ETAG 001

GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL
OF
METAL ANCHORS
FOR USE IN CONCRETE

Part five: BONDED ANCHORS
Edition March 2002
1st Amended November 2006
2nd Amended February 2008
3rd Amended April 2013

INTRODUCTORY NOTES

In this Part requirements, criteria and test information applicable only for bonded anchors are given. They may be additional to Part 1 or may replace the provisions in Part 1. The same numbering of paragraphs as in Part 1 is used. If a paragraph is not mentioned, then the text in Part 1 applies without modification.

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PART FIVE:

BONDED ANCHORS

2 SCOPE

2.0 General

This Part of the Guideline is for bonded anchors consisting of a bonding material and an embedded metal part. In general bonded anchors are supplied and used as a unit. However, if the metal part is specified by the manufacturer of the bonded anchor according to a European or ISO Standard as embedded part, then this part may be supplied by another party. This Guideline does not cover products intended for the repair of reinforced concrete.

2.1 Anchors

2.1.1 Types and operating principles

This Guideline covers bonded anchors with the following mixing and installation techniques:

Mix proportions

- Only those bonded anchors in which the mix proportions are controlled by the anchor are covered.
  This includes, for example, the following types: glass capsule, soft-skin capsule, pre-packed injection (coaxial or side by side) cartridges, bulk with mechanical proportioning and bulk where all components are mixed exactly as supplied.
  Note:
  Systems where the mix proportions are controlled by the installer, such as the bulk type where component volumes have to be measured by the installer, are not covered.

Mixing techniques

- controlled by anchor, e.g. injection cartridge with static mixer nozzle, bulk type with mechanical mixing.
-. controlled by the installer - e.g. bulk type mixed in the pot.
- controlled during installation - e.g. capsule type

Volume of placed bonding material

- controlled by the anchor, e.g. capsule type.
- controlled by the installer, e.g. injection and bulk types.

Drilled hole

- cylindrical hole
- undercut hole.

Drilling techniques

- rotary hammer (electric drilling machine or driven by compressed air)
- diamond drilling.

Installation techniques

- Capsule placed in the hole and embedded part driven by machine with simultaneous hammering and turning (Figure 2.2a).
- Bonding material injected into the hole. Embedded part may be inserted manually or mechanically (Figure 2.2b).
- Bonding material poured into the hole and embedded part inserted (Figure 2.2c).

Anchor installation may be independent of torque control or dependent on torque control.

Operating principles

- Bonded anchor: placed in cylindrical hole and anchored by bonding the metal parts to the sides of the drilled hole.

- Undercut bonded anchor: placed into an undercut hole; the load transfer is a combination of bonding the metal parts to the wall of the hole and mechanical interlock of the mortar with the undercut in the concrete.

- Torque-controlled bonded anchor: placed into a cylindrical hole, the load transfer is a combination of bonding and expansion, where the expansion is achieved by a special rod.
- Post-installed rebar connections: straight ribbed reinforced bar placed into a cylindrical hole. The post installed rebar connections are designed according to Eurocode 2 and ETA based on TR 023.

The test programme for "Torque-controlled bonded anchor" is specified in Technical Report TR 018 and the test programme for "Post-installed rebar connections" is specified in Technical Report TR 023 to this Part of ETAG.
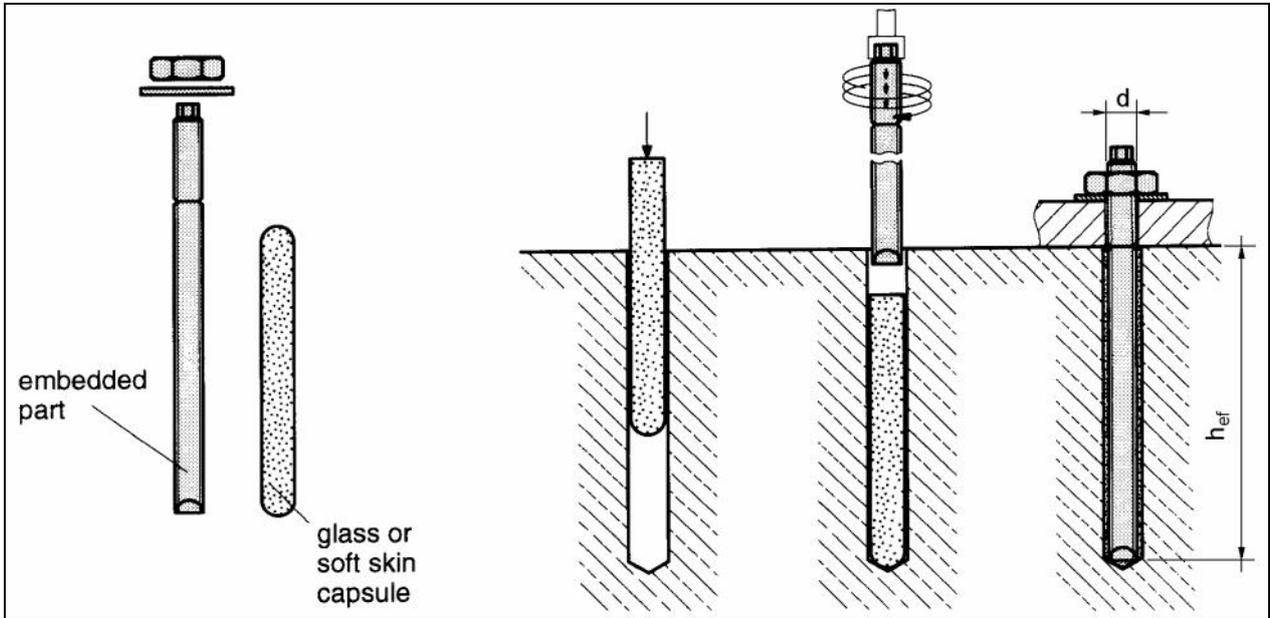
a)   capsule type
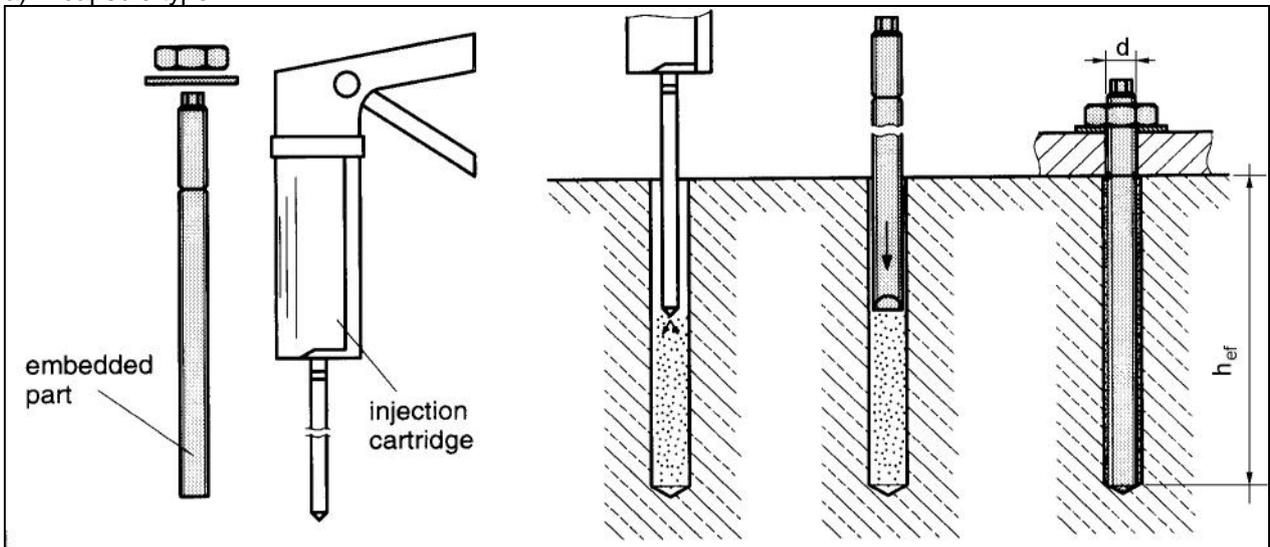
b)   injection type
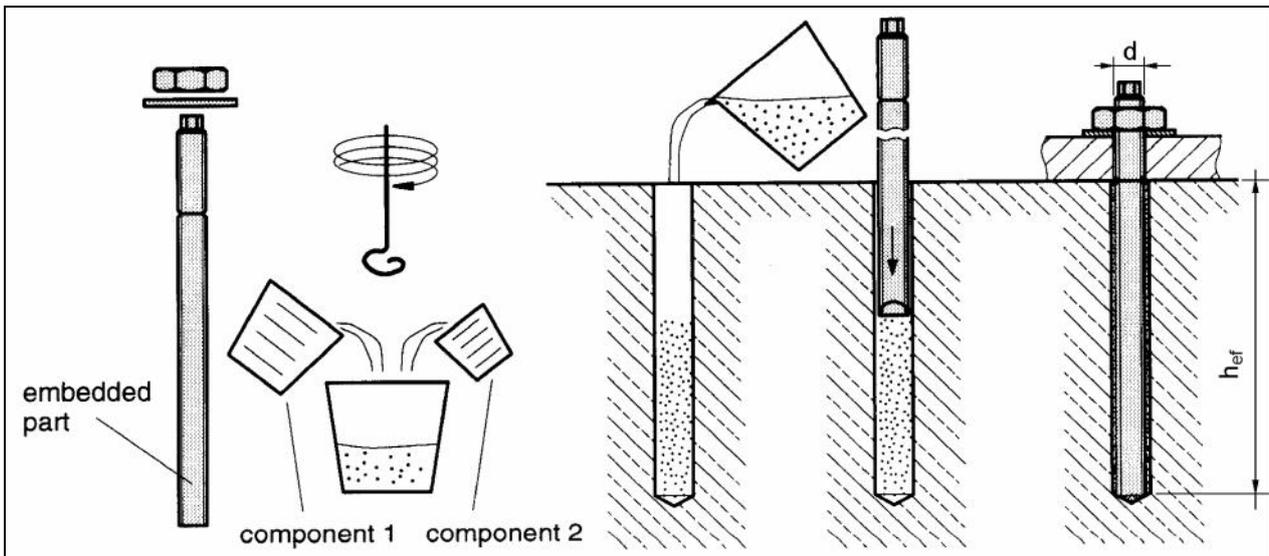
c) bulk type

Figure 2.2   Examples of installation techniques (bonded anchors)

The following default values for the minimum embedment depth shall be used:

d   10mm h_{ef} = 60 mm
    12mm h_{ef} = 70 mm
    16mm h_{ef} = 80 mm
    20mm h_{ef} = 90 mm
    24mm h_{ef} = 4d

Lower values of minimum embedment depth are possible only if 20 tests at least be carried out with quadruple anchor groups according to ETAG 001, Annex A, 5.2.2. These 20 tests could be made with each 5 tests with the smallest 4 sizes; the requirements of ETAG 001 Part 1, 6.1.2.2.3 have to be fulfilled for all anchor sizes.

The embedment depths in the ETA may not be less than the minimum values 40 mm and 4d.

2.1.2   Materials

The bonding materials may be manufactured from synthetic mortar, cementitious mortar or a mixture of the two including fillers and/or additives.

The packaging systems may be glass capsule, soft-skin capsule, cartridge or bulk.

The embedded parts of the anchor may be threaded rod, deformed reinforcing bar, internally threaded socket or other shapes.

If embedded parts are commercial standard rods supplied by another party as the approval holder (e.g. manufacturer of standard rods), then the following conditions have to be fulfilled:

- Material, dimensions and mechanical properties of the metal parts according to the specifications given in an Annex of the ETA
- Confirmation of material and mechanical properties of the metal part by inspection certificate 3.1 according to EN 10204: 2004; the documents shall be stored.
- Marking of the rod with the envisage embedment depth. This may be done by the manufacturer of the rod or the person on job site.

