Deutsches Institut für Bautechnik
DIBt

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Bautechnisches Prüfamt
An institution established by the Federal and Laender Governments

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

European Technical Assessment

ETA-17/0194 of 14 March 2023

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Injection System VMZ dynamic
Product family to which the construction product belongs	Post-installed fasteners in concrete under fatigue cyclic loading
Manufacturer	MKT Metall-Kunststoff-Technik GmbH & Co. KG Auf dem Immel 2 67685 Weilerbach DEUTSCHLAND
Manufacturing plant	Werk 1, D Werk 2, D
This European Technical Assessment contains	23 pages including 3 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 330250-00-0601, Edition 06/2021
This version replaces	ETA-17/0194 issued on 29 November 2021

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Specific Part

1 Technical description of the product

The Injection System VMZ dynamic is a torque controlled bonded anchor consisting of a cartridge with injection mortar VMZ or VMZ Express, an anchor rod with expansion cones and external connection thread, a centring ring (only for through-setting installation), a conical washer, a hexagon nut with spherical contact surface and a locknut. For the pre-setting installation a conical washer with a bore is used. Alternatively the hexagon nut with spherical contact surface can be replaced by a spherical disc with hexagon nut.

The load transfer is realised by mechanical interlock of several cones in the bonding mortar and then via a combination of bonding and friction forces in the anchorage ground (concrete).

The product description is given in Annex A.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The performances given in Section 3 are only valid if the anchor is used in compliance with the specifications and conditions given in Annex B.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the anchor of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic (static and quasi-static loading and seismic loading)	**Performance**
Characteristic resistance to tension load (static and quasi-static loading)	see Annex B2, B3 and C4
Characteristic resistance to shear load (static and quasi-static loading)	see Annex C5
Displacements under short-term and long-term loading (static and quasi-static loading)	see Annex C6
Characteristic resistance and displacements for seismic performance categories C1 and C2	see Annex C4 to C6

Essential characteristic (fatigue loading, Assessment method A: Continuous function of fatigue resistance)	**Performance**
Characteristic fatigue resistance under cyclic tension loading	
Characteristic steel fatigue resistance $\Delta N_{Rk,s,0,n}$ (n = 1 to n = ∞)	see Annex C1 to C3
Characteristic concrete cone, splitting and pull-out fatigue resistance $\Delta N_{Rk,c,0,n}$ $\Delta N_{Rk,sp,0,n}$ $\Delta N_{Rk,p,0,n}$ (n = 1 to n = ∞)	

Essential characteristic (fatigue loading, Assessment method A: Continuous function of fatigue resistance)	**Performance**
Characteristic fatigue resistance under cyclic shear loading	
Characteristic steel fatigue resistance $\Delta V_{Rk,s,0,n}$ (n = 1 to n = ∞)	see Annex C1 to C3
Characteristic concrete edge fatigue resistance $\Delta V_{Rk,c,0,n}$ (n = 1 to n = ∞)	
Characteristic concrete pry out fatigue resistance $\Delta V_{Rk,cp,0,n}$ (n = 1 to n = ∞)	
Characteristic fatigue resistance under combined cyclic tension and shear loading	
Characteristic steel fatigue resistance a_{sn} (n = 1 to n = ∞)	see Annex C1 to C3
Load transfer factor for cyclic tension, shear and combined tension and shear loading	
Load transfer factor ψ_{FN}, ψ_{FV}	see Annex C1 to C3

3.2 Hygiene, health and the environment (BWR 3)

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

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with European Assessment Document No. 330250-00-0601, the applicable European legal act is: [96/582/EC].

The system to be applied is: 1

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable European Assessment Document

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

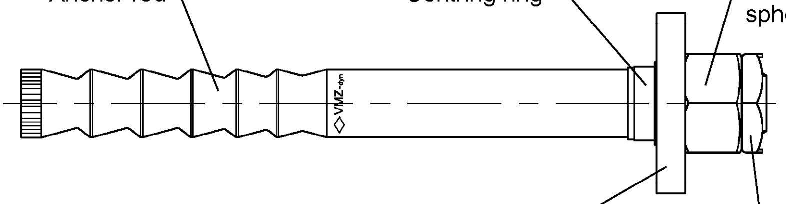
Issued in Berlin on 14 March 2023 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock
Head of Section

beglaubigt:
Stiller

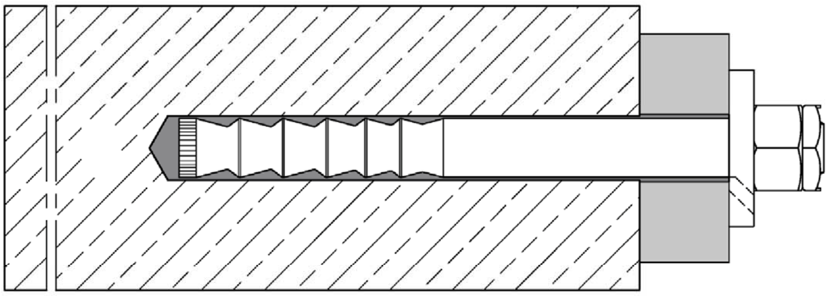
Injection System VMZ dynamic

Anchor rod VMZ dyn		
100 M12 **100 M12 A4** **100 M12 HCR**	**125 M16** **125 M16 A4** **125 M16 HCR**	**170 M20**

