WIT-PE 1000 WITH REBAR

440 ml 585 ml 1400 ml

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
440 ml	side-by-side	**5918 605 440**
585 ml	side-by-side	**5918 605 585**
1400 ml	side-by-side	**5918 605 140**

Ø8 - Ø32

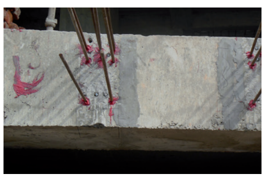
Rebar not supplied by Würth

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	✓

Applications






Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt. Berlin	EAD 330499-01-0601	ETA-19/0542, 06.11.2020
European Technical Assessment	DIBt. Berlin	EAD 330087-00-0601	ETA-19/0543, 17.04.2020
ICC-ES Evaluation Report	ICC	AC 308	ELC-4757, 05.2021
Fire resistance	Ingenieurbüro Thiele	TR 020	22022. 14.05.2020
LEED	eurofins		19.09.19
VOC Emissions Test report	eurofins	DEVL 1101903D. DEVL 1104875A	19.09.19
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Rebar material is according to specifications, steel grade B500B
- Concrete C 20/25, f_{ck} = 20 N/mm^2
- Concrete C 50/60, f_{ck} = 60 N/mm^2
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characteristic resistance

Rebar size				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{Rk}	[kN]	27.5	42.0	56.8	68.8	68.8	109.0	149.7	149.7	218.2	255.6
	C50/60			27.5	43.5	62.2	84.7	108.7	172.4	236.7	236.7	338.8	404.2
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	124.3	135.0	169.4	221.1
Cracked concrete													
Tension	C20/25	N_{Rk}	[kN]	14.1	19.8	35.2	46.7	48.1	76.3	104.8	104.8	152.8	178.9
	C50/60			15.5	21.8	38.8	51.4	58.7	99.9	148.0	154.2	222.1	282.2
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	124.3	135.0	169.4	221.1

Design resistance

Rebar size				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{Rd}	[kN]	19.6	28.0	37.8	45.8	45.8	72.7	99.8	99.8	145.5	170.4
	C50/60			19.6	31.0	44.4	60.5	72.5	114.9	157.8	157.8	230.1	269.4
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4
Cracked concrete													
Tension	C20/25	N_{Rd}	[kN]	9.4	13.2	23.5	31.2	32.1	50.9	69.9	69.9	101.8	119.3
	C50/60			10.3	14.5	25.8	34.3	39.2	66.6	98.7	102.8	148.0	188.0
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4

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Recommended/allowable loads [1)]

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{rec}	[kN]	14.0	20.0	27.0	32.7	32.7	51.9	71.3	71.3	103.9	121.7
	C50/60			14.0	22.2	31.7	43.2	51.8	82.1	112.7	112.7	164.3	192.5
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	59.2	64.3	80.7	105.3
Cracked concrete													
Tension	C20/25	N_{rec}	[kN]	6.7	9.4	16.8	22.3	22.9	36.3	49.9	49.9	72.7	85.2
	C50/60			7,4	10.4	18.5	24.5	28.0	47.6	70.5	73.4	105.7	134.3
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	59.2	64.3	80.7	105.3

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C)
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Rebar material according to specifications, steel grade B500B

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Design steel resistance	$N_{Rd,s}$	[kN]	19.6	31.0	44.4	60.5	79.0	123.4	177.6	192.9	242.0	315.9

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2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	21.4	30.2	44.2	58.6	67.0	113.9	158.3	164.9	237.5	301.6
Cracked concrete												
Combined pull-out concrete cone resistance	$N^0_{Rd,p}$	[kN]	9.4	13.2	23.5	31.2	35.6	60.5	89.7	93.5	134.6	170.9

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Spacing	$s_{cr,p}$	[mm]	234	270	330	375	375	510	630	630	792	900
Edge distance	$c_{cr,p}$	[mm]	117	135	165	188	188	255	315	315	396	450

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p}$, $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p}$, $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p}$, $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p}$, $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,70	0,75	0,90	0,95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$, f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

