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European Technical Assessment Body for construction products

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment

ETA-18/0275 of 26 February 2025

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	Mapei Injection system Mapefix UM Hybrid for concrete
Product family to which the construction product belongs	Bonded fasteners and bonded expansion fasteners for use in concrete
Manufacturer	Mapei S.p.A. Via Cafiero, 22 20158 MILANO (Italy) ITALIEN
Manufacturing plant	Mapei S.p.A., Plant1 Germany
This European Technical Assessment contains	43 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-18/0275 issued on 4 September 2018

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Specific Part

1 Technical description of the product

The "Mapei Injection system Mapefix UM Hybrid for concrete" is a bonded anchor consisting of a cartridge with injection mortar Mapefix UM Hybrid and a steel element according to Annex A 3 and 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 C 1 to C 4, C 6 to C 7, C 9 to C 10, B 3
Characteristic resistance to shear load (static and quasi-static loading)	See Annex C 1, C 5, C 8, C 11
Displacements under short-term and long-term loading	See Annex C 12 to C 14
Characteristic resistance and displacements for seismic performance categories C1 and C2	See Annex C 15 to C 23

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1
Resistance to fire	See Annex C 24 to C 26

3.3 Hygiene, health and the environment (BWR 3)

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

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.

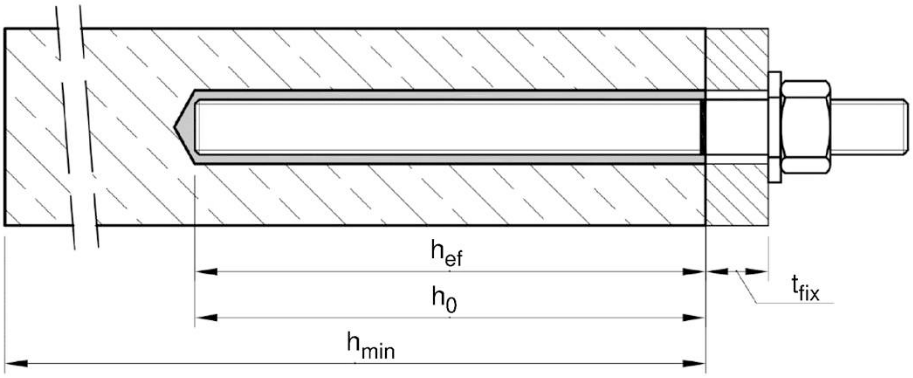
Issued in Berlin on 26 February 2025 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock
Head of Section

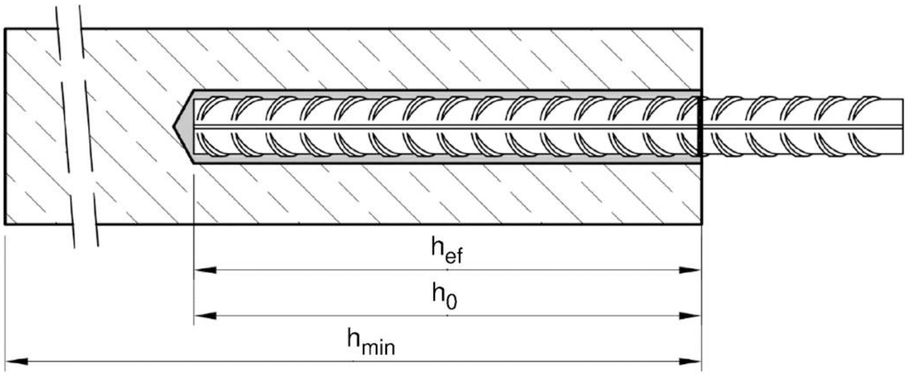
beglaubigt:
Baderschneider

Installation threaded rod M8 up to M30

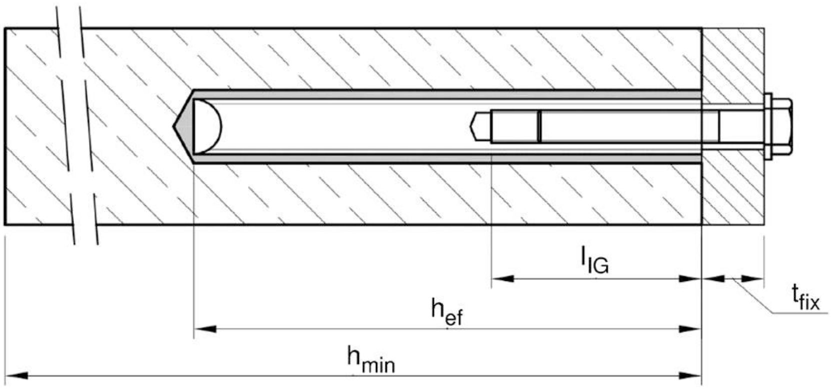
prepositioned installation or
push through installation (annular gap filled with mortar)



Installation reinforcing bar Ø8 up to Ø32



Installation internal threaded anchor rod IG-M6 up to IG-M20



t_{fix}	=	thickness of fixture	h_0	=	drill hole depth
h_{ef}	=	effective embedment depth	l_{IG}	=	thread engagement length
h_{min}	=	minum thickness of member			

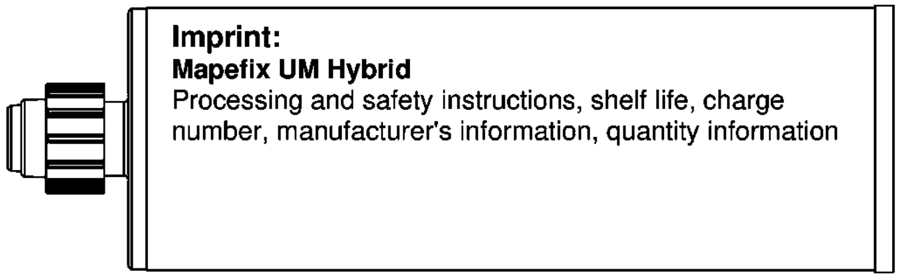
Mapei Injection system Mapefix UM Hybrid for concrete

Product description
Installed condition

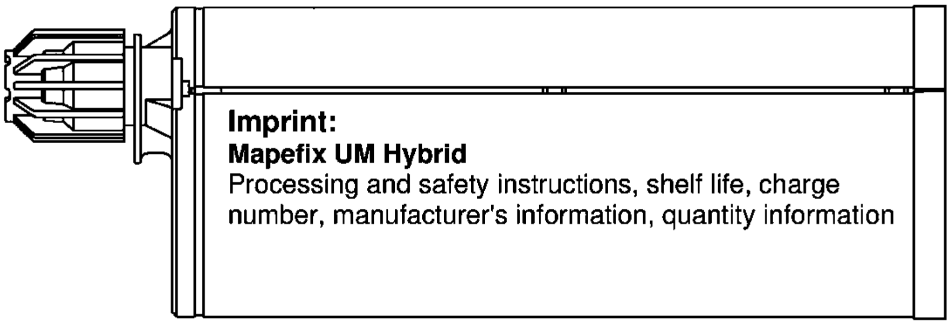
Annex A 1

Cartridge system

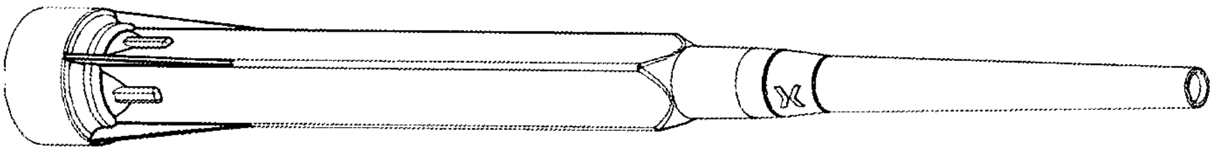
Coaxial Cartridge:
150 ml, 280 ml, 300 ml up to 333 ml and 380 ml up to 420 ml



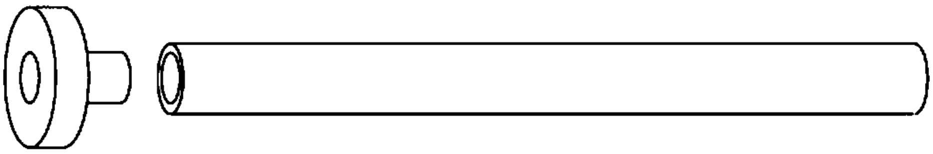
Side-by-Side Cartridge:
235 ml, 345 ml up to 360 ml and 825 ml



Static mixer PM-19E

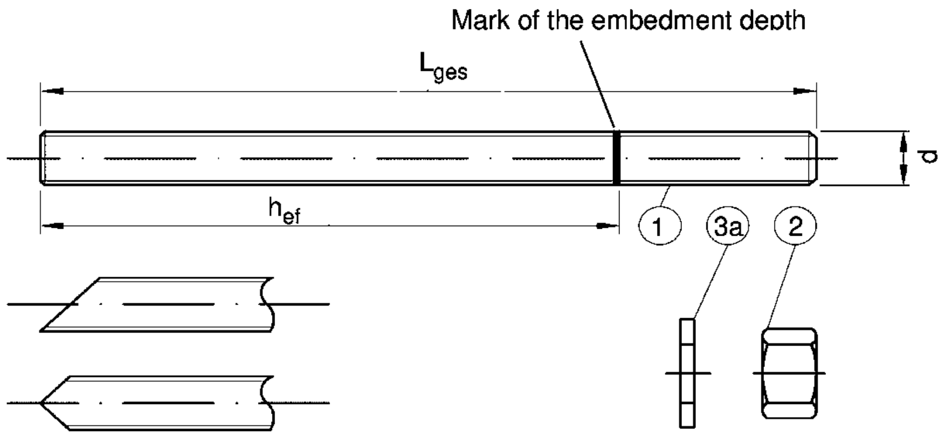


Piston plug VS and mixer extension VL



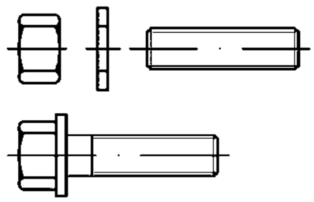
Mapei Injection system Mapefix UM Hybrid for concrete	**Annex A 2**
Product description Injection system	

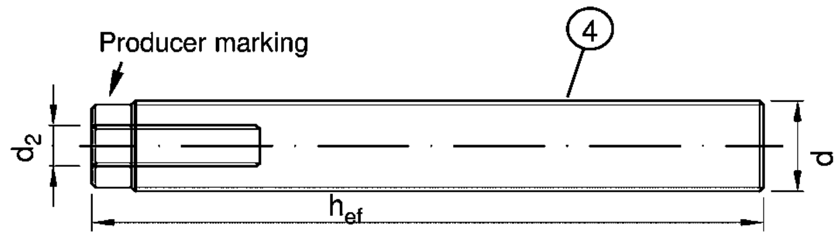
Threaded rod M8 up to M30 with washer and hexagon nut



Commercial standard rod with:
- Materials, dimensions and mechanical properties acc. to Table A1
- Inspection certificate 3.1 acc. to EN 10204:2004. The document shall be stored.
- Marking of embedment depth

