...eine starke Verbindung

PRESTATIEVERKLARING

DoP Nr.: **MKT-340** - nl

✧ **Unieke identificatiecode van het producttype:** **Injectiesysteem VMH voor beton**

✧ **Beoogd(e) gebruik(en):** Injectiesysteem voor verankering in beton, zie bijlage / Annex B

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

✧ **Het systeem of de systemen voor de Beoordeling en verificatie van de prestatiebestendigheid:** 1

✧ **Europees beoordelingsdocument:** **ETAG 001-5, 2013-04**
Europese technische beoordeling: **ETA-17/0716, 08.12.2017**
Technische beoordelingsinstantie: DIBt, Berlin
Aangemelde instantie(s): NB 1343 – MPA, Darmstadt

✧ **Aangegeven prestatie(s):**

Essentiële kenmerken	Prestaties
Mechanische weerstand en stabiliteit (BWR1)	
Karakteristieke weerstanden voor statische en quasi-statische belastingen en karakteristieke weerstanden voor de seismische prestatiecategorieën C1 + C2	Bijlage/Annex C1 – C7
Verschuivingen	Bijlage/Annex C8 – C10
Brandveiligheid (BWR2)	
Brandgedrag	Klasse A1
Brandwerendheid	NPD (No Performance Determined) geen prestatie bepaald

De prestaties van het hierboven omschreven product zijn conform de aangegeven prestaties. Deze prestatieverklaring wordt in overeenstemming met Verordening (EU) nr. 305/2011 onder de exclusieve verantwoordelijkheid van de hierboven vermelde fabrikant verstrekt.

Ondertekend voor en namens de fabrikant door:

Stefan Weustenhagen
(Directeur)
Weilerbach, 08.12.2017

p.p.
Dipl.-Ing. Detlef Bigalke
(Hoofd productontwikkeling)

Het origineel van deze prestatieverklaring was in het Duits geschreven. In geval van afwijkingen in de vertaling is de Duitse versie geldig.

Specification of intended use

Injection System VMH	**Threaded rod**	**Internally threaded anchor rod**	**Rebar**
	VMU-A, V-A, VM-A, commercial standard threaded rod	**VMU-IG**	
Static or quasi-static action	M8 - M30 zinc plated, A4, HCR	IG-M6 - 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 zinc plated[1] (strength class 8.8) A4, HCR	-	-
Base materials	Reinforced or unreinforced normal weight concrete acc. to EN 206-1:2000		
	Strength classes acc. to EN 206-1:2000:C20/25 to C50/60		
	Cracked and 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 or high corrosion resistant steel)
- 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 or high corrosion resistant steel)
- Structures subject to external atmospheric exposure and to permanently damp internal condition, if other particular aggressive conditions exist (high corrosion resistant steel)
  Note: 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 under static or quasi-static actions are designed in accordance with:
  - EOTA Technical Report TR 029 "Design of bonded anchors", Edition September 2010 or
  - CEN/TS 1992-4:2009
- Anchorages under seismic actions (cracked concrete) are designed in accordance with:
  - EOTA Technical Report TR 045 "Design of Metal Anchors under Seismic Action", Edition February 2013
  - Anchorages shall be positioned outside of critical regions (e.g. plastic hinges) of the concrete structure
  - Fastenings in stand-off installation or with a grout layer are not allowed

Installation:

- Dry or wet concrete
- 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
- Fastening screws or threaded rods (incl. nut and washer) must comply with the appropriate material and property class of the internally threaded anchor rod

Injection System VMH for concrete	**Annex B1**
Intended Use Specifications	

Table B1: Installation parameters for threaded rods

Threaded rod			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Diameter of threaded rod	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)]	$d_f \leq$	[mm]	9	12	14	18	22	26	30	33
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 larger clearance hole see TR029 section 1.1; for application 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 rod

