European Provisions for the Testing, Assessment and Design of Anchors in Concrete and Masonry

By

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1 Introduction

In general, provisions for the regulation of construction products in Europe differ from those in the U.S. This article explains the European requirements as they pertain to the assessment and design of anchors in concrete and masonry.

This discussion is substantially derived from an article that first appeared in the Beton Kalender [1] 2007 [1].

The introduction of a construction product into the European market requires either compliance with a harmonized European Code or a European Technical Approval (ETA). The historical development of the ETA process vis-à-vis anchors can be summarized as follows:

The development of criteria for the qualification of construction products under the newly-formed European Union's Construction Products Directive 89/106/EC (CPD) [3] began in the late 1980s. The CPD provides the legal basis for the development of criteria to assess construction products for use in all member states. It defines so-called Essential Requirements that construction products must fulfill, depending on their use and importance in the built environment, and specifies the terms for development of assessment criteria.

Because of intensive industry support, progress in the development of assessment and design provisions for concrete and masonry anchors in this time period was advanced relative to other construction products, and national provisions for concrete anchors were already in existence by the early 1970s. Recognizing the need for criteria to direct the issuance of transnational approvals, the European Organization for Technical Approvals (EOTA) established working groups to address the types of anchors then in existence. The members of the working groups were drawn from members of approval bodies, representatives of Associations of the European Anchor Manufacturers and national experts. The first working group, for mechanical anchors, was formed in the early 1990s.

The first European Technical Approval Guideline (ETAG 001) "Guideline for European Technical Approval of Metal Anchors for Use in Concrete" was adopted and sent to the European member states for ratification by the European Commission in 1997. Two ETAs for torque-controlled expansion anchors (ETA-98/0001 and ETA-98/0002) based on ETAG 001 were issued by the German national approval body DIBt (German Institute for Building Technology) in 1998. These were also the first products in the European construction markets to carry a CE-marking [2].

2 ETAGs, CUAPs and ETAs

2.1 Background

The basis for the European harmonization of Construction Products is the Construction Products Directive (CPD). The harmonization of the products is assured by technical specifications. Products are fit for their intended use if they comply with either:

a.) hEN: Harmonized Standard (by the CEN/CENELEC);

b.) an ETA: European Technical Approval (by the EOTA) [4]; or

c.) a non-harmonized technical specification recognized by the European Commission.

The predominant path for establishing the fitness for use of construction fasteners, e.g., anchors, power-actuated fasteners or cast-in anchors are European Technical Approvals.

1. The Beton Kalender (Concrete Compendium) is an annual publication summarizing design and construction information relevant to concrete construction in Europe.

2.2 EOTA

The European Organization for Technical Approvals (EOTA) [5] is composed of Approval Bodies (also referred to as EOTA Bodies) nominated to issue European Technical Approvals (ETAs) by EU Member States and EFTA States who have contracted to the European Economic Area Agreement. The role of EOTA is primarily to monitor and progress the drafting of new guidelines and to coordinate all activities related to the issuing of ETAs. The guidelines are developed based on a mandate of the European Commission and an approved work program formulated by EOTA working groups.

2.3 European Technical Approval Guidelines (ETAGs) for Anchors

Following the formation of the working group for mechanical anchors, additional groups were established in the ensuing decade to address other anchor types. Working groups for other construction products have been formed in the interim period as well. The working groups continue to issue new Guidelines and revise existing ones as required. Guidelines pertaining to anchorage are currently as follows:

- ETAG 001 Guideline for European Technical Approval of Metal Anchors for Use in Concrete
- ETAG 014 Guideline for European Technical Approval of Plastic Anchors for Fixing of External Thermal Insulation Composite Systems with Rendering
- ETAG 020 Guideline for European Technical Approval of Plastic Anchors for Multiple Use in Concrete and Masonry for Nonstructural Applications
- ETAG 029 Guideline for European Technical Approval of Metal Injection Anchors for Use in Masonry (not yet endorsed by the EC)

2.4 CUAPs for cast-in anchors, power actuated fasteners and special fasteners

Given the logistical hurdles involved in developing ETAGs for all possible construction products, EOTA has developed an alternate path, the Common Understanding of Assessment Procedure (CUAP), for securing approvals for construction products not covered by an existing ETAG (or for an ETAG that is in development). The CUAP describes the assessment criteria for the product and its intended use. Although there is no mandate issued by the European Commission for CUAPs, the approval body applying for the CUAP must receive consent from the European Commission. Similar to a Guideline, a CUAP comprises the required tests, the assessment and the evaluation of the test results. Because the existence of a CUAP can lead to greater requests for approvals for a specific product type, it can serve as an alternative to or a precursor to the development of a guideline. The CUAP draft is sent to all European Approval Bodies for comments and can only be used for issuing an ETA after all the approval bodies have given their consent.

2.5 ETAs for anchors and fasteners

ETAs are granted on the basis of ETAGs and CUAPs by the European Approval Bodies — e.g., in Germany by the DIBt.

2.6 Comprehension Documents and Progress Files

EOTA Comprehension Documents are EOTA internal working documents used to update reference documents and to provide clarification regarding the application or interpretation of particular elements in an issued ETAG. Comprehension Documents are discussed within the Working Group. Once they are endorsed by EOTA, Comprehension Documents are effectively part of the ETAG to which they refer.

In contrast to Comprehension Documents, Progress Files contain actual changes or amendments to an ETAG. The Progress File procedure is similar to that used for Comprehension Documents.

3 ETAG 001 - Guideline for European Technical Approval of Metal Anchors for Use in Concrete

3.1 General

ETAG 001 for the assessment of concrete anchors (e.g., expansion and undercut anchors) was the first approved Guideline for the issuance of European Technical Approvals. The Guideline consists of six parts:

Part 1 - Anchors in general Part 2 - Torque-controlled expansion anchors

Part 3 - Undercut anchors Part 4 - Deformation-controlled expansion anchors

Part 5 - Bonded anchors Part 6 - Anchors for multiple use for nonstructural applications.

All well-established metal anchors for use in concrete available on the European market are included in these parts. The term metal anchors includes all post-installed anchor types, exclusive of plastic anchors and power-actuated fasteners, but including bonded (adhesive) anchors.

The following appendices (Annexes) are part of the guideline:

- Details of tests
- Tests for admissible service conditions - Detailed information
- Design methods for anchorages

In addition, the ETAG mandate contains a system of Attestations of Conformity (AoC), which defines the art and manner of quality control for the product. The AoC system is established by the EC on the basis of such considerations as the consequences of failure and the sensitivity of the product. The different AoC systems make use of a set of methods of conformity control. When the AoC procedure demonstrates conformity with the ETA the manufacturer is permitted to use the CE marking on the product. The required AoC level for anchors qualified under Parts 1 through 5 is 1 [7], whereas for anchors approved under the redundant fastener criteria in Part 6 it is 2+ [8]. Refer to Table 1 for the specific components of quality control associated with these two AoC levels.

