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Prefabricated reinforced components of autoclaved aerated concrete

National foreword

This British Standard is the UK implementation of EN 12602:2016. It supersedes BS EN 12602:2008+A1:2013 which is withdrawn.

National Annex NA provides the nationally determined parameters on prefabricated reinforced components of autoclaved aerated concrete.

The UK participation in its preparation was entrusted to Technical Committee B/523, Prefabricated components of reinforced autoclaved aerated concrete and lightweight aggregate concrete with open structure.

A list of organizations represented on this committee can be obtained on request to its secretary.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12602

September 2016

ICS 91.100.30

Supersedes EN 12602:2008+A1:2013

English Version

Prefabricated reinforced components of autoclaved aerated concrete

Éléments préfabriqués armés en béton cellulaire autoclavé

Vorgefertigte bewehrte Bauteile aus dampfgehärtetem Porenbeton

This European Standard was approved by CEN on 4 June 2016.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 12602:2016) has been prepared by Technical Committee CEN/TC 177 “Prefabricated reinforced components of autoclaved aerated concrete or light-weight aggregate concrete with open structure”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2017, and conflicting national standards shall be withdrawn at the latest by June 2018.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12602:2008+A1:2013.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Regulation (s).

For relationship with Regulation (EU) No. 305/2011, see informative Annex ZA, which is an integral part of this document.

This document uses the methods given in the Guidance paper L, Clause 3.3, of the European Commission.

This European Standard is used together with a national application document. The national application document may only contain information on those parameters which are left open in this European Standard for national choice, known as Nationally Determined Parameters, to be used for the design of the construction products and civil engineering works to be constructed in the country concerned, i.e.:

- values and/or classes where alternatives are given in this European Standard,
- values to be used where a symbol only is given in this European Standard,
- country specific data (geographical, climatic, etc.), e.g. snow map,
- procedure to be used where alternative procedures are given in this European Standard.
- decisions on the application of informative annexes,
- references to non-contradictory complementary information to assist the user to apply this European Standard:

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According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard is for prefabricated reinforced components of autoclaved aerated concrete to be used in building construction for:

a) Structural elements:

- loadbearing wall components;
- retaining wall components;
- roof components;
- floor components;
- linear components (beams and piers).

b) Non-structural elements:

- non-loadbearing wall components (partition walls);
- cladding components (without fixtures) intended to be used for external facades of buildings;
- small box culverts used to form channels for the enclosure of services;
- components for noise barriers.

Depending on the type and intended use of elements for which the components are utilized, the components can be applied – in addition to their loadbearing and encasing function – for purposes of fire resistance, sound insulation and thermal insulation indicated in the relevant clauses of this European Standard.

Components covered by this standard are only intended to be subjected to predominantly non-dynamic actions, unless special measures are introduced in the relevant clauses of this European Standard.

The term “reinforced” relates to reinforcement used for both structural and non-structural purposes.

This European Standard does not cover:

- rules for the application of these components in structures;
- joints (except their strength and integrity E of resistance to fire);
- fixtures;
- finishes for external components, such as tiling.

NOTE AAC components may be used in noise barriers if they are designed to fulfil also the requirements of EN 14388.

2 Normative references

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

EN 678, *Determination of the dry density of autoclaved aerated concrete*

EN 679, *Determination of the compressive strength of autoclaved aerated concrete*

EN 680, *Determination of the drying shrinkage of autoclaved aerated concrete*

EN 772-16, *Methods of test for masonry units - Part 16: Determination of dimensions*

EN 772-20, *Methods of test for masonry units - Part 20: Determination of flatness of faces of aggregate concrete, manufactured stone and natural stone masonry units*

EN 989, *Determination of the bond behaviour between reinforcing bars and autoclaved aerated concrete by the "Push-Out" test*

EN 990, *Test methods for verification of corrosion protection of reinforcement in autoclaved aerated concrete and lightweight aggregate concrete with open structure*

EN 991, *Determination of the dimensions of prefabricated reinforced components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1351, *Determination of flexural strength of autoclaved aerated concrete*

EN 1352, *Determination of static modulus of elasticity under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1355, *Determination of creep strains under compression of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1356, *Performance test for prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure under transverse load*

EN 15304, *Determination of the freeze-thaw resistance of autoclaved aerated concrete*

EN 1737, *Determination of shear strength of welded joints of reinforcement mats or cages for prefabricated components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1738, *Determination of steel stresses in unloaded reinforced components made of autoclaved aerated concrete*

EN 1739, *Determination of shear strength for in-plane forces of joints between prefabricated components of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1740, *Performance test for prefabricated reinforced components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure under predominantly longitudinal load (vertical components)*

EN 1741, *Determination of shear strength for out-of-plane forces of joints between prefabricated components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1742, *Determination of shear strength between different layers of multilayer components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 1992-1-1:2004, *Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings*

EN 10080, *Steel for the reinforcement of concrete - Weldable reinforcing steel - General*

EN 10088-5, *Stainless steels - Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes*

EN 12269-1, *Determination of the bond behaviour between reinforcing steel and autoclaved aerated concrete by the "beam test" - Part 1: Short term test*

EN 12269-2, *Determination of the bond behaviour between reinforcing steel and autoclaved aerated concrete by the beam test - Part 2: Long term test*

EN 12664, *Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Dry and moist products of medium and low thermal resistance*

EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using test data from reaction to fire tests*

EN 13501-2, *Fire classification of construction products and building elements — Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN 15361:2007, *Determination of the influence of the corrosion protection coating on the anchorage capacity of the transverse anchorage bars in prefabricated reinforced components of autoclaved aerated concrete*

EN ISO 354, *Acoustics - Measurement of sound absorption in a reverberation room (ISO 354)*

EN ISO 717-1, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation (ISO 717-1)*

EN ISO 717-2, *Acoustics - Rating of sound insulation in buildings and of building elements - Part 2: Impact sound insulation (ISO 717-2)*

EN ISO 10456, *Building materials and products - Hygrothermal properties -Tabulated design values and procedures for determining declared and design thermal values (ISO 10456)*

EN ISO 10140-1, *Acoustics - Laboratory measurement of sound insulation of building elements - Part 1: Application rules for specific products (ISO 10140-1)*

EN ISO 10140-2 *Acoustics - Laboratory measurement of sound insulation of building elements - Part 2: Measurement of airborne sound insulation (ISO 10140-2)*

EN ISO 10140-3 *Acoustics - Laboratory measurement of sound insulation of building elements - Part 3: Measurement of impact sound insulation (ISO 10140-3)*

EN ISO 10140-4 *Acoustics - Laboratory measurement of sound insulation of building elements - Part 4: Measurement of impact sound insulation (ISO 10140-4)*

EN ISO 10140-5 *Acoustics - Laboratory measurement of sound insulation of building elements - Part 5: Requirements for test facilities and equipment (ISO 10140-5)*

EN ISO 15630-1, *Steel for the reinforcement and prestressing of concrete - Test methods - Part 1: Reinforcing bars, wire rod and wire (ISO 15630-1)*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

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

3.1.1
autoclaved aerated concrete
AAC
concrete that is manufactured from binders such as cement and/or lime combined with fine siliceous based material, cell generating material and water whereby the raw materials are mixed together and cast into

moulds where the mix is allowed to rise and set into cakes; after this part of the process, the cake is cut into the required sizes of components and cured with high pressure steam in autoclaves

3.1.2

raw materials

constituents which combined with additives and agents, where appropriate, can be used in the manufacturing process

3.1.3

reinforcement

strengthening material that is commonly composed of steel mats, cages and/or steel bars; other types of reinforcement can be used; depending on the function of the components, the reinforcement can be structural or non-structural

Note 1 to entry: Structural reinforcement is reinforcement which is necessary for the loadbearing function of the component as part of the structure. It consists of steel.

Note 2 to entry: Non-structural reinforcement is reinforcement which is necessary in order to ensure adequate resistance of the component during handling, transportation and construction. Any suitable kind of reinforcement may be used for this purposes

3.1.4

corrosion protective coating

corrosion protective coating is a coating applied on the surface of the reinforcement to protect the reinforcement against corrosion

3.1.5

declared value

value declared by a manufacturer which is derived from values under specified conditions and rules

3.1.6

pier

vertical loadbearing part of the wall between or besides openings

3.2 Symbols

3.2.1 General symbols

A	area;
b	width of component;
d	effective depth or thickness of component, diameter (e.g. of a bar);
E	modulus of elasticity;
e	eccentricity;
F	force;
f	strength;
h	depth or thickness of component;
i	radius of inertia;
I	moment of inertia;
k	coefficient, factor;
l	length, height of wall component, span length of roof or floor components;
M	bending moment;

N	axial force;
R	resistance, loadbearing capacity;
t	time;
V	shear force;
ε	strain;
γ	partial safety factor;
σ	normal stress;
τ	shear stress;
ϕ	diameter.

3.2.2 Subscripts

a	anchorage, actual;
b	bond;
c	concrete parameter, compression;
comp	component;
cr	critical;
d	design value;
dry	in the dry state
eff	effective value;
g	declared value;
h	horizontal;
k	characteristic value;
l	longitudinal;
M	material;
m	mean or mass;
pl	plastic;
R	resistance;
S	acting in the section;
s	steel parameter, shear;
t	tension;
test	in testing;
u	ultimate;
um	in the moist state;
w	welded, web;
y	yield value (for steel);
0	effective value.

3.2.3 Symbols used in this European Standard (including normative annexes, except Annex C)

A_c	— total cross-sectional area of concrete;

	— area of the compression zone of the cross-section;
	— area of AAC within the tensile zone;
A_{crit}	critical area according to A.6.2.3;
A_{c0}	loaded area according to Figure A.13;
A_{c1}	maximum distribution area according to Figure A.13;
A_{k}	area defined by longitudinal reinforcement according to Figure A.12;
A_{s}	cross-sectional area of tensile reinforcement;
A_{smin}	minimum cross-sectional area of the reinforcement;
A_{swmin}	minimum cross-sectional area of shear reinforcement within length s;
A_{sw}	cross-sectional area of vertical or inclined shear reinforcement;
A_{sl}	— cross-sectional area of the reinforcing bar with the larger diameter of the connection;
	— cross-sectional area of tension reinforcement;
a	— dimension of support perpendicular to the plane of a wall;
	— shear span;
	— larger dimension of a rectangular loaded area (see Figure A.8);
a_{b}	dimension of rectangular loaded area perpendicular to the span of a slab;
a_0	minimum support length;
a_1	horizontal displacement of the envelope of the design bending moment distribution (see Figure A.16);
b	— width of a component;
	— smaller dimension of a rectangular loaded area (see Figure A.8);
b'	centre distance of longitudinal reinforcement according to Figure A.12;
b_{w}	minimum width of the web;
c	— concrete cover;
	— a value, in Megapascals, representing the difference between the characteristic compressive strength and the permissible minimum individual value of the compressive strength;
d	— effective depth of a component;
	— design thickness of a component, for a solid wall $d = h$;
	— diameter of a circular loaded area (see Figure A.9);
$E_{\mathrm{c,eff}}$	effective modulus of elasticity of AAC;
E_{cm}	mean value of the modulus of elasticity of AAC;
$E_{\mathrm{cm,eff}}$	“effective” modulus of elasticity of AAC;
E_{s}	modulus of elasticity of reinforcing steel;
$(EI)_{\mathrm{k}}$	stiffness in bending of a section in the “semi-cracked” state;
$(EI)_0$	stiffness of a section in the uncracked state, assuming $E = E_{\mathrm{cm}}$;
$(EI)_1$	stiffness of a section in the uncracked state;

$(EI)_2$	stiffness of a section in the cracked state;
e	— distance of the axis of the transverse bars in the anchorage zone to the nearest surface of the component (see Figure A.15); — distance of the centroid of the longitudinal bars from the adjacent side face of the AAC component; — basis of natural logarithms;
e_a	additional eccentricity of the longitudinal force due to geometrical imperfections;
e_b	eccentricity in the plane of a wall, $e_b = M/N + e_N$;
e_{cr}	eccentricity e_{c0} of the vertical action including the geometrical imperfections;
e_m	first order eccentricity caused by bending due to horizontal load;
e_N	eccentricity of the vertical axial force in the plane of a wall;
e_o	eccentricity of the longitudinal force at the top of the component;
e_t	first order eccentricity perpendicular to the plane of a wall, taken as the sum of e_0 and e_m;
e_0	first order eccentricity of loads perpendicular to the plane of a component;
F_b	long term anchorage capacity;
F_c	compression force in the AAC in the direction of the longitudinal axis;
F_{ld}	design tensile force in the longitudinal reinforcement to be anchored;
F_s	tensile force in the longitudinal reinforcement;
F_{sl}	tensile force in each of the longitudinal bars;
F_{RA}	ultimate anchorage resistance due to welded cross-bars;
F_{Rdu}	concentrated compressive design force;
F_{wg}	declared shear strength of a welded joint;
f_{bd}	design bond strength;
f_{bk}	characteristic bond strength;
f_{bl}	long term bond strength;
f_{cd}	design value of the compressive strength of AAC;
$f_{c,edge}$	compressive strength of AAC at the edge of a wall component or pier;
f_{ck}	characteristic compressive strength of AAC;
$f_{ck,g}$	declared characteristic compressive strength of AAC;
f_{cflk}	characteristic flexural strength of AAC;
$f_{cflk,eff}$	“effective” characteristic flexural strength of AAC;
f_{ctk}	characteristic value of axial tensile strength of AAC;
f_{ctm}	mean value of axial tensile strength of AAC;
f_{ld}	design bearing strength of AAC;

f_{st}	tensile strength of reinforcing steel;
f_y	yield strength of reinforcing steel;
f_{yd}	design value of yield strength of reinforcing steel;
f_{yk}	characteristic yield strength of reinforcing steel;
f_{ywd}	design yield strength of vertical or inclined shear reinforcement;
f_{ywk}	characteristic yield strength of the stirrups;
$f_{0,2k}$	characteristic 0,2 % proof stress of reinforcing steel;
h	overall depth of a cross-section;
h'	centre distance of longitudinal reinforcement according to Figure A.12;
h_c	distance between A_{c0} and A_{c1};
h_k	thickness of a fictitious box section according to Formula A.34;
h_w	(total) thickness of a wall;
I_c	moment of gyration of compression zone of a cross-section;
i_c	radius of gyration of the compression zone of the cross-section, i.e. I_c/A_c;
K_c	factor for maximum AAC bearing strength depending on the bond class;
K_1	reduction factor in Formula (A.11) for reduced AAC cover;
K_2	spacing factor of stirrups in Formula (A.11);
K_3	factor in Formula (A.11) taking into account the type of the stirrups;
k	— a coefficient for minimum reinforcement which takes into account the nature of the stress distribution; — column factor in Annex B; — distribution coefficient given by Formulae (A.45a) and (A.45b) for calculation of deflections;
k_s	column factor according to Equation (A. 15);
k_1	— factor for the support strength; — reduction factor for the design bond strength taking into account geometrical influences;
k_2	reduction factor for long term and temperature effects;
k_w	is the welding strength factor, see Table 5c;
L	span length between the centre points of the supports;
l	span length;
l_b	basic anchorage length of reinforcement according to 8.4 of EN 1992–1-1:2004;
$l_{b,net}$	required anchorage length of reinforcement (see Figure A.4);
$l_{h,eff}$	effective horizontal length of a wall or pier;
l_{hs}	horizontal length of a support in the plane of a wall;
l_{ht}	horizontal length of a (stiffening) transverse wall;

$l_{\mathrm{k,test}}$	length of the component in functional testing;
l_{s}	shear span;
l_{w}	height of a wall measured between centres of restraint;
l_0	effective length of a component (with respect to buckling);
M_{cr}	cracking moment;
M_{d}	design value of bending capacity;
M_{h}	bending moment;
M_{da}	actual design value of bending moment;
M_{f}	bending moment under frequent combination of loading;
M_{h}	bending moment resulting from horizontal actions;
M_{k}	— bending moment under the total design load; — declared characteristic value of bending capacity;
m	factor for consideration of existing transverse compression in the anchorage zone;
N	axial force (compression positive);
N_{cr}	design axial loadbearing capacity putting the eccentricity equal to e_{cr};
N_{d}	design axial force (compression positive);
N_{Rd}	design axial loadbearing capacity;
N_{Rk}	characteristic loadbearing capacity for longitudinal forces;
$N_{\mathrm{Rk,test}}$	declared characteristic longitudinal loadbearing capacity from performance tests according to EN 1740;
N_{Sd}	design value of axial force in a cross-section;
n	number (e.g. of test results);
n_{p}	number of welded transverse bars available for anchorage within the zone of transverse compression;
n_{t}	number of welded transverse bars in the anchorage zone;
$p, p_{\mathrm{I}}, p_{\mathrm{II}}$	parameters in Formula (A.44);
q_{p}	sum of permanent and quasi-permanent loads;
q_{v}	sum of variable loads;
R_{cd}	design loadbearing capacity;
R_{ck}	characteristic loadbearing capacity;
r	— radius of curvature due to bending moment; — coefficient for the calculation of effective height of door or window piers;
r_{c0}	radius of loaded area according to Figure A.13;
r_{c1}	radius of maximum distribution area according to Figure A.13;
s	— spacing of stirrups;

	— spacing of inclined shear reinforcement measured along the longitudinal axis of a component;
s_{l1}	centre distance of the bars of longitudinal tensile reinforcement;
s_{l2}	centre distance of the bars of required compressive reinforcement;
s_s	spacing of shear reinforcement along the longitudinal axis of the component;
s_t	centre distance of transverse reinforcing bars;
$s_{t,min}$	minimum centre distance of transverse reinforcing bars;
T_{Rd1}	resisting torsional moment of a section without torsional reinforcement;
T_{Rd3}	resisting torsional moment of a section with torsional reinforcement;
T_{Sd}	design torsional moment;
t_t	total effective length of transverse anchorage bars;
V	— shear force; — volume of component;
V_d	— design loadbearing capacity in shear of a joint; — design value of shear capacity;
V_{cd}	contribution of the concrete to shear resistance (= V_{Rd1});
V_k	declared characteristic value of shear capacity;
V_{Sd}	design shear force per unit of length;
V_{wd}	contribution of shear reinforcement to shear resistance;
V_{Rd}	design shear resistance;
V_{Rd1}	design shear resistance of a section without shear reinforcement;
V_{Rd2}	maximum design shear force that can be carried without crushing of the notional concrete compressive struts;
V_{Rd3}	design shear resistance of a section with shear reinforcement;
V_{Sd}	design shear force;
W_T	section modulus for torsion;
v	reduction factor for the design compressive strength of AAC used for the calculation of maximum design shear force V_{Rd2} that can be carried without crushing of the notional concrete compressive struts;
x	— neutral axis depth; — required increase of minimum support length a_0 in case where the concrete cover c of longitudinal reinforcement at the end face of a transversely loaded component exceeds 15 mm;
$\overline{x}$	mean value of the compressive strength of a test series;
x_{min}	minimum individual value of the compressive strength of a test series;
y_{el}	short-term deflection;
y_k	deflection under total design load, assuming a section stiffness of $(EI)_k$;
y_v	instantaneous deflection caused by variable load;

y_0	camber due to prestress;
y_1	instantaneous deflection due to loads occurring before construction of adjoining members, assuming a section in the uncracked state and $E = E_{\mathrm{cm}}$;
y_∞	long term deflection under the quasi-permanent combination of loading;
z	lever arm of internal longitudinal forces;
α	reduction coefficient for design compressive strength of AAC taking into account long term effects;
α_{s}	angle of shear reinforcement with the longitudinal axis;
β	coefficient for the determination of effective height of a wall or pier, depending on the stiffness of lateral support;
γ_{C}	partial safety factor for concrete (AAC);
γ_{comp}	partial safety factor for component;
γ_{F}	partial safety factor for actions;
γ_{M}	partial safety factor for material properties;
γ_{n}	multiplication factor for the partial safety factor γ_{C} for AAC;
γ_{S}	partial safety factor for reinforcing steel;
ε_{c}	strain of AAC;
$\varepsilon_{\mathrm{c}}\ (t_0)$	initial (elastic) strain of AAC;
$\varepsilon_{\mathrm{cc}}$	creep strain of AAC;
$\varepsilon_{\mathrm{cfl}}$	flexural (tensile or compressive) strain of AAC at the opposite side of ε_{c};
$\varepsilon_{\mathrm{cflu}}$	ultimate flexural strain of AAC in the tensioned zone;
$\varepsilon_{\mathrm{su}}$	elongation of reinforcing steel at maximum load;
$\varepsilon_{\mathrm{suk}}$	characteristic value of elongation of reinforcing steel at maximum load;
$\varepsilon_{\mathrm{syfl}}$	tensile or compressive strain of the reinforcing steel at the opposite side of ε_{c};
$\varepsilon_{\mathrm{yd}}$	design yield strain of reinforcing steel;
ε_0	short-term prestrain;
η_{d}	conversion factor for design by testing;
θ	angle of concrete struts with the longitudinal axis;
κ	— curvature; — coefficient for determination of “effective” modulus of elasticity and “effective” flexural tensile strength of AAC; — factor taking into account increased strength of partially loaded areas;
$\lambda_{10\mathrm{dry}}$	thermal conductivity in the dry state at a mean test temperature of 10 °C;
λ_{d}	design thermal conductivity in the moist state, at a moisture content μ_{m};
μ	design coefficient of friction;

μ_{m}	mass related moisture content;
ρ	dry density of AAC;
$\rho_{\mathrm{d,inf}}$	design value of the density of AAC-components (including reinforcement) in the moist state, in case weight acts favourably;
$\rho_{\mathrm{d,sup}}$	design value of the density of AAC-components (including reinforcement) in the moist state, in case weight acts unfavourably;
ρ_{k}	characteristic dry density of AAC (95 % - quantile);
ρ_{m}	mean value of the dry density of AAC;
$\rho\mathrm{sound}$	density to be used for the determination of acoustic behaviour;
$\rho_{\mathrm{T,l}}$	reinforcement ratio of the longitudinal reinforcement resisting torsion;
$\rho_{\mathrm{T,s}}$	reinforcement ratio of stirrups resisting torsion;
ρ_{thermal}	density to be used for the determination of thermal properties;
ρ_{trans}	density to be used for calculation of transportation weight of AAC-components;
ρ_{1}	reinforcement ratio;
σ_{c}	stress of AAC;
σ_{d}	design (compressive) stress;
σ_{cd}	design edge stress of AAC on the compressive side;
σ_{sld}	design tensile stress in the longitudinal torsion reinforcement;
σ_{swd}	design tensile stress in shear reinforcement;
σ_{td}	design edge stress on the tensile side;
τ_{Rd}	basic shear strength;
φ	final creep coefficient;
ϕ_{d}	diameter of a circular loaded area;
ϕ_{s}	diameter of a bar;
ϕsl	diameter of a longitudinal bar;
ϕ_{sw}	diameter of a stirrup;
ϕ_{t}	diameter of transverse bars in the anchorage zone.

3.3 Abbreviations

AAC	autoclaved aerated concrete;
FPC	factory production control;
NPD	Nationally Determined Parameter;
RH	relative humidity;
SLS	serviceability limit state;
ULS	ultimate limit state.

4 Properties and requirements of materials

4.1 Constituent materials of autoclaved aerated concrete

4.1.1 General

The following raw materials, combined with additives and agents, where appropriate, may be used in the manufacturing process:

a) calcareous based materials:

  1) cement;

  2) lime;

  3) recycled AAC;

b) silicious based materials:

  1) natural and/or ground sand;

  2) fly ash (pulverized-fuel ash);

  3) ground granulated blast furnace slag;

c) water;

d) cell generating materials:

  1) chemicals (usually aluminium powder or slurry);

  2) stable preformed foam;

  3) other cell generating agents.

Other suitable raw materials may be included.

4.1.2 Release of dangerous substances

National regulations on dangerous substances may require verification and declaration on release, and sometimes content, when construction products covered by this standard are placed on those markets.

In the absence of European harmonized test methods, verification and declaration on release/content should be done taking into account national provisions in the place of use.

NOTE An informative database covering European and national provisions on dangerous substances is available at the Growth website on EUROPA accessed through *http://ec.europa.eu/growth/tools-databases/cp-ds/*

4.2 Autoclaved aerated concrete parameters

4.2.1 General

In the following subclauses the basic material properties are presented, which may be used for general design considerations. Design values to be used in equations for numeric calculations are indicated in Annex A and Annex B.

4.2.2 Dry density

4.2.2.1 General

The dry density, determined in accordance with EN 678, shall be indicated by the manufacturer on the basis of the mean value of the last six test sets (each consisting of three test specimens), either as declared mean value and declared tolerance or as a declared density class as specified in Table 1.

4.2.2.2 Declared mean dry density

When the manufacturer declares the dry density as a mean value, this shall be within the following limits:

- mean dry density: $\rho_{m,g} \pm \Delta\rho_g$
- individual value of dry density: $\rho_{m,g} \pm 15\ \%$

where

$\rho_{m,g}$ is the declared mean value of the dry density;

$\Delta\rho_g$ is the declared tolerance of the dry density (not more than 10 %).

4.2.2.3 Declared density class

When the manufacturer declares the dry density in accordance with the density classes specified in Table 1, the mean value of the results of the last six test sets (each consisting of three test specimens), and the tests performed according to EN 678, shall be within the indicated limits. Individual values may be up to 25 kg/m^3 more or less than the indicated limits.

Table 1 — Density classes

Dry densities in kilograms per cubic metre

Density class	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**
Mean dry density ρ_m	> 250 ≤ 300	> 300 ≤ 350	> 350 ≤ 400	> 400 ≤ 450	> 450 ≤ 500	> 500 ≤ 550	> 550 ≤ 600	> 600 ≤ 650
Density class	**700**	**750**	**800**	**850**	**900**	**950**	**1000**	
Mean dry density ρ_m	> 650 ≤ 700	> 700 ≤ 750	> 750 ≤ 800	> 800 ≤ 850	> 850 ≤ 900	> 900 ≤ 950	> 950 ≤ 1 000	

4.2.2.4 Derived density values

For the purposes of structural design, the following density values may be used unless national provisions exist:

$$\rho_{d,sup} = \left(\rho_{m,g} + \Delta\rho_g\right)\cdot\left(1+\mu_m/100\right)+m_s/V \quad (1)$$

$$\rho_{d,inf} = \left(\rho_{m,g} - \Delta\rho_g\right)\cdot\left(1+\mu_m/100\right)+m_s/V \quad (2)$$

where

$\rho_{d,sup}$ is the design value of the density of the AAC-components (including reinforcement) in the moist state (moisture content μ_m), in case weight acts unfavourably, in kilograms per cubic metre;

$\rho_{\mathrm{d,inf}}$ is the design value of the density of the AAC-components (including reinforcement) in the moist state (moisture content μ_{m}), in case weight acts favourably, in kilograms per cubic metre;

$\rho_{\mathrm{m,g}}$ is the declared mean value of dry density of AAC, in kilograms per cubic metre;

$\Delta\rho_{\mathrm{g}}$ is the declared tolerance of the dry density of AAC, in kilograms per cubic metre;

μ_{m} is the expected mass related moisture content of AAC under service conditions, in per cent;

m_{s} is the mass of reinforcement, in kilograms;

V is the volume of component, in cubic metre.

In the case of declared density class, the expression ($\rho_{\mathrm{m,g}} + \Delta\rho_{\mathrm{g}}$) shall be taken as the upper limit and the expression ($\rho_{\mathrm{m,g}} - \Delta\rho_{\mathrm{g}}$) as the lower limit of the mean dry density, ρ_{m} as specified in Table 1.

For the determination of thermal insulation properties, the density values $\rho_{\mathrm{m,g}}$ and $\rho_{90\ \%}$ may be used (see Figure 1). In the case of a declared density class, the upper limit of the mean dry density as specified in Table 1 may be taken to determine the thermal conductivity value $\lambda_{10\mathrm{dry}}$ from Table 4.

The determination of sound insulation properties may be based on the declared mean value $\rho_{\mathrm{m,g}}$ of the dry density. In the case of a declared density class, the mean of the upper and the lower limit of the mean dry density according to Table 1 may be used.

For the determination of transportation weight, except for beams (see note), the following equation may be used in the absence of information from the manufacturer:

$$\rho_{\mathrm{trans}} = 1,4 \cdot \rho_{\mathrm{m,g}} + 40\ \mathrm{kg/m^3} \qquad (3)$$

where

ρ_{trans} is the density to be used for calculation of transportation weight of AAC-components, in kilograms per cubic metre;

$\rho_{\mathrm{m,g}}$ is the declared mean value of the dry density of AAC, in kilograms per cubic metre. (In case of a declared density class, $\rho_{\mathrm{m,g}}$ may be taken as the mean of the upper and lower limit of the mean dry density ρ_{m} according to Table 1.)

NOTE In the case of beams, the amount of reinforcement can be higher than 40 kg per m^3.

4.2.3 Characteristic strength values

The characteristic values f_{k} of strength parameters of AAC or AAC-components, as compressive strength or flexural strength of AAC or loadbearing capacity of components according to Annex B, or the bond strength between reinforcement and AAC, is defined as the 5 %-fraktile of that property (p = 0,95) at a confidence level of γ = 0,75. For more information see Annex F (informative).

4.2.4 Compressive strength

The characteristic compressive strength of AAC shall be indicated by the manufacturer either as declared characteristic compressive strength $f_{\mathrm{ck,g}}$ or as a declared compressive strength class as specified in Table 2a.

The actual characteristic compressive strength f_{ck}, determined by statistical interpretation (see 4.2.3) of results of tests carried out in accordance with EN 679, shall be equal to or greater than the declared value $f_{\mathrm{ck,g}}$ or the value f_{ck} required in Table 2a for the declared strength class, respectively.

The actual minimum mean value $f_{\mathrm{c,min}}$ of each test set of three test specimens according to EN 679 shall be at least 0,9 times the declared characteristic strength $f_{\mathrm{ck,g}}$ or the value f_{ck} required in Table 2a for the declared strength class, respectively.

Table 2a — Compressive strength classes for AAC

Strengths in Megapascals

Strength class	**AAC 1,5**	**AAC 2**	**AAC 2,5**	**AAC 3**	**AAC 3,5**	**AAC 4**	**AAC 4,5**	**AAC 5**	**AAC 6**	**AAC 7**	**AAC 8**	**AAC 9**	**AAC 10**
f_{ck}	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	6,0	7,0	8,0	9,0	10,0

4.2.5 Tensile strength and flexural strength

The manufacturer shall declare the flexural strength $f_{\mathrm{cflk,g}}$ from tests. The actual characteristic flexural strength f_{cflk}, determined by statistical interpretation (see 4.2.3) of results of tests carried out in accordance with EN 1351, shall be equal to or greater than the declared value $f_{\mathrm{cflk,g}}$.

In the absence of test results an estimate of the tensile strength or flexural strength, respectively, may be obtained by using the following equations:

$$f_{\mathrm{ctk;0,05}} = 0{,}10\, f_{\mathrm{ck}} \tag{4a}$$

$$f_{\mathrm{ctk;0,95}} = 0{,}24\, f_{\mathrm{ck}} \tag{4b}$$

$$f_{\mathrm{cflk;0,05}} = 0{,}18\, f_{\mathrm{ck}} \tag{5a}$$

$$f_{\mathrm{cflk;0,95}} = 0{,}36\, f_{\mathrm{ck}} \tag{5b}$$

where

$f_{\mathrm{ctk;\,0,05}}$	is the characteristic value of 5 %-quantile of axial tensile strength, in Megapascals;
$f_{\mathrm{ctk;\,0,95}}$	is the characteristic value of 95 %-quantile of axial tensile strength, in Megapascals;
$f_{\mathrm{cflk;\,0,05}}$	is the characteristic value of 5 %-quantile of flexural strength, in Megapascals;
$f_{\mathrm{cflk;\,0,95}}$	is the characteristic value of 95 %-quantile of flexural strength, in Megapascals;
f_{ck}	is the characteristic value of compressive strength according to 4.2.4, in Megapascals.

NOTE When declared flexural strength f_{cflk} is used in design, a reduction factor 0,8 is used to take into account size effect.

4.2.6 Stress-strain diagram

The idealised stress-strain diagram for AAC consists of a linear relationship between stress and strain up to a compressive strain of 0,002 at design compressive strength level, continuing at a constant stress level up to the ultimate limit state for the strain of 0,003 (see A.3.2 and Figure A.2).

4.2.7 Modulus of elasticity

The modulus of elasticity E_{cm}, determined in accordance with EN 1352, shall be indicated by the manufacturer on the basis of the mean value of the last six test sets (each consisting of three test specimens) as declared mean value and declared tolerances.

The values shall be within the following limits:

- mean modulus of elasticity: $E_{\mathrm{cm,g}} \pm \Delta E_{\mathrm{g}}$
- individual value of modulus of elasticity: $E_{\mathrm{cm,g}}$ ± 20 %

where

$E_{\mathrm{cm,g}}$ is the declared mean value of the modulus of elasticity;

ΔE_{g} is the declared tolerance of the modulus of elasticity (not more than 10 %).

In absence of test results, a mean value of the modulus of elasticity may be obtained as follows:

$$E_{\mathrm{cm}} = 5\ (\rho_{\mathrm{m}} - 150) \tag{6}$$

where

E_{cm} is the mean value of the modulus of elasticity of AAC, in Megapascals;

ρ_{m} is the mean value of the dry density of AAC, in kilograms per cubic metre.

4.2.8 Poisson's ratio

Poisson's ratio for elastic strains shall be taken as 0,2. If cracking is permitted in AAC in tension, Poisson's ratio may be taken as 0,0.

4.2.9 Coefficient of thermal expansion

In the absence of experimental data, the coefficient of thermal expansion shall be taken as $8 \times 10^{-6}/K$.

4.2.10 Drying shrinkage

The declared value of drying shrinkage shall be determined according to EN 680. The shrinkage class as specified in Table 2b shall be declared based on the mean conventional reference value $\varepsilon_{\mathrm{cs,ref}}$ or alternatively based on a value taking the total value of drying shrinkage $\varepsilon_{\mathrm{cs,tot}}$ multiplied by a reduction factor 0,5.

NOTE The reduction factor takes into account that the dimensional changes of whole components due to drying shrinkage (or swelling in the case of wetting) depend on the size of the components, the amount and position of the reinforcement and on the initial and practical moisture content of the AAC.

Table 2b — Drying shrinkage classes for AAC

Drying shrinkage class	**0,15**	**0,20**	**0,25**	**0,30**	**0,35**	**0,40**
ε_{c} mm per m	≤ 0,15	≤ 0,20	≤ 0,25	≤ 0,30	≤ 0,35	≤ 0,40

4.2.11 Creep

4.2.11.1 General

The creep coefficient shall be indicated by the manufacturer on the basis of results of tests according to EN 1355, either as a declared mean value or as a declared creep class.

