iBMB MPA TU BRAUNSCHWEIG
Institut für Baustoffe, Massivbau und Brandschutz | Materialprüfanstalt für das Bauwesen

Expert Opinion

- Translation -

Document No.:	(2101/942/16) – CM of 30/11/2017
Client	G&B Fissaggi Corso Savona, 22 10029 Villatellone (TO) Italy
Order date:	13/09/2016
Order Ref.:	-
Order received:	13/09/2016
Subject:	Loaded Gebofix PRO VE-SF injection systems placed in reinforced-concrete members to be assessed for their reaction to fire for determination of the fire resistance time when exposed to a standard temperature-time curve (ETK) fire in accordance with DIN EN 1363-1: 2012-10
Basis for assessment:	See section 1

This Expert Opinion consists of 8 pages, including the cover sheet and 5 annexes.

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Notified body (0761-CPR) -
Approved as a civil engineering testing, inspection and certifying body as well as notified as a civil engineering testing and certifying body.

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1 Background and commission

With their letter of 13/09/2016, G&B Fissaggi commissioned the MPA Braunschweig to prepare an Expert Opinion for Gebofix PRO VE-SF injection systems in connection with reinforced concrete members that are subjected to a fire from one side.

The Expert Opinion is based on the tests made for Gebofix PRO VE-SF injection systems in connection with reinforced-concrete members, which were exposed to a standard temperature-time curve fire in accordance with DIN EN 1363-1: 2012-10.

The following documents were used as a basis for the Expert Opinion:

[1] DIN EN 1363-1: 2012-10; fire resistance tests – part 1: general requirements

[2] European Technical Report TR 020 : 2004-05, Evaluation of Anchorages in Concrete concerning Resistance to Fire

[3] DIN EN 1992-4, Eurocode 2: Design of concrete structures – Part 4: Design of fastenings for use in concrete; German version prEN 1992-4:2013

[4] Test Report No. (2100/679/15), issued by MPA Braunschweig

[5] Client's technical data sheets for Gebofix PRO VE-SF injection systems

[6] ETA-16/0600 of 12/09/2016, Gebofix PRO VE-SF injection systems, issued by the "Technical an Test Institute for Construction Prague", Prague

The Gebofix PRO VE-SF injection systems are designed on the basis of fire tests that were carried out with uncracked reinforced concrete. The Technical Rules and Regulations and the Technical Specifications, which provide details primarily for mechanical fastenings that are suited under cracked conditions in connection with reinforced-concrete members in a fire, do not yet offer a complete design concept for chemical fastening systems. At the moment, a building code attestation (e.g. ETA) that would provide details for the Gebofix PRO VE-SF injection systems in the event of a fire is not available. The approvals that are listed above only contain specifications for the normal intended use at normal temperatures.

2 Description of the protection systems

The Gebofix PRO VE-SF injection systems consist of the G&B injection systems "injection mortar" and a "G&B threaded rod" anchoring bar with nuts and washers. The Gebofix PRO VE-SF injection systems for anchoring in reinforced concrete components primarily under dead load are regulated for the normal purpose of use by European technical application document ETA-16/0600 of 12/09/2016. The injection Gebofix PRO VE-SF injection systems (M8 bis M30) are made from electrogalvanized steel or stainless steel. The nuts and washers are made from electrogalvanized steel or stainless steel like the anchoring bars. The injection system's mode of action makes use of the bond and forms it between the injection mortar, anchoring bar and base material.

The Gebofix PRO VE-SF injection systems were installed according to the installation instructions using the installation tools specified in these documents and relevant tools (heavy - duty hammer drill and drill bit, setting tool and cleaning equipment).

