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ETAG 020

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GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL

of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Part one : G E N E R A L

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PART ONE: GENERAL

FOREWORD

Background of the subject

The Guideline for European Technical Approval (ETA) of „PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONARY FOR NON-STRUCTURAL APPLICATIONS“ sets out the basis for assessing anchors to be used in concrete and masonry and consists of:

Part 1 General

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

The following Annexes are full parts of the Guideline:

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

In this Guideline, the auxiliary verbs are used as follows in accordance with the „Rules for the drafting and presentation of European Standards (PNE-Rules)“ [3]

English	German	French
shall	muss	doit
should	sollte	il convient de
may	darf	peut
can	kann	peut

This Guideline sets out the requirements for anchors, the acceptance criteria they shall meet and guidance in understanding these two central features, also the assessment and test methods used in carrying out assessments. In addition, more general aspects of relevance, including the information required by all parties concerned and quality control, are included.

The general assessment approach adopted in this Guideline is based on combining relevant existing knowledge and experience of anchor behaviour with testing. Using this approach, testing is needed to assess the suitability of anchors.

Anchors and their behaviour in use are of interest to a number of bodies, including manufacturers, planning and design engineers, building contractors and specialist installers. Behaviour in use depends on many factors including the design of the anchor, the embedment concrete and masonry, the quality of installation, the type of loading, etc.

The individual and collective influence of the different factors referred to above are not sufficiently known at present to allow determination, by purely theoretical means, of the behaviour of anchorages under the various types of loading. It is necessary therefore to carry out tests to enable a safe assessment to be made of the influence of the different factors on the loadbearing and long-term stability of anchorages.

Reference documents

[1] Directive relating to construction products (CPD): Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (89/106/EEC) taking account of the modified provisions (93/68/EEC)

[2] Council Directive 89/106/EEC, Construction Products. Interpretative Documents, Brussels, 16-7-1993

[3] Internal Regulations CEN/CENLEC Part 3: Rules for the drafting and presentation of European Standards (PNE-Rules) Edition 1991-09

[4] CEN: Eurocode N° 2. Design of concrete structures – Part 1: General rules and rules for buildings; Ref. N° prEN 1992-1-1:2002-07

[5] EN 206-1:2000-12: Concrete Part 1: Specification, performance, production and conformity

[6] EN 197-1:2000-06: Cement Part 1: Composition, specifications and conformity criteria for common cements

[7] ISO 6783:1982: Coarse aggregates for concrete - determination of particle density and water absorption - hydrostatic balance method

[8] CEN: Eurocode N° 6: Design of masonry structures. Part 1 1: Common rules for reinforced and unreinforced masonry structure; Ref. N° prEN 1996-1-1:2004-04

[9] prEN 771-1 to 6:2000: Specification for masonry units

[10] prEN 12602:1996-10: Prefabricated reinforced components of autoclaved aerated concrete

[11] ISO 3506:1997. Mechanical properties of corrosion-resistant stainless-steel fasteners

[12] ISO 5922:1981. Malleable cast iron

[13] DIN 8035:1976-11. Hammer drills

[14] NF E 66-079. Rotary and rotary impact masonry drill bits with hardened tips. Dimensions. July 1993.

[15] ISO 5468:1992-02: Rotary and rotary impact masonry drill bits hard metal tips, dimensions

[16] ISO 1110:1995-02: Plastics - Polyamides - Accelerated conditioning of test specimens

[17] ISO 3167:2002-02: Plastics; Multipurpose test specimens

[18] ISO 3146:2000-06: Plastics; determination of melting behaviour

[19] ISO 1133:1997: Plastics; Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics

[20] EN 1990:2002 - Eurocode: Basis of Structural Design

[21] EN 1991:2002 - Eurocode 1: Actions on structures

Updating conditions

The edition of a reference document given in this list is that which has been adopted by EOTA for its specific use.

When a new edition becomes available, this supersedes the edition mentioned in the list only when EOTA has verified or re-established (possibly with appropriate linkage) its compatibility with the Guideline.

EOTA comprehension documents permanently take on board all useful information on the updating of reference documents and on the general understanding of this ETAG as developed when delivering ETAs in consensus by the EOTA members.

EOTA Technical reports go into detail in some aspects and as such are not part of the ETAG but express the common understanding of existing knowledge and experience of the EOTA-bodies at that moment. When knowledge and experience is developing, especially through approval work, these reports can be amended and supplemented. When this happens, the effect of the changes upon the ETAG will be determined by EOTA and laid down in the relevant comprehension documents.

Readers and users of this ETAG are advised to check the current status of the content of this document with an EOTA member.

Section one:
INTRODUCTION

1. PRELIMINARIES

1.1. Legal basis

This ETAG has been established in compliance with the provisions of the Council Directive 89/106/EEC (CPD) [1] and has been established taking into account the following steps:

• the final mandate issued by the EC	November 1996
• the final mandate issued by the EFTA	not relevant
• adoption of the Guideline by the Executive Commission of EOTA	June 2004
• opinion of the Standing Committee for Construction	January 2006
• endorsement by the EC	July 2006

This document is published by the Member States in their official language or languages according to art. 11.3 of the CPD.

No existing ETAG is superseded.

1.2. Status of ETAG

a) **An ETA is one of the two types of technical specifications** in the sense of the EC 89/106 Construction Products Directive [1]. This means that Member States shall presume that the approved products are fit for their intended use, i.e. they enable works in which they are employed to satisfy the Essential Requirements during an economically reasonable working life, provided that :

- the works are properly designed and built;
- the conformity of the products with the ETA has been properly attested.

b) **This ETAG is a basis for ETAs**, i.e. a basis for technical assessment of the fitness for use of a products for an intended use. An ETAG is not itself a technical specification in the sense of the CPD.

This ETAG expresses the common understanding of the approval bodies, acting together within EOTA, as to the provisions of the Construction Products Directive 89/106 [1] and of the Interpretative Documents [2], in relation to the products and uses concerned, and is written within the framework of a mandate given by the Commission and the EFTA secretariat, after consulting the Standing Committee for Construction.

c) When accepted by the European Commission after consultation with the Standing Committee for Construction this **ETAG is binding** for the issuing of ETAs for the products for the defined intended uses.

The application and satisfaction of the provisions of an ETAG (examinations, tests and evaluation methods) leads to an ETA and a presumption of fitness of a product for the defined use only through an evaluation and approval process and decision, followed by the corresponding attestation of conformity. This distinguishes an ETAG from a harmonised European standard which is the direct basis for attestation of conformity.

Where appropriate, products which are outside of the precise scope of this ETAG may be considered through the approval procedure without guidelines according to art. 9.2 of the CPD.

The requirements in this ETAG are set out in terms of objectives and of relevant actions to be taken into account. It specifies values and characteristics, the conformity with which gives the presumption that the requirements set out are satisfied, wherever the state of art permits and after having been confirmed as appropriate for the particular product by the ETA.

This Guideline indicates alternate possibilities for the demonstration of the satisfaction of the requirements.

2. Scope

2.1. Scope

2.1.1. General

The Guideline for European Technical Approval (ETA) of „PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS“ sets out the basis for assessing anchors to be used in concrete and masonry and consists of:

Part 1	General
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

The general requirements and assessment procedures applicable to all base materials are set out in Part 1 of the Guideline. The subsequent Parts contain requirements and assessment procedures as well as details of the number of tests to be carried out for each base material and are only applicable in connection with Part 1.

The following Annexes are full parts of the Guideline:

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

This Guideline covers the assessment of post-installed plastic anchors in different base materials according to Parts 2 to 5.

When using plastic anchors, the requirements mainly concerning safety in use as identified in Essential Requirement N°4 (ER 4) of the CPD shall be satisfied; failure of the fixture can represent an immediate risk to human life[1]. However such failure may jeopardise the meeting of other Essential requirements for parts of the work..

The plastic anchors shall be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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 requirements on the strength and stiffness of the fixture are fulfilled and the load transfer in the case of excessive slip or failure of one anchor needs not to be taken into account in the design of the fixture. The values for n_1, n_2 and n_3 are given in the following parts of this guideline.

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(1) The rules in relation to Essential Requirements (ERs) to be satisfied for the works are defined by the member states in their national regulations. As these national regulations determine whether plastic anchors shall or shall not meet the Essential Requirements and hence whether CE marking is appropriate, it is the responsibility of designers and users to select a product for a particular use such that ERs for the work are met.

2.1.2. Anchors

2.1.2.1. Types and operating principles

Plastic anchors consisting of an expansion element and a polymeric sleeve which passes through the fixture.

Polymeric sleeve and expansion element are a unit and of approximately the same length. The polymeric sleeve is expanded by hammering or screwing in the expansion element which presses the sleeve against the wall of the drilled hole.

The polymeric sleeve shall be fixed in the hole in the correct position. An uncontrolled setting of the sleeve in the drilled hole during setting shall be avoided; this can be done e.g. with a collar on the upper end of the sleeve.

Two types of plastic anchors are covered:

- Plastic anchors with a screw as an expansion element (setting: screwed in) see Figure 2.1a).
- Plastic anchors with a nail as an expansion element (setting: hammered in) see Figure 2.1b).

2.1.2.2. Materials

- Expansion element: metal (steel) or polymeric material

  The required tests for the suitability and durability of the plastic anchor in case of an expansion element made out of polymeric material should be decided on by the responsible approval body.

- Polymeric sleeve: Polymeric material
  - Polyamide PA6 and PA6.6
  - polyethylene PE or polypropylene PP
  - other polymeric materials

  Reprocessed material obtained from external sources and recycled material are not allowed to be used as polymeric material.

  Only virgin material (so-called A-material) shall be used. However, reworked material received as own waste material from the manufacturing process may be added to the manufacturing process. This regenerated material is of the same feedstock and identical with the rest of the material. The allowable percentage of this reworked material shall be according to the recommendations of the manufacturer of the virgin material.

2.1.2.3. Dimensions

This Guideline applies to plastic anchors with an external diameter d of the polymeric sleeve and an anchorage depth h_{nom} as follows:

$d \geq 8$ mm; $h_{nom} \geq 40$ mm for use in concrete

$d \geq 8$ mm; $h_{nom} \geq 50$ mm for use in other base materials

2.1.3. Base materials

2.1.3.1. General

This Guideline applies to the use of plastic anchors in concrete (normal weight or autoclaved aerated) and/or masonry units of clay, calcium silicate, normal weight concrete, autoclaved aerated concrete or other similar materials. As far as the specification of the different masonry units is concerned (pr)EN 771-1 to 5 [9] may be taken as reference. Design and construction of masonry structures in which the plastic anchors are to be anchored should be in accordance with Eurocode 6, prEN 1996-1-1 [8] and the relevant national regulations.

Attention is drawn to the fact that the standards for masonry are not very restrictive with regard to details of units (e.g. type, dimensions and location of hollows, number and thickness of webs). Anchor resistance and load displacement behaviour, however, decisively depend on these influencing factors.

This Guideline applies to applications where the minimum thickness of members in which plastic anchors are installed is at least h = 100 mm.

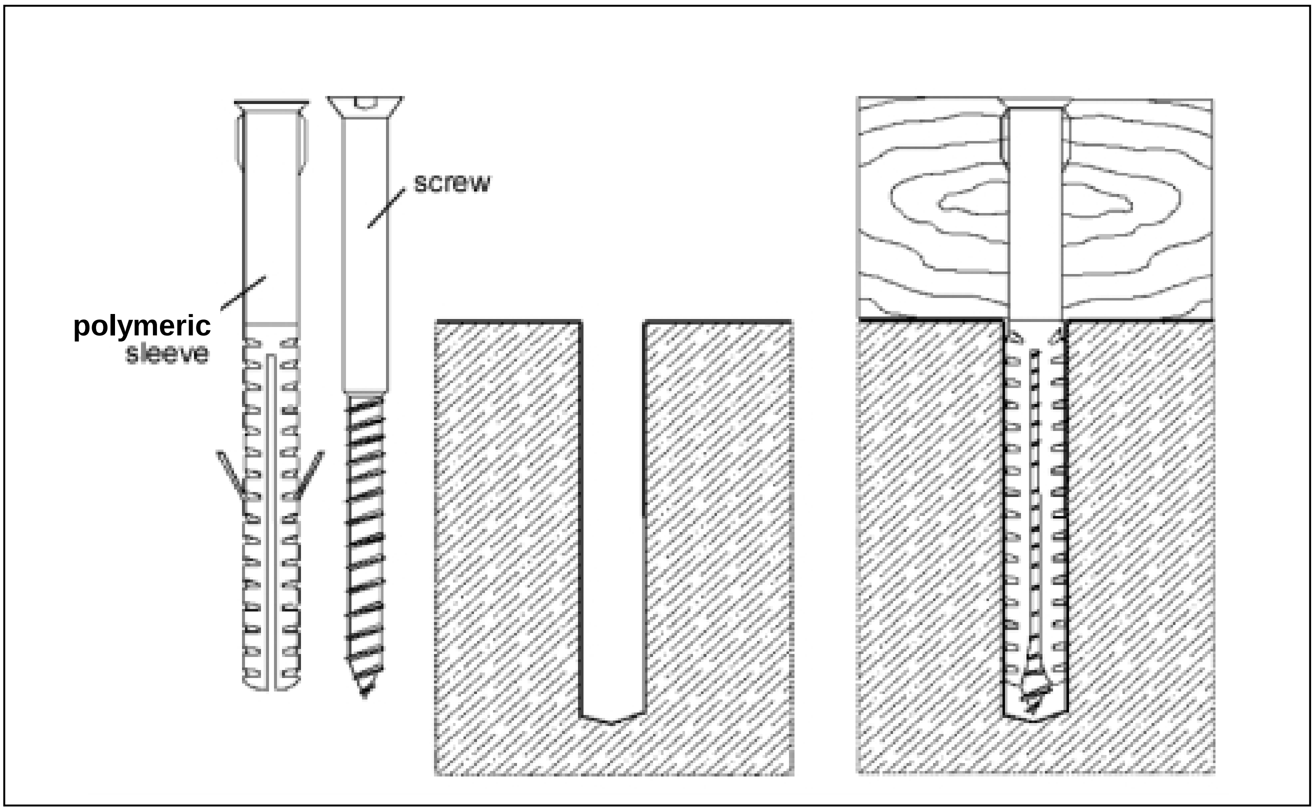

Figure 2.1a Example of plastic anchor (screwed in)

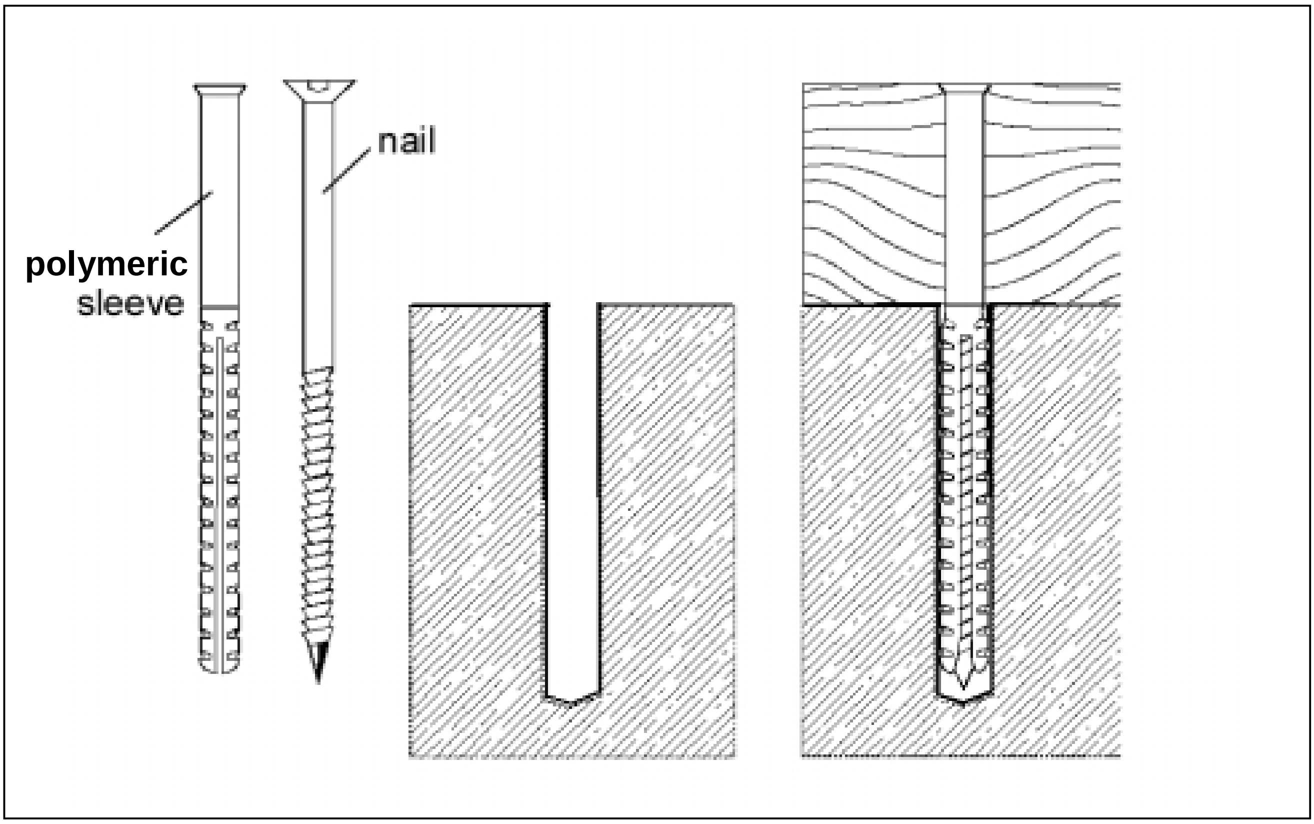

Figure 2.1.b Example of plastic anchors (hammered in)

2.1.3.2. Normal weight concrete

This Guideline applies to the use of plastic anchors in normal weight concrete strength classes C12/15 at least according to EN 206-1 [5].

This Guideline does not cover anchorages made in screeds or toppings, which can be uncharacteristic of the concrete and/or excessively weak.

2.1.3.3. Solid masonry units

In general, solid masonry units do not have any holes or cavities other than those inherent in the material.

However, solid units may have a vertically perforation of up to 15 % of the cross section.

2.1.3.4. Hollow or perforated masonry units

Masonry units consisting of hollow or perforated units have a certain volume percentage of voids which pass through the masonry unit.

For the assessment of plastic anchors anchored in hollow or perforated units it has also to be assumed that the anchor may be situated in solid material (e.g. joints, solid part of unit without holes) so that also tests in solid material may be required.

2.1.3.5. Autoclaved aerated concrete

This Guideline applies to the use of plastic anchors in autoclaved aerated concrete according to EN 771-4 "Autoclaved aerated concrete masonry units" [9] or prEN 12602 "Reinforced components of autoclaved aerated concrete" [10].

2.1.4. Actions

This Guideline covers applications only where the components in which the plastic anchors are embedded are subject to predominantly static or quasi-static loads.

This Guideline applies to plastic anchors subject to static or quasi-static actions in tension, shear or combined tension and shear or bending; it is not applicable to plastic anchors loaded in compression or subject to fatigue, impact, or seismic actions.

2.2. Use Categories

The Guideline applies to anchorages in respect to the following use categories:

a) Use categories are a function of the base material:

Use category **a**: Plastic anchors for use in **normal weight concrete**

Use category **b**: Plastic anchors for use in **solid masonry**

Use category **c**: Plastic anchors for use in **hollow or perforated masonry**

Use category **d**: Plastic anchors for use in **autoclaved aerated concrete**

Combination of different use categories are possible.

b) Use categories on respect to durability aspects:

- use in structures subject to dry, internal conditions,
- use in structures subject to other environmental conditions.

2.3. Assumptions

The state of the art does not enable the development, within a reasonable time, of full and detailed verification methods and corresponding technical criteria/guidance for acceptance for some particular aspects or products. This ETAG contains assumptions taking account of the state of art and makes provisions for appropriate, additional *case-by-case approaches* when examining ETA-applications, within the general framework of the ETAG and under the CPD consensus procedure between EOTA members*.*

The guidance remains valid for other cases which do not deviate significantly. The general approach of the ETAG remains valid but the provisions then need to be modified case by case in an appropriate way. This use of the ETAG is the responsibility of the ETA-body which receives the special application, and subject to consensus within EOTA. Experience in this respect is collected, after endorsement in EOTA-TB, in the ETAG-Format-Comprehension document.

2.4. Design and installation quality

In setting out the assessment procedures in this Guideline, it has been assumed that the design of the anchorages and the specification of the plastic anchor are under the control of an engineer experienced in anchorages. It is also assumed that the anchor installation is undertaken by trained personnel under the supervision of the person responsible for technical matters on site, to ensure that the specifications are effectively implemented.

3. TERMINOLOGY

3.1. Common terminology and abbreviations

This common terminology is based upon the EC Construction Products Directive 89/106 and the Interpretative documents as published in the Official Journal of the EC on 28.2.1994. It is limited to items and aspects relevant for approval work. They are partly definitions and partly clarifications.

3.1.1. Works and Products

3.1.1.1. Construction works (and parts of works) (often simply referred to as “works”) (ID 1.3.1)

Everything that is constructed or results from construction operations and is fixed to the ground.

(This covers both building and civil engineering works, and both structural and non structural elements).

3.1.1.2. Construction products (often simply referred to as “products”) (ID 1.3.2)

Products which are produced for incorporation in a permanent manner in the works and placed as such on the market.

(The term includes materials, elements, components and systems or installations)

3.1.1.3. Incorporation (of products in works) (ID 1.3.2)

Incorporation of a product in a permanent manner in the works means that:

- its removal reduces the performance capabilities of the works, and
- that the dismantling or the replacement of the product are operations which involve construction activities.

3.1.1.4. Intended use (ID 1.3.4)

Role(s) that the product is intended to play in the fulfilment of the Essential Requirements.

(N.B. This definition covers only the intended use as far as relevant for the CPD)

3.1.1.5. Execution (ETAG-format)

Used in this document to cover all types of incorporation techniques such as installation, assembling, incorporation, etc.

3.1.1.6. System (EOTA/TB guidance)

Part of the works realised by:

- particular combination of a set of defined products, and
- particular design methods for the system, and/or
- particular execution procedures.

3.1.2. Performances

3.1.2.1. Fitness for intended use (of products) (CPD 2.1)

Means that the products have such characteristics that the works in which they are intended to be incorporated, assembled, applied or installed, can, if properly designed and built, satisfy the Essential Requirements.

(N.B. This definition covers only the intended fitness for intended use as far as relevant for the CPD)

3.1.2.2. Serviceability (of works)

Ability of the works to fulfil their intended use and in particular the essential requirements relevant for this use.

The products shall be suitable for construction works which (as a whole and in their separate parts) are fit for their intended use, subject to normal maintenance, be satisfied for an economically reasonable working life. The requirements generally concern actions which are foreseeable (CPD Annex I, Preamble).

3.1.2.3. Essential requirements (for works)

Requirements applicable to works, which may influence the technical characteristics of a product, and are set out in objectives in the CPD, Annex I (CPD, art. 3.1).

3.1.2.4. Performance (of works, parts of works or products) (ID 1.3.7)

The quantitative expression (value, grade, class or level) of the behaviour of the works, parts of works or of the products, for an action to which it is subject or which it generates under the intended service conditions (works or parts of works) or intended use conditions (products).

As far as practicable the characteristics of products, or groups of products, should be described in measurable performance terms in the technical specifications and guidelines for ETA. Methods of calculation, measurement, testing (where possible), evaluation of site experience and verification, together with compliance criteria shall be given either in the relevant technical specifications or in references called up in such specifications.

3.1.2.5. Actions (on works or parts of the works) (ID 1.3.6)

Service conditions of the works which may affect the compliance of the works with the essential requirements of the Directive and which are brought about by agents (mechanical, chemical, biological, thermal or electro-mechanical) acting on the works or parts of the works.

Interactions between various products within a work are considered as “actions”.

3.1.2.6. Classes or levels (for essential requirements and for related product performances) (ID 1.2.1)

A classification of product performance(s) expressed as a range of requirement levels of the works, determined in the IDs or according to the procedure provided for in art. 20.2a of the CPD.

3.1.3. ETAG - Format

3.1.3.1. Requirements (for works) (ETAG-format 4.)

Expression and application, in more detail and in terms applicable to the scope of the guideline, of the relevant requirements of the CPD (given concrete form in the IDs and further specified in the mandate, for works or parts of the works, taking into account the durability and serviceability of the works.

3.1.3.2. Methods of verification (for products) (ETAG-format 5.)

Verification methods used to determine the performance of the products in relation to the requirements for the works (calculations, tests, engineering knowledge, evaluation of site experience, etc.).

These verification methods are related only to the assessment of, and for judging the fitness for use. Verification methods for particular designs of works are called here "project testing", for identification of products are called "identification testing", for surveillance of execution or executed works are called "surveillance testing", and for attestation of conformity are called "AC-testing".

3.1.3.3. Specifications (for products) (ETAG-format 6.)

Transposition of the requirements into precise and measurable (as far as possible and proportional to the importance of the risk) or qualitative terms, related to the products and their intended use. *The satisfaction of the specifications is deemed to satisfy the fitness for use of the products concerned.*

Specifications may also be formulated with regard to the verification of particular designs, for identification of products, for surveillance of execution or executed works and for attestation of conformity, when relevant.

3.1.4. Working life

3.1.4.1. Working life (of works or parts of the works) (ID 1.3.5(1)

The period of time during which the performance will be maintained at a level compatible with the fulfilment of the Essential Requirements.

3.1.4.2. Working life (of products)

Period of time during which the performances of the product are maintained - under the corresponding service conditions - at a level compatible with the intended use conditions.

3.1.4.3. Economically reasonable working life: (ID 1.3.5(2)

Working life which takes into account all relevant aspects, such as costs of design, construction and use, costs arising from hindrance of use, risks and consequences of failure of the works during its working life and cost of insurance covering these risks, planned partial renewal, costs of inspections, maintenance, care and repair, costs of operation and administration, of disposal and environmental aspects.

3.1.4.4. Maintenance (of works) (ID 1.3.3(1)

A set of preventive and other measures which are applied to the works in order to enable the works to fulfil all its functions during its working life. These measures include cleaning, servicing, repainting, repairing, replacing parts of the works where needed, etc.

3.1.4.5. Normal maintenance (of works) (ID 1.3.3(2)

Maintenance, normally including inspections, which occurs at a time when the cost of the intervention which has to be made is not disproportionate to the value of the part of the work concerned, consequential costs (e.g. exploitation) being taken into account.

3.1.4.6. Durability (of products)

Ability of the product to contribute to the working life of the work by maintaining its performances, under the corresponding service conditions, at a level compatible with the fulfilment of the essential requirements by the works.

3.1.5. Conformity

3.1.5.1. Attestation of conformity (of products)

Provisions and procedures as laid down in the CPD and fixed according to the directive, aiming to ensure that, with acceptable probability, the specified performance of the product is achieved by the ongoing production.

3.1.5.2. Identification (of a product)

Product characteristics and methods for their verification, allowing to compare a given product with the one that is described in the technical specification.

ABBREVIATIONS

Concerning the Construction products directive:

AC:	Attestation of Conformity
CEC:	Commission of the European Communities
CEN:	Comité Européen de Normalisation
CPD:	Construction Products Directive
EC:	European Communities
EFTA:	European Free Trade Association
EN:	European Standards
FPC:	Factory Production Control
ID:	Interpretative Documents of the CPD
ISO:	International Standardisation Organisation
SCC:	Standing Committee for Construction of the EC

Concerning approval:

EOTA:	European Organisation for Technical Approvals
ETA:	European Technical Approval
ETAG:	European Technical Approval Guideline
TB:	EOTA-Technical Board
UEAtc:	Union Européenne pour l'Agrément technique dans la construction

General:

TC:	Technical Committee
WG:	Working Group

3.2. Specific terminology and abbreviations

3.2.1. General

Anchor	=	a manufactured, assembled component for achieving anchorage between the base material and the fixture.
Anchor group	=	several anchors (working together)
Fixture	=	component to be fixed to the base material
Anchorage	=	an assembly comprising base material, anchor or anchor group and fixture.

