

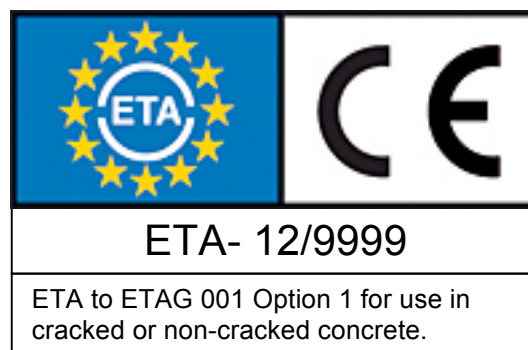


CFA Guidance Note: ETAs & design methods for anchors used in construction.

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1 INTRODUCTION



This Guidance Note has been written to complement BS 8539:2012 *Code of practice for the selection and installation of post-installed anchors in concrete and masonry* published in October 2012 and which, by virtue of restrictions placed on the publication of British Standards, cannot be seen to endorse the use of independent endorsements such as European Technical Approvals/Assessments (ETAs) and which therefore refers to this Guidance Note for elaboration on the subject. What BS 8539 *does* say with regard to ETAs is: "Users of this British Standard are advised to consider the desirability of selecting anchors with a relevant European Technical Approval." It was the clear will of the BS drafting panel that, wherever possible, i.e. for any application for which a suitable anchor with an ETA exists on the market, then such an anchor should be chosen.

ETAs (European Technical Approvals/Assessments), are the only mechanism by which manufacturers can gain independently assessed approvals for anchors to be used in safety critical applications throughout Europe. They also facilitate the comparison of the performance of similar products as they are based on tests carried out to closely controlled methods.

ETAs have, until recently, been awarded after rigorous testing to the requirements of European Technical Approval Guidelines (ETAGs) which are eventually to be replaced by European Assessment Documents (EAD) following implementation of the Construction Products Regulation on 1 July 2013. The first ETAG was published, and the first ETAs granted, in 1997 since which time additional ETAGs have been published (as listed below) to cover the vast majority of drilled in anchor types in the most common structural materials. Many companies large and small have since gained, between them, hundreds of ETAs for their products and there are few applications which cannot be covered using an anchor with an appropriate ETA.

This Guidance Note is intended to help the users of ETAs, i.e. the specifiers and installers of anchors, to understand how to select a product with an ETA to the most appropriate ETAG Part, to understand the basis of the design process and to ensure that installation is carried out to the requirements of the ETA & BS 8539.

As indicated under legal background the situation has changed since the implementation of the Construction Products Regulation in July 2013. This Guidance Note will be updated as and when necessary to keep all stakeholders up to date with the requirements. Readers wishing to be kept informed should log on to the CFA website at www.the-cfa.co.uk and register for the occasional newsletter.

The full benefits to specifiers and users of using anchors with ETAs are summarised in section 9.0.

2 LEGAL BACKGROUND

One of the main aims of the European Union is to avoid barriers to trade between Member States. It also aims to harmonise the rules by which the performance of construction products is expressed, by means of the Construction Products Regulation (CPR) which, on 1 July 2013, replaced the Construction Products Directive.

The CPR requires that manufacturers of all Construction Products that fall within the scope of a harmonised European Standard (hEN) or have been awarded an ETA shall draw up a Declaration of Performance (DoP) and all such products must carry CE marking.

Under the CPR European Technical Approvals will remain valid during their period of validity (up to 5 years) and will gradually be replaced by European Technical Assessments (ETA). ETAGs existing before 1 July

2013 may, for the time being, be used as the basis for awarding ETA but will eventually be transformed into EAD. New products not conforming to existing ETAGs will have new EADs written for them when requested by the manufacturers. A listing of all existing ETAGs is published on the EOTA website (www.eota.eu) under the heading "Publications" use the link: <http://www.eota.eu/en-GB/content/etags-used-as-ead/26/>

3.0 TERMINOLOGY

The basic terminology used in discussing ETAs is outlined below. Much of the day to day terminology used in the business of construction fixings is changing. A Guidance Note: *Anchor terminology and notation*, detailing the correspondence between old and new terms is downloadable from the CFA website.

In particular BS 8539 adopts terminology common to Eurocodes so the term "action" is used for loads to be applied to the anchor via the fixture and "resistance" for the capability of the anchor to resist such actions.

EOTA European Organisation for Technical Assessment – was European Organisation for Technical Approvals

The organisation responsible for developing EADs in line with mandates issued by the European Commission. Includes Assessment Bodies from member states. CEO represents European manufacturers on the relevant EOTA working group.

ETAG Guideline European Technical Approval – being replaced by EAD European Assessment Document

The Key document for manufacturers, approval bodies and test laboratories. The framework for test procedures against which anchors are tested and assessed. ETAGs also carry design methods but newly written EADs will not. In future design methods will be enshrined in a European Standard EN 1992-4 Design of fastenings for use in concrete.

ETA European Technical Approval – being replaced by ETA European Technical Assessment

The Key document for specifiers. It contains details of the anchor specification, application limits, performance characteristics, and installation method. It indicates which ETAG/EAD the anchor is approved/assessed to, which design method is to be used and, in the case of anchors with ETA to ETAG 001, which Option is covered for the category of use (see section 5). Existing ETApprovals are valid for no more than five years. ETAssessments will have no limit to their validity as long as the AVCP is maintained and hence the DoP.

DoP Declaration of Performance

The document in which the manufacturer assumes legal responsibility for maintaining the conformity of the product against the declared performance. Requirements for the DoP are contained in Annex III of the CPR. See also¹. Before the DoP can be completed the AVCP assessment must be established.

