Approval body for construction products and types of construction
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-16/0458 of 6 June 2016

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	WPER500 Walraven Injection system for concrete
Product family to which the construction product belongs	Bonded anchor for diamond coring for use in uncracked concrete
Manufacturer	J. van Walraven B.V. Industrieweg 5 3641 RK MIJDRECHT NIEDERLANDE
Manufacturing plant	Walraven factory A3
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	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 for concrete" is a bonded anchor consisting of a cartridge with injection mortar WPER500 diamond and a steel element. The steel element consists of a commercial threaded rod with washer and hexagon nut in the range of M10 to M24 or reinforcing bar in the range of diameter 10 to 25 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	See Annex C 1 to C 4
Characteristic resistance for design according to CEN/TS 1992-4:2009	See Annex C 5 to C 8
Displacements under tension and shear loads	See Annex C 9 to C 10

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 assessed

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.

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

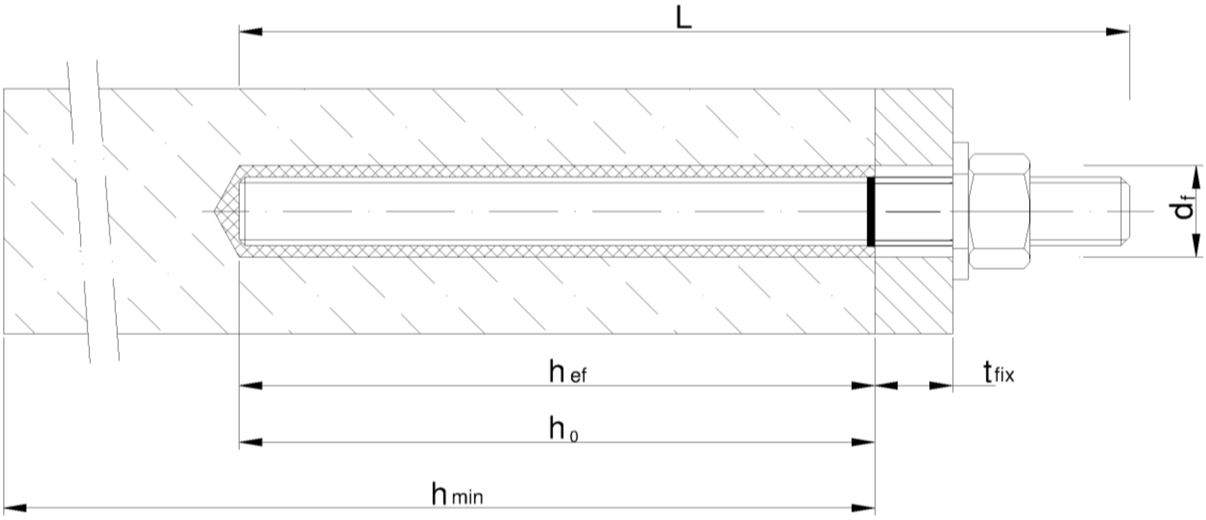
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at Deutsches Institut für Bautechnik.