3.2.2. Anchors

The notations and symbols frequently used in this Guideline are given below. Further particular notation and symbols are given in the text.

a_1	=	spacing between outer anchors in adjoining anchorages in direction 1
a_2	=	spacing between outer anchors in adjoining anchorages in direction 2
b	=	width of the member of the base material
c_1	=	edge distance in direction 1
c_2	=	edge distance in direction 2
c_{cr}	=	edge distance for ensuring the transmission of the characteristic resistance of a single anchor
c_{min}	=	minimum allowable edge distance
d	=	anchor bolt/thread diameter
d_o	=	drill hole diameter
d_{cut}	=	cutting diameter of drill bit
$d_{cut,max}$	=	cutting diameter at the upper tolerance limit (maximum diameter bit)
$d_{cut,min}$	=	cutting diameter at the lower tolerance limit (minimum diameter bit)
$d_{cut,m}$	=	medium cutting diameter of drill bit
d_f	=	diameter of clearance hole in the fixture
d_{nom}	=	outside diameter of anchor
h	=	thickness of member (wall)
h_{min}	=	minimum thickness of member
h_o	=	depth of cylindrical drill hole at shoulder
h_1	=	depth of drilled hole to deepest point
h_{ef}	=	effective anchorage depth
h_{nom}	=	overall anchor embedment depth in the base material
s_1	=	spacing of anchors in an anchor group in direction 1
s_2	=	spacing of anchors in an anchor group in direction 2
s_{cr}	=	spacing for ensuring the transmission of the characteristic resistance of a single anchor
s_{min}	=	minimum allowable spacing
T	=	torque moment
T_{inst}	=	setting torque when the screw of the plastic anchor is fully attached to the anchor collar
T_u	=	maximum torque moment that can be applied to the plastic anchor
t_{fix}	=	thickness of fixture

3.2.3. Base materials

f_c = concrete compression strength measured on cylinders

$f_{c,cube}$ = concrete compression strength measured on cubes

$f_{c,test}$ = compression strength of concrete at the time of testing

f_{cm} = average concrete compression strength

f_{ck} = nominal characteristic concrete compression strength (based on cylinder)

$f_{ck,cube}$ = nominal characteristic concrete compression strength (based on cubes)

ρ = bulk density of unit

f_b = normalised compression strength of masonry unit

$f_{b,test}$ = mean compression strength of the test masonry unit at the time of testing

$f_{y,test}$ = steel tensile yield strength in the test

f_{yk} = nominal characteristic steel yield strength

$f_{u,test}$ = steel ultimate tensile strength in the test

f_{uk} = nominal characteristic steel ultimate strength

3.2.4. Loads/forces

F = force in general

N = normal force (+N = tension force)

V = shear force

N_{Rk}, V_{Rk} = characteristic anchor resistance (5 %-fractile of results) under tension or shear force respectively

3.2.5. Tests

F^t_{Ru} = ultimate load in a test

$F^t_{Ru,m}$ = mean ultimate load in a test series

F^t_{Rk} = 5 %-fractile of the ultimate load in a test series

n = number of tests of a test series

v = coefficient of variation

$\delta(\delta_N, \delta_V)$= displacement (movement) of the anchor at the surface of the base material relative to the surface of the base material in direction of the load (tension, shear) outside the failure area

The displacement includes the steel and base material deformations and a possible anchor slip.

Section two:

GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

GENERAL NOTES

(a) Applicability of the ETAG

This ETAG provides guidance on the assessment of a family of products and their intended uses. It is the manufacturer or producer who defines the product for which he is seeking ETA and how it is to be used in the works, and consequently the scale of the assessment.

It is therefore possible that for some products, which are fairly conventional, only some of the tests and corresponding criteria are sufficient to establish fitness for use. , In other cases, e. g. special or innovative products or materials, or where there is a range of uses, the whole package of tests and assessment may be applicable.

Common clauses:

(b) General layout of this section

The assessment of the fitness of products with regard to their fitness for intended use in construction works is a process with three main steps:

- Chapter 4 clarifies *the specific requirements for the works* relevant to the products and uses concerned, beginning with the Essential Requirements for works (CPD [1] art. 11.2) and then listing the corresponding relevant characteristics of products.
- Chapter 5 extends the list in Chapter 4 into more precise definitions and *the methods available to verify* product characteristics and to indicate how the requirements and the relevant product characteristics are described. This is done by test procedures, methods of calculation and of proof, etc. (selection of the appropriate methods)
- Chapter 6 provides guidance on *the assessing and judging methods* to confirm fitness for the intended use of the products.
- Chapter 7 *assumptions and recommendations* is only relevant in as far as they concern the basis upon which the assessment of the product is made concerning their fitness for the intended use.

(c) Levels or classes or minimum requirements, related to the Essential Requirements and to the product performance (see ID [2] clause 1.2)

According to the CPD [1], “Classes” in this ETAG refer only to mandatory levels or classes laid down in the EC-mandate.

This ETAG indicates, however, the compulsory way of expressing relevant performance characteristics for the product. If, for some uses, at least one Member state has no regulations, a manufacturer always has the right to opt out of one or more of them, in which case the ETA will state “no performance determined” against that aspect, except for those properties for which, when no determination has been made, the product doesn’t any longer fall under the scope of the ETAG; such cases shall be indicated in the ETAG.

(d) Working life (durability) and serviceability

The provisions, test and assessment methods in this guideline or referred to, have been written, based upon the assumed intended working life of the product for the intended use of 50 years, provided that the product is subject to appropriate use and maintenance (cf. Ch. 7). These provisions are based upon the current state of art and the available knowledge and experience.

An "assumed intended working life" means that it is expected that, when an assessment following the ETAG-provisions is made, and when this working life has elapsed, the real working life may be, in normal use conditions, considerably longer without major degradation affecting the essential requirements.

The indications given as to the working life of a product cannot be interpreted as a guarantee given by the producer or the approval body. They should only be regarded as a means for the specifiers to choose the appropriate criteria for products in relation to the expected, economically reasonable working life of the works (based upon ID [2] par. 5.2.2).

For products or components with a shorter estimated working life, the intended use shall be limited to specific applications where the shorter durability is clearly stated.

(e) Fitness for the intended use

According to the CPD [1] it has to be understood that within the terms of this ETAG, products shall "have such characteristics that the works in which they are to be incorporated, assembled, applied or installed, can, if properly designed and built, satisfy the Essential Requirements" (CPD, art. 2.1).

Hence, the products shall be suitable for use in construction works which (as a whole and in their separate parts) are fit for their intended use, account being taken of economy, and in order to satisfy the essential requirements. Such requirements, shall, subject to normal maintenance, be satisfied for an economically reasonable working life. The requirements generally concern actions which are foreseeable. (CPD Annex I, preamble).

(f) Case by case provisions

Not relevant.

(g) Dangerous substances

Not relevant.

4. REQUIREMENTS

for works, and their relationship to the Product characteristics

This chapter sets out the aspects of performance to be examined in order to satisfy the relevant Essential Requirements, by:

- expressing in more detail, within the scope of the ETAG, the relevant Essential Requirements of the CPD in the Interpretative Documents and in the mandate, for works or parts of the works, taking into account the actions to be considered, as well as the expected durability and serviceability of the works.
- applying them to the scope of the ETAG for products, and providing a list of relevant product characteristics and other applicable properties.

When a product characteristic or other applicable property is specific to one of the Essential Requirements, it is dealt with in the appropriate place. If, however, the characteristic or property is relevant to more than one Essential Requirement, it is addressed under the most important one with cross reference to the other(s). This is especially important where a manufacturer claims "No performance determined" for a characteristic or property under one Essential Requirement and it is critical for the assessing and judging under another Essential Requirement. Similarly, characteristics or properties which have a bearing on durability assessments may be dealt with under ER 1 to ER 6, with reference under 4.7. Where there is a characteristic which only relates to durability, this is dealt with in 4.7

This chapter also takes into account further requirements, if any (e.g. resulting from other EC Directives) and identifies the aspects of serviceability including specifying characteristics needed to identify the products. (cf. ETA-format par. II.2).

4.0. General

Table 4.1 The relevant Essential Requirements, the relevant paragraphs of corresponding IDs and related product performance to be assessed.

Essential Requirement	Corresponding ID paragraph	Corresponding performances	Anchor performances and characteristics	Test method for verification of characteristic
ER 4 Safety in use	ID 4 2 impacts of falling objects, forming part of the work, upon users	Stability under predominantly static actions	Suitability under normal site conditions requirements for an acceptable load/displacement behaviour, a certain ultimate load and limited scatter	Tests for suitability – installation safety under site conditions – under repeated/ sustained loads – under different temperatures and humidity
			Admissible service conditions – charact. resistance for tension/shear/ combined tension and shear – characteristic spacing; charact. edge distance – minimum spacing and minimum edge distance – displacement for serviceability limit state	Tests for admissible service conditions – tension and shear loading not influenced by edge and spacing effects – tension loading with characteristic edge distance – with minimum spacing and minimum edge distance – derived from tension/ shear loading (see first dash)
Aspects of Durability			resistance against environmental conditions	Tests under different environmental conditions

4.1. Mechanical resistance and stability (ER 1)

Requirements with the respect to the mechanical resistance and stability of non load bearing parts of the works are not included in this Essential requirement but are under the Essential Requirement under the Essential Requirement safety in use (see 4.4).

4.2. Safety in case of fire (ER 2)

The Essential Requirement laid down in the Council Directive 89/106/EEC is as follows:

The following aspects of performance are relevant to this Essential Requirement for the anchor.

4.2.1. Reaction to fire

The reaction to fire performance of the anchor shall be in accordance with laws, regulations and administrative provisions applicable to the anchor in its intended end use application. This performance shall be expressed in the form of a classification specified in accordance with the relevant EC decision and the appropriate CEN classification standards.

4.2.2. Resistance to fire

The resistance to fire performance of the assembled system of which the anchor form part shall be in accordance with laws, regulations and administrative provisions applicable to the assembled system of which the anchor form part in its intended end use application. This performance shall be expressed in the form of a classification specified in accordance with the relevant EC decision and the appropriate CEN classification standards.

4.3. Hygiene, health and the environment (ER 3)

not relevant

4.4. Safety in use (ER 4)

4.4.1. General

Even though a plastic anchor is a product which is not intended for structural use, mechanical resistance and stability is still required.

Installed plastic anchors shall sustain the design loads in tension, shear and combined tension and shear to which they are subjected for the assumed working life while providing:

(1) an adequate resistance to failure (ultimate limit state),

(2) adequate resistance to displacements (serviceability limit state).

For plastic anchors in general, the following aspects of performance are relevant for the Essential Requirement 4:

4.4.2. Suitability

4.4.2.1. General

The behaviour of plastic anchors, both in normal service conditions and in anticipated adverse conditions (see the following chapters of suitability) shall in all important aspects be predictable.

4.4.2.2. Types of installation

Plastic anchors shall function correctly for the types of installation for which they are intended by the manufacturer.

4.4.2.3. Correct installation

Correct installation of plastic anchors shall be easily achieved under normal site conditions with the equipment specified by the manufacturer, without resulting damage that can adversely affect their behaviour in service. Installation shall be practicable at normal ambient temperatures (within the range 0°C to + 40°C if other limit values are not explicitly prescribed).

It shall be possible to control and verify the correct installation of the anchor.

Except in cases where special tools are provided by the manufacturer, installation should be reasonably easily achieved using the tools normally available on site.

4.4.2.4. Functioning in cracks

The functioning of an plastic anchor, including its ability to sustain its design load with an appropriate safety factor and to limit displacements, shall not be adversely affected by concrete cracks.

4.4.2.5. Moisture content

The functioning of an plastic anchor, including its ability to sustain its design load with an appropriate safety factor and to limit displacements, shall not be adversely affected by humidity of the polymeric sleeve.

4.4.2.6. Temperature

The functioning of a plastic anchor, including its ability to sustain its design load with an appropriate safety factor and to limit displacements, shall not be adversely affected by temperatures in the base material near to the surface within a temperature range to be specified by the manufacturer which may be either:

(a) min T to +40 °C (max short term temperature +40 °C and max long term temperature +24 °C)

(b) min T to +80 °C (max short term temperature +80 °C and max long term temperature +50 °C)

(c) on manufacturers request with min T to T1 (maximum short term temperature: T1 > +40 °C, maximum long term temperature: 0.6 T1 to 1.0 T1)

The lowest service temperature min T= -40 °C or -20 °C or -5 °C is specified by the manufacturer and has to be checked by corresponding pull-out tests described in 5.4.2.6b).

The performance shall not be adversely affected by short term temperatures within the service temperature range or by long term temperatures up to the maximum long term temperature.

Performance at the maximum long term temperature and maximum short term temperature is checked by tests described in 5.4.2.6 and 5.4.2.8.

Functioning shall also be validated for the range of installation temperatures to be specified by the manufacturer in terms of lowest and highest installation ambient temperatures, normally in the range 0 °C to +40 °C. Performance at minimum installation temperature is checked by tests as described in 5.4.2.6c).

There is experience for polyamide for service temperatures down to -20 °C. Therefore the performance of plastic anchors made out of polyamide has to be checked by pull-out tests only at -40 °C, if this lowest service temperature is specified by the manufacturer.

4.4.2.7. Sustained loading

Plastic anchors shall be capable of sustaining their design loads for the assumed working life of the fixture without significant increase in displacement which could render the anchorage ineffective.

4.4.2.8. Relaxation

The functioning of a plastic anchor, including its ability to sustain its design load with an appropriate safety factor and to limit displacements, shall not be adversely affected by relaxation of the anchor.

4.4.2.9. Installation torque moment

The installation torque moment of a plastic anchor shall not adversely affect the behaviour of the anchor.

4.4.3. Admissible service conditions

The service conditions considered in an assessment are, to some extent, subject of the choice of the assessment applicant.

4.4.3.1. Level of loading

Plastic anchors shall sustain a level of loading which ensures they can be used in practical application(s), consistent with their diameter and embedment depth. All plastic anchors are required to sustain tensile loads even, e.g. where the predominant form of loading is in shear.

4.4.3.2. Displacement

The displacement of plastic anchors, both in the short and long term, shall remain within the limits chosen by the designer as a function of the intended use.

4.4.3.3. Edge distance and anchor spacing

In service, plastic anchors shall be able to be used at spacings (anchor to anchor, anchor to edge of member or to joints) compatible with normal structural applications.

4.5. Protection against noise (ER 5)

Not relevant

4.6. Energy economy and heat retention (ER 6)

Not relevant

4.7. Aspects of durability, serviceability and identification

The plastic anchor characteristics should not change during the working life, therefore the mechanical properties on which the suitability and bearing behaviour of the plastic anchor depend shall not be adversely affected by ambient physico-chemical effects such as corrosion and degradation caused by environmental conditions (e.g. alkalinity, moisture, pollution) or by degradation of any coating of the expansion element due to the above mentioned effects.

5. METHODS OF VERIFICATION

5.0. General

This chapter refers to the verification methods used to determine the various aspects of performance of the products in relation to the requirements for the works (calculations, tests, engineering knowledge, site experience, etc.) as set out in chapter 4.

5.1. Mechanical resistance and stability

Not relevant

5.2. Safety in case of fire

5.2.1. Reaction to fire

The metal parts of plastic anchors are assumed to satisfy the requirements for Class A1 of the characteristic reaction to fire, in accordance with the provisions of EC Decision 96/603/EC (as amended) without the need for testing on the basis of its listing in that Decision.

The anchorages are used to fix a cladding or component which is not class A 1 and the plastic parts of the anchor are located in the drilled hole of the base material (concrete or masonry) and fixture. Where the plastic parts of the anchor are embedded in concrete or masonry it may be assumed that these plastic parts do not make any contribution to fire growth or to the fully developed fire and they have no influence to the smoke hazard.

In the context of this end use application the plastic parts embedded in concrete/masonry can be considered to satisfy any reaction to fire requirements.

Where the plastic parts of the anchor are embedded in the cladding/component which is not class A 1 the plastic parts can be considered not to influence the reaction to fire class of the cladding/component.

5.2.2. Resistance to fire

It is not possible to classify an plastic anchor for its fire resistance. The suitability of a plastic anchor for use in a system that is required to provide a specific fire resistance class, may be determined by reference to the simplified design method according to chapter 2.2 and the tabulated data given in Technical Report N° 020 "Evaluation of anchorages in concrete concerning Resistance to Fire". However, an earlier pull-out of the anchor can occur, since the reduction of the strength of the plastic material at higher temperatures may be decisive. Therefore, the characteristic resistance shall always, also for the simplified design method according to 2.2, be determined for the certain product by fire tests according to 2.3.1.1.

It can be assumed that for fastening of facade systems the load bearing behaviour of the specific screwed in plastic anchor with a diameter 10mm and a metal screw with a diameter 7mm and a h_{ef} of 50mm and a plastic sleeve made of polyamide PA6 has a sufficient resistance to fire at least 90 minutes (R90) if the admissible load (no permanent centric tension load) is $\leq$ 0.8kN.

5.3. Hygiene, health and environment

Not relevant

5.4. Safety in use

5.4.1. General

The tests involved in the assessment of plastic anchors fall into 4 categories:

(1) Tests for confirming their suitability

(2) Tests for evaluating the admissible service conditions

(3) Tests for checking durability

(4) Tests for identification

Part 1 of this Guideline gives the general test conditions for testing the suitability of plastic anchors in concrete and masonry. The particular suitability tests and the number of tests are listed in Table 5.1 of the relevant subsequent parts of this Guideline. Special additional suitability tests for the different base materials like hollow masonry are given in the relevant subsequent parts. All suitability tests for plastic anchors in autoclaved aerated concrete are given in Part 5.

Tests for evaluating the admissible service conditions are given in the subsequent parts for the different base materials.

The details of tests are given in Annex A.

It is assumed that for each plastic anchor size there is only one anchorage depth. If the plastic anchors are intended to be installed with two anchorage depths, in general, the tests have to be carried out at both depths. In special cases the number of tests may be reduced.

The tests for the assessment of the plastic anchors should be performed in the base material for which the anchor is intended to be used according to the following Table 5.0.

Table 5.0 Required tests for the intended use of plastic anchors

Use category for the intended use			Required Tests for the intended use
normal weight concrete C 12/15 at least	**solid masonry clay or/and calcium silicate units**	**hollow or perforated units**	
a			tests according to Part **2**, Table 5.1 and Table 5.2
	b		tests according to Part **3**, Table 5.1 and Table 5.2
a	**b**		suitability tests according to Part **2**, Table 5.1, the reduction factors may be used for the characteristic resistance in normal weight concrete and solid masonry. Admissible service condition tests according to Part **2**, Table 5.2 and Part **3**, Table 5.2.
a	**b**	**c**	suitability tests according to Part **2**, Table 5.1, the reduction factors may be used for the characteristic resistance in normal weight concrete and masonry. Admissible service condition tests according to Part **2**, Table 5.2 and Part **3**, Table 5.2 and Part **4**, Table 5.2 in hollow or perforated units for which it is intended to be used. For additional tests see Part **4**.
	b	**c**	suitability tests according to Part **3**, Table 5.1, the reduction factors may be used for the characteristic resistance in masonry. Admissible service condition tests according to Part **3**, Table 5.2 and Part **4**, Table 5.2 in hollow or perforated units for which it is intended to be used. For additional tests see Part **4**.
		c	suitability tests according to Part **3**, Table 5.1. Admissible service condition tests according to Part **4**, Table 5.2, in hollow or perforated units for which it is intended to be used.
d autoclaved aerated concrete P 2 to P 7			tests according to Part **5**

5.4.2. Tests for suitability

5.4.2.1. General

The purpose of the suitability tests is to establish whether an plastic anchor is capable of safe, effective behaviour in service including consideration of adverse conditions both during site installation and in service.

The suitability of plastic anchors for anchorage in concrete and masonry can be adequately assessed by the suitability tests given in Table 5.1 of the relevant subsequent parts of this Guideline. The detailed test conditions are described in the following chapter.

If no other conditions are specified in the following sections or in the subsequent Parts of this Guideline, the tests shall be performed with anchor sleeves with a standard moisture content, installed in holes drilled with drill bits with $d_{cut,m}$ at normal temperature (T ~ 20 °C).

The loads to be applied during the tests according to 5.4.2.7 (repeated load tests) and 5.4.2.8 (sustained load tests) are valid for tests in normal strength concrete only. The loads to be applied during tests in other base materials are given in the corresponding Parts of this Guideline.

5.4.2.2. Types of installation

These tests are for nailed-in plastic anchors only. The tests shall be carried out according to Annex A, 5.2 at minimum installation temperature. After complete setting of the anchor, an additional hammer blow (using a hammer with a reasonable weight) shall be carried out on the anchor. Then a tensile test shall be performed at minimum installation temperature.

5.4.2.3. Influence of the diameter of the drill hole

For the drill hole the maximum diameter ($d_{cut,max}$) and the minimum diameter ($d_{cut,min}$) of drill bit according Annex A, 3 is to be used. The tension tests shall be carried out according to Annex A, 5.2.

5.4.2.4. Functioning in cracks

Tests in cracks with a crack width of 0.35 mm shall be carried out.

5.4.2.5. Moisture content

The moisture content of the polymeric material may influence the plastic anchor behaviour. For the tests 3 different humidity levels are defined.

standard: equilibrium water content at T = +23 °C and 50 % relative humidity.

dry: equilibrium water content at T = +23 °C and ≤ 10 % relative humidity.

wet: equilibrium water content after storing under water (wet condition means water saturated)

For standard humidity the conditioning may be done according to ISO 1110 [16].

The dry conditioning can be reached by drying the polymeric sleeve in an oven at +70 °C until the weight loss is smaller than 0,1 % in 3 consecutive measurements every 24 hours. The wet conditioning can be reached by placing the polymeric sleeve under water until the weight increase is smaller than 0,1 % in 3 consecutive measurements every 24 h.

The tension tests shall be carried out according to Annex A.

5.4.2.6. Temperature

a) Effect of increased temperature

The tests shall be carried out according to Annex A at the following temperatures for the different temperature ranges given in 4.4.2.6

Temperature range a) maximum short term temperature up to +40 °C:

> Test are performed with the maximum short term temperature at +40 °C. The maximum long term temperature at approximately +24 °C is checked by the tests with normal ambient.

Temperature range b) maximum short term temperature up to +80 °C:

> Test are performed with the maximum short term temperature at +80 °C and with the maximum long term temperature at +50 °C.

Temperature range c) on manufacturers request:

> Test are performed with the maximum short term temperature and the maximum long term temperature specified by the manufacturer within the range of 0.6 times to 1.0 times the maximum short term temperature and at temperatures between +21 °C and maximum short term temperature with an increment of ≤ 20 K..

b) Effect of lowest service temperature min T = -40 °C, -20 °C or –5 °C

After installation of the plastic anchors at normal ambient temperature raise the test member temperature to the maximum long term temperature and keep the test member at this temperature for 4 days. After that cool the test member to the lowest service temperature min T (-40 °C or –20 °C or –5 °C) according to the specification of the manufacturer and carry out tension tests according to Annex A. Plastic anchors made out of polyamide have to be checked by pull-out tests only at -40 °C, if these lowest service temperature is specified by the manufacturer.

c) Effect of minimum installation temperature

The plastic anchor shall be installed at the lowest installation temperature (plastic anchor and base material) specified by the manufacturer. After that cool the test member to the required minimum service temperature and carry out tension tests according to Annex A.

5.4.2.7. Sustained loading

The test is performed at normal temperature (T = +20 °C) for temperature range a), b) and c) and at maximum steady temperature for temperature range b) and c) [T = +50 °C for temperature range b)].

The plastic anchor shall be installed at normal temperature.

The plastic anchor is then subjected to a load according to equation (5.3) which is kept constant (variation within ±5 %).

For the tests at the maximum long term temperature [temperature range b) and c)] the test specimens, the loading equipment, the displacement transducers and the installed plastic anchors shall be heated to the maximum long term temperature at least for 24 hours before loading the plastic anchors.

The tests will generally be carried out over at least 5000 hours for polymeric sleeves of PE, PP or other polymeric materials, however tests with at least 3000 hours are sufficient for polymeric sleeves of PA6 or PA6.6 based on current experience with this material.

$$N_P = 0{,}4 \cdot N_{Rk} \tag{5.3}$$

where:

N_{Rk} = characteristic resistance of single anchor given in the ETA for the specific base material

After completion of the sustained load test the plastic anchor shall be unloaded, the displacement measured and immediately after unloading a tension test performed.

5.4.2.8. Relaxation

The plastic anchors are installed in the test member and left there unloaded for 24 hours and up to 500 hours. After that tension tests shall be carried out according to Annex A.

This test is not required for screwed-in plastic anchors with polyamide PA 6 polymeric sleeve, if failure is predominately caused by pulling out the sleeve and the screw together.

5.4.2.9. Maximum torque moment

The plastic anchor shall be installed with a screw driver. The torque moment shall be measured with a calibrated torque moment transducer. The torque moment shall be increased until failure of the plastic anchor.

The torque moment is measured as a function of time. From the gradient of this curve two torque moments can be determined, the one if the screw is fully attached to the anchor collar (T_{inst}) and the maximum value (T_u) that can be applied to the plastic anchor.

5.4.3. Tests for admissible service conditions

All tests for the determination of characteristic resistances to actions (tension, shear with or without lever arm,), spacing and edge distance as well as the load-displacement behaviour are described in the relevant subsequent parts of the Guideline for the different base materials.

The test procedures are described in Annex A.

If existing information is available from the manufacturer and the corresponding test report contains all relevant data, then the Approval Body may reduce the number of tests for admissible service conditions given in the subsequent parts, making use of this existing information. However, it will be considered in the assessment only if the results are consistent with the Institute's test results or experience.

5.5. Protection against noise

Not relevant.

5.6. Energy economy and heat retention

Not relevant.

5.7. Aspects of durability, serviceability and identification

5.7.1. Tests for checking durability of the metal parts (corrosion)

No special tests are required, if the conditions given in 6.7.1 are complied with. 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) special considerations including testing may be necessary, taking into account the environmental conditions and the available experience.

5.7.2. Durability of the coating

The durability of the coating of the metal part that ensures the suitability and the bearing behaviour of the anchor shall be shown. Furthermore it shall be shown that the coating does not negatively affect the durability of the polymeric sleeve. No special test conditions can be given in this Guideline for checking the durability of any coating because they depend on the type of coating. Any appropriate tests should be decided on by the responsible approval body. Zinc coatings (electroplated or hot dip galvanised) need not be subjected to testing if used under dry internal conditions

5.7.3. Tests for checking durability of the polymeric sleeve

The durability of the polymeric sleeve shall be verified against the relevant chemical attack. Relevant chemical attack is considered e.g. high alkalinity (pH = 13.2). Furthermore it shall be verified that any coating of the steel parts do not negatively influence the durability of the polymeric sleeve.

The check for durability against high alkalinity may be done for example by the following tests.

Test specimen:

1. *Tension bars manufactured according to ISO 3167 [17]*
2. *Determination of the water content of the tension bars following ISO 3167 [17]. If the water content is higher than 0,1 percentage by weight, the slices have to be dried.*
3. *Drill holes (diameter 2.8 mm) with a special drill into the centre of the tension bars perpendicular to the flat side of the specimen followed by rubbing the hole with a reamer (diameter 3.0 $\pm$ 0.05 mm).*
4. *Pressing a round pin (diameter 3.5 mm or 3.0 mm respectively) quickly into tension bars.*
5. *Putting the tension bars into different agents (see table 5.2 for number of necessary tension bars).*

   .- Water (reference tests)

   - High alkalinity (pH = 13.2)

   Tests in water (reference test):

   The tension bars with pins are stored under standard climate conditions in a container filled with condensed water. All specimens shall be completely covered for 2000 hours.

   Tests with high Alkalinity:

   The tension bars with pins are stored under standard climate conditions (T = + 21 °C ±3 °C) in a container filled with an alkaline fluid (pH = 13.2). All slices shall be completely covered for 2.000 hours. The alkaline fluid is produced by mixing water with $Ca(OH)_2$ (calcium hydroxide) powder or tablets until the pH-value of 13.2 is reached. The alkalinity should be kept as close as possible to pH 13.2 during the storage and not fall below a value of 13.0. Therefore the pH-value has to be checked and monitored at regular intervals (at least daily).
6. *Visual analysis to observe cracks after storage with a microscope with a magnification $\geq$ 100.*

The tests have to be carried out for each colour of the plastic anchor.