In the following, details regarding the content of ETAG 001 are provided.

Table 1 – Link between quality control and AoC level[2]

AoC level	Cert. of Product Con-formity – AB	Cert. of FPC Con-formity– AB	Declara-tion of Con-formity – Mfr	Initial Type Testing[3] - Mfr or AB	Factory Production Control (FPC) – Mfr	Testing of samples according to Prescribed Test Plan – Mfr	Audit testing – AB	Initial Inspection of Factory and FPC – AB	Ongoing Surveil - lance of FPC – AB
1	yes	no	yes	AB	yes	yes	no	yes	yes
2+	no	yes	yes	Mfr	yes	yes	no	yes	yes

3.2 ETAG 001 Part 1 – Anchors in General

3.2.1 General

The Guideline sets out the requirements for anchors, the acceptance criteria they shall meet, and the procedures and tests methods used in the assessments. Part 1 comprises the test conditions and acceptance criteria applicable to all types of metal anchors. Parts 2 through 5 contain additional and/or exceptional test conditions, required number of tests and acceptance criteria valid for specific anchor types only.

3.2.2 Scope

The Guideline covers the assessment of post-installed metal anchors in normal weight concrete that must fulfill Essential Requirements[4] (Mechanical Resistance and Stability) and 4 (Safety in Use) of the Construction Products Directive. It is assumed that failure of anchorages executed with these products could compromise the stability of the structure, cause risk to human life and/or have considerable economic consequences. A clear separation from anchors used for non-safety related applications (e.g., anchorage of bathroom fixtures) is intended.

[2] AB = Approved body, Mfr = Manufacturer

[3] Not normally required under ETA route insofar as Initial Type Testing is already dealt with as a part of the assessment for ETA.

[4] A complete description of the six Essential Requirements is contained in the Construction Products Directive.

The assumed working life of anchors in concrete is 50 years. Although the working life forms the basis for the assessment, it should not be interpreted as a guarantee given by the manufacturer. The Guideline applies in general to anchors with a minimum thread diameter of 6 mm (M6, 0.24 in.); Part 6 encompasses anchors with a minimum thread diameter of 5 mm (M5, 0.2 in.). Owing to variability in the properties of near-surface concrete, the embedment depth of anchors assessed under Parts 1 through 5 cannot be less than 40 mm (1.6 in.). Part 6 permits embedments as little as 30 mm (1.2 in.) or, in dry interior locations, 25 mm (1.0 in.). The various anchor types and operation modes covered by the Guideline will not be explained in detail; further information can be found in [9]. The concrete strength class must fall between C20/25[5] (2,900 psi), Part 6: C12/15) (1,700 psi) and C50/60 (7,250 psi). The Guideline is currently valid for static or semistatic (quasi-static) loading only. Extensions for seismic and fatigue loading are under consideration.

3.2.3 Options

The extent of the test program for the determination of the admissible service conditions depends on the applicant's request with respect to the range of conditions of use to be assessed for the anchor and the degree of detail desired with respect to the admissible load and use conditions. ETAG 001 therefore provides various options for the assessment; see Table 2. For example, Option 1 provides for separate admissible tension and shear loads, whereas Option 3 provides only one admissible service load value, regardless of load orientation. The optimum combination of load and use conditions is in part dependent on the anticipated application of the product and the degree to which the design will be affected by the assessment conditions. For example, a product that is primarily selected by construction personnel on site for a well-defined application may be better served by a single value for the admissible load, whereas a product that is typically included in the project specifications and must be specifically designed for more complex load cases may require assessment under a more comprehensive option. There are 12 possible assessment permutations available, but only three design options. The relation between the assessment options and the design methods is also given in Table 2.

Additionally, categories exist for checking durability, depending on whether the anchor will be used in dry, interior locations or under other environmental conditions. See Table 3 for the possible combinations. If the anchor is used under dry, interior conditions, no special corrosion protection is necessary. The minimum 5µm-thick (0.0002 in) galvanized zinc coating typically provided to prevent premature oxidation of the anchor surface prior to installation is sufficient for such applications. Note that the concrete passivates the anchor surface in the installed condition. For anchor use in exterior applications, damp environments, industrial applications or other aggressive environments, hot-dip galvanizing, sheradizing or use of an appropriate austenitic stainless steel, e.g., A4 (1.4401 or 1.4571) acc. to EN 10088 may be appropriate. If the anchor is to be used in particularly aggressive conditions such as permanent or alternate 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) use of special alloys with superior resistance to pitting and stress corrosion (e.g., 1.4529) may be required. When applying other corrosion protection measures such as coatings, anchor durability must be demonstrated through testing. In addition, anchors manufactured from stainless steel may be more susceptible to galling, particularly in the threaded parts.

[5]A concrete strength class is typically defined with a prefix C for normal and heavy-weight concrete or LC for lightweight concrete, the minimum characteristic cube strength required (150 mm side length).

Table 2 – Options for anchor assessment according to ETAG 001

Option number	Condition of the concrete		F_{Rk} for the concrete strength classes		F_{Rk} for load directions		Edge distances and spacings				Design method according to ETAG 001 Annex C
	Cracked and un-cracked	Un-cracked only	One value for ≥ C20/25	C20/25 to C50/60	F_{Rk} one value	F_{RK} depending on load direction	c_{cr}	s_{cr}	c_{min}	s_{min}	
1	x			x		x	x	x	x	x	A
2	x		x			x	x	x	x	x	
3	x			x	x		x	x	x	x	B
4	x		x		x		x	x	x	x	
5	x			x	x		x	x			C
6	x		x		x		x	x			
7		x		x		x	x	x	x	x	A
8		x	x			x	x	x	x	x	
9		x		x	x		x	x	x	x	B
10		x	x		x		x	x	x	x	
11		x		x	x		x	x			C
12		x	x		x		x	x			

Table 3 – Possible combinations of categories according to ETAG 001

Use categories		Durability categories	
Cracked and uncracked concrete	Uncracked concrete only	Dry internal conditions	Other environmental conditions
X		X	
			X
	X	X	
			X

3.2.4 Tests

The tests involved in the assessment of anchors fall into three primary categories:

- Tests for confirming anchor suitability (reliability tests)
- Tests for evaluating the admissible service conditions (service-condition tests)
- Tests for checking anchor durability

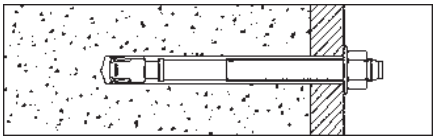
Suitability tests are of vital importance for the evaluation of the anchor. These tests establish whether the anchor demonstrates safe and consistent behavior in service. The following unfavorable conditions, both during site installation and in service, are considered in the tests:

- Installation safety: influence of installation defects (e.g., deviation from the specified hole diameter, interference of reinforcement during drilling, incomplete cleaning of the hole, or inadequate mixing of the adhesive components)
- Response of the anchor to variations in those factors deemed most relevant for the anchor resistance (concrete strength, presence of cracks, moisture content, etc.)
- Reliability under repeated load and sustained loading

Note that gross errors (e.g., use of the wrong drill bit diameter, inappropriate drilling or setting tools, or omission of hole cleaning) are not covered by suitability tests. Gross errors should be avoided by appropriate training of the installers and provision of adequate supervision on the construction site. A well-defined but limited reduction of the anchor capacity is typically allowed in suitability tests. Tests for admissible service conditions, on the other hand, are intended to reflect normal construction site conditions.