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[2)]	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[1)]	$d_f \leq$	[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)] For larger clearance hole see TR029 section 1.1
[2)] With metric thread acc. to EN 1993-1-8:2005+AC:2009

Table B3: Installation parameters for rebar

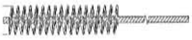
Rebar			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Diameter of rebar	$d = d_{nom}$ =	[mm]	8	10	12	14	16	20	25	28	32
Nominal drill hole diameter	d_0 =	[mm]	12	14	16	18	20	25	32	35	40
Effective anchorage depth	$h_{ef,min}$ =	[mm]	60	60	70	75	80	90	100	112	128
	$h_{ef,max}$ =	[mm]	160	200	240	280	320	400	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	130	150
Minimum edge distance	c_{min}	[mm]	35	40	45	50	50	60	70	75	85

Injection System VMH for concrete

Intended use
Installation parameters

Annex B2

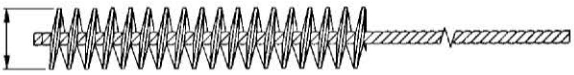
Table B4: Parameter cleaning and setting tools

Threaded rod 	Rebar 	Internally threaded anchor rod 	Drill bit Ø 	Brush Ø 	min. Brush Ø	Retaining washer 	Installation direction and use of retaining washer		
[-]	Ø [mm]	[-]	d_0 [mm]	d_b [mm]	$d_{b,min}$ [mm]	[-]	⬇	➡	⬆
M8			10	11,5	10,5	-	No **retaining washer** required		
M10	8	VMU-IG M 6	12	13,5	12,5	-			
M12	10	VMU-IG M 8	14	15,5	14,5	-			
	12		16	17,5	16,5	-			
M16	14	VMU-IG M10	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			
	25		32	34,0	32,5	VM-IA 32			
M30	28	VMU-IG M20	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 for overhead or horizontal installation
Drill bit diameter (d_0):
18 mm to 40 mm



Steel brush
Drill bit diameter (d_0): all diameters

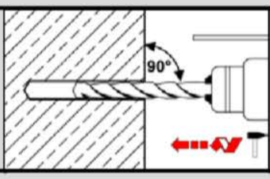
Injection System VMH for concrete

Intended Use
Cleaning and setting tools

Annex B3

Installation Instructions

Drilling of the hole

1.


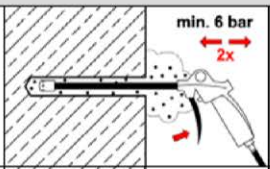
Drill with hammer drill or compressed air drill or vacuum drill a hole into the base material to the size required by the selected anchor (Table B1, B2 or Table B3). In case of aborted drill hole, the drill hole shall be filled with mortar.

Cleaning

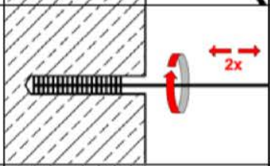
2.

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

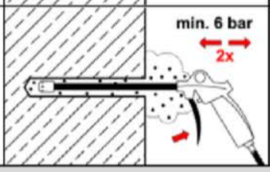
Cleaning with compressed air
Cracked and uncracked concrete: all diameters

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.

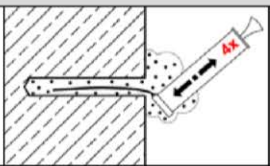
2b.


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, a brush extension must be used.

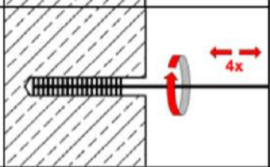
2c.


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.

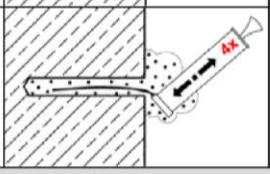
Manual cleaning
Drill hole diameter d_0 ≤ 20mm and drill hole depth h_0 ≤ 10 d_{nom} (uncracked concrete only)

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.