Table 5.2: Necessary number of tests on tension bars with pins

	Diameter of pins [mm]	*water*	*High alkalinity*
reference-test	*3.0*	*5*	*-*
test	*3.5*	*-*	*5*

5.7.4. Influence of UV-exposure

No special test conditions are required. In general the plastic anchors are not exposed UV-radiation for a longer time during the use.

6. ASSESSING AND JUDGING THE FITNESS FOR USE

6.0. General

This chapter details the performance requirements to be met (chapter 4) in precise and measurable (as far as possible and proportional to the importance of the risk) or qualitative terms, related to the product and its intended use, using the outcome of the verification methods (chapter 5).

6.1. Mechanical resistance and stability

Not relevant.

6.2. Safety in case of fire

6.2.1. Reaction to fire

The metal parts of plastic anchors can be classified to class A1 in accordance with the provisions of EC Decision 96/603/EC (as amended).

In the context of the end use application of the anchorages the plastic material of the anchor embedded in concrete/masonry can be considered to satisfy any reaction to fire requirements. Where the plastic parts of the anchor are embedded in the cladding/component which is not class A 1 the plastic parts can be considered not to influence the reaction to fire class of the cladding/component.

6.2.2. Resistance to fire

It is not possible to classify a plastic anchor for its fire resistance. The suitability of a plastic anchor for use in a system that is required to provide a specific fire resistance class, may be determined by reference to the simplified design method according to chapter 2.2 and the tabulated data given in Technical Report N° 020 "Evaluation of anchorages in concrete concerning Resistance to Fire". However, an earlier pull-out of the plastic anchor can occur, since the reduction of the strength of the plastic material at higher temperatures may be decisive. Therefore, the characteristic resistance shall always, also for the simplified design method according to 2.2, be determined for the certain product by fire tests according to 2.3.1.1.

It can be assumed that for fastening of facade systems the load bearing behaviour of the specific screwed in plastic anchor with a diameter 10mm and a metal screw with a diameter 7mm and a h_{ef} of 50 mm and a plastic sleeve made of polyamide PA6 has a sufficient resistance to fire at least 90 minutes (R90) if the admissible load (no permanent centric tension load) is $\leq$ 0.8 kN.

6.3. Hygiene, health and environment

Not relevant.

6.4. Safety in use

6.4.1. General

6.4.1.1. 5 %-fractile of the ultimate loads

The 5 %-fractile of the ultimate loads measured in a test series is to be calculated according to statistical procedures for a confidence level of 90 %. If a precise verification does not take place, in general, a normal distribution and an unknown standard deviation of the population shall be assumed.

$$F_{5\%} = \overline{F}\,(1 - k_s \cdot v) \tag{6.0}$$

e.g.: n = 5 tests: $k_s = 3.40$

n = 10 tests: $k_s = 2.57$

6.4.1.2. Conversion of ultimate loads to take account of concrete-, masonry- and steel strength

In case of pull out failure the influence of the concrete strength greater than C16/20 is not taken into account in the evaluation of the tests.

For concrete strength C12/15 Equation 6.0a is valid.

$$F_{Ru\,(C12/15)} = 0.7 \cdot F_{Ru\,(C20/25)} \qquad (6.0a)$$

The conversion to take account of masonry strength or autoclaved aerated concrete strength is given in the relevant subsequent Parts.

In case of concrete failure (concrete cone or splitting failure) Equation 6.0 b shall be used.

$$F_{Ru\,(fc)} = F^{t}_{Ru} \cdot (f_c/f_{c,test})^{0.5} \qquad (6.0b)$$

In case of steel failure the failure load shall be converted to the nominal steel strength by Equation (6.0c)

$$F_{Ru}\,(f_{uk}) = F^{t}_{Ru} \cdot \frac{f_{uk}}{f_{u,test}} \qquad (6.0c)$$

where:

$F_{Ru}\,(f_{uk})$ = failure load at nominal steel ultimate strength

6.4.1.3. In all tests the following criteria shall be met:

(1) The load-displacement curves shall show a steady increase (see Figure 6.1). 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:

$$N_1 = 0.4\, N_{Ru} \qquad (6.1)$$

where:

N_{Ru} is the maximum load in the single test.

If the requirements on the load-displacement behaviour are not fulfilled by the tension tests according to 5.4.2 and/or 5.4.3, then the factor α_1 shall be calculated.

$$\alpha_1 = \frac{\alpha}{req.\alpha} \qquad (6.2)$$

where:

α	=	lowest ratio N_1/N_u in the test series
N_1	=	load at which uncontrolled slip of the anchor occurs (see Figure 6.1)
N_u	=	failure load in that test
req.α	=	0.4

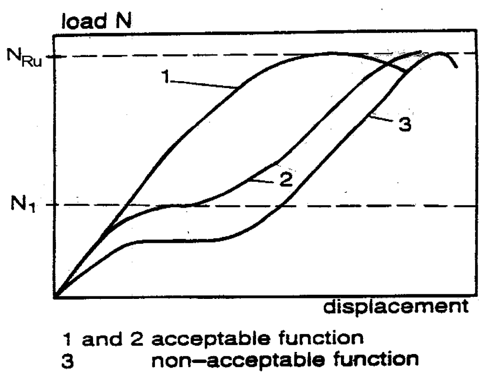

Figure 6.1 Requirements for the load-displacement curve

(2) In each test series, the coefficient of variation of the ultimate load shall be smaller than v = 20 %.

6.4.2. Criteria valid for suitability tests

6.4.2.1. General

Approval for an plastic anchor can only be obtained if the criteria for the suitability tests are met by all test results. Additional to the criteria described in chapter 6.4.1.3 the following criteria shall be considered.

The conditions for the displacement behaviour during the repeated / variable load tests (Section 6.4.2.7) and sustained load tests (Section 6.4.2.8) are valid for tests in normal weight concrete. For tests in other base materials these conditions are given in the corresponding Parts of this Guideline.

In the suitability tests the factor α shall be larger than the value given in Table 5.1 of the subsequent parts:

$$\alpha = \text{lesser value of} \quad \frac{N^t_{Ru,m}}{N^r_{Ru,m}} \tag{6.4a}$$

$$\text{and} \quad \frac{N^t_{Rk}}{N^r_{Rk}} \tag{6.4b}$$

where:

$N^t_{Ru,m}$; N^t_{Rk} = mean value or 5 %-fractile, respectively, of the ultimate loads in a test series

$N^r_{Ru,m}$; N^r_{Rk} = mean value or 5 %-fractile, respectively, of failure loads in the reference tests [e.g. tests for admissible service conditions according to Table 5.2, line 1 (suitability tests in non-cracked concrete) or line 2 (suitability tests in cracked concrete)].

Equation (6.4b) is based on test series with a comparable number of test results in both series. If the number of tests in the two series is very different, then Equation (6.4b) may be omitted when the coefficient of variation of the test series is smaller than or equal to the coefficient of variation of the reference test series or if the coefficient of variation in the suitability tests is $v \leq 15$ %.

If the criteria for the required value of α (see Tables 5.1) is not met in a test series, then the factor α_2 shall be calculated. Exceptions see Section 6.4.2.6 b, 6.4.2.6 c, 6.4.2.7 and 6.4.2.8.

$$\alpha_2 = \frac{\alpha}{req.\alpha} \tag{6.5}$$

where:

α lowest value according to Equation (6.4) in the test series

req. α required value of α according to Tables 5.1

6.4.2.2. Types of installation

These test are for nailed-in anchors only. The required α in the tests is ≥ 0.90. If the requirements concerning α are not fulfilled, α_2 shall be calculated according to Equ. 6.5.

6.4.2.3. Influence of the diameter of drill hole

The required α in the tests is ≥ 0.80 for tests with $d_{cut,max}$ and 1.0 for tests with $d_{cut,min}$. If the requirements concerning α are not fulfilled, α_2 shall be calculated according to Equ. 6.5.

6.4.2.4. Functioning in cracks

The required α in the tests is ≥ 0.75. If the requirements concerning α are not fulfilled, α_2 shall be calculated according to Equ. 6.5.

6.4.2.5. Moisture content

The required α in the tests with dry and wet conditioning of the plastic sleeve is ≥ 0.80. If the requirements concerning α are not fulfilled, α_2 shall be calculated according to Equ. 6.5.

6.4.2.6. Temperature

a) Effect of increased temperature

The required α for the tests at maximum long term temperature is:

> req.$\alpha \geq 1.0$ for temperature ranges b) (T = +50 °C) and c) (0.6T1 to 1.0T1, chosen by the manufacturer)

The required α for the maximum short term temperature are:

> req.$\alpha \geq 0.8$ for +40 °C (temperature range a)
>
> req.$\alpha \geq 0.8$ for +80 °C (temperature range b)
>
> req.$\alpha \geq 0.8$ for +T1 (temperature chosen by the manufacturer)

If the requirements concerning α are not fulfilled in the tests at the maximum long term or maximum short term temperature, α_2 shall be calculated according to Equ. 6.5.

b) Effect of lowest service temperature, min T = -40 °C/-20 °C/-5 °C

The required α for the tests at lowest service temperature is 1.0.

If this condition is not fulfilled, then the lowest service temperature shall be increased to the next step and the tests at minimum installation temperature shall be repeated until the condition is fulfilled.

c) Effect of minimum installation temperature

The required α for the tests at the minimum installation temperature is 1.0.

If this condition is not fulfilled, then the minimum installation temperature shall be increased and the tests at minimum installation temperature shall be repeated until the condition is fulfilled.

6.4.2.7. Sustained load tests

The displacements measured in the tests have to be extrapolated according to Equation (6.6) (Findley approach) to 50 years (tests at normal ambient temperature), or 10 years (tests at maximum long term temperature), respectively.

The curve fitting should start with the displacement measured after approximately 100 h.

$$s(t) = s_o + a \cdot t^b \qquad (6.6)$$

s_o = initial displacement under the sustained load at t = 0 (measured directly after applying the sustained load)

a, b = constants (tuning factors), evaluated by a regression analysis of the deformations measured during the sustained load tests

The extrapolated displacements shall be less than the average value of the displacements at the load at overcoming the friction resistance in the reference tests according to 5.4.3 in non-cracked concrete. The load at overcoming the friction resistance may be evaluated as described in Section 6.4.2.7.

If this condition is not fulfilled, the tests have to repeated with a lower load N_p until the requirement is fulfilled and the characteristic resistance calculated according to the following Parts shall be reduced by the factor N_p (applied) / N_p (required).

The failure loads measured in the pullout tests subsequent to the sustained loading shall be compared with the failure loads measured in the reference tests according to 5.4.3 in non-cracked concrete (sustained load tests at normal temperature) or in the suitability tests at maximum long term temperature (sustained load tests at maximum long term temperature). The value shall be calculated according to 6.4.2.1. The required α is 0.9. If this condition is not fulfilled, α_2 shall be calculated according to Equ. 6.5.

6.4.2.8. Relaxation

The required α in the tests after 24 h is ≥ 0.90 and for tests after up to 1000 h is ≥ 1.0.

If the requirements concerning α are not fulfilled, α_2 shall be calculated according to Equ. 6.5.

6.4.2.9. Maximum torque moment

The installation of the plastic anchor shall be practicable without steel failure or turn-through in the hole.

This condition may be assumed to be fulfilled if the following conditions are met. The ratio of the maximum torque moment T_u to the installation moment T_{inst} shall be determined for every test. The 5 %-fractile of the ratio for all tests shall be at least 1.3.

If this requirement is not met, the tension tests according to Section 5.4.2 have to be carried out with overtorqued anchors.

6.4.3. Admissible service conditions

The assessment of the tests for admissible service conditions and the determination of the characteristic resistance are described in the relevant subsequent parts of the Guideline for the different base materials.

6.5. Protection against noise

Not relevant.

6.6. Energy economy and heat retention

Not relevant.

6.7. Aspects of durability, serviceability and identification

6.7.1. Durability of the metal parts

The assessment/testing required with respect to corrosion resistance will depend on the specification of the plastic anchor in relation to its use. Supporting evidence that corrosion will not occur is not required if the steel parts of the plastic anchor are protected against corrosion, as set out below:

Plastic anchors intended for use in structures subject to dry, internal conditions:

> In general, no special corrosion protection is necessary for steel parts as coatings provided for preventing corrosion during storage prior to use and for ensuring proper functioning (e.g. a zinc coating with a minimum thickness of 5 microns) is considered sufficient.

Plastic anchors for use in structures subject to external atmospheric exposure or exposure in permanently damp internal conditions:

> In general the metal parts of the anchors shall be made of an appropriate grade of stainless steel. The grade of stainless steel suitable for the various service environments (marine, industrial, etc.) shall be in accordance with existing rules. Grade A4 of ISO 3506 [1] or equivalent may be used under internal and external or other environmental conditions if no particularly aggressive conditions exist.

Where a form of protection (material or coating) other than those mentioned above is specified, it will be necessary to provide evidence in support of its effectiveness in the defined service conditions; with due regard to the aggressiveness of the conditions concerned.

If an anchor involves the use of different metals, these shall be electrolytically compatible with each other. In dry internal conditions, carbon steel is compatible with malleable cast iron according to ISO 5922 [12].

Assessment of the durability of the coating is based on the type of coating and the intended conditions of use (i.e. dry internal or external conditions).

6.7.2. Durability of the polymeric sleeve

The assessment/testing required with respect to high alkalinity (pH = 13.2) shall be presented and it will depend on the specification of the plastic anchor in relation to its use.

The durability with respect to high alkalinity is proven, if for all specimen tested according to 5.7.3 no cracks are visible with a microscope using a magnification of at least 100.

6.7.3. Influence of UV-exposure

The manufacturer shall be ensured that the packaging of the plastic anchors protects the anchors for UV-radiation during the storage.

6.7.4. Identification

6.7.4.1. General

Characteristics as specified in the manufacturer's specification for production control and as required above are to be checked using ISO, European or recognised standard test methods as nominated by the manufacturer and accepted by the approval body.

Wherever possible, checks should be carried out on finished components. Where dimensions or other factors prevent testing to a recognised standard, e.g. tensile properties where the required ratio of length to diameter does not exist in the finished component, then the tests should still be carried out on the finished component if practicable, in order to produce results for comparison purposes. Where this is not possible, tests should be carried out on the raw material; however, it shall be noted that where the production process changes the characteristics of the material, then a change to the production process can render the results of these tests invalid.

Deviations of samples from the specification on the manufacturer's drawings shall be identified and appropriate action taken to ensure compliance before testing plastic anchors.

A minimum number of each component of the plastic anchors and special drill bits and setting tools, if appropriate, depending on factors such as the production process and the bag size is to be taken and dimensions measured and checked against the drawings provided by the manufacturer. The tolerances specified for all components shall be complied with and the dimensions of these elements shall conform to the appropriate ISO or European standards where relevant.

The results obtained shall be assessed to ensure that they are within the manufacturer's specification.

6.7.4.2. Identification of the polymeric parts

The product/kit shall be clearly identified. Where possible, reference to European standards shall be made. The chemical constitution and composition of the materials shall be submitted by the applicant to the Approval Body which shall observe strict rules of confidentiality. Under no circumstances shall such information be disclosed to any other party.

This composition shall be checked by the Approval Body on the basis of the declaration made by the applicant, and it shall be documented by fingerprint (IR-spectrum).

The following characteristics for virgin material (see 2.1.2.2) shall be specified, where relevant, in accordance with ISO, European or national standards, together with any others, as necessary:

DSC curve: differential scanning calorimetric ISO 3146 [18]

MFR value: melt mass-flow rate ISO 1133 [19]

MVR value: melt volume-flow rate ISO 1133 [19]

If not all details of the chemical constitution and the composition of the material will be submitted by the applicant to the approval body, then additional identification methods are required:

- Manufacturing process parameters (e.g. temperature, pressure, time, product/production codes)
- Testing of physical characteristics-data (depending on the polymeric material, e. g. nominal physical properties, absorption of humidity, stress-strain behaviour, toughness and notch sensitivity, shear modulus, dynamic stability, creep rupture, action on chemical agents).

The factory production control should consider the extend of the submitted detail of the chemical constitution and the composition of the material.

7. ASSUMPTIONS AND RECOMMENDATIONS UNDER WHICH THE FITNESS FOR USE OF THE PRODUCTS IS ASSESSED

7.0. General

This chapter sets out the assumptions and recommendations for design, installation and execution, packaging, transport and storage, use, maintenance and repair under which the assessment of the fitness for use according to the ETAG can be made (only when necessary and in so far as they have a bearing on the assessment or on the products).

For the assessment of the behaviour of the plastic anchor in other masonry or hollow / perforated bricks, hollow blocks or other different base materials than well defined in the ETA, tests on the construction site are to be carried out according to national requirements or Annex B.

7.1. Design methods for anchorages

The assessment of the anchor should be made assuming that the design method given in the Annex C is used. However, if an alternative design method should be proposed the approval body should judge this design method and the relevance of the assessment, in particular the relevance of the tests to be undertaken.

The overall assumption should be made that the design and dimensioning of anchorages is based on technical considerations and in particular the following:

- 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. Therefore 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.
- the preparation of verifiable calculation notes and drawings for determining the relevant concrete or masonry in the region of the anchorage, the loads to be transmitted and their transmission to the supports of the structure.
- consideration not only of direct loads but also the important additional loads caused by restraint of intrinsic (e.g. shrinkage) or extrinsic deformation (e.g. by temperature variations) in the anchor, in the fixture or in the base material together with verification of the distribution of loads in these structures and assemblies.

7.2. Packaging, transport and storage

<u>Storage conditions</u>

The storage conditions should be clearly stated including any temperature limits.

<u>Temperature requirements for installation</u>

<u>Temperatures for service conditions</u>

The manufacturer should state the range of temperatures for which the quoted characteristic load is valid

Any time limitations should be clearly stated.

7.3. Installation of anchors

Anchor installation should be carried out by trained personnel and under the supervision of the person responsible for technical matters of the site.

The loading capacity and reliability of anchorages are greatly affected by the manner in which the anchors are installed. It is therefore necessary to provide information and appropriate specifications for correct installation of the anchors on site.

Anchors should be used only as supplied by the manufacturer. It is not permissible to exchange the components on which the suitability and loading capacity of the anchors depend.

Anchors should be installed in accordance with the technical approval, the manufacturer's specifications and the drawings prepared for that purpose using the appropriate tools. It is important, in ensuring correct installation, that the engineer responsible transmits all the necessary information to the installer. It is necessary to use the appropriate tools with the corresponding anchor type. Before placing an anchor, checks should be made to ensure that the strength class of the base material in which the anchor is to be placed is not lower than that of the base material to which the characteristic loads apply.

Holes to be drilled perpendicular to the surface unless specifically required otherwise by the manufacturer's specifications. Normally hard metal hammer-drill bits in accordance with ISO or current national standards should be used. Many drill bits exhibit marks indicating that these requirements have been met. If the drill bits do not bear a conformity mark, proof of suitability should be provided.

All special drill bits (e.g. stopdrills or diamond core drill bits) required in accordance with manufacturer's installation instructions to be in compliance with the manufacturer's specifications. This to be confirmed by the factory production control for the drill bits.

The use of unsuitable drill bits may involve a considerable reduction in the loads that the anchorage can transmit.

Holes to be cleared of drilling dust.

Anchors to be installed ensuring not less than the specified embedment depth. The edge distance and spacing to be kept to the specified values, no minus tolerances to be allowed.

When drilling holes in concrete, care to be taken not to damage reinforcement in close proximity to the hole position.

Action to be taken in the event that drilling is aborted, e.g. by encountering reinforcement. For example, it may be recommended to either install the anchors immediately beside the aborted drill hole, provided that anchoring depth is increased by the depth of the aborted drill hole, or make a new drilling at a minimum distance away of twice the depth of the aborted hole. Alternatively, a smaller distance may be chosen, provided the aborted drill hole is filled with high strength mortar.

When installed, anchors should function correctly.

Where it is likely that anchors will be subjected to temperatures below 0 °C, measures should be taken to avoid the ingress of water into the hole and subsequent risk of local cracking of the concrete due to ice pressure.

Control methods on site after installation will in general not be necessary due to the fact that any suitability tests have taken account of minor inaccuracies during installation. Moreover, gross errors are not covered by this Guideline and should be avoided by proper training of the installers and supervision on site.

Section three:

ATTESTATION OF CONFORMITY (AC)

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8. ATTESTATION OF CONFORMITY

8.1. EC decision

The systems of attestation of conformity specified by the European Commission Decision 97/463(EC), is system **2+** described in Council Directive (89/106/EEC) Annex III, 2(ii) [1], first possibility and is detailed as follows:

(a) tasks for the manufacturer

- (1) initial type-testing of the product; (see 8.2.1)
- (2) factory production control; (see 8.2.3)
- (3) testing of samples taken at the factory by the manufacturer in accordance with a prescribed test plan. (see 8.2.2)

(b) tasks for the approved body

- (4) certification of factory production control on the basis of:
- **-** initial inspection of factory and of factory production control; (see 8.2.4)
- **-** continuous surveillance, assessment and approval of factory production control. (see 8.2.4)

8.2. Responsibilities

8.2.1. Initial type-testing

Initial type-testing will be available as part of the work required for the assessment of products for ETA.

The tests will have been conducted by the approval body or under its responsibility (which may include a proportion conducted by an approved laboratory or by the manufacturer) in accordance with chapter 5 of this ETAG. The approval body will have assessed the results of these tests in accordance with chapter 6 of this ETAG, as part of the ETA issuing procedure.

Where appropriate this assessment shall be used by the approved body for certification of factory production control purposes.

8.2.2. Testing of samples taken at the factory

Both large and small companies produce these products, there is a large variation in the volume of products within the range of sizes produced and different production processes introduce further variations. Therefore a precise scheme can only be set up on a case by case basis.

In general it is not normally necessary to conduct tests on installed anchors. Indirect methods will normally be sufficient e.g. control of the manufacturing process and the properties of anchor.

8.2.3. Factory production control (FPC)

The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures. This production control system shall ensure that the product is in conformity with the ETA.

8.2.4. Initial inspection and continuous surveillance, assessment of the factory production control system

Assessment of the factory production control system is the responsibility of the approved body.

An assessment shall be carried out on each production unit to demonstrate that the FPC is in conformity with the ETA and the technical documentation of the relevant ETA. This assessment shall be based on an initial inspection of the factory.

Subsequently continuous surveillance of FPC is necessary to ensure continuing conformity with the ETA.

It is recommended that surveillance inspections be conducted at least twice per year. However, for factories which are the subject of a certified quality assurance system and it is verified in the relevant ETA, surveillance visits may be carried out only once a year.

8.3. Documentation

In order to help the approved body make an evaluation of conformity the approval body issuing the ETA shall supply the information detailed below. This information together with the requirements given in EC Guidance Paper No 7 Construct 95/135 Rev 1, will generally form the basis on which the FPC is assessed by the approved body.

(1) the ETA

(2) basic manufacturing processes

(3) product and materials specifications

(4) test plan

(5) other relevant information

This information shall initially be prepared or collected by the approval body and where appropriate shall be agreed with the manufacturer. The following gives guidance on the type of information required:

(1) The ETA

See chapter 4 of this ETAG.

The nature of any additional (possibly confidential) information shall be declared in the ETA.

(2) Basic manufacturing processes

The basic manufacturing process shall be described in sufficient detail to support the proposed FPC methods.

Anchors are normally manufactured using conventional manufacturing techniques. Any critical process or treatment of the parts which affects performance should be highlighted.

(3) Product and materials specification

Product and materials specifications will be required for the various components and any bought-in components e.g. nuts, washers.

These specifications can take the form of:

detailed drawings (including manufacturing tolerances)

raw materials specifications

references to national, European and/or international standards and grades

manufacturers data sheets e.g. for raw materials not covered by a recognised standard eg friction control coating.

(4) Test plan

The manufacturer and the approval body issuing the ETA shall agree on a test plan (CPD Annex III 1b).

This test plan is necessary to ensure that the product specification remains unchanged.

The validity of the type and frequency of checks/tests conducted during production and on the final product shall be considered as a function of the production process. This will include the checks conducted during manufacture on properties that cannot be inspected at a later stage and for checks on the final product. These will normally include:

- material properties e.g. tensile strength, hardness, surface finish
- determination of the dimensions of component parts
- coating thickness
- check correct assembly.

Where bought-in components/materials are supplied without certificates of relevant properties they shall be subject to checks/tests by the manufacturer before acceptance.

8.4. CE marking and information

Every plastic anchor shall be clearly identifiable before installation and shall be marked by:

- the name or identifying mark of the producer
- the plastic anchors identity (commercial name)
- the minimum anchorage depth or the maximum admissible thickness of the fixture

In addition, the symbol "CE“ can be put on the plastic anchor.

The packaging or the delivery tickets associated with the product shall contain the CE conformity marking. The "CE"-marking shall be accompanied by the following information:

1. identification number of inspection body;
2. name or identifying mark of the producer and manufacturing plant;
3. the last two digits of the year in which the marking was affixed;
4. number of the European Technical Approval;
5. number of the relevant part of the ETAG Plastic Anchor for use in concrete and masonry;
6. size of the plastic anchor;
7. use category a, b, c and/or d

All installation data and the allowable base material shall be shown clearly on the package and/or on an enclosed instruction sheet, preferably using illustration(s).

The minimum data required are:

– allowable base material for the intended use
– drill bit diameter (d_{cut})
– minimum effective anchorage depth (h_{ef})
– minimum hole depth (h_o)
– information on the installation procedure, including the minimum installation temperature and cleaning of the hole, preferably by means of an illustration
– allowable temperature range according to 4.4.2.6 a), b) or c)
– reference to any special installation equipment needed
– identification of the manufacturing batch

All data shall be presented in a clear and explicit form.

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Section four:

ETA CONTENT

9. THE ETA CONTENT

9.1. The ETA-content

9.1.1. Model ETA

The format of the ETA shall be based on the Commission Decision of 1997-07-22, EC Official Journal L236 of 1997-08-27.

9.1.2. Checklist for the issuing body

The technical part of the ETA shall contain information on the following items, in the order and with reference to the relevant 4 Essential Requirements. For each of the listed items, the ETA shall either give the mentioned indication/classification/statement/description or state that the verification/assessment of this item has not been carried out. The items given here are with reference to the relevant clause of this Guideline:

9.1.3. Definition of the anchor and its intended use

- Definition
- Intended use
- Multiple use

9.1.4. Characteristics of the anchor with regard to safety in use and methods of verification

- characteristic values to be used for the calculation of the ultimate limit state
- characteristic values of displacement for serviceability limit state
- Definition of the base material which was used in the tests (type of material, strength, density, type of aggregate, hole dimension and location of the masonry unit). These data have to be covered by the base material on construction works for which the plastic anchor is intended to be used.

In addition to the specific clauses relating to dangerous substances contained in this European Technical Approval, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply.

The ETA is issued for the product/kit on the basis of agreed data/information, deposited with {the Approval Body name} which identifies the product/kit that has been assessed and judged. Changes to the product/production process/kit, which could result in this deposited data/information being incorrect, should be notified to the {the Approval Body name} before the changes are introduced. The {Approval body name} will decide whether or not such changes affect the ETA and consequently the validity of the CE marking on the basis of the ETA and if so whether further assessment/alterations to the ETA, shall be necessary. Evaluation of conformity and CE-marking.

9.1.5. Assumptions under which the fitness of the anchor for the intended use was favourably assessed

- Design methods for anchorages
- Transport and storage
- Installation of anchors

European Organisation for Technical Approvals
Europäische Organisation für Technische Zulassungen
Organisation Européenne pour l’Agrément Technique

ETAG 020

Edition March 2006

GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL

of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Part two : PLASTIC ANCHORS FOR USE IN NORMAL WEIGHT CONCRETE

Kunstlaan 40 Avenue des Arts, B - 1040 Brussels

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PART TWO : PLASTIC ANCHORS FOR USE IN NORMAL WEIGHT CONCRETE

FOREWORD

In this Part of ETAG "Plastic Anchors for Multiple Use in Concrete and Masonry for Non-Structural Applications" the methods of verification and the assessments required for the use of plastic anchors in normal weight concrete are given. For a general assessment of plastic anchors, on principle, Part 1 applies.