The characteristic anchor resistance for specified concrete strength classes in cracked and uncracked concrete is evaluated. A crack width of w = 0.3 mm (0.012 in.) represents the 95% fractile of all cracks occurring in a structure under semipermanent loads. Large variations in the recorded anchor strength in admissible service condition tests are not permitted.

3.3 ETAG 001 Parts 2, 3 and 4 – Torque-controlled expansion anchors, undercut anchors and deformation-controlled expansion anchors. Parts 2, 3 and 4 contain additional requirements and assessment procedures as well as exceptions to Part 1.



Expansion Anchor

Suitability tests for torque-controlled expansion anchors include installation tests, tests in low- and high-strength concrete, reliability under repeated loads as well as maximum torque-moment tests. For anchors to be used in cracked concrete, additional tests for sensitivity to crack-movements (opening and closing) as might occur over the life of the anchorage are required. Suitability tests for undercut anchors depend on the anchor type and the type of installation. For displacement-controlled or torque-controlled installation of anchors, the effect of incomplete expansion as well as the influence of the hole diameter are checked.

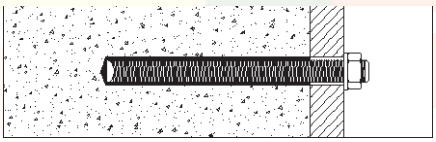
Field Application

3.4 ETAG 001 Part 5 – Bonded anchors (adhesive anchors)

3.4.1 General

Inasmuch as a specific length of time must elapse before adhesives will cure and thereby attain their maximum bond strength, adhesive anchors typically cannot be loaded immediately after setting. The required curing time (between setting and loading) usually depends on the type of adhesive and the concrete temperature at the time of installation. Additionally, variations in the temperatures in the concrete during the anchor service life may have an impact on the bond strength of the adhesive. Supplemental requirements and tests for adhesive anchors are provided in Part 5 to assess these factors. In addition, tests for the durability of the adhesive vis-à-vis exposure to chlorides and sulfur are required.

3.4.2 Scope



Adhesive Anchor

Part 5 [10] of ETAG 001 covers common adhesive and capsule systems as well as undercut and torque-controlled adhesive anchors. Details for torque-controlled adhesive anchors are specified in Technical Report TR 018 [11].

Adhesive anchors are generally installed in cylindrical holes drilled by means of rotary impact hammers (electric drilling machine or driven by compressive air) equipped with carbide bits or diamond core drills. The drilling method and cleaning process, in as much as they are essential to the anchor performance, must be considered in the evaluation.

3.4.3 Use categories

In addition to the durability categories established for metal anchors, the following use categories are offered for adhesive anchors:

Use category 1:

- Installation in dry or wet concrete
- Service life in dry or wet concrete

Use category 2:

- Installation in dry or wet concrete or in water-flushed holes (not sea water)
- Service life in dry or wet concrete or under water (not sea water)

The manufacturer can choose between the following three temperature ranges, the minimum service temperature being -40°C (-40°F) in all cases:

- Maximum short-term temperature +40°C (104°F) and a maximum long-term temperature[6] of +23°C (73°F)
- Maximum short-term temperature +80°C (176°F) and a maximum long-term temperature +50°C (122°F)
- Maximum long-term temperature 60% to 100% of short-term temperature, whereby the maximum short-term temperature is established by the applicant

[6]Short-term temperatures are assumed to occur within a relatively brief time span (e.g., owing to diurnal cycles), whereas long-term temperatures are sustained for extended periods.

3.4.4 Tests

Suitability tests (reliability tests) take into account use categories (installation, intended use and temperature) as well as the influence of hole cleaning, insofar as these may be of great importance for the functioning of the anchor. Installation safety tests are conducted under various use scenarios that present unique conditions for the installation: dry concrete, wet (saturated) concrete and submerged concrete. Installation safety tests are conducted with a reduced cleaning process to measure the influence of incomplete cleaning. The cleaning of the hole must be reduced to two blowing operations and one brushing operation, provided the manufacturer's installation instructions specify hole cleaning with at least four blowing and two brushing operations. If the instruction specifies less than this the number of hole cleaning operations is reduced proportionally to the next whole number. If the manufacturer's installation instructions specify two blowing and one brushing operation, the suitability tests are carried out without the brushing operation. The hole cleaning equipment specified by the manufacturer is used. If the hole cleaning or the equipment is not sufficiently specified, the tests are conducted without hole cleaning.

Tests for evaluating sensitivity to freeze/thaw conditions, as well as sustained load tests at standard ambient temperature and at maximum long-term temperature, are required for checking bonding behavior. Tests for functioning in low-strength and high-strength concrete, crack width cycling and repeated loads are similar to the tests for metal anchors outlined in Part 1.

For determination of the influence of concrete variability, tests are conducted in the following test members:

- Concrete C20/25 (2,900 psi) originating from at least three different batches if the concrete is delivered from different concrete suppliers and from at least four different batches if the concrete is from the same concrete supplier
- Concrete C50/60 (7,250 psi) originating from at least two different batches

Reference tension tests have to be conducted as so called confined tests (close supports) in all concrete batches. The results of reference tension tests are used when determining the influence of the different concrete parameters.

The durability of the adhesive is verified by slice tests. In these tests, the sensitivity of the installed anchor to different environmental exposures is investigated. The test is conducted as follows: A medium diameter anchor is installed in a concrete member (cylinder/cube). After the adhesive material has hardened, the concrete member is cut into 30 mm (1.2 in.) thick slices. Slices are stored in an alkaline fluid (pH = 13.2) for 2000 hours; optionally, 80 cycles are carried out on slices in a sulfur dioxide atmosphere (Kesternich Test). Other slices are stored under normal environmental conditions. Subsequently, the residual bond strength of the slice is measured by punching the threaded rod out of the slice.

If a decrease in bonding strength appears because of the storage in alkaline fluid or under sulfur dioxide atmosphere, the characteristic tension resistance of the anchor is reduced accordingly.