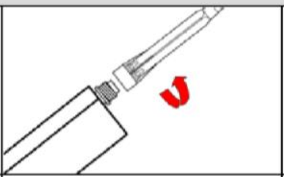
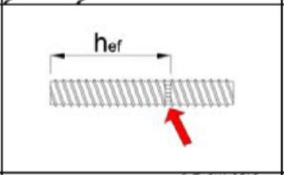
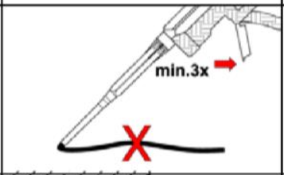
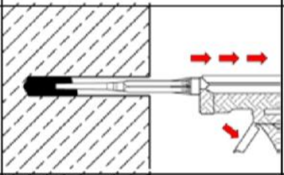
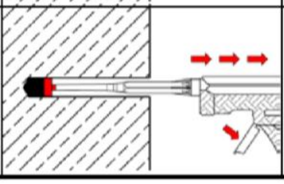
Check brush diameter (Table B4). Brush the hole with an appropriate sized wire brush ≥ $d_{b,min}$ (Table B4) a minimum of **four** times.
If the bore hole ground is not reached with the brush, a brush extension must be used.

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. For embedment larger than 190 mm, an 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 embedment depth $h_{ef} > 250$mm • Overhead installation: Drill bit-Ø $d_0 \geq 18$ mm

Installation instructions (continuation)

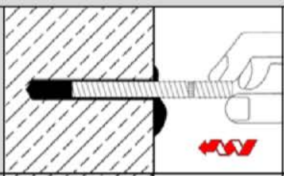
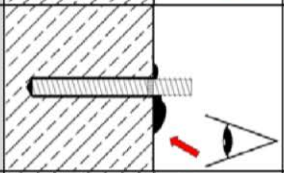
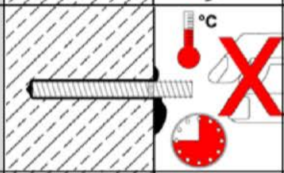
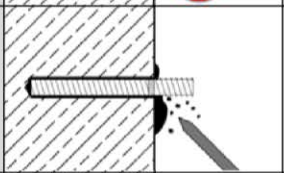
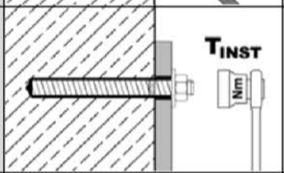
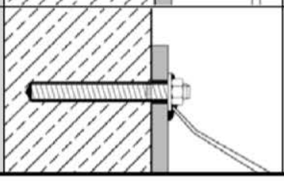
Inserting the anchor		
7.		Push the threaded rod or reinforcing bar into the hole while turning slightly to ensure proper distribution of the adhesive until the embedment depth is reached. The anchor shall be free of dirt, grease, oil or other foreign material.
8.		Make sure that the anchor is fully seated up to the full embedment depth and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. 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 by using a calibrated torque wrench.
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.

Tabelle B1: Working time and curing time

Concrete temperature	Maximum working time	Minimum curing time	
		dry concrete	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 and shear resistance