2.2   Concrete

2.2.2   Concrete members

Part 5 applies to applications where the minimum thickness of members in which anchors are installed is
h ≥ 100 mm.

The minimum member thickness depends on application parameters and it is given by:
        h = h_{ef} + Δh   ≥ 100 mm
The values given for Δh under (a) and (b) are valid for holes drilled with electrical hammer drilling machines and diamond drilling. For compressed air drilling these values shall be evaluated by tests.

(a) $\Delta h \geq 2d_o$
        ≥ 30 mm
        Applicable to all anchor types. No application restrictions.

(b) $\Delta h \geq d_o$
        ≥ 15 mm
        Applicable to all anchor types.
        This may be applied where the remote face of the concrete member is accessible and can be inspected to ensure there has been no break-through. In case of a break-through, measures shall be taken to ensure that the full bonded length, h_{ef}, will be achieved and any potential loss of bonding material, for instance due to spalling, shall be compensated for. When this is not possible, e.g. with capsule anchors, then the hole shall be redrilled at a distance according to Part 1, 7.3.

(c) $\Delta h = 0$
        Applicable to injection type anchors.
        This may be applied where it can be ensured that the full bonded length, h_{ef}, will be achieved, and compensation shall be made for any potential loss of bonding material.

Option a) is mandatory.
The manufacturer may additionally apply for an ETA to options (b) or (c). In those tests where minimum member thickness is required, they shall be carried out with each anchor size in its minimum member thickness.

2.3   Actions

In contrast to Part 1, the transmission of compressive forces on the anchor is allowed.

2.4   Categories

In contrast to Part 1, it is necessary to consider the different intended uses according to installation or service conditions in the base material.

use category **1**:   Installation in dry or wet concrete
                   Service condition in dry or wet concrete

use category **2**:   Installation in dry or wet concrete or in a flooded hole (not sea water)
                   Service condition in dry or wet concrete or under water (not sea water)

3   TERMINOLOGY

3.2   Particular terminology and abbreviations

3.2.1   General (additional terms)

<u>Service temperature range:</u> Range of ambient temperatures after installation and during the lifetime of the anchorage.

<u>Short term temperature:</u> Temperatures within the service temperature range which vary over short intervals, e.g. day/night cycles and freeze/thaw cycles.

<u>Maximum short term temperature:</u> Upper limit of the service temperature range.

<u>Long term temperature:</u> Temperature, within the service temperature range, which will be approximately constant over significant periods of time. Long term temperatures will include constant or near constant temperatures, such as those experienced in cold stores or next to heating installations.

<u>Maximum long term temperature:</u> Specified by the manufacturer within the range of 0,0,6 times to 1,0 x times the maximum short term temperature.

<u>Normal ambient temperature:</u> Temperature 21 °C $\pm$ 3 °C (for test conditions only)

<u>Open time</u>: The maximum time from end of mixing to when the insertion of the anchor into the bonding material shall be completed.

<u>Installation ambient temperature range</u>: The environmental temperature range of the base material allowed by the manufacturer for installation.

<u>Anchor component installation temperature range</u>: The temperature range of the bonding material and embedded part immediately prior to installation.

<u>Curing time</u>: The minimum time from the end of mixing to the time when the anchor may be torqued or loaded (whichever is longer). The curing time depends on the ambient temperature.

4 REQUIREMENTS FOR WORKS

4.1 Mechanical resistance and stability (ER 1)

4.1.1.2 Temperature

<u>Service temperature range</u>

The functioning of a bonded 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 concrete near to the surface within a temperature range to be specified by the manufacturer which may be either:

(a)   - 40 °C to   + 40 °C (max short term temperature + 40 °C and max long term temperature + 24 °C)
(b)   - 40 °C to   + 80 °C (max short term temperature + 80 °C and max long term temperature + 50 °C)
(c)   on manufacturers request with –40 °C to T1 (short term:T1>+40 °C, long term:0,0,6 T1 to 1,0 T1)

In general bonded anchors are not affected by service temperatures down to - 40 °C. If there is no experience for unknown bonding materials on their performance at - 40 °C then normal pull-out tests at - 40 °C will be required.

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 5.1.3.1(a) and 5.1.2.5.

<u>Installation temperature range and curing time</u>

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, lowest and highest anchor component installation temperatures and associated curing times.

Performance at lowest installation temperature and at normal ambient temperature is checked by tests as described in 5.1.3.1(b) and 5.1.3.1(c). The manufacturer has to provide corresponding data for the upper installation temperature limit and the associated curing times and for temperatures in between.

4.1.2.1 Correct installation

In addition to the requirements of Part 1, 4.1.2.1:
Dependent on the applications as specified by the manufacturer, it shall be possible to install anchors in dry and wet concrete (use category 1 according to 2.4) or in dry and wet concrete and in a flooded hole (not sea water)(use category 2 according to 2.4) and also in the specified installation directions with the drilling techniques specified by the manufacturer.

4.3 Hygiene, health and the environment

4.3.1 Content and /or release of dangerous substances

The applicant shall either
   - submit the chemical constitution and composition of the product and/or constituents of the product to the Approval Body which will observe strict rules of confidentiality
or

- submit a written declaration to the Approval Body stating whether or not and in which concentration the product and/or constituents of the product contains substances which have to be classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the EGDS - taking into account the installation conditions of the construction product and the release scenarios resulting from there.

The use of recycled materials shall always be indicated, because this could lead to the implementation of further assessment and verification methods.

The information concerning the presence of dangerous substances listed in Council Directive 67/548/EEC and Regulation (EC) No 1272/2008 regulated at European level and listed in the "Indicative list on dangerous substances" of the EGDS (Expert Group on Dangerous Substances of the EU Commission) and/or of other dangerous substances, shall be circulated as part of the evaluation report by the issuing Approval Body to the other Approval Bodies, under strict conditions of confidentiality.

5   METHODS OF VERIFICATION

5.0   General

In this section two test methods are distinguished: unconfined tests (see Figure 5.1) and confined tests (see figure 5.2). Unconfined tests allow an unrestricted formation of the rupture concrete cone. They are performed according (see figure 5.1) to Annex A, 4. In confined tests concrete cone failure is eliminated by transferring the reaction force close to the anchor into the concrete.
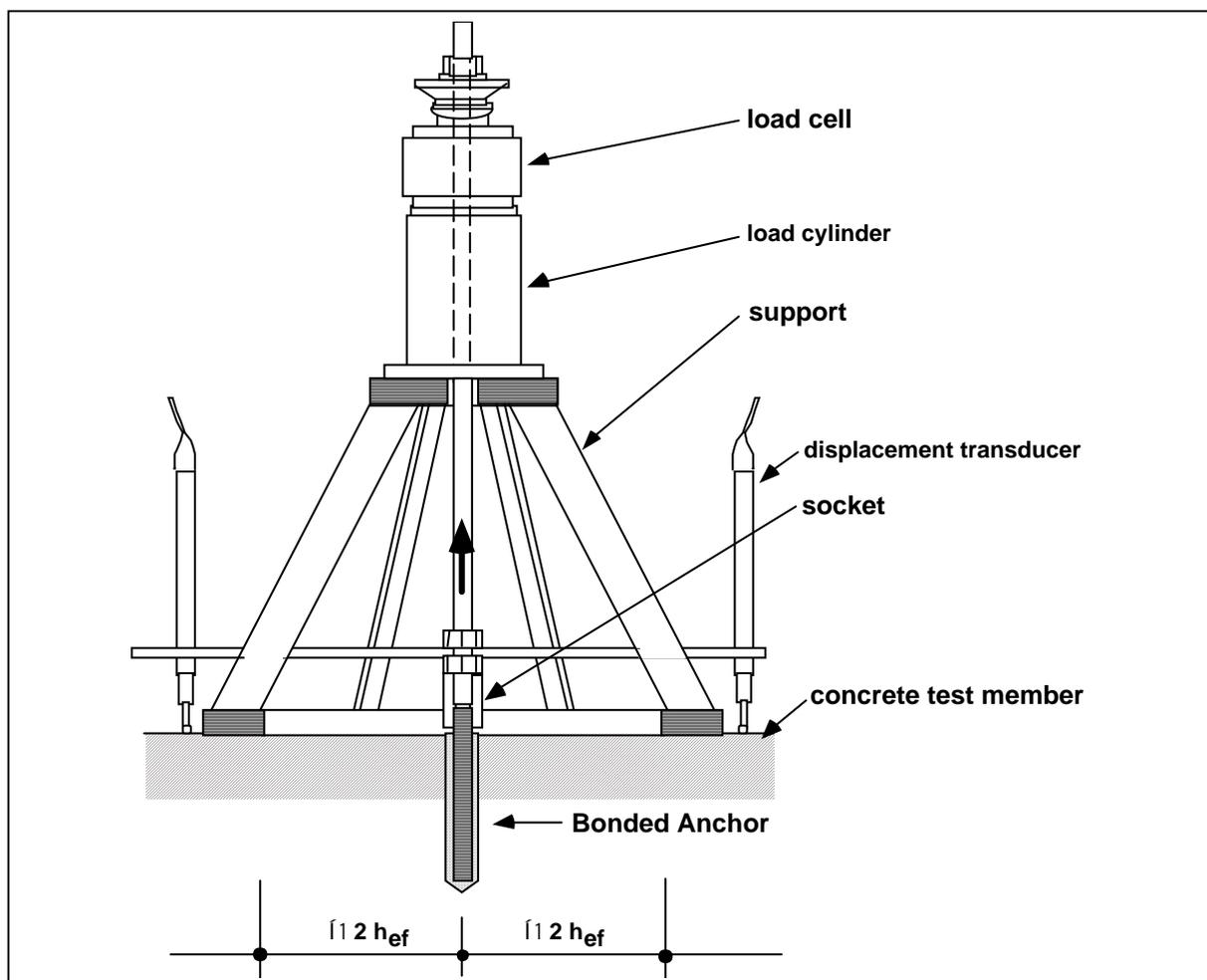

