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Institut für Baustoffe, Massivbau und Brandschutz | Materialprüfanstalt für das Bauwesen

Expert Opinion

- Translation -

Document No.:	(291/513/14) – CM of 11/02/2014
Client	Chemfix Products Ltd Mill Street East, Dewsbury West Yorkshire WF12 BQ
Order date:	20/09/2013
Order Ref.:	-
Order received:	31/01/2014
Subject:	Loaded Chemfix injection systems 500 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 : 1999-10
Basis for assessment:	See section 1

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

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Notified body (0761-CPD)
MPA Braunschweig has been approved and notified as a civil engineering supervisory, inspection and certification body. MPA Braunschweig has been ISO/IEC17025 accredited as a testing and calibration laboratory and ISO/IEC17020 accredited as an inspection body.

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1 Background and commission

With their letter of 20/09/2013, Chemfix Products Ltd commissioned the MPA Braunschweig to prepare an Expert Opinion for Chemfix injection systems 500 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 Chemfix injection systems 500 in connection with reinforced-concrete members, which were exposed to a standard temperature-time curve fire in accordance with DIN EN 1363-1 : 1999-10.

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

[1] DIN EN 1363 -1: 1999-10; 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] CEN/TS 1992-4-1 : 2009-5, Design of fastenings for use in concrete - Part 1: General (pre-standard)
[4] CEN/TS 1992-4-5 : 2009-5, Design of fastenings for use in concrete - Part 4-5: Post-installed fasteners - Chemical systems (pre-standard)
[5] Betonkalender 2012: Infrastruktur, Befestigungstechnik, Eurocode 2.
[6] Test Report No. (3290/512/14), issued by MPA Braunschweig
[7] Client's technical data sheets for Chemfix injection systems 500
[8] ETA-13/0491 of 13/06/2013, Chemfix injection systems 500, issued by the German approval authority DIBt, Berlin

The Chemfix injection systems 500 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 Chemfix injection systems 500 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 system that is assessed for the purpose of this Expert Opinion consists of the Chemfix 500 mortar compound and anchor rods that are required from case to case. The anchor rods are made from electrogalvanised steel / stainless steel. The principle of action of the products is based on the bond between the steel component (anchor rod), the Chemfix 500 mortar compound and the uncracked reinforced-concrete base (strength classes C20/25 to C50/60). The fire safety assessment is limited to anchoring elements under static loads in uncracked concrete. For a more detailed description of the system, reference is made to the above approval ([8]).

Table 1: Chemfix injection systems 500 in connection with Chemfix anchor rods (bonded anchor action)

Chemfix injection system 500	**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 5.8)	M8 to M30							
Anchor rod (stainless steel 1.4401, 1.4404, 1.4571)	M8 to M30							

For further details of the systems, reference is made to the annexes, the Chemfix installation instructions for the Chemfix injection systems 500 and the approvals listed above.

3 Assessment regarding fire resistance time as a function of the maximum Chemfix injection system 500 loading in connection with reinforced-concrete members

The Chemfix injection systems 500, consisting of the Chemfix 500 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 for Chemfix injection systems 500 in uncracked reinforced concrete (strength classes C20/25 to C50/60) as a 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 Chemfix injection system 500 under tension in a standard temperature-time curve fire attacking one side of the system in accordance with DIN EN 1363-1 : 1999-10. Steel failure becomes decisive as soon as the bond strength of the Chemfix injection systems 500 exceeds the resistance respecting steel failure. Load bearing capacities beyond the steel failure of the Chemfix injection system 500 cannot be specified.

The load bearing capacity respecting bond failure (anchor bar pull-out) describes the resistance of the Chemfix injection system 500 (anchor rod in connection with the mortar) and the reinforced-concrete base (strength classes C20/25 to C50/55) 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 : 1999-10. 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 3-1: Proposed rating for the Chemfix injection systems 500 (dimension M8 – M30) made from electrogalvanised steel, regarding their fire resistance time as a function of stress σ_s under centric tensile load and the minimum placement depth

designation	Chemfix 500 M8	Chemfix 500 M10	Chemfix 500 M12	Chemfix 500 M16	Chemfix 500 M20	Chemfix 500 M24	Chemfix 500 M27	Chemfix 500 M30
stress cross section [N/mm²]	36	58,00	84,4	157	247	353	459	561
min. setting deep [mm]	80	90	110	125	170	210	250	280
fire resistance time	max. load							
tu	N_{fire} (t [kN]							
[min]	M8	M10	M12	M16	M20	M24	M27	M30
30	0,82	2,57	3,75	10,27	16,79	24,00	31,20	38,14
60	0,45	1,42	2,07	6,01	9,96	14,23	18,50	22,61
90	0,26	0,85	1,23	3,88	6,54	9,35	12,15	14,85
120	0,17	0,56	0,81	2,82	4,83	6,90	8,98	10,97

For the normal intended use, loads resulting from the ETA [8] 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 Chemfix injection system 500 in connection with the reinforced-concrete base (strength classes C20/25 to C50/55) 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 : 1999-10. 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 CEN/TS 1992-4-1 : 2009-5, 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 of the Chemfix injection system 500 in accordance with the approval ([8]).

$N^0_{Rk,p}$ ⇒ initial value of the characteristic resistance of the Chemfix injection system 500 in accordance with the approval ([8]). 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 ([8]). 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

$V_{fire(t)}$ ⇒ is the rated value determined for Chemfix injection systems 500 in uncracked reinforced concrete (strength classes C20/25 to C50/60) as a 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 Chemfix injection system 500 in connection with the reinforced-concrete base (strength classes C20/25 to C50/55) 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 : 1999-10.

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.

3.2.1.1 Resistance 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 CEN/TS 1992-4-1 : 2009-5, 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 for the Chemfix injection system 500 in accordance with approval ([8]).

$N_{Rk,p,fire(90)}$ ⇒ 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 CEN/TS 1992-4-1 : 2009-5, 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 of the Chemfix injection system 500 in reinforced concrete in accordance with the approval ([8]). $V^0_{Rk,c}$ can be determined in accordance with TR029 or CEN/TS 1992-4-1 : 2009-5.

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 Chemfix injection systems 500 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 Chemfix injection systems 500 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 Chemfix injection systems 500 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 : 1999-10 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 Chemfix injection system 500 and the edge.

4.5 The validity of this Expert Opinion will expire on 11/02/2017.

This document is the translated version of Expert Opinion 291/513/14 – CM dated 11/02/2014. The legally binding text is the aforementioned German Expert Opinion.

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Braunschweig, 20 June 2014