Threaded rod				M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30
Steel failure											
Tension load											
Characteristic tension resistance	Steel, Property class 4.6 and 4.8	$N_{Rk,s}$	[kN]	15	23	34	63	98	141	184	224
	Steel, Property class 5.6 and 5.8	$N_{Rk,s}$	[kN]	18	29	42	78	122	176	230	280
	Steel, Property class 8.8	$N_{Rk,s}$	[kN]	29	46	67	125	196	282	368	449
	Stainless steel A4 and HCR, Property class 50	$N_{Rk,s}$	[kN]	18	29	42	79	123	177	230	281
	Stainless steel A4 and HCR, Property class 70	$N_{Rk,s}$	[kN]	26	41	59	110	171	247	-	-
Partial factor	Steel, Property class 4.6	$\gamma_{Ms,N}$	[-]	2,0							
	Steel, Property class 4.8	$\gamma_{Ms,N}$	[-]	1,5							
	Steel, Property class 5.6	$\gamma_{Ms,N}$	[-]	2,0							
	Steel, Property class 5.8	$\gamma_{Ms,N}$	[-]	1,5							
	Steel, Property class 8.8	$\gamma_{Ms,N}$	[-]	1,5							
	Stainless steel A4 and HCR, Property class 50	$\gamma_{Ms,N}$	[-]	2,86							
	Stainless steel A4 and HCR, Property class 70	$\gamma_{Ms,N}$	[-]	1,87						-	-
Shear load											
Steel failure <u>without</u> lever arm											
Characteristic shear resistance	Steel, Property class 4.6 and 4.8	$V_{Rk,s}$	[kN]	7	12	17	31	49	71	92	112
	Steel, Property class 5.6 and 5.8	$V_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
	Steel, Property class 8.8	$V_{Rk,s}$	[kN]	15	23	34	63	98	141	184	224
	Stainless steel A4 and HCR, Property class 50	$V_{Rk,s}$	[kN]	9	15	21	39	61	88	115	140
	Stainless steel A4 and HCR, Property class 70	$V_{Rk,s}$	[kN]	13	20	30	55	86	124	-	-
Steel failure <u>with</u> lever arm											
Characteristic bending moment	Steel, Property class 4.6 and 4.8	$M_{Rk,s}$	[Nm]	15	30	52	133	260	449	666	900
	Steel, Property class 5.6 and 5.8	$M_{Rk,s}$	[Nm]	19	37	65	166	324	560	833	1123
	Steel, Property class 8.8	$M_{Rk,s}$	[Nm]	30	60	105	266	519	896	1333	1797
	Stainless steel A4 and HCR, Property class 50	$M_{Rk,s}$	[Nm]	19	37	66	167	325	561	832	1125
	Stainless steel A4 and HCR, Property class 70	$M_{Rk,s}$	[Nm]	26	52	92	232	454	784	-	-
Partial factor	Steel, Property class 4.6	$\gamma_{Ms,V}$	[-]	1,67							
	Steel, Property class 4.8	$\gamma_{Ms,V}$	[-]	1,25							
	Steel, Property class 5.6	$\gamma_{Ms,V}$	[-]	1,67							
	Steel, Property class 5.8	$\gamma_{Ms,V}$	[-]	1,25							
	Steel, Property class 8.8	$\gamma_{Ms,V}$	[-]	1,25							
	Stainless steel A4 and HCR, Property class 50	$\gamma_{Ms,V}$	[-]	2,38							
	Stainless steel A4 and HCR, Property class 70	$\gamma_{Ms,V}$	[-]	1,56						-	-

Injection System VMH for concrete

Performance
Characteristic values for **threaded rods** under **tension** and **shear loads**

Annex C1

Table C2: 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 tension resistance	$N_{Rk,s}$	[kN]	see Table C1							
	$N_{Rk,s,C1}$	[kN]	$1{,}0 \cdot N_{Rk,s}$							
	$N_{Rk,s,C2}$	[kN]	NPD		$1{,}0 \cdot N_{Rk,s}$	No Performance Determined (NPD)				
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	12	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	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	6,5	7,0	7,5	8,5	8,5	8,5	8,5	8,5
	$\tau_{Rk,C2}$	[N/mm²]	NPD		3,6	No Performance Determined (NPD)				
Temperature range II: 120°C / 72°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	5,5	6,0	6,5	7,5	7,5	7,5	7,5	7,5
	$\tau_{Rk,C2}$	[N/mm²]	NPD		3,1	No Performance Determined (NPD)				
Temperature range III: 160°C / 100°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	5,0	5,5	6,0	6,5	6,5	6,5	6,5	6,5
	$\tau_{Rk,C2}$	[N/mm²]	NPD		2,5	No Performance Determined (NPD)				
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							
Factor according to CEN/TS1992-4-5 – uncracked concrete	k_8	[-]	10,1							
Factor according to CEN/TS1992-4-5 – cracked concrete	k_8	[-]	7,2							
Concrete cone failure										
Factor according to CEN/TS1992-4-5 – uncracked concrete	k_{ucr}	[-]	10,1							
Factor according to CEN/TS1992-4-5 – cracked concrete	k_{cr}	[-]	7,2							
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]	$2 * h_{ef}\ (2{,}5 - h / h_{ef})$							
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**	$\gamma_2 = \gamma_{inst}$	[-]	1,0 (1,2)[1)]				1,2			
Installation factor **Manual cleaning**	$\gamma_2 = \gamma_{inst}$	[-]	1,2				-			

