HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

W-HAZ-B/A4

Stainless steel - A4 (AISI 316): M8 - M16

W-HAZ-S/A4

Stainless steel - A4 (AISI 316): M8 - M16

W-HAZ-SK/A4

Stainless steel - A4 (AISI 316): M8 - M12

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

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

Variable effective anchorage depths possible!

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-02/0031 / 2021-28-01
Shock test, Critical infra-structure protection	BABS, CH-Bern		BZS D 09-0605 /2010-04-28

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/mm^2
- Concrete C 50/60, f_{ck} = 60 N/mm^2

Mean ultimate resistance

Thread size				**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth		h_{ef}	[mm]	60	71	80	100
Non-cracked concrete							
Tension	C20/25	$N_{Ru,m}$	[kN]	21.6	33.2	42.3	76.6
Shear	C20/25	$V_{Ru,m}$	[kN]	32.4	47.9	72.9	111.1
Cracked concrete							
Tension	C20/25	$N_{Ru,m}$	[kN]	18.1	28.9	33.9	62.8
Shear	C20/25	$V_{Ru,m}$	[kN]	32.4	47.9	72.9	111.1

Characteristic resistance

Thread size				**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth		h_{ef}	[mm]	60	71	80	100
Non-cracked concrete							
Tension	C20/25	N_{Rk}	[kN]	16.0	25.0	35.0	49.2
	C50/60			25.3	39.5	55.3	77.8
Shear	C20/25	V_{Rk}	[kN]	24.0	37.0	62.0	92.0
	C50/60			24.0	37.0	62.0	92.0
Cracked concrete							
Tension	C20/25	N_{Rk}	[kN]	9.0	16.0	24.6	34.4
	C50/60			14.2	25.3	39.0	54.4
Shear	C20/25	V_{Rk}	[kN]	24.0	37.0	49.3	68.9
	C50/60			24.0	37.0	62.0	92.0

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Design resistance

Thread size					12/M8	15/M10	18M12	24/M16
Effective anchorage depth			h_{ef}	[mm]	60	71	80	100
Non-cracked concrete								
Tension	S and SK	C20/25	N_{Rd}	[kN]	10.7	16.7	23.3	32.8
		C50/60			13.9	21.9	32.1	51.9
	B	C20/25			10.7	16.7	23.3	32.8
		C50/60			16.9	26.4	36.9	51.9
Shear	S and SK	C20/25	V_{Rd}	[kN]	17.6	27.2	45.6	65.6
		C50/60			17.6	27.2	45.6	67.6
	B	C20/25			19.2	29.6	46.9	65.6
		C50/60			19.2	29.6	49.6	73.6
Cracked concrete								
Tension	S and SK	C20/25	N_{Rd}	[kN]	6.0	10.7	16.4	23.0
		C50/60			9.5	16.9	26.0	36.3
	B	C20/25			6.0	10.7	16.4	23.0
		C50/60			9.5	16.9	26.0	36.3
Shear	S and SK	C20/25	V_{Rd}	[kN]	17.6	27.2	32.9	45.9
		C50/60			17.6	27.2	45.6	67.6
	B	C20/25			19.2	27.5	32.9	45.9
		C50/60			19.2	29.6	49.6	72.6

Recommended/allowable loads [1)]

Thread size					12/M8	15/M10	18M12	24/M16
Effective anchorage depth			h_{ef}	[mm]	60	71	80	100
Non-cracked concrete								
Tension	S and SK	C20/25	N_{rec}	[kN]	7.6	11.9	16.7	23.4
		C50/60			9.9	15.7	22.9	37.0
	B	C20/25			7.6	11.9	16.7	23.4
		C50/60			12.0	18.8	26.4	37.0
Shear	S and SK	C20/25	V_{rec}	[kN]	12.6	19.4	32.6	46.9
		C50/60			12.6	19.4	32.6	48.3
	B	C20/25			13.7	21.1	33.5	46.9
		C50/60			13.7	21.1	35.4	52.6
Cracked concrete								
Tension	S and SK	C20/25	N_{rec}	[kN]	4.3	7.6	11.7	16.4
		C50/60			6.8	12.0	18.6	25.9
	B	C20/25			4.3	7.6	11.7	16.4
		C50/60			6.8	12.0	18.6	25.9
Shear	S and SK	C20/25	V_{rec}	[kN]	12.6	19.4	23.5	32.8
		C50/60			12.6	19.4	32.6	48.3
	B	C20/25			13.7	19.6	23.5	32.8
		C50/60			13.7	21.1	35.4	51.9

