

BS 8539:2012+A1:2021



BSI Standards Publication

**Code of practice for the selection and
installation of post-installed anchors in
concrete and masonry**

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 October 2012. It was prepared by Technical Committee B/514, *Access and support equipment*. A list of organizations represented on this committee can be obtained on request to the committee manager.

Supersession

BS 8539:2012+A1:2021 supersedes BS 8539:2012, which is withdrawn.

Information about this document

This British Standard is intended to be used by a wide range of people involved in the selection and installation of anchors, and some clauses are of particular interest to specific parties, as follows:

- all parties: [Clause 3](#) and [Clause 4](#);
- designers: [Clause 5](#), [6.3](#) and [Clause 10](#);
- specifiers: [Clause 5](#), [6.4](#), [6.6](#), [Clause 9](#), [Clause 10](#), [Annex A](#), [Annex B](#), [Annex C](#) and [Annex D](#);
- manufacturers/suppliers: [Clause 5](#), [6.2](#), [6.5](#) and [Clause 10](#);
- contractors: [Clause 7](#), [Clause 8](#) and [10](#);
- installers: [Clause 7](#) and [Clause 10](#);
- testers: [Clause 9](#) and [Annex B](#).

It is recommended that all parties read the whole document.

Text introduced or altered by Amendment No.1 is indicated in the text by the tags A1 A1. Minor editorial changes are not tagged.

Amendment A1 introduces the following principal changes:

- the change in the anchor design method from ETAG001 in BS EN 1992-4:2018, Annex C;
- changes to ensure consistency with the Construction Product Regulations [\[3\]](#);
- replacing references to European Technical Approval Guidelines (ETAGs) with the relevant European Assessment Documents (EADs) references;
- updating other references, including associated terminology.

Product certification/inspection/testing. Users of this British Standard are advised to consider the desirability of selecting anchors with a relevant European Technical A1 Assessment A1 (ETA)¹⁾. ETAs are awarded by Approval Bodies after a comprehensive test and assessment regime carried out to the relevant A1 European Assessment Document (EAD) A1 or Common Understanding of Assessment Procedure (CUAP), which also contain appropriate conformity attestation arrangements. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

NOTE Anchors with ETAs, depending on the particular A1 EAD A1 and options within it, can be designed to suit a wide range of application conditions (see [Clause 5](#) and [Annex A](#)). Guidance on ETAs is given in ETAs and design methods for anchors used in construction [\[1\]](#) and the EOTA website (www.eota.be).

¹⁾ A1 Text deleted. A1

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentation conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the Construction Products Regulations 1991 [3] and Construction Products (Amendment) Regulations 1994 [4].

Introduction

Anchors play an important role in construction, in particular:

- a) they allow for the secure attachment of a fixture, which can be a structural element, to the base material;
- b) there is a wide variety of anchors available for different applications.

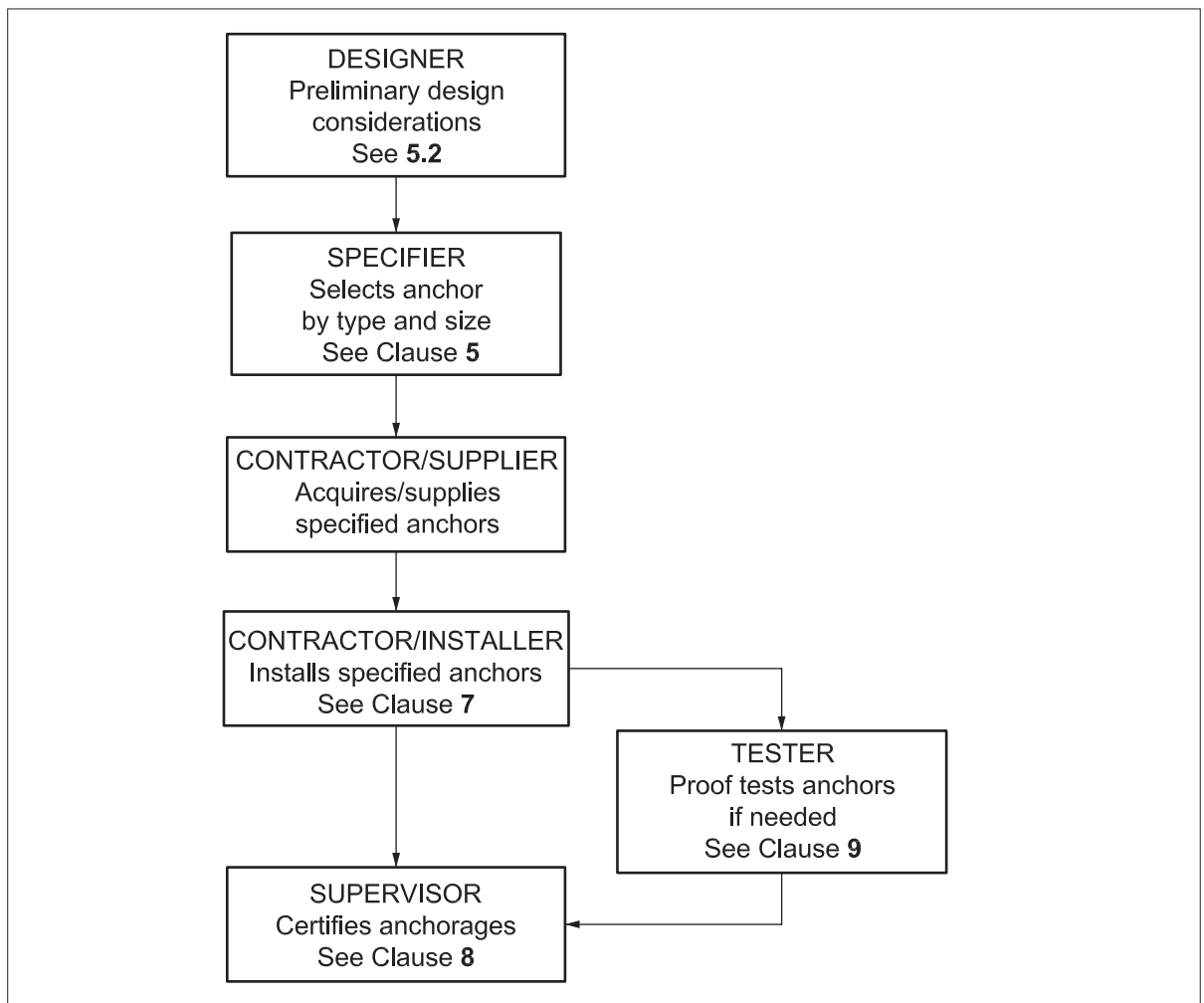
Every anchorage has three elements:

- anchor: the device that fastens the fixture to the base material;
- base material: the material into which the anchor is installed;
- fixture: the item to be fixed to the base material.