CE marking

Any construction product for which the manufacturer has drawn up a DoP must carry CE marking and, generally speaking – as there are very few harmonised European Standards covering anchoring products - this means it must have an ETA and have achieved the AVCP (see below) before the manufacturer may affix CE marking. CE marking enables products to be offered for sale throughout the EU. It is not intended as a quality mark but effectively the requirements are sufficiently strict that, *in this case*, it may be regarded as one. Under the CPR CE marking is mandatory for construction products which carry an ETA.

AVCP system of Assessment and Verification of Constancy of Performance – replaces Attestation Of Conformity

The system of AVCP determines the conformity of the product against its technical specification as contained in the hEN or ETA to ensure that both the product and its performance remain unchanged in regular production from that tested in the ETA procedure. AVCPs may have different levels dependent on the implications for the product on health and safety. The manufacturer is required to have a fully documented factory production control system. The ETAGs/EADs for anchors require AVCP to high levels as safety critical applications are covered.

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Certain terms used in BS 8539 have meanings particular to that code of practice:

Specifier

Person responsible for the selection of the anchor. (May be the designer.)

Designer

Person with overall responsibility of the design of a structure, including the anchorage, throughout the whole design and construction phase. (May be the specifier.)

Selection

Overall process of selecting the type and size of an anchor or group of anchors (the design process is part of this).

Design

The process of determining the size of anchor in relation to the loads to be transferred.

4 ETAGs and ETAs

As stated in the definitions above ETAs are awarded following tests and assessments carried out to the appropriate ETAG whose scope is as outlined below. The ETA is the formal document carrying the performance data against which the design process for selecting the size of anchor is carried out. When using manufacturer's published data users should check, by reference to the actual ETA, that quoted performance actually comes from the ETA.

The choice of appropriate ETAG is outlined in sequence charts in section 5.

4.1 Test regimes and assessment criteria

ETAGs contain comprehensive test regimes with demanding requirements, this mean specifiers can have full confidence in the functioning of the approved anchor and in the published performance characteristics.

Requirements are laid down for three key aspects:

Suitability, Admissible Service Conditions, Durability.

Suitability tests

These tests investigate the sensitivity of anchors to various influencing factors, where appropriate, such as low and high concrete strength, repeated loads, location in cracks, repeated crack openings, sustained loads, elevated temperatures and aspects of installation such as hole cleaning, drill diameter tolerance, installation torque, humidity and temperature. Tests are only required in cracked concrete when the approval covers use in cracked concrete.

Admissible Service Conditions tests

These tests determine the characteristic resistances as well as appropriate edge and spacing distances dependent on the option chosen by the manufacturer.

Durability

Various environmental conditions are considered. Generally no tests are required if zinc plated anchors are restricted to dry indoor conditions and stainless steel anchors are used for normal external atmospheric exposure or permanently damp internal conditions. For harsh environments different materials or coatings may be approved following special tests. Bonded anchor materials are subject to special accelerated ageing tests.

Assessment criteria applied to test results

Comprehensive requirements for all suitability tests include:

- Load/displacement curves are assessed to ensure smooth curves with no uncontrolled slip.
- Products must show a limited scatter of results.
- Comparison of ultimate values from tests with various influencing factors against results from a reference test.

Special requirements are also set for individual tests.

Characteristic resistances for some anchors may be higher or lower than for previously published values due to the harmonised safety approach of the ETAG. Resistances for cracked concrete are generally lower than for non-cracked concrete.

4.2 ETAGS issued to date.

At the time of publication the following ETAGs have been published.

- ETAG 001 Metal anchors for use in concrete
- ETAG 014 Plastic anchors for fixing of external thermal insulation composite systems with rendering.
- ETAG 020 Plastic anchors for multiple use in concrete or masonry for non-structural applications
- ETAG 029 Metal injection anchors for use in masonry

Alongside these main documents are a series of Technical Reports covering various associated aspects

- TR 018 Assessment of torque-controlled bonded anchors
- TR 020 Evaluation of Anchorages in Concrete concerning Resistance to Fire
- TR 023 Assessment of post-installed rebar connections
- TR 029 Design of bonded anchors
- TR 045 Design of metal anchors for use in concrete under seismic actions

These are referred to in the more detailed discussion of the scope of each ETAG below.

The EOTA website www.eota.eu lists ETAGs endorsed by the Commission (downloadable) under the heading Publications, along with Technical Reports and details of revisions to ETAGs contained in History/Progress Files and a full list of ETAs awarded to date.

4.3 Individual ETAGs in more detail.

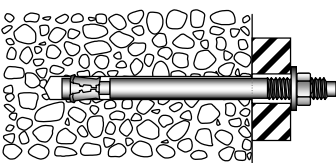
4.3.1 ETAG 001 Metal anchors for use in concrete Parts 1 - 5

- Part 1 General
- Part 2 Torque controlled expansion anchors
- Part 3 Undercut anchors
- Part 4 Deformation controlled anchors
- Part 5 Bonded anchors*
- Part 6 Anchors for multiple use in non-structural applications
- Annex A Test requirements
- Annex B Tests for admissible service conditions
- Annex C Design methods**
- Annex E Assessment of metal anchors under seismic action**

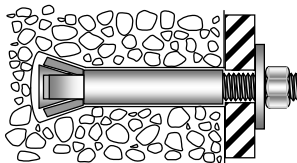
* Requirements for Torque controlled bonded anchors are covered in an EOTA Technical Report: TR 018 Assessment of Torque controlled bonded anchors, while Assessment of post-installed rebar connections is dealt with in TR 023.