[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.

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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
- Tables calculated for standard effective anchorage depths. Larger effective anchorage depths possible

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			12/M8	15/M10	18M12	24/M16
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
SK	$N_{Rd,s}$	[kN]	13.9	21.9	32.1	-
S			13.9	21.9	32.1	58.8
B			17.3	27.3	40.0	73.3

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			12/M8	15/M10	18M12	24/M16
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Non-cracked concrete						
SK	$N^0_{Rd,p}$	[kN]	10.7	16.7	23.3	-
S and B			10.7	16.7	23.3	33.3
Cracked concrete						
SK	$N^0_{Rd,p}$	[kN]	6.0	10.7	16.7	-
S and B			6.0	10.7	16.7	24.0

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			12/M8	15/M10	18M12	24/M16
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Non-cracked concrete						
SK	$N^0_{Rd,c}$	[kN]	15.2	19.6	23.5	-
S and B			15.2	19.6	23.5	32.8
Cracked concrete						
SK	$N^0_{Rd,c}$	[kN]	10.7	13.7	16.4	-
S and B			10.7	13.7	16.4	23.0

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

Thread size			12/M8	15/M10	18M12	24/M16
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Characteristic spacing	$s_{cr,N}$	[mm]	180	213	240	300
Characteristic edge distance	$c_{cr,N}$	[mm]	90	107	120	150

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

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			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Non-cracked concrete						
Splitting resistance	$N^0_{Rd,sp}$	[kN]	10.7	16.7	23.3	32.8

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

Thread size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Characteristic spacing	$s_{cr,sp}$	[mm]	360	470	530	600
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	235	265	300
Minimum member thickness	h_{min}	[mm]	120	140	160	200

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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

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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

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

Screw size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
SK	$V_{Rd,s}$	[kN]	17.6	27.2	45.6	-
S			17.6	27.2	45.6	67.6
B			19.2	29.6	49.6	73.6

2. Concrete pry-out pesistance

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

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

Screw size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0

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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 $c \geq \max (10\ h_{ef}\ ; 60\ d)$. 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 17: Design resistance $V^{0}_{Rd,c}$ in case of concrete edge failure