Figure 5.1   Example of a tension test rig for <u>unconfined</u> tests

The rig - steel plate shall be stiff and the area of support large to avoid high compression of the concrete. Recommendation: compression strength under the steel plate < 0,7 of the concrete compression strength.
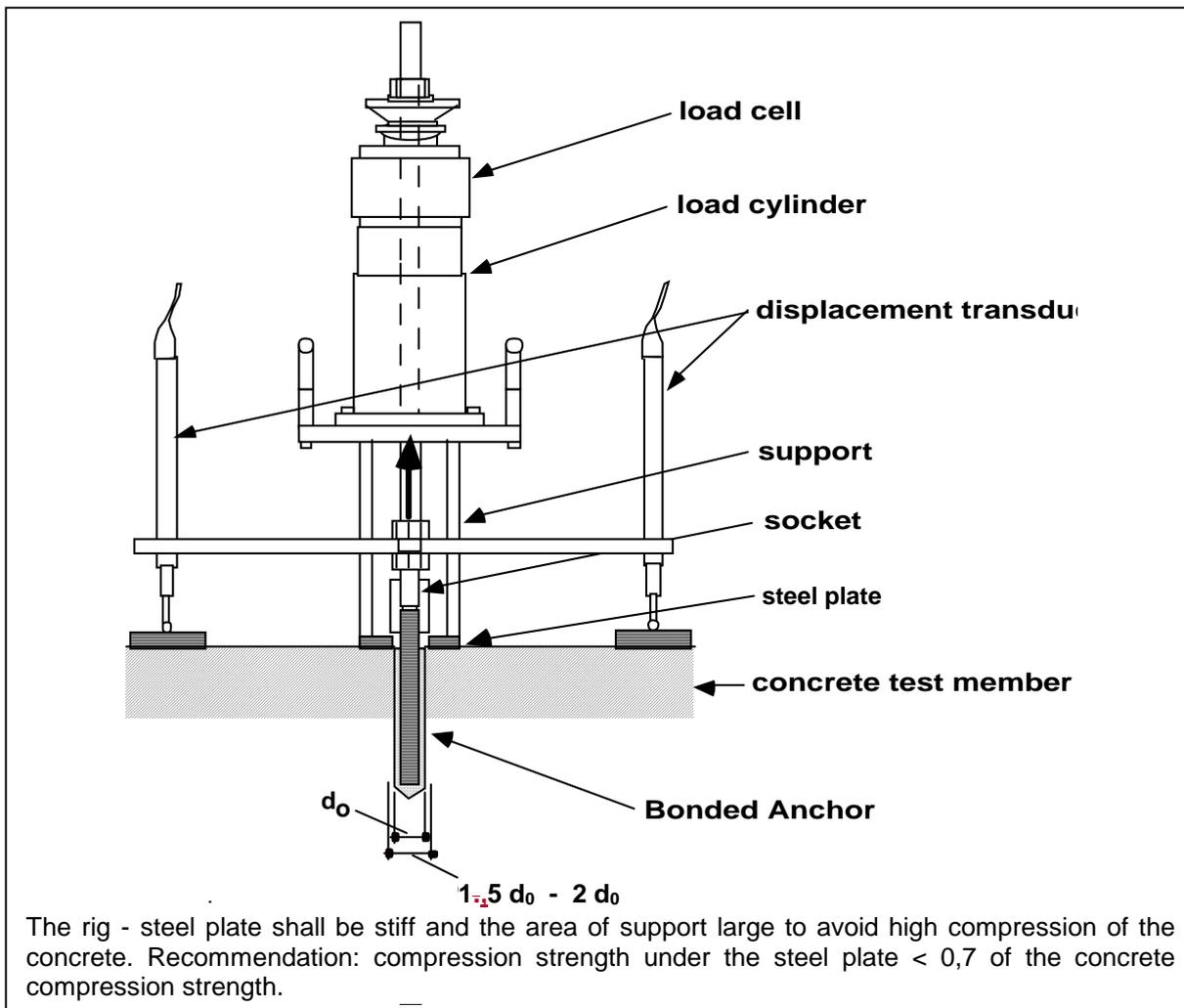
Figure 5.2   Example of a tension test rig for <u>confined</u> tests

5.1   Methods related to 4.1 (mechanical resistance and stability)

5.1.1   General

Under tension loading bonded anchors may show "combined pull-out and concrete cone failure", "concrete cone failure", "steel failure" and "splitting failure".

The failure mode "combined pull-out and concrete cone failure" is characterized by pulling the embedded part (with or without the surrounding mortar) out of the concrete. Depending on various influencing factors single anchors and especially anchor groups may show combined pull-out and concrete cone failures starting from <u>any point</u> along the embedment depth.

The failure mode "concrete cone failure" is characterized by a concrete failure starting from the <u>deepest point</u> of embedment. This failure mode may be observed for single anchors or anchor groups with or without an influence of edge distances. The concrete cone failure mode shows the highest possible resistance of bonded anchors and may be predicted according to current experience as given for torque controlled expansion anchors (ETAG 001, Part 2) or undercut anchors (ETAG 001, Part 3).

"Steel failure" or "splitting failure" may limit the resistance of bonded anchors compared to the resistance of "combined pull-out and concrete cone failure" or "concrete cone failure".

In the required tests various influencing factors on the performance of bonded anchors are checked (suitability tests: e.g. hole cleaning, mixing technique, tests for admissible service conditions: e.g. temperature effects, durability tests). In general these influencing factors are only related to "combined pull-out and concrete cone" resistance and not to the other failure modes as "concrete cone", "steel" or "splitting failure" (e.g. tension tests with "concrete cone failure" at 20° C and "concrete cone failure" at 80° C show same performance). By varying

the influencing factors the failure mode may change (e.g. tests with "concrete cone failure" at 20° C and "combined pull-out and concrete cone failure" at 80° C show lower performance at 80° C). If the tests are performed in such a way that "combined pull-out and concrete cone failure" is observed (e.g. at 20° C and 80° C) the largest difference in performance is observed. This influencing factor is decisive for the evaluation of a bonded anchor system.

So the main aim of the test regime is to establish a resistance for "combined pull-out and concrete cone failure" - if required, modified by the influencing factors-, which is published as τ_{Rk} in the ETA. The characteristic bond resistance allows a design of bonded anchors for "combined pull-out and concrete cone" resistance at variable embedment depth with or without group- or edge effects. The resistance for "concrete cone" and "steel failure" can be calculated according to current experience.

To avoid "steel failure" in the tests embedded parts of a higher strength than specified by the manufacturer and published in the ETA may be used as long as the functioning of the anchor is not influenced. This condition is fulfilled if the geometry of the embedded part of higher strength steel is identical with the specified embedded part.
In cases where the use of high strength anchor elements (steel strength   10.9) is insufficient to prevent "steel failure" the anchor embedment depth shall be reduced. This principle may overrule the required embedment depth for the suitability tests (5.1.2) and admissible service condition tests (5.1.3).
Special conditions for tests according to line 1 of Table 5.1 or 5.2 are given in 5.1.2.

The unconfined tests with minimum specified embedment depth in the admissible service condition tests may show "concrete cone failure". If these results are used for evaluating the characteristic bond resistance (eventually modified by the various influencing factors) the approach is conservative. More precise results may be achieved if the minimum embedment depth is chosen in a way that bond failure ("combined pull-out and concrete cone failure") is decisive.

Bonded anchors with a high bond resistance may show only "concrete cone failure" or "steel failure" in unconfined tests. In this case it is recommended to perform all tests as confined tests and to evaluate τ_{Rk} taking the modification factor   setup into account (see Equation 6.17.1).

For the assessment of a bonded anchor the overall test programme has to be carried out including at least the following minimum number of different concrete batches within the programme of testing:

Assessment for C20/25:   on at least 3 different batches, if the concrete comes from different
                               concrete suppliers
                               on at least 4 different batches, if the concrete comes from the same
                               concrete supplier

Assessment for C50/60:   on at least 2 different batches, if the concrete comes from the same or from
                               different concrete suppliers.

If concrete batches come from the same concrete supplier it shall be ensured that each batch is made from a different delivery of either cement or aggregates.

Reference Tension Tests (R) shall be performed because they are needed for the evaluation of the results of the suitability tests and to take account of the influence of certain parameters on the tension load resistance of bonded anchors. They shall be made in each batch. All reference tests shall be carried out as follows:
– in dry concrete
– at normal ambient temperature (T = + 21° C $\pm$ 3 °C)
– anchor installation in accordance with the manufacturer's published instructions
– as confined test; they shall be made at approximately the same curing time as the corresponding suitability tests or tests for admissible service condition.
In general, the reference tests shall be made in the same concrete batch as the tests to which they shall be compared (for exception, see note (6) in Table 5.1 and note (4) in Table 5.2). The reference tests shall be made in non-cracked concrete (cracked concrete, Δw = 0,3mm), if their results shall be compared with results of tests in non-cracked concrete (cracked concrete).

It is necessary to carry out at least 5 reference tests in each series. If the coefficient of variation of the failure loads is > 15 %, then the number of reference tests shall be increased.

If the manufacturer applies for embedded parts of bonded anchors which are geometrically identical but of different material, then all tests shall be made with one material. For the other material, only the torque tests according to Part 1, Table 5.1 or 5.2, line 7 shall be carried out and if the embedded part has a reduced section along the length shear tests according to Part 1, Table 5.4, line 5 and 6 or line 7 and 8 for the evaluation of the characteristic shear resistance are necessary.

If the approval is to cover more than one drilling technique, then all tests shall be done with all drilling techniques.

5.1.2 Tests for suitability

The types of tests, test conditions, the number of required tests and the criteria applied to the results are given in Table 5.1 (anchors for use in cracked and non-cracked concrete) and Table 5.2 (anchors for use in non-cracked concrete only). Detailed information about special tests are given in the chapters after the Tables.

In all suitability tests, the hole shall be drilled with a drill bit $d_{cut,m}$. In general a torque shall not be applied to the anchor. Only in torque tests are the anchors torqued to failure.

The suitability tests shall be performed with the depth requested by the manufacturer. If the manufacturer applies for bonded anchors with several embedment depths, the installation safety tests according to line 1, Table 5.1 or 5.2 shall be done with the maximum embedment depth requested by the manufacturer, the other suitability tests with the medium value between the minimum and maximum requested embedment depth.
To avoid steel failure in the installation safety tests with maximum embedment depth, as an example the following test procedure may be employed:
Use a test member consisting of two concrete blocks which are stacked on the top of each other without permanent connection. The drilling and cleaning of the hole as well as the injection of the hole for anchors with the maximum embedment depth is done in the two parts. After that remove the upper concrete block, set the anchor in the bottom block and after curing carry out the tension test.

Table 5.1   Suitability tests for bonded anchors to be used in cracked and non-cracked concrete (10)

	Purpose of test	Concrete	Crack width Δw (mm)	s	i	m	i	l	load/dis behav.	req. α (2)	Rem. suit. tests	Test proced. suit. tests	Remarks Ref. test R (5)
1	Installation safety - (a) dry concrete	C20/25	0	5 R	-	5 R	-	5 R		≥ 0,8(8)	(3)	5.1.2.1 (a)	C20/25
	(b) wet concrete	C20/25	0	5 R	-	5 R	-	5 R		≥ 0,75(8)	(3)	5.1.2.1 (b)	C20/25
	(c) flooded hole installation	C20/25	0	5 R	-	5 R	-	5 R		≥ 0,75(8)	(3)	5.1.2.1 (c)	C20/25
	(d) mixing technique	C20/25	0	-	-	5 R	-	-	6.1.1.1 (a) to (c)	≥ 0,8(8)	(3)	5.1.2.1 (d)	C20/25
3	Functioning in low strength concrete	C20/25	0,5	5 R	-	5 R	-	5 R		≥ 0,8	(3)	5.1.2.2	$\Delta w = 0,3$ C20/25
4	Functioning in high strength concrete	C50/60	0,5	5 R	-	5 R	-	5 R		≥0,8 or ≥1,0	(3)	5.1.2.2	$\Delta w = 0,3$ C50/60(6)
5	Functioning in crack movements	C20/25	0,1 - 0,3	5 R	5	5 R	5	5 R	6.1.1.1 and Part 1 6.1.1.2 (a)	≥ 0,9	(4) (7)	5.1.2.3	$\Delta w = 0,3$ C20/25(7)
6	Functioning under sustained loads	C20/25	0	-	-	5 R	-	-	6.1.1.1(a) to (c), (e)	≥ 0,9	(3)	5.1.2.5	C20/25
7	Maximum torque moment	C50/60	0	5	5	5	5	5	Part 1, 6.1.1.2 (d)		-	5.1.2.6	-
8	Functioning under freeze/thaw cond.	C50/60	0	-	-	5 R	-	-	6.1.1.1(a) to (c), (f)	≥ 0,9	(3)	5.1.2.7	C50/60
9	Functioning with Installation direction	C20/25	0	-	-	-	-	5 R	6.1.1.1 (a) to (c)	≥ 0,9	(3) (9)	5.1.2.8	C20/25

Notes to Table 5.1

(1)   Anchor size: s = smallest; i = intermediate; m = medium; l = largest
m = M12 or smallest size if that is larger than M12.

(2)   see section 6.1.1.1 (d).

(3)   These suitability tests shall be performed as confined tests.

(4)   The test "functioning in crack movements" shall be carried out as unconfined test (Annex A, 5.5). The following tension tests to failure shall be carried out as confined tests.

(5)   R: The reference tests shall be carried out with the same anchor diameter and in the same slab or same concrete batch as in the corresponding suitability tests.

