Deutsches Institut für Bautechnik

Approval body for construction products and types of construction

Bautechnisches Prüfamt

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European Technical Assessment

ETA-18/0154 of 16 July 2021

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™
Product family to which the construction product belongs	System for post-installed rebar connection with mortar
Manufacturer	ITW Australia (Ramset) 1 Ramset Drive Chirnside Park VIC 3116 AUSTRALIEN
Manufacturing plant	ITW Australia
This European Technical Assessment contains	20 pages including 3 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 330087-01-0601, Edition 06/2021
This version replaces	ETA-18/0154 issued on 27 February 2018

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Specific Part

1 Technical description of the product

The subject of this European Technical Assessment is the post-installed connection, by anchoring or overlap connection joint, of reinforcing bars (rebars) in existing structures made of normal weight concrete, using the injection mortar "RAMSET Chemset^{TM} 801 Xtrem^{TM}" or "RAMSET Chemset^{TM} 800 Xtrem^{TM}" in accordance with the regulations for reinforced concrete construction.

Ribbed reinforcing bars made of steel with a diameter ϕ from 8 to 32 mm according to Annex A and the injection mortar "RAMSET Chemset^{TM} 801 Xtrem^{TM}" or "RAMSET Chemset^{TM} 800 Xtrem^{TM}" are used for rebar connections. The rebar is placed into a drilled hole filled with injection mortar and is anchored via the bond between rebar, injection mortar and concrete.

The product description is given in Annex A.

2 Specification of the intended use in accordance with the applicable European assessment Document

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 verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the rebar connections of at least 50 and/or 100 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, 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.

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

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	Performance
Characteristic resistance under static and quasi-static loading	See Annex C 1 to C3
Characteristic resistance under seismic loading	No performance assessed

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1
Resistance to fire	See Annex C 4

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

In accordance with European Assessment Document EAD No. 330087-01-0601, the applicable European legal act is: [96/582/EC].

The system to be applied is: 1

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable European Assessment Document

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 16 July 2021 by Deutsches Institut für Bautechnik

Dipl.-Ing. Beatrix Wittstock
Head of Section

beglaubigt:
Baderschneider

Deutsches Institut für Bautechnik DIBt

Injection mortar

Injection mortar CHEMSET™ 800 XTREM™, CHEMSET™ 801 XTREM™ 380 ml and 750 ml: Vinylester adhesive two components

Marking

Trade name
CHEMSET™ 800 XTREM™ (Regular Version)
CHEMSET™ 801 XTREM™ (Tropical Version)

Identifying mark of the producer **Ramset**

Expire date
Curing and processing time
Charge code number

Static mixer

ISNP mixing nozzle

ISNE mixing nozzle

High flow mixing nozzle

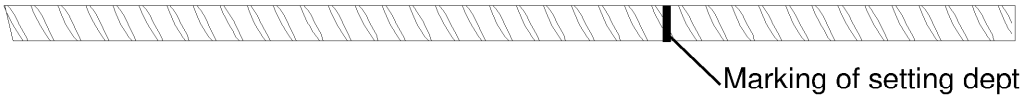
RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Product description
Injection system CHEMSET™ 801 XTREM™

Annex A1

Deutsches Institut für Bautechnik DIBt

Figure A6: Ribbed reinforcing bar (rebar):



Properties of the ribbed reinforcing bar (rebar):

- Rebar according to EN 1992-1-1:2004+AC:2010 Annex C
- Bars or de-coiled rods class B or C
- Nominal diameter ϕ: 8 to 32 mm
- Rib height h in the range of $0{,}05\ \phi \le h \le 0{,}07\ \phi$
- Yield strength f_{yk} and k according to NDP or NCL of EN 1992-1-1/NA
- Ultimate strength $f_{uk} = f_{tk} = k \cdot f_{yk}$

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™	
Product description Specification rebar	**Annex A2**

