... eine starke Verbindung

DICHIARAZIONE DI PRESTAZIONE

DoP No. **MKT-2.1-701_it**

✧ **Codice di identificazione unico del prodotto-tipo:** **Sistema di iniezione VME plus**

✧ **Usi previsti:** Sistema di iniezione per l'ancoraggio nel calcestruzzo, vedere Allegato / Annex B

✧ **Fabbricante:** MKT Metall-Kunststoff-Technik GmbH & Co.KG
Auf dem Immel 2
67685 Weilerbach

✧ **Sistema o sistemi di valutazione e verifica della costanza della prestazione:** 1

✧ **Documento per la valutazione europea:** **EAD 330499-01-0601**
Valutazione tecnica europea: **ETA-19/0483, 12.05.2021**
Organismo di valutazione tecnica: DIBt, Berlin
Organismi notificati: NB 2873 – Technische Universität Darmstadt

✧ **Prestazioni dichiarate:**

Caratteristiche essenziali	Prestazione
Resistenza meccanica e stabilità (BWR 1)	
Resistenze caratteristiche sotto carico di trazione (effetti statici e quasi statici)	Allegato / Annex B3, C1, C3-C6, C9-C11, C13-C15
Resistenze caratteristiche sotto stress trasversale (effetti statici e quasi statici)	Allegato / Annex C2, C7, C12, C16
Turni	Allegato / Annex C18 – C21
Resistenza caratteristica e turni per la categoria di prestazioni sismiche C1 + C2	Allegato / Annex C8, C17-C19
Igiene, salute e ambiente (BWR 3)	
Contenuto, emissione e / o rilascio di sostanze pericolose	Nessuna prestazione determinata

La prestazione del prodotto sopra identificato è conforme all'insieme delle prestazioni dichiarate. La presente dichiarazione di responsabilità viene emessa, in conformità al regolamento (EU) n. 305/2011, sotto la sola responsabilità del fabbricante sopra identificato.

Firmato a nome e per conto del fabbricante da:

Stefan Weustenhagen
(Direttore Generale)
Weilerbach, 12.05.2021

p.p.
Dipl.-Ing. Detlef Bigalke
(Direttore del Sviluppo del Prodotto)

L'originale di questa dichiarazione di prestazione è stata scritta in tedesco. In caso di deviazioni nella traduzione, la versione tedesca è valida.

Specification of intended use

Static and quasi-static action	working life 50 years	working life 100 years
Threaded rod **Internally threaded anchor rod** **Rebar**	**M8 - M30** **VMU-IG M6 - VMU-IG M20** **Ø8 - Ø32**	
Base material	cracked or uncracked concrete	
	strength classes C20/25 to C50/60 compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013+A1:2016	
Hole drilling	cracked concrete: hammer drilling / compressed air drilling / vaccum drilling	
	uncracked concrete: hammer drilling / compressed air drilling / vaccum drilling / diamond drilling	
Temperature range [1)]	I: -40°C to +40°C II: -40°C to +72°C	I: -40°C to +40°C II: -40°C to +72°C

Seismic action	performance category C1	performance category C2
Threaded rod **Internally threaded anchor rod** **Rebar**	**M8 - M30** **Ø8 - Ø32**	**M12 - M24** ---
Base material	cracked or uncracked concrete	
	strength classes C20/25 to C50/60 compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013+A1:2016	
Hole drilling	hammer drilling / compressed air drilling / vaccum drilling	
Temperature range [1)]	I: -40°C to +40°C II: -40°C to +72°C	I: -40°C to +40°C II: -40°C to +72°C

[1)] Temperature Range I: max. long term temperature +24°C and max. short term temperature +40°C
Temperature Range II: max. long term temperature +50°C and max. short term temperature +72°C

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 A4, Table A1 corresponding corrosion resistance classes CRC according to EN 1993-1-4:2006+A1:2015

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 or Technical Report TR 055, February 2018

Installation:

- Dry or wet concrete or waterfilled drillholes (not seawater)
- Hole drilling by hammer drill, compressed air drill, vacuum drill or diamond drill mode
- Overhead installation allowed
- Anchor installation carried out by appropriately qualified personnel and under the responsibility of the person responsible for technical matters of the site
- Internally threaded anchor rod: Screws and threaded rods (incl. nut and washer) must at least correspond to the material and strength class of the internally threaded anchor rod used

Table B1: Installation parameters for threaded rods

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Diameter of threaded rod		$d=d_{nom}$	[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 anchorage 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	Pre-setting installation	$d_f \leq$	[mm]	9	12	14	18	22	26	30	33
	Through setting installation	$d_f \leq$	[mm]	12	14	16	20	24	30	33	40
Maximum installation torque		$max.T_{inst} \leq$	[Nm]	10	20	40 (35)[1)]	60	100	170	250	300
Minimum thickness of member		h_{min}	[mm]	h_{ef} + 30mm ≥100mm			$h_{ef} + 2d_0$				
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)] max. installation torque for property class 4.6

Table B2: Installation parameters for internally threaded anchor rods

Internally threaded anchor rod			IG-M 6	IG-M 8	IG-M 10	IG-M 12	IG-M 16	IG-M 20
Inner diameter of threaded rod	d_2	[mm]	6	8	10	12	16	20
Outer diameter of threaded 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 anchorage 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	$max.T_{inst} \leq$	[Nm]	10	10	20	40	60	100
Minimum screw-in depth	l_{IG}	[mm]	8	8	10	12	16	20
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30mm ≥ 100mm		$h_{ef} + 2d_0$			
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 thread acc. to EN 1993-1-8:2005+AC:2009

Table B3: Installation parameters for rebar

Rebar			Ø 8	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 [1)]	d_0	[mm]	10 12	12 14	14 16	18	20	25	30 32	30 32	35	40
Effective anchorage 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)] for ∅8, ∅10,∅12, ∅24 and ∅25 both nominal drill hole diameter can be used

Injection System VME plus

Intended use
Installation parameters

Annex B3

Table B4: Parameter for cleaning and setting tools

Threaded rod	Internally threaded anchor rod	Rebar	Drill bit ∅	Brush ∅	min. Brush ∅
					
[-]	[-]	∅ [mm]	d_0 [mm]	d_b [mm]	$d_{b,min}$ [mm]
M8		8	10	11,5	10,5
M10	VMU-IG M6	8 / 10	12	13,5	12,5
M12	VMU-IG M8	10 / 12	14	15,5	14,5
		12	16	17,5	16,5
M16	VMU-IG M10	14	18	20,0	18,5
		16	20	22,0	20,5
M20	VMU-IG M12		22	24,0	22,5
		20	25	27,0	25,5
M24	VMU-IG M16		28	30,0	28,5
M27		24 / 25	30	31,8	30,5
		24 / 25	32	34,0	32,5
M30	VMU-IG M20	28	35	37,0	35,5
		32	40	43,5	40,5

