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GUIDELINE FOR EUROPEAN TECHNICAL APPROVAL
of
METAL INJECTION ANCHORS FOR USE IN MASONRY

Annex A: DETAILS OF TESTS

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TABLE OF CONTENTS

INTRODUCTION	3
A.1 TEST SAMPLES	3
A.2 TEST MEMBERS	3
A.2.1 General	3
A.2.2 Test member for solid masonry material	3
A.2.3 Test member for hollow or perforated bricks and hollow blocks	3
A.2.4 Test member for autoclaved aerated concrete	4
A.2.4.1 Requirements for test specimens	4
A.2.4.2 Definition of test specimens/samples	4
A.2.4.3 Material characteristics	4
A.3 ANCHOR INSTALLATION	5
A.4 TEST EQUIPMENT	6
A.5 TEST PROCEDURE	9
A.5.1 General	9
A.5.2 Tension test	9
A.5.3 Shear test	9
A.5.4 Installation in dry or wet substrate	10
A.5.5 Influence of temperature on characteristic resistances	10
A.5.6 Tests under repeated loading	11
A.5.7 Tests under sustained loading	11
A.5.8 Maximum torque moment	12
A.5.9 Functioning under freeze/thaw conditions	12
A.5.10 Durability of the bonding material	12
A.6 TEST REPORT	13

Introduction

If details are not given in the following, these details shall be taken from ETAG 001, Annex A: Edition 1997, Amendment November 2006 [14].

A.1 Test samples

Samples shall be chosen to be representative of normal production as supplied by the manufacturer, including sleeve, threaded rod, deformed reinforced bar, internal threaded socket, or other shapes and the mortar.

Sometimes the tests are carried out with samples specially produced for the tests before issuing the European Technical Approval. If so, it shall be verified that the metal injection anchors subsequently produced conform in all respects, particularly suitability and bearing behaviour, with the anchors tested.

A.2 Test members

A.2.1 General

This ETAG applies to the use of injection anchors in masonry units of clay, calcium silicate, normal weight concrete, lightweight aggregate concrete, autoclaved aerated concrete (AAC) or other similar materials. The tests shall be performed in single units or in a wall. If tests are done in a wall, the thickness of the joints shall be about 10 mm and the joints shall be completely filled with mortar of strength class M2.5 with a strength $\leq 5 \text{ N/mm}^2$. If tests are performed with a mortar strength greater than M2.5 then the minimum mortar strength shall be given in the European Technical Approval. The units for test members of AAC may be glued together.

The walls may be lightly pre-stressed (about $0,2 \text{ N/mm}^2$ compressive pre-stressing) in the vertical direction to allow handling and transportation of the wall. The pre-stressing force should be applied in the quarter points of the wall in order to achieve a uniform distribution of stress in the wall.

If the tests are carried out in single units, the single units may also be lightly pre-stressed (about $0,2 \text{ N/mm}^2$ compressive pre-stressing).

A.2.2 Test member for solid masonry material (use category b)

The unit shall have a compressive strength between 20 and 40 N/mm^2 , unless where masonry units with a smaller compressive strength are given in the ETA, the test member shall then have the corresponding compressive strength.

All suitability tests and the tests according to this Guideline, Table 2.4.3, line 1 and 2 for admissible service conditions shall be performed with single injection anchors approximately in the centre of the unit under tension loading. The shear tests according to this Guideline, Table 2.4.3, line 3, shall be performed with single injection anchors approximately in the centre of the unit or in the wall under shear loading not influenced by edge effects. The tension tests according to this Guideline, Table 2.4.3, line 4 and the shear tests according to this Guideline, Table 2.4.3, line 5 shall be performed at the free edge of a unit (tests in units) or the wall (tests in a wall) with an edge distance $c=c_{\min}$.

The determined characteristic resistance given in the European Technical Approval is valid only for the unit sizes which are used in the tests or for larger sizes.

A.2.3 Test member for hollow or perforated bricks and hollow blocks (use category c)

Hollow or perforated bricks and hollow blocks shall be made of clay or calcium silicate, normal weight concrete or lightweight concrete. The location of the injection anchor with respect to the perforation shall be chosen such that the smallest anchor resistance can be expected.