3.5 ETAG 001 Part 6 – Anchors for the multiple use for nonstructural applications

3.5.1 General

Part 6 [12] of ETAG 001 was adopted in January 2003. Whereas Parts 1 through 5 of ETAG 001 cover the general use of anchors and, in particular, single anchors, Part 6 provides additional utility for the approval of anchors used in redundant applications.

The intended use of anchors approved under Part 6 is for the anchorage of nonstructural component applications, such as the suspension of ceilings and pipes where multiple anchors are used in series. In these applications, the failure of one fastening point is unlikely to cause the collapse of the component, insofar as the load can redistribute to adjacent anchors. In view of this, Part 6 mandates a reduced test program that is intended to result in a probability of failure that is consistent with that established for single anchor applications under Part 2 though 5. In addition, anchors covered by Part 6 extend to smaller diameters, smaller anchorage depths and a reduced system of conformity.

3.5.2 Scope

Part 6 covers post-installed metal anchors with a minimum thread size M5 and a minimum drill hole diameter of 5 mm (0.2 in.). The minimum effective anchorage depth in concrete is 30 mm (1.2 in.). It can be reduced to 25 mm (1.0 in) for special cases, e.g., where dry internal conditions exist. Anchors under Part 6 are qualified for use in normal weight concrete of strength classes C12/15 (1,700 psi) through C50/60 (7,250 psi). The minimum member thickness is 80 mm (3.2 in.) and must be at least twice the anchorage depth.

The design of the attached component (pipe, ceiling runner, etc.) must be such that in case of excessive slip or failure of one anchor the load will be transmitted to neighboring anchors. The design of the component may specify the number n1 of attachments per component and the number n2 of anchors per attachment. In addition, by limiting the design load Nsd on any one attachment to a value ≥ n3 up to which the available strength and stiffness of the fixture is assumed to fulfill the requirement for load transfer in the case of excessive slip or failure of one anchor, the necessity of explicitly checking the attachment is eliminated. The definition of multiple use according to the Member States is given in Annex 1 of ETAG 001, Part 6. If a Member State does not provide a definition, the following default values are applicable:

$n1 \geq 4$; $n2 \geq 1$ and $n3 \leq 3.0$ kN (670 lbf) or

$n1 \geq 3$; $n2 \geq 1$ and $n3 \leq 2.0$ kN (450 lbf).

These default values are based on research into the behavior of redundant fastenings; they also comply with existing German approvals. The probability of failure of these nonstructural applications in case of excessive slip or failure of one anchor is in the same range as the probability of failure of a single anchor according to ETAG 001 Parts 2 through 5.

3.5.3 Tests and Evaluation

As in the other parts of the Guideline the type and number of required suitability tests and the criteria for the assessment are specified in tables. In general, all the tests are conducted as tension tests on single anchors not influenced by spacings or edge distances.

Tests for admissible service conditions are conducted as tension tests in cracked concrete with a crack width of 0.2 mm (0.008 in.) Three possible design methods are given in ETAG 001, Annex C. If design method C is used, the tests for the minimum required spacing and edge distance may be omitted, provided the spacing and edge distances comply with the values in Table 4. In addition, the admissible service condition tests depend on the design method. Hence, the choice of the design method is a precondition for assessing the anchor.

The peak loads achieved in the suitability tests must meet, dependent on the type of test, a minimum threshold of 75% to 100% of the maximum load of the reference tests under standard conditions. Where this is not the case, a reduction factor similar to the other parts of the Guideline must be applied when determining the characteristic resistance of the anchor.

Part 6 mandates reduced requirements on the load/displacement behavior compared to ETAG 001 Parts 1 through 5. A reduction in load and/or a horizontal or near-horizontal part in the curve caused by uncontrolled slip of the anchor is not acceptable up to a load of 40% of the maximum load (compared to 70% of the maximum load for the other parts of the Guideline). Unlike Parts 1 through 5, Part 6 specifies no limits on the scatter of the load/displacement curves in ETAG 001, Part 6.

Table 4 – Spacings, edge distances and concrete member thickness according to ETAG 001

Installation parameters	Deformation-controlled expansion anchors	All other anchors
Spacing s_{cr}	≥ 200 mm (7.9 in.) and ≥ 4 h_{ef}	≥ 200 mm (7.9 in.) and ≥ 4 h_{ef}
Edge distance c_{cr}	≥ 150 mm (5.9 in.) and ≥ 3 h_{ef}	≥ 100 mm (5.9 in.) and ≥ 3 h_{ef}
Thickness of concrete member	≥ 80 mm (3.2 in.) and ≥ 2 h_{ef}	≥ 80 mm (3.2 in.) and ≥ 2 h_{ef}

3.6 ETAG 001 Annexes A, B and C

The three annexes are mandatory parts of the Guideline.

Annex A "Details of tests" contains all information necessary for the performance of approval tests. As the concrete has a great influence on the test results, the concrete test members must be documented precisely regarding the composition (aggregates, type of cement, cement content and water/cement ratio), concrete strength, dimensions and casting/curing to show compliance with the Guideline. Furthermore, the anchors and their installation are defined, as well as the required test equipment. The test procedures for the different tests are explained, and the required data to be included in the test report are listed.

Annex B "Tests for admissible service conditions, detailed information" sets out the number and type of tests that are required for the determination of the admissible service conditions. These depend on the option chosen by the manufacturer (see Table 1) and on the current experience available regarding the load-bearing behavior of the anchors. Provided that current experience exists for a certain anchor type, the simplified approach stated in Annex B may be used to evaluate the characteristic failure loads. The number of tests can be reduced substantially when using this simplified method.

Annex C "Design methods for anchorages" describes the three different design methods for anchorages. The design methods correlate with the chosen option according to Table 2. The information given in the ETA includes only the characteristic values for approved single anchors. The design of the anchorages (e.g., arrangement of anchors in a group of anchors, effect of edges or corners of the concrete member) is carried out according to the respective design method. The design method for anchorages in concrete according to Annex C will in future be superseded by the CEN standard CEN/TC 250/SC 2/WG 2 in "Design of Fastenings for Use in Concrete" [13] which addresses both post-installed as well as cast-in anchors. This document has recently been published as an Annex to Eurocode 2[7]. It is to be expected that, in future, ETAs for anchors will make reference to this standard instead of Annex C.

3.7 Technical Reports of ETAG 001

3.7.1 General

Technical Reports (TRs) amend the Guidelines in certain details, e.g., by establishing special test methods.

Technical Reports are developed as supporting reference documents to European Technical Approval Guidelines (ETAG). Technical Reports go into detail in some aspects and express the common understanding of existing knowledge and experience of the Approval Bodies at a particular point in time. Where knowledge and experience is developing, especially through approval work, such reports can be amended and supplemented. The following Technical Reports are available in the field of anchorages to concrete:

- TR 018 Assessment of torque-controlled bonded anchors (March 2003)
- TR 020 Evaluation of anchorages in concrete concerning resistance to fire (May 2004)
- TR 023 Assessment of post-installed rebar connections (November 2006)
- TR 029 Design of bonded anchors (June 2007).

