge distance	$c_{cr,N}$	[mm]	$1{,}5 \cdot h_{ef}$				
Characteristic spacing	$s_{cr,N}$	[mm]	$2 \cdot c_{cr,N}$				
Factor – cracked concrete	$k_{cr,N}$	[-]	7,7				
Factor – uncracked concrete	$k_{ucr,N}$	[-]	11,0				

1) Fastenings with anchorage depth h_{ef} < 40 mm are restricted to the use of structural components which are statically indeterminate and subject to internal exposure conditions only

2) Applicable concrete thickness h_{sp} and area A_{sp} according to Table B3 to determine characteristic edge distance $c_{cr,sp}$

3) $N^0_{Rk,c}$ according to EN 1992-4:2018

4) In absence of other national regulations

Table C3: Characteristic values for **shear loads** under static and quasi-static action

Fastener size				**S-BZ3 / S-BZ3 A4 / S-BZ3 HCR**				
				M8	**M10**	**M12**	**M16**	**M20**
Installation factor		γ_{inst}	[-]	1,0				
Steel failure <u>without</u> lever arm								
Characteristic resistance – **<u>unfilled</u>** annular gap	S-BZ3	$V^0_{Rk,s}$	[kN]	15,7	26,8	38,3	60,0	83,8
	S-BZ3 A4 / HCR	$V^0_{Rk,s}$	[kN]	16,8	27,8	39,8	69,5	108,5
Characteristic resistance – **<u>filled</u>** annular gap	S-BZ3	$V^0_{Rk,s}$	[kN]	17,3	26,7	38,6	60,6	86,1
	S-BZ3 A4 / HCR	$V^0_{Rk,s}$	[kN]	16,8	27,8	44,9	80,1	108,5
Partial factor [2)]		γ_{Ms}	[-]	1,25				
Ductility factor		k_7	[-]	1,0				
Steel failure <u>with</u> lever arm								
Characteristic bending resistance	S-BZ3	$M^0_{Rk,s}$	[Nm]	30	60	105	240	412
	S-BZ3 A4 / HCR	$M^0_{Rk,s}$	[Nm]	27	55	99	223	390
Partial factor [2)]		γ_{Ms}	[-]	1,25				
Concrete pry-out failure								
Pry-out factor	S-BZ3	k_8	[-]	2,8	3,1	3,0	3,6	3,3
	S-BZ3 A4 / HCR	k_8	[-]	2,7	2,8	3,3	3,4	3,3
Concrete edge failure								
Effective length of fastener in shear loading		l_f	[mm]	h_{ef} [1)]				
Outside diameter of fastener		d_{nom}	[mm]	8	10	12	16	20

[1)] Fastenings with anchorage depth $h_{ef} < 40$ mm are restricted to the use of structural components which are statically indeterminate and subject to internal exposure conditions only.

[2)] In absence of other national regulations.

Table C4: Characteristic values for **seismic loading,** performance category **C1**

Fastener size				**S-BZ3 / S-BZ3 A4 / S-BZ3 HCR**									
				M8		**M10**		**M12**		**M16**		**M20**	
Effective anchorage depth		$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90	100
Tension load													
Installation factor		γ_{inst}	[-]	1,0									
Steel failure													
Characteristic resistance	S-BZ3	$N_{Rk,s,C1}$	[kN]	19,8		30,4		44,9		79,3		126,2	
	S-BZ3 A4 / HCR	$N_{Rk,s,C1}$	[kN]	19,8		30,4		44,9		74,6		126,2	
Pull-out													
Characteristic resistance	S-BZ3	$N_{Rk,p,C1}$	[kN]	9,1		15,0		22,0		30,0		45,1	
	S-BZ3 A4 / HCR	$N_{Rk,p,C1}$	[kN]	9,0		17,0		22,0		35,0		45,1	
Shear load													
Steel failure without lever arm													
Characteristic resistance - **unfilled** annular gap	S-BZ3	$V_{Rk,s,C1}$	[kN]	11,7	13,4	22,5	24,4	30,0	33,8	48,8	52,3	83,8	
	S-BZ3 A4 / HCR	$V_{Rk,s,C1}$	[kN]	11,0	12,7	20,6	22,2	33,2	33,2	61,1	64,3	108,5	
Characteristic resistance - **filled** annular gap	S-BZ3	$V_{Rk,s,C1}$	[kN]	14,0	14,7	24,1	24,4	37,0	38,6	60,2	60,2	86,1	
	S-BZ3 A4 / HCR	$V_{Rk,s,C1}$	[kN]	12,6	16,8	24,5	27,5	36,7	39,8	67,7	74,2	108,5	
Factor for anchorages	**unfilled** annular gap	α_{gap}	[-]	0,5									
	filled annular gap	α_{gap}	[-]	1,0									

