



Public-law institution jointly founded by the federal states and the Federation

European Technical Assessment Body for construction products



## European Technical Assessment

## ETA-17/0716 of 1 August 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	Injection System VMH for concrete
Product family to which the construction product belongs	Bonded fasteners and bonded expansion fasteners for use in concrete
Manufacturer	MKT Metall-Kunststoff-Technik GmbH & Co. KG Auf dem Immel 2 67685 Weilerbach DEUTSCHLAND
Manufacturing plant	Werk 1, D Werk 2, D
This European Technical Assessment contains	38 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 330499-02-0601, Edition 11/2023
This version replaces	ETA-17/0716 issued on 11 May 2021



Page 2 of 38 | 1 August 2024

The European Technical Assessment is issued by the Technical Assessment Body in its official language. Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and shall be identified as such.

Communication of this European Technical Assessment, including transmission by electronic means, shall be in full. However, partial reproduction may only be made with the written consent of the issuing Technical Assessment Body. Any partial reproduction shall be identified as such.

This European Technical Assessment may be withdrawn by the issuing Technical Assessment Body, in particular pursuant to information by the Commission in accordance with Article 25(3) of Regulation (EU) No 305/2011.



#### **Specific Part**

#### 1 Technical description of the product

The "Injection system VMH for concrete" is a bonded anchor consisting of a cartridge with injection mortar VMH and a steel element according to Annex A 3 to A 5.

The steel element is placed into a drilled hole filled with injection mortar and is anchored via the bond between metal part, injection mortar and concrete.

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 anchor 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 anchor of at least 50 and/or 100 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, C 1, C 3, C 4, C 5, C 9, C 10, C 12, C 13
Characteristic resistance to shear load (static and quasi-static loading)	See Annex C 2, C 6, C 11, C 14
Displacements under short-term and long-term loading	See Annex C 17 to C19
Characteristic resistance and displacements for seismic performance categories C1 and C2	See Annex C 7, C 8, C 15, C 16, C 17

#### 3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1
Resistance to fire	See Annex C 20 to C 22

#### 3.3 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content, emission and/or release of dangerous substances	No performance assessed



Page 4 of 38 | 1 August 2024

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

In accordance with EAD 330499-02-0601 the applicable European legal act is: [96/582/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 at Deutsches Institut für Bautechnik.

Issued in Berlin on 1 August 2024 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock Head of Section *beglaubigt:* Baderschneider



# Installation threaded rod M8 to M30 Pre-setting installation or through-setting installation (optional annular gap filled with mortar) tfix $h_{ef} = h_0$ hmin Installation internally threaded anchor rod IG M6 to IG M20 $h_{ef} = h_0$ tfix hmin Installation reinforcing bar Ø8 to Ø32 = effective anchorage depth hef $h_{ef} = h_0$ = depth of drill hole ho h<sub>min</sub> = minimum thickness of member hmin = thickness of fixture t<sub>fix</sub> Injection System VMH for concrete Annex A1 **Product description** Installation situation

#### Page 6 of European Technical Assessment ETA-17/0716 of 1 August 2024



Cartridge Injection Mortar VMH			
Coaxial cartridge 150 ml, 280 ml, 300 ml bis 330 ml, 380 ml bis 420 ml		Imprint: VMH processing and safety instructions, sl charge number, manufacturer's infor quantity information	nelf life, mation,
Side-by-side cartridge 235 ml, 345 ml bis 360 ml, 825 ml		Imprint: VMH processing and safety instructions, charge number, manufacturer's info quantity information	shelf life, rmation,
Static mixer VM-XHP			
Retaining washer and extension	nozzle		
			)
njection System VMH for concrete			
Product description Cartridge, static mixer and retaining washer			Annex A2

## Page 7 of European Technical Assessment ETA-17/0716 of 1 August 2024

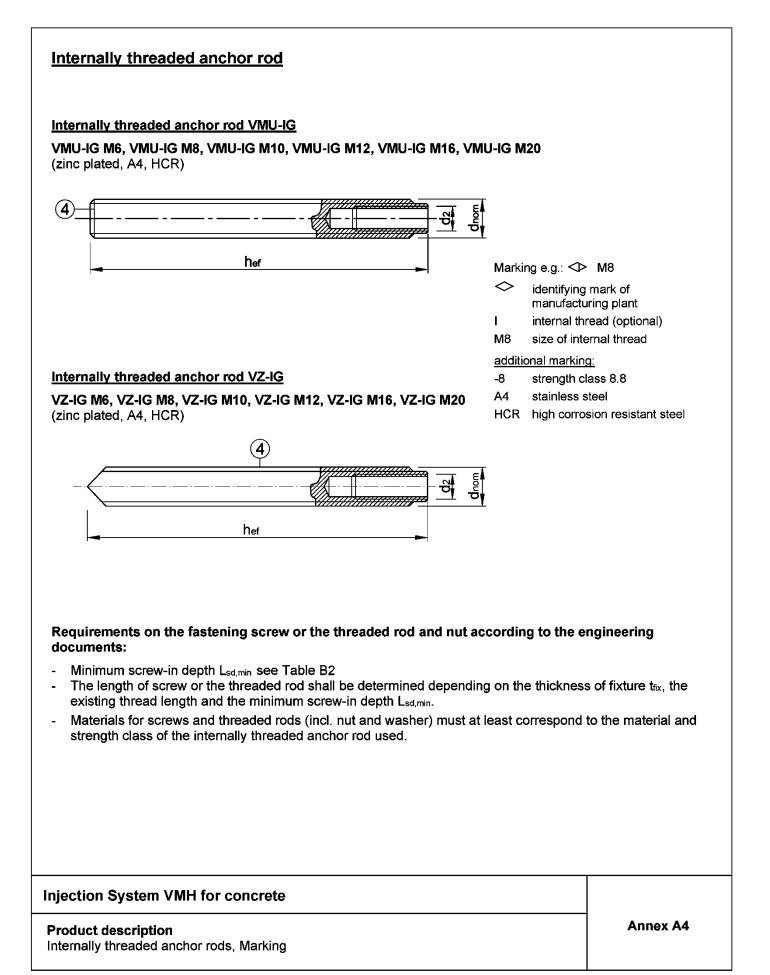
English translation prepared by DIBt



## Threaded rod Threaded rod VMU-A and V-A M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A4, HCR) with washer and hexagon nut VMU-A 1 dnom Iges Marking e.g.: M10 identifying mark of $\diamond$ manufacturing plant V-A M10 size of thread optional: mark of additional marking: embedment depth -8 strength class 8.8 1 A4 stainless steel dnor HC high corrosion resistant steel Threaded rod VM-A (material sold by the metre, to be cut at the required length) M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A2, A4, HCR) - Materials, dimensions and mechanical properties see Table A1 Commercial standard threaded rod with: M8, M10, M12, M16, M20, M24, M27, M30 (zinc plated, A2, A4, HCR) - Materials, dimensions and mechanical properties see Table A1 - Inspection certificate 3.1 acc. to EN 10204:2004 (documents must be retained) Filling washer VS and reducing adapter for filling the gap between threaded rod and fixture 3b Thickness of filling washer for diameter < M24: t = 5 mm ≥ M24: t = 6 mm Injection System VMH for concrete Annex A3 Product description Threaded rods, Marking, Filling washer

8.06.01-115/24





#### Page 9 of European Technical Assessment ETA-17/0716 of 1 August 2024

English translation prepared by DIBt



Part	Designation		Material a	and me	chanical p	oroperti	es		
electr hot-di	p galvanized ≥ 50	μm acc. to E ) μm in avera μm acc. to E	ge acc. to	EN ISO	1461:202	2, EN IS	SO 10684:200	04+AC:2009 or	
		Property class	characte ultimate s	eristic	charact yield str		fracture elongation	EN ISO 683-4:2018	
		4.6		400		240	A <sub>5</sub> > 8 %	EN 10263:2017	
1	Threaded rod	4.8	£	400		320	A5 > 8 %	Commercial standa	
		5.6	f <sub>uk</sub> [N/mm²]	500	f <sub>yk</sub> [N/mm²]	300	A <sub>5</sub> > 8 %	threaded rod:	
		5.8	[14/1111]	500		400	A5 > 8 %	EN ISO 898-1:2013	
		8.8		800		640	A₅≥ 12% <sup>1)</sup>		
		4	for class 4	4.6 or 4.	8 rods				
2	Hexagon nut	5	for class 4	4.6, 4.8,	5.6 or 5.8	rods		EN ISO 898-2:2022	
		8	for class 4	4.6, 4.8,	5.6, 5.8 o	r 8.8 roc	ls		
3a	Washer		e.g.: EN I EN ISO 8			NISO 7	093:2000, EN	NISO 7094:2000,	
3b	Washer with bore     Steel, zinc plated								
					Steel electroplated or sherardized $A_5 > 8\%$				
4 Stain	Internally threaded anchor rod Iess steel A2 <sup>2)</sup>	5.8 8.8	Steel, ele	ctroplate			A <sub>5</sub> > 8% A <sub>5</sub> > 8% \$567 / 1.454		
Stain Stain	anchor rod	8.8 C C C C C	Steel, ele RC II (1.4 RC III (1.4 RC V (1.44	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4	4307 / 1.4 4404 / 1.4 1565)	311 / 1.4 571 / 1.4	A <sub>5</sub> > 8% 1567 / 1.454 1578)		
Stain Stain	anchor rod less steel A2 <sup>2)</sup> less steel A4	8.8 C C C C C C C C C C C C C C C C C C	Steel, ele RC II (1.4 RC III (1.4	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic trength	4307 / 1.4 4404 / 1.4	311 / 1.4 571 / 1.4 eristic rength	A <sub>5</sub> > 8% 1567 / 1.454 1578) fracture elongation		
Stain Stain High	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st	8.8 C ceel HCR C Property	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4 characte	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic	4307 / 1.4 4404 / 1.4 1565) charact	311 / 1.4 571 / 1.4 eristic rength 210	A₅ > 8% 4567 / 1.454 4578) fracture	1) EN 10088-1:2014	
Stain Stain	anchor rod less steel A2 <sup>2)</sup> less steel A4	8.8 C C C C C C C C C C C C C C C C C C	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4 characte	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic trength	4307 / 1.4 4404 / 1.4 4565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ]	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup>	$A_5 > 8\%$ 1567 / 1.4547 1578) fracture elongation $A_5 > 8\%$ $A_5 \ge 12\%^{1)}$	) EN 10088-1:2014	
Stain Stain High	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st	8.8 CC CC Property class 50 70 80 <sup>3)</sup>	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4) characte ultimate s	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic trength 500 700 800	4307 / 1.4 4404 / 1.4 4565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ]	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup>	$A_5 > 8\%$ $1567 / 1.454^{-1}$ 1578) fracture elongation $A_5 > 8\%$	) EN 10088-1:2014	
Stain Stain High	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st Threaded rod	8.8 ceel HCR C Property class 50 70 80 <sup>3)</sup> 50	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4 characte ultimate s f <sub>uk</sub> [N/mm <sup>2</sup> ]	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic strength 500 700 800 50 rods	4307 / 1.4 4404 / 1.4 565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ]	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup>	$A_5 > 8\%$ 1567 / 1.4547 1578) fracture elongation $A_5 > 8\%$ $A_5 \ge 12\%^{1)}$	I) EN 10088-1:2014 EN ISO 3506-1:202	
Stain Stain High	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st	8.8 teel HCR C Property class 50 70 80 <sup>3)</sup> 50 70	Steel, ele <b>RC II</b> (1.4 <b>RC V</b> (1.4) characte ultimate s f <sub>uk</sub> [N/mm <sup>2</sup> ] for class s	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic trength 500 700 800 50 rods 50 or 70	4307 / 1.4 4404 / 1.4 565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ] rods	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup>	$A_5 > 8\%$ 1567 / 1.4547 1578) fracture elongation $A_5 > 8\%$ $A_5 \ge 12\%^{1)}$	EN 10088-1:2014 EN ISO 3506-1:202 EN 10088-1:2014	
Stain Stain High	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st Threaded rod	8.8 ceel HCR C Property class 50 70 80 <sup>3)</sup> 50	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4 characte ultimate s f <sub>uk</sub> [N/mm <sup>2</sup> ]	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic trength 500 700 800 50 rods 50 or 70	4307 / 1.4 4404 / 1.4 565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ] rods	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup>	$A_5 > 8\%$ 1567 / 1.4547 1578) fracture elongation $A_5 > 8\%$ $A_5 \ge 12\%^{1)}$	EN 10088-1:2014 EN ISO 3506-1:202	
Stain Stain High	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st Threaded rod	8.8 teel HCR C Property class 50 70 80 <sup>3)</sup> 50 70	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4) characte ultimate s f <sub>uk</sub> [N/mm <sup>2</sup> ] for class s for class s for class s e.g.: EN I EN ISO 7	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic ttrength 500 700 800 50 rods 50 or 70 50, 70 o SO 7089 094:200	4307 / 1.4 4404 / 1.4 4565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ] rods r 80 rods 9:2000, EN	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup> 600 (640) <sup>4)</sup>	$A_5 > 8\%$ $1567 / 1.454^{-1}$ 1578) fracture elongation $A_5 > 8\%$ $A_5 ≥ 12\%^{1)}$ $A_5 ≥ 12\%^{1)}$ $A_5 ≥ 12\%^{1)}$	EN 10088-1:2014 EN ISO 3506-1:202 EN 10088-1:2014 EN 10088-1:2014 EN ISO 3506-2:202	
Stain Stain High 1 2	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st Threaded rod Hexagon nut	8.8 teel HCR C Property class 50 70 80 <sup>3)</sup> 50 70	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4: characte ultimate s f <sub>uk</sub> [N/mm <sup>2</sup> ] for class ! for class ! for class ! for class ! e.g.: EN I EN ISO 7 stainless	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic strength 500 700 800 50 rods 50 or 70 50, 70 o SO 7089 094:200 steel A4	4307 / 1.4 4404 / 1.4 4565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ] rods r 80 rods 9:2000, EN	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup> 600 (640) <sup>4)</sup>	$A_5 > 8\%$ $1567 / 1.454^{-1}$ 1578) fracture elongation $A_5 > 8\%$ $A_5 ≥ 12\%^{1)}$ $A_5 ≥ 12\%^{1)}$ $A_5 ≥ 12\%^{1)}$	EN 10088-1:2014 EN ISO 3506-1:202 EN 10088-1:2014	
Stain Stain High 1 2 3a	anchor rod less steel A2 <sup>2)</sup> less steel A4 corrosion resistant st Threaded rod Hexagon nut Washer	8.8 <b>ceel HCR C</b> Property class 50 70 80 <sup>3)</sup> 50 70 80 <sup>3)</sup>	Steel, ele RC II (1.4 RC III (1.4 RC V (1.4: characte ultimate s f <sub>uk</sub> [N/mm <sup>2</sup> ] for class ! for class ! for class ! for class ! e.g.: EN I EN ISO 7 stainless	ctroplate 301 / 1.4 401 / 1.4 529 / 1.4 eristic strength 500 700 800 50 rods 50 or 70 50, 70 o SO 7089 094:200 steel A4	4307 / 1.4 4404 / 1.4 4565) charact yield str f <sub>yk</sub> [N/mm <sup>2</sup> ] rods r 80 rods 9:2000, EN	311 / 1.4 571 / 1.4 eristic rength 210 450 (560) <sup>4)</sup> 600 (640) <sup>4)</sup>	$A_5 > 8\%$ $1567 / 1.454^{-1}$ 1578) fracture elongation $A_5 > 8\%$ $A_5 ≥ 12\%^{1)}$ $A_5 ≥ 12\%^{1)}$ $A_5 ≥ 12\%^{1)}$	EN 10088-1:2014 EN ISO 3506-1:202 EN 10088-1:2014 EN 10088-1:2014 EN ISO 3506-2:202	