3.7.2 TR 020 - Evaluation of Anchorages in Concrete Concerning Resistance to Fire

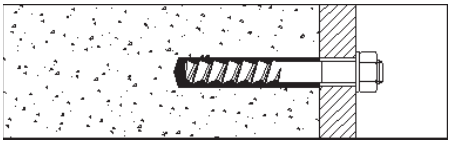
Tests with fire exposure as well as fundamental research have shown that in case of fire not only is the resistance of the exposed unprotected metal parts of the anchors reduced, but in addition the resistance to pull-out and concrete breakout failure is diminished. Technical Report [14] includes reduction factors for the different failure modes as well as test procedures under which a design for fire exposure can proceed on the basis of ETAG 001, Annex C. The Technical Report includes a simplified design method using reduction factors developed by fundamental research (tests with fire exposure) as well as an experimental determination of the duration of the fire resistance of anchorages in cracked and uncracked concrete. The characteristic tension strength (characteristic resistance) of an anchor in case of steel failure is given in tables in TR020. These values are also valid for the unprotected

[7] *Eurocode 2: Design of concrete structures is one of a set of ten European standards that contain common structural rules for the design of buildings and civil engineering structures.*

steel parts of the anchor outside the concrete. It is conservative to use these values for shear resistance. Higher characteristic resistances for shear and tension loads shall be determined by tests with fire exposure.

In tests for the determination of the pull-out failure load, steel failure must be precluded by protecting the anchor element against premature failure. These tests are conducted in cracked concrete.

3.7.3 TR 018 – Assessment of Torque-Controlled Bonded (Adhesive) Anchors



Torque-Controlled Bonded Anchor

Torque-controlled adhesive anchors are installed in cylindrical holes in the concrete. As with other anchor types, adhesive anchors are installed in normal cylindrical holes. They are designed such that the application of torque simultaneously breaks the bond of the adhesive with the anchor element and produces an expansion force that enhances the tension load-transfer capability of the adhesive-concrete interface. This symbiosis of adhesive and torque-controlled expansion anchor combines the advantages of both systems. General speaking, torque-controlled adhesive anchors are more efficient in cracked concrete than common adhesive anchors.

The assessment and evaluation of the torque-controlled adhesive anchors is determined according to ETAG 001, Part 2 (Torque-controlled expansion anchors) and Part 5 (Bonded anchors). In addition slip-force tests must be conducted, in order to verify the consistent loss of adhesion between the anchor rod (cones) and the adhesive during installation.

3.7.4 TR 023 – Assessment of Post-Installed Rebar Connections

Technical Report 023 [20] covers post-installed rebar connections for development or splicing of straight deformed reinforcing bars with adhesive designed in accordance with Eurocode 2. The adhesive shall comply with ETAG 001 Part 5. Because of concerns for bar corrosion, the TR covers only applications in noncarbonated concrete. Fire resistance of post-installed rebar connections, as well as their resistance to fatigue, dynamic or seismic loading, are not covered by this report. Only post-installed rebar connections may be conducted that are also allowed with straight deformed cast-in bars according to Eurocode 2, e.g., those in the following applications:

- Noncontact lap splices with existing reinforcement in a concrete member,
- Development of reinforcement in a concrete compression member, and
- Development of reinforcement to cover the line of acting tensile forces in a flexural member.

The required tests for post-installed rebar connections are very comparable with the tests for adhesive anchors according to ETAG 001 Part 5. However, in addition, the drilling, hole cleaning and adhesive injection procedures for the longer hole depth associated with these applications must be verified. The equipment and the tools provided by the manufacturer must be used. In this connection, special training of personnel engaged in the installation of such reinforcing is required.

3.7.5 TR 029 – Design of Bonded Anchors

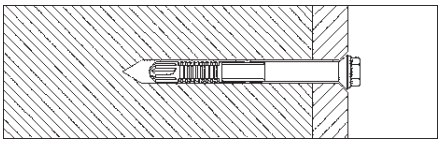
ETAs for adhesive anchors based on ETAG 001 Part 5 and Annex C are in general valid only for an intended embedment depth of 8 to 12 anchor diameters and for a bond resistance less than 15 N/mm2 (2,200 psi). Technical Report TR 029 [21] was developed more than ten years later, and therefore it covers new bonded anchors with a significant higher bond resistance and an expanded application range. The modified design concept includes embedment depths between 4 and 20 diameters with a minimum embedment of 40 mm (1.5 in.). In addition, varying embedment depths are included instead of fixed values.

For this extended application range, a modified design method based on Annex C of ETAG 001 is given in TR 029. The assessment and some tests are modified as well.

4 Other European Technical Approval Guidelines for Anchorage

The following are brief descriptions of additional Guidelines concerned with fastening to concrete and masonry that have been developed since the introduction of ETAG 001. It can be seen that the development of ETAGs has followed a pattern of accommodation for the technical and practical requirements of the European construction environment.

4.1 ETAG 020 – Guideline for Plastic Anchors for Multiple Use in Concrete and Masonry for Nonstructural Applications



Plastic Anchor

ETAG 020 [15], which specifically addresses the use of plastic (e.g., polyamide) anchors for use in concrete and masonry, is similar in structure to ETAG 001. Unlike ETAG 001, however, which addresses only concrete, ETAG 020 is divided into parts according to base materials—a reflection of the many types of masonry base materials used in construction.

The Guideline comprises the following:

Part 1 – General Requirements

Part 2 - Plastic Anchors for Use in Normal Weight Concrete

Part 3 - Plastic Anchors for Use in Solid Masonry

Part 4 - Plastic Anchors for Use in Hollow or Perforated Masonry

Part 5 - Plastic Anchors for Use in Autoclaved Aerated Concrete (AAC)

Annex A - Details of Tests

Annex B - Recommendations for tests to be carried out on the construction works (informative)

Annex C - Design methods for anchorages

The development of ETAG 020 was not without controversy. The use of plastic anchors is commonly viewed as being outside of the safety-relevant domain and is further associated with the do-it-yourself trade. Nevertheless, the increasing use of plastic anchors for the attachment of fundamental building components such as facades and cladding, necessitated the regulation of these products. The Guideline is limited in scope, however, to applications where a clear correlation to the CPD concerning safety in use can be established, i.e., where failure of the attachment could lead to an immediate risk to human life. Furthermore, it addresses only multiple use applications (no single point fastenings using plastic anchors are permitted).

In addition to normal weight concrete, ETAG 020 covers a wide range of base materials, including solid clay brick, calcium silicate brick and normal weight concrete units, as well as hollow clay, hollow calcium silicate, perforated concrete masonry units and autoclaved aerated concrete (AAC) units.

