fischer Injection mortar FIS V, FIS VS and FIS VW

Anchor design according to fischer specification

1. Types

FIS A M6 - M30 – threaded rod (gvz, A4, C)
straight cut

RG M8 - M30 - threaded rod (gvz, A4, C)
some dimensions with external hexagon head

FIS V - Injection mortar FIS V 360 S, FIS V 950 S

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ETA CE
European Technical Approval - Option 7 for non-cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

ICC ES
ESR-2786
See ICC-ES Evaluation Report at www.ic-es.org
Inspection agency: AA-707 *)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

FIS VS - Injection mortar
FIS VS 300 T, FIS VS 360 S

FIS VW - Injection mortar
FIS VW 360 S

Features and Advantages

- European Technical Approval option 7*) for uncracked concrete.
- ICC approval *) for non-cracked concrete.
- Fire resistance classifications according to test report independently proved gives the safety in case of fire.
- The Hybrid mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- The approval guarantees the safe function at a large temperature range of -40 °C up to +120 °C.
- Different mortar versions and a large range of accessories gives the opportunity for different applications and a wide temperature range of the anchor base.
- Variable embedment depth enables the application in all kind of building structures.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- A stand-off installation is easier to realize because threaded rods didn't need a torque moment.
- FIS VS mortar version with lower maximum processing time and lower application pressure.
- FIS VW mortar version with accelerated curing especially during winter.

*) The conditions of use in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook.

Materials

Threaded rod :	- Carbon steel, zinc plated (5 µm) and passivated (gvz)
	- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
	- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529.
Injection mortar:	- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type			FIS V M6				FIS V M8				FIS V M10				FIS V M12			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	60				80				90				110			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C)[2)]																		
tension	C 20/25	N_u [kN]	11.6	12.3	12.3	12.3	20.0	26.6	26.6	26.6	30.5	37.5	37.5	37.5	45.2	55.0	55.0	55.0
shear	≧ C 20/25	V_u [kN]	6.3	10.1	8.9	8.9	11.5	18.4	16.1	16.1	18.3	29.2	25.6	25.6	26.6	42.5	37.2	37.2

Anchor type			FIS V M16				FIS V M20				FIS V M24				FIS V M30			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	125				170				210				280			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C)[2)]																		
tension	C 20/25	N_u [kN]	83.0	96.9	96.9	96.9	122.3	122.3	122.3	122.3	171.7	171.7	171.7	171.7	270.3	270.3	270.3	270.3
shear	≧ C 20/25	V_u [kN]	49.5	79.1	69.2	69.2	77.2	123.5	108.0	108.0	111.2	177.9	155.7	155.7	176.7	282.7	247.4	247.4

[1)] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2)] (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type			FIS V M6				FIS V M8				FIS V M10				FIS V M12			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	60				80				90				110			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C)[2)]																		
tension	C 20/25	N_{Rk} [kN]	10.2	10.2	10.2	10.2	22.1	22.1	22.1	22.1	31.1	31.1	31.1	31.1	45.6	45.6	45.6	45.6
shear	C 20/25	V_{Rk} [kN]	5.0	8.0	7.0	7.0	9.0	15.0	13.0	13.0	15.0	23.0	20.0	20.0	21.0	34.0	30.0	30.0

Anchor type			FIS V M16				FIS V M20				FIS V M24				FIS V M30			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	125				170				210				280			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C)[2)]																		
tension	C 20/25	N_{Rk} [kN]	80.4	80.4	80.4	80.4	101.5	101.5	101.5	101.5	142.5	142.5	1425	142.5	224.3	224.3	224.3	224.3
shear	C 20/25	V_{Rk} [kN]	39.0	63.0	55.0	55.0	61.0	98.0	86.0	86.0	89.0	141.0	124.0	124.0	141.0	225.0	197.0	197.0

[1)] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2)] (short term temperature / long term temperature)

