MKT®

...eine starke Verbindung

DECLARATION OF PERFORMANCE

DoP Nr.: **MKT-341** - en

- **Unique identification code of product-type:** **Injection System VMH for concrete**
- **Intended use/es:** Injection system for use in concrete, see Annex B
- **Manufacturer:** MKT Metall-Kunststoff-Technik GmbH & Co.KG, Auf dem Immel 2, 67685 Weilerbach
- **System/s of AVCP:** 1
- **European Assessment Document:** **EAD 330499-01-0601**
  - European Technical Assessment: **ETA-17/0716, 06.12.2018**
  - Technical Assessment Body: DIBt, Berlin
  - Notified body/ies: NB 1343 – MPA, Darmstadt
- **Declared performance/s:**

Essential characteristics	Performance
Mechanical resistance and stability (BWR1)	
Characteristic resistance to tension load (static and quasi-static loading)	Annex C1, C3, C5, C7
Characteristic resistance to shear load (static and quasi-static loading)	Annex C2, C4, C6, C8
Displacements (static and quasi-static loading)	Annex C9 – C11
Characteristic resistance for seismic performance category C1	Annex C3, C4, C7, C8
Characteristic resistance and displacements for seismic performance category C2	Annex C3, C4, C9
Hygiene, health and the environment (BWR3)	
Content, emission and/or release of dangerous substances	NPD (No Performance Determined)

The performance of the product identified above is in conformity with the set of declared performance/s.
This declaration of performance is issued, in accordance with Regulation (EU) No 305/2011, under the sole responsibility of the manufacturer identified above.

Signed for and on behalf of the manufacturer by:

Stefan Weustenhagen
(General manager)
Weilerbach, 06.12.2018

p.p. **Dipl.-Ing. Detlef Bigalke**
(Head of product development)

ETA CE

The original of this declaration of performance was written in German. In the event of deviations in the translation, the German version shall be valid.

Specification of intended use

Injection System VMH	Threaded rod	Internally threaded anchor rod	Rebar
Static or quasi-static action	M8 - M30 zinc plated, A2, A4, HCR	VMU-IG M6 - VMU-IG M20 electroplated, A4, HCR	Ø8 - Ø32
Seismic action, category C1	M8 - M30 zinc plated[1], A4, HCR	-	Ø8 - Ø32
Seismic action, category C2	M12 – M24 zinc plated[1] (property class 8.8) A4, HCR (poperty class ≥ 70)	-	-

Base materials	compacted, reinforced or unreinforced normal weight concrete (without fibers) acc. to EN 206:2013
	Strength classes acc. to EN 206:2013: C20/25 to C50/60
	Cracked or uncracked concrete
Temperature Range I -40 °C to +80 °C	max. long term temperature +50 °C and max. short term temperature +80 °C
Temperature Range II -40 °C to +120 °C	max. long term temperature +72 °C and max. short term temperature +120 °C
Temperature Range III -40 °C to +160 °C	max. long term temperature +100 °C and max. short term temperature +160 °C

[1] except hot-dip galvanised

Use conditions (Environmental conditions):

Structures subject to dry internal conditions	zinc plated steel, stainless steel A2 or A4 high corrosion resistant steel HCR
Structures subject to external atmospheric exposure (including industrial and marine environment) and to permanently damp internal condition, if no particular aggressive conditions exist	stainless steel A4 high corrosion resistant steel HCR
Structures subject to external atmospheric exposure and to permanently damp internal condition, if other particular aggressive conditions exist [2]	high corrosion resistant steel HCR

[2] Particular aggressive conditions are e.g. permanent, alternating immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g. in desulphurization plants or road tunnels where de-icing materials are used)

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

Installation:

- Dry or wet concrete or waterfilled boreholes (not seawater)
- Hole drilling by hammer or compressed air drill or vacuum drill mode
- Overhead installation allowed
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site
- 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[1]	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
Installation torque		$T_{inst} \leq$	[Nm]	10	20	40 (35)[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 applications under seismic loading the diameter of clearance hole in the fixture shall be at maximum d_{nom} + 1mm or alternatively the annular gap between fixture and threaded rod shall be completely filled with mortar

[2] Installation torque for M12 with steel grade 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
Installation torque	$T_{inst} \leq$	[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} + 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 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	d_0	[mm]	12	14	16	18	20	25	32	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