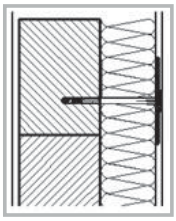
A range of suitability tests are included for anchors to be installed in concrete:

- Setting capacity (nailed-in anchors only)
- Sensitivity to large and small drilled hole diameter
- Sensitivity to crack width: 0.35 mm cracks (0.01 in.)
- Sensitivity to concrete condition (wet and dry)
- Reliability in high and low temperatures
- Reliability under sustained loads
- Reliability after 24 h and 500 h relaxation
- Establishment of maximum permissible torque moment (for anchors using screws).

For applications in masonry, the tests are conducted in single bricks or in walls. For applications in masonry materials that do not correspond in terms of geometry, composition or strength with the tested units, tests on site according to Annex B are mandated.

For the assessment of anchors to be used in AAC units, tests are conducted in strength classes P2 and P7. For applications in prefabricated reinforced AAC members, the influence of cracks on the capacity of the anchor must be established through testing.

4.2 ETAG 014 – Guideline for Plastic Anchors for Fixing of External Insulation Composite Systems and Prefabricated Units



ETAG 014, which provides the basis for the assessment of plastic anchors for securing external insulation composite systems (ETICS) and prefabricated units (Vêtures), was endorsed by EOTA in November 2001 [16], and thus predates the development of the more general ETAG 020.

Nevertheless, the maintenance of a special ETAG for these types of plastic anchors was justified for the following reasons:

ETICS

- The plastic anchors used for these fastenings have a reduced diameter and embedment (outside of the scope of ETAG 020 for normal plastic anchors) and are equipped with unique appurtenances designed to capture the insulation without significantly damaging it,
- The assumed intended working life of the insulation systems address is only 25 years, and
- The metal parts (screw, nail) are protected from exposure to the elements by the insulation.

Furthermore, the large number of fastening points associated with attachment of these insulation systems implies a high degree of redundancy, justifying fewer and less stringent requirements than ETAG 020.

The Guideline applies to the use of plastic anchors in concrete and masonry. The risk to human life in case of anchor failure is deemed to be low. The anchor consists of an expansion element (screw or nail) and a plastic sleeve with a plate or a collar. The diameter of the plastic sleeve shall be at least 5 mm (0.2 in.), the effective anchorage depth at least 25 mm (1.0 in). The expansion element may consist of metal or polymeric material. The plastic sleeve may consist of polyamide, polyethylene, polypropylene or other polymeric-material.

This Guideline is applicable for five different use categories: normal weight concrete, solid masonry, hollow and perforated masonry, lightweight aggregate concrete and autoclaved aerated concrete.

The tests involved in the assessment of anchors are:

- Tests for confirming their suitability (reliability tests),
- Tests for evaluating the admissible service conditions (service-condition tests), and
- Tests for checking durability.

Because it is difficult to provide values for all different types of masonry and to include all influences, there is the possibility to have tests carried out on the construction site. Guidance for the tests and their evaluation is given in Annex D.

4.3 ETAG 029 – Guideline covering metal injection anchors for use in masonry

The Guideline for metal injection anchors for use in masonry [17] includes

- Annex A "Details of tests,"
- Annex B (informative) "Recommendations for tests to be carried out on the construction works," and
- Annex C "Design methods for anchorages."

The Guideline is finalized at the EOTA level but has not yet been endorsed by the EC. The system of conformity "1" is stipulated in the EC mandate. The basic principals were derived from Guideline ETAG 001, Part 5 (i.e., for the adhesive) and from Guideline ETAG 020 (for the base material).

The Guideline for metal injection anchors for use in masonry applies to anchors for which requirements for mechanical resistance and stability and safety in use in the sense of the Essential Requirements No 1 (ER1) and No 4 (ER4) of the CPD should be fulfilled. Failure of anchorages made with these products would cause an immediate risk to human life and/or lead to considerable economic consequences. As with mechanical anchors according to ETAG 001 Parts 1 through 5, anchorages with single anchors are approved. The assumed working life of the injection anchors is 50 years.

This ETAG covers applications only where masonry members in which anchors are embedded are subject to static or semistatic loading.

Injection anchors consist of a metal part (threaded rod, deformed reinforced bar, internal treaded socket, etc.) and injection mortar (adhesive). For applications in hollow or perforated masonry units, mesh sleeves made of metal or plastic are supplied to retain the adhesive around the anchor element and create an interlock with the masonry unit. This Guideline applies only to anchors having a minimum thread size of 6 mm (M6, 0.24 in.) and a minimum embedment depth of 50 mm (2 in.). The minimum thickness of the masonry unit in which the anchor is embedded is 100 mm (4 in.).

The manufacturer of the adhesive has the opportunity to choose between several use categories comprised of type of masonry, installation and use in dry interior conditions or in wet base material, and the application temperature range. A diagram of the possible use category combinations can be seen in Table 5.

Table 5 – Use categories according to ETAG 029

Masonry	Installation/Use in masonry	Short-term temperature
Solid masonry + (b)	dry/dry (d/d)	-40°C (-40°F) up to +40°C (104°F) (T_a)
Hollow or perforated masonry (c)	wet/dry (w/d)	-40°C (-40°F) up to +80°C (176°F) (T_b)
Autoclaved aerated concrete (d)	wet/wet (w/w) *	On manufacturers request (T_c)

+ Also covers units with vertical perforations comprising up to 15% of the unit cross section.

* Also includes use category dry/wet (d/w).

All categories may be combined arbitrarily.

The tests involved in the assessment of anchors are:

- Tests for confirming their suitability (reliability tests),
- Tests for evaluating the admissible service conditions (service-condition tests), and
- Tests for checking durability of the adhesive and the metal parts.

The following suitability tests are necessary for these anchors:

- Setting capacity in dry and wet base material,
- Reliability under the influence of different temperatures,
- Reliability under sustained and repeated loads,
- Reliability under freeze/thaw conditions, and
- Determination of the maximum torque moment.

As with other anchor types, a certain reduction in failure load, scatter of test results and deviation of load/displacement behavior in comparison to the behavior under normal conditions is acceptable.

Tension and shear tests for single anchors are conducted to determine the admissible service conditions and the minimum edge distance. The minimum spacing may be determined on anchor groups if deviating from the recommended values.

Annex A "Details of tests" is analogous to Annex A for other anchor types.

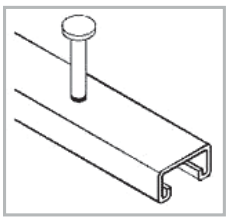
Annex B (informative) "Recommendations for tests to be carried out on the construction works" is similar to the corresponding annex for plastic anchors. In lieu of pull-out tests, a determination of the characteristic capacity via proof load testing is possible.

