STAHLFIX

PE 21

PURE EPOXY

STYRENE FREE

Product of the 21st Century

2/2014

NEW GENERATION OF CHEMICAL ANCHORS

FOR FIXING OF REBARS AND THREADED STUDS

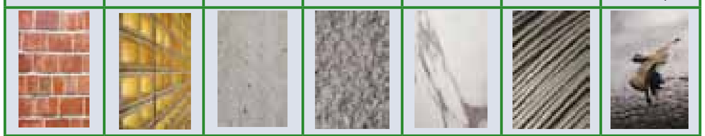
Stahlfix PE 21 / Pure Epoxy Styrene Free (2/2014)

Stahlfix Pure Epoxy 21

STAHLFIX

Product information

PE 21 is a 2 component high strength pure epoxy chemical anchoring resin system. It is designed for deep embedment and large diameter holes due to its zero shrinkage, and longer working times.
For diamond drilled holes, with rebar, and in areas of high chemical exposure eg. Seasalt and swimming pools.
Available in Sizes: 400ml Cartridge or 600ml Cartridge.



Bricks	Hollow	Concrete	Stone	Marble	Rebar	Damp
		✓	✓	✓	✓	✓
		✓	✓	✓	✓	✓

Approvals

- ETA Option 1 ETAG 001 for cracked concrete
- with studs and rebar TR029 (ETA 14/0062)
- ETA Option 1 ETAG 001 for rebar TR023 (ETA 14/0067)
- ETA approved in flooded holes, wet and dry concrete
- WRC Water Approval
- BS6920 Use in potable water
- F240 Fire Test report
- Seismic Test report

Tensile Zone

Small Edge distance and spacing

Variable embedment depth

Fire Resistance

Seismic

European Technical Approval

CE Conformity

Deutsches Institut für Bautechnik DIBt

EOTA

CSTB le futur en construction

- High bond strength with High load resistance
- Used with all grades of threaded rod and rebar in accordance with TR029
- Ideal for deep embedment installations
- Used in non-cracked and cracked concrete, dry and wet concrete.
- Used in flooded holes
- Used for overhead applications
- Ideal for diamond drilled holes
- Ideal for elevated temperatures - temperature ranges I, II and III
- Ideal for rebar installations under TR023 and EN1992-1-1:2004 EC2
- Zero shrinkage enables large diameter installations
- Close edge distance and small spacing
- Manual cleaning up to 20mm diameter and embedment depths of 240mm
- Independently tested and approved - anchor life 50 years
- Suitable for Seismic zones
- Long working times
- F240 Fire test report
- High chemical resistance
- Use with potable water
- A+ Rating VOC Content
- 30 Month shelf life

VOC CLASSIFICATION*

A+

A+ A B C

*Information on the emission of volatile substances in indoor air, with a risk of inhalation toxicity, on a scale ranging from class A+ (very low emissions) to C (high emissions) level.

Stahlfix Pure Epoxy 21

Shelf Life and Storage

This product should be stored between +5˚C & +25˚C.
The Shelf life of the product is 30 months from the manufacture date.

Gelling and Curing Times

Base Material Temperature	45	40	35	25	15	5
Typical Gel Time (mins)	6	10	16	20	60	120
Min. Load Time (mins)	90	120	180	360	960	1020

Typical characteristic and design resistance performance with 5.8 grade studding and associated installation data

Stud	Characteristic Resistance (kN)		Design Resistance (kN)		Recommended Load (kN)		Characteristic distances (mm)			Min Edge and Spacing	Nominal	Hole Diameter	Hole Diameter	Max
Ø	Tension	Shear	Tension	Shear	Tension	Shear	Edge	Spacing	Edge	(mm)	Embedment	concrete	fixture	Torque
(mm)	N_{rk}	V_{rk}	N_{rd}	V_{rd}	N_{rec}	V_{rec}	$C_{cr,N}$	$S_{cr,N}$	$C_{cr,V}$	C_{min}, S_{min}	(mm)	(mm)	(mm)	(Nm)
	19.00		12.70		9.07						60			
8	19.00	9.00	12.70	7.20	9.07	5.14	80	160	80	40	80	10	9	10
	19.00		12.70		9.07						160			
	28.27		15.71		11.22						60			
10	30.20	15.00	20.10	12.00	14.36	8.57	100	200	90	50	90	12	12	20
	30.20		20.10		14.36						200			
	39.58		21.99		15.71						70			
12	43.80	21.00	29.20	16.80	20.86	12.00	120	240	110	60	110	14	14	40
	43.80		29.20		20.86						240			
	56.30		31.28		22.34						80			
16	81.60	39.00	54.40	31.20	38.86	22.29	160	320	125	80	125	18	18	80
	81.60		54.40		38.86						320			
	73.51		35.01		25.00						90			
20	127.40	61.00	84.90	48.80	60.64	34.86	200	400	180	100	170	24	22	120
	127.40		84.90		60.64						400			
	90.48		43.08		30.77						100			
24	183.60	88.00	122.40	70.40	87.43	50.29	240	480	220	120	210	28	26	160
	183.60		122.40		87.43						480			
	111.97		53.32		38.08						110			
27	230.00	115.00	109.52	92.00	78.23	65.71	270	540	240	135	240	32	30	180
	230.00		109.52		78.23						540			
	135.72		64.63		46.16						120			
30	280.00	142.50	186.67	114.00	133.33	81.43	300	600	280	150	280	35	32	200
	280.00		186.67		133.33						600			
	148.25		70.60		50.43						130			
33	342.12	173.50	228.08	138.80	162.91	99.14	330	660	310	165	300	37	36	250
	347.00		186.67		133.34						660			
	174.74		83.21		59.43						150			
36	396.07	212.50	264.05	170.00	188.60	121.43	360	720	330	180	340	40	38	300
	425.00		283.33		202.38						720			

= steel failure

Table notes See Page 30

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Design Resistance used with various stud strengths, material and rebar.

5.8 Grade Steel Studding

Stud Diameter (mm)	Hole Diameter (mm)												h_{ef} Failure (mm)	$F_{d,s}$ Design Load (kN)
8	10	8.4	10.5	12.7									61	12.7
10	12	10.5	13.1	15.7	20.1								77	20.1
12	14		15.7	18.8	25.1	29.2							93	29.2
16	20				31.4	39.2	49.0	54.4					139	54.4
Depth (mm)		40	50	60	80	100	125	160	200	240	280	320		

Stud Diameter (mm)	Hole Diameter (mm)															h_{ef} Failure (mm)	$F_{d,s}$ Design Load (kN)
20	24	31.2	39.0	46.8	58.4	70.1	81.8	84.9								218	84.9
24	28		43.0	51.6	64.5	77.4	90.3	103.2	122.4							285	122.4
27	32		48.4	58.0	72.5	87.0	101.5	116.1	145.1	159.1						329	159.1
30	35			64.5	80.6	96.7	112.8	128.9	161.2	188.0	194.5					362	194.5
33	38			65.9	82.4	98.9	115.4	131.9	164.9	192.3	219.8	240.6				438	240.6
36	40				83.1	99.8	116.4	133.0	166.3	194.0	221.7	266	283.2			511	283.2
Depth (mm)		80	100	120	150	180	210	240	300	350	400	480	600	660	720		

A4-70 Stainless Steel Studding

Stud Diameter (mm)	Hole Diameter (mm)												h_{ef} Failure (mm)	$F_{d,s}$ Design Load (kN)
8	10	8.4	10.5	12.6	13.7								65	13.7
10	12	10.5	13.1	15.7	20.9	21.7							83	21.7
12	14		15.7	18.8	25.1	31.6							100	31.6
16	20				31.4	39.2	49.0	58.8					150	58.8
Depth (mm)		40	50	60	80	100	125	160	200	240	280	320		

Stud Diameter (mm)	Hole Diameter (mm)															h_{ef} Failure (mm)	$F_{d,s}$ Design Load (kN)
20	24	31.2	39.0	46.8	58.4	70.1	81.8	91.7								235	91.7
24	28		43.0	51.6	64.5	77.4	90.3	103.2	128.9	132.1						307	132.1
27	32		48.4	58.0	72.5	80.2									*1	166	80.2
30	35			64.5	80.6	96.7	98.1								*1	183	98.1
33	38			65.9	82.4	98.9	115.4	121.3							*1	221	121.3
36	40				83.1	99.8	116.4	133.0	142.8						*1	258	142.8
Depth (mm)		80	100	120	150	180	210	240	300	350	400	480	600	660	720		

*1 = Tensile strength 500N/mm2

[shaded box] = steel failure

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Design Resistance used with various stud strengths, material and rebar.

High bond reinforcing bars F yk =500N/mm2

Rebar Diameter (mm)	Hole Diameter (mm)										h_{ef} Failure (mm)	$F_{d,s}$ Design Load (kN)
8	10 – 12	12.3	15.4	21.9							142	21.9
10	12	15.4	19.2	23.0	34.1						178	34.1
12	15	16.8	20.9	25.1	31.4	37.7	44.0	49.2			235	49.2
16	20		26.5	31.8	39.8	47.8	55.7	63.7	79.6	87.4	330	87.4
Depth (mm)		80	100	120	150	180	210	240	300	350		

Rebar Diameter (mm)	Hole Diameter (mm)															h_{ef} Failure (mm)	$F_{d,s}$ Design Load (kN)
20	25	26.9	32.3	40.4	48.5	56.6	64.6	72.7	80.8	94.3	107.7					507	136.6
25	30		40.4	50.5	60.6	70.7	80.8	90.9	101.0	117.8	134.7	168.3				584	196.5
28	35		42.7	53.4	64.1	74.8	85.5	96.1	106.8	124.6	142.4	178.0	213.7			752	267.8
32	40			61.0	73.3	85.5	97.7	109.9	122.1	142.4	162.8	203.5	244.2	293.0		859	349.7
36	44			64.6	77.6	90.5	103.4	116.3	129.3	150.8	172.4	215.5	258.5	310.3	344.7	1029	443.5
40	50							129.3	143.6	167.6	191.5	239.4	287.3	344.7	383.0	1141	546.3
Depth (mm)		100	120	150	180	210	240	270	300	350	400	500	600	720	800		

= steel failure

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Characteristic and Design Load resistances based on characteristic bond strengths for hef 4d (minimum embedment) to 20d