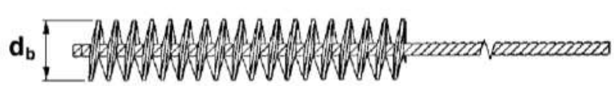
Table B4: Parameter cleaning and setting tools

Threaded rod	Internally threaded anchor rod	Rebar	Drill bit ⌀	Brush ⌀	min. Brush ⌀	Retaining washer	Installation direction and use		
[-]	[-]	⌀ [mm]	d_0 [mm]	d_b [mm]	$d_{b,min}$ [mm]	[-]	⬇	➡	⬆
M8			10	11,5	10,5	No **retaining washer** required			
M10	VMU-IG M 6	8	12	13,5	12,5				
M12	VMU-IG M 8	10	14	15,5	14,5				
		12	16	17,5	16,5				
M16	VMU-IG M10	14	18	20,0	18,5	VM-IA 18	h_{ef} > 250mm	h_{ef} > 250mm	all
		16	20	22,0	20,5	VM-IA 20			
M20	VMU-IG M12		22	24,0	22,5	VM-IA 22			
		20	25	27,0	25,5	VM-IA 25			
M24	VMU-IG M16		28	30,0	28,5	VM-IA 28			
M27			30	31,8	30,5	VM-IA 30			
		24/25	32	34,0	32,5	VM-IA 32			
M30	VMU-IG M20	28	35	37,0	35,5	VM-IA 35			
		32	40	43,5	40,5	VM-IA 40			

Blow-out pump (volume 750ml)
Drill bit diameter (d_0): 10 mm to 20 mm
Drill hole depth (h_0): ≤ 10 d_{nom}
for uncracked concrete

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

Retaining washer
Drill bit diameter (d_0):
18 mm to 40 mm

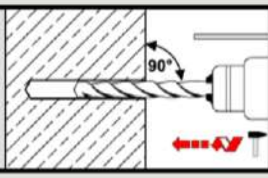


Steel brush
Drill bit diameter (d_0): all diameters

Installation Instructions

Drilling of the hole

1.



Drill with hammer drill or compressed air drill or vacuum drill a hole into the base material to the size required by the selected anchor (Table B1, B2 or B3). In case of aborted drill hole, the drill hole shall be filled with mortar.

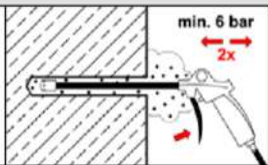
Cleaning

2.

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

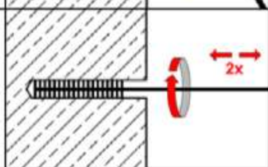
<u>Cleaning with compressed air</u>
Cracked and uncracked concrete, all diameters

2a.



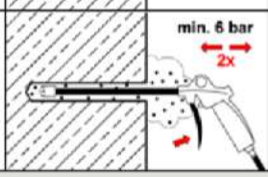
Starting from the bottom or back of the bore hole, blow out the hole with compressed air (min. 6 bar) a minimum of **two** times until return air stream is free of noticeable dust.
If the bore hole ground is not reached, an extension must be used.

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 bore hole ground is not reached with the brush, an appropriate brush extension must be used.

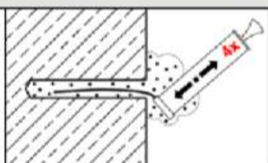
2c.



Starting from the bottom or back of the bore 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 bore hole ground is not reached, an extension must be used.

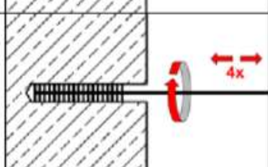
<u>Manual cleaning</u>
Drill hole diameter $d_0 \leq$ 20mm and drill hole depth $h_0 \leq 10\ d_{nom}$ (uncracked concrete only)

2a.



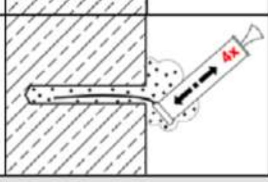
Starting from the bottom or back of the bore hole, blow out the hole with the blow-out pump a minimum of **four** times.

2b.



Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush ≥ $d_{b,min}$ (Table B4) a minimum of **four** times.
If the bore hole ground is not reached with the brush, an appropriate brush extension must be used.

