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EAD **330424-00-0604**

December 2017

European Assessment Document for

Screw anchors for autoclaved aerated concrete and lightweight aggregate concrete

This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

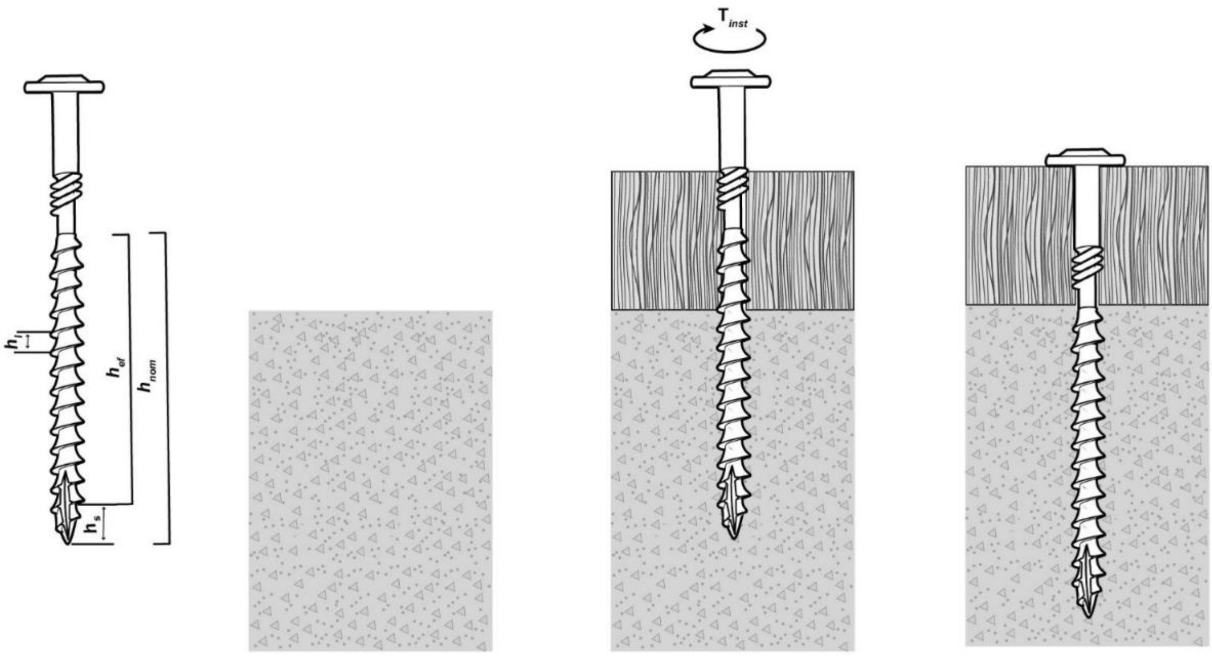
The screw anchors for autoclaved aerated concrete and lightweight aggregate concrete (in the following referred to as screw anchors) covered by the EAD are made from carbon steel wire. The screw anchors are threaded over part of the length and have corrosion protection coating. They are screwed directly into the base material without pre-drilling.

The screw anchors can be supplied with different head formations:

- hexagonal washer head,
- head with inner thread,
- countersunk head or pan head,
- wafer head

and different recesses:

- cross recess,
- TX-recess.



This EAD covers screw anchors which are set perpendicular to the surface of the Autoclaved Aerated Concrete (AAC) or of the Lightweight Aggregate Concrete (LAC) member. This EAD assesses the performance for screw anchors that are only used once (without re-installation or loosening and retightening). ETAs issued based on this EAD shall indicate this scope.

The product is not covered by a harmonised European standard (hEN) and it is not covered by EAD 330232-01-0601[1], since EAD 330232-01-0601 covers concrete screws used in pre-drilled holes and only in normal weight concrete.

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

In this EAD the assessment is made to determine characteristic values of the screw anchors for calculation in accordance with EN 1992-4 [10] and for non-loadbearing applications such as fixing of claddings, insulation panels, frame for light weight partitions, roof truss or similar under static and quasi-static actions in tension and/or shear loading and bending:

The screws are intended to be used in:

- Solid autoclaved aerated concrete (AAC) members
    - Masonry units acc. to EN 771-4 [2], for the test program these members represent the intended use of non-cracked concrete.
    - Prefabricated reinforced components acc. to EN 12602 [3], for the test program these members represent the intended use of cracked concrete.
- Solid lightweight aggregate concrete (LAC) members
    - Masonry units acc. to EN 771-3 [4], for the test program these members represent the intended use of non-cracked concrete.
    - Prefabricated reinforced components acc. to EN 1520 [4].

The screw anchors are intended to be used in following strength ranges of AAC:

Low strength AAC			
mean dry density		ρ_m [kg/m³]	≥ 350
mean compressive strength	masonry	$f_{c,m}$ [N/mm²]	1,8 to 2,8
Strength class according to EN 12602/Table 2a	slabs	Class	AAC 2
High strength AAC			

1 All undated references to standards in this EAD are to be understood as references to the dated versions listed in clause 4

mean dry density		ρ_m [kg/m³]	> 650
mean compressive strength	masonry	$f_{c,m}$ [N/mm²]	6,5 to 8,0
Strength class according to EN 12602/Table 2a	slabs	Class	AAC 6

The screw anchors are intended to be used in following strength ranges of LAC:

Low strength LAC		
Mean dry density	σ_m (kg/m³)	≥ 400
Mean compressive strength of masonry units according to EN 771-3	$f_{c,m}$ (N/mm²)	All strengths
Strength class according to EN 1520 table 7	Class	LAC2
High strength LAC		
Mean dry density	σ_m (kg/m³)	≥ 2000
Mean compressive strength of masonry units according to EN 771-3	$f_{c,m}$ (N/mm²)	All strengths
Strength class according to EN 1520 table 7	Class	LAC25

This EAD applies to:

- Applications where the minimum thickness of members in which anchors are installed is:
  - The minimum anchorage depth of the anchor min h_{ef} shall be 50 mm. Where $h_{ef} = h_{nom} - h_s$
  - The maximum anchorage depth shall be max $h_{ef} = h_{min}$ -30 mm.
- Anchorage base temperature range in service condition -40 °C to +80 °C
- Screw anchors which are set perpendicular to the surface of the AAC or LAC member.
- Screw anchors set in joints
- Screw anchors that are only used once (without re-installation or loosening and retightening). ETAs issued based on this EAD shall indicate this scope
- Screw anchors not subject to compression actions
- Installations with contact with reinforcements.