The same numbering of paragraphs as in Part 1 is used.

The plastic anchors for use in normal weight concrete shall be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore the design of the fixture may specify the number n1 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

The required tests for suitability are given in Table 5.1 and the tests for admissible service conditions are given in Table 5.2. The determination of admissible service conditions and determination of characteristic resistances for plastic anchors to be used in concrete are completely given in this Part.

Section two:

GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

5. METHODS OF VERIFICATION

5.4. Safety in use

5.4.2. Tests for suitability

The types of suitability tests, test conditions, the number of required tests and the criteria applied to the results are given in Tables 5.1. In general, all the tests shall be performed with single plastic anchors without edge and spacing effects under tension loading.

The tests shall be carried out according to Annex A.

Table 5.1 Suitability tests for plastic anchors for use in concrete

	1	2	3	4	5	6	7			8	9
	Purpose of test	Base material Concrete	Crack width Δw (mm)	Drill bit	Ambient temperature (1)	Condition of polymeric sleeve (6)	Minimum. number of tests per anchor sizes (9) (10)			Criteria ultimate load req.α	Remarks to the test procedure described in Part 1
							s	m	l		
1	Setting capacity for nailed-in anchors only	C 20/25	0	$d_{cut,m}$	min t(2)	standard	5	5	5	≥ 0.9	5.4.2.2
2	Functioning, depending on the diameter of drill hole	C 20/25	0	$d_{cut,min}$ $d_{cut,max}$ (11)	normal normal	standard standard	5 5	5 5	5 5	≥ 1,0 ≥ 0.8	5.4.2.3
3	Functioning in cracks	C 20/25	0,35	$d_{cut,max}$	normal	standard	5	5	5	0,75	5.4.2.4
4	Functioning under conditioning	C 20/25	0	$d_{cut,m}$ $d_{cut,m}$	normal normal	dry wet	- -	5 5	- -	≥ 0.8 ≥ 0.8	5.4.2.5
5	Functioning, Effect of temperature	C 20/25	0	$d_{cut,m}$ $d_{cut,m}$ $d_{cut,m}$ $d_{cut,m}$	min t C(3) 0° C(4) +50° C(5) +80° C(5)	standard standard standard standard	- - - -	5 5 5 5	- - - -	≥1.0 ≥1.0 ≥1.0 ≥0.8(8)	5.4.2.6
6	Functioning sustained loads	C 20/25	0	$d_{cut,m}$ $d_{cut,m}$	normal + 50° C(5)	standard standard	5 5	5 5	5 5	≥0.9 ≥0.9	5.4.2.7
7	Functioning 24 h relaxation 500h	C 20/25	0	$d_{cut,m}$ $d_{cut,m}$	normal normal	standard standard	- -	5 5	- -	≥0.9 ≥1.0	5.4.2.8 (7)
8	Maximum torque moment	C 20/25	0	$d_{cut,m}$	normal	standard	5	5	5		5.4.2.9

(1) Normal ambient temperature: 21 ± 3^0C (plastic anchor and concrete),

(2) Minimum installation temperature as specified by the manufacturer; normally 0 °C to + 5 °C.

(3) Tests with lowest service temperature as specified by the manufacturer –5°C, –20°C, –40°C

(4) Installation at minimum installation temper. as specified by the manufacturer; normally 0 °C to + 5 °C.

(5) For the temperature range b), Part 1, 4.4.2.6 for other temperature range see Part 1, 5.4.2.6 and 6.4.2.6

(6) Conditioning of polymeric sleeve according to Part 1, 5.4.2.5

(7) This test is not required for screwed-in plastic anchors of polyamide PA 6 based on current experience with this material.

(8) Reference values from the tests with maximum long term temperature +50° C

(9) Anchor size: s = small; m = medium; l = large

(10) If more than 3 sizes shall be assessed, then all sizes (also intermediate sizes) shall be tested according to line 1, 2, 3, 7 and 9. If the tests from line 1 and 2 of Table 5.2 show regularity in failure mode and ultimate load the intermediate sizes shall not be tested.

(11) The test series with $d_{cut,max}$ may be omitted if the test series according to Table 5.2, line 2 are carried out with $d_{cut,max}$

5.4.3. Tests for admissible service conditions

For determination of the admissible service conditions the tests given in Table 5.2 shall be carried out.

If existing information is available from the manufacturer and the corresponding test report contains all relevant data, then the Approval Body may reduce the number of tests for admissible service conditions, making use of this existing information. However, it will be considered in the assessment only if the results are consistent with the Institute's test results.

All tests for determination of admissible service conditions shall be carried out in concrete C 20/25 at normal ambient temperature (+21°C ± 3°C) and standard conditioning of the polymeric sleeve. The drill holes shall be drilled using $d_{cut,m}$ drill bits. The anchor installation shall be carried out according with the manufacturer's published instructions.

Table 5.2 Tests for admissible service conditions for plastic anchors for use in concrete

	1	2	3	4	5	6	7			8
	Purpose of test	Crack width Δw (mm)	Load di-rec-tion	Distances	Member thickness h	Remarks	Number of tests (2)			Test procedure described in Annex A
							s	m	l	
1	Reference tension tests in non-cracked concrete	0	N	$s > s_{cr,N}$ $c > c_{cr,N}$	$\geq h_{min}$	test with single anchors	5	5	5	Annex A 5.2
2	Characteristic resistance for tension loading not influenced by edge and spacing effects	0.2	N	$s > s_{cr,N}$ $c > c_{cr,N}$	$\geq h_{min}$	test with single anchors	5	5	5	Annex A 5.2
3	Edge distance for characteristic tension resistance	0	N	$s > s_{cr,N}$ $c_1 = c_2 = c_{cr,N}$	$= h_{min}$	test with single anchor at the corner	4	4	4	Annex A 5.2
4	Characteristic resistance for shear loading not influenced by edge and spacing effects	0	V	$s > s_{cr,N}$ $c > c_{cr,N}$	$\geq h_{min}$	test with single anchors	5	5	5	Annex A 5.4
5	Minimum edge distance and spacing	0	(1)	$s = s_{min}$ $c = c_{min}$	$= h_{min}$	double anchor group at the edge at uncast side of test member	5	5	5	Annex A 5.5.1

(1) Torque moment increased in steps of 0.2 T_{inst} for screwed-in plastic anchors

(2) Anchor size: s = small; m = medium; l = large; intermediate sizes need not to be tested

6. ASSESSING AND JUDGING THE FITNESS FOR USE

6.4. Safety in use

6.4.2. Criteria valid for suitability tests

In the suitability tests according table 5.1 the criteria described in Part 1, 6.4 shall be met. The values of the reference tests are taken from the tests according to Table 5.2, line 1 (for non-cracked concrete) and Table 5.2, line 2 (for cracked concrete) with the worst expansion direction.

6.4.3. Admissible service conditions

6.4.3.1. General

The criteria described in Part 1, 6.4.1 shall be met for all tests.

The characteristic resistance corresponds to the 5 %-fractile of the failure loads for concrete strength f_{ck} or steel strength f_{uk} respectively.

6.4.3.2. Characteristic resistance of single anchor under tension loading

The characteristic resistances for single anchors without edge and spacing effects under tension loading are assessed from the test according to Table 5.2, line 2 with the most unfavourable expansion conditions. The values are valid for all concrete strengths ≥ C 16/20, the effect of concrete strength being neglected. In special cases the characteristic resistances for concrete strength C 12/15 can be taken at 0.7 times the characteristic resistances for concrete strength C 20/25.

The characteristic resistances for single anchors under tension loading shall be calculated as follow:

$$N_{Rk} = N_{Rk,0} \bullet \min^{1)} (\min \alpha_1 \,;\, \min \alpha_{2,\text{ line 1 to 3 and line 6 to 8}}) \bullet \min \alpha_{2,\text{ line 4to5}} \qquad (6.7)$$

1) The lowest value of min α_1 or min $\alpha_{2,\text{ line 1 to 3 and line 6 to 8}}$ is governing.

N_{Rk} = characteristic resistance as given in the ETA. These values should be rounded to the following numbers: 0.3 / 0.4 / 0.5 / 0.6 / 0.75 / 0.9 / 1.2 / 1.5 / 2 / 2.5 / 3 / 3.5 / 4 / 4.5 /

$N_{Rk,0}$ = characteristic resistance from the tests according to Table 5.2, line 2

min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)

min $\alpha_{2,\text{line 4to5}}$ = minimum value α_2 (reduction factor from the ultimate load of the suitability tests) according to Part 1, Equation (6.5) of suitability tests. Table 5.1, line 4 and 5 (conditioning and temperature) (≤ 1.0)

min $\alpha_{2,\text{line 1to8}}$ = minimum value α_2 (reduction factor from the ultimate load of the suitability tests) according to Part 1, Equation (6.5) of suitability tests. Table 5.1, line 1 to 3 and line 6 to 8 (≤ 1.0)

6.4.3.3. Characteristic resistance of single anchor under shear loading

The characteristic resistances for single anchors without edge and spacing effects under shear loading are assessed from the test according to Table 5.2, line 4 using Equation 6.8 a and b.

$$V_{Rk,s} = V_{Rk,s} \bullet \frac{f_{uk}}{f_{u,test}} \tag{6.8a}$$

$$V_{Rk,s} \leq 0{,}5 \cdot A_s \cdot f_{uk} \tag{6.8b}$$

V^t_{Rks} = 5% fractile of ultimate load from shear tests according to Table 5.2, line 4

V_{Rks} = characteristic anchor resistance under shear force

f_{uk} = nominal characteristic steel ultimate strength

f_{yk} = nominal characteristic steel yield strength

6.4.3.4. Edge distance for characteristic tension resistance

The edge distance $c_{cr,N}$ for maximum pull-out capacity of the plastic anchor is evaluated from the results of tension tests on single anchors at the corner ($c_1 = c_2 = c_{cr,N}$) according to Table 5.2, line 3. The average failure load in the tests with plastic anchors at the corner shall be approximately equal with the values valid for anchors without edge and spacing effects. If this condition is not fulfilled, the tests have to be repeated with a larger edge distance. For plastic anchors in concrete strength C12/15 the evaluated values for the edge distance shall be increased by the factor 1.4.

6.4.3.5. Minimum spacing and minimum edge distance

The minimum spacing s_{min} and minimum edge distance c_{min} shall be evaluated from the results of installation tests with double anchor groups ($c = c_{min}$, $s = s_{min}$) according to Table 5.2, line 5. The 5 %-fractile of the torque moments, $T_{5\%}$ at which a hairline crack has been observed in the concrete at one anchor of the double anchor group, shall fulfil Equation (6.9).

$$T_{5\%} \geq 1.7 \bullet req.T_{inst} (f_{c,test}/f_{ck})^{0.5} \tag{6.9}$$

For plastic anchors in concrete strength C12/15 the evaluated values for minimum spacing and minimum edge distance shall be increased by the factor 1.4.

6.4.3.6. Displacement behaviour

As a minimum, the displacements under short and long term tension and shear loading shall be given in the ETA for a load F which corresponds approximately to the value according to Equation (6.10)

$$F = \frac{F_{Rk}}{\gamma_F \bullet \gamma_M} \tag{6.10}$$

F_{Rk} = characteristic resistance according to 6.4.3.2

γ_F = 1.4

γ_M = material partial safety factor according to Annex C for the corresponding failure mode

The displacements under short term tension and shear loading (δ_{NO} and δ_{VO}) are evaluated from the tests on single anchors without edge or spacing effects according to Table 5.2, lines 2 and 4. The value derived shall correspond approximately to the 95 %-fractile for a confidence level of 90 %.

Under shear loading, the displacements might increase due to a gap between fixture and anchor. The influence of this gap is taken into account in design (see Annex C).

The long term displacements under tension loading, $\delta_{N\infty}$, shall be calculated from the results of the repeated load tests and sustained load tests (Table 5.1, lines 6 and 7) according to Equation (6.11).

$$\delta_{N\infty} = \frac{\delta_{m2}}{2.0} \qquad (6.11)$$

with

δ_{m2} = average displacement in the repeated load tests after 10^5 load cycles or the sustained load tests after terminating the tests (see Annex A) respectively. The larger value is decisive.

The long term shear displacements $\delta_{V\infty}$ may be assumed to be approximately equal to 1.5-times the value δ_{VO}.

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of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Part three : PLASTIC ANCHORS FOR USE IN SOLID MASONRY MATERIALS

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PART THREE : PLASTIC ANCHORS FOR USE IN SOLID MASONRY MATERIALS

FOREWORD

In this Part of ETAG "Plastic Anchors for Multiple Use in Concrete and Masonry for Non-Structural Applications" the methods of verification and the assessments required for the use of plastic anchors in solid masonry materials (clay or calcium silicate or normal weight concrete) with a minimum mortar strength class of M2.5 are given. For a general assessment of plastic anchors, on principle, Part 1 applies.

In general, solid masonry units do not have any holes or cavities other than those inherent in the material. However, solid units may have a vertically perforation of up to 15% of the cross section.

The required tests for suitability are given in Table 5.1 and the tests for admissible service conditions are given in Tale 5.2. The determination of admissible service conditions and determination of characteristic resistances for plastic anchors to be used in solid masonry materials are completely given in 6.4.3.

The same numbering of paragraphs as in Part 1 is used.

The plastic anchors for use in solid masonry materials shall be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

Section two:

GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

5. METHODS OF VERIFICATION

5.4. Safety in use

5.4.2. Tests for suitability

The tests may be performed in single units or in a wall. If test are done in a wall, the thickness of the joints should be about 10mm and the joints should be completely filled with mortar of strength class M2.5 with a strength ≤ 5 N/mm². If tests have been performed in walls with a mortar strength higher than M2.5 then the minimum mortar strength shall be given in the ETA. The walls may be lightly prestressed in vertical direction to allow handling and transportation the wall.

In general, the tests should be carried out in the base material for which the plastic anchor is intended to be used. Bricks should be used with the compressive strength between 20 to 30 N/mm² . The determined characteristic resistances for the ETA are valid only for the brick sizes which are used in the tests or larger brick sizes; therefore the information about the brick sizes shall be given in the ETA.

The types of suitability tests, test conditions, the number of required tests and the criteria applied to the results are given in Tables 5.1.

If there are existing tests for suitability carried out in concrete (according to Part 2, Table 5.1) for the plastic anchors, then the results of these suitability tests ($\min\alpha_1$, $\min\alpha_2$ and $\min\alpha_V$) may be taken for the determination of the characteristic values of the plastic anchors to be used in solid masonry.

Table 5.1 Suitability tests for plastic anchors for use in solid masonry

	1	2	3	4	5	6			7	8
	Purpose of test	Base material: solid masonry	Drill bit	Ambient temperature (1)	Condition of polymeric sleeve (6)	Minimum number of tests per anchor sizes (9)			Criteria ultimate load req. α	Remarks to the test procedure described in Part 1
						s	m	l		
1	Setting capacity for nailed-in anchors only	(10)	$d_{cut,m}$	min t°C(2)	standard	5	5	5	≥ 0.9	5.4.2.2
2	Functioning, depending on the diameter of hole	(10)	$d_{cut,min}$	normal	standard	5	5	5	≥ 1,0	5.4.2.3
			$d_{cut,max}$ (12)	normal	standard	5	5	5	≥ 0.8	
4	Functioning under conditioning	(10)	$d_{cut,m}$	normal	dry	-	5	-	≥ 0.8	5.4.2.5
			$d_{cut,m}$	normal	wet	-	5	-	≥ 0.8	
5	Functioning, Effect of temperature	(10)	$d_{cut,m}$	min t° C(3)	standard	-	5	-	≥1.0	5.4.2.6
			$d_{cut,m}$	0° C(4)	standard	-	5	-	≥1.0	
			$d_{cut,m}$	+50° C(5)	standard	-	5	-	≥1.0	
			$d_{cut,m}$	+80° C(5)	standard	-	5	-	≥0.8(8)	
6	Functioning under sustained loads	(10)	$d_{cut,m}$	normal	standard	5	5	5	≥0.9	5.4.2.7
			$d_{cut,m}$	+ 50° C(5)	standard	5	5	5	≥0.9	(11)
7	Functioning 24 h	(10)	$d_{cut,m}$	normal	standard	-	5	-	≥0.9	5.4.2.8
	relaxation 500h		$d_{cut,m}$	normal	standard	-	5	-	≥1.0	(7)
8	Maximum torque moment	(10)	$d_{cut,m}$	normal	standard	5	5	5		5.4.2.9

(1) Normal ambient temperature: 21 ± 3^0C (plastic anchor and base material),

(2) Minimum installation temperature as specified by the manufacturer; normally 0 °C to + 5 °C.

(3) Tests with lowest temperature as specified by the manufacturer –5°C, –20°C, –40°C

(4) Installation at minimum installation temp. as specified by the manufacturer; normally 0 °C to + 5 °C.

(5) For temperature range b), Part 1, 4.4.2.6; for other temperature range see Part 1, 5.4.2.6 and 6.4.2.6

(6) Conditioning of plastic anchor sleeve according to Part 1, 5.4.2.5

(7) This test is not required for screwed-in plastic anchors with polyamide PA 6 polymeric sleeve.

(8) Reference values from the tests with maximum long term temperature +50° C

(9) Anchor size: s = small; m = medium; l = large

If more than 3 sizes shall be assessed the intermediate sizes shall not be tested if the tests from line 1 of Table 5.2 show regularity in failure mode and ultimate load.

(10) Base material for the tests see 5.4.2

(11) N_{Rk} Part 1, 5.4.2.8 (5.3); characteristic resistance N_{Rk} as given in the ETA evaluated according to 6.4.3.3

(12) The test series with $d_{cut,max}$ may be omitted if the test series according to Table 5.2, line 1 are carried out with $d_{cut,max}$

5.4.3. Tests for admissible service conditions

The tests may be performed in single units or in a wall. If test are done in a wall, the thickness of the joints should be about 10mm and the joints should be completely filled with mortar of strength class M2.5 with a strength ≤ 5 N/mm². If tests have been performed in walls with a mortar strength higher than M2.5 then the minimum mortar strength shall be given in the ETA. The walls may be lightly prestressed in vertical direction to allow handling and transportation the wall.

In general, the tests should be carried out in the base material for which the plastic anchor is intended to be used. Bricks should be used with the compressive strength between 20 to 30 N/mm² . The determined characteristic resistances for the ETA are valid only for the brick sizes which are used in the tests or larger brick sizes; therefore the information about the brick sizes has to be given in the ETA.

For determination of the admissible service conditions the tests given in Table 5.2 shall be carried out.

If existing information is available from the manufacturer and the corresponding test report contains all relevant data, then the Approval Body may reduce the number of tests for admissible service conditions, making use of this existing information. However, it will be considered in the assessment only if the results are consistent with the Institute's test results.

All tests for determination of admissible service conditions should be carried out according to Annex A in the base material for which the plastic anchor is intended to be used at normal ambient temperature (+21°C ± 3°C) and standard conditioning of the polymeric sleeve. The drill holes should be drilled using $d_{cut,m}$ drill bits.

The minimum edge distance c_{min} and minimum spacing s_{min} should be given by the manufacturer and should be confirmed by the tests according to Table 5.2, line 2.

Table 5.2 Tests for admissible service conditions for plastic anchors for use in solid masonry

	1	2	3	4	5	6	7
	Purpose of test	Load direction	Distances	Member thickness h	Remarks	Minimum number of tests for s,m,l (4)	Test procedure described in Annex A
1	Characteristic resistance for tension loading not influenced by edge and spacing effects	N	$s > s_{min}$ $c > c_{min}$	$\geq h_{min}$	test with single anchors (1)	5	Annex A 5.2
2	Minimum edge distance for characteristic tension resistance	N	$s > s_{min}$ (3) $c = c_{min}$	$= h_{min}$	test with single anchor (2)	5	Annex A 5.2

(1) Tension tests with single anchors in the centre of the brick

(2) Tension tests with single anchors near the free edge to determined the characteristic resistance depending on the minimum edge distance c_{min}

(3) Tension tests with double anchor group with s_{min} near the free edge ($c = c_{min}$) to determine the characteristic resistance for the minimum spacing s_{min} and the minimum edge distance c_{min} are required if the chosen minimum spacing is lower than the following values:

$s_{min} < 4\ c_{min}$ (groups with spacing parallel to the edge)

$s_{min} < 2\ c_{min}$ (groups with spacing perpendicular to the edge)

(4) Anchor sizes small (s), medium (m) and large (l) of an anchor system should be tested; intermediate sizes need not to be tested

6. ASSESSING AND JUDGING THE FITNESS FOR USE

6.4. Safety in use

6.4.1.2. Conversion of ultimate loads to take account of concrete-, masonry- and steel strength

In contrast to Equation (6.0b) the conversion of the test results in solid masonry should be carried out according to chapter 6.4.3.2.

6.4.1.3. In all tests the following criteria shall be met

(2) In general, in each test series, the coefficient of variation of the ultimate load should be smaller than v = 20 % in the suitability tests and v = 15 % in the admissible service condition tests.

If the coefficient of variation of the ultimate load in the suitability test is greater than 20%, then the following α_V-value has to be taken into account:

$$\alpha_V = \frac{1}{1+0{,}03\times(v[\%]-20)} \leq 1.0 \qquad (6.6a)$$

If the coefficient of variation of the ultimate load in the admissible service condition test is greater than 15%, then the following α_V-value has to be taken into account:

$$\alpha_V = \frac{1}{1+0{,}03\times(v[\%]-15)} \leq 1.0 \qquad (6.6b)$$

6.4.2. Criteria valid for suitability tests

In the suitability tests according Table 5.1 the criteria described in Part 1, 6.4 should be met. The values of the reference tests are taken from the tests according to Table 5.2, line 1 for the corresponding solid masonry material.

If there are existing tests for suitability carried out in concrete (according to Part 2, Table 5.1) for the plastic anchors, then the results of these suitability tests ($\min\alpha_1$, $\min\alpha_2$ and $\min\alpha_V$) may be taken for the determination of the characteristic values of the plastic anchors to be used in solid masonry.

6.4.3. Admissible service conditions

6.4.3.1. General

In all tension tests, the requirement for the load/displacement curves should satisfy the requirements laid down in Part 1, 6.4.1.3 (1). The requirements on the coefficient of variation of the ultimate loads is given in 6.4.1.3 (2) and Equation (6.6b).

6.4.3.2. Characteristic resistance of single anchor for the different conditions

(1) Tension loading not influenced by edge and spacing effects (Table 5.2, line 1)

The characteristic resistances of single anchors without edge and spacing effects under tension loading shall be calculated as follows:

$$N_{Rk1} = N_{Rk1,0} \times \min^{1)} (\min \alpha_1 \,;\, \min \alpha_{2,\text{ line }1,2,7,8}) \times \min \alpha_{2,\text{ line }4,5} \times \min \alpha_V \qquad (6.7)$$

[1)] *The lowest value of min α_1 or min $\alpha_{2,\text{ line }1,2,7,8}$ is govern.*

with: $N_{Rk1,0}$ = characteristic resistance evaluated from the results of tests according to Table 5.2, line 1

The tests should be carried out in bricks with compressive strengths between 20 to 30 N/mm² for determination of the characteristic resistance for bricks

≥ 20 N/mm². For compressive strength < 20 N/mm² down to 10 N/mm² a reduction factor of 0.7 is taken into account.

min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)

min $\alpha_{2,line\ 4,5}$ = minimum value α_2 (reduction factor from the ultimate loads in the suitability tests) according to Part 1,Equ. (6.5) of suitability tests according to Table 5.1, line 4 and 5 (conditioning and temperature) (≤ 1.0)

min $\alpha_{2,line\ 1,2,7,8}$ = minimum value α_2 (reduction factor from the ultimate loads in the suitability tests) according to Part 1,Equ. (6.5) of suitability tests according to Table 5.1, line 1, 2, 7 and 8 (≤ 1.0)

min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

(2) Tension loading influenced by minimum edge effects (Table 5.2, line 2)

The characteristic resistances of single anchors near the free edge under tension loading should be calculated as follows:

$$N_{Rk2} = N^{t}_{Rk2} \times \frac{f_b}{f_{b,test}} \times \min \alpha_1 \times \min \alpha_V \quad ^{1)} \qquad (6.8)$$

with: N^{t}_{Rk2} = characteristic resistance evaluated from the results of tests according to Table 5.2, line 2

f_b = normalised mean compressive strength of the chosen masonry unit in the ETA

$f_{b,test}$ = mean compressive strength of the test masonry unit

min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)

min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

1) If pull-out failure is observed in tests according to Table 5.2, line 2, then the evaluation should be done according to Equation (6.7).

(3) Tension loading influenced by minimum spacing effects (Table 5.2, footnote (3))

In the design concept it is assumed that a group with 2 or 4 anchors with $s \geq s_{min}$ has he same characteristic resistance than a single anchor with a large spacing to neighbouring anchors. Therefore the characteristic resistances of single anchors N_{Rk3} with minimum spacing near the free edge under tension loading shall be calculated according to 6.4.3.2 (2), however as value N^{t}_{Rk2} the characteristic resistance evaluated from the results of tests according to Table 5.2, footnote (3) shall be taken.

If pull-out failure is observed in tests according to Table 5.2, footnote (3), then the evaluation should be done according to Equation (6.7).

(4) Shear loading

If no shear tests available, the characteristic shear resistances $V_{Rk,b}$ for brick edge failure may be calculated according to Annex C for concrete edge failure $V_{Rk,c}$ as follows:

$V_{Rk,b} = 0.5\ V_{Rk,c}$ (shear loading in direction to the free edge)

$V_{Rk,b} = 1.0\ V_{Rk,c}$ (shear loading in other directions)

The concrete strength $f_{ck,cube}$ has to be replaced by the brick normalised mean compressive strength f_b in the relevant Equation of Annex C.

If shear tests towards the edge are performed and brick edge failure occurs the characteristic shear resistance shall be calculated as follows:

$$V_{Rk,b} = V_{Ru}^{t} \times \frac{f_b}{f_{b,test}} \times \min \alpha_V \qquad (6.9)$$

with: V_{Ru}^{t} = characteristic resistance evaluated from the results of tests

f_b = normalised mean compressive strength of the chosen masonry unit in the ETA

$f_{b,test}$ = mean compressive strength of the test masonry unit

$\min \alpha_V$ = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

The characteristic shear resistances $V_{Rk,s}$ of the metal expansion element for single anchors may be calculated as follows:

$$V_{Rk,s} = 0.5 \times A_s \times f_{uk} \qquad (6.10)$$

with: As = stressed cross section of steel

f_{uk} = characteristic steel ultimate tensile strength (nominal value)

6.4.3.3. Characteristic resistance of single anchor in the ETA

For the determination of the characteristic resistance $\mathbf{F_{Rk}}$ the design values for N_{Rk1}, N_{Rk2} , N_{Rk3} , $V_{Rk,s}$, and $V_{Rk,b}$ have to be calculated under consideration of the appropriated partial safety factors. The corresponding partial safety factors are given in 7.1.2.

The minimum design value is decisive for the characteristic resistance $\mathbf{F_{Rk}}$ given in the ETA.

The value of the characteristic resistance $\mathbf{F_{Rk}}$ should be rounded to the following numbers:

0.3 / 0.4 / 0.5 / 0.6 / 0.75 / 0.9 / 1.2 / 1.5 / 2 / 2.5 / 3 / 3.5 / 4 / 4.5 / 5 / 6 / 7.5 / 9/ kN

6.4.3.4. Displacement behaviour

As a minimum, the displacements under short and long term tension and shear loading shall be given in the ETA for a load F which corresponds approximately to the value according to Equation (6.11)

$$F = \frac{F_{Rk}}{\gamma_F \times \gamma_M} \qquad (6.11)$$

with; F_{Rk} = characteristic resistance according to 6.4.3.3

γ_F = 1.4

γ_M = corresponding material partial safety factor

The displacements under short term tension loading (δ_{NO}) are evaluated from the tests with single anchors without edge or spacing effects according to Table 5.2, line 1. The value derived should correspond approximately to the 95 %-fractile for a confidence level of 90 %.