The performance of anchors is influenced by many application parameters, which need to be taken into account in their selection. Performance is also affected by the quality of installation.

If anchors are not selected and installed correctly, they might not have the capability to resist loads as intended. The security of the fixture and, in some cases, the structure might then be compromised, leading to failure with consequential economic loss, injury, or even death. This British Standard is intended to facilitate all stakeholders involved in the use of anchors to achieve the security required by the design.

[Figure 1](#) shows a simple outline of the overall approach to be taken to ensure that connections are safe and that they meet the overall design requirements.

Figure 1 — Flowchart for overall process of selection and installation of anchors

1 Scope

This British Standard gives recommendations for the safe selection and installation of anchors for use in concrete and masonry. It is intended to provide practical guidance for designers, specifiers, manufacturers, suppliers, contractors, installers and testers of anchors.

In particular, this British Standard applies to the selection and installation of anchors which are used in safety-critical applications.

This British Standard is restricted to the use of anchors which are inserted into concrete and masonry in drilled holes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[N1] CONSTRUCTION FIXINGS ASSOCIATION. *Procedure for site testing construction fixings – 2012*. CFA Guidance Note. [A1] Thurmaston [A1], Leicestershire: CFA, 2012.

3 Terms, definitions and symbols

NOTE Where possible, terminology and notation have been used which are common with European standards. Some new terminology and notation have been developed for aspects not covered by European standards.

3.1 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1.1 actions

3.1.1.1 action

load (force) transferred into a base material by a fixture via an anchor

3.1.1.2 bending action

action applied to an anchor with a lever arm

3.1.1.3 characteristic action

action applied by a fixture to an anchor or group of anchors

NOTE This is sometimes known as an “unfactored load” or “applied load”.

3.1.1.4 characteristic permanent action

component of a characteristic action that is likely to act throughout the life of the structure, and for which the variation in magnitude with time is negligible

NOTE This is commonly known as a “dead load”.

3.1.1.5 characteristic variable action

component of a characteristic action for which the variation in magnitude with time is neither negligible nor monotonic (i.e. in the same direction)

NOTE This is commonly known as an “imposed load” or “live load”.

3.1.1.6 combined action

combination of tensile and shear actions applied simultaneously

3.1.1.7 design action

action derived from the characteristic action by application of a partial safety factor for the action

NOTE This is sometimes known as a “factored load”.

3.1.1.8 non-static action

action which can be characterized by fatigue, seismic or shock actions

3.1.1.9 quasi-static action

variable action which is treated as being static

3.1.1.10 seismic action

action resulting from seismic activity (earthquakes) transmitted from the ground to the anchorage via the building structure

3.1.1.11 shock action

single action of high magnitude occurring over short duration (milliseconds)

3.1.1.12 static action

action comprising loads which are constant (permanent actions) and/or those which change only slowly (variable actions)

3.1.2 anchor

manufactured device for achieving a connection between a fixture and the base material

NOTE This is also known as a fixing or fastener. In CEN Technical Specifications, the terms “anchor” and “fastener” are used synonymously.

3.1.3 anchor group

two or more anchors used in combination to achieve a connection between a single fixture and the base material

NOTE This is not the same as multiple use (3.1.26).

3.1.4 anchorage

assembly comprising a base material, an anchor or anchor group, and a fixture

NOTE In CEN Technical Specifications, the term “fastening” is used.

3.1.5 base material

material of a structure into which an anchor is installed

3.1.6 base plate

part of a fixture forming the direct contact between an anchor or group of anchors and the base material

3.1.7 bending moment

result of an action applied to a fixture at a lever arm which can result in a tensile action being applied to an anchor

3.1.8 client

person who commissions or procures the carrying out of a project

3.1.9 competent

suitably trained and qualified by knowledge and practical experience, and provided with the necessary instructions, to enable the required task(s) to be carried out correctly

3.1.10 compression

direction of loading along the axis of an anchor toward the base material

NOTE When used as an adjective, this is known as “compressive”.

3.1.11 concrete strength

compressive strength of the concrete base material into which an anchor is to be installed

NOTE This is derived from compression tests on cylinders/cubes, e.g. C20/25.

3.1.12 contractor

organization or employer whose employees undertake, carry out or manage construction work

3.1.13 construction stage

period of time starting when preparation of a construction site begins and ending when work on the project is completed

3.1.14 cracked concrete

concrete likely to be subjected to tension at any point in its lifetime

NOTE Guidance on the determination of cracked concrete is given in  BS EN 1992-4. 

3.1.15 creep

time-dependent phenomenon that results in an increase in initial deformation under constant load, which in turn could result in relaxation in a fixture

NOTE Anchors which suffer from creep might sustain significant loads under short-term test conditions but fail at significantly lower loads if applied over the long term.

3.1.16 design life

period for which an anchorage is intended to remain in use

NOTE This is normally 50 years for building structures.

3.1.17 designer

person with overall responsibility for the design of a structure, which includes the anchorage, throughout the whole design and construction stage

NOTE The designer might or might not be the specifier.

3.1.18 embedment depths**3.1.18.1 effective embedment depth**

depth from the surface of a load-bearing structure to the lowest point where an anchor engages with the base material

3.1.18.2 nominal embedment depth

depth from the surface of a load-bearing structure to the lowest part of an anchor

3.1.19 elevated temperature

temperature higher than the range of service temperatures normally considered

3.1.20 fixture

component to be fixed to the base material

3.1.21 global safety factor approach

determination of recommended resistance by application of a single safety factor (γ) to either the characteristic or ultimate (mean average) resistance of an anchor

3.1.22 installer

person or organization trained in the process of installing anchors

NOTE The installer is usually employed by a contractor.