3.2 Design resistance [1]

Anchor type			FIS V M6				FIS V M8				FIS V M10				FIS V M12			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	60				80				90				110			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension	C 20/25	N_{Rd} [kN]	5.7	5.7	5.7	5.7	12.3	12.3	12.3	12.3	17.3	17.3	17.3	17.3	25.3	25.3	25.3	25.3
shear	C 20/25	V_{Rd} [kN]	4.0	6.4	4.5	5.6	7.2	12.0	8.3	10.4	12.0	18.4	12.8	16.0	16.8	27.2	19.2	24.0

Anchor type			FIS V M16				FIS V M20				FIS V M24				FIS V M30			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	125				170				210				280			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension	C 20/25	N_{Rd} [kN]	44.7	44.7	44.7	56.4	56.4	56.4	56.4	56.4	79.2	79.2	79.2	79.2	124.6	124.6	124.6	124.6
shear	C 20/25	V_{Rd} [kN]	31.2	50.4	35.3	44.0	48.8	78.4	55.1	68.8	71.2	112.8	79.5	99.2	112.8	180.0	126.3	157.6

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2] (short term temperature / long term temperature)

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3.3 Recommended resistance [1] [3]

Anchor type			FIS V M6				FIS V M8				FIS V M10				FIS V M12			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	60				80				90				110			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension	C 20/25	N_R [kN]	4.0	4.0	4.0	4.0	8.8	8.8	8.8	8.8	12.3	12.3	12.3	12.3	18.1	18.1	18.1	18.1
shear	C 20/25	V_R [kN]	2.9	4.6	3.2	4.0	5.1	8.6	6.0	7.4	8.6	13.1	9.2	11.4	12.0	19.4	13.7	17.1

Anchor type			FIS V M16				FIS V M20				FIS V M24				FIS V M30			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	125				170				210				280			
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension	C 20/25	N_R [kN]	31.9	31.9	31.9	31.9	40.3	40.3	40.3	40.3	56.5	56.5	56.5	56.5	89.0	89.0	89.0	89.0
shear	C 20/25	V_R [kN]	22.3	36.0	25.2	31.4	34.9	56.0	39.4	49.1	50.9	80.6	56.8	70.9	80.6	128.6	90.2	112.6

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2] (short term temperature / long term temperature)

[3] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS V M6					FIS V M8					FIS V M10				
				gvz		A4	C		gvz		A4	C		gvz		A4	C
			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9		
design resistance	$N_{Rd,s}$	[kN]	7.3	10.7	14.3	7.5	9.3	12.8	20.0	26.1	13.9	17.3	19.3	31.3	41.4	21.9	27.3

Anchor type			FIS V M12					FIS V M16					FIS V M20				
				gvz		A4	C		gvz		A4	C		gvz		A4	C
			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9		
design resistance	$N_{Rd,s}$	[kN]	28.7	45.3	60.2	31.6	39.3	52.7	84.0	112.1	58.8	73.3	82.0	130.7	175.0	92.0	114.7

Anchor type			FIS V M24					FIS V M30				
				gvz		A4	C		gvz		A4	C
			5.8	8.8	10.9			5.8	8.8	10.9		
design resistance	$N_{Rd,s}$	[kN]	118.0	188.0	252.1	132.1	164.7	187.3	299.3	374.0	209.8	261.3

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
non-cracked concrete														
temperature range (+ 80 °C / + 50 °C) [1]														
	$N^0_{Rd,p}$	[kN]	4.7	5.7	6.8	9.8	12.3	14.7	15.4	17.3	23.0	22.1	25.3	33.2
temperature range (+ 120 °C / + 72 °C) [1]														
	$N^0_{Rd,p}$	[kN]	3.4	4.1	4.9	8.5	10.6	12.7	13.3	14.9	19.9	18.1	20.7	27.1

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
non-cracked concrete														
temperature range (+ 80 °C / + 50 °C) [1]														
	$N^0_{Rd,p}$	[kN]	34.9	44.7	53.6	53.1	56.4	79.6	72.4	79.2	108.6	106.8	124.6	160.2
temperature range (+ 120 °C / + 72 °C) [1]														
	$N^0_{Rd,p}$	[kN]	29.7	38.0	45.6	44.7	47.5	67.0	60.3	66.0	90.5	88.0	102.6	131.9