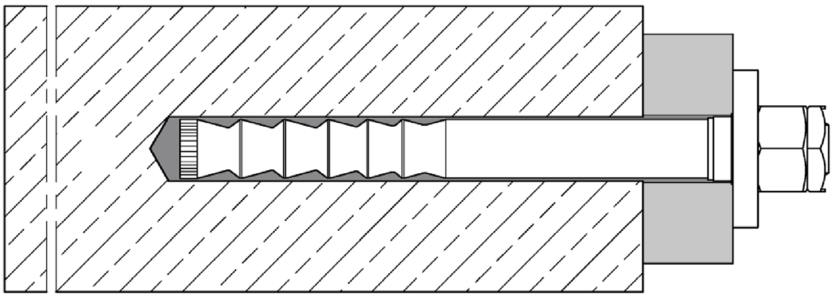


Installation situation

Pre-setting installation



Through-setting installation



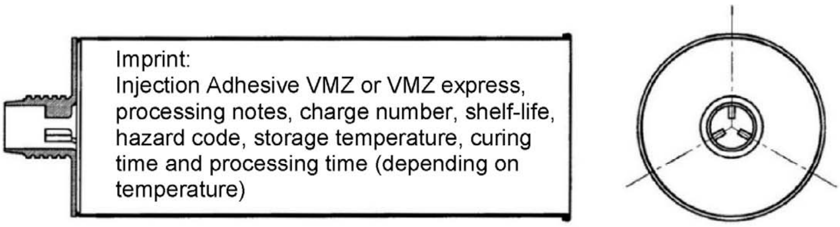
Injection System VMZ dynamic

Product description
Anchor rod and installation situation

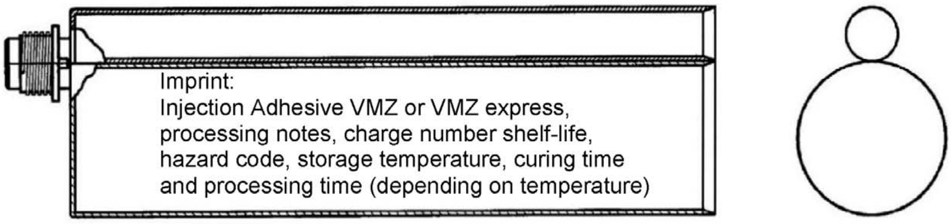
Annex A1

Injection System VMZ dynamic

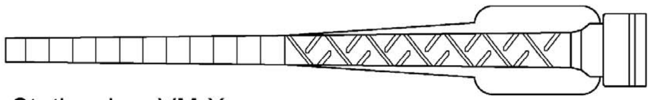
Mortar cartridge



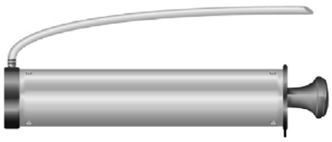
Sealing cap



Reducing adapter



Static mixer VM-X



Blow-out pump VM-AP

Air Blower VM-ABP

Cleaning Brush RB

Injection System VMZ dynamic	Annex A2
Product description Cartridges and cleaning tools	

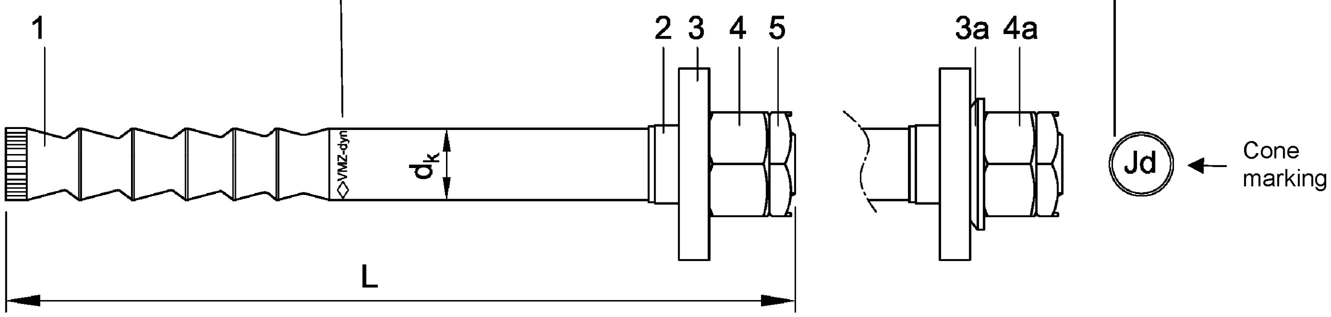
Marking

Marking: e.g. ◇VMZ-dyn 12-25

◇	identifying mark of manufacturing plant
VMZ-dyn	anchor identity
12	size of thread
25	maximum thickness of fixture
A4	additional marking of stainless steel A4, if not on conical washer
HCR	additional marking of high corrosion resistant steel

Cone marking: e.g.

J Marking of length
d dynamic

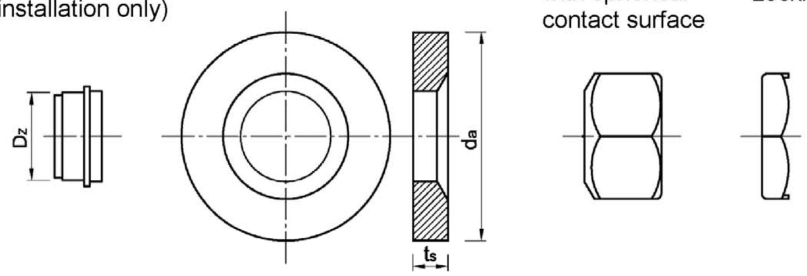


Centring ring (through-setting installation only)

Conical washer

Hexagon nut with spherical contact surface

Locknut



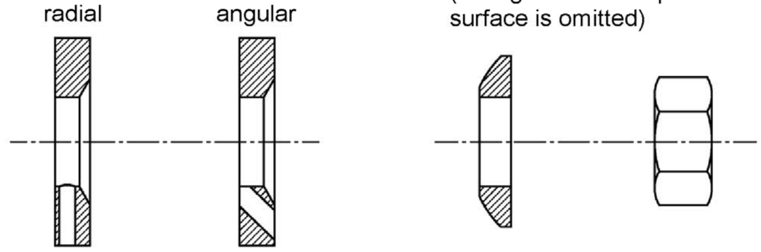
Marking of the anchor version on the conical washer / conical washer with bore
(alternatively: marking on the anchor rod)

Anchor version:		Marking:
galvanized	-	no marking
A4	-	A4
HCR	-	HCR

Alternatively:
Conical washer with bore

radial angular

Alternatively:
Spherical disc with hexagon nut
(hexagon nut with spherical contact surface is omitted)



Marking of length	I	J	K	L	M	N	O	P	Q
Length of anchor min ≥	139,7	152,4	165,1	177,8	190,5	203,2	215,9	228,6	241,3
Length of anchor max <	152,4	165,1	177,8	190,5	203,2	215,9	228,6	241,3	254,0

Marking of length	R	S	T	U	V	W	X	Y	Z	>Z
Length of anchor min ≥	254,0	279,4	304,8	330,2	355,6	381,0	406,4	431,8	457,2	482,6
Length of anchor max <	279,4	304,8	330,2	355,6	381,0	406,4	431,8	457,2	482,6	