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e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.
b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	28.0	37.8	45.8	45.8	72.7	99.8	99.8	145.5	170.4
Cracked concrete												
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	19.6	26.5	32.1	32.1	50.9	69.9	69.9	101.8	119.3

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	375	510	630	630	810	900
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	188	255	315	315	405	450

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,N} = 3\ h_{ef} \text{ and } c_{cr,N} = 1.5\ h_{ef}$$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,\,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

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4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Splitting resistance	$N^0_{Rd,sp}$	[kN]	21.4	28.0	37.8	45.8	45.8	72.7	99.8	99.8	145.5	170.4

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Characteristic spacing	$s_{cr,sp}$	[mm]	360	420	528	600	590	816	1004	1004	1296	1440
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	295	408	502	502	648	720
Minimum member thickness	h_{min}	[mm]	110	120	142	161	165	218	274	274	340	380

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \leq 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \leq 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

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II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Design steel resistance	$V_{Rd,s}$	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.6	5.8	8.3	12.2	12.2	14.3	17.2
Cracked concrete												
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.0	4.1	5.9	8.6	8.6	10.2	12.2

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

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d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

c_1/d	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

e. Influence of edge distance c_2

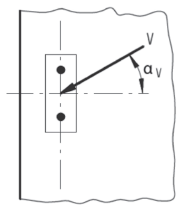
$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

$c_{2/c1}$ [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

f. Influence of load direction



$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α[1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

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Design bond strength

Service temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +72°C	+50°C	+72°C

Working life of 50 years

1- Non-cracked concrete

Thread size				**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø24**	**Ø25**	**Ø28**	**Ø32**
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	10.7	10.7	10.7	10.7	10.7	10.7	10.0	10.0	10.0	10.0
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.3	7.3
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	8.9	8.9	8.9	8.9	8.9	8.9	8.3	8.3	8.3	8.3
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	8.0	8.0	8.0	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	8.7	8.7	8.7	8.0	8.0	7.3	7.3	7.3	7.3
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	7.3	7.3	6.7	6.7	6.7	6.3	6.3	6.3	6.0	6.0
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	7.8	7.2	7.2	7.2	5.7	5.7	5.2	5.2	5.2	5.2
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.1	6.1	5.6	5.6	4.8	4.5	4.5	4.5	4.3	4.3

2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	4.7	4.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Temperature range II				4.0	4.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Temperature range I	Flooded bore hole			3.9	3.9	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Temperature range II				3.3	3.3	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9

Working life of 100 years

1- Non-cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	10.7	10.7	10.7	10.7	10.7	10.7	10.0	10.0	10.0	10.0
Temperature range II				8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.3	7.3
Temperature range I	Flooded bore hole			8.9	8.9	8.9	8.9	8.9	8.9	8.3	8.3	8.3	8.3
Temperature range II				6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range II				8.0	8.0	8.0	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Temperature range I	Flooded bore hole			7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range II				6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	8.7	8.7	8.7	8.0	8.0	7.3	7.3	7.3	7.3
Temperature range II				7.3	7.3	6.7	6.7	6.7	6.3	6.3	6.3	6.0	6.0
Temperature range I	Flooded bore hole			7.8	7.2	7.2	7.2	5.7	5.7	5.2	5.2	5.2	5.2
Temperature range II				6.1	6.1	5.6	5.6	4.8	4.5	4.5	4.5	4.3	4.3

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2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm^2]	4.3	4.3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Temperature range II	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm^2]	3.7	3.7	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Temperature range III	Flooded bore hole	$\tau_{Rd,cr}$	[N/mm^2]	3.6	3.6	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Temperature range III	Flooded bore hole	$\tau_{Rd,cr}$	[N/mm^2]	3.1	3.1	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm^2]	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm^2]	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm^2]	0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82

2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.86	0.86	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.86	0.86	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82

Working life of 100 years

1- Non-cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82

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2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.85	0.85	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Temperature range III	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.85	0.85	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87