(6)   For Options 1, 3 and 5 (different characteristic values for C20/25 and C50/60) the corresponding reference tests shall be carried out in a crack width of 0,3mm. The required α-factor shall be ≥ 0,8. For Options 2, 4 and 6, reference tests (for line 3) will not be required, because in these options the characteristic resistance is independent of the concrete strength, therefore the results of the suitability tests will be compared with the results of reference tests carried out in low strength concrete ($\Delta w = 0,3$ mm, line 2), the required α-factor shall be ≥ 1,0

(7)   The corresponding reference tests for the tension tests after the crack movements tests are required only for smallest, medium and largest sizes. They shall be carried out with $\Delta w = 0,3$ mm. The results of the reference tests for intermediate sizes shall be derived from results of reference tests with the other diameters by using the mean bond strength of the neighbouring sizes.

(8)   For $\gamma_2 = 1,2$. For other partial safety factors, see Table 6.1 in 6.1.2.2.2.

(9)   The tests shall be performed with largest diameter applied for installation direction

(10)   This Table is not valid for bonded anchor systems if expansion forces by the anchor are created; these torque-controlled bonded anchors have to be assessed according to the Technical Report 018.

Table 5.2   Suitability tests for bonded anchors to be used in non-cracked concrete only

	Purpose of test	Concrete	Crack width Δw (mm)	Minimum number of tests for anchor size (1)					Criteria		Rem. suit. tests	Test Procedur. Suit. Tests	Remarks Ref. test R (5)
				s	i	m	i	l	load/dis. beh.	req. α (2)			
1	Installation safety - (a) dry concrete	C20/25	0	5R	-	5R	-	5R		≥ 0,8(8)	(3)	5.1.2.1 (a)	C20/25
	(b) wet concrete	C20/25	0	5R	-	5R	-	5R		≥ 0,75(8)	(3)	5.1.2.1 (b)	C20/25
	(c) flooded hole installation	C20/25	0	5R	-	5R	-	5R		≥ 0,75(8)	(3)	5.1.2.1 (c)	C20/25
	(d) mixing technique	C20/25	0	-	-	5R	-	-	6.1.1.1 (a) to (c)	≥ 0,8(8)	(3)	5.1.2.1 (d)	C20/25
4	Functioning in high strength concrete	C50/60	0	5	-	5	-	5		≥ 1,0	(3) (4)	5.1.2.2	-
5	Functioning under repeated loads	C20/25	0	-	-	5R	-	-	6.1.1.1 and Part 1 6.1.1.2 (b)	≥ 1,0	(3)	5.1.2.4	C20/25
6	Functioning under sustained loads	C20/25	0	-	-	5R	-	-	6.1.1.1(a) to (c), (e)	≥0,9	(3)	5.1.2.5	C20/25
7	Maximum torque moment	C50/60	0	5	5	5	5	5	Part 1, 6.1.1.2 (d)		-	5.1.2.6	
8	Functioning under freeze/thaw cond.	C50/60	0	-	-	5R	-	-	6.1.1.1(a) to (c), (f)	≥ 0,9	(3)	5.1.2.7	C50/60
9	Functioning with Installation direction	C20/25	0	-	-	-	-	5R	6.1.1.1 (a) to (c)	≥ 0,9	(3) (9)	5.1.2.8	C20/25

Notes to Table 5.2

(1)   Anchor size: s = smallest; i = intermediate; m = medium; l = largest
         m = M12 or smallest size if that is larger than M12.

(2)   see section 6.1.1.1 (d).

(3)   These suitability tests are performed as confined tests.

(4)   Suitability tests for functioning in non-cracked high strength concrete (line 3) will only be required for Options 8, 10 and 12. In these options the characteristic resistance is independent of the concrete strength, therefore the results of the suitability tests in high strength concrete shall be compared with the results of the reference tests in low strength concrete. The required α-factor shall be > 1,0 For Options 7, 9 and 11 suitability tests in high strength concrete are not needed, because the anchor behaviour in high strength concrete is checked in tests for admissible service conditions.

(5)   R: The reference tests shall be carried out with same anchor diameter and in the same slab or same concrete batch as in the corresponding suitability tests.

(8)   For γ2 = 1,2. For other partial safety factors, see Table 6.1 in 6.1.2.2.2.

(9)   The tests shall be performed with largest diameter applied for installation direction

5.1.2.1 Installation safety tests

Confined tension tests in non-cracked concrete C20/25.

The following test conditions are defined for drilling the hole with an electric hammer drilling machine. In general the conditions are also valid for other drilling techniques. However some modifications of the installation safety tests might be necessary which shall be agreed by the Approval Bodies.

5.1.2.1 (a)   Effect of hole cleaning technique in dry substrate

Tests in dry concrete.

Drill downwards to the depth defined by the manufacturer.
Clean the hole with the hand pump and brush supplied by the manufacturer, using two blowing and one brushing operation in the order prescribed in the manufacturer's installation instructions. This test procedure is valid only if the manufacturer's installation instructions specify hole cleaning with at least four blowing and two brushing operations. If the instructions specify less than this, then the above requirement (2 blows + 1 brush) shall be reduced proportionately and the number of blows/ brushes shall be lowered to the next whole number. Therefore where the manufacturer's installation instructions recommend two blowing and one brushing operations, the suitability tests shall be carried out without the brushing operation.
If precise instructions for hole cleaning are not provided by the manufacturer's installation instructions, then the tests are carried out without hole cleaning.

Install the embedded part in accordance with the manufacturer's installation instructions.

5.1.2.1 (b)   Effect of hole cleaning technique in wet substrate

Hole cleaning and installation according to 5.1.2.1 (a). However the concrete in the area of anchorage shall be water saturated when the hole is drilled, cleaned and the embedded part is installed.

The following procedure may be applied to ensure a water saturated concrete in the area of the anchorage:
1. A hole with $\varnothing$ approximately $0{,}5 \times d_0$ (d_0 = drill hole diameter of the tested anchor) is drilled in the concrete substrate to the recommended depth ,

2. The hole is filled with water and remains flooded for 8 days until water has percolated into the concrete at a distance equal to $1{,}5d$ to $2d$ from the axis of the hole,

3. Water is sucked out of the hole,

4. The final hole is drilled at the recommended diameter d_0,

Clean the hole according to the description for dry concrete (5.1.2.1(a)) and install the embedded part in accordance with the manufacturer's installation instructions.

If methods other than those described above are used it shall be shown by appropriate methods that the concrete in the area of the anchorage is water saturated.

5.1.2.1 (c)   Effect of hole cleaning technique in flooded hole

The tests are made in concrete which is water saturated in the area of the anchorage. To ensure a water saturated concrete in the area of the anchorage the procedure of 5.1.2.1(b) shall be applied. After cleaning the hole according to 5.1.2.1(a), fill the hole with water. Without removing water from the hole, place the bonding material and insert the embedded part as described in the manufacturer's installation instructions.

These tests are not required for anchors where the manufacturer's installation instructions state that water shall be completely removed before anchor installation. Installation instructions shall make it clear that simply inserting a capsule or injecting bonding material does not adequately remove water, and a proper process shall be described to remove water completely.

5.1.2.1 (d)   Effect of mixing technique

Tests are only required for those anchor types where the mixing technique is controlled by the installer, such techniques include:
a)   mixing components until a colour change is affected throughout the material
b)   mixing with recommended equipment for a specified time
c)   carrying out a repetitive mixing operation for a specified number of times.

Tests shall be carried out on incomplete mixes, i.e. by reducing the specified process by 25 %.
For example, in the case of a), the test is carried out after mixing for 75 % of the time taken to achieve an even colour throughout the material.

Tests are not required for capsule type bonded anchors, because the effect of mixing on the anchor behaviour is already covered by the other suitability tests.

5.1.2.1 (e)   Effect of hole drilling tolerances

From experience, tolerances of drill bits for cylindrical holes do not adversely affect the performance of bonded anchors, therefore tests are not required.

5.1.2.1 (f)   Effect of variation in volume of bonding material

Tests are not required.

5.1.2.2 Functioning in low (C20/25) or high strength concrete (C50/60)

The tests shall be carried out according to Annex A, however as confined tests.

5.1.2.3 Functioning in crack movements

The tests shall be carried out according to Annex A, 5.5, however the constant tension load N_p shall be calculated from Equation (5.4).

$$N_p = \frac{0.75 \cdot N_{Rk,p}}{\gamma_{Mc}} \cdot \frac{1}{\alpha_2} \cdot \frac{1}{\alpha_3} \cdot \frac{1}{\alpha_4} \qquad (5.4)$$

$N_{Rk,p}$ = characteristic resistance for pullout failure given in the ETA for cracked concrete C20/25
γ_{Mc} = partial safety factor given in the ETA
α_2 = ratio according to Equation (6.15), tests at maximum long term temperature $\leq 1{,}0$
α_3 = ratio according to Equation (6.16), tests at maximum short term temperature $\leq 1{,}0$
α_4 = ratio according to Equation (6.22), tests for checking durability of adhesive $\leq 1{,}0$

The tension test after crack movements shall be done as a confined test.

5.1.2.4 Functioning under repeated loads

The tests shall be carried out in non-cracked concrete C20/25 according to Annex A, 5.6, however as confined tests. The maximum load N_{max} on the anchor shall be calculated by Equation (5.5).

$$N_{max} = \frac{1.1 \cdot N_{Rk,p}}{\gamma_{Mc}} \cdot \frac{1}{\alpha_2} \cdot \frac{1}{\alpha_3} \cdot \frac{1}{\alpha_4} \qquad (5.5)$$

$N_{Rk,p}$ = characteristic resistance for pullout failure given in the ETA for non-cracked concrete C20/25
γ_{Mc} = partial safety factor given in the ETA
α_2 = ratio according to Equation (6.15), tests at maximum long term temperature $\leq 1{,}0$
α_3 = ratio according to Equation (6.16), tests at maximum short term temperature $\leq 1{,}0$
α_4 = ratio according to Equation (6.22), tests for checking durability of adhesive $\leq 1{,}0$

5.1.2.5 Functioning under sustained loads

Tests shall be carried out in non-cracked concrete C20/25, both at normal ambient temperature and maximum long term temperature.

(a) Tests at normal ambient temperature

Install anchors at normal ambient temperature.

Load anchor to N_{sust} according to Equation (5.6a):

$$N_{sust} = \frac{1.1 \cdot N_{Rk,p}}{\gamma_{Mc}} \cdot \frac{1}{\alpha_2} \cdot \frac{1}{\alpha_3} \cdot \frac{1}{\alpha_4} \qquad (5.6a)$$

$N_{Rk,p}$ = characteristic resistance for pullout failure given in the ETA for non-cracked concrete C20/25

γ_{Mc} = partial safety factor given in the ETA

α_2 = ratio according to Equation (6.15), tests at maximum long term temperature $\leq 1,0$

α_3 = ratio according to Equation (6.16), tests at maximum short term temperature $\leq 1,0$

α_4 = ratio according to Equation (6.22), tests for checking durability of adhesive $\leq 1,0$

Maintain load at N_{sust} and maintain temperature at normal ambient temperature and measure the displacements until they appear to have stabilised, but at least for three months (in special justified cases the Approval Body may allow a shorter duration for the sustained load test). Temperatures in the room may vary by $\pm$ 3K due to day/night and seasonal effects but the required test room temperature shall be achieved as an mean over the test period. The frequency of monitoring displacements shall be chosen so as to demonstrate the characteristics of the anchor. As displacements are greatest in the early stages, the frequency shall be high initially and reduced with time. As an example, the following regime would be acceptable:

During first hour: every 10 minutes
During next 6 hours: every hour
During next 10 days: every day
From then on: every 5-10 days.

To check the remaining load capacity after the sustained load test, unload the anchor and carry out a confined tension test.

(b) Test at maximum long term temperature

These tests are not needed for temperature range (a), see 4.1.1.2 (-40 °C to +40 °C), because the effect of the maximum long term temperature (+24 °C) is tested under normal ambient temperature.
It is recommended to perform the tests in concrete specimen made from the same batch as the specimen used for the tests according to 5.1.3.1(a).

