fischer Injection mortar FIS EM

Anchor design according to fischer specification

1. Types

FIS A M8 - M42 - threaded rod (gvz, A4 and C)

RG M8 - M30 - threaded rod (gvz, A4 and C)

Injection mortar FIS EM 390 S, FIS EM 585 S FIS EM 1100 S

European Technical Approval – Option 1 for cracked concrete *)

ICC ES ESR-1990 – See ICC-ES Evaluation Report at www.ic-es.org – Inspection agency: AA-707 *)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- ICC-ES Evaluation Report *) for non-cracked concrete, Seismic categories A+B.
- Expansion stress free anchoring guarantees for a save use with small spacing and edge distances.
- Less cleaning procedures of the drill hole due to the high-quality epoxy resin.
- The resin seals the drill hole and avoids penetration of dampness and therefore gives corrosion protection for the embedded steel.
- Variable embedment depth enables the application in all kinds of building structure.
- Large range of available fixing length gives perfect allocation to the given fixture.
- Suitable for underwater installations. (See reduction factor; Section 4.2).
- Suitable for diamond drilled holes guarantees highest flexibility on site. (See reduction factor; Section 4.2).
- Longer curing time for simple installation.
- Low shrinkage of the mortar.
- Approved for temperatures from –40 °C to +72 °C.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook. ETA is currently only valid for diameters up to M30 and carbon steel grade up to 8.8. The ICC-ES Evaluation Report is currently only valid for non-cracked concrete, diameters up to M36 and carbon steel grade up to 8.8.

Materials

Threaded rod :
- Carbon steel grade 5.8 and 8.8 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:
- Epoxy resin, cement and hardener

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

Mean values

Anchor type			FIS EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			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]	80				90				110				120			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_u [kN]	20.0	31.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0	60.9	88.7	85.1	85.1
shear	≧ C 20/25	V_u [kN]	11.5	18.4	16.1	16.1	18.3	29.2	25.6	25.6	26.6	42.5	37.2	37.2	36.2	58.0	50.7	50.7
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_u [kN]	18.5	18.5	18.5	18.5	26.0	26.0	26.0	26.0	38.2	38.2	38.2	38.2	48.6	48.6	48.6	48.6
shear	≧ C 20/25	V_u [kN]	11.5	18.4	16.1	16.1	18.3	29.2	25.6	25.6	26.6	42.5	37.2	37.2	36.2	58.0	50.7	50.7

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			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				190				210			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_u [kN]	83.0	94.3	94.3	94.3	129.2	149.6	149.6	149.6	159.6	176.8	176.8	176.8	185.9	205.4	205.4	205.4
shear	≧ C 20/25	V_u [kN]	49.5	79.1	69.2	69.2	77.2	123.5	108.0	108.0	95.4	152.7	133.6	133.6	111.2	177.9	155.7	155.7
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_u [kN]	57.9	57.9	57.9	57.9	98.4	98.4	98.4	98.4	120.2	120.2	120.2	120.2	139.7	139.7	139.7	139.7
shear	≧ C 20/25	V_u [kN]	49.5	79.1	69.2	69.2	77.2	123.5	108.0	108.0	95.4	152.7	133.6	133.6	111.2	177.9	155.7	155.7

Anchor type			FIS EM M27				FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	5.8	5.8
h_{ef}		[mm]	250				280				330	360	400
non-cracked concrete													
temperature range (+ 60 °C / + 35 °C)[2)]													
tension	C 20/25	N_u [kN]	241.5	266.8	266.8	266.8	295.1	316.3	316.3	316.3	404.6	461.1	540.0
shear	≧ C 20/25	V_u [kN]	144.6	231.3	202.4	202.4	176.7	282.7	247.4	247.4	257.4	307.4	353.1
cracked concrete													
temperature range (+ 60 °C / + 35 °C)[2)]													
tension	C 20/25	N_u [kN]	181.4	181.4	181.4	181.4	215.1	215.1	215.1	215.1	245.5	290.2	347.2
shear	≧ C 20/25	V_u [kN]	144.6	231.3	202.4	202.4	176.7	282.7	247.4	247.4	257.4	307.4	353.1

[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 ≤ + 60 °C and long term temperature T ≤ + 35 °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 EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			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]	80				90				110				120			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{RK} [kN]	19.0	30.0	26.0		29.0	42.5	41.0		43.0	58.3	59.0	58.3	58.0	66.4	81.0	66.4
shear	≧ C 20/25	V_{RK} [kN]	9.0	15.0	13.0		15.0	23.0	20.0		21.0	34.0	30.0		29.0	46.0	40.0	
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{RK} [kN]	14.1				19.8				29.0				36.9			
shear	≧ C 20/25	V_{RK} [kN]	9.0	15.0	13.0		15.0	23.0	20.0		21.0	34.0	30.0		29.0	46.0	40.0	