Mechanical characteristics

Steel grade	Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
	Stressed cross section	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
	Section modulus	W	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
460A	Yield strength	f_y	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	f_u	[N/mm²]	483	483	483	483	483	483	483	483	483	483
	Design bending moment	$M^0_{Rd,s}$	[Nm]	19	38	66	104	155	303	524	593	833	1243
460B	Yield strength	fy	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	fu	[N/mm²]	497	497	497	497	497	497	497	497	497	497
	Design bending moment	$M^0_{Rd,s}$	[Nm]	20	39	68	107	160	312	540	610	857	1279
B500B	Yield strength	f_y	[N/mm²]	500	500	500	500	500	500	500	500	500	500
	Tensile strength	f_u	[N/mm²]	550	550	550	550	550	550	550	550	550	550
	Design bending moment	$M^0_{Rd,s}$	[Nm]	22	43	75	118	177	345	597	675	948	1415

Material specifications

Product form		Bars and de-coiled rods		
Class		**A**	**B**	**V**
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600		
Minimum value of $k = (f_t/f_y)_k$		≥ 1,05	≥ 1,08	≥ 1,15 < 1,35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 2,5	≥ 5,0	≥ 7,5
Bendability		Bend/Rebend test		
Maximum deviation from nominal mass (individual bar or wire) (%)	Nominal bar size (mm) ≤ 8 > 8	+/- 6,0 +/- 4,5		

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Chemical resistance

Chemical agent	Concentration	Resistant	Not Resistant
Acetic acid (Vinegar)	40		●
Acetone	10		●
Ammonia, aqueous solution	5	●	
Aniline	100		●
Beer	100	●	
Benzine (kp 100-140°F)	100	●	
Benzene	100		●
Boric Acid, aqueous solution		●	
Calcium carbonate, suspended in water	All	●	
Calcium chloride, suspended in water		●	
Calcium hydroxide, suspended in water		●	
Carbon tetrachloride	100	●	
Caustic soda (Sodium hydroxide)	40	●	
Citric acid	All	●	
Chlorine	All	●	
Diesel oil	100	●	
Ethyl alcohol, aqueous solution	50		●
Formaldehyde, aqueous solution	30	●	
Formic acid (Methanoic acid)	100		●
Formic acid (Methanoic acid)	10	●	
Freon		●	
Fuel Oil		●	
Gasoline (premium grade)	100	●	
Glycol (Ethylene glycol)		●	
Hydrogen peroxide	30		●
Hydrochloric acid (Muriatic Acid)	Conc.		●
Isopropyl alcohol	100		●
Lactic acid	All		●
Laitance		●	
Linseed oil	100	●	
Lubricating oil	100	●	
Magnesium chloride, aqueous solution	All	●	
Methanol	100		●
Motor oil (SAE 20 W-50)	100	●	
Nitric acid	10		●
Oleic acid	100	●	
Perchloroethylene	100	●	
Petroleum	100	●	
Phenol, aqueous solution (Carbonic acid)	8		●
Phosphoric acid	85	●	
Phosphoric acid	10	●	
Potash lye (potassium hydroxide, 10% and 40% solutions)		●	
Potassium carbonate, aqueous solution	All	●	
Potassium chlorite, aqueous solution	All	●	
Potassium nitrate, aqueous solution	All	●	
Sodium carbonate, aqueous solution	All	●	
Sodium chloride, aqueous solution	All	●	
Sodium phosphate, aqueous solution	All	●	
Sodium silicate	All	●	
Sulfuric acid	30		●
Tartaric acid	All	●	
Tetrachloroethylene	100	●	
Toluene			●
Turpentine	100	●	
Trichloroethylene	100		●