Install anchors at normal ambient temperature.
Load anchor to N_{sust} according to Equation (5.6b):

$$N_{sust} = \frac{1.1 \cdot N_{Rk,p}}{\gamma_{Mc}} \cdot \frac{1}{\alpha_3} \cdot \frac{1}{\alpha_4} \qquad (5.6b)$$

$N_{Rk,p}$ = characteristic resistance for pullout failure given in the ETA for non-cracked concrete C20/25

γ_{Mc} = partial safety factor given in the ETA

α_3 = ratio according to Equation (6.16), tests at maximum short term temperature $\leq 1,0$

α_4 = ratio according to Equation (6.22), tests for checking durability of adhesive. $\leq 1,0$

Raise the temperature of the test chamber to the maximum long term temperature at a rate of approximately 20 °C per hour.

Maintain load N_{sust} and maintain temperature at the maximum long term temperature. For the duration of the tests, the allowed variation of the temperature of the test chamber and the frequency of monitoring displacements 5.1.2.5(a) applies.

To check the remaining load capacity after the sustained load test, unload the anchor and carry out a confined tension test at the maximum long term temperature.

5.1.2.6 Torque tests

Tests according to Annex A, 5.10.

In addition, it has to be checked if the 95% of tension force generated in the torque tests at $T = 1,3\ T_{inst}$ is not larger than the characteristic resistance for pullout failure $N_{Rk,p} = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk,ucr}$
with
h_{ef}: min embedment depth for the corresponding diameter
$\tau_{Rk,ucr}$: characteristic bond resistance for non-cracked concrete C20/25 as given in the ETA.

5.1.2.7 Functioning under freeze/thaw conditions

The tests are performed in non-cracked freeze-thaw resistant concrete C50/60 in accordance with EN 206. As test member in general a cube with side length of 200 mm to 300 mm or 15d to 25d shall be used, splitting of concrete shall be prevented.

Cover the top surface of the test member with tap water to a depth of 12 mm, other exposed surfaces shall be sealed to prevent evaporation of water.
Load anchor to N_{sust} according to Equation (5.7):

$$N_{sust} = \frac{N_{Rk,p}}{\left(\gamma_{Mc} \cdot \gamma_f\right)} \qquad\qquad (5.7)$$

$N_{Rk,p}$ = characteristic resistance for pullout failure given in the ETA for non-cracked concrete C50/60
γ_{Mc} = partial safety factor given in the ETA
γ_f = partial safety factor for actions = 1,4Carry out 50 freeze/thaw cycles as follows:
- Raise temperature of chamber to $(+ 20 \pm 2)$ °C within 1 hour, maintain chamber temperature at $(+ 20 \pm 2)$ °C for 7 hours.
- Lower temperature of chamber to (-20 ± 2) °C within 2 hours, maintain chamber temperature at (-20 ± 2) °C for 14 hours (total of 16 hours).
If the test is interrupted, the samples shall always be stored at a temperature of (-20 ± 2) °C between the cycles.

The displacements shall be measured during the temperature cycles.
After completion of 50 cycles carry out a confined tension test at normal ambient temperature.

5.1.2.8 Effect of installation directions

The effect of installation directions shall be shown by appropriate tests or investigations. If the conditions in 6.1.1.2(g) are satisfied, then further tests are not required. However, for the critical overhead installation, it is necessary to carry out tension tests, unless the manufacturer's installation instructions exclude overhead use.

5.1.3 Tests for admissible service conditions

The test conditions are given in Part 1, 5.1.3 and Annex B. They are summarised in Table 5.4 of Part 1. Table 5.4 applies to anchors to be used in cracked and non-cracked concrete according to Option 1. In addition to Part 1, 5.1.3 and Annex B, tests according to 5.1.3.1, 5.1.3.2 and 5.1.4 shall be carried out.

The current experience for bonded anchors is valid only for anchors with an embedment depth in the range as given in 2.1.1.

The tests shall be performed with the depth requested by the manufacturer. If the manufacturer applies for bonded anchors with several embedment depths, the tests for admissible service conditions shall be done as unconfined tests for all diameters with the minimum requested embedment depth.

Table 5.5 and Table 5.6 show the required number of tests for determination of the admissible service conditions where the design model with characteristic bond resistance τ_{Rk} according to the Technical Report 029 is used.

Table 5.5 is given for bonded anchors to be used in cracked and non-cracked concrete based on unconfined tests. A1 - tests with intermediate anchor sizes may be omitted only if a continuous bond resistance is shown with A1 tests as confined tests for all anchor sizes.

Table 5.6 is given for bonded anchors to be used in cracked and non-cracked concrete based on confined tests and calculated with α_{setup}.

Test series A3 and A4 may be omitted for anchors to be used in non-cracked concrete only.

For all tests for determination of admissible service conditions for tension resistance, Reference tension tests (R) shall be carried out in the same slab or batch (see 5.1.1) with the medium anchor size (see note 1 in Tables 5.1 and 5.2).The reference tests for cracked concrete shall be carried out in a crack width of 0,3 mm.

Table 5.5   Admissible service condition tests for bonded anchors to be used in cracked and non-cracked concrete based on unconfined test

	Purpose of test	Concrete	Crack width Δw (mm)	Minimum number of tests for anchor size				
				s	i	m	i	l
A1 (1)	Tension in non-cracked low strength concrete	C20/25	0	5	-	5	-	5
A1 conf				5	5	5	5	5
A2 (1)	Tension in non-cracked high strength concrete	C50/60	0	5	-	5	-	5
A3 (1)	Tension in cracked low strength concrete	C20/25	0,3 mm	5	-	5	-	5
A4 (1)	Tension in cracked high strength concrete	C50/60	0,3 mm	5	-	5	-	5
A14 (1)	Tension test in corner	C20/25	0	5	-	5	-	5
A20 (1)	Minimum spacing and edge distances	C20/25	0	5	-	5	-	5

Notes to Table 5.5

(0)   R-tests for batch factor not included in table
(1)   Anchor size: s = smallest; i = intermediate; m = medium; l = largest
         Example for threaded rods:
         A1 confined tests show continuous bond resistance for all sizes.
         The applicant demands approval for 3 sizes; test all sizes.
         The applicant demands approval for 5 sizes; test 3 sizes (see table).
         The applicant demands approval for 8 sizes; test 4 sizes.
         The applicant demands approval for 11 sizes; test 5 sizes.
         The sizes shall be equally distributed in the range of all sizes.

Table 5.6 **Admissible service condition tests for bonded anchors to be used in cracked and non-cracked concrete based on confined test and calculated with r_{setup}**
Alternative to table 5.5

| | Purpose of test | Concrete | Crack width Δw (mm) | Minimum number of tests for anchor size | | | | |
				s	i	m	i	l
A1 conf	Tension in non-cracked low strength concrete	C20/25	0	5	5	5	5	5
A2 (1) conf	Tension in non-cracked high strength concrete	C50/60	0	5	-	5	-	5
A3 (1) conf	Tension in cracked low strength concrete	C20/25	0,3 mm	5	-	5	-	5
A4 (1) conf	Tension in cracked high strength concrete	C50/60	0,3 mm	5	-	5	-	5
A14 (1)	Tension test in corner	C20/25	0	5	-	5	-	5
A20 (1)	Minimum spacing and edge distances	C20/25	0	5	-	5	-	5

Notes to Table 5.6

(0)   R-tests for batch factor not included in table

(1)   Anchor size: s = smallest; i = intermediate; m = medium; l = largest
Example for threaded rods:
A1 confined tests show continuous bond resistance for all sizes.
The applicant demands approval for 3 sizes; test all sizes.
The applicant demands approval for 5 sizes; test 3 sizes (see table).
The applicant demands approval for 8 sizes; test 4 sizes.
The applicant demands approval for 11 sizes; test 5 sizes.
The sizes shall be equally distributed in the range of all sizes.

5.1.3.1 Influence of temperature on characteristic resistances

The tests according to 5.1.3.1(a) to 5.1.3.1(c) shall be carried out in concrete from the same concrete batch.

a) Effect of increased temperature

The tests shall be carried out in non-cracked concrete C20/25 at the following temperatures for the different temperature ranges given in 4.1.1.2:

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 at normal ambient temperature.

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 manufacturer's 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.

The tests are performed in non-cracked concrete C20/25. They may be carried out in slabs or, where space of the heating chamber is restricted, in cubes. Splitting of the concrete shall be prevented by means of confinement (dimensions, reinforcement or transverse pressure).

Anchor size: M12 (or smallest in range if smallest size is larger than M12).

Test method:
Install anchors at normal ambient temperature according to manufacturer's installation instructions.
Raise test member temperature to required test temperature at a rate of approximately 20K per hour. Cure test member at this temperature for 24 hours.
While maintaining the temperature of the test member in the area of the embedded part at a distance of 1d from the concrete surface at $\pm$ 2K of the required value, carry out confined tension test.
        Note: The check that the requirement on the temperature in the test member is fulfilled shall be done once and then the test procedure shall be kept constant.

Number of tests: $\geq$ 5 tests per temperature.

b) Effect of low installation temperature

The tests are performed in non-cracked concrete C20/25. For test member dimensions, see 5.1.3.1a).

Anchor size: M12 (or smallest in range if smallest size is larger than M12).

Test method:
Drill and clean hole according to manufacturer's installation instructions then cool test member to the lowest installation ambient temperature specified by the manufacturer, and the bonding material and embedded part to the lowest anchor component installation temperature specified by the manufacturer. Install anchor, maintain the temperature of the test member at the lowest installation ambient temperature for the curing time quoted by the manufacturer at that temperature.
Carry out confined tension test at the end of the curing time while maintaining the temperature of the test member in the area of the embedded part at a distance of 1d from the concrete surface at the specified lowest installation temperature $\pm$ 2K.
        Note: The same note as for the test method in 5.1.3.1a) applies.

Number of tests: $\geq$ 5 tests

c) Minimum curing time at normal ambient temperature

Perform confined tension tests at normal ambient temperature at the corresponding minimum curing time specified by the manufacturers.

        Note: One series of the reference tests according to 5.1.3 may be made at minimum curing time.

Number of tests: $\geq$ 5 tests

5.1.3.2 Shelf life

The manufacturer shall provide evidence in support of the quoted shelf life, including storage conditions.

5.1.4   Tests for checking durability

Part 1, 5.1.4 applies. In addition, the durability of the bonding material shall be verified by slice tests. With slice tests, the sensitivity of installed anchors to different environmental exposures can be shown.

Test specimen:
The concrete compressive strength class shall be C20/25. The diameter or side length of the concrete specimen shall be equal to or exceed 150mm. The test specimen may be manufactured from cubes or cylinders or may be cut from a larger slab. They can be cast; it is also allowed to diamond core concrete cylinders from slabs.
One anchor (medium size M12 or smallest size if the smallest size is larger than M12) to be installed per cylinder or cube on the central axis in dry concrete, drill bit $d_{cut,m}$, according to the manufacturer's installation instructions .
The embedded part shall be made out of stainless steel.
After curing of the adhesive according to manufacturer's instructions the concrete cylinders or cubes are carefully sawn into 30mm thick slices with a diamond saw. The top slice shall be discarded.
To gain sufficient information from the slice tests, at least 30 slices are necessary (10 slices for every environmental exposure test and 10 slices for the comparison tests under normal climate conditions.

Storage of the test specimen under environmental exposure:
The slices with adhesive anchors are subjected to water with high alkalinity and condensed water with sulphurous atmosphere. For comparison tests slices stored under normal climate conditions (dry / +21 °C $\pm$ 3 °C / relative humidity 50 $\pm$ 5%) for 2000 hours are necessary.
High Alkalinity:
The slices are stored under standard climate conditions 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 KOH (potassium hydroxide) powder or tablets until the pH-value of 13.2 is reached. The alkalinity of pH = 13.2 shall be kept as close as possible to 13.2 during the storage and not fall below a value of 13.0. Therefore the pH-value has to be checked and monitored in regular intervals (at least daily). The producing of alkaline fluid by mixing water with KOH (potassium hydroxide) powder or tablets could be given as an example. If other materials are used then it has to be shown that same results and comparable assessment are achieved respectively.
Sulphurous atmosphere:
The tests in sulphurous atmosphere shall be performed according to EN ISO 6988:1994 "Metallic and other non-organic coatings – Sulphur dioxide test with general condensation of moisture". The slices are put into the test chamber, however in contrast to EN ISO 6988 the theoretical sulphur dioxide concentration shall be 0,67 % at beginning of a cycle. This theoretical sulphur dioxide concentration corresponds to 2 dm^3 of SO$_2$ for a test chamber volume of 300 dm^3. At least 80 cycles shall be carried out.