** Design of bonded anchors is covered in TR 029 and anchors under seismic actions under TR 045.

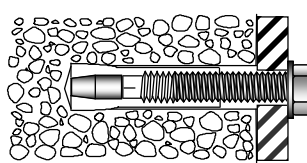
Part 2 Torque controlled



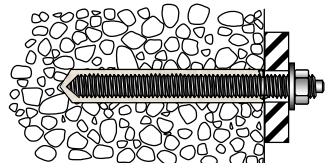
Part 3 Undercut



Part 4 Deformation controlled



Part 5 Bonded anchors



These illustrations are general examples only, other configurations of anchors also fall within these categories.

Anchors approved to ETAG 001 Parts 1 – 5 are suitable for single or multiple use in applications which are either statically determinate or statically indeterminate (see 4.3.2. below). They are qualified according to one of 12 options which cover the various application parameters as shown in Table 1 below, including concrete strength and condition (i.e. cracked or non-cracked); loading direction and edge/spacing criteria. Critical among these is that options 1- 6 cover use in cracked or non-cracked concrete while options 7 – 12 cover use in non-cracked concrete only. Low numbered options, 1 and 7, are the most comprehensive while high numbered options, 6 and 12, involve severe limitations, see Table 1 and section 6.2.

Currently the subject of fatigue is not covered by ETAG parts specifically although manufacturers may have their own data. EOTA are drafting the following annexes to ETAG 001 which are expected to be published within the foreseeable future.

- Annex D Assessment of metal anchors under dynamic (fatigue) actions
- Annex F Evaluation of anchorages in concrete concerning resistance to fire (To be based on TR 20).

Table 1 Options for ETAs qualified according to ETAG 001.

Option No.	Concrete		Characteristic resistance quoted for				Reduced Edge & Spacing	Design Method*
	Cracked & Non-cracked	Non-cracked only	C20/25 only	C20/25 up to C50/60	One (lowest) value - any direction	Tensile & Shear values		
1	✓			✓		✓	✓	A
2	✓		✓			✓	✓	A
3	✓			✓	✓		✓	B
4	✓		✓		✓		✓	B
5	✓			✓	✓			C
6	✓		✓		✓			C
7		✓		✓		✓	✓	A
8		✓	✓			✓	✓	A
9		✓		✓	✓		✓	B
10		✓	✓		✓		✓	B
11		✓		✓	✓			C
12		✓	✓		✓			C

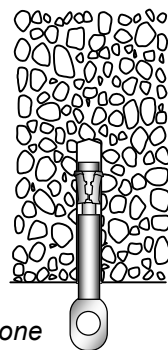
* See section 6.2 for a brief outline of the different Design Methods

When selecting an anchor for a particular application care will be needed to check that the Option of a particular ETA covers the application parameters.

4.3.2 ETAG 001 Metal anchors for use in concrete Part 6: Anchors for multiple use in non-structural applications.

This ETAG Part is sufficiently different to the other parts of ETAG 001 as to be regarded as a different ETAG. It is aimed primarily at fixings for the top fixing of suspended ceilings, see also².

Anchors approved to this ETAG are suitable for use in concrete which may be cracked on non-cracked and for applications which are statically indeterminate only i.e. are safety critical but where load sharing can take place and the failure of an individual anchor will not lead to the collapse of the whole system. In order to use anchors with ETA to this ETAG part the preconditions of the definition of “Multiple use” must be satisfied, if they are not then anchors to ETAG 001 Parts 1 – 5 should be used.



The definition of “multiple use” is as follows for anchors to ETAG 001 Part 6*:

<<The design of the fixture is such, that in the case of excessive slip or failure of one anchor the load can be transmitted to neighbouring anchors without significantly violating the requirements on the fixture in the serviceability and ultimate limit state. For example the design of the fixture may specify the number n_1 of fixing points to fasten the fixture and the number n_2 of anchors per fixing point. Furthermore by specifying the design value of actions N_{Sd} on a fixing point to a value $\leq n_3^$ (kN) up to which the strength and stiffness of the fixture are fulfilled and the load transfer in the case of excessive slip or failure of one anchor need not to be taken into account in the design of the fixture.*

In the absence of a definition by a Member State the following default values may be taken:

$$n_1 \geq 4; n_2 \geq 1 \text{ and } n_3 \leq 3.0\text{kN or}$$

$$n_1 \geq 3; n_2 \geq 1 \text{ and } n_3 \leq 2.0\text{kN} \quad * \text{ values for } n_3 \text{ are different for ETAG 020 see below.}$$

The value n_3 might be increased if in the design it is shown that the requirements on the strength and stiffness of the fixture in the serviceability and ultimate states after the failure of one anchor are fulfilled.>>

The above values for n_1 , n_2 and n_3 apply in the UK.

The above definition of “Multiple use” means that when an application fulfils the preconditions for n_1 , n_2 and n_3 the stiffness of the fixture does not need to be considered in the design.

The first of the above definitions is illustrated in the figure below, the second is similar.

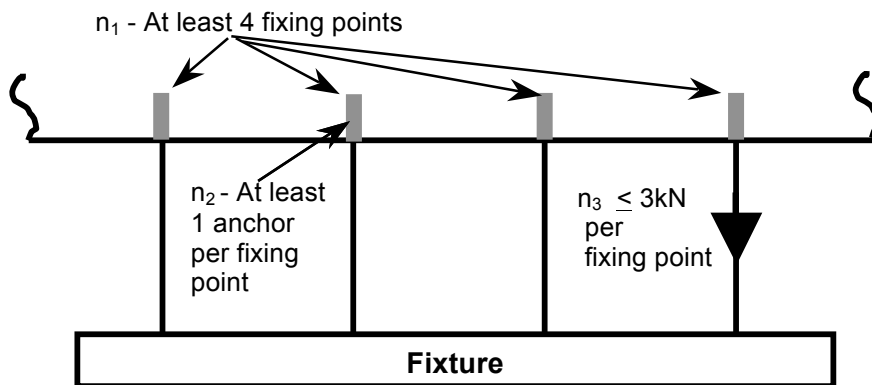


Figure 1 Illustration of parameters qualifying an application as “Multiple use”.

