



Approval body for construction products and types of construction

Bautechnisches Prüfamt

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European Technical Assessment

ETA-16/0461 of 6 June 2016

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:

Trade name of the construction product

Product family to which the construction product belongs

Manufacturer

Manufacturing plant

This European Technical Assessment contains

This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of

Deutsches Institut für Bautechnik

WPER500 Walraven Injection system for concrete

Bonded anchor for use in concrete

J. van Walraven B.V. Industrieweg 5 3641 RK MIJDRECHT NIEDERLANDE

Walraven factory A3

27 pages including 3 annexes which form an integral part of this assessment

Guideline for European technical approval of "Metal anchors for use in concrete", ETAG 001 Part 5: "Bonded anchors", April 2013, used as European Assessment Document (EAD) according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011.

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Specific Part

1 Technical description of the product

The "WPER500 Walraven Injection System for concrete" is a bonded anchor consisting of a cartridge with injection mortar WPER500 and a steel element. The steel element consist of a commercial threaded rod with washer and hexagon nut in the range of M8 to M30 or a reinforcing bar in the range of diameter 8 to 32 mm.

The steel element is placed into a drilled hole filled with injection mortar and is anchored via the bond between metal part, injection mortar and 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	Performance
Characteristic resistance for design according to TR 029 and TR 045	See Annex C 1 to C6
Characteristic resistance for design according to CEN/TS 1992-4:2009 and TR 045	See Annex C 7 to C 12
Displacements under tension and shear loads	See Annex C 13 / C 14

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Anchorages satisfy requirements for Class A1
Resistance to fire	No performance determined (NPD)

3.3 Hygiene, health and the environment (BWR 3)

Regarding dangerous substances there may be requirements (e.g. transposed European legislation and national laws, regulations and administrative provisions) applicable to the products falling within the scope of this European Technical Assessment. In order to meet the provisions of Regulation (EU) No 305/2011, these requirements need also to be complied with, when and where they apply.

3.4 Safety in use (BWR 4)

The essential characteristics regarding Safety in use are included under the Basic Works Requirement Mechanical resistance and stability.



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

In accordance with guideline for European technical approval ETAG 001, April 2013, used as European Assessment Document (EAD) according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011, 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 at Deutsches Institut für Bautechnik.

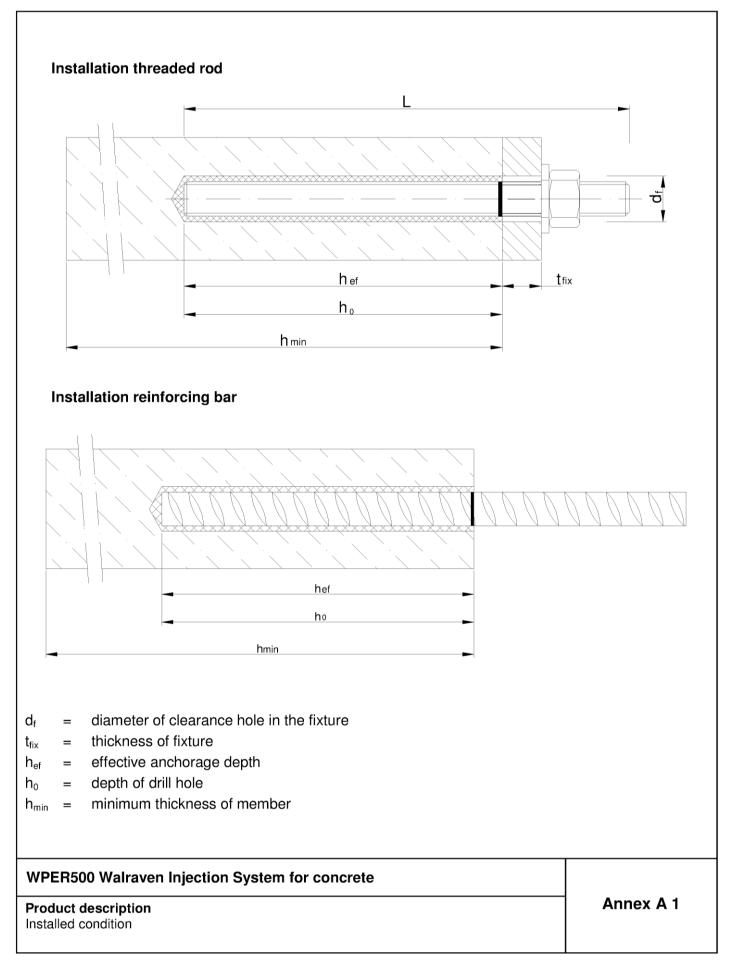
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Uwe Bender Head of Department *beglaubigt:* Baderschneider

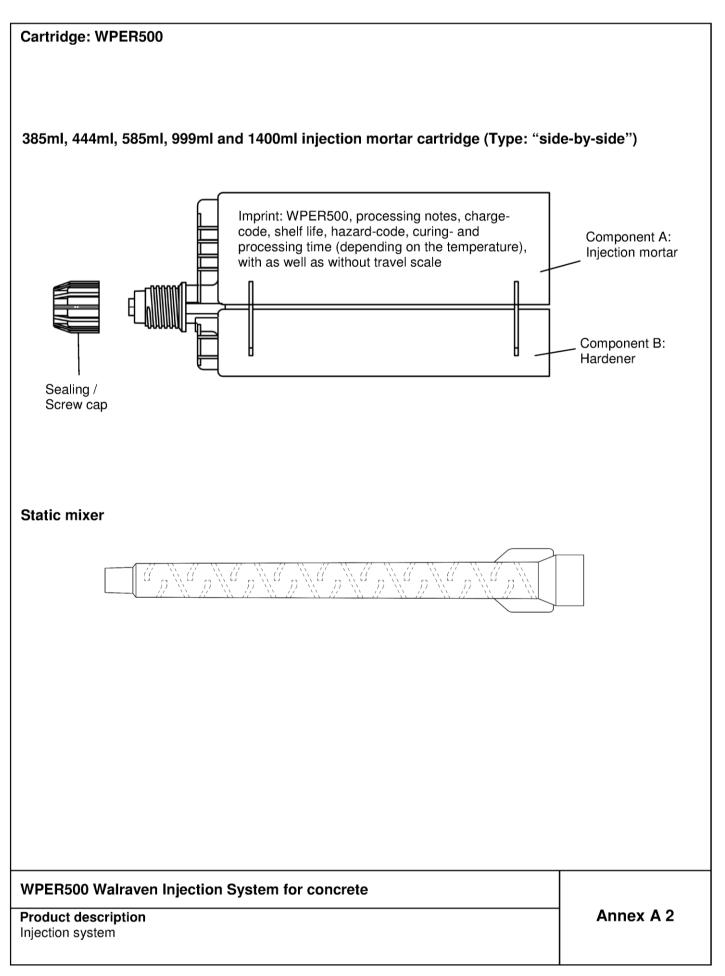
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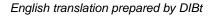
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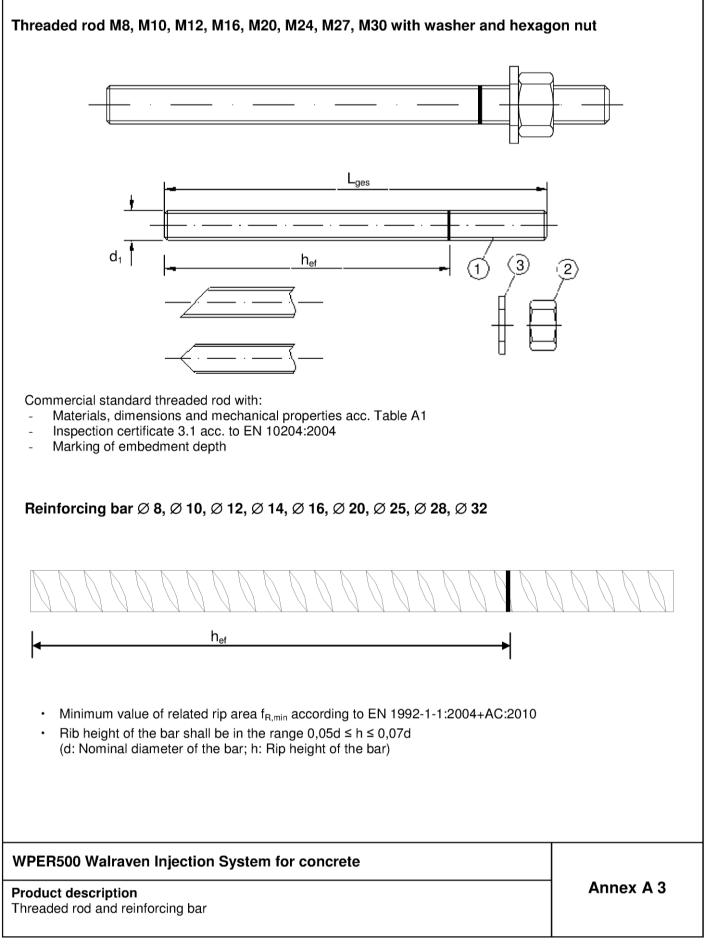