Table 1: Gebofix PRO VE-SF injection systems in connection with G&B anchor rods (bonded anchor action)

G&B injection system Gebofix PRO VE-SF	**Anchor rod dimension (stress cross section A_s [mm])**							
Type of anchor rod	M8 (36.60)	M10 (58.00)	M12 (84.30)	M16 (157.00)	M20 (245.00)	M24 (353.00)	M27 (459.00)	M30 (561.00)
Anchor rod (strength class ≥ 4.8)	M8 to M30							
Anchor rod (stainless steel 1.4401, 1.4404, 1.4571, 1.4529)	M8 to M30							

For further details of the systems, reference is made to the annexes, the G&B Fissaggi installation instructions for the Gebofix PRO VE-SF injection systems and the approvals listed above.

3 Assessment regarding fire resistance time as a function of the maximum Gebofix PRO VE-SF injection systems loading in connection with reinforced-concrete members

The Gebofix PRO VE-SF injection systems, consisting of the G&B injection systems mortar compound and the steel elements required from case to case (anchor rod, threaded bolt), can be assessed for their fire resistance time on the basis of the existing fire performance approvals in connection with reinforced concrete structures.

3.1 Assessment regarding fire resistance time as a function of maximum loading in a fire (centric tensile load)

The above-mentioned systems were assessed for their fire resistance time as a function of maximum loading in a fire (centric tensile load) with respect to system failure (steel failure and bond failure by anchor bar pull-out) on the basis of fire tests that had been performed based on Technical Report TR 020 : 2004-05 in uncracked reinforced concrete. The design values are shown in table 3.1.

$N_{fire(t)}$ ⇒ is the rated value determined depending on the function of the fire resistance time. This value considers the steel failure values (section 3.1.1) and pull-out (section 3.1.2).

For the purposes discussed here, the load bearing capacity respecting steel failure describes the resistance of the steel components (anchor bars, threaded bolts) of the Gebofix PRO VE-SF injection systems under tension in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10. Steel failure becomes decisive as soon as the bond strength of the Gebofix PRO VE-SF injection systems exceeds the resistance respecting steel failure. Load bearing capacities beyond the steel failure of the Gebofix PRO VE-SF injection systems cannot be specified.

The load bearing capacity respecting bond failure (anchor bar pull-out) describes the resistance of the Gebofix PRO VE-SF injection systems (anchor rod in connection with the mortar) in connection with the reinforced-concrete base (strength classes C20/25 to C50/60) when exposed to tensile loads in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10. The bond strength is influenced by temperature. In the event of a fire, there are temperature gradients along the element anchoring depth. The load bearing capacity of the anchor is limited either by the bond, the concrete or steel failure. From a certain anchoring depth, steel failure can become decisive. Higher load bearing capacities cannot be specified.

Table 2: Proposed rating for the Gebofix PRO VE-SF injection systems (dimension M8 – M30) made from electrogalvanised steel or stainless steel, regarding their fire resistance time as a function of stress σ_s under centric tensile load and the minimum placement depth

designation	**Gebofix PRO VE-SF**							
stress cross section [N/mm²]	36,0	58,0	84,4	157,0	247,0	353,0	459,0	561,0
min. Setting deep [mm]	80	90	110	125	170	210	250	280
fire resistance time / **tu**	**max. load** $N_{fire}(t)$[kN]							
[min]	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
30	0,59	0,75	2,00	3,73	5,82	8,39	10,91	13,33
60	0,38	0,52	1,70	3,17	4,95	7,14	9,28	11,34
90	0,17	0,28	1,40	2,62	4,08	5,88	7,65	9,35
120	0,07	0,17	1,25	2,34	3,65	5,25	6,83	8,35

For the normal intended use, loads resulting from the ETA [6] may be decisive.

3.1.1 Load bearing capacity respecting concrete failure / concrete cone failure (centric tensile load)

For the purposes discussed here, the load bearing capacity respecting concrete failure describes the resistance of the Gebofix PRO VE-SF injection systems in connection with the reinforced-concrete base (strength classes C20/25 to C50/60) as a function of the position and installation of the anchors under tension in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10. Concrete failure becomes decisive, as soon as the load-bearing capacity of the base, in connection with the fastening means, is no longer adequate.

It is recommended to demonstrate the resistance against the failure mode "concrete cone failure" on the basis of DIN EN 1992-4, Annex D (informative).