Any Manufacturer's Product Installation Instructions (MPII) (e.g., installation tools, torque moments) shall be reported in the ETA.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the screw anchor for the intended use of 50 years when installed in the works (provided that the screw anchor is subject to appropriate installation (see 1.1)). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

The notations and symbols frequently used in this EAD are given below. Further particular notation and symbols are given in the text. The notations of EAD 330232-00-0601[6] may also be noticed.

a	=	spacing between outer anchors in adjoining fastenings
c	=	edge distance
c_{cr}	=	characteristic edge distance
c_{min}	=	minimum allowable edge distance
d	=	screw anchor diameter
d_f	=	diameter of clearance hole in the fixture
h	=	thickness of concrete member
h_{min}	=	minimum thickness of concrete member
h_{ef}	=	effective anchorage depth
h_{nom}	=	overall screw anchor embedment depth
h_s	=	length of the tip of the screw anchor (= length of the embedded end of the screw anchor without the full height of thread)
s	=	spacing of the screw anchors
s_{cr}	=	characteristic spacing
s_{min}	=	minimum allowable spacing
T	=	torque moment
T_{inst}	=	maximum installation torque moment
T_u	=	maximum torque moment during failure
t_{fix}	=	thickness of fixture.

1.3.1 Base material and metal parts of screw anchors

f_c	=	compression strength of aerated concrete or lightweight concrete member
$f_{c,test}$	=	compression strength of the test concrete at the time of testing
$f_{y,test}$	=	steel tensile yield strength in the test
f_{yk}	=	nominal characteristic steel yield strength
$f_{u,test}$	=	steel ultimate tensile strength in the test
f_{uk}	=	nominal characteristic steel ultimate strength.

1.3.2 Loads/forces

F	=	force in general
N	=	normal force (+N = tension force)
V	=	shear force
M	=	moment
N_{Rk}, V_{Rk}	=	characteristic screw anchor resistance (5%-fractile of results) under tension or shear force.

2 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than the assumed working life.

1.3.3 Tests

F^t_{Ru}	=	ultimate load in a test
$F_{Ru,m}$	=	mean ultimate load in a test series
F_{Rk}	=	5%-fractile of the ultimate load in a test series
n	=	number of tests of a test series
v	=	coefficient of variation
$\delta(\delta_N, \delta_V)$	=	displacement (movement) of the screw anchors at the concrete surface relative to the concrete surface in direction of the load (tension, shear) outside the failure area. The displacement includes the steel and concrete deformations and a possible screw anchor slip.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of screw anchors is assessed in relation to the essential characteristics.

Table 2.1.1Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Method of verification and assessment	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Characteristic resistance under static and quasi-static loading		
	Characteristic resistance in any load direction	2.2.1.6.1	N_{Rk} [kN] for tension and V_{Rk} [kN] for shear or F_{Rk} [kN]
	Resistance to steel failure under shear load with lever arm	2.2.1.6.2	$M_{Rk,s}$ [Nm]
	Minimum edge distance and spacing	2.2.1.8	c_{min}, s_{min} [mm]
	Characteristic edge distance and spacing	2.2.1.8	c_{cr}, s_{cr} [mm]
	Minimum thickness of AAC or LAC member	2.2.1.5	h_{min} [mm]
3	Displacement of screw anchor for serviceability limit state	2.2.3	δ_0, δ_∞ [mm]
Basic Works Requirement 2: Safety in case of fire			
4	Reaction to fire	2.2.4	Class
Basic Works Requirement 4: Safety in use			
2	Characteristic resistance in any load direction	2.2.1.6.1	N_{Rk} [kN] for tension and V_{Rk} [kN] for shear or F_{Rk} [kN]
	Resistance to steel failure under shear load with lever arm	2.2.1.6.2	$M_{Rk,s}$ [Nm]
	Minimum edge distance and spacing	2.2.1.8	c_{min}, s_{min} [mm]
	Characteristic edge distance and spacing	2.2.1.8	c_{cr}, s_{cr} [mm]
	Minimum thickness of AAC or LAC member	2.2.1.5	h_{min} [mm]
Aspects of durability			
2	Durability of corrosion protection	2.2.2	Description

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Characteristic resistance under static and quasi-static loading

The test program for the assessment consists of:

- Basic tension tests and basic shear tests to assess basic values of characteristic resistance and
- Any other tests (functioning tests) to assess the characteristic resistance regarding various effects for the relevant application range according to the intended use.

The purpose of the basic tension and shear tests is to determine the basic technical data required to predict the performance of the screw anchors under service conditions and derive corresponding design information.

Functioning tests are performed to assess the sensitivity of the screw anchors system regarding variations in the properties of the base material and foreseeable deviations from the manufacturer’s installation instructions and establish a safe, effective and robust behaviour of the screw anchors system under normal and adverse installation conditions.

All tests shall be performed on the final product, any deviations from this shall be justified. The screw anchors shall be set following the manufacturer's instructions, if no other setting instructions are specified in this document. The tests shall be performed following the EAD 330232-01-0601[6] as far as applicable.

In the test program prefabricated reinforced components (Slabs) of autoclaved aerated concrete according to EN 12602 [3] represent the intended use of cracked concrete and autoclaved aerated concrete masonry units (Masonry) according to EN 771-4 [2] represent the intended use of non-cracked concrete. Members of lightweight aerated concrete according to EN 771-3 [4] (masonry) and EN 1520 [4] (slabs) represent the intended use in lightweight aerated concrete.