Slice tests:
After the storage time, the thickness of the slices is measured and the metal segments of the bonded anchors are pushed out of the slice, the slice is placed centrally to the hole of the steel rig plate. If slices are unreinforced then splitting may be prevented by confinement. Care shall be taken to ensure that the loading punch acts centrally on the anchor rod.

The results of at least 10 tests shall be taken for every environmental exposure and for comparison; results with splitting failure shall be ignored.

5.3 Methods related to 4.3 (hygiene, health and the environment)

5.3.1 Method of verification

The product and/or constituents of the product listed in the EOTA TR 034: "General Checklist for ETAGs/CUAPs/ETAs -Content and/or release of dangerous substances in products/kits", which have to be considered will be verified by the given methods taking into account the installation conditions of the construction product and the release scenarios resulting from there. Regulations related to placing the product on the market may also need to be taken into account.

Regarding the release scenarios referred to in the EOTA TR 034, the use category IA2 (Product with no direct contact to (e.g. covered products) but possible impact on indoor air) have to be considered.

6 ASSESSING AND JUDGING THE FITNESS OF ANCHORS FOR AN INTENDED USE

6.0(b) Conversion of ultimate loads to take account of concrete and steel strength

Part 1, 6.0(b) applies. However, for pullout failure (including pullout failure of single anchors with a typical shallow cone at the loaded end), a linear relationship between the failure loads in low and high strength concrete may be assumed for simplification.

6.1 Assessing and judging related to 4.1 (mechanical resistance and stability)

6.1.1 Suitability

6.1.1.1 Criteria valid for all tests

In all tests according to lines 1 to 6 and 8 to 9 of Tables 5.1 and 5.2 the following criteria shall be met.

 (a) Instead of the requirement on the load-displacement curves in Part 1, 6.1.1.1 (a) with respect to uncontrolled slip the following evaluation shall be done:

With bonded anchors uncontrolled slip occurs when the mortar with the embedded part is pulled out of the drilled hole (because then the load displacement behaviour depends significantly on irregularities of the drilled hole). The corresponding load when uncontrolled slip starts is called load at loss of adhesion $N_{u,adh}$.

$N_{u,adh}$ shall be evaluated for every test from the measured load displacement curve. In general the load at loss of adhesion is characterised by a significant change of stiffness, see Figure 6.1a). If the change in stiffness at a defined load is not so obvious, e.g. the stiffness is smoothly decreasing, the load at loss of adhesion shall be evaluated as follows:

1) Compute the tangent to the load-displacement curve at a load $0,3\ N_u$ (N_u = peak load in test). In general the tangent stiffness can be taken as the secant stiffness between the points 0/0 and $0,3\ N_u/\delta_{0,3}$ ($\delta_{0,3}$ = displacement at $N = 0,3\ N_u$).
2) Divide the tangent stiffness with a factor of 1,5.
3) Draw a line through the point 0/0 with the stiffness as calculated in 2).
4) The point of intersection between this line and the measured load-displacement curve gives the load $N_{u,adh}$ where the adhesion fails, see Figure 6.1b).

If there is a peak in the load-displacement curve, to the left side of this line, which is higher than the load at intersection, $N_{u,adh}$ is taken as the peak load, see Figure 6.1c).

If there is a very stiff load-displacement curve at the beginning ($\delta_{0,3} \leq 0,05$mm) the drawing of the line for the calculation can be shifted to the point ($0,3\ N_u/\delta_{0,3}$), see Figure 6.1d).

For all suitability tests factor α_1 shall be calculated according to Equation (6.12):

$$\boxed{}\ \alpha_1 \quad = \frac{N_{u,\,adh}}{N_{Rk,\,p}} \cdot \frac{\gamma_{Mc}}{\gamma_4} \tag{6.12}$$

$N_{u,adh}$ = load at loss of adhesion as defined above
$N_{Rk,p}$ = characteristic resistance for pullout failure given in the ETA for concrete strength class and state of concrete (cracked, non-cracked) corresponding to the evaluated suitability test.
γ_4 = 1,3
γ_{Mc} = partial safety factor given in the ETA

The minimum value of α_1 of all suitability tests is decisive. If the value of α_1 is less than 1,0 then the characteristic resistance $N_{Rk,p}$ shall be reduced according to 6.1.2.2.1(b).
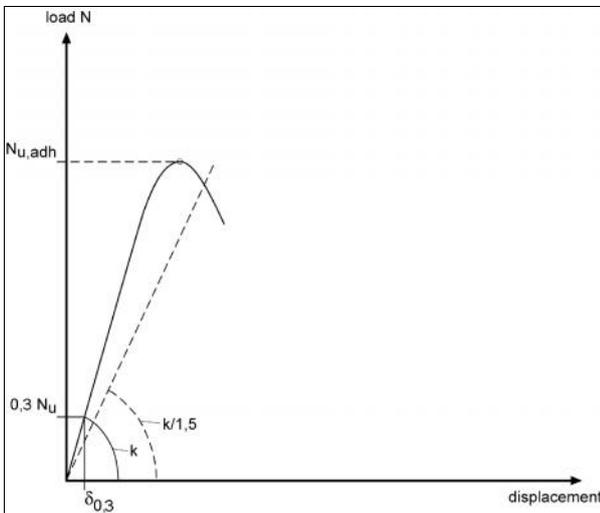
The evaluation of the load at loss of adhesion is not required when failure occurs between mortar and embedded part along the entire embedment depth (see definition of uncontrolled slip). In this case the factor α_1 shall be taken as 1,0.
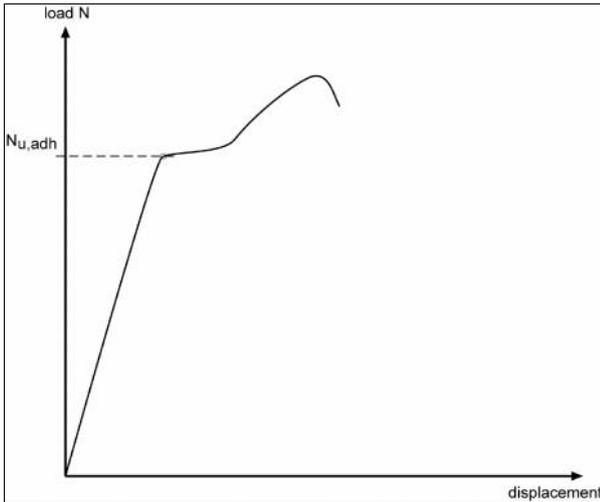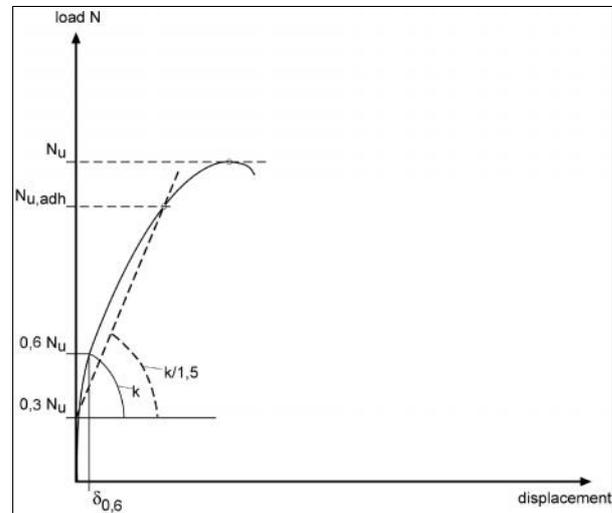
a) load at loss of adhesion by a significant change of stiffness
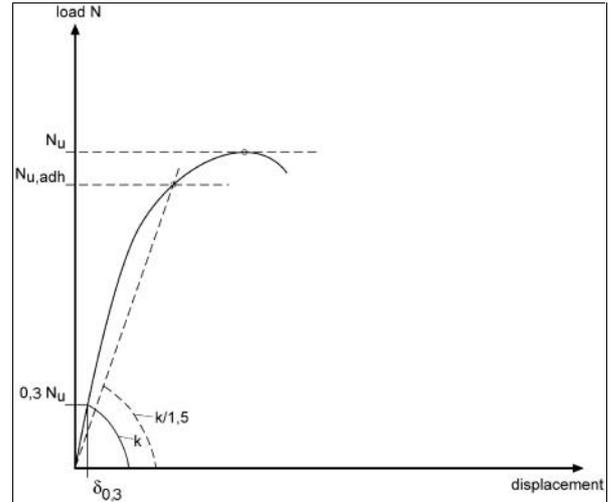
b) evaluation of load at loss of adhesion

c) evaluation of load at loss of adhesion

d) evaluation of load at loss of adhesion

Figure 6.1   Examples of load-displacement curves

(b) The criteria of the scatter of the load/displacement curves given in Part 1, 6.1.1.1 (b) are valid.

(c) In each test series, the coefficient of variation of the ultimate loads shall be smaller than v = 30 %.

(d) Instead of Equation (6.2) of Part 1, 6.1.1.1(d) the following Equation shall be used for calculation of the value α:

$$\alpha = \min\left(\frac{\tau_{u,m}^{t,i}}{\tau_{u,m}^{r,i}} \ ; \ \frac{\tau_{u,5\%}^{t,i}}{\tau_{u,5\%}^{r,i}} \right) \qquad (6.13)$$

$\boxed{} ; \left(\tau_{u,5\%}^{t,i} \right)$ = mean (5% fractile) of bond resistance of the suitability tests carried out in slab i

$\tau_{u,m}^{r,i} ; \left(\tau_{u,5\%}^{r,i} \right)$ = mean (5% fractile) of bond resistance of the corresponding reference test carried out in the same slab i or same batch

The bond strength of each test is calculated according to Equation (6.17).

A comparison of the characteristic values in Equation (6.13) is not required, if the conditions in Part 1, 6.1.1.1(d) are fulfilled or if the coefficient of variation of the ultimate bond strength values are < 15% in both test series.

The results of the sustained load tests at maximum long term temperature according to 5.1.2.5(b) shall be compared with the results of the corresponding test at maximum long term temperature according to 5.1.3.1a).

6.1.1.2 Additional criteria valid for specific tests

(e) Sustained load tests
The displacements measured in the tests have to be extrapolated according to Equation (6.14) (Findley approach) to 50 years (tests at normal ambient temperature), or 10 years (tests at maximum long term temperature), respectively. The trend line according to Equation (6.14) may be constructed with data from not less than the last 20 days (minimum of 20 data points) of the sustained load test. The extrapolated displacements shall be less than the mean value of the displacements $s_{u,adh}$ in the corresponding reference tests at normal ambient temperature or maximum long term temperature respectively. $s_{u,adh}$ is the displacement at $N_{u,adh}$ (loss of adhesion).

$$s(t) \quad = s_o + a \bullet t^b \tag{6.14}$$

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

(f) Freeze/thaw tests
The rate of displacement increase shall reduce with increasing number of freeze/thaw cycles to a value almost equal to zero.

(g) Effect of installation directions
When installed in accordance with the manufacturer's installation instructions for the direction concerned, the gap between the anchor and the wall of the hole shall be completely filled with mortar and there shall be no loss of bonding material from the hole following anchor setting after cleaning the surface. The embedded part shall not move significantly during curing time.
For tests with overhead installation the conditions in 6.1.1.1a) to 6.1.1.1c) and 6.1.1.1d) with $\alpha = 0,9$ shall be fulfilled.

