Mai 2023

Association Steel Fibre Technology

CFE Construction Fixings Europe

INFO

CONCRETE FASTENER QUALIFICATION AND DESIGN IN EUROPE

Recent history

On European level first regulations for concrete fastener qualification and design (single point fastening) have been introduced more than 25 years ago with the Guideline for European Technical Approval, ETAG 001 “Metal anchors for use in concrete” ([1]; qualification methods in parts 1 – 5 and design methods in Annex C), which represented a major step forward towards unification of procedures in the member states for construction products not covered by harmonized European Norms (hEN). ETAGs are published by the „European Organisation for Technical Assessment“ (EOTA), the association of the technical assessment bodies of all European member states. Consequently, the first corresponding European Technical Approval (ETA) followed for a metal expansion fastener one year later in 1998. For concrete definition these documents were referring to pre-versions of EN 206 [8]. Since then, in this arena hundreds of ETAs have been published showing the acceptance and relevance of this path.

From August 2009 on, the design of fastenings to concrete was regulated in CEN/TS 1992-4 ([2]; parts 1 to 5) that still referred to specific anchor related data given in an ETA.

With the introduction of the Construction Product Regulation in 2013 (CPR) [9] the legal framework changed and the qualification of products according to an ETAG needed to be transferred into European Assessment Documents (EAD), while the design, if not regulated in a European Norm (EN), is treated in Technical Reports (TR) endorsed by EOTA. So starting from thereon, the qualification part of the abovementioned ETAG 001 was transferred into EADs for qualification (mainly EAD 330232 for mechanical fasteners [5] and EAD 330499 for bonded fasteners, last amended in 2022 [7]).

Since 2018, concrete fastener design is regulated in EN 1992-4 [3] supplemented by EOTA Technical Reports, which treat additional aspects so far not regulated in the EN. For concrete definition, all these documents refer to EN 206 [8], in which the addition of steel fibres has been included with the amendment A2 in 2007.

Basis for fastener qualification

Fasteners introduce (tension) actions into the concrete at specific points, using the local concrete tensile strength. The load transfer is verified via the fastener qualification and the design that account for effects of cracking and spalling as well as influences from edges and spacing. An extensive description of the behaviour of all kinds of fasteners to concrete and the relevant aspect for qualification and design can be found in [10].

The qualification as per EAD 330232 [5] and EAD 330499 [7] differentiates for uncracked and cracked concrete. The qualification program for cracked concrete considers the effect of cracking in several test series. Thereby, for reference and basic test series in normal concrete with both, a low concrete compressive strength class C20/25 and a high concrete compressive strength class C50/60, a crack width of 0,3 mm is considered – corresponding to the serviceability state of concrete in concrete member design as per EC 2. Also testing series under constant loading and opening and closing of the crack (between 0,1 mm and 0,3 mm) are conducted. To account for larger crack openings under adverse conditions in the ultimate limit state, additional testing under an increased crack width of 0,5 mm is conducted, again in low (C20/25) and high strength (C50/60) concrete. In addition, the specific test program for each fastener type as per applicable EAD requires checking of the robustness and suitability under different adverse use conditions that may have an influence on their load bearing behaviour.

In all tests series the concrete is not reinforced with respect to the fastener load transfer. This especially means, that under unconfined test setup (including series in cracked concrete), the reinforcement present in the concrete members has to be arranged such that it does not interfere with the failure modes (e.g., formation of an unrestricted breakout cone).

In the so far valid version “01” of the above EADs the qualification was limited to compacted reinforced or unreinforced normal weight concretes of strength classes in the range of C20/25 to C50/60 without fibres in accordance with EN 206 [8]. This covered range represents the main field of concrete fastener application that has been thoroughly investigated in the past five decades. Outside this range the knowledge base is limited.

Current design of fasteners in context of Eurocode 2

EN 1992-1-1 [3] so far covers normal weight concretes without fibres with strength classes in the range of C12/15 to C90/105 and lightweight concretes in the range of LC12/13 to LC80/88. On the other hand, on the side of concrete specification and production, since the introduction of EN 206:2013 [8] fibres are explicitly regulated (while their use has not been excluded in previsions versions). In some EU member states, there are already supplementary regulations on steel fibre concrete, e.g., in Germany the DAfStb guideline on steel fibre concrete [12], which has been introduced by the building authorities and supplements DIN EN 1992-1-1 regarding the design and construction of steel fibre reinforced concrete.