Internal threaded rod IG-M6 to IG-M20

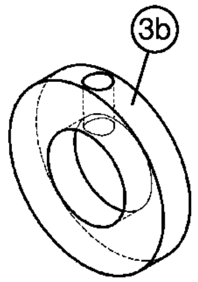




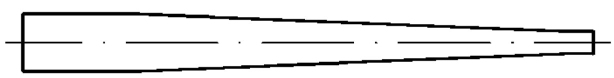
Producer marking: e.g. M8

I	Marking Internal thread
	Mark
M8	Thread size (Internal thread)
A4	additional mark for stainless steel
HCR	additional mark for high-corrosion resistance steel

Filling washer



Mixer reduction nozzle



Mapei Injection system Mapefix UM Hybrid for concrete	Annex A 3
Product description Threaded rod; Internal threaded rod Filling washer; Mixer reduction nozzle	

Table A1: Materials

Part	Designation	Material				
Steel, zinc plated (Steel acc. to EN ISO 683-4:2018 or EN 10263:2017) - zinc plated ≥ 5 µm acc. to EN ISO 4042:2022 or - hot-dip galvanised ≥ 40 µm acc. to EN ISO 1461:2022 and EN ISO 10684:2004+AC:2009 or - sherardized ≥ 45 µm acc. to EN ISO 17668:2016						
1	Threaded rod	Property class		Characteristic steel ultimate tensile strength	Characteristic steel yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	4.6	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A_5 > 8%
			4.8	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A_5 > 8%
			5.6	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A_5 > 8%
			5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A_5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A_5 ≥ 12% 3)
2	Hexagon nut	acc. to EN ISO 898-2:2022	4	for anchor rod class 4.6 or 4.8		
			5	for anchor rod class 5.6 or 5.8		
			8	for anchor rod class 8.8		
3a	Washer	Steel, zinc plated, hot-dip galvanised or sherardized (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000)				
3b	Filling washer	Steel, zinc plated, hot-dip galvanised or sherardized				
4	Internal threaded anchor rod	Property class		Characteristic steel ultimate tensile strength	Characteristic steel yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A_5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A_5 > 8%
Stainless steel A2 (Material 1.4301 / 1.4307 / 1.4311 / 1.4567 or 1.4541, acc. to EN 10088-1:2014) **Stainless steel A4** (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) **High corrosion resistance steel** (Material 1.4529 or 1.4565, acc. to EN 10088-1: 2014)						
1	Threaded rod 1)4)	Property class		Characteristic steel ultimate tensile strength	Characteristic steel yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2020	50	f_{uk} = 500 N/mm²	f_{yk} = 210 N/mm²	A_5 ≥ 8%
			70	f_{uk} = 700 N/mm²	f_{yk} = 450 N/mm²	A_5 ≥ 12% 3)
			80	f_{uk} = 800 N/mm²	f_{yk} = 600 N/mm²	A_5 ≥ 12% 3)
2	Hexagon nut 1)4)	acc. to EN ISO 3506-1:2020	50	for anchor rod class 50		
			70	for anchor rod class 70		
			80	for anchor rod class 80		
3a	Washer	A2: Material 1.4301 / 1.4307 / 1.4311 / 1.4567 or 1.4541, acc. to EN 10088-1:2014 A4: Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014 HCR: Material 1.4529 or 1.4565, acc. to EN 10088-1: 2014 (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000)				
3b	Filling washer	Stainless steel A4, High corrosion resistance steel				
4	Internal threaded anchor rod 1)2)	Property class		Characteristic steel ultimate tensile strength	Characteristic steel yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2020	50	f_{uk} = 500 N/mm²	f_{yk} = 210 N/mm²	A_5 > 8%
			70	f_{uk} = 700 N/mm²	f_{yk} = 450 N/mm²	A_5 > 8%

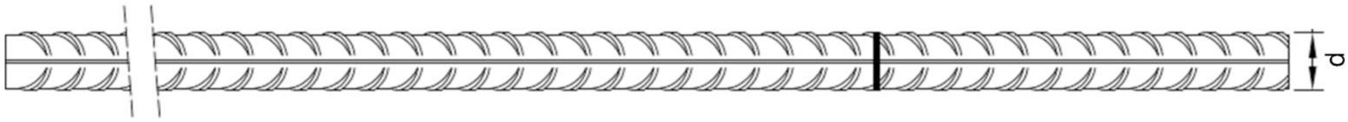
1) Property class 70 or 80 for anchor rods and hexagon nuts up to M24 and Internal threaded anchor rods up to IG-M16
2) for IG-M20 only property class 50
3) A_5 > 8% fracture elongation if no use for seismic performance category C2
4) Property class 80 only for stainless steel A4 and HCR

Mapei Injection system Mapefix UM Hybrid for concrete

Product description
Materials threaded rod and internal threaded rod

Annex A 4

Reinforcing bar: ø8 up to ø32



Minimum value of related rip area $f_{R,min}$ according to EN 1992-1-1:2004+AC:2010
Rib height of the bar shall be in the range $0{,}05d \le h_{rib} \le 0{,}07d$
(d: Nominal diameter of the bar; h_{rib}: Rib height of the bar)

Table A2: Materials Reinforcing bar

Part	Designation	Material
Rebar		
1	Reinforcing steel according to EN 1992 1 1:2004+AC:2010, Annex C	Bars and rebars from ring class B or C f_{yk} and k according to NDP or NCI according to EN 1992-1-1/NA $f_{uk} = f_{tk} = k \cdot f_{yk}$

Mapei Injection system Mapefix UM Hybrid for concrete

Product description
Materials reinforcing bar

Annex A 5

Specification of the intended use

Fasteners subject to (Static and quasi-static loads):

	Working life 50 years		Working life 100 years	
Base material	uncracked concrete	cracked concrete	uncracked concrete	cracked concrete
HD: Hammer drilling HDB: Hammer drilling with hollow drill bit CD: Compressed air drilling	M8 to M30, Ø8 to Ø32, IG-M6 to IG-M20		M8 to M30, Ø8 to Ø32, IG-M6 to IG-M20	
Temperature Range:	I: - 40 °C to +40 °C 1) II: - 40 °C to +80 °C 2) III: - 40 °C to +120 °C 3) IV: - 40 °C to +160 °C 4)		I: - 40 °C to +40 °C 1) II: - 40 °C to +80 °C 2)	

Fasteners subject to (seismic action):

	Performance Category C1	Performance Category C2
Base material	Cracked and uncracked concrete	
HD: Hammer drilling HDB: Hammer drilling with hollow drill bit CD: Compressed air drilling	M8 to M30, Ø8 to Ø32	M12 to M24
Temperature Range:	I: - 40 °C to +40 °C 1) II: - 40 °C to +80 °C 2) III: - 40 °C to +120 °C 3) 5) IV: - 40 °C to +160 °C 4) 5)	I: - 40 °C to +40 °C 1) II: - 40 °C to +80 °C 2) III: - 40 °C to +120 ° C 3) 5) IV: - 40 °C to +160 ° C 4) 5)

Fasteners subject to (Fire exposure):

Base material	uncracked and cracked concrete
HD: Hammer drilling HDB: Hammer drilling with hollow drill bit CD: Compressed air drilling	M8 to M30, Ø8 to Ø32, IG-M6 to IG-M20
Temperature Range:	I: - 40 °C to +40 °C 1) II: - 40 °C to +80 °C 2) III: - 40 °C to +120 °C 3) IV: - 40 °C to +160 °C 4)

1) (max. long-term temperature +24°C and max. short-term temperature +40°C)
2) (max. long-term temperature +50°C and max. short-term temperature +80°C)
3) (max. long-term temperature +72°C and max. short-term temperature +120°C)
4) (max. long-term temperature +100°C and max. short-term temperature +160°C)
5) Only for working life of 50 years

Mapei Injection system Mapefix UM Hybrid for concrete

Intended use
Specifications

Annex B 1

Base materials:

- Compacted, reinforced or unreinforced normal weight concrete without fibres according to EN 206:2013 + A2:2021.
- 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 according to EN 1993-1-4:2006+ A2:2020 corresponding to corrosion resistance class:
  - Stainless steel Stahl A2 according to Annex A 4, Table A1: CRC II
  - Stainless steel Stahl A4 according to Annex A 4, Table A1: CRC III
  - High corrosion resistance steel HCR according to Annex A 4, Table A1: CRC V

Design:

- 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.).
- Fasteners are designed under the responsibility of an engineer experienced in fasteners and concrete work.
- The fasteners are designed in accordance to EN 1992-4:2018 and Technical Report TR 055, Edition February 2018
- The fasteners under fire exposure are designed in accordance to Technical Report TR 082, Edition June 2023.

Installation:

- Dry, wet concrete or flooded bore holes (not sea-water).
- Hole drilling by hammer (HD), hollow (HDB) or compressed air (CD).
- Overhead installation allowed.
- Fastener installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.
- Installationtemperature in concrete:
  -5°C up to +40°C for the standard variation of temperature after installation.

Mapei Injection system Mapefix UM Hybrid for concrete	**Annex B 2**
Intended use Specifications (Continued)	

Table B1: Installation parameters for threaded rod

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Effective embedment depth	$h_{ef,min}$	[mm]	60	60	70	80	90	96	108	120
	$h_{ef,max}$	[mm]	160	200	240	320	400	480	540	600
Diameter of clearance hole in the fixture[1]	Prepositioned installation $d_f \leq$	[mm]	9	12	14	18	22	26	30	33
	Push through installation d_f	[mm]	12	14	16	20	24	30	33	40
Maximum installation torque	max T_{inst}	[Nm]	10	20	40[2]	60	100	170	250	300
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$				
Minimum spacing	s_{min}	[mm]	40	50	60	75	95	115	125	140
Minimum edge distance	c_{min}	[mm]	35	40	45	50	60	65	75	80

1) For application under seismic loading the diameter of clearance hole in the fixture shall be at maximum d_1 + 1mm or alternatively the annular gap between fixture and threaded rod shall be filled force-fit with mortar.