The tension tests according to this Guideline, Table 2.4.3, line 4 and the shear tests according to this Guideline, Table 2.4.3, line 5 shall be performed at the free edge of a unit (tests in units) or the wall (tests in a wall) with an edge distance $c=c_{\min}$.

The determined characteristic resistance given in the European Technical Approval is valid only for bricks and blocks which have been used in the tests regarding base material, size of the units, compressive strength and configuration of the voids.

A.2.4 Test member for autoclaved aerated concrete (use category d)

A.2.4.1 Requirements for test specimens

At the time of testing the autoclaved aerated concrete (AAC) test specimens shall meet the following conditions:

Low strength AAC		
mean dry density	ρ_m (kg/m ³)	≥ 350
mean compressive strength	$f_{c,m}$ (N/mm ²)	1,8 to 2,8
High strength AAC		
mean dry density	ρ_m (kg/m ³)	≥ 650
mean compressive strength	$f_{c,m}$ (N/mm ²)	6,5 to 8,0

A.2.4.2 Definition of test specimens/samples

Test specimens: Testing of injection anchors is carried out on single units or walls with units mortared or glued together.

Samples: Samples (cubes/cylinders) are taken from the test specimen for determination of the material characteristics (see Figure A.2.4).
(cube: 100 x 100 x 100 mm); (cylinder: diameter 100 mm, height 100 mm)

The sample for determination of the material characteristic shall be taken from the same height as the position of the anchor relating to the direction of rise of the aerated concrete specimen, because the strength differs depending on the height of the direction of rise.

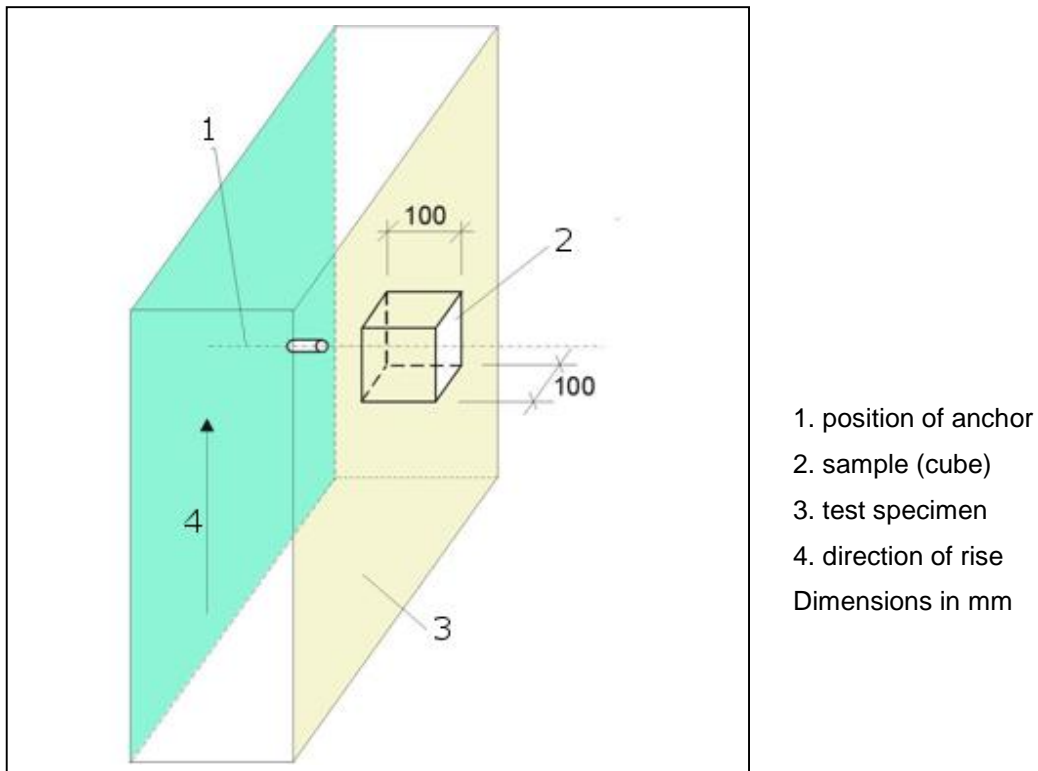


Figure A.2.4 – Taking of samples for autoclaved aerated concrete (AAC)