Note: “Multiple use” does not mean or imply that an anchor can be re-used, most cannot.

4.3.3 ETAG 014 Plastic anchors for fixing of external thermal insulation composite systems with rendering.

Approvals may be gained in a variety of base materials including concrete (normal weight; lightweight aggregate or autoclaved aerated) and/or masonry units of clay, calcium silicate, aggregate concrete, autoclaved aerated concrete or other similar materials. See also 4.4 below.

4.3.4 ETAG 020 Plastic anchors for multiple use in concrete or masonry for non-structural applications

- 5 parts cover 1) General requirements, use in 2) normal weight concrete, 3) solid masonry, 4) hollow or perforated masonry and 5) autoclaved aerated concrete.
- 3 annexes cover A) Details of tests, B) Recommendations for tests to be carried out on the construction works and C) Design Methods for anchorages.

Anchors approved to ETAG 020 are suitable for use in applications which are statically indeterminate only and satisfy the definition of “Multiple use” specific to this ETAG which is similar to that of ETAG 001 Part 6, see 4.2.2 above, with the following values for n_3 .

$$n_1 \geq 4; n_2 \geq 1 \text{ and } n_3 \leq 4.5\text{kN or}$$

$$n_1 \geq 3; n_2 \geq 1 \text{ and } n_3 \leq 3.0\text{kN.}$$

See also 4.4 below.

4.3.5 ETAG 029 Metal injection anchors for use in masonry

- 1 part covers all test and assessment requirements
- 3 annexes cover A) Details of tests, B) Recommendations for tests to be carried out on the construction works and C) Design Methods for anchorages

Anchors approved to ETAG 029 are suitable for use in applications which are either statically determinate or statically indeterminate. See also 4.4 below.

4.4 Qualification of the masonry of the job.

When anchors with ETAs according to ETAG 014, ETAG 020 or ETAG 029 are specified for use in masonry and the particular masonry of the job in question falls into the category of masonry covered by the ETA but the masonry units of the job do not meet or exceed the strength and dimensions of those quoted in the ETA then site tests are necessary to determine the allowable resistance. A procedure for carrying out such job site tests is called up in an annex of the relevant ETAG, however as the test requirements are particularly onerous (15 tests are to be carried out to failure) BS 8539 also allows tests to be carried out to an alternative procedure in which as few as 5 tests may be carried out and the results analysed to a statistical approach. This test regime is outlined in BS 8539 Annex B.2.2.1 and details of how to carry out the tests in CFA Guidance Note *Procedure for site testing construction fixings - 2012*.

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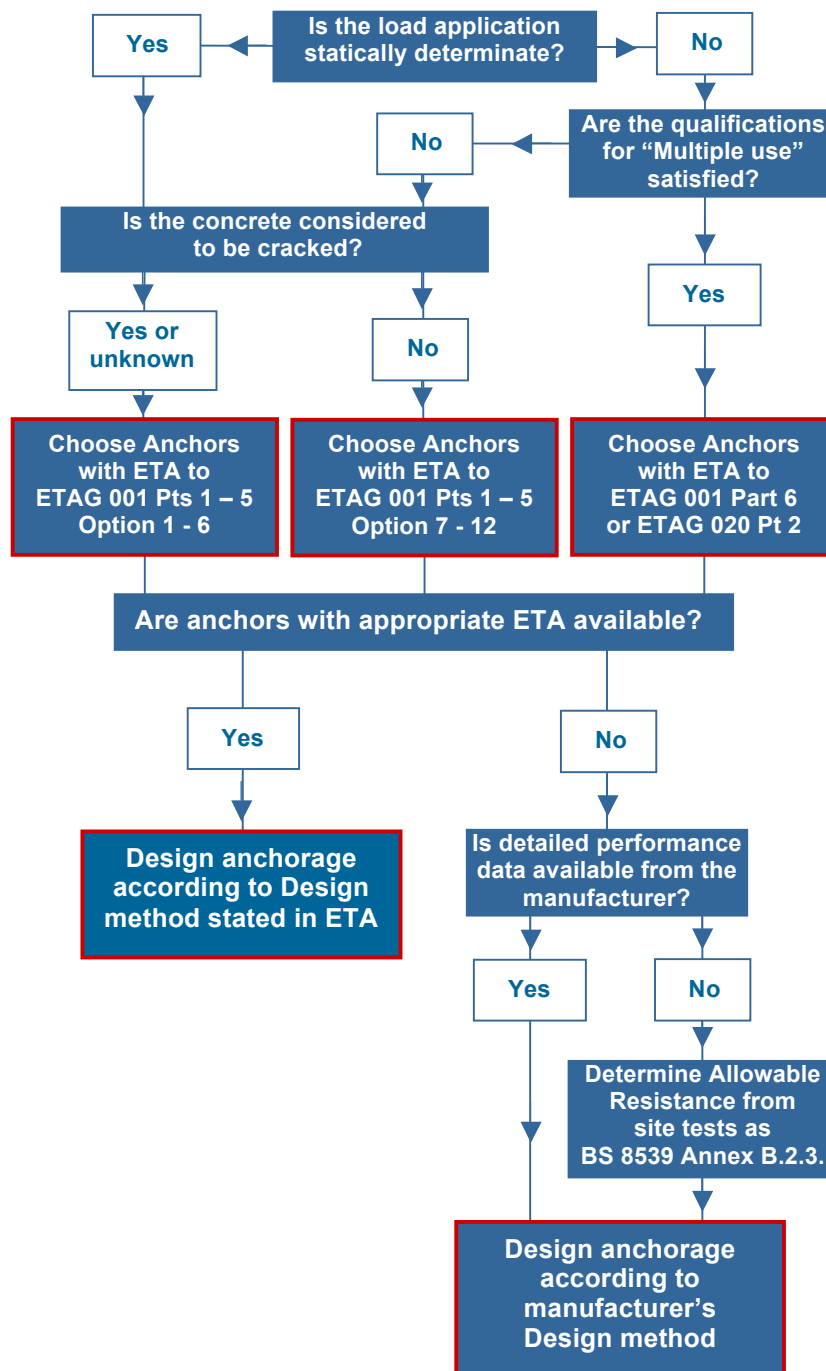
5 ANCHOR SELECTION.

