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Authorised and notified according
to Article 29 of the Regulation (EU)
No 305/2011 of the European
Parliament and of the Council of 9
March 2011

MEMBER OF EOTA



European Technical Assessment ETA-25/0648 of 2026/03/03

I General Part

Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011: ETA-Danmark A/S

Trade name of the construction product:

Ramset ChemSet™ Reo 502 Xtrem™
Ramset ChemSet™ Epcon G5 Xtrem™

Product family to which the above construction product belongs:

Bonded fastener with threaded rods or rebars for use in concrete for a working life of 50 and 100 years

Manufacturer:

ITW Construction Asia Pacific (Ramset)
1 Ramset Drive
Chirnside Park
VIC 3116
Australia

Manufacturing plant:

ITW Construction Asia Pacific (Ramset)
1 Ramset Drive
Chirnside Park
VIC 3116
Australia

This European Technical Assessment contains:

36 pages including 29 annexes which form an integral part of the document

This European Technical Assessment is issued in accordance with Article 95(4) of Regulation (EU) 2024/3110, on the basis of:

EOTA EAD 330499-02-0601, "Bonded fasteners for use in concrete"

This version replaces:

The ETA with the same number issued on 2026-01-06

Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and should be identified as such.

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II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product

The Ramset ChemSet Reo 502 Xtrem / ChemSet Epcon G5 Xtrem fastening system is a bonded anchor (injection type) for concrete consisting of a mortar with a threaded rod in sizes M10, M12, M16, M20, M24, M27 and M30, and rebar in sizes R10, R12, R16, R20, R25 and R32.

The threaded rod can be made of electroplated carbon steel, stainless steel or HCR.

The threaded rod or rebar is anchored via the bond between anchor rod or rebar, chemical mortar and concrete.

The product specification is given in Annex A.

The characteristic material values, dimensions and tolerances of the anchors not indicated in Annexes shall correspond to the respective values laid down in the technical documentation¹ of this European Technical Assessment.

2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter EAD)

The performances given in Section 3 are only valid if the anchor is used in compliance with the specifications and conditions given in Annex B.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the anchor of 50 and 100 years.

The indications given on the working life cannot be interpreted as a guarantee given by the producer or Assessment Body, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

¹ The technical documentation of this European Technical Assessment is deposited at ETA-Danmark and, as far as relevant for the tasks of the Notified bodies involved in the attestation of conformity procedure, is handed over to the notified bodies.

3 Performance of the product and references to the methods used for its assessment

Characteristic	Assessment of characteristic
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3.1 Mechanical resistance and stability (BWR1)

Characteristic resistance to tension load (static and quasi-static loading)

Resistance to steel failure	See Annex C
Resistance to combined pull-out and concrete failure	See Annex C
Resistance to pull-out failure	Not relevant
Resistance to concrete cone failure	See Annex C
Edge distance to prevent splitting under load	See Annex C
Robustness	See Annex C
Maximum installation torque	See Annex B
Installation torque	Not relevant
Minimum edge distance and spacing	See Annex B

Characteristic resistance to shear load (static and quasi-static loading)

Resistance to steel failure	See Annex C
Resistance to pry-out failure	See Annex C
Resistance to concrete edge failure	See Annex C

Displacements under short-term and long-term loading

Displacements under short-term and long-term loading	See Annex C
Resistance in steel fibre reinforced concrete	No Performance assessed

Characteristic resistance and displacements for seismic performance categories C1 and C2

Resistance to tension for seismic performance category C1	See Annex C
Resistance to tension and displacements for seismic performance category C2	See Annex C
Resistance to shear load for seismic performance category C1	See Annex C
Resistance to shear load and displacements for seismic performance categories C2	See Annex C

Characteristic	Assessment of characteristic
3.2 Safety in case of fire (BWR2)	
Reaction to fire	Class A1
	Resistance to fire
Fire resistance to steel failure under tension loading	See Annex C
Fire resistance to bond failure under tension loading	See Annex C
Fire resistance to steel failure under shear loading	See Annex C
3.3 Hygiene, health and the environment (BWR3)	
Content, emission and/or release of dangerous substances	No performance assessed

See additional information in section 3.9.

3.9 General aspects related to the performance of the product.

The European Technical Assessment is issued for the product on the basis of agreed data/information, deposited with ETA-Danmark, which identifies the product that has been assessed and judged. Changes to the product or production process, which could result in this deposited data/information being incorrect, should be notified to ETA-Danmark before the changes are introduced. ETA-Danmark will decide whether or not such changes affect the ETA and consequently the validity of the CE marking on the basis of the ETA and if so whether further assessment or alterations to the ETA, shall be necessary.

The assessment of fitness of the anchor for the intended use in relation to Basic Requirements has been made in accordance with EAD 330499-02-0601, "Bonded fasteners for use in concrete" option 1 and 7 and seismic C1 and C2 categories.

4 Assessment and verification of constancy of performance (hereinafter AVCP) system applied, with reference to its legal base.

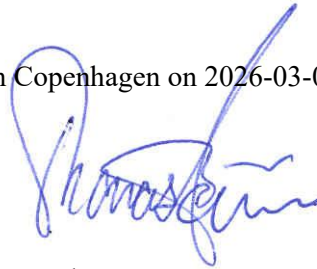
4.1 AVCP system

According to the decision 96/582/EC of the European Commission, the system(s) of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 1.

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE marking.

Issued in Copenhagen on 2026-03-03 by



Thomas Bruun
Managing Director, ETA-Danmark

Injection mortar
Epoxy adhesive two components

Ramset ChemSet™ Reo 502 Xtrem™
Ramset ChemSet™ Epcon G5 Xtrem™



Marking

Trade name
ChemSet™ Reo 502 Xtrem™
ChemSet™ Epcon G5 Xtrem™
Identifying mark of the producer **Ramset**

Expire date
Curing and processing time
Charge code number

Static mixer

ISNE mixing nozzle



High flow mixing nozzle



RAMSET Chemset™ Reo 502 Xtrem™
RAMSET Chemset™ Epcon G5 Xtrem™

Product description
Injection system

Annex A1

Product description : Steel elements and Injection mortar

Steel elements :

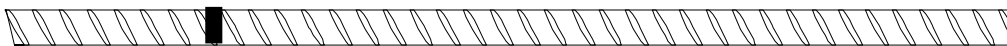
- Commercial standard threaded rods M10 to M30 with identifying mark of the embedment depth:

- Electroplated carbon steel grade 5.8 to 10.9 ⁽¹⁾ ,
- Stainless steel A4
- Steel HCR

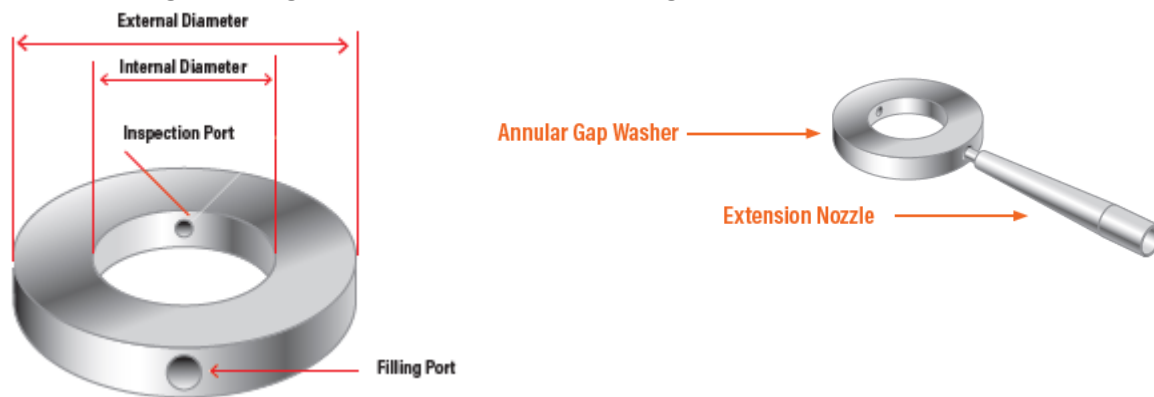


⁽¹⁾ : The commercial threaded rods for grade 10.9 have to verify elongation fracture lower than 15%.