Issued in Berlin on 6 June 2016 by Deutsches Institut für Bautechnik

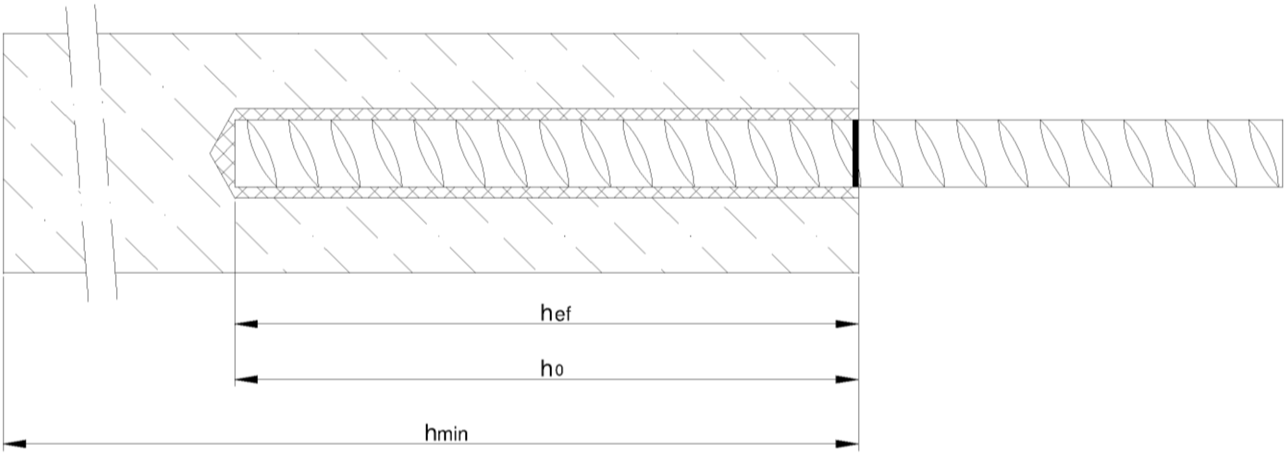
Uwe Bender
Head of Department

beglaubigt:
Baderschneider

Installation threaded rod



Installation reinforcing bar



d_f	=	diameter of clearance hole in the fixture
t_{fix}	=	thickness of fixture
h_{ef}	=	effective anchorage depth
h_0	=	depth of drill hole
h_{min}	=	minimum thickness of member

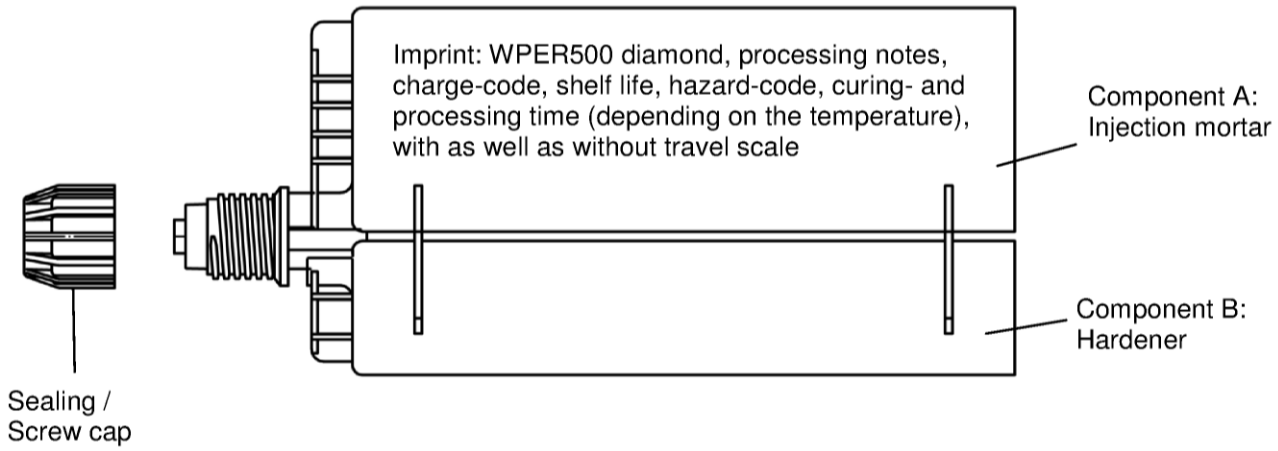
WPER500 Walraven Injection System for concrete

Product description
Installed condition

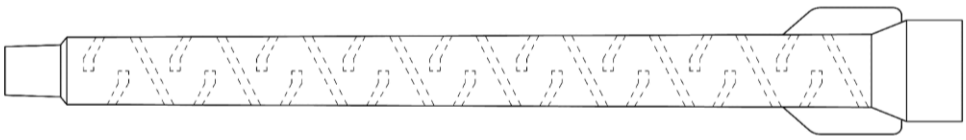
Annex A 1

Cartridge: WPER500 diamond

385ml, 444ml, 585ml, 999ml and 1400ml injection mortar cartridge (Type: "side-by-side")