A.2.4.3 Material characteristics

For determination of the material characteristics the following conditions apply:

Test specimens shall be taken from each batch (cycle of production) on delivery from the manufacturing plant and from each pallet on delivery from the retailer. Test specimens shall always be taken from series production. The direction of rise shall be discernible on the test specimen.

At the beginning of testing the test specimens shall be at least 4 weeks old. The moisture content of the concrete during the time of testing shall be ≤ 30 M% measured on the sample (cube/cylinder) or AAC block. The test specimens shall be stored in the test laboratory or under comparable conditions such that air can gain access on all sides. The clear distance between test specimens and from the floor shall be at least 50 mm.

Determination of the material characteristics (compressive strength, dry density) and moisture content is always carried out on the sample (cube/cylinder) or an AAC block. The characteristics shall be determined on at least 5 samples (cube/cylinder) or blocks. The compressive strength shall be determined as the mean value. Testing of the compressive strength is performed in the direction of metal injection anchor setting (see Figure A.2.4).

A.3 Anchor installation

The injection anchors shall be installed in accordance with the installation instruction supplied by the manufacturer, unless explicitly required differently for a specific test. In tension and shear tests a torque shall not be applied to the anchor. Only in torque tests are the anchors torqued to failure. Torque shall be applied to the anchor by a torque wrench having traceable calibration. The measuring error shall not exceed 5 % of the applied torque throughout the whole measurement range.

For the installation safety tests special conditions are specified in this Guideline.

The holes for injection anchors shall be perpendicular to the surface of the member.

In the tests, the drilling tools and the type of drilling specified by the manufacturer shall be used. A drilling machine with a reasonable mass shall be used.

If hard metal hammer-drill bits are required, these bits shall meet the requirements of the standards (e.g. ISO 5468) with regard to dimensional accuracy, symmetry, symmetry of insert tip, height of tip and tolerance on concentricity. The diameter of the cutting edges as a function of the nominal drill bit diameter is given in Table A.3.1. In all tests (suitability tests and tests for admissible service conditions) the cylindrical hole is drilled with a medium diameter ($d_{cut,m}$) of the drill bit.

Table A.3.1 – Cutting diameter of hard metal hammer-drill bits

Nominal drill bite diameter d_0 (mm)	6	8	10	12	14	16	18	20	22	24	30
Size of test drill bit related to nominal drill bit diameter (mm)	+0,4 +0,15	+ 0,45 + 0,2			+ 0,5 + 0,2					+ 0,55 + 0,2	
Medium cutting diameter of drill bit $d_{cut,m}$ (mm)	6,25	8,3	10,3	12,3	14,3	16,3	18,3	20,3	22,35	24,35	30,35

A.4 Test equipment

Tests shall be carried out using measuring equipment having traceable calibration. The load application equipment shall be designed to avoid any sudden increase in load especially at the beginning of the test. The measuring error of the load shall not exceed 2 % throughout the whole measuring range.

Displacements shall be recorded continuously (e.g. by means of displacement electrical transducers) with a measuring error not greater than 0,02 mm.

For the tension tests, two test methods are distinguished: unconfined tests (see Figure A.4.1) and confined tests (see Figure A.4.2). Unconfined tests allow an unrestricted formation of the rupture cone of the base material. For this reason the clear distance between the support reaction and an injection anchor shall be at least $2 h_{ef}$ (tension test) or $2 c_1$ (shear tests with edge influence). In shear tests without edge influence where steel failure is expected, the clear distance may be less than $2 c_1$. In confined tests, cone failure is eliminated by transferring the reaction force close to the anchor into the base material.