In addition to the standard design procedures, Annex C "Design methods for anchorages" includes a simplified procedure that establishes a value for all load directions. A reduction factor is applied in both design methods for masonry with nonfilled joints or where the joint condition is not verifiable (plastered walls). Additionally, it must be shown that the extraction of a single masonry unit from the wall under anchor tension loading is precluded.

5 Common Understanding of Assessment Procedure (CUAPs)

As discussed in Section 2.4, European Technical Approvals may be generated with Guidelines or, alternately, with CUAPs. Unlike Guidelines, which are placed in their entirety in the public domain by EOTA, CUAPs are identified only by title [5, 18]. The specific CUAP provisions must be obtained from the approval bodies. Some representative CUAPs are described below.

5.1 CUAP for anchor channels



Anchor Channel

Anchor channels are comprised of segments of C-shaped channel profiles fabricated from hot-rolled or cold-formed steel with at least two anchor elements attached to the channel web. The anchors must be attached to the channel during anchor fabrication at the plant (i.e., may not be welded on site). The number of anchors that may be attached to the channel is not limited. Anchor channels are set in the formwork so that the rim of the channel is flush with the concrete surface. They accept various forms of T-bolts, spring nuts or other forms of interlocking attachments.

The anchor channels, anchors, screws, nuts and washers are fabricated from carbon or stainless steels. Anchor channels addressed by the CUAP range in length from 100 mm to 6 m (4 in. to ca. 20 ft.). The channel profile must have a depth of 15 to 50 mm (0.6 to 2 in.), and a width of 25 to 75 mm (1 to 3 in.). The anchor length as measured from the attachment point to the channel should be at least 60 mm (2.4 in.).

The anchors are either welded or cold-forged to the channel web. Welded anchors may consist of T-profiles, shear studs or headed bolts. Cold-forged anchors consist of round bolts (minimum diameter 5 mm) with a forged head at the embedded end. (The head may also consist of a nut threaded onto the end of a stud.) During manufacture, the anchor elements are inserted into holes in the back of the channel and secured by a cold forging process.

Anchor channels are intended for use under predominantly static load or semistatic load in reinforced or unreinforced normal weight concrete of strength class C12/15 to C90/105 (1,700 to 13,000 psi). Anchor channels may be qualified for use in concrete that may crack over the anchor service life. They may be used for the transmission of tension, and shear or oblique loads, as long as the loads act perpendicular to the longitudinal axis of the channel.

Verification and evaluation of suitability.

The CUAP addresses only loads applied perpendicular to the longitudinal axis of the channel. Uses where the load acts along the channel axis are not addressed. Characteristic resistances are determined through tests specified in the CUAP and ETAG 001 [6] in conjunction with the design method according to CEN/TC 250/SC 2/WG 2 [13]. Design for both cracked and uncracked concrete is included; however, all tests are conducted in uncracked concrete.

In addition to the usual anchor failure modes, anchor channels exhibit the following additional failure modes:

- Failure of the connection of the anchor to the channel;
- Failure of the spring nut, T-bolt, etc., used to transfer loads to the channel;
- Failure by local distortion of the channel flange and subsequent extraction of the spring nut, T-bolt, etc.; and
- Flexural failure/buckling of the channel.

Depending on the kind of steel used, various durability categories are applicable. For proof of durability no special verifications are necessary if the following conditions are met:

- All steel parts are protected by a minimum concrete cover according to the national provisions of the Member States;
- For dry, interior locations: Channels and anchors fabricated from carbon steel are hot-dip galvanized (coating ≥ 50 µm), and the threaded fasteners are electro-galvanized (plating ≥ 5 µm) and/or mechanically zinc-coated (plating ≥ 10 µm);

- For dry interior conditions as well as humid internal conditions, external atmosphere, industrial atmosphere and marine environments, if no particularly aggressive conditions exist: All parts fabricated from a suitable austenitic stainless steel (1.4401, 1.4404 or 1.4571); and
- For dry interior conditions, humid internal conditions, external atmosphere, industrial atmosphere, marine environments and particularly aggressive conditions: All parts fabricated from high-grade stainless steel (1.4529 or 1.4547). Aggressive conditions may include permanent or alternating immersion in seawater (e.g., coastal splash zones), chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g., in desulphurization plants or road tunnels where deicing salts are used).

If other corrosion protection measures are employed, the effect of the corrosion protection must be separately verified taking into account the various environmental influences.

The following admissible service conditions for the channel bar are set forth in the ETA:

- characteristic resistances of all steel parts under tension and shear loading,
- geometric data of the channel,
- factors for the load distribution,
- characteristic and minimum spacing and edge distances of the anchor,
- characteristic spacing and edge distances for splitting,
- minimum thickness of the concrete member,
- anchorage depth,
- required torque,
- existence of supplementary reinforcement, and
- admissible displacements under tension and shear loading.

Verifications are carried out for the following failure modes:

- Characteristic resistances under tension load:
  - concrete cone failure
  - splitting failure
  - blow-out failure
  - design tension resistance of supplementary reinforcement
- Characteristic resistances under shear load:
  - steel failure with lever arm
  - concrete pry-out failure
  - concrete edge failure
  - design shear resistance of supplementary reinforcement
- Influence length of load distribution to the individual anchors

5.2 The CUAP for embed plates with welded studs

This CUAP deals with anchor assemblies consisting most generally of one or several anchors, usually shear studs, welded to a steel plate. Depending on the welding method, the welding is performed either in the manufacturing plant or on the construction site. The steel plate with the welded-on anchor bolts is mounted in the formwork, producing a surface-flush anchorage to which other components can be welded. The plate and anchors may consist of carbon steel or suitable stainless steels.

The following anchor bolts may be used:

- Headed studs of nonalloy or stainless steel for stud arc welding with the dimensions and the symbol "SD" according to clauses 4 and 6, Table 13 of EN ISO 13918-1998 [19]. It is also permitted to use stacked headed studs welded on top of each other by means of stud arc welding. A padded ring is to be placed underneath the head of the first headed stud. The padded ring is intended to prevent load transfer through the upper bolt head.
- Headed anchor bolts of generic type
- Headed deformed reinforcing bars of grade B 500 B

For steel plates that are loaded by tensile forces in the through-thickness direction, the risk of lamellar tearing of the plate needs to be considered. For fatigue loading applications, only ultrasonic inspected plates may be used.

Headed studs for stud arc welding according to EN ISO 13918:1998 are welded to the steel plate by means of drawn stud arc welding with ceramic ferrules or protective gas. Welding of the headed studs via stud arc welding may be performed in the manufacturing plant or on site. Other anchor bolts or headed reinforcing bars are welded to the steel plate via metal inert gas welding (MIG welding) at the manufacturing plant.

Verification and evaluation of suitability.