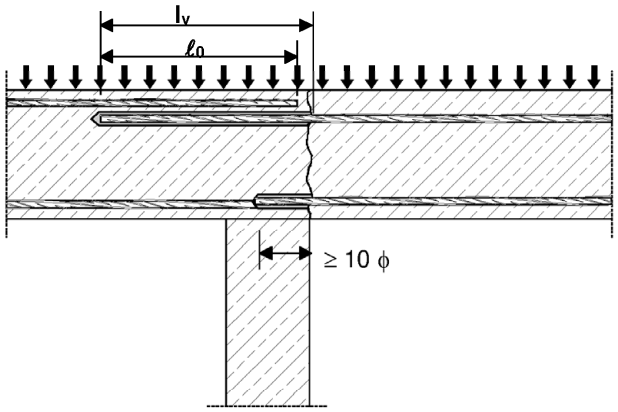


Figure A1: Overlap joint for rebar connections of slabs and beams

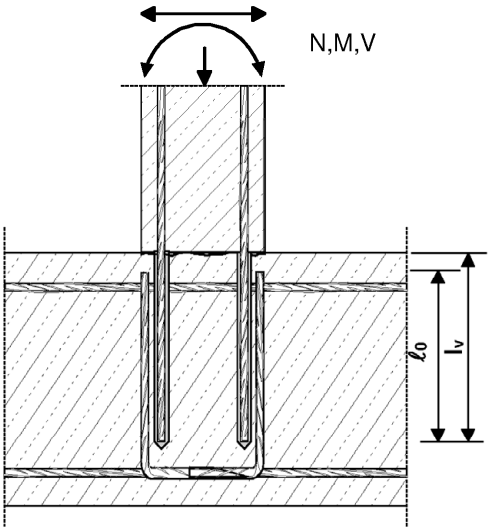


Figure A2: Overlap joint at a foundation of a column or wall where the rebars are stressed in tension

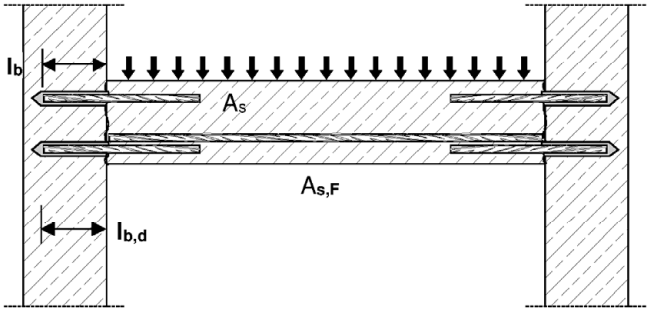


Figure A3: End anchoring of slabs or beams, designed as simply supported

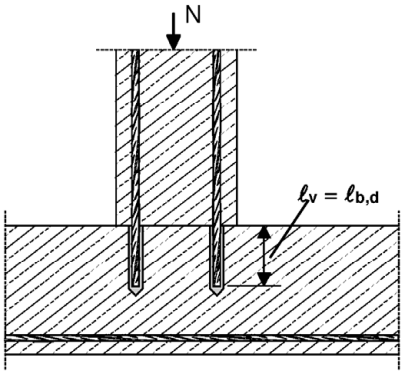


Figure A4: Rebar connection for components stressed primarily in compression. The rebars are stressed in compression

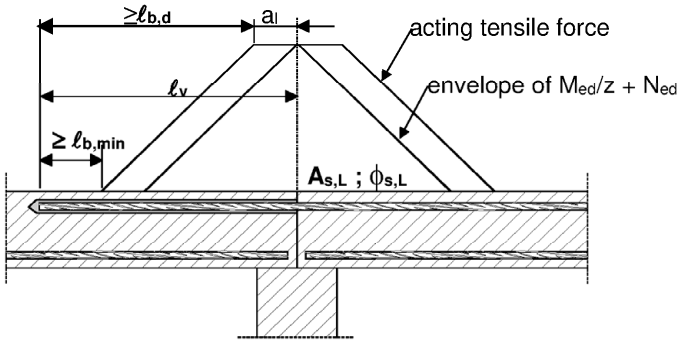


Figure A5: Anchoring of reinforcement to cover the line of acting tensile force

Note to Figure A1 to A5:

- In the Figures no transverse reinforcement is plotted, the transverse reinforcement as required by EN 1992-1-1:2004+AC:2010 shall be present.
- Preparing of joints according to Annex B2

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Product description
Specification rebar

Annex A3

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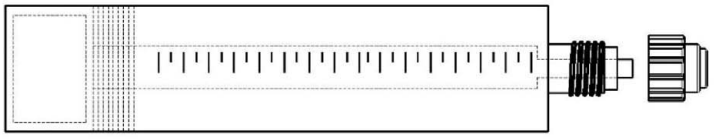
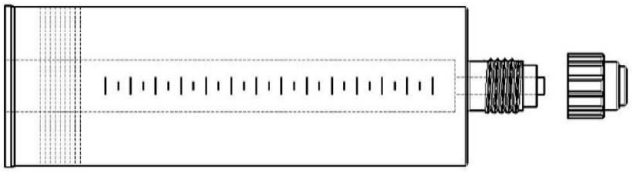
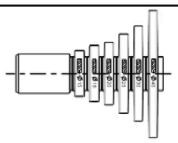
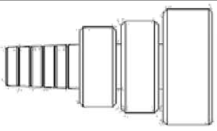
Cartridges

380 ml coaxiale cartridge	
750 ml coaxiale cartridge	

Injection accessories for deep hole

Plastic extension must be use for hole deeper h_0 > 250 mm
Piston plug for hole deeper must be use for hole deeper h_0 > 350 mm

Cartridge volume	Mixing Nozzle	Extension for piston plug	Piston plug
All cartridges	ISNE mixing nozzle ISNP missing nozzle	Ø13x1000	
Cartridge 750 ml	High flow mixing nozzle	Ø20x1000	

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Product description
Cartridges
Injection accessories for deep hole

Annex A4

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Specifications of intended use

Anchorages subject to:

- Static and quasi static loading
- Fire exposure.