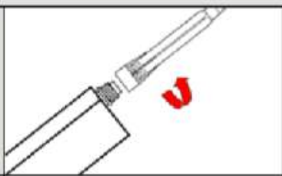
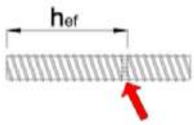
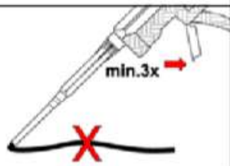
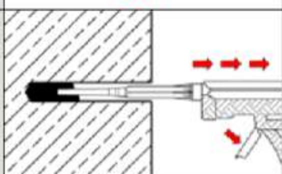
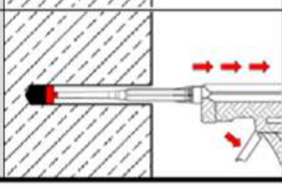
2c.



Starting from the bottom or back of the bore hole blow out the hole again a minimum of **four** times.

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

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 B5) as well as for new cartridges, a new static-mixer shall be used.
4.		Prior to inserting the rod into the filled bore hole, 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 colour.
6a.		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 bore hole ground is not reached, an appropriate extension nozzle shall be used. Observe working times given in Table B5.
6b.		Retaining washer and mixer nozzle extensions shall be used according to Table B4 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)

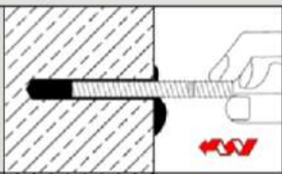
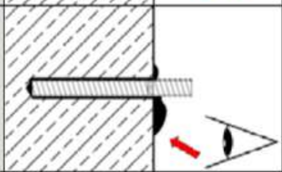
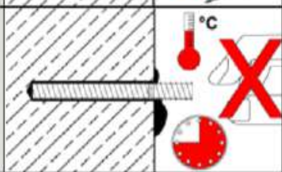
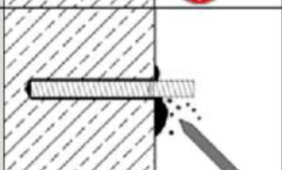
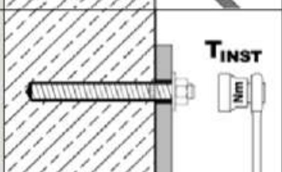
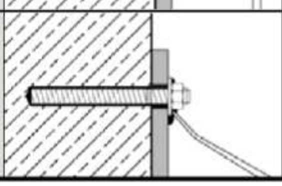
Inserting the anchor		
7.		Push the threaded rod or reinforcing bar into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached. The anchor shall be free of dirt, grease, oil or other foreign material.
8.		Make sure that excess mortar is visible at the top of the hole. 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).
9.		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 B5).
10.		Remove excess mortar.
11.		The fixture can be mounted after curing time. Apply installation torque T_{inst} according to Table B1 or B2.
12.		Annular gap between anchor rod and attachment may optionally be filled with mortar. Therefore, replace regular washer by washer with bore and plug on reducing adapter on static mixer. Annular gap is completely filled, when excess mortar seeps out.

Table B5: Working time and curing time

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

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

Threaded rod				M8	M10	M12	M16	M20	M24	M27	M30
Steel failure [1)]											
Cross sectional area		A_s	[mm²]	36,6	58,0	84,3	157	245	353	459	561
Characteristic resistance under tension load											
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	-	-
	A4 and HCR Property class 80	$N_{Rk,s}$	[kN]	29	46	67	126	196	282	-	-
Partial factor											
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						-	-
	A4 and HCR Property class 80	$\gamma_{Ms,N}$	[-]	1,6						-	-

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.

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

Threaded rod				M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30
Steel failure											
Cross sectional area		A_s	[mm²]	36,5	58,0	84,3	157	245	353	459	561
Characteristic resistances 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]	9 (8)	15 (13)	21	39	61	88	115	140
	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	-	-
	A4 and HCR, Property class 80	$M^0_{Rk,s}$	[Nm]	30	59	105	266	519	896	-	-
Partial factor											
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						-	-
	A4 and HCR, Property class 80	$\gamma_{Ms,V}$	[-]	1,33						-	-

[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

Table C3: Characteristic values of **tension loads** for **threaded rods** under static, quasi-static action and seismic action C1 + C2