2) Maximum installation torque for M12 with steel Grade 4.6 is 35 Nm

Table B2: Installation parameters for reinforcing bar

Reinforcing bar			Ø 8[1]	Ø 10[1]	Ø 12[1]	Ø 14	Ø 16	Ø 20	Ø 24[1]	Ø 25[1]	Ø 28	Ø 32
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter	d_0	[mm]	10 / 12	12 / 14	14 / 16	18	20	25	30 / 32	30 / 32	35	40
Effective embedment depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	96	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	500	560	640
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm		$h_{ef} + 2d_0$							
Minimum spacing	s_{min}	[mm]	40	50	60	70	75	95	120	120	130	150
Minimum edge distance	c_{min}	[mm]	35	40	45	50	50	60	70	70	75	85

1) both nominal drill hole diameter can be used

Table B3: Installation parameters for Internal threaded anchor rod

Internal threaded anchor rod			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Internal diameter of anchor rod	d_2	[mm]	6	8	10	12	16	20
Outer diameter of anchor rod[1]	$d = d_{nom}$	[mm]	10	12	16	20	24	30
Nominal drill hole diameter	d_0	[mm]	12	14	18	22	28	35
Effective embedment depth	$h_{ef,min}$	[mm]	60	70	80	90	96	120
	$h_{ef,max}$	[mm]	200	240	320	400	480	600
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	7	9	12	14	18	22
Maximum installation torque	max T_{inst}	[Nm]	10	10	20	40	60	100
Thread engagement length min/max	l_{IG}	[mm]	8/20	8/20	10/25	12/30	16/32	20/40
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm		$h_{ef} + 2d_0$			
Minimum spacing	s_{min}	[mm]	50	60	75	95	115	140
Minimum edge distance	c_{min}	[mm]	40	45	50	60	65	80

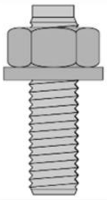
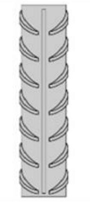
1) With metric threads

Mapei Injection system Mapefix UM Hybrid for concrete

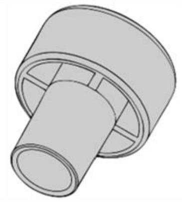
Intended use
Installation parameters

Annex B 3

Table B4: Parameter cleaning and installation tools





Threaded Rod	Re-inforcing bar	Internal threaded anchor rod	d_0 Drill bit - ∅ HD, HDB, CD	d_b Brush - ∅		$d_{b,min}$ min. Brush - ∅	Piston plug	Installation direction and use of piston plug		
[mm]	[mm]	[mm]	[mm]		[mm]	[mm]		⬇	➡	⬆
M8	8		10	BR10	11,5	10,5	No plug required			
M10	8 / 10	IG-M6	12	BR12	13,5	12,5				
M12	10 / 12	IG-M8	14	BR14	15,5	14,5				
	12		16	BR16	17,5	16,5				
M16	14	IG-M10	18	BR18	20,0	18,5	VS18	h_{ef} > 250 mm	h_{ef} > 250 mm	all
	16		20	BR20	22,0	20,5	VS20			
M20		IG-M12	22	BR22	24,0	22,5	VS22			
	20		25	BR25	27,0	25,5	VS25			
M24		IG-M16	28	BR28	30,0	28,5	VS28			
M27	24 / 25		30	BR30	31,8	30,5	VS30			
	24 / 25		32	BR32	34,0	32,5	VS32			
M30	28	IG-M20	35	BR35	37,0	35,5	VS35			
	32		40	BR40	43,5	40,5	VS40			

Cleaning and installation tools

HDB – Hollow drill bit system

The hollow drill system consists of Heller Duster Expert Hohlbohrer and a class M vacuum cleaner with a minimum negative pressure of 253 hPa and a flow rate of minimum 150 m³/h (42 l/s).

Hand pump

(Volume 750 ml, $h_0 \leq 10\ d_s$, $d_0 \leq 20$mm)

Compressed air tool

(min 6 bar)

Brush BR

Piston Plug VS

Brush extension

Mapei Injection system Mapefix UM Hybrid for concrete	**Annex B 4**
Intended use Cleaning and setting tools	

Table B5: Working time and curing time

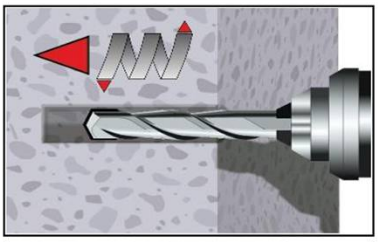
Temperature in base material			Maximum working time	Minimum curing time 1)
T			t_{work}	t_{cure}
- 5 °C	to	- 1 °C	50 min	5 h
0 °C	to	+ 4 °C	25 min	3,5 h
+ 5 °C	to	+ 9 °C	15 min	2 h
+ 10 °C	to	+ 14 °C	10 min	1 h
+ 15 °C	to	+ 19 °C	6 min	40 min
+ 20 °C	to	+ 29 °C	3 min	30 min
+ 30 °C	to	+ 40 °C	2 min	30 min
Cartridge temperature			+5°C to +40°C	

1) The minimum curing time is only valid for dry base material.
In wet base material the curing time must be doubled.

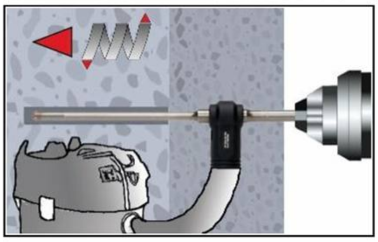
Mapei Injection system Mapefix UM Hybrid for concrete	Annex B 5
Intended use Working time and curing time	

Installation instructions

Drilling of the bore hole



1a. **Hammer drilling (HD) / Compressed air drilling (CD)**
Drill a hole to the required embedment depth.
Drill bit diameter according to Table B1, B2 or B3.
Aborted drill holes shall be filled with mortar.
Proceed with Step 2 (MAC or CAC).

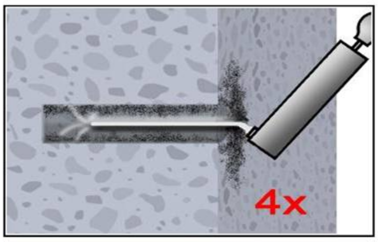


1b. **Hollow drill bit system (HDB) (see Annex B 4)**
Drill a hole to the required embedment depth.
Drill bit diameter according to Table B1, B2 or B3.
The hollow drilling system removes the dust and cleans the bore hole.
Proceed with Step 3.

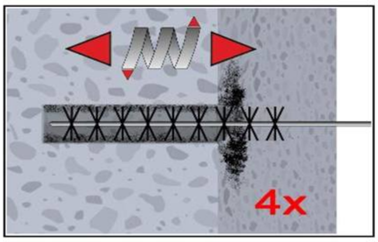
Attention! Standing water in the bore hole must be removed before cleaning.

Manual Air Cleaning (MAC)

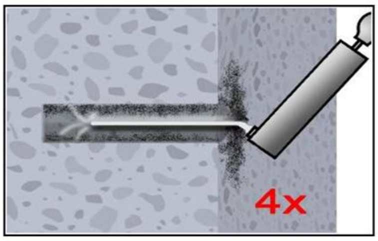
for bore hole diameter $d_0 \leq 20$mm and bore hole depth $h_0 \leq 10d_{nom}$ (uncracked concrete only)



2a. Blow the bore hole clean minimum 4x from the bottom or back by hand pump (Annex B 4).



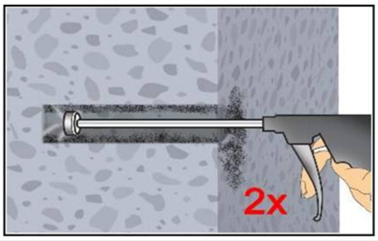
2b. Brush the bore hole minimum 4x with brush BR according to Table B4 over the entire embedment depth in a twisting motion (if necessary, use a brush extension).



2c. Finally blow the bore hole clean minimum 4x from the bottom or back by hand pump (Annex B 4).

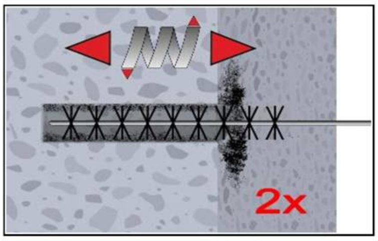
Compressed Air Cleaning (CAC):

All diameter in cracked and uncracked concrete, all drilling methods

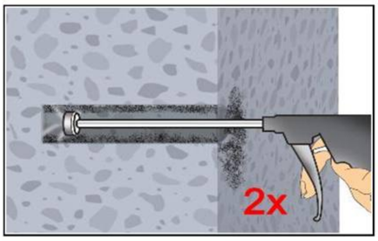


2a. Blow the bore hole clean minimum 2x with compressed air (min. 6 bar) (Annex B 4) over the entire embedment depth until return air stream is free of noticeable dust. (If necessary, an extension shall be used.)

Installation instructions (continuation)

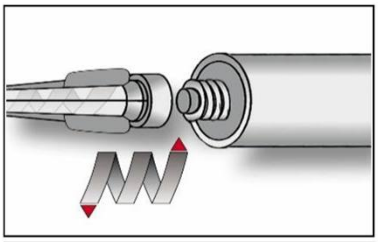


2b. Brush the bore hole minimum 2x with brush BR according to Table B4 over the entire embedment depth in a twisting motion. (If necessary, a brush extension shall be used .)

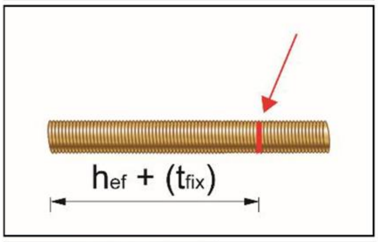


2c. Finally blow the bore hole clean minimum 2x with compressed air (min. 6 bar) (Annex B 4) over the entire embedment depth until return air stream is free of noticeable dust. (If necessary, an extension shall be used.)

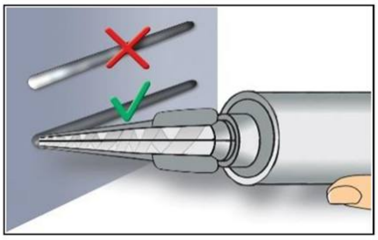
Cleaned bore hole has to be protected against re-contamination in an appropriate way,
If necessary, repeat cleaning process directly before dispensing the mortar. In-flowing water must not contaminate the bore hole again.



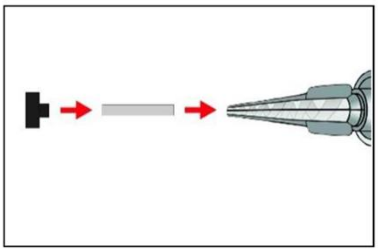
3. Screw on static-mixing nozzle PM-19E and load the cartridge into an appropriate dispensing tool.
For every working interruption longer than the maximum working time t_{work} (Annex B 5) as well as for new cartridges, a new static-mixer shall be used.



4. Mark embedment depth on the anchor rod. Consider t_{fix} in case of push through installations.
The anchor rod shall be free of dirt, grease, oil or other foreign material.



5. Not proper mixed mortar is not sufficient for fastening.
Dispense and discard mortar until an uniform grey colour is shown (at least 3 full strokes).

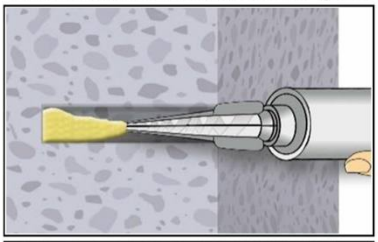


6. Piston plugs VS and mixer nozzle extensions VL shall be used according to Table B4 for the following applications:
- Horizontal and vertical downwards direction: Drill bit-Ø $d_0 \geq 18$ mm and embedment depth $h_{ef} > 250$mm
- Vertical upwards direction: Drill bit-Ø $d_0 \geq 18$ mm

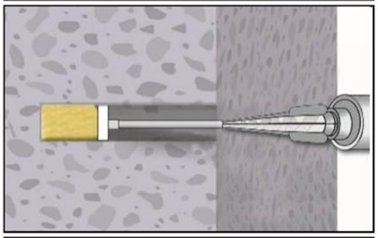
Assemble mixing nozzle, mixer extension and piston plug before injecting mortar.