Requirements for test specimens (autoclaved aerated concrete):

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

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

Requirements for test specimens (lightweight aerated concrete):

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

Low strength LAC		
mean dry density	σ_m (kg/m³)	≥ 400
mean compressive strength of masonry units according to EN 771-3	$f_{c,m}$ (N/mm²)	As specified Manufacturer's Product Installation Instructions (MPII)
Strength class according to EN 1520 table 7	Class	LAC2
High strength LAC		
mean dry density	σ_m (kg/m³)	≥ 2000
mean compressive strength of masonry units according to EN 771-3	$f_{c,m}$ (N/mm²)	As specified by Manufacturer's Product Installation Instructions (MPII)
Strength class according to EN 1520 table 7	Class	LAC25

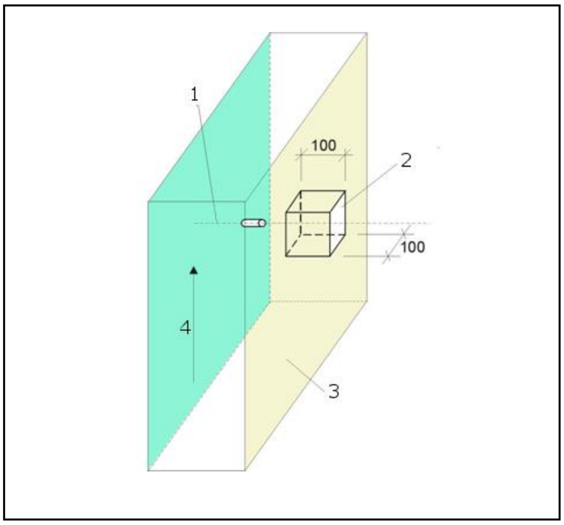
Definition of test specimens/samples:

Test specimens: Testing of screw anchors is carried out on single units (slabs or bricks) 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 2.2.1.1).

(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 screw 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.



1. Position of screw
2. Sample (cube)
3. Test specimen
4. Direction of rise

Dimensions in mm

Figure 2.2.1.1 Taking of unit cube

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 mass-related moisture content of the concrete during the time of testing shall be ≤ 30 % measured on the sample (cube/cylinder) or LAC/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 LAC/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 (arithmetic average) value. Testing of the compressive strength is performed in the direction of the screw anchor (see Figure 2.2.1.1).

2.2.1.1 Functioning tests

The purpose of the functioning test is to establish whether the screw anchor is capable of safe, effective behaviour in service including consideration of various effects for the relevant application range according to the intended use both during site installation and in service.

The required tests for the screw anchor are given in Table 2.2.1.1.1 Reference tests for these functioning tests are the tests A1 according to Table 2.2.2.1.2.1.

Table 2.2.1.1.1 Functioning tests for use in cracked and non-cracked AAC

	Purpose of test	Strength class of AAC	Member	Crack width Δw [mm]	Minimum number of tests (5)			Criteria req. α
					s	m	ℓ	
F2	Functioning in wet AAC (3)	Low (1)	Masonry	0	5	5	5	≥ 0,8
F3	Functioning in AAC of low strength	Low (1)	Slab (4)	0,5	5	5	5	≥ 0,8
F4	Functioning in AAC of high strength	High (2)	Slab (4)	0,5	5	5	5	≥ 0,8
F5	Functioning in crack movements	High (2)	Slab (4)	0,1-0,3	5	5	5	≥ 0,9
F6	Functioning under sustained loads	Low (1)	Masonry	0	-	5	-	≥ 0,9
F7	Functioning after repeated loads	Low (1) High (2)	Masonry	0	-	3 3	-	≥ 1,0
F8	Maximum torque moment	Low (1)	Masonry	0	5	5	5	
F9	Contact with reinforcement	Low (1)	Slab	0,3	5	5	5	≥ 0,85
F10	Resistance to hydrogen embrittlement. (6)	High (2)	Slab/masonry	0	5	5	5	0,9

(1) Minimum strength class of AAC AAC2 unless oterhwise specified by the applicant)
(2) Maximum strength class of AAC, AAC 6 unless otherwise specified by the applicant
(3) Before installation, storage of test specimen under water for 48 h and dropping off for 2 h while keeping side of later installation of screw anchor to the bottom
(4) The slabs are made in accordance with EN 12602

(5) Screw anchor size: s = smallest; m = medium; l = largest
(6) Applies to screw anchors with steel strength higher than 1000 N/mm2 and hardness greater than 350 HV referring to the total cross section for both surface and core hardness according to EN ISO 6507-1.

Table 2.2.1.1.2 Functioning tests for use in lightweight aerated concrete (LAC)

	Purpose of test	Strength class of AAC	Member	Crack width Δw [mm]	Minimum number of tests (5)			Criteria req. α
					s	m	l	
F2	Functioning in wet LAC (3)	Low (1)	Slab/Masonry	0	5	5	5	≥ 0,8
F3	Functioning in LAC of low strength	Low (1)	Slab (4)	0,5	5	5	5	≥ 0,8
F4	Functioning in LAC of high strength	High (2)	Slab (4)	0,5	5	5	5	≥ 0,8
F5	Functioning in crack movements	High (2)	Slab (4)	0,1-0,3	5	5	5	≥ 0,9
F6	Functioning under sustained loads	Low (1)	Slab/Masonry	0	-	5	-	≥ 0,9
F7	Functioning after repeated loads	Low (1) High (2)	Slab/Masonry	0	-	3 3	-	≥ 1,0
F8	Maximum torque moment	Low (1)	Masonry	0	5	5	5	
F9	Contact with reinforcement	Low (1)	Slab	0,3	5	5	5	≥ 0,85
F10	Resistance to hydrogen embrittlement. (6)	High (2)	Slab/masonry	0	5	5	5	≥ 0,9

(1) Minimum strength class of LAC:
- In the case of prefabricated reinforced lightweight concrete units – LAC 2 according to EN 1520, unless otherwise specified by applicant
- In the case of one type of lightweight aggregate concrete blocks – tests performed in used lightweight aggregate concrete blocks
- In the case of two or more types of lightweight aggregate concrete blocks – tests performed in the lightweight aggregate concrete blocks with the lowest compressive strength

(2) Maximum strength class of LAC:
- In the case of prefabricated reinforced lightweight concrete units – LAC 25 according to EN 1520, unless otherwise specified by applicant
- In the case of one type of lightweight aggregate concrete blocks – tests performed in used lightweight aggregate concrete blocks
- In the case of two or more types of lightweight aggregate concrete blocks – tests performed in the lightweight aggregate concrete blocks with the highest compressive strength