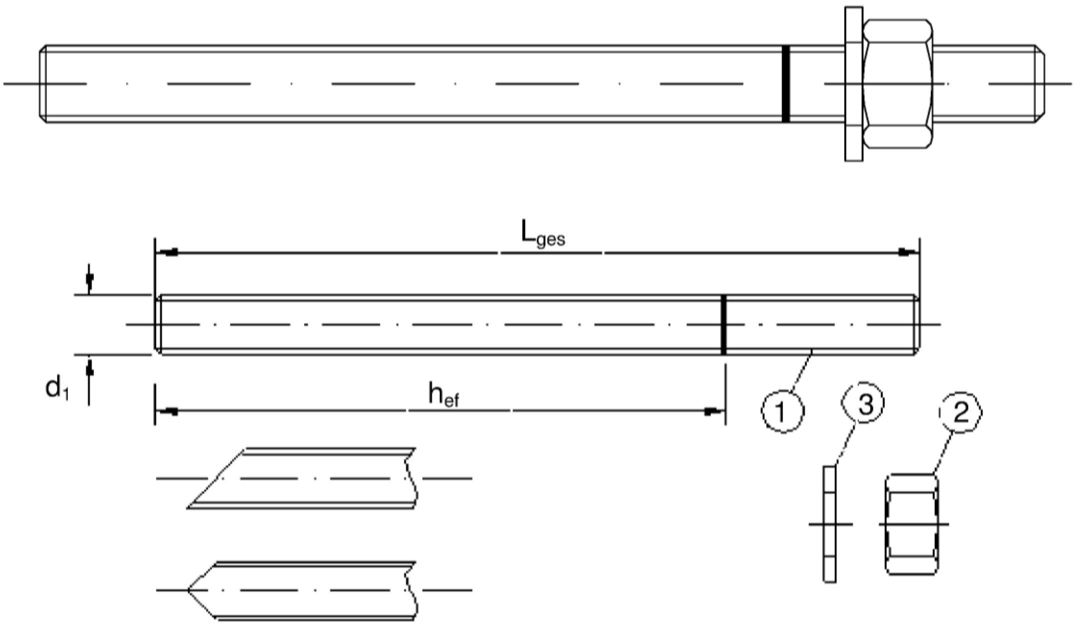


Static mixer



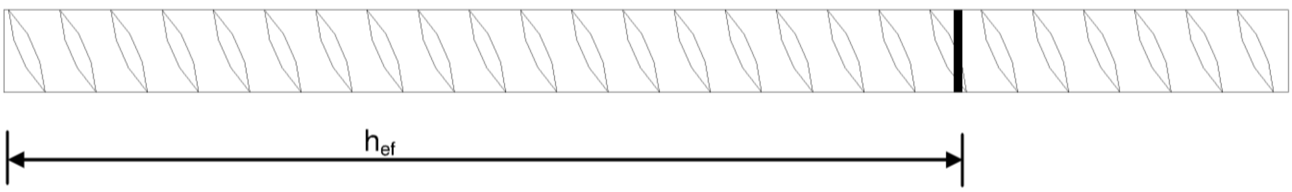
WPER500 Walraven Injection System for concrete	Annex A 2
Product description Injection system	

Threaded rod M10, M12, M16, M20, M24 with washer and hexagon nut



Commercial standard threaded rod with:
- Materials, dimensions and mechanical properties acc. Table A1
- Inspection certificate 3.1 acc. to EN 10204:2004
- Marking of embedment depth

Reinforcing bar ∅ 10, ∅ 12, ∅ 14, ∅ 16, ∅ 20, ∅ 25



- Minimum value of related rip area $f_{R,min}$ according to EN 1992-1-1:2004+AC:2010
- Rib height of the bar shall be in the range 0,05d ≤ h ≤ 0,07d
  (d: Nominal diameter of the bar; h: Rip height of the bar)

WPER500 Walraven Injection System for concrete	Annex A 3
Product description Threaded rod and reinforcing bar	