There are many factors to be taken into account when selecting the most appropriate anchor, these are elaborated in BS 8538 section 5 and in a CFA Guidance Note: *Anchor Selection*.

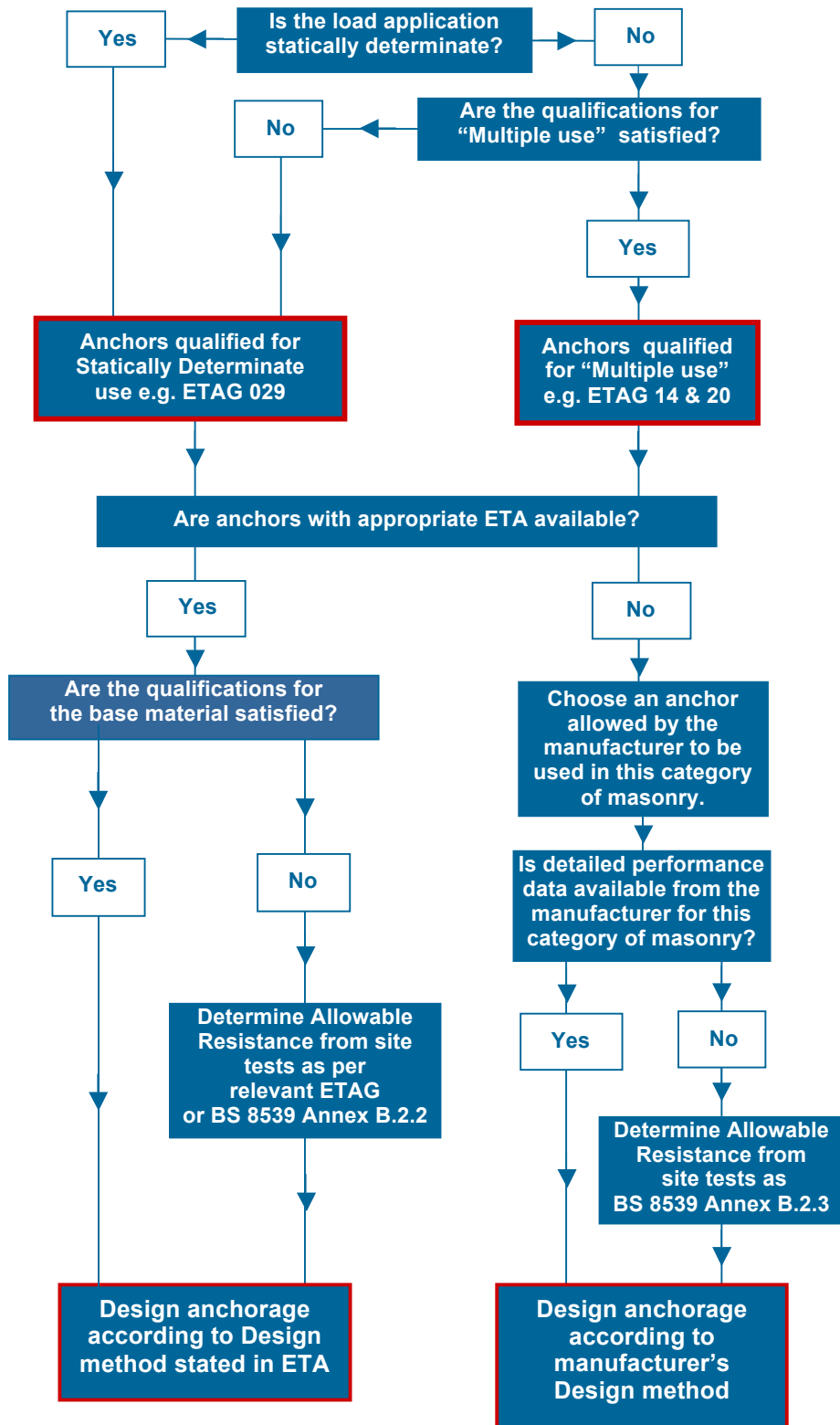
BS 8539 splits the selection process into two phases - the selection of the anchor type and, once that is determined, the choice of correct size to satisfy the loading requirements of the application. The latter process is referred to as Design and the methods by which it is carried out are Design Methods, these are elaborated in section 6.0 of this Guidance Note and Annex A of BS 8539.

One aspect of vital importance to the first phase referred to above, choosing the anchor type, is that, wherever possible, anchors qualified with an ETA to the most appropriate ETAG should be chosen. The following sequence diagrams are intended to assist with the selection of the most appropriate product, one for use in concrete and one for anchors to be used in masonry. Both also indicate the approach that should be followed if no anchor is available with an appropriate ETAG.

