... eine starke Verbindung

DECLARATION OF PERFORMANCE
DoP No. MKT-322 - en

1. Unique identification code of the product-type: **MKT Injection System VMU plus**

2. Type, batch or serial number or any other element allowing identification of the construction product as required pursuant to Article 11(4):
ETA-11/0415, Annex A2 and A3
Batch number: see packaging of the product.

3. Intended use or uses of the construction product, in accordance with the applicable harmonised technical specification, as foreseen by the manufacturer:

Generic type	bonded anchor	
for use in	cracked and uncracked concrete C20/25 - C50/60 (EN 206)	
Option	1	
Loading	static or quasi-static: - threaded rod (M8-M30) - internally threaded anchor rod (IG-M6 to IG-M20) - reinforcing bar (Ø8 – Ø32) seismic category C1: - threaded rod M8 – M30 (except hot-dip galvanised) - reinforcing bar Ø8 – Ø32	
Material	**Threaded rod: M8, M10, M12, M16, M20, M24, M27, M30**	
	zinc-plated steel (hot-dip galvanized steel, electroplated, sherardized)	dry internal conditions only
	stainless steel (A4):	internal and external use without particular aggressive conditions
	high corrosion resistant steel (HCR):	internal and external use with particular aggressive conditions
	Internally threaded anchor rod: IG-M6, IG-M8, IG-M10, IG-M12, IG-M16, IG-M20	
	steel, electroplated	dry internal conditions only
	stainless steel (A4):	internal and external use without particular aggressive conditions
	high corrosion resistant steel (HCR):	internal and external use with particular aggressive conditions
	Reinforcing bar (B500 B): Ø8, Ø10, Ø12, Ø14, Ø16, Ø20, Ø25, Ø28, Ø32	
Temperature range (if applicable)	Range I: -40°C to +40°C Range II -40°C to +80°C Range III: -40°C to +120°C	

4. Name, registered trade name or registered trade mark and contact address of the manufacturer as required pursuant to Article 11(5):
MKT Metall-Kunststoff-Technik GmbH & Co. KG
Auf dem Immel 2
D - 67685 Weilerbach

5. Where applicable, name and contact address of the authorised representative whose mandate covers the tasks specified in Article 12(2): --

6. System or systems of assessment and verification of constancy of performance of the construction product as set out in Annex V: **System 1**

7. In case of the declaration of performance concerning a construction product covered by a harmonised standard: --

8. In case of the declaration of performance concerning a construction product for which a European Technical Assessment has been issued:

Deutsches Institut für Bautechnik, Berlin

issued

ETA-11/0415

on the basis of

ETAG 001-5

The notified body 1343-CPR performed under system 1:

(i) determination of the product type on the basis of type testing (including sampling), type calculation, tabulated values or descriptive documentation of the product;

(ii) initial inspection of the manufacturing plant and of factory production control;

(iii) continuous surveillance, assessment and evaluation of factory production control.

and issued: Certificate of constancy of performance 1343-CPR-M 550-10/08.14

9. Declared performance:

Essential characteristics	Design method	Performance			Harmonized technical specification
		Threaded rod	Internally threaded anchor rod	Rebar	
characteristic resistance for tension (static or quasi-static)	TR 029, CEN/TS 1992-4	Annex C1, C2 and C3	Annex C6 and C7	Annex C9 and C10	ETAG 001
characteristic resistance for shear (static or quasi-static)	TR 029, CEN/TS 1992-4	Annex C1 and C4	Annex C8	Annex C11	
characteristic resistance for seismic C1	TR 045	Annex C5	-	Annex C12	
displacement for serviceability limit state	TR 029, CEN/TS 1992-4	Annex C13	Annex C13	Annex C14	

Where pursuant to Article 37 or 38 in the Specific Technical Documentation has been used, the requirements with which the product complies: --

10. The performance of the product identified in points 1 and 2 is in conformity with the declared performance in point 9.

This declaration of performance is issued under the sole responsibility of the manufacturer identified in point 4.

Signed for and on behalf of the manufacturer by:

Stefan Weustenhagen
(General Manager)
Weilerbach, 08.12.2017

i.V.