The long term tension loading displacements $\delta_{N\infty}$ may be assumed to be approximately equal to 2.0-times the value δ_{NO}.

The displacements under short term shear loading (δ_{VO}) are evaluated from the corresponding shear tests with single anchors. The value derived should correspond approximately to the 95 %-fractile for a confidence level of 90 %.

If no shear tests are performed the displacements under short term shear loading (δ_{VO}) for a plastic anchor with metal expansion element may be determined for the load according to Equation (6.11) with a shear stiffness of 1200 N/mm.

The long term shear loading displacements $\delta_{V\infty}$ may be assumed to be approximately equal to 1.5-times the value δ_{VO}.

Under shear loading, the displacements might increase due to a gap between fixture and anchor. The influence of this gap shall be taken into account in the design.

7. ASSUMPTIONS AND RECOMMENDATIONS UNDER WHICH THE FITNESS FOR USE OF THE PRODUCTS IS ASSESSED

7.1. Design methods for anchorage in solid masonry

7.1.1. Multiple use

The plastic anchors for use in solid masonry materials should be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

7.1.2. Design and safety concept

The design concept with partial safety factors should be used for anchorages in solid masonry.

In the absence of national regulations the following partial safety factors for resistances γ_M may be used:

Steel failure: Tension loading:

$$\gamma_{Ms} = \frac{1.2}{f_{yk} \; / \; f_{uk}} \geq 1.4 \qquad (7.1)$$

Shear loading of the anchor with and without lever arm:

$$\gamma_{Ms} = \frac{1.0}{f_{yk} / f_{uk}} \geq 1.25 \qquad f_{uk} \leq 800 \text{ N/mm}^2 \text{ and } f_{yk}/f_{uk} \leq 0.8 \qquad (7.2)$$

$$\gamma_{Ms} = 1.5 \qquad f_{uk} > 800 \text{ N/mm}^2 \text{ or } f_{yk}/f_{uk} > 0.8 \qquad (7.3)$$

Other failure modes: $\gamma_M = 2.5$ (7.4)

7.1.3. Specific conditions for the design method in masonry

(1) The ETA should contain only <u>one</u> characteristic resistance $\mathbf{F_{Rk}}$ independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance shall also be given.

(2) The characteristic resistance $\mathbf{F_{Rk}}$ for a single plastic anchor may also be taken for a group of two or four plastic anchors with a spacing equal or larger than the minimum spacing s_{min}.

The distance between single plastic anchors or a group of anchors should be $s \geq 250$mm.

(3) If the vertical joints of the wall are designed <u>not</u> to be filled with mortar then the design resistance N_{Rd} has to be limited to 2.0 kN to ensure that a pull-out of one brick out of the wall will be prevented. This limitation can be omitted if interlocking units are used for the wall or when the joints are designed to be filled with mortar.

(4) If the joints of the masonry <u>are not visible</u> the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor $\alpha_j = 0.5$.

If the joints of the masonry <u>are visible</u> (e.g. unplastered wall) following has to be taken into account:

> The characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the wall is designed such that the joints are to be filled with mortar.
>
> If the wall is designed such that the joints are <u>not</u> to be filled with mortar then the characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the minimum edge distance c_{min} to the vertical joints is observed. If this minimum edge distance c_{min} can not be observed then the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor $\alpha_j = 0.5$.

Section four:
ETA CONTENT

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9. THE ETA CONTENT

9.1.4. Characteristics of the anchor with regard to safety in use and methods of verification

- characteristic values to be used for the calculation of the ultimate limit state:

The ETA should contain only one characteristic resistance $\mathbf{F_{Rk}}$ for one base material independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance shall also be given.

The determined characteristic resistances for the ETA are valid only for the brick sizes which are used in the tests or larger brick sizes; therefore the information about the brick sizes has to be given in the ETA. Furthermore, if the tests have been performed in walls with a mortar strength higher than M2.5 then the minimum mortar strength shall also be given in the ETA.

If smaller brick sizes are present on the construction site or if the mortar strength is smaller than the required value the characteristic resistance of the plastic anchor may be determined by "job site tests" according to Annex B.

9.1.6. Assumptions under which the fitness of the anchor for the intended use was favourably assessed

The specific conditions (2), (3) and (4) for the design method according to 7.1.3 should be given in the ETA as well.

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GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL

of

PLASTIC ANCHORS
FOR MULTIPLE USE IN CONCRETE AND MASONRY
FOR NON-STRUCTURAL APPLICATIONS

Part four : PLASTIC ANCHORS FOR USE IN HOLLOW OR PERFORATED MASONRY

Kunstlaan 40 Avenue des Arts, B - 1040 Brussels

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PART FOUR : PLASTIC ANCHORS FOR USE IN HOLLOW OR PERFORATED MASONRY

FOREWORD

In this Part of ETAG "Plastic Anchors for Multiple Use in Concrete and Masonry for Non-Structural Applications" the methods of verification and the assessments required for the use of plastic anchors in hollow or perforated masonry (hollow or perforated bricks and hollow blocks to be made of clay or calcium silicate or normal weight concrete) are given. For a general assessment of plastic anchors, in principle, Part 1 applies.

Masonry units consisting of hollow or perforated units have a certain volume percentage of voids which pass through the masonry unit, compare Table 3.1 of EC 06 [8].

The required tests for suitability are given in 5.4.2 and the tests for admissible service conditions are given in Table 5.2. The determination of admissible service conditions and determination of characteristic resistances for plastic anchors to be used in hollow or perforated masonry are completely given in 6.4.3.

The same numbering of paragraphs as in Part 1 is used.

The plastic anchors for use in hollow or perforated masonry should be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

Section two:

GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

5. METHODS OF VERIFICATION

5.4. Safety in use

5.4.2. Tests for suitability

The types of suitability tests, test conditions, the number of required tests and the criteria applied to the results should be taken in accordance with 5.4.2 and Table 5.1 of Part 3 (solid masonry).

For the assessment of plastic anchors to be used in hollow or perforated masonry it has also to be assumed that the anchor may be situated in solid material (e.g. joints, solid part of unit without holes) so that also tests in solid material are required.

In general plastic anchors for use in hollow or perforated masonry will be assessed for use in solid material as well. Therefore suitability tests carried out in solid material (according to Part 3, Table 5.1) or in concrete (according to Part 2, Table 5.1) are available and the results of these suitability tests ($\min\alpha_{1,}$ $\min\alpha_2$ and $\min\alpha_V$) may be taken for the determination of the characteristic values of the plastic anchors to be used in hollow or perforated masonry.

5.4.3. Tests for admissible service conditions

The tests may be performed in single units or in a wall. If test are done in a wall, the thickness of the joints should be about 10mm and the joints should be completely filled with mortar of strength class M2.5 with a strength ≤ 5 N/mm^2. If tests have been performed in walls with a mortar strength higher than M2.5 then the minimum mortar strength shall be given in the ETA. The walls may be lightly prestressed in vertical direction to allow handling and transportation the wall.

For determination of the admissible service conditions the tests given in Table 5.2 shall be carried out.

If existing information is available from the manufacturer and the corresponding test report contains all relevant data, then the Approval Body may reduce the number of tests for admissible service conditions, making use of this existing information. However, it will be considered in the assessment only if the results are consistent with the Institute's test results.

All tests for determination of admissible service conditions should be carried out according to Annex A in the base material for which the plastic anchor is intended to be used at normal ambient temperature (+21°C ± 3°C) and standard conditioning of the polymeric sleeve. The drill holes should be drilled using $d_{cut,m}$ drill bits.

The minimum edge distance c_{min} and minimum spacing s_{min} should be given by the manufacturer and should be confirmed by the tests according to Table 5.2, line 2.

The determined characteristic resistances for the ETA are valid for the bricks and blocks only which are used in the tests regarding base material, size of units, compressive strength and configuration of the voids. Therefore the following information have to be given in the test report and in the ETA:

Base material, size of units, normalised compressive strength; volume of all holes (% of the gross volume); volume of any hole (% of the gross volume); minimum thickness in and around holes (web and shell); combined thickness of webs and shells (% of the overall width); appropriation to a group of Table 3.1 of EC 06.

Table 5.2 Tests for admissible service conditions for plastic anchors for use in hollow or perforated masonry

	1	2	3	4	5	6	7
	Purpose of test	Load direction	Distances	Member thickness h	Remarks	Minimum number of tests for s,m,l (4)	Test procedure described in Annex A
1	Characteristic resistance for tension loading not influenced by edge and spacing effects	N	$s > s_{min}$ $c > c_{min}$	$\geq h_{min}$	test with single anchors (1)	5	Annex A 5.2
2	Minimum edge distance for characteristic tension resistance	N	$s > s_{min}$ (3) $c = c_{min}$	$= h_{min}$	test with single anchor (2)	5	Annex A 5.2

(1) The tests shall be carried out at the most unfavourable setting position in the brick, which give the lowest characteristic resistance of the anchor

(2) Tension tests with single anchors near the free edge of a wall to determine the characteristic resistance depending on the minimum edge distance c_{min}

(3) Tension tests with double anchor group with s_{min} near the free edge ($c = c_{min}$) to determine the characteristic resistance for the minimum spacing s_{min} and the minimum edge distance c_{min} are required if the chosen minimum spacing is lower than the following values:

$s_{min} < 4\ c_{min}$ (groups with spacing parallel to the edge)

$s_{min} < 2\ c_{min}$ (groups with spacing perpendicular to the edge)

(4) Anchor sizes small (s), medium (m) and large (l) of an anchor system should be tested; intermediate sizes need not to be tested

Shear tests towards the edge are required only if the edge distance to the edge of the wall is smaller than 100mm or F_{Rk} is greater than 2,5kN or the expansion element is made of polymeric material. These shear tests should be carried out according to Annex A; at least 5 shear tests with single anchor and minimum edge distance are required.

In general the tests should be carried out with min h_{ef} given by the manufacturer. These test results are valid for min h_{ef} only because the performance of the anchor with larger embedment depth as the min h_{ef} can be reduced depending on the volume of holes (see Figure 5.1). If the manufacturer provide a wide range of thickness of fixture t_{fix} for the individual anchor then the possible larger embedment depths (larger embedment depth if t_{fix} is smaller than max t_{fix}) should be tested or the performance of the anchor should be determined by job site tests according to Annex B.

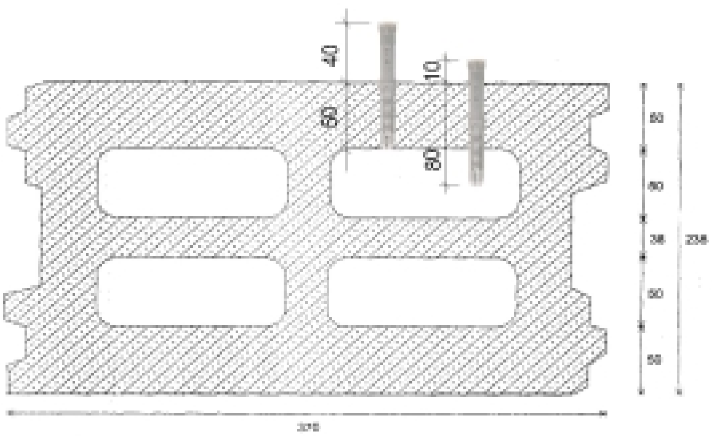

Figure 5.1 Example of plastic anchor with a total length of 90mm designed for a maximum thickness of fixture of 40mm (max t_{fix} = 40mm) in different setting positions

6. ASSESSING AND JUDGING THE FITNESS FOR AN USE

6.4. Safety in use

6.4.1.2. Conversion of ultimate loads to take account of concrete-, masonry- and steel strength

In contrast to Equation (6.0b) the conversion of the test results in hollow or perforated masonry should be carried out according to chapter 6.4.3.2.

6.4.1.3. In all tests the following criteria shall be met

(2) In general, in each test series, the coefficient of variation of the ultimate load should be smaller than v = 20 % in the suitability tests and v = 15 % in the admissible service condition tests.

If the coefficient of variation of the ultimate load in the suitability test is greater than 20%, then the following α_V-value has to be taken into account:

$$\alpha_V = \frac{1}{1+0{,}03\times(v[\%]-20)} \leq 1.0 \qquad (6.6a)$$

If the coefficient of variation of the ultimate load in the admissible service condition test is greater than 15%, then the following α_V-value has to be taken into account:

$$\alpha_V = \frac{1}{1+0{,}03\times(v[\%]-15)} \leq 1.0 \qquad (6.6b)$$

6.4.2. Criteria valid for suitability tests

In the suitability tests the criteria described in Part 1, 6.4 should be met. The values of the reference tests are taken from the tests according to Table 5.2, line 1.

If there are existing tests for suitability carried out in solid masonry (according to Part 3, Table 5.1) or in concrete (according to Part 2, Table 5.1) for the plastic anchors, then the results of these suitability tests (minα_1, minα_2 and minα_V) may be taken for the determination of the characteristic values of the plastic anchors to be used in hollow or perforated masonry.

6.4.3. Admissible service conditions

6.4.3.1. General

In all tension tests, the requirement for the load/displacement curves should satisfy the requirements laid down in Part 1, 6.4.1.3 (1). The requirements on the coefficient of variation of the ultimate loads is given in 6.4.1.3 (2) and Equation (6.6b).

6.4.3.2. Characteristic resistance of single anchor for the different conditions

(1) Tension loading not influenced by edge and spacing effects (Table 5.2, line 1)

The characteristic resistances of single anchors without edge and spacing effects under tension loading shall be calculated as follows:

$$N_{Rk1} = N_{Rk1,0} \times \min^{1)} (\min \alpha_1 ; \min \alpha_{2,\text{ line }1,2,7,8}) \times \min \alpha_{2,\text{ line }4,5} \times \min \alpha_V \qquad (6.7)$$

1) The lowest value of min α_1 or min $\alpha_{2,\text{ line }1,2,7,8}$ is govern.

with: $N_{Rk1,0}$ = characteristic resistance evaluated from the results of tests according to Table 5.2, line 1

In the absence of better information the influence of the unit compressive strength has to be considered with the ratio $f_b/f_{b,test}$ according to Equation (6.8).

min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)

min $\alpha_{2,\text{line }4,5}$ = minimum value α_2 (reduction factor from the ultimate loads in the suitability tests) according to Part 1,Equ. (6.5) of suitability tests according to Table 5.1, line 4 and 5 (conditioning and temperature) (≤ 1.0)

min $\alpha_{2,\text{line }1,2,7,8}$ = minimum value α_2 (reduction factor from the ultimate loads in the suitability tests) according to Part 1,Equ. (6.5) of suitability tests according to Table 5.1, line 1, 2, 7 and 8 (≤ 1.0)

min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

(2) Tension loading influenced by minimum edge effects (Table 5.2, line 2)

The characteristic resistances of single anchors near the free edge under tension loading should be calculated as follows:

$$N_{Rk2} = N^t_{Rk2} \times \frac{f_b}{f_{b,test}} \times \min\alpha_1 \times \min\alpha_V \quad ^{1)} \qquad (6.8)$$

with: N^t_{Rk2} = characteristic resistance evaluated from the results of tests according to Table 5.2, line 2

f_b = normalised mean compressive strength of the chosen masonry unit in the ETA

$f_{b,test}$ = mean compressive strength of the test masonry unit

min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)

min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

1) If pull-out failure is observed in tests according to Table 5.2, line 2, then the evaluation should be done according to Equation (6.7).

(3) Tension loading influenced by minimum spacing effects (Table 5.2, footnote (3))

In the design concept it is assumed that a group with 2 or 4 anchors with s ≥ s_{min} has he same characteristic resistance than a single anchor with a large spacing to neighbouring anchors. Therefore the characteristic resistances of single anchors N_{Rk3} with minimum spacing near the free edge under tension loading shall be calculated according to 6.4.3.2 (2), however as value N^t_{Rk2} the characteristic resistance evaluated from the results of tests according to Table 5.2, footnote (3) shall be taken.

If pull-out failure is observed in tests according to Table 5.2, footnote (3), then the evaluation should be done according to Equation (6.7).

(4) Shear loading

If shear tests towards the edge are performed and brick edge failure occurs the characteristic shear resistance shall be calculated as follows:

$$V_{Rk,b} = V^t_{Ru} \times \frac{f_b}{f_{b,test}} \times \min\alpha_V \qquad (6.9)$$

with: V^t_{Ru} = characteristic resistance evaluated from the results of tests

f_b = normalised mean compressive strength of the chosen masonry unit in the ETA

$f_{b,test}$ = mean compressive strength of the test masonry unit min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

If the edge of the wall c_{min} is greater than 100mm or F_{Rk} is smaller than 2,5kN no shear tests are required and the characteristic shear resistances $V_{Rk,s}$ of the metal expansion element for single anchors may be calculated as follows:

$$V_{Rk,s} = 0.5 \times A_s \times f_{uk} \qquad (6.10)$$

with: As = stressed cross section of steel

f_{uk} = characteristic steel ultimate tensile strength (nominal value)

6.4.3.3. Characteristic resistance of single anchor in the ETA

For the determination of the characteristic resistance $\mathbf{F_{Rk}}$ the design values for N_{Rk1}, N_{Rk2}, N_{Rk3}, $V_{Rk,b,}$ and $V_{Rk,s}$ have to be calculated under consideration of the appropriated partial safety factors. The corresponding partial safety factors are given in 7.1.2.

The minimum design value is decisive for the characteristic resistance $\mathbf{F_{Rk}}$ given in the ETA.

The value of the characteristic resistance $\mathbf{F_{Rk}}$ should be rounded to the following numbers:

0.3 / 0.4 / 0.5 / 0.6 / 0.75 / 0.9 / 1.2 / 1.5 / 2 / 2.5 / 3 / 3.5 / 4 / 4.5 / 5 / 6 / 7.5 / 9/ kN

6.4.3.4. Displacement behaviour

As a minimum, the displacements under short and long term tension and shear loading shall be given in the ETA for a load F which corresponds approximately to the value according to Equation (6.11)

$$F = \frac{F_{Rk}}{\gamma_F \times \gamma_M} \qquad (6.11)$$

with; F_{Rk} = characteristic resistance according to 6.4.3.3

γ_F = 1.4

γ_M = corresponding material partial safety factor

The displacements under short term tension loading (δ_{NO}) are evaluated from the tests with single anchors without edge or spacing effects according to Table 5.2, line 1. The value derived should correspond approximately to the 95 %-fractile for a confidence level of 90 %.

The long term tension loading displacements $\delta_{N\infty}$ may be assumed to be approximately equal to 2.0-times the value δ_{NO}.

The displacements under short term shear loading (δ_{VO}) are evaluated from the corresponding shear tests with single anchors. The value derived should correspond approximately to the 95 %-fractile for a confidence level of 90 %.

If no shear tests are performed the displacements under short term shear loading (δ_{VO}) for a plastic anchors with metal expansion element may be determined for the load according to Equation (6.11) with a shear stiffness of 500 N/mm.

The long term shear loading displacements $\delta_{V\infty}$ may be assumed to be approximately equal to 1.5-times the value δ_{VO}.

Under shear loading, the displacements might increase due to a gap between fixture and anchor. The influence of this gap is taken into account in design.

7. ASSUMPTIONS AND RECOMMENDATIONS UNDER WHICH THE FITNESS FOR USE OF THE PRODUCTS IS ASSESSED

7.1. Design methods for anchorage in hollow or perforated masonry

7.1.1. Multiple use

The plastic anchors for use in hollow or perforated masonry should be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

7.1.2. Design and safety concept

The design concept with partial safety factors should be used for anchorages in hollow or perforated masonry.

In the absence of national regulations the following partial safety factors for resistances γ_M may be used:

Steel failure: Tension loading:

$$\gamma_{Ms} = \frac{1.2}{f_{yk} / f_{uk}} \geq 1.4 \qquad (7.1)$$

Shear loading of the anchor with and without lever arm:

$$\gamma_{Ms} = \frac{1.0}{f_{yk} / f_{uk}} \geq 1.25 \qquad f_{uk} \leq 800 \text{ N/mm}^2 \text{ and } f_{yk}/f_{uk} \leq 0.8 \qquad (7.2)$$

$$\gamma_{Ms} = 1.5 \qquad f_{uk} > 800 \text{ N/mm}^2 \text{ or } f_{yk}/f_{uk} > 0.8 \qquad (7.3)$$

Other failure modes: $\gamma_M = 2.5$ (7.4)

7.1.3. Specific conditions for the design method in masonry

(1) The ETA should contain only one characteristic resistance $\mathbf{F_{Rk}}$ independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance shall also be given in the ETA.

(2) The characteristic resistance $\mathbf{F_{Rk}}$ for a single plastic anchor may also be taken for a group of two or four plastic anchors with a spacing equal or larger than the minimum spacing s_{min}.

The distance between single plastic anchors or a group of anchors should be $s \geq 250$mm.

(3) If the vertical joints of the wall are designed not to be filled with mortar then the design resistance N_{Rd} has to be limited to 2.0 kN to ensure that a pull-out of one brick out of the wall will be prevented. This limitation can be omitted if interlocking units are used for the wall or when the joints are designed to be filled with mortar.

(4) If the joints of the masonry <u>are not visible</u> the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor α_j = 0.5.

If the joints of the masonry <u>are visible</u> (e.g. unplastered wall) following has to be taken into account:

> The characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the wall is designed such that the joints are to be filled with mortar.
>
> If the wall is designed such that the joints are <u>not</u> to be filled with mortar then the characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the minimum edge distance c_{min} to the vertical joints is observed. If this minimum edge distance c_{min} can not be observed then the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor α_j = 0.5.

Section four:
ETA CONTENT

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9. THE ETA CONTENT

9.1.4. Characteristics of the anchor with regard to safety in use and methods of verification

- characteristic values to be used for the calculation of the ultimate limit state:

The ETA should contain only <u>one</u> characteristic resistance $\mathbf{F_{Rk}}$ for one base material independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance shall also be given in the ETA.

The determined characteristic resistances for the ETA are valid for the bricks and blocks only which are used in the tests regarding base material, size of units, compressive strength and configuration of the voids. Therefore the following information have to be given in the test report and in the ETA:

Base material, size of units, normalised compressive strength; volume of all holes (% of the gross volume); volume of any hole (% of the gross volume); minimum thickness in and around holes (web and shell); combined thickness of webs and shells (% of the overall width); appropriation to a group of Table 3.1 of EC 06.

If tests have been performed in walls with a mortar strength higher than M2.5 then the minimum mortar strength shall be given in the ETA.

The characteristic resistance of the plastic anchor may be determined by "job site tests" according to Annex B, if the plastic anchor has an ETA with characteristic values for the <u>same base material</u> as it is present on the construction works. Furthermore job site tests for use in solid masonry are possible only if the plastic anchor has an ETA for use in solid masonry and job site tests for use in hollow or perforated masonry are possible only if the plastic anchor has an ETA for use in hollow or perforated masonry

In general the characteristic resistances are valid for min h_{ef} <u>only</u> because the performance of the anchor with larger embedment depth as the min h_{ef} may be reduced depending on the volume of holes. If the manufacture provide a wide range of thickness of fixture t_{fix} for the individual anchor then the possible different characteristic resistances for larger embedment should be given in the ETA or this performance of the anchor should be determined by job site tests according to Annex B.

9.1.6. Assumptions under which the fitness of the anchor for the intended use was favourably assessed

The specific conditions (2), (3) and (4) for the design method according to 7.1.3 should be given in the ETA as well.

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GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL

of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Part five : PLASTIC ANCHORS FOR USE IN AUTOCLAVED AERATED CONCRETE (AAC)

Kunstlaan 40 Avenue des Arts, B - 1040 Brussels

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PART FIVE: PLASTIC ANCHORS FOR USE IN AUTOCLAVED AERATED CONCRETE (AAC)

FOREWORD

In this Part of ETAG "Plastic Anchors for Multiple Use in Concrete and Masonry for Non-Structural Applications" the methods of verification and the assessments required for the use of plastic anchors in autoclaved aerated concrete (AAC) are given. For a general assessment of plastic anchors, on principle, Part 1 applies.
This Guideline applies to the use of plastic anchors in autoclaved aerated concrete between strength classes P 2 and P 7, inclusively, according to EN 771-4 [9] "Autoclaved aerated concrete masonry units" or prEN 12 602 [10] "Reinforced components of autoclaved aerated concrete".

The required tests for suitability are given in Table 5.1 a and b and the tests for admissible service conditions are given in Table 5.2 a and b. The determination of admissible service conditions and determination of characteristic resistances for plastic anchors to be used in AAC are completely given in 6.4.3.

The same numbering of paragraphs as in Part 1 is used.

The plastic anchors for use in autoclaved aerated concrete (AAC) shall be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

Section two:
GUIDANCE FOR THE ASSESSMENT OF THE FITNESS FOR USE

5. METHODS OF VERIFICATION

5.4. Safety in use

5.4.2. Tests for suitability

The tests shall be carried out according to Annex A.

In general, all the tests shall be performed with single plastic anchors without edge and spacing effects under tension loading.

(1) Tests for plastic anchors for use in non-cracked AAC (AAC blocks)

The tests may be performed in single units or in a wall with units glued together. The walls may be lightly prestressed in vertical direction to allow handling and transportation the wall.

The types of suitability tests, test conditions, the number of required tests and the criteria applied to the results are given in Table 5.1 a: non-cracked AAC (AAC blocks).

Suitability tests of the functioning under conditioning and temperature may be omitted if there are information about the influence (α-factor) of the load bearing behaviour from suitability tests in concrete according to Part 2 or in solid masonry according to Part 3.

(2) Tests for plastic anchors for use in reinforced AAC (prefabricated reinforced AAC members)

Some additional tests have to be carried out in prefabricated reinforced AAC, if the anchor shall also be assessed for the use in reinforced AAC. The types of the additional suitability tests, test conditions, the number of required tests and the criteria applied to the results are given in Table 5.1 b: reinforced AAC (prefabricated reinforced AAC members).

Table 5.1a Suitability tests for plastic anchors for use in non-cracked AAC (AAC blocks)

	1	2	3	4	5	6	7	8
	Purpose of test	strength of AAC	Drill bit	Ambient tempera-ture (1)	Condition polymeric sleeve (8)	Minimum number of tests per anchor size (11)	Criteria ultimate load req.α	Remarks to the test procedure described in Part 1
1	Setting capacity for nailed-in anchors only	Low strength AAC 2	$d_{cut,max}$ $d_{cut,max}$	mint°C(2) mint°C(2)	standard standard	5 5	$\geq$ 0.9 $\geq$ 0.9	5.4.2.2
4	Functioning under conditioning of anchor sleeve	Low strength AAC 2	$d_{cut,m}$ $d_{cut,m}$	normal normal	dry wet	5 5	$\geq$ 0.8 $\geq$ 0.8	5.4.2.5
5	Functioning, effect of temperature	Low strength AAC 2	$d_{cut,m}$ $d_{cut,m}$ $d_{cut,m}$ $d_{cut,m}$	mint°C(3) 0°C(4) +50°C(6) +80°C(6)	standard standard standard standard	5 5 5 5	$\geq$1.0 $\geq$1.0 $\geq$1.0 $\geq$0.8(10)	5.4.2.6
7	Functioning under sustained loads	Low strength AAC 2	$d_{cut,m}$ $d_{cut,m}$	normal +50°C(6)	standard standard	5 5	$\geq$0.9 $\geq$0.9	5.4.2.7 (13)
9	Maximum torque moment	Low strength AAC 2	$d_{cut,m}$	normal	standard	5		5.4.2.8

Table 5.1b Additional suitability tests for plastic anchors for use in reinforced AAC (prefabricated reinforced AAC members)

	1	2	3	4	5	6	7	8	9
	Purpose of test	Strength of reinforced AAC	Crack width Δw (mm)	Drill bit	Ambient temperature (1)	Condition polymeric sleeve (8)	Minimum. number of tests per anchor size	Criteria ultimate load req.α	Remarks to the test procedure described in Part 1
3a	Functioning in cracks (14)	AAC 2 AAC 7	0.35 0.35	$d_{cut,m}$ $d_{cut,m}$	normal normal	standard standard	5 5	$\geq$ 0.75 $\geq$ 0.75	5.4.2.4

(1) Normal ambient temperature: 21 ± 3 °C (plastic anchor and bas material AAC),

(2) Minimum installation temperature as specified by the manufacturer; normally 0 °C to + 5 °C.