Properties of adhesive

Property		Testing method	Result / Mean value
Stability			
UV-resistance (sunlight)			resistant
Temperature resistance			72°C
Water resistance			resistant
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 66,0 N/mm^2
Compressive properties	Compressive strength		after 24 hours:122 N/mm^2
Tensile properties	Tensile strength	DIN EN ISO 527-2	44,2 N/mm^2
	Coefficient of elasticity		6,300 N/mm^2
	Mean strain at fracture		1,0 %
Shrinkage		DIN 52450	≤ 1,4 ‰
Shore-hardness A		DIN EN ISO 868	99,4
Shore-hardness D			86,1
Density		Weighing	≤ 1,50 kg/dm^3
Thermal conductivity		DIN EN 993-15	0,50 W/mK
Specific heat capacity			1,350 J/Kg K
Electrical resistance		DIN IEC 93	8,0 . 10_{12} Ω
Workability features			
Water tightness / impermeability		DIN EN 12390-8	0 mm
Working time (20°C)			3 min
Curing time (20°C)			30 mins
Shelf-life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

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Working and curing times

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
0°C to 4°C	90 min	144 h
5°C to 9°C	80 min	48 h
10°C to 14°C	60 min	28 h
15°C to 19°C	40 min	18 h
20°C to 24°C	30 min	12 h
25°C to 34°C	12 min	9 h
35°C to 39°C	8 min	6 h
+40°C	8 min	4 h

[1)] for wet base material the curing time must be doubled

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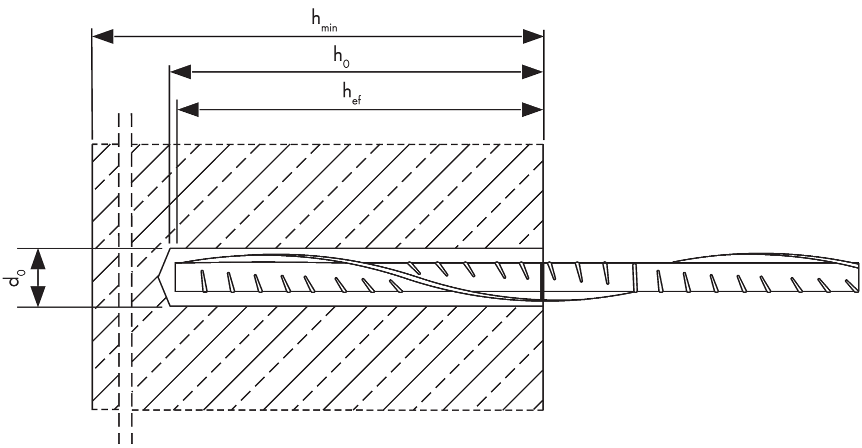
Installation parameters

Rebar size			Ø 8[1]	Ø 10[1]	Ø 12[1]	Ø 14	Ø 16	Ø 20	Ø 24[1]	Ø 25[1]	Ø 28	Ø 32
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter	d_0	[mm]	10 / 12	12 / 14	14 / 16	18	20	25	30 / 32	30 / 32	35	40
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	96	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	500	560	640
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$						
Minimum spacing	s_{min}	[mm]	40	50	60	70	75	85	120	120	130	150
Minimum edge distance	c_{min}	[mm]	35	40	45	50	50	60	70	70	75	85

[1] both nominal drill hole diameter can be used



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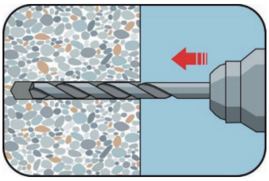
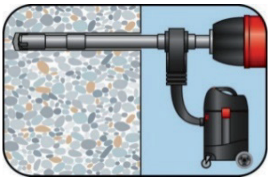
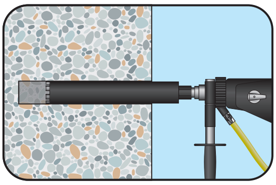
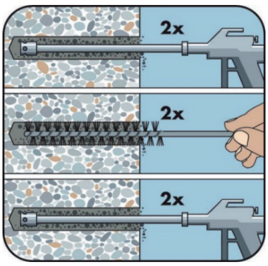
Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B1.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.
	**1c.**	**Diamond drilling (DD)** Drill with diamond drill a hole into the base material to the size and embedment depth required by the selected anchor. Proceed with Step B2.
B1) Bore hole cleaning		
CAC: Cleaning for all bore hole diameter and bore hole depth with drilling method HD and CD		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