3.1.23 lateral

direction of loading perpendicular to the axis of an anchor

3.1.24 manufacturer

person or organization who develops, manufactures, and supplies anchors

3.1.25 masonry

building element constructed from masonry units, such as bricks, blocks or stones

3.1.26 multiple use

particular application category where multiple anchors are employed to support an installation system, in which failure of a single anchor will not cause collapse of the whole supported structure

NOTE 1 This applies only to anchors qualified to certain ETAGs, and requires specific application parameters to be satisfied. An application qualifies as multiple use if the number (n_1) of fixing points, the number (n_2) of anchors per fixing point $\langle A_1 \rangle$ are in accordance with EAD 330747-00-0601 [6]²⁾ and PD CEN/TR 17079:2018:

- $n_1 \geq 3$ and $n_2 \geq 1$ $\langle A_1 \rangle$

NOTE 2 Examples include suspended ceilings or runs of mechanical/electrical containment.

NOTE 3 This is not the same as reuse.

3.1.27 non-cracked concrete

concrete unlikely to be subjected to tension at any point in its lifetime

NOTE Guidance on the determination of non-cracked concrete is given in $\langle A_1 \rangle$ BS EN 1992-4. $\langle A_1 \rangle$

3.1.28 partial safety factor approach

application of partial factors of safety to characteristic actions and resistances to determine the respective design values, in order to verify that no relevant limit state is exceeded

3.1.29 partial safety factor for action

partial safety factor applied to the characteristic action to derive the design action

3.1.30 partial safety factor for material

partial safety factor applied to the characteristic resistance to determine the design resistance

3.1.31 preliminary test

test carried out on site to determine the allowable resistance in the case where no characteristic resistance or recommended resistance is available

NOTE Also known as “test for allowable resistance (simplified approach)”; see [B.2.3.1](#).

3.1.32 progressive collapse

sequential spread of local damage from an initiating event, from element to element, resulting in the collapse of a number of elements

3.1.33 proof load

load applied in a proof test

3.1.34 proof tests

tests carried out on a proportion of anchors to validate correct installation

²⁾ $\langle A_1 \rangle$ ETAG 020 will be replaced by EAD 330284-00-0601 [29], but at the time of publishing this British Standard it has not been implemented. $\langle A_1 \rangle$

3.1.35 resistance**3.1.35.1 resistance**

capacity of an anchorage to resist actions

3.1.35.2 allowable resistance

maximum working load derived from tests carried out on site when the proposed anchor is to be used in a base material approved by the manufacturer but for which there is no recommended resistance (load)

3.1.35.3 characteristic resistance

resistance derived as the 5% fractile of the mean ultimate resistance, determined from tests or by empirical calculation depending on mode of failure

NOTE This is based upon a 90% probability (confidence level) that 95% of anchors will exceed the characteristic resistance.

3.1.35.4 design resistance

resistance derived from the characteristic resistance by the application of partial safety factors

3.1.35.5 mean ultimate resistance

average failure load determined in a series of tests

3.1.35.6 recommended resistance

maximum working load recommended by a manufacturer

NOTE This is sometimes referred to as “recommended load” or “permissible load”. It is associated with the global safety factor approach, where it is derived from the characteristic action divided by a global safety factor.

3.1.36 redundancy

situation where there are more load paths than strictly necessary to carry the load through the structure, or part thereof

3.1.37 robustness

ability of a structure/structural system to accept a certain amount of damage without that structure failing to any degree

NOTE Robustness implies insensitivity to local failure.

3.1.38 safety-critical application

application in which the failure of anchors can:

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

NOTE This definition is adapted from  BS EN 1992-4. 

3.1.39 selection

overall process of selecting the type and size of an anchor or group of anchors

NOTE The process of design of the anchor will be one part of this process.

3.1.40 shear

lateral loading that can be coincident with the face of a base material or applied at a lever arm

NOTE Where used to describe anchor performance, “shear” is taken to mean coincident with the face of the base material.

3.1.41 specification

complete reference of an anchor in sufficient detail to facilitate its supply and installation

3.1.42 specifier

person or organization responsible for the selection (including anchor design) and specification of an anchor

NOTE The specifier might or might not be the designer.

3.1.43 statically determinate

application in which the stability of a fixture is dependent on every anchor supporting it

3.1.44 statically indeterminate

application in which stability of a fixture is not dependent on every anchor supporting it, i.e. there is a degree of redundancy

3.1.45 supplier

person or organization that supplies anchors

3.1.46 supervisor

person who supervises the installer, usually employed by the contractor

3.1.47 tension

direction of loading along the axis of an anchor and tending to pull the anchor out of the base material

NOTE When used as an adjective, this is known as “tensile”.

3.1.48 test load

load to be applied during a test

3.1.49 tester

person or organization that tests anchors on site

3.2 Symbols

For the purposes of this British Standard, the following symbols apply.

α factor used in checking the compatibility of design actions compared with design resistances in the case of combined actions

c_{cr} characteristic edge distance, at which full performance may be used

NOTE 1 Previously referred to as “critical edge distance”.

c_{min} minimum edge distance, at which performance has to be reduced according to manufacturer’s data

d_0 nominal diameter of drill bit

F action or resistance with direction unspecified

$F_{R,all}$	allowable resistance
F_{Rd}	design resistance
F_{Rk}	characteristic resistance
$F_{Ru,m}$	mean ultimate resistance from a series
$\boxed{A_1} F_{Ed} \boxed{A_1}$	design action
$\boxed{A_1} F_{Ek} \boxed{A_1}$	characteristic action
F_{rec}	recommended resistance
$f_{ck,cube}$	concrete compressive strength (cube)
$f_{ck,cylinder}$	concrete compressive strength (cylinder)
G_k	characteristic permanent action
H	thickness of base material
h_0	depth of cylindrical drilled hole with full diameter
h_1	depth of drilled hole to deepest point
h_{ef}	effective embedment depth from the surface of the load-bearing structure
h_{nom}	nominal embedment depth of the anchor from the surface of the load-bearing structure
K	special factor that adjusts the width of the tolerance interval to account for uncertainty <i>NOTE 2 In this British Standard, the K factor is taken from standard statistical tables, to give a 90% probability (confidence level) that 95% will exceed the calculated characteristic resistance.</i>
M_{Rd}	design bending moment
N	tensile actions or resistances
N_{1st}	load at first movement in a test
$N_{1st,m}$	mean load at first movement in a test series
N_p	tensile load applied in a proof load test
$N_{R,all}$	allowable tensile resistance
N_{Rd}	design tensile resistance
N_{Rk}	characteristic tensile resistance
$N_{Rk,ETA}$	characteristic tensile resistance quoted in an ETA for this category of base material
N_{Rk1}	characteristic tensile resistance for a specific base material in a test
N_{Ru}	ultimate tensile resistance recorded in a single test
$N_{Ru,m}$	mean ultimate tensile resistance from a series of tests
N_{rec}	recommended tensile resistance
$\boxed{A_1} N_{Ed} \boxed{A_1}$	design tensile action
$\boxed{A_1} N_{Ek} \boxed{A_1}$	characteristic tensile action