Base material:

- Compacted Reinforced or unreinforced normal weight concrete without fibres of strength classes C 20/25 to C50/60 according to EN 206:2013+A1:2016
- Maximum chloride content of 0,40 % (CL 0.40) related to the cement content according to
- EN 206:2013+A1:2016
- Non-carbonated concrete

Note: In case of a carbonated surface of the existing concrete structure the carbonated layer shall be removed in the area of the post-installed rebar connection with a diameter of ϕ + 60 mm prior to the installation of the new rebar. The depth of concrete to be removed shall correspond to at least the minimum concrete cover in accordance with EN 1992-1-1:2004+AC:2010.The foregoing may be neglected if building components are new and not carbonated and if building components are in dry conditions.

Temperature range:

- - 40°C to +80°C: max short term temperature +80°C, max long term temperature +50°C

Design:

- Anchorages are designed under the responsibility of an engineer experienced in anchorages and concrete work.
- Verifiable calculation notes and drawings are prepared taking account of the forces to be transmitted.
- Design according to EN 1992-1-1:2004+AC:2010, EN 1992-1-2:2004+AC:2008 and Annex B 2 and B 3.
- 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.

Installation:

- Drilling technique:
  - Hammer drilling technique: all sizes
  - Hammer drilling with hollow drill bit XTD: sizes ϕ 12-25
  - Compressed air drilling: all sizes
  - Diamond drilling technique with roughening tool: sizes ϕ 12-32
- Use category:
  - dry or wet concrete (not in flooded holes) for Hammer drilling technique, compressed air drilling and diamond drilling technique with roughening tool
  - Only dry concrete for hammer drilling with hollow drill bit XTD
  - Installation direction downwards, horizontal and overhead

- The installation of post-installed rebar resp. tension anchors shall be done only by suitable trained installer and under supervision on site; the conditions under which an installer may be considered as suitable trained and the conditions for supervision on site are up to the Member States in which the installation is done.

- Check the position of the existing rebars (if the position of existing rebars is not known, it shall be determined using a rebar detector suitable for this purpose as well as on the basis of the construction documentation and then marked on the building component for the overlap joint).

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™	
Intended Use Specifications	**Annex B1**

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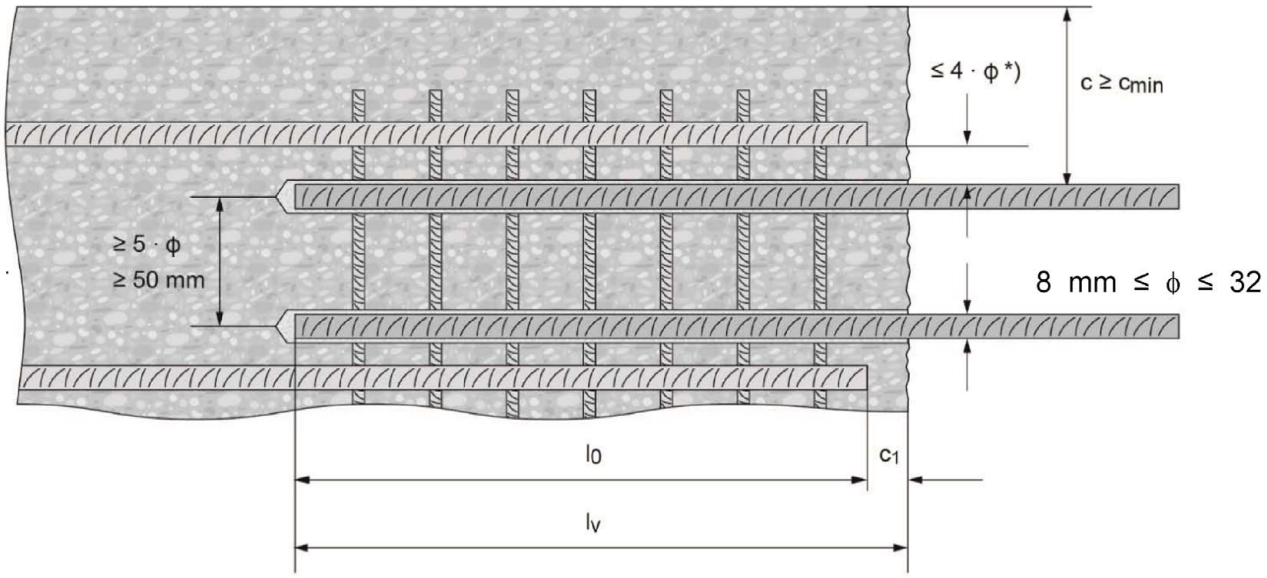
Figure B1: Construction rules for post-installed rebars