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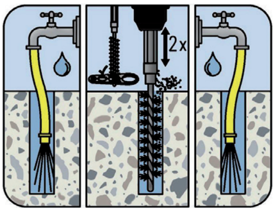
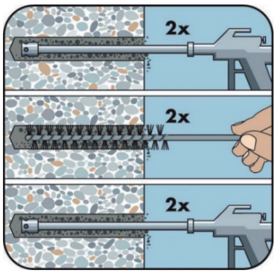
B2) Bore hole cleaning



2a.	Rinsing with water until clear water comes out.
2b.	Check the brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension must be used.
2c.	Rinsing again with water until clear water comes out.

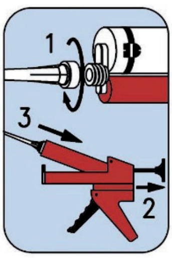
Attention! Standing water in the bore hole must be removed before proceeding to cleaning.



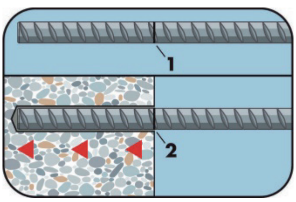
2a.	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,mi}$n a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension 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 no contaminate the bore hole again.

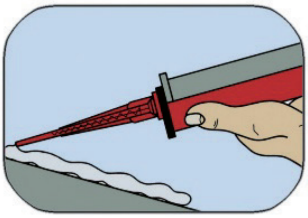
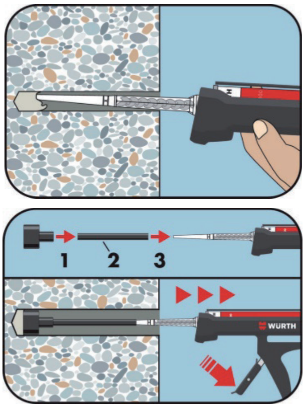
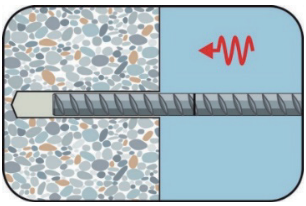
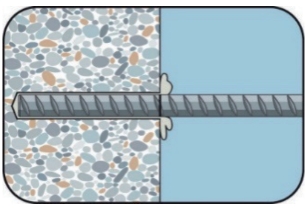
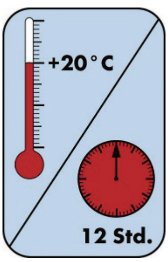
C) Preparation of bar and cartridge



3a.	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.



3b.	Prior to inserting the reinforcing bar into the filled bore hole, the position of the embedment depth shall be marked (e.g. with tape) on the reinforcing bar. After that, insert the bar in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.

	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole with adhesive until the level mark at the mixer extension is visible at the top of the hole. For embedment larger than 190 mm, an extension nozzle shall be used. Slowly withdraw the static mixing nozzle. Using a piston plug during injection of the mortar helps to avoid creating air pockets. For overhead and horizontal installation and bore holes deeper than 240 mm, a piston plug and the appropriate mixer extension must be used. Observe the gel-/working times.
E) Setting the rebar		
	**5a.**	Push the reinforcing bar into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	Be sure that the bar is inserted in the bore hole until the embedment mark is at the concrete surface 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 horizontal and overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Observe gelling time t_{gel}. Attend that the gelling time can vary according to the base material temperature. Do not move or load the bar until full curing time t_{cure} has elapsed.

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Filling Quantity

Anchor type: M8 - M30

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	32	35	40
Drill depth	h_0 / h_1	[mm]	= l_v									
Filling volume per 10mm embedment depth		[ml]	0.81	1.01	1.21	1.43	1.66	2.59	4.85	4.47	5.07	6.62

Assumed waste of 15 % included.