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			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				190				210			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{RK} [kN]	70.6				111.9				132.3				153.7			
shear	≧ C 20/25	V_{RK} [kN]	39.0	63.0	55.0		61.0	98.0	86.0		76.0	122.0	107.0		89.0	141.0	124.0	
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{RK} [kN]	44.0				74.8				91.9				110.8			
shear	≧ C 20/25	V_{RK} [kN]	39.0	63.0	55.0		61.0	98.0	86.0		76.0	122.0	107.0		89.0	141.0	124.0	

Anchor type			FIS EM M27				FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	5.8	5.8
h_{ef}		[mm]	250				280				330	360	400
non-cracked concrete													
temperature range (+ 60 °C / + 35 °C)[2)]													
tension	C 20/25	N_{RK} [kN]	199.6				236.6				302.7	344.9	404.0
shear	≧ C 20/25	V_{RK} [kN]	115.0	184.0	161.0		141.0	225.0	197.0		204.3	244.0	280.3
cracked concrete													
temperature range (+ 60 °C / + 35 °C)[2)]													
tension	C 20/25	N_{RK} [kN]	148.4				184.7				186.6	220.5	263.9
shear	≧ C 20/25	V_{RK} [kN]	115.0	184.0	161.0		141.0	225.0	197.0		204.3	244.0	280.3

[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 ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details", section 7).

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

3.2 Design resistance[1)]

Anchor type			FIS EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			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]	80				90				110				120			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{Rd} [kN]	12.7	20.0	13.9	17.3	19.3	28.3	21.9	27.3	28.7	38.8	31.6	38.8	38.7	44.3	43.3	44.3
shear	≧ C 20/25	V_{Rd} [kN]	7.2	12.0	8.3	10.4	12.0	18.4	12.8	16.0	16.8	27.2	19.2	24.0	23.2	36.8	25.6	32.0
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{Rd} [kN]	9.4				13.2				19.4				24.6			
shear	≧ C 20/25	V_{Rd} [kN]	7.2	12.0	8.3	10.4	12.0	18.4	12.8	16.0	16.8	27.2	19.2	24.0	23.2	36.8	25.6	32.0

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			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				190				210			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{Rd} [kN]	47.1				74.6				88.2				102.5			
shear	≧ C 20/25	V_{Rd} [kN]	31.2	50.4	35.3	44.0	48.8	78.4	55.1	68.8	60.8	97.6	68.6	85.6	71.2	112.8	79.5	99.2
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[2)]																		
tension	C 20/25	N_{Rd} [kN]	24.4				41.5				51.1				61.6			
shear	≧ C 20/25	V_{Rd} [kN]	31.2	50.4	35.3	44.0	48.8	78.4	55.1	68.8	60.8	97.6	68.6	85.6	71.2	112.8	79.5	99.2

Anchor type			FIS EM M27				FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	5.8	5.8
h_{ef}		[mm]	250				280				330	360	400
non-cracked concrete													
temperature range (+ 60 °C / + 35 °C)[2)]													
tension	C 20/25	N_{Rd} [kN]	133.1				157.7				201.8	230.0	269.3
shear	≧ C 20/25	V_{Rd} [kN]	92.0	147.2	103.2	128.8	112.8	180.0	126.3	157.6	163.4	195.2	224.2
cracked concrete													
temperature range (+ 60 °C / + 35 °C)[2)]													
tension	C 20/25	N_{Rd} [kN]	82.5				102.6				103.7	122.5	146.6
shear	≧ C 20/25	V_{Rd} [kN]	92.0	147.2	103.2	128.8	112.8	180.0	126.3	157.6	163.4	195.2	224.2

[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 ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details", section 7).

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

3.3 Recommended resistance [1) 2)]

Anchor type			FIS EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			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]	80				90				110				120			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[3)]																		
tension	C 20/25	N_R [kN]	9.0	14.3	9.9	12.4	13.8	20.2	15.7	19.5	20.5	27.7	22.5	27.7	27.6	31.6	30.9	31.6
shear	≧ C 20/25	V_R [kN]	5.1	8.6	6.0	7.4	8.6	13.1	9.2	11.4	12.0	19.4	13.7	17.1	16.6	26.3	18.3	22.9
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[3)]																		
tension	C 20/25	N_R [kN]	6.7				9.4				13.8				17.6			
shear	≧ C 20/25	V_R [kN]	5.1	8.6	6.0	7.4	8.6	13.1	9.2	11.4	12.0	19.4	13.7	17.1	16.6	26.3	18.3	22.9

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			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				190				210			
non-cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[3)]																		
tension	C 20/25	N_R [kN]	33.6				53.3				63.0				73.2			
shear	≧ C 20/25	V_R [kN]	22.3	36.0	25.2	31.4	34.9	56.0	39.4	49.1	43.4	69.7	49.0	61.1	50.9	80.6	56.8	70.9
cracked concrete																		
temperature range (+ 60 °C / + 35 °C)[3)]																		
tension	C 20/25	N_R [kN]	17.5				29.7				36.5				44.0			
shear	≧ C 20/25	V_R [kN]	22.3	36.0	25.2	31.4	34.9	56.0	39.4	49.1	43.4	69.7	49.0	61.1	50.9	80.6	56.8	70.9