Table B5: Retaining washer

Drill bit ∅ 		Installation direction and use		
d_0 [mm]	[-]	⬇	➡	⬆
10	No **retaining washer** required			
12				
14				
16				
18	VM-IA 18	h_{ef} > 250mm	h_{ef} > 250mm	all
20	VM-IA 20			
22	VM-IA 22			
25	VM-IA 25			
28	VM-IA 28			
30	VM-IA 30			
32	VM-IA 32			
35	VM-IA 35			
40	VM-IA 40			

Vacuum drill bit
Vacuum drill bit (MKT Hollow drill bit SB, Würth Hammer drill bit with suction or Heller Duster Expert hollow drill bit system) and a vacuum cleaner with minimum negative pressure of 253 hPa and flow rate of minimum 42 l/s (150 m³/h)

Recommended compressed air tool (min 6 bar)
Drill bit diameter (d_0): all diameters

Injection System VME plus

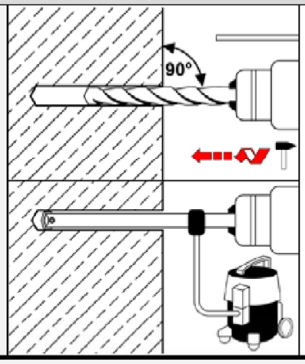
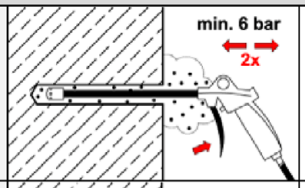
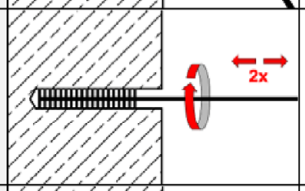
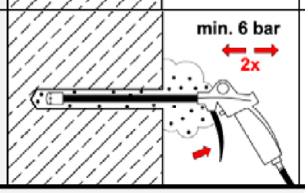
Intended use
Cleaning and setting tools

Annex B4

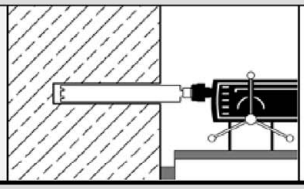
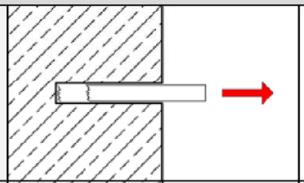
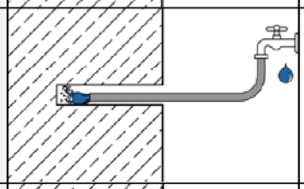
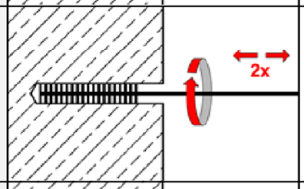
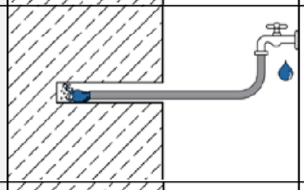
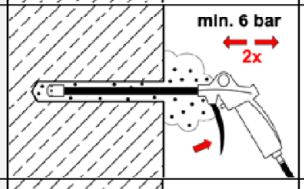
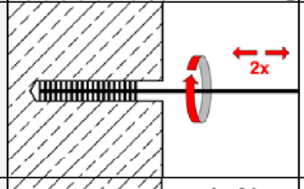
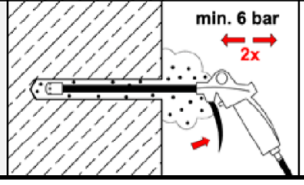
Table B6: Working time and curing time

Concrete temperature	Working time	Minimum curing time	
		dry concrete	wet concrete
0°C to +4°C	90 min	144 h	288 h
+5°C to +9°C	80 min	48 h	96 h
+10°C to +14°C	60 min	28 h	56 h
+15°C to +19°C	40 min	18 h	36 h
+20°C to +24°C	30 min	12 h	24 h
+25°C to +34°C	12 min	9 h	18 h
+35°C to +39°C	8 min	6 h	12 h
+40°C	8 min	4 h	8 h
Cartridge temperature	+5°C to +40°C		

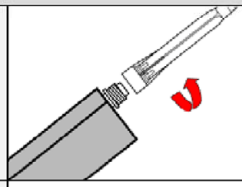
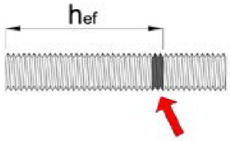
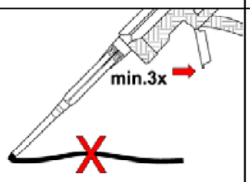
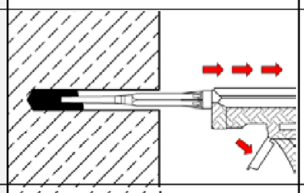
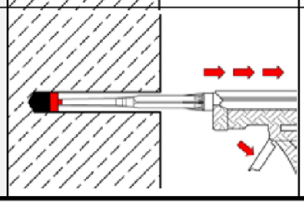
Installation instructions

Drilling of the drill hole and cleaning: Hammer drilling, compressed air drilling and vacuum drilling		
1		**Hammer drilling or compressed air drilling:** Drill with hammer drill or compressed air drill a hole into the base material with prescribed nominal drill hole diameter (Table B1, B2 or B3) and selected drillhole depth. Continue with step 2. In case of aborted drill hole, the drill hole shall be filled with mortar. **Vacuum drilling:** see Annex B4 Drill drillhole with prescribed nominal drill hole diameter (Table B1, B2 or B3) and selected drillhole depth. This drilling method removes dust and cleans the drillhole during drilling. Continue with step 3. In case of aborted drill hole, the drill hole shall be filled with mortar.
Attention! Standing water in the drill hole must be removed before cleaning!		
Cleaning: dry, wet and water-filled drill holes with all diameter in uncracked and cracked concrete (Cleaning not applicable when using vacuum drilling)		
2a		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) a minimum of **two** times until return air stream is free of noticeable dust. If the drillhole ground is not reached, an extension must be used.
2b		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush ≥ $d_{b,min}$ (Table B4) a minimum of **two** times. If the drillhole ground is not reached with the brush, an appropriate brush extension must be used.
2c		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) again a minimum of **two** times until return air stream is free of noticeable dust. If the drillhole ground is not reached, an extension must be used.
After cleaning, the drillhole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the drillhole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the drillhole again.		

