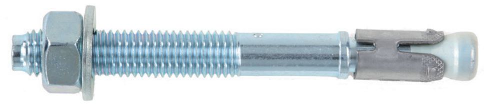
WÜRTH

FIXANCHOR W-FAZ/S



Galvanized (5 microns): M8 - M27

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

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

Type of installation		
Pre-positioned	In-place	Stand-off
–	✓	–

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	EAD 330232-01-0601	ETA-99/0011 /2018-10-02
ICC-ES Evaluation Report	ICC	AC 193	ESR-2461 /2012-09-01
Fire resistance	DIBt, Berlin	TR 020	ETA-99/0011 /2018-10-12
Sprinkler systems	VdS	VdS CEA 4001:2010-11 (04)	27.03.12
Evaluation Report high strength concrete C80/95	Ing. Büro Thiele, Pirmasens	EAD 330232-01-0601 /ETAG 001	21742_2 /2017-08-10
Shock test, Critical infra-structure protection	BABS, CH-Bern		BZS D 09-0604 /2010-05-18

Basic loading 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 is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size				M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	13.4	19.4	31.1	41.0	55.0	90.4	84.7
Shear	C20/25	$V_{Ru,m}$	[kN]	14.5	24.0	36.1	60.0	89.0	131.8	181.7
Cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	9.5	13.6	25.7	32.4	49.6	72.8	73.0
Shear	C20/25	$V_{Ru,m}$	[kN]	14.5	24.0	36.1	60.0	89.0	131.8	181.7

Characteristic resistance

Thread size				M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	12.0	16.0	25.0	35.0	49.2	60.7	68.8
	C50/65			16.0	25.3	39.5	55.3	77.8	95.9	108.7
Shear	C20/25	V_{Rk}	[kN]	12.2	20.1	30.0	55.0	69.0	114.0	169.4
	C50/65			12.2	20.1	30.0	55.0	69.0	114.0	169.4
Cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	5.0	9.0	16.0	25.0	34.4	42.5	48.1
	C50/65			7.9	14.2	25.3	39.5	54.4	67.1	76.1
Shear	C20/25	V_{Rk}	[kN]	12.2	20.1	30.0	55.0	69.0	114.0	134.8
	C50/65			12.2	20.1	30.0	55.0	69.0	114.0	169.4

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Design resistance

Thread size				M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	8.0	10.7	16.7	23.3	32.8	40.4	45.8
	C50/65			10.5	16.9	26.4	36.9	51.9	63.9	72.5
Shear	C20/25	V_{Rd}	[kN]	9.8	16.1	24.0	44.0	51.9	91.2	128.3
	C50/65			9.8	16.1	24.0	44.0	51.9	91.2	135.5
Cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	3.3	6.0	10.7	16.7	23.0	28.3	32.1
	C50/65			5.3	9.5	16.9	26.4	36.3	44.8	50.7
Shear	C20/25	V_{Rd}	[kN]	9.8	16.1	24.0	43.2	51.9	79.3	89.8
	C50/65			9.8	16.1	24.0	44.0	51.9	91.2	135.5

Recommended/allowable loads [1)]

Thread size				M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	5.7	7.6	11.9	16.7	23.4	28.9	32.7
	C50/65			7.5	12.0	18.8	26.4	37.0	45.7	51.8
Shear	C20/25	V_{rec}	[kN]	7.0	11.5	17.1	31.4	37.1	65.1	91.7
	C50/65			7.0	11.5	17.1	31.4	37.1	65.1	96.8
Cracked concrete										
Tension	C20/25	N_{rec}	[kN]	2.4	4.3	7.6	11.9	16.4	20.2	22.9
	C50/65			3.8	6.8	12.0	18.8	25.9	32.0	36.2
Shear	C20/25	V_{rec}	[kN]	7.0	11.5	17.1	30.8	37.1	56.6	64.2
	C50/65			7.0	11.5	17.1	31.4	37.1	65.1	96.8

[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)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table

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

1. Design steel tensile resistance

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

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Design steel resistance	$N_{Rd,s}$	[kN]	10.5	17.6	26.7	40.0	53.8	84.0	130.7

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

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

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	8.0	10.7	16.7	23.3	32.8	40.4	45.8
Cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	3.3	6.0	10.7	16.7	23.0	28.3	32.1