- Only tension forces in the axis of the rebar may be transmitted.
- The transfer of shear forces between new concrete and existing structure shall be designed additionally according to EN 1992-1-1:2004+AC:2010.
- The joints for concreting must be roughened to at least such an extent that aggregate protrude.



*) If the clear distance between lapped bars exceeds 4.ϕ, then the lap length shall be increased by the difference between the clear bar distance and 4.ϕ

- c: concrete cover of post-installed rebar
- c_1: concrete cover at end-face of existing rebar
- c_{min}: minimum concrete cover according to Table B1 and to EN 1992-1-1:2004+AC:2010, Section 4.4.1.2
- ϕ: diameter of post-installed rebar
- l_0: lap length, according to EN 1992-1-1:2004+AC:2010, Section 8.7.3
- l_v: effective embedment depth ≥ $l_0 + c_1$
- d_0 nominal drill bit diameter, see Annex B3
- Minimum spacing between two post-installed bars a = 50 mm ≥ 5ϕ

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Intended used
General construction rules for post-installed rebars

Annex B2

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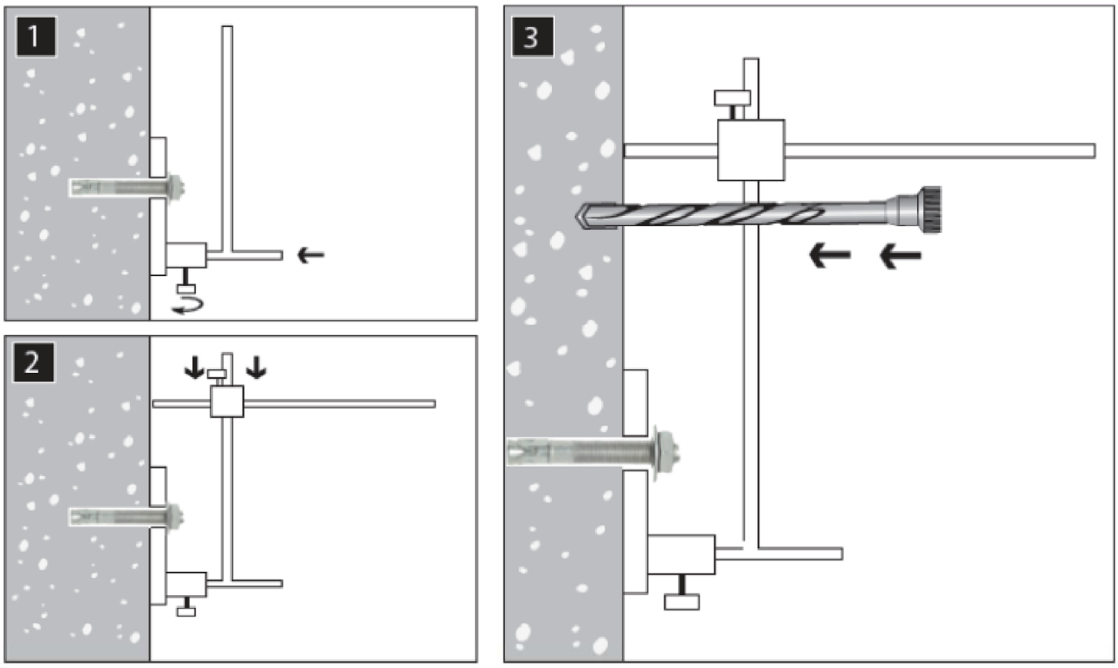
Table B1: Minimum concrete cover c_{min} [1] of post-installed rebar