Length of fire exposure ≤ 90 minutes:

$$N^0_{RK,p,fire(90)} = h_{ef}/200 \times N^0_{RK,p(90)} \qquad \leq N^0_{Rk,p}$$

Length of fire exposure ≥ 90 ≤ 120 minutes:

$$N^0_{RK,p,fire(120)} = 0.8 \times h_{ef}/200 \times N^0_{Rk,p(120)} \qquad \leq N^0_{Rk,p}$$

h_{ef} ⇒ effective anchoring depth in accordance with the approval ([6]).

$N^0_{Rk,p} \Rightarrow$ initial value of the characteristic resistance in accordance with the approval ([6]). The characteristic load bearing capacity for bonded anchors in accordance with [3] is in this case determined for the normal intended use with the failure combination concrete cone failure and pull-out ($N^0_{Rk,p}$), consideration given to the characteristic bond strength τ_{RK}.

If fastenings are located near edges in a fire, the critical centre / edge distance has to be accounted for with $s_{cr,N} = 2c_{cr,N} = 4h_{ef}$ for concrete failure. Additional parameters (geometry, spalling, eccentricity, position within the member and other influencing factors) may have to be separately accounted for.

3.1.2 Load bearing capacity respecting gaps (centric tensile load)

Verification respecting gaps (without fire exposure) is made on the basis of the building code approvals ([6]). Up-to-date technical standards do not require any verification under conditions of a fire, because it is assumed that the reinforcement will take the gap forces.

3.2 Assessment regarding fire resistance time as a function of maximum loading in a fire (lateral load)

The fire resistance time as a function of maximum loading in a fire (lateral load) of the systems described above was determined on the basis of section 3.1, assuming that

$$V_{fire(t)} = N_{fire(t)}$$

applies. In addition, proof regarding concrete failure has to be established in accordance with section 3.2.2

$V_{fire(t)}$ $\Rightarrow$ is the rated value determined depending on the function of the fire resistance time.

3.2.1 Load bearing capacity respecting concrete failure (lateral load)

For the purposes discussed here, the load bearing capacity respecting concrete failure describes the characteristic resistance of the Gebofix PRO VE-SF injection systems in connection with the reinforced-concrete base (strength classes C20/25 to C50/60) as a function of the position and installation of the anchors under tension in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1: 2012-10.

Concrete failure becomes decisive, as soon as the load-bearing capacity of the base, in connection with the fastening means, is no longer adequate and/or the required fire resistance time of the reinforced-concrete structure can no longer be complied with.

3.2.1.1Resistance respecting concrete failure / rear-end concrete cone failure under lateral loads

It is recommended to demonstrate the resistance against the failure mode "rear-end concrete cone failure" on the basis of DIN EN 1992-4, Annex D (informative).

$V^0_{Rk,cp,fire(90)} = k \times N_{Rk,p,fire(90)}$

$V^0_{Rk,cp,fire(120)} = k \times N_{Rk,p,fire(120)}$

k value ⇒ coefficient in accordance with approval ([6]).

$N_{Rk,p,fire(90)}$ ⇒ see section 3.1.1

Additional parameters (geometry, spalling, eccentricity, position within the member and other influencing factors) may have to be separately accounted for.

Resistance respecting concrete failure / concrete edge failure (lateral load)

It is recommended to demonstrate the resistance against the failure mode "concrete edge failure" on the basis of DIN EN 1992-4, Annex D (informative).

$V^0_{Rk,c,fire(90)} = 0.25 \times V^0_{Rk,c}$

$V^0_{Rk,c,fire(120)} = 0.20 \times V^0_{Rk,c}$

$V^0_{Rk,c}$ ⇒ initial value of the characteristic resistance in reinforced concrete in accordance with the approval ([6]). $V^0_{Rk,c}$ can be determined in accordance with TR029 or DIN EN 1992-4.

Additional parameters (geometry, spalling, eccentricity, position within the member and other influencing factors) may have to be separately accounted for.