[1)] Value in brackets for cracked concrete

Injection System VMH for concrete

Performance
Characteristic values of **tension loads** for **threaded rods**

Annex C2

Table C3: 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	$V_{Rk,s}$	[kN]	see Table C1							
	$V_{Rk,s,C1}$	[kN]	$0{,}70 \cdot V_{Rk,s}$							
	$V_{Rk,s,C2}$	[kN]	NPD		$0{,}80 \cdot V_{Rk,s}$	No Performance Determined (NPD)				
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Steel failure with lever arm										
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	see Table C1							
	$M^0_{Rk,s,C1}$	[Nm]	No Performance Determined (NPD)							
	$M^0_{Rk,s,C2}$	[Nm]								
Partial factor	$\gamma_{Ms,V}$	[-]	see Table C1							
Concrete pry-out failure										
Factor k acc. to TR 029 Factor k_3 acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0							
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0							
Concrete edge failure										
Effective length of anchor	l_f	[mm]	$l_f = \min(h_{ef}; 8\ d_{nom})$							
Outside diameter of anchor	d_{nom}	[mm]	8	10	12	16	20	24	27	30
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0							

Injection System VMH for concrete

Performance
Characteristic values of **shear loads** for **threaded rods**

Annex C3

Table C4: Characteristic values of **tension loads** for **internally threaded anchor rod** under static, quasi-static action

Internally threaded anchor rod				**IG-M 6**	**IG-M 8**	**IG-M 10**	**IG-M 12**	**IG-M 16**	**IG-M 20**
Steel failure [1]									
Characteristic tension resistance, Steel, strength class 5.8		$N_{Rk,s}$	[kN]	10	18	29	42	79	123
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic tension resistance, Steel, strength 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, strength class 70		$N_{Rk,s}$	[kN]	14	26	41	59	110	124 [3]
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: 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]	12	11	10	9,5	9,0	9,0
Characteristic bond resistance in <u>cracked</u> concrete C20/25									
Temperature range I: 80°C / 50°C		$\tau_{Rk,cr}$	[N/mm²]	7,0	7,5	8,5	8,5	8,5	8,5
Temperature range II: 120°C / 72°C		$\tau_{Rk,cr}$	[N/mm²]	6,0	6,5	7,5	7,5	7,5	7,5
Temperature range III: 160°C / 100°C		$\tau_{Rk,cr}$	[N/mm²]	5,5	6,0	6,5	6,5	6,5	6,5
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					
Factor according to CEN/TS1992-4-5	uncracked concrete	k_8	[-]	10,1					
	cracked concrete			7,2					
Concrete cone failure									
Factor according to CEN/TS1992-4-5	uncracked concrete	k_{ucr}	[-]	10,1					
	cracked concrete	k_{cr}	[-]	7,2					
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 * 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**		$\gamma_2 = \gamma_{inst}$	[-]	1,0 (1,2)[2]			1,2		
Installation factor **Manual cleaning**		$\gamma_2 = \gamma_{inst}$	[-]	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] Value in brackets for cracked concrete
[3] For VMU-IG M20: Internally threaded rod: strength class 50; Fastening screws or threaded rods (incl. nut and washer): strength class 70