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

Table C1: Characteristic **steel resistances** for **threaded rods** under tension and shear loads

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						-	-

Table C2: Characteristic values for **threaded rods** under **tension loads** in **cracked concrete**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic tension resistance		$N_{Rk,s}$	[kN]	see table C1							
Combined pull-out and concrete cone failure											
Characteristic bond resistance in cracked concrete C20/25											
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	4,0	5,0	5,5	5,5	5,5	5,5	6,5	6,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	4,0	4,0	5,5	5,5	no performance determined (NPD)			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	2,5	3,5	4,0	4,0	4,0	4,0	4,5	4,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	2,5	3,0	4,0	4,0	no performance determined (NPD)			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	2,0	2,5	3,0	3,0	3,0	3,0	3,5	3,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	2,0	2,5	3,0	3,0	no performance determined (NPD)			
Increasing factor for $\tau_{Rk,cr}$		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/TS 1992-4-5		k_8	[-]	7,2							
Concrete cone failure											
Factor according to CEN/TS 1992-4-5		k_{cr}	[-]	7,2							
Edge distance		$c_{cr,N}$	[mm]	$1,5\ h_{ef}$							
Axial distance		$s_{cr,N}$	[mm]	$3,0\ h_{ef}$							
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2						
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4				no performance determined (NPD)			

Table C3: Characteristic values for **threaded rods** under **tension loads** in **uncracked concrete**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Steel failure											
Characteristic tension resistance		$N_{Rk,s}$	[kN]	see table C1							
Combined pull-out and concrete cone failure											
Characteristic bond resistance in uncracked concrete C20/25											
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	10	12	12	12	12	11	10	9
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	7,5	8,5	8,5	8,5	no performance determined (NPD)			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	7,5	9	9	9	9	8,5	7,5	6,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,5	6,5	no performance determined (NPD)			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,5	6,5	6,5	6,5	5,5	5,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	4,0	5,0	5,0	5,0	no performance determined (NPD)			
Increasing factor for $\tau_{Rk,ucr}$		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/TS 1992-4-5		k_8	[-]	10,1							
Concrete cone failure											
Factor according to CEN/TS 1992-4-5		k_{ucr}	[-]	10,1							
Edge distance		$c_{cr,N}$	[mm]	$1,5\ h_{ef}$							
Axial distance		$s_{cr,N}$	[mm]	$3,0\ h_{ef}$							
Splitting failure											
Edge distance for		$c_{cr,sp}$	[mm]	$1{,}0 \cdot h_{ef} \le 2 \cdot h_{ef}\left(2{,}5-\frac{h}{h_{ef}}\right) \le 2{,}4 \cdot h_{ef}$							
Axial distance		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$							
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2						
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4				no performance determined (NPD)			

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Characteristic values for **threaded rods** under **tension loads** in **uncracked concrete**

Annex C3

Table C4: Characteristic values for **threaded rods** under **shear loads** in **cracked and uncracked concrete**

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							
Ductility factor acc. to CEN/TS 1992-4-5	k_2	[-]	0,8							
Steel failure with lever arm										
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	see table C1							
Concrete pry-out failure										
Factor k acc. to TR 029 or 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]	8	10	12	16	20	24	27	30
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0							

Table C5: Characteristic values for **threaded rods** under **seismic action,** category **C1**

Threaded rod				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Tension load											
Steel failure											
Characteristic tension resistance		$N_{Rk,s,seis}$	[kN]	$1,0 \cdot N_{Rk,s}$ (see table C1)							
Combined pull-out and concrete cone failure											
Characteristic bond resistance in concrete C20/25 to C50/60											
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	2,5	3,1	3,7	3,7	3,7	3,8	4,5	4,5
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	2,5	2,5	3,7	3,7	no performance determined (NPD)			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,6	2,2	2,7	2,7	2,7	2,8	3,1	3,1
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,6	1,9	2,7	2,7	no performance determined (NPD)			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	2,0	2,1	2,4	2,4
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	no performance determined (NPD)			
Increasing factor for $\tau_{Rk,seis}$		ψ_c	[-]	1,0							
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2						
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4				no performance determined (NPD)			
Shear load											
Steel failure without lever arm											
Characteristic shear resistance		$V_{Rk,s,seis}$	[kN]	$0,7 \cdot V_{Rk,s}$ (see table C1)							
Steel failure with lever arm											
Characteristic bending moment		$M^0_{Rk,s,seis}$	[Nm]	No Performance Determined (NPD)							

Table C6: Characteristic values of **tension loads** for **internally threaded anchor rods** in **cracked concrete**