Injection System VMZ dynamic

Product description
Components, Marking

Annex A3

Table A1: Materials

Part	Designation	Steel, zinc plated ≥ 5µm	Stainless steel A4 (CRC III)	High corrosion resistant steel HCR (CRC V)
1	Anchor rod	Steel, acc. to EN ISO 683-4:2018, galvanized and coated	High corrosion resistant steel 1.4529, acc. to EN 10088:2014, coated	
2	Centring ring	Plastic		
3	Conical washer	Steel, galvanized	Stainless steel, 1.4401 or 1.4571 acc. to EN 10088:2014	High corrosion resistant steel, 1.4529, acc. to EN 10088:2014
3a	Spherical disc	Steel, galvanized	Stainless steel, 1.4401 or 1.4571 acc. to EN 10088:2014	High corrosion resistant steel, 1.4529, acc. to EN 10088:2014
4	Hexagon nut with spherical contact surface	Steel, galvanized	EN ISO 3506-2:2020, stainless steel, Property class 70, 1.4401 or 1.4571, acc. to EN 10088:2014	EN ISO 3506-2:2020, high corrosion resistant steel, Property class 70, 1.4529 or 1.4565, acc. to EN 10088:2014
4a	Hexagon nut			
5	Locknut	Steel, galvanized	Stainless steel, 1.4401 or 1.4571 acc. to EN 10088:2014	High corrosion resistant steel, 1.4565, 1.4529 or 1.4547, acc. to EN 10088:2014
6	Mortar Cartridge	Vinylester resin, styrene-free		

Table A2: Dimensions

Part	Anchor size				100 M12	125 M16	170 M20
1	Anchor rod	Thread		-	M12	M16	M20
		Effective anchorage depth	$h_{ef} \geq$	[mm]	100	125	170
		Shaft diameter	$d_k =$	[mm]	12,5	16,5	22,0
		Length	L_{min}	[mm]	143	180	242
			L_{max}	[mm]	531	565	623
2	Centring ring	External diameter	D_z	[mm]	14	18	23,5
3	Conical washer	Thickness	t_s	[mm]	6	7	8
		External diameter	$d_a \geq$	[mm]	30	38	50
3a	Spherical disc	External diameter	$d_s =$	[mm]	24	30	36
4	Hexagon nut with spherical contact surface	Width across nut	SW	[mm]	18 / 19	24	30
4a	Hexagon nut	Width across nut	SW	[mm]	19	24	30
5	Locknut	Width across nut	SW	[mm]	19	24	30

Injection System VMZ dynamic

Product description
Materials and dimensions

Annex A4

Specifications of intended use

Injection System VMZ dynamic	100 M12	125 M16	170 M20
Fatigue cyclic loading		✓	
Static and quasi-static action		✓	
Seismic action (Category C1 + C2)		✓	
Cracked or uncracked concrete		✓	
Strength classes acc. to EN 206:2013+A1:2016		C20/25 to C50/60	
Compacted reinforced or unreinforced normal weight concrete without fibers acc. to EN 206:2013+A1:2016		✓	
Temperature range I -40 °C to +80 °C		maximum long-term temperature +50 °C maximum short-term temperature +80 °C	

Use conditions (Environmental conditions):

- Structures subject to dry internal conditions: all materials
- For all other conditions:
  Intended use of materials according to Annex A4, Table A1 corresponding to the corrosion resistance class CRC to EN 1993-1-4:2015

Design:

- Anchorages are designed under the responsibility of an engineer experienced in anchorages and concrete work.
- 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 according to:
  - EOTA TR 061:2020 (Design method I and II) or
  - EN 1992-4:2018

Installation:

- Anchor shall only be used as a complete fastening unit delivered in series. Components of the anchor must not be replaced.
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the site manager.
- Installation admissible in dry and wet concrete and in water-filled borehole.
- Drill hole must be cleaned directly prior to installation of the anchor or the drill hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the drill hole.
- Water filled drill holes must not be polluted – otherwise the cleaning of the drill hole must be repeated.
- The anchor component installation temperature shall be at least +5 °C; during curing of the injection mortar the temperature of the concrete must not fall below -15 °C (for the standard variation of temperature after installation).
- It must be ensured that icing does not occur in the drill hole.
- Installation direction D3: vertically downwards and upwards as well as horizontally.
- Drilling by hammer drill bit, compressed air drill or vacuum drill bit.
- The filling of the annular gap can be omitted if it is ensured that the anchor is only loaded in axial direction.

Table B1: Installation parameters

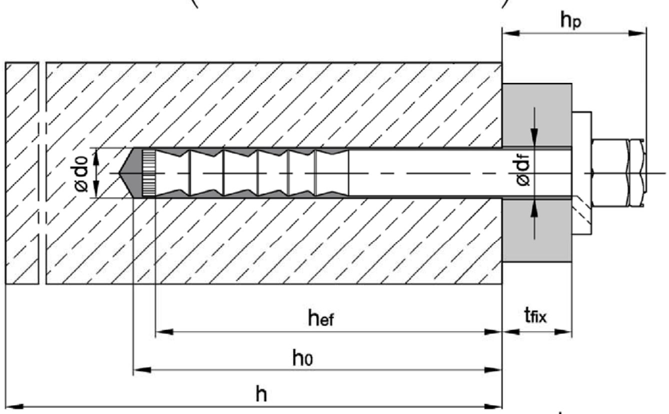
Anchor size / version			100 M12	100 M12 A4 100 M12 HCR	125 M16	125 M16 A4 125 M16 HCR	170 M20
Effective anchorage depth	$h_{ef} \geq$	[mm]	100		125		170
Nominal diameter of drill hole	$d_0 =$	[mm]	14		18		24
Depth of drill hole [1]	$h_0 \geq$	[mm]	105		130		180
Diameter of cleaning brush	$D \geq$	[mm]	15,0		19,0		25,0
Installation torque	$T_{inst} =$	[Nm]	30		50		80
Diameter of clearance hole in the fixture	$d_f =$	[mm]	15		19		25
Fixture thickness [2]	$t_{fix,min} \geq$	[mm]	12		16		20
	$t_{fix,max} \leq$	[mm]	200				
Overstand	$h_p =$	[mm]	$31 + t_{fix}$	$24 + t_{fix}$	$39 + t_{fix}$	$30 + t_{fix}$	$48 + t_{fix}$

[1] If the present fixture thickness is lower than the maximum fixture thickness of the anchor, the depth of drill hole should be increased accordingly