Table A1: Materials

Part	Designation	Material
Steel, zinc plated ≥ 5 µm acc. to EN ISO 4042:1999 or Steel, hot-dip galvanised ≥ 40 µm acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009		
1	Anchor rod	Steel, EN 10087:1998 or EN 10263:2001 Property class 4.6, 5.8, 8.8, EN 1993-1-8:2005+AC:2009
2	Hexagon nut, EN ISO 4032:2012	Steel acc. to EN 10087:1998 or EN 10263:2001 Property class 4 (for class 4.6 rod) EN ISO 898-2:2012, Property class 5 (for class 5.8 rod) EN ISO 898-2:2012, Property class 8 (for class 8.8 rod) EN ISO 898-2:2012
3	Washer, EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Steel, zinc plated or hot-dip galvanised
Stainless steel		
1	Anchor rod	Material 1.4401 / 1.4404 / 1.4571, EN 10088-1:2005, ≤ M24: Property class 70 EN ISO 3506-1:2009
2	Hexagon nut, EN ISO 4032:2012	Material 1.4401 / 1.4404 / 1.4571 EN 10088:2005, ≤ M24: Property class 70 (for class 70 rod) EN ISO 3506-2:2009
3	Washer, EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Material 1.4401, 1.4404 or 1.4571, EN 10088-1:2005
High corrosion resistance steel		
1	Anchor rod	Material 1.4529 / 1.4565, EN 10088-1:2005, ≤ M24: Property class 70 EN ISO 3506-1:2009
2	Hexagon nut, EN ISO 4032:2012	Material 1.4529 / 1.4565 EN 10088-1:2005, ≤ M24: Property class 70 (for class 70 rod) EN ISO 3506-2:2009
3	Washer, EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000 or EN ISO 7094:2000	Material 1.4529 / 1.4565, EN 10088-1:2005
Reinforcing bars		
1	Rebar EN 1992-1-1:2004+AC:2010, Annex C	Bars and de-coiled rods class B or C f_{yk} and k according to NDP or NCL of EN 1992-1-1/NA:2013 $f_{uk} = f_{tk} = k \cdot f_{yk}$

WPER500 Walraven Injection System for concrete

Product description
Materials

Annex A 4

Specifications of intended use

Anchorages subject to:
- Static and quasi-static loads: M10 to M24, Rebar Ø10 to Ø25.

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: M10 to M24, Rebar Ø10 to Ø25.

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

Installation:
- Dry or wet concrete: M10 to M24, Rebar Ø10 to Ø25.
- Flooded holes (not sea water): M10 to M24, Rebar Ø10 to Ø25.
- Hole drilling by diamond 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	**Annex B 1**
Intended Use Specifications	

Table B1: Installation parameters for threaded rod

Anchor size		M 10	M 12	M 16	M 20	M 24
Nominal drill hole diameter	d_0 [mm] =	12	14	18	24	28
Embedment depth and bore hole depth	$h_{ef,min}$ [mm] =	60	70	80	90	96
	$h_{ef,max}$ [mm] =	200	240	320	400	480
Diameter of clearance hole in the fixture	d_f [mm] ≤	12	14	18	22	26
Diameter of steel brush	d_b [mm] ≥	14	16	20	26	30
Torque moment	T_{inst} [Nm]	20	40	80	120	160
Thickness of fixture	$t_{fix,min}$ [mm] >	0				
	$t_{fix,max}$ [mm] <	1500				
Minimum thickness of member	h_{min} [mm]	h_{ef} + 30 mm ≥ 100 mm		$h_{ef} + 2d_0$		
Minimum spacing	s_{min} [mm]	50	60	80	100	120
Minimum edge distance	c_{min} [mm]	50	60	80	100	120

Table B2: Installation parameters for rebar

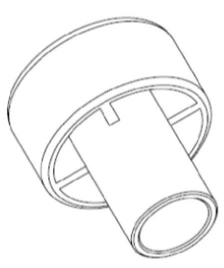
Rebar size		∅ 10	∅ 12	∅ 14	∅ 16	∅ 20	∅ 25
Nominal drill hole diameter	d_0 [mm] =	14	16	18	20	24	32
Embedment depth and bore hole depth	$h_{ef,min}$ [mm] =	60	70	75	80	90	100
	$h_{ef,max}$ [mm] =	200	240	280	320	400	500
Diameter of steel brush	d_b [mm] ≥	16	18	20	22	26	34
Minimum thickness of member	h_{min} [mm]	h_{ef} + 30 mm ≥ 100 mm	$h_{ef} + 2d_0$				
Minimum spacing	s_{min} [mm]	50	60	70	80	100	125
Minimum edge distance	c_{min} [mm]	50	60	70	80	100	125