4 Additional information

4.1 This Expert Opinion does not replace the required building code attestation (Building Code Test Certificate, National Technical Approval, ETA).

4.2 The above assessment only applies to Gebofix PRO VE-SF injection systems in connection with uncracked reinforced-concrete members, due regard given to the conditions specified in the client's technical data sheets.

4.3 The assessment for the Gebofix PRO VE-SF injection systems only applies in connection with reinforced-concrete systems that are subjected to a fire from one side, and that can at least be classified into the fire resistance class that corresponds to that of the injection system.

4.4 The rating of the Gebofix PRO VE-SF injection systems relates to the fastening means in connection with reinforced-concrete members that are subjected to a standard temperature-time curve fire in accordance with DIN EN 1363-1: 2012-10 from one side. When more than one side are exposed to a fire of max. 90 minutes, the rated values may be applied only, if the steel failure becomes decisive, the fire resistance class of the reinforced-concrete member is not adversely affected, and a distance of $c \geq 300$ mm and $c \geq 2h_{ef}$ is maintained between the Gebofix PRO VE-SF injection systems and the edge.

4.5 The validity of this Expert Opinion will expire on 30/11/2022.

This document is a transfer. The legally binding text is the aforementioned German Expert Opinion.

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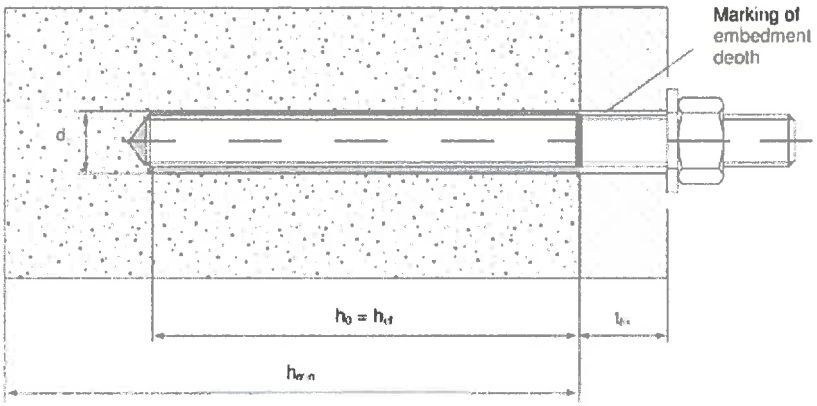


Table 3: technical data

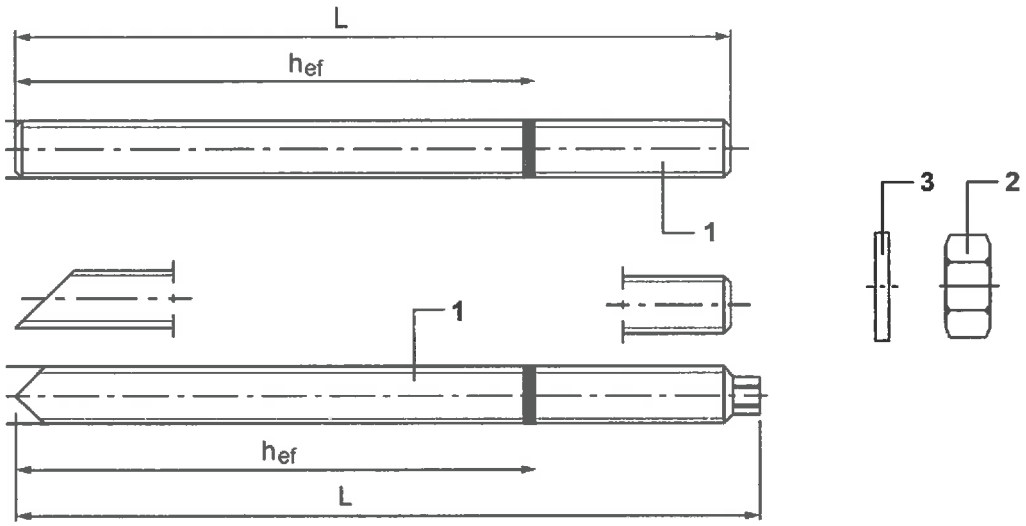
Anchor size		M8	M10	M12	M16	M20	M24	M27	M30
Nominal drill hole diameter	d_0 [mm] =	10	12	14	18	22	26	30	35
Effective anchorage depth	$h_{ef,min}$ [mm] =	64	80	96	128	160	192	216	240
	$h_{ef,max}$ [mm] =	160	200	240	320	400	480	540	600
Diameter of clearance hole in the fixture	d_f [mm] ≤	9	12	14	18	22	26	30	33
Diameter of the steel brush	d_b [mm] ≥	12	14	16	20	26	30	35	43
Torque moment	T_{inst} [Nm] ≤	10	20	40	80	150	200	240	275
Thickness of fixture	$t_{fix,min}$ [mm] >	0							
	$t_{fix,max}$ [mm] <	1500							
Minimum thickness of member	h_{min} [mm]	h_{ef} + 30 mm ≥ 100 mm				$h_{ef} + 2d_0$			
Minimum effecttive anchorage depth									
Minimum spacing	s_{min} [mm]	35	40	50	65	80	96	110	120
Minimum edge distance	c_{min} [mm]	35	40	50	65	80	96	110	120
Maximum effecttive anchorage depth									
Minimum spacing	s_{min} [mm]	80	100	120	160	200	240	270	300
Minimum edge distance	c_{min} [mm]	80	100	120	160	200	240	270	300