Anchor type			FIS EM M27				FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	5.8	5.8
h_{ef}		[mm]	250				280				330	360	400
non-cracked concrete													
temperature range (+ 60 °C / + 35 °C)[3)]													
tension	C 20/25	N_R [kN]	95.1				112.7				144.2	164.3	192.4
shear	≧ C 20/25	V_R [kN]	65.7	105.1	73.7	92.0	80.6	128.6	90.2	112.6	116.7	139.4	160.2
cracked concrete													
temperature range (+ 60 °C / + 35 °C)[3)]													
tension	C 20/25	N_R [kN]	58.9				73.3				74.1	87.5	104.7
shear	≧ C 20/25	V_R [kN]	65.7	105.1	73.7	92.0	80.6	128.6	90.2	112.6	116.7	139.4	160.2

[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 ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details", section 7).

[2)] 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.

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

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:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s\,1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c\,1,p,A} \cdot f_{c\,1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s\,1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c\,1,A} \cdot f_{c\,1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s\,1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c\,1,sp,A} \cdot f_{c\,1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS EM M8				FIS EM M10				FIS EM M12			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8		
design resistance	$N_{Rd,s}$	[kN]	12.7	20.0	13.9	17.3	19.3	31.3	21.9	27.3	28.7	45.3	31.6	39.3

Anchor type			FIS EM M14				FIS EM M16				FIS EM M20			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8		
design resistance	$N_{Rd,s}$	[kN]	38.7	61.3	43.3	54.0	52.7	84.0	58.8	73.3	82.0	130.7	92.0	114.7

Anchor type			FIS EM M22				FIS EM M24				FIS EM M27			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8		
design resistance	$N_{Rd,s}$	[kN]	101.3	162.0	113.4	146.3	118.0	188.0	132.1	164.7	153.3	245.3	172.2	214.7

Anchor type			FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			gvz		A4	C			
			5.8	8.8			5.8	5.8	5.8
design resistance	$N_{Rd,s}$	[kN]	187.3	299.3	210.2	262.0	272.3	325.3	373.7

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 [2) 3)]

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
non-cracked concrete																							
temperature range (60 °C / 35 °C) [1)]																							
	$N^0_{Rd,p}$	[kN]	16.1	21.4	42.9	18.8	28.3	62.8	26.4	41.5	90.5	30.8	49.3	114.9	31.3	48.9	125.1	40.8	77.1	181.5	46.4	94.8	219.6
temperature range (72 °C / 50 °C) [1)]																							
	$N^0_{Rd,p}$	[kN]	13.1	17.4	34.9	15.1	22.6	50.3	21.1	33.2	72.4	26.4	42.2	98.5	24.6	38.4	98.3	34.6	65.3	153.6	39.3	80.3	185.8
cracked concrete																							
temperature range (60 °C / 35 °C) [1)]																							
	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	15.6	24.4	62.6	22.0	41.5	97.7	25.0	51.1	118.3
temperature range (72 °C / 50 °C) [1)]																							
	$N^0_{Rd,p}$	[kN]	6.0	8.0	16.1	7.5	11.3	25.1	10.6	16.6	36.2	13.2	21.1	49.3	13.4	20.9	53.6	18.8	35.6	83.8	21.4	43.8	101.4

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
non-cracked concrete																				
temperature range (60 °C / 35 °C) [1)]																				
	$N^0_{Rd,p}$	[kN]	52.3	114.4	261.4	66.2	153.2	330.8	75.4	175.9	377.0	108.6	248.8	407.2	127.4	294.1	477.8	147.8	351.9	554.2
temperature range (72 °C / 50 °C) [1)]																				
	$N^0_{Rd,p}$	[kN]	44.2	96.8	221.2	50.9	117.8	254.5	62.8	146.6	314.2	86.0	197.0	322.3	100.9	232.8	378.3	117.0	278.6	438.7
cracked concrete																				
temperature range (60 °C / 35 °C) [1)]																				
	$N^0_{Rd,p}$	[kN]	28.1	61.6	140.7	35.6	82.5	178.1	44.0	102.6	219.9	45.2	103.7	169.6	53.1	122.5	199.1	61.6	146.6	230.9
temperature range (72 °C / 50 °C) [1)]																				
	$N^0_{Rd,p}$	[kN]	24.1	52.8	120.6	30.5	70.7	152.7	37.7	88.0	188.5	38.9	89.2	145.9	45.7	105.4	171.2	53.0	126.1	198.6

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

[2)] For underwater installation the resistence values have to be multiplied by a factor of 0.7.