Sequence diagram for the selection of anchors with the most appropriate ETAG for use in concrete.



Sequence diagram for the selection of anchors with the most appropriate ETAG for use in masonry.



5.1 Commentary on the sequence diagrams

The use of anchors with ETA is necessary only for applications regarded as being safety critical, ETAG 001 in particular refers to applications in which the failure of anchors can:

- a) result in collapse or partial collapse of the structure; and/or
- b) cause risk to human life; and/or
- c) lead to significant economic loss

Is the application relevant with respect to safety?

To answer this question requires engineering judgement and is the responsibility of the specifier. In general safety relevance must be assumed when the failure of the anchorage would compromise the stability of the works, cause risk to human life and/or lead to considerable economic consequences.

If this can be answered definitely with “no” the user can select and use anchors without ETA. If the reply is “yes” approved products should be used or anchors chosen which can demonstrate compliance with the Building Regulations by some other means. It is always possible to imagine a chain of events leading to the worst consequences resulting from the failure of any anchorage. This would suggest that all applications should be considered to be safety relevant. However the probability of this chain of events arising should be taken into account.

The recommendation of BS 8539 is clear that for any safety critical application anchors with ETA should be used if there are such anchors on the market.

Is the part to be fixed part of the building structure?

Simplified, the answer to the question is easy: What happens if the fixed part is removed? If the column of a warehouse is removed the structure will collapse (if the respective loads occur). Therefore, the column is part of the load bearing structure. However, if a pipeline in a building is removed the load bearing structure is preserved but the use of the building is restricted. Therefore, the pipeline is not part of the load bearing structure.

Is the load statically determinate or indeterminate?

An application is statically determinate if the stability of the fixture is dependent on every anchor supporting it and the failure of one could lead to collapse of that element within the works.

It is therefore indeterminate if the stability of the fixture is not dependent on every anchor supporting it, i.e. there is a degree of redundancy. This means that if one anchor fails, or more likely suffers some displacement, as a result of the applied load, the fixture, be it a simple bracket or run of pipework or the grid of a suspended ceiling, will have sufficient stiffness to transfer the load to adjacent anchors. In the general case proving redundancy is difficult and requires sophisticated structural analysis. For most cases therefore it is simpler and safer to assume the application to be statically determinate and to select anchors with ETA which satisfy that requirement e.g. to ETAG 001 Parts 1 - 5. In the case of suspended ceilings and similar light duty applications involving multiple anchors no such analysis is required if an anchor qualified to ETAG 001 Part 6 is used as long as the application satisfies the criterion for “Multiple use” as defined in the ETAG and outlined in section 4.3.2. For applications involving Plastic anchors to ETAG 020 “Multiple use” is defined in 4.3.4. This issue is also elaborated in BS 8539.

Is the concrete considered to be cracked?

The responsibility for the decision as to whether the concrete in the area of an anchorage is cracked or not rests solely with the specifying engineer.

Concrete may be cracked as a result of a variety of causes. ETAG 001 Annex C allows each Member State to give guidance on the distinction between cracked and non-cracked concrete. In the absence of such guidance a method is given for determining whether a particular part of the structure is cracked or not, by calculating the stress condition. If no such consideration is made then cracked concrete should be assumed.

This means it is possible to solve the problem as there are numerous qualified products on the market.

However, the qualification class of the product makes the application more expensive.

Verifying that concrete is not cracked can be required when the amount of the load occurring and the geometrical conditions (small structures, close spacing and edge distances of the anchors) require detailed calculation by exploring all possibilities. The capacity of anchors suitable for cracks given in the ETA can be at least 40% greater when they are anchored in concrete which is not cracked. The extra effort in the calculation can thus be justified.