Table 4: technical data

Base material temperature	Gel time (working time)	Minimum curing time in dry concrete[1)]
+5°C to +9°C	10 min	145 min
+10°C to +19°C	6 min	85 min
+20°C to +29°C	4 min	50 min
+30°C	4 min	40 min
Cartridge temperature	+5°C to +20°C	

[1)] In wet concrete the curing time **must** be doubled.

G&B Threaded rod with washer and hexagon nut



1. Threaded rod, 2. washer, 3. hexagon nut

Table 5: G&B drill bit and Steel bruch

Anchor	Size (mm)	Nominal drill bit diameter d_o (mm)	Steel Brush d_b (mm)	Steel Brush (min brush diameter) $d_{b,min}$ (mm)
				
Threaded Rod 	M8	10	12	10.5
	M10	12	14	12.5
	M12	14	16	14.5
	M16	18	20	18.5
	M20	22	26	22.5
	M24	26	30	26.5
	M27	30	35	30.5
	M30	35	43	35.5

G&B Static mixer

G&B "injection mortar"

150 ml, 380 ml to 420 ml cartridge (Type: coaxial)

345 ml and 825 ml cartridge (Type: "side-by-side")

165 ml and 300 ml cartridge (Type: "foil tube")

Installation Instructions [6]

Base materials

- Reinforced or unreinforced normal weight concrete according to EN 206-1:2000.
- Strength classes C20/25 to C50/60 according to EN 206-1:2000.
- Non-cracked concrete M8 to M30, Rebar Ø8 to Ø32.
- Cracked concrete: M12 to M24.

Temperature range:

- I: -40°C to +40°C (max long term temperature +24°C and max short term temperature +40°C)
- II: -40°C to +80°C (max long term temperature +50°C and max short term temperature +80°C)

Use conditions (Environmental conditions)

- Structures subject to dry internal conditions (zinc coated steel, stainless steel, high corrosion resistance steel).
- Structures subject to external atmospheric exposure including industrial and marine environment, if no particular aggressive conditions exist (stainless steel A4, high corrosion resistance steel).
- Structures subject to permanently damp internal condition, if no particular aggressive conditions exist (stainless steel A4, high corrosion resistance steel).
- Structures subject to permanently damp internal condition, with particular aggressive conditions exist (high corrosion resistance steel).

Note: Particular aggressive conditions are e.g. permanent, alternating immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g. in desulphurization plants or road tunnels where de-icing materials are used).