[3)] For applications with diamond drilled holes the resistence values have to be multiplied with a factor of 0.75.

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	$f_{b,N,p}$	[-]	0.98	0.99	1.00	1.02	1.04	1.06	1.07	1.08	1.09

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

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
temperature range (60 °C / 35 °C) 1)																							
	$s_{cr,Np}$	[mm]	180	234	234	180	270	283	210	330	339	225	360	383	240	375	437	270	510	527	279	570	579
	$c_{cr,Np}$	[mm]	90	117	117	90	135	141	105	165	170	113	180	191	120	188	219	135	255	263	140	285	290
temperature range (72 °C / 50 °C) 1)																							
	$s_{cr,Np}$	[mm]	180	211	211	180	253	253	210	304	304	225	354	354	240	375	388	270	484	484	279	533	533
	$c_{cr,Np}$	[mm]	90	105	105	90	126	126	105	152	152	113	177	177	120	188	194	135	242	242	140	266	266

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
temperature range (60 °C / 35 °C) 1)																				
	$s_{cr,Np}$	[mm]	288	630	632	324	711	711	360	759	759	432	911	911	468	987	987	504	1063	1063
	$c_{cr,Np}$	[mm]	144	315	316	162	355	355	180	379	379	216	455	455	234	493	493	252	531	531
temperature range (72 °C / 50 °C) 1)																				
	$s_{cr,Np}$	[mm]	288	581	581	324	624	624	360	693	693	432	810	810	468	878	878	504	945	945
	$c_{cr,Np}$	[mm]	144	291	291	162	312	312	180	346	346	216	405	405	234	439	439	252	473	473

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 EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
eff. anchorage depth	h_{ef}	[mm]	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**90**	**170**	**400**	**93**	**190**	**440**
non-cracked concrete																							
design resistance	$N^0_{Rd,c}$	[kN]	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2	21.9	44.3	157.7	24.1	47.1	192.7	28.7	74.6	269.3	30.2	88.2	310.7
cracked concrete																							
design resistance	$N^0_{Rd,c}$	[kN]	11.2	17.2	48.6	11.2	20.5	67.9	14.1	27.7	89.2	15.6	31.5	112.4	17.2	33.5	137.4	20.5	53.2	192.0	21.5	62.9	221.5

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**	**144**	**330**	**540**	**156**	**360**	**585**	**168**	**400**	**630**
non-cracked concrete																				
design resistance	$N^0_{Rd,c}$	[kN]	31.7	102.5	354.0	37.8	133.1	422.5	44.3	157.7	494.8	58.2	201.8	422.5	65.6	230.0	476.4	73.3	269.3	532.4
cracked concrete																				
design resistance	$N^0_{Rd,c}$	[kN]	22.6	73.0	252.4	26.9	94.9	301.2	31.5	112.4	352.7	41.5	143.9	301.2	46.8	163.9	339.6	52.3	192.0	379.5

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	$f_{b,N,c}$	[-]	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 EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
eff. anchorage depth	h_{ef}	[mm]	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**90**	**170**	**400**	**93**	**190**	**440**
	$s_{cr,N}$	[mm]	180	240	480	180	270	600	210	330	720	225	360	840	240	375	960	270	510	1200	279	570	1320
	$c_{cr,N}$	[mm]	90	120	240	90	135	300	105	165	360	113	180	420	120	188	480	135	255	600	139.5	285	660

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**	**144**	**330**	**540**	**156**	**360**	**585**	**168**	**400**	**630**
	$s_{cr,N}$	[mm]	288	630	1440	324	750	1620	360	840	1800	432	990	1620	468	1080	1755	504	1200	1890
	$c_{cr,N}$	[mm]	144	315	720	162	375	810	180	420	900	216	495	810	234	540	878	252	600	945

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_s	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 EM M8**			**FIS EM M10**			**FIS EM M12**			**FIS EM M14**			**FIS EM M16**			**FIS EM M20**			**FIS EM M22**		
eff. anchorage depth		**h_{ef}**	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**90**	**170**	**400**	**93**	**190**	**440**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	120	160	320	120	180	400	140	220	480	150	240	560	160	250	640	180	340	800	186	380	880
		$c_{cr,sp}$	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[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]	271	362	723	271	407	904	316	497	1085	339	542	1266	362	565	1446	407	768	1808	420	859	1989
		$c_{cr,sp}$	[mm]	136	181	362	136	203	452	158	249	542	170	271	633	181	283	723	203	384	904	210	429	994
		h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310	116	161	356	138	218	448	143	240	490