N_{test}	tensile test load applied in preliminary tests
$N_{\text{u,ave}}$	average tensile load recorded in preliminary tests
$N_{\text{u,low}}$	lowest tensile load recorded in preliminary tests
n_0	number of anchors originally required in a test
n'	new number of anchors required with the allowable resistance derived from a test
n_1	number of fixing points
n_2	number of anchors per fixing point
n_3	limiting value of design action on a fixing point for multiple use
Q_k	characteristic variable action
s_{cr}	characteristic spacing, at which full performance may be used <i>NOTE 3 Previously referred to as “critical spacing”.</i>
s_{min}	minimum spacing, at which performance has to be reduced according to manufacturer’s data
s	standard deviation of failure loads about the mean
T_{inst}	manufacturer’s recommended installation torque
V	shear actions or resistances <i>NOTE 4 All actions and resistances shown beginning N, to denote tensile actions or resistances, can be converted to the equivalent for shear actions or resistances by replacing N with V.</i>
V_{Rd}	design shear resistance
V_{rec}	recommended shear resistance
$\langle A_1 \rangle V_{\text{Ed}} \langle A_1 \rangle$	design shear action
$\langle A_1 \rangle V_{\text{Ek}} \langle A_1 \rangle$	characteristic shear action
v	coefficient of variation of the ultimate load in a test series
β	influencing factor used in determining results of site tests <i>NOTE 5 The values of this factor are given in the relevant approval document for the anchor.</i>
β_N	ratio of design tensile action to design tensile resistance
β_V	ratio of design shear action to design shear resistance
δ_{N0}	tensile displacement, short-term
$\delta_{\text{N}\infty}$	tensile displacement, long-term
δ_{V0}	shear displacement, short-term
$\delta_{\text{V}\infty}$	shear displacement, long-term
γ_F	partial safety factor for action, general case
γ_G	partial safety factor for action, permanent action
γ_M	partial safety factor for material, general case

γ_{Mc}	partial safety factor for material, concrete
γ_{Mp}	partial safety factor for material, pull-out
γ_{Msp}	partial safety factor for material, splitting
γ_{Ms}	partial safety factor for material, steel
γ_Q	partial safety factor for action, variable action
ν	global safety factor
ν_{ave}	factor used in determining allowable resistance, from average test result
ν_{low}	factor used in determining allowable resistance, from lowest test result
$\nu_{p, test}$	factor for determining proof test loads
ν_{test}	factor used in preliminary tests to determine N_{test}
Ω	adjustment factor for site conditions

4 Roles and responsibilities

COMMENTARY ON CLAUSE 4

It is vital that all persons and organizations involved in the use of anchors understand their role and responsibilities, in order that the recommendations made in this British Standard can be implemented at each stage of the fulfilment of a project.

A person or organization can take on more than one role.

Any person who at any time changes a specification without notifying the original specifier is deemed to have taken on the role and responsibilities of the specifier (see [4.3](#)).

It is recommended that one person be identified as having overall responsibility for the structure within which an anchorage is expected to function, from commencement of its consideration through the construction stage to commissioning of the building/project. This person will normally be the designer. As certain parts of this activity, such as the specific acts of selection, design and or specification of the anchor itself, may be delegated to others, e.g. specialist subcontractors, the role of specifier is identified so as to set out the responsibilities to be fulfilled by the person with that role. The specifier may be the designer.

The installation of anchors might require the use of procedures or products that are potentially hazardous. Attention is drawn to the Health and Safety at Work, etc. Act 1974 [\[9\]](#).

4.1 Manufacturer/supplier

Anchor manufacturers and suppliers should provide such information as is necessary for the specifier and the installer to ensure the safe selection, specification, installation, use, maintenance, cleaning, dismantling or disposal of the anchor without risk to safety or health.

NOTE See [Clause 6](#) for details of the information to be supplied.

While anchor manufacturers and suppliers may provide advice, for which they should take responsibility, that does not make them the specifier in the context of this British Standard, as they do not have responsibility for the selection of the anchor within the project.

Suppliers of anchors should take care to supply anchors as ordered by customers. Specifications of anchors that have been ordered should not be changed unless the change management procedure in [Clause 10](#) has been followed and the proposed change has been approved by the specifier.

4.2 Designer

The designer should take into account the preliminary design considerations listed in [5.2](#). The designer should also supply all necessary information to the specifier as required to complete the selection process as outlined in [6.3](#).

4.3 Specifier

The specifier should determine the most appropriate anchor for the particular application, by following the selection process given in [Clause 5](#) and using the appropriate design method for that anchor.

NOTE 1 Guidance on design methods is given in [Annex A](#).

The specifier should seek technical assistance from the manufacturer/supplier where necessary and, if the specifier is not the designer, should seek information from the designer as recommended in [6.3](#). The selection process should take into account the most onerous loads to which the anchor might be subjected, and the direction of the loads, including temporary loading applied during the erection phase.

Once the selection and design processes are completed, the specifier should specify the anchor explicitly and completely, so that the anchor installed on site fulfils the design criteria (see [5.5](#) and [6.4](#)).

If any party proposes an alternative anchor to that specified, the specifier should ensure that the change management procedure outlined in [Clause 10](#) is carried out.

If for any reason the specifier determines that site tests of anchors are needed, then the need for such tests should be communicated to all relevant parties, e.g. the contractor and tester, so that they know the objective of such tests and when they are to be carried out, and that they have all the necessary data to carry out such tests (see [6.6](#)). The specifier should then ensure that any actions consequent on the results of such tests are put in hand.