Thread size	12/M8				15/M10				18M12				24/M16			
h_{ef} [mm]	60		100		71		110		80		130		100		150	
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	non-cracked	cracked
50	4.5	3.2	5.1	3.6	-	-	-	-	-	-	-	-	-	-	-	-
55	5.1	3.6	5.7	4.1	-	-	-	-	-	-	-	-	-	-	-	-
60	5.7	4.1	6.4	4.5	-	4.4	-	4.9	-	-	-	-	-	-	-	-
65	6.4	4.5	7.1	5.0	-	4.8	-	5.4	-	-	-	-	-	-	-	-
70	7.0	5.0	7.8	5.5	-	5.3	-	5.9	8.0	5.6	9.0	6.4	-	-	-	-
75	7.7	5.5	8.5	6.0	-	5.8	-	6.4	8.7	6.2	9.8	6.9	-	-	-	-
80	8.4	6.0	9.3	6.6	-	6.3	-	7.0	9.5	6.7	10.6	7.5	-	7.4	-	8.3
85	9.1	6.5	10.0	7.1	9.7	6.9	10.6	7.5	10.2	7.2	11.5	8.1	-	8.0	-	8.9
90	9.8	7.0	10.8	7.6	10.5	7.4	11.4	8.1	11.0	7.8	12.3	8.7	-	8.6	-	9.6
95	10.6	7.5	11.6	8.2	11.2	8.0	12.3	8.7	11.8	8.4	13.2	9.3	-	9.2	-	10.2
100	11.3	8.0	12.4	8.8	12.0	8.5	13.1	9.3	12.6	9.0	14.1	10.0	-	9.8	-	10.9
110	12.9	9.1	14.1	10.0	13.7	9.7	14.8	10.5	14.3	10.2	15.9	11.2	-	11.1	-	12.3
120	14.5	10.3	15.8	11.2	15.3	10.9	16.6	11.8	16.1	11.4	17.7	12.6	-	12.4	-	13.7
130	16.2	11.5	17.6	12.4	17.1	12.1	18.5	13.1	17.9	12.7	19.7	13.9	-	13.8	-	15.1
140	17.9	12.7	19.4	13.7	18.9	13.4	20.4	14.4	19.7	14.0	21.6	15.3	-	15.2	-	16.6
150	19.7	13.9	21.3	15.1	20.7	14.7	22.3	15.8	21.6	15.3	23.7	16.8	-	16.6	-	18.1
160	21.5	15.2	23.2	16.4	22.6	16.0	24.3	17.2	23.6	16.7	25.7	18.2	-	18.1	-	19.7
170	23.4	16.6	25.2	17.8	24.6	17.4	26.3	18.7	25.6	18.1	27.9	19.7	-	19.6	-	21.2
180	25.3	17.9	27.2	19.3	26.5	18.8	28.4	20.1	27.6	19.6	30.0	21.3	29.8	21.1	32.3	22.9
190	27.3	19.3	29.3	20.7	28.6	20.2	30.6	21.6	29.7	21.0	32.3	22.8	32.0	22.7	34.6	24.5
200	29.3	20.7	31.4	22.2	30.7	21.7	32.7	23.2	31.9	22.6	34.5	24.4	34.2	24.3	37.0	26.2
250	39.9	28.3	42.5	30.1	41.7	29.5	44.2	31.3	43.2	30.6	46.4	32.9	46.1	32.7	49.5	35.1
300	51.5	36.5	54.7	38.7	53.6	38.0	56.7	40.2	55.4	39.2	59.3	42.0	59.0	41.8	63.0	44.6
350	64.0	45.3	67.7	47.9	66.4	47.0	70.0	49.6	68.5	48.5	73.1	51.8	72.7	51.5	77.3	54.8
400	77.2	54.7	81.4	57.7	80.0	56.7	84.2	59.6	82.5	58.4	87.7	62.1	87.2	61.8	92.5	65.5
450	91.2	64.6	96.0	68.0	94.4	66.9	99.1	70.2	97.1	68.8	103.0	73.0	102.5	72.6	108.4	76.8
500	105.9	75.0	111.2	78.8	109.5	77.5	114.7	81.2	112.5	79.7	119.1	84.3	118.5	83.9	125.1	88.6
550	121.2	85.9	127.1	90.1	125.2	88.7	130.9	92.8	128.6	91.1	135.8	96.2	135.2	95.8	142.4	100.9
600	137.2	97.2	143.7	101.8	141.5	100.2	147.9	104.7	145.2	102.9	153.2	108.5	152.5	108.0	160.4	113.6
650	153.8	108.9	160.8	113.9	158.5	112.3	165.4	117.1	162.5	115.1	171.1	121.2	170.4	120.7	179.0	126.8
700	170.9	121.0	178.5	126.5	176.0	124.7	183.5	130.0	180.4	127.8	189.7	134.4	188.9	133.8	198.2	140.4
750	-	-	196.8	139.4	194.1	137.5	202.1	143.2	198.8	140.8	208.8	147.9	208.0	147.3	217.9	154.4
800	-	-	215.7	152.8	212.8	150.7	221.3	156.8	217.8	154.3	228.5	161.8	227.6	161.2	238.2	168.7