Internally threaded anchor rod				**IG-M 6**	**IG-M 8**	**IG-M 10**	**IG-M 12**	**IG-M 16**	**IG-M20**
Steel failure [1]									
Characteristic shear resistance Steel, strength class 5.8		$N_{Rk,s}$	[kN]	10	18	29	42	79	123
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic shear resistance Steel, strength class 8.8		$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic shear resistance Stainless steel A4 / HCR, strength 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 cone failure									
Characteristic bond resistance in **cracked** concrete C20/25									
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	5,0	5,5	5,5	5,5	5,5	6,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	4,0	5,5	5,5	no performance determined (NPD)		
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	3,5	4,0	4,0	4,0	4,0	4,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	3,0	4,0	4,0	no performance determined (NPD)		
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	2,5	3,0	3,0	3,0	3,0	3,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	2,5	3,0	3,0	no performance determined (NPD)		
Increasing factor for $\tau_{Rk,cr}$		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/TS 1992-4-5		k_8	[-]	7,2					
Concrete cone failure									
Factor according to CEN/TS 1992-4-5		k_{cr}	[-]	7,2					
Edge distance		$c_{cr,N}$	[mm]	1,5 h_{ef}					
Spacing		$s_{cr,N}$	[mm]	3,0 h_{ef}					
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,2					
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4			no performance determined (NPD)		

[1] Fastening screws or threaded rods (incl. nut and washer) must compley 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: Internally threaded rod: strength class 50; Fastening screws or threaded rods (incl. nut and washer): strength class 70

Table C7: Characteristic values of **tension loads** for **internally threaded anchor rods** in **uncracked concrete**

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 shear resistance Steel, strength class 5.8		$N_{Rk,s}$	[kN]	10	18	29	42	79	123
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic shear resistance Steel, strength class 8.8		$N_{Rk,s}$	[kN]	16	27	46	67	121	196
Partial factor		$\gamma_{Ms,N}$	[-]	1,5					
Characteristic shear resistance Stainless steel A4 / HCR, strength 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 cone failure									
Characteristic bond resistance in **uncracked** concrete C20/25									
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	12	12	12	12	11	9,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	8,5	8,5	8,5	no performance determined		
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	9,0	9,0	9,0	9,0	8,5	6,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	6,5	6,5	6,5	no performance determined		
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	6,5	6,5	6,5	6,5	6,5	5,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,0	5,0	5,0	no performance determined		
Increasing factor for $\tau_{Rk,ucr}$		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/TS 1992-4-5		k_8	[-]	10,1					
Concrete cone failure									
Factor according to CEN/TS 1992-4-5		k_{ucr}	[-]	10,1					
Edge distance		$c_{cr,N}$	[mm]	1,5 h_{ef}					
Spacing		$s_{cr,N}$	[mm]	3,0 h_{ef}					
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 (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,2					
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4			no performance determined		

[1] Fastening screws or threaded rods (incl. nut and washer) must compley 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: Internally threaded rod: strength class 50; Fastening screws or threaded rods (incl. nut and washer): strength class 70

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Performance
Characteristic values for **internally threaded anchor rods** under **tension loads** in **uncracked concrete**

Annex C7

Table C8: Characteristic values for **internally threaded anchor rods** under **shear loads** in **cracked and uncracked concrete**

Internally threaded anchor rod			**IG-M 6**	**IG-M 8**	**IG-M 10**	**IG-M 12**	**IG-M 16**	**IG-M 20**
Steel failure <u>without</u> 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
Ductility factor according to CEN/TS 1992-4-5	k_2	[-]	0,8					
Steel failure <u>with</u> 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 or 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 compley 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 C9: Characteristic values for **rebar** under **tension loads** in **cracked concrete**

Rebar				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Steel failure												
Characteristic tension resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ [1)]								
Combined pull-out and concrete cone failure												
Characteristic bond resistance in cracked concrete C20/25												
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	4,0	5,0	5,5	5,5	5,5	5,5	5,5	6,5	6,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	4,0	4,0	5,5	5,5	5,5	no performance determined (NPD)			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	2,5	3,5	4,0	4,0	4,0	4,0	4,0	4,5	4,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	2,5	3,0	4,0	4,0	4,0	no performance determined (NPD)			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm²]	2,0	2,5	3,0	3,0	3,0	3,0	3,0	3,5	3,5
	flooded bore hole	$\tau_{Rk,cr}$	[N/mm²]	2,0	2,5	3,0	3,0	3,0	no performance determined (NPD)			
Increasing factors for $\tau_{Rk,cr}$		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 acc. to CEN/TS 1992-4-5		k_8	[-]	7,2								
Concrete cone failure												
Factor acc. to CEN/TS 1992-4-5		k_{cr}	[-]	7,2								
Edge distance		$c_{cr,N}$	[mm]	1,5 h_{ef}								
Axial distance		$s_{cr,N}$	[mm]	3,0 h_{ef}								
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2							
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4					no performance determined (NPD)			