Steel brush

Table B3: Parameter cleaning and setting tools

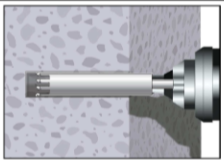
Threaded Rod	Rebar	d_0 Drill bit - Ø	d_b Brush - Ø	$d_{b,min}$ min. Brush - Ø	Piston plug
(mm)	(mm)	(mm)	(mm)	(mm)	(No.)
M10		12	14	12,5	No piston plug required
M12	10	14	16	14,5	
	12	16	18	16,5	
M16	14	18	20	18,5	
	16	20	22	20,5	
M20	20	24	26	24,5	# 24
M24		28	30	28,5	# 28
	25	32	34	32,5	# 32

Recommended compressed air tool (min 6 bar)
Drill bit diameter (d_0): 12 mm to 32 mm

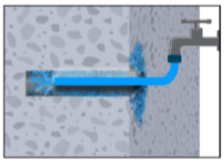


Piston plug for overhead or horizontal installation
Drill bit diameter (d_0): 24 mm to 32 mm

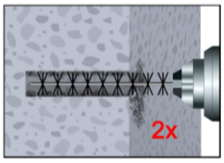
Installation instructions



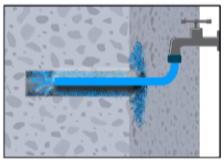
1b. Drill with diamond drill a hole into the base material to the size and embedment depth required by the selected anchor (Table B1 or Table B2).



2a. Rinsing with water until clear water comes out.

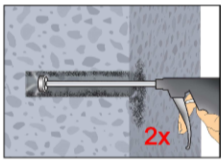


2b. Check brush diameter acc. Table B3 and attach the brush to a drilling machine or a battery screwdriver. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ (Table B3) a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used (Table B3).

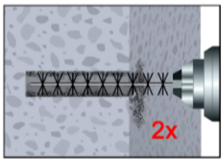


2c. Rinsing again with water until clear water comes out.

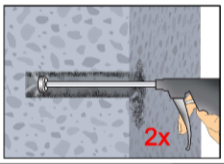
Attention! Standing water in the bore hole must be removed before cleaning.



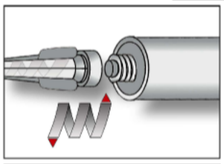
2d. Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (Annex B3) (min. 6 bar) a minimum of two times. If the bore hole ground is not reached an extension shall be used.



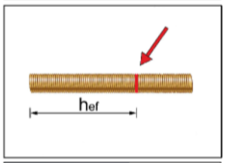
2e. Check brush diameter acc. Table B3 and attach the brush to a drilling machine or a battery screwdriver. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ (Table B3) a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used (Table B3).



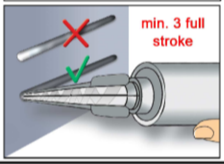
2f. Finally blow the hole clean again with compressed air acc. Annex B3 (min. 6 bar) a minimum of two times. If the bore hole ground is not reached an extension shall be used. **After cleaning, the bore hole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the bore hole again.**



3. Attach a supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. Cut off the foil tube clip before use.
For every working interruption longer than the recommended working time (Table B4) as well as for new cartridges, a new static-mixer shall be used.



4. Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rods.



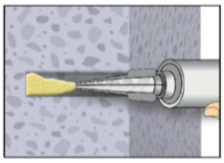
5. Prior to dispensing into the anchor hole, squeeze out separately a minimum of three full strokes and discard non-uniformly mixed adhesive components until the mortar shows a consistent grey colour. For foil tube cartridges is must be discarded a minimum of six full strokes.

WPER500 Walraven Injection System for concrete

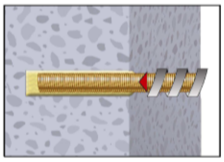
Intended Use
Installation instructions

Annex B 4

Installation instructions (continuation)

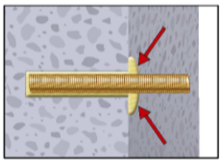


6. Starting from the bottom or back of the cleaned anchor hole fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. For embedment larger than 190 mm an extension nozzle shall be used. For overhead and horizontal installation a piston plug (Annex B 3) and extension nozzle shall be used. Observe the gel-/ working times given in Table B4.

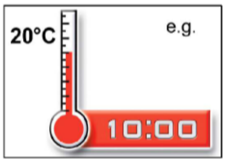


7. Push the threaded rod or reinforcing bar into the anchor hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached.

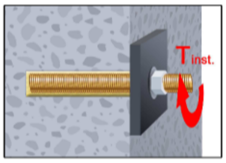
   The anchor should be free of dirt, grease, oil or other foreign material.