[1] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.85	0.90	1.0	1.06	1.14	1.22	1.27	1.31	1.35

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
temperature range (+ 80 °C / + 50 °C) [1]														
	$s_{cr,Np}$	[mm]	131	131	131	192	194	194	240	242	242	288	291	291
	$c_{cr,Np}$	[mm]	66	66	66	96	97	97	120	121	121	144	145	145
temperature range (+ 120 °C / + 72 °C) [1]														
	$s_{cr,Np}$	[mm]	112	112	112	180	180	180	225	225	225	263	263	263
	$c_{cr,Np}$	[mm]	56	56	56	90	90	90	113	113	113	131	131	131

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
temperature range (+ 80 °C / + 50 °C) [1]														
	$s_{cr,Np}$	[mm]	370	370	370	450	450	450	526	526	526	639	639	639
	$c_{cr,Np}$	[mm]	185	185	185	225	225	225	263	263	263	319	319	319
temperature range (+ 120 °C / + 72 °C) [1]														
	$s_{cr,Np}$	[mm]	341	341	341	413	413	413	480	480	480	580	580	580
	$c_{cr,Np}$	[mm]	170	170	170	207	207	207	240	240	240	290	290	290

[1] (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:

- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
non-cracked concrete														
Design resistance	$N^0_{Rd,c}$	[kN]	11.9	15.6	20.6	17.2	24.1	31.7	24.1	28.7	44.3	31.7	38.8	58.2

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
non-cracked concrete														
Design resistance	$N^0_{Rd,c}$	[kN]	47.1	68.1	89.6	68.1	74.6	125.2	89.6	102.5	164.5	125.2	157.7	230.0

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4.3.1 Influence of concrete strength for tension

$$f_{b,N,c} = \sqrt{\frac{f_{ck,cube}}{25}} = \sqrt{\frac{f_{ck,cyl}}{20}}$$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
	$s_{cr,N}$	[mm]	150	180	216	192	240	288	240	270	360	288	330	432
	$c_{cr,N}$	[mm]	75	90	108	96	120	144	120	135	180	144	165	216

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
	$s_{cr,N}$	[mm]	375	480	576	480	510	720	576	630	864	720	840	1080
	$c_{cr,N}$	[mm]	187.5	240	288	240	255	360	288	315	432	360	420	540

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**FIS V M6**			**FIS V M8**			**FIS V M10**			**FIS V M12**		
eff. anchorage depth		h_{ef}	**[mm]**	**50**	**60**	**72**	**64**	**80**	**96**	**80**	**90**	**120**	**96**	**110**	**144**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	100	120	144	128	160	192	160	180	240	192	220	288
		$c_{cr,sp}$	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)											
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	226	271	325	289	362	434	362	407	542	434	497	651
		$c_{cr,sp}$	[mm]	113	136	163	145	181	217	181	203	271	217	249	325
		h_{min}	[mm]	100	100	102	100	110	126	110	120	150	126	140	174

Anchor type				**FIS V M16**			**FIS V M20**			**FIS V M24**			**FIS V M30**		
eff. anchorage depth		h_{ef}	**[mm]**	**125**	**160**	**192**	**160**	**170**	**240**	**192**	**210**	**288**	**240**	**280**	**360**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	250	320	384	320	340	480	384	420	576	480	560	720
		$c_{cr,sp}$	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)											
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	565	723	868	723	768	1085	868	949	1302	1085	1266	1627
		$c_{cr,sp}$	[mm]	283	362	434	362	384	542	434	475	651	542	633	814
		h_{min}	[mm]	161	196	228	208	218	288	248	266	344	310	350	430

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}} \right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness at splitting failure

$$f_h = \left(\frac{h}{h_{min}} \right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