Mapei Injection system Mapefix UM Hybrid for concrete	**Annex B 7**
Intended use Installation instructions (continuation)	

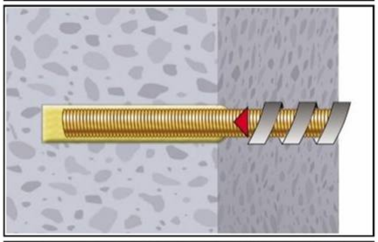
Installation instructions (continuation)



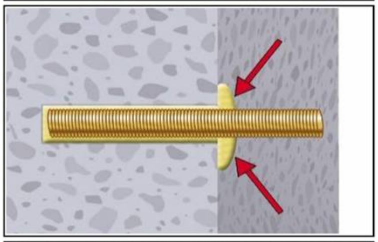
7a. **Injecting mortar without piston plug VS**
Starting at bottom of the hole and fill the hole up to approximately two-thirds with mortar. (If necessary, a mixer nozzle extension shall be used.)
Slowly withdraw of the static mixing nozzle avoid creating air pockets
Observe the temperature related working time t_{work} (Annex B 5).



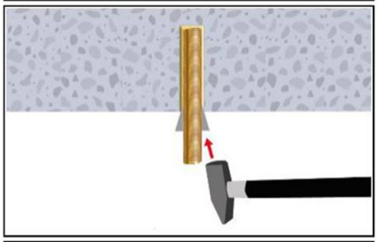
7b. **Injecting mortar with piston plug VS**
Starting at bottom of the hole and fill the hole up to approximately two-thirds with mortar. (If necessary, a mixer nozzle extension shall be used.)
During injection the piston plug is pushed out of the bore hole by the back pressure of the mortar.
Observe the temperature related working time t_{work} (Annex B 5).



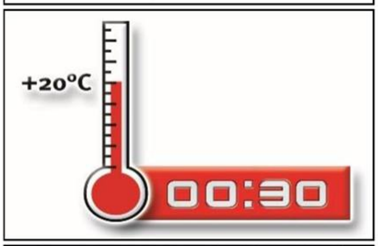
8. Insert the anchor rod while turning slightly up to the embedment mark.



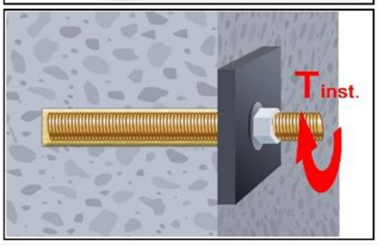
9. Annular gap between anchor rod and base material must be completely filled with mortar. In case of push through installation the annular gap in the fixture must be filled with mortar also.
Otherwise, the installation must be repeated starting from step 7 before the maximum working time t_{work} has expired.



10. For application in vertical upwards direction the anchor rod shall be fixed (e.g. wedges).



11. Temperature related curing time t_{cure} (Annex B 5) must be observed.
Do not move or load the fastener during curing time.



12. Install the fixture by using a calibrated torque wrench. Observe maximum installation torque (Table B1 or B3).
In case of static requirements (e.g. seismic), fill the annular gab in the fixture with mortar (Annex A 2). Therefore replace the washer by the filling washer and use the mixer reduction nozzle .

Mapei Injection system Mapefix UM Hybrid for concrete	**Annex B 8**
Intended use Installation instructions (continuation)	

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Table C1: Characteristic values for steel tension resistance and steel shear resistance of threaded rods

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Cross section area		A_s	[mm²]	36,6	58	84,3	157	245	353	459	561
Characteristic tension resistance, Steel failure [1)]											
Steel, Property class 4.6 and 4.8		$N_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
Steel, Property class 5.6 and 5.8		$N_{Rk,s}$	[kN]	18 (17)	29 (27)	42	78	122	176	230	280
Steel, Property class 8.8		$N_{Rk,s}$	[kN]	29 (27)	46 (43)	67	125	196	282	368	449
Stainless steel A2, A4 and HCR, class 50		$N_{Rk,s}$	[kN]	18	29	42	79	123	177	230	281
Stainless steel A2, A4 and HCR, class 70		$N_{Rk,s}$	[kN]	26	41	59	110	171	247	-[3)]	-[3)]
Stainless steel A4 and HCR, class 80		$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-[3)]	-[3)]
Characteristic tension resistance, Partial factor [2)]											
Steel, Property class 4.6 and 5.6		$\gamma_{Ms,N}$	[-]	2,0							
Steel, Property class 4.8, 5.8 and 8.8		$\gamma_{Ms,N}$	[-]	1,5							
Stainless steel A2, A4 and HCR, class 50		$\gamma_{Ms,N}$	[-]	2,86							
Stainless steel A2, A4 and HCR, class 70		$\gamma_{Ms,N}$	[-]	1,87							
Stainless steel A4 and HCR, class 80		$\gamma_{Ms,N}$	[-]	1,6							
Characteristic shear resistance, Steel failure [1)]											
Without lever arm	Steel, Property class 4.6 and 4.8	$V^0_{Rk,s}$	[kN]	9 (8)	14 (13)	20	38	59	85	110	135
Without lever arm	Steel, Property class 5.6 and 5.8	$V^0_{Rk,s}$	[kN]	11 (10)	17 (16)	25	47	74	106	138	168
Without lever arm	Steel, Property class 8.8	$V^0_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
Without lever arm	Stainless steel A2, A4 and HCR, class 50	$V^0_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
Without lever arm	Stainless steel A2, A4 and HCR, class 70	$V^0_{Rk,s}$	[kN]	13	20	30	55	86	124	-[3)]	-[3)]
Without lever arm	Stainless steel A4 and HCR, class 80	$V^0_{Rk,s}$	[kN]	15	23	34	63	98	141	-[3)]	-[3)]
With lever arm	Steel, Property class 4.6 and 4.8	$M^0_{Rk,s}$	[Nm]	15 (13)	30 (27)	52	133	260	449	666	900
With lever arm	Steel, Property class 5.6 and 5.8	$M^0_{Rk,s}$	[Nm]	19 (16)	37 (33)	65	166	324	560	833	1123
With lever arm	Steel, Property class 8.8	$M^0_{Rk,s}$	[Nm]	30 (26)	60 (53)	105	266	519	896	1333	1797
With lever arm	Stainless steel A2, A4 and HCR, class 50	$M^0_{Rk,s}$	[Nm]	19	37	66	167	325	561	832	1125
With lever arm	Stainless steel A2, A4 and HCR, class 70	$M^0_{Rk,s}$	[Nm]	26	52	92	232	454	784	-[3)]	-[3)]
With lever arm	Stainless steel A4 and HCR, class 80	$M^0_{Rk,s}$	[Nm]	30	59	105	266	519	896	-[3)]	-[3)]
Characteristic shear resistance, Partial factor [2)]											
Steel, Property class 4.6 and 5.6		$\gamma_{Ms,V}$	[-]	1,67							
Steel, Property class 4.8, 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	1,25							
Stainless steel A2, A4 and HCR, class 50		$\gamma_{Ms,V}$	[-]	2,38							
Stainless steel A2, A4 and HCR, class 70		$\gamma_{Ms,V}$	[-]	1,56							
Stainless steel A4 and HCR, class 80		$\gamma_{Ms,V}$	[-]	1,33							

1) Values are only valid for the given stress area A_s. Values in brackets are valid for undersized threaded rods with smaller stress area A_s for hot-dip galvanised threaded rods according to EN ISO 10684:2004+AC:2009.
2) in absence of national regulation
3) Fastener type not part of the ETA

Mapei Injection system Mapefix UM Hybrid for concrete	Annex C 1
Performances Characteristic values for steel tension resistance and steel shear resistance of threaded rods	

Table C2: Characteristic values of tension loads under static and quasi-static action for a working life of 50 and 100 years

Fastener				**All Anchor types and sizes**
Concrete cone failure				
Uncracked concrete		$k_{ucr,N}$	[-]	11,0
Cracked concrete		$k_{cr,N}$	[-]	7,7
Edge distance		$c_{cr,N}$	[mm]	1,5 h_{ef}
Axial distance		$s_{cr,N}$	[mm]	2 $c_{cr,N}$
Splitting				
Edge distance	$h/h_{ef} \geq 2,0$	$c_{cr,sp}$	[mm]	1,0 h_{ef}
	$2,0 > h/h_{ef} > 1,3$			$2 \cdot h_{ef} \left(2,5 - \frac{h}{h_{ef}}\right)$
	$h/h_{ef} \leq 1,3$			2,4 h_{ef}
Axial distance		$s_{cr,sp}$	[mm]	2 $c_{cr,sp}$

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Table C3: Characteristic values of tension loads under static and quasi-static action for a working life of 50 years

Threaded rod					**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure												
Characteristic tension resistance			$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ (or see Table C1)							
Partial factor			$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure												
Characteristic bond resistance in uncracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	17	17	16	15	14	13	13	13
	II: 50°C/80°C		$\tau_{Rk,ucr}$	[N/mm²]	17	17	16	15	14	13	13	13
	III: 72°C/120°C		$\tau_{Rk,ucr}$	[N/mm²]	15	14	14	13	12	12	11	11
	IV: 100°C/160°C		$\tau_{Rk,ucr}$	[N/mm²]	12	11	11	10	9,5	9,0	9,0	9,0
Characteristic bond resistance in cracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	II: 50°C/80°C		$\tau_{Rk,cr}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	III: 72°C/120°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
	IV: 100°C/160°C		$\tau_{Rk,cr}$	[N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
Reduktion factor ψ^0_{sus} in cracked and uncracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	ψ^0_{sus}	[-]	0,90							
	II: 50°C/80°C				0,87							
	III: 72°C/120°C				0,75							
	IV: 100°C/160°C				0,66							
Increasing factors for concrete			ψ_c	[-]	$(f_{ck} / 20)^{0,1}$							
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,ucr} =$		$\psi_c \cdot \tau_{Rk,ucr,(C20/25)}$							
			$\tau_{Rk,cr} =$		$\psi_c \cdot \tau_{Rk,cr,(C20/25)}$							
Concrete cone failure												
Relevant parameter					see Table C2							
Splitting												
Relevant parameter					see Table C2							
Installation factor												
for dry and wet concrete	MAC		γ_{inst}	[-]	1,2					No Performance assessed		
	CAC				1,0							
	HDB				1,2							
for flooded bore hole	CAC				1,4							

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of tension loads under static and quasi-static action for a working life of 50 years (threaded rod)

Annex C 3

Table C4: Characteristic values of tension loads under static and quasi-static action for a working life of 100 years

Threaded rod					**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure												
Characteristic tension resistance			$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ (or see Table C1)							
Partial factor			$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure												
Characteristic bond resistance in uncracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr,100}$	[N/mm²]	17	17	16	15	14	13	13	13
	II: 50°C/80°C		$\tau_{Rk,ucr,100}$	[N/mm²]	17	17	16	15	14	13	13	13
Characteristic bond resistance in cracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr,100}$	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
	II: 50°C/80°C		$\tau_{Rk,cr,100}$	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5	6,5	6,5
Reduktion factor $\psi^0_{sus,100}$ in cracked and uncracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\psi^0_{sus,100}$	[-]	0,90							
	II: 50°C/80°C				0,87							
Increasing factors for concrete			ψ_c	[-]	$(f_{ck} / 20)^{0,1}$							
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,ucr,100}$ =		$\psi_c \cdot \tau_{Rk,ucr,100,(C20/25)}$							
			$\tau_{Rk,cr,100}$ =		$\psi_c \cdot \tau_{Rk,cr,100,(C20/25)}$							
Concrete cone failure												
Relevant parameter					see Table C2							
Splitting												
Relevant parameter					see Table C2							
Installation factor												
for dry and wet concrete	MAC		γ_{inst}	[-]	1,2					No Performance assessed		
	CAC				1,0							
	HDB				1,2							
for flooded bore hole	CAC				1,4							