The test program is similar to that used for headed bolts and undercut anchors. The design procedure is similar to that used for metal anchors in Annex C of ETAG 001 [6]. The necessary tests serve to check the calculated verifications, which were derived from tests on headed bolts.

Welded connections using stud arc welding are checked in accordance with EN ISO 14555 Table 10. For MIG welded specimens (Process 135) tensile tests and impact bending tests ≥ 60° are performed.

The following tests are performed for the determination of the characteristic tension resistance of the headed bolts:

- Determination of the steel capacity
- Concrete cone failure of a single anchor without influence of spacing and edge distance
- Blow-out failure of a single anchor at the member edge.

The characteristic shear capacity of a single anchor is checked at the member edge. The minimum edge distance of the at least 160 mm long headed bolts with a diameter of at least 25 mm is 100 mm, and the concrete strength is at least C20/25 (2,900 psi).

No special tests are required for the verification of the durability of the steel plate with cast-in anchors if one of the following applies:

- Nonalloy steel is used and installation is limited to dry interior conditions.
- Suitable stainless steels (Steel plate 1.4571, 1.4401, 1.4404, 1.4439 and headed bolt 1.4401, 1.4301, 1.4303) in external atmospheric exposure (including industrial and marine environment) if no particularly aggressive conditions exist.

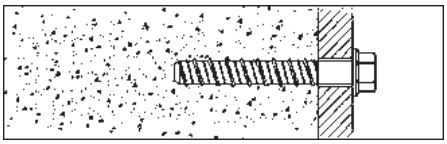
Design and Installation.

Design must consider all loading conditions. If a design method other than that given in the CUAP is used, the test program must be revised as required. Verifiable calculations and drawings are established by taking account of the loads to be transferred. The position of the embed plate is shown on the drawings together with all adjoining reinforcement. The following installation conditions are assumed:

- The installation is carried out by qualified personnel under the supervision of the site manager.
- The embed plate corresponds to that tested without substitution, including the dimensions of the steel plate, size and length of the anchors, grade of steel and welding method.
- The embed plate is placed in the formwork such that no movement of the plate occurs during the placement and compaction of the concrete.
- Complete compaction of the concrete under the steel plate and around the anchor heads.

- Compliance with the prescribed installation parameters.
- All welding of steel components to the embed plate is performed by a contractor meeting the corresponding quality requirements for welding according to EN 729 "Quality requirements for welding – fusion welding of metallic materials".

5.3 The CUAP for concrete screws for anchorage in normal-weight concrete



Concrete Screw

Screw anchors (concrete screws) are fabricated with a thread possessing sufficient hardness to enable the screw anchor to be screwed into a predrilled cylindrical drill hole in the concrete. The anchor head (hexagon head, counter sunk, etc.) is designed to permit manual installation with a wrench or setting with an impact screw driver. The thread of the screw cuts a matching thread into the concrete during setting. Tension forces are resisted by mechanical interlock over the threaded length. Screw anchors may be fabricated from galvanized, coated or stainless steel. The CUAP addresses screw anchors with a minimum drill hole diameter of 6 mm; the minimum effective embedment depth is 40 mm.

Verification and evaluation of suitability.

The tests set out in the CUAP are based on ETAG 001 Part 3 – undercut anchors. Additionally, setting tests are conducted to demonstrate that neither steel failure of the screw nor stripping of the internal thread occurs during setting. The CUAP does not address the removal and resetting of screw anchors.

Reliability tests (suitability tests) and service-condition tests are conducted in accordance with ETAG 001 Part 3.

The additional setting tests to verify the installation process are as follows:

- Setting tests in high-strength concrete, C50/60 (7,250 psi) with the smallest admissible drill diameter.
- Setting tests in low-strength concrete, C20/25 (2,900 psi) with the largest admissible drill diameter.
- Setting with impact screw driver.
- Repeated load tests according to ETAG 001, Part 3. In these tests, a beveled washer is used to check the head for susceptibility to premature fracture.
- Embrittlement tests. The manufacture of screw anchors typically involves processes intended to achieve the necessary hardness in the threads, which may also lead to a greater likelihood of hydrogen embrittlement and stress corrosion fracture. Therefore, in these tests, a sufficient safety margin must be demonstrated against brittle fracture of the screw anchor. No failure may occur during the setting tests, even when the recommended installation torque by the manufacturer is exceeded by a defined margin.

Design and installation.

The design procedures for screw anchors follow from those used for other mechanical anchors according to ETAG 001, Annex C, Method A. When installing screw anchors, special attention must be paid to the use of a calibrated torque wrench or an impact driver with a defined torque limit.

Furthermore, it should be verified that the screw head comes in complete contact with the fixture and that the screw head is not damaged.

6 European Technical Approvals - ETAs

6.1 ETAs for construction products

ETAs may be granted for any construction product

- that deviates significantly from harmonized standards,
- that is not covered by harmonized standards,
- that has not received a mandate for inclusion in a harmonized standard, or
- for which a harmonized standard is not yet available.

European technical approvals are always issued for a particular construction product and the associated manufacturer or, where applicable, all manufacturing plants associated with the product. A list of the issued ETAs are administrated and published by the EOTA office in Brussels [5] and by the German Institute for Building Technology in Germany [18]. ETAs are uniformly organized in accordance with a European template in the following style:

- Cover page (1st page)
- Legal bases and general conditions,
- Specific conditions of the European technical approval, and
- Annexes.

Proponents wishing to obtain an ETA for a specific construction product must apply at one of the EOTA approval bodies. This involves completion of the requisite form and submission of test results and detailed information about the product. The test reports include all information described in the relevant ETAG or CUAP under which the application is made. Based on the information submitted, the approval body then develops an Evaluation Report as well as an ETA draft. These two documents are then distributed to the relevant EOTA approval bodies for review. The review period after receipt of the draft ETA and Evaluation Report is two months. If no comments are received, the ETA is issued as drafted. If comments are received, these must be resolved prior to issuance of the ETA. ETAs are issued in the official language(s) of the Approval Body as well as in English.

6.2 ETAs for anchors and fasteners

To date approximately 600 ETAs have been issued under ETAGs 001, 014, and 020, as well as under the several CUAPs that address anchoring products. These ETAs have been prepared by 11 approval bodies for more than 90 proponents originating from 25 countries. This demonstrates the success and acceptance of the European Approval process in the area of anchorage.

7 Conclusion

In the field of anchors, four European Guidelines for different anchor types for use in masonry and concrete and 10 CUAPs for cast-in anchors, power actuated fasteners and special anchors were acquired. The existing Guidelines are being adjusted on account of new knowledge and conclusions. They will be amended—e.g., with regulations for dynamic and seismic loading—in the future.

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This article is intended to provide information about the European Provisions for the Testing Assessment and Design of Anchors in Concrete and Masonry. It should not be construed as an endorsement or procedural recommendation by ICC-ES®.

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