Stud Ø (mm)	Non Cracked Concrete						Cracked Concrete						Nominal Embed-ment
	Characteristic Resistance (kN)		Design Resistance (kN)		Recommended Load (kN)		Characteristic Resistance (kN)		Design Resistance (kN)		Recommended Load (kN)		
	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	(mm)
	N_{rk}	V_{rk}	N_{rd}	V_{rd}	N_{rec}	V_{rec}	N_{rk}	V_{rk}	N_{rd}	V_{rd}	N_{rec}	V_{rec}	
	22.62		12.57		8.98								60
8	30.16	9.00	16.76	7.20	11.97	5.14	Not Applicable		Not Applicable		Not Applicable		**80**
	60.32		33.51		23.94								160
	28.27		15.71		11.22								60
10	42.41	15.00	23.56	12.00	16.83	8.57							**90**
	94.25		52.36		37.40								200
	39.58		21.99		15.71		19.79		11.00		7.85		70
12	62.20	21.00	34.56	16.80	24.68	12.00	31.10	21.00	17.28	16.80	12.34	12.00	**110**
	135.72		75.40		53.86		67.86		37.70		26.93		240
	56.30		31.28		22.34		26.14		14.52		10.37		80
16	87.96	39.00	48.87	31.20	34.91	22.29	40.84	39.00	22.69	31.20	16.21	22.29	**125**
	225.19		125.11		89.36		104.55		58.08		41.49		320
	73.51		35.01		25.00		33.93		16.16		11.54		90
20	138.86	61.00	66.12	48.80	47.23	34.86	64.09	61.00	30.52	48.80	21.80	34.86	**170**
	326.73		155.58		111.13		150.80		71.81		51.29		400
	90.48		43.08		30.77		41.47		19.75		14.11		100
24	190.00	88.00	90.48	70.40	64.63	50.29	87.09	88.00	41.47	70.40	29.62	50.29	**210**
	434.29		206.81		147.72		199.05		94.79		67.70		480
	111.97		53.32		38.08		51.32		24.44		17.46		110
27	244.29	115.00	116.33	92.00	83.09	65.71	111.97	115.00	53.32	92.00	38.08	65.71	**240**
	549.65		261.74		186.96		251.92		119.96		85.69		540
	135.72		64.63		46.16		62.20		29.62		21.16		120
30	316.67	142.50	150.80	114.00	107.71	81.43	145.14	142.50	69.12	114.00	49.37	81.43	**280**
	678.59		323.14		230.81		311.02		148.10		105.79		600
	148.25		70.60		50.43		67.39		32.09		22.92		130
33	342.12	173.50	162.91	138.80	116.37	99.14	155.51	173.50	74.05	138.80	52.89	99.14	**300**
	752.66		358.41		256.01		342.12		162.91		116.37		660
	174.74		83.21		59.43		76.34		36.35		25.97		150
36	396.07	212.50	188.60	170.00	134.72	121.43	173.04	212.50	82.40	170.00	58.86	121.43	**340**
	838.73		399.40		285.28		366.44		174.49		124.64		720

Table notes : See Page 30

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Bond Strength Factors - Threaded Studs

Influence of concrete strength on combined pull out and concrete cone resistance

Concrete Strength N/mm2 (Mpa)	C15/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
fc =	0.98	1.00	1.02	1.04	1.06	1.08	1.09	1.10

Influence of environmental conditions in non cracked concrete

		M8	M10	M12	M16	M20	M24	M27	M30	M33	M36
Temp I 40°C / 24°C	**Dry and Wet**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Flooded	1.00	0.94	0.87	0.79	0.71	0.65	0.58	0.51	0.43	0.36
Temp II 60°C / 43°C	**Dry and Wet**	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Flooded	0.65	0.63	0.61	0.59	0.57	0.54	0.50	0.49	0.46	0.44
Temp III 72°C / 43°C	**Dry and Wet**	0.57	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.47	0.46
	Flooded	0.57	0.54	0.52	0.51	0.50	0.49	0.46	0.45	0.43	0.42

Influence of environmental conditions in cracked concrete

		M8	M10	M12	M16	M20	M24	M27	M30	M33	M36
Temp I 40°C / 24°C	**Dry and Wet**	n/a	n/a	0.50	0.48	0.46	0.45	0.44	0.42	0.41	0.39
	Flooded	n/a	n/a	0.50	0.42	0.38	0.38	0.35	0.30	0.27	0.24
Temp II 60°C / 43°C	**Dry and Wet**	n/a	n/a	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26
	Flooded	n/a	n/a	0.32	0.29	0.28	0.27	0.27	0.25	0.24	0.23
Temp III 72°C / 43°C	**Dry and Wet**	n/a	n/a	0.27	0.27	0.26	0.25	0.24	0.23	0.23	0.22
	Flooded	n/a	n/a	0.27	0.27	0.26	0.25	0.24	0.23	0.23	0.22

Table notes : See Page 30

Stahlfix Pure Epoxy 21

Characteristic and Design Load resistances for REBAR based on characteristic bond strengths for hef 4d (min embedment) to 20d

	Non Cracked Concrete						Cracked Concrete						
	Characteristic Resistance (kN)		Design Resistance (kN)		Recommended Load (kN)		Characteristic Resistance (kN)		Design Resistance (kN)		Recommended Load (kN)		Nominal Embed-ment
Rebar	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	(mm)
ø	N_{rk}	V_{rk}	N_{rd}	V_{rd}	N_{rec}	V_{rec}	N_{rk}	V_{rk}	N_{rd}	V_{rd}	N_{rec}	V_{rec}	
	16.59		9.22		6.58								60
8	22.12	13.95	12.29	9.30	8.78	6.64	Not Applicable		Not Applicable		Not Applicable		**80**
	44.23		24.57		17.55								160
	20.73		11.52		8.23								60
10	31.10	21.45	17.28	14.30	12.34	10.21							**90**
	69.12		38.40		27.43								200
	26.39		14.66		10.47		14.51		8.06		5.76		70
12	41.47	31.05	23.04	20.70	16.46	14.79	22.81	31.05	12.67	20.70	9.05	14.79	**110**
	90.48		50.27		35.90		49.76		27.65		19.75		240
	38.20		21.22		15.16		18.10		10.05		7.18		80
16	59.69	55.50	33.16	37.00	23.69	26.43	28.27	55.50	15.71	37.00	11.22	26.43	**125**
	152.81		84.89		60.64		72.38		40.21		28.72		320
	50.89		24.24		17.31		22.62		10.77		7.69		90
20	96.13	86.55	45.78	57.70	32.70	41.21	42.73	86.55	20.35	57.70	14.53	41.21	**170**
	226.20		107.71		76.94		100.53		47.87		34.19		400
	70.69		33.66		24.04		27.49		13.09		9.35		100
25	148.44	135.00	70.69	90.00	50.49	64.29	57.73	135.00	27.49	90.00	19.64	64.29	**210**
	353.43		168.30		120.21		137.45		65.45		46.75		500
	83.74		39.88		28.48		34.48		16.42		11.73		112
28	209.36	168.75	99.69	112.50	71.21	80.36	86.21	168.75	41.05	112.50	29.32	80.36	**280**
	418.71		199.39		142.42		172.41		82.10		58.64		560
	109.38		52.08		37.20		45.04		21.45		15.32		128
32	273.44	220.95	130.21	147.30	93.01	105.21	112.59	220.95	53.62	147.30	38.30	105.21	**320**
	546.89		260.42		186.02		225.19		107.23		76.60		640

Table notes : See Page 30

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Bond Strength Factors - REBAR

Influence of concrete strength on combined pull out and concrete cone resistance

Concrete Strength N/mm2 (MPa)	C15/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
fc =	0.98	1.00	1.02	1.04	1.06	1.08	1.09	1.10

Influence of environmental conditions in non cracked concrete

		Ø 8	Ø 10	Ø 12	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Temp I 40°C / 24°C	Dry and Wet	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Flooded	1.00	0.94	0.90	0.85	0.80	0.71	0.65	0.63
Temp II 60°C / 43°C	Dry and Wet	0.67	0.65	0.63	0.62	0.61	0.60	0.60	0.59
	Flooded	0.65	0.64	0.61	0.59	0.58	0.56	0.55	0.47
Temp III 72°C / 43°C	Dry and Wet	0.60	0.58	0.57	0.56	0.56	0.55	0.54	0.53
	Flooded	0.58	0.56	0.53	0.50	0.47	0.45	0.43	0.41

Influence of environmental conditions in cracked concrete

		Ø 8	Ø 10	Ø 12	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Temp I 40°C / 24°C	Dry and Wet	n/a	n/a	0.55	0.47	0.44	0.43	0.42	0.41
	Flooded	n/a	n/a	0.55	0.42	0.40	0.38	0.36	0.35
Temp II 60°C / 43°C	Dry and Wet	n/a	n/a	0.30	0.28	0.26	0.24	0.23	0.23
	Flooded	n/a	n/a	0.30	0.27	0.25	0.23	0.22	0.22
Temp I 72°C / 43°C	Dry and Wet	n/a	n/a	0.30	0.26	0.25	0.24	0.23	0.22
	Flooded	n/a	n/a	0.30	0.26	0.24	0.23	0.23	0.22

Table notes : See Page 30

Stahlfix Pure Epoxy 21

Material Properties for grades of other threaded stud and rebar

Stud Diameter (mm)	Stud Grade 8.8 $N_{rk,s}$ (kN)	Stud Grade 8.8 $N_{rd,s}$ (kN)	Stud Grade 10.9 $N_{rk,s}$ (kN)	Stud Grade 10.9 $N_{rd,s}$ (kN)	Stud Grade A4-70 $N_{rk,s}$ (kN)	Stud Grade A4-70 $N_{rd,s}$ (kN)	Stud Grade A4-80 $N_{rk,s}$ (kN)	Stud Grade A4-80 $N_{rd,s}$ (kN)
M8	29.2	19.5	38.1	27.2	25.6	13.7	29.2	15.6
M10	46.4	30.9	60.3	43.1	40.6	21.7	46.4	24.8
M12	67.4	44.9	87.7	62.6	59.0	31.6	67.4	36.0
M16	125.6	83.7	163.0	116.4	109.9	58.8	125.7	67.2
M20	196.1	130.7	255.0	182.1	171.5	91.7	196.0	104.8
M24	282.5	188.3	367.0	262.1	247.1	132.1	293.0	132.1
M27	367.0	244.7	477.4	341.0	229.4	80.2	229.4	80.2
M30	448.8	299.2	583.0	416.4	280.6	98.1	280.6	98.1
M33	555.2	370.1	721.8	515.5	347.0	121.3	347.0	121.3
M36	653.6	435.7	849.7	606.9	408.4	142.8	408.4	142.8