## Injection System VMH for concrete

## Product description

Materials

Annex A5



### **Reinforcing bar** $\varnothing~8, \varnothing~10, \varnothing~12, \varnothing~14, \varnothing~16, \varnothing~20, \varnothing~24, \varnothing~25, \varnothing~28, \varnothing~32$ T 1 10 W 10 10 W 1 10 10 (5 hef Minimum value of related rip area f<sub>R,min</sub> according to EN 1992-1-1:2004+AC:2010 \_ Rip height of the bar shall be in the range $0,05d \le h \le 0,07d$ (d: Nominal diameter of the bar; h: Rip height of the bar) Table A2: Material - Reinforcing bar

Part	Designation Material					
Rebar						
5	Rebar EN 1992-1-1:2004+AC:2010, Annex C	Bars and de-coiled rods class B or C $f_{yk}$ and k according to NDP or NCI acc. EN 1992-1-1/NA $f_{uk} = f_{tk} = k \cdot f_{yk}$				

## Injection System VMH for concrete

#### Product description

Product description and material reinforcing bar

Annex A6

#### Page 11 of European Technical Assessment ETA-17/0716 of 1 August 2024



Working life	50 years 10	00 years								
	cracked or uncracked concrete									
Base material	compacted, reinforced or unreinforced normal weight concrete									
	strength classes C20/25 to C50/60 (without fibers) acc. to EN 206:2013+A2:2021									
Hole drilling	hammer drilling / compressed air drilling /	Sec. Sec. Proceedings								
Static and quasi-static action										
Threaded rod Internally threaded anchor rod Rebar	M8 - M30 IG M6 - IG M20 Ø8 - Ø32									
Temperature range <sup>1)</sup>	I:       -40°C       to       +40°C       I:       -40°         II:       -40°C       to       +80°C       II:       -40°         III:       -40°C       to       +120°C       II:       -40°         IV:       -40°C       to       +160°C       III:       -40°									
Seismic action										
Performance category C1										
Threaded rod Rebar	M8 - M30 Ø8 - Ø32									
Performance category C2										
Threaded rod	M12 – M24 Steel, zinc plated: property class 8 A4 / HCR property class ≥ 70	3.8;								
Temperature range <sup>1)</sup>	I:       -40°C       to       +40°C       I:       -40         II:       -40°C       to       +80°C       II:       -40         III:       -40°C       to       +120°C       IV:       -40°C       IV:									
Fire exposure										
Threaded rod Internally threaded anchor rod Rebar	M8 - M30 IG M6 - IG M20 Ø8 - Ø32									
Temperature range <sup>1)</sup>	I:       -40°C       to       +40°C       I:       -40         II:       -40°C       to       +80°C       II:       -40         III:       -40°C       to       +120°C       IV:       -40°C       10         IV:       -40°C       to       +160°C       -40°C       10									
Temperature Range II: max. lor Temperature Range III: max. lor	g term temperature +24°C and max. short term te g term temperature +50°C and max. short term te g term temperature +72°C and max. short term te									
jection System VMH for concret	e									



CRC II

#### Specification of intended use

#### Use conditions (Environmental conditions):

- · Structures subject to dry internal conditions: all materials
- · For all other conditions:

Intended use of Materials according to Annex A5, Table A1 corresponding corrosion resistance classes CRC according to EN 1993-1-4:2006+A2:2020

- Stainless steel A2 acc. to Annex A4, Table A1:
- Stainless steel A4 acc. to Annex A2, Table A1:
   CRC III
- High corrosion resistant steel HCR, acc. to Annex A4, Table A1: CRC V

#### Design:

- Verifiable calculation notes and drawings are prepared taking account of the loads to be anchored. The position of the anchor is indicated on the design drawings (e. g. position of the anchor relative to reinforcement or to supports, etc.)
- Anchorages are designed under the responsibility of an engineer experienced in anchorages and concrete work
- Anchorages are designed in accordance with EN 1992-4:2018 and Technical Report TR 055, Edition February 2018
- Anchorages under fire exposure are designed in accordance with Technical Report TR 082, Edition June 2023

#### Installation:

- · Dry or wet concrete or waterfilled drill holes (not seawater)
- · Hole drilling by hammer or compressed air drill or vacuum drill mode
- Overhead installation allowed
- Anchor installation carried out by appropriately qualified personnel and under the responsibility of the person competent for technical matters on site.
- Installation temperature in concrete:
  - -5°C up to +40°C for the standard variation of temperature after installation.
- Clean the drill hole immediately before installing the anchor or protect it against contamination in a suitable manner until installation. In case of water inflow or renewed contamination, cleaning must be repeated before installation.

#### Injection System VMH for concrete

Intended Use Specifications (continuation) Annex B2

#### Deutsches Institut für Bautechnik

Table B1: Installation	on parameters, threaded rods

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30	
Diameter of threade	ed rod	d=d <sub>nom</sub>	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole di	ameter	do	[mm]	10	12	14	18	22	28	30	35
Effective encharage	donth	<b>h</b> ef,min	[mm]	60	60	70	80	90	96	108	120
Effective anchorage	depth	h <sub>ef,max</sub>	[mm]	160	200	240	320	400	480	540	600
Diameter of	Pre-setting installation	d <sub>f</sub> ≤	[mm]	9	12	14	18	22	26	30	33
clearance hole in the fixture <sup>2)</sup>	Through setti installation	<sup>ng</sup> d <sub>f</sub> ≤	[mm]	12	14	16	20	24	30	33	40
Maximum installatio	n torque m	nax.T <sub>inst</sub> ≤	[Nm]	10	20	40 (35) <sup>1)</sup>	60	100	170	250	300
Minimum thickness	of member	$\mathbf{h}_{min}$	[mm]	h <sub>ef</sub> + 30	) mm ≥ 1	00 mm			h <sub>ef</sub> + 2do	)	
Minimum spacing		Smin	[mm]	40	50	60	75	95	115	125	140
Minimum edge dista	ance	Cmin	[mm]	35	40	45	50	60	65	75	80

<sup>1)</sup> Max. installation torque for M12 with steel grade 4.6

<sup>2)</sup> For applications under seismic loading the diameter of clearance hole in the fixture shall be at maximum d<sub>nom</sub> + 1mm or alternatively the annular gap between fixture and threaded rod shall be completely filled with mortar

## Table B2: Installation parameters for internally threaded anchor rods

Internally threaded anchor rod	ded anchor rod IG-M 6 IG				IG-M 10	IG-M 12	IG-M 16	IG-M 20	
Inner diameter of threaded rod	[mm]	6	8	10	12	16	20		
Outer diameter of threaded rod <sup>1)</sup> d=d <sub>nom</sub> [r		[mm]	10	12	16	20	24	30	
Nominal drill hole diameter	do	[mm]	12	14	18	22	28	35	
Effective encharges depth	$\mathbf{h}_{ef,min}$	[mm]	60	70	80	90	96	120	
Effective anchorage depth —	h <sub>ef,max</sub>	[mm]	200	240	320	400	16 24 28 96 480 18 60 16 · 2d <sub>0</sub>	600	
Diameter of clearance hole in the fixture	d <sub>f</sub> ≤	[mm]	7	9	12	14	18	22	
Maximum installation torque m	ax.T <sub>inst</sub> ≤	[Nm]	10	10	20	40	60	100	
Minimum screw-in depth	$L_{sd,min}$	[mm]	8	8	10	12	16	20	
Minimum thickness of member	$\mathbf{h}_{min}$	[mm]	h <sub>ef</sub> + 3 ≥ 100		h <sub>ef</sub> + 2d <sub>0</sub>				
Minimum spacing	Smin	[mm]	50	60	75	95	115	140	
Minimum edge distance	Cmin	[mm]	40	45	50	60	65	80	

1) With metric thread

## Table B3: Installation parameters for rebar

Rebar	Rebar			Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Diameter of rebar	$d=d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter	<sup>• 1)</sup> d <sub>0</sub>	[mm]	10 12	12 14	14 16	18	20	25	30 32	30 32	35	40
Effective anchorage	$\mathbf{h}_{\text{ef,min}}$	[mm]	60	60	70	75	80	90	96	100	112	128
depth	h <sub>ef,max</sub>	[mm]	160	200	240	280	320	400	480	500	560	640
Minimum thickness of member	$\mathbf{h}_{min}$	[mm]	222350 J 1225	h.(+30 mm				h	<sub>ef</sub> + 2d <sub>0</sub>			
Minimum spacing	Smin	[mm]	40	50	60	70	75	95	120	120	130	150
Minimum edge distance	Cmin	[mm]	35	40	45	50	50	60	70	70	75	85
1) Both nominal drill hole diame	eter mav b	e use	d									

<sup>1)</sup> Both nominal drill hole diameter may be used

## Injection System VMH for concrete

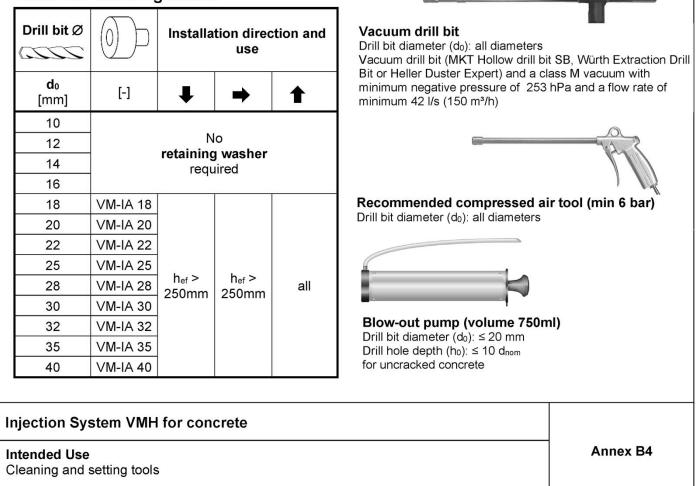
Intended use Installation parameters Annex B3