Installation instructions (continuation)

Drilling of the drill hole and cleaning: Diamond drilling		
1		Drill a hole into the base material with prescribed nominal drill hole diameter (Table B1, B2 or B3) and selected drillhole depth. Continue with step 2. In case of aborted drill hole, the drill hole shall be filled with mortar.
Cleaning: dry, wet and water-filled drill holes with all diameter in uncracked concrete		
2a		Remove drill core at least up to the nominal drill hole depth and check drill hole depth.
2b		Flush drill hole with water, starting from the bottom until clear water gets out of the drill hole.
2c		Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush ≥ $d_{b,min}$ (Table B4) a minimum of **two** times. If the drillhole ground is not reached with the brush, an appropriate brush extension must be used.
2d		Flush drill hole again with water, starting from the bottom until clear water gets out of the drill hole.
2e		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) again a minimum of **two** times until return air stream is free of noticeable dust. If the drillhole ground is not reached, an extension must be used.
2f		Check brush diameter (Table B4). Brush the hole again with an appropriate sized wire brush ≥ $d_{b,min}$ (Table B4) a minimum of **two** times. If the drillhole ground is not reached with the brush, an appropriate brush extension must be used.
2g		Starting from the bottom or back of the drill hole, blow out the hole with compressed air (min. 6 bar) again a minimum of **two** times until return air stream is free of noticeable dust. If the drillhole ground is not reached, an extension must be used.

Installation instructions (continuation)

Injection		
3		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		Prior to inserting the rod into the filled drillhole, the position of the embedment depth shall be marked on the threaded rod or rebar.
5		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 or red colour.
6		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 as the hole fills to avoid air pockets. If the drill hole ground is not reached, an appropriate extension nozzle shall be used. Observe temperature dependent working times given in Table B6.
7		Retaining washer and mixer nozzle extensions shall be used according to Table B5 for the following applications: • Horizontal installation (horizontal direction) and ground installation (vertical downwards direction): Drill bit-Ø $d_0 \geq 18$ mm and anchorage depth $h_{ef} > 250$mm • Overhead installation: Drill bit-Ø $d_0 \geq 18$ mm

Installation instructions (continuation)

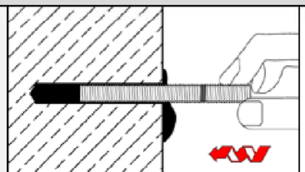
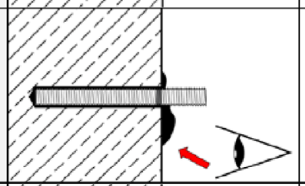
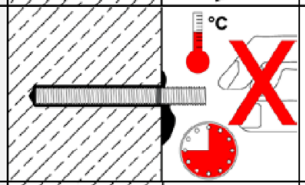
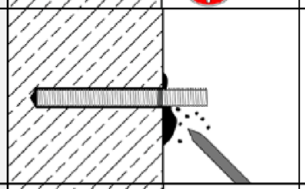
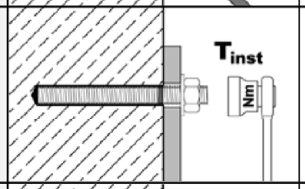
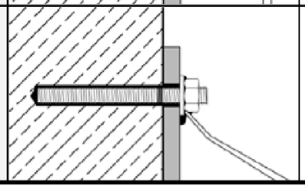
Setting the fastening element		
8		Push the threaded rod or reinforcing bar into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached. The anchor shall be free of dirt, grease, oil or other foreign material.
9		Make sure that excess mortar is visible at the top of the hole and in case of through-setting installation also in the fixture. If these requirements are not maintained, repeat application before end of working time! For overhead installation, the anchor should be fixed (e.g. by wedges).
10		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).
11		Remove excess mortar.
12		The fixture can be mounted after curing time. Apply installation torque T_{inst} according to Table B1 or B2.
13		In case of pre-setting installation the annular gap between anchor rod and fixture can optionally be filled with mortar. Therefore, replace regular washer by washer with drill and plug on reducing adapter on static mixer. Annular gap is completely filled, when excess mortar seeps out.

Table C1: Characteristic **steel resistance** for **threaded rods** under **tension load**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Cross sectional area		A_s	[mm²]	36,6	58,0	84,3	157	245	353	459	561
Characteristic resistance under tension load [1]											
Steel, zinc plated	Property class 4.6 and 4.8	$N_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
	Property class 5.6 and 5.8	$N_{Rk,s}$	[kN]	18 (17)	29 (27)	42	78	122	176	230	280
	Property class 8.8	$N_{Rk,s}$	[kN]	29 (27)	46 (43)	67	125	196	282	368	449
Stainless steel	A2, A4 and HCR Property class 50	$N_{Rk,s}$	[kN]	18	29	42	79	123	177	230	281
	A2, A4 and HCR Property class 70	$N_{Rk,s}$	[kN]	26	41	59	110	171	247	-[3]	-[3]
	A4 and HCR Property class 80	$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-[3]	-[3]
Partial factors [2]											
Steel, zinc plated	Property class 4.6	$\gamma_{Ms,N}$	[-]	2,0							
	Property class 4.8	$\gamma_{Ms,N}$	[-]	1,5							
	Property class 5.6	$\gamma_{Ms,N}$	[-]	2,0							
	Property class 5.8	$\gamma_{Ms,N}$	[-]	1,5							
	Property class 8.8	$\gamma_{Ms,N}$	[-]	1,5							
Stainless steel	A2, A4 and HCR Property class 50	$\gamma_{Ms,N}$	[-]	2,86							
	A2, A4 and HCR Property class 70	$\gamma_{Ms,N}$	[-]	1,87						-[3]	-[3]
	A4 and HCR Property class 80	$\gamma_{Ms,N}$	[-]	1,6						-[3]	-[3]

1) the characteristic resistances apply for all anchor rods with the cross sectional area A_s 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.