The definition of the creep coefficient is as follows:

$$\phi(t_0,t) = \frac{\varepsilon_{\mathrm{cc}}(t_0,t)}{\varepsilon_{\mathrm{c}}(t_0)} \tag{7}$$

where

$\varepsilon_{cc}(t_0, t)$ is the creep strain from time t_0 until time t;

$\varepsilon_c(t_0)$ is the initial (elastic) strain at a given time t_0.

Creep of AAC may be estimated to be proportional to the applied stress for compressive stresses not exceeding 0,45 f_{ck} at the age of loading t_0.

In the absence of experimental data, the final creep coefficient $\phi\ (t_0, t_\infty)$ shall be taken as 1,0.

4.2.11.2 Declared mean creep

When the manufacturer declares the creep coefficient as a mean value, this shall be within the following limits:

— mean value of the creep coefficient: $\phi\ (t_0, t_\infty)$ + 10 %;

— individual value of the creep coefficient: $\phi\ (t_0, t_\infty)$ + 20 %.

4.2.11.3 Declared creep class

When the manufacturer declares the creep coefficient in accordance with the creep classes specified in Table 3, the mean value of the tests performed according to EN 1355, shall be within the indicated limits.

Table 3 — Creep classes

Creep class	**0,5**	**0,6**	**0,7**	**0,8**	**0,9**	**1,0**
Mean creep coefficient $\phi\ (t_0, t_\infty)$	> 0,4	> 0,5	> 0,6	> 0,7	> 0,8	> 0,9
	≤ 0,5	≤ 0,6	≤ 0,7	≤ 0,8	≤ 0,9	≤ 1,0

4.2.12 Specific heat

The specific heat of AAC shall be taken as 1 050 J/kgK.

4.2.13 Thermal conductivity

4.2.13.1 General

The thermal conductivity of AAC shall be declared for the oven–dry state expressed as $\lambda_{10\mathrm{dry}}$ along with the dry density. Declared thermal conductivity values shall either be calculated from the results of measurements carried out on test specimens or taken from Table 4. The design thermal conductivity is the declared thermal conductivity corrected for moisture according to 5.1.4.

The declaration shall include the thermal conductivity with indication of the percentage of the production it intends to refer to (e.g. $\lambda_{10\mathrm{dry}(50\ \%)}$ or $\lambda_{10\mathrm{dry}(90\ \%)}$).

4.2.13.2 Procedure for determination of dry thermal conductivity by testing

Where tests are carried out, the procedure according to 4.2.13.3 to 4.2.13.6 shall be followed.

4.2.13.3 Test method

The reference test method is specified in EN 12664. For AAC the mean reference test temperature shall be 10 °C. Alternative test methods which can require test specimens of different sizes and different conditioning may be used if the correlation between the results of the reference test method and the alternative test method can be given.

4.2.13.4 Test specimens

Test specimens shall be homogeneous. Specimen sizes and requirements as to planeness will depend upon the size of apparatus used and on the thermal conductivity of the material. Test specimens shall contain no reinforcement.

4.2.13.5 Conditioning of test specimens

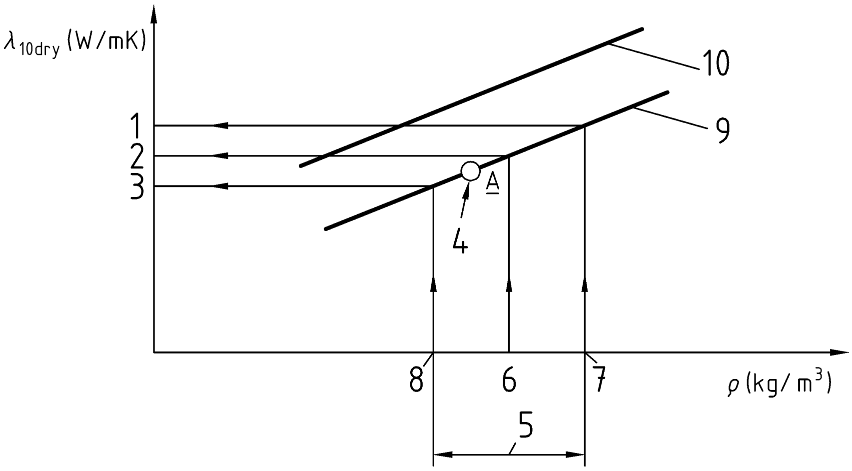
Test specimens shall be conditioned to constant mass in air of (23 ± 2) °C and (50 ± 5) % RH. Constant mass is considered to be obtained when the difference between two consecutive weightings 24 h apart does not exceed 0,2 %.

Other test conditions (e.g. oven-dry state) may be used if the correlation between the reference conditions and the alternative conditions can be given.

4.2.13.6 Determination of the dry mean value and the limit value

In order to ensure that the results are representative of current material produced, tests shall be carried out on test specimens selected from three different production batches within the stated density range of the product under consideration. The mean value of the three test results of thermal conductivity shall be calculated and corrected to zero moisture content as indicated in 5.1.4. The dry density of each of the three test specimens shall be determined in accordance with EN 678, and the mean value of the three results shall be calculated.

A graph of thermal conductivity $\lambda_{10\mathrm{dry}}$ (W/mK) and dry density ρ (kg/m^3) is plotted using the tabulated values given in 4.2.13.7 (line 9 in Figure 1). The mean measured $\lambda_{10\mathrm{dry}}$ value is plotted against the corresponding measured mean dry density (see point A in Figure 1). A line parallel to the line representing the tabulated values is drawn through this point (line 10 in Figure 1). From this line the mean and the limit values of the thermal conductivity shall be determined as a function of the mean dry density of the product and the 10 % and 90 % quantile of the manufactured dry product density with a confidence level of γ = 90 % according to EN ISO 10456.



Key

1	Upper limit	6	Mean manufactured dry density
2	Mean value	7	Dry density not exceeded by 90 % of production
3	Lower limit	8	Dry density not exceeded by 10 % of production
4	Point A: average of test results	9	Line representing tabulated values acc. to Table 4
5	Manufactured dry density range	10	Line parallel to line 9 through point (A)

Figure 1 — Determination of dry thermal conductivity $\lambda_{10\mathrm{dry}}$

4.2.13.7 Use of tabulated values for thermal conductivity

In the absence of test results the thermal conductivity shall be based on the values given in Table 4, related to the dry density (see 4.2.2.4), for the dry state.

Table 4 — Dry thermal conductivity λ_{10dry} of AAC for 50 % and 90 % of production with a confidence level of γ = 90 % (compiled according to EN 1745)

Mean dry density ρ[a] kg/m^3	Thermal conductivity value λ_{10dry} W/mK	
	50 %	90 %
300	0,072	0,085
400	0,096	0,110
500	0,120	0,130
600	0,150	0,160
700	0,170	0,180
800	0,190	0,210
900	0,220	0,240
1 000	0,240	0,260

NOTE 1 Intermediate values may be obtained by interpolation.

NOTE 2 The thermal performance is obtained using the mean dry thermal conductivity $\lambda_{10dry(50\ \%)}$

[a] See Figure 1.

4.2.14 Water vapour permeability

The design value of the water vapour resistance factor shall be taken as 5 or 10, respectively . The lower value is valid for diffusion into a component (wetting) and the higher value for diffusion out of a component (drying).

More accurate values for water vapour permeability and water vapour resistance factor may be determined by tests according to EN ISO 12572.

4.2.15 Water tightness

Where water tightness is required, the components shall be protected against penetration of water, e.g. by suitable rendering, coating, cladding or finishes.

4.3 Reinforcement

4.3.1 Steel

The reinforcement consists of reinforcement steel made by smooth bars or de-coiled products according to EN 10080 or stainless steel according to EN 10088-5.

Unless specified by a harmonized product standard, it shall be demonstrated that the reinforcement purchased from the steel works to be used in prefabricated reinforced components of autoclaved aerated concrete has been subject to an initial type testing, audit testing of samples taken at the factory, initial inspection of the FPC and continuous surveillance of the FPC.

NOTE 1 Appropriate certificate will demonstrate how the manufacturing of reinforcing steel is subject to third party control covering initial type testing, audit testing of samples taken at the factory, initial inspection of the FPC and continuous surveillance of the FPC.

Unless specified by a harmonized product standard for structural stainless reinforcing steel, it shall have a diameter not greater than 12 mm.

Declared strength and ductility properties of reinforcing steel used in AAC components shall comply with the properties of steel after straightening and after autoclaving.

NOTE 2 Thermal elongation for austenitic stainless steel is higher than for normal steel and ferritic or austenitic ferritic stainless steel.

4.3.2 Structural reinforcement

The performance characteristics of reinforcing steel are defined in EN 10080 and shall be tested in accordance with the test methods of that European Standard.

Table 5a together with EN 10088-5 gives the applicable stainless steel grades, their chemical composition and density.

Electrical resistance welding shall be used when connecting stainless steel bars and de-coiled products.

NOTE 1 Corrosion protection layer is often needed also with stainless reinforcing bars and de-coiled products due to autoclaving process.

Table 5a — List of steel grades for stainless reinforcing steel

Steel number	**Steel name**	**Density** [kg/dm^3] **– according to** EN 10088–1	**Comment**
1.4003	X2CrNi12	7,7	Ferritic stainless steel [a]
1.4016	X6Cr17	7,7	Ferritic stainless steel
1.4162	X2CrMnNiN21–5–1	7,8	Austenitic-ferritic steel
1.4362	X2CrNiN23–4	7,8	Austenitic-ferritic steel
1.4462	X2CrNiMoN22–5–3	7,8	Austenitic-ferritic steel

[a] This steel number needs corrosion protection the efficiency of which is verified in accordance with EN 990, see 5.3.3.

The performance characteristics of stainless steel are defined in EN 10088-5 and shall be tested in accordance with the test methods of that European Standard with the following exceptions and additional performance characteristics when used for reinforcing of AAC components:

1) Characteristic values for mechanical properties of stainless reinforcing steel

   Tensile strength values of stainless reinforcing steel shall be declared as characteristic values defined as the 5 % fractile of that property ($p = 0{,}95$) at a confidence level $\gamma = 90\ \%$. When calculating strength values, nominal cross-section area of the product is used. This definition refers to the long term quality level of production.

2) Suitability for bending

   When bent stainless reinforcing steel is used its suitability for bending shall be determined by the bend test according to EN ISO 15630-1, with a minimum angle of bend of 180°. After testing the products shall not show rupture or visible cracks. The mandrel diameter specified for the bend test shall not exceed the relevant maximum diameter specified in Table 5b.

   NOTE 2 The absence of cracks visible to a person with normal or corrected vision is considered as evidence that the test piece withstood the bend test. A superficial ductile tear can occur at the base of the ribs or indentations and is not considered to be a failure. The tear can be considered superficial when the depth of the tear is not greater than the width of the tear.

Table 5b — Mandrel diameter for the bending test

Nominal diameter d (mm)	Maximum mandrel diameter
≤ 16	3d
> 16	6d

3) Dimensions and tolerances

The permissible deviation from the nominal mass per metre shall not be more than:

±6,0 % on nominal diameters 12 mm and below.

The reinforcement shall have adequate ductility in elongation. Adequate ductility may be assumed if the following ductility requirement is satisfied:

$\varepsilon_{uk} > 2,5\ \%$

The declared value of the shear force of welded joints F_{wg} shall fulfil the following requirement:

$$F_{wg} \geq k_w f_{yk} A_{sl} \tag{8}$$

where

k_w is the welding strength factor, see Table 5c;

f_{yk} is the characteristic tensile yield strength;

A_{sl} is the cross sectional area of the reinforcing bar with the larger diameter of the connection.

Table 5c — Welding strength classes and welding strength factors k_w

Welding strength class	k_w
S 1	0,25
S 2	0,50

The shear strength of welded joints shall be determined in accordance with EN 1737. Welding strength classes shall be declared by the manufacturer according to Table 5c.

Class S1 is normally used. Class S2 should be used for steel with special properties specified by national authorities.

4.3.3 Effective diameter of coated bars

The increase of bar diameter by corrosion protection coating can be taken into account in the calculation of anchorage capacity of the transverse anchorage bars (see A.10.3) when the following conditions are met in a pull-out test according to EN 15361:

a) $\phi_{tot,m} \geq \phi_{tot,g}$

b) $f_{cb,c}/f_{cm,C} \geq 0{,}9 f_{cb,B}/f_{cm,B}$

where

$\phi_{tot,m}$	is the measured mean outer diameter of the transverse bar with corrosion protection coating;
$\phi_{tot,g}$	is the declared effective outer diameter of the transverse bar with corrosion protection coating;
$f_{cb,B}$	is the bearing stress of the transverse bar for type B test specimens;
$f_{cb,c}$	is the bearing stress of the transverse bar for type C test specimens;
$f_{cm,B}$	is the compressive strength of AAC for type B test specimens;
$f_{cm,C}$	is the compressive strength of AAC for type C test specimens.

When used in design calculations, the effective diameter $\phi_{tot,g}$ (equal the mean outer diameter of the transverse bars including the corrosion protection coating) shall be declared as mean value in accordance with 5.2 of EN 15361:2007.

4.3.4 Non-structural reinforcement

If required, mechanical properties of the non-structural reinforcement shall be declared by the manufacturer.

4.4 Bond

The use of bond in design according to Annex A shall be declared by the manufacturer as a bond class as specified in Table 6.

Table 6 — Bond classes

Bond class	Explanation
B1	Bond is not taken into account in design
B2-N	Bond is taken into account in design and ACC components are used in normal operational conditions
B2-T	Bond is taken into account in design and ACC components are used in operational conditions up to 50 °C

For bond classes B2-N and B2-T the minimum characteristic bond strength f_{bk} shall be 0,20 MPa.

If the effect of bond is used in design (see bond class B 2), the characteristic bond strength, f_{bk}, (see A.10.2) shall be declared by the manufacturer. The short-term bond strength shall be determined by initial type testing in accordance with EN 12269-1. The actual characteristic bond strength, f_{bk}, determined by statistical interpretation (see 4.2.3) of results shall be equal to or greater than the declared value. The initial type testing shall also include testing according to EN 989 in order to establish the correlation between the two methods.

The bond strength shall be subject to factory production control testing in accordance with EN 989 taking into account the correlation factor found in the initial type testing according to EN 12269-1.

When determining design bond strength, f_{bd}, the long term effects and possible effects of temperature extremes shall be taken into account.

Long-term effects and temperature effects shall be determined according to EN 12269-2 to verify that the declared reduction factor k_2 used in design, see A.10.2, is acceptable. The reduction factor k_2 may be applied for normal operational conditions, i.e. class N, or operational conditions up to 50 °C, i.e. class T. Before long-term testing, initial short-term tests shall be performed in accordance with EN 12269-1.

The reduction factor k_2 may be considered acceptable if the long-term bond strength f_{bl} obtained in the final short-term tests after 200 000 load cycles in accordance with EN 12269-2 fulfils the following requirement:

$$f_{\mathrm{bl,mean}} \geq 0{,}7 k_2 f_{\mathrm{bm}} \tag{9}$$

where

$f_{\mathrm{bl,mean}}$ is the mean value of the long-term bond strength according to EN 12269-2 obtained in the final short-term tests after 200 000 load cycles;

k_2 is the reduction factor taking into account the long term influences and temperature effects on the bond between reinforcing bars and AAC;

f_{bm} is the mean value of the short-term bond strength determined in accordance with EN 12269-1.

NOTE The bond strength values $f_{\mathrm{bl,mean}}$ and f_{bm} will be determined on test specimens prepared from the same sample.

4.5 Thermal prestress

4.5.1 General

The use of thermal prestress in design according to Annex A shall be declared by the manufacturer as a prestress class specified in Table 7.

Table 7 — Prestress classes

Prestress Class	Explanation
P 1	Thermal prestress is not taken into account in design
P 2	Thermal prestress is taken into account in design

Due to different deformation properties of AAC and steel, prestress can be generated during autoclaving and the subsequent cooling. In components where prestress might cause end cracks, see Formula (E.17), stirrups or other transverse reinforcements shall be provided to withstand splitting forces.

If the effect of prestress is taken into account in the design procedure in SLS, the mean value of the short-term prestrain ($\varepsilon_{0\mathrm{m}}$) shall be declared by the manufacturer. In addition it shall be verified that no significant long term slip exist between reinforcement and AAC. Furthermore, it has to be demonstrated that the bond stresses between the reinforcement and the AAC in SLS do not exceed the design bond strength f_{bd} (see A.10.2.2) or the anchorage capacity F_{RA} (see A.10.3) for any loading case. The development length of the prestress shall be less than 15 % of the length of the component, at each end.

The value of short-term prestrain (ε_0) is derived from measured steel strains in unloaded components according to EN 1738, using recognized methods, e.g. such as presented in informative Annex E.

Due to creep and shrinkage of AAC and the relaxation of the steel reinforcement the prestress will diminish in the course of time. This shall be taken into account if the effect of prestress is used in design by using recognized methods, e.g. such as presented in E.2 of informative Annex E.

The increase of slip between reinforcing bar and AAC during long term loading shall not be higher than 5 % of the initial slip of the long term test according to EN 12269-2.

4.5.2 Declared mean initial prestrain $\varepsilon_{0\mathrm{m,g}}$

The manufacturer may declare the initial prestrain as a mean value which shall fulfil the following conditions:

- mean initial prestrain: $\geq \varepsilon_{0\mathrm{m,g}} - 10$ %;
- individual value of measured initial prestrain: $\geq \varepsilon_{0\mathrm{m,g}} - 20$ %;

When calculating the mean initial prestrain, the last six tests shall be considered.

5 Properties and requirements of components

5.1 General

NOTE Information about methods for declaring mechanical and fire resistance performances can be found in Annex H.

5.1.1 Mechanical resistance

The components fulfil the requirement to mechanical resistance if they are designed in accordance with 5.2.4.

5.1.2 Acoustic properties

5.1.2.1 Airborne sound reduction

The airborne sound reduction of the components will mainly depend on the weight per surface area.

When required, the airborne sound reduction of walls, floors and roofs constructed of components shall be measured according to EN ISO 10140-1, -2, -4, -5 and expressed as single number quantity for rating according to EN ISO 717-1 (reference method).

For road traffic noise reducing devices the airborne sound reduction may be determined according to EN 1793-2.

Tests should be conducted in standardised end-use conditions with joints between components sealed and with no finishes except for the minimum thickness of screed on floors (if applicable). The results derived from such tests would be applicable to elements of any area having the same or better specification.

As an alternative to testing, the airborne sound reduction may be estimated according to EN 12354-1.

5.1.2.2 Impact sound insulation

When required, the impact sound insulation of floors constructed of components shall be measured according to EN ISO 10140-1, -3, -5 and expressed as single number quantity for rating according to EN ISO 717-2 (reference method).

Tests should be conducted in standardised end-use conditions with a minimum thickness of screed (if applicable) and without a ceiling finish. The results derived from such tests would be applicable to floors having the same or better specification but of any area.

As an alternative to testing, the impact sound insulation may be estimated according to EN 12354-2.

5.1.2.3 Sound absorption

The sound absorption will mainly depend on the surface texture. When required, it shall be determined according to EN ISO 354.

For road traffic noise reducing devices the sound absorption characteristic may be determined according to EN 1793-1.

5.1.3 Reaction to fire and resistance to fire

5.1.3.1 Reaction to fire

AAC shall be tested and classified as specified in EN 13501-1. If the content of equally distributed organic material is less than 1 % by mass or volume (whichever is the more onerous), the AAC[1] is classified in Euroclass A1 without the need for testing.

5.1.3.2 Resistance to fire

When resistance to fire of AAC components is required, the fire resistance shall be declared by the manufacturer and shall be classified by testing, by using tabulated data or by calculation.

a) Classification of resistance to fire by testing shall be done in accordance with EN 13501-2.

NOTE The test methods for the different types of components are specified in EN 13501–2. These are: EN 1364–1 for testing of non loadbearing walls, EN 1365–1 for testing of loadbearing walls, EN 1365–2 for testing of floors and roofs, EN 1365–3 for testing of beams, and EN 1365–4 for testing of piers.

b) Classification of resistance to fire using tabulated data shall be done in accordance with Annex C.

c) Classification of resistance to fire by calculation methods shall be done in accordance with Annex C.

5.1.4 Design thermal resistance and design thermal conductivity

The design thermal resistance can be determined in accordance with EN ISO 6946 using the design thermal conductivity λ_{d} to be determined according to Formula (11)a):

$$\lambda_{\mathrm{d}} = \lambda_{10\mathrm{dry}} \cdot e^{f_{\mathrm{u}} \cdot \mu_{\mathrm{m}}} \qquad (11a)$$

where

λ_{d} is the design thermal conductivity in the moist state, at a moisture content μ_{m}, in watts per metre Kelvin;

e is the basis of natural logarithms (2,718);

$\lambda_{10\mathrm{dry}}$ is the thermal conductivity in the dry state, in watts per metre Kelvin (see NOTE 2);

μ_{m} is the moisture content, mass by mass;

f_{u} is the moisture conversion coefficient, mass by mass. In the absence of test data the value of f_{u} shall be taken as 2,0.

NOTE 1 The moisture content is supposed to be given by the national application documents for different applications.

NOTE 2 The thermal performance is obtained by using the mean dry thermal conductivity $\lambda_{10\mathrm{dry}(50\ \%)}$.

Alternatively, moisture conversion coefficients and moisture conversion factors can be derived from tests, carried out at several practical moisture contents.

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1) Commission Decision 96/603/EEC, Materials to be considered as reaction to fire Class A without the need for testing.

The design thermal resistance can then be determined according to Formula (11)b):

$$\lambda_\mathrm{d} = \lambda_\mathrm{10dry} \cdot F_\mathrm{m} \qquad (11b)$$

where

λ_10dry is the thermal conductivity in the dry state, in watts per metre Kelvin (see NOTE 2 above);

F_m is the moisture conversion factor derived from tests.

5.2 Technical requirements and declared properties

5.2.1 Dimensions and tolerances

The essential dimensions (length or height, thickness, width, planeness and parallelism of the contact faces in the joints) determined in accordance with EN 991 or EN 772-16 or EN 772-20, respectively, and their tolerances shall be declared by the manufacturer.

The deviation of nominally rectangular components from squareness in their plane, determined in accordance with EN 991 is limited to 3 mm/0,5 m. For vertical wall components placed in a thin bed of mortar the deviation from squareness shall be limited to 0,2 mm/0,5 m.

Tighter tolerances than specified in Table 8, class T1, may be declared by the manufacturer.

The maximum deviations for components shall meet the tolerance requirements of Table 8.

Table 8 — Dimensional tolerances of components

Dimensions in millimetres

Tolerance class	T 1	T 2	T3
Length	±5	±3,0	±3,0
Height	±3	±1,0	±1,0
Width	±3	±1,5	±1,5
Planeness of the contact faces in the joints	No requirement	No requirement	≤ 1,0
Parallelism of the contact faces in the joints	No requirement	No requirement	≤ 1,0

Tongued and grooved edge profiles or other jointing systems may be provided.

The position of the structural reinforcement shall either be declared by the manufacturer or given in the design document for each product. The actual effective depth compared to the design value shall not be reduced by more than 5 mm. The position of the transverse reinforcing bars shall not deviate from the nominal value by more than ± 10 mm.

5.2.2 Mass of the components

The dry mass and the mass including the delivery humidity of the components may be stated as mean values (see 4.2.2.4).

5.2.3 Dimensional stability

In the absence of experimental data the values given in Table 9 shall be used for final shrinkage strain $\varepsilon_{0\infty}$ in the design of AAC components.

Table 9 — Final shrinkage strains $\varepsilon_{0\infty}$ for AAC components

Relative humidity %	Notional size 2 A_c/u mm	
	50	150
50	0,25 ‰	0,15 ‰
80	0,15 ‰	0,10 ‰

Ac is the cross-sectional area of AAC-component;

u is the perimeter of AAC component in contact with atmosphere.

Linear interpolation is permitted.

5.2.4 Load-bearing capacity

5.2.4.1 General

All relevant structural properties of a product shall be evaluated for both the ultimate and the serviceability limit states.

The design method used according to Annex A or Annex B shall be declared by the manufacturer.

The design values for the load-bearing capacities shall be determined according to one of the following methods:

a) by calculation (see 5.2.4.2);

b) by functional testing of components (see 5.2.4.3);

c) by calculation and physical testing (see 5.2.4.4)

NOTE 1 For certain applications of the products in the works, either testing according to Annex B or calculation method according to Annex A might be required.

NOTE 2 Actions and safety factors for actions are subject to national regulations or other rules valid in the place of use of the product. Design loads are predefined values, depending on the intended use of the product.

5.2.4.2 Design by calculation

The evaluation of design values for the capacities obtained by calculation shall be in accordance with Annex A.

5.2.4.3 Design by functional testing of components

In case of design by testing, declared values of the loadbearing capacity shall be based on functional testing of the components, in accordance with Annex B. The characteristic loadbearing capacity shall be determined by statistical interpretation of test results (see 4.2.3).

5.2.4.4 Design by calculation and physical testing

Physical testing of finished products is required to support calculation in the following cases:

— alternative design rules;

— structural arrangements with uncommon design models (uncommon modelling for structural design).

In these cases physical testing of a sufficient number of full scale specimens is needed before starting the production in order to verify the reliability of the design model assumed for the calculation. This shall be done with load-tests up to ultimate design conditions.

5.2.5 Deflections

The deflections of roof or floor components or beams under a given action shall be determined by calculation (see Annex A). It is also possible to determine the short-term deflections by functional testing of components (see Annex B).

5.2.6 Joint strength

When required as part of the design, the strength of joints between components shall be declared by the manufacturer on the basis of results determined from tests in accordance with EN 1739 (reference method) for in-plane shear and in accordance with EN 1741 (reference method) for out of plane shear. Alternatively, for specific joint types the joint strength shall be determined by calculation.

5.2.7 Minimum requirements

5.2.7.1 Minimum thickness

The minimum nominal thickness of a non-structural component is 30 mm. The minimum nominal thickness of a structural component depending of the chosen thickness class is specified in Table 10.

Table 10 — Thickness classes of structural components

Thickness Classes	Minimum nominal thickness
Th 1	70
Th 2	100

5.2.7.2 Minimum requirements for structural reinforcement

5.2.7.2.1 General

The rules given in this clause apply to structural reinforcement of AAC components subjected to predominantly static loading.

The components shall contain the necessary amount of reinforcement required for:

- limiting the width of cracks from transportation, handling, and service loads (see A.9.3);
- in the case of structurally reinforced components: avoidance of brittle bending failure of the cross-sections at the formation of the first crack (see A.3.4);
- distribution of loads.

The nominal diameter of the bars shall be ≥ 4 mm and ≤ 12 mm for slabs and ≥ 4 mm and ≤ 25 mm for beams.

The anchorage of the bars shall be achieved by welded transverse bars or by means of bond, if applicable.

The concrete cover of the bars shall be at least 10 mm and not smaller than the diameter of the bar except at the ends of the component when cut surface of the reinforcement is properly protected against corrosion.

5.2.7.2.2 Spacing of the bars

a) Longitudinal bars

The tensile reinforcement shall contain at least three bars for floor components and roof components and at least 2 bars for wall components. For beams and narrow fitting pieces with a width ≤ 375 mm two tensile bars are acceptable.

The centre distance s_{l1} of the bars of the required tensile reinforcement shall be such that:

— 50 mm ≤ $s_{l1} \leq 2d$ for floor components and roof components;

— 2,5 $\phi_{sl} \leq s_{l1} \leq 2d$ for beams;

— 50 mm ≤ s_{l1} ≤ 700 mm for wall components.

where

ϕ_{sl} is the diameter of the longitudinal bar;

d is the effective depth of the cross-section.

In loadbearing overhangs (balconies etc.) ≥ 4 h reinforcement shall contain at least two bars. The centre distance of the longitudinal bars shall not exceed 150 mm + $h/10$, where h is the slab thickness, in millimetres.

The centre distance s_{l2} of the bars of the required compressive reinforcement shall be such that

— 50 mm ≤ s_{l2} ≤ 700 mm.

b) Transverse bars

The centre distance s_t of the transverse bars required for anchorage of longitudinal reinforcement shall be such that:

— for b_w ≤ 750 mm: 50 mm ≤ s_t ≤ 500 mm;

— for b_w > 750 mm: 50 mm ≤ s_t ≤ 333 mm.

where

b_w is the width of the components

The centre distance s_t of transverse bars required for other purposes (in the central area of AAC component apart from the anchorage zone) shall be such that

— for b ≤ 750 mm: 50 mm ≤ s_t ≤ 1200 mm;

— for b > 750 mm: 50 mm ≤ $s_t \leq 3d$

c) Shear reinforcement

The spacing s_s of required bars along the longitudinal axis of the component shall not exceed 0,9 $d/\sin \alpha$,

where

d is the effective depth of the cross-sections;

α is the angle of the shear reinforcement with the longitudinal axis.

5.2.7.2.3 Permissible curvatures

The minimum diameter to which a bar is bent shall be such as to avoid crushing or splitting of the AAC inside the bend of the bar, and to avoid bending cracks in the bar.

For structural reinforcement the minimum diameter to which a bar is bent (diameter of the mandrel) shall be not less than $4\phi_S$ for bars with $\phi_S \leq 12$ mm and $7\ \phi_S$ for bars with $\phi_S > 12$ mm.

5.2.7.3 Chases and holes

All reductions of the cross-sectional area shall be taken into account in design of the components except the following cases:

- Chases parallel to the longitudinal reinforcement, not affecting the reinforcement, with the following maximum dimensions:

  depth: ≤ 30 mm or one fourth of the component thickness (which one is the smallest);

  width: ≤ 40 mm

  distance from each other: ≥ 500 mm.

- Small individual holes and notches, not affecting the reinforcement in roof and floor components as well as the anchorage zone when the width of the hole or notch is not more than 15 % of the width of the component.

5.3 Durability

5.3.1 General

Durability in this context means that the component is able to fulfil throughout its service life its function with respect to serviceability, strength, and stability without significant reduction of utility or excessive unforeseen maintenance.

To provide the required durability it is necessary to protect the reinforcement reliably against corrosion. Furthermore, the components shall not be exposed to environmental conditions they cannot withstand for long. Under certain conditions a protection of the AAC surface can be necessary.

5.3.2 Environmental conditions

5.3.2.1 General

Environment in this context means the chemical and physical actions to which the AAC-components are exposed and which result in effects on the AAC or the reinforcement that are not considered as loads in structural design. These actions are classified as exposure classes in Table 11.

Special considerations shall be made to environmental conditions and duration of exposure during construction. The manufacturer shall state any necessary exposure limitations and protective measures to the normal use of the components.

5.3.2.2 Environmental classification

The manufacturer shall declare the exposure class(es) for the intended uses of the product according to Table 11.

Table 11 — Exposure classes and protective measures related to environmental conditions

Exposure classes [a]			Protection
Passive	AAC components inside buildings with low humidity and without chemical attack	X0 XD1	No protection required
Moderate	AAC components inside buildings with high humidity; AAC components exposed to rain and freezing or moderate level of chemical attack	XD2 XD3 XS1 XF1 XA1 XA2	Recommended protection by suitable measures
Aggressive	AAC components directly submerged in seawater or high level of chemical attack	XS2 XS3 XF2 XF3 XF4 XA3	Special protective measures are required [b].

[a] Definition of exposure classes, see EN 206.

[b] In the case of an aggressive environment, e.g. with a high content of CO_2, SO_2 or de-icing salt, special protective measures are required, e.g. applying of a special protective coating on the surface of the components.

NOTE Exposure classes XC are not relevant since durability is not influenced by carbonation due to corrosion protection coating of the reinforcement

In the case of moderate or aggressive environment the protective measures shall be coordinated to the nature of the attack. They shall be capable of avoiding impairment of the properties of the AAC underlying structural design and the building physical verifications and shall be suitable of avoiding damage of the reinforcement.

5.3.3 Corrosion protection of reinforcement

Structural reinforcement shall always be protected against corrosion by means of a coating applied on its surface, unless it consists of corrosion resistant material (e.g. stainless steel).

The efficiency of the corrosion protection shall be verified in accordance with EN 990.

The corrosion protection system is considered to be suitable for reinforced components if it passes either the short-term test according to Method M2 (alternating drying and wetting cycles) of EN 990 or the short-term test according to method 3 (temperature cycles) of EN 990. In case of dispute Method M2 is the reference test method.

A test is considered to have being passed:

- if the steel surface is free from corrosion or if only first signs of corrosions (no flaky rust or pitting) are visible in separate places which are approximately uniformly distributed over the bars and cover not more than 5 % of the surface of each individual bar,

  or

- if the corroded surface area does not exceed by more than 5 % that observed on the bars of unexposed companion specimens which were stored in a non-corrosive atmosphere at a relative humidity ≤ 70 % until the end of the corrosion test.

Corrosion protection coating is not required for non-structural reinforcement when the concrete cover for components with characteristic compressive strength of the AAC $f_{ck} \leq 4{,}0$ MPa is at least 45 mm and for components with characteristic compressive strength of the AAC $f_{ck} > 4{,}0$ MPa is at least 70 mm. The corrosion protection may also be dispensed with for components for walls under environmental conditions according to Table 11 exposure class X0, with a thickness of at least 70 mm and centric transportation reinforcement.

5.3.4 Freeze and thaw resistance

When the components are exposed to freeze and thaw conditions, the manufacturer shall declare freeze/thaw resistance according to EN 15304.

The required number of freeze/thaw cycles and any limits for mass loss and/or strength reduction should be given in the national application document.

6 Assessment and verification of constancy of performance – AVCP

6.1 Introduction

The compliance of prefabricated reinforced components of autoclaved aerated concrete with the requirements of this standard and with the performances declared by the manufacturer in the DoP shall be demonstrated by:

- determination of the product type
- factory production control by the manufacturer, including product assessment.

The manufacturer shall always retain the overall control and shall have the necessary means to take responsibility for the conformity of the product with its declared performance(s).

6.2 Type testing

6.2.1 General

All performances related to characteristics included in this standard shall be determined when the manufacturer intends to declare the respective performances unless the standard gives provisions for declaring them without performing tests. (e.g. use of previously existing data, CWFT and conventionally accepted performance).

Assessment previously performed in accordance with the provisions of this standard, may be taken into account provided that they were made to the same or a more rigorous test method, under the same AVCP system on the same product or products of similar design, construction and functionality, such that the results are applicable to the product in question.

For the purposes of assessment, the manufacturer's products may be grouped into families, where it is considered that the results for one or more characteristics from any one product within the family are representative for that same characteristics for all products within that same family.

NOTE Products may be grouped in different families for different characteristics.

Reference to the assessment method standards should be made to allow the selection of a suitable representative sample.