Stud Diameter (mm)	Stud Grade 8.8 $V_{rk,s}$ (kN)	Stud Grade 8.8 $V_{rd,s}$ (kN)	Stud Grade 10.9 $V_{rk,s}$ (kN)	Stud Grade 10.9 $V_{rd,s}$ (kN)	Stud Grade A4-70 $V_{rk,s}$ (kN)	Stud Grade A4-70 $V_{rd,s}$ (kN)	Stud Grade A4-80 $V_{rk,s}$ (kN)	Stud Grade A4-80 $V_{rd,s}$ (kN)
M8	14.6	11.7	19.0	15.2	12.8	8.2	14.6	9.4
M10	23.2	18.6	30.2	24.1	20.3	13.0	23.2	14.9
M12	33.7	27.0	43.8	35.1	29.5	18.9	33.7	21.6
M16	62.8	50.2	81.6	65.3	55.0	35.2	62.8	40.3
M20	98.0	78.4	127.4	101.9	85.8	55.0	98.0	62.8
M24	141.2	113.0	183.6	146.8	123.6	79.2	141.2	90.5
M27	183.5	146.8	238.7	191.0	114.7	48.4	114.7	48.4
M30	224.4	179.5	291.5	215.9	140.3	89.9	140.3	89.9
M33	277.6	222.1	360.9	288.7	173.5	111.2	173.5	111.2
M36	326.8	261.4	424.8	283.2	204.2	130.9	204.2	130.9

Rebar Diameter (mm)	Rebar BSt 500 to DIN 488 $N_{rk,s}$ (kN)	Rebar BSt 500 to DIN 488 $N_{rd,s}$ (kN)	Rebar BSt 500 to DIN 488 $V_{rk,s}$ (kN)	Rebar BSt 500 to DIN 488 $V_{rd,s}$ (kN)
8	28.0	20.0	14.0	9.3
10	43.0	30.7	21.5	14.3
12	62.0	44.3	31.0	20.7
14	85.0	60.7	42.5	28.3
18	140.0	100.0	70.0	46.7
16	111.0	79.3	55.5	37.0
20	173.0	123.6	86.5	57.7
22	209.0	149.3	104.5	69.7
25	270.0	192.9	135.0	90.0
32	442	315.7	221	147.3
36	563.2	443.5	281.6	187.7
40	693.8	546.3	346.9	231.3

Table notes : See Page 30

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Effect of Anchor Spacing - Tension

Anchor Spacing	Stud / Rebar Diameter										
(mm)	8	10	12	16	20	24	27	30	33	36	40
40	0.64										
50	0.67	0.63									
60	0.70	0.65	0.63								
70	0.73	0.67	0.64								
80	0.76	0.69	0.66	0.63							
90	0.79	0.72	0.68	0.64							
100	0.82	0.74	0.70	0.65	0.63						
120	0.87	0.79	0.74	0.68	0.65	0.63	0.63				
150	0.96	0.86	0.80	0.73	0.68	0.65	0.64	0.63			
160	1.00	0.88	0.82	0.74	0.70	0.66	0.65	0.63	0.63	0.63	0.63
175		0.92	0.85	0.76	0.71	0.67	0.66	0.64	0.63	0.63	0.63
200		1.00	0.90	0.80	0.74	0.69	0.69	0.66	0.65	0.65	0.65
225			0.95	0.84	0.77	0.72	0.71	0.68	0.67	0.67	0.66
240			1.00	0.86	0.79	0.73	0.72	0.69	0.68	0.68	0.67
250				0.87	0.80	0.74	0.73	0.70	0.69	0.68	0.68
275				0.91	0.83	0.76	0.75	0.72	0.71	0.70	0.69
280				0.92	0.84	0.77	0.76	0.73	0.71	0.70	0.69
300				0.95	0.86	0.79	0.78	0.74	0.73	0.72	0.71
320				1.00	0.88	0.81	0.80	0.76	0.74	0.73	0.72
350					0.92	0.83	0.82	0.78	0.77	0.75	0.73
400					1.00	0.88	0.87	0.82	0.80	0.78	0.76
440						0.92	0.91	0.85	0.83	0.81	0.79
480						1.00	0.94	0.88	0.86	0.84	0.81
540							1.00	0.93	0.91	0.88	0.84
600								1.00	0.96	0.92	0.88
660									1.00	0.96	0.91
720										1.00	0.95
800											1.00

Effect of Edge Distance - Tension

Edge Distance	Stud / Rebar Diameter										
(mm)	8	10	12	16	20	24	27	30	33	36	40
40	0.64										
50	0.73	0.63									
60	0.82	0.70	0.63								
70	0.90	0.77	0.68								
80	1.00	0.84	0.74	0.63							
90		0.91	0.80	0.67							
100		1.00	0.86	0.71	0.63						
110			0.92	0.76	0.66						
120			1.00	0.80	0.70	0.64					
140				0.89	0.77	0.67	0.63	0.63			
160				1.00	0.84	0.72	0.70	0.65	0.63	0.67	
180					0.91	0.78	0.75	0.70	0.66	0.71	0.68
200					1.00	0.84	0.81	0.76	0.71	0.74	0.71
220						0.89	0.86	0.81	0.75	0.78	0.75
240						1.00	0.92	0.86	0.80	0.82	0.78
270							1.00	1.00	0.87	0.87	0.83
300								1.00	0.94	0.93	0.88
330									1.00	0.98	0.93
360										1.00	0.98
400											1.00

Effect of Edge Distance - Shear

Edge	Stud / Rebar Diameter										
(mm)	8	10	12	16	20	24	27	30	33	36	40
40	0.25										
50	0.44	0.30									
60	0.63	0.48	0.30								
70	0.81	0.65	0.44								
80	1.00	0.83	0.58	0.40							
90		1.00	0.72	0.53							
100			0.86	0.67	0.35						
110			1.00	0.80	0.44						
125				1.00	0.58	0.35					
140					0.72	0.46	0.35	0.30			
160					0.91	0.62	0.51	0.35	0.32	0.33	
180					1.00	0.77	0.63	0.46	0.37	0.43	
200						0.92	0.75	0.57	0.46	0.50	0.32
220						1.00	0.88	0.68	0.56	0.56	0.53
240							1.00	0.78	0.65	0.63	0.59
280								1.00	0.84	0.77	0.72
310									1.00	1.00	0.82
330										1.00	0.89
400											1.00

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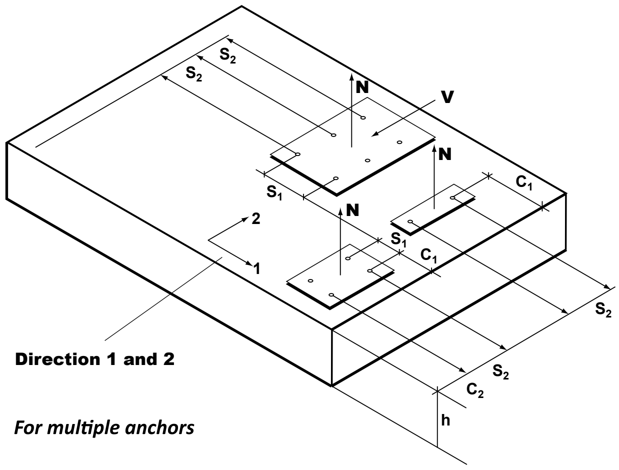
*Design according to Anchor theory



*Design according to Anchor theory **

$$FR_N = \frac{N_{rd}}{1.4} \cdot f_B \cdot f_{RN} \cdot f_A \qquad \text{(tensile)}$$

$$FR_v = \frac{V_{rd}}{1.4} \cdot f_B \cdot f_{RV} \cdot f_A \qquad \text{(shear)}$$

FR_α (shear + tensile)

$$FR_\alpha = FR_N - (FR_N - FR_V)\frac{\alpha}{90}$$

f_B = Resistance factor of Concrete

$f_B = 1 + 0.02\,(1 - \frac{\alpha}{90}) \bullet (f_{cc,eff} - 25)$

$[15 \le f_{cc,eff} \le 55]$

α = Angle of load

f_A = Reduction factor "Spacing"

f_{cc} = Resistance on cube N/mm²

f_R = Reduction factor "edge distance"

For multiple anchors

$$f_A = f_{A1}(s_1) \,.\, f_{A2}(s_2) \,.\, f_{Ax}(s_x)$$

$$f_{RN} = f_{RN1}(c_1) \,.\, f_{RN2}(c_2) \,.\, f_{RNx}(c_x)$$

$$f_{RV} = f_{RV1}(c_1) \,.\, f_{RV2}(c_2) \,.\, f_{RVx}(c_x)$$

$h = h_{nom} + 40mm$

h_{nom} = embedment depth

N_{rd}, V_{rd} = Approved design resistance

FR_N, FR_V, FR_α = Recommended loads

** Design according to post-installed rebar theory : see design pages 11/12/13

Post Installed rebar theory

The actual position of the reinforcement in the existing structure shall be determined on the basis of the construction documentation and taken into account when designing.
The design of post-installed rebar connections according to Annex 2 and determination of the internal section forces to be transferred in the construction joint shall be verified in accordance with EN 1992-1-1:2004. When ascertaining the tensile force in the rebar, allowance shall be made for the statically effective height of the bonded-in reinforcement.
The verification of the immediate local force transfer to the concrete has been provided.
The verification of the transfer of the loads to be anchored to the building component shall be provided.
The spacing between post-installed rebars shall be greater than the minimum of 5 d_s and 500mm

Determination of basic anchorage length

The required basic anchorage length $\ell_{b,rqd}$ shall be determined in accordance with EN 1992-1-1, Section 8.4.3.

$\ell_{b,rqd} = (d_s / 4)\ (\ _{sd} / f_{bd})$

with : ds = diameter of the rebar

$_{sd}$ = calculated stress of the rebar

f_{bd} = design value of bond strength according to Page 14
in consideration of the coefficient relared to the quality of bond conditions and of the coefficient related to the bar diameter and of the drilling technique.

Determination of design anchorage length

The required basic anchorage length ℓ_{bd} shall be determined in accordance with EN 1992-1-1, Section 8.4.4.