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a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out 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	1.10	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

3. Design concrete cone resistance

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

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	10.2	15.2	19.2	25.7	32.8	40.4	45.8
Cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	7.2	10.7	13.4	18.0	23.0	28.3	32.1

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Characteristic spacing	$s_{cr,N}$	[mm]	138	180	210	255	300	345	375
Characteristic edge distance	$c_{cr,N}$	[mm]	69	90	105	128	150	173	188

a. Influence of concrete strength

Table 6: 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	1.10	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 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 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [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}, 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

c. 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 8: 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	≥ 1.0
$f_{cx,1}$	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

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

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 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	6.0	8.0	13.3	20.0	26.7	41.5	33.3

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Characteristic spacing	$s_{cr,sp}$	[mm]	138.0	180.0	210.0	255.0	300.0	345.0	375.0
Characteristic edge distance	$c_{cr,sp}$	[mm]	69.0	90.0	105.0	127.5	150.0	172.5	187.5
Minimum member thickness	h_{min}	[mm]	100	120	140	170	200	230	250

a. Influence of concrete strength

Table 11: 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	1.10	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 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 12: 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	≥ 1.0
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

c. 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 13: 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	≥ 1.0
$f_{cx,1,sp}$	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

d. 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 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
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 $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Design steel resistance	$V_{Rd,s}$	[kN]	9.8	16.1	24.0	44.0	51.9	91.2	135.5

2. Concrete pry-out resistance

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

Table 16: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Concrete pry-out resistance factor	k_8	[-]	2.4	2.4	2.4	2.4	2.8	2.8	2.8

3. Concrete edge resistance

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

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ 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 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	M8		M10		M12		M16		M20		M24		M27	
h_{ef} [mm]	46		60		70		85		100		115		125	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
40	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-
45	-	2.5	-	2.7	-	-	-	-	-	-	-	-	-	-
50	4.0	2.9	4.4	3.1	-	-	-	-	-	-	-	-	-	-
55	4.6	3.2	5.0	3.5	-	-	-	-	-	-	-	-	-	-
60	5.2	3.7	5.6	3.9	-	4.2	-	4.6	-	-	-	-	-	-
65	5.7	4.1	6.2	4.4	-	4.7	-	5.1	-	-	-	-	-	-
70	6.4	4.5	6.8	4.8	-	5.1	-	5.6	-	-	-	-	-	-
75	7.0	4.9	7.5	5.3	7.9	5.6	-	6.1	-	-	-	-	-	-
80	7.6	5.4	8.2	5.8	8.6	6.1	9.4	6.7	-	-	-	-	-	-
85	8.3	5.9	8.9	6.3	9.4	6.6	10.2	7.2	-	-	-	-	-	-
90	9.0	6.4	9.6	6.8	10.1	7.2	11.0	7.8	-	-	-	-	-	-
95	9.7	6.8	10.3	7.3	10.9	7.7	11.8	8.3	-	8.9	-	-	-	-
100	10.4	7.4	11.1	7.8	11.6	8.2	12.6	8.9	-	9.5	14.4	10.2	-	-
110	11.8	8.4	12.6	8.9	13.2	9.4	14.2	10.1	-	10.8	16.2	11.5	-	-
120	13.4	9.5	14.2	10.1	14.9	10.5	16.0	11.3	-	12.1	18.1	12.8	-	-
130	14.9	10.6	15.8	11.2	16.6	11.7	17.8	12.6	18.9	13.4	20.1	14.2	-	-
140	16.6	11.7	17.5	12.4	18.3	13.0	19.6	13.9	20.9	14.8	22.1	15.6	-	-
150	18.3	12.9	19.3	13.7	20.1	14.3	21.5	15.2	22.8	16.2	24.1	17.1	-	-
160	20.0	14.2	21.1	14.9	22.0	15.6	23.5	16.6	24.9	17.6	26.2	18.6	-	-
170	21.8	15.4	22.9	16.2	23.9	16.9	25.5	18.0	26.9	19.1	28.4	20.1	-	-
180	23.6	16.7	24.8	17.6	25.8	18.3	27.5	19.5	29.1	20.6	30.6	21.7	31.6	22.4
190	25.4	18.0	26.8	19.0	27.8	19.7	29.6	20.9	31.2	22.1	32.8	23.3	33.9	24.0
200	27.3	19.4	28.7	20.4	29.9	21.2	31.7	22.5	33.4	23.7	35.1	24.9	36.3	25.7
250	37.5	26.5	39.3	27.8	40.7	28.8	43.0	30.4	45.1	32.0	47.2	33.4	48.7	34.5
300	48.6	34.4	50.7	35.9	52.4	37.1	55.2	39.1	57.8	40.9	60.3	42.7	62.0	43.9
350	60.5	42.8	63.0	44.6	65.0	46.0	68.3	48.4	71.3	50.5	74.2	52.6	76.2	54.0
400	73.2	51.8	76.1	53.9	78.4	55.5	82.1	58.2	85.6	60.7	88.9	63.0	91.2	64.6
450	86.6	61.4	90.0	63.7	92.6	65.6	96.8	68.6	100.7	71.3	104.4	74.0	107.0	75.8
500	-	-	104.5	74.0	107.4	76.1	112.1	79.4	116.5	82.5	120.7	85.5	123.5	87.5
550	-	-	119.7	84.8	122.9	87.1	128.1	90.8	133.0	94.2	137.5	97.4	140.7	99.6
600	-	-	135.5	96.0	139.0	98.5	144.8	102.5	150.1	106.3	155.1	109.8	158.5	112.3