NOTE 2 In the case of tests to determine the allowable resistance, this might mean that the proposed anchor is confirmed as the specified anchor, or that it is not suitable and an alternative anchor is to be proposed and, possibly, tested. In the case of proof tests, it might mean confirmation to the contractor and installer that the quality of installation has been proven to be satisfactory and no further action is necessary, or that it has been found to be unsatisfactory and that specified remedial action is needed.

4.4 Contractor

The contractor should ensure that the specified anchor is procured and that the installer is trained for the correct installation of that anchor type. In addition, the contractor should ensure that the installer is working under competent supervision. If any party proposes an alternative anchor to that specified, the contractor should ensure that the specifier or other responsible person carries out the change management procedure outlined in [Clause 10](#).

It is essential that the contractor is satisfied at the time of installation of anchors that the strength of the base material is at least that assumed by the specifier in the design and selection of anchors. If not, the contractor should liaise with the specifier and await instructions.

If site tests are deemed necessary, the contractor should ensure that the required tests are carried out by a competent tester, using the appropriate procedure as set out in [Annex B](#) and in the location prescribed by the specifier or a location appropriate to the test objective. The contractor should also ensure that the information required by the tester is communicated to them before the tests are carried out, and that the results of the tests are communicated to the specifier and recorded in project documentation. They should ensure that any actions deemed necessary following such tests are carried out.

4.5 Installer

The installer should familiarize themselves with the correct installation procedures. Installation of anchors should be undertaken only by installers who have received adequate training from a competent trainer.

The installer should ensure that the correct drilling and setting tools are available for the proper installation of the anchor. The installer should comply in all respects with the manufacturer's installation instructions and material safety data sheets.

The installer should not proceed with the installation of the anchors if, due to site conditions, e.g. hitting reinforcement during drilling, the anchors cannot be set in accordance with the manufacturer's instructions. Any conflict should be referred back to the specifier and, if necessary, the anchor supplier, so that a solution can be designed and an alternative anchor or an alternative method can be specified (see [Clause 10](#)).

If the installer is required to install anchors specifically for the purpose of tests, they should ensure that the anchors are installed in the locations prescribed by the specifier or contractor.

4.6 Supervisor

The supervisor should ensure that the anchors have been installed in accordance with the manufacturer's instructions and the design criteria, and should complete certification of the completed anchorage to that effect (see [Clause 8](#)). The supervisor should ensure that the installer is aware of the consequences of failing to adhere to the correct installation instructions.

In the case of small projects, the role and responsibilities of the supervisor may be undertaken by the installer if so authorized by the contractor.

4.7 Tester

Where deemed necessary, the tester should carry out tests using the appropriate procedure as set out in [Annex B](#). The tester should ensure that the anchors are installed in accordance with the manufacturer's installation instructions and in the test locations prescribed by the specifier or other person responsible for the supervision of the tests, e.g. contractor. The tester should record results in a full and comprehensive manner and communicate them to the specifier or responsible person requesting the tests.

5 Selection and specification of anchors

COMMENTARY ON CLAUSE 5

The term "selection" is used for the overall process of choosing an anchor, including both type and size, and within that process the term "design" is reserved for the specific process of determining the size of anchor required.

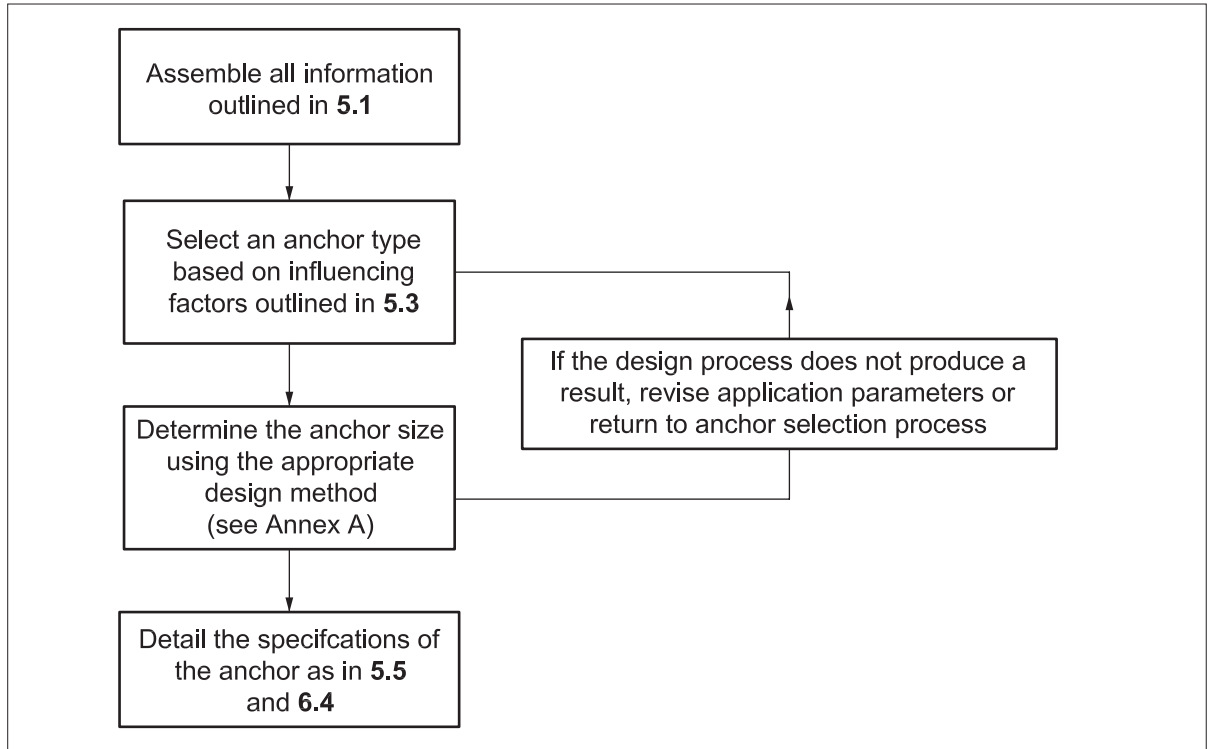
The selection of an anchor for any application, and especially those which are safety-critical, requires consideration of a great many different factors which can broadly be divided into two main subjects, with some overlap:

- a) *those to do with determining the type of anchor, including its suitability for the base material concerned, its ability to cope with various environmental factors (temperature, humidity, fire) and its fitness for the practicalities of the application, e.g. the need for immediate loading, the need to be installed through the fixture or to be removable after use or even reused. These aspects are dealt with in 5.3 and different anchor types are described in [Annex C](#);*

- b) those to do with determining the size of the anchor (diameter and length) – the process known as design. This process is essentially governed by the actions to be carried and the chosen anchor's resistance needed to withstand those actions. These aspects are discussed in [5.4](#) and [Annex A](#).