During tension tests (see A.5.2) the load shall be applied concentrically to the injection anchor. To achieve this, hinges shall be incorporated between the loading device and the injection anchor or between the loading device and fixture (tests with double anchor groups).

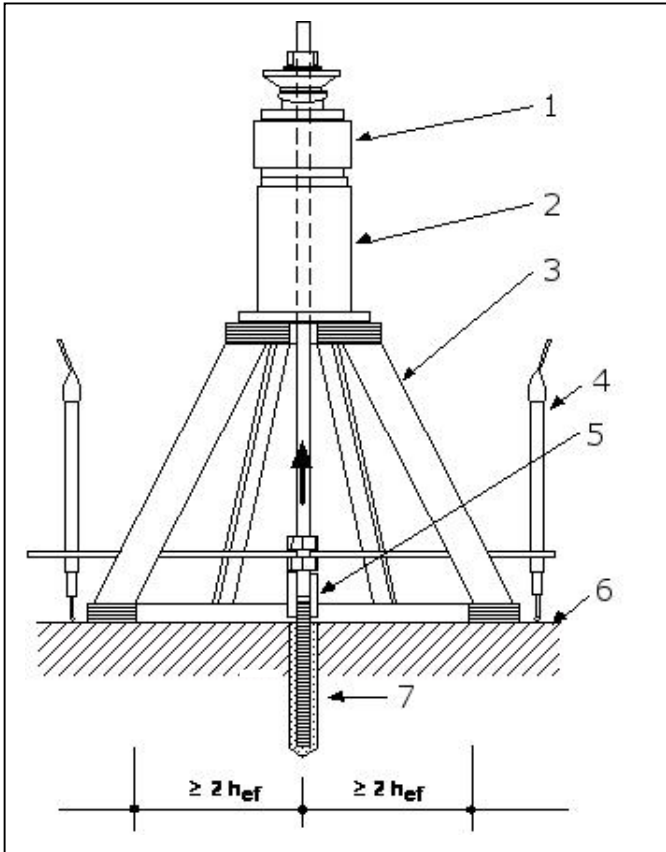
In shear tests (see A.5.4 and Figure A.4.3), the load shall be applied parallel to the surface of the base material. The height of the fixture shall be approximately equal to the outside diameter of the anchor. The diameter of the clearance hole in the fixture shall correspond to the sizes given in Table A.4.1. To reduce friction, smooth sheets (e.g. PTFE) with a maximum thickness of 2 mm shall be placed between the fixture and the test member.

During shear tests the load shall be applied such that pull out failure of the anchor or pry out failure is also covered. To achieve this, hinges shall be incorporated between the loading device and the fixture.

In torque tests the torque moment during installation until failure is measured. For this a calibrated torque moment transducer with a measuring error < 3 % throughout the whole measuring range shall be used.

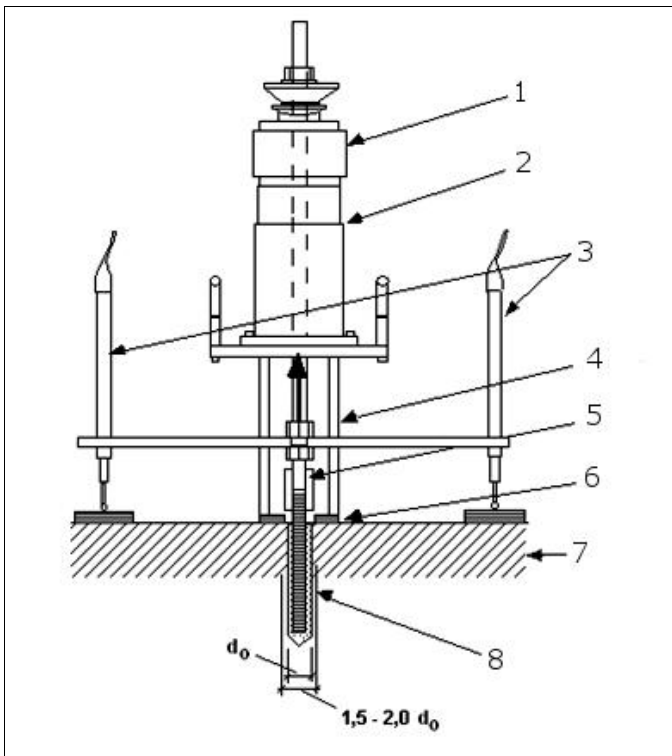
Table A.4.1 – Diameter of clearance hole in the fixture