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Thread size	M8		M10		M12		M16		M20		M24		M27	
h_{ef} [mm]	46		60		70		85		100		115		125	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
650	-	-	-	-	155.8	110.3	162.0	114.8	167.8	118.8	173.2	122.7	176.9	125.3
700	-	-	-	-	173.1	122.6	179.8	127.4	186.1	131.8	192.0	136.0	195.9	138.8
750	-	-	-	-	-	-	198.2	140.4	204.9	145.2	211.3	149.6	215.5	152.7
800	-	-	-	-	-	-	217.1	153.8	224.3	158.9	231.1	163.7	235.7	166.9
850	-	-	-	-	-	-	236.6	167.6	244.3	173.0	251.5	178.1	256.4	181.6
900	-	-	-	-	-	-	256.6	181.7	264.7	187.5	272.4	192.9	277.5	196.6
950	-	-	-	-	-	-	277.0	196.2	285.7	202.3	293.8	208.1	299.2	212.0
1000	-	-	-	-	-	-	-	-	307.1	217.5	315.6	223.6	321.4	227.7
1100	-	-	-	-	-	-	-	-	351.3	248.8	360.8	255.6	367.2	260.1
1200	-	-	-	-	-	-	-	-	397.3	281.4	407.7	288.8	414.7	293.8
1300	-	-	-	-	-	-	-	-	-	-	456.4	323.3	464.0	328.7
1400	-	-	-	-	-	-	-	-	-	-	506.7	358.9	515.0	364.8
1500	-	-	-	-	-	-	-	-	-	-	-	-	567.5	402.0
1600	-	-	-	-	-	-	-	-	-	-	-	-	621.6	440.3

a. Influence of concrete strength

Table 18: 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	1.10	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 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 19: 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.

c. Influence of edge distance

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.

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

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [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: $c_1 \leq c_2$

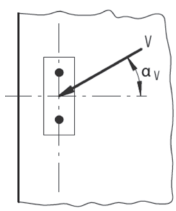
d. Influence of load direction

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

Table 21: 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.



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e. Influence of concrete member thickness

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

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	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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Mechanical characteristics

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Governing cross section									
Stressed cross section	A_s	[mm²]	21.2	36.3	52.8	91.6	153.9	156.7	244.8
Section modulus	W	[mm³]	13.8	30.9	54.1	123.7	269.4	276.7	540.2
Yield strength	f_y	[N/mm²]	580	580	580	520	420	640	640
Tensile strength	f_u	[N/mm²]	740	740	740	650	560	800	800
Stressed cross section of threaded part									
Stressed cross section	A_s	[mm²]	36.6	58.0	84.3	156.7	244.8	352.5	459.0
Section modulus	W	[mm³]	31.2	62.3	109.2	276.7	540.2	933.5	1387.0
Yield strength	f_y	[N/mm²]	504	504	504	504	420	640	640
Tensile strength	f_u	[N/mm²]	630	630	630	630	560	800	800
Design bending moment	$M^0_{Rd,s}$	[Nm]	18.4	37.6	65.6	167.2	272.9	718.4	1065