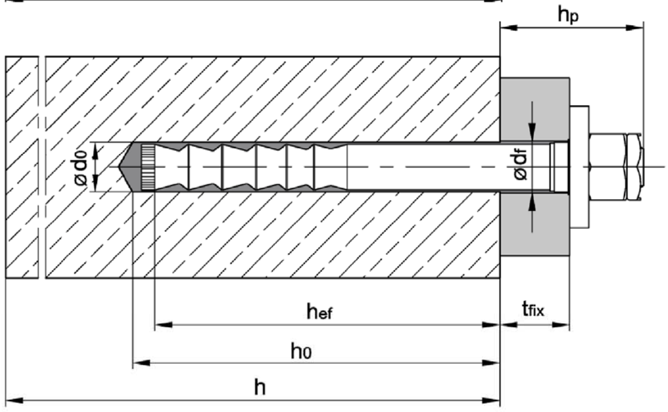
[2] $t_{fix,min}$ may be replaced by $t_{fix,min,red}$, if, when determining the anchor under the highest load, the action ΔV_{Ed} is smaller than the fatigue resistance in transverse direction

$$t_{fix,min,red} = \left(0{,}5 + 0{,}5 \cdot \frac{\Delta V_{Ed}}{\Delta V_{Rd,s,E,n} * \psi_{FV}}\right) \cdot t_{fix,min}$$

Pre-setting installation



Through-setting installation



Injection System VMZ dynamic

Intended use
Installation parameters

Annex B2

Table B2: Minimum thickness of concrete and minimum spacing and edge distance

Anchor size			**100 M12**	**125 M16**	**170 M20**
Minimum thickness of concrete member	h_{min}	[mm]	130	160	220
Cracked concrete					
Minimum spacing	s_{min}	[mm]	50	60	80
Minimum edge distance [1)]	c_{min}	[mm]	70 (50)	80 (60)	110 (80)
Uncracked concrete					
Minimum spacing	s_{min}	[mm]	80	60	80
Minimum edge distance	c_{min}	[mm]	75	80	110

[1)] Values in brackets are valid if edge reinforcement d = 8 mm is installed

Injection System VMZ dynamic	**Annex B3**
Intended use Minimum thickness of concrete, spacing and edge distances	

Table B3: Processing time and curing time, VMZ

Temperature in the drill hole	Maximum processing time	Minimum curing time in dry concrete [1)]
- 15 °C to - 10 °C	45 min	7 d
- 9 °C to - 5 °C	45 min	10:30 h
- 4 °C to - 1 °C	45 min	6:00 h
0 °C to + 4 °C	20 min	3:00 h
+ 5 °C to + 9 °C	12 min	2:00 h
+ 10 °C to + 19 °C	6 min	1:20 h
+ 20 °C to + 29 °C	4 min	45 min
+ 30 °C to + 34 °C	2 min	25 min
+ 35 °C to + 39 °C	1,4 min	20 min
+ 40 °C	1,4 min	15 min
Cartridge temperature ≥ 5°C		

[1)] Curing time in wet concrete shall be doubled

Table B4: Processing time and curing time, VMZ express

Temperature in the drill hole	Maximum processing time	Minimum curing time in dry concrete [1)]
- 5 °C to - 1 °C	20 min	4:00 h
0 °C to + 4 °C	10 min	2:00 h
+ 5 °C to + 9 °C	6 min	1:00 h
+ 10 °C to + 19 °C	3 min	40 min
+ 20 °C to + 29 °C	1 min	20 min
+ 30 °C	1 min	10 min
Cartridge temperature ≥ 5°C		

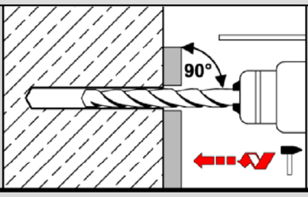
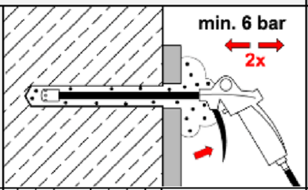
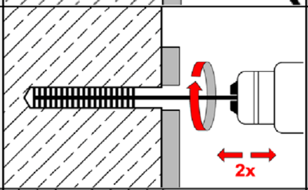
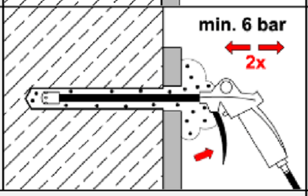
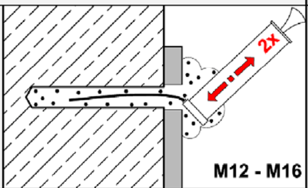
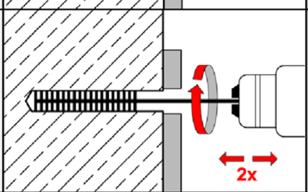
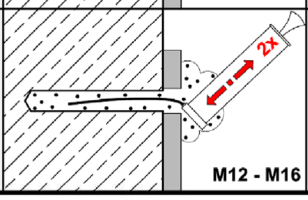
[1)] Curing time in wet concrete shall be doubled

Injection System VMZ dynamic

Intended use
Processing time and curing time

Annex B4

Installation instructions – Through-setting installation

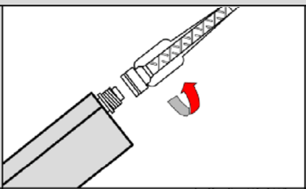
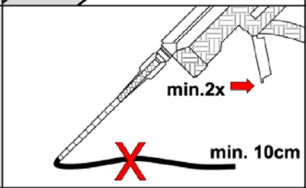
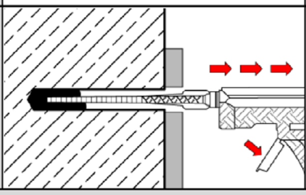
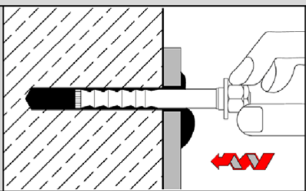
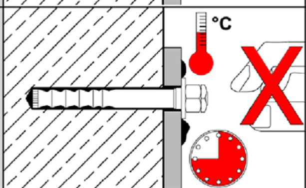
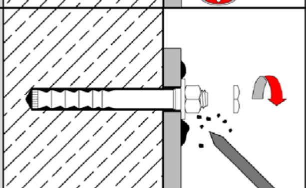
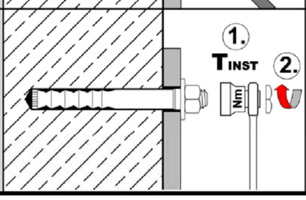
Hole drilling		
1		Drill hole perpendicular to concrete surface with hammer drill, compressed air drill or vacuum drill bit.
Cleaning		**Drill hole must be cleaned directly prior to installation of the anchor**
2	**all sizes**	**<u>Cleaning with compressed air</u>**
2a		Connect Air Blower to compressed air (min. 6 bar, oil-free). Open air valve and blow out drill hole along the entire depth with back and forth motion at least **two times**.
2b		Check diameter of Cleaning Brush. If brush can be pushed into the drill hole without any resistance, it must be replaced. Chuck brush into drill machine. Turn on drill machine. Brush drill hole back and forth along the entire drill hole depth at least **two times** while rotated by drill machine.
2c		Connect Air Blower to compressed air (min. 6 bar, oil-free). Open air valve and blow out drill hole along the entire depth with back and forth motion at least **two times**.
	M12 - M16	**<u>Manual cleaning</u>** (alternative cleaning method)
2a		Blow out drill hole from the bottom using Blow-out Pump at least **two times**.
2b		Check diameter of Cleaning Brush. If brush can be pushed into the drill hole without any resistance, it must be replaced. Chuck brush into drill machine. Turn on drill machine. Brush drill hole back and forth along the entire drill hole depth at least **two times** while rotated by drill machine.
2c		Blow out drill hole from the bottom using Blow-out Pump at least **two times**.