Threaded rod	Internally threaded anchor rod	Rebar	Drill bit Ø	Brush ∅	min. Brush Ø
				d <sup>p</sup> ann ann ann ann ann ann ann ann ann an	
[-]	[-]	Ø [mm]	<b>d</b> ₀ [mm]	<b>d</b> ₅[mm]	<b>d</b> <sub>b,min</sub> [mm]
M8	-	8	10	11,5	10,5
M10	IG M6	8 / 10	12	13,5	12,5
M12	IG M8	10 / 12	14	15,5	14,5
-	-	12	16	17,5	16,5
M16	IG M10	14	18	20,0	18,5
-	-	16	20	22,0	20,5
M20	IG M12	-	22	24,0	22,5
-	-	20	25	27,0	25,5
M24	IG M16	-	28	30,0	28,5
M27	-	24 / 25	30	31,8	30,5
-	-	24 / 25	32	34,0	32,5
M30	IG M20	28	35	37,0	35,5
	-	32	40	43,5	40,5

## Table R4: Parameter cleaning and cotting tools

## Table B5: Retaining washer





Dri	lling			
	1		<ul> <li>Hammer drill or compressed air drill</li> <li>Drill with hammer drill or compressed air drill a hole into the size required by the selected anchor (Table B1, B2 or I step 2. In case of aborted drill hole, the drill hole shall be fi</li> <li>Vacuum drill bit: see Annex B4</li> <li>Drill hole into the base material to the embedment size and required by the selected anchor (Table B1, B2 or B3). This removes dust and cleans the drill hole during drilling. Contribution</li> </ul>	B3). Continue with lled with mortar. d embedment depth s drilling system inue with <u>step 3</u> .
Cle	anin	(not applicable w	In case of aborted hole, the drill hole shall be filled with mo nen using a vacuum drill)	ortar.
	1		vater in the drill hole must be removed before cleaning!	
	Clea	ning with compre		
	2a	min. 6 b		return air stream is
	2b	<b>1</b> <sup>52</sup>	Check brush diameter (Table B4). Brush the hole with an a wire brush ≥ d <sub>b,min</sub> (Table B4) a minimum of <b>two</b> times. If the drill hole ground is not reached with the brush, an ap extension must be used.	
2	2c	min. 6 b 2x	Starting from the bottom or back of the drill hole, blow out to compressed air (min. 6 bar) again a minimum of <b>two</b> times stream is free of noticeable dust. If the drill hole ground is not reached, an extension must be	s until return air
		ual cleaning acked concrete, dry	and wet drill holes; drill hole diameter $d_0 \le 20$ mm and drill hole	e depth h₀ ≤ 10 d <sub>nom</sub>
	2a		Starting from the bottom or back of the drill hole, blow out the blow-out pump a minimum of <b>four</b> times until return air stree noticeable dust.	
	2b	<b>1</b>	Check brush diameter (Table B4). Brush the hole with an a wire brush ≥ d <sub>b,min</sub> (Table B4) a minimum of <b>four</b> times. If the drill hole ground is not reached with the brush, an ap extension must be used.	
	2c	A CONTRACTOR OF THE OWNER OWNE	Starting from the bottom or back of the drill hole blow out the minimum of <b>four</b> times until return air stream is free of noti	
dis	pensi		has to be protected against re-contamination in an appropriate or drill hole. If necessary, the cleaning has to be repeated direct	
ec	tion	System VMH for	concrete	



Inj	ection	
3	WIE J	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time (Table B6) as well as for new cartridges, a new static-mixer shall be used.
4	hef	Prior to inserting the rod into the filled drill hole, the position of the embedment depth shall be marked on the threaded rod or rebar. For through-setting installation, observe t <sub>fix</sub> . The fastening element must be free of dirt, grease, oil and other foreign materials.
5	min.3x ➡	Prior to dispensing into the drill hole, squeeze out separately a minimum of three full strokes and discard non-uniformly mixed adhesive components until the mortar shows a consistent grey color.
6a		<b>Filling without retaining washer:</b> Starting from the bottom or back of the cleaned drill hole fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle (with mixer extension if necessary) as the hole fills to avoid air pockets. Observe working times given in Table B6.
6b		<b>Filling with retaining washer</b> (according to Table B5): Insert the retaining washer up to the bottom of the drill hole (use a mixer extension if necessary) and fill the drill hole approx. 2/3 with mortar. During injection, the back pressure of the mortar pushes the retaining washer out of the drill hole. The processing times according to table B6 must be observed.

## Injection System VMH for concrete

Intended Use Installation instructions (continuation) Annex B6



Sett	ting the fastening elem	ent
7		Push the fastening element into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached.
8		After installation, the annular gap between anchor rod and must be completely filled with mortar, in the case of through-setting installation also in the fixture. If these requirements are not fulfilled, repeat application before end of working time! For overhead installation, the anchor should be fixed (e.g. by wedges).
9	C	Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured (attend Table B6).
10		Remove excess mortar.
11		The fixture can be mounted after curing time. Apply installation torque $\leq T_{inst}$ according to Table B1 or B2.
12		In case of pre-setting installation, the annular gap between anchor rod and fixture may optionally be filled with mortar. Therefore, replace regular washer by filling washer and plug on reducing adapter on static mixer. Annular gap is completely filled, when excess mortar seeps out.

## Table B6: Working time and curing time

Comorate	. 4		Marking time	Minimum o	curing time
Concrete	e ten	nperature	Working time	dry concrete	dry concrete
-5°C	to	-1°C	50 min	5 h	10 h
0°C	to	+4°C	25 min	3,5 h	7 h
+5°C	to	+9°C	15 min	2 h	4 h
+10°C	to	+14°C	10 min	1 h	2 h
+15°C	to	+19°C	6 min	40 min	80 min
+20°C	to	+29°C	3 min	30 min	60 min
+30°C	to	+40°C	2 min	30 min	60 min
Cartridge	e ten	nperature		+ 5°C to + 40°C	

## Injection System VMH for concrete

#### **Intended Use**

Installation instructions (continuation) / Working and curing time

Annex B7



Thread	led rod			M8	M10	M12	M16	M20	M24	M27	M3(
Steel fa	ailure			•					1		
Cross s	sectional area	As	[mm²]	36,6	58,0	84,3	157	245	353	459	561
Charac	teristic resistance under tens	ion load	1)	•							
ed	Property class 4.6 and 4.8	N <sub>Rk,s</sub>	[kN]	15 (13) <sup>1)</sup>	23 (21) <sup>1)</sup>	34	63	98	141	184	224
Steel, zinc plated	Property class 5.6 and 5.8	N <sub>Rk,s</sub>	[kN]	18 (17) <sup>1)</sup>	29 (27) <sup>1)</sup>	42	79	123	177	230	281
zin	Property class 8.8	N <sub>Rk,s</sub>	[kN]	29 (27) <sup>1)</sup>	46 (43) <sup>1)</sup>	67	126	196	282	367	449
steel	Property class 50 (A2 / A4 / HCR)	N <sub>Rk,s</sub>	[kN]	18	29	42	79	123	177	230	28 <sup>-</sup>
Stainless steel	Property class 70 (A2 / A4 / HCR)	N <sub>Rk,s</sub>	[kN]	26	41	59	110	172	247	321	393
Stair	Property class 80 (A4 / HCR)	N <sub>Rk,s</sub>	[kN]	29	46	67	126	196	282	_4)	_4)
Partial	factor <sup>2)</sup>										
	Property class 4.6	γMs,N	[-]				2	,0			
, ted	Property class 4.8	γMs,N	[-]				1	,5			
Steel, zinc plated	Property class 5.6	γMs,N	[-]				2	,0			
zino	Property class 5.8	γMs,N	[-]				1	,5			
	Property class 8.8	γMs,N	[-]				1	,5			
steel	Property class 50 (A2 / A4 / HCR)	γMs,N	[-]				2,	86			
Stainless steel	Property class 70 (A2 / A4 / HCR)	γMs,N	[-]				1, (1,	87 5) <sup>3)</sup>			
Stair	Property class 80 (A4 / HCR)	γMs,N	[-]				,6 5) <sup>3)</sup>			_4)	_4

<sup>4)</sup> Anchor type not part of the ETA

## Injection System VMH for concrete

#### Performance

Characteristic values for threaded rods under tension loads



Thread	led rod			M8	M10	M12	M16	M20	M24	M27	М3
Steel f	ailure								I		1
Cross	sectional area	As	[mm²]	36,6	58,0	84,3	157	245	353	459	56
Charao	cteristic resistances under shear lo	ad <sup>1)</sup>									
Steel f	ailure <u>without</u> lever arm										
ed	Property class 4.6 and 4.8	V <sup>0</sup> Rk,s	[kN]	9 (8)	14 (13)	20	38	59	85	110	13
Steel, zinc plated	Property class 5.6 and 5.8	$V^0{}_{Rk,s}$	[kN]	11 (10)	17 (16)	25	47	74	106	138	16
zin	Property class 8.8	$V^0{}_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	22
SS	Property class 50 (A2 / A4 / HCR)	V <sup>0</sup> Rk,s	[kN]	9	15	21	39	61	88	115	14
Stainless steel	Property class 70 (A2 / A4 / HCR)	V <sup>0</sup> Rk,s	[kN]	13	20	30	55	86	124	161	19
St	Property class 80 (A4 / HCR)	V <sup>0</sup> Rk,s	[kN]	15	23	34	63	98	141	_4)	
Steel f	ailure <u>with</u> lever arm										
ted	Property class 4.6 and 4.8	$M^0_{Rk,s}$	[Nm]	15 (13)	30 (27)	52	133	260	449	666	90
Steel, zinc plated	Property class 5.6 and 5.8	M <sup>0</sup> Rk,s	[Nm]	19 (16)	37 (33)	65	166	325	561	832	11
zin	Property class 8.8	M <sup>0</sup> Rk,s	[Nm]	30 (26)	60 (53)	105	266	519	898	1332	17
SS	Property class 50 (A2 / A4 / HCR)	M <sup>0</sup> Rk,s	[Nm]	19	37	65	166	325	561	832	11
Stainless steel	Property class 70 (A2 / A4 / HCR)	M <sup>0</sup> Rk,s	[Nm]	26	52	92	233	454	785	1165	15
Ś	Property class 80 (A4 / HCR)	M <sup>0</sup> Rk,s	[Nm]	30	60	105	266	519	898	_4)	-4
Partial	factor <sup>2)</sup>										
77	Property class 4.6	γ̂Ms,∨	[-]				1,	67			
el, ated	Property class 4.8	γMs,∨	[-]				1,	25			
Steel zinc pla	Property class 5.6	γMs,V	[-]	1			1,	67			
zinc	Property class 5.8	γMs,V	[-]					25			
	Property class 8.8	γMs,V	[-]				1,:	25			
ess	Property class 50 (A2 / A4 / HCR)	γMs,∨	[-]				2,	38			
Stainless steel	Property class 70 (A2 / A4 / HCR)	γMs,∨	[-]				1,56 (	1,25) <sup>3)</sup>	l.	1	
St	Property class 80 (A4 / HCR)	γMs,∨	[-]			1,33 (	1,25) <sup>3)</sup>			_4)	

<sup>1)</sup> The characteristic resistances apply for all anchor rods with the cross-sectional area A<sub>s</sub> specified here: VMU-A, V-A, VM-A. For commercial standard threaded rods with a smaller cross-sectional area (e.g. hot-dip galvanized threaded rods M8, M10 according to EN ISO 10684:2004 + AC:2009), the values in brackets are valid