$\ell_{bd} = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \cdot \alpha_5\ \ell_{b,rqd} \geq \ell_{bmin}$

with: $\ell_{b,rqd} = (d_s / 4)\ (_{sd} / f_{bd})$

α_1 = 1.0 for straight bars
α_2 = 0.7…1.0 calculated acc. To EN 1992 -1-1, Table 8.2
α_3 = 1.0 because of no transverse reinforcement
α_4 = 1.0 because of no welded transverse reinforcement
α_5 = 0.7 …1.0 for influence to transverse pressure acc. To EN 1992 -1-1, Table 8.2

ℓ_{bmin} = minimum anchorage length acc. To EN 1992-1-1

= max {0.3 $\ell_{b,rqd}$; 10d_s; 100mm} under tension
= max {0.3 $\ell_{b,rqd}$; 10d_s; 100mm} under compression

Overlap joints

The required design lap length ℓ_0 shall be determined in accordance with EN1992-1-1, Section 8.7.3.

$$\ell_0 = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_5 \cdot \alpha_6 \; \ell_{b,rqd} \geq \ell_{0,min}$$

with: $\ell_{b,rqd} = (d_s / 4)\ (_{sd} / f_{bd})$

α_1 = 1.0 for straight bars
α_2 = 0.7…1.0 cal culated acc. To EN 1992-1-1, Table 8.2
α_3 = 1.0 because of no transverse reinforcement
α_5 = 0.7 …1.0 for influence to transverse pressure acc. To EN 1992 -1-1, Table 8.2
α_6 = 1.0 …1.5 for influence of percentage of lapped bars relative to the total cross-section area acc. EN1992-1-1, Table 8.3

$\ell_{0,min}$ = minimum lap length acc. To EN1992-1-1

= max $\{0.3 \cdot \alpha_6\ \ell_{b,rqd};\ 15 d_s;\ 200\text{mm}\}$

The maximum possible embedment depth is given in Annex 5 depending on diameter of the rebar.

Embedment depth for overlap joints

For calculation of the effective embedment depth of overlap joints the concrete cover at end-face of bonded-in rebar c_1 shall be considered (se Annex 4, Figure 7):

$$\ell_v \geq \ell_0 + c_1$$

with: ℓ_0 = required lap length acc. To section 4.3.4 and to EN 1992-1-1

c_1 = concrete cover at end-face of bonded-in rebar

If the clear distance between the overlapping rebars is greater than 4 d_s the lap length shall be enlarged by the difference between the clear distance and 4 d_s

Concrete cover

The concrete cover required for bonded-in rebars is shown in Annex 5, Table 3, in relation to the drilling method and the hole tolerance.
Furthermore the minimum concrete cover given in EN1992-1-1, section 4.4.1.2 shall be observed.

Transverse reinforcement

The requirements of transverse reinforcement in the area of the post-installed rebar connection connection shall comply with EN 1992-1-1, Section 8.7.4.

Connection Joint

The transfer of shear forces between new concrete and existing structure shall be designed according to EN1992-1-1. The joints for concreting must be roughened to at least such an extent that aggregate protrude.
In case of a carbonated surface the existing concrete structure the carbonated layer shall be removed in the area of the post-installed rebar connection with a diameter of d_s + 60mm prior to installation of the new rebar.
The depth of the concrete to be removed shall correspond to at least the minimum concrete cover for the respective environmental conditions in accordance with EN1992-1-1.
The foregoing may be neglected if building components are new and not carbonated and if building components are in dry conditions.

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Post installed rebar connections

Minimum anchorage length [1)] and lap splice length for C20/25 and maximum installation length (l_{max})

Rebar		$l_{b,min}$ (mm)	$l_{0,min}$ (mm)	$l_{max,min}$ (mm)
Ø d_s	**$f_{y,k}$ (N/mm^2)**			
8mm	500	113	200	1000
10mm	500	142	200	1000
12mm	500	170	200	1200
14mm	500	198	210	1400
16mm	500	227	240	1600
20mm	500	284	300	2000
22mm	500	312	330	2000
24mm	500	340	360	2000
25mm	500	354	375	2000

1) According to EN 1992-1-1:2004 $l_{b,min}$ (8.6) and $l_{0,min}$ (8.11) for good bond conditions and $a_{⊠}$ = 1,0
with maximum yield stress for rebar B500 B and $⊠_M$ = 1,15

Design values of the ultimate bond resistance f_{bd} [1)] in N/mm^2 for all drilling methods for good conditions

Rebar Ø	**Concrete Class**								
Ø d_s	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/60	C50/60
8mm to 25mm	1.6	2	2.3	2.7	3	3.4	3.7	4	4.3

1) Tabulated values for fbd are valid for good bond condition according to EN1992-1-1:2004. For all other bond conditions multiply the values for fbd by 0.7.

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Post installed rebar connections

Values for pre-calculation of overlap joints

Rebar - Ø ds	$\alpha_1=\alpha_2=\alpha_3=\alpha_4=\alpha_5=1.0$			α_2 or $\alpha_5=0.7$; $\alpha_1=\alpha_3=\alpha_4=1.0$		
	Anchorage length l_{bd}	Design value N_{rd}	Mortar volume	Anchorage length l_{bd}	Design value N_{rd}	Mortar volume
(mm)	(mm)	(kN)	(ml)	(mm)	(kN)	(ml)
8	200	11.56	15	200	16.52	15
	240	13.87	18	220	18.17	17
	290	16.76	22	230	18.99	17
	378	21.85	29	265	21.88	20
10	200	14.45	18	200	20.64	18
	270	19.51	24	230	23.74	21
	340	24.57	31	270	27.87	24
	400	28.9	36	300	30.97	27
	473	34.18	43	331	34.17	30
12	200	17.34	21	200	24.77	21
	290	25.15	31	250	30.97	26
	380	32.95	40	300	37.16	32
	480	41.62	51	350	43.35	37
	567	49.16	60	397	49.18	42
14	210	21.24	25	210	30.35	25
	320	32.37	39	270	39.02	33
	440	44.51	53	340	49.13	41
	550	55.64	66	400	57.81	48
	662	66.97	80	463	66.91	56
16	240	27.75	33	240	39.64	33
	370	42.78	50	310	51.2	42
	500	57.81	68	380	62.76	52
	630	72.83	86	460	75.97	62
	756	87.4	103	529	87.37	72
20	300	43.35	64	300	61.93	64
	460	66.48	98	390	80.51	83
	620	89.6	131	480	99.09	102
	780	112.72	165	570	117.68	121
	945	136.57	200	662	136.67	140
22	330	52.46	93	330	74.94	93
	510	81.07	144	430	97.65	122
	680	108.1	192	530	120.36	150
	860	136.71	243	630	143.07	178
	1040	165.32	294	728	165.32	206
24	360	62.43	152	360	89.19	152
	550	95.38	232	470	116.44	198
	750	130.06	317	580	143.69	245
	940	163.01	397	690	170.94	291
	1134	196.65	479	794	196.7	335
25	375	67.74	141	375	96.77	141
	580	104.77	218	490	126.45	184
	780	140.9	293	600	154.84	226
	980	177.03	369	710	183.22	267
	1181	213.34	444	827	213.42	311

Example For:
C20/25;
good bond condition;
Rebar Yield Strength
500 N/mm^2 (500 MPa)

*** Minimum anchorage length. The design value is valid for "good bond conditions" according to EN 1992-1-1.**

All other condition: multiply value by 0.7. Mortar volume based on equation: $V = 1.2 \cdot (d^2_0 - d^2_d) \cdot \Pi \cdot l_b / 4$

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Post installed rebar schematics

Application examples of post-installed rebar

Figure 1: **Overlap joints in slabs and beams.**

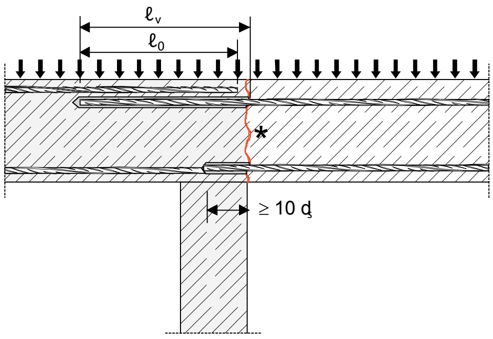


Figure 2: **Overlap joint in foundation of a column or wall where the rebars are stressed in tension.**

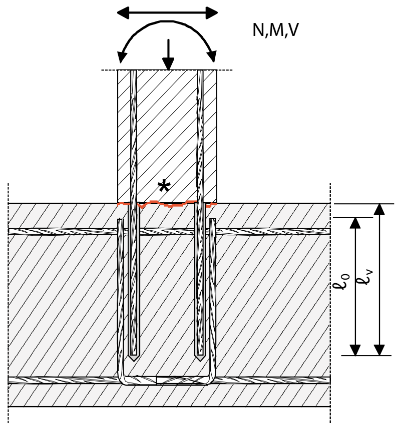


Figure 3: **End anchoring of slabs or beams, designed as simply supported.**

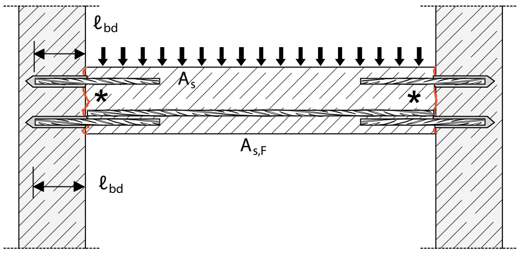


Figure 4: **Rebar connection of components stressed primarily in compression. The rebar are stressed in compression.**

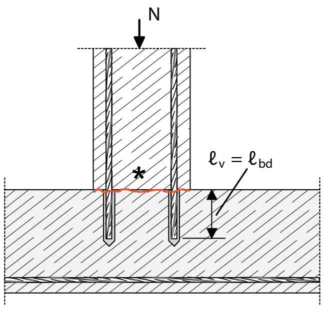
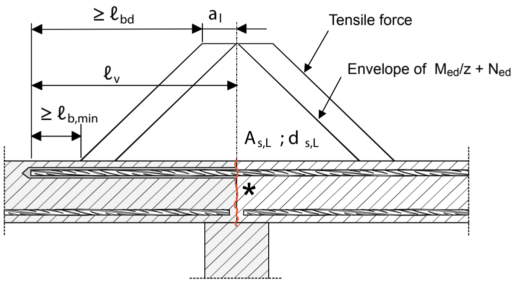


Figure 5: **Anchoring of reinforcement to cover the line of acting tensile force.**



Note to figure 1 to 5 :

In the figures no transverse reinforcement is plotted, the transverse reinforcement as required by EC 2 shall be present.
The shear transfer between old and new concrete shall be designed according to EC2. Description of the bonded-in rebars and overlap joints see Annex 4 and 5.