Injection System VMZ dynamic

Intended use
Installation instructions – Through-setting installation

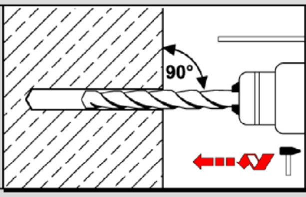
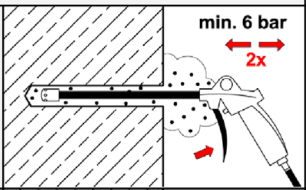
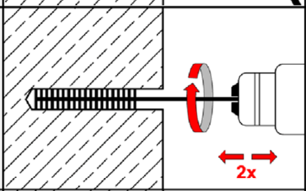
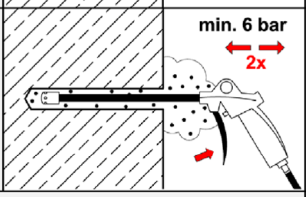
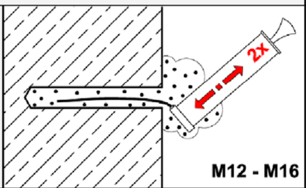
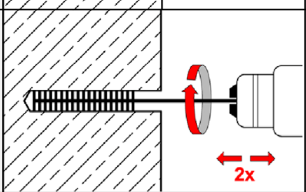
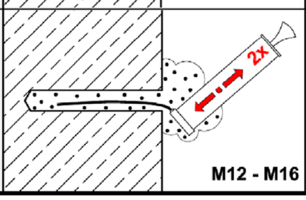
Annex B5

Installation instructions – Through-setting installation (continuation)

Injection		
3		Check minimum shelf-life on VMZ cartridge. Never use when expired. Remove cap from VMZ cartridge. Screw static mixer on cartridge. When using a new cartridge always use a new static mixer. Never use cartridge without static mixer and never use static mixer without helix inside.
4		Insert cartridge in dispenser. Before injecting discard mortar (at least 2 full strokes or a line of 10 cm) until it shows a consistent grey colour. Never use this mortar.
5		Prior to injection, check if static mixer reaches the bottom of the drill hole. If it does not reach the bottom, plug mixer extension onto static mixer, in order to properly fill the drill hole. Fill hole with a sufficient quantity of injection mortar. Start from the bottom of the drill hole and work out to avoid trapping air pockets.
Insertion of anchor rod		
6		Insert the pre-assembled anchor within processing time by hand, rotating slightly up to the full embedment depth, until the conical washer is in contact with the fixture. The anchor rod is properly set when the annular gap between anchor rod and fixture is completely filled. If no mortar is visible on the surface of the fixture, pull out the anchor rod immediately, let the mortar cure, drill out the hole and start again from step 2.
7		Follow minimum curing time shown in Annex B4 as well as on cartridge label. During curing time anchor rod must not be moved or loaded.
8		Remove excess mortar after curing time. Remove locknut.
9		1. Apply installation torque T_{inst} according to Table B1 by using torque wrench. 2. Screw on locknut until hand tight then tighten 1/4 to ½ turn using a screw wrench.

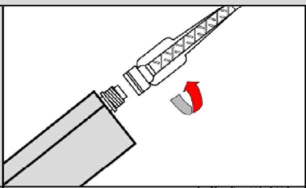
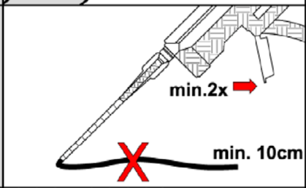
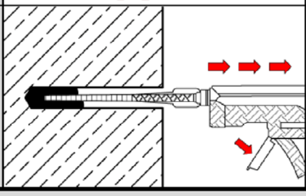
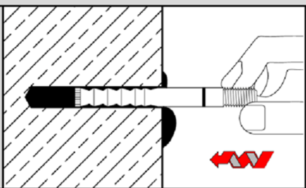
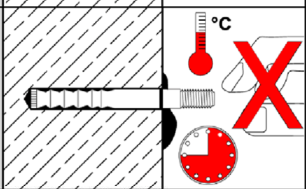
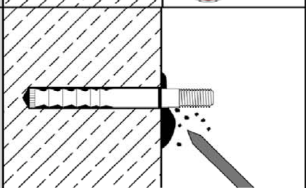
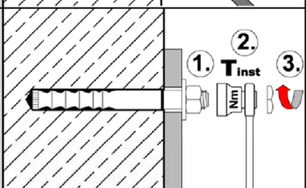
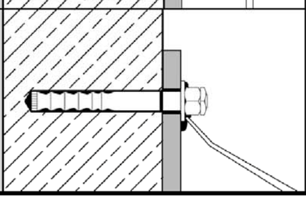
Injection System VMZ dynamic	**Annex B6**
Intended use Installation instructions – Through-setting installation (continuation)	