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							
	$N_{Rk,s,eq,C1}$	[kN]	$1{,}0 \cdot N_{Rk,s}$							
	$N_{Rk,s,eq,C2}$	[kN]	NPA		$1{,}0 \cdot N_{Rk,s}$				NPA	
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: 80°C / 50°C	$\tau_{Rk,ucr}$	[N/mm²]	17	17	16	15	14	13	13	13
Temperature range II: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm²]	15	14	14	13	12	12	11	11
Temperature range III: 160°C / 100°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: 80°C / 50°C	$\tau_{Rk,cr} = \tau_{Rk,eq,C1}$	[N/mm²]	7,0	7,5	8,0	9,0	8,5	7,0	7,0	7,0
	$\tau_{Rk,eq\,C2}$	[N/mm²]	NPA		3,6	3,5	3,3	2,3	NPA	
Temperature range II: 120°C / 72°C	$\tau_{Rk,cr} = \tau_{Rk,eq\,C1}$	[N/mm²]	6,0	6,5	7,0	7,5	7,0	6,0	6,0	6,0
	$\tau_{Rk,eq\,C2}$	[N/mm²]	NPA		3,1	3,0	2,8	2,0	NPA	
Temperature range III: 160°C / 100°C	$\tau_{Rk,cr} = \tau_{Rk,eq\,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,0	5,5	5,5	5,5
	$\tau_{Rk,eq\,C2}$	[N/mm²]	NPA		2,5	2,7	2,5	1,8	NPA	
Increasing factors 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										
Factor k_1 – uncracked concrete	$k_{ucr,N}$	[-]	11,0							
Factor k_1 – cracked concrete	$k_{cr,N}$	[-]	7,7							
Splitting failure										
Edge distance – $h/h_{ef} \geq 2{,}0$	$c_{cr,sp}$	[mm]	$1{,}0\ h_{ef}$							
Edge distance – $2{,}0 > h/h_{ef} > 1{,}3$	$c_{cr,sp}$	[mm]	$2 \cdot h_{ef}\ (2{,}5 - h / h_{ef})$							
Edge distance – $h/h_{ef} \leq 1{,}3$	$c_{cr,sp}$	[mm]	$2{,}4\ h_{ef}$							
Spacing	$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$							
Installation factor										
Compressed air cleaning – dry or wet concrete	γ_{inst}	[-]	1,0							
Compressed air cleaning – water filled bore hole	γ_{inst}	[-]	1,4							
Manual cleaning – dry or wet concrete	γ_{inst}	[-]	1,2				NPA			

Table C4: Characteristic values of **shear loads** for **threaded rods** under static, quasi-static action and seismic action C1 + C2

Threaded rod			M8	M10	M12	M16	M20	M24	M27	M30
Steel failure without lever arm										
Characteristic shear resistance	$V^0_{Rk,s}$ 1)	[kN]	$0{,}5 \cdot A_s \cdot f_{uk}$ or see Table C2							
	$V_{Rk,s,eq,C1}$	[kN]	$0{,}70 \cdot V^0_{Rk,s}$							
	$V_{Rk,s,eq,C2}$	[kN]	NPA		$0{,}70 \cdot V^0_{Rk,s}$				NPA	
Ductility factor	k_7	[-]	1,0							
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C2							
Steel failure with lever arm										
Characteristic bending resistance	$M^0_{Rk,s}$	[Nm]	$1{,}2 \cdot W_{el} \cdot f_{uk}$ or see Table C2							
	$M^0_{Rk,s,eq,C1}$	[Nm]	No Performance Assessed (NPA)							
	$M^0_{Rk,s,eq,C2}$	[Nm]								
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}; 300mm)	
Outside diameter of anchor	d_{nom}	[mm]	8	10	12	16	20	24	27	30
Factor for annular gap: **without** annular gap filling	α_{gap}	[-]	0,5							
Factor for annular gap: **with** annular gap filling	α_{gap}	[-]	1,0							
Installation factor	γ_{inst}	[-]	1,0							