<sup>2)</sup> In absence of other national regulations

<sup>3)</sup> Value in brackets for anchor rods VMU-A or V-A

<sup>4)</sup> Anchor type not part of the ETA

### Injection System VMH for concrete

#### Performance

Characteristic values for threaded rods under shear loads



# Table C3: Characteristic values of concrete cone failure and splitting failure, working life 50 and 100 years

Threaded rods / I	nternally threaded ancho	or rods / I	Rebars	all sizes
Concrete cone fai	ilure			
Factor k <sub>1</sub>	uncracked concrete	<b>k</b> ucr,N	[-]	11,0
	cracked concrete	k <sub>cr,N</sub>	[-]	7,7
Edge distance		Ccr,N	[mm]	1,5 • h <sub>ef</sub>
Spacing		<b>S</b> cr,N	[mm]	2,0 • c <sub>cr,N</sub>
Splitting failure				
Characteristic resis	stance	$N^0_{Rk,sp}$	[kN]	min (N <sub>Rk,p</sub> ; N <sup>0</sup> <sub>Rk,c</sub> )
	h/h <sub>ef</sub> ≥ 2,0			1,0 • h <sub>ef</sub>
Edge distance	2,0> h/h <sub>ef</sub> > 1,3	Ccr,sp	[mm]	2 • h <sub>ef</sub> (2,5 - h / h <sub>ef</sub> )
	h/h <sub>ef</sub> ≤ 1,3			2,4• h <sub>ef</sub>
Spacing		<b>S</b> cr,sp	[mm]	2,0 • C <sub>cr,sp</sub>

## Injection System VMH for concrete

#### Performance Characteristic values of concrete cone failure and splitting failure



Threaded ro	d				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure								5				
Characteristic	resistance	e	<b>N</b> Rk,s	[kN]			c		• f <sub>uk</sub> Table C	1		
Partial factor			γMs,N	[-]				see Ta	able C1			
Combined p	ull-out and	d concrete failur	e									
Characterist	ic bond re	sistance in <u>uncr</u>	<u>acked</u> o	concrete (	C20/25	5						
	1	24°C / 40°C			17	17	16	15	14	13	13	13
Temperature	П	50°C / 80°C	-	[NI/mm2]	17	17	16	15	14	13	13	13
range	III	72°C / 120°C	$ au_{Rk,ucr}$	[N/mm²]	15	14	14	13	12	12	11	11
	IV	100°C / 160°C			12	11	11	10	9,5	9,0	9,0	9,0
Characterist	ic bond re	sistance in <u>crac</u>	<u>ked</u> cor	ncrete C2	0/25			•				
	1	24°C / 40°C			7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
Temperature	II	50°C / 80°C		FN1/ 21	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
range	III	72°C / 120°C	τ <sub>Rk,cr</sub>	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
	IV	100°C / 160°C			5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
Reduction fa	ctor ψ <sup>0</sup> sus	in concrete C20/	25									
		24°C / 40°C						0,	90			
Temperature	П	50°C / 80°C	0					0,	87			
range	III	72°C / 120°C	$\psi^0$ sus	[-]				0,	75			
	IV	100°C / 160°C						0,	66			
Characterist	ic bond re	sistance in conc	rete ≥ (	C25/30								
Increasing fac τ <sub>Rk</sub> = ψ <sub>c</sub> · τ			ψc	[-]				(f <sub>ck</sub> / :	<b>20)</b> <sup>0,1</sup>			
Concrete co	ne failure	1										
Relevant par	ameter							see Ta	able C3			
Splitting fail	ure											
Relevant par	ameter							see Ta	ble C3			
Installation f												
dry or wet		acuum cleaning						1	,2			
concrete		manual cleaning	γinst	[-]		1	,2			erforma	nce ass	sessec
water filled drill hole		ssed air cleaning ssed air cleaning	γinst	[-]					,0 ,4			

## Injection System VMH for concrete

#### Performance

Characteristic values of tension loads for threaded rods, working life 50 years



Steel failure				M8	M10	M12	M16	M20	M24	M27	M30
ol ( ) ( ) (									I		I
Characteristic resis	stance	N <sub>Rk,s</sub>	[kN]			o	As r see T	• f <sub>uk</sub> able C	1		
Partial factor		γMs,N	[-]			C	r see T	able C	1		
Combined pull-ou	it and concrete fa	ilure									
Characteristic bor	nd resistance in <u>u</u>	ncracked	concrete (	C20/25							
Temperature	l 24°C / 40°C	-	[NI/mm2]	17	17	16	15	14	13	13	13
range	II 50°C / 80°C	τRk,ucr,100	[N/mm²]	17	17	16	15	14	13	13	13
Characteristic bor	nd resistance in <u>c</u>	racked cor	ncrete C2	)/25							
Temperature	l 24°C / 40°C		[NI/mm2]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
range	II 50°C / 80°C	τRk,cr,100	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
Reduction factor	$\psi^0_{sus}$ in concrete	C20/25	81								
Temperature	I 24°C / 40°C	$\Psi^0$ sus,100	<b>L</b> 1				0,	90			
range	II 50°C / 80°C	Ψ <sup>-</sup> sus,100	[-]				0,	87			
Characteristic bor	nd resistance in c	oncrete ≥ (	C25/30								
Increasing factor $\psi$	- 65 - 600 (950-96)	Ψc	[-]				(f <sub>ck</sub> / :	20) <sup>0,1</sup>			
τ <sub>Rk</sub> = ψ <sub>c</sub> · τ Concrete cone fai											
Relevant paramete							see Ta		1		
Splitting failure	51						300 10				
Relevant paramete	or						see Ta				
•							See 12	ible Co			
Installation factor				1				0			
dry or wet —	vacuum cle				1	0	1	,2			
concrete	manual cle		[-]		1	,2	4		rformar	ice ass	sesse
water filled	compressed air cle							,0			
drill hole	compressed air cle	eaning γ <sub>inst</sub>	[-]				1	,4			



Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure <u>without</u> lever an	m									
Characteristic resistance Steel, zinc plated Class 4.6, 4.8, 5.6 and 5.8	V <sup>0</sup> Rk,s	[kN]					A₅ • f <sub>uk</sub> Γable C2			
Characteristic resistance Steel, zinc plated, class 8.8, stainless steel A2, A4 and HCR	V <sup>0</sup> Rk,s	[kN]					Գ₅ ∙ f <sub>uk</sub> Γable C2			
Ductility factor	<b>k</b> 7	[-]				1	,0			
Partial factor	γ̂Ms,∨	[-]				see Ta	ble C2			
Steel failure <u>with</u> lever arm										
Characteristic bending resistance	M <sup>0</sup> Rk,s	[Nm]					V <sub>el</sub> ∙ f <sub>uk</sub> able C2			
Elastic section modulus	Wel	[mm³]	31	62	109	277	541	935	1387	1874
Partial factor	γ̂Ms,∨	[-]				or see T	able C2			
Concrete pry-out failure										
Pry-out Faktor	k <sub>8</sub>	[-]				2	,0			
Concrete edge failure										
Effective length of anchor	lf	[mm]			min (h <sub>ef</sub> ;	12 d <sub>nom</sub> )			m (h <sub>ef</sub> ;30	
Outside diameter of anchor	d <sub>nom</sub>	[mm]	8	10	12	16	20	24	27	30
Installation factor	γinst	[-]				1	,0			
jection System VMH for co	oncrete									



Threaded rod					M8	M10	M12	M16	M20	M24	M27	M30
Steel failure												
Characteristic re	eistan		NRk,s,C1	[kN]				1,0 •	N <sub>Rk,s</sub>			
	51510110		NRk,s,C2	[kN]	-	2)		1,0 •	N <sub>Rk,s</sub>		د	2)
Partial factor			γMs,N	[-]				see Ta	ble C1			
Combined pull	-out an	id concrete failu	ire									
Characteristic	bond r	esistance in con	crete C20	)/25 to C5	0/60							
	Ŀ	24°C / 40°C	$ au_{Rk,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
		1. 24 07 40 0	$ au_{Rk,C2}$	[N/mm²]	_	2)	3,6	3,5	3,3	2,3	ن	2)
	П:	50°C / 80°C	$ au_{Rk,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
Temperature _	п.	30 07 80 0	$ au_{Rk,C2}$	[N/mm²]	-	2)	3,6	3,5	3,3	2,3	c.	2)
range		72°C / 120°C	€7. TRk,C1	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
_		72 07 120 0	$ au_{Rk,C2}$	[N/mm²]	-	2)	3,1	3,0	2,8	2,0	Ľ.	2)
	IV/·	100°C / 160°C	$ au_{Rk,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
	IV.	100 C / 100 C	$ au_{Rk,C2}$	[N/mm²]	_	2)	2,5	2,7	2,5	1,8	Ľ.	2)
Installation fac	tor											
Compressed air		dry or wet conc		. 1				1	,0			
cleaning	37	water filled drill I	nole <sup>Yinst</sup>	[-]				1	,4			
Vacuum cleanin	g	dry or wet conc	rete <sub>Yinst</sub>	[-]				1	,2			

<sup>1)</sup> Performance category C2: steel, zinc plated, property class 8.8; stainless steel A4 and HCR, property class  $\geq$  70 <sup>2)</sup> No performance assessed

### Injection System VMH for concrete

#### Performance Characteristic values for threaded rods under seismic action



Threaded rod						M8	M10	M12	M16	M20	M24	M27	M30
Steel failure													
Characteristic resis	stance	<b>1</b> )	NRk,	s,C1	[kN]				1,0 •	N <sub>Rk,s</sub>			
Characteristic resis	stance	3 ./	N <sub>Rk,</sub>	s,C2	[kN]	-	2)		1,0 •	N <sub>Rk,s</sub>		ت	2)
Partial factor			γr	Ms,N	[-]				see Ta	ble C1			
Combined pull-ou	ut and	l concrete failu	ıre										
Characteristic bo	nd re	<b>sistance</b> in cor	ncrete	C20	)/25 to C5	0/60							
	Ŀ	24°C / 40°C	τ <sub>r</sub>	k,C1	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
Temperature	1.	24 0740 0	τr	k,C2	[N/mm²]		2)	3,6	3,5	3,3	2,3	د	2)
range	II:	50°C / 80°C	τ <sub>R</sub>	k,C1	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
	н.	50 C / 80 C	τ <sub>R</sub>	k,C2	[N/mm²]	-	2)	3,6	3,5	3,3	2,3	2	2)
Installation factor	•												
Compressed air		dry or wet conc			<b>L</b> 1				1	,0			
cleaning	Ň	vater filled drill	hole	γinst	[-]				1	,4			
Vacuum cleaning		dry or wet concrete yinst		[-]				1	,2				

<sup>1)</sup> Performance category C2: steel, zinc plated, property class 8.8; stainless steel A4 and HCR, property class ≥ 70 <sup>2)</sup> No performance assessed

## Table C9: Characteristic values of shear load for threaded rods, seismic action (performance category C1 + C2), working life 50 and 100 years

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure <u>v</u>	<u>vithout</u> lever arm										
Characteristic	resistence <sup>1</sup> )	V <sub>Rk,s,C1</sub>	[kN]				0,7 ·	V <sup>0</sup> Rk,s		~	
Characteristic	resistance" -	VRk,s,C2	[kN]	-	2)		0,7 ·	V <sup>0</sup> Rk,s		2	2)
Partial factor		γ̂Ms,∨	[-]				see Ta	able C2	2		
Easter for	without hole						1	,0			
Factor for anchorages with hole clearance between fastener and fixture		$lpha_{gap}$	[-]				0	,5			

<sup>1)</sup> Performance category C2: steel, zinc plated, property class 8.8; stainless steel A4 and HCR, property class ≥ 70 <sup>2)</sup> No performance assessed