6.0 DESIGN METHODS

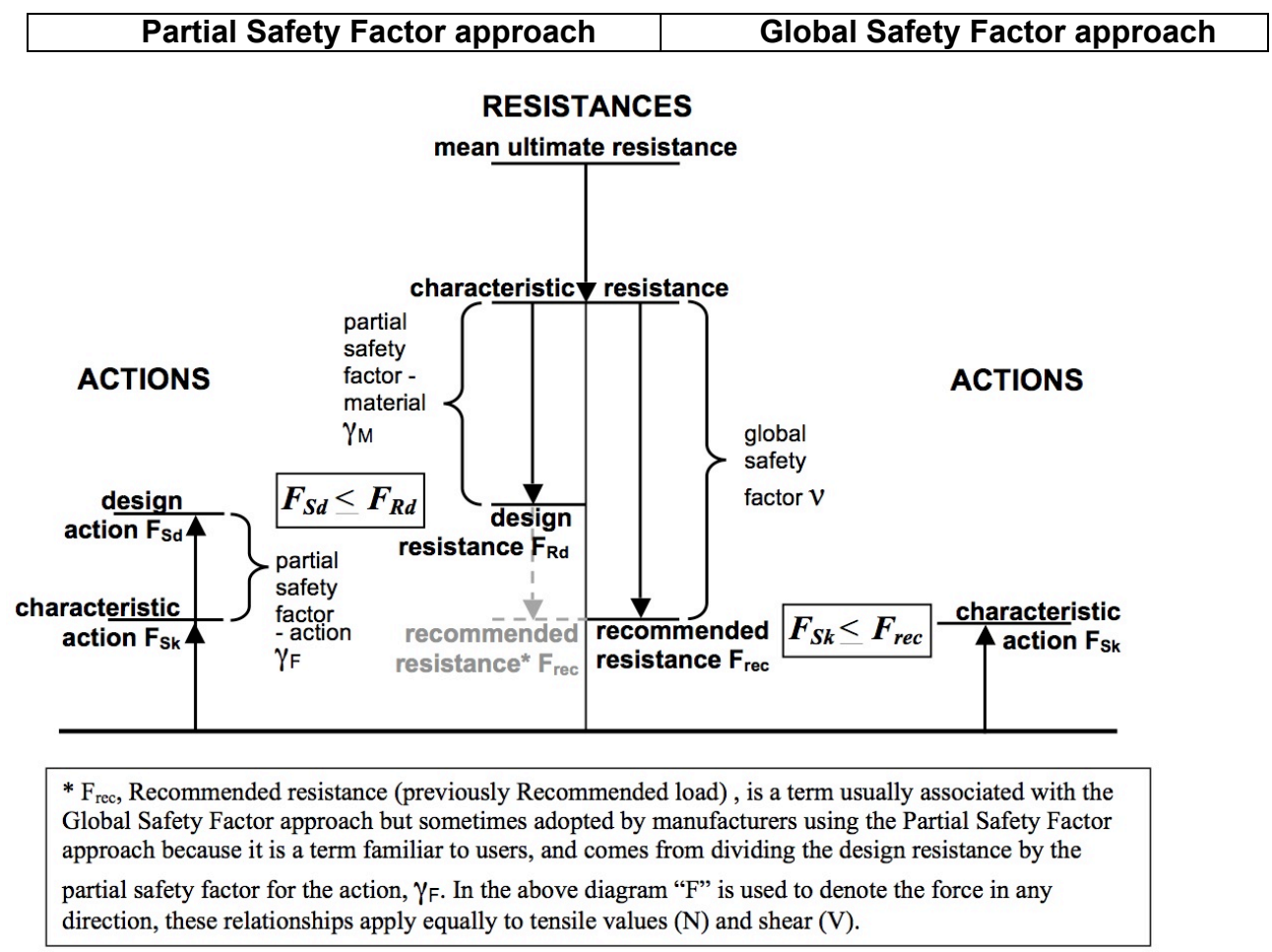
Once the *type* of anchor has been determined the size can then be ascertained according to the relevant design method.

The design of anchors with ETA is based on a common safety concept described below.

6.1 Safety concept

The safety concept can be simply stated as the requirement that the applied load must be less than the ability of the anchor to support it with a suitable margin of safety. The precise safety margin depends on the design approach.

Anchors with ETA use Design methods based on the Partial Safety Factor (PSF) approach, see 6.2. Anchors without ETA or similar (usually national) approvals will utilise the Global Safety Factor (GSF) approach, see 6.3. The two approaches are summarised below in terms of the relation between loads.



ETAG Annexes

Currently design methods for most anchors with ETA are published as an annex to the appropriate ETAG e.g. ETAG 001 Annex C or in the case of bonded anchors, an EOTA Technical Report TR 029 *Design methods for bonded anchors*.

CEN Technical Specifications to CEN/TS 1992

Since 2009 anchors may have a design method according to a CEN Technical Specification CEN/TS 1992-4 Parts 1 – 5 covering the various anchor types: Headed fasteners, Anchor channels, Post-installed mechanical fasteners and Post-installed chemical systems. The basis of the design methods enshrined in these TS' is the same as ETAG 001 Annex etc. but varies in detail. As part of the preparation for the implementation of the CPR these five Technical Specifications will be amalgamated into one document and published as a European standard, EN 1992-4 *Design of Fastenings for Use in Concrete* probably during 2014. Watch the CFA website (Approvals etc.) for details.

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6.2 Partial Safety Factor Approach

Ultimate limit state

Note: In the following section the notation F is used to denote a force (action or resistance) in a direction unspecified. In practice F will usually be replaced by N for tensile forces and V for shear.

The primary requirement for safety is:

$$F_{Sd} \leq F_{Rd}$$

Where F_{Sd} = Design Action in accordance with the relevant code

F_{Rd} = Design Resistance

F_{Sd} is determined by the application of a partial safety factor γ_F to the characteristic action F_{Sk}

$$F_{Sd} = F_{Sk} \cdot \gamma_F$$

γ_F is usually taken as 1.4 unless the permanent and variable components of the characteristic action (G_k and Q_k) are known, and they act in the same direction, in which case the following applies:

$$F_{Sd} = G_k \cdot \gamma_G + Q_k \cdot \gamma_Q$$

Where G_k (Q_k) = Characteristic value of permanent (variable) action

γ_G (γ_Q) = Partial safety factor for permanent (variable) action
and are given in ETAG 001 as respectively 1.35 and 1.5.

$$F_{Rd} = F_{Rk} / \gamma_M$$

Where F_{Rk} = Characteristic resistance of the anchor

γ_M = Partial safety factors for the base material

The characteristic resistances and partial safety factor for the material are given in the ETA.

Serviceability limit state

Displacements at service loads are quoted in the ETA for use in the serviceability limit state design.

Three design approaches are elaborated in ETAG 001 Annex C as indicated in Table 1 above – section 4.3.1. These are related to the options. Design method A being the most comprehensive and provides a sophisticated design concept in order to gain optimum performance of the anchors and at the same time an economical design. The method distinguishes between different load directions (tension, shear, combined tension and shear), low and high concrete strengths plus characteristic and minimum edge and spacing distances. Methods B and C are simplified approaches offering progressively less flexibility of application parameters as outlined in Table 1.

In Design method A the following different failure modes are covered:

Tension actions:

- steel failure
- concrete cone failure
- pull-out / pull-through failure
- splitting failure
- combined concrete and bond failure in the case of bonded anchors

Shear actions:

- steel failure
- concrete edge failure
- pryout failure

The design resistance F_{Rd} is calculated for every mode of failure considering all influencing parameters, such as embedment depth, cross-sectional area and steel strength of the anchor, axial and edge spacings, thickness of concrete member, concrete strength, reinforcement, eccentricity of load and condition of concrete (cracked or uncracked). The design resistance is compared with the corresponding design action F_{Sd} . The most unfavourable mode of failure is decisive for each load direction.