Reinforcing bars $\phi 10$ to $\phi 32$ with materials and mechanical properties according to Table A4



RAMSET Annular gap filling washer to fill the annular gap between steel element and fixture



RAMSET Annular gap filling washer

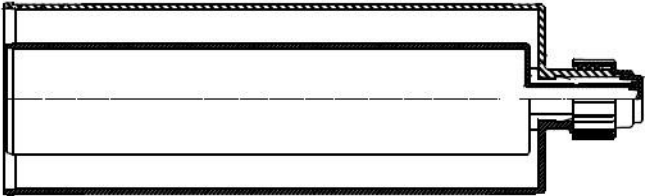
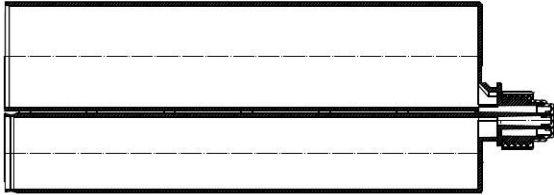
Size Studs	M10	M12	M16	M20	M24
Internal Diameter [mm]	12	14	17	21	25
External diameter [mm]	26	28	34	41	48
Thickness of filling washer [mm]	5	5	5	5	5
Coating	10 μ m zinc plate				

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Product description
Steel elements

Annex A2

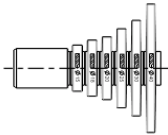
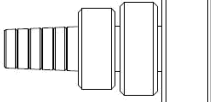
Cartridges

600 ml coaxial cartridge	
450ml side by side cartridge	

Injection accessories for deep hole



Plastic extension and piston plug for hole deeper $h_0 > 250$ mm and for overhead installation

Cartridge volume	Mixing Nozzle	Extension for piston plug	Piston plug
All cartridges	ISNE mixing nozzle or High flow mixing nozzle	Ø13x1000	
			

RAMSET Chemset™ Reo 502 Xtrem™
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Product description
Cartridges
Injection accessories for deep hole

Annex A3

Table A1: Materials

	Size	Material and EN/ISO reference
Steel elements – Zinc coated steel		
Threaded rods Grade 5.8	M10 to M30	Carbon steel grade 5.8 according to ISO 898-1 Electroplated zinc coated 5µm min. or Hot dip galvanized 45µm min.
Threaded rods Grade 8.8	M10 to M30	Carbon steel grade 8.8 according to ISO 898-1 Electroplated zinc coated 5µm min. or Hot dip galvanized 45µm min.
Threaded rods Grade 10.9*	M10 to M30	Carbon steel grade 10.9 (A% ≤ 15%) according to ISO 898-1 Electroplated zinc coated 5µm min. or Hot dip galvanized 45µm min. *Galvanized rod of high strength are sensitive to hydrogen induced brittle failure
Washer	-	Electroplated zinc coated 5µm min., or Hot dip galvanized 45µm min.
Nut	-	Strength class of nut adapted to strength class of threaded rod. Electroplated zinc coated 5µm min., or Hot dip galvanized 45µm min.
Steel elements – Stainless steel		
Threaded rods Grade A4-70	M10 to M30	Stainless steel A4-70 : 1.4401; 1.4404; 1.4578; 1.4571; 1.4439; 1.4362 acc. EN 10088-1
Nut		Strength class of nut adapted to strength class of threaded rod., Stainless steel A4 according to EN 20898-2
Washer		Stainless steel A4 according to EN 20898-2
Steel elements – High resistance corrosion version (HCR)		
Threaded rods HCR	M10 to M30	Stainless steel HCR acc. EN 10088, 1.4529 / 1.4565 $f_{uk} \geq 650 \text{ MPa}$ acc..EN 10088
Nut	-	Stainless steel HCR acc..EN 10088, 1.4529 / 1.4565 $f_{uk} \geq 650 \text{ MPa}$ acc.EN 10088
Washer	-	Stainless steel HCR acc..EN 10088, 1.4529 / 1.4565 EN ISO 7089

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Product description
Threaded rods - Materials

Annex A4

Table A2 : Materials properties for reinforcing bars**(Refer to EN 1992-1-1 Annex C Table C.1 and C.2N)**

Reinforcing bars $\phi 10$ to $\phi 32$		Bars and de-coiled rods	
Class		B	C
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600	
Minimum value of $k = (f_t/f_y)_k$		$\geq 1,08$	$\geq 1,15$ $< 1,35$
Characteristic strain at maximum force, ϵ_{uk} (%)		$\geq 5,0$	$\geq 7,5$
Height of the rib h_{rib}		$0,05 \phi \leq h_{rib} \leq 0,07 \phi$	
Bendability		Bend / Rebend test	
Maximum deviation from nominal mass (individual bar or wire) (%)	Nominal bar size (mm) ≤ 8 > 8	$\pm 6,0$ $\pm 4,5$	
Minimum relative rib area, $f_{R,min}$	Nominal bar size (mm) 8 to 12 > 12	0,040 0,056	

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Product description

Reinforcing bars

Annex A5

Design:

- Fasteners are designed under the responsibility of an engineer experienced in fasteners and concrete work.
- Verifiable calculation notes and drawings are prepared taking account of the loads to be anchored. The position of the fastener is indicated on the design drawings (e. g. position of the fastener relative to reinforcement or to supports, etc.).
- The fasteners are designed in accordance with EN 1992-4 and EOTA Technical Report 086. Fasteners under seismic actions shall be positioned outside of critical regions (e.g., plastic hinges) of the concrete structure. Fastening in stand-off installation or with a grout layer under seismic action are not covered in this European technical assessment (ETA).
- For applications with resistance to fire exposure, the fasteners are designed in accordance with EOTA TR 082 "Design of bonded fasteners in concrete under fire conditions"

Installation:

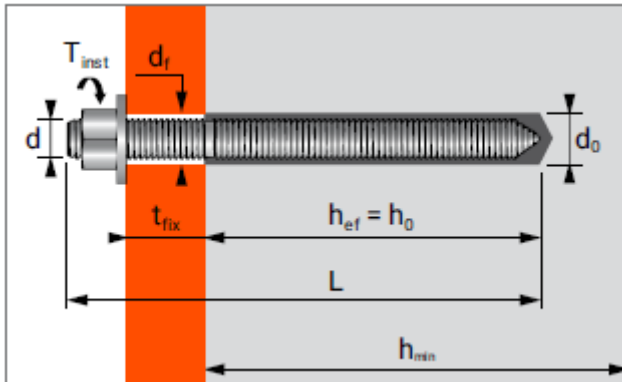
- Use category:
 - Dry, wet (use category 1) and flooded holes (use category 2) for Hammer drilling technique, compressed air drilling and diamond drilling technique
 - Installation direction downwards, horizontal and overhead
- Drilling technique:
 - Hammer drilling technique: Threaded rods M10 to M30 , rebar $\phi 10$ to $\phi 32$
 - Compressed air drilling: Threaded rods M10 to M30 , rebar $\phi 10$ to $\phi 32$
 - Diamond drilling technique: Threaded rods M12 to M30 , rebar $\phi 12$ to $\phi 32$
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.
- Use of the anchor only as supplied by the manufacturer without exchanging the components of an anchor.
- Anchor installation in accordance with the manufacturer's specifications and drawings and using the appropriate tools
- Effective anchorage depth, edge distances and spacing not less than the specified values without minus tolerances.