1) For property class 4.6 and 4.8: $V^0_{Rk,s} = 0{,}6 \cdot A_s \cdot f_{uk}$

Table C5: Characteristic values of **tension loads** for **internally threaded anchor rod** under static, 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 [1]									
Characteristic tension resistance, Steel, property class 5.8		$N_{Rk,s}$	[kN]	10	18	29	42	79	123
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension resistance, Steel, property class 8.8		$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension 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									
Temperature range	I: 80°C / 50°C	$\tau_{Rk,ucr}$	[N/mm²]	17	16	15	14	13	13
Temperature range	II: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm²]	14	14	13	12	12	11
Temperature range	III: 160°C / 100°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: 80°C / 50°C	$\tau_{Rk,cr}$	[N/mm²]	7,5	8,0	9,0	8,5	7,0	7,0
Temperature range	II: 120°C / 72°C	$\tau_{Rk,cr}$	[N/mm²]	6,5	7,0	7,5	7,0	6,0	6,0
Temperature range	III: 160°C / 100°C	$\tau_{Rk,cr}$	[N/mm²]	5,5	6,0	6,5	6,0	5,5	5,5
Increasing factors 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									
Factor k_1	uncracked concrete	$k_{ucr,N}$	[-]	11,0					
	cracked concrete	$k_{cr,N}$	[-]	7,7					
Splitting failure									
Edge distance	$h/h_{ef} \geq 2,0$	$c_{cr,sp}$	[mm]	$1,0\ h_{ef}$					
	$2,0 > h/h_{ef} > 1,3$			$2 \cdot h_{ef}\ (2,5 - h / h_{ef})$					
	$h/h_{ef} \leq 1,3$			$2,4\ h_{ef}$					
Spacing		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$					
Installation factor									
Compressed air cleaning	dry or wet concrete	γ_{inst}	[-]	1,0					
	waterfilled borehole	γ_{inst}	[-]	1,4					
Manual cleaning	dry or wet concrete	γ_{inst}	[-]	1,2			NPA		

[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

Table C6: Characteristic values of **shear loads** for **internally threaded anchor rod** under 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]	5	9	15	21	39	61
	Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
	Characteristic resistance, property class 8.8	$V^0_{Rk,s}$	[kN]	8	14	23	34	60	98
	Partial factor	$\gamma_{Ms,V}$	[-]	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 moment, property class 5.8	$M^0_{Rk,s}$	[Nm]	8	19	37	66	167	325
	Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
	Characteristic bending moment, property class 8.8	$M^0_{Rk,s}$	[Nm]	12	30	60	105	267	519
	Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Stainless steel	Characteristic bending moment, 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 C7: Characteristic values of **tension loads** for **rebar** under static, quasi-static action and seismic action 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													
Characteristic tension resistance		$N_{Rk,s} = N_{Rk,s,eq,C1}$	[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 <u>uncracked</u> concrete C20/25													
Temperature range	I: 80°C / 50°C	$\tau_{Rk,ucr}$	[N/mm²]	14	14	14	14	13	13	13	13	13	13
	II: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm²]	13	12	12	12	12	11	11	11	11	11
	III: 160°C / 100°C	$\tau_{Rk,ucr}$	[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 <u>cracked</u> concrete C20/25													
Temperature range	I: 80°C / 50°C	$\tau_{Rk,cr} = \tau_{Rk,eq,C1}$	[N/mm²]	5,5	5,5	6,0	6,5	6,5	6,5	6,5	7,0	7,0	7,0
	II: 120°C / 72°C	$\tau_{Rk,cr} = \tau_{Rk,eq,C1}$	[N/mm²]	4,5	5,0	5,0	5,5	5,5	5,5	5,5	6,0	6,0	6,0
	III: 160°C / 100°C	$\tau_{Rk,cr} = \tau_{Rk,eq,C1}$	[N/mm²]	4,0	4,5	4,5	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Increasing 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													
Factor k_1	uncracked concrete	$k_{ucr,N}$	[-]	11,0									
	cracked concrete	$k_{cr,N}$	[-]	7,7									
Splitting failure													
Edge distance	$h/h_{ef} \geq 2,0$	$c_{cr,sp}$	[mm]	$1,0\ h_{ef}$									
	$2,0 > h/h_{ef} > 1,3$			$2 \cdot h_{ef}\ (2,5 - h / h_{ef})$									
	$h/h_{ef} \leq 1,3$			$2,4\ h_{ef}$									
Spacing		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$									
Installation factor													
Compressed air cleaning	dry or wet concrete	γ_{inst}	[-]	1,0									
	waterfilled borehole	γ_{inst}	[-]	1,4									
Manual cleaning	dry or wet concrete	γ_{inst}	[-]	1,2					NPA				