Drilling method	Bar diameter ϕ	Without drilling aid	With drilling aid
Hammer drilling	< 25 mm	30 + 0,06 $l_v \geq 2\phi$	30 + 0,02 $l_v \geq 2\phi$
	≥ 25 mm	40 + 0,06 $l_v \geq 2\phi$	40 + 0,02 $l_v \geq 2\phi$
Hammer drilling with hollow drill bit XTD	< 25 mm	30 + 0,06 $l_v \geq 2\phi$	30 + 0,02 $l_v \geq 2\phi$
	≥ 25 mm	40 + 0,06 $l_v \geq 2\phi$	40 + 0,02 $l_v \geq 2\phi$
Compressed air drilling	< 25 mm	50 + 0,08 $l_v \geq 2\phi$	50 + 0,02 $l_v \geq 2\phi$
	≥ 25 mm	60 + 0,08 $l_v \geq 2\phi$	60 + 0,02 $l_v \geq 2\phi$
Diamond core drilling	< 25 mm	Drill stand is used as drilling aid	30 + 0,02 $l_v \geq 2\phi$
	≥ 25 mm		40 + 0,02 $l_v \geq 2\phi$

[1] See Annex B2, Figure B1
Note: The minimum concrete cover as specified in EN 1992-1-1:2004+AC:2010 must be observed

Figure B2: Drilling aid system



RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Intended used
Minimum concrete cover c_{min}

Annex B3

Deutsches Institut für Bautechnik DIBt

Table B2: Maximum embedment depth $l_{v,max}$ depending on bar diameter and dispenser

Rebar diameter ϕ	Maximum embedment length $l_{v,max}$ [mm]		
[mm]	Manuel Dispenser	Pneumatic Dispenser	
	380 ml 750 ml	380 ml	750 ml
8	500	600	900
10			
12			
16			
20			
25			
28			
32			

Table B3: Installation parameters

Rebar diameter ϕ	Nominal drilling diameter d_{cut} [mm]			
[mm]	Hammer drilling	Hammer drilling with hollow drill bit XTD [1)]	Diamond core	Diamond core and roughening drill bit
8	10	-	-	-
10	12	-	-	-
12	15	16	16	-
16	20	20	-	20
20	25	25	-	25
25	30	30	-	30
28	35	-	-	35
32	40	-	-	40

[1)] Maximum working length: 600 mm

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Intended used
Maximum embedment depth l_{vmax}
Installation parameters

Annex B4

Deutsches Institut für Bautechnik DIBt

Table B4: Parameters for use of Roughening tool

Diamond coring d_{cut} [mm]	Roughening tool [1] d_{cut} [mm]
20	20
25	25
30	30
35	35
40	40

[1] For checking the wear of roughening drill bit, a wear gauge is delivered with each roughening tool

Table B5: Dimensions of the cleaning tools for reinforcing bars (rebars)

	Nominal diameter of the reinforcing bars (rebars)								
Dimensions	ϕ8	ϕ10	ϕ12	ϕ14	ϕ16	ϕ20	ϕ25	ϕ28	ϕ32
Ø Brush [mm] [1] 	11	13	16	20	22	26	32	37	42
Ø Plastic extension for compress air	6	9	9	13	13	13	13/20	13/20	13/20

[1] The diameter of the round steel brush shall be checked before use. The minimum brush diameter has to be at least equal to the borehole diameter d_0. The round steel brush shall produce natural resistance as it enters the drill hole. If this is not the case, please use a new brush or a brush with a larger diameter.

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™	**Annex B5**
Intended used Parameters for using of roughening drill bit Dimensions of cleaning tools	

Deutsches Institut für Bautechnik DIBt

Table B6: Gel time and curing time for Regular Version

Temperature of base material	Working time	Curing time[1)]
-10°C to -5°C	90 min	24 h
-4°C to 0°C	50 min	240 min
1°C to 5°C	25 min	120 min
6°C to 10°C	15 min	90 min
11°C to 20°C	7 min	60 min
21°C to 30°C	4 min	45 min
31°C to 40°C	2 min	30 min

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

Table B7: Gel time and curing time for Tropical Version:

Temperature of base material	Working time	Curing time[1)]
+ 5°C	60 min	240 min
6°C to 10°C	40 min	180 min
11°C to 20°C	15 min	120 min
21°C to 30°C	8 min	60 min
31°C to 40°C	4 min	60 min

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

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Product description
Minimum curing time and maximum working time

Annex B6

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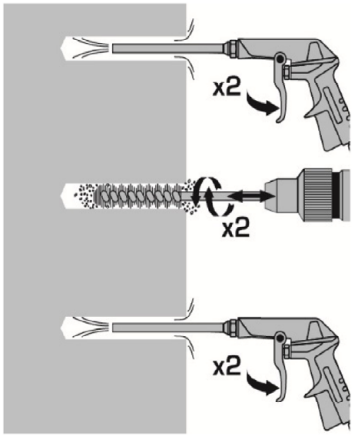
Drilling the hole:

	Rotary hammer drilling or compressed air drilling
	Electrical hammer drilling with XTD hollow drill bit used in relation with the Ramset vacuum. This drilling technique allows for cleaning the hole from the dust debris while operating drilling. No further cleaning is then required before injecting resin.
	Diamond core drilling The roughening tool must be used for core diameter higher than 20 mm.