(3) Before installation, storage of test specimen under water for 48 h and dropping off for 2 h while keeping side of later installation of screw anchor to the bottom
(4) The slabs are made in accordance with EN 1520
(5) Screw anchor size: s = smallest; m = medium; l = largest
(6) Applies to screw anchors with steel strength higher than 1000 N/mm2 and hardness greater than 350 HV referring to the total cross section for both surface and core hardness according to EN ISO 6507-1;

These tests have to be performed according to EAD 330232-01-0601[6] with following details and amendments:

Test procedure F5: Crack cycling under load -see EAD 33 232-01-0601[6] section 2.2.2.4

Experience has shown that the crack movements are difficult to steer with rebar in AAC. Therefore, it is recommended to steer the crack movements with a concrete slab as described in EAD 330232-01-0601[6]. The AAC slab shall be cut and fixed undisplaceable to a cracked concrete slab such that the crack of AAC and concrete slab are directly above each other. The crack opening is created in the concrete slab whereas the measurement of the crack width is located on both sides of the AAC slab over the joint. The screw anchor shall be installed in the middle of the slab.

After screw anchor installation the maximum (max N_s) and minimum (min N_s) loads applied to the test member shall be determined such that the crack width under max N_s is Δw_1 = 0,3 mm and under min N_s is Δw_2 = 0,1 mm. To stabilize crack formation, up to 10 load changes varying between max N_s and min N_s shall be applied. Then a tensile load N_p [Equation (2.2.1.1.1)] is applied to the screw anchor after opening the crack to Δw_1 = 0,3 mm.

$$N_p = 0{,}75\ N_{Rk} / 1{,}73 \qquad (2.2.1.1.1)$$

with N_{Rk} = characteristic resistance evaluated for the corresponding strength-class of AAC

Test procedure F6: Functioning under sustained loads – EAD 33232-01-0601[6] section 2.2.2.1

The screw anchor is subjected to a load according to Equation (2.2.1.1.2) and kept constant (variation within 0/+ 5 %). The duration of the test is in accordance with section 2.2.2.6 of EAD 330499-01-0601.

$$N_p = 0{,}55\ N_{Rk} \qquad (2.2.1.1.2)$$

with N_{Rk} = characteristic resistance evaluated for the corresponding strength-class of AAC

Test procedure F7: Functioning under repeated loads – see EAD 33232-01-0601[6] section 2.2.2.5

The screw anchor is subjected to 10^5 load cycles with a maximum frequency of approximately 6 Hz. During each cycle the load shall change as a sine curve between max N and min N with:

$$\text{Max } N = 0{,}60\ N_{Rk} \qquad (2.2.1.1.3)$$

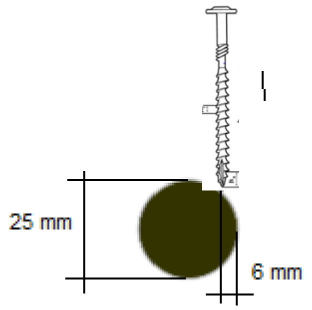
$$\text{min } N = 0{,}25\ N_{Rk}. \qquad (2.2.1.1.4)$$

with N_{Rk} = characteristic resistance evaluated for the corresponding strength-class of AAC

Test procedure F9: Contact with reinforcement – see EAD 33232-01-0601[6] section 2.2.4.2

For these tests a special member with smooth reinforcement bars without ribs of a diameter of 25 mm (f_{uk} = 500 N/mm2) is used. The shallAAC/LAC concrete cover shall be 10 mm. The setting position in the quarter point of the reinforcing bar (shown in Figure 2.2.1.1.1) shall be tested. The single fasteners are tested in tension and loaded to failure. Details of the test are described in EAD 330232-01-0601 [6].

Figure 2.2.1.1.1: Setting position for contact with reinforcement



<u>Test procedure F10: Resistance to hydrogen embrittlement.</u>

Details of the test are described in EAD 330232-01-0601 section 2.2.1.3 [6] with the test performed in the base material according to table 2.2.1.1.1 and 2..2.1.1.2.

2.2.1.2 Tests for evaluating the resistance to tension and shear loads

Prefabricated reinforced components are assumed to represent cracked concrete. Due to the production process, the width of the components is limited to less than about 700 mm, because the LAC/AAC is risen in direction of the width of the component.

Tests for the resistance of the members made of AAC due to the loads introduced by the screw anchor connections are not required, if all of the following restrictions are kept:

- The characteristic value of shear stresses in the member caused by the screw anchor connections are less or equal to 40% of the characteristic values of resistance of the member in the critical cross section.
- The distance to the edges of the slabs of width ≤ 700 mm are ≥ 150 mm.
- The spacing a between fixing points are ≥ 600 mm. Fixing points are single screw anchors, or screw anchor groups of 2 or 4 screw anchors.

AAC masonry units are assumed to represent non-cracked concrete. It is assumed that the screw anchor shall only be set in masonry.

The basic tests are given in Table 2.2.1.2.1.

The definition of spacing and edge distances is given in Figure 2.2.1.2.1 and Figure 2.2.1.2.2. If the joints of the masonry are not filled with mortar, c_{min} has to be kept also to the joint.

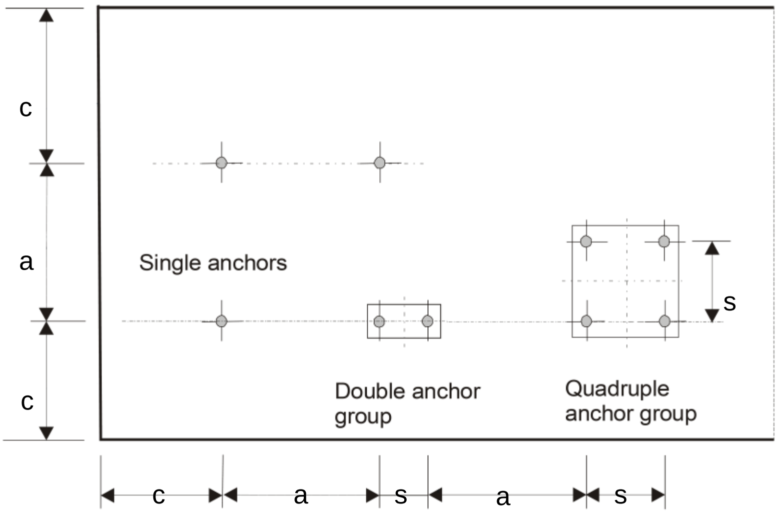


Figure 2.2.1.2.1 Edge distances and spacing in prefabricated reinforced LAC and AAC components