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).



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).



10. 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

Table C1: Characteristic values of resistance for threaded rods under tension loads in non-cracked concrete (Design according to TR 029)

Anchor size threaded rod				M 10	M 12	M 16	M 20	M24
Steel failure								
Characteristic tension resistance, Steel, property class 4.6		$N_{Rk,s}$	[kN]	23	34	63	98	141
Characteristic tension resistance, Steel, property class 5.8		$N_{Rk,s}$	[kN]	29	42	78	122	176
Characteristic tension resistance, Steel, property class 8.8		$N_{Rk,s}$	[kN]	46	67	125	196	282
Characteristic tension resistance, Stainless steel A4 and HCR, property class 70		$N_{Rk,s}$	[kN]	41	59	110	171	247
Combined pullout and concrete cone failure								
Characteristic bond resistance in non-cracked concrete C20/25								
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	11	10	10	9,5	9,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	9,0	10	9,5	9,5	8,5
Temperature range II: 60°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	7,0	6,5	6,0	6,0	5,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,0	6,0	5,5
Temperature range III: 72°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	6,0	6,0	5,5	5,0	5,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,0	6,0	5,0	5,0	5,0
Increasing factor ψ_c		C30/37		1,04				
		C40/50		1,08				
		C50/60		1,10				
Splitting failure								
Edge distance		$c_{cr,sp}$	[mm]	$1{,}0 \cdot h_{ef} \leq 2 \cdot h_{ef} \left(2{,}5 - \frac{h}{h_{ef}}\right) \leq 2{,}4 \cdot h_{ef}$				
Axial distance		$s_{cr,sp}$	[mm]	$2\, c_{cr,sp}$				
Installation safety factor		γ_2		1,0	1,2			

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)

Annex C 1

Table C2: Characteristic values of resistance for threaded rods under shear loads in non-cracked concrete (Design according to TR 029)

Anchor size threaded rod			M 10	M 12	M 16	M 20	M24
Steel failure without lever arm							
Characteristic shear resistance, Steel, property class 4.6	$V_{Rk,s}$	[kN]	12	17	31	49	71
Characteristic shear resistance, Steel, property class 5.8	$V_{Rk,s}$	[kN]	15	21	39	61	88
Characteristic shear resistance, Steel, property class 8.8	$V_{Rk,s}$	[kN]	23	34	63	98	141
Characteristic shear resistance, Stainless steel A4 and HCR, property class 70	$V_{Rk,s}$	[kN]	20	30	55	86	124
Steel failure with lever arm							
Characteristic bending moment, Steel, property class 4.6	$M^0_{Rk,s}$	[Nm]	30	52	133	260	449
Characteristic bending moment, Steel, property class 5.8	$M^0_{Rk,s}$	[Nm]	37	65	166	324	560
Characteristic bending moment, Steel, property class 8.8	$M^0_{Rk,s}$	[Nm]	60	105	266	519	896
Characteristic bending moment, Stainless steel A4 and HCR, property class 70	$M^0_{Rk,s}$	[Nm]	52	92	232	454	784
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							
Installation safety factor	γ_2		1,0				

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

Annex C 2

Table C3: Characteristic values of resistance for rebar under tension loads in non-cracked concrete (Design according to TR 029)

Anchor size reinforcing bar				Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25
Steel failure									
Characteristic tension resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$					
Combined pullout and concrete cone failure									
Characteristic bond resistance in non-cracked concrete C20/25									
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	11	10	10	10	9,5	9,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	9,0	10	10	9,5	9,5	8,5
Temperature range II: 60°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	7,0	6,5	6,5	6,0	6,0	5,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,5	6,0	6,0	5,5
Temperature range III: 72°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	6,0	6,0	6,0	5,5	5,0	5,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,0	6,0	5,5	5,5	5,0	5,0
Increasing factor ψ_c		C30/37		1,04					
		C40/50		1,08					
		C50/60		1,10					
Splitting failure									
Edge distance		$c_{cr,sp}$	[mm]	$1{,}0 \cdot h_{ef} \leq 2 \cdot h_{ef}\left(2{,}5 - \frac{h}{h_{ef}}\right) \leq 2{,}4 \cdot h_{ef}$					
Axial distance		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$					
Installation safety factor		γ_2		1,0	1,2				