Anchor type				**FIS EM M24**			**FIS EM M27**			**FIS EM M30**			**FIS EM M36**			**FIS EM M39**			**FIS EM M42**		
eff. anchorage depth		**h_{ef}**	**[mm]**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**	**144**	**330**	**540**	**156**	**360**	**585**	**168**	**400**	**630**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	192	420	960	216	500	1080	240	560	1200	288	660	1080	312	720	1170	336	800	1260
		$c_{cr,sp}$	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[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]	434	949	2170	488	1130	2441	542	1266	2712	651	1492	2441	705	1627	2644	759	1808	2848
		$c_{cr,sp}$	[mm]	217	475	1085	244	565	1220	271	633	1356	325	746	1220	353	814	1322	380	904	1424
		h_{min}	[mm]	152	266	536	240	310	600	190	350	670	228	414	624	246	450	675	268	500	730

$f_{scr,sp}$

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 / concrete 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

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 EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
design resistance	$V_{Rd,s}$	[kN]	7.2	12.0	8.3	10.4	12.0	18.4	12.8	16.0	16.8	27.2	19.2	24.0	23.2	36.8	25.6	32.0

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
design resistance	$V_{Rd,s}$	[kN]	31.2	50.4	35.3	44.0	48.8	78.4	55.1	68.8	60.8	97.6	68.6	85.6	71.2	112.8	79.5	99.2

Anchor type			FIS EM M27				FIS EM M30				FIS EM M32	FIS EM M36	FIS EM M42
			gvz		A4	C	gvz		A4	C	gvz	gvz	gvz
			5.8	8.8			5.8	8.8					
design resistance	$V_{Rd,s}$	[kN]	92.0	147.2	103.2	128.8	112.8	180.0	126.3	157.6	163.4	195.2	224.2

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 EM M8 to M42
k	2.0

fischer Injection mortar FIS EM

Anchor design according to fischer specification

5.3 Concrete edge failure for the most unfavourable anchor

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

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

	$V^{o}_{Rd,c}$ [kN]																				
	FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
h_{ef}	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
edge distance [mm]																					
40	3.5	3.7	4.4																		
45	4.1	4.3	5.1	4.3	4.7	5.8															
50	4.7	5.0	5.8	4.9	5.3	6.6															
55	5.4	5.6	6.6	5.6	6.0	7.4	5.9	6.6	8.2												
60	6.0	6.3	7.3	6.2	6.8	8.2	6.6	7.3	9.1	6.9	7.7	10.0									
65	6.7	7.0	8.1	6.9	7.5	9.0	7.3	8.1	10.0	7.6	8.5	11.0	7.9	8.9	12.0						
70	7.4	7.8	8.9	7.7	8.3	9.9	8.1	8.9	10.9	8.4	9.4	11.9	8.7	9.7	13.0						
75	8.1	8.5	9.7	8.4	9.0	10.8	8.9	9.7	11.8	9.2	10.2	12.9	9.5	10.6	14.1						
80	8.9	9.3	10.6	9.2	9.8	11.7	9.7	10.6	12.8	10.0	11.1	14.0	10.4	11.5	15.1						
85	9.6	10.1	11.4	9.9	10.7	12.6	10.5	11.4	13.8	10.9	12.0	15.0	11.2	12.4	16.2	12.0	14.1	18.8			
90	10.4	10.9	12.3	10.7	11.5	13.5	11.3	12.3	14.8	11.7	12.9	16.0	12.1	13.3	17.3	12.9	15.1	20.0			
95	11.2	11.7	13.2	11.5	12.3	14.5	12.1	13.2	15.8	12.6	13.8	17.1	13.0	14.3	18.5	13.8	16.1	21.2	14.1	17.0	22.7
100	12.0	12.6	14.1	12.4	13.2	15.5	13.0	14.1	16.8	13.5	14.8	18.2	13.9	15.2	19.6	14.7	17.2	22.5	15.1	18.0	24.0
120	15.5	16.1	18.0	15.9	16.9	19.5	16.6	17.9	21.1	17.2	18.7	22.7	17.7	19.3	24.3	18.7	21.5	27.6	19.1	22.5	29.3
140	19.1	19.9	22.0	19.6	20.8	23.9	20.5	22.0	25.7	21.1	22.9	27.5	21.7	23.5	29.3	22.9	26.1	33.0	23.3	27.3	34.9
160	23.0	23.9	26.3	23.6	24.9	28.4	24.6	26.3	30.4	25.3	27.3	32.5	26.0	28.1	34.5	27.3	30.9	38.6	27.8	32.3	40.7
180	27.1	28.1	30.9	27.8	29.3	33.2	28.9	30.8	35.4	29.7	31.9	37.7	30.4	32.8	39.9	31.9	36.0	44.4	32.5	37.5	46.7
200	31.4	32.5	35.6	32.1	33.8	38.1	33.4	35.6	40.6	34.3	36.8	43.1	35.1	37.7	45.5	36.7	41.2	50.4	37.4	42.9	52.9
250	43.0	44.3	48.2	43.9	46.0	51.3	45.5	48.2	54.4	46.6	49.7	57.4	47.6	50.8	60.4	49.7	55.2	66.3	50.5	57.2	69.3
300	55.6	57.2	61.9	56.7	59.2	65.6	58.6	61.9	69.2	59.9	63.7	72.8	61.2	65.0	76.3	63.6	70.2	83.3	64.6	72.6	86.7
350	69.2	71.1	76.5	70.5	73.4	80.9	72.7	76.5	85.1	74.3	78.6	89.2	75.8	80.2	93.2	78.6	86.2	101.2	79.7	88.9	105.1
400	83.7	85.8	92.1	85.1	88.5	97.0	87.7	92.0	101.8	89.5	94.5	106.5	91.2	96.3	111.0	94.5	103.2	120.0	95.7	106.2	124.4
450	98.9	101.4	108.4	100.6	104.4	114.0	103.5	108.4	119.4	105.5	111.2	124.6	107.5	113.2	129.7	111.2	120.9	139.7	112.6	124.4	144.6
500	115.0	117.7	125.6	116.8	121.2	131.8	120.1	125.6	137.8	122.4	128.6	143.6	124.5	130.9	149.2	128.6	139.5	160.2	130.3	143.3	165.6
550	131.8	134.8	143.5	133.8	138.6	150.4	137.4	143.5	156.9	139.9	146.9	163.2	142.4	149.4	169.4	146.9	158.8	181.4	148.7	163.0	187.3
600	149.2	152.6	162.1	151.5	156.8	169.6	155.4	162.1	176.8	158.2	165.8	183.7	160.9	168.6	190.4	165.8	178.9	203.4	167.8	183.4	209.8
700		190.1	201.4		195.1	210.2	193.5	201.4	218.5	196.8	205.7	226.5	199.9	209.0	234.3	205.8	221.0	249.4	208.1	226.3	256.7
800		230.2	243.1		235.8	253.2		243.2	262.8	237.9	248.1	272.0	241.5	251.9	280.8	248.2	265.7	298.0	250.9	271.8	306.3
900			287.2		279.0	298.6		287.3	309.4	281.2	292.9	319.7	285.3	297.2	329.7	293.0	312.7	348.9	296.0	319.6	358.2
1000			333.5			346.3		333.6	358.3		339.9	369.8	331.4	344.6	380.9	340.0	362.0	402.1	343.4	369.7	412.4
1200			432.3			447.7		432.3	462.3		440.0	476.1		445.8	489.4	440.2	466.9	514.9	444.3	476.1	527.2
1300			484.5			501.4			517.2			532.2		499.3	546.6		522.2	574.2	497.7	532.2	587.5
1400			538.6			556.8			573.9			590.1			605.7		579.4	635.4	552.9	590.3	649.7
1600			652.0			673.0			692.7			711.3			729.2		699.1	763.2		711.6	779.5
1800						795.8			818.1			839.2			859.4		825.4	897.7		839.6	916.0
2000						924.7			949.7			973.3			995.8			1038.5		973.8	1058.9
2200									1087.2			1113.3			1138.2			1185.3			1207.8
2400									1230.3			1259.0			1286.3			1337.8			1362.4
2500												1333.9			1362.4			1416.2			1441.8
2600												1410.1			1439.8			1495.8			1522.5
2800												1566.3			1598.5			1659.0			1687.8
3000															1762.2			1827.3			1858.2
3500															2192.2			2268.8			2305.1
4000																		2738.4			2780.2
4500																					3281.6