The selection process is summarized in [Figure 2](#).

Figure 2 — Flowchart for selection process



5.1 Information to be assembled

In order to undertake the anchor selection process, a minimum amount of information should be assembled beforehand by the specifier. This should include:

- project details;
- the design actions applied to the anchor and their nature (static/dynamic etc.);
- details of the base material type, thickness and likely strength at the time of installation, including condition of the concrete in the area of anchorages, i.e. cracked or non-cracked;
- preferred edge distance and centre spacings;
- details of the base plate, material and thickness, and proposed hole diameter;
- possible need for shims or grouting;
- environmental conditions including elevated temperatures or fire rating requirements, corrosion conditions and required durability, likely temperature at time of installation (only if resin bonded anchors are being considered);
- details of the type of anchor being considered;
- the European Technical $\boxed{A_1}$ Assessment $\langle A_1 \rangle$ (ETA) of the anchor, in its most up to date edition, if it has one;
- manufacturer's software for the selection of the anchor being considered;
- manufacturer's technical catalogue if no ETA or software is available;
- the results of the preliminary design considerations (see [5.2](#)).

5.2 Preliminary design considerations

The following three aspects should be assessed by the designer, before the specifier determines the choice of anchor.

a) **Ability of the structure to sustain the design actions.**

The designer should confirm that the structure to which the fixture is to be attached has the ability to sustain the design action. The application of test loads with test equipment which directs reaction loads into the structure will not inform this decision.

b) **Concrete status.**

The designer should determine the status of the concrete in the area of the anchors, i.e. is it cracked or non-cracked, in line with [5.3.3.2.2](#). If this cannot be determined then cracked concrete should be assumed.

c) **Robustness, redundancy and progressive collapse**

The designer should assess the level of robustness (see [3.1.37](#)) required for the anchorage(s) and take account of the following factors:

- sufficient redundancy is needed in the system such that one isolated failure of an anchorage does not result in the overloading of other anchorages, leading to progressive collapse;
- appropriate material specifications are needed for anchorages where this is relevant to load patterns, substrate conditions or corrosion control, due to environmental conditions;
- anchorages working in shear often have a greater robustness compared to anchors working in pure tension, e.g. there might be an option, when locating top fixings for a suspended ceiling, of fixing into a vertical rather than a horizontal surface.

To ensure robustness from the point of view of anchors, and to avoid failures generally, it is necessary to determine whether or not the application is statically determinate or statically indeterminate, as anchors may be qualified in relation to these definitions and this feature is fundamental to the selection of properly qualified anchors (see [Annex D, Figure D.1](#) and [Figure D.2](#)).

Applications in which the failure of any anchor supporting the fixture will lead to its collapse are referred to as being “statically determinate” (see [3.1.43](#)), while those which have been designed with sufficient redundancy (see [3.1.36](#)) that the failure of one anchor will not lead to progressive collapse (see [3.1.32](#)) are referred to as “statically indeterminate” (see [3.1.44](#)). The majority of applications are statically determinate. If determinacy is not known then anchors qualified for statically determinate use should be selected.

NOTE 1 The majority of anchors with an ETA are qualified for statically determinate use. The status of different $\boxed{A_1}$ EADs $\langle A_1 \rangle$ in relation to statical determinacy is indicated in the CFA Guidance Note ETAs and design methods for anchors used in construction [1]³⁾.

NOTE 2 If the application conforms to the definition of “multiple use” (see [3.1.26](#)) as defined in $\boxed{A_1}$ EAD 330747-00-061 [6] $\langle A_1 \rangle$ or in ETAG 20 [7]³⁾, then it can be regarded as statically indeterminate, and anchors conforming to those $\boxed{A_1}$ EAD or $\langle A_1 \rangle$ ETAGs may be specified without the need for special consideration of the stiffness of the supported structure.

Applications vulnerable to progressive collapse (including suspended ceilings, and suspended services such as pipework, ductwork or cable tray), and which do not satisfy the preconditions of multiple use, should be designed using anchors qualified for statically determinate use.

³⁾ $\boxed{A_1}$ ETAG 020 will be replaced by EAD 330284-00-0601 [29], but at the time of publishing of this British Standard has not, as yet, been implemented. $\langle A_1 \rangle$

NOTE 3 Guidance on robustness is given in the ISE publication *Practical guide to structural robustness and disproportionate collapse in buildings* [10].

5.3 Factors determining anchor type

5.3.1 General

The specifier should determine the type of anchor to be specified, taking account of the factors described in 5.3.2 to 5.3.6, along with the features and capabilities of the different anchor types as outlined in Annex C.

5.3.2 Anchor reliability

Specifiers should satisfy themselves that the selected anchor will function reliably in the range of conditions which could be encountered on site.

NOTE Factors which can influence the performance of an anchor include its tolerance to drilled hole diameter, its functioning in concrete of different strengths and at different installation or service temperatures, and, depending on the type of anchor, its tolerance to likely variations in the installation method, e.g. tightening torque (torque-controlled anchors), hole cleaning, reliable formation of an undercut (undercut anchor), etc. One means of ensuring that all such factors have been taken into account is to select an anchor conforming to an ETAG appropriate to the application.

5.3.3 Base material

5.3.3.1 General

Not all anchors work in all base materials, so the specifier should ensure that the proposed anchors are suitable for the base material concerned.

NOTE Guidance on concrete is given in 5.3.3.2, and on masonry in 5.3.3.3.

5.3.3.2 Concrete

Product certification/inspection/testing. Users of this British Standard are advised to consider the desirability of selecting anchors with a European Technical $\boxed{A_1}$ Assessment $\langle A_1 \rangle$ (ETA)⁴⁾. Annex D, Figure D.1 shows the selection process for anchors in concrete with and without an ETA.

5.3.3.2.1 Structural form

The specifier should evaluate the type and strength of concrete structure, as there might be factors which could influence the choice of anchor or its positioning.