Table A1: Materials

Part	Designation	Material					
	, zinc plated \geq 5 µm acc. to EN ISO 4042:19						
	, bot-dip galvanised \geq 40 μ m acc. to EN ISO 4042.18		C:2009				
		Steel, EN 10087:1998 or EN 10263:200					
1	Anchor rod	Property class 4.6, 5.8, 8.8, EN 1993-1-8:2005+AC:2009					
		$A_5 > 8\%$ fracture elongation					
		Steel acc. to EN 10087:1998 or EN 102					
2	Hexagon nut, EN ISO 4032:2012	Property class 4 (for class 4.6 rod) EN IS					
	0	Property class 5 (for class 5.8 rod) EN IS Property class 8 (for class 8.8 rod) EN IS					
	Washer, EN ISO 887:2006,		50 090-2.2012				
3	EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Steel, zinc plated or hot-dip galvanised					
Stain	less steel						
		Material 1.4401 / 1.4404 / 1.4571, EN 10	088-1:2005,				
4	Apphor rod	> M24: Property class 50 EN ISO 3506-					
1	Anchor rod	≤ M24: Property class 70 EN ISO 3506-					
		$A_5 > 8\%$ fracture elongation					
		Material 1.4401 / 1.4404 / 1.4571 EN 10					
2	Hexagon nut, EN ISO 4032:2012	> M24: Property class 50 (for class 50 ro					
	Washer, EN ISO 887:2006,	≤ M24: Property class 70 (for class 70 ro	d) EN ISO 3506-2:2009				
3	EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Material 1.4401, 1.4404 or 1.4571, EN 1	0088-1:2005				
High	corrosion resistance steel						
		Material 1.4529 / 1.4565, EN 10088-1:20					
1	Anchor rod	> M24: Property class 50 EN ISO 3506-					
		≤ M24: Property class 70 EN ISO 3506-	1:2009				
		$A_5 > 8\%$ fracture elongation	05				
2	Hexagon nut, EN ISO 4032:2012	Material 1.4529 / 1.4565 EN 10088-1:20 > M24: Property class 50 (for class 50 ro					
2	Hexagon hut, EN 130 4052.2012	\leq M24: Property class 50 (for class 50 rd \leq M24: Property class 70 (for class 70 rd					
	Washer, EN ISO 887:2006,						
3	EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Material 1.4529 / 1.4565, EN 10088-1:20	005				
Reinf	orcing bars						
		Bars and de-coiled rods class B or C					
1	Rebar EN 1992-1-1:2004+AC:2010, Annex C	Bars and de-colled rods class B or C f_{yk} and k according to NDP or NCL of EN $f_{uk} = f_{tk} = k \cdot f_{yk}$	1992-1-1/NA:2013				
	1	1					
WP	ER500 Walraven Injection System for o	concrete					
Prod	luct description		Annex A 4				



Specifications of intended use

Anchorages subject to:

- Static and quasi-static loads: M8 to M30, Rebar Ø8 to Ø32.
- Seismic action for Performance Category C1: M12 to M30, Rebar Ø12 to Ø32.
- Seismic action for Performance Category C2: M12 and M16.

Base materials:

- Reinforced or unreinforced normal weight concrete according to EN 206-1:2000.
- Strength classes C20/25 to C50/60 according to EN 206-1:2000.
- Non-cracked concrete: M8 to M30, Rebar Ø8 to Ø32.
- Cracked concrete: M12 to M30, Rebar Ø12 to Ø32.

Temperature Range:

- · I: 40 °C to +40 °C (max long term temperature +24 °C and max short term temperature +40 °C)
- II: 40 °C to +60 °C (max long term temperature +43 °C and max short term temperature +60 °C)
- III: 40 °C to +72 °C (max long term temperature +43 °C and max short term temperature +72 °C)

Use conditions (Environmental conditions):

- Structures subject to dry internal conditions (zinc coated 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: M8 to M30, Rebar Ø8 to Ø32.
- Flooded holes (not sea water): M8 to M30, Rebar Ø8 to Ø32.
- Hole drilling by hammer or compressed air 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.

WPER500 Walraven Injection System for concrete

Intended Use

Specifications



Table B1: Installation	parameters for	or threa	aded ro	a						
Anchor size		M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30	
Nominal drill hole diameter	d ₀ [mm] =	10	12	14	18	24	28	32	35	
Effective encharges donth	h _{ef,min} [mm] =	60	60	70	80	90	96	108	120	
Effective anchorage depth	h _{ef,max} [mm] =	96	120	144	192	240	288	324	360	
Diameter of clearance hole in the fixture	d _f [mm] ≤	9	12	14	18	22	26	30	33	
Diameter of steel brush	d _b [mm] ≥	12	14	16	20	26	30	34	37	
Torque moment	T _{inst} [Nm] ≤	10	20	40	80	120	160	180	200	
Thickness of fixture	t _{fix,min} [mm] >				()				
Thickness of fixture	t _{fix,max} [mm] <	1500								
Minimum thickness of member	h _{min} [mm]		_{ef} + 30 m ≥ 100 mn				$h_{ef} + 2d_0$			
Minimum spacing	s _{min} [mm]	40	50	60	80	100	120	135	150	
Minimum edge distance	c _{min} [mm]	40	50	60	80	100	120	135	150	

Table B2: Installation parameters for rebar

Rebar size		Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Nominal drill hole diameter	d ₀ [mm] =	12	14	16	18	20	24	32	35	40
Effective encharge donth	h _{ef,min} [mm] =	60	60	70	75	80	90	100	112	128
Effective anchorage depth	h _{ef,max} [mm] =	96	120	144	168	192	240	300	336	384
Diameter of steel brush	d _b [mm] ≥	14	16	18	20	22	26	34	37	41,5
Minimum thickness of member	h _{min} [mm]		30 mm 0 mm				h _{ef} + 2d ₀)		
Minimum spacing	s _{min} [mm]	40	50	60	70	80	100	125	140	160
Minimum edge distance	c _{min} [mm]	40	50	60	70	80	100	125	140	160

WPER500 Walraven Injection System for concrete

Intended Use Installation parameters



Steel brush

Parameter cleaning and setting tools Table B3:

Threaded Rod	Rebar	d₀ Drill bit - Ø	d _♭ Brush - Ø	d _{b,min} min. Brush - Ø	Piston plug	
(mm)	(mm)	(mm)	(mm)	(mm)	(No.)	
M8		10	12	10,5		
M10	8	12	14	12,5		
M12	10	14	16	14,5	No	
	12	16	18	16,5	piston plug required	
M16	14	18	20	18,5		
	16	20	22	20,5		
M20	20	24	26	24,5	# 24	
M24		28	30	28,5	# 28	
M27	25	32	34	32,5	# 32	
M30	28	35	37	35,5	# 35	
	32	40	41,5	40,5	# 38	





Hand pump (volume 750 ml) Drill bit diameter (d₀): 10 mm to 20 mm





Recommended compressed air tool (min 6 bar) Drill bit diameter (d₀): 10 mm to 40 mm

Piston plug for overhead or horizontal installation Drill bit diameter (d₀): 24 mm to 40 mm

WPER500 Walraven Injection System for concrete

Intended Use

Cleaning and setting tools



Installation inst	ructions	
	 Drill with hammer drill a hole into the base material to the size a depth required by the selected anchor (Table B1 or Table B2). I drill hole: the drill hole shall be filled with mortar 	
	Attention! Standing water in the bore hole must be removed	d before cleaning.
2x	2a. Starting from the bottom or back of the bore hole, blow the hole compressed air (min. 6 bar) or a hand pump (Annex B 3) a mini the bore hole ground is not reached an extension shall be used	mum of two times. If
or	The hand-pump can be used for anchor sizes up to bore hole d	ameter 20 mm.
2x	For bore holes larger than 20 mm or deeper 240 mm, compress must be used.	ed air (min. 6 bar)
<u>*******</u> *** 2x	 2b. Check brush diameter (Table B3) and attach the brush to a drilli or a battery screwdriver. Brush the hole with an appropriate size > d_{b,min} (Table B3) a minimum of two times. If the bore hole ground is not reached with the brush, a brush ex shall be used (Table B3). 	ed wire brush
or	2c. Finally blow the hole clean again with compressed air (min. 6 ba (Annex B 3) a minimum of two times. If the bore hole ground is extension shall be used. The hand-pump can be used for anchor sizes up to bore hole d For bore holes larger than 20 mm or deeper 240 mm, compress <u>must</u> be used.	not reached an ameter 20 mm.
2x	After cleaning, the bore hole has to be protected against re an appropriate way, until dispensing the mortar in the bore the cleaning repeated has to be directly before dispensing In-flowing water must not contaminate the bore hole again.	hole. If necessary, the mortar.
	3. Attach a supplied static-mixing nozzle to the cartridge and load correct dispensing tool. Cut off the foil tube clip before use. For every working interruption longer than the recommended we (Table B4) as well as for new cartridges, a new static-mixer sha	orking time
in the formation of the second	4. Prior to inserting the anchor rod into the filled bore hole, the pose embedment depth shall be marked on the anchor rods.	ition of the
min. 3 full stroke	5. Prior to dispensing into the anchor hole, squeeze out separately full strokes and discard non-uniformly mixed adhesive component shows a consistent grey colour. For foil tube cartridges is must be minimum of six full strokes.	nts until the mortar
WPER500 Walrave	en Injection System for concrete	
		Anney R 4

Installation instructions



Installation inst	ructions (continuation)
	6. Starting from the bottom or back of the cleaned anchor hole fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. For embedment larger than 190 mm an extension nozzle shall be used. For overhead and horizontal installation a piston plug (Annex B 3) and extension nozzle shall be used. Observe the gel-/ working times given in Table B4.
	7. Push the threaded rod or reinforcing bar into the anchor hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached.
	The anchor should be free of dirt, grease, oil or other foreign material.
	8. Be sure that the anchor is fully seated at the bottom of the hole 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 application the anchor rod should be fixed (e.g. wedges).
20°C e.g.	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 B4).
	 After full curing, the add-on part can be installed with the max. torque (Table B2) by using a calibrated torque wrench.