External diameter d or d_{nom} (mm)	6	8	10	12	14	16	18	20	22	24	30
Diameter of clearance hole in the fixture d_f (mm)	7	9	12	14	16	18	20	22	24	26	33



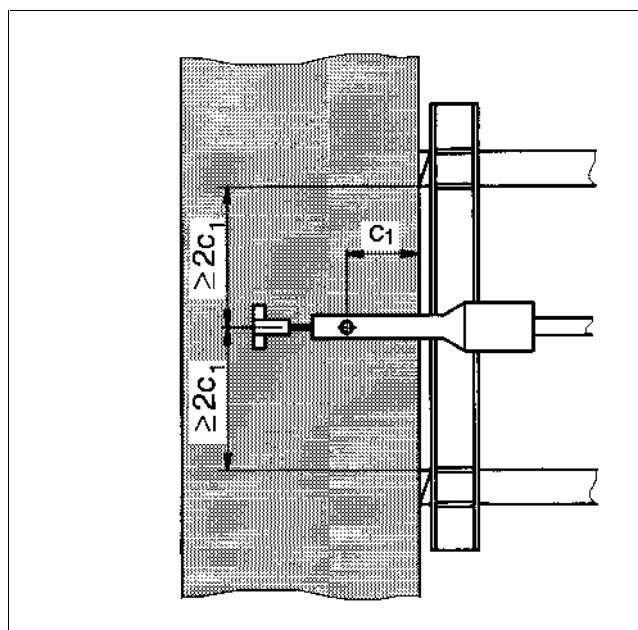
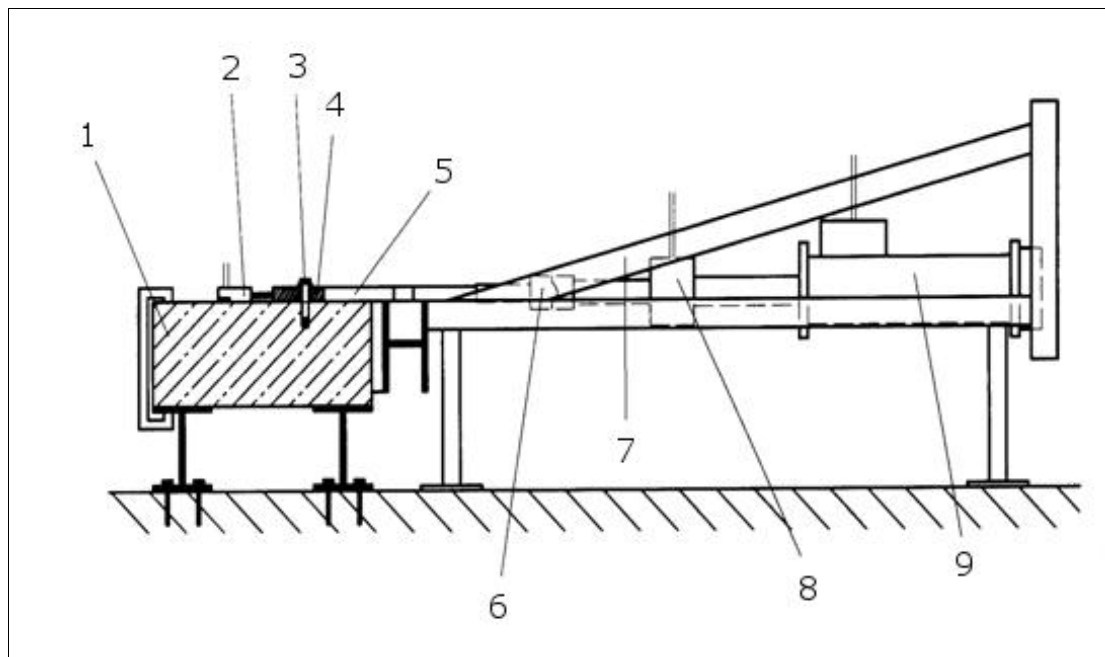
- 1 load cell
- 2 load cylinder
- 3 support
- 4 displacement transducer
- 5 socket
- 6 test member
- 7 injection anchor