In addition, the determination of the product type shall be performed for all characteristics included in the standard for which the manufacturer declares the performance:

- at the beginning of the production of a new or modified prefabricated reinforced components of autoclaved aerated concrete (unless a member of the same product range), or
- at the beginning of a new or modified method of production (where this may affect the stated properties); or

they shall be repeated for the appropriate characteristic(s), whenever a change occurs in the prefabricated reinforced components of autoclaved aerated concrete design, in the raw material or in the supplier of the components, or in the method of production (subject to the definition of a family), which would affect significantly one or more of the characteristics.

Where components are used whose characteristics have already been determined, by the component manufacturer, on the basis of assessment methods of other product standards, these characteristics need not be re-assessed. The specifications of these components shall be documented.

Products bearing regulatory marking in accordance with appropriate harmonized European specifications may be presumed to have the performances declared in the DoP, although this does not replace the responsibility on the prefabricated reinforced components of autoclaved aerated concrete manufacturer to ensure that the prefabricated reinforced components of autoclaved aerated concrete as a whole is correctly manufactured and its component products have the declared performance values.

6.2.2 Test samples, testing and compliance criteria

The number of samples of prefabricated reinforced components of autoclaved aerated concrete to be tested/assessed shall be in accordance with Table 12.

Table 12 — Number of samples to be tested and compliance criteria

Characteristic	**Requirement**	**Type of component** [a]												**Assessment method**	**No. of samples**
		Structural use							Non-structural use						
		Walls (W)			Roof (1)	Floor (2)	Beam (B)	Pier (O)	Walls (W)[a]		Cladding (C)	Box culvert (B)	For Sound (S)		
		W1 W2 W3 W4	**W5**	**W6**	**RF-1**	**RF-2**	**BL**	**PL**	**W7**	**W8**	**CN**	**BN**	**SB**		
Density	4.2.2	x	x	x	x	x	x	x	x	x	x	x	x	EN 678	3x3
Compressive strength	4.2.4	x	x	x	x	x	x	x			x	x	x	EN 679	3x3
Flexural strength	4.2.5	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 1351	3x3
Thickness of coating on the reinforcement	4.3.3	x	x	x	x	x	x	x			x	x	x	Physical measurement	6
Corrosion protection	5.3.3	x[c]	x[c]	x[c]	x[c]	x[c]	x[c]	x[c]			x[c]	x[c]	x[c]	EN 990	3[1]+3
Diameter (bar + coating)	4.3.3	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]						Physical measurement	6
Reinforcement cover	5.2.7.2.1	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]						Physical measurement	6
Durability against Freeze–thaw	5.3.4	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]			x[b]	x[b]	x[b]	EN 15304[j]	6[1]+6
Dimensions	5.2.1	x	x	x	x	x	x	x	x	x	x	x	x	EN 991	3
Parallelism of the contact faces in the joints		x[j]	x[j]	x[j]	x[j]	x[j]			x[j]	x[j]				EN 772–16	3
Planeness of the contact faces in the joints		x[j]	x[j]	x[j]	x[j]	x[j]			x[j]	x[j]				EN 772–20	3
Loadbearing capacity under transverse load	5.2.4	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 1356	3

Characteristic	**Require-ment**	**Type of component** [a]												**Assessment method**	**No. of samples**
		Structural use							Non-structural use						
		Walls (W)			Roof (1)	Floor (2)	Beam (B)	Pier (O)	Walls (W)[a]		Cladding (C)	Box culvert (B)	For Sound (S)		
		W1 W2 W3 W4	**W5**	**W6**	**RF-1**	**RF-2**	**BL**	**PL**	**W7**	**W8**	**CN**	**BN**	**SB**		
Loadbearing capacity under predominantly longitudinal load	5.2.4	x[b]						x[b]						EN 1740	3
Thermal conductivity	4.2.13	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	x[e]	EN 12664	3x3
Resistance to fire	5.1.3.2	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	x[d]	EN 13501–2	1
Reaction to fire	5.1.3.1	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	x[h]	EN 13501–1	1
Airborne sound reduction	5.1.2.1	x			x	x			x	x	x		x	EN ISO 10140-1, -2, -4, -5 EN ISO 717-1	1 1
Impact sound reduction	5.1.2.2				x	x								EN ISO 10140-1, -3, -5 EN ISO 717-2	1 1
Sound absorption coefficient	5.1.2.3	x[f]	x[f]	x[f]	x[f]	x[f]	x[f]	x[f]	x[f]	x[f]	x[f]		x[f]	EN ISO 354	1
Short-term bond	4.4	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]							EN 989 EN 12269–1	3 3
Long term bond	4.4	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]							EN 12269–2	3
Pre-stress	4.5	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]							EN 1738	3
Modulus of elasticity	4.2.7	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]						EN 1352	3x3
Drying shrinkage	4.2.10	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 680	3x3
Creep	4.2.11	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]						EN 1355	3x3

Characteristic	Require-ment	Type of component [a]												Assessment method	No. of samples
		Structural use							Non-structural use						
		Walls (W)			Roof (1)	Floor (2)	Beam (B)	Pier (O)	Walls (W)[a]		Cladding (C)	Box culvert (B)	For Sound (S)		
		W1 W2 W3 W4	**W5**	**W6**	**RF-1**	**RF-2**	**BL**	**PL**	**W7**	**W8**	**CN**	**BN**	**SB**		
Steel/stainless steel: — yield strength — tensile strength — elongation of rupture — modulus of elasticity (only for stainless steel) — bar diameter — strength of welded joints — suitability for bending — dimensions, mass and tolerances	4.3	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]						EN 10080/ EN 10088–5 EN 1737 EN ISO 15630 -1	According to product standard 3 3 3
Joint strength	5.2.6	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 1739 EN 1741	3 3
Shear resistance between layers of multilayer components	4.2.3 or B.3.3.3.1	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	x[g]	EN 1742	3

Characteristic	**Require-ment**	**Type of component** [a]													**Assessment method**	**No. of samples**
		Structural use							Non-structural use							
		Walls (W)			Roof (1)	Floor (2)	Beam (B)	Pier (O)	Walls (W)[a]		Cladding (C)	Box culvert (B)	For Sound (S)			
		W1 W2 W3 W4	**W5**	**W6**	**RF-1**	**RF-2**	**BL**	**PL**	**W7**	**W8**	**CN**	**BN**	**SB**			

The manufacturer may declare roof and floor components only with RF.

1 reference test specimen

[a] Type of component:

W: wall component

W1: loadbearing wall with structural reinforcement (vertical)

W2: loadbearing wall with structural reinforcement (horizontal)

W3: loadbearing wall without structural reinforcement (vertical)

W4: loadbearing wall without structural reinforcement (horizontal)

W5: retaining wall (vertical) W6: retaining wall (horizontal)

W7: non-loadbearing wall (vertical) W8: non-loadbearing wall (horizontal)

RF: roof and floor component (−1: Roof; −2: Floor) BL: beam

PL: vertical loadbearing part of the wall between or beside openings (pier)

CN: cladding component BN: box culvert

SB: component for noise barriers

[b] Only if used in design on the basis of a declared value based on measurements.

[c] Only valid for components with structural reinforcement.

[d] Not necessary if it has been verified by calculation or approved tables.

[e] Not necessary when thermal conductivity values are obtained from approved tables.

[f] Only if declared on the basis of a measured value.

[g] Only relevant in case of multilayer components.

[h] Reaction to fire test is only necessary if the content of organic material is higher than 1 % by mass or volume (whichever is higher).

[i] According to test method valid at the place of use of the component.

[j] Only if required (see Table 8).

NOTE Explaining difference with the codes (WL, WN,…) in Tables ZA1.1 to ZA1.8.

6.2.3 Test reports

The results of the determination of the product type shall be documented in test reports. All test reports shall be retained by the manufacturer for at least 10 years after the last date of production of the prefabricated reinforced components of autoclaved aerated concrete to which they relate.

6.2.4 Shared other party results

A manufacturer may use the results of the product type determination obtained by someone else (e.g. by another manufacturer, as a common service to manufacturers, or by a product developer), to justify his own declaration of performance regarding a product that is manufactured according to the same design (e.g. dimensions) and with raw materials, constituents and manufacturing methods of the same kind, provided that:

- the results are known to be valid for products with the same essential characteristics relevant for the product performance;
- in addition to any information essential for confirming that the product has such same performances related to specific essential characteristics, the other party who has carried out the determination of the product type concerned or has had it carried out, has expressly accepted[2] to transmit to the manufacturer the results and the test report to be used for the latter's product type determination, as well as information regarding production facilities and the production control process that can be taken into account for FPC;
- the manufacturer using other party results accepts to remain responsible for the product having the declared performances and he also:
  - ensures that the product has the same characteristics relevant for performance as the one that has been subjected to the determination of the product type, and that there are no significant differences with regard to production facilities and the production control process compared to that used for the product that was subjected to the determination of the product type; and
  - keeps available a copy of the determination of the product type report that also contains the information needed for verifying that the product is manufactured according to the same design and with raw materials, constituents and manufacturing methods of the same kind.

6.2.5 Additional provisions for structural elements/components and/or structural kits

When M1 is used

a) determination of the geometrical data, including sampling, of each structural product or kit;

b) determination of the properties, including sampling, of the materials and components used; and

c) elaboration of a testing report.

When M2 is used

d) Determination of the geometrical data, including sampling, of each structural product or kit and validation of the methods used;

e) Determination of the properties of the materials and constituent products used;

f) selection of tabulated values, partial factors for materials, loads, etc., other NDPs and design assumptions;

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[2] The formulation of such an agreement can be done by license, contract, or any other type of written consent.

g) calculation of the mechanical and fire resistance performances of the structural product according to the methods established in this European standard; and

h) elaboration of a product-type calculation report.

When M3a is used

i) Analysis and acceptance of the design documentation provided by the client;

j) Determination of the geometrical data, including sampling, of the structural product or kit and validation of the methods used; and

k) Determination of the properties, including sampling, of the materials and constituent products used;

When M3b is used

l) Determination of the geometrical data, including sampling, of the structural product or kit and validation of the methods used;

m) Determination of the properties, including sampling, of the materials and components used;

n) selection of tabulated values, partial factors for materials, loads, etc., other NDPs and design assumptions in accordance with the requirements established in the client's order;

o) calculation of the mechanical and fire resistance performances of the structural product according to the methods established in the client's order; and

p) elaboration of a product-type calculation report.

6.2.6 Additional provisions for semi-structural elements/components and/or semi-structural kits

When M1 is used

a) determination, including sampling, of the geometrical data of each structural product or kit;

b) determination, including sampling of the properties of the materials and components used; and

c) elaboration of testing report.

When M2 is used

d) Determination, including sampling, of the geometrical data of each structural product or kit and validation of the methods used;

e) Determination, including sampling, of the properties of the materials and constituent products used;

f) selection of tabulated values, partial factors for materials, loads, etc., other NDPs and design assumptions;

g) calculation of the mechanical and fire resistance performances of the structural product according to the methods established in this European standard; and

h) elaboration of a product-type calculation report.

When M3a is used

i) Analysis and acceptance of the design documentation provided by the client;

j) Determination, including sampling, of the geometrical data of each structural product or kit and validation of the methods used; and

k) Determination, including sampling, of the properties of the materials and constituent products used.

When M3b is used

l) Determination, including sampling, of the geometrical data of each structural product or kit and validation of the methods used;

m) Determination, including sampling, of the properties of the materials and components used or validation of the FPC results;

n) selection of tabulated values, partial factors for materials, loads, etc., other NDPs and design assumptions in accordance with the requirements of the client;

o) calculation of the mechanical and fire resistance performances of the structural product according to the methods established by the client; and

p) elaboration of a product-type calculation report.

6.3 Factory production control (FPC)

6.3.1 General

The manufacturer shall establish, document and maintain an FPC system to ensure that the products placed on the market comply with the declared performance of the essential characteristics.

The FPC system shall consist of procedures, regular inspections and tests and/or assessments and the use of the results to control raw and other incoming materials or components, equipment, the production process and the product.

All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures.

This factory production control system documentation shall ensure a common understanding of the evaluation of the constancy of performance and enable the achievement of the required product performances and the effective operation of the production control system to be checked. Factory production control therefore brings together operational techniques and all measures allowing maintenance and control of the compliance of the product with the declared performances of the essential characteristics.

In case the manufacturer has used shared or cascading product type results, the FPC shall also include the appropriate documentation as foreseen in 6.2.4 and 6.2.5.

6.3.2 Requirements

6.3.2.1 General

The manufacturer is responsible for organizing the effective implementation of the FPC system in line with the content of this product standard. Tasks and responsibilities in the production control organization shall be documented and this documentation shall be kept up-to-date.

The responsibility, authority and the relationship between personnel that manages, performs or verifies work affecting product constancy, shall be defined. This applies in particular to personnel that need to initiate actions preventing product non-constancies from occurring, actions in case of non-constancies and to identify and register product constancy problems.

Personnel performing work affecting the constancy of performance of the product shall be competent on the basis of appropriate education, training, skills and experience for which records shall be maintained.

In each factory the manufacturer may delegate the action to a person having the necessary authority to:

— identify procedures to demonstrate constancy of performance of the product at appropriate stages;

- identify and record any instance of non-constancy;
- identify procedures to correct instances of non-constancy.

The manufacturer shall draw up and keep up-to-date documents defining the factory production control. The manufacturer's documentation and procedures should be appropriate to the product and manufacturing process. The FPC system should achieve an appropriate level of confidence in the constancy of performance of the product. This involves:

a) the preparation of documented procedures and instructions relating to factory production control operations, in accordance with the requirements of the technical specification to which reference is made;

b) the effective implementation of these procedures and instructions;

c) the recording of these operations and their results;

d) the use of these results to correct any deviations, repair the effects of such deviations, treat any resulting instances of non-conformity and, if necessary, revise the FPC to rectify the cause of non-constancy of performance.

Where subcontracting takes place, the manufacturer shall retain the overall control of the product and ensure that he receives all the information that is necessary to fulfill his responsibilities according to this European standard.

If the manufacturer has part of the product designed, manufactured, assembled, packed, processed and/or labelled by subcontracting, the FPC of the subcontractor may be taken into account, where appropriate for the product in question.

The manufacturer who subcontracts all of his activities may in no circumstances pass the above responsibilities on to a subcontractor.

NOTE Manufacturers having an FPC system, which complies with EN ISO 9001 standard and which addresses the provisions of the present European standard are considered as satisfying the FPC requirements of the Regulation (EU) No 305/2011.

6.3.2.2 Equipment

6.3.2.2.1 Testing

All weighing, measuring and testing equipment shall be calibrated and regularly inspected according to documented procedures, frequencies and criteria.

6.3.2.2.2 Manufacturing

All equipment used in the manufacturing process shall be regularly inspected and maintained to ensure use, wear or failure does not cause inconsistency in the manufacturing process. Inspections and maintenance shall be carried out and recorded in accordance with the manufacturer’s written procedures and the records retained for the period defined in the manufacturer's FPC procedures.

6.3.2.3 Raw materials and components

The specifications of all incoming raw materials and components shall be documented, as shall the inspection scheme for ensuring their compliance. In case supplied kit components are used, the constancy of performance system of the component shall be that given in the appropriate harmonized technical specification for that component.

6.3.2.4 Traceability and marking

Individual products, product batches or packages (where relevant) shall be identifiable and traceable with regard to their production origin. The manufacturer shall have written procedures ensuring that processes related to affixing traceability codes and/or markings are inspected regularly.

6.3.2.5 Controls during manufacturing process

The manufacturer shall plan and carry out production under controlled conditions.

6.3.2.6 Product testing and evaluation

The manufacturer shall establish procedures to ensure that the stated values of the characteristics he declares are maintained. The characteristics, and the means of control, are as in Tables 13 and 14.

Table 13 — Testing of the finished product; AAC components for structural uses

Characteristic	**Require-ment**	**Type of component**							**Assessment method**	**Frequency (valid when produced)**	**Remarks**
		Walls (W)[a]			Roof (1)	Floor (2)	Beam (B)	Pier (O)			
		W1 W2 W3 W4	W5	W6	RF-1	RF-2	BL	PL			
Density	4.2.2	x	x	x	x	x	x	x	EN 678	Every 500 m^3 at least once per week	Relevant for properties such as thermal conductivity, etc. For each AAC type
Compressive strength	4.2.4	x	x	x	x	x	x	x	EN 679	Every 500 m^3 at least once per week	For each AAC type
Flexural strength	4.2.5	x[b]	x[b]	x[b]				x[b]	EN 1351	Twice per year	For each AAC type
Thickness of coating on the reinforcement	4.3.3	x	x	x	x	x	x	x	Physical measurement	Once per week	Only in cases of structural reinforcement
Corrosion protection	5.3.3	x	x	x	x	x	x	x	EN 990 Visual inspection	Twice per year Once per day	

Characteristic	Require-ment	Type of component							Assessment method	Frequency (valid when produced)	Remarks
		Walls (W)[a]			Roof (1)	Floor (2)	Beam (B)	Pier (O)			
		W1 W2 W3 W4	W5	W6	RF-1	RF-2	BL	PL			
Diameter (bar + coating)	4.3.3	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	Physical measurement	Twice per month	
Reinforcement cover	5.2.7.2.1	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	Physical measurement	Twice per month	
Dimensions	5.2.1	x	x	x	x	x	x	x	EN 991	Once per week	
Parallelism of the contact faces in the joints		x[j]	x[j]	x[j]	x[j]	x[j]			EN 772–16	Once per week	Only applied in the case of tolerance class T 3 according to Table 8
Planeness of the contact faces in the joints		x[j]	x[j]	x[j]	x[j]	x[j]			EN 772–20	Once per week	Only applied in the case of tolerance class T 3 according to Table 8
Loadbearing capacity under transverse load	5.2.4		x[b]	x[b]	x[b]	x[b]	x[b]		EN 1356	Every 1500 m^3 / 10 000 components, at least twice per month, whichever is the most severe	Only relevant in the case of verification by testing

Characteristic	**Require-ment**	**Type of component**							**Assessment method**	**Frequency (valid when produced)**	**Remarks**
		Walls (W)[a]			Roof (1)	Floor (2)	Beam (B)	Pier (O)			
		W1 W2 W3 W4	W5	W6	RF-1	RF-2	BL	PL			
Loadbearing capacity under predominantly longitudinal load	5.2.4	x						x	EN 1740	Every 1500 m³ / 10 000 components, at least twice per month, whichever is the most severe	Only relevant in the case of verification by testing
Thermal conductivity	4.2.13	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 12664	Once per year	Not necessary when thermal conductivity is taken from acknowledged values in tables
Push out bond	4.4	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]		EN 989	Once every three months	
Pre-stress	4.5	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]		EN 1738	Once every three months	
Modulus of elasticity	4.2.7	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 1352	Once per year	
Creep	4.2.11	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 1355	Once per five years	

Characteristic	**Require-ment**	**Type of component**							**Assessment method**	**Frequency (valid when produced)**	**Remarks**
		Walls (W)[a]			Roof (1)	Floor (2)	Beam (B)	Pier (O)			
		W1 W2 W3 W4	W5	W6	RF-1	RF-2	BL	PL			
Steel/stainless steel: — yield strength — tensile strength — elongation of rupture — modulus of elasticity (only for stainless steel) — bar diameter — strength of welded joints — suitability for bending — dimensions, mass and tolerances	4.3	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	x[b]	EN 10080/ EN 10088–5 EN 1737 EN ISO 15630-1	According to EN 10080 or when the reinforcing bars are straightened at the factory the frequency of testing is once per 50 t of the same combination of steel grades and diameters manufactured on the same welding machine	

Characteristic	**Require-ment**	**Type of component**							**Assessment method**	**Frequency (valid when produced)**	**Remarks**
		Walls (W)[a]			Roof (1)	Floor (2)	Beam (B)	Pier (O)			
		W1 W2 W3 W4	W5	W6	RF-1	RF-2	BL	PL			

The manufacturer may declare roof and floor components only with RF.

[a] Type of component:

W: wall component

W1: loadbearing wall with structural reinforcement (vertical)

W2: loadbearing wall with structural reinforcement (horizontal)

W3: loadbearing wall without structural reinforcement (vertical)

W4: loadbearing wall without structural reinforcement (horizontal)

W5: retaining wall (vertical)

W6: retaining wall (horizontal)

RF: roof and floor component (−1: Roof; −2: Floor)

BL: beam

PL: vertical loadbearing part of the wall between or beside openings (pier)

[b] Only if used in design on the basis of a declared value based on measurements.

[j] Only if required (see Table 8).

NOTE Explaining difference with the codes (WL, WN,…) in Tables ZA1.1 to ZA1.8.

Table 14 — Testing of the finished product; AAC components for non-structural uses

Characteristic	Requirement	Type of component [a]					Assessment Method	Frequency (valid when produced)	Remarks
		Walls (W)[a]		Cladding (C)	Box culvert (B)	For Sound (S)			
		W7	**W8**	**CN**	**BN**	**SB**			
Density	4.2.2	x	x	x	x	x	EN 678	Every 500 m³ at least once per week	Relevant for properties such as thermal conductivity, etc. For each AAC type
Compressive strength	4.2.4			x	x	x	EN 679	Every 500 m³ at least once per week	For each AAC type
Flexural strength	4.2.5	x[b]	x[b]	x[b]	x[b]	x[b]	EN 1351	Twice per year	For each AAC type
Reinforcement cover	5.2.7.2.1			x[b]		x[b]	Physical measurement	Once per week	
Corrosion protection	5.3.3			x[b]		x[b]	EN 990 Visual inspection	Twice per year Once per day	Only in cases of structural reinforcement
Dimensions Parallelism of the contact faces in the joints Planeness of the contact faces in the joints	5.2.1	x x x	x x x	x	x	x	EN 991 EN 772–16 EN 772–20	Once per week Once per week Once per week	Only applied in the case of tolerance class T 3 according to Table 8 Only applied in the case of tolerance class T 3 according to Table 8
Loadbearing capacity under transverse load	5.2.4	x	x	x	x	x	EN 1356	Every 1500 m³ / 10 000 components, at least twice per month, whichever is the most severe	Only relevant in the case of verification by testing

Characteristic	Require ment	Type of component [a]					Assessment Method	Frequency (valid when produced)	Remarks
		Walls (W)[a]		Cladding (C)	Box culvert (B)	For Sound (S)			
		W7	**W8**	**CN**	**BN**	**SB**			
Thermal conductivity	4.2.13	x[b]	x[b]	x[b]	x[b]	x[b]	EN 12664	Once per year	Not necessary when thermal conductivity us taken from acknowledged values in tables

[a] Type of component:

W: wall component

W7: non-loadbearing wall (vertical)

W8: non-loadbearing wall (horizontal)

CN: cladding component

BN: box culvert

SB: component for sound barriers

[b] Only if used in design on the basis of a declared value based on measurements.

NOTE Explaining difference with the codes (WL, WN,...) in Tables ZA1.1 to ZA1.8.

When stainless reinforcing steel is used, the acceptance criteria of test results determined in accordance with EN 10088-5 for the characteristics 0,2 % proof strength $R_{p0,2}$, tensile strength R_m, percentage total elongation at maximum force A_{gt} and ratio tensile strength/proof strength R_m / $R_{p0,2}$of the finished reinforcing bars or de-coiled products are given in Annex G.

6.3.2.7 Non-complying products

The manufacturer shall have written procedures which specify how non-complying products shall be dealt with. Any such events shall be recorded as they occur and these records shall be kept for the period defined in the manufacturer's written procedures.

Where the product fails to satisfy the acceptance criteria, the provisions for non-complying products shall apply, the necessary corrective action(s) shall immediately be taken and the products or batches not complying shall be isolated and properly identified.

Once the fault has been corrected, the test or verification in question shall be repeated.

The results of controls and tests shall be properly recorded. The product description, date of manufacture, test method adopted, test results and acceptance criteria shall be entered in the records under the signature of the person responsible for the control/test.

With regard to any control result not meeting the requirements of this European standard, the corrective measures taken to rectify the situation (e.g. a further test carried out, modification of manufacturing process, throwing away or putting right of product) shall be indicated in the records.

6.3.2.8 Corrective action

The manufacturer shall have documented procedures that instigate action to eliminate the cause of non-conformities in order to prevent recurrence.

6.3.2.9 Handling, storage and packaging

The manufacturer shall have procedures providing methods of product handling and shall provide suitable storage areas preventing damage or deterioration.

6.3.3 Product specific requirements

The FPC system shall address this European Standard and ensure that the products placed on the market comply with the declaration of performance.

The FPC system shall include a product specific FPC, which identifies procedures to demonstrate compliance of the product at appropriate stages, i.e.:

a) the controls and tests to be carried out prior to and/or during manufacture according to a frequency laid down in the FPC test plan,

   and/or

b) the verifications and tests to be carried out on finished products according to a frequency laid down in the FPC test plan

If the manufacturer uses only finished products, the operations under b) shall lead to an equivalent level of compliance of the product as if FPC had been carried out during the production.

If the manufacturer carries out parts of the production himself, the operations under b) may be reduced and partly replaced by operations under a). Generally, the more parts of the production that are carried out by the manufacturer, the more operations under b) may be replaced by operations under a).

In any case the operation shall lead to an equivalent level of compliance of the product as if FPC had been carried out during the production.

NOTE Depending on the specific case, it can be necessary to carry out the operations referred to under a) and b), only the operations under a) or only those under b).

The operations under a) refer to the intermediate states of the product as on manufacturing machines and their adjustment, and measuring equipment etc. These controls and tests and their frequency shall be chosen based on product type and composition, the manufacturing process and its complexity, the sensitivity of product features to variations in manufacturing parameters etc.

The manufacturer shall establish and maintain records that provide evidence that the production has been sampled and tested. These records shall show clearly whether the production has satisfied the defined acceptance criteria and shall be available for at least three years.

6.3.4 Initial inspection of factory and of FPC

Initial inspection of factory and of FPC shall be carried out when the production process has been finalized and in operation. The factory and FPC documentation shall be assessed to verify that the requirements of 6.3.2 and 6.3.3 are fulfilled.

During the inspection it shall be verified:

a) that all resources necessary for the achievement of the product characteristics included in this European standard are in place and correctly implemented,

   and

b) that the FPC-procedures in accordance with the FPC documentation are followed in practice, and

c) that the product complies with the product type samples, for which compliance of the product performance to the DoP has been verified.

All locations where final assembly or at least final testing of the relevant product is performed, shall be assessed to verify that the above conditions a) to c) are in place and implemented. If the FPC system covers more than one product, production line or production process, and it is verified that the general requirements are fulfilled when assessing one product, production line or production process, then the assessment of the general requirements does not need to be repeated when assessing the FPC for another product, production line or production process.

All assessments and their results shall be documented in the initial inspection report.

Additional provisions for structural elements/components and/or structural kits when method M1 is applied.

Evaluation of the permanent internal production control, in particular with regard to documented procedures for both the selection of representative samples according to the provisions of this standard and the checking of both the geometrical data of the structural product and the material properties.

Additional provisions for structural elements/components and/or structural kits when method M2 is applied.

Verification that the product-type determination has been undertaken in accordance with the provisions of this European Standard.

Evaluation of whether the production system enables the achievement of the required product characteristics and the effective operation of the FPC.

Verification that, in addition to checking whether the product-type calculation has been performed and whether the method and the calculation process are documented, when the FPC includes calculation of the mechanical properties for the manufactured products (samples), a documented FPC system in accordance with this European standard is established, used and maintained ensuring:

d) the correct selection of representative samples;

e) for the various products manufactured, the correct determination of product and material properties necessary as input for calculations, for the individual products;

f) adequate equipment and competent personnel to perform correct calculations;

g) that the calculation has been performed, that its basis (e.g. safety factors used) is correct, and that the method, process and results used as a basis for performance declarations are adequately documented and registered; and

h) that, in the case of electronic processing and reporting, only sufficiently documented and validated software and properly functioning computer equipment are used, and adequate measures of data protection and integrity are in place.

Additional provisions for structural elements/components and/or structural kits when method M3a is applied.

Evaluation of the permanent internal production control, in particular with regard to documented procedures for the selection of representative samples according to the provisions of this standard and the checking of both the geometrical data of the structural product and the material properties. The manufacturing conditions for the product shall be checked to ensure that they enable the information accompanying the marking to comply with the provisions of this European standard.

Additional provisions for structural elements/components and/or structural kits when method M3b is applied.

Verification that the product-type calculation has been undertaken in accordance with the provisions of this European Standard.

Evaluation of whether the production system enables the achievement of the required product characteristics and the effective operation of FPC.

Verification that, in addition to checking whether the TC has been performed and whether the method and the calculation process are documented, when the FPC includes calculation of the mechanical properties for the manufactured products (samples), a documented FPC system in accordance with this European standard is established, used and maintained, ensuring:

i) the correct selection of representative samples;

j) for the various products manufactured, the correct determination of product and material properties necessary as input for calculations, for the individual products;

k) adequate equipment and competent personnel to perform correct calculations;

l) that the calculation has been performed, that its basis (e.g. safety factors used) is correct, and that the method, process and results used as a basis for performance declarations are adequately documented and registered; and

m) that, in the case of electronic processing and reporting, only sufficiently documented and validated software and properly functioning computer equipment are used, and adequate measures of data protection and integrity are in place.

6.3.5 Continuous surveillance of FPC

Surveillance of the FPC shall be undertaken once per year. The surveillance of the FPC shall include a review of the FPC test plan(s) and production processes(s) for each product to determine if any changes have been made since the last assessment or surveillance. The significance of any changes shall be assessed.

Checks shall be made to ensure that the test plans are still correctly implemented and that the production equipment is still correctly maintained and calibrated at appropriate time intervals.

The records of tests and measurement made during the production process and to finished products shall be reviewed to ensure that the values obtained still correspond with those values for the samples submitted to the determination of the product type and that the correct actions have been taken for non-compliant products.

Additional provisions for structural elements/components and/or structural kits when method M1 is applied.

The manufacturing conditions for the product shall be checked to ensure that they enable the information accompanying the marking to comply with the provisions of this European standard.

Additional provisions for structural elements/components and/or structural kits when method M2 is applied.

Regarding the continuous surveillance, assessment and approval of FPC, it shall be verified, with the appropriate frequency specified in the product hEN, that the documentation regarding the calculation method is still valid (regardless whether modified or not) and to check the continued use and maintenance of a documented FPC system in accordance with this European standard ensuring 6.3.4 d) to h) as listed above.

Additional provisions for structural elements/components and/or structural kits when method M3a is applied.

Checking the permanent internal production control, in particular the manufacturing conditions for each product, to ensure that they enable to achieve both the constancy of the mechanical and fire resistance performances of the product-type and the compliance with the provisions of this European Standard of the information accompanying the product.

Additional provisions for structural elements/components and/or structural kits when method M3b is applied.

Verification that, with the appropriate frequency specified in the this European standard, to verify that the documentation regarding the calculation method is still valid (regardless whether modified or not) and to check the continued use and maintenance of a documented FPC system in accordance with this European standard ensuring 6.3.4 j) to m) as listed above.

6.3.6 Procedure for modifications

If modifications are made to the product, production process or FPC system that could affect any of the product characteristics declared according to this standard, then all the characteristics for which the manufacturer declares performance, which may be affected by the modification, shall be subject to the determination of the product type, as described in 6.2.1.

Where relevant, a re-assessment of the factory and of the FPC system shall be performed for those aspects, which may be affected by the modification.

All assessments and their results shall be documented in a report.

6.3.7 One-off products, pre-production products (e.g. prototypes) and products produced in very low quantity

The prefabricated reinforced components of autoclaved aerated concrete produced as a one-off, prototypes assessed before full production is established, and products produced in very low quantities (less then 500 m^3 per year) shall be assessed as follows.

For type assessment, the provisions of 6.2.1, 3rd paragraph apply, together with the following additional provisions:

- in case of prototypes, the test samples shall be representative of the intended future production and shall be selected by the manufacturer;
- on request of the manufacturer, the results of the assessment of prototype samples may be included in a certificate or in test reports issued by the involved third party.

The FPC system of one-off products and products produced in very low quantities shall ensure that raw materials and/or components are sufficient for production of the product. The provisions on raw materials and/or components shall apply only where appropriate. The manufacturer shall maintain records allowing traceability of the product.

For prototypes, where the intention is to move to series production, the initial inspection of the factory and FPC shall be carried out before the production is already running and/or before the FPC is already in practice. The following shall be assessed:

- the FPC-documentation; and
- the factory.

In the initial assessment of the factory and FPC it shall be verified:

a) that all resources necessary for the achievement of the product characteristics included in this European standard will be available, and

b) that the FPC-procedures in accordance with the FPC-documentation will be implemented and followed in practice, and

c) that procedures are in place to demonstrate that the factory production processes can produce a product complying with the requirements of this European standard and that the product will be the same as the samples used for the determination of the product type, for which compliance with this European standard has been verified.

Once series production is fully established, the provisions of 6.3 shall apply.

7 Basis for design

7.1 Design methods

The structural design may either be based on calculation (Annex A) or documented through functional testing of components (Annex B). The design method used shall be stated by the manufacturer.

NOTE The design methods are based on the concept of EN 1992–1-1:2004 (Annex A) and EN 1990:2002 (Annex B).

7.2 Limit states

Limit states are states beyond which the structure no longer satisfies the design performance requirements.

Limit states are classified into:

- ultimate limit states (ULS);
- serviceability limit states (SLS).

Ultimate limit states are those associated with collapse, or with other forms of structural failure which may endanger the safety of people. States prior to structural collapse which, for simplicity, are considered in place of the collapse itself are also treated as ultimate limit states. Ultimate limit states which can require consideration include:

- loss of equilibrium of the structure or any part of it considered as a rigid body;
- failure by excessive deformation, rupture, or loss of stability of the structure or any part of it, including supports and foundations.

Serviceability limit states correspond to states beyond which specified service requirements are no longer met. Serviceability limit states which can require consideration include:

- deformations or deflections which affect the appearance or effective use of the structure (including the malfunction of machines or services) or cause damage to finishes or non-structural elements;
- vibrations which cause discomfort to people, damage to the building or its contents, or which limit its functional effectiveness;
- cracking of the concrete which is likely to affect appearance, durability or water tightness adversely;
- damaging of concrete in the presence of excessive compression which is likely to lead to loss of durability.

7.3 Actions

The actions and effects of actions (e.g. internal forces, stresses) to be considered are the following:

- permanent:

actions due to gravity, soil pressure, deformations during construction;

- variable:

actions imposed on roofs, floors and walls; wind, snow, and ice; thermal actions; actions on parking floors;

- accidental:

impact, explosions, actions due to fire, earthquake.

The components shall be designed also for the actions during handling, transport and erection.

NOTE The actions are specified in EN 1990 and EN 1991 (all parts).

8 Marking, labelling and designation

8.1 Standard designation

Prefabricated reinforced components of AAC shall be identified by at least the following designations:

a) number of this European Standard (EN 12602:2016);

b) type of component (abbreviations, see Table 12);

c) declared compressive strength (expressed as characteristic value or as compressive strength class);

d) declared dry density of the AAC (expressed as mean value or as density class);

e) dimensions (length, thickness, width).