For fastening design, EN 1992-4:2018 [4] covers compacted normal weight concrete without fibres with strength classes in the range C12/15 to C90/105 all in accordance with EN 206 [8]. However, the “range of concrete strength classes in which particular fasteners may be used is given in the relevant European Technical Product Specification and may be more restrictive than stated above” (EC2-4). Because ETAs published until summer of last year were referring to the EADs valid at that time, this meant that only concretes of strength classes C20/25 to C50/60 were covered in design. Beside of the lack of appropriate fastener qualification the design so far was also out of

the scope of EN 1992-4 as the whole Eurocode 2 did not address this.

Current status of fastener qualification for use in SFRC

Due to an increasing demand to extend the field of application, in recent time the EOTA Expert Group Fixings (EGF) worked on the implementation of SFRC and the full range of concrete strength classes as per EN 1992-4:2018 [4] in the EADs. Thus, in the latest amendments for fastener qualification in EAD 330499-02-0604 [7] and in variant EAD 330232-01-0601-v05 [5], testing programs for fastener qualification in normal weight concrete C12/15 – C90/105 as included in EN 1992-4:2018 [4] and in steel fibre reinforced concretes (SFRC; strength classes C20/25 to C50/60) have been introduced. While EAD 330499-02-0604 has been recently adopted by the European Commission, the draft of variant EAD 330232-01-0601-v05 is currently being coordinated within EOTA and the European Commission. The programs follow the logic for normal weight concrete and require additional test series in SFRC to show equivalency with the corresponding series in normal weight concrete. Potential advantages of the fibres (increased concrete tension strength or effect of crack bridging) are not considered in order to stay on the safe side. The extension is limited to the addition of steel fibres according to EN 14889 [11] up to a maximum of 80 kg/m³, which covers the upper limit of the practical application range. For design purposes it is intended to add a statement in the ETA that for fasteners adequately qualified in SFRC the regulations EN 1992-4 [4] can and shall be followed. Extensions for consideration of seismic effects are currently under discussion and in a further step fatigue actions shall be considered as well.

Outlook

The publication of EAD 330499-02-0604 [7] in the official journal of the European Union (eur-lex.europa.eu/oj/direct-access.html) is expected soon and the final adoption of the variant EAD 330232-01-0601-v05 [5] should also follow in the in the near future, so that the first ETAs can be anticipated later this year. To close this gap in the meantime, the option of qualification on national level qualification remains for use, e.g., via a general design approval in Germany (“Allgemeine Bauartgenehmigung”).

It should also be noted that, as part of the ongoing revision of the Eurocodes in the successor document to EN 1992-1-1 [3], the design of steel fibre reinforced concrete will be addressed in a new informative annex.

Dr. Georg Welz, Hilti Entwicklungsgesellschaft mbH

Peter Schillinger, fischerwerke GmbH & Co. KG

Association Steel Fibre Technology

CFE Construction Fixings Europe

Literature:

1. ETAG 001-Edition 1997: Guideline for European Technical Approval of Metal Injection Anchors for use in Concrete; EOTA, Brussels.
2. CEN/TS 1992-4, parts 1-5. Design of Fastenings for Use in Concrete. Edition 2009. CEN, Brussels, 2009.
3. EN 1992-1-1:2004-12+AC:2010-11: Design of concrete structures – Part 1-1: General rules and rules for buildings.
4. EN 1992-4:2018, Eurocode 2: Design of concrete structures – Part 4: Design of fastenings for use in concrete.
5. EAD 330232-01-0601: Mechanical fasteners for use in concrete. EOTA, Brussels, Belgium.
6. EAD 330232-01-0601-v05: Mechanical fasteners for use in concrete C12/15 to C90/105 and in steel fibre reinforced concrete. EOTA, Brussels, Belgium, draft version – not yet published.
7. EAD 330499-02-0601: Bonded fasteners for use in concrete. EOTA, Brussels, Belgium, August 2022.
8. EN 206:2013+A2:2021, Concrete – Specification, performance, production and conformity.
9. Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.
10. Eligehausen, R.; Mallée. R.; Silva, J. F.: Anchorage in concrete construction. Ernst & Sohn Verlag, Berlin 2006.
11. EN 14889-1:2006, Fibres for concrete – Part 1: Steel fibres – Definitions, specifications and conformity.
12. DAfStb-Richtlinie Stahlfaserbeton, Edition June 2021 (in German).

Contact:

Construction Fixings Europe
A sub-association of European Tool Committee
CEO
cfe@construction-fixings.eu
www.construction-fixings.eu

Association Steel Fibre Technology e. V. (AST)

Römerstraße 42 | 59075 Hamm
www.ast-ev.com
info@ast-ev.com