Installation instructions – Pre-setting installation

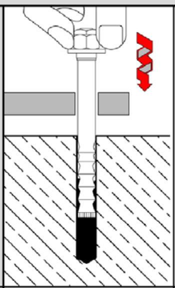
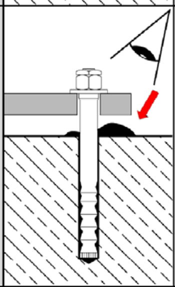
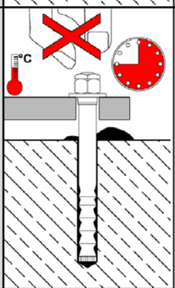
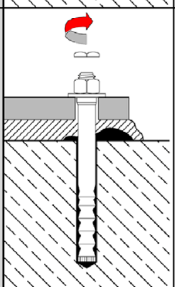
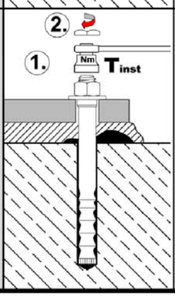
Hole drilling		
1		Drill perpendicular to concrete surface with hammer drill, vacuum drill or compressed air drill.
Cleaning		**Drill hole must be cleaned directly prior to installation of the anchor**
2	**all sizes**	**<u>Cleaning with compressed air</u>**
2a		Connect Air Blower to compressed air (min. 6 bar, oil-free). Open air valve and blow out drill hole along the entire depth with back and forth motion at least **two times**.
2b		Check diameter of Cleaning Brush. If brush can be pushed into the drill hole without any resistance, it must be replaced. Chuck brush into drill machine. Turn on drill machine. Brush drill hole back and forth along the entire drill hole depth at least **two times** while rotated by drill machine.
2c		Connect Air Blower to compressed air (min. 6 bar, oil-free). Open air valve and blow out drill hole along the entire depth with back and forth motion at least **two times**.
	M12 - M16	**<u>Manual cleaning</u>** (alternative cleaning method)
2a		Blow out drill hole from the bottom using Blow-out Pump at least **two times**.
2b		Check diameter of Cleaning Brush. If brush can be pushed into the drill hole without any resistance, it must be replaced. Chuck brush into drill machine. Turn on drill machine. Brush drill hole back and forth along the entire drill hole depth at least **two times** while rotated by drill machine.
2c		Blow out drill hole from the bottom using Blow-out Pump at least **two times**.

Injection System VMZ dynamic	**Annex B7**
Intended use Installation instructions – Pre-setting installation	

Installation instructions – Pre-setting installation (continuation)

Injection		
3		Check minimum shelf-life on VMZ cartridge. Never use when expired. Remove cap from VMZ cartridge. Screw static mixer on cartridge. When using a new cartridge always use a new Mixer Nozzle. Never use cartridge without static mixer and never use static mixer without helix inside.
4		Insert cartridge in Dispenser. Before injecting discard mortar (at least 2 full strokes or a line of 10 cm) until it shows a consistent grey colour. Never use this mortar.
5		Prior to injection check if static mixer reaches the bottom of the drill hole. If it does not reach the bottom, plug mixer extension onto static mixer in order to properly fill the drill hole. Fill hole with a sufficient quantity of injection mortar. Start from the bottom of the drill hole and work out to avoid trapping air pockets.
Insertion of anchor rod		
6		Mark the embedment depth on the anchor rod. Insert the anchor rod by hand, rotating slightly up within processing time. The anchor rod is properly set when excess mortar seeps from the hole. If the hole is not completely filled, pull out anchor rod, let mortar cure, drill out hole and start again from step 2.
7		Follow minimum curing time shown in Annex B4 as well as on cartridge label. During curing time anchor rod must not be moved or loaded.
8		Remove excess mortar after curing time.
9		1. Fixture, washer and nut (without centring ring) can be mounted. 2. Apply installation torque T_{inst} according to Table B1 by using torque wrench. 3. Screw on locknut hand-tight then tighten ¹/₄ to ½ turn using a screw wrench.
10		Annular gap between anchor rod and fixture must be filled with injection mortar through the bore of the conical washer using the adapter plugged onto the static mixer. The annular gap is properly filled when excess mortar seeps out.

Installation instructions – Installation with clearance between concrete and anchor plate (if the fastener is only loaded in axial direction)

Work steps 1 - 5 as illustrated in Annex B5 and B6		
Insertion of anchor rod		
6		Inserting the pre-assembled anchor within processing time by hand, rotating slightly until the conical washer lies against the fixture.
7		Check for excess mortar seeping out of the hole. If the hole is not completely filled, pull out anchor rod, let mortar cure, drill out hole and start again from step 2. The annular gap in the fixture does not have to be filled.
8		Follow minimum curing time shown in Annex B4 as well as on cartridge label. During curing time anchor rod must not be moved or loaded.
9		Remove locknut after curing time and backfilling of anchor plate.
10		1. Apply installation torque T_{inst} according to Annex B2 (Table B1) by using torque wrench. 2. Screw on locknut hand-tight then tighten ¼ to ½ turn using a screw wrench.

Injection System VMZ dynamic

Intended use
Installation instructions – Installation with clearance between concrete and anchor plate

Annex B9

Table C1: Characteristic values of the **fatigue resistance** under **tension load** after **n load cycles without static actions (F_{Elod} = 0) design method I** according to **TR 061**

Anchor size / version			**100 M12**	**100 M12 A4 100 M12 HCR**	**125 M16**	**125 M16 A4 125 M16 HCR**	**170 M20**
Steel failure							
Characteristic resistance without static actions		[kN]	$\Delta N_{Rk,s,0,n}$				
Number of load cycles n		1	53,9	53,9	83,4	83,4	112,1
		≤ 10^3	48,3	52,6	78,8	72,5	92,7
		≤ $3\cdot10^3$	45,9	50,9	77,1	68,2	89,9
		≤ 10^4	41,4	47,6	73,1	62,4	83,4
		≤ $3\cdot10^4$	35,9	42,8	66,3	56,7	73,8
		≤ 10^5	29,1	36,3	55,8	50,5	60,9
		≤ $3\cdot10^5$	24,2	30,1	45,5	45,7	50,7
		≤ 10^6	21,1	24,9	37,4	41,8	44,9
		> 10^6	20,1	21,2	34,0	37,3	43,5
Partial factor	$\gamma_{Ms,fat,n}$	[-]	according to TR 061, Eq. (3)				
Exponent for combined loading	α_{sn}	[-]	1,5	1,2	1,5	1,5	1,5
Pull-out							
Characteristic resistance without static actions	$\Delta N_{Rk,p,0,n}$	[kN]	$(\Delta N_{Rk,s,0,n} / \gamma_{Ms,fat,n}) \cdot \gamma_{Mp,fat}$				
Partial factor	$\gamma_{Mp,fat}$	[-]	1,5				
Concrete failure							
Characteristic resistance without static actions	$\Delta N_{Rk,c,0,n}$	[kN]	$\eta_{k,c,N,fat,n} \cdot N_{Rk,c}$ [1)]				
	$\Delta N_{Rk,sp,0,n}$	[kN]	$\eta_{k,c,N,fat,n} \cdot N_{Rk,sp}$ [1)]				
Reduction factor		[-]	$\eta_{k,c,N,fat,n}$				
Number of load cycles n		1	1,0				
		≤ 10^3	0,932				
		≤ $3\cdot10^3$	0,893				
		≤ 10^4	0,841				
		≤ $3\cdot10^4$	0,794				
		≤ 10^5	0,750				
		≤ $3\cdot10^5$	0,722				
		≤ 10^6	0,704				
		> 10^6	0,693				
Effective anchorage depth	h_{ef}	[mm]	100		125		170
Partial factor	$\gamma_{Mc,fat}$	[-]	1,5				
Exponent for combined loading	α_c	[-]	1,5				
Load-transfer factor for fastener groups	ψ_{FN}	[-]	0,79				