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of tension loads under static and quasi-static action for a working life of 100 years (threaded rod)

Annex C 4

Deutsches Institut für Bautechnik

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Table C5: Characteristic values of shear loads under static and quasi-static action for a working life of 50 and 100 years

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure without lever arm										
Characteristic shear resistance Steel, strength class 4.6, 4.8 and 5.6, 5.8	$V^0_{Rk,s}$	[kN]	$0{,}6 \cdot A_s \cdot f_{uk}$ (or see Table C1)							
Characteristic shear resistance Steel, strength class 8.8 Stainless Steel A2, A4 and HCR, all strength classes	$V^0_{Rk,s}$	[kN]	$0{,}5 \cdot A_s \cdot f_{uk}$ (or see Table C1)							
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Ductility factor	k_7	[-]	1,0							
Steel failure with lever arm										
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1{,}2 \cdot W_{el} \cdot f_{uk}$ (or see Table C1)							
Elastic section modulus	W_{el}	[mm³]	31	62	109	277	541	935	1387	1874
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Concrete pry-out failure										
Factor	k_8	[-]	2,0							
Installation factor	γ_{inst}	[-]	1,0							
Concrete edge failure										
Effective length of fastener	l_f	[mm]	$\min(h_{ef};\ 12 \cdot d_{nom})$						$\min(h_{ef};\ 300mm)$	
Outside diameter of fastener	d_{nom}	[mm]	8	10	12	16	20	24	27	30
Installation factor	γ_{inst}	[-]	1,0							

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of shear loads under static and quasi-static action for a working life of 50 and 100 years (threaded rod)

Annex C 5

Table C6: Characteristic values of tension loads under static and quasi-static action for a working life of 50 years

Internal threaded anchor rods					IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Steel failure[1]										
Characteristic tension resistance, Steel, strength class		5.8	$N_{Rk,s}$	[kN]	10	17	29	42	76	123
		8.8	$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor, strength class 5.8 and 8.8			$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension resistance, Stainless Steel A4 and HCR, Strength class 70 [2]			$N_{Rk,s}$	[kN]	14	26	41	59	110	124
Partial factor			$\gamma_{Ms,N}$	[-]	1,87					2,86
Combined pull-out and concrete cone failure										
Characteristic bond resistance in uncracked concrete C20/25										
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	17	16	15	14	13	13
	II: 50°C/80°C		$\tau_{Rk,ucr}$	[N/mm²]	17	16	15	14	13	13
	III: 72°C/120°C		$\tau_{Rk,ucr}$	[N/mm²]	14	14	13	12	12	11
	IV: 100°C/160°C		$\tau_{Rk,ucr}$	[N/mm²]	11	11	10	9,5	9,0	9,0
Characteristic bond resistance in cracked concrete C20/25										
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	7,5	8,0	9,0	8,5	7,0	7,0
	II: 50°C/80°C		$\tau_{Rk,cr}$	[N/mm²]	7,5	8,0	9,0	8,5	7,0	7,0
	III: 72°C/120°C		$\tau_{Rk,cr}$	[N/mm²]	6,5	7,0	7,5	7,0	6,0	6,0
	IV: 100°C/160°C		$\tau_{Rk,cr}$	[N/mm²]	5,5	6,0	6,5	6,0	5,5	5,5
Reduktion factor ψ^0_{sus} in cracked and uncracked concrete C20/25										
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	ψ^0_{sus}	[-]	0,90					
	II: 50°C/80°C				0,87					
	III: 72°C/120°C				0,75					
	IV: 100°C/160°C				0,66					
Increasing factors for concrete			ψ_c	[-]	$(f_{ck} / 20)^{0,1}$					
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,ucr} =$		$\psi_c \cdot \tau_{Rk,ucr,(C20/25)}$					
			$\tau_{Rk,cr} =$		$\psi_c \cdot \tau_{Rk,cr,(C20/25)}$					
Concrete cone failure										
Relevant parameter					see Table C2					
Splitting failure										
Relevant parameter					see Table C2					
Installation factor										
for dry and wet concrete	MAC		γ_{inst}	[-]	1,2			No Performance assessed		
	CAC				1,0					
	HDB				1,2					
for flooded bore hole	CAC				1,4					

[1] Fastenings (incl. nut and washer) must comply with the appropriate material and property class of the internal threaded rod. The characteristic tension resistance for steel failure is valid for the internal threaded rod and the fastening element.
[2] For IG-M20 strength class 50 is valid

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of tension loads under static and quasi-static action for a working life of 50 years (internal threaded anchor rod)

Annex C 6

Table C7: Characteristic values of tension loads under static and quasi-static action for a working life of 100 years

Internal threaded anchor rods				IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Steel failure[1]									
Characteristic tension resistance, Steel, strength class	5.8	$N_{Rk,s}$	[kN]	10	17	29	42	76	123
	8.8	$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor, strength class 5.8 and 8.8		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension resistance, Stainless Steel A4 and HCR, Strength class 70 [2]		$N_{Rk,s}$	[kN]	14	26	41	59	110	124
Partial factor		$\gamma_{Ms,N}$	[-]	1,87					2,86
Combined pull-out and concrete cone failure									
Characteristic bond resistance in uncracked concrete C20/25									
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr,100}$	[N/mm²]	17	16	15	14	13	13
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr,100}$	[N/mm²]	17	16	15	14	13	13
Characteristic bond resistance in cracked concrete C20/25									
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr,100}$	[N/mm²]	6,0	6,5	6,5	6,5	6,5	6,5
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr,100}$	[N/mm²]	6,0	6,5	6,5	6,5	6,5	6,5
Reduktion factor $\psi^0_{sus,100}$ in cracked and uncracked concrete C20/25									
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\psi^0_{sus,100}$	[-]	0,90					
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\psi^0_{sus,100}$	[-]	0,87					
Increasing factors for concrete		ψ_c	[-]	$(f_{ck} / 20)^{0,1}$					
Characteristic bond resistance depending on the concrete strength class		$\tau_{Rk,ucr,100} =$		$\psi_c \cdot \tau_{Rk,ucr,100,(C20/25)}$					
		$\tau_{Rk,cr,100} =$		$\psi_c \cdot \tau_{Rk,cr,100,(C20/25)}$					
Concrete cone failure									
Relevant parameter				see Table C2					
Splitting failure									
Relevant parameter				see Table C2					
Installation factor									
for dry and wet concrete	MAC	γ_{inst}	[-]	1,2			No Performance assessed		
	CAC	γ_{inst}	[-]	1,0					
	HDB	γ_{inst}	[-]	1,2					
for flooded bore hole	CAC	γ_{inst}	[-]	1,4					

[1] Fastenings (incl. nut and washer) must comply with the appropriate material and property class of the internal threaded rod. The characteristic tension resistance for steel failure is valid for the internal threaded rod and the fastening element.
[2] For IG-M20 strength class 50 is valid

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of tension loads under static and quasi-static action for a working life of 100 years (internal threaded anchor rod)

Annex C 7

Table C8: Characteristic values of shear loads under static and quasi-static action for a working life of 50 and 100 years

Internal threaded anchor rods				IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Steel failure without lever arm[1]									
Characteristic shear resistance, Steel, strength class	5.8	$V^0_{Rk,s}$	[kN]	5	9	15	21	38	61
	8.8	$V^0_{Rk,s}$	[kN]	8	14	23	34	60	98
Partial factor, strength class 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	1,25					
Characteristic shear resistance, Stainless Steel A4 and HCR, Strength class 70[2]		$V^0_{Rk,s}$	[kN]	7	13	20	30	55	40
Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Ductility factor		k_7	[-]	1,0					
Steel failure with lever arm[1]									
Characteristic bending moment, Steel, strength class	5.8	$M^0_{Rk,s}$	[Nm]	8	19	37	66	167	325
	8.8	$M^0_{Rk,s}$	[Nm]	12	30	60	105	267	519
Partial factor, strength class 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	1,25					
Characteristic bending moment, Stainless Steel A4 and HCR, Strength class 70[2]		$M^0_{Rk,s}$	[Nm]	11	26	52	92	233	456
Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Concrete pry-out failure									
Factor		k_8	[-]	2,0					
Installation factor		γ_{inst}	[-]	1,0					
Concrete edge failure									
Effective length of fastener		l_f	[mm]	$\min(h_{ef};\ 12 \cdot d_{nom})$					$\min(h_{ef};\ 300mm)$
Outside diameter of fastener		d_{nom}	[mm]	10	12	16	20	24	30
Installation factor		γ_{inst}	[-]	1,0					

[1] Fastenings (incl. nut and washer) must comply with the appropriate material and property class of the internal threaded rod. The characteristic tension resistance for steel failure is valid for the internal threaded rod and the fastening element.
[2] For IG-M20 strength class 50 is valid

Table C9: Characteristic values of tension loads under static and quasi-static action for a working life of 50 years

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 tension resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ [1]									
Cross section area		A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		$\gamma_{Ms,N}$	[-]	1,4 [2]									
Combined pull-out and concrete failure													
Characteristic bond resistance in uncracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Temperature range III: 72°C/120°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	13	12	12	12	12	11	11	11	11	11
Temperature range IV: 100°C/160°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	9,5	9,5	9,5	9,0	9,0	9,0	9,0	9,0	8,5	8,5
Characteristic bond resistance in cracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature range III: 72°C/120°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
Temperature range IV: 100°C/160°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Reduktion factor ψ^0_{sus} in cracked and uncracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	ψ^0_{sus}	[-]	0,90									
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	ψ^0_{sus}	[-]	0,87									
Temperature range III: 72°C/120°C	Dry, wet concrete and flooded bore hole	ψ^0_{sus}	[-]	0,75									
Temperature range IV: 100°C/160°C	Dry, wet concrete and flooded bore hole	ψ^0_{sus}	[-]	0,66									
Increasing factors for concrete		ψ_c	[-]	$(f_{ck} / 20)^{0,1}$									
Characteristic bond resistance depending on the concrete strength class		$\tau_{Rk,ucr} =$		$\psi_c \cdot \tau_{Rk,ucr,(C20/25)}$									
		$\tau_{Rk,cr} =$		$\psi_c \cdot \tau_{Rk,cr,(C20/25)}$									
Concrete cone failure													
Relevant parameter				see Table C2									
Splitting													
Relevant parameter				see Table C2									
Installation factor													
for dry and wet concrete	MAC	γ_{inst}	[-]	1,2					No Performance assessed				
for dry and wet concrete	CAC	γ_{inst}	[-]	1,0									
for dry and wet concrete	HDB	γ_{inst}	[-]	1,2									
for flooded bore hole	CAC	γ_{inst}	[-]	1,4									

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of national regulation

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Table C10: Characteristic values of tension loads under static and quasi-static action for a working life of 100 years