[1)] $f_{uk} = f_{tk} = k \cdot f_{yk}$

Table C10: Characteristic values for **rebar** under **tension loads** in **uncracked concrete**

Rebar				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Steel failure												
Characteristic tension resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$ [1)]								
Combined pull-out and concrete cone failure												
Characteristic bond resistance in uncracked concrete C20/25												
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	10	12	12	12	12	12	11	10	8,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	7,5	8,5	8,5	8,5	8,5	no performance determined (NPD)			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	7,5	9,0	9,0	9,0	9,0	9,0	8,0	7,0	6,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,5	6,5	6,5	no performance determined (NPD)			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,5	6,5	6,5	6,5	6,0	5,0	4,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	4,0	5,0	5,0	5,0	5,0	no performance determined (NPD)			
Increasing factors for $\tau_{Rk,ucr}$		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 acc. to CEN/TS 1992-4-5		k_8	[-]	10,1								
Concrete cone failure												
Factor acc. to CEN/TS 1992-4-5		k_{ucr}	[-]	10,1								
Edge distance		$c_{cr,N}$	[mm]	$1,5\ h_{ef}$								
Axial distance		$s_{cr,N}$	[mm]	$3,0\ h_{ef}$								
Splitting failure												
Edge distance for		$c_{cr,sp}$	[mm]	$1,0 \cdot h_{ef} \le 2 \cdot h_{ef}\left(2,5-\frac{h}{h_{ef}}\right) \le 2,4 \cdot h_{ef}$								
Axial distance		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$								
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2							
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4					no performance determined (NPD)			

[1)] $f_{uk} = f_{tk} = k \cdot f_{yk}$

Table C11: Characteristic values for **rebar** under **shear loads** in **cracked and uncracked concrete**

Rebar			**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)]								
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)]								
Concrete pry-out failure											
Factor k acc. to TR 029 or 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]	8	10	12	14	16	20	25	28	32
Installation factor	$\gamma_2 = \gamma_{inst}$	[-]	1,0								

[1)] $f_{uk} = f_{tk} = k \cdot f_{yk}$

Table C12: Characteristic values for **rebar** under **seismic action,** category **C1**

Rebar				**⌀ 8**	**⌀ 10**	**⌀ 12**	**⌀ 14**	**⌀ 16**	**⌀ 20**	**⌀ 25**	**⌀ 28**	**⌀ 32**
Tension load												
Steel failure												
Characteristic tension resistance		$N_{Rk,s,seis}$	[kN]	$A_s \cdot f_{uk}$ [1)]								
Combined pull-out and concrete cone failure												
Characteristic bond resistance in concrete C20/25 to C50/60												
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	2,5	3,1	3,7	3,7	3,7	3,7	3,8	4,5	4,5
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	2,5	2,5	3,7	3,7	3,7	no performance determined (NPD)			
Temperature range II: 80°C/50°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,6	2,2	2,7	2,7	2,7	2,7	2,8	3,1	3,1
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,6	1,9	2,7	2,7	2,7	no performance determined (NPD)			
Temperature range III: 120°C/72°C	dry and wet concrete	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	2,0	2,0	2,1	2,4	2,4
	flooded bore hole	$\tau_{Rk,seis}$	[N/mm²]	1,3	1,6	2,0	2,0	2,0	no performance determined (NPD)			
Increasing factor for $\tau_{Rk,seis}$		ψ_c	[-]	1,0								
Installation factor (dry and wet concrete)		$\gamma_2 = \gamma_{inst}$	[-]	1,0	1,2							
Installation factor (flooded bore hole)		$\gamma_2 = \gamma_{inst}$	[-]	1,4					no performance determined (NPD)			
Shear load												
Steel failure without lever arm												
Characteristic shear resistance		$V_{Rk,s,seis}$	[kN]	$0,35 \cdot A_s \cdot f_{uk}$ [1)]								
Steel failure with lever arm												
Characteristic bending moment		$M^0_{Rk,s,seis}$	[Nm]	no performance determined (NPD)								