WPER500 Walraven Injection System for concrete	**Annex C 3**
Performances Characteristic values of resistance for rebar under tension loads in non-cracked concrete (Design according to TR 029)	

Table C4: Characteristic values of resistance for rebar under shear loads in non-cracked concrete (Design according to TR 029)

Anchor size reinforcing bar			Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25
Steel failure without lever arm								
Characteristic shear resistance	$V_{Rk,s}$	[kN]	$0{,}50 \cdot A_s \cdot f_{uk}$					
Steel failure with lever arm								
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	$1.2 \cdot W_{el} \cdot f_{uk}$					
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								
Installation safety factor	γ_2		1,0					

Table C5: Characteristic values of resistance for threaded rods under tension loads in non-cracked concrete (Design according to CEN/TS 1992-4)

Anchor size threaded rod				M 10	M 12	M 16	M 20	M24
Steel failure								
Characteristic tension resistance, Steel, property class 4.6		$N_{Rk,s}$	[kN]	23	34	63	98	141
Characteristic tension resistance, Steel, property class 5.8		$N_{Rk,s}$	[kN]	29	42	78	122	176
Characteristic tension resistance, Steel, property class 8.8		$N_{Rk,s}$	[kN]	46	67	125	196	282
Characteristic tension resistance, Stainless steel A4 and HCR, property class 70		$N_{Rk,s}$	[kN]	41	59	110	171	247
Combined pullout and concrete cone failure								
Characteristic bond resistance in non-cracked concrete C20/25								
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	11	10	10	9,5	9,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	9,0	10	9,5	9,5	8,5
Temperature range II: 60°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	7,0	6,5	6,0	6,0	5,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,0	6,0	5,5
Temperature range III: 72°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	6,0	6,0	5,5	5,0	5,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,0	6,0	5,0	5,0	5,0
Increasing factor ψ_c		C30/37		1,04				
		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]	$1{,}0 \cdot h_{ef} \leq 2 \cdot h_{ef}\left(2{,}5 - \frac{h}{h_{ef}}\right) \leq 2{,}4 \cdot h_{ef}$				
Axial distance		$s_{cr,sp}$	[mm]	2 $c_{cr,sp}$				
Installation safety factor		γ_{inst}		1,0	1,2			

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

Annex C 5

Table C6: Characteristic values of resistance for threaded rods under shear loads in non-cracked concrete (Design according to CEN/TS 1992-4)

Anchor size threaded rod			M 10	M 12	M 16	M 20	M24
Steel failure without lever arm							
Characteristic shear resistance, Steel, property class 4.6	$V_{Rk,s}$	[kN]	12	17	31	49	71
Characteristic shear resistance, Steel, property class 5.8	$V_{Rk,s}$	[kN]	15	21	39	61	88
Characteristic shear resistance, Steel, property class 8.8	$V_{Rk,s}$	[kN]	23	34	63	98	141
Characteristic shear resistance, Stainless steel A4 and HCR, property class 70	$V_{Rk,s}$	[kN]	20	30	55	86	124
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, Steel, property class 4.6	$M^0_{Rk,s}$	[Nm]	30	52	133	260	449
Characteristic bending moment, Steel, property class 5.8	$M^0_{Rk,s}$	[Nm]	37	65	166	324	560
Characteristic bending moment, Steel, property class 8.8	$M^0_{Rk,s}$	[Nm]	60	105	266	519	896
Characteristic bending moment, Stainless steel A4 and HCR, property class 70	$M^0_{Rk,s}$	[Nm]	52	92	232	454	784
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	γ_{inst}		1,0				
Concrete edge failure							
Effective length of anchor	l_f	[mm]	$l_f = \min(h_{ef}; 8\ d_{nom})$				
Outside diameter of anchor	d_{nom}	[mm]	10	12	16	20	24
Installation safety factor	γ_{inst}		1,0				

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

Annex C 6

Table C7: Characteristic values of resistance for rebar under tension loads in non-cracked concrete (Design according to CEN/TS 1992-4)