*** Roughened joint**

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Minimum Curing Time

Concrete Temperature	Gel - Working Time	Minimum curing time in dry concrete	Minimum curing time in wet concrete
5°C	120 min	1020 min	x 2
15°C	60 min	960 min	x 2
25°C	25 min	360 min	x 2
35°C	16 min	180 min	x 2
40°C	10 min	120 min	x 2
45°C	6 min	90 min	x 2

- Full cure 24 hours

Temperature Ranges

Temperature Range	Concrete Service Temperature	Maximum Long Term Concrete Temp	Maximum Short Term Concrete Temp
Range I	-40°C to +40°C	+24°C	+40°C
Range II	-40°C to +60°C	+43°C	+60°C
Range III	-40°C to +72°C	+43°C	+72°C

Service temperature range: Range of ambient temperatures after installation and during the lifetime of the anchor.

Short term temperature : Temperatures within the service temperature range which vary over short intervals, e.g. day/night cycles and freeze/thaw cycles.

Long term temperature: Temperature, within the service temperature range, which will be approximately constant over significant periods of time.

Long term temperatures will include constant or near constant temperatures, such as those experienced in cold stores or next to heating installations.

Physical Properties

	N/mm2 (MPa)	Test Method
Compressive Strength	120	EN 196 Part 1
Flexural Strength	39	EN 196 Part 1
E Modulus	3420	EN 196 Part 1
Density	1.42 kg/dm^3	-
Shrinkage	< 0.4%	-
VOC Content	A+ Rating	

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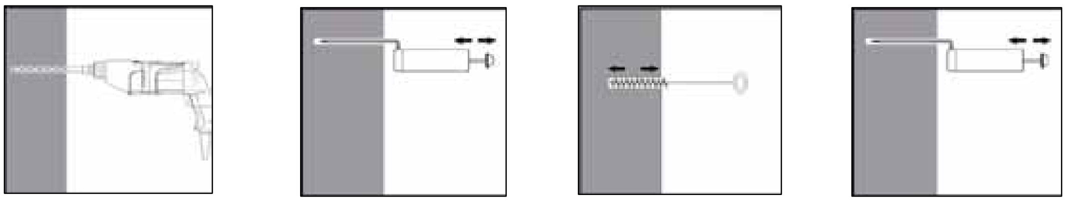
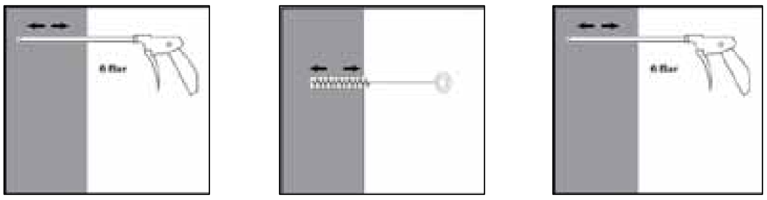
Installation parameters: drilling hole cleaning and installation

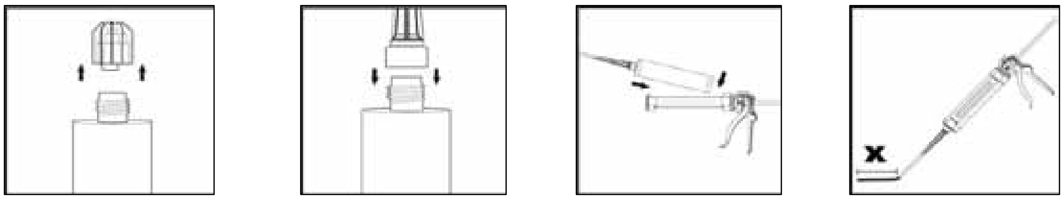


Drill hole in the substrate to the required embedment depth using the appropriately sized carbide drill bit. Bore hole cleaning Just before setting an anchor, the bore hole must be free of dust and debris. The manual pump shall be used for blowing out bore holes up to diameters do ≤ 24mm and embedment depths up to hef ≤ 10d. Blow out at least 4 times from the back of the bore hole, using an extension if needed. Brush 4 times with the specified brush size by inserting the steel brush to the back of the hole (if needed with an extension) in a twisting motion and removing it. Blow out again with manual pump at least 4 times.

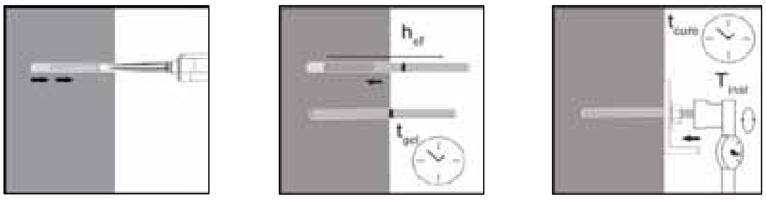
Compressed air cleaning (CAC) for all bore hole diameters do and all bore hole depths



Blow 2 times from the back of the hole (if needed with a nozzle extension) over the whole length with oil-free compressed air (min. 6 bar at 6 m^3/h). Brush 2 times with the specified brush size by inserting the steel brush to the back of the hole (if needed with an extension) in a twisting motion and removing it.
X 2 Blow out again with compressed air at least 2 times.



Remove the threaded cap from the cartridge. Tightly attach the mixing nozzle. Do not modify the mixer in any way. Made sure the mixing element is inside the mixer. Use only the supplied mixer. Insert the cartridge into the dispenser gun. Discard the initial trigger pulls of adhesive. Discard the first 10ml of resin.



Inject the adhesive starting at the back of the hole, slowly withdrawing the mixer with each trigger pull. Fill holes approximately 2/3 full, to ensure that the annular gap between the anchor and the concrete is completely filled with adhesive along the embedment depth. Before use, verify that the threaded rod is dry and free of contaminants. Install the threaded rod to the required embedment depth during the open gel time tgel has elapsed. The working time tgel. The anchor can be loaded after the required curing time tcure. The applied torque shall not exceed the values Tmax given.

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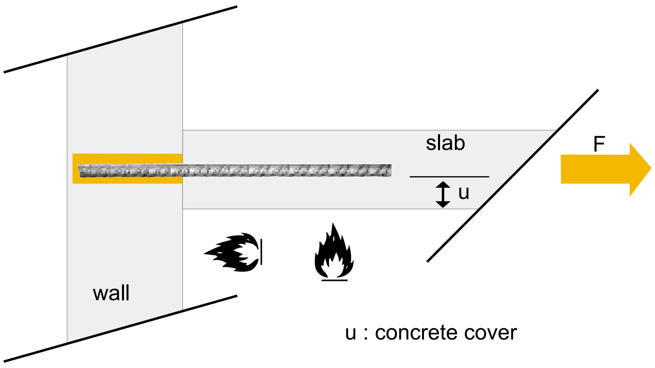
Stahlfix PE 21 injection systems in wall to slab connection with concrete reinforcing bar and subjected to fire exposure according to Eurocode 2

RESISTANCE TO FIRE FOR STEEL REINFORCEMENT wall/slab



The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the design according to other accidental solicitations, these shall be done is addition.

The table below gives performance subjected to fire exposure in wall to slab connection with concrete reinforcing bar, with STAHLFIX PE 21 resin, in concrete _ C20/25.

The values in white character specified the proof of requirements to fire is satisfied with ηfi = 0,7 in concrete class C20/25 (see method below).

Design method for resistance to fire according to Eurocode 2: Fire proof using design resistance: $R_{d,fi} \leq E_{d,fi}$

$R_{d,fi}$ Design resistance in the fire situation

$E_{d,fi}$ Design effect of actions in the fire situation. This value could be calculated from the the calculation at normal temperature : **$E_{d,fi} = \eta_{fi} \times F_{Rdu}$**

F_{Rdu} Design ultimate limit load at normal temperature for one rebar sealing at the ls anchorage depth (mm)

η_{fi} Reduction factor for design load level in the fire situation ηfi equal to 0,739

Rebar Ø (mm)	Drill (mm)	Ls (mm)	Fe E500 Rebar maximum load (kN) in case of fire	Design resistance (kN) in case of fire according to Eurocode 2 for a fire duration of 30 to 240 min.					
				Fire duration (minutes)					
				R30	R60	R90	R120	R180	R240
Concrete cover [(1)] (mm)				10	20	25	35	50	70
		120		6,3	2,7	1,6	1,2	0,8	0,9
		185		16,2	10,1	6,7	5,1	3,3	2,9
		220			16,2	11,3	8,8	6,0	4,9
8	12	250	16,2			16,2	12,8	9,0	7,1
		275					16,2	12,1	9,3
		305						16,2	12,4
		340							16,2
Concrete cover [(1)] (mm)				10	20	25	35	50	70
		140		10,1	5,3	3,4	2,4	1,5	1,4
		180		19,1	11,3	7,6	5,5	3,4	3,1
		205		25,3	15,8	11,1	8,3	5,3	4,7
10	14	250	25,3		25,3	19,2	15,0	10,3	8,7
		280				25,3	20,7	14,6	12,2
		305					25,3	18,9	15,6
		340						25,3	21,2
		365							25,3
Concrete cover [(1)] (mm)				12	20	25	35	50	70
		160		16,4	8,6	5,5	3,8	2,8	2,4
		230		36,4	23,3	17,0	11,9	9,0	7,0
		260			31,6	23,8	17,2	13,4	10,5
		280			36,4	28,9	21,4	16,9	13,3
		300				34,5	26,0	20,8	16,5
12	16	310	36,4			36,4	28,5	22,9	18,2
		320					31,1	25,2	20,0
		340					36,4	30,1	24,0
		365						36,4	29,5
		380							33,1
		395							36,4
Concrete cover [(1)] (mm)				14	20	25	35	50	70
		180		24,0	13,5	9,1	7,1	4,6	3,8
		250		49,6	32,5	25,0	21,6	15,1	11,8
		280			42,1	33,1	28,8	20,9	16,5
14	18	305	49,6		49,6	40,0	35,3	26,3	21,1
		335				49,6	43,7	33,4	27,4
		360					49,6	39,9	33,2
		380						49,6	42,2
		425							49,6

(1) : Minimum concrete cover according Eurocode 2 - partie 1.2

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STAHLFIX

RESISTANCE TO FIRE FOR STEEL REINFORCEMENT wall/slab (continued)