If required, depending on the product and its intended use, the following technical information shall be given:

f) loadbearing capacity;

g) reaction to fire;

h) resistance to fire;

i) thermal conductivity or thermal resistance;

j) sound insulation and sound absorption.

A code derived from a coding system by which one more requirements are made available on the basis of EN 12602 can be used. The explanation of the code system shall be supplied.

EXAMPLE 1 Load-bearing wall component [300 × 625 × 2 650] conforming to this European Standard of compressive strength class AAC 4, density class 450, reaction to fire according Euroclass A1, resistance to fire 120 min, thermal conductivity $\lambda_{10\mathrm{dry}}$ = 0,12 W/mK (p = 50 %)

EN 12602 — WL/AAC 4/450/A1/REI120 / $\lambda_{10\mathrm{dry}}$ 0,12/300 × 625 × 2 650

EXAMPLE 2 Roof or floor component [250 × 750 × 6 500] conforming to this European Standard with a declared com-pressive strength 4,8 MPa, density class 550, reaction to fire according Euroclass A1, resistance to fire 60 min, thermal conductivity $\lambda_{10\mathrm{dry}}$ = 0,14 W/mK (p = 50 %)

EN 12602 — RF/AAC 4,8/550/A1/REI 60/ $\lambda_{10\mathrm{dry}}$ 0,14/250 × 750 × 6 500

EXAMPLE 3 Load-bearing wall component [300 × 625 × 2650] conforming to this European Standard of compressive strength class AAC 4, density class 450, reaction to fire according Euroclass A1, resistance to fire 120 min, thermal conductivity λ10dry = 0,12 W/mK (p = 50 %)

EN 12602 — WL/AAC 4/450/Code

Code: A1/REI120 / $\lambda_{10\mathrm{dry}}$ 0,12/300 × 625 × 2 650

8.2 Production detail information

Production detail information should consist of:

a) Information on dimensions, reinforcing steel, lifting devices, inserts, etc.;

b) where required, the relevant material properties, the product tolerances and weights.

8.3 Additional information on accompanying documents

The manufacturer may give further information, which can be contained in product catalogues or on the accompanying commercial documents, on for instance the following items and properties:

a) background information on design (e.g. design method Annex A or Annex B);

b) bond;

c) thermal prestress;

d) mass of the component;

e) direct airborne sound reduction index;

f) environmental class;

g) shrinkage;

h) thermal expansion;

i) creep;

j) tolerances and squareness;

k) modulus of elasticity;

l) handling, storage, transportation;

m) erection specification for installation;

n) position of the component;

o) orientation of the component.

NOTE For labelling see ZA.3 of Annex ZA.

Annex A
(normative)

Design by calculation

NOTE 1 The design by calculation is based on the concept of EN 1992–1-1 as far as possible. Some modifications have been made in order to take into account the specific material properties/behaviour of AAC.

NOTE 2 Design values to be used can be determined according to the provision of this Annex A, using the relevant partial safety factors.

NOTE 3 Values of the properties can be determined on the basis of calculation and be given as declared values in the CE-marking, according to the relevant provision in Annex ZA. The declared values are based on one of the three methods expressed in Guidance Paper L, Clause 3.3.3.2 (a).

NOTE 4 For the choice of design method see 5.2.4.1.

A.1 General

(1)P Depending on the character of the individual clauses, distinction is made in this Annex A between Principles and Application Rules.

(2)P The Principles comprise:

- general statements and definitions for which there is no alternative, as well as
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3)P In this Annex A the Principles are marked by a number in brackets followed by the letter P.

(4)P The Application Rules are generally recognized rules which follow the Principles and satisfy their requirements.

(5)P In this Annex A Application Rules are those paragraphs marked by a number in brackets which is not followed by the letter P.

(6)P Design by calculation shall be based upon documented material parameters, using analytical methods that adequately describe the structural behaviour of the components.

(7) The A.3 to A.10 describe general calculation procedures that may be used for components subjected to bending, shear, or axial compression, whereas Clause 5 of the product standard gives specific rules applicable to the different types of components.

(8)P More detailed analyses may be carried out on the basis of the design assumptions given in A.3.1.

A.2 Ultimate limit states (ULS) General design assumptions

(1)P Depending on the specific nature of the structure, on the limit state being considered, and on the specific conditions of design or execution, analysis for the ultimate limit states may be linear elastic with or without redistribution, nonlinear or plastic.

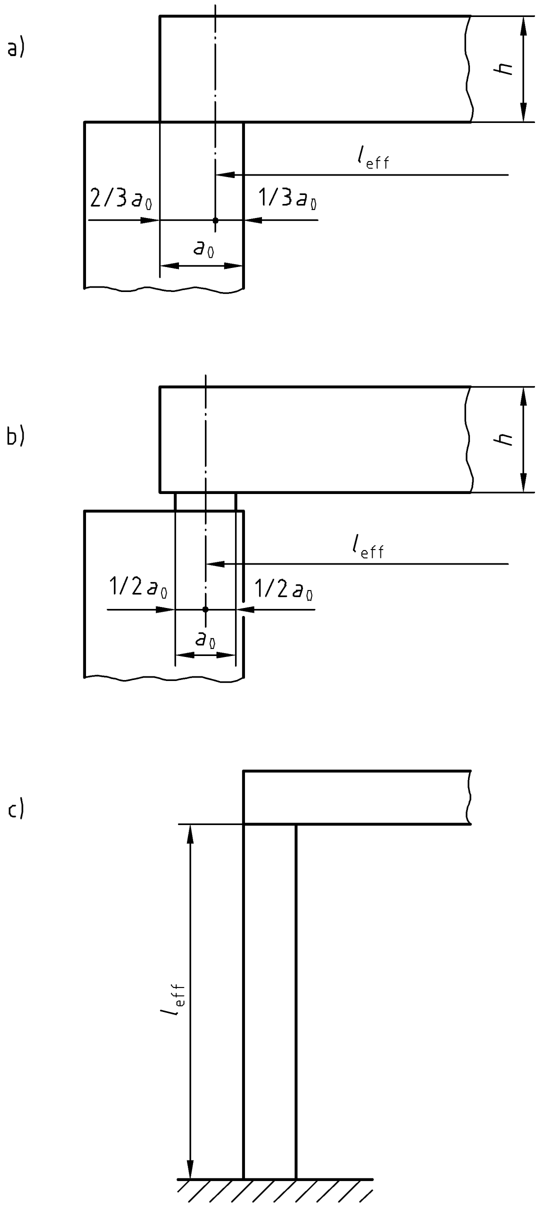
(2)P If reinforcement and AAC are acting together by bond and/or by transverse bars, the strain in reinforcement is the same as that in the surrounding AAC. For the required bond properties and number of transverse bars and their spacing, see A.10.2 and A.10.3.

(3)P The stresses in the AAC in compression are derived from an established design stress-strain relationship, see for example Figure A.2.

(4)P The stresses in the reinforcement are derived from an established design stress-strain relationship, see for example Figure A.3.

(5)P The deformations and second order effects shall be calculated on the basis of the mean values of the material properties (such as E_{cm} according to 4.2.7). For cross-sectional design, the design values of the properties shall be used.

(6) The effective span l_{eff} of the component shall be determined according to Figure A.1.



Key

a_0	support length
h	slab thickness
l_{eff}	effective span
a)	horizontal AAC component supported without bearing
b)	horizontal AAC component supported with bearing
c)	vertical AAC component

Figure A.1 — Determination of effective span l_{eff}

A.3 Ultimate limit states (ULS): design for bending and combined bending and axial compression

A.3.1 Design assumptions

(1)P In analysing a cross-section to determine its ultimate resistance, the design sizes are taken as the nominal sizes.

The assumptions given below shall be used:

a) Plane sections remain plane.

b) Tensile strength (including the flexural strength) of the AAC is ignored for the design of structurally reinforced AAC components. For non-structurally reinforced wall components with bending from non-permanent transverse load see A.5.

c) For cross-sections subject to pure longitudinal compression, the strain of the AAC is limited to |-0,002|.

d) For cross-sections not fully in compression, the strain in the compressed zone is limited to |-0,003|. In intermediate situations, the strain in the compressed zone is limited to |-0,002| at a level of 1/3 of the height of the section from the most compressed face.

e) The cross section shall have sufficient rotation capacity which is fulfilled if the tensile strain of the reinforcement is greater than 0,001, and thus achieving ductile failure.

f) Adoption of the above assumptions leads to the range of possible strain diagrams shown in Figure A.4.

g) Effect of longitudinal reinforcement present in the compression zone shall not be taken into account when calculating the axial loadbearing capacity, unless the reinforcing bars are sufficiently restrained to the principal reinforcement in the tension zone, e.g. by stirrups.

h) In the analysis of a cross-section which has to resist bending combined with a small longitudinal compression force, the effect of the design ultimate longitudinal force may be ignored if the corresponding longitudinal stress, due to the longitudinal load, does not exceed 0,08 f_{ck}.

i) Local reduction in the effective depth shall be considered in the cross-sectional analysis.

A.3.2 Stress-strain diagram for AAC

(1)P The design value of the compressive strength of AAC is defined by Formula (A.1):

$$f_{\text{cd}} = f_{\text{ck}} / \gamma_{\text{c}} \qquad \text{(A.1)}$$

where

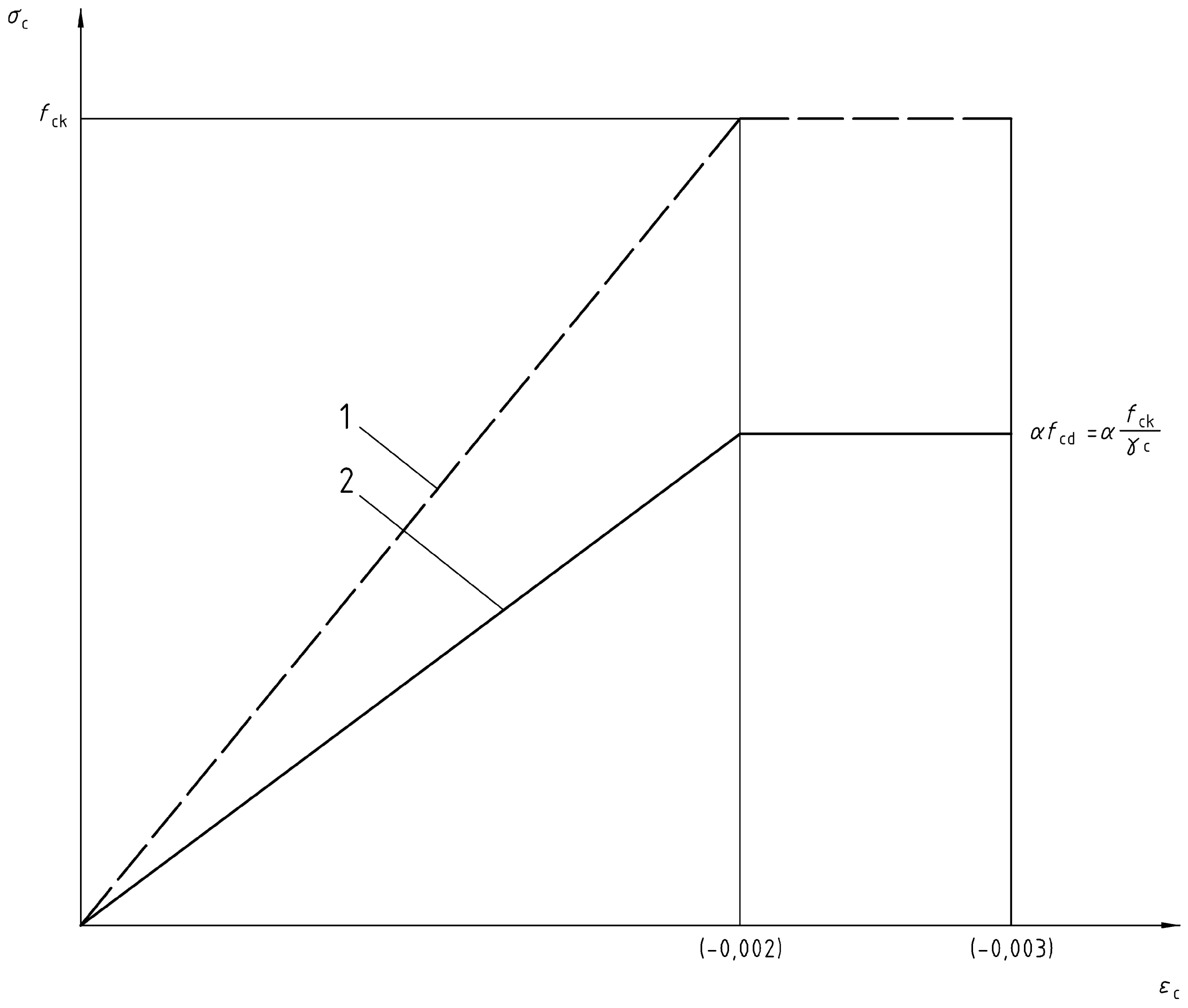
f_{cd} is the design value of the compressive strength of the AAC;

f_{ck} is the characteristic compressive strength of the AAC;

γ_{c} is the partial safety factor of AAC for ductile or brittle failure.

NOTE 1 The value of γ_{c} for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

(2) The stress-strain diagram for AAC for cross-sectional design is given in Figure A.2. Other established stress-strain diagrams may be also used if they are equivalent with respect to the amount and position of the resulting compression force in the cross section.



Key

1 Idealised diagram

2 Design diagram

Figure A.2 — Bi-linear stress-strain diagram for AAC in compression for cross-sectional design

(3) The factor α in Figure A.2 is a coefficient taking into account the long term effects on the compressive strength and of the unfavourable effects resulting from the way the load is applied.

NOTE 2 The value of α for use in a country may be found in its national application document. The recommended value of α for use is 0,85.

A.3.3 Stress-strain diagram for reinforcing steel

(1)P The design value of the yield stress of reinforcing steel is defined by Formula (A.2):

$$f_{yd} = f_{yk}/\gamma_S \tag{A.2}$$

where

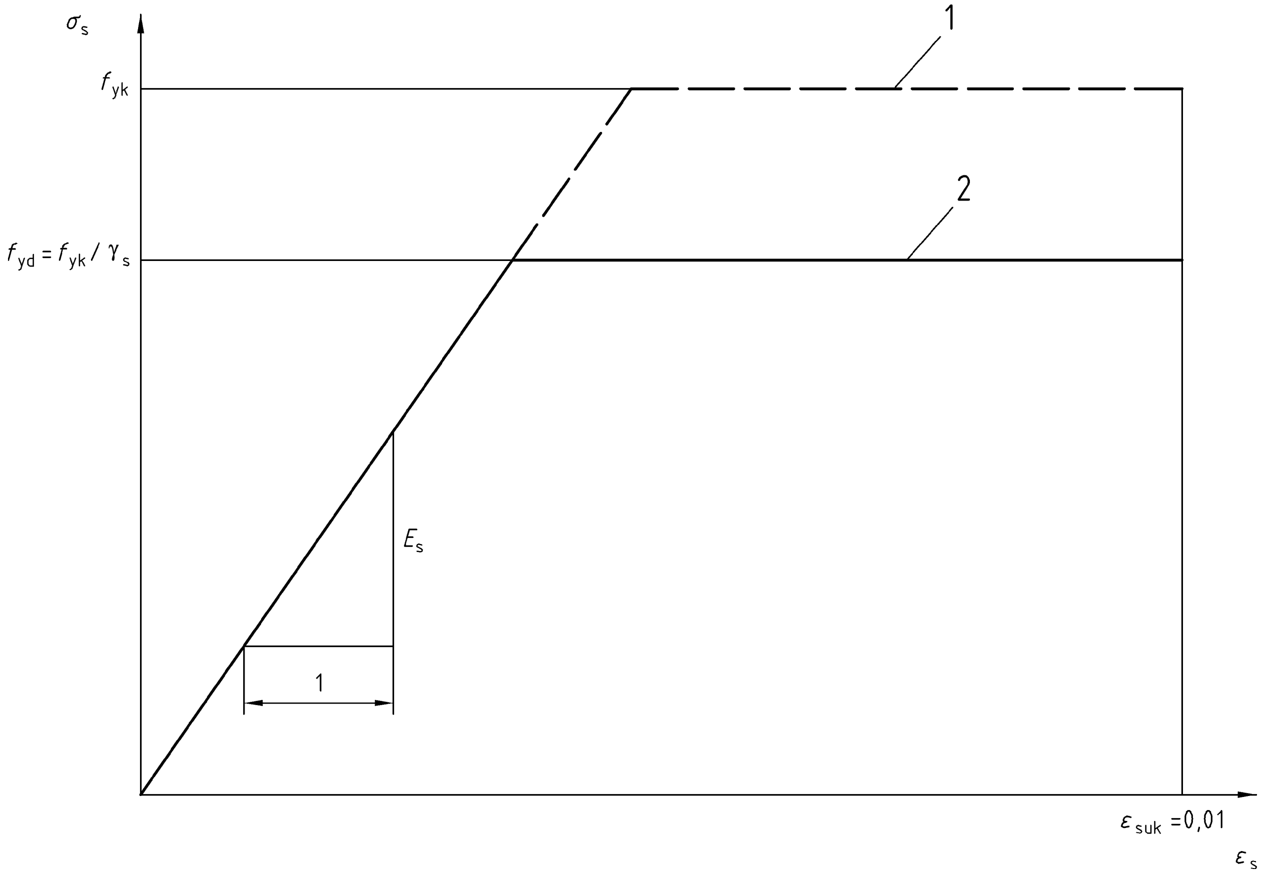
f_{yd} is the design value of the yield stress of reinforcing steel;

f_{yk} is the characteristic yield stress of reinforcing steel;

γ_S is the partial safety factor for reinforcing steel.

NOTE The value of γ_S for use in a country may be found in its national application document. The recommended value for use is given in Table D.4.

(2) The design stress-strain diagram for reinforcing steel is given in Figure A.3. Other established stress-strain diagrams may be used. E_S is the modulus of elasticity of reinforcing steel (e.g. 2×10^5 MPa).

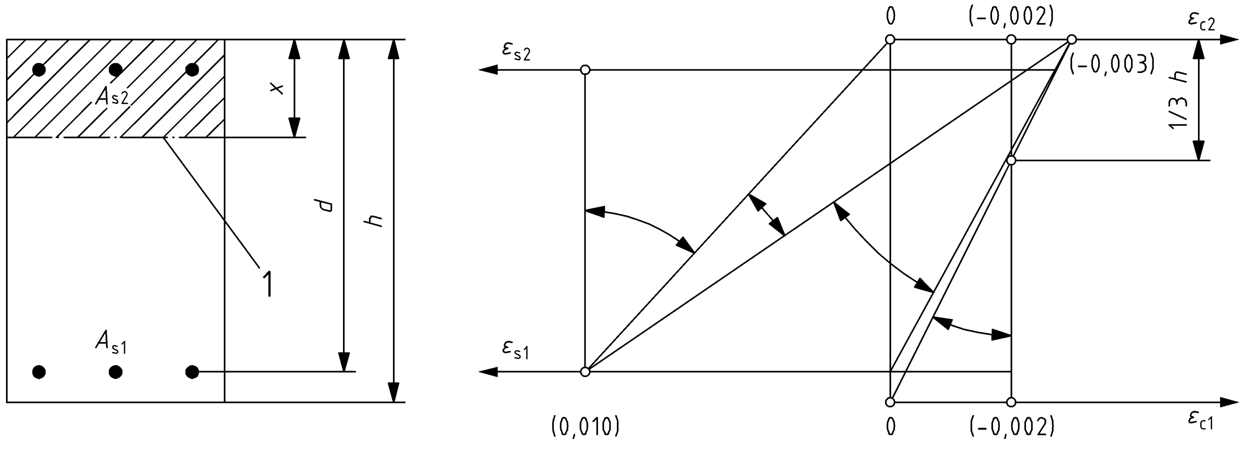


Key

1 Idealised diagram

2 Design diagram

Figure A.3 — Design stress-strain diagram for reinforcing steel



Key

1 Neutral axis

Figure A.4 — Strain diagrams in the ultimate limit state

A.3.4 Minimum reinforcement

(1)P For structural reinforced components the characteristic bending capacity of the cracked cross-section shall be greater than the characteristic cracking moment, in order to avoid brittle failure at the formation of the first crack. This shall be ensured by providing a minimum content of reinforcement to be determined by calculation. The tensile strength shall be taken as the flexural strength according to 4.2.5 in the uncracked cross-section, but shall be ignored in the calculation of the cracked cross-section.

(2) Unless a more rigorous calculation shows a lesser area to be adequate, the required minimum area of structural reinforcement may be calculated from Formula (A.3):

$$A_{\mathrm{smin}} = k\, A_{\mathrm{c}} f_{\mathrm{cflm}} / f_{\mathrm{yk}} \tag{A.3}$$

where

A_{smin} is the minimum reinforcement area;

A_{c} is the area of AAC within the tensile zone;

f_{cflm} is the mean flexural strength of AAC, determined by Formulae (5)a) and (5b) for bending. For pure tension determined by Formulae (4)a) and (4b);

f_{yk} is the tensile strength of the reinforcement;

k is a coefficient which takes into account the nature of the stress distribution.

In case of pure tension in the whole cross-section k = 1,0.

In case of pure bending without normal compressive force k = 0,4.

(3)P For AAC beams a minimum shear reinforcement is required. In wall, floor and roof components, and in components with minor structural importance the minimum shear reinforcement may be omitted.

(4) For beams the minimum cross-sectional area of shear reinforcement within length s may be calculated from Formula (A.4):

$$A_{\mathrm{swmin}} = \min \begin{cases} 1{,}1 \cdot \tau_{\mathrm{Rd}} \left(1 - 0{,}83 d / 1000\right)\left(1 + 240 \rho_1\right) b_{\mathrm{w}} \cdot \dfrac{s}{\sigma_{\mathrm{swd}} \cdot \left(1 + \cot \alpha_{\mathrm{s}}\right) \cdot \sin \alpha_{\mathrm{s}}} \\ 1{,}1 \cdot \dfrac{V_{\mathrm{Sd}} \cdot s}{d \cdot \sigma_{\mathrm{swd}} \cdot \left(1 + \cot \alpha_{\mathrm{s}}\right) \cdot \sin \alpha_{\mathrm{s}}} \end{cases} \tag{A.4}$$

where

A_{swmin} is the minimum cross-sectional area of shear reinforcement within length s, in millimetres;

τ_{Rd} is the design value of the basic shear strength, in Megapascals; see A.4.1.2.1;

f_{yk} is the characteristic yield strength of the shear reinforcement, in Megapascals;

d is the effective depth in millimetres;

ρ_1 is the reinforcement ratio;

s is the spacing of the shear reinforcement, in millimetres;

b_{w} is the minimum width of the section, in millimetres;

V_{Sd} is the design value of shear force, in Newtons;

σ_{swd} is the design value of the steel stress in the shear reinforcement, in Megapascals;

α_{s} is the angle of the shear reinforcement with the longitudinal axis, see Figure A.5.

A.4 Shear

A.4.1 Shear design for components predominantly under transverse load

A.4.1.1 General

(1)P This clause applies to the shear resistance of components with constant depth under transverse load and designed in accordance with A.3.

(2)P When determining the necessary longitudinal reinforcement in areas subjected to shear, account shall be taken of the possible increase of the tensile force beyond the value corresponding to the bending moment.

NOTE This increase is covered by the "shift rule" with an offset of a_l given in A.10.3 (see Figure A.16).

(3)P The method for shear design, set out in the subsequent clauses, is based on the following three values of design shear resistance:

— V_{Rd1} is the design shear resistance of the section without shear reinforcement;

— V_{Rd2} is the maximum design shear force that can be carried without crushing of the notional AAC compressive struts. The presence of an axial force has to be considered when determining the compressive force in the struts;

— V_{Rd3} is the design shear force that can be carried by a section with shear reinforcement.

(4)P Any section for which the design shear force, V_{Sd}, is less than V_{Rd1} does not require shear reinforcement. A design method is given in A.4.1.2. This does not apply for AAC beams.

(5)P For sections where V_{Sd} exceeds V_{Rd1}, a design shear reinforcement shall be provided such that: $V_{Sd} \leq V_{Rd3}$. A design method is given in A.4.1.3.

(6)P The design shear force in components shall not exceed V_{Rd2} in any section, see A.4.1.3.3.

(7)P The attainment of V_{Rd1} and V_{Rd3} depends significantly on the proper anchorage of the tension reinforcement in each of any possible plane of failure. Rules are provided to ensure this in A.10.

(8) Close to supports where the configuration of the loading and support reaction is such that a proportion of the load is carried to the support by direct compression (direct support), allowance may be made for the reduced shear force which the section effectively has to support. Any such reduction shall be ignored when checking V_{Rd2}.

(9) The reduction of the contribution of the design shear force V_{Sd} for loads situated at a distance $x < 2{,}5d$ from the front edge of the support may be taken into account by multiplying these loads with a factor β calculated from Formula (A.5):

$$\beta = 0{,}3 + 0{,}28\, x/d \leq 1 \tag{A.5}$$

where

x is the distance of the load to the front edge of the support;

d is the effective depth of the component.

If the shear force is reduced using Formula (A.5) the total required tension reinforcement shall be anchored at the support.

(10) Because of the reduction of the shear force due to direct transmission of loads close to supports it will normally be conservative to evaluate V_{Sd} at a distance d from the face of a direct support for components with continuously distributed loading.

A.4.1.2 Components not requiring design shear reinforcement

(1) The design shear resistance V_{Rd1} for transversally loaded components is given by the following empirical Formula (A.6):

$$V_{\mathrm{Rd1}} = \max \begin{cases} \tau_{\mathrm{Rd}} \left(1 - 0{,}83 d / 1000\right)\left(1 + 240 \rho_1\right) b_{\mathrm{w}} d \\ 0{,}5 \dfrac{f_{\mathrm{ctk;0,05}}}{\gamma_{\mathrm{C}}} b_{\mathrm{w}} d \end{cases} \tag{A.6}$$

where

V_{Rd1} is the design shear resistance, in Newtons;

τ_{Rd} is the basic shear strength = 0,063 $f_{\mathrm{ck}}^{0,5} / \gamma_{\mathrm{C}}$, in Megapascals;

$f_{\mathrm{ctk;0,05}}$ is the characteristic value of the 5 %-quantile of axial tensile strength, in MPa, see Formula (4)a);

γ_{C} is the partial safety factor of AAC for brittle failure;

d is the effective depth of the section, in millimetres ($d \leq 400$ mm);

ρ_1 is the reinforcement ratio, defined as:

$\rho_1 = A_{\mathrm{sl}} / b_{\mathrm{w}} d \leq 0{,}005$

and where

A_{sl} is the cross-sectional area of tension reinforcement, in square millimetres;

b_{w} is the minimum width of the section over the effective depth, in millimetres.

NOTE The value of γ_{C} for use in a country may be found in its national application document. The recommended value for use are given in Table D.4.

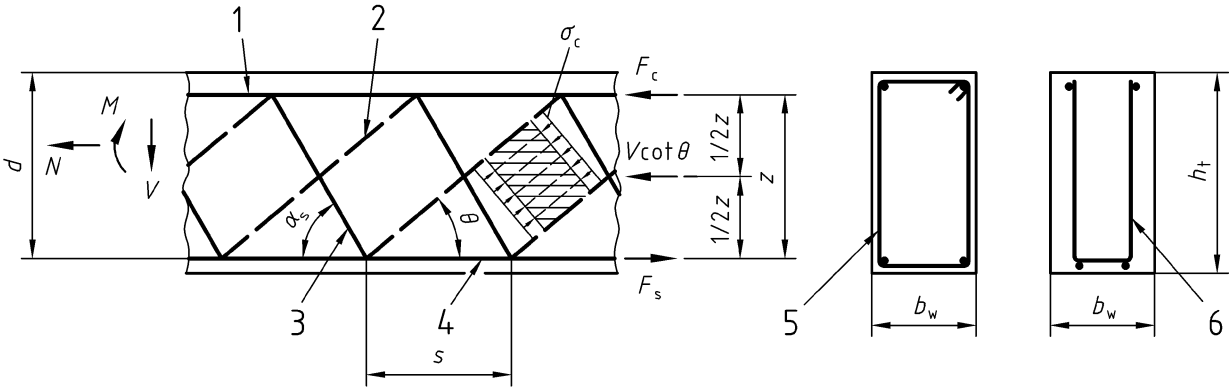
A.4.1.3 Components requiring design shear reinforcement

A.4.1.3.1 Shear resistance

(1)P The following equations for inclined shear reinforcement are only valid for stirrups which are welded with the upper and lower longitudinal reinforcement.

(2)P Where the load is not acting at the top of the component, or when the support is not at the bottom of the component, suspension reinforcement shall be provided to transfer the load to the top of the component.

(3)P For shear design, the structure is assumed to consist of a compressive zone and a tensile zone separated by a distance equal to the internal lever arm z. The shear zone has a depth equal to z and a width b_{w}. The internal lever arm is calculated perpendicular to the longitudinal reinforcement. The notation used is given in Figure A.5.



Key

1 compression zone

2 struts

3 shear reinforcement

4 tensile zone

5 example of a closed stirrup

6 example of an open stirrup

Figure A.5 — Notation for components subjected to shear

The parameters given in Figure A.5 are:

α_S is the angle of the shear reinforcement with the longitudinal axis;

θ is the angle of the AAC struts with the longitudinal axis, assumed to be 45°;

σ_C is the AAC stress in the struts;

F_S is the tensile force in the longitudinal reinforcement;

F_C is the compression force in the AAC in the direction of the longitudinal axis;

b_W is the minimum width of the section;

z denotes, for a component with constant depth, the internal lever arm corresponding to the maximum bending moment in the component under consideration. In shear analysis, an approximate value $z = 0{,}9\,d$ may normally be used for components with a slenderness $l/\,h_t > 5$, where

d is the effective depth;

l is the span length;

h_t is the overall depth of the cross section.

(4)P The detailing rules given in 5.2.7.2.2 c) apply to the provision of shear reinforcement.

(5) The shear resistance of a section with shear reinforcement is given by the Formula (A.7):

$$V_{Rd3} = V_{cd} + V_{wd} \tag{A.7}$$

where

V_{cd} is the contribution of the AAC and is equal to V_{Rd1} (see A.4.1.2);

V_{wd} is the contribution of the shear reinforcement.

(6) The contribution of vertical shear reinforcement is given by Formula (A.8):

$$V_{\mathrm{wd}} = \frac{A_{\mathrm{sw}}}{s} z \sigma_{\mathrm{swd}} \tag{A.8}$$

where

A_{sw} is the area of the vertical shear reinforcement in the considered cross-section;

s is the spacing of the shear reinforcement;

σ_{swd} is the design tensile stress in the shear reinforcement, see A.4.1.3.2.

(7) The contribution of inclined shear reinforcement is given by the Formula (A.9):

$$V_{\mathrm{wd}} = \frac{A_{\mathrm{sw}}}{s} z \sigma_{\mathrm{swd}} \left(1 + \cot \alpha_{\mathrm{s}}\right) \sin \alpha \leq \frac{d}{\sin \alpha_{\mathrm{s}}} \sqrt{\frac{v f_{\mathrm{ck}}}{\gamma_{\mathrm{C}}} \cdot \frac{b_{\mathrm{w}} \cdot \sigma_{\mathrm{swd}} \cdot A_{\mathrm{s}}}{2s}} \tag{A.9}$$

where

A_{sw} is the area of the inclined shear reinforcement in the considered cross-section;

s is the spacing of the shear reinforcement measured along the longitudinal axis (see Figure A.5);

σ_{swd} is the design tensile stress in the shear reinforcement, see A.4.1.3.2;

d is the effective depth;

b_{w} is the minimum width of the section;

f_{ck} is the characteristic compressive strength of AAC;

γ_{C} is the partial safety factor of AAC for brittle failure;

v is the effectiveness factor, taking into account the reduction of compressive strength f_{ck} in the web of the component. For AAC v = 0,56.

NOTE The value of γ_{C} for use in a country may be found in its national application document. The recommended value for use are given in Table D.4.

A.4.1.3.2 Design steel stress in the shear reinforcement

(1) The design tensile stress in the shear reinforcement, can be determined from either of the following Formulae (A.10) or (A.11):

$$\sigma_{\mathrm{swd}} = \begin{cases} \dfrac{250}{\gamma_{\mathrm{S}}}\left(1 - 0{,}02\dfrac{l}{d}\right) \cdot \left(1{,}2 - 60\dfrac{A_{\mathrm{sw}}}{s \cdot b_{\mathrm{w}}}\right) \leq \dfrac{f_{\mathrm{ywk}}}{\gamma_{\mathrm{S}}} \leq 300\,\mathrm{MPa}, \text{for closed stirrups} \\ \dfrac{150}{\gamma_{\mathrm{S}}}\left(1 - 0{,}02\dfrac{l}{d}\right) \cdot \left(1{,}2 - 60\dfrac{A_{\mathrm{sw}}}{s \cdot b_{\mathrm{w}}}\right) \leq \dfrac{f_{\mathrm{ywk}}}{\gamma_{\mathrm{S}}} \leq 300\,\mathrm{MPa}, \text{for open stirrups} \end{cases} \tag{A.10}$$

$$\sigma_{\mathrm{swd}} = 0{,}45 K_1 K_2 f_{\mathrm{co}} \frac{\left(\phi_{\mathrm{sl}}\right)^2 + \left(K_3 \phi_{\mathrm{sw}}\right)^2}{\left(\phi_{\mathrm{sw}}\right)^2} \leq \frac{f_{\mathrm{ywk}}}{\gamma_{\mathrm{S}}} \leq 200\,\mathrm{MPa} \tag{A.11}$$

Formula (A.11) is only valid for vertical stirrups, open or closed.

NOTE 1 Formula (A.10) gives better predictions for slender beams than Formula (A.11).

where

l is the span length;

d is the effective depth;

f_{ywk} is the characteristic yield strength of the stirrups;

γ_{S} is the partial safety factor for steel;

f_{co} is the contact stress, $f_{\mathrm{co}} = 2{,}4 f_{\mathrm{cd}}$ for welded shear reinforcement and $f_{\mathrm{co}} = f_{\mathrm{cd}}$ for non-welded shear reinforcement;

f_{cd} is the design compressive strength of AAC, $f_{\mathrm{cd}} = f_{\mathrm{ck}}/\gamma_{\mathrm{C}}$;

f_{ck} is the characteristic compressive strength of the AAC;

γ_{C} is the partial safety factor of AAC for brittle failure;

ϕ_{sl} is the diameter of the top or bottom longitudinal bars, whichever is the smallest;

ϕ_{sw} is the diameter of the stirrups;

$K_3 = 1$ in case of closed stirrups and $K_3 = 0$ in case of open stirrups;

K_1 is the reduction factor for reduced AAC cover:

$K_1 = 1$ for closed stirrups and $K_1 = 0{,}33\ e/\phi_{\mathrm{sl}} \leq 1$ for open stirrups;

K_2 is the spacing factor of stirrups: $K_2 = s/\phi_{\mathrm{sl}} \leq 14$;

e is the distance of the centroid of the longitudinal bars at the open ends of stirrups from the adjacent side face of the AAC component;

s is the spacing of the stirrups.