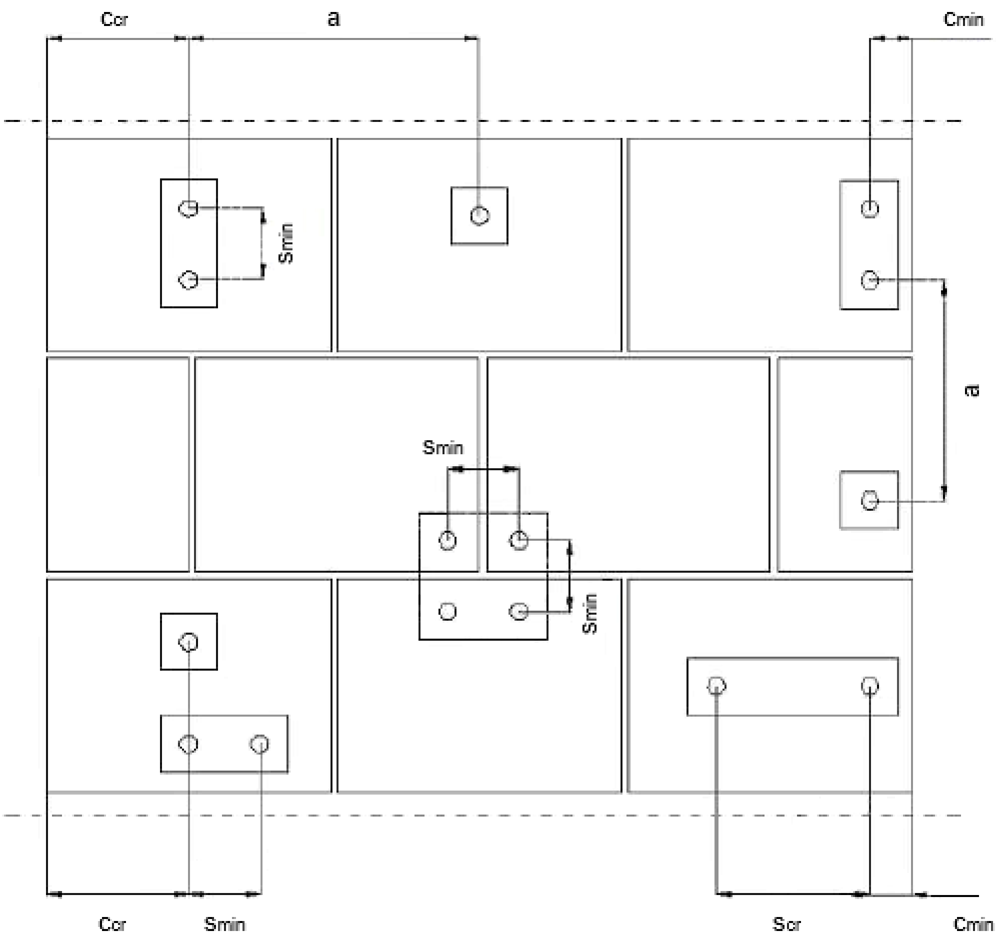


Figure 2.2.1.2.2 Edge distances and spacing in LAC and AAC masonry units

Table 2.2.1.2.1 Basic tests for determination of tension and shear load resistance for both LAC and AAC. Tests have to be done for each material (AAC and LAC) to be assessed and covered by the ETA..

	Purpose of test	Strength class	Crack width Δw [mm] (4)	Load direc-tion	Spacing, edge distance	Thick-ness of member	Num-ber of tests per size	Remarks
A1	Characteristic tension resistance not influenced by edge and spacing effects	Low (1) High (2)	0,3 0,3	N N	$c > c_{cr}$	$h \geq h_{min}$	10 10	single screw anchor
A2	Characteristic shear resistance not influenced by edge and spacing effects (5)	Low (1) High (2)	0,3 0,3	V V	$c > c_{cr}$	$h \geq h_{min}$	5 5	single screw anchor
Optional tests								
A3	Characteristic tension resistance at the edge	Low (1)	0	N	$c = c_{min}$	$h = h_{min}$	5	single screw anchor at the edge
A4	Characteristic shear resistance at the edge	Low (1)	0	V	$c = c_{min}$	$h = h_{min}$	5	single screw anchor at the edge
A5	Characteristic tension resistance at the corner	Low (1)	0	N	$c_1=c_2=c_{min}$	$h = h_{min}$	8	single screw anchor in the corner
A6	Characteristic shear resistance at the corner	Low (1)	0	V	$c_1=c_2=c_{min}$	$h = h_{min}$	8	single screw anchor in the corner
A7	Characteristic tension resistance of screw anchor groups	Low (1)	0	N	$s = s_{min}$ $c = c_{min}$	$h = h_{min}$	5	Double / quadruple group
A8	Characteristic shear resistance of screw anchor groups	Low (1)	0	V	$s = s_{min}$ $c = c_{min}$	$h = h_{min}$	5	Double / quadruple group

(1) Minimum strength class of LAC/AAC, for which the ETA is applied for (i.e. LAC/AAC 2)
(2) Maximum strength class of LAC/AAC, for which the ETA is applied for (e.g., AAC 7 or LAC25)
(3)
(4) Not relevant for masonry units (LAC/ACC)
(Series A1 and A2 are to be performed with Δw = 0 mm)
(5) For the intended use in plastered masonry (the joints are not visible) additional tests in joints not filled with mortar are necessary. If such products
are not tested and assessed, the relevant ETA shall allow the use only if the setting position in a joint only can be excluded (e.g., removal of the plaster around the installation position).

2.2.1.3 Determination of ultimate loads

5%-fractile of the ultimate loads

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

$F_{Ru}^{t} = F_{5\%} = F_{Ru,m}(1 - k_s \cdot v)$ (2.2.1.3.1)

e.g.,: n = 5 tests: $k_s = 3{,}40$

n = 10 tests: $k_s = 2{,}57$.