Subsequent to the proof for separate tension and shear loads an interaction requirement has to be fulfilled for combined tension and shear loads.

In addition to the parameters which differentiate the 12 options, such as concrete strength and condition (i.e. cracked or non-cracked), loading direction, spacing centres and edge distances, there are many other parameters which need to be considered in arriving at a design that will satisfy all the necessary criteria and assumptions on which the ETA has been based.

Some of these parameters include:- concrete member thickness, plate stiffness of the fixture, diameter of clearance holes in the fixture and eccentricity of loading in tension, shear or bending and will be taken into account by the design method.

Design of the anchor is intended to be carried out by a suitably qualified engineer.

Most manufacturers provide software to assist in the selection of fixings for these safety critical applications. This is undoubtedly the most efficient way to ensure that all the necessary criteria have been taken into account although selection using Technical Data sheets will still, in theory, be possible. Manufacturers sometimes publish performance characteristics based on criteria other than ETA. The basis of data used in the design process should therefore be checked.

6.3 Global safety factor approach.

This design approach is based on the use of a global safety factor, which is used to relate the performance of the anchor in the base material to the recommended resistance.

The requirements for the characteristic action are:

a) When manufacturer's data is used and site tests have not been needed:

characteristic action \leq recommended resistance,

i.e. $F_{Sk} \leq F_{rec}$

b) When the Allowable Resistance has been determined from site tests:

characteristic action \leq allowable resistance,

i.e. $F_{Sk} \leq F_{R,all}$

7.0 ANCHOR INSTALLATION IN COMPLIANCE WITH ETA

7.1. Anchors

All CFA manufacturers give the information on the specific conditions for installing their anchors. This information respects the requirements of the corresponding ETA and may be printed either directly on anchor boxes or on a leaflet within boxes. This information includes:

- drill bit diameter,
- thread diameter,
- maximum thickness of the fixture,
- minimum installation depth,
- minimum hole depth,
- required torque moment,
- information on the installation procedure, including cleaning of the hole, preferably by means of an illustration,
- reference to any special installation equipment needed,
- identification of the manufacturing batch.


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7.2. Installation of anchors

The fitness for use of the anchor is assumed if the anchor is installed as follows:

- anchor installation carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters on the job site
 - use of the anchor only as supplied by the manufacturer without exchanging the components of an anchor;
 - anchor installation in accordance with the manufacturer's specifications, including the use of a suitably qualified drill bit*;
 - anchor positioning in accordance with drawings prepared for that purpose by an engineer;
 - thickness of the fixture corresponding to the range of required thickness values for the type of anchor;
 - check of concrete being well compacted, e.g. without significant voids;
 - clearing the hole of drilling dust;
 - anchor installation ensuring the specified embedment depth, that is the appropriate depth marking of the anchor not exceeding the concrete surface or embedment depth control;
 - keeping of the edge distance and spacing to the specified values without minus tolerances;
 - positioning of the drill holes without damaging the reinforcement;
 - in case of an aborted hole: either the new hole should be drilled at a minimum distance away of twice the depth of the aborted hole or at a smaller distance if the aborted drill hole is filled with high strength mortar. If under shear or oblique tension load the aborted hole must be filled if it is in the direction of the load;
 - application of the recommended torque moment using a calibrated torque wrench
- * Drill bits carrying the inspection mark will satisfy this requirement,
(go to www.pgm-online.org for more information)

Inspection mark 

8 BENEFITS OF USING ANCHORS WITH ETA

The use of CE-marked anchors with an ETA has numerous benefits for specifiers and installers quite apart from complying with the recommendations of BS 8539.

Anchors approved in accordance with the comprehensive test regimes and assessment criteria of the relevant ETAG/EAD will necessarily correspond to state-of-the-art anchoring technology.

The liabilities of both specifiers and installers are safeguarded.

The thorough investigation of anchor functioning in the suitability tests means that installation safety is assured and anchors will not be sensitive to reasonable variations from the manufacturer's installation instructions which may occur in the construction process.

Performance values may be relied upon.

Design according to the relevant design method, along with software to guide the selection process, means that specifiers can be confident that the most suitable anchor has been chosen. This ensures economic design of anchors with an appropriate safety margin. ETAs are accepted in all EU member states – a benefit in the case of foreign contracts.

CE marking of anchors demonstrates a permanent internal factory production control of the manufacturing process which is regularly monitored by an independent body, so the specifier can be confident that the product supplied to the job site has the same performance as that tested in the approval process.

Installers benefit from clear installation instructions, which manufacturers are obliged to provide, while site engineers can identify the installed product from obligatory markings.

Overall this combination of benefits means that all parties to the construction process and the resulting building can be confident in the long term security of the anchorages used, including the user of the building who will never even be aware of the existence of the anchors.

This is one of a series of Guidance Notes downloadable free from the CFA website at www.the-cfa.co.uk

For more information contact:

Construction Fixings Association

Tel 01664 823687

Email: Use "Contact us" via the website: www.the-cfa.co.uk

¹ Article: CE marking and Declaration of Performance under the CPR – CFA website www.the-cfa.co.uk

² Best practice guide to the selection and installation of top fixings for suspended ceilings. Published jointly by the CFA and

² Best practice guide to the selection and installation of top fixings for suspended ceilings. Published jointly by the CFA and Association of Interior Specialists. 2012.