Table B4: Minimum curing time

Concrete temperature	Gelling- working time	Minimum curing time in dry concrete	Minimum curing time in wet concrete
≥ 5 °C	120 min	50 h	100 h
≥ + 10 °C	90 min	30 h	60 h
≥ + 20 °C	30 min	10 h	20 h
≥ + 30 °C	20 min	6 h	12 h
≥ + 40 °C	12 min	4 h	8 h

WPER500 Walraven Injection System for concrete

Intended Use Installation instructions (continuation) Curing time



Anchor size threaded ro		M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30		
Steel failure											
Characteristic tension resisted, property class 4.6	stance,	N _{Rk,s}	[kN]	15	23	34	63	98	141	184	224
Characteristic tension resi Steel, property class 5.8	stance,	N _{Rk,s}	[kN]	18	29	42	78	122	176	230	280
Characteristic tension resi Steel, property class 8.8	stance,	N _{Rk,s}	[kN]	29	46	67	125	196	282	368	449
Characteristic tension resi Stainless steel A4 and HC property class 50 (>M24) a	R,	N _{Rk,s}	[kN]	26	41	59	110	171	247	230	281
Combined pull-out and c	oncrete cone failure										
Characteristic bond resista	ance in non-cracked con	crete C20/2	25								
Temperature range I:	dry and wet concrete	$\tau_{\text{Rk,ucr}}$	[N/mm²]	15	15	15	14	13	12	12	12
40°Č/24°C	flooded bore hole	$\tau_{\text{Rk,ucr}}$	[N/mm²]	15	14	13	10	9,5	8,5	7,5	7,0
Temperature range II: 60°C/43°C	dry and wet concrete	$\tau_{\text{Rk,ucr}}$	[N/mm²]	9,5	9,5	9,0	8,5	8,0	7,5	7,5	7,5
	flooded bore hole	$\tau_{\text{Rk,ucr}}$	[N/mm²]	9,5	9,5	9,0	8,5	7,5	7,0	6,5	6,0
Temperature range III:	dry and wet concrete	$\tau_{\text{Rk,ucr}}$	[N/mm²]	8,5	8,5	8,0	7,5	7,0	7,0	6,5	6,5
72°Ċ/43°C	flooded bore hole	$\tau_{\text{Rk,ucr}}$	[N/mm²]	8,5	8,5	8,0	7,5	7,0	6,0	5,5	5,5
		C30/37		1,04							
Increasing factors for conc Ψ_c	crete	C40/50		1,08							
		C50/60					1,	10			
Splitting failure											
Edge distance		C _{cr,sp}	[mm]		1,0) · h _{ef} ≤ 2	$2 \cdot h_{ef} (2$	$5 - \frac{h}{h_{ef}}$)≤ 2,4 ·	า _{ef}	
Axial distance		S _{cr,sp}	[mm]				2 c	cr,sp			
Installation safety factor (d	ry and wet concrete)	γ2			1	,2			1	,4	
Installation safety factor (fl	ooded bore hole)	γ2		1,4							

WPER500 Walraven Injection System for concrete

Performances

Characteristic values of resistance for threaded rods under tension loads in non-cracked concrete (Design according to TR 029)



Anchor size threaded r	od			M 12	M 16	M 20	M24	M 27	M 30
Steel failure									
Characteristic tension re Steel, property class 4.6	sistance,	$N_{Rk,s} = N_{Rk,s,seis}$	[kN]	34	63	98	141	184	224
Characteristic tension re Steel, property class 5.8	sistance,	$N_{Rk,s} = N_{Rk,s,seis}$	[kN]	42	78	122	176	230	280
Characteristic tension re Steel, property class 8.8		N _{Rk,s} =N _{Rk,s,seis}	[kN]	67	125	196	282	368	449
Characteristic tension re Stainless steel A4 and H property class 50 (>M24	CR,	$N_{Rk,s} = N_{Rk,s,seis}$	[kN]	59	110	171	247	230	281
Combined pull-out and	concrete cone failure								
Characteristic bond resis	stance in cracked concret	e C20/25							
		$ au_{Rk,cr}$	[N/mm ²]	7,5	6,5	6,0	5,5	5,5	5,5
	dry and wet concrete	$\tau_{\rm Rk,seis,C1}$	[N/mm ²]	7,1	6,2	5,7	5,5	5,5	5,5
Cemperature range I:		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	2,4	2,2	No Performance Determined (NPD)			
40°C/24°C		$\tau_{\rm Rk,cr}$	[N/mm²]	7,5	6,0	5,0	4,5	4,0	4,0
	flooded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	7,1	5,8	4,8	4,5	4,0	4,0
		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	2,4	2,1	No Pe	No Performance Determined (NPD)		
	dry and wet concrete	$\tau_{Rk,cr}$	[N/mm ²]	4,5	4,0	3,5	3,5	3,5	3,5
		$\tau_{\text{Rk,seis,C1}}$	[N/mm²]	4,3	3,8	3,4	3,5	3,5	3,5
Femperature range II:		$\tau_{\text{Rk,seis,C2}}$	[N/mm²]	1,4	1,4	No Performance Determined (NPD)			
60°C/43°C		$\tau_{Rk,cr}$	[N/mm ²]	4,5	4,0	3,5	3,5	3,5	3,5
	flooded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	4,3	3,8	3,4	3,5	3,5	3,5
		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	1,4	1,4	No Pe	rformance [Determined	(NPD)
		$\tau_{Rk,cr}$	[N/mm²]	4,0	3,5	3,0	3,0	3,0	3,0
	dry and wet concrete	$\tau_{\text{Rk,seis,C1}}$	[N/mm²]	3,9	3,4	3,0	3,0	3,0	3,0
Temperature range III:		$\tau_{\text{Rk,seis,C2}}$	[N/mm²]	1,3	1,2	No Pe	rformance [Determined	(NPD)
72°C/43°C		$\tau_{Rk,cr}$	[N/mm²]	4,0	3,5	3,0	3,0	3,0	3,0
	flooded bore hole	$\tau_{\rm Rk,seis,C1}$	[N/mm ²]	3,9	3,4	3,0	3,0	3,0	3,0
		$\tau_{\text{Rk,seis,C2}}$	[N/mm²]	1,3	1,2	No Pe	rformance [Determined	(NPD)
ncreasing factors for co	norete	C30/37				1,	04		
only static or quasi-stati		C40/50				1,	08		
hc for the second		C50/60				1,	10		
nstallation safety factor	(dry and wet concrete)	γ2		1	,2		1	,4	
nstallation safety factor	(flooded bore hole)	γ2				1	,4		

WPER500 Walraven Injection System for concrete

Performances

Characteristic values of resistance for threaded rods under tension loads in cracked concrete (Design according to TR 029 and TR 045)



Table C3:Characteristic values of resistance for threaded rods under shear loads in
cracked and non-cracked concrete (Design according to TR 029 and TR
045)

Anchor size threaded rod		M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30	
Steel failure without lever arm										
	V _{Rk,s}	[kN]	7	12	17	31	49	71	92	112
Characteristic shear resistance, Steel, property class 4.6	V _{Rk,s,seis,C1}	[kN]		ormance	14	27	42	56	72	88
	V _{Rk,s,seis,C2}	[kN]		mined PD)	13	25	No Perf	No Performance Determined (
	V _{Rk,s}	[kN]	9	15	21	39	61	88	115	140
Characteristic shear resistance, Steel, property class 5.8	V _{Rk,s,seis,C1}	[kN]		ormance	18 34		53	70	91	111
	$V_{\text{Rk},\text{s},\text{seis},\text{C2}}$	[kN]		mined PD)	17	31	No Perf	ormance	Determine	d (NPC
	$V_{Rk,s}$	[kN]	15	23	34	63	98	141	184	224
Characteristic shear resistance, Steel, property class 8.8	$V_{Rk,s,seis,C1}$	[kN]		ormance mined	30	55	85	111	145	177
	V _{Rk,s,seis,C2}	[kN]		PD)	27	50	No Perf	ormance	Determine	d (NPC
Characteristic shear resistance,	V _{Rk,s}	[kN]	13	20	30	55	86	124	115	140
Stainless steel A4 and HCR,	V _{Rk,s,seis,C1}	[kN]		ormance	26	48	75	98	91	111
property class 50 (>M24) and 70 (\leq M24)	V _{Rk,s,seis,C2}	[kN]		mined PD)	24	44	No Perf	ormance	Determine	d (NPE
Steel failure with lever arm		-	-							
	М ⁰ _{Rk,s}	[Nm]	15	30	52	133	260	449	666	900
Characteristic bending moment, Steel, property class 4.6	M ⁰ _{Rk,s,seis,C1}	[Nm]			No Dorf		Determine			
	M ⁰ _{Rk,s,seis,C2}	[Nm]			No Peri	ormance	Determine	a (NPD)		
Characteristic bending moment, Steel, property class 5.8	M ⁰ _{Rk,s}	[Nm]	19	37	65	166	324	560	833	1123
	M ⁰ _{Rk,s,seis,C1}	[Nm]	No Porformanco I			Dotorming				
	M ⁰ _{Rk,s,seis,C2}	[Nm]		No Performance Determi				a (NFD)		
	$M^0_{Rk,s}$	[Nm]	30	60	105	266	519	896	1333	1797
Characteristic bending moment, Steel, property class 8.8	$M^0_{Rk,s,seis,C1}$	[Nm]			No Porf	ormanco	Dotorming			
	$M^0_{\rm Rk,s,seis,C2}$	[Nm]			NOFEI	ormance	Jetennine	nined (NPD)		
Characteristic bending moment,	$M^0_{\ \mbox{Rk},s}$	[Nm]	26	52	92	232	454	784	832	1125
Stainless steel A4 and HCR,	$M^0_{\rm Rk,s,seis,C1}$	[Nm]			No Perf	ormance	Determine			
property class 50 (>M24) and 70 (\leq M24)	$M^0_{Rk,s,seis,C2}$	[Nm]				ormaneer	Determine	(N D)		
Concrete pry-out failure										
Factor k in equation (5.7) of Technical Report TR 029 for the design of Bonded Anchors	k	[-]				2	,0			
Installation safety factor	γ ₂ 1						,0			
Concrete edge failure	-		1							
Installation safety factor	γ_2					1	,0			
Installation safety factor	γ2					1	,0			