#### Injection System VMH for concrete

#### Performance

Characteristic values for threaded rods under seismic action



nternally thread	ded anchor rod VM	J-IG and	VZ-IG	IG M6	IG M8	IG M10	IG M12	IG M16	IG M20
Steel failure 1)									
Characteristic re	sistance,	5.8 NRI	"s [kN]	10	17	29	42	76	123
steel, zinc plated	, property class	8.8 NRI	,s [kN]	16	27	46	67	121	196
Partial factor		γMs	м [-]			1	,5		0
Characteristic resteel A4 / HCR, p	sistance, stainless property class	70 NRI	,s [kN]	14	26	41	59	110	172 (123) <sup>2</sup>
Partial factor		γMs	м [-]			1,87			1,87 (2,86) <sup>2</sup>
Combined pull-	out and concrete fa	ilure							
Characteristic b	ond resistance in <u>u</u>	ncracke	<u>d</u> concret	e C20/25					
_	I: 24°C / 40	°C		17	16	15	14	13	13
Temperature	II: 50°C / 80	°C	[NI/mm2]	17	16	15	14	13	13
ange	III: 72°C / 120	°C	<sub>cr</sub> [N/mm²]	14	14	13	12	12	11
	IV: 100°C / 160	°C		11	11	10	9,5	9,0	9,0
Characteristic b	ond resistance in <u>c</u>	racked	concrete C	20/25					
	I: 24°C / 40	°C		7,5	8,0	9,0	8,5	7,0	7,0
Temperature	II: 50°C / 80	°C		7,5	8,0	9,0	8,5	7,0	7,0
ange	III: 72°C / 120		<sub>cr</sub> [N/mm²]	6,5	7,0	7,5	7,0	6,0	6,0
	IV: 100°C / 160			5,5	6,0	6,5	6,0	5,5	5,5
Reduction facto	or ψ <sup>0</sup> sus in concrete C					,	,		,
	l: 24°C / 40					0.	90		
Temperature —	II: 50°C / 80	°C				,	87		
ange	III: 72°C / 120		us [-]	-			75		
	IV: 100°C / 160	°C				0,	66		
Characteristic b	ond resistance in c	oncrete	≥ C25/30						
ncreasing factor	ψ <sub>c</sub> for		/c [-]			(f <sub>ck</sub> / 2	<b>20)</b> 0,1		
τ <sub>Rk</sub>	= Ψc · TRk (C20/25)	, v	/c [-]			V'CK /			
Concrete cone	failure								
Relevant param	eter					see Ta	ble C3		
Splitting failure									
Relevant param	eter					see Ta	ble C3		
nstallation fact	or								
dry or wet —	vacuum clean					1	,2		
concrete —	manual clean	-	st [-]		1,2			ormance a	ssessed
vaterfilled	ompressed air clean	-				1	,0		
drill hole	compressed clean		st [-]			1	,4		
Fastening screws the internally threa for the internally th	or threaded rods (incl. aded anchor rod. The cl nreaded anchor rod and property class 50	nut and w	tic tension r	esistance					
ection System	NMH for concret	e							



# Table C11: Characteristic values of tension load for internally threaded anchor rod, static and quasi-static action, working life 100 years

Internally threaded anchor roc	I VMU	J-IG and	VZ-IG	IG M6	IG M8	IG M10	IG M12	IG M16	IG M2
Steel failure <sup>1)</sup>				K			L		1
Characteristic resistance,	5.8	N <sub>Rk,s</sub>	[kN]	10	17	29	42	76	123
steel, zinc plated, property class	8.8	N <sub>Rk,s</sub>	[kN]	16	27	46	67	121	196
Partial factor		γMs,N	[-]			1	,5		
Characteristic resistance, stainless steel A4 / HCR, property class	70	N <sub>Rk,s</sub>	[kN]	14	26	41	59	110	172 (123)
Partial factor		γMs,N	[-]			1,87			1,87 (2,86)
Combined pull-out and concre	te fai	lure							(_,)
Characteristic bond resistance	e in <u>u</u>	ncracked	concrete	C20/25					
Temperature I: 24°C/4	10°C	_	[N]/mama2]	17	16	15	14	13	13
range II: 50°C / 8	30°C	$ au_{Rk,ucr,100}$	[N/mm²]	17	16	15	14	13	13
Characteristic bond resistance	e in <u>c</u>	racked co	oncrete C	20/25					
Temperature I: 24°C/2	10°C	-	[NI/mm2]	6,0	6,5	6,5	6,5	6,5	6,5
range II: 50°C / 8	30°C	τRk,cr100	[N/mm²]	6,0	6,5	6,5	6,5	6,5	6,5
Reduction factor $\psi^0{}_{sus}$ in concr	ete C	20/25							
Temperature I: 24°C / 4		$\Psi^0$ sus,100	[-]			0,	90		
range II: 50°C / 8	30°C	φ sus,100				0,	87		
Characteristic bond resistance	in c	oncrete ≥	C25/30						
Increasing factor $\psi_c$ for $\tau_{Rk} = \psi_c \cdot \tau_{Rk (C20/25)}$		ψc	[-]			(f <sub>ck</sub> / 2	<b>20)</b> <sup>0,1</sup>		
Concrete cone failure									
Relevant parameter						see Ta	able C3		
Splitting failure									
Relevant parameter						see Ta	able C3		
Installation factor									
day or wet	ning					1	,2		
dry or wet manual clea	ning	γinst	[-]		1,2		No perfo	ormance a	ssesse
compressed air clea	ning					1	,0		
waterfilled compresse drill hole clea	d air ning	γinst	[-]			1	,4		

for the internally threaded anchor rod and the fastening element

<sup>2)</sup> Value in brackets: property class 50

## Injection System VMH for concrete

### Performance

Characteristic values of **tension loads** for **internally threaded anchor rod**, working life **100 years** 



# Table C12: Characteristic values of shear load for internally threaded anchor rod, static and quasi-static action, working life 50 and 100 years

Interna	ally threaded and	hor rod VN:	IU-IG ar	nd VZ-IG	IG M6	IG M8	IG M10	IG M12	IG M16	IG M20
Steel f	ailure <u>without</u> lev	ver arm <sup>1)</sup>								
ted	Characteristic resistance	property class 5.8	V <sup>0</sup> Rk,s	[kN]	6	10	17	25	45	74
Steel, zinc plated	Characteristic resistance	property class 8.8	V <sup>0</sup> Rk,s	[kN]	8	14	23	34	61	98
zi	Partial factor		γMs,∨	[-]			1,	25		
Stainless steel	Characteristic resistance A4 / HCR	property class 70	V <sup>0</sup> Rk,s	[kN]	7	13	20	30	55	86 (62) <sup>2)</sup>
Sta s	Partial factor		γMs,∨	[-]			1,56			1,56 (2,38) <sup>2</sup>
Ductility	y factor		<b>k</b> 7	[-]			1	,0		
Steel f	ailure <u>with</u> lever	arm 1)			•					
ted	Characteristic bending resistance	property class 5.8	M <sup>0</sup> Rk,s	[Nm]	8	19	37	66	167	325
Steel, zinc plated	Characteristic bending resistance	property class 8.8	M <sup>0</sup> Rk,s	[Nm]	12	30	60	105	267	519
	Partial factor		γMs,∨	[-]			1,	25		
Stainless steel	Characteristic bending resistance A4 / HCR	property class 70	M <sup>0</sup> Rk,s	[Nm]	11	26	53	92	234	454
S	Partial factor		γMs,∨	[-]			1,	56		
Concre	ete pry-out failur	e								
Pry-out	t factor		k <sub>8</sub>	[-]			2	,0		
Concre	ete edge failure									
Effectiv	ve length of ancho	or	lf	[mm]		mir	n (h <sub>ef</sub> ;12 d	nom)		min (h <sub>ef</sub> ; 300mm)
Outside	e diameter of ancl	hor	$d_{nom}$	[mm]	10	12	16	20	24	30
Installa	tion factor		γinst	[-]			1	,0		
									2 2	

<sup>1)</sup> Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod (exception: IG M20). The characteristic shear resistance for steel failure of the given strength class is valid for the internally threaded anchor rod and the fastening element.

<sup>2)</sup> Value in brackets: Internally threaded rod: property class 50 with fastening screws or threaded rods (incl. nut and washer): property class 70

## Injection System VMH for concrete

#### Performance

Characteristic values of shear loads for internally threaded anchor rod



		cteristic values g life <b>50 years</b>		ision loa	ad fo	or <b>reb</b>	oar, s	tatic	and	qua	si-sta	atic a	actio	n,
Reinforcing	bar				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure														
Characteristic	c resistar	nce	N <sub>Rk,s</sub>	[kN]					As •	<b>f</b> uk <sup>1)</sup>				
Cross section	al area		As	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor			γMs,N	[-]			÷ .	·	1,4	<b>4</b> <sup>2)</sup>		de v		
Combined p	ull-out a	nd concrete fai	lure											
Characterist	ic bond	resistance in <u>u</u>	ncracke	<u>d</u> concre	te C2	0/25	_							
	l:	24°C / 40°C			14	14	14	14	13	13	13	13	13	13
Temperature	<u> </u>	50°C / 80°C	Tol	[N/mm²]	14	14	14	14	13	13	13	13	13	13
range	111:	72°C / 120°C	$ au_{Rk,ucr}$		13	12	12	12	12	11	11	11	11	11
	IV:	100°C / 160°C			9,5	9,5	9,5	9,0	9,0	9,0	9,0	9,0	8,5	8,5
Characterist	ic bond	resistance in <u>c</u>	racked c	oncrete	C20/2	5								
	!:	24°C / 40°C			5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature	11:	50°C / 80°C	τ <sub>Rk,cr</sub>	[N/mm <sup>2</sup> ]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
range		72°C / 120°C	URK,CI	[]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	IV:	100°C / 160°C			4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Reduction fa	octor $\psi^{0}s$	us in concrete C	20/25											
	!:	24°C / 40°C							0,	90				
Temperature	11:	50°C / 80°C	$\psi^0$ sus	[-]						87				
range	- 111:	72°C / 120°C	φ 303							75				
		100°C / 160°C							0,	66				
		resistance in co	oncrete	≥ C25/30	<b></b>									
Increasing fac	ctor ψ <sub>c</sub> fc <sub>Rk =</sub> ψ <sub>c</sub> · τ <sub>f</sub>		ψc	[-]					(f <sub>ck</sub> / 2	20) <sup>0,1</sup>				
Concrete co														
Relevant par	ameter							s	ее Та	able C	3			
Splitting faile	ure													
Relevant par	ameter							s	ee Ta	able C	3			
Installation f	actor													
		vacuum cleani	ng						1	,2				
dry or wet concrete		manual cleani	ng γ <sub>ins</sub>	t [-]	2		1,2			Nop	perform	nance	asses	ssed
CONCIECE	compr	ressed air cleani	ng						1	,0				
waterfilled drill hole	compr	ressed air cleani	ng γ <sub>ins</sub>	t [-]					1	,4				

f<sub>uk</sub> shall be taken from the specifications of reinforcing bars
 In absence of national regulation

## Injection System VMH for concrete

#### Performance

Characteristic values of tension loads for rebar, working life 50 years



Table C14:		cteristic valu g life <b>100 y</b> e		ension	oad f	or reb	oar, s	tatio	and	qua	si-sta	atic a	actio	n,
Reinforcing	bar				Ø	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure					-1							1		
Characteristic	c resistar	nce	NR	,s [kN]					As •	<b>f</b> uk <sup>1)</sup>				
Cross sectior	nal area		ŀ	As [mm²	50	79	113	154	201	314	452	491	616	804
Partial factor			γMs	,N [-]					1,	<b>4</b> <sup>2)</sup>				
Combined p	ull-out a	nd concrete f	ailure											
Characterist	ic bond	resistance in	uncracl	<u>ked</u> conc	rete C	20/25								
Temperature	l:	24°C / 40°C			14	14	14	14	13	13	13	13	13	13
range		50°C / 80°C	τRk,ucr,1	00 [N/mm	<sup>2</sup> ] 14	14	14	14	13	13	13	13	13	13
Characterist	ic bond	resistance in	cracked	concret	e C20/	25				1			1	
Temperature	I:	24°C / 40°C		<b>FN1</b>	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
range		50°C / 80°C	τRk,cr,1	00 [N/mm	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Reduction fa	actor $\psi^0_s$	us in concrete	C20/25											
Temperature	I:	24°C / 40°C	0						0,	90				
range	II:	50°C / 80°C	$\Psi^0$ sus,1	oo [-]					0,	87				
Characterist	ic bond	resistance in	concret	e ≥ C25/3	0									
Increasing fac			N	ν <sub>c</sub> [-]					(f <sub>ck</sub> /	<b>20)</b> <sup>0,1</sup>				
τ <sub>R</sub> Concrete co	$k = \Psi_{c} \cdot \tau_{R}$								UN					
Relevant par		e			<b>T</b>				ее Та		2			
											5			
Splitting fail					1					able C	2			
Relevant par								5	see Ta	able C	3			
Installation f	actor		.	1	1					2				
dry or wet		vacuum clea	-				4.0		1	,2				
concrete		manual clea		inst [-]			1,2				perforr	nance	asse	ssed
waterfilled		ressed air clea			_					,0				
drill hole	comp	ressed air clea	ning γ	inst [-]					1	,4				