NOTE 2 The values of γ_{C} and γ_{S} for use in a country may be found in its national application document. The recommended value for use are given in Table D.4.

A.4.1.3.3 Design shear Resistance V_{Rd2}

(1) When checking against crushing of the AAC compression struts, V_{Rd2} is given by the Formula (A.12):

$$V_{\mathrm{Rd2}} = b_{\mathrm{w}} z \nu f_{\mathrm{cd}} \left(\frac{\cot\theta + \cot\alpha_{\mathrm{s}}}{1 + \cot^2\theta} \right) \tag{A.12}$$

where

ν is the effectiveness factor, taking into account the reduction of compressive strength f_{ck} in the web of the component. For AAC $\nu = 0{,}56$;

f_{cd} is the design compressive strength of AAC, $f_{\mathrm{cd}} = f_{\mathrm{ck}}/\gamma_{\mathrm{C}}$;

f_{ck} is the characteristic compressive strength of the AAC;

γ_{C} is the partial safety factor of AAC for brittle failure;

α_{S} is the angle of inclined shear reinforcement to longitudinal axis;

b_{w} is the minimum width of the section;

θ see Figure A.5;

z see Figure A.5.

NOTE The value of γ_{C} for use in a country may be found in its national application document. The recommended value for use is given in Table D.4.

A.5 Ultimate limit states induced by structural deformation (buckling)

A.5.1 General

(1)P When determining the loadbearing capacity of slender AAC components subjected to compression or combined bending and compression, account shall be taken of the effects of structural deformation and eccentricities occurring perpendicular to the plane of the components and their influence on the buckling of the components.

(2) Two methods given in A.5.2 and A.5.3 are presented. They are both suitable for designing vertical loadbearing AAC components which can be classified as slender isolated columns and are mainly loaded by a centric or eccentric longitudinal load and possibly also by a transverse load (e.g. horizontal wind load, earth pressure). The slenderness of the components shall not exceed the value λ according to Formula (A.13).

$$\lambda = l_0 / i_c \leq 120 \tag{A.13}$$

where

l_0 is the effective length of the component;

i_c is the radius of gyration in the direction of the weak axis, for rectangular cross-section $i_c = 0{,}289\ h_t$ where h_t is the overall depth of the cross-section.

(3) The mean short-term modulus of elasticity E_{cm} may be used in design when calculating deformations (creep may be ignored) if the slenderness of the component (see Formula (A.13)) is less than 100.

NOTE Since the principle of superposition is not applicable for the combined effect of longitudinal load and transverse load, it is necessary to study the following load cases to find out the most critical effect:

a) the greatest value for N_d and the corresponding smallest value for M_{1d};

b) the greatest value for N_d and the corresponding greatest value for M_{1d};

c) the greatest value for M_{1d} and the corresponding smallest value for N_d;

d) the greatest value for M_{1d} and the corresponding greatest value for N_d.

where

M_{1d} is the design value for the bending moment due to transverse load (see A.5.3.2);

N_d is the design value for the longitudinal compression force.

The loading cases b) and d) do not necessarily cause the same effect because of the combination rules for actions.

A.5.2 Method based on Euler formula

(1) The design loadbearing capacity N_{Rd} can be determined according to Formula (A.14) as the loadbearing capacity of that part of the cross-section which can be regarded as centrally loaded.

$$N_{Rd} = k_s\, \alpha\, f_{cd}\, A_c \tag{A.14}$$

where

k_s is the column factor determined according to Formula (A.15);

$$k_s = \frac{1}{\left[1+\left(\frac{f_{ck}}{E_{cm}\pi^2}\right)\cdot\left(\frac{l_0}{i_c}\right)^2\right]} \qquad (A.15)$$

where

E_{cm} is the mean modulus of elasticity of AAC;

l_0 is the effective length of the component;

i_c is the radius of gyration of the compression zone, $i_c = \sqrt{(I_c / A_c)}$ where I_c is the second moment of area (moment of gyration) of the compression zone of the cross-section, for rectangular cross-sections according to Formula (A.16).

$$i_c = \sqrt{(h_t - 2e_t)^2 / 12} \qquad (A.16)$$

f_{cd} is the design compressive strength of AAC, $f_{cd} = f_{ck}/\gamma_C$;

f_{ck} is the characteristic compressive strength of the AAC;

γ_C is the partial safety factor of AAC for brittle failure;

α is the coefficient taking account of long term effects on the compressive strength of AAC (see A.3.2);

A_c is the area of the compression zone of the cross-section, for rectangular cross-sections according to Formula (A.17).

$$A_c = b_w (h_t - 2e_t) \qquad (A.17)$$

where

b_w is the minimum width of the cross-section;

h_t is the overall depth of the cross-section;

e_t is the first order eccentricity perpendicular to the direction of the weak axis:

$e_t = e_o + e_a + e_m$;

e_o is the eccentricity of the longitudinal force at the top of the component;

e_a is the assumed additional eccentricity due to imperfections: $e_a = \sqrt{l_0 / 40}$, in millimetres, where l_0 is the effective length, in millimetres;

e_m is the first order eccentricity caused by bending due to horizontal load,

$e_m = M_{1d}/N_d$

where M_{1d} is the design value for the bending moment due to horizontal load and N_d is the design value for the axial force.

NOTE The value of γ_C for use in a country may be found in its national application document. The recommended value of γ_C for use is given in Table D.4.

A.5.3 Modified model column method

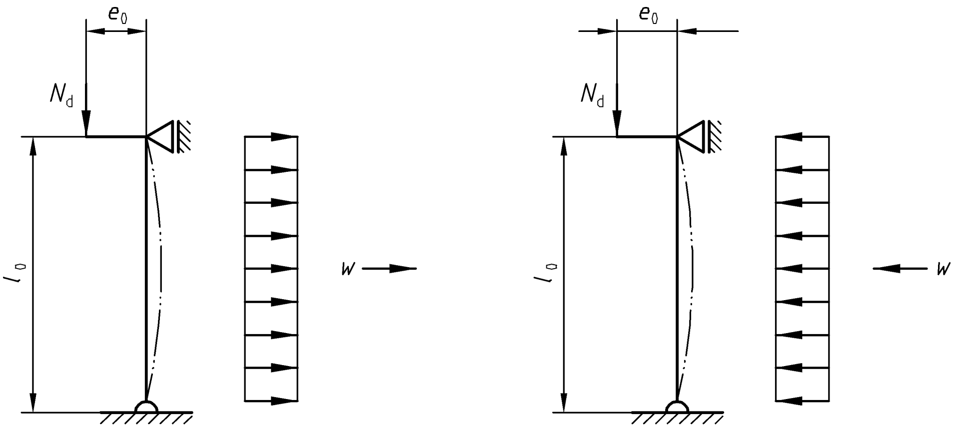
A.5.3.1 General

(1) It is assumed that both ends of the component are articulately supported as presented in Figure A.6. Thus the effective length of the component l_0 is equal to its free length. It is also assumed that the eccentricity of the longitudinal compression force at the bottom of the component is zero.

(2) Since the horizontal force can act in two opposite directions (for example wind pressure and wind suction) two different load cases shall be distinguished: load case 1 and load case 2, see Figure A.6.

(3) Different equations are given for components with structural reinforcement and components with non-structural reinforcement, i.e. reinforcement is not taken into account in the design method.

(4) The cross-section of an non-structurally reinforced component is assumed to be tension resistant only for wind loads and similar short-term loads. Thus a non-structurally reinforced cross-section shall be designed for two design situations: At first the cross-section is calculated as non-tension resistant, not taking short-term loads into account when determining design loads. Secondly, the cross-section is calculated as tension resistant, i.e. uncracked, taking all loads into account.



a)   b)

Key

a) Load case 1

b) Load case 2

Figure A.6 —Structural model and possible load cases for the modified model column method

A.5.3.2 Effect of slenderness

A.5.3.2.1 Total eccentricity

(1) The total eccentricity attributed to components with constant cross-section in the most heavily stressed section is given by the Formulae (A.18), (A.19a), and (A.19b).

Load case 1:

$$e_{tot} = e_a + e_2 + e_m + 0{,}6\ e_o \tag{A.18}$$

Load case 2 (the greater of the following values shall be taken):

$$e_{tot} = e_a + e_2 + e_m - 0{,}4\ e_o \tag{A.19a}$$

$$e_{tot} = e_a + e_2 - e_m + 0{,}6\ e_o \tag{A.19b}$$

where

e_o is the eccentricity of the longitudinal compression force at the top of the component;

e_a is the assumed additional eccentricity due to imperfections: $e_a = \sqrt{l_0 / 40}$, in millimetres, where l_0 is the effective length, in millimetres;

e_m is the first order eccentricity caused by bending due to the horizontal load;

$e_m = M_{1d}/N_d$ where M_{1d} is the design value for the bending moment due to the horizontal load and N_d is the design value of the longitudinal compression force;

e_2 is the second order eccentricity as defined in A.5.3.2.2 or A.5.3.2.3.

A.5.3.2.2 Second order eccentricity

(1) The maximum deflection which equals the second order eccentricity of a component may be assumed to be:

$$e_2 = \left(l_0^2 / 10\right) \cdot \left(1 / r\right) \tag{A.20}$$

where

l_0 is the effective length;

$1/r$ is the curvature of the component.

(2) The curvature of the component is derived from the strains as presented in Figure A.7.

(3) The following Formulae (A.21) to (A.24) are derived for e_2.

Structurally reinforced cross-sections:

$$e_2 = \left(l_0^2 / 10\right) \cdot \left(-\varepsilon_c + \varepsilon_{syfl}\right) / d \tag{A.21}$$

Non-structurally reinforced non-tension resistant cross-sections:

— When the cross-section is fully in compression:

$$e_2 = \left(l_0^2 / 10\right) \cdot \left(-\varepsilon_c + \varepsilon_{cfl}\right) / h_t \tag{A.22}$$

— When the cross-section is partly cracked:

$$e_2 = \left(l_0^2 / 10\right) \cdot \left(-\varepsilon_{c0} / x\right) \tag{A.23}$$

Non-structurally reinforced tension resistant cross-sections:

$$e_2 = \left(l_0^2 / 10\right) \cdot \left(-\varepsilon_c + \varepsilon_{cfl}\right) / h_t \tag{A.24}$$

where

l_0 is the effective length of the component;

d is the effective depth of a reinforced cross-section;

x is the depth of the part of the cross-section in compression;

h_t is the overall depth of the cross-section;

ε_c is the compressive extreme fibre strain of AAC (derived from the equilibrium of the internal forces and external forces);

ε_{syfl} is the tensile or compressive strain of the reinforcing steel at the opposite side of ε_c (derived from the equilibrium of the internal forces and external forces; tension positive, compression negative);

ε_{c0} is the compressive strain of AAC which gives the equilibrium of the internal and external forces; it is a negative value between 0 and the elastic limit compressive strain, see A.5.3.2.3;

ε_{cfl} is the flexural (tensile or compressive) strain of AAC at the opposite side of ε_c (derived from the equilibrium of the internal forces and external forces; tension positive, compression negative).

(4) When strain values are calculated from stresses, usually the short-term modulus of elasticity E_{cm} presented in 4.2.7 can be used.

In practise the use of these equations leads to an iterative process where the strain distribution of the cross-section shall be estimated before the curvature can be derived from the equilibrium of internal forces and external forces.

A.5.3.2.3 Approximate second order eccentricity

(1) It is possible to calculate an approximate maximum value of the second order eccentricity, e_2, for a rectangular cross-section without iteration. This value is always on the safe side.

Structurally reinforced cross-sections:

$$e_2 = 2\left(l_0^2 / 10\right) \cdot \varepsilon_{yd} / 0{,}9d \qquad \text{(A.25)}$$

Non-structurally reinforced tension resistant cross-sections:

$$e_2 = \left(l_0^2 / 10\right) \cdot \left(-\varepsilon_{c1} + \varepsilon_{cflu}\right) / h_t \qquad \text{(A.26)}$$

where

l_0 is the effective length of the component;

d is the effective depth of a reinforced cross-section;

h_t is the overall depth of the cross-section;

ε_{yd} is the design yield strain of reinforcing steel;

$\varepsilon_{yd} = f_{yd}/E_s$ where f_{yd} is the design yield strength of the reinforcing steel and E_s is its modulus of elasticity;

ε_{c1} is the elastic limit compressive strain (= – 0,002) of AAC;

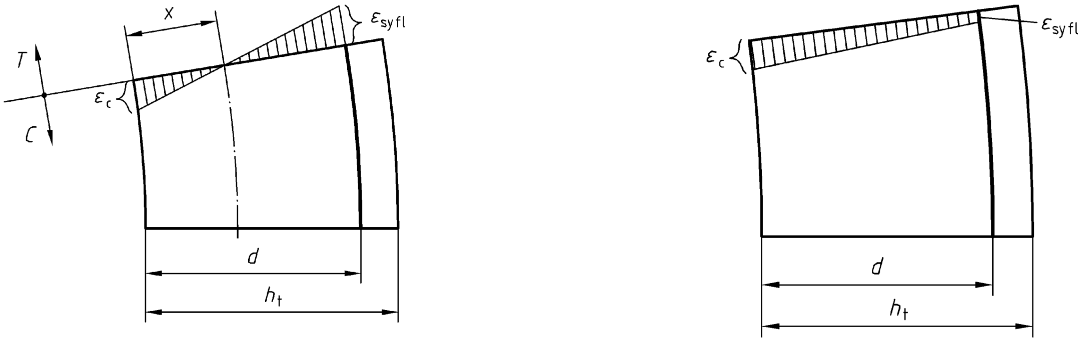
ε_{cflu} is the ultimate flexural strain of AAC in the tensioned zone,

$\varepsilon_{cflu} = f_{cflk}/E_{cm}$ where f_{cflk} is the characteristic flexural strength of AAC (see A.5.3.3.3 (4)) and E_{cm} is its mean modulus of elasticity (see A.5.1 (3)).

NOTE For a non-structurally reinforced non-tension resistant cross-section there is no maximum value for e_2.

Structurally reinforced cross-sections

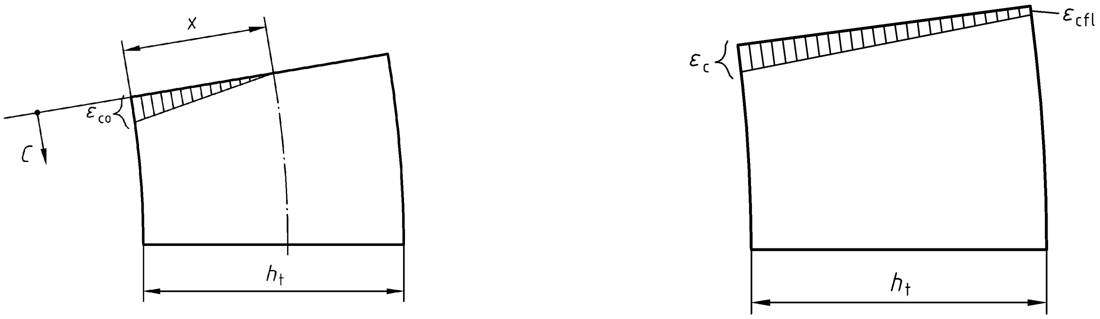
great curvature **small curvature**



a) **b)**

Non-structurally reinforced tension resistant cross-sections:

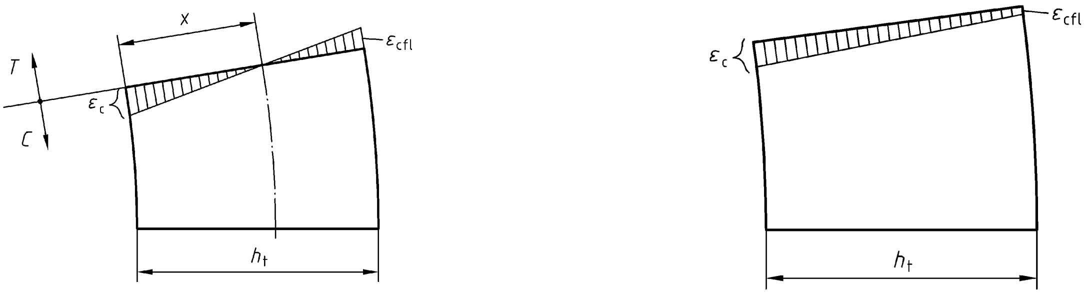
great curvature **small curvature**



c) **d)**

Non-structurally reinforced non-tension resistant cross-sections:

great curvature **small curvature**



e) **f)**

Key

T Tension

C Compression

Figure A.7 — Relation between curvature and strain Two curvatures (great curvature and small curvature) are presented

A.5.3.3 Design of critical cross-section for compression and bending

A.5.3.3.1 General

(1) The effect of slenderness and transverse loading is taken into account by using e_{tot} (see A.5.3.2) as the eccentricity of the design longitudinal compression force. The critical cross-section is designed for the longitudinal compression force N_{d} and the bending moment M_{d} where $M_{\mathrm{d}} = N_{\mathrm{d}}\, e_{\mathrm{tot}}$

where

M_{d} is the design value for the bending moment due to transverse load;

N_{d} is the design value for the longitudinal compression force.

NOTE In the equations given below absolute values are used for strength values, stresses, M_{d} and N_{d}.

A.5.3.3.2 Structurally reinforced cross-section

(1) Calculations shall be based on design assumptions and diagrams presented in A.3. The reinforcement present in the compression zone shall not be taken into account.

A.5.3.3.3 Non-structurally reinforced cross-section

(1) Linear elastic stress distribution of AAC and a rectangular cross-section is assumed. The following requirements shall be fulfilled:

(2) Non-structurally reinforced non-tension resistant cross-sections:

The design compressive edge stress σ_{cd} shall fulfil the following requirement:

$$\sigma_{\mathrm{cd}} = N_{\mathrm{d}} / \left(b_{\mathrm{w}} x\right) + 3\left[2M_{\mathrm{d}} - N_{\mathrm{d}}\left(h_{\mathrm{t}} - x\right)\right] / \left(b_{\mathrm{w}} x^{2}\right) \leq \alpha\, \sigma_{\mathrm{co}} / \gamma_{\mathrm{C}} \tag{A.27}$$

NOTE 1 When N_{d} is small, then the equilibrium between internal forces is reached with a compressive stress $\alpha\, \sigma_{\mathrm{co}}/\gamma_{\mathrm{C}}$ which is a value between 0 and αf_{cd} corresponding to $\varepsilon_{\mathrm{co}}$, see A.5.3.2.2.

(3) Non-structurally reinforced tension resistant cross-sections:

The design edge stresses shall fulfil the following requirements on the compressive side (σ_{cd}) and on the tensile side (σ_{td}):

$$\sigma_{\mathrm{cd}} = N_{\mathrm{d}} / \left(b_{\mathrm{w}} h_{\mathrm{t}}\right) + \left(6M_{\mathrm{d}}\right) / \left(b_{\mathrm{w}} h_{t}^{2}\right) \leq \alpha\, f_{\mathrm{ck}} / \gamma_{\mathrm{C}} \tag{A.28}$$

$$\sigma_{\mathrm{td}} = N_{\mathrm{d}} / \left(b_{\mathrm{w}} h_{\mathrm{t}}\right) + \left(6M_{\mathrm{d}}\right) / \left(b_{\mathrm{w}} h_{t}^{2}\right) \leq f_{\mathrm{cflk}} / \gamma_{\mathrm{C}} \tag{A.29}$$

where

N_{d} is the design longitudinal compression force;

M_{d} is the design bending moment, where $M_{\mathrm{d}} = N_{\mathrm{d}}\, e_{\mathrm{tot}}$;

b_{w} is the minimum width of the cross-section;

h_{t} is the overall depth of the cross-section;

x is the smaller of the values: $x = h_{\mathrm{t}}$ and $x = 3\,(h_{\mathrm{t}}/2 - e_{\mathrm{tot}})$, where e_{tot} is the total eccentricity, see A.5.3.2;

α is a coefficient taking account of long term effects on the compressive strength (see A.3.2);

σ_{co} is the compressive stress of AAC (between 0 and αf_{cd}) which corresponds to $\varepsilon_{\mathrm{co}}$, see A.5.3.2.2;

f_{cd} is the design compressive strength of AAC; $f_{\mathrm{cd}} = f_{\mathrm{ck}}/\gamma_{\mathrm{C}}$;

f_{ck} is the characteristic compressive strength of AAC;

γ_{C} is the partial safety factor of AAC for brittle failure;

f_{cflk} is the characteristic flexural strength of AAC.

NOTE 2 The value of γ_{C} for use in a country may be found in its national application document. The recommended value of γ_{C} for use is given in Table D.4.

(4) Characteristic flexural strength of AAC f_{cflk} derived from tests according to EN 1351 shall be reduced with a factor of 0,8, when used in Formula (A.29).

A.6 Punching

A.6.1 General

(1)P The principles and rules given in this clause complement those given in A.4. They are concerned with punching shear in slabs containing flexural reinforcement determined according to A.3. Punching shear is a problem typical of two-way bending slabs. It can result from a concentrated load or reaction acting on a relatively small area, called “the loaded area”, of a slab.

(2)P The shear resistance shall be checked within a critical area. Outside the critical area the slab has to satisfy the requirements of A.4.

A.6.2 Scope and definitions

A.6.2.1 Loaded area

(1) The provisions of this section are applicable to the following shapes of loaded area where *h* denotes the thickness of the AAC cross-section under the punching load:

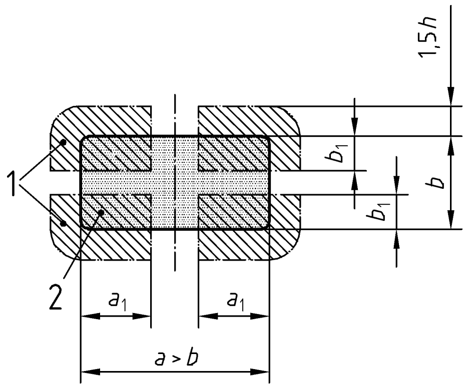
— circular, with diameter not exceeding 3,5 *h*;

— rectangular, with perimeter not exceeding 11 *h* and the ratio of length to width not exceeding 2 and not less than 0,5;

— any shape, the limiting dimensions being fixed by analogy with the shapes mentioned above.

(2) It is assumed that the loaded area is not so close to other concentrated forces that their critical perimeters intersect, i.e. not in a zone subjected to significant forces of a different origin.

(3) If the conditions in (1) are not satisfied for a rectangular loaded area since the shear force is concentrated near the unsupported edge, the critical perimeters according to Figure A.8 should be taken into account only in the absence of a more detailed analysis.



Key

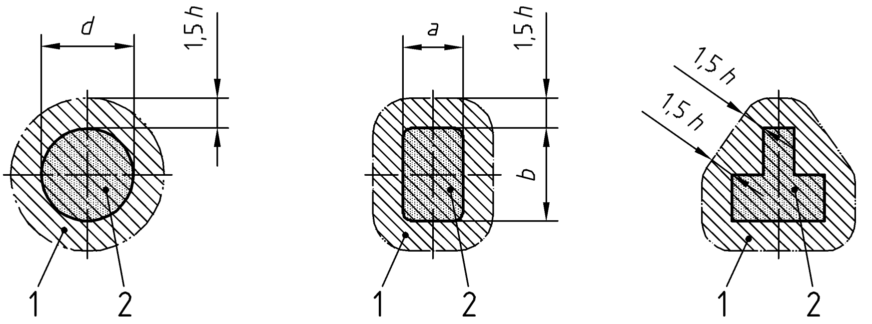
1	critical area
2	loaded areas

$$a_1 \leq \begin{cases} a/2 \\ b \\ 2{,}8h - b_1 \end{cases} \qquad b_1 \leq \begin{cases} b/2 \\ 1{,}4h \end{cases}$$

Figure A.8 — Application of punching provisions in non-standard cases

A.6.2.2 Critical perimeter

(1) The critical perimeter for circular or rectangular loaded areas located away from unsupported edges is defined as a perimeter surrounding the loaded area and at a defined distance from it (assumed to be 1,5 *h*), see Figure A.9.



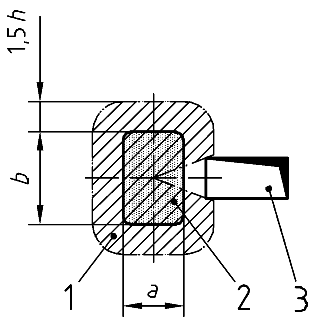
Key

1	critical area
2	loaded areas $d < 35\,h$ $2\,(a + b) < 11\,h$ $b < 2\,a$

Figure A.9 — Critical perimeter around loaded areas located away from an unsupported edge

(2) For loaded areas situated near openings the following applies: the part of the critical perimeter contained between two tangents drawn to the outline of the opening from the centre of the loaded area is considered to be ineffective, see Figure A.10.

(3) For a loaded area situated near an unsupported edge or a corner, the critical perimeter should be taken as shown in Figure A.11 if this gives a critical area less than that obtained from the rules given above.



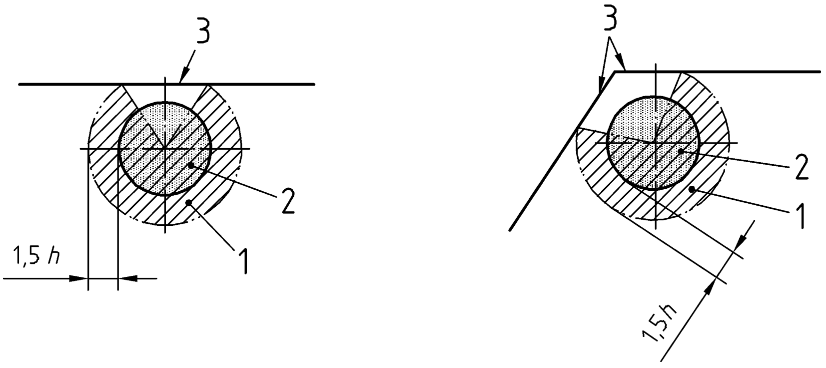
Key

1 critical area

2 loaded areas

3 opening

Figure A.10 — Critical perimeter near an opening



Key

1 critical area

2 loaded areas

3 free edges

Figure A.11 — Critical sections near unsupported edges

A.6.2.3 Critical area

(1) The critical area is the area within the critical perimeter (see A.6.2.2). In cases of pull-out loading (anchors), this area shall be reduced by the cross-sectional area of the drill-hole.

A.6.3 Design method for punching shear

(1) The method for punching shear design does not take reinforcement into account. It relates the punching shear resistance to the critical area. The resistance of an AAC component loaded by a point load is given by Formula (A.30).

$$V_{\mathrm{Rd}} = 0{,}42 \cdot A_{\mathrm{crit}} \cdot \tau_{\mathrm{Rd}} \tag{A.30}$$

where

A_{crit} is the critical area according to A.6.2.3, in square millimetre;

τ_{Rd} is the basic shear strength, $\tau_{\mathrm{Rd}} = 0{,}063 f_{\mathrm{ck}}{}^{0{,}5} / \gamma_{\mathrm{C}}$, in Megapascals;

γ_C is the partial safety factor of AAC for brittle failure.

NOTE The value of γ_C for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

(2) The applied punching load shall satisfy Formula (A.31).

$$V_{Sd} \leq V_{Rd} \tag{A.31}$$

A.7 Primary torsion/combined primary torsion and shear

(1)P Where the static equilibrium of a structure depends upon the torsional resistance of AAC components, design for torsion will be necessary.

(2) A design torsional moment T_{Sd} can be taken without any torsional reinforcement if one of the Formulae (A.32a to A.32c) is fulfilled:

$$\frac{T_{Sd}}{T_{Rd1}} \leq 0{,}2 \text{ and } \frac{V_{Sd}}{V_{Rd1}} \leq 0{,}95 \tag{A.32a}$$

$$\frac{V_{Sd}}{V_{Rd1}} \leq 0{,}2 \text{ and } \frac{T_{Sd}}{T_{Rd1}} \leq 0{,}95 \tag{A.32b}$$

$$\frac{T_{Sd}}{T_{Rd1}} + \frac{V_{Sd}}{V_{Rd1}} \leq 1{,}2 \tag{A.32c}$$

where

V_{Sd} is defined in A.4.1.1;

V_{Rd1} is defined in A.4.1.2;

T_{Rd1} is the resisting torsional moment, to be taken as $0{,}06 f_{cd} W_T$;

f_{cd} is the design compressive strength of AAC; $f_{cd} = f_{ck}/\gamma_C$;

f_{ck} is the characteristic compressive strength of the AAC;

γ_C is the partial safety factor of AAC for brittle failure;

W_T is the section modulus for torsion.

NOTE 1 The value of γ_C for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

(3) When none of the Formulae (A.32a) to (A.32c) is satisfied, a torsional reinforcement is required which meets the Formula (A.33).

$$\frac{T_{Sd}}{T_{Rd3}} + \frac{V_{Sd}}{V_{Rd3}} \leq 1 \tag{A.33}$$

where

V_{Rd3} is defined in A.4.1.3;

T_{Rd3} is the resisting torsional moment of a section with torsional reinforcement according to Formula (A.34):

$$T_{Rd3} = 2\, A_k\, h_k\, \sigma_{sld}\, \rho_{T,l} = 2\, A_k\, h_k\, \sigma_{swd}\, \rho_{T,s} \tag{A.34}$$

$A_k = b'\ h'$ is the area defined by the centres of the longitudinal reinforcement in each corner of the cross-section, see Figure A.12;

h_k is the thickness of a fictitious box section according to Formula (A.35):

$$h_k = \min\{b/6;\ h/6\}; \qquad \text{(A.35)}$$

σ_{sld} is the design tensile stress in the longitudinal torsion reinforcement;

σ_{swd} is the design tensile stress in the stirrups;

$\sigma_{sld}; \sigma_{swd} < f_{yd}$ is the admissible tensile stress in the reinforcement due to torsion according to Formula (A.36):

$$\sigma_{swd} = \left(f_{cd} / \sqrt{2}\right)\left(b' + h'\right) / (\pi \phi_{sw}) \qquad \text{(A.36)}$$

f_{cd} is the design compressive strength of AAC, $f_{cd} = f_{ck}/\gamma_C$;

f_{ck} is the characteristic compressive strength of AAC;

γ_C is the partial safety factor of AAC for brittle failure;

ϕ_{sw} is the diameter of the stirrups;

$\rho_{T,l}$ is the reinforcement ratio of the longitudinal reinforcement resisting torsion according to Formula (A.37):

$$\rho_{T,l} = A_{s,l} / [2h_k\ (b' + h')] \qquad \text{(A.37)}$$

$A_{s,l}$ is the cross-sectional area of the longitudinal torsion reinforcement;

$\rho_{T,s}$ is the reinforcement ratio of the stirrups resisting torsion according to Formula (A.38):

$$\rho_{T,s} = A_{sw} / (h_k\ s) \qquad \text{(A.38)}$$

A_{sw} is the cross-sectional area of the stirrups resisting torsion;

s is the spacing of the stirrups.

NOTE 2 The value of γ_C for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

(4)P Torsional reinforcement shall consist of closed stirrups perpendicular to the longitudinal axis of the component, combined with longitudinal bars. Closed stirrups shall not be made of pairs of U-stirrups lapping one another. The spacing of the stirrups shall be not larger as min{b, h} or 25 cm. Longitudinal bars shall be arranged such that there is at least one bar at each corner of the section, the others being distributed uniformly around the inner periphery of the stirrups.

(5)P The anchorage of the longitudinal reinforcement shall be designed for tensile forces due to bending and torsion.

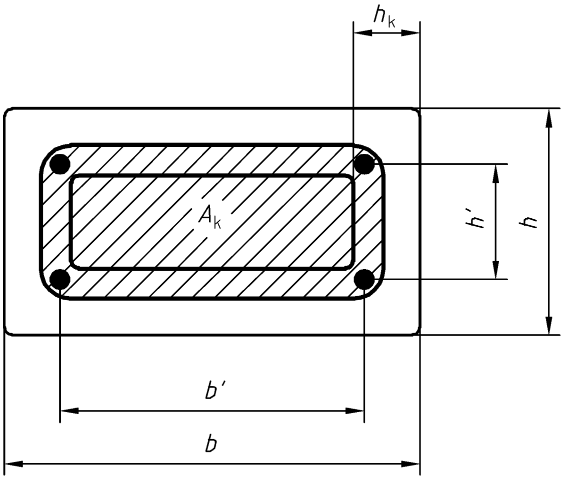


Figure A.12 — Idealised box section

A.8 Concentrated forces

(1)P When concentrated forces are acting on a certain part of the AAC surface, the loadbearing capacity of the AAC component can be increased if compressive stresses can be distributed in AAC to an area greater than the loaded area.

(2) In this case the concentrated compressive design force F_{Rdu} is given by the Formula (A.39).

$$F_{\mathrm{Rdu}} = A_{\mathrm{c0}} \cdot \alpha \cdot f_{\mathrm{cd}} \cdot \sqrt[3]{A_{\mathrm{c1}} / A_{\mathrm{c0}}} \leq \kappa \, f_{\mathrm{cd}} A_{\mathrm{c0}} \qquad \text{(A.39)}$$

where

κ = 2,0, not taking into account local indentations;

α is the reduction coefficient for design compressive strength of AAC taking into account long term effects;

κ = 3,3, taking into account local indentations;

f_{cd} is the design value of compressive strength of AAC, $f_{\mathrm{cd}} = f_{\mathrm{ck}}/\gamma_{\mathrm{C}}$;

f_{ck} is the characteristic compressive strength of the AAC;

γ_{C} is the partial safety factor of AAC for brittle failure;

A_{c0} is the loaded area;

A_{c1} is the maximum distribution area of load in AAC taking into account that the distribution of forces in AAC follows the principle presented in Figure A.13;

h_{c} is the distance between A_{c0} and A_{c1}:

$h_{\mathrm{c}} \geq 3(r_{\mathrm{c1}} - r_{\mathrm{c0}})$.

NOTE 1 The value of γ_{C} for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

NOTE 2 The value of α for use in a country may be found in its national application document. The recommended value of α for use is 0,85.