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 EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
h_{ef}	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
edge distance [mm]																		
105	16.4	20.1	26.9															
110	17.4	21.2	28.3															
120	19.5	23.6	31.1	20.3	25.5	33.7												
130	21.6	26.0	33.9	22.5	28.0	36.8												
140	23.8	28.5	36.8	24.8	30.6	39.8	25.8	32.4	42.9									
160	28.3	33.6	42.8	29.5	36.0	46.1	30.6	38.0	49.4	32.9	41.7	49.9						
175	31.8	37.6	47.5	33.1	40.2	50.9	34.4	42.3	54.5	36.8	46.2	55.0	38.0	48.4	58.0			
180	33.1	38.9	49.0	34.4	41.6	52.6	35.6	43.8	56.2	38.2	47.8	56.7	39.4	50.0	59.8			
190	35.5	41.7	52.2	36.9	44.4	55.9	38.2	46.7	59.7	40.9	50.9	60.2	42.2	53.3	63.4	43.5	56.1	66.6
200	38.0	44.5	55.5	39.5	47.4	59.3	40.9	49.8	63.2	43.6	54.1	63.7	45.0	56.6	67.0	46.4	59.5	70.4
250	51.2	59.1	72.3	53.0	62.6	76.8	54.8	65.5	81.4	58.2	70.8	82.1	59.8	73.7	85.9	61.5	77.2	89.9
300	65.5	74.9	90.2	67.7	79.0	95.4	69.7	82.4	100.7	73.8	88.5	101.5	75.7	91.8	105.9	77.7	95.9	110.4
350	80.8	91.6	109.1	83.3	96.3	115.0	85.7	100.2	120.9	90.4	107.2	121.9	92.6	111.0	126.9	94.9	115.6	131.9
400	97.0	109.3	128.9	99.8	114.6	135.5	102.6	119.0	142.1	107.9	126.8	143.2	110.5	131.1	148.7	113.0	136.2	154.3
450	114.0	127.8	149.5	117.2	133.7	156.8	120.3	138.6	164.1	126.2	147.3	165.3	129.1	152.0	171.4	132.0	157.7	177.5
500	131.8	147.1	170.9	135.4	153.6	178.9	138.8	159.0	186.9	145.4	168.6	188.2	148.6	173.8	194.9	151.8	180.0	201.5
600	169.7	187.9	216.1	173.9	195.7	225.5	178.1	202.1	234.8	186.0	213.4	236.4	189.8	219.6	244.1	193.6	226.8	251.8
700	210.3	231.5	264.0	215.3	240.6	274.8	220.1	248.0	285.4	229.4	261.0	287.3	233.9	268.1	296.1	238.2	276.5	304.9
800	253.4	277.7	314.5	259.2	288.1	326.6	264.7	296.5	338.6	275.3	311.3	340.8	280.4	319.3	350.8	285.5	328.7	360.6
900	298.9	326.3	367.4	305.4	337.9	380.9	311.7	347.4	394.3	323.7	363.9	396.8	329.4	372.8	407.8	335.1	383.4	418.7
1000	346.6	377.1	422.6	353.9	390.0	437.5	360.9	400.5	452.2	374.3	418.8	455.0	380.7	428.7	467.1	387.0	440.3	479.1
1200	448.3	485.1	539.2	457.1	500.6	556.9	465.6	513.1	574.3	481.7	535.0	577.8	489.5	546.8	592.1	497.1	560.6	606.3
1400	557.6	600.8	663.7	568.0	618.9	684.3	578.0	633.6	704.4	597.0	659.1	708.5	606.1	672.8	725.0	615.0	688.8	741.3
1600	674.0	723.7	795.5	686.0	744.5	818.8	697.6	761.3	841.7	719.5	790.4	846.5	729.9	806.0	865.2	740.2	824.3	883.7
1800		853.2	934.0	810.7	876.7	960.2	823.8	895.7	985.8	848.6	928.6	991.3	860.5	946.1	1012.3	872.0	966.6	1032.9
2000		989.1	1078.8		1015.3	1107.9		1036.5	1136.3	984.1	1073.1	1142.5	997.4	1092.6	1165.7	1010.3	1115.3	1188.5
2200		1130.9	1229.7		1159.9	1261.7		1183.3	1292.8	1125.5	1223.6	1299.8	1140.2	1245.1	1325.2	1154.5	1270.1	1350.3
2400			1386.4		1310.2	1421.3		1335.8	1455.2		1379.9	1462.8	1288.8	1403.4	1490.6	1304.5	1430.7	1517.8
2600			1548.5		1466.0	1586.3		1493.7	1623.0		1541.7	1631.4		1567.2	1661.5	1459.9	1596.7	1690.9
2800			1715.8			1756.6		1657.0	1796.1		1708.8	1805.3		1736.3	1837.7		1768.2	1869.3
3000			1888.3			1932.0			1974.4		1880.9	1984.4		1910.5	2019.0		1944.7	2052.9
3500			2340.4			2391.6			2441.1		2332.4	2453.1		2367.1	2493.5		2407.2	2533.0
4000			2820.8			2879.6			2936.3			2950.3		2852.1	2996.6		2898.1	3041.8
4500			3327.5			3394.0			3458.0			3474.2			3526.4			3577.4
5000			3859.0			3933.2			4004.7			4023.0			4081.2			4138.0
5500						4496.1			4575.0			4595.5			4659.8			4722.4
6000									5167.9						5261.0			5329.5
6500																		5958.2