 $^{1)}\,f_{uk}\,shall$  be taken from the specifications of reinforcing bars

<sup>2)</sup> In absence of national regulation

### Injection System VMH for concrete

#### Performance

Characteristic values of tension loads for rebar, working life 100 years



# Table C15: Characteristic values of shear load for rebar, static and quasi-static action,working life 50 and 100 year

				1	1			1				
Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure <u>without</u> lever a	ırm											
Characteristic shear resistance	V <sup>0</sup> Rk,s	[kN]				(	0,50 • A	$h_{s} \cdot f_{uk}^{1}$	)			
Cross sectional area	As	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor	γMs,V	[-]					1,	5 <sup>2)</sup>				
Ductility factor	<b>k</b> 7	[-]					1	,0				
Steel failure <u>with</u> lever arm												
Characteristic bending resistance	M <sup>0</sup> Rk,s	[Nm]	n] $1,2 \cdot W_{el} \cdot f_{uk}^{(1)}$									
Elastic section modulus	Wel	[mm <sup>3</sup> ]	50	98	170	269	402	785	1357	1534	2155	3217
Partial factor	γMs,V	[-]					1,	5 <sup>2)</sup>				
Concrete pry-out failure												
Pry-out Factor	k <sub>8</sub>	[-]					2	,0				
Concrete edge failure												
Effective length of rebar	lf	[mm]	n] min (h <sub>ef</sub> ; 12 d <sub>nom</sub> ) min (h <sub>ef</sub> ; 300mm)							Omm)		
Outside diameter of rebar	d <sub>nom</sub>	[mm]	8	10	12	14	16	20	24	25	28	32
Installation factor	γinst	[-]	1,0									

<sup>1)</sup> f<sub>uk</sub> shall be taken from the specifications of reinforcing bars

<sup>2)</sup> In absence of national regulation

### Injection System VMH for concrete



Table C16: C (p	naracterist erformanc								nic a	ctior	ı			
Reinforcing ba	r				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure					•									
Characteristic r	esistance		NRk,s,C1	[kN]		_			A <sub>s</sub> •	f <sub>uk</sub> 1)				
Cross sectional	area		As	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor			γMs,N	[-]					1,4	↓ <sup>2)</sup>				
Combined pull	-out and co	ncrete	failure											
Characteristic	bond resist	ance in	concrete	e C20/25 1	to C5(	0/60								
	l: 24°C	: / 40°C			5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature	II: 50°C	: / 80°C	<b>T</b> =1 = 1	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
range	III: 72°C/	/ 120°C	$ au_{Rk,C1}$	[[N/1111-]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	IV: 100°C/	/ 160°C			4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Installation fac	tor													
dry or wet	vacuum c	leaning	γinst	[-]					1	,2				
concrete	compres	sed air	γinst	[-]					1	,0				
waterfilled drill hole		leaning	γînst	[-]					1	,4				

 $^{\rm 1)}\,f_{uk}\, shall \, be taken from the specifications of reinforcing bars <math display="inline">^{\rm 2)}$  In absence of national regulation

## Injection System VMH for concrete



	aracteristic value erformance categ							nic a	ctior	ו			
Reinforcing bar	r			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure				•				Į					<b>.</b>
Characteristic re	esistance	NRk,s,C1	[kN]					$A_{s} \boldsymbol{\cdot}$	<b>f</b> uk <sup>1)</sup>				
Cross sectional	area	As	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		γMs,N	[-]					1,4	<b>1</b> <sup>2)</sup>				
Combined pull-	out and concrete f	ailure											
Characteristic I	oond resistance in	concrete	e C20/25 1	to C50	0/60								
Temperature	l: 24°C / 40°C	-	[NI/mm2]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
range	II: 50°C / 80°C	τrk,C1	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Installation fact	tor												
dry or wet	vacuum cleaning	γinst	[-]					1	,2				
concrete	compressed air	γinst	[-]					1	,0				
waterfilled drill hole	cleaning	γinst	[-]					1	,4				
<sup>2)</sup> In absence of nat Table C18: Ch	from the specifications ional regulation naracteristic value ismic action (pe	es of <b>s</b> l	hear loa			'	king	life 5	0 and	1 100	yea	rs	
Reinforcing bar	ſ			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32

Steel failure <u>without</u> lever arm											<i>l.</i>	
Characteristic resistance	V <sub>Rk,s,C1</sub>	[kN]				0	,35 • A	A <sub>s</sub> ∙ f <sub>uk</sub>	1)			
Cross sectional area	As	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor	γMs,∨	[-]					1,5	5 <sup>2)</sup>				

<sup>1)</sup> f<sub>uk</sub> shall be taken from the specifications of reinforcing bars

<sup>2)</sup> In absence of national regulation

## Injection System VMH for concrete

## Performance

 $Characteristic \ values \ for \ rebar \ under \ seismic \ action$ 



Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Displacement facto uncracked concrete,		uasi-static acti	on	1						
Temperature range	δ <sub>N0</sub> -factor		0,031	0,032	0,034	0,037	0,039	0,042	0,044	0,04
I: 24°C / 40°C - II: 50°C / 80°C	$\delta_{N\infty}$ -factor		0,040	0,042	0,044	0,047	0,051	0,054	0,057	0,06
Temperature range	$\delta_{N0}$ -factor	[mm [ <mark>N/mm²</mark> ]	0,032	0,034	0,035	0,038	0,041	0,044	0,046	0,04
III: 72°C / 120°C	$\delta_{N\infty}$ -factor	<sup>1</sup> N/mm <sup>2</sup>	0,042	0,044	0,045	0,049	0,053	0,056	0,059	0,06
Temperature range	$\delta_{N0}$ -factor		0,121	0,126	0,131	0,142	0,153	0,163	0,171	0,17
IV: 100°C / 160°C	δ <sub>N∞</sub> -factor		0,124	0,129	0,135	0,146	0,157	0,168	0,176	0,18
Displacement facto cracked concrete, sta		si-static action								
Temperature range I: 24°C / 40°C			0,081	0,083	0,085	0,090	0,095	0,099	0,103	0,10
II: 50°C / 80°C	δ <sub>N∞</sub> -factor		0,104	0,107	0,110	0,116	0,122	0,128	0,133	0,13
Temperature range	$\delta_{N0}$ -factor	[mm [ <del>N/mm²</del> ]	0,084	0,086	0,088	0,093	0,098	0,103	0,107	0,11
III: 72°C / 120°C	δ <sub>N∞</sub> -factor	<sup>L</sup> N/mm <sup>2</sup>	0,108	0,111	0,114	0,121	0,127	0,133	0,138	0,14
Temperature range	$\delta_{N0}$ -factor		0,312	0,321	0,330	0,349	0,367	0,385	0,399	0,41
IV: 100°C / 160°C	$\delta_{N\infty}$ -factor		0,321	0,330	0,340	0,358	0,377	0,396	0,410	0,42
Displacement, seis	mic action (	C2)								
	Sul an (DL a)				0,24	0,27	0,29	0,27		
All temperature	$\delta$ N,C2 (DLS)	[mm]		2)	-,	-,		10.100		2)

 $\tau$ : acting bond stress for tension  $\delta_{N0} = \delta_{N0}$ -factor  $\cdot \tau$ ;

 $\delta_{N\infty} = \delta_{N\infty}$ -factor  $\cdot \tau$ ;

<sup>2)</sup> No performance assessed

## Table C20: Displacements under shear load (threaded rod)

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Displacement factor cracked and uncrac		static and qua	asi-static	action						
All temperature	$\delta_{V0}$ -factor	, mm	0,06	0,06	0,05	0,04	0,04	0,03	0,03	0,03
ranges	δ <sub>V∞</sub> -factor	$\left[\frac{1}{kN}\right]$	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
Displacement, seis	smic action (	C2)								
All temperature	$\delta_{\text{V,C2(DLS)}}$	[mm]		2)	3,6	3,0	3,1	3,5	_	2)
ranges	$\delta_{\text{V,C2(ULS)}}$	[mm]	-	_,	7,0	6,6	7,0	9,3	_	_/
<sup>1)</sup> Calculation of the dis $\delta_{V0} = \delta_{V0}$ -factor · V; $\delta_{V\infty} = \delta_{V\infty}$ -factor · V; <sup>2)</sup> No performance asse		V: acting she	ar load							
njection System V	MH for con	crete								
Performance Displacements (thread	ded rod)								Annex (	217



Internally threaded and	hor rod VMU-I	G and VZ-IG	IG M 6	IG M8	IG M10	IG M12	IG M16	IG M20
Displacement factor <sup>1)</sup> uncracked concrete, stat	ic and quasi-sta	atic action						
Temperature range I: 24°C / 40°C	$\delta_{N0}$ -factor		0,032	0,034	0,037	0,039	0,042	0,046
II: 50°C / 80°C	$\delta_{N\infty}$ -factor		0,042	0,044	0,047	0,051	0,054	0,060
Temperature range	δ <sub>N0</sub> -factor	, mm ,	0,034	0,035	0,038	0,041	0,044	0,048
III: 72°C / 120°C	δ <sub>N∞</sub> -factor	$\left[\frac{1}{N/mm^2}\right]$	0,044	0,045	0,049	0,053	0,056	0,062
Temperature range	δ <sub>N0</sub> -factor		0,126	0,131	0,142	0,153	0,163	0,179
IV: 100°C / 160°C	δ <sub>N∞</sub> -factor		0,129	0,135	0,146	0,157	0,168	0,184
Displacement factor <sup>1)</sup> cracked concrete, static a	and quasi-static	c action						
Temperature range I: 24°C / 40°C	$\delta_{N0}$ -factor		0,083	0,085	0,090	0,095	0,099	0,106
II: 50°C / 80°C	δ <sub>N∞</sub> -factor		0,107	0,110	0,116	0,122	0,128	0,137
Temperature range	$\delta_{N0}$ -factor	, mm ,	0,086	0,088	0,093	0,098	0,103	0,110
III: 72°C / 120°C	δ <sub>N∞</sub> -factor	[ <del>N/mm²</del> ]	0,111	0,114	0,121	0,127	0,133	0,143
Temperature range	$\delta_{N0}$ -factor		0,321	0,330	0,349	0,367	0,385	0,412
IV: 100°C / 160°Č	δ <sub>N∞</sub> -factor		0,330	0,340	0,358	0,377	0,396	0,424

<sup>1)</sup> Calculation of the displacement

 $\delta_{N0} = \delta_{N0}$ -factor  $\cdot \tau$ ;  $\tau$ : acting bond stress for tension

 $\delta_{N^{\infty}} = \delta_{N^{\infty}}$ -factor  $\cdot \tau$ ;

## Table C22: Displacements under shear load (internally threaded anchor rod)

Internally threaded anch	or rod VMU-I	G and VZ-IG	IG M 6	IG M8	IG M10	IG M12	IG M16	IG M20
Displacement factor <sup>1)</sup> cracked and uncracked co	oncrete, static	and quasi-stat	tic action					
All temperature ranges -	δ <sub>v0</sub> -factor	$[\frac{mm}{kN}]$ 0,07 0	0,06 0,06		0,05	0,04	0,04	
An temperature ranges	δ <sub>∨∞</sub> -factor	<sup>L</sup> kN <sup>J</sup>	0,10	0,09	0,08	0,08	0,06	0,06
$\delta_{V_0} = \delta_{V_0}$ -factor · V; $\delta_{V_{\infty}} = \delta_{V_{\infty}}$ -factor · V;		shear load						
njection System VMH fo	or concrete							
erformance	readed ancho	rod)					Annex	C18



Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Displacement factor uncracked concrete,		uasi-static	action									
Temperature range I: 24°C / 40°C -	$\delta_{NO}$ -factor		0,031	0,032	0,034	0,035	0,037	0,039	0,042	0,043	0,045	0,04
II: 50°C / 80°C	$\delta_{N\infty}$ -factor	-	0,040	0,042	0,044	0,045	0,047	0,051	0,054	0,055	0,058	0,06
Temperature range	δ <sub>N0</sub> -factor	F 1	0,032	0,034	0,035	0,036	0,038	0,041	0,044	0,045	0,047	0,05
III: 72°C / 120°C	δ <sub>N∞</sub> -factor	<sup>[</sup> <del>N/mm<sup>2</sup>]</del>	0,042	0,044	0,045	0,047	0,049	0,053	0,056	0,057	0,060	0,06
Temperature range	$\delta_{NO}$ -factor		0,121	0,126	0,131	0,137	0,142	0,153	0,163	0,164	0,172	0,18
IV: 100°C / 160°C	$\delta_{N\infty}$ -factor		0,124	0,129	0,135	0,141	0,146	0,157	0,168	0,169	0,177	0,19
Displacement factor cracked concrete, sta		si-static a	ction									
Temperature range I: 24°C / 40°C -	δ <sub>N0</sub> -factor		0,081	0,083	0,085	0,087	0,090	0,095	0,099	0,099	0,103	0,10
II: 50°C / 80°C	δ <sub>N∞</sub> -factor		0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,128	0,133	0,14
Temperature range	$\delta_{NO}$ -factor	, mm ,	0,084	0,086	0,088	0,090	0,093	0,098	0,103	0,103	0,107	0,11
III: 72°C / 120°C	$\delta_{N\infty}$ -factor	<sup>[</sup> <del>N/mm<sup>2</sup>]</del>	0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,133	0,138	0,14
Temperature range	$\delta_{NO}$ -factor		0,312	0,321	0,330	0,340	0,349	0,367	0,385	0,385	0,399	0,42
IV: 100°C / 160°Č	δ <sub>N∞</sub> -factor		0,321	0,330	0,340	0,349	0,358	0,377	0,396	0,396	0,410	0,44
<sup>)</sup> Calculation of the disp $\delta_{N0} = \delta_{N0}$ -factor $\cdot \tau$ ; $\delta_{N\infty} = \delta_{N\infty}$ -factor $\cdot \tau$ ;		acting bon	d stress	s for tens	sion							