Cleaning the hole:

Hammer drilling technique

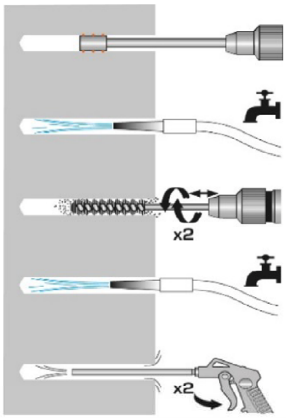


1. Using compress air cleaning (min 6 bars), use the appropriate extension, starting from the top of the hole blow out at least 2 times by moving downward to the bottom of the hole then moving upward to the top of the hole and until no dust is evacuated. (not less than 10s per each blowing).
2. Using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

Hammer drilling technique

Electrical hammer drilling with XTD hollow drill bit used in relation with the Ramset vacuum. This drilling technique allows for cleaning the hole from the dust debris while operating drilling. No further cleaning is then required before injecting resin.

Diamond core drilling technique



1. For core diameter higher than 20 mm, remove water in the hole and use the roughening drill bit before applying cleaning procedure
2. Clean the hole with tap water.
3. 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 move upward to the top of the hole. Repeat this operation.
4. Clean the hole with tap water
5. 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™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Product description
Installation instruction

Annex B7

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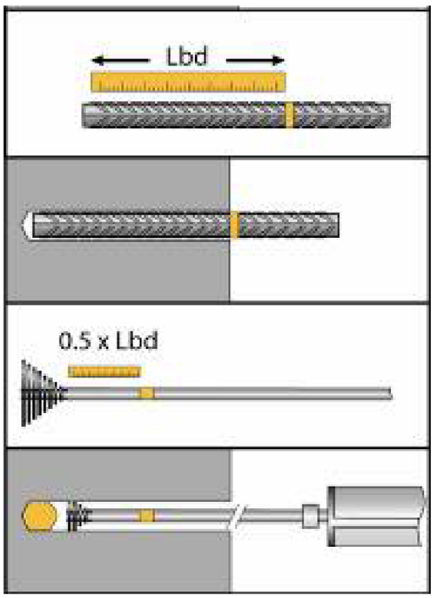
Safety precaution:

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

- Storage temperature of cartridge +0°C to +35 °C
- Cartridge temperature at time of installation: Must be ≥ +5°C
- Base material temperature at time of installation: Must be between -10°C and +40°C
- Check the date of expiry of the cartridge

Dispensing into the hole:



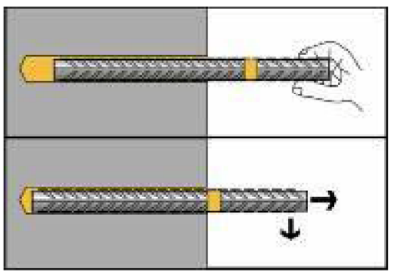
1. Put the anchorage depth mark on the rebar

2. Check the anchorage depth

3. Cut the piston plug at the relevant diameter. The volume of resin that need to be injected in the hole must be indicated on the mixing nozzle or its extension. The marking must be placed at 0.5 time the anchorage depth

4. Dispense the first part to waste until an even colour is achieved (≈ 20cm). 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 the hole until the mark appear. For pneumatic dispenser with 380 ml cartridge, the maximum pressure is 6 bars.

Inserting the rebar:



1. Immediately insert the rebar, 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 (See Annex B6 Table B6 or B7) which varies according to temperature of base material.

2. Leave the rebar undisturbed until the curing time has elapse. (See Annex B6 Table B6 or B7)

RAMSET Chemset™ 801 Xtrem™ / RAMSET Chemset™ 800 Xtrem™

Product description
Installation instruction

Annex B8

Deutsches Institut für Bautechnik DIBt

Minimum anchorage length and minimum lap length

The minimum anchorage length $l_{b,min}$ and the minimum lap length $l_{0,min}$ according to EN 1992-1-1:2004+AC:2010 shall be multiplied by the relevant amplification factor $\alpha_{lb}=\alpha_{lb,100y}$ given in Table C1.