In case of aborted hole, drilling of new hole at a minimum distance away of twice the depth of the aborted hole, or smaller distance provided that the aborted drill hole is filled with high strength mortar and no shear or oblique tension loads in the direction of aborted hole.

RAMSET Chemset™ Reo 502 Xtrem™
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Annex B2

Intended used
Specifications

Table B1 : Installation data with standard, minimum and maximum embedment depth for threaded rods

Nominal diameter	$\varnothing d_0$ Nominal diameter of the drill bit	d_f Clearance hole in the fixture	T_{inst} Tightening torque	$h_{ef} = h_0$ Effective embedment depth and drill hole depth		h_{min} minimum thickness of the concrete member
				Minimum	Maximum	
	[mm]	[mm]	[N.m]	[mm]	[mm]	
M10	12	12	20	60	200	$h_{ef} + 30$ $\geq 100 \text{ mm}$
M12	14	14	30	70	240	
M16	18	18	60	80	320	$h_{ef} + 2d_0$
M20	25	22	120	90	400	
M24	28	26	150	96	480	
M27	30	30	165	108	540	
M30	35	33	180	120	600	

Table B2 : Minimum spacing and edge distances for threaded rods

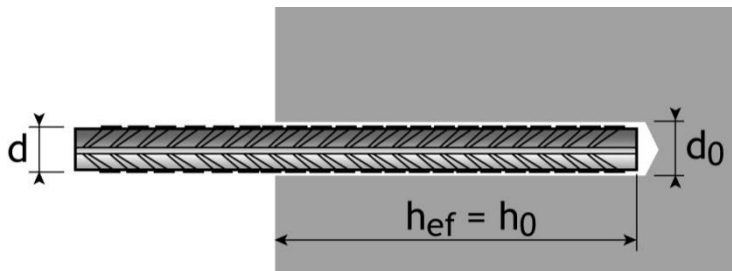
			Threaded rods						
			M10	M12	M16	M20	M24	M27	M30
Minimum spacing	s_{min}	[mm]	40	50	70	85	90	115	140
Minimum edge distance	c_{min}	[mm]	40	40	45	55	60	75	90

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Intended used

Installation parameters for threaded rods

Annex B3

Table B3 : Installation data with standard, minimum and maximum embedment depth for reinforcing bars

Nominal diameter	Ø d ₀ Nominal diameter of the drill bit	h _{ef} = h ₀ Effective embedment depth and drill hole depth		h _{min} minimum thickness of the concrete member
		Minimum	Maximum	min
	[mm]	[mm]	[mm]	[mm]
Ø10	12	60	200	h _{ef} + 30 ≥ 100 mm
Ø12	15	70	240	
Ø16	20	80	320	h _{ef} + 2d ₀
Ø20	25	90	400	
Ø25	30	100	500	
Ø32	40	128	640	

Table B4 : Minimum spacing and edge distances for reinforcement bars

			Reinforcing bars					
			Ø10	Ø12	Ø16	Ø20	Ø25	Ø32
Minimum spacing	s _{min}	[mm]	40	50	70	85	90	140
Minimum edge distance	c _{min}	[mm]	40	40	45	55	60	90

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Intended used
Installation parameters for reinforcing bars

Annex B4

Table B5: Gel time and curing time

Temperature of base material	Working time	Curing time ¹⁾
5°C	75 min	30 h
10°C	45 min	22 h
15°C	35 min	14 h
20°C	22 min	7 h
25°C	14 min	5 h
30°C	8 min	4 h
35°C	6 min	3 h
40°C	4 min	2 h 45 min

¹⁾ For wet concrete and diamond core drilling method, the curing time must be doubled

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Product description

Minimum curing time and maximum working time

Annex B5

Table B6 : Dimensions of the cleaning tools for threaded rods

Threaded rods							
Dimensions	M10	M12	M16	M20	M24	M27	M30
Ø drilled hole [mm] Drill bit or diamond core	12	14	18	25	28	30	35
Ø Brush [mm] 	13	15	20	26	30	32	37

Table B7 : Dimensions of the cleaning tools for reinforcing rebars

Reinforcing rebars						
Dimensions	Ø10	Ø12	Ø16	Ø20	Ø25	Ø32
Ø drilled hole [mm] Drill bit or diamond core	12	15	20	25	30	40
Ø Brush [mm] 	13	16	22	26	32	42

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Product description
Cleaning tools

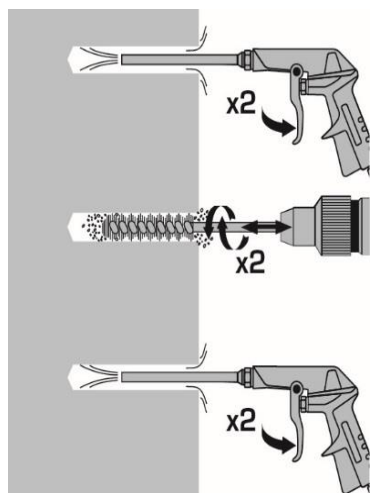
Annex B6

Drilling the hole:**Hammer drilling or compressed air drilling technique**

Drill hole to the required embedment depth with a hammer drill set in rotation-hammer mode using an appropriately sized carbide drill bit (See Table B6 / B7)

Diamond core drilling technique

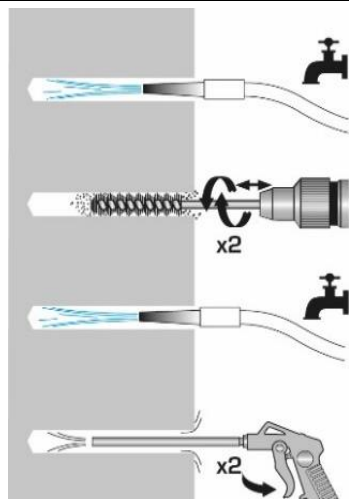
Diamond coring is permissible when suitable diamond core drilling machines and the corresponding core bits are used (See Table B6/ B7)

Cleaning the hole:**Hammer drilling or compressed air drilling technique**

1. Using compress air cleaning (min 6 bars), use the appropriate plastic extension for compressed air cleaning, starting from the top of the hole blow out at least 2 times by moving downward to the bottom of the hole then moving upward to the top of the hole and until no dust is evacuated. (not less than 10s per each blowing).

2. Using the relevant brush and extension fitted on a Ramset drilling machine, starting from the top of the hole, move downward to the bottom of the hole then moving upward to the top of the hole. Repeat this operation.

3. Using compress air cleaning (min 6 bars), use the appropriate extension, starting from the top of the hole blow out at least 2 times by moving downward to the bottom of the hole then moving upward to the top of the hole and until no dust is evacuated. (not less than 10s per each blowing).

Diamond core drilling technique

1. Clean the hole with tap water with a pipe adapted to enter in the hole. Starting from the top of the hole, move downward to the bottom of the hole then move upward to the top of the hole until water is becoming clear.