6.1.2 Admissible service conditions

6.1.2.1 Criteria

Criteria valid for all tension tests

(a) Instead of the requirements on the load/displacement curves in Part 1, 6.1.2.1(a) with respect to uncontrolled slip the factor α_1 shall be calculated according to Equation (6.12). The minimum value of α_1 of all tests is decisive.
If the value α_1 is less than 1,0 then the characteristic resistance $N_{Rk,p}$ shall be reduced according to 6.1.2.2.1(b).

(b) The criteria on the load/displacement behaviour of Part 1, 6.1.2.1(b) apply.

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

Additional criteria valid for specific tests

(d) **Tests at maximum long term temperature**
From the failure loads measured in the tests at maximum long term temperature the factor α_2 shall be calculated according to Equation (6.15).

$$\alpha_2 = \min\left(\frac{N_{u,m}^{mlt}}{N_{u,m}^{r}} \; ; \; \frac{N_{u,5\%}^{mlt}}{N_{u,5\%}^{r}} \right) \qquad (6.15)$$

$N_{u,m}^{mlt} ; \left(N_{u,5\%}^{mlt}\right)$ = mean (5% fractile of) failure loads of the tests at maximum long term temperature

$\boxed{} ; \boxed{}$ = mean (5% fractile of) failure loads of corresponding reference tests performed at normal ambient temperature.

A comparison of the 5% fractile of failure loads in Equation (6.15) is not required, if the conditions in Part 1, 6.1.1.1(d) are fulfilled or if the coefficient of variation of failure loads is < 15% in both test series.

If the value α_2 is less than 1,0 then the characteristic resistance $N_{Rk,p}$ shall be reduced according to 6.1.2.2.1(b).

(e) **Tests at maximum short term temperature**
From the failure loads measured in the tests at maximum short term temperature the factor α_3 shall be calculated according to Equation (6.16)

$$\alpha_3 = \min\left(\frac{N_{u,m}^{mst}}{0,8 \cdot N_{u,m}^{mlt}} \; ; \; \frac{N_{u,5\%}^{mst}}{0,8 \cdot N_{u,5\%}^{mlt}} \right) \qquad (6.16)$$

$N_{u,m}^{mst} ; \left(N_{u,5\%}^{mst}\right)$ = mean (5% fractile of) failure loads of the tests at maximum short term temperature

$N_{u,m}^{mlt} ; \left(N_{u,5\%}^{mlt}\right)$ = mean (5% fractile of) failure loads of the tests at maximum long term temperature. For temperature range a) according to 4.1.1.2 the results of tests at normal ambient temperature may be taken.

A comparison of the 5% fractile of failure loads in Equation (6.16) is not required, if the conditions in Part 1, 6.1.1.1(d) are fulfilled or if the coefficient of variation of failure loads is < 15% in both test series.

If the value α_3 is less than 1,0 then the characteristic resistance $N_{Rk,p}$ shall be reduced according to 6.1.2.2.1(b).

(f) **Tests at minimum installation temperature**
The mean failure loads and the 5% fractile of failure loads measured in tests at the minimum installation temperature and corresponding minimum curing time shall be at least equal to the corresponding values measured in tests at normal ambient temperature and corresponding minimum curing time. These requirements apply also for the tests at other installation temperatures and corresponding minimum curing times.

A comparison of the 5% fractile of failure loads is not required, if the conditions in Part 1, 6.1.1.1(d) are fulfilled or if the coefficient of variation of failure loads is < 15% in both test series.

If the condition is not fulfilled, then the minimum curing time at the minimum installation temperature shall be increased and the tests at minimum installation temperature shall be repeated until the condition is fulfilled. This applies also for the tests at other installation temperatures and corresponding minimum curing times.

(g) **Tests at normal ambient temperature and corresponding minimum curing time**
The mean failure loads and the 5% fractile of failure loads measured in tests at the normal ambient temperature and corresponding minimum curing time shall be at least 0,9 times the values measured in reference tests with a "long curing time" in the tests for admissible service conditions. The "long curing time" is the maximum curing time normally used in admissible service conditions tests (24 hours for resins, 14 days for cementious mortars).

A comparison of the 5% fractile of failure loads is not required, if the conditions in Part 1, 6.1.1.1(d) are fulfilled or if the coefficient of variation of failure loads is < 15% in both test series.

If this condition is not fulfilled, then the minimum curing time at normal ambient temperature shall be increased and the corresponding tests shall be repeated or the characteristic resistance for pull out failure given in the ETA is reduced according to 6.1.2.2.1(b).

6.1.2.2 Assessment of admissible service conditions

6.1.2.2.1 Characteristic resistance of single anchor

(a)   General

Part 1, 6.1.2.2.1(a) applies. In addition, for evaluating the characteristic tension resistance N_{Rk} for concrete cone failure and pullout failure ($N_{Rk,c} = N_{Rk,p}$) the following provisions given in Equations (6.17 to 6.20) are valid. However, for pullout failure (including pullout failure of single anchors with a typical shallow cone at the loaded end) a characteristic bond resistance τ_{Rk} instead of a characteristic resistance N_{Rk} may be given in the ETA; therefore the Equations (6.17.1 and 6.20.1) are valid, Equation (6.18) is unchanged and Equation (6.19) is not relevant.

- From the results of the tension tests for admissible service conditions the bond strength of each test is calculated according to Equation (6.17):

$$\tau^i_{Ru} \quad = \quad \frac{N^i_u(C20/25)}{\pi \cdot d \cdot h_{ef}} \qquad (6.17)$$

where

$\boxed{}$ = bond strength of a tension test with diameter d in slab i or batch i

$\boxed{}$ (C20/25) = peak load of a tension test with diameter d in slab i or batch i converted to C20/25 according to 6.0(b).

d = diameter of embedded part

h_{ef} = embedment depth

$$\boxed{} \quad = \quad \alpha_{setup} \; \frac{N^i_u(C20/25)}{\pi \cdot d \cdot h_{ef}} \qquad (6.17.1)$$

α_{setup} = 1,0 if service condition tests are performed as unconfined tests

= 0,75 if service condition tests in non-cracked concrete are performed as confined tests

= 0,70 if service condition tests in cracked concrete are performed as confined tests

- To take the influence of different concrete parameters on the failure load into account the bond strength values τ^i_{Ru} according to Equation (6.17) shall be converted by Equation (6.18) using the results of reference tests:

$$\tau_{Ru} \quad = \quad \tau^i_{Ru} \bullet \frac{\min \tau^r_{Ru,m,\varnothing m}}{\tau^{r,i}_{Ru,m,\varnothing m}} \qquad (6.18)$$

τ_{Ru} = bond strength at normal ambient temperature

τ^i_{Ru} = bond strength according to Equation (6.17)

$\min \tau^r_{Ru,m,\varnothing m}$ = minimum value of the mean bond resistances of <u>all</u> reference tests series

(test for suitability and admissible service conditions with anchor diameter 'medium')

$\boxed{}$ = mean bond resistance of reference test with anchor diameter 'medium' carried out in the same slab i or same batch i as those used for the tension tests for admissible service conditions.

The converting to the minimum bond resistance according to Equation (6.18) (modification of τ^i_{Ru}) can be omitted, if the coefficient of variation of the ultimate bond resistance of all results in the reference test series with diameter medium is ≤ 15 %. Thereby the characteristic resistance of the bond strength of the admissible service condition tests has to be determined with a coefficient of variation of 15 %.

- From the values τ_{Ru} according to Equation (6.18) the characteristic bond strength resistance τ_{Rk} shall be evaluated according to Part 1, 6.1.2.2.1. In general, a constant value τ_{Rk} valid for all anchor diameters shall be assumed. If the test data show that the bond strengths vary in a regularly definable way (not randomly) with respect to anchor diameter, then the values τ_{Rk} may be evaluated as a continuous function of the anchor diameter. Also a function with no more than one extremum is possible if all test results show this product behaviour; e.g. it does not come from the influence of the different concrete batches.

- The characteristic tension resistance for concrete cone failure and pullout failure is calculated from Equation (6.19) using the characteristic bond resistance τ_{Rk} as described above:

$$N_{Rk,0} = \tau_{Rk} \bullet \pi \bullet d \bullet h_{ef} \qquad (6.19)$$

(b)   Reduction of the characteristic tension resistance

The characteristic tension resistance shall be reduced if certain requirements are not met as described in the following:

(1) Load/displacement behaviour, tension loading
If the value of α_1 calculated according Equation (6.12) for the suitability tests (6.1.1.1(a)) and for the admissible service condition tests (6.1.2.1(a)) is less than 1,0, then the characteristic resistance $N_{Rk,p} = N_{Rk,c}$ shall be reduced according to Equation (6.20).

(2) Crack movement tests, repeated load tests and sustained load tests and freeze/thaw tests
If in the crack movement tests, repeated and sustained load tests and freeze/thaw tests the requirements on the load/displacement behaviour are not fulfilled (see 6.1.1.1 and Part 1, 6.1.1.1) then the characteristic resistance shall be reduced and the tests shall be repeated until the requirements are fulfilled. The minimum value of the characteristic resistances evaluated from the above tests is decisive.

If for a certain anchor size the characteristic resistance calculated from the results of the crack movement tests according to Equation (5.4) is smaller than the value evaluated according to 6.1.2.2.1 then this value of N_{Rk} is decisive for the diameter in question.

If the characteristic resistance calculated from the results of the repeated load tests, sustained load tests and freeze/thaw tests according to Equation (5.5), (5.6) or (5.7) is smaller than the value evaluated according to 6.1.2.2.1 for the medium anchor diameter then the characteristic resistance $N_{Rk,p} = N_{Rk,c}$ of all anchor diameters shall be reduced by the same ratio.

(3) Ultimate load in suitability tests
If the value α on the ultimate load in the suitability tests (see 6.1.1.1(d), Equation (6.13)) for the tests according to Table 5.1, line 1 to 6 and 8,9 or Table 5.2, line 1 to 6 and 8,9 respectively is less than the req. α according to Table 5.1 or 5.2 respectively in one test series, then the characteristic tension resistance $N_{Rk,p} = N_{Rk,c}$ shall be reduced according to Equation (6.20).

(4) Ultimate load in the tests at increased temperature
If the requirements on the ultimate loads in the test at increased temperature (see 6.1.2.1(d) and 6.1.2.1(e)) are not fulfilled then the characteristic tension resistance for $N_{Rk,p} = N_{Rk,c}$ shall be reduced according to Equation (6.20).

The above approach assumes that a constant characteristic resistance N_{Rk} is used up to the maximum long term temperature. On request of the manufacturer the influence of temperature on N_{Rk} may be given in the ETA. However, then the required test program and the evaluation of the test results shall be agreed on by the responsible Approval Body.