Table C1: Amplification factor $\alpha_{lb} = \alpha_{lb,100y}$ related to concrete strength class for Hammer drilling and compressed air drilling with a working life of 50 or 100 years

Rebar diameter	Amplification factor $\alpha_{lb} = \alpha_{lb,100y}$ [-]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ8	1,0								
ϕ10	1,0								
ϕ12	1,0								
ϕ14	1,0							1,1	
ϕ16	1,0						1,1		
ϕ20	1,0						1,1	1,2	1,2
ϕ25	1,0				1,1		1,2	1,3	1,3
ϕ28	1,0				1,1		1,2	1,3	1,4
ϕ32	1,0				1,2		1,3	1,4	1,5

Table C2: Bond efficiency factor $k_b = k_{b,100y}$ for Hammer drilling and compressed air drilling with a working life of 50 or 100 years.

Rebar diameter	Bond efficiency factor $k_b = k_{b,100y}$ [-]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ8-ϕ32	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

Table C3: Design values of the bond strength $f_{bd,PIR} = f_{bd,PIR,100y}$ in N/mm² for Hammer drilling and compressed air drilling with a working life of 50 or 100 years

$f_{bd,PIR} = k_b \cdot f_{bd}$

$f_{bd,PIR,100y} = k_{b,100y} \cdot f_{bd}$

f_{bd}: Design value of the bond strength in N/mm² considering the concrete strength classes and the rebar diameter for good bond condition (for all other bond conditions multiply the values by $\eta_1 = 0,7$) and recommended partial factor $\gamma_c = 1,5$ according to EN 1992-1-1:2004+AC:2010

k_b and $k_{b,100y}$: Bond efficiency factor according to Table C2

Rebar diameter	Bond strength $f_{bd,PIR} = f_{bd,PIR,100y}$ [N/mm²]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ8-ϕ32	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3

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Performance
Minimum anchor length and minimum lap length, amplification factor, bond efficiency factor and design value of bond strength

Annex C1

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Minimum anchorage length and minimum lap length

The minimum anchorage length $l_{b,min}$ and the minimum lap length $l_{0,min}$ according to EN 1992-1-1:2004+AC:2010 shall be multiplied by the relevant amplification factor α_{lb} given in Table C4.

Table C4: Amplification factor α_{lb} for Hammer drilling with XTD hollow drill bit with a working life of 50 years

Rebar diameter	Amplification factor α_{lb} [-]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ12-ϕ25	1,5								

Table C5: Bond efficiency value k_b for Hammer drilling with XTD hollow drill bit with a working life of 50 years

Rebar diameter	Bond efficiency factor k_b [-]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ12-ϕ25	1,0								

Table C6: Design values of the bond stregth $f_{bd,PIR}$ in N/mm² for Hammer drilling with XTD hollow drill bit with a working life of 50 years

$f_{bd,PIR} = k_b \cdot f_{bd}$

f_{bd}: Design value of the bond strength in N/mm² considering the concrete strength classes and the rebar diameter for good bond condition (for all other bond conditions multiply the values by $\eta_1 = 0,7$) and recommended partial factor $\gamma_c = 1,5$ according to EN 1992-1-1:2004+AC:2010

k_b: Bond efficiency factor according to Table C5

Rebar diameter	Bond strength $f_{bd,PIR}$ [N/mm²]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ12-ϕ25	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3

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Performance
Minimum anchor length and minimum lap length, amplification factor, bond efficiency factor and design value of bond strength

Annex C2

Deutsches Institut für Bautechnik DIBt

Minimum anchorage length and minimum lap length

The minimum anchorage length $l_{b,min}$ and the minimum lap length $l_{0,min}$ according to EN 1992-1-1:2004+AC:2010 shall be multiplied by the relevant amplification factor α_{lb} given in Table C7.

Table C7: Amplification factor α_{lb} for Diamond drilling with a working life of 50 years

Rebar diameter	Amplification factor α_{lb} [-]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ12	1,0							1,1	1,2
ϕ14									
ϕ16									
ϕ20									1,1
ϕ25								1,0	
ϕ28									1,0
ϕ32									

Table C8: Bond efficiency value k_b for Diamond drilling with a working life of 50 years

Rebar diameter	Bond efficiency factor k_b [-]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ12-ϕ20	1,0								
ϕ25	1,0								0,9
ϕ28	1,0							0,9	0,9
ϕ32	1,0						0,9	0,8	0,9

Table C9: Design values of the bond strength $f_{bd,PIR}$ in N/mm² for Diamond drilling With a working life of 50 years

$f_{bd,PIR} = k_b \cdot f_{bd}$

f_{bd}: Design value of the bond strength in N/mm² considering the concrete strength classes and the rebar diameter for good bond condition (for all other bond conditions multiply the values by $\eta_1 = 0,7$) and recommended partial factor $\gamma_c = 1,5$ according to EN 1992-1-1:2004+AC:2010

k_b: Bond efficiency factor according to Table C8.