Performances

Characteristic values of resistance for threaded rods under shear loads in cracked and non-cracked concrete, (Design according to TR 029 and TR 045)



	aracteristic va n-cracked cou								on loa	ds in		
Anchor size reinforcing	bar			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure												
Characteristic tension resi	stance	N _{Rk,s}	[kN]					$A_{s}\boldsymbol{\cdot} f_{uk}$				
Combined pull-out and c	concrete cone failur	е										
Characteristic bond resista	ance in non-cracked	concrete C2	20/25									
Temperature range I:	dry and wet concrete	$\tau_{\text{Rk},\text{ucr}}$	[N/mm²]	14	14	13	13	12	12	11	11	11
40°C/24°C	flooded bore hole	$ au_{\text{Rk,ucr}}$	[N/mm²]	14	13	11	10	9,5	8,5	7,5	7,0	6,0
Temperature range II:	dry and wet concrete	$ au_{\rm Rk,ucr}$	[N/mm²]	8,5	8,5	8,0	8,0	7,5	7,0	7,0	6,5	6,5
60°C/43°C	flooded bore hole	$ au_{Rk,ucr}$	[N/mm²]	8,5	8,5	8,0	8,0	7,5	7,0	6,0	5,5	5,0
Temperature range III:	dry and wet concrete	$ au_{\mathrm{Rk},\mathrm{ucr}}$	[N/mm²]	7,5	7,5	7,5	7,0	7,0	6,5	6,0	6,0	6,0
72°C/43°C	flooded bore hole	$ au_{\mathrm{Rk},\mathrm{ucr}}$	[N/mm²]	7,5	7,5	7,5	7,0	7,0	6,0	5,5	5,0	4,5
		C30/37						1,04				
Increasing factors for conc Ψ_c	crete	C40/50						1,08				
•		C50/60						1,10				
Splitting failure												
Edge distance		C _{cr,sp}	[mm]			1,0 · h _{ef}	≤2·h _e	$_{\rm ef}igg(2,\!5-$	$\left(\frac{h}{h_{ef}}\right) \le 2$	2,4 · h _{ef}		
Axial distance		S _{cr,sp}	[mm]					2 c _{cr,sp}				
Installation safety factor (c concrete)	lry and wet	γ2				1,2				1	,4	
Installation safety factor (f	looded bore hole)	γ2						1,4				

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Performances

Characteristic values of resistance for rebar under tension loads in non-cracked concrete (Design according to TR 029)



	haracteristic val racked concrete							ads ir	1	
Anchor size reinforci	ng bar			Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure										1
Characteristic tension	resistance	N _{Rk,s} =N _{Rk,s,seis,C1}	[kN]				$A_{s} \boldsymbol{\cdot} f_{uk}$			
Combined pull-out ar	nd concrete cone failure	•								
Characteristic bond res	sistance in cracked concret	e C20/25								
	dry and wet concrete	$ au_{Rk,cr}$	[N/mm²]	7,5	7,0	6,5	6,0	5,5	5,5	5,5
Temperature range I:	dry and wet concrete	$ au_{Rk,seis,C1}$	[N/mm²]	6,9	6,4	6,2	5,7	5,5	5,5	5,5
40°C/24°C	flooded bore hole	$ au_{Rk,cr}$	[N/mm²]	7,5	6,5	6,0	5,0	4,5	4,0	4,0
	hooded bore hole	$ au_{Rk,seis,C1}$	[N/mm²]	6,9	6,0	5,7	4,8	4,5	4,0	4,0
	dry and wat apparate	$ au_{Rk,cr}$	[N/mm²]	4,5	4,0	4,0	3,5	3,5	3,5	3,5
Temperature range II:	dry and wet concrete	$\tau_{\text{Rk,seis,C1}}$	[N/mm²]	4,1	3,7	3,8	3,3	3,5	3,5	3,5
60°C/43°C	flooded bore hole	$\tau_{\text{Rk,cr}}$	[N/mm²]	4,5	4,0	4,0	3,5	3,5	3,5	3,0
	liboded bore hole	$\tau_{Rk,seis,C1}$	[N/mm²]	4,1	3,7	3,8	3,3	3,5	3,5	3,0
		$\tau_{Rk,cr}$	[N/mm²]	4,0	3,5	3,5	3,0	3,0	3,0	3,0
Temperature range III:	dry and wet concrete	$\tau_{Rk,seis,C1}$	[N/mm²]	3,7	3,2	3,3	2,9	3,0	3,0	3,0
72°C/43°C	flooded bore hole	$\tau_{\text{Rk,cr}}$	[N/mm²]	4,0	3,5	3,5	3,0	3,0	3,0	3,0
	liboded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm²]	3,7	3,2	3,3	2,9	3,0	3,0	3,0
		C30/37					1,04			
Increasing factors for c (only static or quasi-sta Ψc		C40/50					1,08			
Ψ ⁰		C50/60					1,10			
Installation safety facto	or (dry and wet concrete)	γ2			1,2			1	,4	
Installation safety facto	or (flooded bore hole)	γ2					1,4			

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Characteristic values of resistance for rebar under tension loads in cracked concrete (Design according to TR 029 and TR 045)



Table C6: Characterist and non-crac											k
Anchor size 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											
	$V_{Rk,s}$	[kN]				0,	50 • A _s •	f _{uk}			
Characteristic shear resistance	$V_{Rk,s,seis,C1}$	[kN]	Perfor	lo mance mined PD)			0,	44 • A _s •	f _{uk}		
Steel failure with lever arm											
Characteristic bending moment	M ⁰ _{Rk,s}	[Nm]				1.	2 • W _{el} •	f _{uk}			
characteristic behaling moment	$M^0_{\rm Rk,s,seis,C1}$	[Nm]			No F	Performar	nce Dete	rmined (N	NPD)		
Concrete pry-out failure	•										
Factor k in equation (5.7) of Technical Report TR 029 for the design of bonded anchors	k	[-]					2,0				
Installation safety factor	γ2						1,0				
Concrete edge failure											
Installation safety factor	γ2						1,0				
WPER500 Walraven Injection								_	Ann	ex C 6	6
Characteristic values of resistance f concrete, (Design according to TR (ads in c	racked a	and non-	cracked	1				



Anchor size threaded rod				M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30
Steel failure											
Characteristic tension resista Steel, property class 4.6	ance,	N _{Rk,s}	[kN]	15	23	34	63	98	141	184	224
Characteristic tension resist	ance,	N _{Bk.s}	[kN]	18	29	42	78	122	176	230	280
Steel, property class 5.8 Characteristic tension resista	ance,	N _{Rk,s}	[kN]	29	46	67	125	196	282	368	449
Steel, property class 8.8 Characteristic tension resista Stainless steel A4 and HCR, property class 50 (>M24) an		N _{Rk,s}	[kN]	26	41	59	110	171	247	230	281
Combined pull-out and co					1						
Characteristic bond resistan	ce in non-cracked concrete	e C20/25									
Temperature range I:	dry and wet concrete	$ au_{Rk,ucr}$	[N/mm ²]	15	15	15	14	13	12	12	12
40°C/24°C	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm ²]	15	14	13	10	9,5	8,5	7,5	7,0
Temperature range II:	dry and wet concrete	$\tau_{\rm Rk,ucr}$	[N/mm²]	9,5	9,5	9,0	8,5	8,0	7,5	7,5	7,5
60°Ċ/43°C	flooded bore hole	$\tau_{\rm Rk,ucr}$	[N/mm²]	9,5	9,5	9,0	8,5	7,5	7,0	6,5	6,0
Temperature range III:	dry and wet concrete	$\tau_{\rm Rk,ucr}$	[N/mm²]	8,5	8,5	8,0	7,5	7,0	7,0	6,5	6,5
72°Ċ/43°C	flooded bore hole	$\tau_{\rm Rk,ucr}$	[N/mm ²]	8,5	8,5	8,0	7,5	7,0	6,0	5,5	5,5
		C30/37					1,	04			
Increasing factors for concre Ψ_c	ite	C40/50					1,	08			
		C50/60					1,	10			
Factor according to CEN/TS 1992-4-5 Section 6	.2.2.3	k ₈	[-]				10),1			
Concrete cone failure											
Factor according to CEN/TS 1992-4-5 Section 6	231	k _{ucr}	[-]				10),1			
Edge distance	.2.0.1	C _{cr,N}	[mm]				1,5	h _{ef}			
Axial distance		S _{cr,N}	[mm]				3,0	h _{ef}			
Splitting failure		I									
Edge distance		C _{cr,sp}	[mm]		1	,0 ⋅ h _{ef} ≤	$2 \cdot h_{ef} \left(2 \right)$	$5 - \frac{h}{h_{ef}}$	≤ 2,4 · h	əf	
Axial distance		S _{cr,sp}	[mm]				2 c	cr,sp			
	and wet concrete)	γinst			1	,2			1	,4	
Installation safety factor (dry	ded bore hole)	γinst					1	,4			