Rebar Ø (mm)	Drill (mm)	Ls (mm)	Fe E500 Rebar maximum load (kN) in case of fire	Design resistance (kN) in case of fire according to Eurocode 2 for a fire duration of 30 to 240 minutes					
				Fire duration (minutes)					
				R30	R60	R90	R120	R180	R240
Concrete cover(1) (mm)				16	20	25	35	50	70
		160		19,9	9,9	5,9	4,9	3,9	3,6
		200		34,8	19,2	12,7	10,1	6,9	5,8
		220		42,7	25,0	17,3	13,9	9,4	7,6
		240		50,9	31,3	22,5	18,2	12,5	10,0
		275		64,8	43,7	33,0	27,3	19,3	15,4
		300			53,6	41,5	34,9	25,3	20,2
16	22	330	64,8		64,8	53,1	45,3	33,6	27,1
		340				57,2	49,0	36,7	29,6
		360				64,8	57,0	43,3	35,1
		380					64,8	50,4	41,2
		400							47,7
		420						64,8	54,8
		450							64,8
Concrete cover(1) (mm)				20	20	25	35	50	70
		200		41,4	19,0	13,0	10,7	8,2	7,2
		240		61,5	34,4	24,9	20,3	14,6	11,7
		280		82,5	51,8	39,5	33,0	24,2	19,4
		315		101,2	68,1	53,9	45,7	34,3	27,8
20	28	380	101,2		101,2	84,1	73,0	57,0	47,7
		415				101,2	89,8	71,4	60,7
		440					101,2	82,7	70,9
		480						101,2	89,0
		505							101,2
Concrete cover(1) (mm)				25	25	25	35	50	70
		250		86,6	44,2	28,4	23,3	17,5	15,2
		310		128,3	79,1	57,3	50,5	36,5	30,3
		360		158,1	110,2	84,8	75,9	57,3	48,1
		400			136,3	108,6	98,1	76,4	64,9
25	32	435	158,1		158,1	130,9	118,8	95,0	81,4
		480				158,1	147,2	121,4	105,1
		500					158,1	134,1	116,6
		540						158,1	140,9
		570							158,1
Concrete cover(1) (mm)				32	32	32	35	50	70
		320		177,9	108,0	70,4	54,4	41,8	35,9
		350		204,1	133,2	93,2	73,8	59,1	50,7
		380		230,4	158,5	116,5	94,8	77,3	66,8
		415		259,0	188,2	144,1	120,2	99,6	86,8
32	40	500	259		259,0	213,2	185,6	159,1	141,1
		555				259,0	230,8	201,5	180,6
		590					259,0	230,1	207,5
		625						259,0	235,8
		655							259,0

(1) : Minimum concrete cover according Eurocode 2 - partie 1.2

Example:

- Application:
  - Design of works for Ø20 rebar in park
  - Requirement : fire duation 4 hours
  - Ultimate load : 110 kN.
- Ambient temperature: Anchoring depth according to EC2 rules for ultimate load of 110kN in concrete class C20/25

$$L_s = \frac{F_{Rdu}}{\pi \cdot f_{bd} \cdot ø\ fer} = \frac{110{,}10^3}{\pi \times 2{,}7 \times 20}$$

Ls = 648 mm

- Fire proof: fire duration 4 hours for one anchoring depth equal to 397 mm

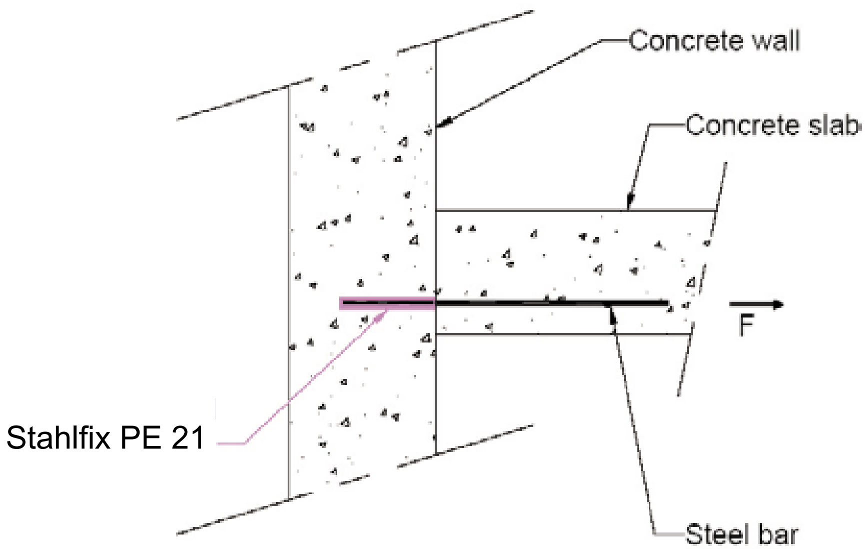
$R_{d,fi(180\ min)}$ = 110,2 kN > 77 kN [=0,7 x 110 kN]

STAHLFIX

Wall to slab connection (anchoring)

For a wall to slab connection the temperature along the bonding interface is not uniform and depends on the fire duration and the anchoring length. Therefore, the temperature profiles are obtained by finite element modelling for each fire duration and each anchor length considered.

Model description



Wall to slab connection

The modelled fire is the standard temperature / time curve with duration of 30, 60, 90, 120, 180 and 240 minutes. The considered anchor lengths range from 10 times the rebar diameter to the length that enables a load equal to the rebar yielding load.

The simulations are made taking into account the minimal concrete cover for each rebar diameter and fire exposure duration as given in the Eurocode 3 part 1.2 + NA (table 5). The anchoring length varied from 10 times the rebar diameter to the length allowing a force equal to the maximum load in a rebar not submitted to a fire.

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		Fire duration (min)											
(mm)	D (mm)	30		60		90		120		180		240	
		C-C (mm)	S-T (mm)	*C-C (mm)*	S-T (mm)	*C-C (mm)*	S-T (mm)	*C-C (mm)*	S-T (mm)	*C-C (mm)*	S-T (mm)	*C-C (mm)*	*S-T (mm)*
8	12	*10*	60	*20*	70	*25*	90	*35*	110	*50*	150	*70*	*175*
10	14	*10*	60	*20*	70	*25*	90	*35*	110	*50*	150	*70*	*175*
12	16	*12*	60	*20*	70	*25*	90	*35*	110	*50*	150	*70*	*175*
14	18	*14*	60	*20*	70	*25*	90	*35*	110	*50*	150	*70*	*175*
16	20	*16*	60	*20*	70	*25*	90	*35*	110	*50*	150	*70*	*175*
20	25	*20*	60	*20*	70	*25*	90	*35*	110	*50*	150	*70*	*175*
25	30	*25*	75	*25*	75	*25*	90	*35*	110	*50*	150	*70*	*175*
28	*35*	*28*	*84*	*28*	*84*	*28*	90	*35*	110	*50*	150	*70*	*175*
32	40	*32*	96	*32*	96	*32*	96	*35*	110	*50*	150	*70*	*175*

Where :

- D is the drill hole diameter
- C-C is the concrete cover
- S-T slab thickness

table 5 : Summary of the modelled configurations each rebar diameter () and fire duration.

The boundary conditions are:

- On the heated sides, heat flux density, as a function of the gas temperature equal to the conventional temperature / time relationship.
- On the unexposed sides, heat flux density with a constant gas temperature of 20°C.

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REINFORCEMENT FRAME WITH 3 layers of reinforcement

The table below gives performance subjected to fire exposure in wall to beam connection (width 20, 30 and «40 cm and more») with concrete reinforcing bar, with STAHLFIX PE21 resin, in concrete _ C20/25, in take into account the exposure on 3 sides.

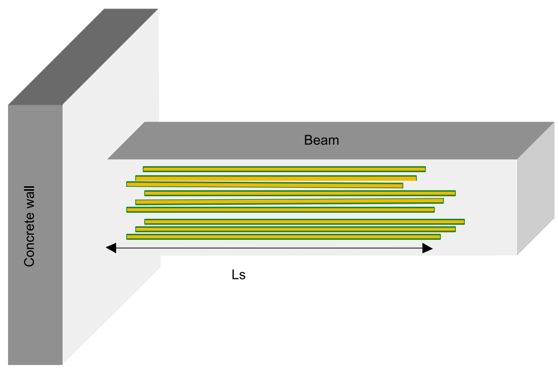
Design method for resistance to fire according to Eurocode 2: Fire proof using design resistance: $R_{d,fi} \le E_{d,fi}$

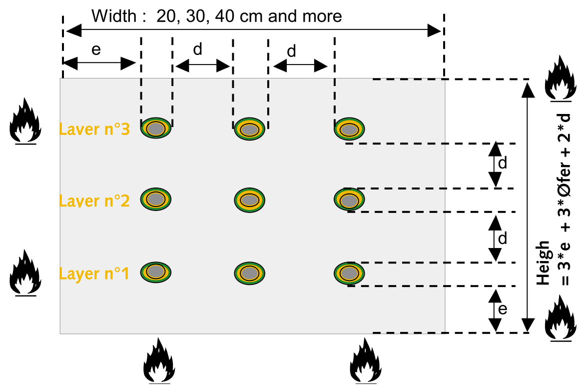
$R_{d,fi}$ Design resistance in the fire situation

$E_{d,fi}$ Design effect of actions in the fire situation. This value could be calculated from the the calculation at normal temperature: **$E_{d,fi} = \eta_{fi} \times F_{Rdu}$**

F_{Rdu} Design ultimate limit load at normal temperature for one rebar sealing at the ls anchorage depth (mm)

η_{fi} Reduction factor for design load level in the fire situationηfi is equal to 0,739