Figure A.4.1 – Example of a tension test rig for unconfined tests



- 1 load cell
- 2 load cylinder
- 3 displacement transducer
- 4 support
- 5 socket
- 6 steel plate
- 7 test member
- 8 injection anchor

Figure A.4.2 – Example of a tension test rig for confined tests



- 1 test member
- 2 displacement transducer
- 3 anchor
- 4 fixture
- 5 loading plate
- 6 universal joint
- 7 support
- 8 load cell
- 9 load cylinder

Figure A.4.3 – Example of a shear test rig

A.5 Test procedure

A.5.1 General

The injection anchors shall be installed in accordance with the installation instructions supplied by the manufacturer, except where deviations are specified in this Guideline. The drill holes shall be drilled using $d_{cut,m}$ drill bits. If the approval is to cover more than one drilling technique, then tests where drilling has an influence shall be carried out for all drilling techniques.

The tests for determination of **admissible service conditions** shall be carried out in the base material for which the injection anchor is intended to be used at normal ambient temperature ($+21\text{ °C} \pm 3\text{ °C}$). The tests shall be carried out at the most unfavourable setting position in the brick of the hollow or perforated masonry, which give the lowest characteristic resistance of the anchor (exception: tests with minimum edge distance according to Table 2.4.3, line 4 of this Guideline). If the anchor is to be placed in the underside of a slab made of bricks, in the test the anchor shall be installed upwards in a vertical direction. The tests shall be carried out as unconfined tension tests.

The **reference tension tests** shall be carried out for determination of the results of the suitability tests. They have to be carried out with the same masonry units regarding base material, size of units and compressive strength as are used for the corresponding suitability tests. The tests shall be carried out as confined tension tests in the same way as the corresponding suitability tests.

The **suitability tests** shall be carried out in the base material according to 2.4.1.1. The anchors shall be installed according to the installation instructions of the manufacturer (except the installation safety tests, see A.5.4) in a horizontal direction in the centre of the brick. The tension tests shall be carried out as confined tension tests.

For all tests the load shall be increased in such a way that the peak load occurs after 1 to 3 minutes from commencement. Load and displacement shall be recorded either continuously or at least in about 100 intervals (up to peak load). The tests may be carried out with load or displacement control. In case of displacement control, the test shall be continued after the maximum load up to at least 75 % of the maximum load to be measured (to allow the drop of the displacement curve).

A.5.2 Tension test

After installation, the injection anchor is connected to the test rig and loaded to failure. The displacements of the anchor relative to the surface of the test member shall be measured by use of either one displacement transducer on the socket of the test rig or at least two displacement transducers on either side (unconfined test: at a distance of $\geq 2,0 h_{ef}$ from the anchor); the mean value shall be recorded in the latter case.

The anchors of an anchor group shall be connected by a rigid fixture. The tension load shall be applied centrally to the fixture. The connection between the fixture and the load jack shall be hinged to permit differential anchor displacement to occur.

When testing injection anchors at the free edge of a test member, the test rig shall be placed such that an unrestricted failure towards the edge is possible. It may be necessary to support the test rig outside the test member.

A.5.3 Shear test

After installation, the injection anchor is connected to the test rig without gap between the anchor and the loading plate. The tension rod shall be attached to the fixture with a hinge. Then it is loaded to failure.

The displacements of the anchor relative to the base material shall be measured in the direction of the load application, for example by use of a displacement transducer fixed behind the injection anchor (seen from the direction of load application) on the base material.

When testing anchors at an edge, the test rig shall be arranged such that an unrestricted brick edge failure may occur.