Injection System VMH for concrete

Performance
Characteristic values of **tension loads** for **internally threaded anchor rod**

Annex C4

Table C5: Characteristic values of **shear loads** for **internally threaded anchor rod** under static and quasi-static action

Internally threaded anchor rod			**IG-M 6**	**IG-M 8**	**IG-M 10**	**IG-M 12**	**IG-M 16**	**IG-M 20**
Steel failure without lever arm[1]								
Characteristic shear resistance Steel, strength class 5.8	$V_{Rk,s}$	[kN]	5	9	15	21	39	61
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic shear resistance Steel, strength class 8.8	$V_{Rk,s}$	[kN]	8	14	23	34	60	98
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic shear resistance Stainless steel A4 / HCR, strength class 70	$V_{Rk,s}$	[kN]	7	13	20	30	55	62 [2]
Partial factor	$\gamma_{Ms,V}$	[-]	1,56					2,38
Steel failure with lever arm[1]								
Characteristic bending moment, Steel, strength class 5.8	$M^0_{Rk,s}$	[Nm]	8	19	37	66	167	325
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic bending moment, Steel, strength class 8.8	$M^0_{Rk,s}$	[Nm]	12	30	60	105	267	519
Partial factor	$\gamma_{Ms,V}$	[-]	1,25					
Characteristic bending moment, Stainless steel A4 / HCR, strength 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								
Factor k acc. to TR 029 Factor k_3 acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0					
Concrete edge failure								
Effective length of anchor	l_f	[mm]	$l_f = \min(h_{ef}; 8\ d_{nom})$					
Outside diameter of anchor	d_{nom}	[mm]	10	12	16	20	24	30
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	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. 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: strength class 50; Fastening screws or threaded rods (incl. nut and washer): strength class 70

Table C6: 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 25	Ø 28	Ø 32
Steel failure											
Characteristic tension resistance	$N_{Rk,s} = N_{Rk,s,C1}$	[kN]	$A_s \cdot f_{uk}$ [1]								
Cross section area	A_s	[mm²]	50	79	113	154	201	314	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
Temperature range II: 120°C / 72°C	$\tau_{Rk,ucr}$	[N/mm²]	13	12	12	12	12	11	11	11	11
Temperature range III: 160°C / 100°C	$\tau_{Rk,ucr}$	[N/mm²]	10	10	9,5	9,5	9,5	9,0	9,0	9,0	9,0
Characteristic bond resistance in <u>cracked</u> concrete C20/25											
Temperature range I: 80°C / 50°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	5,0	5,5	6,0	6,0	7,5	7,5	7,5	7,5	8,0
Temperature range II: 120°C / 72°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	4,5	5,0	5,0	5,5	6,5	6,5	6,5	6,5	7,0
Temperature range III: 160°C / 100°C	$\tau_{Rk,cr} = \tau_{Rk,C1}$	[N/mm²]	4,0	4,5	4,5	5,0	5,5	6,0	6,0	5,5	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								
Factor according to CEN/TS1992-4-5: uncracked concrete	k_8	[-]	10,1								
Factor according to CEN/TS1992-4-5: cracked concrete	k_8	[-]	7,2								
Concrete cone failure											
Factor according to CEN/TS1992-4-5: uncracked concrete	k_{ucr}	[-]	10,1								
Factor according to CEN/TS1992-4-5: cracked concrete	k_{cr}	[-]	7,2								
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]	$2 * h_{ef} (2,5 - h / h_{ef})$								
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**	$\gamma_2 = \gamma_{inst}$	[-]	1,0 (1,2) [3]					1,2			
Installation factor **Manual cleaning**	$\gamma_2 = \gamma_{inst}$	[-]	1,2					-			

[1] f_{uk} shall be taken from the specifications of reinforcing bars
[2] in absence of nation regulation
[3] Value in brackets for cracked concrete