2. Using the relevant brush and extension fitted on a Ramset drilling machine, starting from the top of the hole, move downward to the bottom of the hole then moving upward to the top of the hole. Repeat this operation.

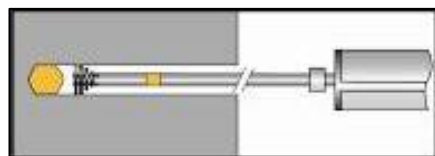
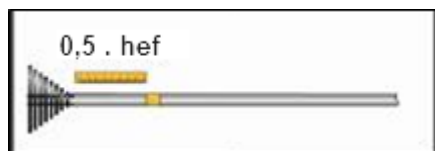
3. Clean the hole with tap water with a pipe adapted to enter in the hole. Starting from the top of the hole, move downward to the bottom of the hole then move upward to the top of the hole until water is becoming clear.

4. Using compress air cleaning (mini 6 bars), use the appropriate extension, starting from the top of the hole blow out at least 2 times by moving downward to the bottom of the hole then moving upward to the top of the hole and until no dust is evacuated. (not less than 10s per each blowing).

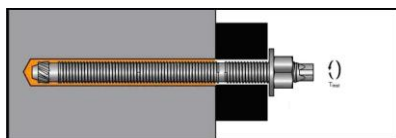
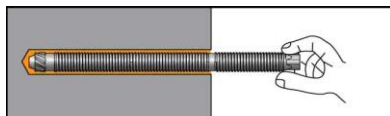
RAMSET Chemset™ Reo 502 Xtrem™
RAMSET Chemset™ Epcon G5 Xtrem™

Product description
Installation instructions

Annex B7

Dispensing into the hole:

1. Dispense the first part to waste until an even colour is achieved (≈ 5 cm).
2. For hole deeper $h_0 > 250$ mm and also for overhead installations, the injection is only possible with the using of piston plug, and plastic extension.
3. Cut the piston plug at the relevant diameter. The volume of resin that needs to be injected in the hole must be indicated on the mixing nozzle or its extension. The marking must be placed at 0.5 times the anchorage depth
4. Insert the nozzle to the far end of the hole, and inject the resin, withdrawing the nozzle as the hole fills in order to avoid trapping air bubbles. Fill 50% of the drill hole to ensure enough adhesive volume between concrete and reinforcing bar. For pneumatic dispenser, the maximum pressure is 6 bars.

Inserting the steel element :

1. Immediately insert the studs or rebars, slowly and with a slight twisting motion. Remove excess resin from around the mouth of the hole before it sets. Control the embedment depth during the working time which varies according to temperature of base material (See Table B5). Don't disturb anchor between specified cure time.

2. After curing time (See Table B5), attach the fixture and tight the nut at the specified torque (See Table B1).

Safety precaution:

The safety data sheet must be read before using the product and the safety instructions followed.

- Storage temperature of cartridge $+5^{\circ}\text{C}$ to $+35^{\circ}\text{C}$
- Cartridge temperature at time of installation: Must be $\geq +5^{\circ}\text{C}$
- Base material temperature at time of installation: Must be between 5°C and $+40^{\circ}\text{C}$
- Check the date of expiry of the cartridge

RAMSET Chemset™ Reo 502 Xtrem™
RAMSET Chemset™ Epcon G5 Xtrem™

Product description
Installation instructions

Annex B8

Table C1 : Essential characteristic for threaded rods under tension load in concrete

Threaded rod			M10	M12	M16	M20	M24	M27	M30
For working life of 50 years and 100 years									
Steel failure									
Characteristic resistance – Commercial threaded rods	N _{Rk,s}	[kN]	A _s · f _{uk}						
Partial safety factor Commercial threaded rods	γ _{Ms,N¹⁾}	[-]	1,2 · f _{uk} /f _{yk} ≥ 1,4						
Steel grade 5.8	N _{Rk,s}	[kN]	29,0	42,2	78,5	122,5	176,5	229,5	280,5
Steel grade 8.8			46,4	67,4	125,6	196,0	282,4	367,2	448,8
Steel grade 10.9			60,3	87,7	163,0	255,0	367,0	477,0	583,0
Stainless Steel grade A4-70			40,6	59	109,9	171,5	247,1	321,3	392,7
HCR Steel 1.4529			40,6	59	109,9	171,5	247,1	321,3	392,7
HCR Steel 1.4565			40,6	59	109,9	171,5	247,1	321,3	392,7
Partial safety factor Grade 5.8, 8.8, 10.9	γ _{Ms,N¹⁾}	[-]	1,5						
Partial safety factor Stainless Steel grade A4-70			1,87						
Partial safety factor HCR Steel 1.4529			1,5						
Partial safety factor HCR Steel 1.4565			1,87						
Installation factor									
Hammer drilling for dry and wet holes	γ _{inst}	[-]	1,0						
Hammer drilling for flooded holes	γ _{inst}	[-]	1,2	1,4					
Diamond drilling for dry and wet holes	γ _{inst}	[-]	1,2						
Diamond drilling for flooded holes	γ _{inst}	[-]	1,2						
Concrete cone failure									
Factor for cracked concrete	K _{cr,N}	[-]	7,7						
Factor for uncracked concrete	K _{ucr,N}	[-]	11,0						
Edge distance	C _{cr,N}	[mm]	1,5 · h _{ef}						
Spacing	S _{cr,N}	[mm]	3,0 · h _{ef}						
Splitting failure									
Edge distance C _{cr,sp} [mm] for	h/h _{ef} ≥ 2,4		1.0 · h _{ef}						
	2,4 > h/h _{ef} > 1,4		4,6 · h _{ef} – 1,5 · h						
	h/h _{ef} ≤ 1,4		2,5 · h _{ef}						
Spacing	S _{cr,sp}	[mm]	2 · C _{cr,sp}						
1) In absence of national regulations									

RAMSET Chemset™ Reo 502 Xtrem™
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Performance

Essential characteristics for threaded rods
under tension loading for a working life of 50 or 100 years

Annex C1

**Table C1 (Continued) : Essential characteristic for threaded rods
under tension load in concrete under static and quasi static loading**

Threaded rod			M10	M12	M16	M20	M24	M27	M30
For working life of 50 years and 100 years									
Combined pull-out and concrete cone failure									
Characteristic bond resistance in uncracked concrete C20/25 with HAMMER DRILLING									
Dry and wet holes									
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	17,1	16,3	15,1	14,2	13,5	13,1	12,7
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	14,5	13,8	12,8	12,0	11,4	11,1	10,8
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	4,5	4,3	3,9	3,7	3,5	3,4	3,3
Flooded holes									
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	17,1	16,3	15,1	14,0	12,7	11,9	11,2
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	14,5	13,8	12,8	11,8	10,7	10,1	9,5
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	4,5	4,3	3,9	3,7	3,3	3,1	2,9
Influence of concrete factor on bond strength $\tau_{Rk,uncr}$ in uncracked concrete									
Temperature range I, II and III : $\Psi_c = (f_{ck}/20)^m$	m	[-]	0,20	0,20	0,30	0,30	0,40	0,40	0,40
Characteristic bond resistance in cracked concrete C20/25 with HAMMER DRILLING									
Dry and wet holes									
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	6,6	9,2	9,6	9,7	9,5	9,3	9,2
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	5,6	7,8	8,1	8,2	8,0	7,9	7,8
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	1,7	2,4	2,5	2,5	2,5	2,4	2,4
Flooded holes									
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	6,6	9,2	9,6	9,7	8,9	8,3	8,1
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	5,6	7,8	8,1	8,2	7,5	7,2	6,9
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	1,7	2,4	2,5	2,5	2,3	2,2	2,1
Temperature range I, II and III : $\Psi_c = (f_{ck}/20)^m$	m	[-]	0,10	0,10	0,10	0,20	0,20	0,20	0,30
Influence of sustained load									
Temperature range I: 24°C / 40°C	$\Psi_{sus,100}^0$	[-]	0,72						
Temperature range II: 36°C / 60°C	$\Psi_{sus,100}^0$	[-]	0,72						
Temperature range III: 45°C / 75°C	$\Psi_{sus,100}^0$	[-]	0,91						