2) in absence of national regulation

3) Anchor type not part of the ETA

Table C2: Characteristic **steel resistance** for **threaded rods** under **shear load**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Cross sectional area		A_s	[mm²]	36,6	58,0	84,3	157	245	353	459	561
Characteristic resistance under shear load [1]											
Steel failure without lever arm											
Steel, zinc plated	Property class 4.6 and 4.8	$V^0_{Rk,s}$	[kN]	9 (8)	14 (13)	20	38	59	85	110	135
	Property class 5.6 and 5.8	$V^0_{Rk,s}$	[kN]	11 (10)	17 (16)	25	47	74	106	138	168
	Property class 8.8	$V^0_{Rk,s}$	[kN]	15 (13)	23 (21)	34	63	98	141	184	224
Stainless steel	A2, A4 and HCR, property class 50	$V^0_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
	A2, A4 and HCR, property class 70	$V^0_{Rk,s}$	[kN]	13	20	30	55	86	124	-	-
	A4 and HCR, property class 80	$V^0_{Rk,s}$	[kN]	15	23	34	63	98	141	-	-
Steel failure with lever arm											
Steel, zinc plated	Property class 4.6 and 4.8	$M^0_{Rk,s}$	[Nm]	15 (13)	30 (27)	52	133	260	449	666	900
	Property class 5.6 and 5.8	$M^0_{Rk,s}$	[Nm]	19 (16)	37 (33)	65	166	324	560	833	1123
	Property class 8.8	$M^0_{Rk,s}$	[Nm]	30 (26)	60 (53)	105	266	519	896	1333	1797
Stainless steel	A2, A4 and HCR, property class 50	$M^0_{Rk,s}$	[Nm]	19	37	66	167	325	561	832	1125
	A2, A4 and HCR, property class 70	$M^0_{Rk,s}$	[Nm]	26	52	92	232	454	784	-[3]	-[3]
	A4 and HCR, property class 80	$M^0_{Rk,s}$	[Nm]	30	59	105	266	519	896	-[3]	-[3]
Partial factor [2]											
Steel, zinc plated	Property class 4.6	$\gamma_{Ms,V}$	[-]	1,67							
	Property class 4.8	$\gamma_{Ms,V}$	[-]	1,25							
	Property class 5.6	$\gamma_{Ms,V}$	[-]	1,67							
	Property class 5.8	$\gamma_{Ms,V}$	[-]	1,25							
	Property class 8.8	$\gamma_{Ms,V}$	[-]	1,25							
Stainless steel	A2, A4 and HCR, property class 50	$\gamma_{Ms,V}$	[-]	2,38							
	A2, A4 and HCR, property class 70	$\gamma_{Ms,V}$	[-]	1,56						-[3]	-[3]
	A4 and HCR, property class 80	$\gamma_{Ms,V}$	[-]	1,33						-[3]	-[3]

1) the characteristic resistances apply for all anchor rods with the cross sectional area A_s 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.

2) in absence of national regulation

3) Anchor type not part of the ETA

Table C3: Characteristic values for **concrete cone** and **splitting failure**

Threaded rods / Internally threaded anchor rods / Rebars				**all sizes**
Concrete cone failure				
Factor k_1	uncracked concrete	$k_{ucr,N}$	[-]	11,0
	cracked concrete	$k_{cr,N}$	[-]	7,7
Edge distance		$c_{cr,N}$	[mm]	$1,5 \cdot h_{ef}$
Spacing		$s_{cr,N}$	[mm]	$2 \cdot c_{cr,N}$
Splitting failure				
Characteristic resistance		$N^0_{Rk,sp}$	[kN]	min ($N_{Rk,p}$; $N^0_{Rk,c}$)
Edge distance	$h/h_{ef} \geq 2,0$	$c_{cr,sp}$	[mm]	$1,0 \cdot h_{ef}$
	$2,0 > h/h_{ef} > 1,3$			$2 \cdot h_{ef} (2,5 - h / h_{ef})$
	$h/h_{ef} \leq 1,3$			$2,4 \cdot h_{ef}$
Spacing		$s_{cr,sp}$	[mm]	$2 \cdot c_{cr,sp}$

Table C4: Characteristic values of **tension load** for **threaded rods, static** and **quasi-static action,** working life **50 years**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic 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: 40°C / 24°C	hammer- or compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	20	20	19	19	18	17	16	16
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	15	15	15	14	13	13	12	12
Temperature range I: 40°C / 24°C	vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	17 (16)[1]	16	16	16 (15)[1]	15	14	14	13
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	13	13	12	12	11
Characteristic bond resistance in cracked concrete C20/25											
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0
Reductionfactor ψ^0_{sus} in concrete C20/25											
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	ψ^0_{sus}	[-]	0,80							
Temperature range II: 72°C / 50°C		ψ^0_{sus}	[-]	0,68							
Increasing factors for concrete	C25/30	ψ_c	[-]	1,02							
	C30/37		[-]	1,04							
	C35/45		[-]	1,07							
	C40/50		[-]	1,08							
	C45/55		[-]	1,09							
	C50/60		[-]	1,10							
Concrete cone failure											
Relevant parameter				see Table C3							
Splitting failure											
Relevant parameter				see Table C3							
Installation factor											
dry or wet concrete		γ_{inst}	[-]	1,0							
waterfilled drill hole		γ_{inst}	[-]	1,2							

[1] value in brackets: characteristic bond resistance for waterfilled drill holes

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

Annex C4

Table C5: Characteristic values of **tension load** for **threaded rods, static** and **quasi-static action,** working life **100 years**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic 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: 40°C / 24°C	Hammer- or compressed air drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	20	20	19	19	18	17	16	16
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr,100}$	[N/mm²]	15	15	15	14	13	13	12	12
Temperature range I: 40°C / 24°C	Vacuum drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	17 (16)[1]	16	16	16 (15)[1]	15	14	14	13
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr,100}$	[N/mm²]	14	14	14	13	13	12	12	11
Characteristic bond resistance in cracked concrete C20/25											
Temperature range I: 40°C / 24°C	Hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr,100}$	[N/mm²]	6,5	6,5	7,5	7,5	7,5	7,5	7,5	7,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,cr,100}$	[N/mm²]	5,5	5,5	6,5	6,5	6,5	6,5	6,5	6,5
Increasing factors for concrete	C25/30	ψ_c	[-]	1,02							
	C30/37		[-]	1,04							
	C35/45		[-]	1,07							
	C40/50		[-]	1,08							
	C45/55		[-]	1,09							
	C50/60		[-]	1,10							
Concrete cone failure											
Relevant parameter				see Table C3							
Splitting failure											
Relevant parameter				see Table C3							
Installation factor											
dry or wet concrete		γ_{inst}	[-]	1,0							
waterfilled drill hole		γ_{inst}	[-]	1,2							

[1] Value in brackets: characteristic bond resistance for waterfilled drill holes

Injection System VME plus

Performance
Characteristic values of **tension loads** for **threaded rods,** working life **100 years**

Annex C5

Table C6: Characteristic values of **tension load** for **threaded rods, static** and **quasi-static action,** working life **50** and **100 years, diamond drilling** in uncracked concrete

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic 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											Working life **50 years**
Temperature range I: 40°C / 24°C	diamond drilling	$\tau_{Rk,ucr}$	[N/mm²]	15	14	14	13	12	12	11	11
Temperature range II: 72°C / 50°C	diamond drilling	$\tau_{Rk,ucr}$	[N/mm²]	12	12	11	10	9,5	9,5	9,0	9,0
Reduction factor ψ^0_{sus} in uncracked concrete C20/25											
Temperature range I: 40°C / 24°C	diamond drilling	ψ^0_{sus}	[-]	0,77							
Temperature range II: 72°C / 50°C	diamond drilling	ψ^0_{sus}	[-]	0,72							
Characteristic bond resistance in uncracked concrete C20/25											Working life **100 years**
Temperature range I: 40°C / 24°C	diamond drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	15	14	14	13	12	12	11	11
Temperature range II: 72°C / 50°C	diamond drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	11	11	10	10	9,5	9,0	8,5	8,5
Increasing factors for concrete	C25/30	ψ_c	[-]	1,04							
	C30/37		[-]	1,08							
	C35/45		[-]	1,12							
	C40/50		[-]	1,15							
	C45/55		[-]	1,17							
	C50/60		[-]	1,19							
Concrete cone failure											
Relevant parameter				see Table C3							
Splitting failure											
Relevant parameter				see Table C3							
Installation factor											
dry or wet concrete		γ_{inst}	[-]	1,0							
waterfilled drill hole		γ_{inst}	[-]	1,2			1,4				