A.5.4 Installation in dry or wet substrate

(a) Installation in dry substrate

These tests have to be done for all use categories. Confined tension tests in dry solid bricks (dry conditions according to EN 772-1:2011, 7.3.2 [16]).

Drill downwards to the depth required by the manufacturer.

Clean the hole with the hand pump and brush supplied by the manufacturer, using two blowing and one brushing operations 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 and carry out tension tests.

(b) Installation in wet masonry

These tests may be omitted for use category d/d (dry).

Confined tension tests in wet solid bricks.

Hole cleaning and installation according to A.5.4 (a). However the substrate in the area of anchorage shall be water saturated when the hole is drilled, cleaned and the embedded part is installed.

If bricks are put under water for one day (at least for 24 hrs) water saturated substrate will be achieved.

A.5.5 Influence of temperature on characteristic resistances

a) Effect of increased temperature

The confined tension tests shall be carried out at the following temperatures for the different temperature ranges given in 2.3.2.3 of this Guideline:

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

Tests 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 (Tb) maximum short term temperature up to +80 °C:

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

Temperature range (Tc) 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.

Anchor size: medium diameter

Test method:

Install anchors at normal ambient temperature according to manufacturer's installation instructions.

Raise the test member temperature to the required test temperature at a rate of approximately 20 K per hour. Cure the 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 substrate surface at ± 2 K of the required value, carry out the confined tension test.

Number of tests: ≥ 5 tests per temperature.

b) Effect of low installation temperature

Anchor size: medium diameter

Test method:

Drill and clean the hole according to the manufacturer's installation instructions then cool the 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 the anchor and 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 tests 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 substrate surface at the specified lowest installation temperature ± 2 K.

Number of tests: ≥ 5 tests

c) Minimum curing time at normal ambient temperature

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

Number of tests: ≥ 5 tests

A.5.6 Tests under repeated loading

The injection anchor is subjected to 1×10^5 load cycles with a maximum frequency of approximately 6 Hz. During each cycle the load shall be varied as a sine curve between max N and min N according to equation (A.5.1) and (A.5.2). The displacements shall be measured during the first loading up to max N and either continuously or at least after 1, 10, 100, 1 000, 10 000 and 100 000 load cycles.

$$\max N = 0,4 \cdot N_{Ru,m} \quad (A.5.1)$$

$$\min N = 0,2 \cdot N_{Ru,m} \quad (A.5.2)$$

$N_{Ru,m}$ = mean ultimate load in the test series according to Table 2.4.3, line 2 of this Guideline.

After completion of the load cycles the anchor shall be unloaded, the displacement measured and a confined tension test performed.

A.5.7 Tests under sustained loading

The test is performed at normal temperature ($T = +21 \text{ °C} \pm 3 \text{ °C}$) for temperature range (Ta), (Tb) and (Tc) and at maximum long term temperature for temperature range (Tb) and (Tc) [$T = +50 \text{ °C}$ for temperature range b)].

The anchor shall be installed at normal temperature.

The anchor is then subjected to a tension load according to equation (A.5.3) which is kept constant (variation within $\pm 5 \%$). Maintain the load and temperature and measure the displacements until they appear to have stabilised, but at least for three months.

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

$$N_p = 0,4 \cdot N_{Ru,m} \quad (A.5.3)$$

$N_{Ru,m}$ = mean ultimate load in the test series according to Table 2.4.3, line 2 of this Guideline.

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

A.5.8 Maximum torque moment

The torque moment shall be measured with a calibrated torque moment transducer. The torque moment shall be increased until failure of the injection anchor.

The maximum torque moment for use category **c** (use in hollow or perforated masonry) shall be carried out in hollow units. The tests shall be carried out at the most unfavourable setting position, which give the lowest failure torque moments.

The suitability tests for use categories **b** (use in solid masonry) shall be carried out in solid masonry and for use categories **d** (use in autoclaved aerated concrete masonry) shall be done in autoclaved aerated concrete.