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Performance

Essential characteristics for threaded rods
under static and quasi-static tension loading
for a working life of 50 or 100 years with hammer drilling

Annex C2

**Table C1 (Continued): Essential characteristic for threaded rods
under tension load in concrete under static and quasi static loading**

Threaded rod			M12	M16	M20	M24	M27	M30
For working life of 50 years and 100 years								
Combined pull-out and concrete cone failure								
Characteristic bond resistance in uncracked concrete C20/25 with DIAMOND DRILLING								
Dry and wet holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	15,8	13,9	12,6	11,6	11,0	10,5
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	13,5	11,8	10,7	9,8	9,3	8,9
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	4,1	3,6	3,3	3,0	2,9	2,7
Flooded holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	15,8	13,9	12,6	11,6	11,0	10,5
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	13,5	11,8	10,7	9,8	9,3	8,9
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	4,1	3,6	3,3	3,0	2,9	2,7
Influence of concrete factor on bond strength $\tau_{Rk,uncr}$ in uncracked concrete								
Temperature range I, II and III : $\Psi_c = (f_{ck}/20)^m$	m	[-]	0,00	0,00	0,00	0,10	0,20	0,50
Characteristic bond resistance in cracked concrete C20/25 with DIAMOND DRILLING								
Dry and wet holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	6,4	6,7	7,5	7,3	7,2	7,1
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	5,4	5,7	6,4	6,2	6,1	6,0
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	2,0	1,9	1,9	1,9	1,9	1,8
Flooded holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	6,4	6,7	7,5	7,3	7,2	7,1
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	5,4	5,7	6,4	6,2	6,1	6,0
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	2,0	1,9	1,9	1,9	1,9	1,9
Influence of concrete factor on bond strength $\tau_{Rk,cr}$ in cracked concrete								
Temperature range I, II and III : $\Psi_c = (f_{ck}/20)^m$	m	[-]	0,10	0,10	0,20	0,30	0,40	0,50
Influence of sustained load								
Temperature range I: 24°C / 40°C	$\Psi_{sus,100}^0$	[-]	0.72					
Temperature range II: 36°C / 60°C	$\Psi_{sus,100}^0$	[-]	0.72					
Temperature range III: 45°C / 75°C	$\Psi_{sus,100}^0$	[-]	0.91					

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Performance
Essential characteristics for threaded rods
under static and quasi-static tension loading
for a working life of 50 or 100 years with diamond drilling

Annex C3

Table C2 : Essential characteristic for reinforcing bars under tension load in concrete

Reinforcing bar		ϕ10	ϕ12	ϕ16	ϕ20	ϕ25	ϕ32	
For working life of 50 years and 100 years								
Steel failure								
Characteristic resistance	N _{Rk,s}	[kN]	A _s · f _{uk}					
Characteristic resistance rebar Fe E500 according to EN 1992-1-1	N _{Rk,s}	[kN]	42,4	61,1	108,6	169,6	265,1	434,3
Partial safety factor rebar Fe E500 according to EN 1992-1-1	γ _{Ms,N}	[-]	1,4					
Installation factor								
Hammer drilling for dry and wet holes	γ _{inst}	[-]	1,0					
Hammer drilling for flooded holes	γ _{inst}	[-]	1,0				1,4	
Diamond drilling for dry and wet holes	γ _{inst}	[-]	1,0					
Diamond drilling for flooded holes	γ _{inst}	[-]	1,0				1,4	
Concrete cone failure								
Factor for cracked concrete	K _{cr,N}	[-]	7,7					
Factor for uncracked concrete	K _{ucr,N}	[-]	11,0					
Edge distance	C _{cr,N}	[mm]	1,5 · h _{ef}					
Spacing	S _{cr,N}	[mm]	3,0 · h _{ef}					
Splitting failure								
Edge distance C _{cr,sp} [mm] for	h/h _{ef} ≥ 2,4		1,0 · h _{ef}					
	2,4 > h/h _{ef} > 1,4		4,6 · h _{ef} – 1,5 · h					
	h/h _{ef} ≤ 1,4		2,5 · h _{ef}					
Spacing	S _{cr,sp}	[mm]	2 · C _{cr,sp}					
Influence of sustained load								
Temperature range I: 24°C / 40°C	Ψ ⁰ _{sus,100}	[-]	0,72					
Temperature range II: 36°C / 60°C	Ψ ⁰ _{sus,100}	[-]	0,72					
Temperature range III: 45°C / 75°C	Ψ ⁰ _{sus,100}	[-]	0,91					

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Performance

Essential characteristics for reinforcing bars
under tension loading for a working life of 50 or 100 years

Annex C4

**Table C2 (Continued) : Essential characteristic for reinforcing bars
under tension load in concrete under static and quasi static loading**

Reinforcing bar			φ10	φ12	φ16	φ20	φ25	φ32
For working life of 50 years and 100 years								
Combined pull-out and concrete cone failure								
Characteristic bond resistance in uncracked concrete C20/25 with HAMMER DRILLING								
Dry and wet holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	14,5	14,5	14,4	14,4	14,3	14,3
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	12,3	12,2	12,2	12,2	12,1	12,1
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	3,8	3,8	3,8	3,8	3,7	3,7
Flooded holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	14,5	14,5	14,4	14,2	13,4	13,0
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	12,3	12,2	12,2	12,0	11,4	11,0
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	3,8	3,8	3,8	3,7	3,5	3,4
Influence of concrete factor on bond strength $\tau_{Rk,uncr}$ in uncracked concrete								
Temperature range I and II $\Psi_C = (f_{ck}/20)^m$	m	[-]	0,00	0,05	0,05	0,05	0,10	0,10
Characteristic bond resistance in cracked concrete C20/25 with HAMMER DRILLING								
Dry and wet holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	10,8	10,6	10,4	10,2	10,1	9,9
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	9,1	9,0	8,8	8,7	8,5	8,4
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	2,8	2,8	2,7	2,7	2,6	2,6
Flooded holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	10,8	10,6	10,4	10,1	9,5	9,0
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	9,1	9,0	8,8	8,6	8,0	7,6
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	2,8	2,8	2,7	2,6	2,5	2,3
Influence of concrete factor on bond strength $\tau_{Rk,cr}$ in cracked concrete								
Temperature range I and II $\Psi_C = (f_{ck}/20)^m$	m	[-]	0,10	0,10	0,10	0,20	0,20	0,30
Influence of sustained load								
Temperature range I: 24°C / 40°C	$\Psi_{sus,100}^0$	[-]	0,72					
Temperature range II: 40°C / 60°C	$\Psi_{sus,100}^0$	[-]	0,72					
Temperature range III: 45°C / 75°C	$\Psi_{sus,100}^0$	[-]	0,91					