Rebar diameter	Bond strength $f_{bd,PIR}$ [N/mm²]								
	Concrete strength class								
	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
ϕ12-ϕ20	1,6	2,0	2,3	2,7	3,0	3,4	3,7	4,0	4,3
ϕ25									4,0
ϕ28								3,7	4,0
ϕ32							3,4	3,4	3,7

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Performance
Minimum anchor length and minimum lap length, amplification factor, bond efficiency factor and design value of bond strength

Annex C3

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Bond strength $f_{bd,fi} = f_{bd,fi,100y}$ at increased temperature for concrete strength classes C12/15 to C50/60

The bond strength $f_{bd,fi} = f_{bd,fi,100y}$ at increased temperature has to be calculated by the following equation:

$$f_{bd,fi} = f_{bd,fi,100y} = k_{fi}(\theta) \bullet f_{bd,PIR} \bullet \gamma_c / \gamma_{M,fi}$$

where

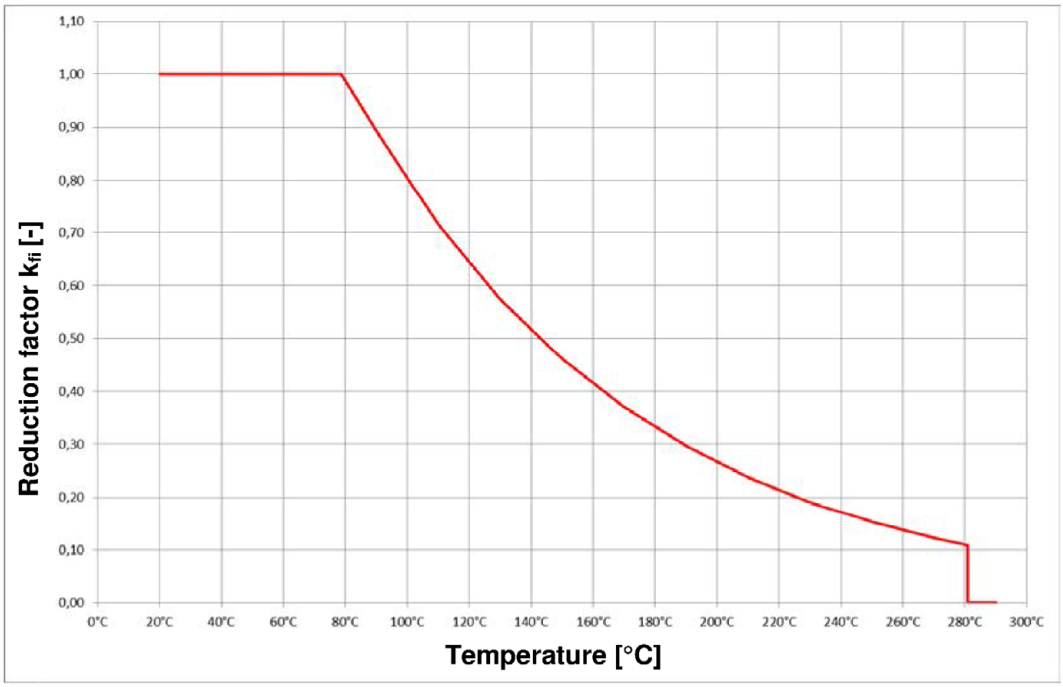
$\theta < 281$ °C: $k_{fi}(\theta) = \min \{1{,}0; 23{,}755\ e^{-0{,}011 \bullet \theta} / (f_{bd,PIR} \bullet 4{,}3)\}$

$\theta > 281$ °C: $k_{fi}(\theta) = 0$

$f_{bd,fi}$	Bond strength at increased temperature in N/mm² for a working life of 50 years (all drilling methods)
$f_{bd,fi,100y}$	Bond strength at increased temperature in N/mm² for a working life of 100 years (Hammer and compressed air drilling)
(θ)	Temperature in °C in the mortar layer
$k_{fi}(\theta) = k_{fi,100y}(\theta)$	Reduction factor at increased temperature
$f_{bd,PIR}$	Design values of the bonds strength in N/mm² according to Tables C3, C6 and C9 considering the concrete classes, the rebar diameter, the drilling method and the bond condition according to EN 1992-1-1:2004+AC:2010
γ_c	Partial factor according to EN 1992-1-1:2004+AC:2010
$\gamma_{M,fi}$	Partial factor according to EN 1992-1-2:2004+AC:2010

For evidence at increased temperature the anchorage length shall be calculated according to EN 1992-1-1:204+AC:2010, Equation 8.3 using the temperature-dependent bond strength $f_{bd,fi}$.

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



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Performance
Bond strength at increased temperature

Annex C4