4

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\, N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^{o}_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS V M6					FIS V M8					FIS V M10					FIS V M12				
			gvz			A4	C	gvz			A4	C	gvz			A4	C	gvz			A4	C
			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9		
design resistance	$V_{Rd,s}$	[kN]	4.0	6.4	6.7	4.5	5.6	7.2	12.0	12.2	8.3	10.4	12.0	18.4	19.3	12.8	16.0	16.8	27.2	28.1	19.2	24.0

Anchor type			FIS V M16					FIS V M20					FIS V M24					FIS V M30				
			gvz			A4	C	gvz			A4	C	gvz			A4	C	gvz			A4	C
			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9		
design resistance	$V_{Rd,s}$	[kN]	31.2	50.4	52.3	35.3	44.0	48.8	78.4	82.0	55.1	68.8	71.2	112.8	118.0	79.5	99.2	112.8	180.0	187.3	126.3	157.6

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\, N_{Rd,c})$$

k-factor

Anchor type	FIS V M6 to M30
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}; 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS V M6			FIS V M8			FIS V M10			FIS V M12		
h_{ef}	50	60	72	64	80	96	80	90	120	96	110	144
edge distance [mm]												
40	3.2	3.3	3.4	3.6	3.7	3.9						
45	3.8	3.9	4.0	4.2	4.3	4.5	4.5	4.7	5.0			
50	4.4	4.5	4.6	4.8	5.0	5.2	5.2	5.3	5.7			
55	5.0	5.1	5.3	5.4	5.6	5.9	5.9	6.0	6.4	6.3	6.6	7.0
60	5.6	5.8	5.9	6.1	6.3	6.6	6.6	6.8	7.2	7.1	7.3	7.8
65	6.3	6.4	6.6	6.8	7.0	7.3	7.3	7.5	8.0	7.9	8.1	8.7
70	6.9	7.1	7.3	7.5	7.8	8.0	8.1	8.3	8.8	8.6	8.9	9.5
75	7.6	7.8	8.0	8.2	8.5	8.8	8.8	9.0	9.6	9.4	9.7	10.3
80	8.3	8.5	8.8	9.0	9.3	9.6	9.6	9.8	10.4	10.3	10.6	11.2
85	9.1	9.3	9.5	9.7	10.1	10.4	10.4	10.7	11.3	11.1	11.4	12.1
90	9.8	10.0	10.3	10.5	10.9	11.2	11.3	11.5	12.1	12.0	12.3	13.0
95	10.6	10.8	11.1	11.3	11.7	12.1	12.1	12.3	13.0	12.9	13.2	14.0
100	11.3	11.6	11.9	12.1	12.6	12.9	13.0	13.2	13.9	13.8	14.1	14.9
120	14.6	14.9	15.3	15.6	16.1	16.5	16.6	16.9	17.7	17.5	17.9	18.9
140	18.2	18.5	18.9	19.3	19.9	20.4	20.4	20.8	21.8	21.5	22.0	23.1
160	21.9	22.3	22.8	23.2	23.9	24.4	24.5	24.9	26.0	25.8	26.3	27.6
180	25.9	26.4	26.9	27.3	28.1	28.7	28.8	29.3	30.5	30.2	30.8	32.2
200	30.0	30.6	31.1	31.7	32.5	33.2	33.3	33.8	35.2	34.9	35.6	37.1
250	41.2	41.9	42.6	43.3	44.3	45.2	45.3	46.0	47.7	47.3	48.2	50.1
300	53.5	54.3	55.2	56.0	57.2	58.3	58.5	59.2	61.3	60.8	61.9	64.1
350	66.7	67.6	68.7	69.6	71.1	72.4	72.5	73.4	75.8	75.3	76.5	79.1
400	80.7	81.9	83.1	84.1	85.8	87.3	87.5	88.5	91.3	90.6	92.0	95.1
450	95.6	96.9	98.3	99.5	101.4	103.1	103.3	104.4	107.6	106.8	108.4	111.8
500	111.3	112.7	114.2	115.6	117.7	119.6	119.8	121.2	124.6	123.8	125.6	129.4
550		129.2	130.9	132.4	134.8	136.9	137.1	138.6	142.4	141.6	143.5	147.7
600		146.5	148.3	150.0	152.6	154.9	155.1	156.8	161.0	160.0	162.1	166.7
650			166.4	168.2	171.0	173.6	173.8	175.6	180.2	179.1	181.4	186.4
700			185.1		190.1	192.9	193.2	195.1	200.0	198.9	201.4	206.7
750			204.4		209.9	212.8	213.1	215.1	220.5	219.3	222.0	227.7
800					230.2	233.3	233.7	235.8	241.5	240.3	243.2	249.3
900						276.1		279.0	285.4	284.0	287.3	294.2
1000						321.0			331.5	329.9	333.6	341.3
1100									379.7		381.9	390.5
1200									429.8			441.7
1300												494.9
1400												549.8
1500												606.5