Design:

- The anchorages are designed in accordance with the EOTA Technical Report TR 029 "Design of bonded anchors" under the responsibility of an engineer experienced in anchorages and concrete work.
- Verifiable calculation notes and drawings are prepared taking account of the loads to be anchored. The position of the anchor is indicated on the design drawings.
- Anchorages under seismic actions (cracked concrete) have to be designed in accordance with EOTA Technical Report TR 045 "Design of Metal Anchors under Seismic Action".

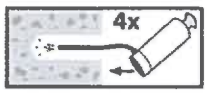
Installation:

- Dry or wet concrete or flooded hole.
- Hole drilling by hammer drill mode.
- Overhead installation allowed.
- Anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.

Installation Instructions [6]

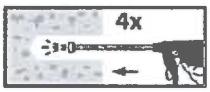
1. Drill with hammer drill a hole into the base material to the size and embedment depth required by the selected anchor (Table B1 or Table B2). In case of aborted drill hole: the drill hole shall be filled with mortar

Attention! Standing water in the bore hole must be removed before cleaning.



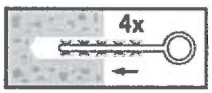
2a. Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) or a hand pump (Annex B3) a minimum of four times. If the bore hole ground is not reached an extension shall be used.

or

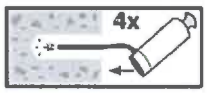


The hand pump can only be used for anchor sizes in uncracked concrete up to bore hole diameter 20mm or embedment depth up to 240mm.

Compressed air (min. 6 bar) can be used for all sizes in cracked and uncracked concrete.

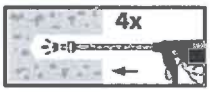


2b. Check brush diameter (Table B3) and attach the brush to a drilling machine or battery screwdriver. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ (Table B3) a minimum of four times.
If the bore hole ground is not reached with the brush, a brush extension shall be used (Table B3).

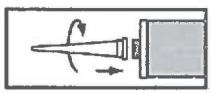


2c. Finally blow the hole clean again with compressed air or a hand pump (Annex B3) a minimum of four times. If the bore hole ground is not reached an extension shall be used.
The hand pump can only be used for anchor sizes in uncracked concrete up to bore hole diameter 20mm or embedment depth up to 240mm.
Compressed air (min. 6 bar) can be used for all sizes in cracked and uncracked concrete.

or



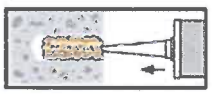
After cleaning, the bore hole has to be protected against re-contamination in an appropriate way, until dispensing the mortar in the bore hole. If necessary, the cleaning repeated has to be directly before dispensing the mortar.



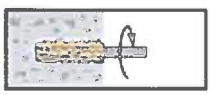
3. Attach a supplied static mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. Cut off the foil tube clip before use.
For every working interruption longer than the working time (Table B4 and B5) as well as for new cartridges, a new static-mixer shall be used.

4. Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rods.

5. Prior to dispensing into the anchor hole, squeeze out separately a minimum of three full strokes and discard non-uniformly mixed adhesive components until the mortar shows a consistent colour. For foil tube cartridges is must be discarded a minimum of six full strokes.



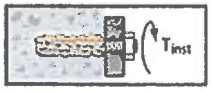
6. Starting from the bottom or back of the cleaned anchor hole fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. For embedment depth larger than 190 mm an extension nozzle shall be used. For overhead and horizontal installation in bore holes a piston plug and extansion nozzle according to Annex B3 shall be used. Observe the gel-/ Working times given in Tabe B4 and B5.



7. Push the threaded rod or reinforcing bar into the anchor hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The anchor should be free of dirt, grease, oil or other foreign material.

8. Be sure that the anchor is fully seated at the bottom of the hole and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For overhead application the anchor rod should be fixed (e.g. wedges).

9. Allow the adhesive to cure to the specified time to applying any load or torque. Do not move or load the anchor until it is fully cured (attend Table B4 and B5).



10. After full curing, the add-on part can be installed with the max. torque (Table B1) by using a calibrated torque wrench.