Injection System VME plus

Performance
Characteristic values of **tension loads** for **threaded rods,** working life **50** and **100 years, diamond drilling**

Annex C6

Table C7: Characteristic values of **shear loads** for **threaded rods, static** and **quasi-static action**

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure <u>without</u> lever arm										
Characteristic shear resistance Steel, property class 4.6, 4.8, 5.6 and 5.8	$V^0_{Rk,s}$	[kN]	$0{,}6 \cdot A_s \cdot f_{uk}$ or see Table C2							
Characteristic shear resistance Steel, property class 8.8 Stainless steel A2, A4 and HCR (all property classes)	$V^0_{Rk,s}$	[kN]	$0{,}5 \cdot A_s \cdot f_{uk}$ or see Table C2							
Ductility factor	k_7	[-]	1,0							
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C2							
Steel failure <u>with</u> lever arm										
Characteristic bending resistance	$M^0_{Rk,s}$	[Nm]	$1{,}2 \cdot W_{el} \cdot f_{uk}$ or see Table C2							
Elastic section modulus	W_{el}	[mm³]	31	62	109	277	541	935	1387	1874
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C2							
Concrete pry-out failure										
Pry-out factor	k_8	[-]	2,0							
Concrete edge failure										
Effective length of anchor	l_f	[mm]	$\min(h_{ef};12\,d_{nom})$						$\min(h_{ef};300\text{mm})$	
Outside diameter of anchor	d_{nom}	[mm]	8	10	12	16	20	24	27	30
Installation factor	γ_{inst}	[-]	1,0							

Table C8: Characteristic values of **tension 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**
Tension loads											
Steel failure											
Characteristic resistance **C1**		$N_{Rk,s,C1}$	[kN]	$1,0 \cdot N_{Rk,s}$							
Characteristic resistance **C2** steel, zinc plated, property class 8.8 stainless steel A4 and HCR, property class ≥ 70		$N_{Rk,s,C2}$	[kN]	-[1]		$1,0 \cdot N_{Rk,s}$				-[1]	
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C1							
Combined pull-out and concrete failure											
Characteristic bond resistance in concrete C20/25 to C50/60											
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,C1}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5
		$\tau_{Rk,C2}$	[N/mm²]	-[1]		5,8	4,8	5,0	5,1	-[1]	
Temperature range II: 72°C / 50°C		$\tau_{Rk,C1}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0
		$\tau_{Rk,C2}$	[N/mm²]	-[1]		5,0	4,1	4,3	4,4	-[1]	
Installation factor											
Dry or wet concrete		γ_{inst}	[-]	1,0							
Waterfilled drill hole		γ_{inst}	[-]	1,2							

[1] No performance assessed

Table C9: Characteristic values of **shear loads** for **threaded rods, seismic action** (performance category **C1 + C2**)

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Shear loads											
Steel failure <u>without</u> lever arm											
Characteristic resistance **C1**		$V_{Rk,s,C1}$	[kN]	$0,7 \cdot V^0_{Rk,s}$							
Characteristic resistance **C2** steel, zinc plated, property class 8.8 stainless steel A4 and HCR, property class ≥ 70		$V_{Rk,s,C2}$	[kN]	-[1]		$0,7 \cdot V^0_{Rk,s}$				-[1]	
Partial factor		$\gamma_{Ms,N}$	[-]	see Table C2							
Factor for anchorages	without annular gap	α_{gap}	[-]	1,0							
	with annular gap between threaded rod and fixture			0,5							

[1] No performance assessed

Injection System VME plus

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

Annex C8

Table C10: Characteristic values of **tension loads** for **internally threaded anchor rod, static** and **quasi-static action,** working life **50 years**

Internally threaded anchor rod				**VMU-IG M 6**	**VMU-IG M 8**	**VMU-IG M 10**	**VMU-IG M 12**	**VMU-IG M 16**	**VMU-IG M 20**
Steel failure [1]									
Characteristic resistance, steel, zinc plated, property 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 5.8 and 8.8		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic resistance, Stainless steel A4 / HCR, property class 70		$N_{Rk,s}$	[kN]	14	26	41	59	110	124 [2]
Partial factor		$\gamma_{Ms,N}$	[-]	1,87					2,86
Combined pull-out and concrete failure									
Characteristic bond resistance in <u>uncracked</u> concrete C20/25									
Temperature range I: 40°C / 24°C	hammer- or compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	20	19	19	18	17	16
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	15	15	14	13	13	12
Temperature range I: 40°C / 24°C	vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	16	16	16 (15)[3]	15	14	13
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	14	14	13	13	12	11
Characteristic bond resistance in <u>cracked</u> concrete C20/25									
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr}$	[N/mm²]	7,0	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	7,0	7,0	7,0	7,0	7,0
Reductionfactor ψ^0_{sus}									
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	ψ^0_{sus}	[-]	0,80					
Temperature range II: 72°C / 50°C		ψ^0_{sus}	[-]	0,68					
Increasing factor for concrete		ψ_c	C25/30	1,02					
			C30/37	1,04					
			C35/45	1,07					
			C40/50	1,08					
			C45/55	1,09					
			C50/60	1,10					
Concrete cone failure									
Relevant parameter				see Table C3					
Splitting failure									
Relevant parameter				see Table C3					
Installation factor									
dry or wet concrete		γ_{inst}	[-]	1,0					
waterfilled drill hole		γ_{inst}	[-]	1,2					

[1] Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod. The characteristic tension resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element.