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Characteristic values of resistance for threaded rods under tension loads in non-cracked concrete (Design according to CEN/TS 1992-4)



Table C8: Characteristic values of resistance for threaded rods under tension loads in cracked concrete (Design according to CEN/TS 1992-4 and TR 045)

Anchor size threaded rod	l			M 12	M 16	M 20	M24	M27	M30
Steel failure									
Characteristic tension resis	tance,	N _{Rk.s} =N _{Rk.s.seis}	[kN]	34	63	98	141	184	224
Steel, property class 4.6 Characteristic tension resis	stance,	N _{Rk,s} =N _{Rk,s,seis}	[kN]	42	78	122	176	230	280
Steel, property class 5.8 Characteristic tension resis	tance								
Steel, property class 8.8	anoc,	$N_{Rk,s} = N_{Rk,s,seis}$	[kN]	67	125	196	282	368	449
Characteristic tension resis Stainless steel A4 and HCI property class 50 (>M24) a	R,	$N_{\text{Rk,s}} = N_{\text{Rk,s,seis}}$	[kN]	59	110	171	247	230	281
Combined pull-out and co	oncrete failure								
Characteristic bond resista	nce in cracked concrete C2	0/25							
		$\tau_{\text{Rk,cr}}$	[N/mm ²]	7,5	6,5	6,0	5,5	5,5	5,5
	dry and wet concrete	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	7,1	6,2	5,7	5,5	5,5	5,5
Temperature range I:		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	2,4	2,2	No Perf	ormance l	Determine	d (NPD
40°C/24°C		$ au_{Rk,cr}$	[N/mm ²]	7,5	6,0	5,0	4,5	4,0	4,0
	flooded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	7,1	5,8	4,8	4,5	4,0	4,0
		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	2,4	2,1	No Perf	ormance l	Determine	d (NPD
		$ au_{Rk,cr}$	[N/mm ²]	4,5	4,0	3,5	3,5	3,5	3,5
	dry and wet concrete	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	4,3	3,8	3,4	3,5	3,5	3,5
Temperature range II:		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	1,4	1,4	No Perf	ormance l	Determine	d (NPD
60°C/43°C		$ au_{Rk,cr}$	[N/mm ²]	4,5	4,0	3,5	3,5	3,5	3,5
	flooded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	4,3	3,8	3,4	3,5	3,5	3,5
		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	1,4	1,4	No Perf	ormance l	Determine	d (NPD
		$ au_{Rk,cr}$	[N/mm ²]	4,0	3,5	3,0	3,0	3,0	3,0
	dry and wet concrete	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	3,9	3,4	3,0	3,0	3,0	3,0
Temperature range III:		$\tau_{\text{Rk,seis,C2}}$	[N/mm ²]	1,3	1,2	No Perf	ormance I	Determine	d (NPD
72°C/43°C		$ au_{Rk,cr}$	[N/mm ²]	4,0	3,5	3,0	3,0	3,0	3,0
	flooded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm ²]	3,9	3,4	3,0	3,0	3,0	3,0
		$\tau_{\text{Rk,seis,C2}}$	[N/mm²]	1,3	1,2	No Perf	ormance l	Determine	d (NPD
Increasing factors for conci		C30/37				1,	04		
(only static or quasi-static a	actions)	C40/50				1,	08		
Ψc		C50/60				1,	10		
Factor according to CEN/TS 1992-4-5 Section	6.2.2.3	k ₈	[-]			7	,2		
Concrete cone failure									
Factor according to CEN/TS 1992-4-5 Section	6.2.3.1	k _{cr}	[-]				,2		
Edge distance		C _{cr,N}	[mm]				i h _{ef}		
Axial distance		S _{cr,N}	[mm]			3,0) h _{ef}		
Installation safety factor (dr	y and wet concrete)	γinst		1	,2		1	,4	
Installation safety factor (flo	oded bore hole)	γinst				1	,4		

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Characteristic values of resistance for threaded rods under tension loads in cracked concrete (Design according to CEN/TS 1992-4 and TR 045)



Table C9: Characteristic values of resistance for threaded rods under shear loads in cracked and non-cracked concrete (Design according to CEN/TS 1992-4 and TR 045)

Anchor size threaded rod			M 8	M 10	M 12	M 16	M 20	M24	M 27	М 3
Steel failure without lever arm										
	V _{Rk,s}	[kN]	7	12	17	31	49	71	92	112
Characteristic shear resistance, Steel, property class 4.6	V _{Rk,s,seis,C1}	[kN]	No Perfe	ormance	14	27	42	56	72	88
	V _{Rk,s,seis,C2}	[kN]	Determin	ed (NPD)	13	25	No Per	formance l	Determined	(NPD)
a	V _{Rk,s}	[kN]	9	15	21	39	61	88	115	140
Characteristic shear resistance, Steel, property class 5.8	V _{Rk,s,seis,C1}	[kN]		ormance	18	34	53	70	91	111
	V _{Rk,s,seis,C2}	[kN]	Determin	ed (NPD)	17	31	No Per	formance I	Determined	d (NPD)
	V _{Rk,s}	[kN]	15	23	34	63	98	141	184	224
Characteristic shear resistance, Steel, property class 8.8	V _{Rk,s,seis,C1}	[kN]		ormance	30	55	85	111	145	177
	$V_{Rk,s,seis,C2}$	[kN]	Determin	ed (NPD)	27	50	No Per	formance I	Determined	(NPD
Characteristic shear resistance,	V _{Rk,s}	[kN]	13	20	30	55	86	124	115	140
Stainless steel A4 and HCR, property class 50 (>M24) and 70 (\leq M24)	V _{Rk,s,seis,C1}	[kN]		ormance	26	48	75	98	91	111
	$V_{\text{Rk},\text{s},\text{seis},\text{C2}}$	[kN]	Determin	ed (NPD)	24	44	No Per	formance I	Determined	d (NPD
Ductility factor according to CEN/TS 1992-4-5 Section 6.3.2.1	k ₂					0	,8			
Steel failure with lever arm	•									
	M ⁰ _{Rk,s}	[Nm]	15	30	52	133	260	449	666	900
Characteristic bending moment, Steel, property class 4.6	M ⁰ _{Rk,s,seis,C1}	[Nm]			No Por	formance I	Dotorminor			
	M ⁰ _{Rk,s,seis,C2}	[Nm]			NO Per	Ionnance i	Jetenninet			_
	M ⁰ _{Rk,s}	[Nm]	19	37	65	166	324	560	833	112
Characteristic bending moment, Steel, property class 5.8	M ⁰ _{Rk,s,seis,C1}	[Nm]			No Per	formance I	Determined			
	M ⁰ _{Rk,s,seis,C2}	[Nm]						. (
Characteristic bending moment,	M ⁰ _{Rk,s}	[Nm]	30	60	105	266	519	896	1333	179
Steel, property class 8.8	M ⁰ _{Rk,s,seis,C1}	[Nm]			No Per	formance l	Determined	(NPD)		
	M ⁰ _{Rk,s,seis,C2}	[Nm]						. ,		
Characteristic bending moment,	M ⁰ _{Rk,s}	[Nm]	26	52	92	232	454	784	832	112
Stainless steel A4 and HCR, property class 50 (>M24) and 70 (\leq M24)	M ⁰ _{Rk,s,seis,C1}	[Nm]			No Per	formance l	Determined	d (NPD)		
	$M^0_{\rm Rk,s,seis,C2}$	[Nm]						. ,		
Concrete pry-out failure										
Factor in equation (27) of CEN/TS 1992-4-5 Section 6.3.3	k3					2	,0			
Installation safety factor	γinst					1	,0			
Concrete edge failure ³⁾	•									
Effective length of anchor	lı.	[mm]				l _f = min(h	l _{ef} ; 8 d _{nom})			
Outside diameter of anchor	d _{nom}	[mm]	8	10	12	16	20	24	27	30
Installation safety factor	Yinst					1	,0			
	1									

Characteristic values of resistance for threaded rods under shear loads in cracked and non-cracked concrete, (Design according to CEN/TS 1992-4 and TR 045)



	acteristic value cracked concre									ls in		
Anchor size reinforcing ba	r			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure												
Characteristic tension resista	ance	N _{Rk,s}	[kN]					A _s ∙ f _{uk}				
Combined pull-out and cor	ncrete failure											
Characteristic bond resistand	e in non-cracked concre	ete C20/25	5									
Temperature range I:	dry and wet concrete	$\tau_{\text{Rk,ucr}}$	[N/mm²]	14	14	13	13	12	12	11	11	11
40°C/24°C	flooded bore hole	$ au_{Rk,ucr}$	[N/mm²]	14	13	11	10	9,5	8,5	7,5	7,0	6,0
Temperature range II:	dry and wet concrete	$ au_{Rk,ucr}$	[N/mm²]	8,5	8,5	8,0	8,0	7,5	7,0	7,0	6,5	6,5
60°C/43°C	flooded bore hole	$\tau_{\rm Rk,ucr}$	[N/mm²]	8,5	8,5	8,0	8,0	7,5	7,0	6,0	5,5	5,0
Temperature range III:	dry and wet concrete	$\tau_{\rm Rk,ucr}$	[N/mm²]	7,5	7,5	7,5	7,0	7,0	6,5	6,0	6,0	6,0
72°Ċ/43°C	flooded bore hole	$\tau_{\rm Rk,ucr}$	[N/mm²]	7,5	7,5	7,5	7,0	7,0	6,0	5,5	5,0	4,5
	-	C30/37						1,04				
Increasing factors for concrete Ψ_c	te	C40/50						1,08				
		C50/60						1,10				
Factor according to CEN/TS 1992-4-5 Section 6.	2.2.3	k ₈	[-]					10,1				
Concrete cone failure												
Factor according to CEN/TS 1992-4-5 Section 6.	2.3.1	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		C _{cr,sp}	[mm]			1,0 · h _e	_{ef} ≤2 · h,	ef (2,5	$\left(\frac{h}{h_{ef}}\right) \le 2$,4 · h _{ef}		
Axial distance		S _{cr,sp}	[mm]					$2 c_{\text{cr,sp}}$				
Installation safety factor (dry	and wet concrete)	γinst				1,2				1	,4	
Installation safety factor (floo	ded bore hole)	γinst						1,4				
WPER500 Walrave	n Injection Syste	m for o	concrete)						Anne	x C 10	0