Table C5: Characteristic values for **seismic loading,** performance category **C2**

Fastener size				**S-BZ3 / S-BZ3 A4 / S-BZ3 HCR**										
				M8		**M10**		**M12**		**M16**		**M20**		
Effective anchorage depth		$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90	100	140
Tension load														
Installation factor		γ_{inst}	[-]	1,0										
Steel failure														
Characteristic resistance	S-BZ3	$N_{Rk,s,C2}$	[kN]	19,8		30,4		44,9		79,3		126,2		
	S-BZ3 A4 / HCR	$N_{Rk,s,C2}$	[kN]	19,8		30,4		44,9		74,6		126,2		
Pull-out														
Characteristic resistance	S-BZ3	$N_{Rk,p,C2}$	[kN]	2,8	3,6	7,3	12,5	10,7	19,0	19,8	35,2	35,1	37,6	42,9
	S-BZ3 A4 / HCR	$N_{Rk,p,C2}$	[kN]	2,3	3,2	5,0	7,7	8,0	13,8	19,0	29,4	35,1	37,6	42,9
Shear load														
Steel failure without lever arm														
Characteristic resistance - **unfilled** annular gap	S-BZ3	$V_{Rk,s,C2}$	[kN]	7,3	11,3	15,4	19,0	18,3	28,0	39,4	43,3	69,0		
	S-BZ3 A4 / HCR	$V_{Rk,s,C2}$	[kN]	7,5	8,6	12,5	15,9	22,4	25,6	42,7	46,1	88,9		
Characteristic resistance - **filled** annular gap	S-BZ3	$V_{Rk,s,C2}$	[kN]	9,7	10,8	17,7	19,9	27,6	28,9	46,0	48,8	73,3		
	S-BZ3 A4 / HCR	$V_{Rk,s,C2}$	[kN]	9,4	9,7	16,5	17,1	24,5	28,5	47,4	47,4	88,9		
Factor for anchorages	**unfilled** annular gap	α_{gap}	[-]	0,5										
	filled annular gap	α_{gap}	[-]	1,0										

Table C6: Characteristic values **for tension and shear load** under **fire exposure, S-BZ3** (steel, zinc plated)

Fastener size				S-BZ3				
				M8	**M10**	**M12**	**M16**	**M20**
Tension load								
Steel failure								
Characteristic resistance	R30	$N_{Rk,s,fi}$	[kN]	1,2	2,6	4,6	7,7	9,4
	R60			1,0	1,9	3,3	5,6	8,2
	R90			0,7	1,3	2,1	3,5	6,9
	R120			0,6	1,0	1,5	2,5	6,3
Shear load								
Steel failure without lever arm								
Characteristic resistance	R30	$V_{Rk,s,fi}$	[kN]	4,0	7,5	12,3	20,7	11,0
	R60			2,7	5,1	8,5	14,2	10,6
	R90			1,4	2,7	4,6	7,7	10,2
	R120			0,8	1,6	2,7	4,5	10,0
Steel failure with lever arm								
Characteristic resistance	R30	$M^0_{Rk,s,fi}$	[Nm]	4,1	9,6	19,1	43,8	29,1
	R60			2,8	6,6	13,1	30,1	28,0
	R90			1,5	3,5	7,2	16,4	26,9
	R120			0,8	2,0	4,2	9,6	26,3

$N_{Rk,p,fi}$ and $N_{Rk,c,fi}$ according to EN 1992-4:2018

Table C7: Characteristic values **for tension and shear load** under **fire exposure, S-BZ3 A4** and **S-BZ3 HCR**