[1)] see table C4

Injection System VMZ dynamic

Performance
Characteristic fatigue resistance under **tension load**, **design method I** according to **TR 061**

Annex C1

Table C2: Characteristic values of the **fatigue resistance** under **shear load** after **n load cycles without static actions (F_{Elod} = 0) design method I** according to **TR 061**

Anchor size / version			**100 M12**	**100 M12 A4 100 M12 HCR**	**125 M16**	**125 M16 A4 125 M16 HCR**	**170 M20**
Steel failure							
Characteristic resistance without static actions		[kN]	$\Delta V_{Rk,s,0,n}$				
Number of load cycles n		1	34,0		63,0		149,0
		≤ 10^3	27,6	31,3	54,0		113,5
		≤ $3 \cdot 10^3$	23,8	28,3	47,2		91,6
		≤ 10^4	18,6	23,5	36,5		65,0
		≤ $3 \cdot 10^4$	14,1	18,1	26,2		43,9
		≤ 10^5	10,5	12,8	18,4		29,0
		≤ $3 \cdot 10^5$	8,9	9,8	15,6		23,2
		≤ 10^6	8,2	8,5	15,0		21,3
		> 10^6	8,2		15,0		21,1
Partial factor	$\gamma_{Ms,fat,n}$	[-]	according TR 061, Eq. (3)				
Exponent for combined loading	α_{sn}	[-]	1,5	1,2	1,5	1,5	1,5
Concrete failure							
Characteristic resistance without static actions	$\Delta V_{Rk,cp,0,n}$	[kN]	$\eta_{k,c,V,fat,n} \cdot V_{Rk,cp}$ 1)				
	$\Delta V_{Rk,c,0,n}$	[kN]	$\eta_{k,c,V,fat,n} \cdot V_{Rk,c}$ 1)				
Reduction factor		[-]	$\eta_{k,c,N,fat,n}$				
Number of load cycles n		1	1,0				
		≤ 10^3	0,799				
		≤ $3 \cdot 10^3$	0,760				
		≤ 10^4	0,725				
		≤ $3 \cdot 10^4$	0,700				
		≤ 10^5	0,680				
		≤ $3 \cdot 10^5$	0,668				
		≤ 10^6	0,660				
		> 10^6	0,652				
Effective anchor length	l_f	[mm]	100		125		170
Outside diameter	d_{nom}	[mm]	14		18		24
Partial factor	$\gamma_{Mc,fat}$	[-]	1,5				
Exponent for combined loading	α_c	[-]	1,5				
Load-transfer factor for fastener groups	ψ_{FV}	[-]	0,81				

1) see table C4

Table C3: Characteristic fatigue **limit resistance** for design according to **EN 1992-4:2018** and **design method II** according to **TR 061**

Anchor size / version			**100 M12**	**100 M12 A4** **100 M12 HCR**	**125 M16**	**125 M16 A4** **125 M16 HCR**	**170 M20**
Tension load							
Steel failure							
Characteristic fatigue resistance	$\Delta N_{Rk,s,0,\infty}$	[kN]	20,1	21,2	34,0	37,3	43,5
Partial factor	$\gamma_{Ms,fat}$	[-]	1,35				
Load-transfer factor for fastener groups	ψ_{FN}	[-]	0,79				
Pull-out							
Characteristic fatigue resistance	$\Delta N_{Rk,p,0,\infty}$	[kN]	$(\Delta N_{Rk,s,0,\infty} / \gamma_{Ms,N,fat}) \cdot \gamma_{Mp,fat}$				
Partial factor	$\gamma_{Mp,fat}$	[-]	1,5				
Concrete failure							
Characteristic fatigue resistance	$\Delta N_{Rk,c,0,\infty}$	[kN]	$0{,}693\ N_{Rk,c}$ [1)]				
	$\Delta N_{Rk,sp,0,\infty}$	[kN]	$0{,}693\ N_{Rk,sp}$ [1)]				
Effective anchorage depth	h_{ef}	[mm]	100		125		170
Partial factor	$\gamma_{Mc,fat}$	[-]	1,5				
Shear load							
Steel failure without lever arm							
Characteristic fatigue resistance	$\Delta V_{Rk,s,0,\infty}$	[kN]	8,2		15,0		21,1
Partial factor	$\gamma_{Ms,fat}$	[-]	1,35				
Load-transfer factor for fastener groups	ψ_{FV}	[-]	0,81				
Concrete pry-out failure							
Characteristic fatigue resistance	$\Delta V_{Rk,cp,0,\infty}$	[kN]	$0{,}652\ V_{Rk,cp}$ [1)]				
Partial factor	$\gamma_{Mc,fat}$	[-]	1,5				
Concrete edge failure							
Characteristic fatigue resistance	$\Delta V_{Rk,c,0,\infty}$	[kN]	$0{,}652\ V_{Rk,c}$ [1)]				
Effective length of anchor	l_f	[mm]	100		125		170
Outside diameter of anchor	d_{nom}	[mm]	14		18		24
Partial factor	$\gamma_{Mc,fat}$	[-]	1,5				
Exponents for combined loading	α_s α_{sn}	[-]	1,5	1,2	1,5		1,5
	α_c	[-]	1,5				