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 tension resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ [1)]									
Cross section area		A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		$\gamma_{Ms,N}$	[-]	1,4 [2)]									
Combined pull-out and concrete failure													
Characteristic bond resistance in uncracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr,100}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,ucr,100}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
Characteristic bond resistance in cracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr,100}$	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,cr,100}$	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Reduktion factor $\psi^0_{sus,100}$ in cracked and uncracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\psi^0_{sus,100}$	[-]	0,90									
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\psi^0_{sus,100}$	[-]	0,87									
Increasing factors for concrete		ψ_c	[-]	$(f_{ck} / 20)^{0,1}$									
Characteristic bond resistance depending on the concrete strength class		$\tau_{Rk,ucr,100} =$		$\psi_c \cdot \tau_{Rk,ucr,100,(C20/25)}$									
		$\tau_{Rk,cr,100} =$		$\psi_c \cdot \tau_{Rk,cr,100,(C20/25)}$									
Concrete cone failure													
Relevant parameter				see Table C2									
Splitting													
Relevant parameter				see Table C2									
Installation factor													
for dry and wet concrete	MAC	γ_{inst}	[-]	1,2					No Performance assessed				
for dry and wet concrete	CAC	γ_{inst}	[-]	1,0									
for dry and wet concrete	HDB	γ_{inst}	[-]	1,2									
for flooded bore hole	CAC	γ_{inst}	[-]	1,4									

1) f_{uk} shall be taken from the specifications of reinforcing bars
2) in absence of national regulation

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of tension loads under static and quasi-static action for a working life of 100 years (rebar)

Annex C 10

Table C11: Characteristic values of shear loads under static and quasi-static action for a working life of 50 and 100 years

Reinforcing bar			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Steel failure without lever arm												
Characteristic shear resistance	$V^0_{Rk,s}$	[kN]	$0{,}50 \cdot A_s \cdot f_{uk}$ [1)]									
Cross section area	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	1,5[2)]									
Ductility factor	k_7	[-]	1,0									
Steel failure with lever arm												
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1.2 \cdot W_{el} \cdot f_{uk}$ [1)]									
Elastic section modulus	W_{el}	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
Partial factor	$\gamma_{Ms,V}$	[-]	1,5[2)]									
Concrete pry-out failure												
Factor	k_8	[-]	2,0									
Installation factor	γ_{inst}	[-]	1,0									
Concrete edge failure												
Effective length of fastener	l_f	[mm]	$\min(h_{ef};\ 12 \cdot d_{nom})$							$\min(h_{ef};\ 300\text{mm})$		
Outside diameter of fastener	d_{nom}	[mm]	8	10	12	14	16	20	24	25	28	32
Installation factor	γ_{inst}	[-]	1,0									

1) f_{uk} shall be taken from the specifications of reinforcing bars
2) in absence of national regulation

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of shear loads under static and quasi-static action
for a working life of 50 and 100 years (rebar)

Annex C 11

Table C12: Displacements under tension load[1)]

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Uncracked concrete C20/25 under static and quasi-static action for a working life of 50 and 100 years										
Temperature range I: 24°C/40°C II: 50°C/80°C	δ_{N0}-factor	[mm/(N/mm²)]	0,031	0,032	0,034	0,037	0,039	0,042	0,044	0,046
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,040	0,042	0,044	0,047	0,051	0,054	0,057	0,060
Temperature range III: 72°C/120°C	δ_{N0}-factor	[mm/(N/mm²)]	0,032	0,034	0,035	0,038	0,041	0,044	0,046	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,045	0,049	0,053	0,056	0,059	0,062
Temperature range IV: 100°C/160°C	δ_{N0}-factor	[mm/(N/mm²)]	0,121	0,126	0,131	0,142	0,153	0,163	0,171	0,179
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,124	0,129	0,135	0,146	0,157	0,168	0,176	0,184
Cracked concrete under static and quasi-static action for a working life of 50 and 100 years										
Temperature range I: 24°C/40°C II: 50°C/80°C	δ_{N0}-factor	[mm/(N/mm²)]	0,081	0,083	0,085	0,090	0,095	0,099	0,103	0,106
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,104	0,107	0,110	0,116	0,122	0,128	0,133	0,137
Temperature range III: 72°C/120°C	δ_{N0}-factor	[mm/(N/mm²)]	0,084	0,086	0,088	0,093	0,098	0,103	0,107	0,110
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,108	0,111	0,114	0,121	0,127	0,133	0,138	0,143
Temperature range IV: 100°C/160°C	δ_{N0}-factor	[mm/(N/mm²)]	0,312	0,321	0,330	0,349	0,367	0,385	0,399	0,412
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,321	0,330	0,340	0,358	0,377	0,396	0,410	0,424

1) Calculation of the displacement
$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau$; τ: action bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{-factor} \cdot \tau$;

Table C13: Displacements under shear load[1)]

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Uncracked and cracked concrete under static and quasi-static action for a working life of 50 and 100 years										
All temperature ranges	δ_{V0}-factor	[mm/kN]	0,06	0,06	0,05	0,04	0,04	0,03	0,03	0,03
	$\delta_{V\infty}$-factor	[mm/kN]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05

1) Calculation of the displacement
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V$; V: action shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;

Table C14: Displacements under tension load[1)]

Internal threaded anchor rods			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Uncracked concrete under static and quasi-static action for a working life of 50 and 100 years								
Temperature range I: 24°C/40°C II: 50°C/80°C	δ_{N0}-factor	[mm/(N/mm²)]	0,032	0,034	0,037	0,039	0,042	0,046
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,047	0,051	0,054	0,060
Temperature range III: 72°C/120°C	δ_{N0}-factor	[mm/(N/mm²)]	0,034	0,035	0,038	0,041	0,044	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,044	0,045	0,049	0,053	0,056	0,062
Temperature range IV: 100°C/160°C	δ_{N0}-factor	[mm/(N/mm²)]	0,126	0,131	0,142	0,153	0,163	0,179
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,129	0,135	0,146	0,157	0,168	0,184
Cracked concrete under static and quasi-static action for a working life of 50 and 100 years								
Temperature range I: 24°C/40°C II: 50°C/80°C	δ_{N0}-factor	[mm/(N/mm²)]	0,083	0,085	0,090	0,095	0,099	0,106
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,170	0,110	0,116	0,122	0,128	0,137
Temperature range III: 72°C/120°C	δ_{N0}-factor	[mm/(N/mm²)]	0,086	0,088	0,093	0,098	0,103	0,110
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,111	0,114	0,121	0,127	0,133	0,143
Temperature range IV: 100°C/160°C	δ_{N0}-factor	[mm/(N/mm²)]	0,321	0,330	0,349	0,367	0,385	0,412
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,330	0,340	0,358	0,377	0,396	0,424

[1)] Calculation of the displacement
$\delta_{N0} = \delta_{N0}$-factor $\cdot\ \tau$; τ: action bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}$-factor $\cdot\ \tau$;

Table C15: Displacements under shear load[1)]

Internal threaded anchor rods			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Uncracked and cracked concrete under static and quasi-static action for a working life of 50 and 100 years								
All temperature ranges	δ_{V0}-factor	[mm/kN]	0,07	0,06	0,06	0,05	0,04	0,04
	$\delta_{V\infty}$-factor	[mm/kN]	0,10	0,09	0,08	0,08	0,06	0,06

[1)] Calculation of the displacement
$\delta_{V0} = \delta_{V0}$-factor $\cdot$ V;   V: action shear load
$\delta_{V\infty} = \delta_{V\infty}$-factor $\cdot$ V;

Table C16: Displacements under tension load[1)]

Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Uncracked concrete under static and quasi-static action for a working life of 50 and 100 years												
Temperature range I: 24°C/40°C II: 50°C/80°C	δ_{N0}-factor	[mm/(N/mm²)]	0,031	0,032	0,034	0,035	0,037	0,039	0,042	0,043	0,045	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,040	0,042	0,044	0,045	0,047	0,051	0,054	0,055	0,058	0,063
Temperature range III: 72°C/120°C	δ_{N0}-factor	[mm/(N/mm²)]	0,032	0,034	0,035	0,036	0,038	0,041	0,044	0,045	0,047	0,050
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,045	0,047	0,049	0,053	0,056	0,057	0,060	0,065
Temperature range IV: 100°C/160°C	δ_{N0}-factor	[mm/(N/mm²)]	0,121	0,126	0,131	0,137	0,142	0,153	0,163	0,164	0,172	0,186
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,124	0,129	0,135	0,141	0,146	0,157	0,168	0,169	0,177	0,192
Cracked concrete under static and quasi-static action for a working life of 50 and 100 years												
Temperature range I: 24°C/40°C II: 50°C/80°C	δ_{N0}-factor	[mm/(N/mm²)]	0,081	0,083	0,085	0,087	0,090	0,095	0,099	0,099	0,103	0,108
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,128	0,133	0,141
Temperature range III: 72°C/120°C	δ_{N0}-factor	[mm/(N/mm²)]	0,084	0,086	0,088	0,090	0,093	0,098	0,103	0,103	0,107	0,113
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,133	0,138	0,148
Temperature range IV: 100°C/160°C	δ_{N0}-factor	[mm/(N/mm²)]	0,312	0,321	0,330	0,340	0,349	0,367	0,385	0,385	0,399	0,425
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,321	0,330	0,340	0,349	0,358	0,377	0,396	0,396	0,410	0,449

1) Calculation of the displacement
$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau$; τ: action bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{-factor} \cdot \tau$;

Table C17: Displacements under shear load[1)]

Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Uncracked and cracked concrete under static and quasi-static action for a working life of 50 and 100 years												
All temperature ranges	δ_{V0}-factor	[mm/kN]	0,06	0,05	0,05	0,04	0,04	0,04	0,03	0,03	0,03	0,03
	$\delta_{V\infty}$-factor	[mm/kN]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05	0,04	0,04

1) Calculation of the displacement
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V$; V: action shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;

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Performances
Displacements under static and quasi-static action
for a working life of 50 and 100 years (rebar)

Annex C 14

Table C18: Characteristic values of tension loads under seismic action (performance category C1) for a working life of 50 years

Threaded rod					M8	M10	M12	M16	M20	M24	M27	M30
Steel failure												
Characteristic tension resistance			$N_{Rk,s,eq,C1}$	[kN]	$1{,}0 \cdot N_{Rk,s}$							
Partial factor			$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure												
Characteristic bond resistance in cracked and uncracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	II: 50°C/80°C		$\tau_{Rk,eq,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	III: 72°C/120°C		$\tau_{Rk,eq,C1}$	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
	IV: 100°C/160°C		$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
Increasing factors for concrete			ψ_c	[-]	1,0							
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,eq,C1} =$		$\psi_c \cdot \tau_{Rk,eq,C1,(C20/25)}$							
Installation factor												
for dry and wet concrete	CAC		γ_{inst}	[-]	1,0							
	HDB				1,2							
for flooded bore hole	CAC				1,4							

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Performances
Characteristic values of tension loads under seismic action (performance category C1) for a working life of 50 years (threaded rod)

Annex C 15

Table C19: Characteristic values of tension loads under seismic action (performance category C1) for a working life of 100 years