BEAM'S WIDTH = 40 CM

Rebar Ø (mm)	Drilling Ø (mm)	Distance between layers [d] (mm)	$R_{d,fi}$ (kN) Rebar maximum load in case of fire	Layers identification	Rebar anchorage depth (Ls in mm) for all layers for the rebar maximum load in case of fire (Rebar Fe E500)					
					Fire duration (minutes)					
					R30	R60	R90	R120	R180	R240
Concrete cover [e] (mm)					28	52	70	85	110	136
8	12	60	16,2	layer n°1	169	206	233	255	292	321
				layer n°2	160	193	218	239	275	305
				layer n°3	158	189	212	231	266	296
10	14	60	25,3	layer n°1	189	226	255	278	316	348
				layer n°2	179	213	240	262	300	332
				layer n°3	177	209	233	254	291	323
12	16	60	36,4	layer n°1	207	246	275	299	339	373
				layer n°2	197	233	260	283	323	358
				layer n°3	195	228	254	276	314	348
14	18	60	49,6	layer n°1	226	265	294	319	361	395
				layer n°2	216	252	280	303	345	380
				layer n°3	214	247	273	296	336	372
16	22	60	64,8	layer n°1	244	283	313	338	381	417
				layer n°2	234	270	299	323	365	402
				layer n°3	233	266	292	315	356	393
20	28	75	101,2	layer n°1	281	320	350	376	420	457
				layer n°2	270	305	333	357	400	439
				layer n°3	269	303	329	351	392	431
25	32	90	158,1	layer n°1	327	366	397	423	467	503
				layer n°2	316	350	378	402	445	484
				layer n°3	315	349	375	397	439	476
32	40	120	259,0	layer n°1	392	431	461	487	532	568
				layer n°2	380	414	440	464	507	545
				layer n°3	380	413	439	461	502	538

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BEAM'S WIDTH = 30 CM

Rebar Ø (mm)	Drilling Ø (mm)	Distance between layers [d] (mm)	$R_{d,fi}$ (kN) Rebar maximum load in case of fire	Layers identification	Rebar anchorage depth (Ls in mm) for all layers for the rebar maximum load in case of fire (Rebar Fe E500)					
					Fire duration (minutes)					
					R30	R60	R90	R120	R180 (1)	R240 (1)
Concrete cover [e] (mm)					30	55	80	85		
8	12	60	16,2	layer n°1	169	205	228	257		
				layer n°2	158	191	213	243		
				layer n°3	157	187	207	236		
10	14	60	25,3	layer n°1	188	225	250	280		
				layer n°2	178	212	235	266		
				layer n°3	176	207	229	259		
12	16	60	36,4	layer n°1	207	244	270	300		
				layer n°2	196	231	255	287		
				layer n°3	194	227	249	280		
14	18	60	49,6	layer n°1	225	263	289	320		
				layer n°2	215	250	275	307		
				layer n°3	213	246	269	301		
16	22	60	64,8	layer n°1	244	282	308	340		
				layer n°2	233	269	294	326		
				layer n°3	232	265	288	320		
20	28	75	101,2	layer n°1	280	319	346	378		
				layer n°2	269	303	328	361		
				layer n°3	268	301	324	356		
25	32	90	158,1	layer n°1	327	365	392	424		
				layer n°2	315	348	373	406		
				layer n°3	314	347	370	402		
32	40	120	259,0	layer n°1	391	430	457	489		
				layer n°2	379	412	436	468		
				layer n°3	379	412	435	467		

BEAM'S WIDTH = 20 CM

Rebar Ø (mm)	Drilling Ø (mm)	Distance between layers [d] (mm)	$R_{d,fi}$ (kN) Rebar maximum load in case of fire	Layers identification	Rebar anchorage depth (Ls in mm) for all layers for the rebar maximum load in case of fire (Rebar Fe E500)					
					Fire duration (minutes)					
					R30	R60	R90	R120 (1)	R180 (1)	R240 (1)
Concrete cover [e] (mm)					30	55	80			
8	12	60	16,2	layer n°1	169	207	236			
				layer n°2	159	195	226			
				layer n°3	157	192	223			
10	14	60	25,3	layer n°1	188	227	257			
				layer n°2	178	215	248			
				layer n°3	176	212	245			
12	16	60	36,4	layer n°1	207	246	277			
				layer n°2	196	235	268			
				layer n°3	195	231	265			
14	18	60	49,6	layer n°1	225	265	297			
				layer n°2	215	254	287			
				layer n°3	213	250	284			
16	22	60	64,8	layer n°1	244	284	316			
				layer n°2	233	272	306			
				layer n°3	232	269	303			
20	28	75	101,2	layer n°1	281	321	353			
				layer n°2	269	307	342			
				layer n°3	269	306	340			
25	32	90	158,1	layer n°1	327	367	399			
				layer n°2	315	353	388			
				layer n°3	315	352	386			
32	40	120	259,0	layer n°1	391	431	464			
				layer n°2	379	417	451			
				layer n°3	379	416	451			

(1) : The fire duration are limited in accordance with beams' widths, according to Eurocode 2 partie 1.2.

Design according to TR 045; Design under seismic action

The decision of the selection of the seismic performance category is in the responsibility of each individual Member State. Furthermore, the values of $a_g \cdot S$ assigned to the seismicity levels may be different in the National Annexes to EN 1998-1:2004 (EC*) compared to the values given in Table 18.
The recommended category C1 and C2 given in Table 18 are given in the case that no National requirements are defined.

Table 18: Recommended seismic performance categories for anchors

Seismicity level [a)]		Importance Class acc. EN 1998-1:2004, 4.2.5			
	$a_g \cdot S$ [c)]	I	II	III	IV
Very low [b)]	$a_g \cdot S \leq 0{,}05g$	No additional requirement			
Low [b)]	$0{,}05\,g < a_g \cdot S \leq 0{,}1g$	C1	C1 [d)] or C2 [e)]		C2
> Low [b)]	$a_g \cdot S \leq 0{,}1g$	C1	C2		

a) The values defining the seismicity levels may be found in the National Annex of EN 1998-1.
b) Definition according to EN 1998-1:2004, 3.2.1.
c) a_g = Design ground acceleration on Type A ground (EN 1998-1:2004, 3.2.1.).
S = Soil factor (see e.g. EN 1998-1:2004, 3.2.2).
d) C1 attachments of non-structural elements
e) C2 for connections between structural elements of primary and/or secondary seismic members

Calculation of characteristic seismic resistance $R_{k,seis}$

Tension load: $R_{k,seis} = \alpha_{gap} \cdot \alpha_{seis} \cdot \alpha_{N.seis} \cdot R^0_k$

With $R^0_k = N_{Rk.s}, N_{Rk.p}, N_{Rk.c}, N_{Rk.sp}$ (calculation according to CEN/TS 1992-4 or TR029)
$\alpha_{N.seis}$ = see Table 19 or Table 20 for $N_{Rk,p}$ and $N_{Rk,p}$
$\alpha_{N.seis}$ = 1,0 for $N_{Rk,c}$ and $N_{Rk,sp}$
α_{gap} = see Table 21
α_{seis} = see Table 21

Tension load: $R_{k,seis} = \alpha_{gap} \cdot \alpha_{seis} \cdot \alpha_{V.seis} \cdot R^0_k$

With $R^0_k = V_{Rk.s}, V_{Rk.c}, V_{Rk.c}, V_{Rk.cp}$ (calculation according to CEN/TS 1992-4 or TR029)
$\alpha_{V.seis}$ = see Table 19 or Table 20 for $V_{Rk,s}$
$\alpha_{V.seis}$ = 1,0 for $V_{Rk,c}$ and $V_{Rk,cp}$
α_{gap} = see Table 21
α_{seis} = see Table 21

Table 19: Reduction factors $\alpha_{N.seis}$ and $\alpha_{V.seis}$ for seismic design category C1 for threaded rods

Anchor size threaded rods			M 12	M 16	M 20	M 24	M 27	M 30
Tension load								
Steel Failure ($N_{Rk,s}$)	$\alpha_{N.seis}$	[-]	1,0					
Combined pull-out and concrete failure ($N_{Rk,p}$)	$\alpha_{N.seis}$	[-]	0,68	0,68	0,68	0,69	0,69	0,69
Shear load								
Steel failure without lever arm ($V_{Rk,s}$)	$\alpha_{N.seis}$	[-]	0,70					

Table 19: Reduction factors $\alpha_{N.seis}$ and $\alpha_{V.seis}$ for seismic design category C1 for reinforcing bar

Anchor size reinforcing bar			Ø 12	Ø 16	Ø 20	Ø 24	Ø 27	Ø 30
Tension load								
Steel Failure ($N_{Rk,s}$)	$\alpha_{N.seis}$	[-]	1,0					
Combined pull-out and concrete failure ($N_{Rk,p}$)	$\alpha_{N.seis}$	[-]	0,68	0,68	0,68	0,69	0,69	0,69
Shear load								
Steel failure without lever arm ($V_{Rk,s}$)	$\alpha_{N.seis}$	[-]	0,70					

Table 21: Reduction factors α_{gap} and α_{seis} for resistance under seismic actions

Loading	Failure modes	α_{gap}	α_{seis} – Single Fastener	α_{seis} – Fastener group
Tension	Steel Failure	1,0	1,0	1,0
	Pull-out failure	1,0	1,0	0,85
	Combined pull-out and concrete failure	1,0	1,0	0,85
	Concrete cone failure	1,0	0,85	0,75
	Splitting failure	1,0	1,0	0,85
Shear	Steel failure without lever arm	0,5 1)	1,0	0,85
	Steel failure with lever arm	NPD 2)	NPD 2)	NPD 2)
	Concrete edge failure	0,5 1)	1,0	0,85
	Concrete pry-out failure	0,5 1)	0,85	0,75

1) The limitation for the size of the clearance hole is given in TR 029 Table 4.1
α_{gap} = 1,0 in case of no clearance between fastener and fixture

2) No Performance Determined

Post Installed Structural Rebar

Design in a seismic zone

For utilisation in seismic zones, the injection system for the anchoring of reinforcement bars Stahlfix PE21 shall be designed by verifying in particular:

- Use of the system is limited to new constructions or structures undergoing major repair work
- The structure in which the rebar is set shall be designed for seismic action and the reinforcement shall be designed to pick up the forces that are generated by the subsequently post-installed rebars.
- The design study shall be performed at the same time as the reinforcement of the initial structure is tested.
- The study shall allow for tie bars to pick up the shear forces.