## Table C24: Displacements under shear load (rebar)

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Displacement factors cracked and uncra		e, static an	d quas	i-static	action							
All temperature	$\delta_{V0}$ -factor	, mm ,	0,06	0,05	0,05	0,04	0,04	0,04	0,03	0,03	0,03	0,03
ranges	δ <sub>V∞</sub> -factor	$\left[\frac{1}{kN}\right]$	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05	0,04	0,04
$\delta_{V0} = \delta_{V0}$ -factor · V; $\delta_{V\infty} = \delta_{V\infty}$ -factor · V;		V: acting she		8								
njection System	MH for co	ncrete										
erformance Displacements (reba	r)									Ar	nnex C	19



Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure								1,			
Steel zinc plated (pro	perty class	s ≥ 5.8)	and stainless steel	A2, A4	, HCR	(prope	ty clas	s ≥ 50)	)		
			R30	1,1	1,7	3,0	5,7	8,8	12,7	16,5	20,2
Characteristic			R60	0,9	1,4	2,3	4,2	6,6	9,5	12,4	15,
tension resistance	N <sub>Rk,s,fi</sub>	[kN]	R90	0,7	1,0	1,6	3,0	6,7	6,7	8,7	10,
			R120	0,5	0,8	1,2	2,2	4,9	4,9	6,4	7,9
Characteristic bond		ce in cra	acked and uncrack	ed co	ncrete	C20/2	5 up to	C50/6	0 unde	er fire	
exposure for tempe			θ < 24°C				1	,0			
Temperature- dependent	k <sub>fi,p</sub> (θ)	[-]	24°C ≤ θ ≤ 379°C			1.3(		,0 <sup>0,011*θ</sup> ≤	:10		
reduction factor	Kii,p(O)		θ > 379°C			1,00		,0	. 1,0		
- 8'0 Factor k <sub>f1</sub> (θ) [-]											
o,o o Characteristic bond rea		100 TRk.fi( $\theta$ )	150 200 Temperatu [N/mm <sup>2</sup> ]	250 ire θ [°C]	- 300		<sub>50</sub> 5(θ) * τι	400 Rk.cr(20/2)	450 5) 1)		
characteristic bond reafor a given temperature	sistance e (θ)	τ <sub>Rk,fi</sub> (θ)	Temperatu					400 Rk,cr(20/25	1259666		_
Characteristic bond reformation a given temperature street failure without	sistance e (θ) : <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²]	ıre θ [°C]		k <sub>fi,l</sub>	<sub>o</sub> (θ) * τι	Rk,cr(20/2	5) 1)	_	
Characteristic bond refor a given temperatur Steel failure without	sistance e (θ) : <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²]	ıre θ [°C] A2, A4	, HCR	k <sub>fi,i</sub>	<sub>o</sub> (θ) * τ <sub>i</sub>	Rk,cr(20/25 s ≥ 50)	5) <sup>1)</sup>	16.5	20.
Characteristic bond re- for a given temperatur Steel failure without Steel zinc plated (pro	sistance e (θ) : <b>lever arn</b> perty class	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8)	Temperatu [N/mm <sup>2</sup> ] and stainless steel	ıre θ [°C]		k <sub>fi,l</sub>	o(θ) * τι ty clas 5,7	Rk,cr(20/2	5) 1)	16,5	
Characteristic bond rea for a given temperatur <b>Steel failure without</b> Steel zinc plated (pro	sistance e (θ) : <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] and stainless steel R30	are θ [°C] A2, A4 1,1	, HCR 1,7	k <sub>fi,j</sub> (proper 3,0	<sub>o</sub> (θ) * τ <sub>i</sub>	Rk,cr(20/2 s ≥ 50) 8,8	<sup>5) 1)</sup>	16,5 12,4 8,7	15,
Characteristic bond rea for a given temperatur <b>Steel failure without</b> Steel zinc plated (pro	sistance e (θ) : <b>lever arn</b> perty class	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8)	Temperatu [N/mm <sup>2</sup> ] and stainless steel 2 R30 R60	A2, A4 1,1 0,9	, HCR 1,7 1,4	k <sub>fi,</sub> (proper 3,0 2,3	ty clas 5,7 4,2	Rk,cr(20/2 s ≥ 50) 8,8 6,6	<sup>5) 1)</sup> 12,7 9,5	12,4	15, 10,
Characteristic bond re- for a given temperatur Steel failure without Steel zinc plated (pro Characteristic shear resistance	sistance e (θ) c <b>lever arm</b> perty class	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8)	Temperatu [N/mm <sup>2</sup> ] and stainless steel , R30 R60 R90	A2, A4 1,1 0,9 0,7	, HCR 1,7 1,4 1,0	k <sub>fi,l</sub> (proper 3,0 2,3 1,6	(θ) * τ <sub>i</sub> ty clas 5,7 4,2 3,0	Rk,cr(20/2 s ≥ 50) 8,8 6,6 4,7	<sup>5) 1)</sup> 12,7 9,5 6,7	12,4 8,7	15, 10,
Characteristic bond re- for a given temperatur Steel failure without Steel zinc plated (pro Characteristic shear resistance	sistance e (θ) t <b>lever arm</b> perty class V <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8) [kN]	Temperatu [N/mm <sup>2</sup> ] and stainless steel 2 R30 R60 R90 R120	A2, A4 1,1 0,9 0,7 0,5	, HCR 1,7 1,4 1,0 0,8	k <sub>fi,</sub> (proper 3,0 2,3 1,6 1,2	ty clas 5,7 4,2 3,0 2,2	s ≥ 50) 8,8 6,6 4,7 3,4	<sup>5) 1)</sup> 12,7 9,5 6,7 4,9	12,4 8,7	15, 10,
Characteristic bond re- for a given temperatur Steel failure without Steel zinc plated (pro Characteristic shear resistance	sistance e (θ) t <b>lever arm</b> perty class V <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8) [kN]	Temperatu [N/mm <sup>2</sup> ] and stainless steel 2 R30 R60 R90 R120	A2, A4 1,1 0,9 0,7 0,5	, HCR 1,7 1,4 1,0 0,8	k <sub>fi,</sub> (proper 3,0 2,3 1,6 1,2	ty clas 5,7 4,2 3,0 2,2	s ≥ 50) 8,8 6,6 4,7 3,4	<sup>5) 1)</sup> 12,7 9,5 6,7 4,9	12,4 8,7	15, 10, 7,9
Characteristic bond re- for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b> Steel zinc plated (pro Characteristic	sistance e (θ) c <b>lever arm</b> perty class V <sub>Rk,s,fi</sub> ver arm perty class	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8) [kN] s ≥ 5.8)	Temperatu [N/mm <sup>2</sup> ] and stainless steel R30 R60 R90 R120 and stainless steel	A2, A4 1,1 0,9 0,7 0,5 A2, A4	, HCR 1,7 1,4 1,0 0,8 , HCR	(prope 3,0 2,3 1,6 1,2 (prope	(θ) * τ <sub>0</sub> (τ) clas 5,7 4,2 3,0 2,2 (t) clas	s ≥ 50) 8,8 6,6 4,7 3,4 s ≥ 50)	5) <sup>1)</sup> 12,7 9,5 6,7 4,9	12,4 8,7 6,4	20, 15, 10, 7,¢
Characteristic bond re- for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b> Steel zinc plated (pro Characteristic	sistance e (θ) t <b>lever arm</b> perty class V <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8) [kN]	Temperatu [N/mm <sup>2</sup> ] and stainless steel 2 R30 R60 R90 R120 and stainless steel 2 R30	A2, A4 1,1 0,9 0,7 0,5 A2, A4 1,1	, HCR 1,7 1,4 1,0 0,8 , HCR 2,2	k <sub>fi,</sub> (proper 3,0 2,3 1,6 1,2 (proper 4,7	(θ) * τ <sub>1</sub> ty clas 5,7 4,2 3,0 2,2 ty clas 12,0	Rk,cr(20/2) s ≥ 50) 8,8 6,6 4,7 3,4 s ≥ 50) 23,4	5) 1) 12,7 9,5 6,7 4,9 40,4	12,4 8,7 6,4 59,9	15, 10, 7,9 81, 60, 42,
0,0	sistance e (θ) c <b>lever arm</b> perty class V <sub>Rk,s,fi</sub> ver arm perty class	τ <sub>Rk,fi</sub> (θ) n s ≥ 5.8) [kN] s ≥ 5.8)	Temperatu [N/mm <sup>2</sup> ] and stainless steel R30 R60 R90 R120 and stainless steel R30 R30 R60	A2, A4 1,1 0,9 0,7 0,5 A2, A4 1,1 0,9	, HCR 1,7 1,4 1,0 0,8 , HCR 2,2 1,8	(proper 3,0 2,3 1,6 1,2 (proper 4,7 3,5	ty clas 5,7 4,2 3,0 2,2 ty clas 12,0 9,0	s ≥ 50) 8,8 6,6 4,7 3,4 s ≥ 50) 23,4 17,5	<sup>5) 1)</sup> 12,7 9,5 6,7 4,9 40,4 30,3	12,4 8,7 6,4 59,9 44,9	15, 10, 7,9 81, 60,

Characteristic values of tension and shear loads under fire exposure (threaded rods)