continued next page

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS V M16			FIS V M20			FIS V M24			FIS V M30		
h_{ef}	125	160	192	160	170	240	192	210	288	240	280	360
edge distance [mm]												
65	8.9	9.5	10.0									
70	9.7	10.4	11.0									
75	10.6	11.3	11.9									
80	11.5	12.2	12.9									
85	12.4	13.2	13.9	13.8	14.1	15.6						
90	13.3	14.2	14.9	14.8	15.1	16.7						
95	14.3	15.1	15.9	15.8	16.1	17.8						
100	15.2	16.2	16.9	16.9	17.2	18.9	18.4	19.0	21.0			
120	19.3	20.3	21.2	21.2	21.5	23.6	23.0	23.6	25.9			
140	23.5	24.8	25.8	25.7	26.1	28.4	27.8	28.5	31.1			
160	28.1	29.4	30.6	30.5	30.9	33.5	32.9	33.6	36.5	36.3	38.0	41.1
180	32.8	34.3	35.6	35.5	36.0	38.9	38.1	38.9	42.2	42.0	43.8	47.2
200	37.7	39.4	40.8	40.7	41.2	44.4	43.6	44.5	48.0	47.8	49.8	53.4
250	50.8	52.9	54.6	54.6	55.2	59.0	58.1	59.1	63.4	63.2	65.5	69.9
300	65.0	67.5	69.5	69.5	70.2	74.8	73.6	74.9	79.9	79.6	82.4	87.5
350	80.2	83.1	85.4	85.4	86.2	91.5	90.2	91.6	97.3	97.1	100.2	106.0
400	96.3	99.6	102.2	102.2	103.2	109.1	107.6	109.3	115.7	115.4	119.0	125.5
450	113.2	116.9	119.9	119.9	120.9	127.5	125.9	127.8	134.9	134.7	138.6	145.8
500	130.9	135.0	138.3	138.3	139.5	146.8	145.0	147.1	155.0	154.7	159.0	166.9
550	149.4	153.9	157.5	157.5	158.8	166.8	164.9	167.1	175.8	175.5	180.2	188.8
600	168.6	173.5	177.4	177.5	178.9	187.6	185.5	187.9	197.3	197.0	202.1	211.4
650	188.5	193.8	198.0	198.1	199.6	209.0	206.8	209.4	219.5	219.2	224.7	234.7
700	209.0	214.7	219.3	219.4	221.0	231.1	228.7	231.5	242.4	242.1	248.0	258.7
750	230.1	236.3	241.2	241.3	243.0	253.8	251.3	254.3	265.9	265.6	271.9	283.3
800	251.9	258.4	263.7	263.8	265.7	277.2	274.5	277.7	290.1	289.8	296.5	308.6
900	297.2	304.6	310.5	310.6	312.7	325.7	322.7	326.3	340.1	339.9	347.4	360.9
1000	344.6	352.9	359.5	359.7	362.0	376.4	373.1	377.1	392.5	392.2	400.5	415.4
1100	394.2	403.3	410.6	410.9	413.4	429.3	425.7	430.1	446.9	446.7	455.8	472.1
1200	445.8	455.8	463.8	464.0	466.9	484.2	480.3	485.1	503.4	503.2	513.1	530.9
1300	499.3	510.2	518.8	519.1	522.2	541.0	536.8	542.0	561.9	561.7	572.4	591.6
1400		566.4	575.8	576.1	579.4	599.7	595.2	600.8	622.2	622.0	633.6	654.2
1500		624.4	634.4	634.8	638.4	660.1	655.3	661.3	684.3	684.2	696.6	718.6
1600		684.1	694.8	695.3	699.1	722.3	717.2	723.7	748.2	748.1	761.3	784.8
1700			756.9		761.4	786.2	780.8	787.6	813.7	813.6	827.7	852.6
1800			820.6			851.7	846.0	853.2	880.9	880.8	895.7	922.1
1900			885.8			918.7	912.7	920.4	949.6	949.6	965.3	993.2
2000						987.3		989.1	1019.9	1019.9	1036.5	1065.8
2200						1128.9		1130.9	1164.9	1165.0	1183.3	1215.5
2400						1276.2			1315.6	1315.8	1335.8	1371.0
2600									1471.8		1493.7	1531.9
2800									1633.2		1657.0	1698.1
3000												1869.4
3200												2045.6
3400												2226.5
3600												2412.0