[2] for VMU-IG M20: property class 50

[3] value in bracket is valid for waterfilled drill hole

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

Internally threaded anchor rod				**VMU-IG M 6**	**VMU-IG M 8**	**VMU-IG M 10**	**VMU-IG M 12**	**VMU-IG M 16**	**VMU-IG M 20**
Steel failure [1]									
Characteristic resistance, steel, zinc plated, property 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 5.8 and 8.8		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic resistance, Stainless steel A4 / HCR, property class 70		$N_{Rk,s}$	[kN]	14	26	41	59	110	124 [2]
Partial factor		$\gamma_{Ms,N}$	[-]	1,87					2,86
Combined pull-out and concrete failure									
Characteristic bond resistance in <u>uncracked</u> concrete C20/25									
Temperature range I: 40°C / 24°C	hammer- or compressed air drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	20	19	19	18	17	16
Temperature range II: 72°C / 50°C	hammer- or compressed air drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	15	15	14	13	13	12
Temperature range I: 40°C / 24°C	vacuum drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	16	16	16 (15)[3]	15	14	13
Temperature range II: 72°C / 50°C	vacuum drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	14	14	13	13	12	11
Characteristic bond resistance in <u>cracked</u> concrete C20/25									
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr,100}$	[N/mm²]	6,5	7,5	7,5	7,5	7,5	7,5
Temperature range II: 72°C / 50°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr,100}$	[N/mm²]	5,5	6,5	6,5	6,5	6,5	6,5
Increasing factor for concrete		ψ_c	C25/30	1,02					
			C30/37	1,04					
			C35/45	1,07					
			C40/50	1,08					
			C45/55	1,09					
			C50/60	1,10					
Concrete cone failure									
Relevant parameter				see Table C3					
Splitting failure									
Relevant parameter				see Table C3					
Installation factor									
dry or wet concrete		γ_{inst}	[-]	1,0					
waterfilled drill hole		γ_{inst}	[-]	1,2					

[1] fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod. The characteristic tension resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element.

[2] for VMU-IG M20: property class 50

[3] value in bracket is valid for waterfilled drill hole

Table C12: Characteristic values of **tension loads** for **internally threaded anchor rod, static** and **quasi-static action,** working life **50 and 100 years, diamond drilling**

Internally threaded anchor rod					**VMU-IG M 6**	**VMU-IG M 8**	**VMU-IG M 10**	**VMU-IG M 12**	**VMU-IG M 16**	**VMU-IG M 20**
Steel failure [1]										
Characteristic resistance, steel, zinc plated, property 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 5.8 and 8.8		$\gamma_{Ms,N}$	[-]		1,5					
Characteristic resistance, stainless steel A4 / HCR, property class 70		$N_{Rk,s}$	[kN]		14	26	41	59	110	124 [2]
Partial factor		$\gamma_{Ms,N}$	[-]		1,87					2,86
Combined pull-out and concrete failure										
Characteristic bond resistance in uncracked concrete C20/25										**Working life 50 years**
Temperature range I: 40°C / 24°C	diamond drilling	$\tau_{Rk,ucr}$	[N/mm²]		14	14	13	12	12	11
Temperature range II: 72°C / 50°C	diamond drilling	$\tau_{Rk,ucr}$	[N/mm²]		12	11	10	9,5	9,5	9,0
Reduktionsfaktor ψ^0_{sus}										
Temperature range I: 40°C / 24°C	diamond drilling	ψ^0_{sus}	[-]		0,77					
Temperature range II: 72°C / 50°C	diamond drilling	ψ^0_{sus}	[-]		0,72					
Characteristic bond resistance in uncracked concrete C20/25										**Working life 100 years**
Temperature range I: 40°C / 24°C	diamond drilling	$\tau_{Rk,ucr,100}$	[N/mm²]		14	14	13	12	12	11
Temperature range II: 72°C / 50°C	diamond drilling	$\tau_{Rk,ucr,100}$	[N/mm²]		11	10	10	9,5	9,0	8,5
Increasing factor for $\tau_{Rk,ucr}$		ψ_c		C25/30	1,04					
				C30/37	1,08					
				C35/45	1,12					
				C40/50	1,15					
				C45/55	1,17					
				C50/60	1,19					
Concrete cone failure										
Relevant parameter					see Table C3					
Splitting failure										
Relevant parameter					see Table C3					
Installation factor										
dry or wet concrete		γ_{inst}	[-]		1,0					
waterfilled drill hole		γ_{inst}	[-]		1,2		1,4			

[1] fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod. The characteristic tension resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element.

[2] for VMU-IG M20: property class 50

[3] value in bracket is valid for waterfilled drill hole

Table C13: Characteristic values of **shear loads** for **internally threaded anchor rod, static** and **quasi-static action**

Internally threaded anchor rod					**VMU-IG M 6**	**VMU-IG M 8**	**VMU-IG M 10**	**VMU-IG M 12**	**VMU-IG M 16**	**VMU-IG M 20**
Steel failure without lever arm [1]										
Steel, zinc plated	Characteristic resistance, property class	5.8	$V^0_{Rk,s}$	[kN]	6	10	17	25	45	74
		8.8	$V^0_{Rk,s}$	[kN]	8	14	23	34	60	98
	Partial factor 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic resistance, A4 / HCR, property class 70		$V^0_{Rk,s}$	[kN]	7	13	20	30	55	62 [2]
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Ductility factor			k_7	[-]	1,0					
Steel failure with lever arm [1]										
Steel, zinc plated	Characteristic bending resistance, property 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 5.8 and 8.8		$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic bending resistance A4 / HCR, property class 70		$M^0_{Rk,s}$	[Nm]	11	26	53	92	234	643 [2]
	Partial factor		$\gamma_{Ms,V}$	[-]	1,56					2,38
Concrete pry-out failure										
Pry-out factor			k_8	[-]	2,0					
Concrete edge failure										
Effective length of anchor			l_f	[mm]	min (h_{ef};12 d_{nom})					min (h_{ef}; 300mm)
Outside diameter of anchor			d_{nom}	[mm]	10	12	16	20	24	30
Installation factor			γ_{inst}	[-]	1,0					

[1] 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: VMU-IG M20). The characteristic shear resistance for steel failure of the given strength class are valid for the internally threaded anchor rod and the fastening element.

[2] for VMU-IG M20: Internally threaded rod: property class 50;
Fastening screws or threaded rods (incl. nut and washer): property class 70

Table C14: Characteristic values of **tension loads** for **rebar, static** and **quasi-static action,** working life **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 sectional 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: 40°C / 24°C	hammer- and compressed air drilling	$\tau_{Rk,ucr}$	[N/mm²]	16	16	16	16	16	16	15	15	15	15
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	12	12	12	12	12	12	12	12	11	11
Temperature range I: 40°C / 24°C	vacuum drilling	$\tau_{Rk,ucr}$	[N/mm²]	14 (13)[3]	14 (13)[3]	13	13	13	13	13	13	13	13
Temperature range II: 72°C / 50°C		$\tau_{Rk,ucr}$	[N/mm²]	12 (11)[3]	12 (11)[3]	12 (11)[3]	11	11	11	11	11	11	11
Characteristic bond resistance in cracked concrete C20/25													
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Reductionfactor ψ^0_{sus}													
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	ψ^0_{sus}	[-]	0,80									
Temperature range II: 72°C / 50°C		ψ^0_{sus}	[-]	0,68									
Increasing factor for concrete		ψ_c	C25/30	1,02									
			C30/37	1,04									
			C35/45	1,07									
			C40/50	1,08									
			C45/55	1,09									
			C50/60	1,10									
Concrete cone failure													
Relevant parameter				see Table C3									
Splitting failure													
Relevant parameter				see Table C3									
Installation factor													
dry or wet concrete		γ_{inst}	[-]	1,0									
waterfilled drill hole		γ_{inst}	[-]	1,2									