Threaded rod					**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure												
Characteristic tension resistance			$N_{Rk,s,eq,C1}$	[kN]	$1{,}0 \cdot N_{Rk,s}$							
Partial factor			$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure												
Characteristic bond resistance in cracked and uncracked concrete C20/25												
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	6	6,5	6,5	6,5	6,5	6,5	6,5
	II: 50°C/80°C		$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	6	6,5	6,5	6,5	6,5	6,5	6,5
Increasing factors for concrete			ψ_c	[-]	1,0							
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,eq,C1} =$		$\psi_c \cdot \tau_{Rk,eq,C1,(C20/25)}$							
Installation factor												
for dry and wet concrete	CAC		γ_{inst}	[-]	1,0							
	HDB				1,2							
for flooded bore hole	CAC				1,4							

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Performances
Characteristic values of tension loads under seismic action (performance category C1) for a working life of 100 years (threaded rod)

Annex C 16

Table C20: Characteristic values of shear loads under seismic action (performance category C1) for a working life of 50 and 100 years

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure										
Characteristic shear resistance (Seismic C1)	$V_{Rk,s,eq,C1}$	[kN]	$0{,}70 \cdot V^0_{Rk,s}$							
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Factor for annular gap	α_{gap}	[-]	0,5 (1,0)[1)]							

1) Value in brackets valid for filled annular gab between fastener and clearance hole in the fixture. Use of special filling washer Annex A 3 is recommended

Table C21: Characteristic values of tension loads under seismic action (performance category C1) for a working life of 50 years

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 tension resistance		$N_{Rk,s,eq,C1}$	[kN]	$1{,}0 \cdot A_s \cdot f_{uk}$ 1)									
Cross section area		A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor		$\gamma_{Ms,N}$	[-]	1,4 2)									
Combined pull-out and concrete failure													
Characteristic bond resistance in cracked and uncracked concrete C20/25													
Temperature range I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature range II: 50°C/80°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
Temperature range III: 72°C/120°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
Temperature range IV: 100°C/160°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Increasing factors for concrete		ψ_c	[-]	1,0									
Characteristic bond resistance depending on the concrete strength class		$\tau_{Rk,eq,C1} =$		$\psi_c \cdot \tau_{Rk,eq,C1,(C20/25)}$									
Installation factor													
for dry and wet concrete	CAC	γ_{inst}	[-]	1,0									
for dry and wet concrete	HDB	γ_{inst}	[-]	1,2									
for flooded bore hole	CAC	γ_{inst}	[-]	1,4									

1) f_{uk} shall be taken from the specifications of reinforcing bars

2) in absence of national regulation

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Performances
Characteristic values of tension loads under seismic action (performance category C1) for a working life of 50 years (rebar)

Annex C 18

Table C22: Characteristic values of tension loads under seismic action (performance category C1) for a working life of 100 years

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 tension resistance			$N_{Rk,s,eq,C1}$	[kN]	$1{,}0 \cdot A_s \cdot f_{uk}$ 1)									
Cross section area			A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor			$\gamma_{Ms,N}$	[-]	1,4 2)									
Combined pull-out and concrete failure														
Characteristic bond resistance in cracked and uncracked concrete C20/25														
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C1}$	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
	II: 50°C/80°C		$\tau_{Rk,eq,C1}$	[N/mm²]	4,5	4,5	4,5	4,5	4,5	4,0	4,0	4,0	4,0	4,0
Increasing factors for concrete			ψ_c	[-]	1,0									
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,eq,C1} =$		$\psi_c \cdot \tau_{Rk,eq,C1,(C20/25)}$									
Installation factor														
for dry and wet concrete	CAC		γ_{inst}	[-]	1,0									
	HDB				1,2									
for flooded bore hole	CAC				1,4									

1) f_{uk} shall be taken from the specifications of reinforcing bars
2) in absence of national regulation

Table C23: Characteristic values of shear loads under seismic action (performance category C1) for a working life of 50 and 100 years

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 shear resistance	$V_{Rk,s,eq}$	[kN]	$0{,}35 \cdot A_s \cdot f_{uk}$ 1)									
Cross section area	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	1,5 2)									
Factor for annular gap	α_{gap}	[-]	0,5 (1,0) 3)									

1) f_{uk} shall be taken from the specifications of reinforcing bars
2) in absence of national regulation
3) Value in brackets valid for filled annular gab between fastener and clearance hole in the fixture. Use of special filling washer Annex A 3 is recommended

Table C24: Characteristic values of tension loads under seismic action (performance category C2) for a working life of 50 years

Threaded rod					**M12**	**M16**	**M20**	**M24**
Steel failure								
Characteristic tension resistance, Steel, strength class 8.8 Stainless Steel A4 and HCR, Strength class ≥70			$N_{Rk,s,eq,C2}$	[kN]	$1{,}0 \cdot N_{Rk,s}$			
Partial factor			$\gamma_{Ms,N}$	[-]	see Table C1			
Combined pull-out and concrete failure								
Characteristic bond resistance in cracked and uncracked concrete C20/25								
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C2}$	[N/mm²]	3,6	3,5	3,3	2,3
	II: 50°C/80°C		$\tau_{Rk,eq,C2}$	[N/mm²]	3,6	3,5	3,3	2,3
	III: 72°C/120°C		$\tau_{Rk,eq,C2}$	[N/mm²]	3,1	3,0	2,8	2,0
	IV: 160°C/100°C		$\tau_{Rk,eq,C2}$	[N/mm²]	2,5	2,7	2,5	1,8
Increasing factors for concrete			ψ_c	[-]	1,0			
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,eq,C2} =$		$\psi_c \cdot \tau_{Rk,eq,C2,(C20/25)}$			
Installation factor								
for dry and wet concrete	CAC		γ_{inst}	[-]	1,0			
	HDB				1,2			
for flooded bore hole	CAC				1,4			

Table C25: Characteristic values of tension loads under seismic action (performance category C2) for a working life of 100 years

Threaded rod					M12	M16	M20	M24
Steel failure								
Characteristic tension resistance, Steel, strength class 8.8 Stainless Steel A4 and HCR, Strength class ≥70			$N_{Rk,s,eq,C2}$	[kN]	$1{,}0 \cdot N_{Rk,s}$			
Partial factor			$\gamma_{Ms,N}$	[-]	see Table C1			
Combined pull-out and concrete failure								
Characteristic bond resistance in cracked and uncracked concrete C20/25								
Temperature range	I: 24°C/40°C	Dry, wet concrete and flooded bore hole	$\tau_{Rk,eq,C2}$	[N/mm²]	3,6	3,5	3,3	2,3
	II: 50°C/80°C		$\tau_{Rk,eq,C2}$	[N/mm²]	3,6	3,5	3,3	2,3
Increasing factors for concrete			ψ_c	[-]	1,0			
Characteristic bond resistance depending on the concrete strength class			$\tau_{Rk,eq,C2} =$		$\psi_c \cdot \tau_{Rk,eq,C2,(C20/25)}$			
Installation factor								
for dry and wet concrete		CAC	γ_{inst}	[-]	1,0			
		HDB			1,2			
for flooded bore hole		CAC			1,4			

Table C26: Characteristic values of shear loads under seismic action (performance category C2) for a working life of 50 and 100 years

Threaded rod			M12	M16	M20	M24
Steel failure						
Characteristic shear resistance Steel, strength class 8.8 Stainless Steel A4 and HCR, Strength class ≥70	$V_{Rk,s,eq,C2}$	[kN]	$0{,}70 \cdot V^0_{Rk,s}$			
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1			
Factor for annular gap	α_{gap}	[-]	0,5 (1,0)[1)]			

1) Value in brackets valid for filled annular gab between fastener and clearance hole in the fixture. Use of special filling washer Annex A 3 is recommended

Table C27: Displacements under tension load

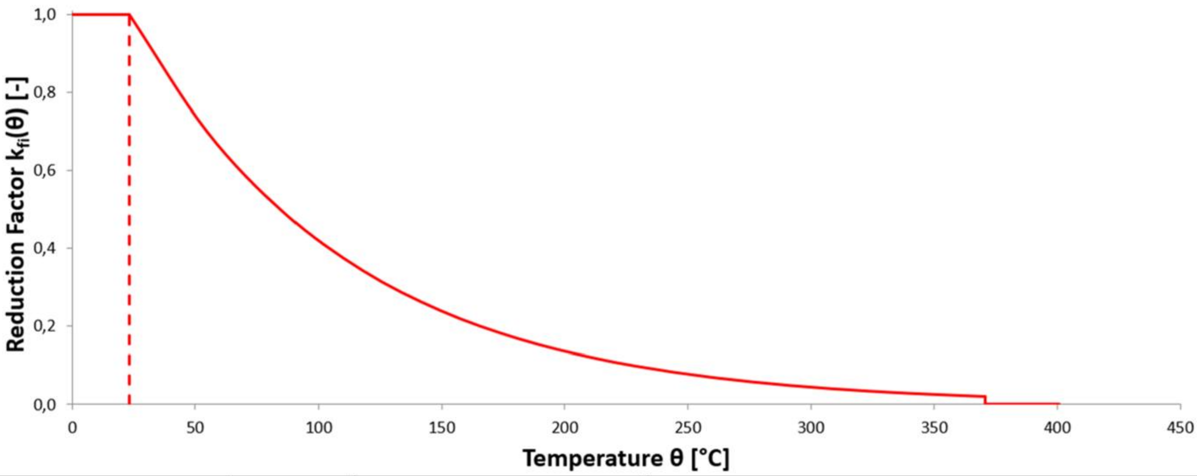
Threaded rod			M12	M16	M20	M24
Cracked concrete under seismic action (performance category C2) for a working life of 50 and 100 years						
All temperature ranges	$\delta_{N,eq,C2(50\%)} = \delta_{N,eq,C2(DLS)}$	[mm]	0,24	0,27	0,29	0,27
	$\delta_{N,eq,C2(100\%)} = \delta_{N,eq,C2(ULS)}$	[mm]	0,55	0,51	0,50	0,58

Table C28: Displacements under shear load

Threaded rod			M12	M16	M20	M24
Cracked concrete under seismic action (performance category C2) for a working life of 50 and 100 years						
All temperature ranges	$\delta_{V,eq,C2(50\%)} = \delta_{V,eq,C2(DLS)}$	[mm]	3,6	3,0	3,1	3,5
	$\delta_{V,eq,C2(100\%)} = \delta_{V,eq,C2(ULS)}$	[mm]	7,0	6,6	7,0	9,3

Table C29: Characteristic values of tension and shear loads under fire exposure in hammer drilled holes (HD), compressed air drilled holes (CD) and in hammer drilled holes with hollow drill bit (HDB)

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure											
Characteristic tension resistance; Steel, Stainless Steel A2, A4 and HCR, strength class 5.8 resp. 50 and higher	$N_{Rk,s,fi}$	[kN]	Fire exposure time [min]: 30	1,1	1,7	3,0	5,7	8,8	12,7	16,5	20,2
			60	0,9	1,4	2,3	4,2	6,6	9,5	12,4	15,1
			90	0,7	1,0	1,6	3,0	4,7	6,7	8,7	10,7
			120	0,5	0,8	1,2	2,2	3,4	4,9	6,4	7,9
Characteristic bond resistance in cracked and uncracked concrete C20/25 up to C50/60 under fire conditions for a given temperature θ											
Temperature reduction factor	$k_{fi,p}(\theta)$	[-]	θ < 24°C	1,0							
			24°C ≤ θ ≤ 379°C	$1{,}301 \cdot e^{-0{,}011 \cdot \theta} \le 1{,}0$							
			θ > 379°C	0,0							