Thread size	12/M8				15/M10				18M12				24/M16			
h_{ef} [mm]	60		100		71		110		80		130		100		150	
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	non-cracked	cracked
850	-	-	235.0	166.5	231.9	164.3	241.1	170.7	237.3	168.1	248.7	176.1	247.8	175.5	259.0	183.5
900	-	-	254.9	180.5	251.6	178.2	261.3	185.1	257.3	182.3	269.4	190.8	268.5	190.2	280.4	198.6
950	-	-	275.2	194.9	-	-	282.0	199.8	277.8	196.8	290.6	205.8	289.6	205.2	302.2	214.1
1000	-	-	296.0	209.7	-	-	303.2	214.8	298.8	211.6	312.3	221.2	311.3	220.5	324.6	229.9
1100	-	-	-	-	-	-	347.0	245.8	-	-	357.1	252.9	356.0	252.1	370.6	262.5
1200	-	-	-	-	-	-	-	-	-	-	403.6	285.9	402.4	285.1	418.5	296.5
1300	-	-	-	-	-	-	-	-	-	-	451.9	320.1	450.6	319.2	468.1	331.6
1400	-	-	-	-	-	-	-	-	-	-	-	-	500.5	354.5	519.4	367.9
1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	572.3	405.3
1600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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.

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

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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

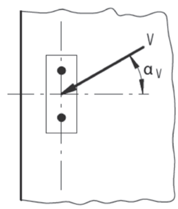
$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

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.

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				12/M8	15/M10	18/M12	24/M16
Effective anchorage depth		h_{ef}	[mm]	60	71	80	100
Governing cross section (bolt)							
Stressed cross section		A_s	[mm²]	36.6	58	84.3	157
Section modulus		W	[mm³]	31.2	62.3	109.1	276.6
Yield strength		f_y	[N/mm²]	560	560	560	560
Tensile strength		f_u	[N/mm²]	700	700	700	700
Governing cross section (screw)							
Stressed cross section		A_s	[mm²]	36.6	58	84.3	157
Section modulus		W	[mm³]	31.2	62.3	109.1	276.6
Yield strength		f_y	[N/mm²]	450	450	450	450
Tensile strength		f_u	[N/mm²]	700	700	700	700
Design bending moment	B	$M^0_{Rd,s}$	[Nm]	20.8	41.6	73.6	185.6
	S and SK			16.7	33.3	59.0	148.7

*For larger effective anchorage depths, design bending moments are higher

Material specifications

Product description	**Stainless steel A4**
Threaded bolt	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014
Washer	Stainless steel, EN 10088:2014
Distance sleeve	Steel tube stainless steel, 1.4401, 1.4404 or 1.4571; EN 10217-7:2014, EN 10216-5:2013
Ring	Polyethylene
Expansion sleeve	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014
Threaded cone	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014
Hexagon nut	Stainless steel, strength class 70, EN ISO 3506-2:2009
Hexagon head screw	Stainless steel, strength class 70, EN ISO 3506-1:2009
Countersunk screw	Stainless steel, strength class 70, EN ISO 3506-1:2009
Countersunk washer	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014, zinc plated