Characteristic values of resistance for rebar under tension loads in non-cracked concrete (Design according to CEN/TS 1992-4)



	aracteristic valu Icrete (Design a							ds in	cracke	ed
Anchor size reinforcing	g bar			Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Steel failure							1			1
Characteristic tension re	sistance	$N_{\text{Rk},s} = N_{\text{Rk},s,seis,C1}$	[kN]				$A_{s}\boldsymbol{\cdot}f_{uk}$			
Combined pull-out and	l concrete failure									
Characteristic bond resis	stance in cracked concre	te C20/25								
	dry and wat concrete	$\tau_{\rm Rk,cr}$	[N/mm ²]	7,5	7,0	6,5	6,0	5,5	5,5	5,5
Temperature range I:	dry and wet concrete	$\tau_{Rk,seis,C1}$	[N/mm²]	6,9	6,4	6,2	5,7	5,5	5,5	5,5
40°Ċ/24°C	a static second	$ au_{\mathrm{Rk,cr}}$	[N/mm²]	7,5	6,5	6,0	5,0	4,5	4,0	4,0
	flooded bore hole	$\tau_{\text{Rk,seis,C1}}$	[N/mm²]	6,9	6,0	5,7	4,8	4,5	4,0	4,0
		$ au_{Rk,cr}$	[N/mm²]	4,5	4,0	4,0	3,5	3,5	3,5	3,5
Temperature range II:	dry and wet concrete	$\tau_{\rm Rk,seis,C1}$	[N/mm²]	4,1	3,7	3,8	3,3	3,5	3,5	3,5
60°C/43°C		$ au_{Rk,cr}$	[N/mm²]	4,5	4,0	4,0	3,5	3,5	3,5	3,0
	flooded bore hole	$ au_{\mathrm{Rk},\mathrm{seis},\mathrm{C1}}$	[N/mm²]	4,1	3,7	3,8	3,3	3,5	3,5	3,0
		$ au_{Rk,cr}$	[N/mm²]	4,0	3,5	3,5	3,0	3,0	3,0	3,0
Temperature range III:	dry and wet concrete	$ au_{Rk,seis,C1}$	[N/mm²]	3,7	3,2	3,3	2,9	3,0	3,0	3,0
72°C/43°C		$ au_{Rk,cr}$	[N/mm²]	4,0	3,5	3,5	3,0	3,0	3,0	3,0
	flooded bore hole	$ au_{Rk,seis,C1}$	[N/mm²]	3,7	3,2	3,3	2,9	3,0	3,0	3,0
Increasing factors for co	ncrete	C30/37					1,04			
(only static or quasi-stati		C40/50					1,08			
ψ_{c}		C50/60					1,10			
Factor according to CEN/TS 1992-4-5 Section	on 6.2.2.3	k ₈	[-]				7,2			
Concrete cone failure										
Factor according to CEN/TS 1992-4-5 Section	on 6.2.3.1	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 safety factor	(dry and wet concrete)	γinst			1,2			1	,4	
Installation safety factor	(flooded bore hole)	γinst					1,4			

WPER500 Walraven Injection System for concrete

Performances

Characteristic values of resistance for rebar under tension loads in cracked concrete (Design according to CEN/TS 1992-4 and TR 045)

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Table C12: Characteristic value and non-cracked co)
Anchor size 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											
	$V_{Rk,s}$	[kN]				0,	50 • A _s •	f _{uk}			
Characteristic shear resistance	$V^0_{\rm Rk,s,seis,C1}$	[kN]		mance mined			0,4	14 • A _s •	f _{uk}		
Ductility factor according to CEN/TS 1992-4-5 Section 6.3.2.1	k ₂						0,8				
Steel failure with lever arm	_	_									
Characteristic bending moment	M ⁰ _{Rk,s}	[Nm]				1.	2 ∙ W _{el} ∙	f _{uk}			
Characteristic bending moment	$M^0_{\rm Rk,s,seis,C1}$	[Nm]			No Pe	erformar	nce Dete	rmined ((NPD)		
Concrete pry-out failure											
Factor in equation (27) of CEN/TS 1992-4-5 Section 6.3.3	k ₃						2,0				
Installation safety factor	γinst						1,0				
Concrete edge failure											
Effective length of anchor	l _t	[mm]				$I_f = m$	nin(h _{ef} ; 8	d _{nom})			
Outside diameter of anchor	d _{nom}	[mm]	8	10	12	14	16	20	25	28	32
Installation safety factor	γinst						1,0				

WPER500 Walraven Injection System for concrete

Performances

Characteristic values of resistance for rebar under shear loads in cracked and non-cracked concrete, (Design according to CEN/TS 1992-4 and TR 045)