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of national regulation
[3] value in brackets: characteristic bond resistance for waterfilled drill holes

Table C15: Characteristic values of **tension loads** for **rebar, static** and **quasi-static action,** working life **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 sectional 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 <u>uncracked</u> concrete C20/25													
Temperature range I: 40°C / 24°C	hammer- and compressed air drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	16	16	16	16	16	16	15	15	15	15
Temperature range II: 72°C / 50°C	hammer- and compressed air drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	12	12	12	12	12	12	12	12	11	11
Temperature range I: 40°C / 24°C	vacuum drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	14 (13)[3]	14 (13)[3]	13	13	13	13	13	13	13	13
Temperature range II: 72°C / 50°C	vacuum drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	12 (11)[3]	12 (11)[3]	12 (11)[3]	11	11	11	11	11	11	11
Characteristic bond resistance in <u>cracked</u> concrete C20/25													
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr,100}$	[N/mm²]	6,5	6,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5
Temperature range II: 72°C / 50°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,cr,100}$	[N/mm²]	5,5	5,5	6,5	6,5	6,5	6,5	6,5	6,5	6,5	6,5
Increasing factor for concrete		ψ_c	C25/30	1,02									
			C30/37	1,04									
			C35/45	1,07									
			C40/50	1,08									
			C45/55	1,09									
			C50/60	1,10									
Concrete cone failure													
Relevant parameter				see Table C3									
Splitting failure													
Relevant parameter				see Table C3									
Installation factor													
dry or wet concrete		γ_{inst}	[-]	1,0									
waterfilled drill hole		γ_{inst}	[-]	1,2									

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of national regulation
[3] value in brackets: characteristic bond resistance for waterfilled drill holes

Table C16: Characteristic values of **tension loads** for **rebar, static** and **quasi-static action,** working life **50 and 100 years, diamond drilling**

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 sectional 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												**Working life 50 years**	
Temperature range I: 40°C / 24°C	diamond drilling	$\tau_{Rk,ucr}$	[N/mm²]	14	13	13	13	12	12	11	11	11	11
Temperature range II: 72°C / 50°C	diamond drilling	$\tau_{Rk,ucr}$	[N/mm²]	11	11	10	10	10	9,5	9,5	9,5	9,0	9,0
Reductionfactor ψ^0_{sus}													
Temperature range I: 40°C / 24°C	diamond drilling	ψ^0_{sus}	[-]	0,77									
Temperature range II: 72°C / 50°C	diamond drilling	ψ^0_{sus}	[-]	0,72									
Characteristic bond resistance in uncracked concrete C20/25												**Working life 100 years**	
Temperature range I: 40°C / 24°C	diamond drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	14	13	13	13	12	12	11	11	11	11
Temperature range II: 72°C / 50°C	diamond drilling	$\tau_{Rk,ucr,100}$	[N/mm²]	11	10	10	10	9,5	9,0	9,0	9,0	8,5	8,5
Increasing factor for concrete	ψ_c		C25/30	1,04									
			C30/37	1,08									
			C35/45	1,12									
			C40/50	1,15									
			C45/55	1,17									
			C50/60	1,19									
Concrete cone failure													
Relevant parameter				see Table C3									
Splitting failure													
Relevant parameter				see Table C3									
Installation factor													
dry or wet concrete	γ_{inst}		[-]	1,0									
waterfilled drill hole	γ_{inst}		[-]	1,2				1,4					

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

Table C17: Characteristic values of **shear loads** for **rebar, static** and **quasi-static action**

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 arm												
Characteristic shear resistance	$V^0_{Rk,s}$	[kN]	$0{,}50 \cdot A_s \cdot f_{uk}$ [1]									
Cross sectional 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 <u>with</u> lever arm												
Characteristic bending resistance	$M^0_{Rk,s}$	[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												
Pry-out factor	k_8	[-]	2,0									
Concrete edge failure												
Effective length of rebar	l_f	[mm]	min (h_{ef};12 d_{nom})							min (h_{ef}; 300mm)		
Outside diameter of rebar	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

Table C18: Characteristic values of **tension load** for **rebar, seismic action** (performance category **C1**), working life **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 resistance		$N_{Rk,s,C1}$	[kN]	$A_s \cdot f_{uk}$ [1]									
Cross sectional 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 concrete C20/25 to C50/60													
Temperature range I: 40°C / 24°C	hammer-, compressed air or vacuum drilling	$\tau_{Rk,C1}$	[N/mm²]	7,0	7,0	8,5	8,5	8,5	8,5	8,5	8,5	8,5	8,5
Temperature range II: 72°C / 50°C		$\tau_{Rk,C1}$	[N/mm²]	6,0	6,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0	7,0
Installation factor													
dry or wet concrete		γ_{inst}	[-]	1,0									
waterfilled drill hole		γ_{inst}	[-]	1,2									

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

Table C19: Characteristic values of **shear loads** for **rebar, seismic action** (performance category **C1**)

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 arm												
Characteristic resistance	$V_{Rk,s,C1}$	[kN]	$0,35 \cdot A_s \cdot f_{uk}$ [1]									
Cross sectional 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									

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

Table C20: Displacements under tension load, threaded rod

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Hammer-, compressed air or vacuum drilling										
Displacement factor[1)] Uncracked concrete, static and quasi-static action, working life 50 and 100 years										
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,028	0,029	0,030	0,033	0,035	0,038	0,039	0,041
	$\delta_{N\infty}$- factor		0,028	0,029	0,030	0,033	0,035	0,038	0,039	0,041
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,038	0,039	0,040	0,044	0,047	0,051	0,052	0,055
	$\delta_{N\infty}$- factor		0,047	0,049	0,051	0,055	0,059	0,064	0,067	0,070
Displacement factor[1)] Cracked concrete, static and quasi-static action, working life 50 and 100 years										
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,069	0,071	0,072	0,074	0,076	0,079	0,081	0,082
	$\delta_{N\infty}$- factor		0,100	0,115	0,122	0,128	0,135	0,142	0,155	0,171
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,092	0,095	0,096	0,099	0,102	0,106	0,109	0,110
	$\delta_{N\infty}$- factor		0,134	0,154	0,163	0,172	0,181	0,189	0,207	0,229
Displacement Uncracked and cracked concrete, seismic action (C2)										
All temperature ranges	$\delta_{N,C2\ (DLS)}$	[mm]	-[2)]		0,21	0,24	0,27	0,36	-[2)]	
	$\delta_{N,C2\ (ULS)}$				0,54	0,51	0,54	0,63		
Diamond drilling										
Displacement factor[1)] Uncracked concrete, static and quasi-static action, working life 50 years										
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,011	0,012	0,012	0,013	0,014	0,014	0,015	0,015
	$\delta_{N\infty}$- factor		0,018	0,019	0,019	0,020	0,022	0,023	0,024	0,025
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,013	0,014	0,014	0,015	0,016	0,016	0,018	0,018
	$\delta_{N\infty}$- factor		0,052	0,053	0,055	0,058	0,062	0,065	0,068	0,070
Displacement factor[1)] Uncracked concrete, static and quasi-static action, working life 100 years										
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,011	0,012	0,012	0,013	0,014	0,014	0,015	0,015
	$\delta_{N\infty}$- factor		0,020	0,021	0,021	0,023	0,024	0,025	0,026	0,027
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,013	0,014	0,014	0,015	0,016	0,016	0,018	0,018
	$\delta_{N\infty}$- factor		0,038	0,039	0,040	0,043	0,045	0,047	0,049	0,051