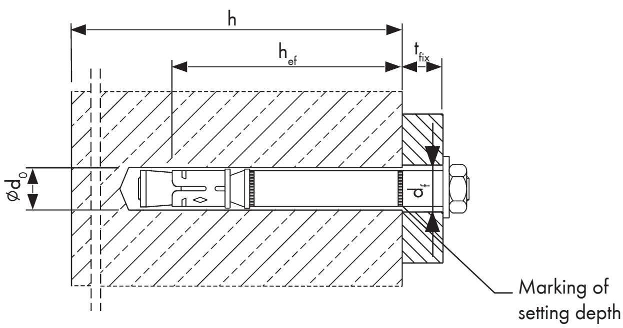
Installation parameters

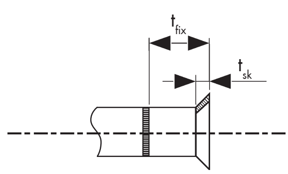
Thread size			12/M8	15/M10	18/M12	24/M16
Size of thread		[-]	M8	M10	M12	M16
Minimum effective anchorage depth	$h_{ef,min}$	[mm]	60	71	80	100
	$h_{ef,max}$	[mm]	100	110	130	150
Nominal drill hole diameter	d_0	[mm]	12	15	18	24
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	12.5	15.5	18.5	24.5
Depth of drill hole	$h_1 \geq$	[mm]	h_{ef} + 20	h_{ef} + 24	h_{ef} + 25	h_{ef} + 30
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	14	17	20	26
Thickness of countersunk washer W-HAZ-SK	t_{sk}	[mm]	5	6	7	-
Minimum thickness of fixture W-HAZ-SK	$t_{fix,min}$ 2)	[mm]	10	14	18	-
Installation torque T_{inst} (W-HAZ-B)	T_{inst} =	[Nm]	35	55	90	170
Installation torque T_{inst} (W-HAZ-S)	T_{inst} =	[Nm]	30	50	80	170
Installation torque T_{inst} (W-HAZ-SK)	T_{inst} =	[Nm]	17.5	42.5	50	-
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 60	h_{ef} + 69	h_{ef} + 80	h_{ef} + 100
Uncracked concrete						
Minimum spacing 1) 3)	s_{min}	[mm]	50	60	70	80
	for c ≥	[mm]	80	120	140	180
Minimum edge distance 1) 3)	c_{min}	[mm]	50	85	70	180
	for s ≥	[mm]	80	185	160	80
Cracked concrete						
Minimum spacing 1) 3)	s_{min}	[mm]	50	60	70	80
	for c ≥	[mm]	80	120	140	180
Minimum edge distance 1) 3)	c_{min}	[mm]	50	60	70	80
	for s ≥	[mm]	80	120	160	200

1) Intermediate values by linear interpolation

2) Depending on the existing shear load, the thickness of the fixture may be reduced to the thickness of the countersunk washer t_{sk}. It must be verified that the present shear load can be transferred completely into the distance sleeve (bearing of hole).

3) For fire exposure from more than one side c ≥ 300 mm or c_{min} ≥ 300 mm applies.





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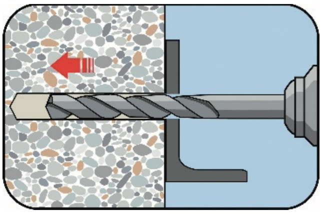
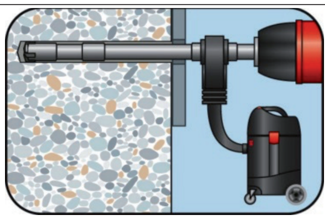
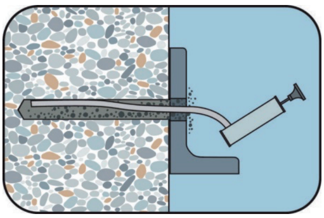
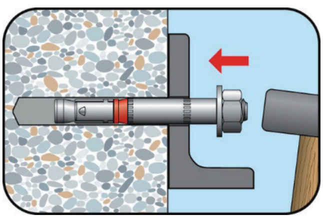
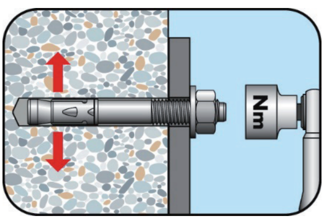
Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. In case of aborted drill hole, the drill hole shall be filled with mortar.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected anchor. This drilling system removes the dust and cleans the bore hole during drilling (all conditions). Proceed with Step C.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the fastener		
	**3a.**	Drive the anchor with hammer impact into the drill hole and check the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.