Anchor size reinforcing bar				Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25
Steel failure									
Characteristic tension resistance		$N_{Rk,s}$	[kN]	$A_s \cdot f_{uk}$					
Combined pullout and concrete cone failure									
Characteristic bond resistance in non-cracked concrete C20/25									
Temperature range I: 40°C/24°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	11	10	10	10	9,5	9,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	9,0	10	10	9,5	9,5	8,5
Temperature range II: 60°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	7,0	6,5	6,5	6,0	6,0	5,5
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,5	6,5	6,5	6,0	6,0	5,5
Temperature range III: 72°C/43°C	dry and wet concrete	$\tau_{Rk,ucr}$	[N/mm²]	6,0	6,0	6,0	5,5	5,0	5,0
	flooded bore hole	$\tau_{Rk,ucr}$	[N/mm²]	5,0	6,0	5,5	5,5	5,0	5,0
Increasing factor ψ_c		C30/37		1,04					
		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]	$1,0 \cdot h_{ef} \leq 2 \cdot h_{ef} \left(2,5 - \frac{h}{h_{ef}}\right) \leq 2,4 \cdot h_{ef}$					
Axial distance		$s_{cr,sp}$	[mm]	$2\ c_{cr,sp}$					
Installation safety factor		γ_{inst}		1,0	1,2				

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

Annex C 7

Table C8: Characteristic values of resistance for rebar under shear loads in non-cracked concrete (Design according to CEN/TS 1992-4)

Anchor size reinforcing bar			Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25
Steel failure without lever arm								
Characteristic shear resistance	$V_{Rk,s}$	[kN]	$0{,}50 \cdot A_s \cdot f_{uk}$					
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]	$1.2 \cdot W_{el} \cdot f_{uk}$					
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	γ_{inst}		1,0					
Concrete edge failure								
Effective length of anchor	l_f	[mm]						
Outside diameter of anchor	d_{nom}	[mm]	10	12	14	16	20	25
Installation safety factor	γ_{inst}		1,0					

Table C9: Displacements under tension load[1] (threaded rod)

Anchor size threaded rod			**M 10**	**M 12**	**M 16**	**M 20**	**M24**
Temperature range 40°C/24°C for non-cracked concrete C20/25							
Displacement	δ_{N0}-factor	[mm/(N/mm²)]	0,013	0,015	0,020	0,024	0,029
Displacement	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,052	0,061	0,079	0,096	0,114
Temperature range 72°C/43°C and 60°C/43°C for non-cracked concrete C20/25							
Displacement	δ_{N0}-factor	[mm/(N/mm²)]	0,015	0,018	0,023	0,028	0,033
Displacement	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,060	0,070	0,091	0,111	0,131

[1] Calculation of the displacement
$\delta_{N0} = \delta_{N0}$-factor $\cdot \tau$; τ: action bond strength
$\delta_{N\infty} = \delta_{N\infty}$-factor $\cdot \tau$;

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

Anchor size threaded rod			**M 10**	**M 12**	**M 16**	**M 20**	**M24**
Displacement	δ_{V0}-factor	[mm/(kN)]	0,06	0,05	0,04	0,04	0,03
Displacement	$\delta_{V\infty}$-factor	[mm/(kN)]	0,08	0,08	0,06	0,06	0,05

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

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Table C11: Displacements under tension load[1] (rebar)

Anchor size reinforcing bar			**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**
Temperature range 40°C/24°C for non-cracked concrete C20/25								
Displacement	δ_{N0}-factor	[mm/(N/mm²)]	0,013	0,015	0,018	0,020	0,024	0,030
Displacement	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,052	0,061	0,070	0,079	0,096	0,118
Temperature range 72°C/43°C and 60°C/43°C for non-cracked concrete C20/25								
Displacement	δ_{N0}-factor	[mm/(N/mm²)]	0,015	0,018	0,020	0,023	0,028	0,034
Displacement	$\delta_{N\infty}$-factor	[mm/(N/mm²)]	0,060	0,070	0,081	0,091	0,111	0,136

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

Anchor size reinforcing bar			**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**
Displacement	δ_{V0}-factor	[mm/(kN)]	0,05	0,05	0,04	0,04	0,04	0,03
Displacement	$\delta_{V\infty}$-factor	[mm/(kN)]	0,08	0,07	0,06	0,06	0,05	0,05

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

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Performances
Displacements (rebar)

Annex C 10