Injection System VMZ dynamic

Performance
Characteristic **fatigue limit resistance** for design according to **EN 1992-4** and **design method II** according to **TR 061**

Annex C3

Table C4: Characteristic values under **tension load** for **static and quasi-static** or **seismic action**

Anchor size / version				**100 M12 100 M12 A4 100 M12 HCR**	**125 M16 125 M16 A4 125 M16 HCR**	**170 M20**
Steel failure						
Characteristic resistance		$N_{Rk,s}$ $N_{Rk,s,C1}$ $N_{Rk,s,C2}$	[kN]	57	111	188
Partial factor		γ_{Ms}	[-]	1,5		
Pull-out failure						
Characteristic resistance (C20/25)	uncracked concrete	$N_{Rk,p}$	[kN]	49,2	68,8	109
	cracked concrete	$N_{Rk,p}$	[kN]	34,4	48,1	76,3
	seismic C1	$N_{Rk,p,C1}$	[kN]	36,0	43,7	88,2
	seismic C2	$N_{Rk,p,C2}$	[kN]	17,6	26,1	59,7
Concrete cone failure						
Characteristic edge distance		$c_{cr,N}$	[mm]	$1{,}5 \cdot h_{ef}$		
Factor k1	uncracked concrete	$k_{ucr,N}$	[-]	11,0		
	cracked concrete	$k_{cr,N}$	[-]	7,7		
Effective anchorage depth		h_{ef}	[mm]	100	125	170
Splitting For each proof of splitting failure, $N_{Rk,sp}$ shall be calculated according to EN 1992-4:2018, equation (7.23). The higher value for $N_{Rk,sp}$ of case 1 and case 2 may be applied for the design.						
Standard thickness of concrete		$h_{min,1} \geq$	[mm]	200	250	340
Case 1	Characteristic resistance (C20/25)	$N^0_{Rk,sp}$	[kN]	40	50	109
	Characteristic edge distance	$c_{cr,sp}$	[mm]	$1{,}5 \cdot h_{ef}$		
Case 2	Characteristic resistance	$N^0_{Rk,sp}$	[kN]	min [$N_{Rk,p}$; $N^0_{Rk,c}$]		
	Characteristic edge distance	$c_{cr,sp}$	[mm]	$2 \cdot h_{ef}$	$2 \cdot h_{ef}$	$1{,}5 \cdot h_{ef}$
Minimum thickness of concrete		$h_{min,2} \geq$	[mm]	130	160	220
Case 1	Characteristic resistance (C20/25)	$N^0_{Rk,sp}$	[kN]	30	40	75
	Characteristic edge distance	$c_{cr,sp}$	[mm]	$1{,}5 \cdot h_{ef}$		
Case 2	Characteristic resistance	$N^0_{Rk,sp}$	[kN]	min [$N_{Rk,p}$; $N^0_{Rk,c}$]		
	Characteristic edge distance	$c_{cr,sp}$	[mm]	$3 \cdot h_{ef}$	$3 \cdot h_{ef}$	$2{,}6 \cdot h_{ef}$
Increasing factor for $N_{Rk,p}$ and $N^0_{Rk,sp}$ (case 1)		ψ_c	[-]	$\left(\frac{f_{ck}}{20}\right)^{0,5}$		
Installation factor		γ_{inst}	[-]	1,0		

Injection System VMZ dynamic

Performance
Characteristic values for **tension load** under **static and quasi static** or **seismic action**

Annex C4

Table C5: Characteristic values under **shear load** for **static and quasi-static** or **seismic action**

Anchor size / version			**100 M12 100 M12 A4 100 M12 HCR**	**125 M16 125 M16 A4 125 M16 HCR**	**170 M20**
Steel failure without lever arm					
Characteristic resistance	$V^0_{Rk,s}$	[kN]	34	63	149
	$V^0_{Rk,s,C1}$	[kN]	27,2	39,1	82,3
	$V^0_{Rk,s,C2}$	[kN]	27,2	50,4	108,8
Partial factor	γ_{Ms}	[-]	1,25		
Ductility factor	k_7	[-]	1,0		
Steel failure with lever arm					
Characteristic bending resistance	$M^0_{Rk,s}$	[Nm]	105	266	519
Partial factor	γ_{Ms}	[-]	1,25		
Concrete pry-out failure					
Pry-out factor	k_8	[-]	2,0		
Concrete edge failure					
Effective length of anchor in shear load	l_f	[mm]	100	125	170
Diameter of anchor	d_{nom}	[mm]	14	18	24
Installation factor	γ_{inst}	[-]	1,0		
Factor for anchorages with filled annular gap	α_{gap}	[-]	1,0		

Injection System VMZ dynamic	**Annex C5**
Performance Characteristic values under **shear load** for **static and quasi-static** or **seismic action**	

Table C6: Displacements under tension load for static and quasi-static or seismic action

Anchor size / version			**100 M12 100 M12 A4 100 M12 HCR**	**125 M16 125 M16 A4 125 M16 HCR**	**170 M20**
Tension load in **cracked** concrete	N	[kN]	17,1	24	38
Displacements	δ_{N0}	[mm]	0,6	0,7	0,8
	$\delta_{N\infty}$	[mm]	1,3	1,3	1,3
Tension load in **uncracked** concrete	N	[kN]	24	33	53,3
Displacements	δ_{N0}	[mm]	0,4	0,6	0,6
	$\delta_{N\infty}$	[mm]	1,3	1,3	1,3
Displacements under **seismic tension loads C2**					
Displacements	$\delta_{N,C2(DLS)}$	[mm]	1,1	1,5	1,9
	$\delta_{N,C2(ULS)}$	[mm]	3,0	4,4	4,5

Table C7: Displacements under shear load for static and quasi-static or seismic action

Anchor size / version			**100 M12 100 M12 A4 100 M12 HCR**	**125 M16 125 M16 A4 125 M16 HCR**	**170 M20**
Shear load	V	[kN]	19,3	36	75
Displacements	δ_{V0}	[mm]	3,3	3,8	4,3
	$\delta_{V\infty}$	[mm]	5,0	5,7	6,5
Displacements under **seismic shear loads C2**					
Displacements	$\delta_{V,C2(DLS)}$	[mm]	2,5	2,9	3,5
	$\delta_{V,C2(ULS)}$	[mm]	5,1	6,8	9,3

Injection System VMZ dynamic	**Annex C6**
Performance Displacements under **static and quasi-static** or **seismic action**	