(5) Ultimate load in the durability tests
If the requirements on the ultimate loads in the tests according to 5.1.4 are not fulfilled (see 6.1.3, Equation (6.22)) then the characteristic tension resistance $N_{Rk,p} = N_{Rk,c}$ shall be reduced according to Equation (6.20) or the characteristic bond resistance τ^0_{Rk} shall be reduced according to Equation (6.20.1).

$$N_{Rk} = N_{Rk,0} \bullet \min(\min \frac{\alpha}{req.\alpha} \; ; \; \min \frac{\alpha_1}{req.\alpha}) \bullet \alpha_2 \bullet \alpha_3 \bullet \alpha_4 \qquad (6.20)$$

N_{Rk} = characteristic resistance as given in the ETA

$N_{Rk,0}$ = characteristic resistance according to Equation (6.19)

$\min \dfrac{\alpha}{req.\alpha}$ = minimum ratio of all suitability tests $\leq 1,0$

$\min \dfrac{\alpha_1}{req.\alpha}$ = minimum ratio all suitability and admissible service condition tests $\leq 1,0$

α = value according to Equation (6.13) (criteria for suitability tests)

req. α = required value of α according to Table 5.1 or 5.2

α_1 = value according to Eq. (6.12) (criteria according 6.1.1.1 (a) and 6.1.2.1 (a); load/displacement behaviour)

α_2 = value according to Eq. (6.15) (tests at maximum long term temperature) $\leq 1,0$

α_3 = value according to Eq. (6.16) (tests at maximum short term temperature) $\leq 1,0$

α_4 = value according to Eq. (6.22) (tests for checking durability of adhesive) $\leq 1,0$

$$\tau_{Rk} = \tau^0_{Rk} \bullet \min(\min \frac{\alpha}{req.\alpha} \; ; \; \min \frac{\alpha_1}{req.\alpha}) \bullet \alpha_2 \bullet \alpha_3 \bullet \alpha_4 \qquad (6.20.1)$$

τ^0_{Rk} = characteristic bond resistance evaluated according to 6.1.2.2.1(a) third dash

τ_{Rk} = characteristic bond resistance as given in the ETA

The characteristic bond resistance shall be rounded as follows:

τ_{Rk} [N/mm²]	step $\Delta\tau_{Rk}$ [N/mm²]	e.g.
10	0,5	4 / 4.5 / 5 / 5.5 …
> 10, 20	1,0	12 / 13 / 14 / 15…
> 20	2,0	26 / 28 / 30 / 32 …

6.1.2.2.2 Partial safety factor $x2$ and $x3$

The partial safety factor γ_2 is evaluated from the results of the suitability tests according to line1 of Table 5.1 or Table 5.2 respectively according to Table 6.1:

Table 6.1 Values of req. α in the installation safety tests for bonded anchors

partial safety factor γ_2	req. α for tests according to Table 5.1 or 5.2, respectively	
	lines 1(a) and 1(d)	lines 1(b) and 1(c)
1,0	$\geq 0,95$	$\geq 0,9$
1,2	$\geq 0,8$	$\geq 0,75$
1,4	$\geq 0,7$	$\geq 0,65$

For a coefficient of variation of the ultimate loads in the suitability tests, $20\% \leq v \leq 30\%$ an additional safety factor γ_3 shall be given in the ETA.

$$\gamma_3 = 1 + (v(\%) - 20) \cdot 0,03 \qquad (6.21a)$$

For a coefficient of variation of the ultimate loads in the tension tests for admissible service conditions, $15\% \leq v \leq 20\%$ an additional safety factor γ_3 shall be given in the ETA

$$\gamma_3 = 1 + (v(\%) - 15) \cdot 0,03 \qquad (6.21b)$$

The maximum value γ_3 from Equation (6.21a) and (6.21b) is decisive.

6.1.2.2.8 Displacement behaviour

In general the displacements are evaluated according to Part 1, 6.1.2.2.8, only the displacements under short-term and long-term loading (δ_{NO} and δ_{VO}) in non-cracked concrete are evaluated from the sustained load tests.

6.1.3 Assessment of durability

In respect to corrosion, Part 1, 6.1.3 is valid for the metal parts of bonded anchors.

When checking durability for conditions b) and c) (see 2.2.2), any exposure of the embedded parts at the remote face of the concrete member shall be taken into account.

In the slice tests according to 5.1.4 it shall be shown that the bond strength of the slices stored in an alkaline liquid and sulphurous atmosphere media is at least as high as that of the bond strength of the comparison tests on slices stored under normal conditions. To show compliance with this requirement the factor α_4 shall be calculated according to Equation (6.22).

$$\alpha_4 = \frac{\min \tau_{um(stored)}}{\tau_{um,dry}} \qquad (6.22)$$

$\min \tau_{um(stored)}$ = minimum mean bond strength of the slices stored in different media

$\tau_{um,dry}$ = mean bond strength of the comparison tests on slices stored under normal condition

The factor α_4 shall be 1,0 for the tests in alkaline fluid and 0,9 for the tests in sulphurous atmosphere. If the value α_4 is less than the above required values then the characteristic resistance $N_{Rk,p}$ shall be reduced according to 6.1.2.2.1(b).

The bond strength in the slice tests shall be calculated according to Equation (6.23)

$$\tau_u = \frac{N_u}{\pi \cdot d \cdot h_{sl}} \qquad (6.23)$$

N_u = measured maximum load
d = diameter of the embedded part
h_{sl} = thickness of slice, measured values

6.3 Assessment related to ER3

6.3.1 Methods of assessing and judging

The product and/or constituents of the product listed in the EOTA TR 034: "General Checklist for ETAGs/CUAPs/ETAs -Content and/or release of dangerous substances in products/kits", which have to be considered will be verified by the given methods taking into account the installation conditions of the construction product and the release scenarios resulting from there. Regulations related to placing the product on the market may also need to be taken into account.

The content of cadmium contained in zinc coatings shall be declared by the applicant.

Note (to be implemented in the ETA):
For dangerous substances falling under the scope of the CPD for which
- no assessment and verification methods are given (or cannot be found in TR 034) or
- "no performance determined" is declared or
- the chosen verification and assessment method does not comply with the regulatory requirement of a particular Member State

there might be the necessity for an additional assessment.

6.7 Identification of anchors

All components of the materials shall be described in a chemically unambiguous way and be identified by standard tests (e.g. fingerprinting tests). All component amounts shall be specified either by mass, volume or percentage, with appropriate tolerances.

In addition to the tests mentioned in Part 1, the following characteristics shall be specified where relevant in accordance with ISO, European or national standards, together with any others as appropriate.

1 <u>Organic Bonding agents</u>

Resin, hardener and additives shall be identified by the following tests:

- density
- viscosity
- ignition loss and ash content
- conventional dry extract
- grain size analysis
- tensile strength
- bending strength
- compressive strength
- open time
- reactivity (gel or setting time) (this may be tested with a standardised formulation, not necessarily that specified for the bonding anchor).

In addition, the following tests are necessary:

Resin and hardener cured by polyaddition mechanism
Epoxies
- epoxy index (equivalent)
- amine equivalent

Polyurethanes
- hydroxyl equivalent
- isocyanate equivalent

Resin and hardener cured by polymerisation
Unsaturated polyester, vinylester (epoxymethacrylates) and vinylesterurethanes (urethanmethacrylates)
- hardener (catalyst) content of peroxide

Methylmethacrylates (MMA)
- hardener, content of peroxide

Filler
- specification of filler material (e.g. tested by density) including type
- specification of filler shape (e.g. fibre, balls, ...)
- grain size analysis

2 <u>Inorganic bonding agents</u>

- material specification by chemical analysis
- active binder batching
- grain size analysis
- density
- dry extract
- setting test
- shrinkage and swelling test
- bend and compressive strength at 7 and 28 days
- ignition loss and ash content

Filler, additives
- specification of filler material and additives
- specification of filler shape

7 ASSUMPTIONS UNDER WHICH THE ETA IS TO BE ASSESSED

7.1 Design methods for anchorages

For the design method for anchorages with bonded anchors the design method A, B or C of Annex C according to Option chosen can be used.

The current experience for bonded anchors is valid only for anchors with an embedment depth in the range as given in 2.1.1. For bonded anchors outside of this range the full test programme has to be carried out.

The design model for the design of fastenings with bonded anchors using the characteristic bond resistance τ_{Rk} is given in the Technical Report 029.

The following chapter has to be considered if the design method with characteristic resistance N_{Rk} according to Annex C is used.

The current experience for spacing and edge distances for ensuring the characteristic resistance to tension loads of a bonded anchor are:

$$s_{cr,N} \geq 2\ h_{ef}$$
$$c_{cr,N} \geq 1\ h_{ef}$$
$$h \geq 2\ h_{ef}$$

For a thickness of concrete member $h \geq 2\ h_{ef}$ splitting failure will not occur and a check for splitting failure is not necessary.

If the minimum member thickness is smaller than $2\ h_{ef}$ the characteristic resistance of the anchor shall be evaluated from tests with single anchors at the corner and the member thickness chosen (Part 1,Table 5.4 line 14). This characteristic resistance is valid for member thickness $h_{min} \leq h < 2\ h_{ef}$.

The following modifications in Annex C, 5.2.2 for the resistance to tension loads shall be taken into account:

- Instead of the initial value of the characteristic resistance in case of concrete cone failure $N°_{Rk,c}$ according to Annex C, Equation (5.2a) the characteristic resistance N_{Rk} determined from Equation 6.20 (6.1.2.2.1(b)) shall be used.
- The factor $\psi_{ucr,N}$ (Annex C, 5.2.2.4 f) is to be established from corresponding tests. Alternatively this value is taken $\psi_{ucr,N} = 1,0$ and different N_{Rk} for cracked and non-cracked concrete are used for $N°_{Rk,c}$.

The characteristic resistance for compression loading is equal to $N_{Rk,p}$

7.2 Recommendations for packaging, transport and storage

Any special transport conditions shall be stated on accompanying documents.

Any special storage conditions shall be stated on packaging including
    Storage temperature range
    Restrictions such as keeping away from heat and direct sunlight
    Expiry date.

7.3 Installation of anchors

The following requirements are in addition to those made in Part 1.

The manufacturer's printed installation instruction shall be reported in the ETA. These installation instructions shall be identical to the document used to established testing requirements for product assessment.

Where pictograms are used their meaning shall be clear and unambiguous. If necessary, text in the appropriate language shall be added to clarify the meaning.

Terminology
The precise meaning of all terms, such as installation ambient temperature, bonding material installation temperature, open time, curing time, etc. shall be clear to the user.

Base material condition
Any limitations on the condition of base material shall be stated. For instance if anchors may not be installed in cracked concrete or may not be installed in holes filled with water.

Hole cleaning
Instructions for hole cleaning shall specify in detail the type of cleaning equipment to be used, e.g. the volume of blow out pump and diameter and material of brush, together with the precise cleaning procedure including the number and order of blowing/brushing actions.

Temperature limits
The following temperature limits shall be specified:
Installation ambient temperature range
Bonding material installation temperature range.

Operational time limits
Open time and curing time shall be stated in relation to the relevant temperature limits, e.g.:
Open time related to bonding material installation temperature
Curing time in relation to installation ambient temperature

If tables are used to indicate times-versus-temperature ranges, they shall be inclusive so that the relevant time is clear for all temperatures within the appropriate range. An accepted example is given in the following:

	Installation ambient temperature °C	Curing time (minutes)
e.g.	5 - 15	120 min
	16 - 25	60 min

The following example is not accepted:

Installation ambient temperature °C	Curing time (minutes)
5	120 min
15	60 min

When curing times are stated it shall be made clear that this is the earliest time that the anchor may be torqued or loaded. A longer waiting time may be recommended for proof of ultimate load tests on site, if so, this shall be stated.

Where anchors are installed using adapters attached to the anchor rod or socket, then the precise time when such adapters may be removed shall be stated.

Mixing instruction
For bulk components mixed by the operator it shall be stated that part mixing is not allowed and all components shall be mixed in the quantities as supplied.

The mixing equipment, its maintenance and the mixing procedures shall be described in sufficient detail to ensure thorough mixing as required. The point at which mixing is complete shall be clearly stated whether this be a mixing time or a mixed condition such as an even colour throughout the mix.

Bonding material placement controlled by the installer
For systems where the volume of material is controlled by the installer, e.g. injection and bulk systems, the instructions shall advise the user on how to insert the correct volume and ensure that the annulus is completely filled.
Instructions for placement shall describe how to ensure that air is not entrapped during placement of the resin or insertion of the rod.

9   THE ETA CONTENT

In addition to the requirements of Part 1, 9.1.3:

9.1.3 In addition, the different intended uses according to the installation and/or service conditions have to be given in the ETA.

9.1.4 9.2(b)   Characteristics of the anchor with regard to hygiene, health and the environment

In section II.2 "characteristics of products and methods of verification " the ETA shall include the following note:
"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."

Note: For dangerous substances falling under the scope of the CPD for which

-          no assessment and verification methods are given (or cannot be found in TR 034)
or
-          "no performance determined" is declared
or
-          the chosen verification and assessment method does not comply with the regulatory requirement of a particular Member State

there might be the necessity for an additional assessment.