Fastener size				**S-BZ3 A4 / S-BZ3 HCR**				
				M8	**M10**	**M12**	**M16**	**M20**
Tension load								
Steel failure								
Characteristic resistance	R30	$N_{Rk,s,fi}$	[kN]	4,0	6,9	11,0	18,1	36,9
	R60			2,9	5,0	8,0	13,1	27,4
	R90			1,8	3,1	4,9	8,1	17,9
	R120			1,2	2,1	3,4	5,6	13,1
Shear load								
Steel failure <u>without</u> lever arm								
Characteristic resistance	R30	$V_{Rk,s,fi}$	[kN]	8,5	17,6	32,0	52,6	73,5
	R60			6,2	12,6	22,6	37,1	51,8
	R90			3,9	7,5	13,1	21,5	30,1
	R120			2,8	5,0	8,4	13,8	19,2
Steel failure <u>with</u> lever arm								
Characteristic resistance	R30	$M^0_{Rk,s,fi}$	[Nm]	8,7	22,7	49,8	111,5	194,7
	R60			6,3	16,2	35,1	78,6	137,2
	R90			4,0	9,7	20,4	45,6	79,7
	R120			2,8	6,5	13,0	29,2	50,9

$N_{Rk,p,fi}$ and $N_{Rk,c,fi}$ according to EN 1992-4:2018

Table C8: Displacements under **tension load, S-BZ3** (steel, zinc plated)

Fastener size			S-BZ3										
			M8		M10		M12		M16		M20		
Displacements under static or quasi-static action $\delta_{N0} = \delta_{N0\text{-factor}} \cdot N$ N: acting tension load $\delta_{N\infty} = \delta_{N\infty\text{-factor}} \cdot N$													
Effective anchorage depth	$h_{ef} \geq$	[mm]	35		40		50		65		90		
Cracked concrete													
Factor for displacement	$\delta_{N0\text{-factor}}$	[mm/kN]	0,13		0,05		0,04		0,03		0,04		
	$\delta_{N\infty\text{-factor}}$	[mm/kN]	0,29		0,20		0,15		0,11		0,05		
Uncracked concrete													
Factor for displacement	$\delta_{N0\text{- factor}}$	[mm/kN]	0,03		0,01		0,004		0,005		0,02		
	$\delta_{N\infty\text{- factor}}$	[mm/kN]	0,03		0,03		0,03		0,03		0,03		
Displacement under seismic action C2													
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90	100	140
Displacements for DLS	$\delta_{N,\,C2(DLS)}$	[mm]	3,9	4,9	2,8	4,7	2,4	4,2	2,5	4,5	4,2	4,5	5,1
Displacements for ULS	$\delta_{N,\,C2(ULS)}$	[mm]	11,3	14,3	9,4	16,1	7,3	12,9	7,2	12,8	11,7	12,5	14,3

Table C9: Displacements under **tension load, S-BZ3 A4** and **S-BZ3 HCR**

Fastener size			S-BZ3 A4 / S-BZ3 HCR										
			M8		M10		M12		M16		M20		
Displacements under static or quasi-static action $\delta_{N0} = \delta_{N0\text{-factor}} \cdot N$ N: acting tension load $\delta_{N\infty} = \delta_{N\infty\text{-factor}} \cdot N$													
Effective anchorage depth	$h_{ef} \geq$	[mm]	35		40		50		65		90		
Cracked concrete													
Factor for displacement	$\delta_{N0\text{-factor}}$	[mm/kN]	0,11		0,06		0,05		0,02		0,04		
	$\delta_{N\infty\text{-factor}}$	[mm/kN]	0,27		0,17		0,16		0,08		0,05		
Uncracked concrete													
Factor for displacement	$\delta_{N0\text{- factor}}$	[mm/kN]	0,02		0,00		0,001		0,00		0,02		
	$\delta_{N\infty\text{- factor}}$	[mm/kN]	0,05		0,05		0,05		0,05		0,03		
Displacement under seismic action C2													
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90	100	140
Displacements for DLS	$\delta_{N,\,C2(DLS)}$	[mm]	2,0	2,9	2,6	4,1	3,3	5,7	3,3	5,1	4,2	4,5	5,1
Displacements for ULS	$\delta_{N,\,C2(ULS)}$	[mm]	7,7	11,1	10,8	16,8	10,4	18,0	9,0	13,9	11,7	12,5	14,3