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Performance

Essential characteristics for reinforcing bars
under static and quasi-static tension loading
for a working life of 50 or 100 years with diamond drilling

Annex C5

**Table C2 (Continued) : Essential characteristic for reinforcing bars
under tension load in concrete under static and quasi static loading**

Reinforcing bar			φ12	φ16	φ20	φ25	φ32
For working life of 50 years and 100 years							
Combined pull-out and concrete cone failure							
Characteristic bond resistance in uncracked concrete C20/25 with DIAMOND DRILLING							
Dry and wet holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	15,1	14,1	13,3	12,6	11,9
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	12,9	12,0	11,3	10,7	10,1
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	4,0	3,7	3,5	3,3	3,1
Flooded holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,uncr}$	[N/mm ²]	15,1	14,1	13,3	12,6	11,9
Temperature range II: 36°C / 60°C	$\tau_{Rk,uncr}$	[N/mm ²]	12,9	12,0	11,3	10,7	10,1
Temperature range III: 45°C / 75°C	$\tau_{Rk,uncr}$	[N/mm ²]	4,0	3,7	3,5	3,3	3,1
Influence of concrete factor on bond strength $\tau_{Rk,uncr}$ in uncracked concrete							
Temperature range I and II $\Psi_c = (f_{ck}/20)^m$	m	[-]	0,00	0,00	0,00	0,10	0,50
Characteristic bond resistance in cracked concrete C20/25 with DIAMOND DRILLING							
Dry and wet holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	9,3	9,9	11,1	10,9	10,7
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	7,9	8,4	9,5	9,3	9,1
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	3,0	3,0	2,9	2,8	2,8
Flooded holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,cr}$	[N/mm ²]	9,3	9,9	11,1	10,9	10,7
Temperature range II: 36°C / 60°C	$\tau_{Rk,cr}$	[N/mm ²]	7,9	8,4	9,5	9,3	9,1
Temperature range III: 45°C / 75°C	$\tau_{Rk,cr}$	[N/mm ²]	3,0	3,0	2,9	2,8	2,8
Influence of concrete factor on bond strength $\tau_{Rk,cr}$ in cracked concrete							
Temperature range I and II $\Psi_c = (f_{ck}/20)^m$	m	[-]	0,10	0,10	0,20	0,40	0,50
Influence of sustained load							
Temperature range I: 24°C / 40°C	$\Psi_{sus,100}^0$	[-]	0,72				
Temperature range II: 40°C / 60°C	$\Psi_{sus,100}^0$	[-]	0,72				
Temperature range III: 45°C / 75°C	$\Psi_{sus,100}^0$	[-]	0,91				

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Performance

Essential characteristics for reinforcing bars
under static and quasi-static tension loading
for a working life of 50 or 100 years with diamond drilling

Annex C5

**Table C3 : Essential characteristic for threaded rods
under shear load in concrete under static and quasi static loading**

Threaded rod			M10	M12	M16	M20	M24	M27	M30
For working life of 50 years and 100 years									
Steel failure without level arm									
Characteristic resistance – Commercial threaded rods	$V^0_{Rk,s}$	[kN]	$K_6 \cdot N_{Rk,s}$						
Factor for commercial threaded rods	K_6	[-]	0,5						
Steel grade 5.8	$V^0_{Rk,s}$	[kN]	14,5	21,1	39,3	61,3	88,3	114,8	140,3
Steel grade 8.8			23,2	33,7	62,8	98,0	141,2	183,6	224,4
Steel grade 10.9			30,2	43,9	81,5	127,5	183,5	238,5	291,5
Stainless steel grade A4-70			20,3	29,5	55,0	85,8	123,6	160,7	196,4
HCR Steel 1.4529			20,3	29,5	55,0	85,8	123,6	160,7	196,4
HCR Steel 1.4565			20,3	29,5	55,0	85,8	123,6	160,7	196,4
Partial safety factor									
Partial safety factor commercial threaded rods	$\gamma_{Ms,V^1)}$	[-]	1,0 . $f_{uk}/f_{yk} \geq 1,25$ when $f_{uk} \leq 800 \text{ N/mm}^2$ and $f_{yk}/f_{uk} \geq 0,8$ 1,0 . $f_{uk}/f_{yk} \geq 1,5$ when $f_{uk} > 800 \text{ N/mm}^2$ or $f_{yk}/f_{uk} > 0,8$						
Partial safety factor Grade 5.8, 8.8			1,25						
Partial safety factor Grade 10.9			1,5						
Partial safety factor Grade A4-70			1,56						
Partial safety factor HCR Steel 1.4529			1,25						
Partial safety factor HCR Steel 1.4565			1,56						
Ductility factor	K_7	[-]	1,0 for steel with rupture elongation $A_5 > 8\%$						
Steel failure with level arm									
Characteristic bending moment - Commercial threaded rods	$M^0_{Rk,s}$	[Nm]	$1,2 \cdot W_{el} \cdot f_{uk}$						
Steel grade 5.8	$M^0_{Rk,s}$	[Nm]	37	66	166	325	561	832	1125
Steel grade 8.8			60	105	266	519	898	1332	1799
Steel grade 10.9			75	131	333	649	1123	1664	2249
Stainless Steel grade A4-70			52	92	233	454	786	1165	1574
HCR Steel 1.4529			52	92	233	454	786	1165	1574
HCR Steel 1.4565			52	92	233	454	786	1165	1574
Concrete pryout failure									
Concrete pryout factor	K_8	[-]	2,0						
Concrete edge failure									
Concrete pryout factor	l_f	[mm]	$\min(h_{ef} ; 12.d_{nom})$					$\min(h_{ef} ; 8.d_{nom})$	
External diameter	d_{nom}	[mm]	10	12	16	20	24	27	30
¹⁾ In absence of national regulations									

¹⁾ In absence of national regulations

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Performance

Essential characteristics for threaded rods
under static and quasi-static shear loading
for a working life of 50 or 100 years

Annex C6

**Table C4 : Essential characteristic for reinforcing bars
under shear load in concrete under static and quasi static loading**

Reinforcing bar			φ10	φ12	φ16	φ20	φ25	φ32
For working life of 50 years and 100 years								
Steel failure without level arm								
Characteristic resistance	V ⁰ _{Rk,s}	[kN]	0,5 . A _s . f _{uk} ¹⁾					
Partial safety factor	γ _{Ms,V} ²⁾		1,0 . f _{uk} /f _{yk} ≥ 1,25 when f _{uk} ≤ 800 N/mm ² and f _{yk} /f _{uk} ≥ 0,8 1,0 . f _{uk} /f _{yk} ≥ 1,5 when f _{uk} > 800 N/mm ² or f _{yk} /f _{uk} > 0,8					
Characteristic resistance Rebar Fe E500 according to EN 1992-1-1	V ⁰ _{Rk,s}	[kN]	21,2	30,5	54,3	84,8	132,5	217,1
Partial safety factor Rebar Fe E500 according to EN 1992-1-1	γ _{Ms,V} ²⁾	[-]	1,5					
Ductility factor	K ₇	[-]	1,0					
Steel failure with level arm								
Characteristic resistance	M ⁰ _{Rk,s}	[Nm]	1,2 . W _{el} . f _{uk}					
Characteristic resistance Rebar Fe E500 according to EN 1992-1-1	M ⁰ _{Rk,s}	[Nm]	63,6	109,9	260,6	508,9	994,0	2084,6
Ductility factor	K ₇	[-]	1,0					
Concrete pryout failure								
Concrete pryout factor	K ₈	[-]	2,0					
Concrete edge failure								
Concrete pryout factor	l _f	[mm]	min(h _{ef} ; 12.d _{nom})				min(h _{ef} ; 8.d _{nom})	
External diameter	d _{nom}	[mm]	10	12	16	20	25	32
1) f _{uk} according to the rebar specification								
2) En l'absence de réglementation nationale,								