$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		ded rod		M 8	M 10	M 12	M 16	M 20	M24	M 27	M 30
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Non-cracked conc	rete C20/25	under static and	quasi-statio	action						
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Temperature range I:	δ_{N0} -factor	[mm/(N/mm ²)]	0,011	0,013	0,015	0,020	0,024	0.029	0,032	0,03
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $											0,14
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Temperature range II:			0,013	0,015	0,018	0,023	0,028	0,033	0,037	0,04
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	60°C/43°C	$\delta_{N_{\infty}}$ -factor	[mm/(N/mm ²)]	0,050	0,060	0,070	0,091	0,111	0,131	0,146	0,16
$ \begin{array}{ c c c c c c c c c c c c c c c c c c $	Temperature range III:	δ_{N0} -factor	[mm/(N/mm ²)]	0,013	0,015	0,018	0,023	0,028	0,033	0,037	0,04
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	72°C/43°C	$\delta_{N\infty}\text{-}factor$	[mm/(N/mm ²)]	0,050	0,060	0,070	0,091	0,111	0,131	0,146	0,16
$ \frac{40^{\circ}C/4^{\circ}C}{1000} \frac{\delta_{N_{w}}-factor}{10000} \frac{[mm/(N/mm^{\circ})]}{\delta_{N_{w}}-factor} \frac{[mm/(N/mm^{\circ})]}{[mm/(N/mm^{\circ})]} \\ Temperature range II: \frac{\delta_{N_{w}}-factor}{\delta_{N_{w}}-factor} \frac{[mm/(N/mm^{\circ})]}{[mm/(N/mm^{\circ})]} \\ \frac{\delta_{N_{w}}-factor}{\delta_{N_{w}}-factor} \cdot \tau; \\ \frac{\delta_{N_{w}}-factor}{\delta_{N_{w}}-factor} \cdot \tau; \\ \frac{Table C14: Displacement S under shear load^{1)} (threaded rod) \\ \frac{\delta_{N_{w}}-factor}{\delta_{N_{w}}-factor} \frac{[mm/(kN]]}{\delta_{N_{w}}-factor} \cdot \tau; \\ \frac{Table c14: Displacement S under shear load^{1)}}{\delta_{N_{w}}-factor} \frac{M 8 M 10 M 12 M 16 M 20 M24 M 27 M 3 M Non-cracked and cracked concrete C20/25 under static, quasi-static and seismic C1 action \\ \frac{\delta_{N_{w}}-factor}{\delta_{N_{w}}-factor} \frac{[mm/(kN]]}{\delta_{N_{w}}-factor} \frac{[mm/(kN]}{\delta_{N_{w}}-factor} \frac{[mm/(kN]}{\delta_{N_{w}}-factor} \frac{[mm/(kN]}{\delta_$	Cracked concrete	C20/25 und	ler static, quasi-sta	atic and sei	smic C	1 action	1				
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Temperature range I:	δ_{N0} -factor	[mm/(N/mm ²)]			0,032	0,037	0,042	0,048	0,053	0,05
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			• • •			0,21	0,21	0,21	0,21	0,21	0,21
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Temperature range II:	δ_{N0} -factor	[mm/(N/mm ²)]			0,037	0,043	0,049	0,055	0,061	0,06
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	60°C/43°C	$\delta_{N\infty}$ -factor	[mm/(N/mm ²)]			0,24	0,24	0,24	0,24	0,24	0,24
$\begin{aligned} \begin{array}{c c c c c c c c c c c c c c c c c c c $	Temperature range III:	δ_{N0} -factor	[mm/(N/mm ²)]		,	0,037	0,043	0,049	0,055	0,061	0,06
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	72°C/43°C	$\delta_{N\infty}\text{-}factor$	[mm/(N/mm ²)]			0,24	0,24	0,24	0,24	0,24	0,24
$\frac{10^{\circ}C/24^{\circ}C}{10^{\circ}C/24^{\circ}C}$ $\frac{\delta_{N,seis(ULS)}}{\delta_{N,seis(ULS)}} [mm/(N/mm^2)]$ Temperature range II: $\frac{\delta_{N,seis(ULS)}}{60^{\circ}C/43^{\circ}C} [mm/(N/mm^2)]$ Temperature range III: $\frac{\delta_{N,seis(ULS)}}{\delta_{N,seis(ULS)}} [mm/(N/mm^2)]$ $\frac{\delta_{N,seis(ULS)}}{\delta_{N,seis(ULS)}} [mm/(N/mm^2)]$ $\frac{\delta_{N,seis(ULS)}}{\delta_{N,seis(ULS)}}$	Cracked concrete	C20/25 und	ler seismic C2 acti	on							
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Temperature range I:	$\delta_{N,seis(DLS)}$	[mm/(N/mm²)]			0,03	0,05				
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			[mm/(N/mm ²)]			0,06	0,09				
$\frac{1}{10} \frac{1}{10} \frac$	40°C/24°C	UN,SEIS(ULS)			armanoa	0.02	0.05				
$\frac{72^{\circ}C/43^{\circ}C}{\delta_{N,seis}(ULS)} [mm/(N/mm^{2})] \qquad 0,06 0,09$ $(1) Calculation of the displacement \\ \delta_{N0} = \delta_{N0} - factor \cdot \tau; \\ \delta_{Nee} = \delta_{Nee} - factor \cdot \tau; \\ \delta_{Nee} = \delta_{Nee} - factor \cdot \tau; \\ Shee = \delta_{Nee} - factor \cdot \tau; \\ \delta_{Nee} = \delta_{Nee} - factor \cdot \tau; \\ Shee = \delta_{Nee} - factor \cdot \tau; \\ Shee = \delta_{Nee} - factor (mm/(kN)) = 0,06 0,06 0,06 0,04 0,04 0,03 0,03 0,03 0,06 0,06 0,06 0,06 0,06 0,06 0,05 0,04 0,04 0,03 0,03 0,06 0,06 0,06 0,06 0,06 0,05 0,05 0,05 0,06 0,05 0,06 0,05 0,05 0,06 0,05 0,06 0,05 0,05 0,06 0,05 0,06 0,05 0,06 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,06 0,05 0,05 0,05 0,06 0,05 0$			[mm/(N/mm²)]			0,03	0,05	No Dorf	ormonoo l	Dotormino	
$\frac{1}{2} (1,1) = \frac{1}{2} (1,1$	Temperature range II:	$\delta_{N,seis(\text{DLS})}$	1 (//	Deter	mined		,	No Perf	ormance I	Determine	d (NPD
$\begin{split} & \delta_{\text{NO}} = \delta_{\text{NO}} - \text{factor} \cdot \tau; \\ & \mathbf{Table C14: Displacements under shear load^{1)} (threaded rod)} \\ & \mathbf{Anchor size threaded rod} & \mathbf{M 8} & \mathbf{M 10} & \mathbf{M 12} & \mathbf{M 16} & \mathbf{M 20} & \mathbf{M 24} & \mathbf{M 27} & \mathbf{M 3} \\ & \mathbf{Anchor size threaded rod} & \mathbf{M 8} & \mathbf{M 10} & \mathbf{M 12} & \mathbf{M 16} & \mathbf{M 20} & \mathbf{M 24} & \mathbf{M 27} & \mathbf{M 3} \\ & \mathbf{Non-cracked and cracked concrete C20/25 under static, quasi-static and seismic C1 action} \\ & \mathbf{All temperature} & & \delta_{\text{Vo}} - \text{factor} & [mm/(kN)] & 0,06 & 0,06 & 0,05 & 0,04 & 0,04 & 0,03 & 0,03 & 0,0 \\ & \delta_{\text{Vo}} - \text{factor} & [mm/(kN)] & 0,09 & 0,08 & 0,08 & 0,06 & 0,06 & 0,05 & 0,05 & 0,05 \\ & \mathbf{Cracked concrete C20/25 under seismic C2 action} \\ & \mathbf{All temperature} & & \delta_{\text{V,seis(DLS)}} & [mm/kN] & & \text{No Performance} & 0,2 & 0,1 \\ & \delta_{\text{V,seis(ULS)}} & [mm/kN] & & \text{No Performance} & 0,2 & 0,1 \\ & \delta_{\text{V,seis(ULS)}} & [mm/kN] & & \text{No Performance} & 0,2 & 0,1 \\ \hline \end{array}$	Temperature range II: 60°C/43°C Temperature range III:	$\frac{\delta_{N,seis(DLS)}}{\delta_{N,seis(ULS)}}$	[mm/(N/mm ²)]	Deter	mined	0,06	0,09	No Perf	ormance I	Determine	d (NPD
Non-cracked and cracked concrete C20/25 under static, quasi-static and seismic C1 actionAll temperature ranges δ_{V0} -factor $[mm/(kN)]$ $0,06$ $0,06$ $0,05$ $0,04$ $0,04$ $0,03$ $0,03$ $0,03$ $0,06$ All temperature ranges $\delta_{V_{o}}$ -factor $[mm/(kN)]$ $0,09$ $0,08$ $0,08$ $0,06$ $0,06$ $0,05$	$\label{eq:constraint} \begin{array}{l} \mbox{Temperature range II:} \\ 60^\circ C/43^\circ C \end{array}$	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)]	Deter	mined	0,06 0,03	0,09 0,05	No Perf	ormance I	Determine	d (NPC
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\label{eq:constraint} \begin{array}{l} \mbox{Temperature range II:} \\ \mbox{60°C/43°C} \end{array}$	$\begin{array}{l} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt	Deter (NI	mined PD)	0,06 0,03 0,06	0,09 0,05 0,09	No Perf	ormance I	Determine	d (NPC
$\frac{\delta_{V_{\infty}} - factor}{\delta_{V_{\infty}} - factor} [mm/(kN)] = 0,09 = 0,08 = 0,08 = 0,06 = 0,06 = 0,05 = 0,$	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di		[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt	Deter (NI	mined PD)	0,06 0,03 0,06 ed rod	0,09 0,05 0,09				
$\frac{\delta_{V_{\infty}} - factor}{\delta_{V_{\infty}} - factor} [mm/(kN)] = 0,09 = 0,08 = 0,08 = 0,06 = 0,06 = 0,05 = 0,$	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ splaceme \\ ded \ rod \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt	Deter (Ni	hread M 10	0,06 0,03 0,06 ed rod	0,09 0,05 0,09) M 16	M 20	M24		
Cracked concrete C20/25 under seismic C2 action All temperature ranges δ _{V,seis(DLS)} [mm/kN] No Performance Determined (NPD) 0,2 0,1 No Performance Determined (NPD)	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread Non-cracked and o	$ \begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array} \\ \begin{array}{c} splaceme \\ ded \ rod \\ cracked \ con \\ \end{array} $	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt ents under shea	r load ¹⁾ (1 M 8 er static, qu	thread M 10	0,06 0,03 0,06 ed rod M 12 tic and	0,09 0,05 0,09) M 16 seismic	M 20 C1 act	M24	M 27	M 30
$ \begin{array}{c c} All \ temperature \\ ranges \end{array} & \begin{array}{c c} \delta_{V,seis(DLS)} & [mm/kN] \\ \hline \delta_{V,seis(ULS)} & [mm/kN] \end{array} & \begin{array}{c c} No \ Performance \\ Determined \\ (NPD) \end{array} & \begin{array}{c c} 0,2 & 0,1 \\ 0,2 & 0,1 \end{array} & No \ Performance \ Determined (NPD) \end{array} \\ \end{array} \\ \end{array} $	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt ents under shea ncrete C20/25 under [mm/(kN)]	Deter (NI 2011) (1 2011) (1 20	hread M 10 0,06	0,06 0,03 0,06 ed rod M 12 tic and 0,05	0,09 0,05 0,09) M 16 seismic 0,04	M 20 C1 act 0,04	M24 ion 0,03	M 27 0,03	M 30
$\frac{O_{V,seis(DLS)}}{anges} \begin{bmatrix} O_{V,seis(DLS)} & [mm/kN] \end{bmatrix} \\ mm/kN] \begin{bmatrix} mm/kN \end{bmatrix} \\ (NPD) \end{bmatrix} \begin{bmatrix} 0,2 \\ 0,2 \end{bmatrix} \begin{bmatrix} 0,1 \\ 0,2 \end{bmatrix} \\ O_{V,seis(DLS)} \\ O_{V,seis(DLS)} \end{bmatrix} \begin{bmatrix} 0,1 \\ 0,2 \end{bmatrix} \\ O_{V,seis(DLS)} \\ O_{V,$	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread Non-cracked and o All temperature ranges	$\begin{array}{c} \overline{\delta}_{N,seis(DLS)}\\ \overline{\delta}_{N,seis(ULS)}\\ \overline{\delta}_{N,seis(ULS)}\\ \overline{\delta}_{N,seis(ULS)}\\ e \ displaceme\\ \cdot \ \tau;\\ \cdot \ \tau;\\ splaceme\\ ded \ rod\\ cracked \ cor\\ \overline{\delta}_{Vo}\mbox{-}factor\\ \overline{\delta}_{V\infty}\mbox{-}factor\\ \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt ents under shea ncrete C20/25 unde [mm/(kN)] [mm/(kN)]	Deter (NI er load ¹⁾ (1 M 8 er static, qu 0,06 0,09	hread M 10 0,06	0,06 0,03 0,06 ed rod M 12 tic and 0,05	0,09 0,05 0,09) M 16 seismic 0,04	M 20 C1 act 0,04	M24 ion 0,03	M 27 0,03	M 3 (
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread Non-cracked and o All temperature ranges Cracked concrete	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt ents under shea [mm/(kN)] [mm/(kN)] [mm/(kN)]	Deter (N) (N) (N) (N) (N) (N) (N) (N) (N) (N)	mined PD) thread M 10 lasi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04	M24 ion 0,03	M 27 0,03	М 30
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread Non-cracked and o All temperature ranges Cracked concrete All temperature	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] nt ents under shea ncrete C20/25 unde [mm/(kN)] [mm/(kN)] [mm/(kN)] [mm/(kN]	Deter (NI	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 30 0,03 0,05
$\frac{\delta_{V,seis(ULS)}}{\delta_{V,seis(ULS)}} [mm/kN] \qquad \qquad Determined (NPD) \qquad 0,2 \qquad 0,1 \qquad No Performance Determined (NFD) \qquad 0,2 \qquad 0,1 \qquad 0,2 \qquad 0,2 \qquad 0,1 \qquad 0,2 \qquad$	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ splaceme \\ ded \ rod \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt	Deter (Ni	hread M 10	0,06 0,03 0,06 ed rod	0,09 0,05 0,09) M 16	M 20	M24		
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread Non-cracked and o All temperature ranges Cracked concrete All temperature	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm ²)] [mm/(N/mm ²)] [mm/(N/mm ²)] nt ents under shea [mm/(kN)] [mm/(kN)] [mm/(kN)]	Deter (N) (N) (N) (N) (N) (N) (N) (N) (N) (N)	mined PD) thread M 10 Iasi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor $\delta_{N\infty} = \delta_{N\infty}$ -factor Table C14: Di Anchor size thread Non-cracked and o All temperature ranges Cracked concrete All temperature	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] nt ents under shea ncrete C20/25 unde [mm/(kN)] [mm/(kN)] [mm/(kN)] [mm/(kN]	Deter (NI	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
$e_{VO} = e_{VO}$ had e_{VO}	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] imm/(N/mm²)] imm/(kN)] imm/(kN)] imm/kN] imm/kN]	Deter (NI 2011) (1 2011) (1 20	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
$\delta_{V_{\infty}} = \delta_{V_{\infty}}$ -factor V;	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th $\delta_{V0} = \delta_{V0}$ -factor	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] imm/(N/mm²)] imm/(kN)] imm/(kN)] imm/kN] imm/kN]	Deter (NI 2011) (1 2011) (1 20	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th $\delta_{V0} = \delta_{V0}$ -factor	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] imm/(N/mm²)] imm/(kN)] imm/(kN)] imm/kN] imm/kN]	Deter (NI 2011) (1 2011) (1 20	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th $\delta_{V0} = \delta_{V0}$ -factor	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] imm/(N/mm²)] imm/(kN)] imm/(kN)] imm/kN] imm/kN]	Deter (NI 2011) (1 2011) (1 20	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th $\delta_{V0} = \delta_{V0}$ -factor	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] imm/(N/mm²)] imm/(kN)] imm/(kN)] imm/kN] imm/kN]	Deter (NI 2011) (1 2011) (1 20	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
$\delta_{V_{\infty}} = \delta_{V_{\infty}} \text{-factor} \cdot \ V;$	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th $\delta_{V0} = \delta_{V0}$ -factor $\delta_{V\infty} = \delta_{V\infty}$ -factor	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] nt ents under shea ncrete C20/25 unde [mm/(kN)] [mm/(kN)] [mm/(kN)] [mm/kN] [mm/kN] nt	Deter (Ni er load ¹⁾ (1 M 8 er static, qu 0,06 0,09 on No Perf Deter (Ni	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3
	Temperature range II: $60^{\circ}C/43^{\circ}C$ Temperature range III: $72^{\circ}C/43^{\circ}C$ ¹⁾ Calculation of th $\delta_{N0} = \delta_{N0}$ -factor Table C14: Di Anchor size thread Non-cracked and of Anchor size thread Non-cracked and of All temperature ranges Cracked concrete All temperature ranges ¹⁾ Calculation of th $\delta_{V0} = \delta_{V0}$ -factor $\delta_{V\infty} = \delta_{V\infty}$ -factor	$\begin{array}{c} \delta_{N,seis(DLS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ \overline{\delta}_{N,seis(ULS)} \\ e \ displaceme \\ \cdot \ \tau; \\ \cdot \ \tau; \\ \end{array}$	[mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] [mm/(N/mm²)] nt ents under shea ncrete C20/25 unde [mm/(kN)] [mm/(kN)] [mm/(kN)] [mm/kN] [mm/kN] nt	Deter (Ni er load ¹⁾ (1 M 8 er static, qu 0,06 0,09 on No Perf Deter (Ni	thread M 10 Masi-stat 0,06 0,08	0,06 0,03 0,06 ed rod M 12 tic and 0,05 0,08	0,09 0,05 0,09 M 16 seismic 0,04 0,06	M 20 C1 act 0,04 0,06	M24 ion 0,03 0,05	M 27 0,03 0,05	M 3 (0,03) 0,05