Injection System VMH for concrete

Performance
Characteristic values of **tension loads** for **rebar**

Annex C6

Table C7: 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 25	Ø 28	Ø 32
Steel failure without lever arm											
Characteristic shear resistance	$V_{Rk,s}$	[kN]	$0,50 \cdot A_s \cdot f_{uk}$ 1)								
	$V_{Rk,s,C1}$	[kN]	$0,37 \cdot A_s \cdot f_{uk}$ 1)								
Cross section area	A_s	[mm²]	50	79	113	154	201	314	491	616	804
Partial factor	$\gamma_{Ms,V}$	[-]	1,5 2)								
Ductility factor according to CEN/TS 1992-4-5	k_2	[-]	0,8								
Steel failure with lever arm											
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}$ 1)								
	$M^0_{Rk,s,C1}$	[Nm]	No Performance Determined (NPD)								
Elastic section modulus	W_{el}	[mm³]	50	98	170	269	402	785	1534	2155	3217
Partial factor	$\gamma_{Ms,V}$	[-]	1,5 2)								
Concrete pry-out failure											
Factor k acc. to TR 029 Factor k_3 acc. to CEN/TS 1992-4-5	$k_{(3)}$	[-]	2,0								
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0								
Concrete edge failure											
Effective length of rebar	l_f	[mm]	$l_f = \min(h_{ef}; 8\ d_{nom})$								
Outside diameter of rebar	d_{nom}	[mm]	8	10	12	14	16	20	25	28	32
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0								

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

Injection System VMH for concrete

Performance
Characteristic values of **shear loads** for **rebar**

Annex C7

Table C8: Displacements under tension loads[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	$\delta_{N,seis (DLS)}$ -factor	[mm/(N/mm²)]	(NPD)		0,120	No Performance Determined (NPD)				
	$\delta_{N,seis (ULS)}$ -factor	[mm/(N/mm²)]			0,140					

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

Table C9: 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	$\delta_{V,seis(DLS)}$ -factor	[mm/(kN)]	(NPD)		0,27	No Performance Determined (NPD)				
	$\delta_{V,seis(ULS)}$ -factor	[mm/(kN)]			0,27					

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

Injection System VMH for concrete

Performance
Displacements (threaded rod)

Annex C8

Table C10: Displacements under tension load[1] (internally threaded anchor rod)

Internally threaded anchor rod			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
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
$\delta_{N0} = \delta_{N0}\text{-factor} \cdot \tau$; τ: acting bond stress for tension
$\delta_{N\infty} = \delta_{N\infty}\text{-factor} \cdot \tau$;

Table C11: Displacements under shear load[1] (internally threaded anchor rod)

Internally threaded anchor rod			IG-M6	IG-M8	IG-M10	IG-M12	IG-M16	IG-M20
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
$\delta_{V0} = \delta_{V0}\text{-factor} \cdot V$; V: acting shear load
$\delta_{V\infty} = \delta_{V\infty}\text{-factor} \cdot V$;

Table C12: Displacements under tension load[1] (rebar)

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	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	0,043	0,045	0,048
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,040	0,042	0,044	0,045	0,047	0,051	0,055	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	0,045	0,047	0,050
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,042	0,044	0,045	0,047	0,049	0,053	0,057	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	0,164	0,172	0,186
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,124	0,129	0,135	0,141	0,146	0,157	0,169	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	0,103	0,108
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,104	0,107	0,110	0,113	0,116	0,122	0,128	0,133	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	0,107	0,113
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,108	0,111	0,114	0,118	0,121	0,127	0,133	0,138	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	0,399	0,425
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,321	0,330	0,340	0,349	0,358	0,377	0,396	0,410	0,449

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

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

Rebar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	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
	$\delta_{V\infty}$-factor	[mm/(kN)]	0,09	0,08	0,08	0,06	0,06	0,05	0,05	0,04	0,04

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

Injection System VMH for concrete

Performance
Displacements (rebar)

Annex C10