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Performance

Essential characteristics for reinforcing bars
under static and quasi-static shear loading
for a working life of 50 or 100 years

Annex C7

Table C5 : Displacement for threaded rods under tensile load in concrete

Threaded rod		M10	M12	M16	M20	M24	M27	M30
Displacement in uncracked concrete and in cracked concrete								
With HAMMER DRILLING								
δ_{N0}	[mm/(N/mm ²)]	0,04	0,04	0,04	0,04	0,04	0,06	0,06
$\delta_{N\infty}$	[mm/(N/mm ²)]	0,05	0,06	0,07	0,07	0,08	0,08	0,07
With DIAMOND DRILLING								
δ_{N0}	[mm/(N/mm ²)]	-	0,04	0,04	0,04	0,04	0,06	0,06
$\delta_{N\infty}$	[mm/(N/mm ²)]	-	0,06	0,07	0,07	0,08	0,08	0,07

Table C6 : Displacement for reinforcing bars under tensile load in concrete

Rebar		φ10	φ12	φ16	φ20	φ25	φ32
Displacement in cracked and non cracked concrete							
δ_{N0}	[mm/(N/mm ²)]	0,04	0,05	0,05	0,05	0,06	0,06
$\delta_{N\infty}$	[mm/(N/mm ²)]	0,09	0,06	0,07	0,05	0,08	0,06

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Performance

Displacement under static and quasi-static tension loading

Annex C8

**Table C7 : Essential characteristic for threaded rods
under tensile load in concrete under seismic loading category C1**

Threaded rod			M10	M12	M16	M20	M24	M30
For working life of 50 years and 100 years								
Steel failure								
Characteristic resistance – Commercial threaded rods	N _{Rk,s,C1}	[kN]	N _{Rk,s}					
Combined pull-out and concrete cone failure								
Characteristic bond resistance in cracked concrete C20/25 with HAMMER DRILLING								
Dry and wet holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm ²]	6,2	8,6	9,3	9,2	9,5	8,3
Temperature range II: 36°C / 60°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm ²]	5,3	7,3	7,8	7,8	8,0	7,1
Temperature range III: 45°C / 75°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm ²]	1,6	2,3	2,4	2,4	2,5	2,2
Flooded holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm ²]	6,2	8,6	9,3	9,2	8,9	7,3
Temperature range II: 36°C / 60°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm ²]	5,3	7,3	7,8	7,8	7,5	6,2
Temperature range III: 45°C / 75°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm ²]	1,7	2,4	2,5	2,5	2,3	1,9
Influence of concrete factor on bond strength $\tau_{Rk,C1}$ and $\tau_{Rk,100,C1}$								
Temperature range I, II and III	Ψ_c	[-]	1,0					

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Performance

Essential characteristics for threaded rods
Seismic tension loading category C1
for a working life of 50 or 100 years with hammer drilling

Annex C9

**Table C7 (Continued) : Essential characteristic for threaded rods
under tensile load in concrete under seismic loading category C1**

Threaded rod			M12	M16	M20	M24	M30
For working life of 50 years and 100 years							
Steel failure							
Characteristic resistance – Commercial threaded rods	N _{Rk,s,C1}	[kN]	N _{Rk,s}				
Combined pull-out and concrete cone failure							
Characteristic bond resistance in cracked concrete C20/25 with DIAMOND DRILLING							
Dry and wet holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm²]	6,4	6,7	7,5	7,3	6,7
Temperature range II: 36°C / 60°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm²]	5,4	5,7	6,4	6,2	5,6
Temperature range III: 45°C / 75°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm²]	2,0	1,9	1,9	1,9	1,7
Flooded holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm²]	6,4	6,7	7,5	7,3	6,7
Temperature range II: 36°C / 60°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm²]	5,4	5,7	6,4	6,2	5,6
Temperature range III: 45°C / 75°C	$\tau_{Rk,C1} = \tau_{Rk,100,C1}$	[N/mm²]	2,0	1,9	1,9	1,9	1,7
Influence of concrete factor on bond strength $\tau_{Rk,C1}$ and $\tau_{Rk,100,C1}$							
Temperature range I, II and III	Ψ_C	[-]	1,0				

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Performance

Essential characteristics for threaded rods
Seismic tension loading category C1
for a working life of 50 or 100 years with diamond drilling

Annex C10

**Table C8 : Essential characteristic for threaded rod
under shear load in concrete under seismic loading category C1**

Threaded rod			M10	M12	M16	M20	M24	M30
For working life of 50 years and 100 years								
Annular gap factor without filling annular gap	α_{gap}	[-]	0,5					
Annular gap factor with Ramset filling washer	α_{gap}	[-]	1.0 ¹⁾					
Steel failure without level arm								
Steel grade 5.8	$V_{Rk,s,C1}$	[kN]	10,2	17,7	32,2	50,2	55,6	88,4
Steel grade 8.8			16,2	28,3	51,5	80,4	89,0	141,4
Stainless steel grade A4-70			14,2	24,8	45,1	70,3	77,8	123,7
HCR Steel 1.4529			14,2	24,8	45,1	70,3	77,8	123,7
HCR Steel 1.4565			14,2	24,8	45,1	70,3	77,8	123,7

1) According to EN 1992-4

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Performance

Essential characteristics for threaded rods
Seismic shear loading category C1
for a working life of 50 or 100 years with hammer and diamond drilling

Annex C11

**Table C9 : Essential characteristic for threaded rods
under tensile load in concrete under seismic loading category C2**

Threaded rod			M10	M12	M16	M20	M24	M30
For working life of 50 years and 100 years								
Steel failure								
Characteristic resistance – Commercial threaded rods	$N_{Rk,s,C2}$	[kN]	$N_{Rk,s}$					
Combined pull-out and concrete cone failure								
Characteristic bond resistance in cracked concrete C20/25 with HAMMER DRILLING								
Dry and wet holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm²]	4,0	5,2	4,1	3,8	2,9	4,8
Temperature range II: 36°C / 60°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm²]	3,4	4,4	3,5	3,2	2,5	4,0
Temperature range III: 45°C / 75°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm²]	1,0	1,4	1,1	1,0	0,8	1,2
Flooded holes								
Temperature range I: 24°C / 40°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm²]	4,0	5,2	4,1	3,7	2,7	4,3
Temperature range II: 36°C / 60°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm²]	3,4	4,4	3,5	3,2	2,3	3,6
Temperature range III: 45°C / 75°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm²]	1,0	1,4	1,1	1,0	0,7	1,1
Influence of concrete factor on bond strength $\tau_{Rk,C2}$ and $\tau_{Rk,100,C2}$								
Temperature range I, II and III	Ψ_c	[-]	1,0					

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Performance

Essential characteristics for threaded rods
Seismic tensile loading category C2
for a working life of 50 or 100 years with hammer drilling

Annex C12

**Table C9 (Continued) : Essential characteristic for threaded rods
under tensile load in concrete under seismic loading category C2**