(3) Tests with lowest service temperature as specified by the manufacturer –5°C, –20°C, –40°C

(4) Installation at minimum installation temp. as specified by the manufacturer; normally 0 °C to + 5 °C.

(6) For temperature range b), Part 1, 4.4.2.6; for other temperature range see Part 1, 5.4.2.6 and 6.4.2.6

(8) Conditioning of polymeric anchor sleeve according to Part 1, 5.4.2.5

(10) Reference values from the tests with maximum long term temperature +50°C

(11) Number of tests, if one anchor size only; if more than one size shall be assessed, then the smallest, the medium and the largest size shall be tested. Intermediate sizes shall be tested according to line 1, 7, 9; these intermediate sizes shall not be tested, if the tests from line 1 of Table 5.2 a show regularity in failure mode and ultimate load.

(13) N_{Rk} Part 1, 5.4.2.7 (5.3); characteristic resistance N_{Rk} as given in the ETA evaluated according to 6.4.3.3

(14) The tests shall be carried out with the most unfavourable direction of expansion determined in test line 1, Table 5.2a.

5.4.3. Tests for admissible service conditions

For determination of the admissible service conditions the tests given in Tables 5.2 a and/or b shall be carried out for all sizes.
If existing information is available from the manufacturer and the corresponding test report contains all relevant data, then the Approval Body may reduce the number of tests for admissible service conditions, making use of this existing information. However, it will be considered in the assessment only if the results are consistent with the Institute's test results.
All tests for determination of admissible service conditions shall be carried out in single units or in a wall for non-cracked AAC and in prefabricated reinforced AAC at normal ambient temperature (+21°C ± 3°C) and standard conditioning of the polymeric sleeve. The drill holes shall be drilled using $d_{cut,m}$ drill bits. The anchor installation shall be carried out according with the manufacturer's published instructions.

Table 5.2 a Tests for admissible service conditions for plastic anchors for use in non-cracked AAC (AAC blocks)

	1	2	3	4	5	6	7
	Purpose of test	Strength of AAC	Load direc-tion	Distances	Member thickness h	Minimum number of tests for s.m.l (2)	Remarks
1	Characteristic resistance for tension loading not influenced by edge and spacing effects	AAC 2 AAC 7	N	$s>s_{min}$ $c>c_{min}$	$\geq h_{min}$	5 5	test with single anchor in the centre of the block
2	Edge distance to end of wall for characteristic tension resistance (1)	AAC 2	N	$s>s_{min}$ $c=c_{min}$	$=h_{min}$	5	test with single anchor at the corner

Table 5.2 b Tests for admissible service conditions for plastic anchors for use in reinforced AAC (prefabricated reinforced AAC members)

	1	2	3	4	5	6	7	8
	Purpose of test	Strength class of reinforced AAC	Crack width Δw [mm]	Load direction	Distances	Member thickness h	Minimum number of tests s.m.l (2)	Remarks
1	Characteristic resistance for tension loading not influenced by edge and spacing effects	AAC 2 AAC 7	0,2	N	$s>s$ $c>c_{min}$	$\geq h_{min}$	5 5	test with single anchor
2	Edge distance to end of member for characteristic tension resistance (1)	AAC 2	0	N	$s>s$ $c=c_{min}$	$=h_{min}$	5	test with single anchor at the corner

(1) Tension tests with double anchor group with s_{min} near the free edge ($c = c_{min}$) to determine the characteristic resistance depending for the minimum spacing s_{min} and the minimum edge distance c_{min} are required if the chosen minimum spacing is lower than the following values:

$s_{min} < 4\ c_{min}$ (groups with spacing parallel to the edge)

$s_{min} < 2\ c_{min}$ (groups with perpendicular perpendicular to the edge)

(2) Anchor sizes small (s), medium (m) and large (l) of an anchor system should be tested; intermediate sizes need not to be tested

6. ASSESSING AND JUDGING THE FITNESS FOR USE

6.4. Safety in use

6.4.1.2. Conversion of ultimate loads to take account of concrete-, masonry- and steel strength

In contrast to Equation (6.0b) the conversion of the test results in autoclaved aerated concrete shall be carried out as follows:

(1) General

The tests results shall be converted as far as compressive strength and dry density are concerned.

(2) Compressive strength

- AAC blocks:
  For AAC blocks the characteristic compressive strength shall be determined from the declared value of compressive strength according to prEN 771-4 [10] using the factor of 0.9.

$$f_{ck} = 0.9\, f_{c,decl}$$

- Prefabricated reinforced AAC members:
  For prefabricated reinforced AAC members the characteristic compressive strengths f_{ck} of strength AAC 2 and AAC 7 given in prEN 12 602 [10] shall be used for conversion of the test results.

(3) Dry density

As reference values of dry density the following minimum values of dry density shall be used for AAC for conversion of the test results:

AAC 2: $\rho_{min} = 350$ kg/m^3

AAC 7: $\rho_{min} = 650$ kg/m^3

(4) Conversion of test results

The test results obtained for low and high strength AAC shall be converted using the following Equation:

$$F_{R_u}^{t_K} = F_{R_u}^{t} \quad \frac{\rho_{min}^{3/4} \text{ x } f_{ck}}{\rho_{test}^{3/4} \text{ x } f_{c,test}} \quad \text{(kN)} \qquad (6.5)$$

From the above, the 5 %-fractile for the ultimate load shall be derived.

(5) Characteristic failure load (ultimate load) of the different strength of AAC

For the strength between low and high strength AAC the characteristic failure loads shall be determined by linear interpolation of the converted test results.

6.4.1.3 In all tests the following criteria shall be met

(2) In general, in each test series, the coefficient of variation of the ultimate load shall be smaller than v = 20 % in the suitability tests and v = 15 % in the admissible service condition tests.
If the coefficient of variation of the ultimate load in the suitability test is greater than 20%, then the following α_v-value has to be taken into account:

$$\alpha_v = \frac{1}{1 + 0{,}03 \times (v[\%] - 20)} \leq 1.0 \qquad (6.6a)$$

If the coefficient of variation of the ultimate load in the admissible service condition test is greater than 15%, then the following α_v-value has to be taken into account:

$$\alpha_v = \frac{1}{1 + 0{,}03 \times (v[\%] - 15)} \leq 1.0 \qquad (6.6.b)$$

6.4.2. Criteria valid for suitability tests

In the suitability tests according to Table 5.1 a and/or b the criteria described in the relevant sections of Part 1, 6.4 shall be met. The values of the reference tests are taken from the tests according to Table 5.2 a, line 1 (for non-cracked AAC) and Table 5.2 b, line 1 (for reinforced AAC) with the worst expansion direction of the anchor.

If there are existing tests for suitability of the functioning under conditioning and temperature carried out in concrete according to Part 2 or in solid masonry according to Part 3, Table 5.1, line 4 and 5, then the results of these suitability tests (minα_1, minα_2 and minα_V) may be taken for the determination of the characteristic values of the plastic anchors to be used in autoclaved aerated concrete.

6.4.3. Admissible service conditions

6.4.3.1. General

In all tension tests, the requirement for the load/displacement curves shall satisfy the requirements laid down in Part 1, 6.4.1.3 (1). The requirement of the coefficient of variation of the ultimate load is taken from 6.4.1.3 (2) Equation (6.6b).

6.4.3.2. Characteristic resistance of single anchor for the different conditions

(1) Tension loading not influenced by edge and spacing effects (Table 5.2a or b, line 1)

The characteristic resistances for single anchors without edge and spacing effects under tension loading shall be calculated as follows:

$$N_{Rk1} = N_{Rk1,0} \times \min^{1)} (\min \alpha_1 ; \min \alpha_{2,\, line\, 1,7}) \times \min \alpha_{2,\, line\, 4,5} \times \min \alpha_V \qquad (6.7)$$

[1)] The lowest value of min α_1 or min $\alpha_{2,\, line\, 1,7}$ is govern.

with:

- $N_{Rk1,0}$ = characteristic resistance from the tests Table 5.2a or b, line 1 converted according to 6.4.1.2.
- min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)
- min $\alpha_{2,line\ 4,5}$ = minimum value α_2 (reduction factor from the ultimate loads of the suitability tests) according to Part 1,Equ. (6.5) of suitability tests according to Table 5.1, line 4 and 5 (conditioning and temperature) (≤ 1.0)
- min $\alpha_{2,line\ 1,7}$ = minimum value α_2 (reduction factor from the ultimate loads of the suitability tests) according to Part 1,Equ. (6.5) of suitability tests according to Table 5.1, line 1 and 7 (≤ 1.0)
- min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

(2) Tension loading influenced by minimum edge effects (Table 5.2a or b, line 2)

The characteristic resistances for single anchors near the free edge under tension loading shall be calculated as follows:

$$N_{Rk2} = N_{Rk2,0} \times \min \alpha_1 \times \min \alpha_V \quad ^{1)} \qquad (6.8)$$

with:

- $N_{Rk2,0}$ = characteristic resistance from the tests Table 5.2a or b, line 2 converted according to 6.4.1.2.
- min α_1 = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)
- min α_V = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

[1)] If pull-out failure is observed in tests according to Table 5.2a or b, line 2, then the evaluation should be done according to Equation (6.7).

(3) Tension loading influenced by minimum spacing effects (Table 5.2a or b, footnote (1))

The characteristic resistances for single anchors with minimum spacing near the free edge under tension loading shall be calculated as follows:

$$N_{Rk3} = N_{Rk3,0} \times \min \alpha_1 \times \min \alpha_V \quad ^{1)} \tag{6.9}$$

with: $N_{Rk3,0}$ = characteristic resistance from the tests Table 5.2a or b, footnote (1) converted according to 6.4.1.2.

$\min \alpha_1$ = minimum value α_1 (reduction factor from the load/displacement behaviour) according to Part 1, Equation (6.2) of all tests (≤ 1.0)

$\min \alpha_V$ = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

1) If pull-out failure is observed in tests according to Table 5.2a or b, footnote (1), then the evaluation should be done according to Equation (6.7).

(4) Shear loading

If no shear tests available, the characteristic shear resistances $V_{Rk,AAC}$ for aerated concrete edge failure may be calculated according to, Annex C for concrete edge failure as follows:

$V_{Rk,AAC} = 0.5\ V_{Rk,c}$. (shear loading in direction to the free edge)

$V_{Rk,AAC} = 1.0\ V_{Rk,c}$. (shear loading in other directions)

The concrete strength $f_{ck,cube}$ has to be replaced by the aerated concrete strength f_{ck} in the relevant Equation of Annex C.

If shear tests towards the edge are performed and aerated concrete edge failure occurs the characteristic shear resistance shall be calculated as follows:

$$V_{Rk,AAC} = V_{Rk,AAC,0} \times \min \alpha_V \tag{6.10}$$

with: $V_{Rk,AAC,0}$= characteristic resistance evaluated from the results of shear tests converted according to 6.4.1.2

$\min \alpha_V$ = minimum value α_V to consider a coefficient of variation of the ultimate loads in the suitability and admissible service condition tests larger than 20% or 15% respectively, Equations (6.6a) and (6.6b).

The characteristic shear resistances $V_{Rk,s}$ of the metal expansion element for single anchors may be calculated as follows:

$$V_{Rk,s} = 0.5 \times A_s \times f_{uk} \tag{6.11}$$

with: As = stressed cross section of steel

f_{uk} = characteristic steel ultimate tensile strength (nominal value)

6.4.3.3 Characteristic resistance of single anchor in the ETA

For the determination of the characteristic resistance $\mathbf{F_{Rk}}$ the <u>design</u> values for N_{Rk1}, N_{Rk2}, N_{Rk3}, $V_{Rk,s}$, and $V_{Rk,AAC}$ have to be calculated under consideration of the appropriated partial safety factors. The corresponding partial safety factors are given in 7.1.2.

The minimum <u>design</u> value is decisive for the characteristic resistance $\mathbf{F_{Rk}}$ given in the ETA.

The value of the characteristic resistance $\mathbf{F_{Rk}}$ should be rounded to the following numbers:

0.3 / 0.4 / 0.5 / 0.6 / 0.75 / 0.9 / 1.2 / 1.5 / 2 / 2.5 / 3 / 3.5 / 4 / 4.5 / 5 / 6 / 7.5 / 9/ kN

6.4.3.4 Displacement behaviour

As a minimum, the displacements under short and long term tension and shear loading shall be given in the ETA for a load F which corresponds approximately to the value according to Equation (6.12)

$$F = \frac{F_{Rk}}{\gamma_F \times \gamma_M} \qquad (6.12)$$

with; F_{Rk} = characteristic resistance according to 6.4.3.3
γ_F = 1.4
γ_M = corresponding material partial safety factor

The displacements under short term tension loading (δ_{NO}) are evaluated from the tests with single anchors without edge or spacing effects according to Table 5.2a, line 1 or Table 5.2.b, line 1. The value derived shall correspond approximately to the 95 %-fractile for a confidence level of 90 %.
The long term tension loading displacements $\delta_{N\infty}$ may be assumed to be approximately equal to 2.0-times the value δ_{NO}.

The displacements under short term shear loading (δ_{VO}) are evaluated from the corresponding shear tests with single anchors. The value derived should correspond approximately to the 95 %-fractile for a confidence level of 90 %.
If no shear tests are performed the displacements under short term shear loading (δ_{VO}) for a plastic anchors with metal expansion element may be determined for the loading according to Equation (6.12) with a shear stiffness of 500 N/mm.
The long term shear loading displacements $\delta_{V\infty}$ may be assumed to be approximately equal to 1.5-times the value δ_{VO}.
Under shear loading, the displacements might increase due to a gap between fixture and anchor. The influence of this gap is taken into account in design.

7. ASSUMPTIONS AND RECOMMENDATIONS UNDER WHICH THE FITNESS FOR USE OF THE PRODUCTS IS ASSESSED

7.1. Design methods for anchorage in autoclaved aerated concrete

7.1.1. Multiple use

The plastic anchors for use in autoclaved aerated concrete (AAC) shall be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 may be taken:

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

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

7.1.2. Design and safety concept

The design concept with partial safety factors should be used for anchorages in autoclaved aerated concrete.

In the absence of national regulations the following partial safety factors for resistances γ_M may be used:

Steel failure: Tension loading:

$$\gamma_{Ms} = \frac{1.2}{f_{yk} \,/\, f_{uk}} \geq 1.4 \qquad (7.1)$$

Shear loading of the anchor with and without lever arm:

$$\gamma_{Ms} = \frac{1.0}{f_{yk} \,/\, f_{uk}} \geq 1.25 \qquad f_{uk} \leq 800 \text{ N/mm}^2 \text{ and } f_{yk}/f_{uk} \leq 0.8 \qquad (7.2)$$

γ_{Ms} = 1.5 f_{uk} > 800 N/mm^2 or f_{yk}/f_{uk} > 0.8 (7.3)

Other failure modes: γ_M = 2.0 (7.4)

7.1.3. Specific conditions for the design method in autoclaved aerated concrete

(1) The ETA should contain only one characteristic resistance $\mathbf{F_{Rk}}$ independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance shall also be given.

(2) The characteristic resistance $\mathbf{F_{Rk}}$ for a single plastic anchor may be taken also for a group of two or four plastic anchors with a spacing equal or larger than the minimum spacing s_{min}.

The distance between single plastic anchors or a group of anchors should be $s \geq 250$mm.

(3) If the vertical joints of the wall are designed not to be filled with mortar then the design resistance N_{Rd} has to be limited to 2.0 kN to ensure that a pull-out of one brick out of the wall will be prevented. This limitation can be omitted if interlocking units are used for the wall or when the joints are designed to be filled with mortar.

(4) If the joints of the masonry are not visible the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor α_j = 0.5.
If the joints of the masonry are visible (e.g. unplastered wall) following has to be taken into account:

> The characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the wall is designed such that the joints are to be filled with mortar.
> If the wall is designed such that the joints are not to be filled with mortar then the characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the minimum edge distance c_{min} to the vertical joints is observed. If this minimum edge distance c_{min} can not be observed then the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor α_j = 0.5.

(5) For prefabricated reinforced components the following has to be taken into account if no special tests or calculation for the resistance of the member made of AAC will carried out:

- The design value of shear resistance in the member caused by the anchorage are less or equal to 40% of the design value of resistance of the member in the critical cross section.
- The edge distance c is ≥ 150 mm for slabs of width ≤ 700 mm.
- The spacing s of fixing points is ≥ 600 mm. Fixing points are single anchors or groups of 2 or 4 anchors.

Section four:
ETA CONTENT

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9. THE ETA CONTENT

9.1.4. Characteristics of the anchor with regard to safety in use and methods of verification

- characteristic values to be used for the calculation of the ultimate limit state:

The ETA should contain only one characteristic resistance $\mathbf{F_{Rk}}$ for one base material independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance shall also be given.

9.1.6. Assumptions under which the fitness of the anchor for the intended use was favourably assessed

The specific conditions (2), (3), (4) and (5) for the design method according to 7.1.3 should be given in the ETA as well.

The ETA also has to include that the plastic anchor shall not be installed and used in water saturated aerated concrete.

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of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Annex A : DETAILS OF TESTS

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ANNEX A : DETAILS OF TESTS

1. TEST SAMPLES

Samples shall be chosen to be representative of normal production as supplied by the manufacturer, including screws, nails and plastic sleeves.

Sometimes the tests are carried out with samples specially produced for the tests before issuing the ETA. If so, it shall be verified that the plastic anchors subsequently produced conform in all respects, particularly suitability and bearing behaviour, with the plastic anchors tested.

2. TEST MEMBERS

2.1. Concrete test member

The test members shall be made in accordance with EN 206-1 [5] and comply with the following:

2.1.1. Aggregates

Aggregates shall be of medium hardness and with a grading curve falling within the boundaries given in Figure 2.1. The maximum aggregate size should be 16 mm or 20 mm. The aggregate density shall be between 2.0 and 3.0 t/m^3 (see EN 206-1 [5] and ISO 6783 [7]).

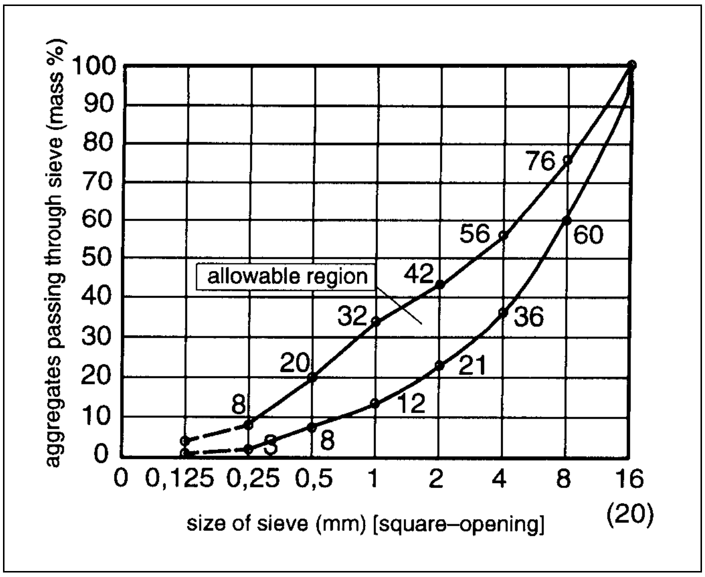

Figure 2.1 Admissible region for the grading curve

2.1.2. Cement

The concrete shall be produced using Portland cement type CEM I 32.5 or CEM I 42.5 (see ENV 197-1 [6]).

2.1.3. Water/cement ratio and cement content

The water/cement ratio should not exceed 0.75 and the cement content should be at least 240 kg/m^3.

No additives likely to change the concrete properties (e.g. fly ash, or silica fume, limestone powder or other powders) should be included in the mix.

2.1.4. Concrete strength

Tests are carried out in concrete strength class C20/25.

The following average compressive strengths at the time of testing plastic anchors shall be obtained :

f_{cm} = 20-30 MPa (cylinder: diameter 150 mm, height 300 mm)

= 25-35 MPa (cube:150 x 150 x 150 mm)

It is recommended to measure the concrete compressive strength either on cylinders diameter 150 mm, height 300 mm, or cubes 150 mm.

If this is not done in certain cases, the concrete compressive strength may be converted thus:

C20/25 : $$f_{cyl} = \frac{1}{1.25} f_{cube\ 150} \quad (2.1a)$$

Conversion factors for cubes of different sizes:

$$f_{cube\ 100} = \frac{1}{0.95} \cdot f_{cube\ 150} \quad (2.1b)$$

$$f_{cube\ 150} = \frac{1}{0.95} \cdot f_{cube\ 200} \quad (2.1c)$$

For every concreting operation, specimens (cylinder, cube) should be prepared having the dimensions conventionally employed in the member country; the specimens being made and treated in the same way as the test members.

Generally, the concrete control specimens should be tested on the same day as the plastic anchors to which they relate. If a test series takes a number of days, the specimens should be tested at a time giving the best representation of the concrete strength at the time of the plastic anchor tests, e.g. in general at the beginning and at the end of the tests.

The concrete strength at a certain age shall be measured on at least 3 specimens, the average value governs.

If, when evaluating the test results, there should be doubts whether the strength of the control specimens represents the concrete strength of the test members, then at least three cores of 100 mm or 150 mm diameter should be taken from the test members outside the zones where the concrete has been damaged in the tests, and tested in compression. The cores shall be cut to a height equal to their diameter, and the surfaces to which the compression loads are applied shall be ground or capped. The compressive strength measured on these cores may be converted into the strength of cubes by Equation (2.1d):

$$f_{c,cube\ 200} = 0.95\ f_{c,cube\ 150} = f_{c,core\ 100} = f_{c,core\ 150} \quad (2.1d)$$

2.1.5. Dimensions of test members

The specification and dimensions of the test members should conform to the following:

(a) Tests in cracked concrete

The tests are carried out on test members with unidirectional cracks, the crack width shall be approximately constant throughout the member thickness. The thickness of the test member should be $h \geq 2h_{ef}$ but at least 100 mm. The thickness of the test member has no effect on the minimum thickness given in the ETA. To control cracking, so-called ‘crack-formers’ may be built into the member, provided they are not situated near the anchorage zone. An example for a test member is given in Figure 2.2.

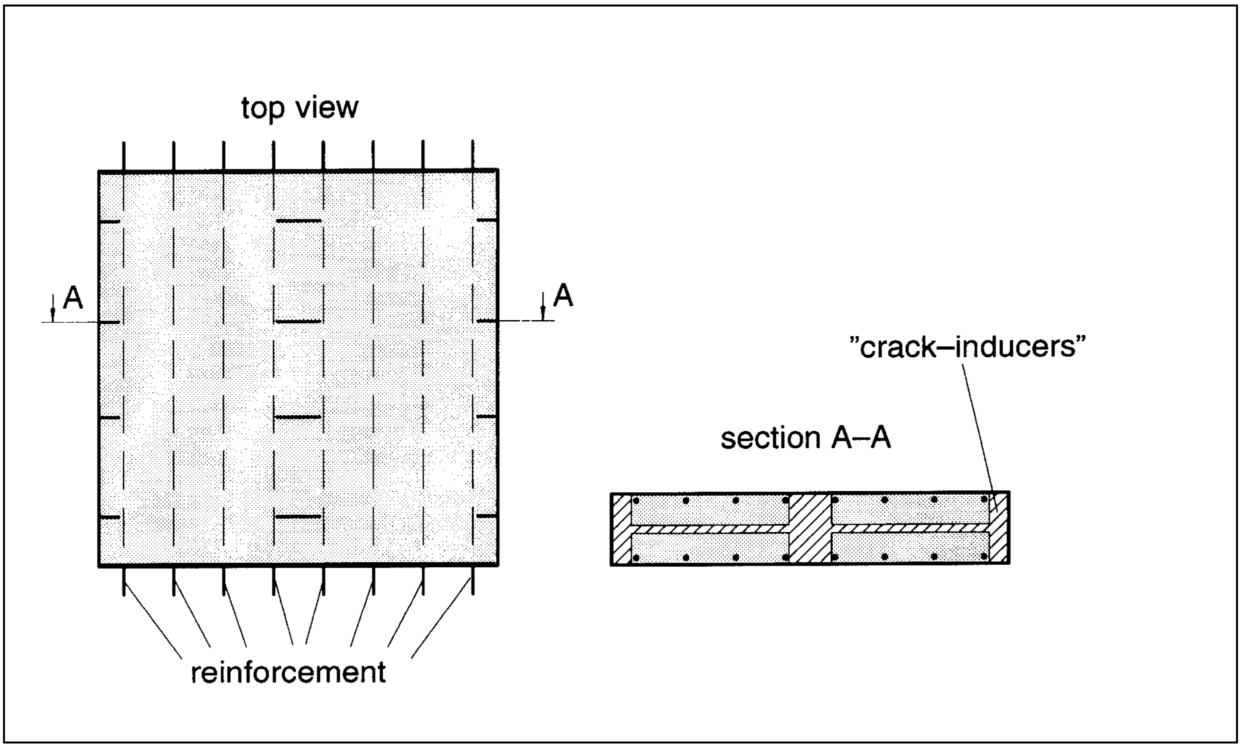

Figure 2.2 Example of a test member for plastic anchors tested in cracked concrete

When using a test member according to Figure 2.2, the reinforcement ratio and/or the member depth should be sufficiently large to allow for a small increase in crack width during loading of the plastic anchor.

(b) Tests in non-cracked concrete

Generally, the tests are carried out on unreinforced test members. Only in the tests according to 5.5 the member may be provided with an edge reinforcement. This edge reinforcement used in the tests shall be stated in the ETA as a minimum requirement. The reinforcement bars should be straight and have a concrete cover on both sides of 15 mm.

In cases where the test member contains reinforcement to allow handling or for the distribution of loads transmitted by the test equipment, the reinforcement shall be positioned such as to ensure that the loading capacity of the tested plastic anchors is not affected. This requirement will be met if the reinforcement is located outside the zone of concrete cones having a vertex angle of 120°.

In general, the thickness of the members should correspond to the minimum member thickness applied by the manufacturer which will be given in the ETA (at least 100 mm).

2.1.6. Casting and curing of test members and specimens

In general, the test members should be cast horizontally. They may also be cast vertically if the maximum height is 1.5 m and complete compaction is ensured.

Test members and concrete specimens (cylinders, cubes) shall be cured and stored indoors for seven days. Thereafter may be stored outside provided they are protected such that frost, rain and direct sun does not cause a deterioration of the concrete compression and tension strength. When testing the plastic anchors the concrete shall be at least 21 days old.

2.2. Test member for masonry material

2.2.1. General

The tests may be performed in single units or in a wall. If tests are done in a wall, the thickness of the joints should be about 10 mm and the joints should be completely filled with mortar of strength class M2.5 with a strength ≤ 5 N/mm². If tests may be performed with a mortar strength greater than M2.5 then the minimum mortar strength shall be given in the ETA. The walls may be lightly prestressed in vertical direction to allow handling and transportation of the wall.

2.2.2. Test member for solid masonry material

The unit should have a compressive strength between 20 and 30 N/mm².

All suitability tests and the tests according to Part 3, Table 5.2, line 1 shall be performed with single plastic anchors approximately in the centre of the unit under tension loading. The tension tests according to Part 3, Table 5.2, line 2 shall be performed at the free edge of a unit (tests in units) or the wall (tests in a wall) with an edge distance $c = c_{min}$.

The determined characteristic resistance given in the ETA is valid only for the unit sizes which are used in the tests or for larger sizes.

2.2.3. Test member for hollow or perforated bricks and hollow blocks

For details of test member see Part 4. The location of the plastic anchor in respect to the perforation should be chosen such that the least plastic anchor resistance can be expected.

2.3. Test member for autoclaved aerated concrete

2.3.1. Requirements for test specimens

At the time of testing the autoclaved aerated concrete (AAC) test specimens shall meet the following conditions:

Low strength AAC	AAC 2	
mean dry density	ρ_m (kg/m³)	≥ 350
mean compressive strength	$f_{c,m}$ (N/mm²)	1.8 to 2.8
High strength AAC	AAC 7	
mean dry density	ρ_m (kg/m³)	> 650
mean compressive strength	$f_{c,m}$ (N/mm²)	6.5 to 8.0

2.3.2. Definition of test specimens/samples

Test specimens: Testing of plastic anchors is carried out on single units or walls with units glued together.