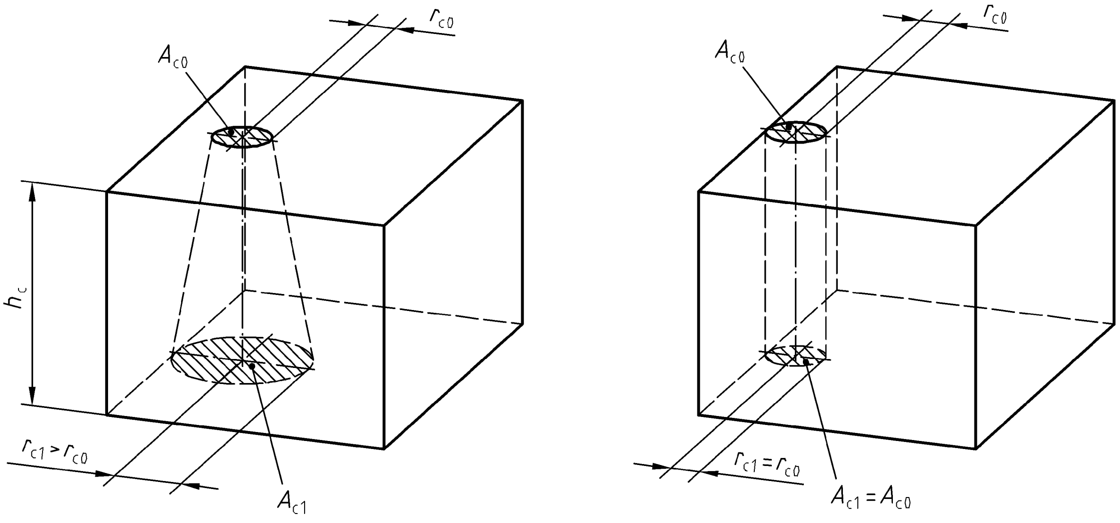


Figure A.13 — Definition of the areas to be introduced in Formula (A.39)

A.9 Serviceability limit states (SLS)

A.9.1 General

(1)P This clause covers the common serviceability limit states. These are:

- stress limitation (see A.9.2);
- crack control (see A.9.3);
- deflection control (see A.9.4).

(2) Information how the effect of prestress may be taken into account in SLS on the basis of a declared prestrain value, $\varepsilon_{0\text{mg}}$, can be found in informative Annex E.

A.9.2 Limitation of stresses under serviceability conditions

A.9.2.1 Basic considerations

(1) Creep may exceed the amount predicted using the methods given in 4.2.11 if the stress in the AAC under the quasi-permanent loads exceeds 0,45 f_{ck} If creep is likely to significantly affect the functioning of the component considered, the stress should be limited to this value.

(2)P Stresses in the steel under serviceability conditions which could lead to inelastic deformation of the steel shall be avoided as this will produce large, permanently open cracks.

(3) This requirement will be met provided that, under the characteristic combination of actions, the tensile stress in ordinary reinforcement does not exceed 0,8 f_{yk}. Where the stress is due only to imposed deformations, a maximum stress of 1,0 f_{yk} will be acceptable.

A.9.2.2 Methods for checking stresses

(1)P In calculating the stresses, account shall be taken of whether or not the section is expected to crack under service loads and also of the effects of creep and shrinkage. Other indirect actions which could influence the stresses, such as temperature, may also need to be considered.

(2) The stress limitations given in A.9.2.1 may generally be assumed to be satisfied without further calculations provided:

a) design for the ultimate limit state has been carried out in accordance with A.3 or A.5;

b) minimum reinforcement provisions of 5.2.7.2 are satisfied;

c) detailing is carried out in accordance with A.10.

(3) Long term effects may be taken into account by assuming a modulus of elasticity reduced by the factor $1/(1 + \varphi)$ (where φ is the creep coefficient according to 4.2.11) for situations where more than 50 % of the stress arise from quasi-permanent actions. Otherwise, they may be ignored.

(4) Stresses are checked employing section properties corresponding to either the uncracked or the fully cracked condition, whichever is appropriate.

(5) Normally, components may be considered to be uncracked if the bending moment under the frequent combination of loading, M_f, does not exceed the cracking moment of the section, M_cr, anywhere within the component. For the calculation M_cr the modulus of elasticity of AAC may be taken as $E_\mathrm{c,eff}$ (see Formula (A.43)) and its mean flexural strength 0,8 f_cflm derived from tests according to EN 1351 or determined by Formulae (5a) and (5b), see 4.2.5, respectively.

(6) Where an uncracked cross-section is used, the whole of the AAC section is assumed to be active, and both AAC and steel are assumed to be elastic in both tension and compression.

(7) Where a cracked cross-section is used, the AAC is assumed to be elastic in compression but to be incapable of sustaining any tension.

(8) At least the minimum area of reinforcement given by A.10.3 is required to satisfy the limitation of the stress in ordinary bonded reinforcement under the action of restrained imposed deformations.

A.9.3 Serviceability limit states of cracking

(1)P Cracking shall be limited to a level that will not impair the proper functioning of the structure or cause its appearance to be unacceptable.

(2)P Calculation of crack widths in order to ensure sufficient corrosion protection of the reinforcement is not necessary for AAC components, as this is achieved in connection with the requirement on the corrosion protective coating.

(3)P In order to achieve a general crack control, the requirements on minimum structural tensile reinforcement area in 5.2.7.2 shall be fulfilled for components under predominantly transverse load.

NOTE Cracking can occur in reinforced AAC components due to bending, shear, torsion or tension, resulting from either direct loading or restraint of imposed deformations. Different cracks can also arise from other causes, such as chemical attacks from the environment. Such cracks may be unacceptable, but their avoidance and control lie outside the scope of this clause.

A.9.4 Serviceability limit states of deformation

A.9.4.1 Basic considerations

(1)P The deformation of a component should not be such that it adversely affects its proper functioning or appearance.

(2)P Appropriate limiting values of deflection, taking into account the function of the structure and the nature of finishes, partitions and fixings, should be clearly defined, either as values declared by the manufacturer for current standard components or as values agreed with the client for components with specific purposes.

(3)P Generally, compliance with deflection limits should be checked by calculation. In many cases it is possible to employ the calculation method to formulate simple rules, such as limits to span/depth ratio which will be adequate to ensure compliance for a whole range of components. In such cases an explicit calculation for a specific component is not deemed necessary.

(4) The limiting deflection values given in (5) and (6) below are derived from ISO 4356 and may be considered as appropriate for buildings such as dwellings, offices, public buildings or factories.

(5) The calculated sag of roof and floor components subjected to quasi-permanent loads should be limited. The sag is assessed relative to the supports. Precamber may be used to compensate for some or all of the deflections.

NOTE 1 The above limit value for use in a country may be found in a national application document. The recommended value for the calculated sag of roof and floor components subjected to quasi-permanent loads is span/250.

(6) Deflections that may cause damage to partitions or other elements in contact with the component and occurring after installation of such members ("active" deflection) should be limited. This limit may be relaxed in cases where the elements which might suffer damage are known to be capable of withstanding greater deflections without being impaired.

NOTE 2 The above limit value for use in a country may be found in a national application document. The recommended value for the deflections that may cause damage to partitions or other elements in contact with the component and occurring after installation of such members ("active deflection") is span/500.

A.9.4.2 Checking deflections by calculation

(1)P Where a calculation is deemed necessary, the deflections shall be calculated under load conditions which are appropriate to the purpose of the check.

(2)P The calculation method shall represent the true behaviour of the component under relevant actions to an accuracy appropriate to the objectives of the calculation. In particular, where components are expected to be cracked, the influence of the cracks on the deformations should be taken into account.

(3)P Where appropriate, the following shall be considered:

- effects of creep and shrinkage;
- stiffening effect of the AAC in tension between the cracks;
- cracking resulting from previous loadings;
- possible slip of reinforcement due to poor bond properties;
- effects of prestrain if declared.

(4) When assessing cracking, the loadings to be taken into account should be at least those defined as “persistent design situation”. For the calculation of deflections it will normally be satisfactory to consider the deflections under the quasi-permanent combination of loading and assuming this load to be of long duration. For the calculation of “active” deflection, due consideration should also be taken to the additional loading that can occur under the frequent combination of loading and assuming this to be of short duration.

(5) Slip of reinforcement shall be taken into account in the cracked zone of the component, in accordance with A.9.2.2 (5), if the bond stresses under frequent combination of loading exceed f_{bd}, where f_{bd} is the design bond strength (see A.10.2.2).

A.9.4.3 Calculation method

(1) Two limiting conditions are assumed to exist for the deformation:

- uncracked condition:

In this state, steel and AAC act together elastically in both tension and compression.

- cracked condition:

In this state, the influence of the AAC in tension is ignored.

(2) The curvature κ can be determined using the Formulae (A.40), (A.41), and (A.42).

$$\kappa = \frac{M}{E_c I_i} \tag{A.40}$$

$$I_i = I_c + nI_s \tag{A.41}$$

$$n = \frac{E_s}{E_c} \tag{A.42}$$

where

E_c is the modulus of elasticity taken as E_{cm} for the short-term part of the load and as $E_{c,eff}$ for the long term part of the load, also when determining n;

I_i is the second moment of area (moment of inertia) of the reinforced AAC cross-section in the uncracked or cracked state depending on the load. In the cracked state only the compression zone of AAC and the reinforcement are taken into account.

(3) For loads of long duration creep should be allowed for by using an effective modulus of elasticity, $E_{c,eff}$, calculated from Formula (A.43).

$$E_{c,eff} = E_{cm} / (1 + \phi) \tag{A.43}$$

where

φ is the creep coefficient in accordance with 4.2.11;

E_{cm} is the mean modulus of elasticity of AAC.

(4) For creep classes ≤ 0,7 (see Table 3) the long term deflection can be calculated from Formula (A.43a)

$$y_\infty = 1{,}35 y_{el} \tag{A.43a}$$

where

y_∞ is the long term deflection under the quasi-permanent combination of loading;

y_{el} is the elastic short-term deflection; in case of pre-stressed components having precamber the precamber shall be considered in the determination of y_{el}.

(5) If M_f is greater than M_{cr}, the component is considered to behave in a manner intermediate between uncracked and cracked condition. For components subjected predominantly to flexure, an adequate prediction of behaviour is given by Formula (A.44).

$$p = kp_{II} + (1 - k)p_I \tag{A.44}$$

where

p is the parameter considered which may be, for example, a strain, a curvature or a deflection;

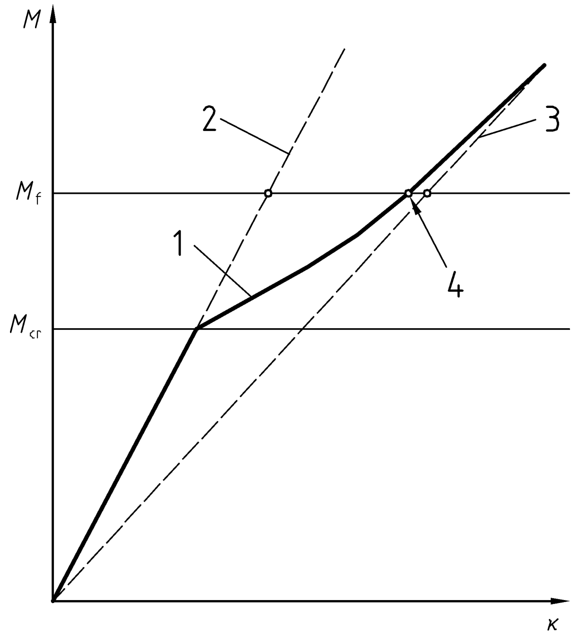
p_I and p_{II} are the values of this parameter calculated for the uncracked and fully cracked section, respectively;

k is a distribution coefficient given by Formulae (A.45a) and (A.45b).

$k = 1 - 0{,}8\ (M_{cr}/M_f)^2$ if slip may be ignored (see A.9.4.2 (5)); (A.45a)

$k = 1 - 0{,}4\ (M_{cr}/M_f)^2$ if slip may not be ignored (see A.9.4.2 (5)). (A.45b)

(6) For partly cracked components a rigorous method of assessing deflections using the method given in (3) above is to compute the curvatures at several sections along the component and then calculate deflection by numerical integration. When the effort involved in this is not deemed justified, it will be acceptable to compute the deflection twice, assuming the whole member to be in the uncracked and cracked condition in turn and then employ Formula (A.44).



Key

1	partly cracked state
2	uncracked state
3	cracked state
4	curvature given by Formula (A.40)
M	bending moment
M_f	bending moment under the frequent combination of loading
M_{cr}	cracking moment of the section
κ	curvature

Figure A.14 — Moment curvature relationship

A.10 Detailing of reinforcement

A.10.1 General

(1)P Minimum requirements are given in 5.2.7.

(2)P Anchorage of the longitudinal tensile or compressive reinforcing bars shall be provided by bond and in such parts of components, where the bond stress under design loads (in ULS) exceeds the design bond strength f_{bd}, exclusively by welded transverse bars. For the tensile bars there shall be always at least one welded transverse bar within the support length of the component.

A.10.2 Bond

A.10.2.1 Characteristic bond strength

(1)P If bond shall be taken into account in design, the characteristic bond strength f_{bk} shall be derived from results of tests carried out in accordance with EN 12269-1. This value may be used for all cases where the cover is at least that of the test specimens.

A.10.2.2 Design bond strength

(1)P The design bond strength shall be derived from the characteristic short-term bond strength according to Formula (A.46).

$$f_{\mathrm{bd}} = k_1\, k_2\, f_{\mathrm{bk}}/\gamma_{\mathrm{C}} \qquad \text{(A.46)}$$

where

k_1 is a reduction factor (short-term effect) taking into account the relationship between the component and the test specimen (geometrical parameters). In absence of more accurate test results, k_1 can be put equal to 0,8;

k_2 is a reduction factor (long term effect) taking into account influences (long term and temperature). In absence of more accurate test results, k_2 can be put equal to 0,2;

f_{bd} is the design bond strength;

f_{bk} is the characteristic short-term bond strength determined in accordance with EN 12269-1;

γ_{C} is the partial safety factor of AAC for brittle failure.

NOTE The value of γ_{C} for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

(2)P If the characteristic bond strength has not been declared, f_{bd} shall be taken as zero, i.e. bond may not be taken into account in design.

A.10.3 Anchorage

(1)P Anchorage of longitudinal reinforcing bars shall be provided by means of welded transverse bars in such parts of the components where the bond stress under design load (ULS) exceeds the design bond strength. The number and distribution of transverse bars in these parts shall be such that in any section Formula (A.47) is satisfied for all reinforcing bars.

$$F_{\mathrm{RA}} \geq F_{\mathrm{ld}} \qquad \text{(A.47)}$$

where

F_{RA} is the anchorage capacity of the transverse anchorage bars;

F_{ld} is the design tensile force in the longitudinal reinforcement.

(2) F_{RA} and F_{ld} may be determined according to Formulae (A.48) and (A.51).

$$F_{\mathrm{RA}} = \sum_{i=1}^{n_{\mathrm{t}}} \min\left[0{,}83\Phi_{\mathrm{tot}}t_{\mathrm{t}}f_{\mathrm{ld}}\left(n_{\mathrm{t}}\right);0{,}60n_{\mathrm{l}}F_{\mathrm{wg}}/\gamma_{\mathrm{s}}\right] \qquad \text{(A.48)}$$

where

F_{wg} is the declared shear strength of a welded joint, see Formula (8);

n_{l} is the number of longitudinal bars;

n_t is the number of transverse bars between the section concerned and the end of the component;

ϕ_{tot} is the effective diameter of the transverse anchorage bars. Declared mean outer diameter of the transverse bar and corrosion protection coating $\phi_{tot,g}$, see 4.3.1, may be used as the effective diameter ϕ_{tot} when the applicability of $\phi_{tot,g}$ is verified by test (according to EN 15361). Otherwise $\phi_{tot} = \phi_t$, where ϕ_t is the diameter of the transverse anchorage bar. Effective diameter ϕ_{tot} shall not be taken greater than the following values: $\phi_{tot} \leq 1{,}5\ \phi_l$ in case of tension in the longitudinal bar and $\phi_{tot} \leq 1{,}0\ \phi_l$ in case of compression in the longitudinal bar, where ϕ_l is the diameter of the longitudinal reinforcement bars.

NOTE 1 The value of ϕ_{tot} ($\phi_{tot} = \phi_t$ obtained by testing according to EN 15361) to be introduced in Formula (A.48) for design may be found in the national application document in the country of use.

t_t is the total effective length of the transverse anchorage bars, see Formula (A.50);

$f_{ld}\ (n_t)$ is the design bearing strength of AAC depending on n_t, see Formula (A.49);

γ_S is the partial safety factor for reinforcing steel, see NOTE 2.

NOTE 2 The value of γ_S for use in a country may be found in its national application document. The recommended value for use is given in Table D.4.

The design bearing strength f_{ld} of AAC (resistance against transverse pressure under a transverse bar) is determined according to Formula (A.49):

$$f_{ld} = K_{c1} m \left(e / \varphi_{tot}\right)^{1/3} \alpha\, f_{ck} / \gamma_C \leq K_{c2} f_{ck} / \gamma_C \qquad \text{(A.49)}$$

where

f_{ck} is the characteristic compressive strength of AAC;

γ_C is the partial safety factor of ACC for brittle failure. However, safety factor γ_C may be taken for ductile failure when calculating the anchorage capacity of the transverse bars which all are at the support, see NOTE 3;

m is a factor for consideration of existing transverse compression (e.g. support pressure) in the anchorage zone, to be taken as

$$m = 1 + 0{,}3 \cdot \frac{n_p}{n_t}$$

where

n_p is the number of transverse anchorage bars within the zone of transverse pressure (e.g. at the support);

e is the distance of the axis of the transverse bars in the anchorage zone to the nearest surface of the component (see Figure A.15);

K_c is the factor for maximum AAC bearing strength. K_{c1} and K_{c2} (see Table A.1) are depending on the bond class B1 and B2, see 4.4.

Table A.1 — Bond Classes

Bond class	K_{c1}	K_{c2}
B1	1,35	2,20
B2	1,50	2,70

For Bond class B2 $K_{\mathrm{c}2}$ may normally be taken as 2,70. It may be increased to 3,20 for the calculation of the anchorage capacity of cross bars at the support subjected to transverse pressure.

NOTE 3 The value of γ_{C} for use in a country may be found in its national application document. The recommended value for use is given in Table D.4.

The total effective length t_{t} of the transverse anchorage bar is determined according to Formula (A.50).

$$t_{\mathrm{t}} = \left(t_1 + t_2 + \ldots + t_{\mathrm{n}}\right) \tag{A.50}$$

where every $t_{\mathrm{i}}^{'} + t_{\mathrm{i}}^{''} = t_{\mathrm{i}} \leq 14\varphi_{\mathrm{t}}$ and every $t_{\mathrm{i}}^{'} + t_{\mathrm{i}}^{''} \leq 8\varphi_{\mathrm{t}}$ (see Figure A.15).

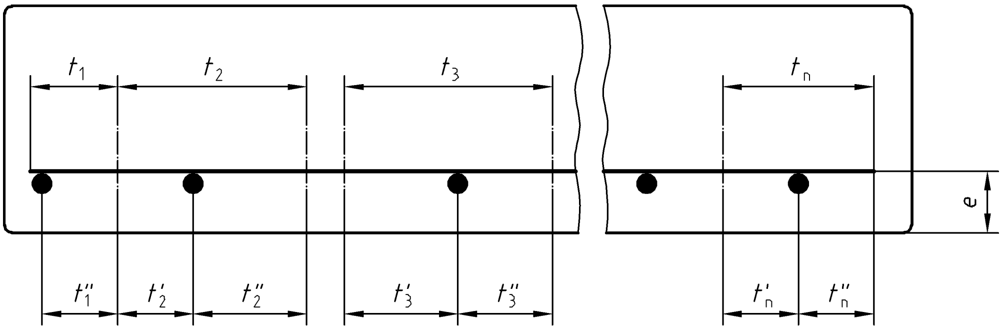


Figure A.15 — Effective length of transverse anchorage bars

The tensile force F_{ld} in the longitudinal reinforcement under design load is determined according to Formula (A.51):

$$F_{\mathrm{ld}} = M_{\mathrm{da}} / z \tag{A.51}$$

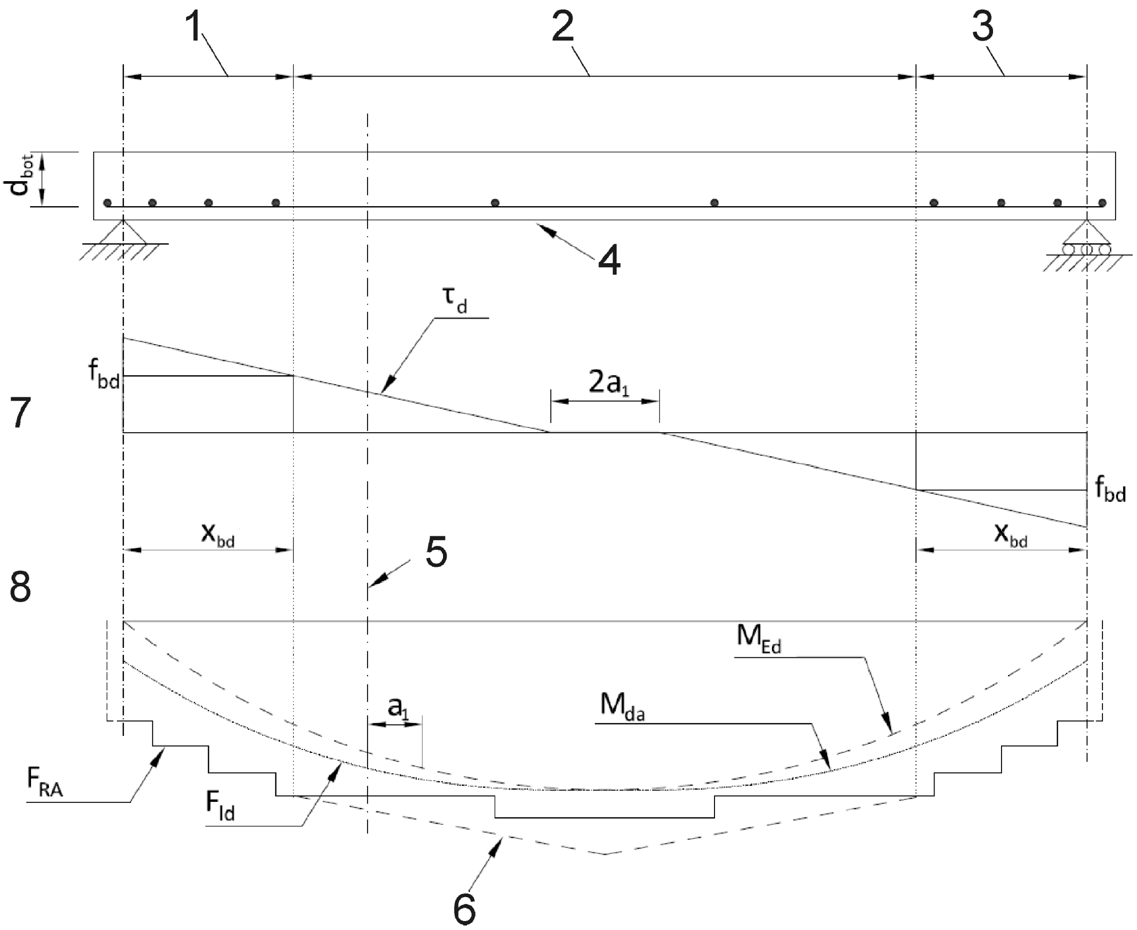
where

M_{da} is the design bending moment at the section concerned obtained by a horizontal displacement a_1, of the envelope line of the design bending moment distribution, see Figure A.16;

For shear reinforced and non shear reinforced components: $a_1 = d$

d is the effective depth of the cross section;

z is the internal lever arm; in the anchorage analysis the approximate value $z = 0{,}9\ d$ can normally be used.



Key

1	anchorage using cross bars
2	anchorage using cross bars or bond strength
3	anchorage using cross bars
4	cross bars in the middle zone
5	section concerned
6	anchorage using bond strength in the middle zone
7	bond stress of longitudinal reinforcement
f_{bd}	design bond strength according to Formula (A.49)
8	tensile force compared to the anchorage capacity
d_{bot}	effective depth of cross section
F_{ld}	tensile force
F_{RA}	anchorage capacity
M_{da}	enlarged design bending moment curve
M_{Ed}	design bending moment curve
τ_d	bond stress under design loads
x_{bd}	distance from support where bond stress exceeds design bond strength

Figure A.16 — Envelope line for determining the tensile force in the longitudinal reinforcement

(3)P When bond is not taken into account, the welded transverse bars within a distance *d* from the end of the component shall be able to resist a tensile force equal to V_{Sd}. V_{Sd} may not be reduced in accordance with A.4.1.1 (8).

A.11 Support length

The manufacturer shall declare the minimum support length when relevant.

The support length a_0 (see Figure A.17) shall be designed taking into account the following influences:

- support pressure;
- tolerances;
- splitting or spalling of support material;
- distance c between the last transverse bar necessary for anchorage and the end of the component;
- splays.

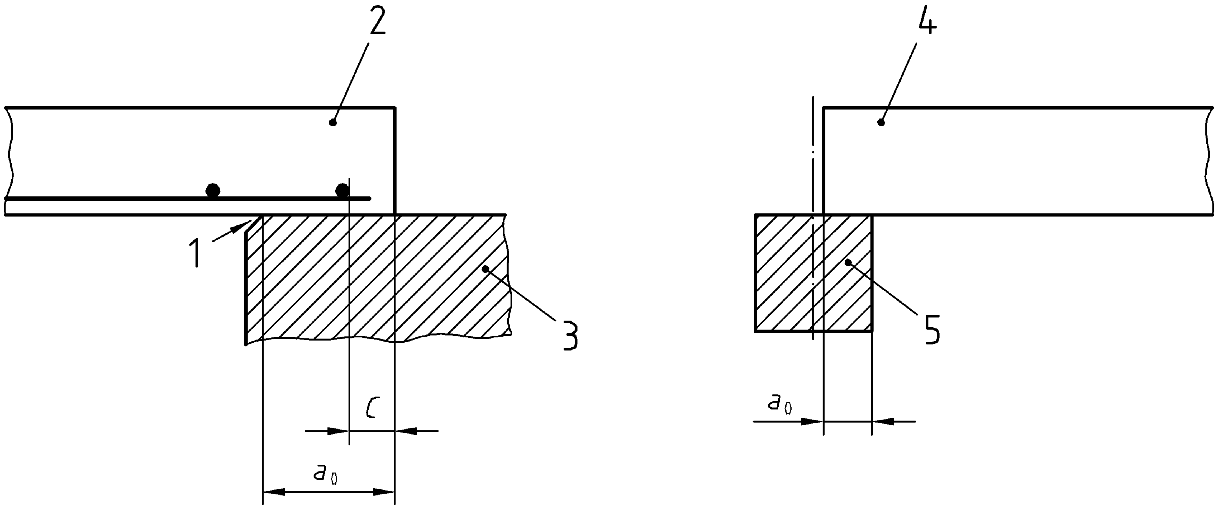
There shall always be at least one welded transverse bar within the support length of the component.

The support length a_0 (minimum values) shall not be less than (tolerances considered) the following recommended values:

- beams: 60 mm;
- floor components: 40 mm;
- roof components: 35 mm.

NOTE Larger support lengths than given above can be required to avoid the failure in the supporting structure.

Dimensions in millimetres



Key

1 Splay

2 Roof/floor component

3 Support

4 wall component

5 column

Figure A.17 — Support length a_0

Annex B
(normative)

Design by testing

NOTE 1 The design by testing is based on the concept of EN 1990:2002 and its Annex D as far as possible.

NOTE 2 Design values to be used can be determined according to the provision of this Annex B, using the relevant partial safety factors.

NOTE 3 Values of the properties can be determined on the basis of tests and be given as declared values in the CE-marking, according to the relevant provision in Annex ZA. The declared values are based on one of the three methods expressed in Guidance Paper L, Clause 3.3.3.2 (a).

NOTE 4 For the choice of design method see 5.2.4.1.

B.1 General

(1)P Depending on the character of the individual clauses, distinction is made in this Annex B between Principles and Application rules.

(2)P The Principles comprise

— general statements and definitions for which there is no alternative, as well as

— requirements and analytical models for which no alternative is permitted unless specifically stated.

(3)P In this Annex B the Principles are marked by a number in brackets followed by the letter P.

(4)P The Application Rules are generally recognized rules which follow the principles and satisfy their requirements.

(5)P In this Annex B Application Rules are those paragraphs marked by a number in brackets which is not followed by the letter P.

(6)P In this annex it is presumed that the manufacturer declares the characteristic loadbearing capacities, type of failure and/or other characteristic properties of the component subject to initial type testing and factory production control by testing.

(7)P The loadbearing capacity shall be declared either by the load and/or by cross section capacities, e.g. moment and shear capacity, derived from the test results.

(8)P The declared values shall be established (by statistical interpretation) on the basis of the initial type testing and factory production testing of components for a direct application or derived from a model including testing for an extended application.

(9) A direct application presumes that a single product or a range of products, subjected to initial type testing and factory production testing of components, is covered by the declared values.

(10) An extended application presumes that the range of products or related products is covered by a declared tentative model, based on a calculation method (theoretical or empirical), verified by testing of samples representative for the range of products.

(11)P The manufacturer shall demonstrate compliance, in accordance with 4.2.3, between declared values and the characteristic values derived from testing of the finished product in accordance with 6.3.3 and Table 13 and Table 14.

(12)P For structural components representative test results from the factory production control shall be utilized by qualified personnel to establish the statistical basis for the characteristic values in accordance with 4.2.3.

(13) Compliance may be demonstrated in accordance with Annex F.

B.2 Safety evaluation

B.2.1 General

(1)P Safety evaluation is carried out in accordance with Annex D.

(2)P In analysis of ultimate limit states the partial safety factors shall consider any relevant safety aspect, i.e. safety classes from consequences of failure, level of factory production control, long term effects, reliability of test or design methods and type of failure.

B.2.2 Brittle and ductile failure

(1)P It is necessary to differentiate between ductile and brittle failure. Ductile failure is a failure with an early warning. Other types of failure are considered as brittle. The evaluation of the type of failure shall be made on the basis of observations in the tests performed in accordance with EN 1356 and EN 1740.

(2)P The manufacturer shall state the type of failure for the component as ductile or brittle.

(3) Ductile failure is assumed when at least one of the following states is achieved:

— failure of the component due to yielding of the reinforcement without decrease of the loadbearing capacity,

— failure of the component recognized by the appearance of visible cracks distributed in a pattern anticipating the failure mode without instant decrease of loadbearing capacity,

— for transversally loaded components, if deflection before failure is ≥ (3/200) L, where L is the span length (between the centre points of the supports).

In all other cases the failure type shall be considered as brittle. If the failure type is not consistently ductile for a type of samples subjected to testing, it shall be declared as brittle.

B.3 Ultimate limit state

B.3.1 General

(1)P In the ultimate limit state the components shall possess an adequate safety level in relation to the effect of specified actions and type of failure.

(2)P It shall be verified that the design loadbearing capacity determined in accordance with this clause is higher than or equal to the design effects of the actions applied.

(3)P For all types of failure the loadbearing capacity shall be determined in relation to the magnitude and position of the applied loads at testing.

(4)P The actual failure type shall be declared together with the loadbearing capacity. If the position of the applied loads differs from that in the test methods given in this B.3, it shall be declared which load case the declared capacity is valid for.

B.3.2 Transversely loaded components

B.3.2.1 Loadbearing capacity

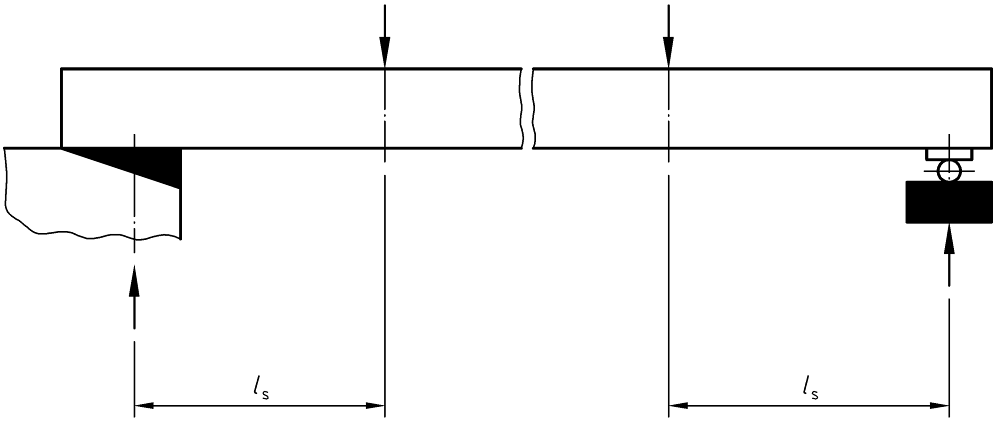
(1)P The characteristic loadbearing capacity of transversely loaded components shall be determined on the basis of the performance test method according to EN 1356. The declared loadbearing capacity may be used to derive the equivalent uniformly distributed loads and/or separate values for bending and shear capacity.

(2)P In design, the bending and shear capacity derived from the test results shall always be conservative to all other combinations of loads considering their positions and magnitude.

(3) The shear capacity is always conservative when determined and declared from the performance test according to EN 1356 with loads positioned in the outer quarter points of the span length. To determine the maximum shear capacity by the performance test EN 1356, other positions of actions may be chosen. The load position in the test shall be shown to give a conservative shear capacity compared to all other possible positions and types of actions.

(4)P For determination of the shear capacity of components without shear reinforcement, actions are not allowed to be positioned closer to the support than 5*d*, where *d* is the component thickness.

(5) The characteristic value for shear capacity of a component may be fully used for all shear spans smaller than that tested, provided that the cross section and the number, diameter and position of transverse bars in the anchorage zones are the same (see Figure B.1).



a) Support on a wall or beam

b) Test situation

Figure B.1 — Definition of shear span l_s

(6)P Components may be designed without stirrups or with stirrups for improved shear capacity (see Figure B.2). If stirrups are used, they shall be welded to the longitudinal bars.

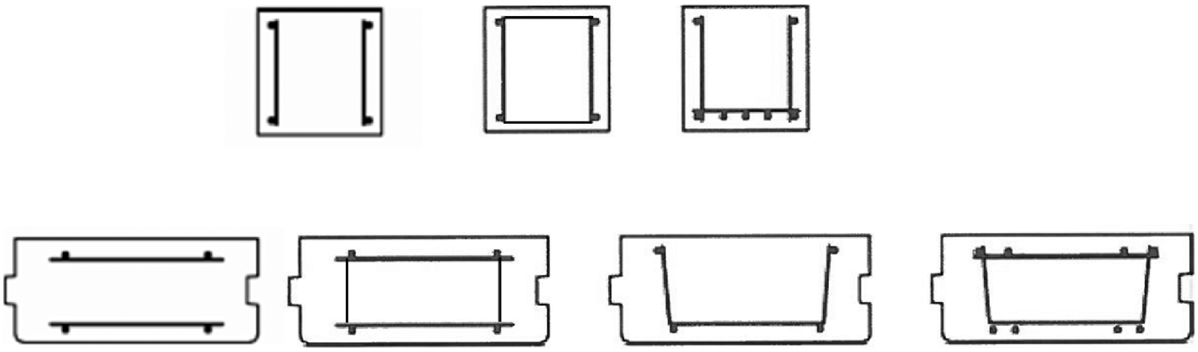


Figure B.2 — Typical reinforcement layouts in AAC-components

B.3.2.2 Design values for bending and shear capacity

(1)P Design values for bending capacity and shear capacity shall be determined from the declared characteristic values derived from test results according to B.3.2.1 taking into account the partial factors.