A.5.9 Functioning under freeze/thaw conditions

The tests are carried out for injection anchors with a service condition in wet substrate only. The tests are performed in freeze-thaw resistant member. The tests may also be carried out in freeze-thaw resistant concrete C50/60; in this case the corresponding reference tests are required in concrete under normal condition as well.

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_p according to Equation (A.5.3).

Carry out 50 freeze/thaw cycles as follows:

- Raise the temperature of the chamber to $+20 \pm 2$ °C within 1 hour, maintain the chamber temperature at $+20 \pm 2$ °C for 7 hours.
- Lower the temperature of the chamber to -20 ± 2 °C within 2 hours, maintain the 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.

A.5.10 Durability of the bonding material

With slice tests, the sensitivity of installed anchors to different environmental exposure can be shown.

The slice tests shall be carried out in concrete.

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 150 mm. 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 diameter) 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 the manufacturer's instructions the concrete cylinders or cubes are carefully sawn into 30 mm 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 tests 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 ± 5 %) for 2 000 hours are necessary.

High alkalinity:

The slices are stored under standard climate conditions in a container filled with an alkaline fluid (pH = 12,5). 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 12,5 is reached. The alkalinity of pH = 12,5 shall be kept as close as possible to 12,5 during the storage and not fall below a value of 12,5. Therefore the pH-value shall be checked and monitored at regular intervals (at least daily).

Sulphurous atmosphere:

The tests in sulphurous atmosphere shall be performed according to EN ISO 6988:1994 [13]. The slices are put into the test chamber, however in contrast to EN ISO 6988:1994 [13] the theoretical sulphur dioxide concentration shall be 0,67 % at the beginning of a cycle. This theoretical sulphur dioxide concentration corresponds to 2 dm³ of SO₂ for a test chamber volume of 300 dm³. 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, then the slice is placed centrally to the hole of the steel rig plate. If slices are unreinforced, 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.

A.6 Test report

As a minimum requirement, the report shall include at least the following information:

General

- Description and type of injection anchor
- Anchor identification (dimensions, materials, coating, production method)
- Name and address of manufacturer
- Name and address of test laboratory
- Date of tests
- Name of person responsible for the tests
- Type of test (e.g. tension, shear, short-term or repeated load test)
- Number of tests
- Testing equipment: load cells, load cylinder, displacement transducer, software, hardware, data recording
- Test rigs, illustrated by sketches or photographs
- Particulars concerning support of the test rig on the test member

Test members

- Base material
- Dimensions of control specimens, and/or cores (if applicable) measured value of compressive strength at the time of testing (individual results and mean value)
- Dimensions of test member, for perforated units also the hole configuration
- Nature and positioning of any reinforcement (for AAC only)
- Direction of concrete pouring (for AAC only)

Anchor installation

- Information on the positioning of the injection anchor
- Distances of anchors from edges of test member
- Tools employed for anchor installation, e.g. impact drilling tool, drilling hammer, other equipment, e.g. torque wrench
- Type of drill bit, manufacturer's mark and measured drill bit dimensions, particularly the effective diameter, d_{cut} , of the hard metal insert
- Information on the direction of drilling
- Information on cleaning of the hole
- Depth of drill hole
- Depth of anchorage
- Information on the direction of installation
- Installation time and testing time or other parameters for control of installation
- Type of attachment

Measured values

- Parameters of load application (e.g. rate of increase of load or size of load increase steps)
- Displacements measured as a function of the applied load
- Any special observations concerning application of the load
- Failure load
- Failure mode
- Radius (maximum radius, minimum radius) and height of a cone produced in the test (where applicable)
- Particulars of repeated load tests
 - minimum and maximum load
 - frequency of cycles
 - number of cycles
 - displacements as function of the number of cycles
- Particulars of sustained load tests
 - constant load on injection anchor and method of applying it
 - anchor displacement as a function of time
- Particulars of torque test
 - maximum torque moment at failure

The above measurements shall be recorded for each test.

- Particulars of identification tests
 - dimensions of the parts of the injection anchor and the drilling- and installation tools
 - properties (e.g. tensile strength, elastic limit, elongation at rupture)