5.3.1 Influence of cracked concrete

f_{cr}

	Non-cracked concrete
f_{cr}	1.0

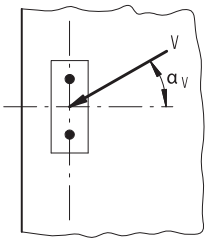
5.3.2 Influence of concrete strength for shear

$$f_{b,V} = \sqrt{\frac{f_{ck,\,cube}}{25}} = \sqrt{\frac{f_{ck,\,cyl}}{20}}$$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.3 Influence of load direction

$f_{\alpha,V}$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angel $\alpha \geqq 90°$ the component of the shear load acting away from the edge can be neglected and the proof can be done with the component of the load acting parallel to the edge.

4

5.3.4 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.5 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.6 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.7 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 **Tension:** $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 **Shear:** $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

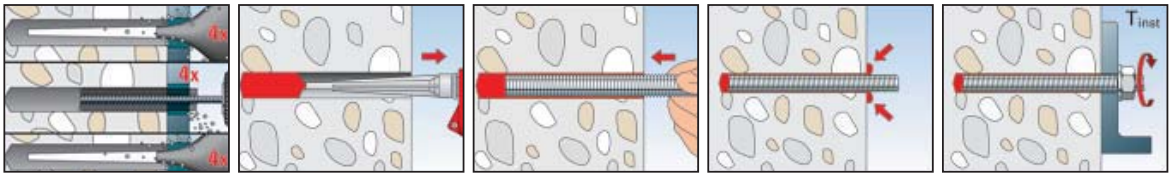
6.3 **Combined tension and shear load:**

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details

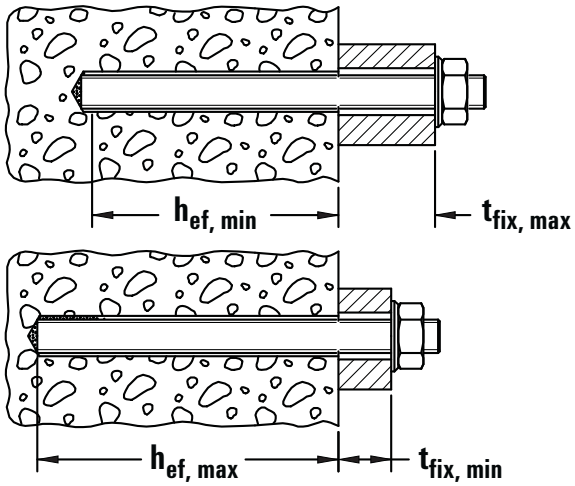


$d_0 \geq 18$ mm with oil free compressed air (P > 6 bar)