(2)P The design value of bending capacity shall be determined as follows:

$$M_{\mathrm{d}} = \frac{1}{\gamma_{\mathrm{comp}}} M_{\mathrm{k}} \qquad \text{(B.1)}$$

where

M_{k} is the declared characteristic value of bending capacity (see 4.2.3) calculated from the results of a test series, using the test method described in EN 1356, including the dead weight and with loads normally positioned at the outer quarter points of the span;

γ_{comp} is the partial safety factor for components.

NOTE 1 The value of γ_{comp} for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

(3)P The design value of shear capacity shall be calculated as follows:

$$V_{\mathrm{d}} = \frac{1}{\gamma_{\mathrm{comp}}} V_{\mathrm{k}} \qquad \text{(B.2)}$$

where

V_{k} is the declared characteristic value of shear capacity (see 4.2.3) calculated from the results of a test series, using the test method described in EN 1356, including the dead weight and with loads in stated positions. Normally the loads are positioned at the outer quarter points of the span.

γ_{comp} is the partial safety factor for components.

NOTE 2 The value of γ_{comp} for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

B.3.2.3 Multilayer components

(1)P The loadbearing capacity and the design values for a transversely loaded multilayer component, with interaction between the layers, shall be determined in accordance with B.3.2.1 and B.3.2.2. The design criteria in B.3.2.4. shall be considered.

(2)P The shear resistance between the layers shall, if it is utilized in design, be declared on the basis of testing according to EN 1742.

(3)P The first recognized failure mode in one of the structural layers shall be considered as being the failure for the whole component.

(4)P Long term effects shall be considered.

B.3.2.4 Design criteria

(1)P For design purposes the manufacturer shall give necessary information based on detailing, assumptions and results, from initial type-testing of the component (see 6.2) and factory production control (see 6.3). Performance tests shall be executed in accordance with EN 1356 and EN 1740.

(2)P Holes, grooves or chases shall only be allowed without detailed analysis if

1) they have the same or smaller dimensions than those used in the test situation and if they are placed in less critical positions,

2) they are in accordance with 5.2.7.3.

B.3.3 Longitudinally loaded components

B.3.3.1 Loadbearing capacity and eccentricity

(1)P The loadbearing capacity of longitudinally loaded components shall be determined in accordance with the performance test method described in EN 1740. In the case of asymmetric reinforcement, the direction of the eccentricity shall be chosen such that it affects the weakest side in an unfavourable manner.

(2)P The manufacturer shall declare the loadbearing capacity of components by stated characteristic values, N_{Rk}, (see 4.2.3) with the corresponding eccentricities (at top and bottom), used in the tests. The characteristic loadbearing capacity, N_{Rk} , for the component is determined from the test results by the Formula (B.3)

$$N_{\mathrm{Rk}} = k \cdot N_{\mathrm{Rk,test}} \tag{B.3}$$

where

k is a column factor considering the effects of slenderness $k = f\{(l_{\mathrm{k,test}}/ l_{\mathrm{k}})^2\}$;

$l_{\mathrm{k,test}}$ is the length of the component in the test;

l_{k} is the length of the actual component;

$N_{\mathrm{Rk,test}}$ is the declared characteristic longitudinal loadbearing capacity of the component derived from performance tests according to EN 1740.

B.3.3.2 Design loadbearing capacity

(1)P The design loadbearing capacity, N_{Rd}, of a component shall be calculated from the declared characteristic loadbearing capacity, by a method considering slenderness and actual eccentricities with influence of buckling. The possible effect of creep shall be considered.

(2)P The design loadbearing capacity can be expressed by the general Formula (B.4):

$$N_{\mathrm{Rd}} = \frac{1}{\gamma_{\mathrm{comp}}} \cdot N_{\mathrm{Rk}} \tag{B.4}$$

where

γ_{comp} is the partial safety factor for components;

N_{Rk} is the declared characteristic longitudinal capacity of the component (see 4.2.3) derived from performance tests according to EN 1740 using the column factor k (see B.3.3.1).

NOTE The value of γ_{comp} for use in a country may be found in its national application document. The recommended value for use is given in Table D.4.

(3) The actual design eccentricity shall be less or equal to the eccentricity used in the test.

(4) The width of single standing components or piers shall not be less than that used in testing.

(5) This application fulfils the above mentioned conditions and may be used to evaluate the design values if the following restrictions are met:

- cross-section of the actual component, including reinforcement, is the same as that of the component used in the performance test;
- relation between the effective design length l_{d} and the length $l_{\mathrm{k,test}}$ used in the performance test is within the following limits:

$0{,}65 < \frac{l_d}{l_k} < 1{,}50;$

— the eccentricity of loads is $e_t < \frac{2}{3} < e_{k,test}$.

where

e_t is the resulting first order eccentricity at top of the component perpendicular to the plane of the component, limited in such a way, that the whole cross-section of the component is under longitudinal pressure (i.e. the longitudinal force acts within the core, which means $e_t < h/6$ when using rectangular cross-sections, where h is the overall depth of the component);

$e_{k,test}$ is the declared eccentricity at the top of the component perpendicular to its plane, i.e. the eccentricity used in the performance test.

— For slenderness $\lambda > 100$ extrapolation is not permitted for $\frac{l_d}{l_{k,test}} > 1{,}0$.

λ is the slenderness of the component used in testing, $\lambda = l_{k,test} / i$;

i is the radius of gyration in the direction of the weak axis; for a rectangular cross-section $i = 0{,}289\ h_t$;

where

h_t is the overall depth of the cross section;

$l_{k,test}$ is the length of the component in testing;

l_d is the actual length of the component;

k is a column factor considering the effects of slenderness $k = f\{(l_{k,test} / l_k)^2\}$, see Figure B.3.

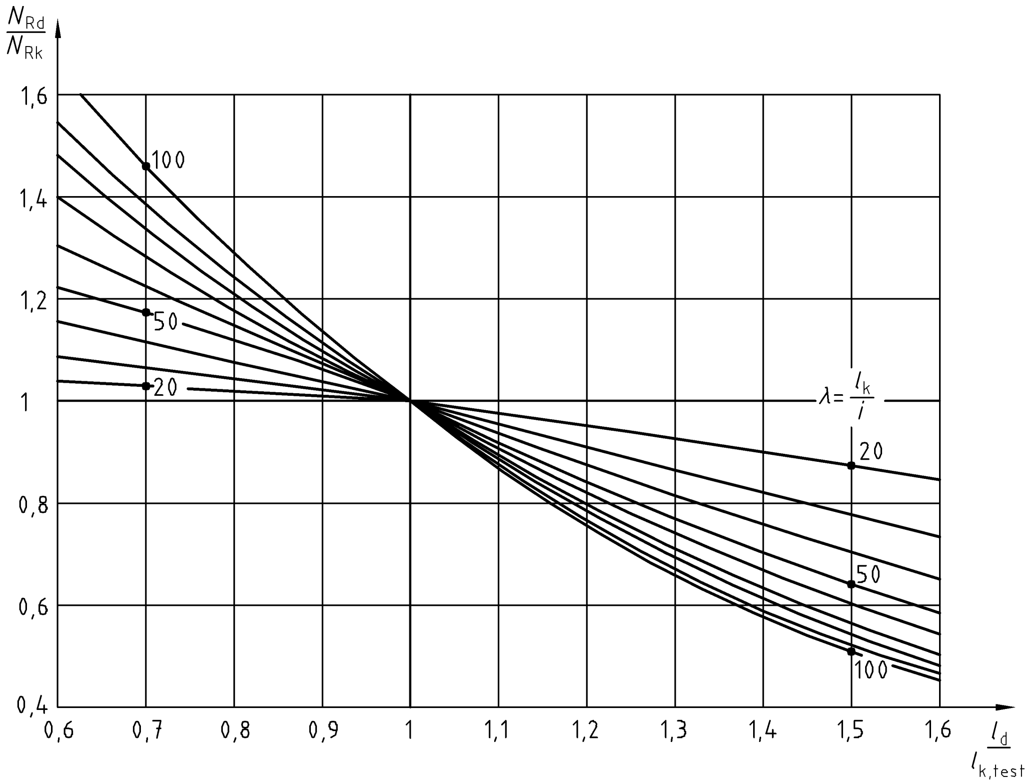


Figure B.3 — Diagram for determination of the column factor *k*

B.3.3.3 Multilayer components

B.3.3.3.1 Loadbearing capacity

(1)P The characteristic loadbearing capacity, N_{Rk}, for a longitudinally loaded multilayer component with or without interaction between layers shall be declared and determined in accordance with the performance test method described in EN 1740 and B.3.3.1.

(2)P The shear resistance between layers shall, if utilized for the verification of the interaction between layers, be declared on the basis of testing according to EN 1742 (see 4.2.3).

(3)P Long term effects shall be considered.

B.3.3.3.2 Design loadbearing capacity

(1)P The design loadbearing capacity for a longitudinally loaded multilayer component shall be calculated from the declared loadbearing capacity by the general Formula (B.5):

$$N_{\mathrm{Rd}} = \frac{1}{\gamma_{\mathrm{comp}}} \cdot N_{\mathrm{Rk}} \tag{B.5}$$

where

γ_{comp} is the partial safety factor for components;

N_{Rk} is the declared characteristic longitudinal capacity of the component (see 4.2.3) derived from performance tests according to EN 1740 using the column factor k (see B.3.3.1).

NOTE The value of γ_{comp} for use in a country may be found in its national application document. The recommended values for use are given in Table D.4.

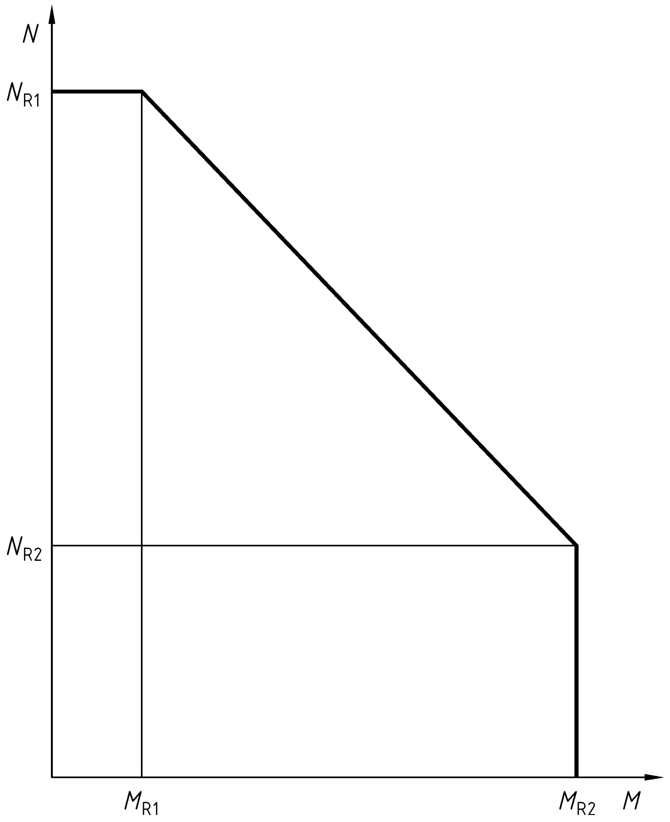
B.3.4 Simultaneously transversely and longitudinally loaded wall components

B.3.4.1 General

(1) Component design for transverse and longitudinal forces may be based on a simplified N/M - interaction diagram which may be obtained for a cross-section of a component (see Figure B.4). The diagram depends upon variables like reinforcement, compressive strength of AAC and cross-section of components.

B.3.4.2 Loadbearing capacity

(1)P The loadbearing capacity of simultaneously transversely and longitudinally loaded components shall be determined in accordance with the performance test methods according to EN 1356 and EN 1740. For the evaluation, the diagram schematically shown in Figure B.4 is used.



Key

N_{R1}	is the maximum loadbearing capacity for longitudinal loading according to B.3.3.2;
N_{R2}	is the maximum loadbearing capacity for simultaneous longitudinal and transverse loads, calculated and then verified by testing in accordance with EN 1740. The bending capacity, M_{R2}, shall be achieved in the test.
M_{R1}	is the minimum bending capacity for bending moments from eccentricities under longitudinal loading according to B.3.3.1;
M_{R2}	is the maximum bending capacity in absence of longitudinal loading according to B.3.2.1.

Figure B.4 — N/M - interaction diagram of the cross-section representing the results of three test series

B.3.5 Anchorage

B.3.5.1 General

(1)P For structurally reinforced components the type of anchorage system shall be stated by the manufacturer as anchorage by cross bars and/or anchorage by bond.

(2)P In a component both anchorage by transverse bars and by bond are allowed for but not in the same section.

B.3.5.2 Anchorage verified by calculation

(1)P Sufficient anchorage capacity shall be presumed if the anchorage system is designed by calculation according to A.10.3 for the declared loadbearing capacity.

B.3.5.3 Anchorage verified by testing

(1)P For components with anchorage by bond, the characteristic bond strength, f_{bk}, shall be declared by the manufacturer (see 4.4).

(2)P If the anchorage system by transverse bars is based on testing, the influence of bond, shall be evaluated by the results from the long term bond test according to EN 12269-2. If the reduction factor k_2, determined from the test results, taking into account long term and temperature influences, is less than 1,0 the loadbearing capacity, R_{ck}, derived from the performance test according to EN 1356 or EN 1740, shall be determined in accordance with Table B.1.

Table B.1 — Design loadbearing capacity R_{cd} of components

Possibilities for the results of the tests EN 12269–2 and EN 1356	$F_{sl} < F_b$ Bending and shear is decisive	$F_b \leq F_{sl} \leq \frac{1{,}2F_b}{k_2}$ Bond failure is decisive	$F_{sl} > 1{,}2\ \frac{F_b}{k_2}$ Anchorage by transverse bars or bending and shear is decisive
Consequence for the component loadbearing capacity	$R_{cd} = \frac{R_{ck}}{\gamma_{comp}}$	$R_{cd} = k_2 \cdot \frac{R_{ck}}{\gamma_{comp}}$	$R_{cd} = \frac{R_{ck}}{\gamma_{comp}}$

Where

F_{sl} is the tensile force in each of the longitudinal bars determined from the test results from performance test according to EN 1356 and considering the number of bars and their diameters;

$F_{sl} = \frac{M_{da}}{n \cdot z}$;

F_b is the long term anchorage capacity calculated from the measured value of the bond strength in accordance with EN 12269–2 ($F_b = f_{bl} \cdot \pi \cdot \phi \cdot l_b$).

$\frac{F_b}{k_2}$ is the short-term anchorage capacity;

k_2 is a reduction factor (long term effect) taking into account influences (long term and temperature). In absence of more accurate test results, k_2, can be put equal to 0,2.

f_{bl} is the conventional long term bond strength;

l_b is the basic anchorage length;

Φ is the diameter of the bar;

R_{cd} is the design loadbearing capacity of the component;

R_{ck} is the characteristic loadbearing capacity of the component;

γ_{comp} is the partial safety factor for component;

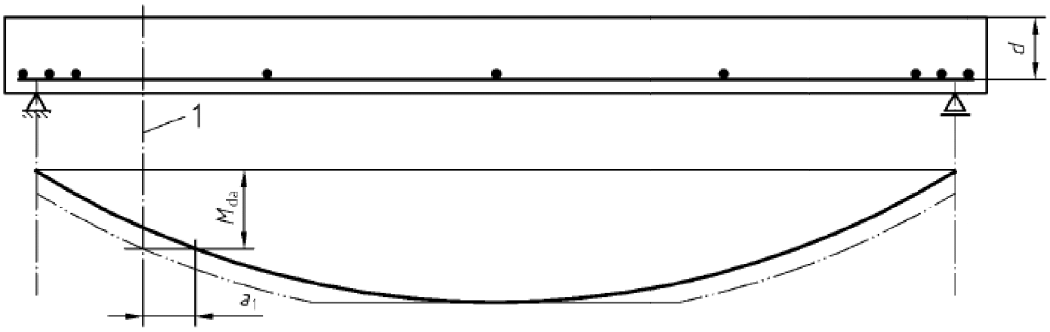
M_{da} is the actual bending moment at the section concerned obtained by a horizontal displacement a_l, of the envelope line of the bending moment distribution, see Figure B.5:

for reinforced structures: $a_l = d$;

d is the effective depth of the cross section;

z is the internal lever arm; in the anchorage analysis the approximate value $z = 0{,}9 \cdot d$ can normally be used;

n is the number of bars (the same diameter).



Key

1 section concerned

Figure B.5 — Envelope line for determining the section of the actual bending moment, M_{da}

(3) By evaluation of the corresponding bending moment and the tensile force in the longitudinal bars, test results may be extended to similar components provided their concrete cover and compressive strength of AAC is equal or higher, the number of longitudinal bars and their diameter is equal to or less than those in the tested components and the number and diameter of the transverse bars remain unchanged.

B.4 Serviceability limit states

B.4.1 Crack width control

(1)P The crack width for a transversely loaded component under serviceability conditions shall be determined from performance tests according to EN 1356, if required.

B.4.2 Deformations

B.4.2.1 General

(1)P The deformation of a component should not be such that it adversely affects its proper functioning or appearance in serviceability limit states.

(2)P In design, the effect of deformations shall be considered for connected, adjacent constructions.

B.4.2.2 Instantaneous deformations

(1)P Instantaneous deformations of transversally loaded components under serviceability conditions shall be determined from performance tests according to EN 1356, if required.

B.4.2.3 Time dependent deformations

(1)P Time dependent deformations shall be calculated according to the principles given in A.9.4.3 on the basis of the test results for the instantaneous deformations according to EN 1356, taking into account shrinkage and creep according to 4.2.10, 4.2.11 and 5.2.3.

Annex C
(normative)

Resistance to fire design of AAC components and structures

NOTE The resistance to fire design of AAC components is based on the concept of EN 1992–1-2 as far as possible. Some modifications have been made in order to take into account the specific material properties/behaviour of AAC.

C.1 General

C.1.1 Scope

(1)P This annex specifies the procedure for classification of AAC components and structures for the accidental situation of fire exposure. It only identifies differences from, or supplements to, normal temperature design.

(2)P This annex applies only to passive methods of fire protection. Active methods are not included.

(3)P This annex applies to AAC structures made of AAC components that are required to fulfil certain functions when exposed to fire, in terms of:

- avoiding premature collapse of the structure (loadbearing function);
- limiting fire spread (flame, hot gases, excessive heat) beyond designated areas (separating function).

(4)P This annex gives principles and application rules for designing structures for specified requirements in respect of the above mentioned functions and levels of performance.

C.1.2 Distinction between principles and application rules

(1)P Depending on the character of the individual clauses, distinction is made in this annex between Principles and Application rules.

(2)P The Principles comprise:

- general statements and definitions for which there is no alternative, as well as
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The Principles are marked by a number in brackets followed by the letter P.

(4)P The Application rules are generally recognized rules which follow the principles and satisfy their requirements. It is permissible to use alternative design rules different from the Application rules given in this annex, provided that it is shown that the alternative rules accord with the relevant principles and have at least the same reliability.

(5) In this annex the application rules are identified by a number in brackets, as in this paragraph.

C.1.3 Terms and definitions

For the purpose of this annex the following terms and definitions apply.

C.1.3.1

critical temperature of reinforcement

the temperature at which failure is expected to occur in reinforcement at a given load level

C.1.3.2

design fire

a specified fire development assumed for design purposes

C.1.3.3

fire compartment

space within a building, extending over one or several floors which is enclosed by separating elements such that fire spread beyond the compartment is prevented during the relevant fire exposure

C.1.3.4

fire resistance

ability of a structure, or part of a structure or a member to fulfil the required functions (loadbearing function and/or separating function) for a specified fire exposure and for a specified period of time

C.1.3.5

loadbearing function (R)

ability of the structure or a member to sustain specified actions during the relevant fire, according to defined criteria

C.1.3.6

integrity (E)

ability of a separating element of building construction when exposed to fire on one side, to prevent the passage through it of flames and hot gases and to prevent the occurrence of flames on the unexposed side

C.1.3.7

insulation (I)

ability of a separating element of building construction when exposed to fire on one side, to restrict the temperature rise of the unexposed face to below specified levels

C.1.3.8

mechanical action (M)

ability of the structure or a member to withstand impact, representing the case where structural failure of another component in a fire causes an impact on the element concerned. The structure/member is subject to impact of predefined force shortly after the time for the desired R, E and/or I classification period

C.1.3.9

wall with mechanical impact

wall separating two spaces (generally two buildings) that is designed for fire resistance and structural stability, and can include resistance to horizontal loading such that, in case of fire and failure of the structure on one side of the wall, fire spread beyond the wall is avoided

C.1.3.10

standard fire resistance

ability of a structure or part of it (usually only members) to fulfil required functions (loadbearing function and/or separating function), for the exposure to heating according to the standard temperature-time curve for a stated period of time

C.1.3.11

temperature analysis

procedure of determining the temperature development in members on the basis of the thermal actions (net heat flux) and the thermal material properties of the members and of protective surfaces, where relevant

C.1.3.12

temperature-time curves

gas temperature in the environment of member surfaces as a function of time. They may be:

- **nominal:** conventional curves, adopted for classification and verification of fire resistance, e.g. the standard temperature-time curve;
- **parametric:** determined on the basis of fire models and the specific physical parameters defining the conditions in the fire compartment

C.1.3.13

thermal actions

actions on the structure described by the net heat flux to the members

C.1.3.14

standard temperature-time curve

following relationship is given for the standard temperature/time curve representing a model of a fully developed fire in a compartment as defined in EN 13501-2:

$$\theta = 345 \log_{10} (8t + 1) + 20$$

where

t is the time from the start of the test in minutes;

θ is the average furnace temperature in °C.

C.1.3.15

indirect fire actions

internal forces and moments caused by thermal expansion

C.1.3.16

member analysis (for fire)

thermal and mechanical analysis of a structural member exposed to fire in which the member is assumed as isolated, with appropriate support and boundary conditions. Indirect fire actions are not considered, except those resulting from thermal gradients

C.1.3.17

global structural analysis (for fire)

structural analysis of the entire structure, when either the entire structure, or only parts of it, are exposed to fire. Indirect fire actions are considered throughout the structure

C.1.3.18

protected members

members for which measures are taken to reduce the temperature rise in the member due to fire

C.1.3.19

separating function

ability of a separating element to prevent fire spread (e.g. by passage of flames or hot gases – integrity) or ignition beyond the exposed surface (insulation) during the relevant fire

C.1.3.20

separating element

loadbearing and non-loadbearing element (e.g. wall or floor) forming part of the enclosure of a fire compartment

C.1.4 Symbols

The following supplementary symbols are used:

a	axis distance of reinforcing steel from the nearest exposed surface;
c	specific heat in J/kgK;
E_d	design effect of actions for normal temperature design;
$E_{d,fi}$	design effect of actions in the fire situation;
E 30 or E 60,...	fire resistance class for the integrity E for 30, or 60... min in standard fire exposure;
$f_{ck}(\theta)$	characteristic value of compressive strength of concrete at temperature θ for a specified strain;
$f_{yk}(\theta)$	characteristic yield strength of reinforcing steel at temperature θ for a specified strain;
I 30 or I 60,...	fire resistance class for the thermal insulation I for 30, or 60... minutes in standard fire exposure;
$k(\theta) = X_k(\theta)/X_k$	reduction factor for a strength or deformation property, dependent on the material temperature θ;
M	mechanical action symbol to be supplemented to the desired R, E and/or I classification period when also mechanical actions are taken into account (e.g. EI-M 30, or EI-M 60…);
$R_{d,fi}$	design resistance in the fire situation; $R_{d,fi}(t)$ at a given time t;
R 30 or R 60,...	fire resistance class for the loadbearing capacity R for 30 min, or 60... min in standard fire exposure;
T	temperature in Kelvin (K) (cf. Θ temperature in °C);
t	time of fire exposure in minutes (min);
w	wall thickness;
$X_{d,fi}$	design strength or deformation property in the fire situation;
X_k	characteristic value of a strength or deformation property for normal temperature design;
$\gamma_{M,fi}$	partial safety factor for a material in fire design;
$\varepsilon_{s,fi}$	strain of the reinforcing steel at temperature θ;
λ	thermal conductivity in W/mK;
$\sigma_{c,fi}$	compressive stress of concrete in fire situation;
$\sigma_{s,fi}$	steel stress in fire situation;
θ	temperature in °C;
θ_{cr}	critical temperature in °C.

The following subscripts are used:

fi	value relevant for the fire situation;
t	dependent on the time;

θ dependent on the temperature.

C.1.5 Units

The following units are recommended for use in calculations:

temperature:	°C;
absolute temperature:	K;
temperature difference:	K;
specific heat:	J/kgK;
coefficient of thermal conductivity:	W/mK.

C.2 Basic principles

C.2.1 Performance requirements

(1)P For the standard fire exposure members shall comply with criteria R, E and I as follows:

- separating only: integrity (criterion E) and insulation (criterion I);
- loadbearing only: mechanical resistance (criterion R);
- separating and loadbearing: R, E and I;
- separating and mechanical action: E and I supplemented by criterion M;
- separating, loadbearing and mechanical action: R, E and I supplemented by criterion M;

(2) Criterion R is assumed to be satisfied where the loadbearing function is maintained during the required time of fire exposure.

(3) The assessment of criterion E is generally made on the basis of the following three aspects simultaneously:

- cracks or openings in excess of given dimensions;
- ignition of a cotton pad;
- sustained flaming on the non-exposed side.

(4) Criterion I may be assumed to be satisfied where the average temperature rise over the whole area of the unexposed surface is limited to 140 K (above the initial average temperature), and the maximum temperature rise at any point of that surface does not exceed 180 K.

(5) Where a vertical separating element with or without loadbearing function has to comply with impact resistance requirement (criterion M), the element should resist a horizontal concentrated load as specified in EN 1363-2.

C.2.2 Design values of material properties

(1)P Design values of material properties are recommended to be characteristic values, i.e. material safety factor in fire design $\gamma_{\mathrm{M,fi}} = 1{,}0$.

NOTE National provisions can require an other $\gamma_{\mathrm{M,fi}}$ – value.

C.2.3 Assessment methods

C.2.3.1 General

(1)P The model of the structural system adopted for design to this annex shall reflect the expected performance of the structure in fire.

(2)P The analysis for the fire situation may be carried out using one of the following:

- member analysis, see C.2.3.2;
- analysis of parts of the structure, see C.2.3.3;
- global structural analysis, see C.2.3.4.

(3) For verifying standard fire resistance requirements, a member analysis is sufficient.

(4) Tabulated data given in C.4.2 and simplified design methods in C.4.3 are based on the standard temperature-time curve.

(5) As an alternative to the use of calculation methods or tabulated data, design may be based on the results of tests or combination of tabulated data, calculation and test results.

C.2.3.2 Member analysis

(1) The restraint conditions at supports and ends of members applicable at time $t = 0$ may generally be assumed to remain unchanged throughout the fire exposure.

(2) Only the effects of thermal deformations resulting from thermal gradients across the cross-section need to be considered. The effects of thermal expansion of the members may be neglected.

(3) Tabulated data or simplified methods given in C.4.2 and C.4.3, respectively, are suitable for verifying members under fire conditions.

C.2.3.3 Analysis of parts of the structure

(1) The parts of the structure to be analysed should be specified on the basis of the potential thermal expansions and deformations such, that their interaction with other parts of the structure can be approximated by time-independent support and boundary conditions during fire exposure.

(2)P Within the part of the structure to be analysed, the relevant failure mode in the fire exposure, the temperature-dependent material properties and member stiffnesses, effects of thermal expansion and deformations (indirect fire actions) shall be taken into account.

(3) The boundary conditions at supports and forces and moments at boundaries of part of the structure may be assumed to remain unchanged throughout the fire exposure.

C.2.3.4 Global structural analysis

(1)P When global structural analysis of the fire situation is carried out, the relevant failure mode in fire exposure, the temperature-dependent material properties and member stiffness, effects of thermal expansion and deformations (indirect fire actions) shall be taken into account.

C.3 Material properties

C.3.1 General

(1)P In fire conditions the temperature-dependent properties shall be taken into account.

(2) The material properties at 20 °C should be assessed according to Clause 4.

(3) The mass of AAC may be considered to be independent of the temperature in the material.

(4) Values for the reduction of the characteristic compressive strength of AAC and of the characteristic strength of reinforcing steel are given in this section. They may be used with the simplified design methods.

(5) The material models given in C.3.2 and C.3.3 should only be applied for heating rates similar to those appearing under standard fire exposure until the time of the maximum temperature.

(6) Alternative formulations of material laws (e.g. for parametric fires) may be applied, provided solutions are within the range of appropriate experimental evidence.

(7) The standard fire conditions are defined between 20 °C and 1 200 °C, the properties are also defined between the same limits.

(8) Additional information on material properties at elevated temperature are given in Annex CA.

C.3.2 AAC

(1) The reduction of the characteristic compressive strength of AAC as a function of the temperature θ is taken into account according to Formula (C.1).

$$f_{\mathrm{ck}}(\theta)=k_{\mathrm{c}}(\theta)\,f_{\mathrm{ck}}(20^{\circ}\mathrm{C}) \tag{C.1}$$

(2) In the absence of more accurate information the coefficient $k_{\mathrm{c}}(\theta)$ may be taken from Figure C.1.

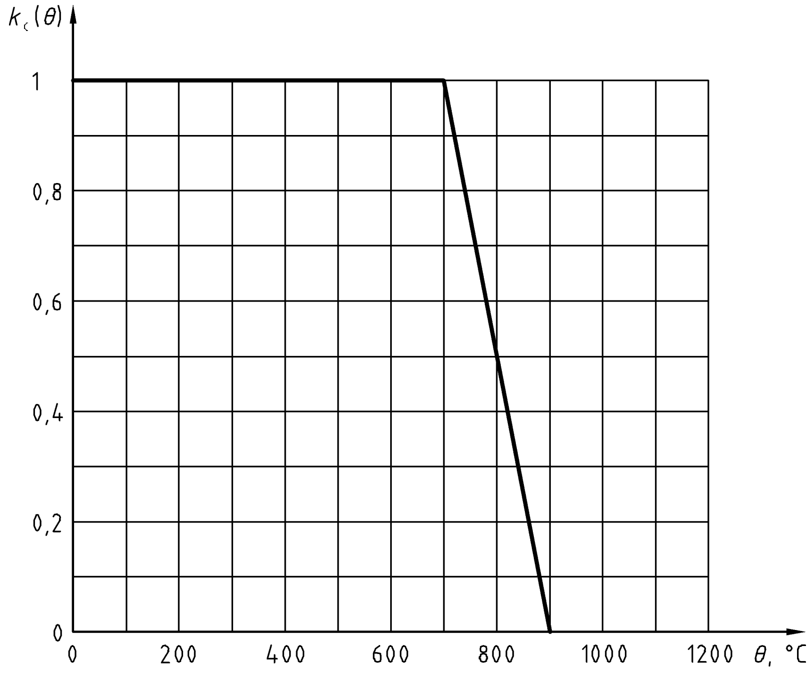


Figure C.1 — Coefficient $k_{\mathrm{c}}(\theta)$ allowing for decrease of compressive strength, f_{ck}, of AAC at elevated temperature

(3) The thermal strain $\varepsilon_{\mathrm{c}}(\theta)$ of AAC at elevated temperature may be determined as follows:

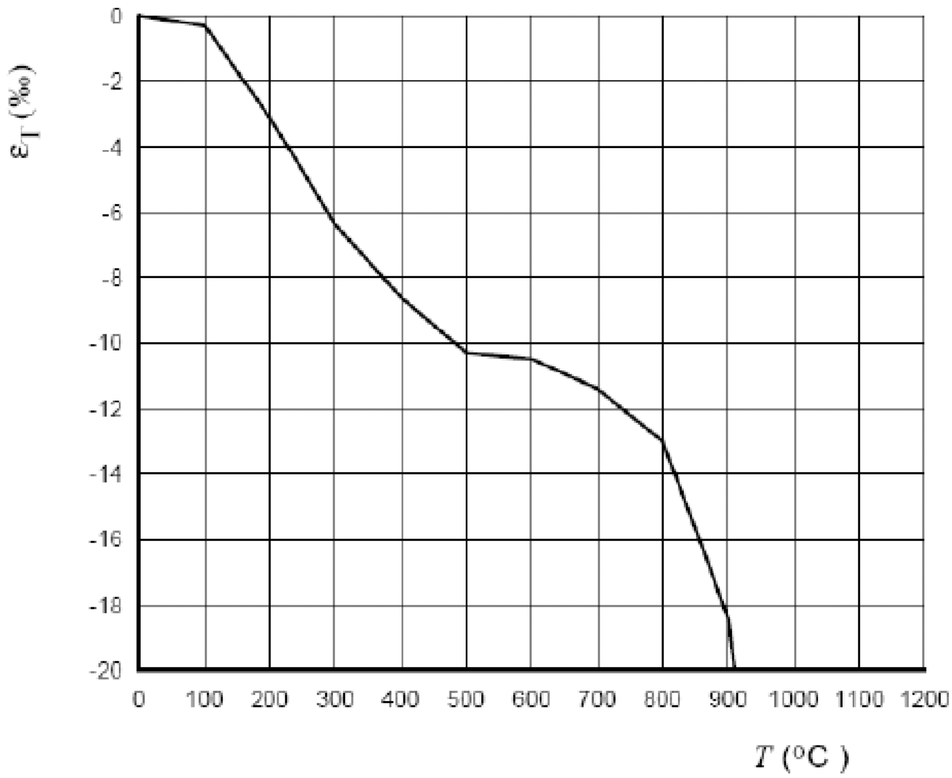


Figure C.2 — Thermal strain of AAC at elevated temperature

NOTE Thermal strain i.e. thermal elongation $\varepsilon_c = \Delta l/l$ where Δl is the length change and l is the total length.

(4) The specific heat of AAC may be considered independent of the temperature in the material. The value is given in 4.2.12.

(5) In the absence of test results, the thermal conductivity of AAC at elevated temperature may be determined from Table C.1:

Table C.1 — Thermal conductivity of AAC $\lambda(\theta)$ at elevated temperature

λ (θ) in W/mK

Temperature °C	**Mean dry density of AAC** kg/m^3			
	300	400	500	600
20 (Room temperature)	0,08	0,10	0,12	0,15
300	0,11	0,12	0,14	0,17
600	0,18	0,19	0,20	0,20
900	0,27	0,28	0,28	0,28
NOTE Intermediate values may be obtained by interpolation.				