Performance



Internally threaded a	anchor ro	d VMU-	IG and VZ-IG	IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Steel failure							, ,		
Steel zinc plated (pro	perty class	s 5.8 an	d 8.8) and stainless	steel A4	and HCI	R (propert	ty class 7	0)	
			R30	0,3	1,1	1,7	3,0	5,7	8,8
Characteristic	N <sub>Rk,s,fi</sub>	[kN]	R60	0,2	0,9	1,4	2,3	4,2	6,6
tension resistance	INKK,S,TI	[KIN]	R90	0,2	0,7	1,0	1,6	3,0	4,7
			R120	0,1	0,5	0,8	1,2	2,2	3,4
Characteristic bond conditions for a give				ed conc	rete C20	/25 up to	C50/60 เ	under fire	)
conditions for a give			θ < 24°C			1	,0		
Temperature	k <sub>fi,p</sub> (θ)	[-]	24°C ≤ θ ≤ 379°C		1	,301 * e -	- / Mar 40	,0	
reduction factor			θ > 379°C			0	,0	·	
<b>[-]</b> 0,8 - 0,6 - 0,4 - 0,4 -		/							
<b>a</b> 0,2 - 0,0 -	50	100	150 200	250	300	350	400	450	
0,0	50	100	150 200 Temperatu	<sup>250</sup> re θ [°C]	300	350	400	450	
0,0	sistance	100 τ <sub>Rk,fi</sub> (θ)			528-094-00 1	<sub>350</sub> k <sub>fi,p</sub> (θ) * τ <sub>f</sub>	11236244		
Characteristic bond res	sistance e (θ)	τ <sub>Rk,fi</sub> (θ)	Temperatu		528-094-00 1		11236244		
Characteristic bond res	sistance e (θ) : <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] d 8.8) and stainless	reθ[°C] steel A4	and HCI	k <sub>fi,p</sub> (θ) * τ <sub>i</sub> R (propert	Rk,cr(20/25) <sup>1</sup> t <b>y class 7</b>	) 0)	
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro	sistance e (θ) : <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] d 8.8) and stainless R30	re θ [°C] steel A4 0,3	and HCI	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> R (propert	rk,cr(20/25) <sup>1</sup> ty class 7 3,0	) 0) 5,7	8,8
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic	sistance e (θ) : <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] d 8.8) and stainless R30 R60	re θ [°C] steel A4 0,3 0,2	and HCI 1,1 0,9	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> R (propert 1,7 1,4	ry class 7 3,0 2,3	0) 5,7 4,2	6,6
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro	sistance e (θ) : <b>lever arn</b> perty class	τ <sub>Rk,fi</sub> (θ) n s 5.8 an	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90	re θ [°C] steel A4 0,3 0,2 0,2	and HCP 1,1 0,9 0,7	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> R (propert 1,7 1,4 1,0	ty class 7 3,0 2,3 1,6	0) 5,7 4,2 3,0	6,6 4,7
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance	sistance e (θ) z <b>lever arm</b> perty class	τ <sub>Rk,fi</sub> (θ) n s 5.8 an	Temperatu [N/mm²] d 8.8) and stainless R30 R60	re θ [°C] steel A4 0,3 0,2	and HCI 1,1 0,9	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> R (propert 1,7 1,4	ry class 7 3,0 2,3	0) 5,7 4,2	6,6
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b>	sistance e (θ) c lever arm perty class V <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n s 5.8 an [kN]	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90 R120	re θ [°C] steel A4 0,3 0,2 0,2 0,1	and HCI 1,1 0,9 0,7 0,5	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> (propert 1,7 1,4 1,0 0,8	ty class 7 3,0 2,3 1,6 1,2	0) 5,7 4,2 3,0 2,2	6,6 4,7
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance	sistance e (θ) c lever arm perty class V <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n s 5.8 an [kN]	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90 R120	re θ [°C] steel A4 0,3 0,2 0,2 0,1	and HCI 1,1 0,9 0,7 0,5	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> (propert 1,7 1,4 1,0 0,8	ty class 7 3,0 2,3 1,6 1,2	0) 5,7 4,2 3,0 2,2	6,6 4,7
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b>	sistance e (θ) perty class V <sub>Rk,s,fi</sub> ver arm perty class	τ <sub>Rk,fi</sub> (θ) s 5.8 an [kN] s 5.8 an	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90 R120 d 8.8) and stainless	re θ [°C] steel A4 0,3 0,2 0,2 0,1 steel A4	and HCI 1,1 0,9 0,7 0,5 and HCI	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> (propert 1,7 1,4 1,0 0,8 R (propert	ty class 7 3,0 2,3 1,6 1,2 ty class 7	0) 5,7 4,2 3,0 2,2 0)	6,6 4,7 3,4
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b> Steel zinc plated (pro	sistance e (θ) c lever arm perty class V <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n s 5.8 an [kN]	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90 R120 d 8.8) and stainless R30	re θ [°C] steel A4 0,3 0,2 0,2 0,1 steel A4 0,2	and HCF 1,1 0,9 0,7 0,5 and HCF 1,1	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> (properf 1,7 1,4 1,0 0,8 (properf 2,2	ty class 7 3,0 2,3 1,6 1,2 ty class 7 4,7	0) 5,7 4,2 3,0 2,2 0) 12,0	6,6 4,7 3,4 23,4
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b> Steel zinc plated (pro Characteristic bending moment	sistance e (θ) perty class V <sub>Rk,s,fi</sub> ver arm perty class M <sup>0</sup> <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) s 5.8 an [kN] s 5.8 an [Nm]	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90 R120 d 8.8) and stainless R30 R60 R90 R120	re θ [°C] steel A4 0,3 0,2 0,2 0,1 steel A4 0,2 0,2 0,2 0,1 0,1	and HCP 1,1 0,9 0,7 0,5 and HCP 1,1 0,9 0,7 0,5	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> (propert 1,7 1,4 1,0 0,8 (propert 2,2 1,8 1,3 1,0	ty class 7 3,0 2,3 1,6 1,2 ty class 7 4,7 3,5 2,5 1,8	0) 5,7 4,2 3,0 2,2 0) 12,0 9,0 6,3 4,7	6,6 4,7 3,4 23,4 17,5 12,3 9,1
Characteristic bond res for a given temperature <b>Steel failure without</b> Steel zinc plated (pro Characteristic shear resistance <b>Steel failure with lev</b> Steel zinc plated (pro Characteristic	sistance e (θ) c lever arm perty class V <sub>Rk,s,fi</sub> ver arm perty class M <sup>0</sup> <sub>Rk,s,fi</sub> bond resista	τ <sub>Rk,fi</sub> (θ) s 5.8 an [kN] s 5.8 an [Nm]	Temperatu [N/mm²] d 8.8) and stainless R30 R60 R90 R120 d 8.8) and stainless R30 R60 R90 R120	re θ [°C] steel A4 0,3 0,2 0,2 0,1 steel A4 0,2 0,2 0,2 0,1 0,1	and HCP 1,1 0,9 0,7 0,5 and HCP 1,1 0,9 0,7 0,5	k <sub>fi,p</sub> (θ) * τ <sub>f</sub> (propert 1,7 1,4 1,0 0,8 (propert 2,2 1,8 1,3 1,0	ty class 7 3,0 2,3 1,6 1,2 ty class 7 4,7 3,5 2,5 1,8	0) 5,7 4,2 3,0 2,2 0) 12,0 9,0 6,3 4,7	6,6 4,7 3,4 23,4 17,5 12,3 9,1



Rebar				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø3
Steel failure													
BSt 500													
			R30	0,5	1,2	2,3	3,1	4,0	6,3	9,0	9,8	12,3	16,
Characteristic	N	<b>FLAU</b>	R60	0,5	1,0	1,7	2,3	3,0	4,7	6,8	7,4	9,2	12,
tension resistance	N <sub>Rk,s,fi</sub>	[kN]	R90	0,4	0,8	1,5	2,0	2,6	4,1	5,9	6,4	8,0	10,
			R120	0,3	0,6	1,1	1,5	2,0	3,1	4,5	4,9	6,0	8,
Characteristic bond				ed co	oncre	te C2	20/25	up to	C50/	60 un	der f	ire	
conditions for a give	n temper	rature 🖯	θ < 22°C					1	,0				
Temperature	k <sub>fi,p</sub> (θ)	[-]	22°C ≤ θ ≤ 370°C				1 268	3*e-		< 1.0			
reduction factor	Ni,p(C)		θ > 370°C				1,200		,0	_ 1,0			
- <sup>80</sup> - 80 - 80 - 80 - 100 Factor k <sub>ll</sub> (θ)	1												
- 2,0 <b>Ger</b> 0,0 0	50	100	150 200	250		300	350		400	45	0		
o,o o	istance		Temperatu			300			21/02294		0		
characteristic bond res	istance e (θ)	τ <sub>Rk,fi</sub> (θ)				300		θ) * τι	21/02294		0	_	
Characteristic bond res for a given temperature Steel failure without	istance e (θ)	τ <sub>Rk,fi</sub> (θ)	Temperatu			300			21/02294		0		_
Characteristic bond res for a given temperature Steel failure without	istance e (θ)	τ <sub>Rk,fi</sub> (θ)	Temperatu			2,3			21/02294		9,8	12,3	16
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500	istance (θ) <b>lever arn</b>	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²]	ire θ [°i	c]		k <sub>fi,p</sub> (	θ) * τι	Rk,cr(20)	(25) <sup>1)</sup>		12,3	-
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic	istance e (θ)	τ <sub>Rk,fi</sub> (θ)	Temperatu [N/mm²] R30	ure θ [°ι 0,5	c] 1,2	2,3	k <sub>fi,p</sub> (	θ) * τ <sub>ι</sub> 4,0	Rk,cr(20)	<sup>(25)</sup> <sup>1)</sup> 9,0	9,8		12
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic shear resistance	istance e (θ) Iever arm	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] R30 R60	0,5 0,5	c] 1,2 1,0	2,3 1,7	k <sub>fi,p</sub> ( 3,1 2,3	θ) * τ <sub>f</sub> 4,0 3,0	6,3 4,7	<sup>(25)</sup> <sup>1)</sup> 9,0 6,8	9,8 7,4	9,2	12 10
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic shear resistance <b>Steel failure with leve</b>	istance e (θ) Iever arm	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] R30 R60 R90	0,5 0,5 0,4	c] 1,2 1,0 0,8	2,3 1,7 1,5	k <sub>fi,p</sub> ( 3,1 2,3 2,0	θ) * τ <sub>f</sub> 4,0 3,0 2,6	6,3 4,7 4,1	9,0 6,8 5,9	9,8 7,4 6,4	9,2 8,0	12 10
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic shear resistance <b>Steel failure with leve</b>	istance e (θ) Iever arm	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] R30 R60 R90 R120	0,5 0,5 0,4 0,3	C] 1,2 1,0 0,8 0,6	2,3 1,7 1,5 1,1	k <sub>fi,p</sub> ( 3,1 2,3 2,0 1,5	θ) * τ <sub>1</sub> 4,0 3,0 2,6 2,0	6,3 4,7 4,1 3,1	9,0 6,8 5,9 4,5	9,8 7,4 6,4 4,9	9,2 8,0 6,0	12 10 8,
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic shear resistance <b>Steel failure with leve</b> BSt 500	istance (θ) lever arm V <sub>Rk,s,fi</sub> er arm	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] R30 R60 R90 R120 R30	0,5 0,5 0,4 0,3 0,6	c] 1,2 1,0 0,8 0,6 1,8	2,3 1,7 1,5 1,1 4,1	k <sub>fi,p</sub> ( 3,1 2,3 2,0 1,5 6,5	θ) * τ <sub>1</sub> 4,0 3,0 2,6 2,0 9,7	6,3 4,7 4,1 3,1 18,8	9,0 6,8 5,9 4,5 32,6	9,8 7,4 6,4 4,9 36,8	9,2 8,0 6,0 51,7	12 10 8, 77
0,0	istance e (θ) Iever arm	τ <sub>Rk,fi</sub> (θ) n	Temperatu [N/mm²] R30 R60 R90 R120 R30 R30 R60	0,5 0,5 0,4 0,3 0,6 0,5	C] 1,2 1,0 0,8 0,6 1,8 1,5	2,3 1,7 1,5 1,1 4,1 3,1	k <sub>fi,p</sub> ( 3,1 2,3 2,0 1,5 6,5 4,8	<ul> <li>θ) * τ<sub>1</sub></li> <li>4,0</li> <li>3,0</li> <li>2,6</li> <li>2,0</li> <li>9,7</li> <li>7,2</li> </ul>	6,3 4,7 4,1 3,1 18,8 14,1	9,0 6,8 5,9 4,5 32,6 24,4	9,8 7,4 6,4 4,9 36,8 27,6	9,2 8,0 6,0 51,7 38,8	12 10 8, 77 57
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic shear resistance <b>Steel failure with leve</b> BSt 500 Characteristic	istance (θ) lever arm V <sub>Rk,s,fi</sub> er arm	τ <sub>Rk,fi</sub> (θ) n [kN]	Temperatu [N/mm²] R30 R60 R90 R120 R30	0,5 0,5 0,4 0,3 0,6	c] 1,2 1,0 0,8 0,6 1,8	2,3 1,7 1,5 1,1 4,1	k <sub>fi,p</sub> ( 3,1 2,3 2,0 1,5 6,5	<ul> <li>θ) * τ<sub>1</sub></li> <li>4,0</li> <li>3,0</li> <li>2,6</li> <li>2,0</li> <li>9,7</li> <li>7,2</li> <li>6,3</li> </ul>	6,3 4,7 4,1 3,1 18,8 14,1	9,0 6,8 5,9 4,5 32,6 24,4 21,2	9,8 7,4 6,4 4,9 36,8 27,6 23,9	9,2 8,0 6,0 51,7 38,8 33,6	12 10 8, 77 57 50
Characteristic bond res for a given temperature <b>Steel failure without</b> BSt 500 Characteristic shear resistance <b>Steel failure with leve</b> BSt 500 Characteristic	istance (θ) Iever arm V <sub>Rk,s,fi</sub> er arm M <sup>0</sup> <sub>Rk,s,fi</sub>	τ <sub>Rk,fi</sub> (θ) n [kN]	Temperatu [N/mm²] R30 R60 R90 R120 R120 R30 R60 R90 R120	0,5 0,5 0,4 0,3 0,6 0,5 0,4 0,3	c] 1,2 1,0 0,8 0,6 1,8 1,5 1,2 0,8	2,3 1,7 1,5 1,1 4,1 3,1 2,6 2,0	k <sub>fi,p</sub> ( 3,1 2,3 2,0 1,5 6,5 4,8 4,2 3,2	<ul> <li>θ) * τ<sub>f</sub></li> <li>4,0</li> <li>3,0</li> <li>2,6</li> <li>2,0</li> <li>9,7</li> <li>7,2</li> <li>6,3</li> <li>4,8</li> </ul>	6,3 4,7 4,1 3,1 18,8 14,1 12,3 9,4	9,0 6,8 5,9 4,5 32,6 24,4 21,2 16,3	9,8 7,4 6,4 4,9 36,8 27,6 23,9 18,4	9,2 8,0 6,0 51,7 38,8 33,6 25,9	12 10 8, 77 57 50 38