Conversion of ultimate loads to take into account the lightweight aggregate concrete (LAC) strength

It is necessary to convert the results of a test series to correlate with a strength different from that of the test cube or test cylinder or test block. In the case of unit failure, this conversion shall be carried out according to Equation:

$$F_{Ru}(f_b) = F_{Ru}^{t} \cdot \left(\frac{f_b}{f_{b,test}} \right)^{\alpha} \text{ (kN)} \quad (2.2.1.3.2)$$

with: $F_{Ru}(f_b)$ = failure load at unit compressive strength f_b (given in the ETA)

α = 0,5 for masonry units of LAC

$f_{b,test}$ = compressive strength of the LAC at the time of testing, with $f_{b,test} \geq f_b$ (if $f_{b,test} < f_b$, then $f_{b,test}$ or the next smaller strength f_b shall be given in the ETA).

Conversion of ultimate loads to take into account the autoclaved aerated concrete (AAC) unit strength:

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

Compressive strength:

For prefabricated reinforced AAC members the characteristic compressive strength f_{ck} of strength classes AAC 2 and AAC 7 given in EN 12602 [3] shall be used for conversion of test results.

For AAC masonry units the characteristic compressive strength shall be determined from the declared value of compressive strength according to EN 771-4 [2] as specified by the MPII (Manufacturer's Product Installation Instructions)

Dry density:

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

low strength AAC: $\rho_{min} = 350$ kg/m³

high strength AAC: $\rho_{min} = 650$ kg/m³.

Conversion of test results:

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

$$F_{Ru}^{t_K} = F_{Ru}^{t} \frac{\rho_{\min}^{3/4} \cdot f_{ck}}{\rho_{test}^{3/4} \cdot f_{c,test}} \text{ (kN)} \quad (2.2.1.3.4)$$

with: $F_{Ru}^{t_K}$ = failure load at unit compressive strength f_{ck} (used for conversion)

ρ_{test} = dry density of the AAC at the time of testing $\geq \rho_{min}$

ρ_{min} = dry density of the AAC given in the ETA

$f_{c,test}$ = compressive strength of the AAC at the time of testing ≥ f_{ck}

Characteristic failure load of the different strength of AAC:

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

Conversion of ultimate loads to take into account the steel strength:

In case of steel failure the failure load shall be converted to the nominal steel strength by following Equation:

$$F_{Ru}(f_{uk}) = F_{Ru}^{t} \cdot \frac{f_{uk}}{f_{u,test}} \qquad (2.2.1.3.4)$$

with: $F_{Ru}(f_{uk})$ = failure load at nominal characteristic steel ultimate strength

$f_{u,test}$ = steel ultimate strength at the time of testing ≥ f_{uk}

2.2.1.4 Criteria valid for all tests

Load/displacement behaviour

The requirement on the load/displacement curves in EAD 330232-01-0601[6], Section A2.5 applies. However, a reduction in load and /or a horizontal or near-horizontal part in the curve by uncontrolled slip of the screw anchor is not acceptable up to a load of:

$$N_1 = 0{,}6\ N_{Ru} \qquad (2.2.1.4.1)$$

(instead of 0,7 N_{Ru} according to EAD 330232-01-0601[6], Equation (A.12)).

The requirements on the scatter of the load/displacement curves in EAD 330232-01-06-01 [6], Section A2.6 apply.

Coefficient of variation of ultimate load

For each of test series defined in tables 2.2.1.1.1 and 2.2.1.1.2, with exceptions for tests F8 (maximum torque moments), the coefficient of variation of the ultimate load α_{CV} shall be calculated.

For a coefficient of variation cv > 20% in the functioning tests, a reduction factor α_{CV} for each test series shall be calculated according to:

$$\alpha_{CV,20} = 1 / (1 + 0{,}03 \cdot (cv[\%] - 20)) \leq 1{,}0 \qquad (2.2.1.4.2a)$$

with: cv20 = coefficient of variation of ultimate load of tests for cv > 20%.

For a coefficient of variation cv > 15% in the basic tests for, a reduction factor α_{CV} for each test series shall be calculated according to:

$$\alpha_{CV,15} = 1 / (1 + 0{,}03 \cdot (cv[\%] - 15)) \leq 1{,}0 \qquad (2.2.1.4.2b)$$

with: cv15 = coefficient of variation of ultimate load of tests cv > 15%.

2.2.1.5 Additional criteria valid for functioning tests

Reduction factor α

For test series F1 to F7 according to Table 2.2.1.1.1 the factor α according to EAD 330232-01-0601[6], section A2.4 shall be calculated. The factor α shall be larger than the values given in Table 2.2.1.1.1 of this

EAD. If the requirements on the ultimate load in the functioning tests are not fulfilled in one or more test series, then the reduction factor α_u shall be calculated according to:

$$\alpha_u = \alpha / \text{req. } \alpha \leq 1{,}0 \qquad (2.2.1.4.3)$$

with: α = value according to EAD 330232-01-0601[6], Equation (A.11) in test series F2 to F7, F9 and F10

req. α = required value of α according to Table 2.2.1.1.1.

Functioning in crack movement tests

The criteria in EAD 330232-01-0601[6], Section 2.2.2.4 applies.

Functioning under sustained loads

The criteria in EAD 330232-01-0601[6], Section 2.2.2.5 applies.

Functioning under repeated loads

The criteria in EAD 330232-01-0601[6], Section 2.2.2.5 applies

The increase of displacements during cycling shall stabilise in a manner indicating that failure is unlikely to occur after some additional cycles. This condition shall be assumed as fulfilled if the displacements after cycling at max N of the test are smaller than the mean value of the displacements at overcoming loss of adhesion in the reference tests.

If the above condition on the displacement is not fulfilled, the tests have to be repeated with a lower maximum load (max N) until this condition is fulfilled. Then the characteristic resistance N_{Rk} shall be reduced by the factor max N (applied) / max N (required).