Table C10: Displacements under **shear load, S-BZ3** (steel, zinc plated)

Fastener size			**S-BZ3**								
			M8		**M10**		**M12**		**M16**		**M20**
Displacements under static or quasi-static action $\delta_{V0} = \delta_{V0\text{-factor}} \cdot V$; $\delta_{V\infty} = \delta_{V\infty\text{-factor}} \cdot V$; V: acting shear load											
Effective anchorage depth	$h_{ef} \geq$	[mm]	35		40		50		65		90
Factor for displacement **unfilled** annular gap	$\delta_{V0\text{-factor}}$	[mm/kN]	0,15		0,09		0,09		0,07		0,06
	$\delta_{V\infty\text{-factor}}$	[mm/kN]	0,22		0,13		0,14		0,11		0,10
Factor for displacement **filled** annular gap	$\delta_{V0\text{-factor}}$	[mm/kN]	0,01		0,04		0,06		0,04		0,02
	$\delta_{V\infty\text{-factor}}$	[mm/kN]	0,015		0,06		0,09		0,06		0,03
Displacement under seismic action C2 [1] **unfilled** annular gap											
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90
Displacements for DLS	$\delta_{V,C2(DLS)}$	[mm]	2,8	2,7	3,0	3,1	3,4	3,7	3,4	3,8	5,1
Displacements for ULS	$\delta_{V,C2(ULS)}$	[mm]	5,1	5,0	5,0	5,5	6,3	9,9	6,0	9,6	9,4
Displacement under seismic action C2 filled annular gap											
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90
Displacements for DLS	$\delta_{V,C2(DLS)}$	[mm]	0,5	0,4	1,4	0,9	1,4	0,7	1,4	1,2	1,3
Displacements for ULS	$\delta_{V,C2(ULS)}$	[mm]	1,7	1,9	5,8	4,5	4,5	3,1	5,0	3,9	5,2

[1] For anchorages with clearance in the fixture the annular gap must also be taken into account.

Table C11: Displacements under **shear load, S-BZ3 A4** and **S-BZ3 HCR**

Fastener size			S-BZ3 A4 / S-BZ3 HCR								
			M8		M10		M12		M16		M20
Displacements under static or quasi-static action $\delta_{V0} = \delta_{V0\text{-factor}} \cdot V$; $\delta_{V\infty} = \delta_{V\infty\text{-factor}} \cdot V$; V: acting shear load											
Effective anchorage depth	$h_{ef} \geq$	[mm]	35		40		50		65		90
Factor for displacement **unfilled** annular gap	$\delta_{V0\text{-factor}}$	[mm/kN]	0,26		0,14		0,12		0,09		0,09
	$\delta_{V\infty\text{-factor}}$	[mm/kN]	0,39		0,20		0,17		0,14		0,13
Factor for displacement **filled** annular gap	$\delta_{V0\text{-factor}}$	[mm/kN]	0,16		0,05		0,05		0,03		0,09
	$\delta_{V\infty\text{-factor}}$	[mm/kN]	0,23		0,08		0,08		0,05		0,13
Displacement under seismic action C2 [1] **unfilled** annular gap											
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90
Displacements for DLS	$\delta_{V,C2(DLS)}$	[mm]	2,8	3,0	3,4	3,5	3,5	4,2	3,8	4,4	5,1
Displacements for ULS	$\delta_{V,C2(ULS)}$	[mm]	5,2	5,1	7,0	8,4	7,5	11,8	7,8	11,1	9,4
Displacement under seismic action C2 filled annular gap											
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	45	40	60	50	70	65	85	90
Displacements for DLS	$\delta_{V,C2(DLS)}$	[mm]	0,9	0,6	1,2	0,5	1,5	1,5	1,6	1,6	4,1
Displacements for ULS	$\delta_{V,C2(ULS)}$	[mm]	2,5	2,6	5,4	3,6	6,0	7,1	6,2	6,2	8,4

[1] For anchorages with clearance in the fixture the annular gap must also be taken into account

Smart Through Bolt S-BZ3 / S-BZ3 A4 / S-BZ3 HCR

Performance
Displacements under shear load

Annex C10