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

[2)] No Performance assessed

Table C21: Displacements under shear load, threaded rod

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
All drilling methods										
Displacement factor[1)] Uncracked and cracked concrete, static and quasi-static action										
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		0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
Displacement Uncracked and cracked concrete, seismic action (C2)										
All temperature ranges	$\delta_{V,C2\ (DLS)}$	[mm]	-[2)]		3,1	3,4	3,5	4,2	-[2)]	
	$\delta_{V,C2\ (ULS)}$				6,0	7,6	7,3	10,9		

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

[2)] No Performance assessed

Table C22: Displacement factors[1] under **tension load**, internally threaded anchor rod

Internally threaded anchor rod			VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
Hammer-, compressed air or vaccum drilling								
Uncracked concrete, static and quasi-static action, working life 50 and 100 years								
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,029	0,030	0,033	0,035	0,038	0,041
	$\delta_{N\infty}$- factor		0,029	0,030	0,033	0,035	0,038	0,041
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,039	0,040	0,044	0,047	0,051	0,055
	$\delta_{N\infty}$- factor		0,049	0,051	0,055	0,059	0,064	0,070
Cracked concrete, static and quasi-static action, working life 50 and 100 years								
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,071	0,072	0,074	0,076	0,079	0,082
	$\delta_{N\infty}$- factor		0,115	0,122	0,128	0,135	0,142	0,171
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,095	0,096	0,099	0,102	0,106	0,110
	$\delta_{N\infty}$- factor		0,154	0,163	0,172	0,181	0,189	0,229
Diamond drilling								
Uncracked concrete, static and quasi-static action, working life 50 years								
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,012	0,012	0,013	0,014	0,014	0,015
	$\delta_{N\infty}$- factor		0,019	0,019	0,020	0,022	0,023	0,025
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,014	0,014	0,015	0,016	0,016	0,018
	$\delta_{N\infty}$- factor		0,053	0,055	0,058	0,062	0,065	0,070
Cracked concrete, static and quasi-static action, working life 100 years								
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,012	0,012	0,013	0,014	0,014	0,015
	$\delta_{N\infty}$- factor		0,021	0,021	0,023	0,024	0,025	0,027
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,014	0,014	0,015	0,016	0,016	0,018
	$\delta_{N\infty}$- factor		0,039	0,040	0,043	0,045	0,047	0,051

[1] Calculation of the displacement

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

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

Table C23: Displacement factors[1] under **shear load**, internally threaded anchor rod

Internally threaded anchor rod			VMU-IG M 6	VMU-IG M 8	VMU-IG M 10	VMU-IG M 12	VMU-IG M 16	VMU-IG M 20
Uncracked and cracked concrete, static and quasi-static action								
All temperature ranges	δ_{V0}- factor	[mm/(kN)]	0,07	0,06	0,06	0,05	0,04	0,04
	$\delta_{V\infty}$- factor		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: acting shear load

$\delta_{V\infty} = \delta_{V\infty}$- factor $\cdot$ V;

Injection System VME plus

Performance
Displacements (internally threaded anchor rod)

Annex C20

Table C24: Displacement factors[1)] under **tension load** (rebar)

Reinforcing bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Hammer-, compressed air or vaccum drilling												
Uncracked concrete, static and quasi-static action, working life 50 and 100 years												
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,028	0,029	0,030	0,031	0,033	0,035	0,038	0,038	0,040	0,043
	$\delta_{N\infty}$- factor		0,015	0,015	0,016	0,017	0,017	0,019	0,020	0,020	0,021	0,023
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,038	0,039	0,040	0,042	0,044	0,047	0,051	0,051	0,054	0,058
	$\delta_{N\infty}$- factor		0,047	0,049	0,051	0,053	0,055	0,059	0,065	0,065	0,068	0,072
Cracked concrete, static and quasi-static action, working life 50 and 100 years												
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,069	0,071	0,072	0,073	0,074	0,076	0,079	0,079	0,081	0,084
	$\delta_{N\infty}$- factor		0,115	0,122	0,128	0,135	0,142	0,155	0,171	0,171	0,181	0,194
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,092	0,095	0,096	0,098	0,099	0,102	0,106	0,106	0,109	0,113
	$\delta_{N\infty}$- factor		0,154	0,163	0,172	0,181	0,189	0,207	0,229	0,229	0,242	0,260
Diamond drilling												
Uncracked concrete, static and quasi-static action, working life 50 years												
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,008	0,009	0,009	0,010	0,011	0,012	0,013	0,013	0,014	0,015
	$\delta_{N\infty}$- factor		0,018	0,018	0,019	0,020	0,021	0,024	0,027	0,027	0,028	0,031
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,009	0,011	0,011	0,012	0,013	0,014	0,015	0,015	0,016	0,018
	$\delta_{N\infty}$- factor		0,048	0,051	0,054	0,058	0,061	0,068	0,076	0,076	0,081	0,088
Uncracked concrete, static and quasi-static action, working life 100 years												
Temperature range I: 40°C / 24°C	δ_{N0}- factor	$[\frac{mm}{N/mm^2}]$	0,008	0,009	0,009	0,010	0,011	0,012	0,013	0,013	0,014	0,015
	$\delta_{N\infty}$- factor		0,018	0,020	0,021	0,022	0,024	0,026	0,029	0,029	0,031	0,034
Temperature range II: 72°C / 50°C	δ_{N0}- factor		0,009	0,011	0,011	0,012	0,013	0,014	0,015	0,015	0,016	0,018
	$\delta_{N\infty}$- factor		0,035	0,037	0,040	0,042	0,045	0,049	0,055	0,055	0,059	0,064

[1)] Calculation of the displacement

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

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

Table C25: Displacement factors[1)] under **shear load** (rebar)

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, static and quasi-static action												
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		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

$\delta_{V0} = \delta_{V0}$- factor $\cdot$ V; V: acting shear load

$\delta_{V\infty} = \delta_{V\infty}$- factor $\cdot$ V;

Injection System VME plus

Performance
Displacements (rebar)

Annex C21