5.3.1 Influence of cracked concrete

f_{cr}

	Cracked concrete	Non-cracked concrete
f_{cr}	0.7	1.0

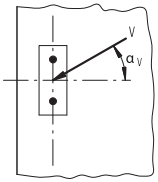
5.3.2 Influence of concrete strength for shear

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

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	$f_{b,V}$	[-]	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

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + (\frac{\sin \alpha_V}{2.5})^2}} \leqq 2.5$$



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

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* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

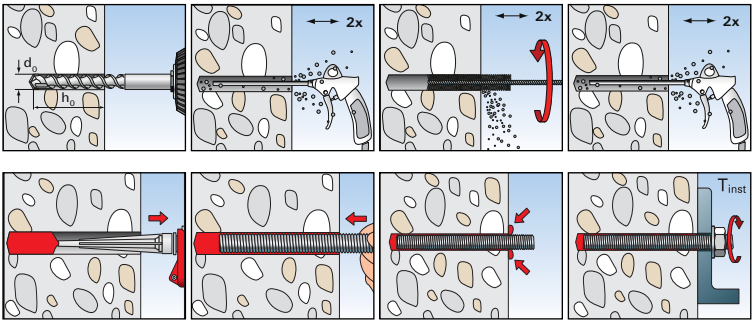
6.3 **Combined tension and shear load:**