				M8	M10	M12	M16	M20	M24	M27	M30
Characteristic bond resistance for a given temperature (θ)	$\tau_{Rk,fi}(\theta)$	[N/mm²]		$k_{fi,p}(\theta) \cdot \tau_{Rk,cr,(C20/25)}$ 1)							
Steel failure without lever arm											
Characteristic shear resistance; Steel, Stainless Steel A2, A4 and HCR, strength class 5.8 resp. 50 and higher	$V_{Rk,s,fi}$	[kN]	Fire exposure time [min]: 30	1,1	1,7	3,0	5,7	8,8	12,7	16,5	20,2
			60	0,9	1,4	2,3	4,2	6,6	9,5	12,4	15,1
			90	0,7	1,0	1,6	3,0	4,7	6,7	8,7	10,7
			120	0,5	0,8	1,2	2,2	3,4	4,9	6,4	7,9
Steel failure with lever arm											
Characteristic bending moment; Steel, Stainless Steel A2, A4 and HCR, strength class 5.8 resp. 50 and higher	$M^0_{Rk,s,fi}$	[Nm]	Fire exposure time [min]: 30	1,1	2,2	4,7	12,0	23,4	40,4	59,9	81,0
			60	0,9	1,8	3,5	9,0	17,5	30,3	44,9	60,7
			90	0,7	1,3	2,5	6,3	12,3	21,3	31,6	42,7
			120	0,5	1,0	1,8	4,7	9,1	15,7	23,3	31,5

1) $\tau_{Rk,cr,(C20/25)}$ characteristic bond resistance for cracked concrete for concrete strength class C20/25 for the relevant temperature range

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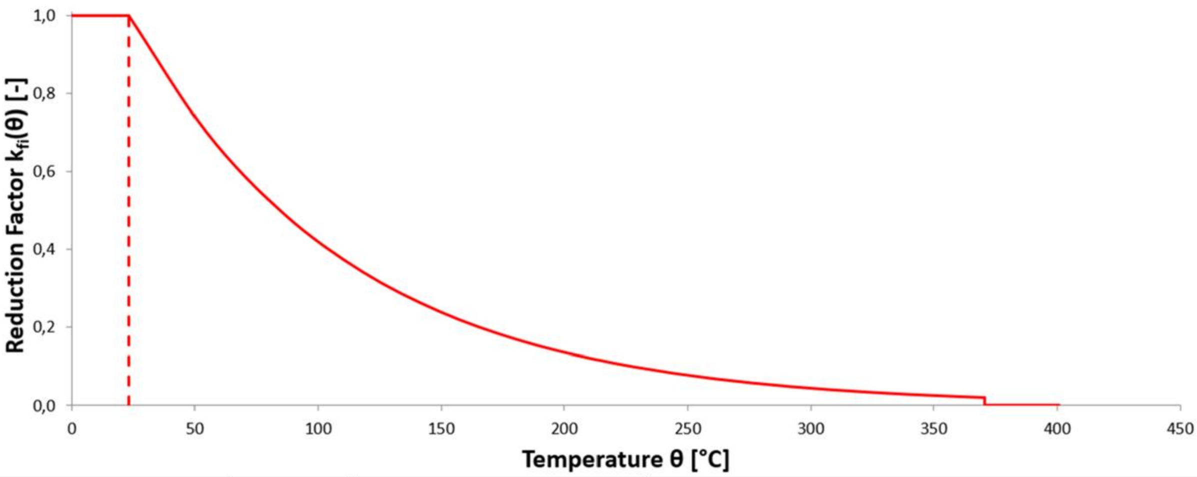
Performances
Characteristic values of tension and shear loads under fire exposure (threaded rod)

Annex C 24

Table C30: Characteristic values of tension and shear loads under fire exposure in hammer drilled holes (HD), compressed air drilled holes (CD) and in hammer drilled holes with hollow drill bit (HDB)

Internal threaded anchor rods					IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
Steel failure										
Characteristic tension resistance; Steel, Stainless Steel A4 and HCR, strength class 5.8 and 8.8 resp. 70	$N_{Rk,s,fi}$	[kN]	Fire exposure time [min]	30	0,3	1,1	1,7	3,0	5,7	8,8
				60	0,2	0,9	1,4	2,3	4,2	6,6
				90	0,2	0,7	1,0	1,6	3,0	4,7
				120	0,1	0,5	0,8	1,2	2,2	3,4
Characteristic bond resistance in cracked and uncracked concrete C20/25 up to C50/60 under fire conditions for a given temperature θ										
Temperature reduction factor	$k_{fi,p}(\theta)$	[-]	$\theta < 24°C$		1,0					
			$24°C \le \theta \le 379°C$		$1{,}301 \cdot e^{-0{,}011 \cdot \theta} \le 1{,}0$					
			$\theta > 379°C$		0,0					
Characteristic bond resistance for a given temperature (θ)	$\tau_{Rk,fi}(\theta)$	[N/mm²]			$k_{fi,p}(\theta) \cdot \tau_{Rk,cr,(C20/25)}$ 1)					
Steel failure without lever arm										
Characteristic shear resistance; Steel, Stainless Steel A4 and HCR, strength class 5.8 and 8.8 resp. 70	$V_{Rk,s,fi}$	[kN]	Fire exposure time [min]	30	0,3	1,1	1,7	3,0	5,7	8,8
				60	0,2	0,9	1,4	2,3	4,2	6,6
				90	0,2	0,7	1,0	1,6	3,0	4,7
				120	0,1	0,5	0,8	1,2	2,2	3,4
Steel failure with lever arm										
Characteristic bending moment; Steel, Stainless Steel A4 and HCR, strength class 5.8 and 8.8 resp. 70	$M^0_{Rk,s,fi}$	[Nm]	Fire exposure time [min]	30	0,2	1,1	2,2	4,7	12,0	23,4
				60	0,2	0,9	1,8	3,5	9,0	17,5
				90	0,1	0,7	1,3	2,5	6,3	12,3
				120	0,1	0,5	1,0	1,8	4,7	9,1



1) $\tau_{Rk,cr,(C20/25)}$ characteristic bond resistance for cracked concrete for concrete strength class C20/25 for the relevant temperature range

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Performances
Characteristic values of tension and shear loads under fire exposure (internal threaded anchor rod)

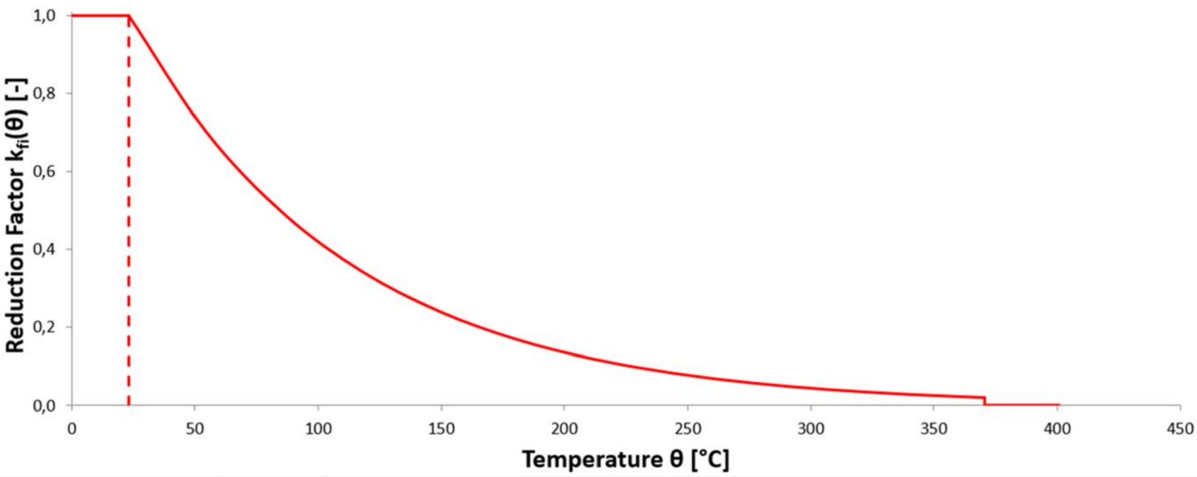
Annex C 25

Table C31: Characteristic values of tension and shear loads under fire exposure in hammer drilled holes (HD), compressed air drilled holes (CD) and in hammer drilled holes with hollow drill bit (HDB)

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 tension resistance; BSt 500	$N_{Rk,s,fi}$	[kN]	Fire exposure time [min]	30	0,5	1,2	2,3	3,1	4,0	6,3	9,0	9,8	12,3	16,1
				60	0,5	1,0	1,7	2,3	3,0	4,7	6,8	7,4	9,2	12,1
				90	0,4	0,8	1,5	2,0	2,6	4,1	5,9	6,4	8,0	10,5
				120	0,3	0,6	1,1	1,5	2,0	3,1	4,5	4,9	6,2	8,0

Characteristic bond resistance in cracked and uncracked concrete C20/25 up to C50/60 under fire conditions for a given temperature θ

Temperature reduction factor	$k_{fi,p}(\theta)$	[-]	$\theta < 22°C$	1,0
			$22°C \leq \theta \leq 370°C$	$1{,}268 \cdot e^{-0{,}011 \cdot \theta} \leq 1{,}0$
			$\theta > 370°C$	0,0



Characteristic bond resistance for a given temperature (θ)	$\tau_{Rk,fi}(\theta)$	[N/mm²]	$k_{fi,p}(\theta) \cdot \tau_{Rk,cr,(C20/25)}$ 1)

					Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Steel failure without lever arm														
Characteristic shear resistance; BSt 500	$V_{Rk,s,fi}$	[kN]	Fire exposure time [min]	30	0,5	1,2	2,3	3,1	4,0	6,3	9,0	9,8	12,3	16,1
				60	0,5	1,0	1,7	2,3	3,0	4,7	6,8	7,4	9,2	12,1
				90	0,4	0,8	1,5	2,0	2,6	4,1	5,9	6,4	8,0	10,5
				120	0,3	0,6	1,1	1,5	2,0	3,1	4,5	4,9	6,2	8,0
Steel failure with lever arm														
Characteristic bending moment; BSt 500	$M^0_{Rk,s,fi}$	[Nm]	Fire exposure time [min]	30	0,6	1,8	4,1	6,5	9,7	18,8	32,6	36,8	51,7	77,2
				60	0,5	1,5	3,1	4,8	7,2	14,1	24,4	27,6	38,8	57,9
				90	0,4	1,2	2,6	4,2	6,3	12,3	21,2	23,9	33,6	50,2
				120	0,3	0,9	2,0	3,2	4,8	9,4	16,3	18,4	25,9	38,6

1) $\tau_{Rk,cr,(C20/25)}$ characteristic bond resistance for cracked concrete for concrete strength class C20/25 for the relevant temperature range

Mapei Injection system Mapefix UM Hybrid for concrete

Performances
Characteristic values of tension and shear loads under fire exposure (reinforcing bar)

Annex C 26