- The calculation of the post-installed rebar and the determination of the internal forces shall be performed in accordance with EN 1992-1-1 (Eurocode 2) and EN 1998-1-1 (Eurocode 8), and shall coincide with the design of the structure.
- The loads applied to the reinforcements taking account of the acceleration shall be the responsibility of the design office. The office may decide to set additional reinforcements or greater anchorage lengths.
- The verification of the local transfer of loads in the concrete shall be performed.
- The verification of the transfer of anchored loads in the structure shall be performed.
- The distance between the reinforcement bars shall be greater than the maximum of 5ds and 50mm acc. to European Technical Approval. d_s = diameter of rebar
- The basic anchorage length $l_{b,rqd,\ seism}$ required for transferring force $A_s \cdot f_{yd}$ in the reinforcement bar where a hypothetical constant load equal to $f_{bd,\ seism}$ over the length of the bar is equal to:

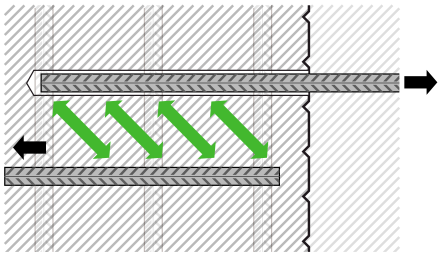
$$l_{b,rqd,seism}=(d_s/4).(\sigma_{sd,seism}/f_{bd,seism})$$

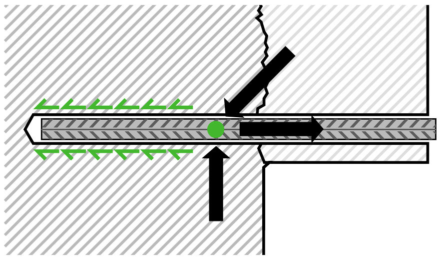
where:
d_s = diameter of the rebar
$\sigma_{sd,seism}$ = design stress in the reinforcement bar calculated acc. to § 4.4 - Verification of safety of EN 1998-1-1 (Eurocode 8) $f_{bd,seism}$ = design bond strength in seismic zones as listed in table 2

- The design anchorage length $l_{bd,seism}$ shall be determined using the following formula:

$$l_{bd,seism} = \alpha1\ \alpha2\ \alpha3\ \alpha4\ \alpha5\ l_{b,rqd,seism} \geq l_{b,min,seism}$$

where:
$\alpha1$ = 1.0 for straight bars
$\alpha2$ = between 0.7 and 1.0 as calculated acc. to EN 1992-1-1.Table 8.2.
$\alpha3$ = 1.0 even in the presence of transverse reinforcement
$\alpha4$ = 1.0 in the absence of welded transverse reinforcement
$\alpha5$ = between 0.7 and 1.0 for influence of transverse pressure acc. to EN 1992-1-1.Table 8.2.





The product verifies ($\alpha2.\alpha3.\alpha5$) ≥ 0.7
$l_{b,min,\ seism}$= minimum anchorage length
$l_{b,min,\ seism}$ == Max (0.3 $l_{b,rqd,seism}$; 10 d_s ; 100mm) under tension
= Max (0.6 $l_{b,rqd,seism}$; 10 d_s ; 100mm) under compression
The permissible maximum anchorage depth is specified in European Technical Approval.

- The design lap length l_{bd} shall be determined acc. to EN 1992-1-1, section 8.7.3: $l_{bd,seism} = \alpha0\ \alpha1\ \alpha2\ \alpha3\ \alpha5\ l_{b,rqd,seism} \geq l_{b,min,seism}$

where:
$\alpha1$ = 1.0 for straight bars
$\alpha2$ = between 0.7 and 1.0 as calculated acc. to EN 1992-1-1.Table 8.2.
$\alpha3$ = 1.0 even in the presence of transverse reinforcement
$\alpha5$ = between 0.7 and 1.0 for influence of transverse pressure compression acc. to EN 1992-1-1.Table 8.2.
$\alpha6$ = between 1.0 and 1.5 for influence of percentage of lapped length relative to total cross-section area according to EN 1992-1-1 Table 8.3.
$l_{0,min,\ seism}$= minimum lap length
$l_{0,min,seism}$ = Max ($0.3.\alpha_6.l_{b,rqd,seism}$; 15 ϕ; 200mm)

The permissible maximum anchorage depth is specified in European Technical Approval.
When the normal force in a column is a tensile force, the anchorage length shall be increased by 50 % with reference to the lengths specified in EN 1992-1-1 for the part that is situated in the critical zone. A table with pre-calculated values is provided in Table 3.

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Design bond Strength

Table 1: Design values of bond strength f_{bd} in N/mm² outside seismic zones

hammer drilling or compressed air drilling acc. to EC 2 for good bond conditions (for all other bond conditions, multiply the values by 0.7)

Rebar ∅	Concrete Class						
d_s	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
8 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
10 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
12 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
14 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
16 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
20 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
25 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
32 mm	2,3	2,7	3,0	3,4	3,7	4,0	4,3
36 mm	2,2	2,6	2,9	3,3	3,6	3,8	4,1
40 mm	2,1	2,5	2,8	3,1	3,4	3,7	4,0

Table 2: Design values of bond strength f_{bd} in N/mm² in seismic zones

hammer drilling or compressed air drilling acc. to EC 2 for good bond conditions (for all other bond conditions, multiply the values by 0.7)

Rebar ∅	Concrete Class					
d_s	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55
8 mm	2,3	2,7	3,0	3,4	3,7	4,0
10 mm	2,3	2,7	3,0	3,4	3,7	4,0
12 mm	2,3	2,7	3,0	3,4	3,7	3,7
14 mm	2,3	2,7	3,0	3,4	3,7	3,7
16 mm	2,3	2,7	3,0	3,4	3,7	3,7
20 mm	2,3	2,7	3,0	3,4	3,7	3,7
25 mm	2,3	2,7	3,0	3,0	3,4	3,4
32 mm	2,3	2,7	3,0	3,0	3,0	3,0
36 mm	2,2	2,6	2,9	2,7	2,7	2,7
40 mm	2,1	2,5	2,7	2,7	2,7	2,7

Stahlfix Pure Epoxy 21

Pre-Calculated Values

Table 3: Pre-calculated values for post-installed rebars using Stahlfix PE21 in seismic zone
Examples of C20/25, good bond conditions, rebar yield strength 500 N/mm² with hammer drilling for all drilling methods

Rebar Diameter mm	Hole Diameter mm	Load applied to bar under accidental seismic action daN	Anchorage length mm	Mortar volume ml	Load applied to bar under accidental seismic action daN	Anchorage length mm	Mortar volume ml
		All α = 1			One of the α = 0.7		
8	12 (10)	754	130	10 (4)	1,077	130	10 (4)
		1,156	200	15 (7)	1,404	170	13 (6)
		1,619	280	21	1,734	210	16 (7)
		2,023	350	26	2,147	260	20
		2,513	435	33	2,513	304	23
10	14 (12)	1,178	163	15 (7)	1,683	163	15 (7)
		1,806	250	23 (10)	2,168	210	19 (9)
		2,529	350	32	2,787	270	24
		3,179	440	40	3,303	320	29
		3,927	543	49	3,927	380	34
12	16 (14)	1,696	196	21 (10)	2,424	196	21 (10)
		2,601	300	32	3,221	260	27
		3,642	420	44	3,964	320	34
		4,596	530	56	4,831	390	41
		5,655	652	69	5,655	457	48
14	18	2,309	228	28	3,299	228	28
		3,642	360	43	4,335	300	36
		4,957	490	59	5,492	380	46
		6,272	620	75	6,503	450	54
		7,697	761	92	7,697	533	64
16	20	3,016	261	35	4,308	261	35
		4,740	410	56	5,615	340	46
		6,474	560	76	7,102	430	58
		8,208	710	96	8,588	520	71
		1,0053	870	118	10,053	609	83
20	25	4,712	326	69	6,732	326	69
		7,370	510	108	8,877	430	91
		1,0116	700	148	11,148	540	115
		1,2862	890	189	13,419	650	138
		1,5708	1,087	230	15,708	761	161
25	32	7,363	408	153	10,519	408	153
		11,561	640	241	13,935	540	203
		15,896	880	331	17,290	670	252
		20,232	1,120	421	20,903	810	305
		24,544	1,359	511	24,544	951	358
32	40	12,064	522	283	17,234	522	283
		18,960	820	445	22,792	690	375
		26,128	1,130	613	28,407	860	467
		33,065	1,430	776	34,353	1,040	565
		40,212	1,739	944	40,212	1,217	661
40	55	18,850	652	876	26,928	652	876
		29,770	1,030	1,383	35,509	860	1,155
		40,753	1,410	1,894	44,593	1,080	1,450
		51,736	1,790	2,404	53,676	1,300	1,746
		62,832	2,174	2,920	62,832	1,522	2,044

NOTE: The required volume of resin, calculated by increasing the theoretical volume by 20% in order to account for any losses occurring on site during the setting. For small diameters (10, 12 and 14), the bracketed values correspond to the minimum drilling diameter where the anchor length is below 250mm

Stahlfix Pure Epoxy 21

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Notes

PAGE 2 :

Typical characteristic and design resistance performance with 5.8 grade studding and associated installation data

All data is based on correct installation - see instructions

No influence of edge and spacing

Minimum base material thickness hef +30mm >100mm for M8 to M12 and for M16 to M30 hef +2 d

h_{ef} range minimum or 4d whichever is greatest to 20d

Concrete strength C20/25 - f_c cube = 25N/mm^2 (25MPa)

5.8 grade stud

Temperature range i maximum long term / short term temperature +24/40 ^{o}C

PAGE 3 :

Design Resistance with various stud strengths, material and rebar.

Note 1 for stainless steel tensile strength is 500N/mm ^{2} (500MPa)

Note 2 for stainless steel tensile strength is 700N/mm ^{2} (500MPa)

Data shown below the minimum embedment depth is for reference only. Please refer to manufacturer for advice.

PAGE 4 and 6 :

Characteristic and Design Load resistances based on characteristic bond strengths for hef 4d (minimum embedment) to 20d

All data is based on correct installation - see instructions

No influence of edge and spacing

Minimum base material thickness hef +30mm >100mm for M8 to M12 and for M16 to M30 hef +2 d

h_{ef} range minimum or 4d whichever is greatest to 20d

Concrete strength C20/25 - f_c cube = 25N/mm^2 (25MPa)

Temperature range i maximum long term / short term temperature +24/40 ^{o}C

PAGE 5 & 7 :

Bond Strength Factors

Select concrete strength and environmental condition and apply to bond strength table on page 4

PAGE 8 :

Material Properties for grades of other threaded rod and rebar

All grades shown for information

M30 studding is 8.8 grade instead of 5.8 grade

M30 for A4-70 tensile strength of 500N/mm ^{2}, (500MPa) instead of 700N/mm ^{2} (700MPa)

Safety factor is 1.5 tension and 1.25 shear for all carbon steel

Safety factor is 1.56 for stainless steel, up to M24, M30 and M36 is 2.0

Safety factor is 1.4 tension and 1.5 shear for BSt 500 rebar

Partial Safety Factors Pages 2,3,4,5,6,7:

1.8 for 8mm-16mm rebar and studs

2.1 for 16mm and above rebar and studs

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