8. Anchor installation data

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
	h_{ef}	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
diameter of thread			M 6			M 8			M 10			M 12		
nominal drill hole diameter	d_0	[mm]	8			10			12			14		
drill depth	h_0	[mm]	50	60	72	64	80	96	80	90	120	96	110	144
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 7			≦ 9			≦ 12			≦ 14		
wrench size	SW	[mm]	10			13			17			19		
required torque	T_{inst}	[Nm]	5			10			20			40		
minimum thickness of concrete member	h_{min}	[mm]	100	100	102	100	110	126	110	120	150	126	140	174
minimum spacing	s_{min}	[mm]	40			40			45			55		
minimum edge distances	c_{min}	[mm]	40			40			45			55		
mortar filling quantity		[scale units]	2	3	3	3	4	4	4	5	5	5	6	7

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
	h_{ef}	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
diameter of thread			M 16			M 20			M 24			M 30		
nominal drill hole diameter	d_0	[mm]	18			24			28			35		
drill depth	h_0	[mm]	125	160	192	160	170	240	192	210	288	240	280	360
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 18			≦ 22			≦ 26			≦ 33		
wrench size	SW	[mm]	24			30			36			46		
required torque	T_{inst}	[Nm]	60			120			150			300		
minimum thickness of concrete member	h_{min}	[mm]	161	196	288	208	218	288	248	266	344	310	350	430
minimum spacing	s_{min}	[mm]	65			85			105			140		
minimum edge distances	c_{min}	[mm]	65			85			105			140		
mortar filling quantity		[scale units]	7	9	11	20	23	30	30	34	45	55	65	85



9. Gelling and curing times

System temperature	Max. processing time		
	FIS VW	FIS V	FIS VS
± 0 °C	5 min.	–	–
+ 5 °C	5 min.	13 min.	–
+ 10 °C	3 min.	9 min.	20 min.
+ 20 °C	1 min.	5 min.	10 min.
+ 30 °C	–	4 min.	6 min.
+ 40 °C	–	2 min.	4 min.

Temperature at anchoring base	Curing time [1]		
	FIS VW	FIS V	FIS VS
- 5 °C to 0 °C	3 h	24 h	–
± 0 °C to + 5 °C	3 h	3 h	6 h
> 5 °C to + 10 °C	50 min.	90 min.	3 h
> 10 °C to + 20 °C	30 min.	60 min.	2 h
> 20 °C to + 30 °C	–	45 min.	60 min.
> 30 °C to + 40 °C	–	35 min.	30 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

[1] For wet concrete the curing time must be doubled.

10. Mechanical characteristics of anchor rod

Anchor type			FIS V M6					FIS V M8					FIS V M10					FIS V M12				
			gvz			A4	C	gvz			A4	C	gvz			A4	C	gvz			A4	C
			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9		
stressed cross sectional area anchor rod	A_s	[mm²]	20.1					36.6					58.0					84.3				
section modolus	W	[mm³]	12.7					31.2					62.3					109.2				
design value of bending moment	$M^0_{Rd,s}$	[Nm]	6.4	9.6	11.4	7.1	8.8	15.2	24.0	28.1	16.7	20.8	29.6	48.0	56.1	33.3	41.6	52.0	84.0	98.0	59.0	73.6
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	900	450	560	400	640	900	450	560	400	640	900	450	560	400	640	900	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	1000	700	700	500	800	1000	700	700	500	800	1000	700	700	500	800	1000	700	700

Anchor type			FIS V M16					FIS V M20					FIS V M24					FIS V M30				
			gvz			A4	C	gvz			A4	C	gvz			A4	C	gvz			A4	C
			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9			5.8	8.8	10.9		
stressed cross sectional area anchor rod	A_s	[mm²]	157.0					245.0					353.0					561.0				
section modolus	W	[mm³]	277.5					540.9					935.5					1874				
design value of bending moment	$M^0_{Rd,s}$	[Nm]	132.8	212.8	249.3	148.7	185.6	259.2	415.2	486.7	291.0	363.2	448.0	716.8	841.3	502.6	627.2	898.4	1438	1687	1008	1258
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	900	450	560	400	640	900	450	560	400	640	900	450	560	400	640	900	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	1000	700	700	500	800	1000	700	700	500	800	1000	700	700	500	800	1000	700	700