- a) **In-situ cast concrete.** This is the most commonly encountered concrete structure for which most anchors, claimed by the manufacturer to be suitable for concrete, are expected to work. All of the issues described in 5.3.3.2.2 to 5.3.3.2.5 should be taken into account when selecting anchors to be installed in in-situ cast concrete. Anchor positions should be specified so as not to damage any embedded reinforcement/pre-stressing steel.
- b) **Pre-cast concrete.** Again, most anchors claimed by the manufacturer to be suitable for in-situ cast concrete are expected to work in solid pre-cast concrete. Pre-cast components are likely to have reinforcement, which may be either passive or pre-stressed. Anchor positions should be specified so as not to damage any embedded reinforcement/pre-stressing steel. For pre-cast sections that are hollow, special anchors might be needed.
- c) **Concrete blocks.** The factors outlined for masonry should be taken into account when selecting anchors to be installed in concrete blocks.

⁴⁾ $\boxed{A_1}$ Text deleted. $\langle A_1 \rangle$

5.3.3.2.2 Cracked/non-cracked concrete

COMMENTARY ON 5.3.3.2.2

Concrete is likely to be cracked from a variety of causes including stress conditions inherent in the structure, those induced by characteristic permanent actions and characteristic variable actions, thermal movements, shrinkage and the restraint of deformation. Anchors qualified for use in cracked concrete are expected to function reliably in the expected widths of cracks developed as a result of tensile stresses in concrete structures designed in accordance with [BS EN 1992](#). In the region of an anchor, the concrete might be cracked or non-cracked.

Anchors should be chosen that are suitable for use in cracked or non-cracked concrete, as appropriate. The specifier should assume the concrete to be cracked unless an exercise has been carried out to determine whether it is cracked or non-cracked (see Note 2).

NOTE 1 Anchors conforming to [A1](#) EAD 330232-00-0601 [8] and EAD 330499-00-0601 [11], options 1 to 6, and to EAD 330747-00-0601 [6] [A1](#), are suitable for use in concrete which is cracked or non-cracked. Anchors conforming to [A1](#) EAD 330232-00-0601 [8] and EAD 330499-00-0601 [11], [A1](#) options 7 to 12 are suitable for use only in concrete which is non-cracked.

NOTE 2 Under some conditions, e.g. restricted structural dimensions, the higher performance allocated to anchors in non-cracked concrete might warrant carrying out the necessary stress analysis to prove that the concrete is non-cracked and utilize the higher performance available for use in that condition. [A1](#) BS EN 1992-4 [A1](#) includes a means of determining this by stress analysis. In certain structures the designer might, by experience, be able to declare the concrete to be non-cracked.

5.3.3.2.3 Concrete strength

COMMENTARY ON 5.3.3.2.3

Concrete strength is quoted in terms of its compressive strength as measured either from cubes, $f_{ck,cube}$ or from cylinders, $f_{ck,cylinder}$, but most commonly these two designations are combined in a reference to strength classes according to BS EN 206, e.g. C20/25, which denotes respectively the mean cylinder and cube strengths in N/mm².

Manufacturers' performance values are generally quoted for a concrete base material, usually at least C20/25. However, certain options in [A1](#) EAD 330232-00-0601 [8] and EAD 330499-00-0601 [11] [A1](#) allow for increased capacities for higher concrete strengths up to C50/60, and in [A1](#) EAD 330747-00-0601 [6] [A1](#) for concrete strengths as low as C12/15. If the specifier has assumed a concrete compressive strength greater than the minimum allowed by the manufacturer, then it is important that this information is communicated to the installer (see 6.4) so that the installer can check that the assumed strength has been reached prior to the time of installation (see 7.4).

When selecting anchors for use in concrete structures where the concrete strength is not known, the design should be carried out with data published for the lowest concrete strength, typically C20/25, as most concrete is likely to be stronger than this in practice.

5.3.3.2.4 Structural dimensions

Specifiers should take into account the following dimensional limitations of the structure, as these limitations affect anchor performance.

a) Edge and spacing parameters.

All anchors require an amount of the base material around them, to support the forces induced during their installation and/or those transferred from the fixture in service. Data should be acquired from the manufacturer identifying the edge distances and centre spacings that will provide full performance (characteristic edge distance, c_{cr} , or characteristic spacing, s_{cr}), and

absolute minimum dimensions (minimum edge distance, $c_{\min}$, or minimum spacing, $s_{\min}$), for which performance should be reduced according to the prescribed design model (see [Figure 3](#)).

NOTE 1 Anchors conforming to [A1](#) EAD 330232-00-0601 [8] and EAD 330499-00-0601 [11] [A1](#) will, depending on their option, include this data. Some options allow design using minimum dimensions, while others allow anchors to be specified only at the critical distances with no closer dimensions allowed.

There is, however, a relationship between the anchor spacing and the edge distance. It might not be possible to use the minimum edge distance, $c_{\min}$, simultaneously with the minimum spacing, $s_{\min}$.

Minus tolerances should not be specified.

b) **Embedment depth.**

The embedment depth should be taken into account in the calculation of tensile resistance of the anchor.

The embedment depths quoted by manufacturers may be measured from the surface of the load-bearing structure to either the deepest point of engagement of the anchor with the base material, h_{ep} , or to the deepest part of the anchor, h_{nom} . (See [7.3.3](#).) Any non-load-bearing element, such as a screed topping, plaster or render, should be regarded, not as part of the base material and therefore not contributing to the embedment depth, but as part of the fixture and an anchor should be chosen with sufficient fixture thickness capability.

The concrete cone resistance for all anchors is influenced by the effective embedment depth, h_{ep} , from which the failure cone emanates. The deeper the effective embedment, the larger the cone and the higher the characteristic tensile resistance, N_{Rk} (see [Figure 4](#)), until the mode of failure changes, e.g. from concrete cone failure to steel failure.

The size of the concrete cone is a function of the anchor's embedment depth; this also means that the deeper the anchor is set, the greater the critical anchor spacing and edge distance becomes. When anchors are in groups, the negative effect from edge and spacing criteria might negate any increase in performance gained from deeper embedment.