1) $f_{uk} = f_{tk} = k \cdot f_{yk}$

Table C13: Displacements under tension loads[1)]
(threaded rod and internally threaded anchor rod)

Threaded rod			M8	M10 IG-M6	M12 IG-M8	M16 IG- M10	M20 IG-M12	M24 IG-M16	M27	M30 IG-M20
Uncracked concrete C20/25										
Temperature range I: 40°C/24°C	δ_{N0}-factor	[mm/(N/mm²)]	0,021	0,023	0,026	0,031	0,036	0,041	0,045	0,049
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,030	0,033	0,037	0,045	0,052	0,060	0,065	0,071
Temperature range II: 80°C/50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,050	0,056	0,063	0,075	0,088	0,100	0,110	0,119
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,072	0,081	0,090	0,108	0,127	0,145	0,159	0,172
Temperature range III: 120°C/72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,050	0,056	0,063	0,075	0,088	0,100	0,110	0,119
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,072	0,081	0,090	0,108	0,127	0,145	0,159	0,172
Cracked concrete C20/25										
Temperature range I: 40°C/24°C	δ_{N0}-factor	[mm/(N/mm²)]	0,090			0,070				
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,105			0,105				
Temperature range II: 80°C/50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,219			0,170				
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,255			0,245				
Temperature range III: 120°C/72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,219			0,170				
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,255			0,245				

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

Table C14: Displacements under shear load[1)]
(threaded rod and internally threaded anchor rod)

Threaded rod			M8	M10 IG-M6	M12 IG-M8	M16 IG- M10	M20 IG-M12	M24 IG-M16	M27	M30 IG-M20
Uncracked concrete C20/25										
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										
All temperature ranges	δ_{V0}-factor	[mm/(kN)]	0,12	0,12	0,11	0,10	0,09	0,08	0,08	0,07
	$\delta_{V\infty}$-factor	[mm/(kN)]	0,18	0,18	0,17	0,15	0,14	0,13	0,12	0,10

[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 VMU plus for concrete

Performance
Displacements (threaded rod and internally threaded anchor rod)

Annex C13

Table C15: **Displacements** under **tension load**[1)] (rebar)

Rebar			**∅ 8**	**∅ 10**	**∅ 12**	**∅ 14**	**∅ 16**	**∅ 20**	**∅ 25**	**∅ 28**	**∅ 32**
Uncracked concrete C20/25											
Temperature range I: 40°C/24°C	δ_{N0}-factor	[mm/(N/mm²)]	0,021	0,023	0,026	0,028	0,031	0,036	0,043	0,047	0,052
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,030	0,033	0,037	0,041	0,045	0,052	0,061	0,071	0,075
Temperature range II: 80°C/50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,050	0,056	0,063	0,069	0,075	0,088	0,104	0,113	0,126
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,072	0,081	0,090	0,099	0,108	0,127	0,149	0,163	0,181
Temperature range III: 120°C/72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,050	0,056	0,063	0,069	0,075	0,088	0,104	0,113	0,126
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,072	0,081	0,090	0,099	0,108	0,127	0,149	0,163	0,181
Cracked concrete C20/25											
Temperature range I: 40°C/24°C	δ_{N0}-factor	[mm/(N/mm²)]	0,090			0,070					
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,105			0,105					
Temperature range II: 80°C/50°C	δ_{N0}-factor	[mm/(N/mm²)]	0,219			0,170					
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,255			0,245					
Temperature range III: 120°C/72°C	δ_{N0}-factor	[mm/(N/mm²)]	0,219			0,170					
	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,255			0,245					

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

Table C16: **Displacements** under **shear load**[1)] (rebar)

Rebar			**∅ 8**	**∅ 10**	**∅ 12**	**∅ 14**	**∅ 16**	**∅ 20**	**∅ 25**	**∅ 28**	**∅ 32**
Uncracked concrete C20/25											
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
Cracked concrete C20/25											
All temperature ranges	δ_{V0}-factor	[mm/(kN)]	0,12	0,12	0,11	0,11	0,10	0,09	0,08	0,07	0,06
	$\delta_{V\infty}$-factor	[mm/(kN)]	0,18	0,18	0,17	0,16	0,15	0,14	0,12	0,11	0,10

[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;