Maximum torque moment

2.2.1.6 The coterie in EAD 330196-01-0604 [12] section 2.2.2.9 appliesCharacteristic resistance of a single screw anchor

Base material failure under tension load

The characteristic resistances of single screw anchor under tension loading shall be calculated as follows:

$$N_{Rk} = N_{Rk,0} \cdot \min \alpha_{u,F2\text{-}F7} \cdot \min \alpha_{cV} \qquad (2.2.1.6.1)$$

with:

$N_{Rk,0}$ = characteristic resistance evaluated from the results of tests according to Table 2.2.1.2.1, line A1, A3 and A5

min $\alpha_{u,F2\text{-}F7,F9,F10}$ = minimum value α_u (reduction factor from the ultimate loads in the functioning tests F2 to F7, F9 and F10 according to Table 2.2.1.1.1 for AAC and table 2.2.1.1.2 for LAC

min α_{CV} = minimum value α_{CV} to consider a coefficient of variation of the ultimate loads in the functioning tests and basic tests according to Equation (2.2.1.4.2a) and (2.2.1.4.2b)

Steel failure under shear load without lever arm

The characteristic resistance $V_{Rk,s}$ shall be determined for the cross-section of the screw anchor.

$$V_{Rk,s} = \alpha \cdot A_s \cdot f_{uk} \qquad (2.2.1.6.214)$$

with: α = 0,5
A_s = stressed cross-section of the screw anchor
f_{uk} = characteristic tensile strength of the screw anchor

Base material failure under shear load

The characteristic resistances of single screw anchor under shear loading shall be calculated as follows:

$V_{Rk,c} = V_{Rk,0} \cdot \alpha_{cV}$ (2.2.1.6.3)

with: $V_{Rk,0}$ = characteristic resistance evaluated from the results of tests according to Table 2.4, line A2, A4 and A6

α_{CV} = value α_{CV} to consider a coefficient of variation of the ultimate loads in the basic tests according to equation 2.2.1.4.2b.

2.2.1.6.1 Characteristic resistance in any load direction

For determination of the characteristic resistance in any load direction the characteristic resistance is controlled by the failure mode resulting to the minimum design strength $F_{Rd,min}$.

$F_{Rd,min}$ [kN] = min ($N_{Rk,p} / \gamma_{Mc}$; $V_{Rk,s} / \gamma_{Ms}$; $V_{Rk,c} / \gamma_{Mc}$) (2.2.1.6.1.1)

with: $N_{Rk,p}$; $V_{Rk,s}$; $V_{Rk,c}$ according to Equations above
γ_{Mc} 2,5 for LAC
2,0 for AAC
γ_{Ms} according to EN 1992-4 [10].

The characteristic resistance (in kN) shall be determined by following Equation:

F_{Rk} [kN] = $F_{Rd,min} \cdot \gamma_M$ (2.2.1.6.1.2)

with: $F_{Rd,min}$ according to Equation above
γ_M depends on decisive failure mode according to Equation (2.2.1.6.1.1).

The value of the characteristic resistance F_{Rk} shall be rounded down to the following numbers:
0,3 / 0,4 / 0,5 / 0,6 / 0,75 / 0,9 / 1,2 / 1,5 / 2 / 2,5 / 3 / 3,5 / 4 / 4,5 / 5 / 5,5 / 6 / 6,5 / 7 / 7,5 / 8 / 8,5 / 9 / 9,5 / 10 / 10,5 / 11 / 11,5 / 12 kN.

2.2.1.6.2 Steel failure under shear load with lever arm

The characteristic resistance $M_{Rk,s}$ shall be determined for the cross-section of the screw anchor:

$M_{Rk,s} = 1.2 \cdot W_{el} \cdot f_{uk}$ (2.2.1.6.2.1)

with: W_{el} = section modulus of the screw anchor
$W_{el} = \pi \cdot r^3/4$
f_{uk} = characteristic tensile strength of screw anchor.

2.2.1.7 Characteristic resistance of screw anchors groups

The characteristic resistances of a double or quadruple screw anchor group under tension loading shall be calculated as follows and the relevant screw anchor group (double or quadruple) shall be given in the ETA:

$N^g_{Rk} = \alpha_{g,N} \cdot N_{Rk}$ (2.2.1.7.1)

with: N^g_{Rk} = characteristic resistance of the screw anchor group under tension loading and under defined spacing s_{min} and under defined edge distance c_{min}, given in the ETA

N_{Rk} = according to Equation (2.2.1.6.1)

$\alpha_{g,N}$ = smaller value of $\frac{N^{t,g}_{Ru,m}}{N^{r}_{Ru,m}}$ and $\frac{N^{t,g}_{Rk}}{N^{r}_{Rk}}$,
group factor for tension loading, shall be rounded to 0,05
≤ 2 (for double screw anchors groups)
≤ 4 (for quadruple screw anchor groups)
Index “g” refers to the number of screws in the group

$N^{t,g}_{Ru,m}$; $N^{t,g}_{Rk}$ = mean value or 5%-fractile of the ultimate loads of a screw anchor group in a test series according to A7 in Table 2.2.1.2.1

$N^{r}_{Ru,m}$; N^{r}_{Rk} = mean value or 5 %-fractile of ultimate loads of a single screw anchor in the relevant reference test according to Table 2.2.1.2.1, A1 (if c_{min} =c_{cr}) or A3 (if this optional test is performed).

The characteristic resistances of a double or quadruple screw anchor group under shear loading shall be calculated as follows:

$$V^{g}_{Rk} = \alpha_{g,V} \cdot V_{Rk} \qquad (2.2.1.7.2)$$

with: V^{g}_{Rk} = characteristic resistance of the screw anchor group under shear loading and under defined spacing s_{min} and under defined edge distance c_{min}, given in the ETA

V_{Rk} = according to Equation (2.2.1.6.3)

$\alpha_{g,V}$ = smaller value of $\frac{V^{t,g}_{Ru,m}}{V^{r}_{Ru,m}}$ and $\frac{V^{t,g}_{Rk}}{V^{r}_{Rk}}$,

group factor for tension loading, shall be rounded to 0,05
≤ 2 (for double screw anchor groups)
≤ 4 (for quadruple screw anchor groups)
Index “g” refers to the number of screws in the group

$V^{t,g}_{Ru,m}$; $V^{t,g}_{Rk}$ = mean value or 5%-fractile of the ultimate loads of a screw anchor group in a test series according to A8 in Table 2.2.1.2.1

$V^{r}_{Ru,m}$; V^{r}_{Rk} = mean value or 5 %-fractile of ultimate loads of a single screw anchor in the relevant reference test according to Table 2.2.1.2.1, A2 (if c_{min} =c_{cr}) or A4 (if this optional test is performed)

2.2.1.8 Spacing and edge distances

For characteristic spacing and edge distances the following values may be used without testing (standard values according to current experience):

spacing $s_{cr} = 3\ h_{ef}$

edge distance $c_{cr} = 1{,}5\ h_{ef}$.