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

Table C8: Characteristic values of **shear loads** for **rebar** under static, quasi-static action and seismic action 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 shear resistance	$V^0_{Rk,s}$	[kN]	$0{,}50 \cdot A_s \cdot f_{uk}$ [1]									
	$V_{Rk,s,eq,C1}$	[kN]	$0{,}37 \cdot A_s \cdot f_{uk}$ [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]									
	$M^0_{Rk,s,eq,C1}$	[Nm]	No Performance Assessed (NPA)									
Elastic section modulus	W_{el}	[mm³]	50	98	170	269	402	785	896	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
Factor for annular gap – **without** annular gap filling	α_{gap}	[-]	0,5									
Factor for annular gap – **with** annular gap filling	α_{gap}	[-]	1,0									
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 C9: **Displacements** under **tension load**[1] (threaded rod)

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Uncracked concrete C20/25 under static and quasi-static action										
Temperature range I: 80°C / 50°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 II: 120°C / 72°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 III: 160°C / 100°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 C20/25 under static and quasi-static action										
Temperature range I: 80°C / 50°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 II: 120°C / 72°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 III: 160°C / 100°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
Cracked concrete C20/25 under seismic action (C2)										
All temperature ranges	$\delta_{N,eq\,(DLS)}$-factor	[mm/(N/mm²)]	NPA		0,120	0,100	0,100	0,120	NPA	
	$\delta_{N,\,eq\,(ULS)}$-factor	[mm/(N/mm²)]			0,140	0,150	0,110	0,150		

[1] Calculation of the displacement
$\delta_{N0} = \delta_{N0}$- factor $\cdot \tau_{Ed}$; $\delta_{N,eq(DLS)} = \delta_{N,eq(DLS)}$-factor $\cdot \tau_{Ed}$; τ_{Ed}: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}$- factor $\cdot \tau_{Ed}$; $\delta_{N,eq(ULS)} = \delta_{N,eq(ULS)}$-factor $\cdot \tau_{Ed}$;

Table C10: **Displacements** under **shear load**[1] (threaded rod)

Threaded rod			**M 8**	**M 10**	**M 12**	**M 16**	**M 20**	**M24**	**M 27**	**M 30**
Uncracked and cracked concrete C20/25 under 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	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,05
Cracked concrete C20/25 under seismic action (C2)										
All temperature ranges	$\delta_{V,eq(DLS)}$-factor	[mm/(kN)]	NPA		0,27	0,13	0,09	0,06	NPA	
	$\delta_{V,eq(ULS)}$-factor	[mm/(kN)]			0,27	0,14	0,10	0,08		

[1] Calculation of the displacement
$\delta_{V0} = \delta_{V0}$-factor $\cdot V_{Ed}$; $\delta_{V,eq(DLS)} = \delta_{V,eq(DLS)}$- factor $\cdot V_{Ed}$; V_{Ed}: acting shear load
$\delta_{V\infty} = \delta_{V\infty}$-factor $\cdot V_{Ed}$; $\delta_{V,eq(ULS)} = \delta_{V,eq(ULS)}$- factor $\cdot V_{Ed}$;

Table C11: **Displacements** under **tension load**[1)] (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 concrete C20/25 under static and quasi-static action								
Temperature range I: 80°C / 50°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 II: 120°C / 72°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 III: 160°C / 100°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 C20/25 under static and quasi-static action								
Temperature range I: 80°C / 50°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)]	0,107	0,110	0,116	0,122	0,128	0,137
Temperature range II: 120°C / 72°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 III: 160°C / 100°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 $\cdot \tau_{Ed}$; τ_{Ed}: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}$-factor $\cdot \tau_{Ed}$;

Table C12: **Displacements** under **shear load**[1)] (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 C20/25 under 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	[mm/(kN)]	0,10	0,09	0,08	0,08	0,06	0,06

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

Table C13: Displacements under tension load[1] (rebar)

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Uncracked concrete C20/25 under static and quasi-static action												
Temperature range I: 80°C / 50°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 II: 120°C / 72°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 III: 160°C / 100°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 C20/25 under static and quasi-static action												
Temperature range I: 80°C / 50°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 II: 120°C / 72°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 III: 160°C / 100°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
$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau_{Ed}$; τ_{Ed}: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{- factor} \cdot \tau_{Ed}$;

Table C14: Displacements under shear load[1] (rebar)

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Cracked and uncracked concrete C20/25 under 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	[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
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V_{Ed}$; V_{Ed}: acting shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V_{Ed}$;