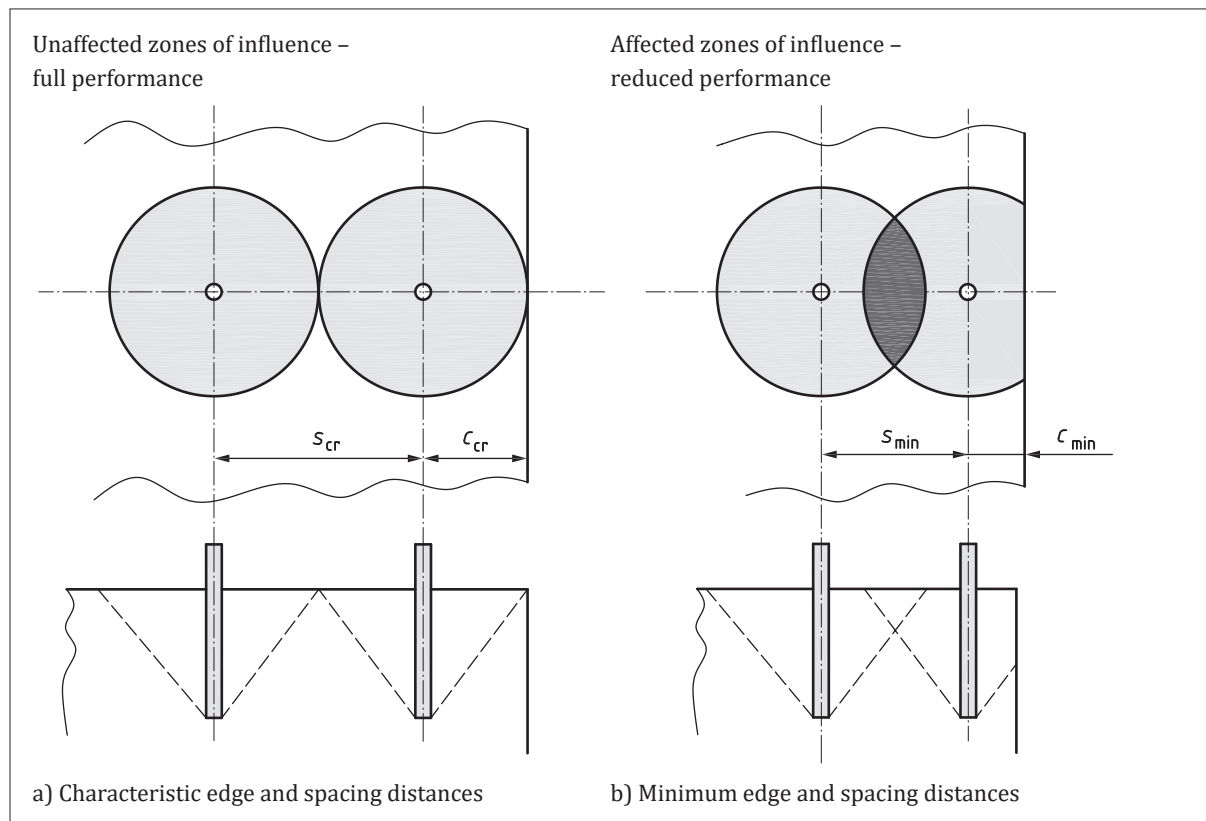
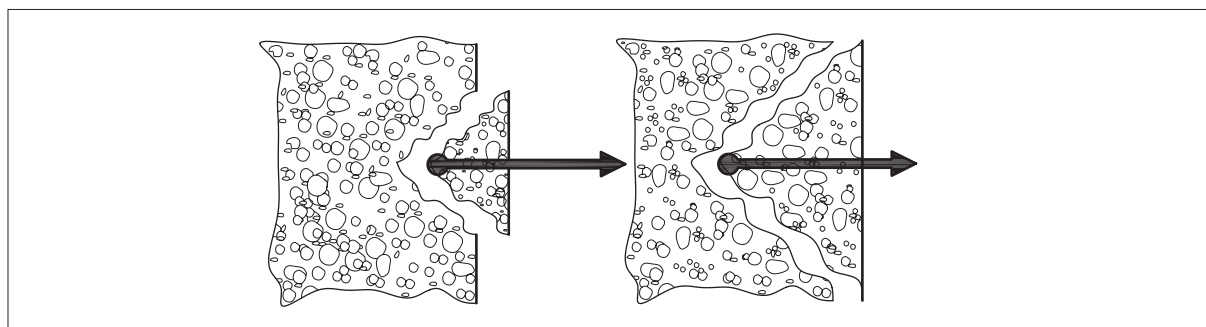
c) **Structural thickness.**

Some anchors require the structural thickness, h , to be very little thicker than the embedment depth of the anchor in order to transfer their rated performance into the structure (e.g. bonded anchors, see [C.1.4](#)), while others, such as torque-controlled expansion anchors (see [C.1.1](#)) need an increased thickness. Others (e.g. deformation-controlled expansion anchors, see [C.1.3](#)) need even more to sustain the impact loads of the anchor being set. Also, for most anchors, there needs to be sufficient material behind the drilled hole to avoid the spalling of the back of the concrete due to the hammer action of the drilling operation; the manufacturer's instructions should be followed.

NOTE 2 A typical allowance is twice the drill diameter, d_o , or at least 30 mm.

If compressive actions are to be transferred through the anchor (see [5.3.4.2.4](#)), this too needs to be taken into account in the overall structural thickness.

Specifiers should check that the minimum structural thickness, as required by the manufacturer for the proposed anchor, is available.

Figure 3 — Characteristic and minimum edge and spacing dimensions**Figure 4** — The relationship between embedment depth and concrete cone failure

5.3.3.2.5 Reinforcement

COMMENTARY ON 5.3.3.2.5

The performance of anchors is usually quoted by manufacturers for non-reinforced concrete. However, reinforcement is required in concrete for many reasons and will usually be present. There are advantages in sufficient (and fully tied) edge reinforcement, although this can impose further restrictions on locating anchors in these areas. This reinforcement provides a design benefit, but only in cracked concrete conditions and then only in shear towards an edge. In the case of densely reinforced structures, anchors with shallow embedment depths might be negatively affected.

Specifiers should take into account the likelihood of reinforcement being encountered during drilling and set out the action to be taken by the installer in that case. Options include the possibility of drilling through the reinforcement, if that will not be detrimental to the structure and if the specifier is satisfied that the anchor will still function despite the reinforcement. Anchors conforming to an **A1** EAD **A1** can be expected to function in a hole drilled in contact with rebar. This avoids the need for repositioning anchors, which invariably means designing and fabricating new brackets or moving the complete fixture.