Material specifications

Product description	Steel, zinc plated	
	galvanized ≥ 5 µm	sherardized ≥ 40 µm
Conical bolt	M8 to M20: Cold formed or machined steel, galvanized, cone plastic coated	M8 to M20: Cold formed or machined steel, sherardized, cone plastic coated
Threaded bolt	M24 and M27: Steel, galvanized	M24 and M27: steel, sherardized
Threaded cone		M24 and M27: Steel, galvanized
Expansion sleeve	M8 to M20: Steel (e.g. 1.4301 or 1.4401) EN 10088:2014, M24 and M27: Steel acc. to EN 10139:1997	M8 to M20: Steel (e.g. 1.4301 or 1.4401) EN 10088:2014, M24 and M27: Steel acc. to EN 10139:1997
Washer	Steel, galvanized	Steel, zinc plated
Filling washer		
Hexagon nut	Steel, galvanized, coated	Steel, zinc plated

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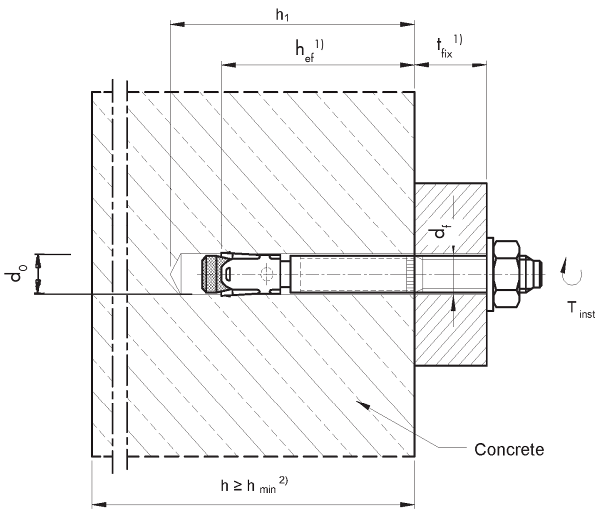
Installation parameters

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Depth of drill hole	$h_1 \geq$	[mm]	60	75	90	110	125	145	160
Nominal drill hole diameter	d_0	[mm]	8	10	12	16	20	24	28
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8,45	10,45	12,5	16,5	20,55	24,55	28,55
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	9	12	14	18	22	26	30
Torque moment	$T_{inst} \leq$	[Nm]	20	25	45	90	160	200	300
Standard thickness of member	h_{min}	[mm]	100	120	140	170	200	230	250
Non-cracked concrete									
Minimum spacing	s_{min}	[mm]	40	45	60	65	90	100	125
	for $c \geq$	[mm]	80	70	120	120	180	180	300
Minimum edge distance	c_{min}	[mm]	50	50	75	80	130	100	180
	for $s \geq$	[mm]	100	100	150	150	240	220	540
Cracked concrete									
Minimum spacing	s_{min}	[mm]	40	45	60	60	95	100	125
	for $c \geq$	[mm]	70	70	100	100	150	180	300
Minimum edge distance	c_{min}	[mm]	40	45	60	60	95	100	180
	for $s \geq$	[mm]	80	90	140	180	200	220	540



1) Effectiv
2) Minimuɜss of fixture t_{fix}
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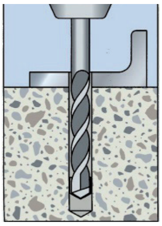
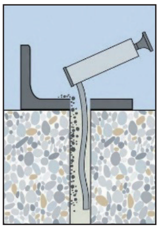
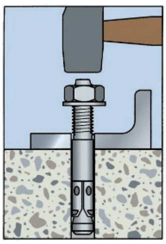
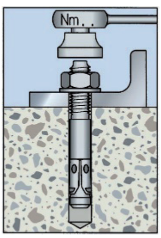
Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor. (see table anchor characteristics). Positioning of drill holes without damaging the reinforcement.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the anchor		
	**3a.**	Drive the anchor with some hammer impacts or with the machine setting tool into the drill hole. Anchor installation ensuring the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.