Samples: Samples (cubes/cylinders) are taken from the test specimen for determination of the material characteristics (see Figure 2.3).
(cube: 100 x 100 x 100 mm); (cylinder: diameter 100 mm, height 100 mm)

The sample for determination of the material characteristic should be taken from the same height as the position of the anchor relating to the direction of rise of the aerated concrete specimen, because the strength differs depending on the height of the direction of rise.

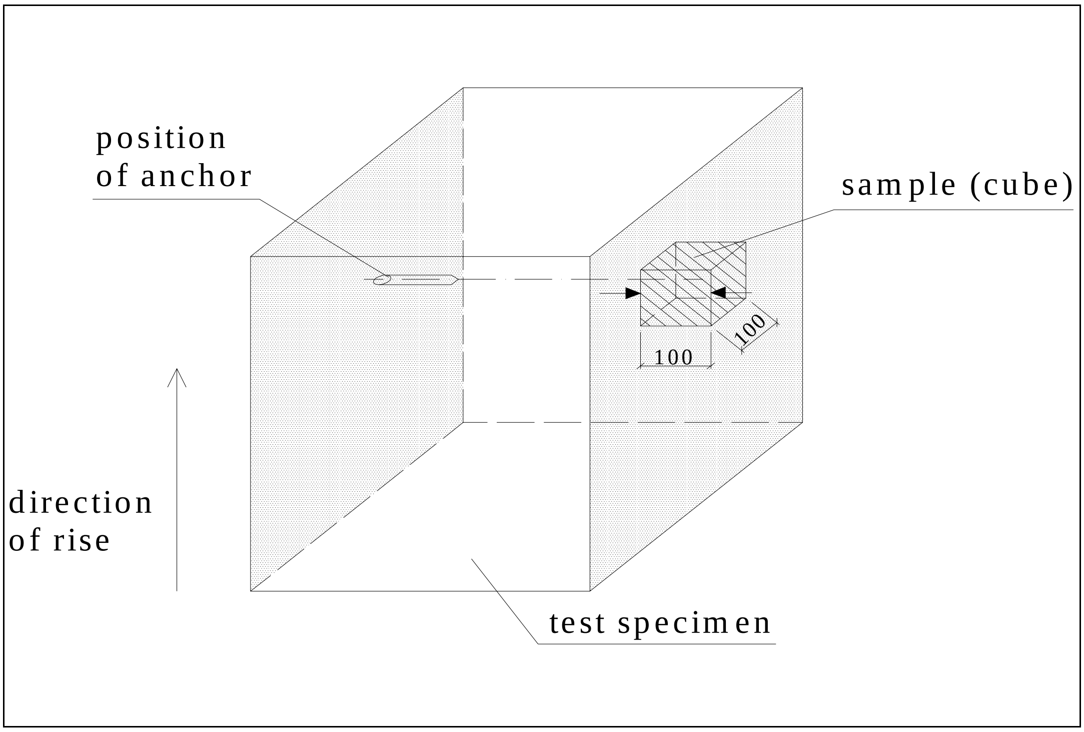

Figure 2.3 Taking of samples

2.3.3. Material characteristics

For determination of the material characteristics the following conditions apply:

Test specimens shall be taken from each batch (cycle of production) on delivery from the manufacturing plant and from each pallet on delivery from the retailer. Test specimens shall always be taken from series production. The direction of rise shall be discernible on the test specimen.

At the beginning of testing the test specimens shall be at least 4 weeks old. The moisture content of the concrete during the time of testing should be 10–30 M% measured on the sample (cube/cylinder). To reach the moisture content the test specimens may be dried at a temperature ≤ 50 °C and shall then be conditioned for 3 weeks until the required moisture content is achieved. The test specimens shall be stored in the testing laboratory or under comparable conditions such, that air gain access on all sides. The clear distance between test specimens and from the floor shall be at least 50 mm.

Determination of the material characteristics (compressive strength, dry density, moisture content) is always carried out on the sample (cube/cylinder). The characteristics shall be determined on at least 5 samples (cube/cylinder). The compressive strength shall be determined as mean value. Testing of the compressive strength is performed in the direction of plastic anchor setting (see Figure 2.3).

Testing of compressive strength, dry density and moisture content shall be carried out at the beginning or at half time of the test procedure when the test procedures take up to 14 days. If the test procedure takes more than 14 days, the material characteristics shall be determined at the beginning and at least at the end of the tests. Deviation of the above is possible if proof can be delivered that at the end of testing the moisture content is equal to at least 10 M%.

3. ANCHOR INSTALLATION

In general, the plastic anchors shall be installed in accordance with the installation instruction supplied by the manufacturer.

In all tests screw-in-anchors shall be installed using a suitable screwgun. Nail-in-anchors shall be installed with a hammer having a reasonable hammer weight commonly used in the practical application.

For the installation safety tests special conditions are specified in the appropriate part of this guideline.

In case of concrete the tested plastic anchors shall be installed in the surface that has been cast against a form of the test member. Exception see section 5.5.

When testing in cracked concrete, plastic anchors are placed in the middle of hairline cracks. The main expansion direction of the plastic anchors shall be controlled in the tests. Details are specified in 5.1.

The holes for plastic anchors shall be perpendicular to the surface of the member.

In the tests the drilling tools and the type of drilling specified by the manufacturer shall be used. A drilling machine with a reasonable weight shall be used.

If hard metal hammer-drill bits are required, these bits shall meet the requirements of the standards DIN 8035 [13] or NF E 66-079 [14] with regard to dimensional accuracy, symmetry, symmetry of insert tip, height of tip and tolerance on concentricity.

The diameter of the cutting edges as a function of the nominal drill bit diameter is given in Figure 3.1.

In all tests for admissible service conditions the cylindrical hole is drilled with a medium diameter ($d_{cut,m}$) of the drill bit. For all tests checking suitability of the plastic anchor see Tables 5.1 in all Parts for the diameter of the drill bit.

The diameter of the drill bit shall be checked every 10 drilling operations to ensure continued compliance.

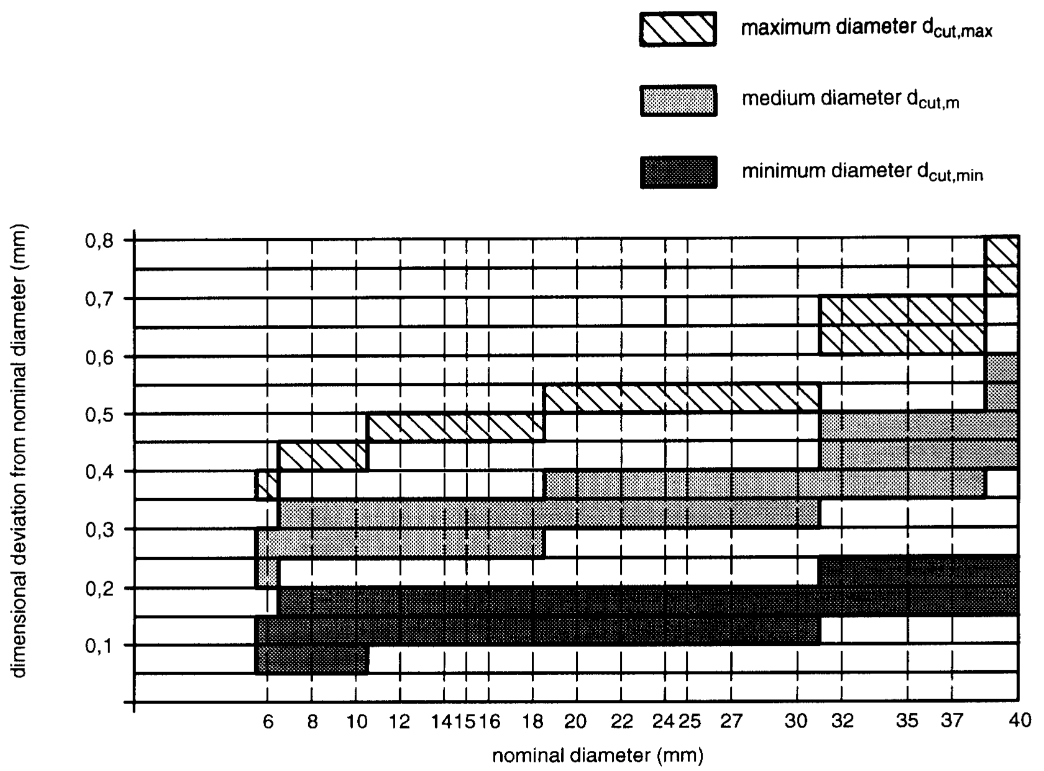

Figure 3.1 Cutting diameter of hard metal hammer-drill bits

4. TEST EQUIPMENT

The plastic anchor shall be installed with a special fixture (see figure 4.1). The fixture should guarantee the exact embedment depth of the plastic anchor. The fixture should have the same form as the sleeve of the plastic anchor. All tests shall be performed with a diameter d_f of the clearance hole in the fixture as specified by the manufacturer e.g. external diameter of plastic anchors +0.5 mm.

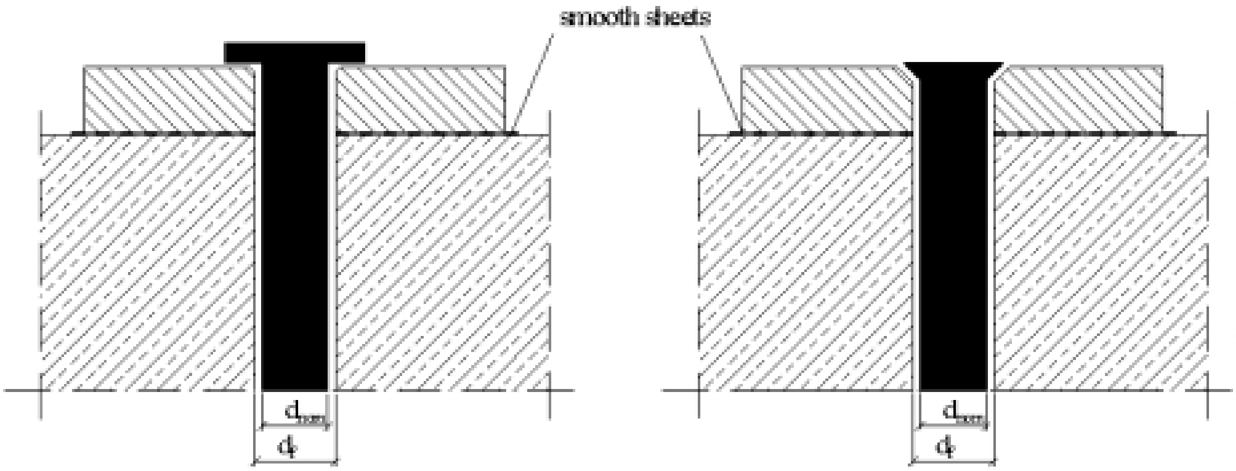

Figure 4.1 Special fixture for tension tests with plastic anchors

Tests shall be carried out using measuring equipment having calibration traceable. The load application equipment shall be designed to avoid sudden increase in load especially at the beginning of the test. The measuring error of the load shall not exceed 2 % throughout the whole measuring range.

Displacements shall be recorded continuously (eg. by means of displacement electrical transducers) with a measuring error not greater than 0.02 mm.

In general, the test rigs should allow the formation of an unrestricted rupture cone of the base material. For this reason the clear distance between the support reaction and an plastic anchor (single plastic anchor) shall be at least 2 h_{ef} (tension test) or 2 c_1 (shear tests with edge influence). In shear tests without edge influence where steel failure is expected the clear distance may be less than 2 $c_{1.}$

During tension tests (see 5.2), the load shall be applied concentrically to the plastic anchor. To achieve this, hinges should be incorporated between the loading device and the plastic anchor. An example of tension test rig is illustrated in Figure 4.2.

In shear tests (see 5.4), the load shall be applied parallel to the surface of the base material. In general the height of the fixture should be equal to the outside diameter of the plastic anchor. To reduce friction, smooth sheets (e.g. PTFE) with a maximum thickness of 2 mm should be placed between the fixture and the test member.

An example of a shear test rig is illustrated in Figure 4.3. As there is a lever arm between the applied load and the support reaction, this eccentricity moment should be taken up by additional reaction forces placed sufficiently far away from the plastic anchor.

In torque tests the torque moment during installation and the torque moment at failure is measured. For this a calibrated torque moment transducer with a measuring error < 3 % throughout the whole measuring range should be used.

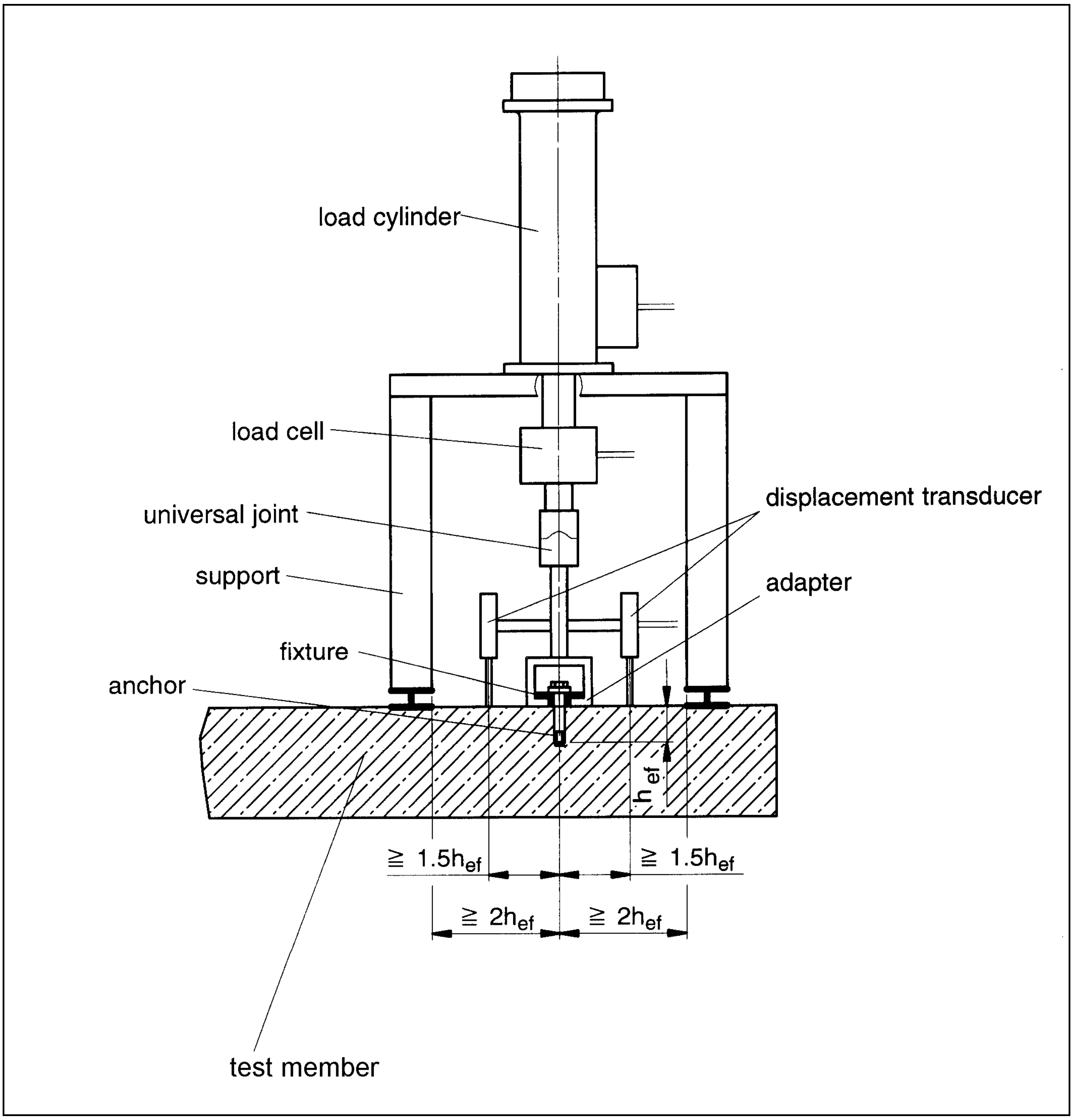

Figure 4.2 Example of a tension test rig

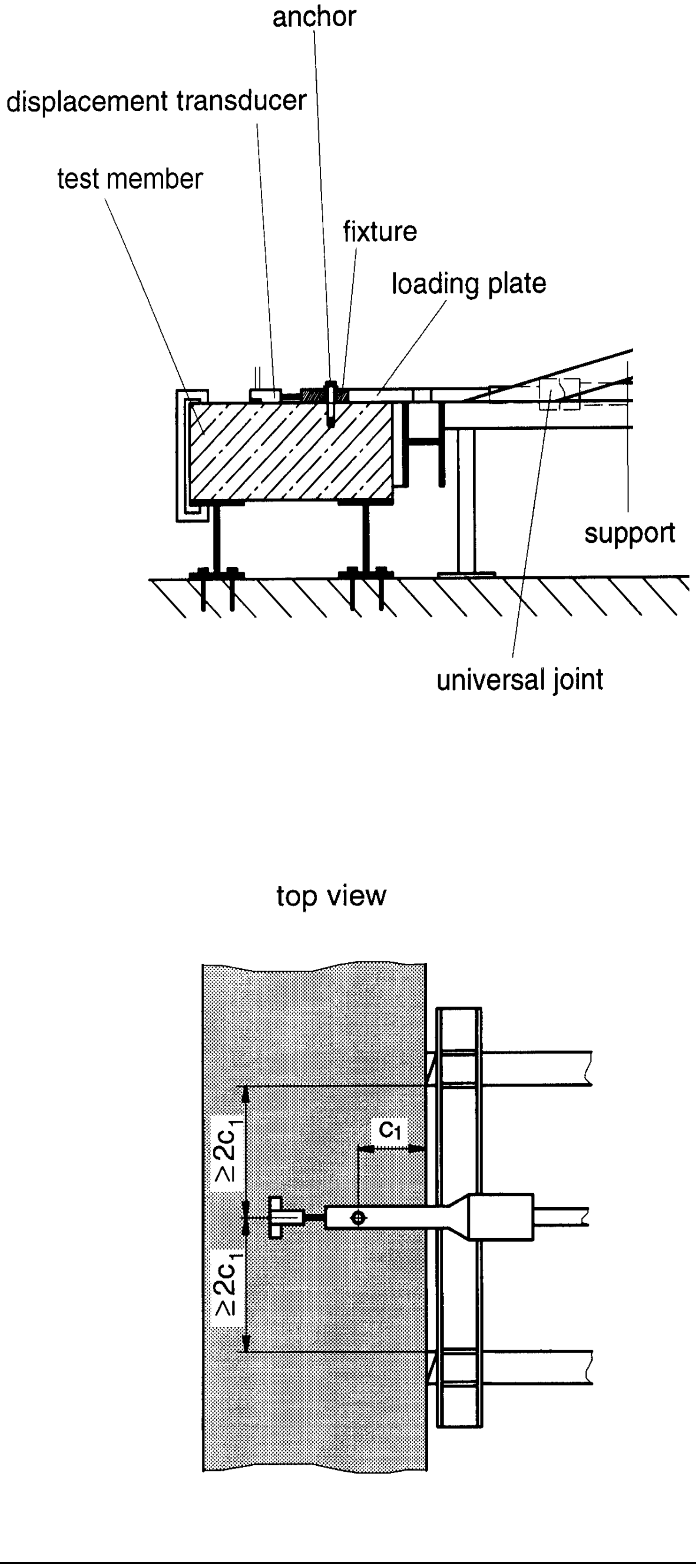

Figure 4.3 Example of a shear test rig

5. TEST PROCEDURE

5.1. General

In general the plastic anchors shall be installed in accordance with the installation instructions supplied by the manufacturer, except where deviations are specified in the corresponding Parts.

In general the tests are done with a standard conditioning of the plastic sleeve except in the suitability tests “Functioning under conditioning”. For standard humidity the conditioning can be done according to ISO 1110 [16]. The dry conditioning can be reached by drying the plastic sleeve in an oven at +70°C until the weight loss is smaller than 0,1 % in 3 consecutive measurements every 24 hours. The wet conditioning can be reached by placing the plastic sleeve under water until the weight increase is smaller than 0,1 % in 3 consecutive measurements every 24 h.

The tension tests in cracked concrete shall be done with the most unfavourable expansion direction in respect with the direction of the crack opening. The worst expansion direction should be derived either from the plastic anchor design or by tests in cracked concrete.

The tests in cracked concrete are performed in unidirectional cracks. The plastic anchor has to be installed in closed hairline cracks The crack width Δw is given in Part 2, Table 5.1 (suitability tests), Table 5.2 (tests for admissible service conditions) and in Part 5, Table 5.1 b and 5.2 b. Δw is the difference between the crack width when loading the plastic anchor and the crack width after installation. In general 5-10 min after the installation of the plastic anchor the crack is widened to the appropriate crack width while the plastic anchor is unloaded. The initial crack width shall be in a range in between ±10 % of the specified value. However, the mean value of a series shall reflect the specified value..

The time difference between crack opening and loading of anchor has to be between 10 minutes and 3 days for all tests in cracked concrete The suitability tests in cracked concrete according to Part 2, Table 5.1, line 3 and the corresponding reference tests in cracked concrete according to Part 2, Table 5.2, line 2 should be performed approximately at the same time after crack opening, because the anchor resistance may increase with time after crack opening.

After opening the crack the plastic anchor is subjected to load while the crack width is controlled, either:

(a) At a constant width, for example, by means of a servo system or

(b) Limited to a width close to the intended value by means of appropriate reinforcement and depth of the test member.

In both cases the crack width at the face opposite to that through which the plastic anchor is installed should be maintained close to the specified value.

For tests in non-cracked concrete the anchor has to be loaded at least 10 minutes after installation except in the tests for relaxation. Suitability tests and corresponding reference tests should be done approximately at the same time.

The load shall be increased in such a way that the peak load occurs after 1 to 3 minutes from commencement. Load and displacement should be recorded either continuously or at least in about 100 intervals up to peak load. The tests may be carried out with load or displacement control*)*. In case of displacement control, then the test should be continued up to at least 75 % of the maximum load to be measured (to allow the drop of the displacement curve) or at least up to 10 mm or 2 s_U displacement if the drop of the displacement curve is smaller than 75 %.

5.2. Tension Test

After installation, the plastic anchor is connected to the test rig and loaded to failure. The displacements of the plastic anchor relative to the surface of the test member at a distance of ≥ 1,5 h_{ef} from the plastic anchor should be measured by use of either one displacement transducer on the head of the plastic anchor or at least two displacement transducers on either side; the average value shall be recorded in the latter case.

When testing plastic anchors at the corner of a test member, then the test rig shall be placed such that an unrestricted failure towards the corner is possible (see Figure 5.1). It may be necessary to support the test rig outside the test member.

When testing in cracked concrete, the crack width shall be regularly measured during the test on both sides of the plastic anchor at a distance of approximately 1,0 h_{ef} and at least on the surface of the test member in which the plastic anchors are installed.

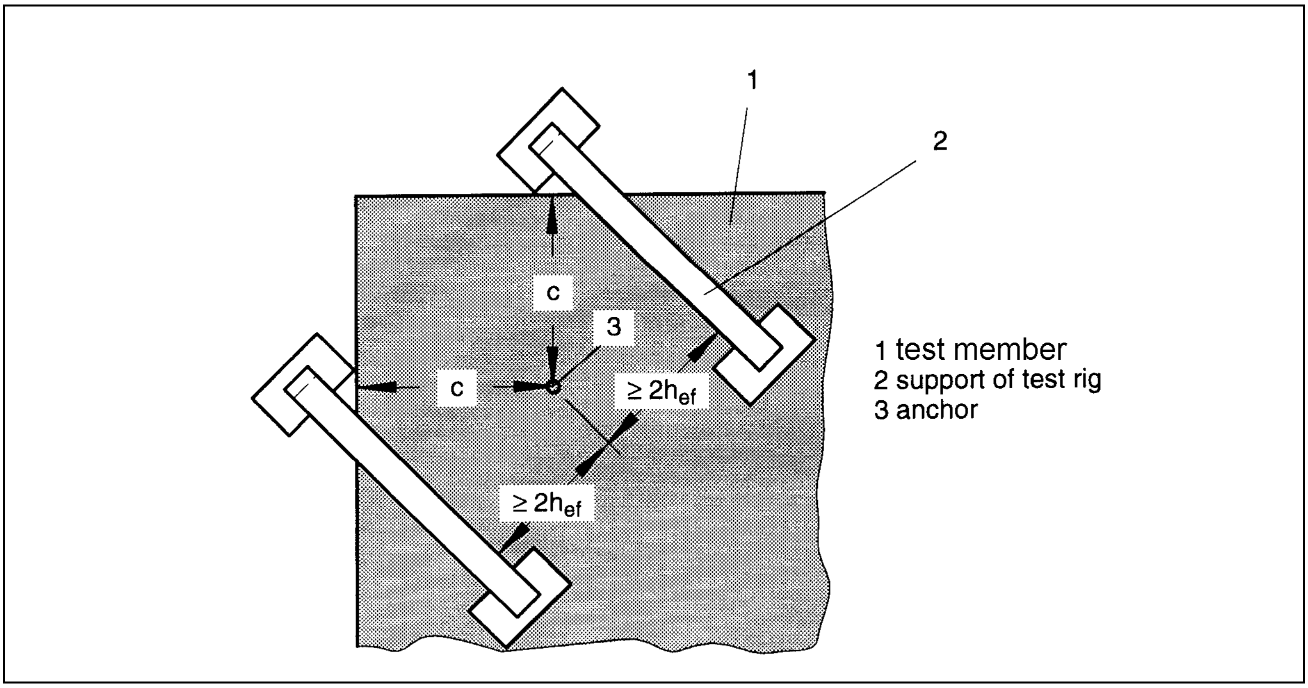

Figure 5.1 Example of the test rig for tension tests on plastic anchors at a corner

5.3. Temperature Test

The tests are carried out in slabs or, where space of the heating chamber is restricted, in cubes or in single masonry units. Splitting of the test member should be prevented.

a) Tests at maximum long term temperature or maximum short term temperature:

Install plastic anchors at normal ambient temperature according to the manufacturer's installation instructions. Raise test member temperature to required maximum long term temperature or maximum short term temperature at a rate of approximately 20 K per hour. Cure test member at this temperature for 24 hours. While maintaining the temperature of the test member in the area of the plastic anchor at a distance of 1d from the concrete surface at ±2 K of the required value, carry out tension test according to 5.2.

b) Tests at lowest service temperature min T = -40 °C, -20 °C or –5 °C:

After installation of the plastic anchors at normal ambient temperature raise the test member temperature to the maximum long term temperature and keep the test member at this temperature for 4 days. After that cool the test member to the lowest service temperature min T (-40 °C or –20 °C or –5 °C) according to the specification of the manufacturer and carry out tension tests according to 5.2. Plastic anchors made out of polyamide have to be checked by pull-out tests only at –40 °C, if these lowest service temperature is specified by the manufacturer.

c) Tests at minimum installation temperature:

The plastic anchor shall be installed at the lowest installation temperature (plastic anchor and base material) specified by the manufacturer. After that cool the test member to the required minimum service temperature and carry out tension tests according to 5.2.

5.4. Shear Test

After installation, the plastic anchor is connected to the test rig without gap between the plastic anchor and the loading plate; it is then loaded to failure. The displacements of the plastic anchor relative to the base material shall be measured in the direction of the load application, for example by use of a displacement transducer fixed behind the plastic anchor (seen from the direction of load application) on the concrete (see Figure 4.2).

5.5. Test for determining minimum spacing and edge distance

5.5.1. Screwed-in plastic anchors for use in normal weight concrete

The tests are carried out with double plastic anchors with a spacing $s = s_{min}$ and an edge distance $c = c_{min}$. The double anchors are placed on an uncast side of a concrete test member with a distance $a \geq 3\ h_{ef}$ between neighbouring groups. The dimensions of the fixture shall be width = $3\ d_f$, length = $s_{min} + 3\ d_f$ and thickness $\cong d_f$.