The minimum edge distance c_{min} and minimum spacing s_{min} are based on the manufacturer’s instructions.

If minimum edge distance c_{min} and minimum spacing s_{min} according to the manufacturer’s instructions are smaller than the standard values c_{cr} and s_{cr}, then the performance is assessed by the corresponding tests according to Table 2.2.1.2.1.

The minimum edge distance c_{min} shall be evaluated from the results of tests according to Table 2.2.1.2.1, line A3 to A6. The minimum spacing s_{min} shall be evaluated from the results of tests according to Table 2.2.1.2.1 A.1, line A7 to A8.

In absence of manufacturer’s instructions c_{min} = c_{cr} and s_{min} = s_{cr}.

2.2.2 Corrosion resistance

The corrosion resistance class (CRC) is stated in the ETA according to EN 1993-1-4, table A.3
The durability of the coating that ensures the functioning and the bearing behaviour of the fastener shall be shown. No special test conditions can be given in this EAD for checking the durability of any coating because they depend on the type of coating.
The following environmental conditions shall be taken into account in assessing durability of coatings:
Dry internal conditions:

- High alkalinity (pH ≥ 13.2)
- Temperature in range: -5° to +40°C

Other environmental conditions:

- High alkalinity (pH ≥ 13.2)
- Temperature in range: -40° to +80°C
- Condensed water
- Clorides
- Sulpur dioxide
- Nitrogen oxide
- Ammonia

Zinc coatings (electroplated or hot dip galvanized) need not be subjected to testing if used under dry internal conditions.

2.2.3 Characteristic displacements

The characteristic displacements for short-term and quasi-permanent loading are specified for the load F in accordance with following Equation:

$$F = F_{Rk} / (\gamma_F \cdot \gamma_M) \quad (2.2.3.1)$$

with: F_{Rk} = characteristic resistance
γ_F = partial safety factor for actions = 1,4
γ_M = depends on decisive failure mode according to Equation (2.2.1.6.1.1)

The displacements δ_{N0} and δ_{V0} under short-term loading are evaluated from test series Table 2.4, line A1 and line A2. The value derived shall correspond to the 95 %-fractile for a confidence level of 90 %.

In the absence of other information $\delta_{N\infty}$ shall be calculated as follows:

For screw anchors the long-term displacements under tension loading, $\delta_{N\infty}$, shall be calculated from the results of crack movement tests (see Table 2.2.1.1.1, line F5) according to Equation.

$$\delta_{N\infty} = \delta_{m1} / 1,5 \quad (2.2.3.2)$$

with $\delta_{N\infty}$ = long term tension displacement

δ_{m1} = mean value of maximum displacements of screw anchor after 103 crack movements tests

For screw anchors to be used in non-cracked AAC/LAC only, the long term displacements under tension loading, $\delta_{N\infty}$, shall be calculated from the results of repeated load (see Table 2.2.1.1.1, line F7) according to following Equation.

$$\delta_{N\infty} = \delta_{m2} / 2,0 \quad (2.2.3.3)$$

with δ_{m2} = mean value of maximum displacements in the repeated load tests after 105 load cycles or the sustained load tests after terminating the tests respectively. The larger value is decisive..

The displacements $\delta_{V\infty}$ under long-term shear loading shall be assumed to be approximately equal to 1.5-times the value δ_{V0}.

2.2.4 Reaction to fire

The screw anchors are considered to satisfy the requirements for performance class A1of the characteristic reaction to fire in accordance with the EC decision 96/603/EC (as amended) without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: 96/582/EC

The system is: 1.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
	Factory production control (FPC) **[including testing of samples taken at the factory in accordance with a prescribed test plan]**				
1	Dimensions (outer diameter, inner diameter, thread length, etc.)	Measuring or optical	Laid down in control plan	3	Every manufacturing batch or 100000 screw anchors,
2	Tensile Load (N_p) or tensile strength (f_{uk})	According to ISO 898-1 [7]		3	
3	Yield strength (f_{yk} or $N_{p0.2}$)	According to ISO 898-1 [7]		3	
4	Core hardness and Surface hardness (at specified functioning relevant points of the product; where relevant)	Tests acc. to ISO 6507 [8] or ISO 6508 [9]		3	
5	Zinc plating (where relevant)	X-ray measurement		3	
6	Fracture elongation A_5	According to ISO 898-1 [7]		3	

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of verification of constancy of performance for screw anchors are laid down in Table 3.3.1.

In this case the cornerstones of the tasks to be undertaken by the notified body under AVCP system 1 are laid down in Table 3.3.1.

Table 3.3.1 Control plan for the notified body; cornerstones

Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control				
The Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control				
The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in table 3.2.1	According to Control plan	According to Control plan	1/year

4 REFERENCE DOCUMENTS

[1] Regulation (EU) No 305/2011 of the European Parliament and of the council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/ECC

[2] EN 771-4:2011+A1:2015: Specification for masonry units – Part 4: Autoclaved aerated concrete masonry units

[3] EN 12602:2016: Prefabricated reinforced components of autoclaved aerated concrete

[4] EN 771-3:2011+A1:2015: Specification for masonry units – Part 3: Aggregate concrete masonry units (Dense and lightweight aggregates)

[5] EN 1520:2011: Prefabricated reinforced components of lightweight aggregate concrete with open structure with structural or non-structural reinforcement

[6] EAD 330232-01-0601 Mechanical fasteners for concrete

[7] ISO 898-1:2013: Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified properly classes – coarse thread and fine pitch thread

[8] EN ISO 6507:2005: Metallic materials - Vickers hardness test

[9] EN ISO 6508:2005: Metallic materials - Rockwell hardness test

[10] EN 1992-4:2018: Eurocode 2 – Design of concrete structures – Part 4: Design of fastenings for use in concrete

[11] ISO 5922:2005: Malleable cast iron.

[12] EAD 330196-01-0604: Plastic anchors made of virgin or non-virgin material for fixing of ETICS with rendering