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

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



fischer Injection mortar FIS EM

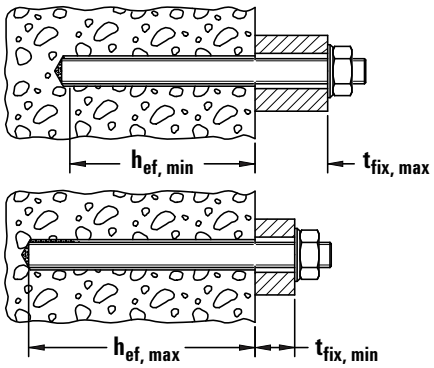
Anchor design according to fischer specification

8. Anchor installation data

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
diameter of thread			M 8			M 10			M 12			M 14			M 16			M 20			M 22		
nominal drill hole diameter	d_0	[mm]	12			14			14			16			18			24			25		
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 9			≦ 12			≦ 14			≦ 16			≦ 18			≦ 22			≦ 24		
clearance-hole in fixture to be attached push-trough installation [1]	d_f	[mm]	≦ 14			≦ 16			≦ 16			≦ 18			≦ 20			≦ 26			≦ 28		
wrench size	SW	[mm]	13			17			19			22			24			30			34		
required torque	T_{inst}	[Nm]	10			20			40			50			60			120			135		
minimum thickness of concrete member	h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310	116	161	356	138	218	448	143	240	490
minimum spacing	s_{min}	[mm]	40			45			55			60			65			85			95		
minimum edge distance	c_{min}	[mm]	40			45			55			60			65			85			95		
mortar filling quantity		[scale units]	3	4	8	4	6	13	5	8	18	6	10	24	7	10	28	11	20	45	12	24	60

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
	h_{ef}	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
diameter of thread			M 24			M 27			M 30			M 36			M 39			M 42		
nominal drill hole diameter	d_0	[mm]	28			30			35			42			45			50		
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 26			≦ 30			≦ 33			≦ 40			≦ 43			≦ 46		
clearance-hole in fixture to be attached push-trough installation [1]	d_f	[mm]	≦ 30			≦ 33			≦ 40			≦ 45			≦ 50			≦ 55		
wrench size	SW	[mm]	36			41			46			55			60			65		
required torque	T_{inst}	[Nm]	150			200			300			400			450			450		
minimum thickness of concrete member	h_{min}	[mm]	152	266	536	240	310	600	190	350	670	228	414	624	246	450	675	268	500	730
minimum spacing	s_{min}	[mm]	105			120			140			180			195			200		
minimum edge distance	c_{min}	[mm]	105			120			140			180			195			200		
mortar filling quantity		[scale units]	14	29	66	17	39	84	25	58	125	39	90	146	46	105	171	69	164	258

[1] hole clearance has to be filled with excess mortar



fischer Injection mortar FIS EM

Anchor design according to fischer specification

9. Gelling and curing times

System temperature	Max. processing time FIS EM
+ 5 °C	4 h
> + 5 °C to + 10 °C	2 h
> + 10 °C to + 20 °C	30 min.
> + 20 °C to + 30 °C	14 min.
> + 30 °C to + 40 °C	7 min.

Temperature at anchoring base	Curing time [1] FIS EM
+ 5 °C	40 h
+ 10 °C	18 h
+ 20 °C	10 h
≥ 30 °C	5 h

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] In wet concrete the curing time has to be doubled.

10. Mechanical characteristics of anchor rod

Anchor type			FIS EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	36.6				58.0				84.3				115.0			
section modolus	W	[mm³]	31.2				62.3				109.2				173.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	15.2	24.0	16.7	20.8	29.6	48.0	33.3	41.6	52.0	84.0	59.0	73.6	83.2	133.6	93.6	116.8
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	157.0				245.0				303				353.0			
section modolus	W	[mm³]	277.5				540.9				743.9				935.5			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	132.8	212.8	148.7	185.6	259.2	415.2	291.0	363.2	357.6	572.8	401.3	500.8	448.0	716.8	502.6	627.2
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			FIS EM M27				FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			gvz		A4	C	gvz		A4	C	gvz	gvz	gvz
			5.8	8.8			5.8	8.8			5.8	5.8	5.8
stressed cross sectional area anchor rod	A_s	[mm²]	459.0				561.0				817.0	976.0	1121
section modolus	W	[mm³]	1387				1874				3294	4301	5294
design value of bending moment	$M^0_{Rd,s}$	[Nm]	666.4	1066	748.1	933.6	898.4	1438	1008	1258	1581	2069	2551
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	400	400
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	500	500