The plastic anchors shall be torqued alternately in steps of $0{,}2\ T_{inst}$. After each load step the concrete surface shall be inspected for cracks. The test is stopped when the torque moment cannot be increased further.

The number of revolutions per load step may be measured for both plastic anchors. Furthermore, the torque moment at the formation of the first hairline crack at one or both plastic anchors and the maximum torque moment that can be applied to the two anchors, shall be recorded.

For nailed-in plastic anchors for use in normal weight concrete Part 1, 5.4.2.2 is applied.

5.5.2. Plastic anchors for use in other base materials

Tension tests shall be performed at the free edge of a unit (tests in units) or the wall (test in a wall) with an edge distance $c = c_{min}$.

5.6. Tests under sustained loading

The test is performed at normal temperature (T = +20 °C) for temperature range a), b) and c) and at maximum steady temperature for temperature range b) and c) [T = +50 °C for temperature range b)].

The plastic anchor shall be installed at normal temperature.

The plastic anchor is then subjected to a load according to equation (5.3) which is kept constant (variation within ±5 %).

For the tests at the maximum long term temperature [temperature range b) and c)] the test specimens, the loading equipment, the displacement transducers and the installed plastic anchors shall be heated to the maximum long term temperature at least for 24 hours before loading the plastic anchors.

The tests will generally be carried out over at least 3000 hours for plastic sleeves of PA6 or PA6.6 and 5000 hours for plastic sleeves of PE, PP or other polymeric materials.

$$N_P = 0{,}4 \cdot N_{R,k} \qquad (5.3)$$

N_{Rk} = characteristic resistance of single anchor given in the ETA for the specific base material

After completion of the sustained load test the plastic anchor shall be unloaded, the displacement measured and immediately after unloading a tension test performed.

5.7. Tests under relaxation

The plastic anchors are installed in the test member and left there unloaded for 24 hours and up to 500 hours. After that tension tests shall be carried out.

This test is not required for screwed-in plastic anchors with polyamide PA6 plastic sleeve, if failure is predominately caused by pulling out the sleeve and the screw together.

5.8. Maximum torque moment

The plastic anchor shall be installed with a screw driver. The torque moment shall be measured with a calibrated torque moment transducer. The torque moment shall be increased until failure of the plastic anchor.

The torque moment is measured as a function of time. From the gradient of this curve two torque moments can be determined, the one if the screw is fully attached to the anchor collar (T_{inst}) and the maximum value (T_u) that can be applied to the plastic anchor.

6. TEST REPORT

As a minimum requirement, the report shall include at least the following information:

General

- Description and type of plastic anchor
- Anchor identification (dimensions, materials, coating, production method)
- Name and address of manufacturer
- Name and address of test laboratory
- Date of tests
- Name of person responsible for test
- Type of test (eg tension, shear, short-term or repeated load test)
- Number of tests
- Testing equipment: load cells, load cylinder, displacement transducer, software, hardware, data recording
- Test rigs, illustrated by sketches or photographs
- Particulars concerning support of test rig on the test member

Test members

- Composition of concrete. Properties of fresh concrete (consistency, density)
- Date of manufacture
- Dimensions of control specimens, and/or cores (if applicable) measured value of compression strength at the time of testing (individual results and average value)
- Dimensions of test member
- Nature and positioning of any reinforcement
- Direction of concrete pouring

Anchor installation

- Information on the positioning of the plastic anchor
- Distances of plastic anchors from edges of test member and between adjacent anchors
- Tools employed for plastic anchor installation, eg. impact drilling tool, drilling hammer, other equipment, eg. torque wrench, hand hammer etc.
- Type of drill bit, manufacturer's mark and measured drill bit dimensions, particularly the effective diameter, d_{cut}, of the hard metal insert
- Information on the direction of drilling
- Information on cleaning of the hole
- Depth of drill hole
- Width of crack when installing the plastic anchor (where applicable)
- Depth of anchorage
- Tightening torque or other parameters for control of installation
- Number of impacts for setting the nailed–in anchor
- Displacement of plastic anchor at the applied torque moment (if measured)
- Quality and type of screws and nuts employed
- Length of thread engagement (where applicable)
- Type of attachment

Measured values

- Parameters of load application (eg. rate of increase of load, size of load increase steps, etc.)
- Displacements measured as a function of the applied load
- Any special observations concerning application of the load
- Width of crack during the loading of the plastic anchor
- Failure load
- Failure mode
- Radius (maximum radius, minimum radius) and height of a concrete cone produced in the test (where applicable)
- - Particulars of repeated load tests
  - minimum and maximum load
  - frequency of cycles
  - number of cycles
  - displacements as function of the number of cycles
- Particulars of sustained load tests
  - constant load on plastic anchor and method of applying it
  - plastic anchor displacement as a function of time
- Particulars of torque test
  - maximum torque moment at installation
  - maximum torque moment at failure

The above measurements shall be recorded for each test.

- Particulars of identification tests
  - dimensions of the parts of the plastic anchor and the drilling- and installation tools
  - properties (eg. tensile strength, elastic limit, elongation at rupture, if applicable)

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GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL

of

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Annex B (informative)

RECOMMENDATIONS FOR TESTS TO BE CARRIED OUT ON CONSTRUCTION WORKS

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ANNEX B (informative): RECOMMENDATIONS FOR TESTS TO BE CARRIED OUT ON CONSTRUCTION WORKS

1. General

This Annex is valid for plastic anchors with an ETA only. The ETA can cover plastic anchors for use in normal weight concrete, solid masonry, hollow or perforated masonry and autoclaved aerated concrete.
The characteristic resistances given in the ETAs for use in solid masonry are valid for the base material and the bricks which have been used in the tests or larger brick sizes and compressive strength of the masonry unit ≥ 10N/mm^2. The characteristic resistances given in the ETAs for use in hollow or perforated masonry are valid for the bricks and blocks only which have been used in the tests regarding base material, size of the units, compressive strength and configuration of the voids.

In the absence of national requirements the characteristic resistance of the plastic anchor may be determined by the following so-called "job site tests", if the plastic anchor has an ETA with characteristic values for the same base material as it is present on the construction works. Furthermore job site tests for use in solid masonry are possible only if the plastic anchor has an ETA for use in solid masonry and job site tests for use in hollow or perforated masonry are possible only if the plastic anchor has an ETA for use in hollow or perforated masonry.

This characteristic resistance to be applied to a plastic anchor should be determined by means of at least 15 pull-out tests carried out on the construction work with a centric tension load acting on the plastic anchor. These tests may also performed in a laboratory under equivalent conditions as used on construction work

Execution and evaluation of the tests as well as issue of the test report and determination of the characteristic resistance should be supervised by the person responsible for execution of works on site and be carried out by a competent person.

Number and position of the plastic anchors to be tested should be adapted to the relevant special conditions of the construction work in question and, for example, in the case of blind and larger areas be increased such that a reliable information about the characteristic resistance of the plastic anchor embedded in the base material in question can be derived. The tests should take account of the unfavourable conditions of practical execution.

2. Assembly

The plastic anchor to be tested should be installed (e.g. preparation of drill hole, drilling tool to be used, drill bit, type of drilling hammer or rotation, thickness of fixture) and as far as spacing and edge distances are concerned be distributed in the same way as foreseen for the intended use.

Depending on the drilling tool hard metal hammer-drill bits or hard metal percussion drill bits, respectively, according to ISO 5468 [15] should be used. New drill bits should be used for one test series or drill bits with $d_{cut} \geq d_{cut,m}$.

3. Execution of test

The test rig used for the pull-out tests should allow a continuous slow increase of load recorded by a calibrated measuring equipment.

The load should act perpendicular to the surface of the base material and be transmitted to the plastic anchor via a hinge. The reaction forces should be transmitted to the base material such that possible breakout of the masonry is not restricted. This condition is considered as fulfilled, if the support reaction forces are transmitted either in adjacent masonry units or at a distance of at least 150mm from the plastic anchors.

The load should be progressively increased so that the load is achieved after not less than about 1 minute. Recording of load is carried out when the ultimate load is achieved.

If no pull-out failure occurs, then other test methods are needed, e.g. proof-loading.

4. Test report

The test report should include all information necessary to assess the resistance of the tested plastic anchor. It should be given to the person responsible for the design of the fastening . The following information is necessary e.g.:

Name of product

Construction work

Building owner

Date and place of tests

Test rig

Type of structure to be fixed

Masonry (type of brick, strength class, all dimensions of bricks and mortar group if possible); Visual assessment of masonry (flush joints, joint clearance, regularity)

Plastic anchors and screws or nails

Cutting diameter of hard metal hammer-drill bits, value measured before and after drilling if no new drill bits are used

Results of tests including indication of value N_1 ; mode of failure

Tests carried out or supervised by; Signature

5. Evaluation of test results

The characteristic resistance F_{Rk1} is obtained from the measured values of N_1 as follows

$F_{Rk1} = 0,5 \bullet N_1$ The characteristic resistance F_{Rk1} has to be equal or smaller than the characteristic resistance F_{Rk} which is given in the ETA for similar masonry (bricks or blocks)

N_1 = the mean value of the five smallest measured values at the ultimate load

In absence of national regulations the partial safety factors for the resistance of the plastic anchor may be taken as γ_M = 2.5 for use in masonry.

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PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

Annex C : DESIGN METHODS FOR ANCHORAGES

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ANNEX C : DESIGN METHODS FOR ANCHORAGES

INTRODUCTION

INTRODUCTION

The design method for anchorages is intended to be used for the design of anchorages under due consideration of the safety and design concept within the scope of the European Technical Approvals (ETA) of plastic anchors.

The design method given in Annex C is based on the assumption that the required tests for assessing the admissible service conditions given in the relevant Parts of this Guideline have been carried out. Therefore Annex C is a pre-condition for assessing and judging of plastic anchors. The use of other design methods will require reconsideration of the necessary tests.

The plastic anchors should be used for multiple fixings. By multiple anchor use it is assumed 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.

Therefore 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.

The following default values for n_1, n_2 and n_3 should be taken:

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

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

1. SCOPE

1.1. Type of anchors, anchor groups and number of anchors

The design method applies to the design of plastic anchors in normal weight concrete, different masonry and autoclaved aerated concrete using anchors which fulfil the requirements of this Guideline. The characteristic values are given in the relevant ETA.

The design method is valid for single anchors and anchor groups with two or four anchors. In an anchor group only anchors of the same type, size and length shall be used.

1.2. Member

1.2.1. Concrete member

The concrete member shall be of normal weight concrete of at least strength class C12/15 according to EN 206 [5] and shall be subjected to only predominantly static loads. The design method is valid for cracked and non-cracked concrete.
If the edge distance of an anchor is smaller than the edge distance $c_{cr,N}$, then a longitudinal reinforcement of at least ∅ 6 shall be provided at the edge of the member in the area of the anchorage depth.

1.2.2. Solid and hollow or perforated masonry

The masonry member should be of solid or hollow or perforated masonry units made of clay or calcium silicate or normal weight concrete.
The detailed information of the corresponding base material is given in the ETA (e.g. *Base material, size of units, normalised compressive strength; volume of all holes (% of the gross volume); volume of any hole (% of the gross volume); minimum thickness in and around holes (web and shell); combined thickness of webs and shells (% of the overall width)*.

1.2.3. Autoclaved aerated concrete

The autoclaved aerated concrete member should be according to EN 771-4 [9] "Autoclaved aerated concrete masonry units" or prEN 12602 [10] "Reinforced components of autoclaved aerated concrete".

1.3. Type and direction of load

This design method applies to plastic anchors subject to static or quasi-static actions in tension, shear or combined tension and shear or bending; it is not applicable to plastic anchors loaded in compression or subject to fatigue, impact, or seismic actions.

2. TERMINOLOGY AND SYMBOLS

2.1. Plastic anchors

The notations and symbols frequently used are given below.

c	=	edge distance
c_1	=	edge distance in direction 1; in case of anchorages close to an edge loaded in shear c_1 is the edge distance in direction of the shear load
c_2	=	edge distance in direction 2; direction 2 is perpendicular to direction 1
$c_{cr,N}$	=	edge distance for ensuring the transmission of the characteristic tensile resistance of a single plastic anchor
c_{min}	=	minimum allowable edge distance
d	=	nominal diameter of the anchor
d_{nom}	=	outside diameter of anchor
h	=	thickness of member (wall)
h_{ef}	=	effective anchorage depth
h_{nom}	=	overall anchor embedment depth in the base material
s	=	spacing of the plastic anchor
s_{min}	=	minimum allowable spacing

2.2. Base material

$f_{ck,cube}$	=	nominal characteristic concrete compression strength (based on cubes)
f_{yk}	=	nominal characteristic steel yield strength
f_{uk}	=	nominal characteristic steel ultimate strength

2.3. Actions and resistances

F	=	force in general (resulting force)
N	=	normal force (positive: tension force, negative: compression force)
V	=	shear force
M	=	moment

F_{Sk} (N_{Sk} ; V_{Sk} ; M_{Sk} ; $M_{T,Sk}$)	=	characteristic value of actions acting on a single anchor or the fixture of an anchor group respectively (normal load, shear load, bending moment, torsion moment)
F_{Sd} (N_{Sd} ; V_{Sd} ; M_{Sd} , $M_{T,Sd}$)	=	design value of actions acting on a single anchor or the fixture of an anchor group respectively (normal load, shear load, bending moment, torsion moment)
N^h_{Sd} (V^h_{Sd})	=	design value of tensile load (shear load) acting on the most stressed anchor of an anchor group
N^g_{Sd} (V^g_{Sd})	=	design value of the sum (resultant) of the tensile (shear) loads acting on the tensioned (sheared) anchors of a group
F_{Rk} (N_{Rk} ; V_{Rk})	=	characteristic value of resistance of a single anchor or an anchor group respectively (normal force, shear force)
F_{Rd} (N_{Rd} ; V_{Rd})	=	design value of resistance of a single anchor or an anchor group respectively (normal force, shear force)

3. DESIGN AND SAFETY CONCEPT

3.1. General

The design of anchorages shall be in accordance with the general rules given in EN 1990 [20]. It shall be shown that the value of the design actions S_d does not exceed the value of the design resistance R_d.

$$S_d \leq R_d \qquad (3.1)$$

S_d = value of design action
R_d = value of design resistance

Actions to be used in design may be obtained from national regulations or in the absence of them from the relevant parts of EN 1991 [21].
The partial safety factors for actions may be taken from national regulations or in the absence of them according to EN 1990 [20].

The design **resistance** is calculated as follows:

$$R_d = R_k/\gamma_M \qquad (3.2)$$

R_k = characteristic resistance of a single anchor or an anchor group
γ_M = partial safety factor for material

3.2. Ultimate limit state

3.2.1. Design resistance

The design resistance is calculated according to Equation (3.2).

3.2.2. Partial safety factors for resistances

In the absence of national regulations the following partial safety factors may be used:

3.2.2.1. Failure (rupture) of the expansion element

a) Metal expansion element:

Tension loading:

$$\gamma_{Ms} = \frac{1.2}{f_{yk} / f_{uk}} \geq 1.4 \qquad (3.3a)$$

Shear loading of the anchor with and without lever arm:

$$\gamma_{Ms} = \frac{1.0}{f_{yk}/f_{uk}} \geq 1.25 \qquad f_{uk} \leq 800 \text{ N/mm}^2 \qquad (3.3b)$$

and $f_{yk}/f_{uk} \leq 0.8$

$\gamma_{Ms} = 1.5$ $\qquad f_{uk} > 800 \text{ N/mm}^2$

or $f_{yk}/f_{uk} > 0.8$

b) Polymeric expansion element:

$\gamma_{Mpol} = 2.5$

(also valid for rupture of the polymeric sleeve)

3.2.2.2. Failure of the plastic anchor

a) For use in concrete

$\gamma_{Mc} = 1.8$

b) For use in masonry

$\gamma_{Mm} = 2.5$

c) For use in autoclaved aerated concrete

$\gamma_{MAAC} = 2.0$

3.3. Serviceability limit state

In the serviceability limit state it shall be shown that the displacements occurring under the characteristic actions (see 6) are not larger than the permissible displacements. The permissible displacements depend on the application in question and should be evaluated by the designer.

In this check the partial safety factors on actions and on resistances may be assumed to be equal 1.0.

4. STATIC ANALYSIS

4.1. Loads acting on anchors

Distribution of loads acting on anchors should be calculated according to theory of elasticity.

For steel failure under tension and shear and for pull-out failure under tension the load acting on the highest loaded anchor shall be determined. For concrete failure under tension and shear the load on the group shall be calculated.

In case of concrete edge failure the shear force is assumed to act on the anchor(s) closest to the edge.

4.2. Shear loads with lever arm

Shear loads acting on an anchor may be assumed to act without lever arm if both of the following conditions are fulfilled:

a) The fixture shall be made of metal and in the area of the anchorage be fixed directly to the base material either without an intermediate layer or with a levelling layer of mortar with a thickness ≤ 3 mm.
b) The fixture shall be in contact with the anchor over its entire thickness.

If these two conditions are not fulfilled the lever arm is calculated according to equation (4.1) (see Fig. 4.1).

$$l = a_3 + e_1 \qquad (4.1)$$

e_1 = distance between shear load and surface of the member
a_3 = $0.5 \cdot d$
d = nominal diameter of the anchor

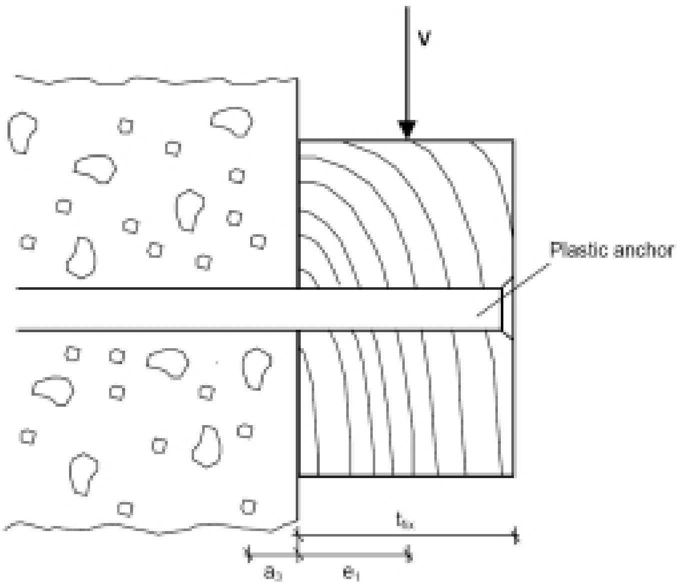

Figure 4.1 Definition of lever arm

5. ULTTIMATE LIMIT STATE

5.1. General

The characteristic resistances of plastic anchors in the ultimate limit state for use in concrete are given in 5.2. The characteristic resistances and the corresponding specific conditions for the design of plastic anchors for use in masonry and aerated concrete respectively are listed in 5.3.

In general, it is assumed that anchor groups have the same resistance as single anchors under tension loads, shear loads and combined tension and shear loads independent of the spacing between the anchors.

Spacing, edge distance as well as thickness of member shall not remain under the given minimum values.

5.2. Ultimate limit state for use in concrete

5.2.1. Resistance to tension loads

5.2.1.1. Required proofs

		single anchor	anchor group	
Failure of the expansion element	metal	$N_{Sd} \leq N_{Rk,s} / \gamma_{Ms}$	$N^{h}_{Sd} \leq N_{Rk,s} / \gamma_{Ms}$	
	polymeric[1)]	$N_{Sd} \leq N_{Rk,pol} / \gamma_{Mpol}$	$N^{h}_{Sd} \leq N_{Rk,pol} / \gamma_{Mpol}$	
pull-out failure		$N_{Sd} \leq N_{Rk,p} / \gamma_{Mc}$	$N^{h}_{Sd} \leq N_{Rk,p} / \gamma_{Mc}$	
concrete cone failure		$N_{Sd} \leq N_{Rk,c} / \gamma_{Mc}$		$N^{g}_{Sd} \leq N_{Rk,c} / \gamma_{Mc}$

1) also valid for rupture of the polymeric sleeve

5.2.1.2. Failure of the expansion element

The characteristic resistance of an anchor in case of failure (rupture) of the expansion element, $N_{Rk,s}$ or $N_{Rk,pol}$ is given in the relevant ETA.

5.2.1.3. Pull-out failure

The characteristic resistance in case of failure by pull-out, $N_{Rk,p}$, shall be taken from the relevant ETA.

5.2.1.4. Concrete cone failure

The characteristic resistance of an anchor or a group of anchors, respectively, in case of concrete cone failure is:

$$N_{Rk,c} = 7.2 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1,5} \cdot \frac{c}{c_{cr,N}} \qquad \frac{c}{c_{cr,N}} \leq 1.0 \qquad (5.1)$$

$f_{ck,cube}$ [N/mm²]; h_{ef} [mm]

with:

$$h_{ef}^{1,5} = \frac{N_{Rk,p}}{7.2 \cdot \sqrt{f_{ck,cube}}} \qquad (5.2)$$

$N_{Rk,p}$ = given in the ETA; $N_{Rk,p}$ [N]

c = edge distance of the outer anchor of the group

$c_{cr,N}$ = edge distance to ensure the transmission of the characteristic resistance; given in the ETA

$f_{ck,cube}$ = nominal characteristic concrete compression strength (based on cubes) values for C50/60 at most

5.2.2. Resistance to shear loads

5.2.2.1. Required proofs

		single anchor	anchor group	
Failure of the expansion element, shear load without lever arm	metal	$V_{Sd} \leq V_{Rk,s} / \gamma_{Ms}$	$V_{Sd}^{h} \leq V_{Rk,s} / \gamma_{Ms}$	
	polymeric	$V_{Sd} \leq V_{Rk,pol} / \gamma_{Mpol}$	$V_{Sd}^{h} \leq V_{Rk,pol} / \gamma_{Mpol}$	
Failure of the expansion element, shear load with lever arm	metal	$V_{Sd} \leq V_{Rk,s} / \gamma_{Ms}$	$V_{Sd}^{h} \leq V_{Rk,s} / \gamma_{Ms}$	
	polymeric	$V_{Sd} \leq V_{Rk,pol} / \gamma_{Mpol}$	$V_{Sd}^{h} \leq V_{Rk,pol} / \gamma_{Mpol}$	
concrete edge failure		$V_{Sd} \leq N_{Rk,c} / \gamma_{Mc}$		$V_{Sd}^{g} \leq V_{Rk,c} / \gamma_{Mc}$

5.2.2.2. Failure of the expansion element, shear load without lever arm

The characteristic resistance of an anchor in case of failure of the expansion element due to shear load without lever arm $V_{Rk,s}$ or $V_{Rk,pol}$ shall be taken from the relevant ETA.

5.2.2.3. Failure of the expansion element, shear load with lever arm

The characteristic resistance of an anchor in case of failure of the expansion element due to shear load with lever arm $V_{Rk,s}$ or ($V_{Rk,pol}$) is given by Equation (5.3).

$$V_{Rk,s} = \frac{M_{Rk,s}}{l} \quad [N] \qquad (5.3a)$$

$$V_{Rk,pol} = \frac{M_{Rk,pol}}{l} \quad [N] \qquad (5.3b)$$

l lever arm according to Equation (4.1)

$M_{Rk,s}$ or $M_{Rk,pol}$ to be taken from the relevant ETA

5.2.2.4. Concrete edge failure

The characteristic resistance for an anchor or an anchor group in the case of concrete cone failure at edges corresponds to:

$$V_{Rk,c} = 0.45 \cdot \sqrt{d_{nom}} \cdot (h_{nom} / d_{nom})^{0.2} \cdot \sqrt{f_{ck,cube}} \cdot c_1^{1,5} \cdot \left(\frac{c_2}{1.5c_1}\right)^{0.5} \cdot \left(\frac{h}{1.5c_1}\right)^{0.5} \quad [N] \qquad (5.4)$$

d_{nom}, h_{nom}, h, c_1, c_2 [mm]; $f_{ck,cube}$ [N/mm²] $\left(\frac{c_2}{1.5c_1}\right)^{0.5} \leq 1.0$ and $\left(\frac{h}{1.5c_1}\right)^{0.5} \leq 1.0$

c_1 edge distance closest to the edge in loading direction

c_2 edge distance perpendicular to direction 1

$f_{ck,cube}$ = nominal characteristic concrete compression strength (based on cubes) values for C50/60 at most

5.2.3. Resistance to combined tension and shear loads

For combined tension and shear loads the following Equations shall be satisfied:

$$\beta_N \leq 1 \qquad (5.5a)$$

$$\beta_V \leq 1 \qquad (5.5b)$$

$$\beta_N + \beta_V \leq 1.2 \qquad (5.5c)$$

β_N (β_V) ratio between design action and design resistance for tension (shear) loading.
In Equation (5.5) the largest value of β_N and β_V for the different failure modes shall be taken (see 5.2.1.1 and 5.2.2.1).

5.3. Ultimate limit state for use in masonry and in autoclaved aerated concrete

The following specific conditions for the design method in masonry and in autoclaved aerated concrete shall be taken into account:

(1) The ETA contains only <u>one</u> characteristic resistance $\mathbf{F_{Rk}}$ independent of the load direction and the mode of failure. The appropriated partial safety factor and the corresponding values c_{min} and s_{min} for this characteristic resistance are also be given in the ETA.

(2) The characteristic resistance $\mathbf{F_{Rk}}$ for a single plastic anchor may also be taken for a group of two or four plastic anchors with a spacing equal or larger than the minimum spacing s_{min}.
The distance between single plastic anchors or a group of anchors should be $s \geq 250$ mm.

(3) If the vertical joints of the wall are designed <u>not</u> to be filled with mortar then the design resistance N_{Rd} has to be limited to 2.0 kN to ensure that a pull-out of one brick out of the wall will be prevented. This limitation can be omitted if interlocking units are used for the wall or when the joints are designed to be filled with mortar.

(4) If the joints of the masonry <u>are not visible</u> the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor $\alpha_j = 0.5$.

(5) If the joints of the masonry <u>are visible</u> (e.g. unplastered wall) following has to be taken into account:

- The characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the wall is designed such that the joints are to be filled with mortar.
- If the wall is designed such that the joints are <u>not</u> to be filled with mortar then the characteristic resistance $\mathbf{F_{Rk}}$ may be used only, if the minimum edge distance c_{min} to the vertical joints is observed. If this minimum edge distance c_{min} can not be observed then the characteristic resistance $\mathbf{F_{Rk}}$ has to be reduced with the factor $\alpha_j = 0.5$.

For prefabricated reinforced components made of autoclaved aerated concrete the following has to be taken into account as well, if no special tests or calculation for the resistance of the member made of AAC have been carried out:

- The design value of shear resistance in the member caused by the anchorage is less or equal to 40 % of the design value of resistance of the member in the critical cross section.

- The edge distance c is $\geq$ 150 mm for slabs of width $\leq$ 700 mm.

- The spacing s of fixing points is $\geq$ 600 mm. Fixing points are single anchors or groups of 2 or 4 anchors.

6. SERVICEABILITY LIMIT STATE

6.1. Displacements

The characteristic displacement of the anchor under defined tension and shear loads shall be taken from the ETA. It may be assumed that the displacements are a linear function of the applied load. In case of a combined tension and shear load, the displacements for the tension and shear component of the resultant load should be geometrically added.

In case of shear loads the influence of the hole clearance in the fixture on the expected displacement of the whole anchorage shall be taken into account.

6.2. Shear load with changing sign

If the shear loads acting on the anchor change their sign several times, appropriate measures shall be taken to avoid a fatigue failure of the anchor (e.g. the shear load should be transferred by friction between the fixture and the base material (e.g. due to a sufficiently high permanent prestressing force)).

Shear loads with changing sign can occur due to temperature variations in the fastened member (e.g. facade elements). Therefore, either these members are anchored such that no significant shear loads due to the restraint of deformations imposed to the fastened element will occur in the anchor or in shear loading with lever arm the bending stresses in the most stressed anchor $\Delta\sigma = \max\sigma - \min\sigma$ in the serviceability limit state caused by temperature variations should be limited to 100 N/mm^2 for steel.