Threaded rod			M12	M16	M20	M24	M30
For working life of 50 years and 100 years							
Steel failure							
Characteristic resistance – Commercial threaded rods	N _{Rk,s,C2}	[kN]	N _{Rk,s}				
Combined pull-out and concrete cone failure							
Characteristic bond resistance in cracked concrete C20/25 with DIAMOND DRILLING							
Dry and wet holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm ²]	4,5	2,9	2,9	1,7	2,0
Temperature range II: 36°C / 60°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm ²]	3,8	2,4	2,5	1,5	1,7
Temperature range III: 45°C / 75°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm ²]	1,2	0,8	0,8	0,5	0,5
Flooded holes							
Temperature range I: 24°C / 40°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm ²]	4,5	2,9	2,9	1,6	1,8
Temperature range II: 36°C / 60°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm ²]	3,8	2,4	2,4	1,4	1,5
Temperature range III: 45°C / 75°C	$\tau_{Rk,C2} = \tau_{Rk,100,C2}$	[N/mm ²]	1,2	0,8	0,8	0,4	0,5
Influence of concrete factor on bond strength $\tau_{Rk,C2}$ and $\tau_{Rk,100,C2}$							
Temperature range I, II and III	Ψ_c	[-]	1,0				

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Performance

Essential characteristics for threaded rods
Seismic tension loading category C2
for a working life of 50 or 100 years with diamond drilling

Annex C13

**Table C10 : Essential characteristic for threaded rods
under shear load in concrete under seismic loading category C2**

Threaded rod			M10	M12	M16	M20	M24	M30
For working life of 50 years and 100 years								
Annular gap factor without filling annular gap	α_{gap}	[-]	0,5					
Annular gap factor with Ramset filling washer	α_{gap}	[-]	1.0 ¹⁾					
Steel failure without level arm								
Steel grade 5.8	$V_{Rk,s,C2}$	[kN]	11,6	17,9	31,5	49,1	52,4	88,4
Steel grade 8.8			18,6	28,7	50,4	78,6	83,9	134,6
Stainless steel grade A4-70			16,2	25,1	44,1	68,8	73,4	117,8
HCR Steel 1.4529			16,2	25,1	44,1	68,8	73,4	117,8
HCR Steel 1.4565			16,2	25,1	44,1	68,8	73,4	117,8

1) According to EN 1992-4

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Performance

Essential characteristics for threaded rods
Seismic shear loading category C2
for a working life of 50 or 100 years with hammer and diamond drilling

Annex C14

**Table C11 : Displacement for threaded rod
under tensile load in concrete under seismic loading C2**

Threaded rod			M10	M12	M16	M20	M24	M30
Displacement with HAMMER DRILLING								
Displacement	$\delta_{N,C2}$ (DLS)	[mm]	0.39	0.52	0.30	0.30	0.54	0.54
	$\delta_{N,C2}$ (ULS)	[mm]	0.58	0.66	1.30	0.88	1.73	1.07
Displacement with DIAMOND DRILLING								
Displacement	$\delta_{N,C2}$ (DLS)	[mm]	-	0.52	0.30	0.30	0.54	0.54
	$\delta_{N,C2}$ (ULS)	[mm]	-	0.66	1.30	0.88	1.73	1.07

**Table C12 : Displacement for threaded rod
under shear load in concrete under seismic loading C2**

Threaded rod			M10	M12	M16	M20	M24	M30
Displacement	$\delta_{V,C2}$ (DLS)	[mm]	2,16	2,17	3,96	3,96	4,17	4,17
	$\delta_{V,C2}$ (ULS)	[mm]	5,02	5,24	10,19	10,19	13,84	13,84

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Performance

Displacements

Seismic tensile and shear loading category C2

for a working life of 50 or 100 years with hammer and diamond drilling

Annex C15

Essential characteristics under fire exposure

Characteristic bond resistance $\tau_{Rk,fi,p}(\theta)$ for concrete strength classes C20/25 to C50/60 with all drilling methods under fire conditions

The characteristic bond strength of single bonded fastener under fire conditions $\tau_{Rk,fi,p}$ for a given temperature (θ) has to be calculated by the following equation:

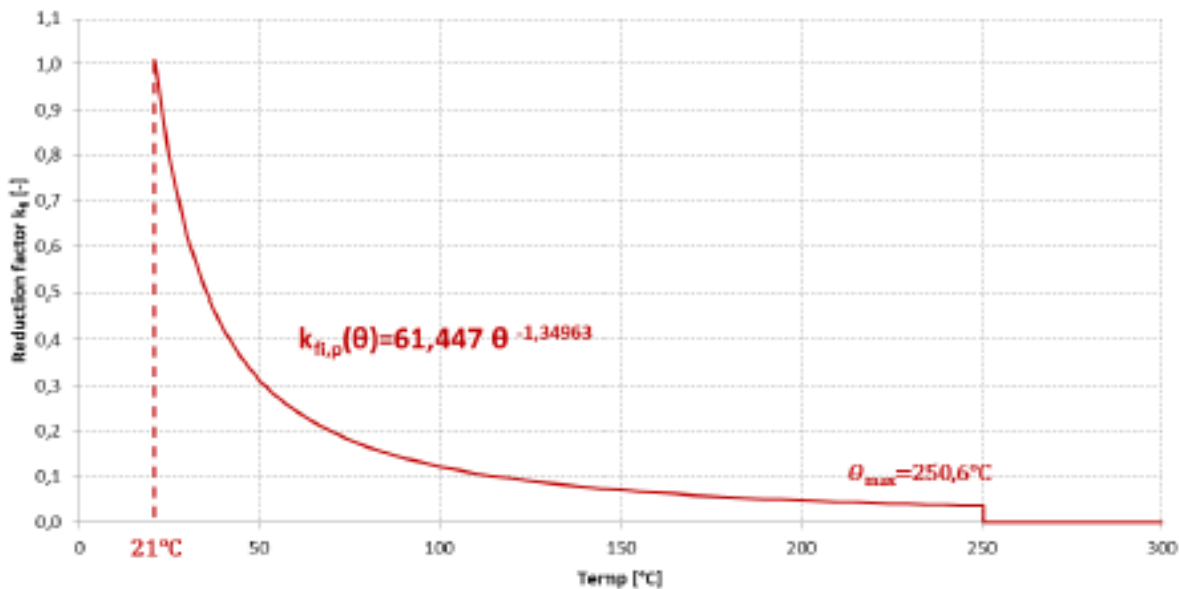
$$\tau_{Rk,fi,p}(\theta) = k_{fi,p}(\theta) \bullet \tau_{Rk,cr,C20/25}$$

where

$$\begin{aligned} \theta < 21^{\circ}\text{C} & \quad k_{fi,p}(\theta) = 1 \\ 21^{\circ}\text{C} \leq \theta \leq 250,6^{\circ}\text{C} & \quad k_{fi,p}(\theta) = K_{fi,p,100y}(\theta) = 61,447 \bullet \theta^{(-1.34963)} \\ \theta > 250,6^{\circ}\text{C} & \quad k_{fi,p}(\theta) = 0 \end{aligned}$$

- $\tau_{Rk,fi,p}$: Characteristic bond resistance for cracked concrete under fire exposure for a given temperature (θ)
- $k_{fi,p}(\theta)$: Reduction factor for bond resistance under fire exposure
- $\tau_{Rk,cr,C20/25}$: Characteristic bond resistance for cracked concrete for concrete strength class C20/25 for the relevant temperature range

Figure C1: Graph of reduction factor $k_b(\theta)$ for concrete strength class C20/25 for good bond conditions



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Performance
Reduction factor for pull-out failure of single fasteners under fire conditons

Annex C16