Anchor size reinfo	orcing bar		Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Non-cracked con	crete C20/	25 under static	and qua	asi-stati	c actior	ו					
Temperature range I:	δ_{N0} -factor	[mm/(N/mm ²)]	0,011	0,013	0,015	0,018	0,020	0,024	0,030	0,033	0,03
40°C/24°C	$\delta_{N_{\infty}}$ -factor	[mm/(N/mm ²)]	0,044	0,052	0,061	0,070	0,079	0,096	0,118	0,132	0,14
Temperature range II:	δ_{N0} -factor	[mm/(N/mm ²)]	0,013	0,015	0,018	0,020	0,023	0,028	0,034	0,038	0,04
60°C/43°C	$\delta_{N\infty}\text{-factor}$	[mm/(N/mm²)]	0,050	0,060	0,070	0,081	0,091	0,111	0,136	0,151	0,17
Temperature range III:	δ_{N0} -factor	[mm/(N/mm²)]	0,013	0,015	0,018	0,020	0,023	0,028	0,034	0,038	0,04
72°C/43°C	$\delta_{N_\infty}\text{-factor}$	[mm/(N/mm²)]	0,050	0,060	0,070	0,081	0,091	0,111	0,136	0,151	0,17
Cracked concrete	e C20/25 ui	nder static, qua	asi-statio	c and se	eismic C	1 actio	n				
Temperature range I:	δ_{N0} -factor	[mm/(N/mm ²)]			0,032	0,035	0,037	0,042	0,049	0,055	0,06
40°C/24°C	$\delta_{N_{\infty}}$ -factor	[mm/(N/mm ²)]	1 '	-	0,21	0,21	0,21	0,21	0,21	0,21	0,2
Temperature range II:	δ_{N0} -factor	[mm/(N/mm ²)]			0,037	0,040	0,043	0,049	0,056	0,063	0,07
60°C/43°C	$\delta_{N\infty}$ -factor	[mm/(N/mm ²)]	1.	-	0,24	0,24	0,24	0,24	0,24	0,24	0,24
Temperature range III:	δ_{N0} -factor	[mm/(N/mm ²)]			0,037	0,040	0,043	0,049	0,056	0,063	0,07
72°C/43°C	$\delta_{N_{\infty}}$ -factor	[mm/(N/mm ²)]	1	-	0,24	0,24	0,24	0,24	0,24	0,24	0,24
$\begin{split} \delta_{N0} &= \delta_{N0} \text{-factor} \\ \delta_{N\infty} &= \delta_{N\infty} \text{-factor} \end{split}$ Table C16: D	isplacen		hear lo	oad ¹⁾ (r	ebar)			I	1	1	Γ
$\delta_{N_{\infty}} = \delta_{N_{\infty}}$ -factor Table C16: D	isplacen		hear lo Ø 8	øad ¹⁾ (r Ø10	ebar) Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø3
$\delta_{N\infty} = \delta_{N\infty}$ -factor Table C16: D Anchor size reinfo	isplacen prcing bar		Ø 8	Ø 10	Ø 12		Ø 16	Ø 20	Ø 25	Ø 28	Ø3
$\delta_{N\infty} = \delta_{N\infty}$ -factor Table C16: D Anchor size reinfo For concrete C20/ All temperature	isplacen prcing bar		Ø 8	Ø 10	Ø 12		Ø 16 0,04	Ø 20 0,04	Ø 25	Ø 28 0,03	Ø 3
$\delta_{N\infty} = \delta_{N\infty}$ -factor Table C16: D Anchor size reinfor For concrete C20/ All temperature ranges ¹⁾ Calculation of th	isplacen prcing bar (25 under state) δ_{V0} -factor $\delta_{V\infty}$ -factor ne displacen	static, quasi-st [mm/(kN)] [mm/(kN)]	Ø 8 atic and	Ø 10 seismid	Ø 12 c C1 act	ion			I		
$\delta_{N_{\infty}} = \delta_{N_{\infty}}$ -factor Table C16: D Anchor size reinfor For concrete C20/ All temperature ranges	isplacen prcing bar 25 under s δ_{V0} -factor $\delta_{V\infty}$ -factor ne displacen \cdot V;	static, quasi-st [mm/(kN)] [mm/(kN)]	Ø 8 atic and 0,06	Ø 10 seismid 0,05	Ø 12 c C1 act 0,05	i on 0,04	0,04	0,04	0,03	0,03	0,0

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