C.3.3 Steel

(1) The reduction of the characteristic yield strength of reinforcing steel, f_{yk}, as a function of the temperature θ is taken into account by the coefficient $k_s(\theta)$ according to Formula C.2.

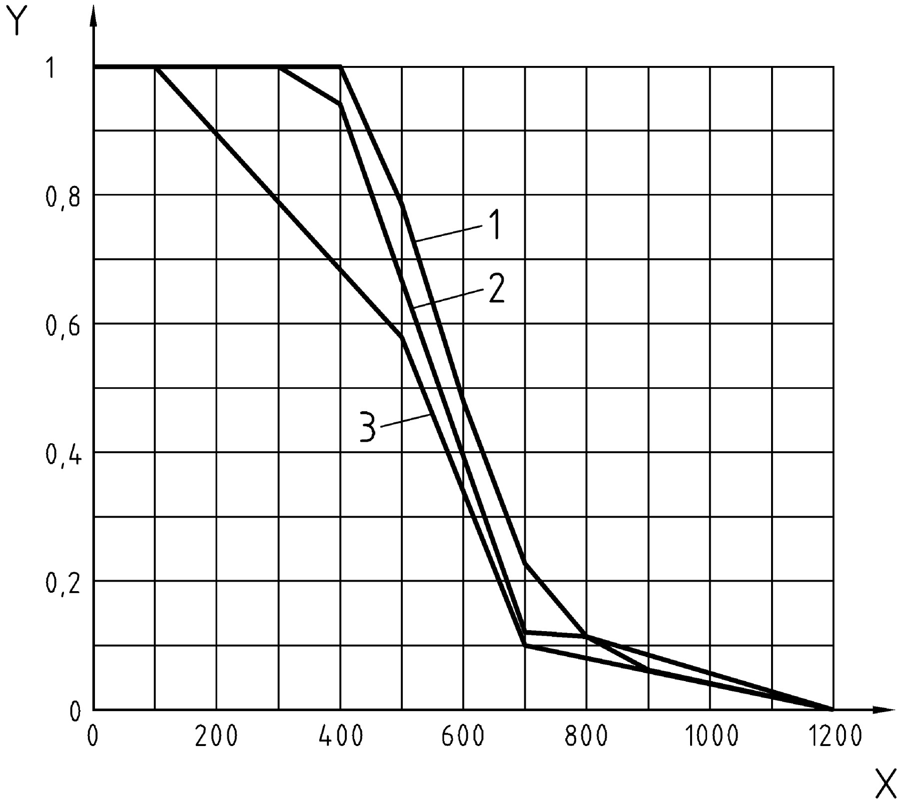
$$f_{yk}(\theta)=k_s(\theta)f_{yk}(20°C) \qquad (C.2)$$

(2) Where $k_S(\theta)$ is taken from documented data it should be derived from tests performed under constant stress and variable temperature (transient tests).

(3) In the absence of more accurate information the $k_S(\theta)$ values given in Figure C.3 may be used for reinforcement.

— For tension reinforcement of floor and roof components and beams where $\varepsilon_{S,fi} \geq 2$ %, the $k_S(\theta)$ values may be taken from Figure C.3, curve 1 for hot rolled steel and curve 2 for cold worked steel.

— For compression reinforcement in columns and compressive zones of beams and slabs the $k_S(\theta)$ values at 0,2 % proof strain may be taken from Figure C.3, curve 3. This also applies for tension reinforcement where $\varepsilon_{S,fi} < 2$ % when using the simplified calculation method.



Key

X	θ [° C]
Y	$K_S(\theta)$
Curve 1	Tension reinforcement (hot rolled) for strains $\varepsilon_{S,fi} \geq 2{,}0$ %
Curve 2	Tension reinforcement (cold worked) for strains $\varepsilon_{S,fi} \geq 2{,}0$ %
Curve 3	Compression reinforcement and tension reinforcement for strains $\varepsilon_{S,fi} < 2{,}0$ %

Figure C.3 — Coefficient $K_S(\theta)$ allowing for decrease of characteristic strength f_{yk} of tension and compression reinforcement

(4) For reinforcing steel, the thermal strain $\varepsilon_S(\theta)$ at elevated temperature may be determined from the following with reference to the length at 20 °C:

$$\varepsilon_s(\theta) = -2{,}416 \times 10^{-4} + 1{,}2 \times 10^{-5}\,\theta + 0{,}4 \times 10^{-8}\,\theta^2 \quad \text{for } 20\ °\text{C} \le \theta \le 750\ °\text{C}$$

$$\varepsilon_s(\theta) = 11 \times 10^{-3} \quad \text{for } 750\ °\text{C} \le \theta \le 860\ °\text{C} \qquad (\text{C.3})$$

$$\varepsilon_s(\theta) = -6{,}2 \times 10^{-3} + 2 \times 10^{-5}\,\theta \quad \text{for } 860\ °\text{C} \le \theta \le 1\,200\ °\text{C}$$

C.4 Structural fire design methods

C.4.1 General

(1)P The following design procedures may be used:

a) detailing according to recognized design solutions (tabulated data), see C.4.2;

b) simplified design methods for specific types of members, see C.4.3.

(2) Protective layers, see C.5, may be taken into account when using tabulated data or calculation methods.

C.4.2 Tabulated data

C.4.2.1 General

(1) Instead of using more precise methods for structural fire design, tabulated data according to C.4.2.3 to C.4.2.5 may be applied.

The tables are valid for the standard fire exposure (standard temperature-time curve) as defined in C.1.3.14.

(2) The tables have been developed on an empirical basis confirmed by calculation, experience and theoretical evaluation of tests.

(3) Unless stated otherwise no further checks are required at elevated temperature except the verification of anchorage capacity of reinforcement which shall be done according to C.4.4.

C.4.2.2 General design rules

(1) Requirements for integrity E and insulation I may be considered to be satisfied if the minimum thickness of walls or slabs is according to Tables C.2, C.3 or C.4 and if the joints are according to informative Annex CB. Fire resistance of structures having connections or openings going through the walls or slabs shall be considered separately.

(2) For loadbearing capacity R the minimum requirements concerning section sizes and heat protection (axis distance a) of reinforcing bars have been set up in the tables so that

$$E_{\mathrm{d,fi}} / R_{\mathrm{d,fi}} \le 1{,}0 \qquad (\text{C.4})$$

where

$E_{\mathrm{d,fi}}$ is the design effect of actions in the fire situation;

$R_{\mathrm{d,fi}}$ is the design loadbearing capacity (resistance) in the fire situation.

(3) The tables are based on a critical steel temperature of θ_{cr} = 600 °C.

(4) Symbols used in the tables are defined in Figure C.4.

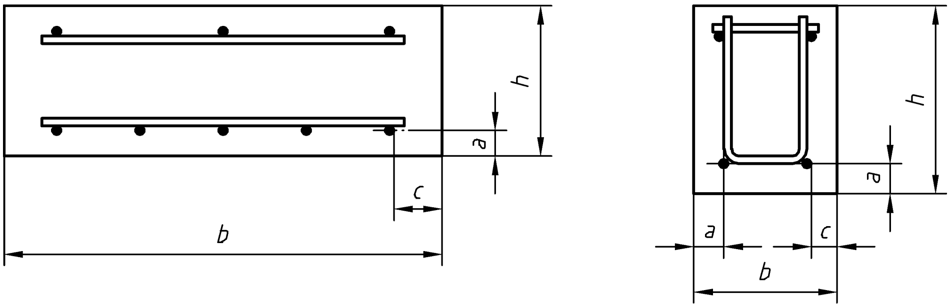


Figure C.4 — Sections of AAC components showing nominal axis distance *a* and nominal concrete cover *c* of reinforcement

C.4.2.3 Walls

C.4.2.3.1 Non-loadbearing walls (partitions)

(1) The minimum wall thickness should not be less than the values given in Table C.2 for resistance to fire EI.

(2) To avoid excessive thermal deformations and subsequent failure of integrity between walls, the ratio of clear height of wall to wall thickness (L/h) should not exceed 40 for vertical wall components.

Table C.2 — Minimum wall thickness of non loadbearing AAC walls with a dry density between 350 kg/m^3 and 700 kg/m^3

Standard fire resistance	Minimum wall thickness mm
EI 30	50
EI 60	50
EI 90	75
EI 120	75
EI 180	100
EI 240	150
EI 360	150

C.4.2.3.2 Loadbearing walls

(1) Minimum dimensions and minimum axis distances should not be less than the values given in Table C.3a and Table C.3b for resistance to fire REI or R.

(2) To avoid excessive thermal deformations and subsequent failure of integrity between walls, the ratio of clear height of wall to wall thickness (L/h) should not exceed 30 for vertical wall components.

Table C.3a — Minimum wall thickness and axis distance a_{min} for separating loadbearing AAC walls. AAC dry density 350 kg/m^3 to 700 kg/m^3 and structural or non-structural reinforcement for resistance to fire REI

Standard fire resistance	Non-structural reinforced wall components Minimum wall thickness mm	Structural reinforced wall components Minimum wall thickness/ minimum axis distance a_{min} mm
REI 30	100	100/10
REI 60	100	100/15
REI 90	100	125/20
REI 120	100	150/25
REI 180	150	175/30
REI 240	200	200/35

Table C.3b — Minimum wall thickness and minimum axis distance a_{min} for non separating loadbearing AAC walls supported on at least two opposite ends of the components. AAC dry density 350 kg/m^3 to 700 kg/m^3 and structural or non-structural reinforcement for resistance to fire R

Standard fire resistance	Non structural reinforced wall components Minimum wall Thickness mm	Structural reinforced wall components Minimum wall thickness/ minimum axis distance a_{min} mm
R 30	100	100/10
R 60	100	125/15
R 90	125	150/20
R 120	150	175/25
R 180	175	200/30
R 240	200	250/35

C.4.2.4 Beams

(1) Minimum dimensions and minimum axis distances in relation to the maximum span length should not be less than the values given in Table C.4 for resistance to fire R when beams are designed as simply supported.

(2) The table applies for beams which can be exposed to fire on three sides and not on the upper side.

Table C.4 — Minimum dimensions (height h_{min} and width b_{min}) in mm and minimum axis distance a_{min} in mm to the bottom side and to the vertical sides of AAC beams in relation to the maximum span length

Minimum density in kg/m^3								450	550	650
Minimum dimensions in mm		h_{min}			b_{min}			a_{min}		
Maximum span length in m		2	4	6	2	4	6			
Fire Resistance	R 30	150	200	250	100	200	200	20	20	20
	R 60	175	200	300	100	200	250	30	25	20
	R 90	200	250	300	200	250	300	50	40	30

C.4.2.5 Floor and roof components

(1) Minimum dimensions and minimum axis distances in relation to the maximum span length should not be less than the values given in Table C.5 for resistance to fire REI when reinforced floor and roof components are designed as simply supported one way slabs.

Table C.5 — Minimum thickness h_{min} in mm and minimum axis distance a_{min} in mm of AAC floor and roof components in relation to maximum span length

Minimum density 350 kg/m^3								
Maximum span length	3 m		4,5 m		6 m		7,5 m	
Fire resistance	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}
REI 30	100	15	150	15	175	20	240	20
REI 60	100	25	150	25	200	25	240	35
REI 90	150	45	150	45	200	45	240	45
REI 120	175	50	175	55	200	55	240	55
Minimum density 450 kg/m^3								
Maximum span length	3 m		4,5 m		6 m		7,5 m	
Fire resistance	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}
REI 30	100	15	150	15	175	15	240	20
REI 60	100	22	150	22	200	22	240	30
REI 90	150	35	150	35	200	35	240	35
REI 120	175	40	175	45	200	45	240	45
Minimum density 550 kg/m^3								
Maximum span length	3 m		4,5 m		6 m		7,5 m	
Fire resistance	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}
REI 30	100	15	150	15	175	15	240	15
REI 60	100	20	150	20	200	20	240	20
REI 90	150	30	150	30	200	30	240	30
REI 120	175	35	175	35	200	35	240	35
Minimum density 700 kg/m^3								
Maximum span length	3 m		4,5 m		6 m		7,5 m	
Fire resistance	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}	h_{min}	a_{min}
REI 30	100	15	150	15	175	15	240	15
REI 60	100	20	150	20	200	20	240	20
REI 90	150	25	150	25	200	25	240	25
REI 120	175	30	175	30	200	30	240	35
NOTE Interpolation between dry densities may be used.								

C.4.3 Simplified design methods

C.4.3.1 Calculation methods for resistance to fire R

C.4.3.1.1 General

(1) The calculation methods described below determine the ultimate loadbearing capacity of a structure at elevated temperature having reduced material properties which are defined based on the temperature profile of the cross-section.

(2) The methods are based on the assumption that AAC exposed to more than 800 °C does not contribute to the loadbearing capacity, while AAC with lower temperature can be assumed to retain its normal temperature strength. Reduced steel strength according to Formula (C.2) can be used in calculation of loadbearing capacity only when steel temperature is ≤ 500 °C. Steel with a temperature > 500 °C is not be taken into account.

(3) The methods are applicable to structures subjected to a standard fire exposure until the maximum gas temperature is reached.

(4) In addition, it should be verified that the anchorage capacity of reinforcement is adequate according to C.4.4.

(5) The strength reduction factor α for the consideration of long term effects on the compressive strength of AAC (see A.3.2) can be assumed to be 1,0 in fire design.

C.4.3.1.2 Temperature profiles

(1) Temperatures in a AAC structure exposed to fire may be determined from tests or by calculation. Without more accurate information from the manufacturer the typical temperature profiles of AAC based on standard fire exposure presented in Annex CC may be used in design.

(2) It is assumed that the isotherms of a rectangular cross-section are parallel with the sides except corners.

C.4.3.1.3 Zone method with or without taking deformations into account

(1)P For loadbearing AAC components exposed to fire where both strength and deformation properties influence the loadbearing capacity, the effect from second order strain and other thermal induced strain shall be considered.

(2) The total strain may be assumed:

$$\varepsilon = \varepsilon_{\mathrm{th}} + \varepsilon_{\sigma} + \varepsilon_{\mathrm{cr}} + \varepsilon_{\mathrm{sh}} + \varepsilon_{\mathrm{tr}}$$

where

$\varepsilon_{\mathrm{th}}$ thermal strain;

ε_{σ} instantaneous stress dependent strain;

$\varepsilon_{\mathrm{cr}}$ creep strain;

$\varepsilon_{\mathrm{sh}}$ thermal induced shrinkage strain;

$\varepsilon_{\mathrm{tr}}$ transient state of strain;

NOTE 1 For AAC components the creep $\varepsilon_{\mathrm{cr}}$ may normally be neglected in comparison to the other thermal strain effects.

NOTE 2 Transient strain is a strain caused by thermal micro cracking on fire exposed AAC, which due to compression will diminish the thermal expansion, see Formula (C.5).

(3)P When determining the loadbearing capacity of AAC components exposed to fire taking deformations into account, changes of modulus of elasticity with temperature shall be considered.

(4) The temperature dependency of the modulus of elasticity may be estimated from Table CA.1 in Annex CA.

(5) The transient strain depends on the temperature level and compression stress, and may be expressed as a function of the thermal induced strain, noting that it is acting the opposite way:

$$\varepsilon_{\mathrm{tr}} = -2{,}35 \frac{\sigma}{f_{\mathrm{cd}20^\circ}} \varepsilon_{\mathrm{th}} \tag{C.5}$$

(6) The strain caused by thermal induced shrinkage in AAC may be expressed as a function of the thermal induced strain and the temperature, noting that it is acting the opposite way:

$$\varepsilon_{\mathrm{sh}} = -0{,}5 \cdot \sqrt{\frac{\theta_{\mathrm{M}} - \theta_0}{\theta_0}} \cdot \varepsilon_{\mathrm{th}} \tag{C.6}$$

where

θ_{M} is the temperature at point M;

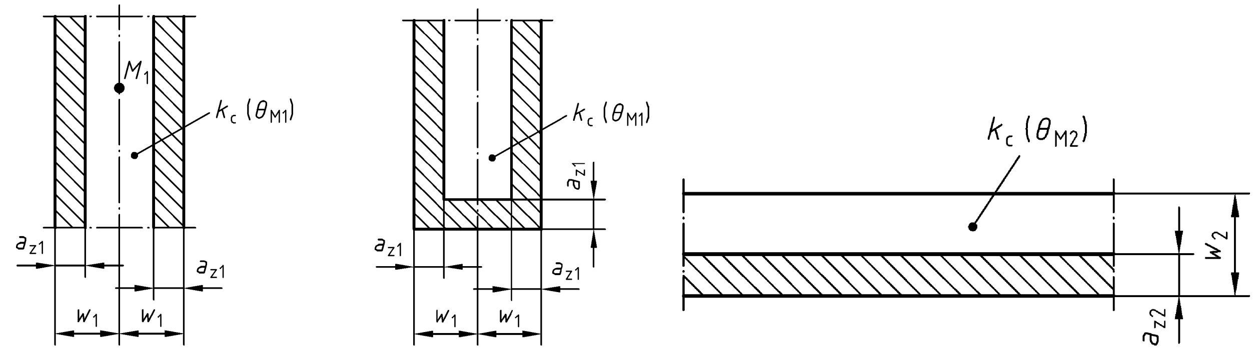
θ_0 is the reference temperature put equal to 20 °C.

(7) In the following a method called the zone method to determine the loadbearing capacity for AAC components taking deformation into account is given. The method is applicable to the standard temperature-time curve only.

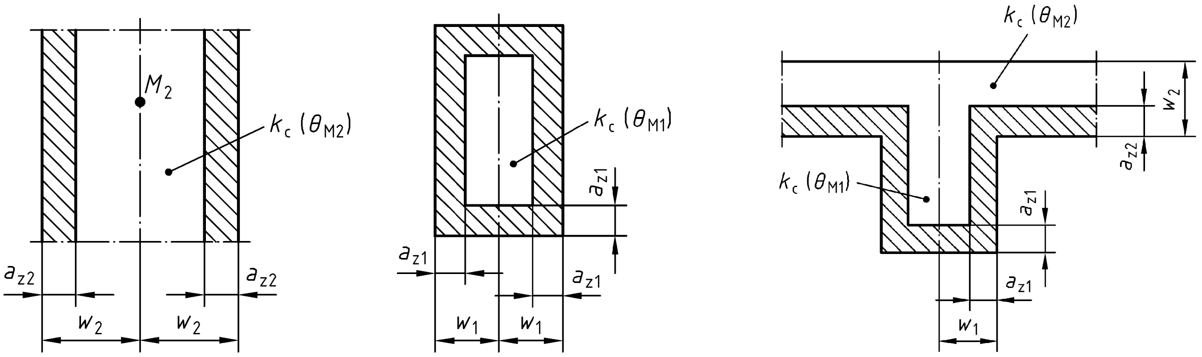
(8) The fire exposed cross-section is divided into a number ($n \geq 3$) of parallel zones of equal thickness (rectangular elements) where the mean temperature and the corresponding mean compressive strength f_{cd} and modulus of elasticity of each zone is assessed.

(9) The fire damaged cross-section is represented by a reduced cross-section ignoring a damaged zone of thickness a_{z} at the fire exposed sides, see Figure C.5. Reference is made to an equivalent wall, see Figure C.5 (a) and (d). The point M is an arbitrary point on the centre line of the equivalent wall used to determine the reduced compressive strength for the whole of the reduced cross-section. When two opposite sides are exposed to fire the width is assumed to be $2w$, see Figure C.5 (a). For a rectangular wall exposed to fire on one face only, the width is assumed to be w, see Figure C.5 (c). This is modelled by designing a wall exposed to fire on both sides with a width equal to $2w$, see Figure C.5 (d).

(10) For the bottom and ends of rectangular members exposed to fire, where the width is less than the height, the value of a_{z} is assumed to be the same as the calculated values for the sides, Figure C.5 (b),(e),(f).



a) (wall) **b) (wall end)** **c) (slab)**



d) (thick wall) **e) (column)** **f) (beam)**

Figure C.5 — Reduction of strength and cross-section for sections exposed to fire

(11) The damage zone, a_Z, is estimated as follows for an equivalent wall exposed on both sides:

a) The half thickness of the wall is divided into n parallel zones of equal thickness, where $n \geq 3$, see Figure C.6.

b) The temperature is calculated for the middle of each zone.

c) The corresponding compressive strength reduction, $k_c(\theta_n)$, is determined, see C.3.2.

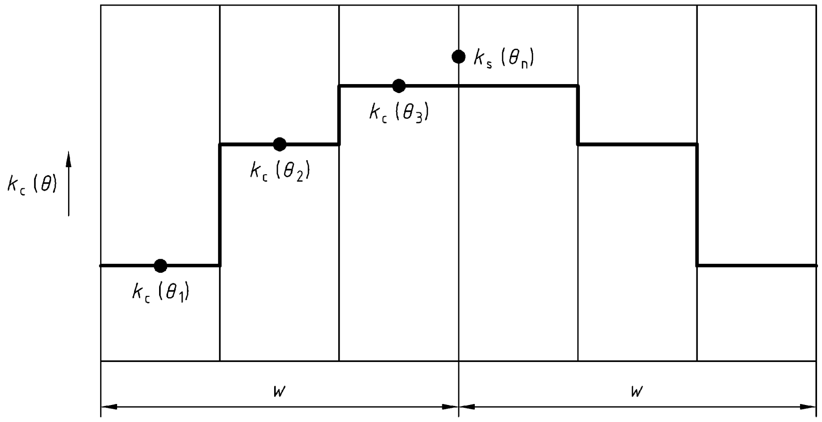


Figure C.6 — Division of a wall, with both sides exposed to fire, into zones for use in calculation of strength reduction and a_Z values

(12) The mean reduction coefficient for a particular zone, incorporating a factor $(1 - 0{,}2/n)$ which allows for the variation in temperature within each zone, may be calculated by:

$$k_{\mathrm{c,m}} = \frac{(1-0{,}2/n)}{n}\sum_{1}^{n} k_{\mathrm{c}}(\theta_{\mathrm{i}}) \tag{C.7}$$

where $k_{\mathrm{c}}(\theta_{\mathrm{i}})$ is the strength reduction factor, see C.3.2.

(13) The width of the damaged zone for beams, slabs or members in plane shear may be calculated by:

$$a_{\mathrm{z}} = w\left[1-\frac{k_{\mathrm{c,m}}}{k_{\mathrm{c}}(\theta_{\mathrm{M}})}\right] \tag{C.8}$$

where $k_{\mathrm{c}}(\theta_{\mathrm{M}})$ denotes the reduction coefficient for AAC at point M.

(14) For columns, walls and other constructions, where second order effects have to be considered, a_{z} may be calculated by:

$$a_{\mathrm{z}} = w\left[1-\left(\frac{k_{\mathrm{c,m}}}{k_{\mathrm{c}}(\theta_{\mathrm{M}})}\right)^{1{,}3}\right] \tag{C.9}$$

(15) When the reduced cross-section is found the loadbearing capacity and deformations may be determined, assuming that the average strength and average modulus of elasticity in the whole cross section is given as the reduced strength and modulus of elasticity at point M, see Formula (C.10). The fire design then follows the cold design procedure using Annex A.

$$\begin{aligned} f_{\mathrm{c,M}} &= k_{\mathrm{c}}(\theta_{\mathrm{M}}) f_{\mathrm{c20}} \\ E_{\mathrm{c,M}} &= k_{\mathrm{E}}(\theta_{\mathrm{M}}) E_{\mathrm{c20}} \end{aligned} \tag{C.10}$$

where $k_{\mathrm{E}}(\theta_{\mathrm{M}})$ is the reduction factor for the modulus of elasticity at point M and $k_{\mathrm{c}}(\theta_{\mathrm{M}})$ is the strength reduction factor at point M.

C.4.3.1.4 Simplified zone method without taking deformations into account

(1) This method is applicable where deformation properties are not relevant for the verification of loadbearing capacity. Only the strength reduction at elevated temperature is taken into account.

(2) The procedure is first to determine the strength of reinforcement at elevated temperature. The strength properties of AAC at normal temperature can be used in design when the AAC cross-section is reduced from fire exposed surfaces in accordance with Table C.6. The ultimate loadbearing capacity of the structure in fire situation is calculated in accordance of Annex A, with the reduced cross-section using the strength properties of reinforcement at elevated temperature and strength properties of AAC at normal temperature.

(3) The strength of reinforcement at elevated temperature is determined from Figure C.3 when the critical temperature of the reinforcing steel is known. The critical temperature of the reinforcing steel can be determined from the temperature profile based on the required fire resistance time and the nominal axis distance of the reinforcing bar.

Table C.6 — Reduction of the dimensions of AAC cross-section from fire exposed surfaces

Fire resistance class min	**Reduction of the dimensions of AAC cross-section** mm			
	AAC dry density			
	≥ 300 kg/m^3	**≥ 400 kg/m^3**	**≥ 500 kg/m^3**	**≥ 600 kg/m^3**
R30	0	0	0	0
R60	10	10	5	5
R90	15	15	10	10
R120	25	20	15	10
R180	40	30	25	20

C.4.3.2 Verification of resistance to fire E

(1) For a specified fire resistance class the integrity E can be considered adequate when the joint details and the minimum thickness of wall, floor or roof components are according to informative Annex CB.

C.4.3.3 Verification of resistance to fire I

(1) For a specified fire resistance class the insulation I can be considered adequate when it is verified, based on the temperature profile, that the average temperature rise on the unexposed face is limited to 140 K above the initial average temperature, with the maximum temperature rise at any point limited to 180 K above the initial average temperature.

C.4.4 Anchorage

(1) The anchorage capacity of reinforcement may be calculated according to A.10 using reduced temperature related material properties. The bond along the longitudinal bars shall be neglected unless this property at relevant elevated temperature is declared by the manufacturer.

C.5 Protective layers

(1)P Required fire resistance may also be obtained by the application of protective layers.

(2) The properties and performance of the material for protective layers should be assessed by tests.

Annex CA
(informative)

Modulus of elasticity and maximum strain of AAC and reinforcing steel at elevated temperature

(1) Modulus of elasticity $E_{\mathrm{c}}(\theta)$ and strain $\varepsilon_{\mathrm{c1}}(\theta)$ in compression of AAC at maximum stress, see Figure CA.1, can be determined from Table CA.1.

Table CA.1 —Values for the parameters of stress-strain relationship of AAC in compression at elevated temperature

AAC temperature °C	$E_{\mathrm{c}}(\theta)$ / E_{c} (20 °C)	$\varepsilon_{\mathrm{c1}}(\theta)$ ‰
20	1,0	3,5
150	0,80	4,0
250	0,60	6,0
350	0,48	10
450	0,33	15
550	0,22	20
650	0,10	35
750	0,07	50

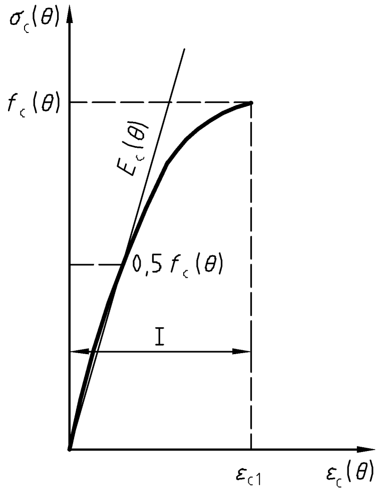


Figure CA.1 — Stress-strain relationship of AAC under compression at elevated temperature

(2) Modulus of elasticity $E_{\mathrm{s}}(\theta)$ and strain $\varepsilon_{\mathrm{s2}}(\theta)$ of reinforcing steel at maximum stress, see Figure CA.2, can be determined from Table CA.2.

Table CA.2 — Values for the parameters of stress-strain relationship of reinforcing steel at elevated temperature

a) Hot rolled reinforcing steel (e.g. class B or C according to EN 1992–1-1**)**		
Steel temperature °C	$E_S(\theta)$ / E_S (20 °C)	$\varepsilon_{S2}(\theta)$ %
20	1,0	1
100	1,0	15
200	0,90	15
300	0,80	15
400	0,70	15
500	0,60	15
600	0,31	15
700	0,13	15
b) Cold worked reinforcing steel (e.g. class A according to EN 1992–1-1**)**		
Steel temperature °C	$E_S(\theta)$ / E_S (20 °C)	$\varepsilon_{S2}(\theta)$ %
20	1,0	1
100	1,0	5
200	0,87	5
300	0,72	5
400	0,56	5
500	0,40	5
600	0,24	5
700	0,08	5

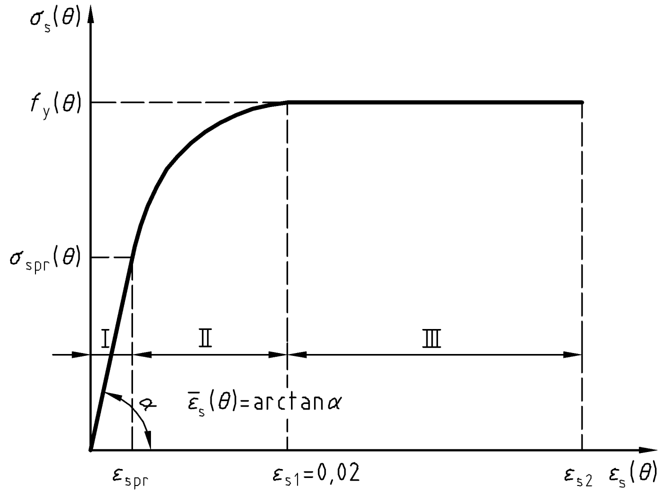


Figure CA.2 — Stress-strain relationship of reinforcing steel at elevated temperature

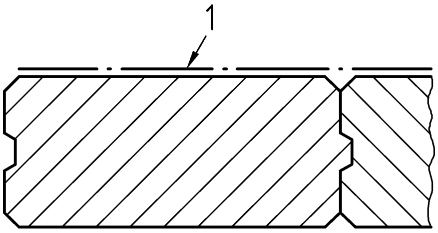
Annex CB
(informative)

Joints between AAC components satisfying resistance to fire E

CB.1 Floor and roof components with dry joints

(1) When tightly connected components with dry joints (maximum joint gap ≤ 2 mm) are used (see e.g. Figure CB.1) and the thickness of the floor or roof components satisfies the minimum thickness requirement given in Table C.6 or the calculated thickness based on C.4.3.1.3 for the relevant standard fire resistance period, the integrity E can be considered satisfied up to E60 on the condition that the movement of air through the joint is prevented, e.g. by a cover.

(2) When the structure includes mineral topping with a thickness ≥ 5 mm, preventing free air flow, the integrity E can be considered satisfied up to E120.



Key

1 Topping

Figure CB.1 — Example of a dry joint in structures made of floor or roof components with cover (e.g. topping) preventing movement of air through the joint

CB.2 Floor and roof components with mortar joints

(1) When the components are connected by mortar joints (see e.g. Figure CB.2) and the thickness of the floor or roof components satisfies the minimum thickness requirement given in Table C.6 or the calculated thickness based on C.4.3.1.3 for the relevant standard fire resistance period, the integrity E can be considered satisfied up to E120.

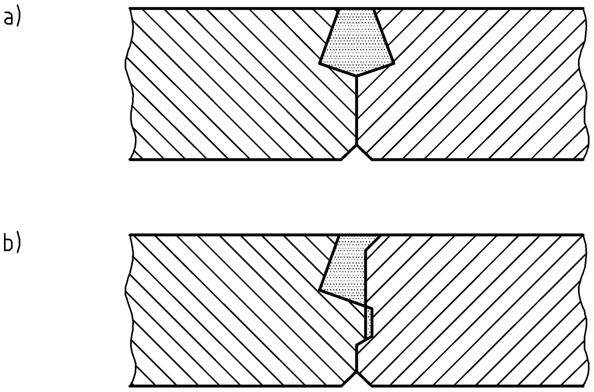
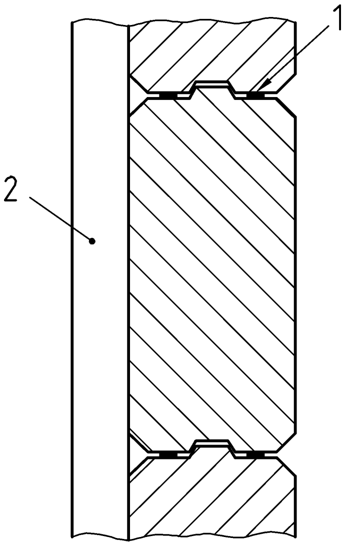


Figure CB.2 — Examples of mortar joints in structures made of floor or roof components

CB.3 Vertical and horizontal wall components with dry joints

When dry joints with two sealing strips are used (see e.g. Figure CB.3) and the thickness of the wall components satisfies the minimum thickness requirement given in Table C.2 for the relevant standard fire resistance period, the integrity E can be considered satisfied up to E360.



Key

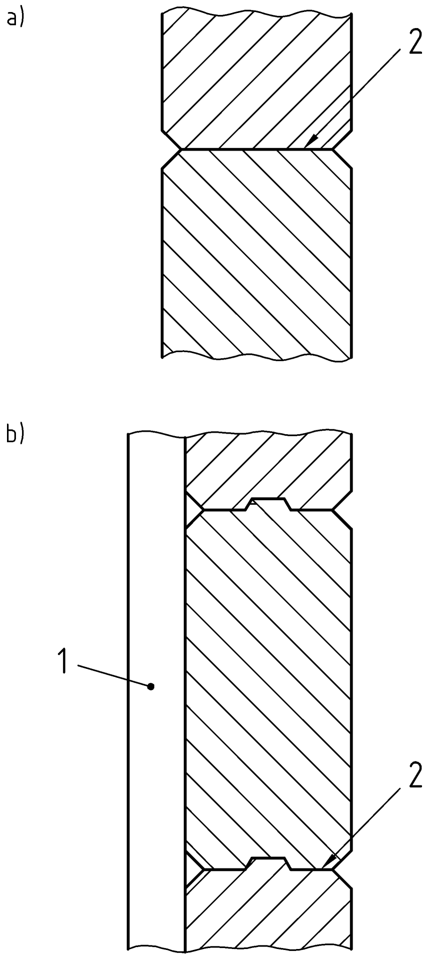
1 Sealing strip

2 Supporting structure

Figure CB.3 — Example of dry joints with two sealing strips in structures made of horizontal wall components

CB.4 Vertical and horizontal wall components with mortar joints

When thin layer mortar joints (see e.g. Figure CB.4) or mortar in grooved joints are used and the thickness of the wall components satisfies the minimum thickness requirement given in Table C.2 for the relevant standard fire resistance period, the integrity E can be considered satisfied up to E240 for vertical wall components and up to E360 for horizontal wall components.



Key

1	Supporting structure
2	Thin layer mortar joint

Figure CB.4 — Examples of thin layer mortar joints in structures made of vertical or horizontal wall components

Annex CC
(normative)

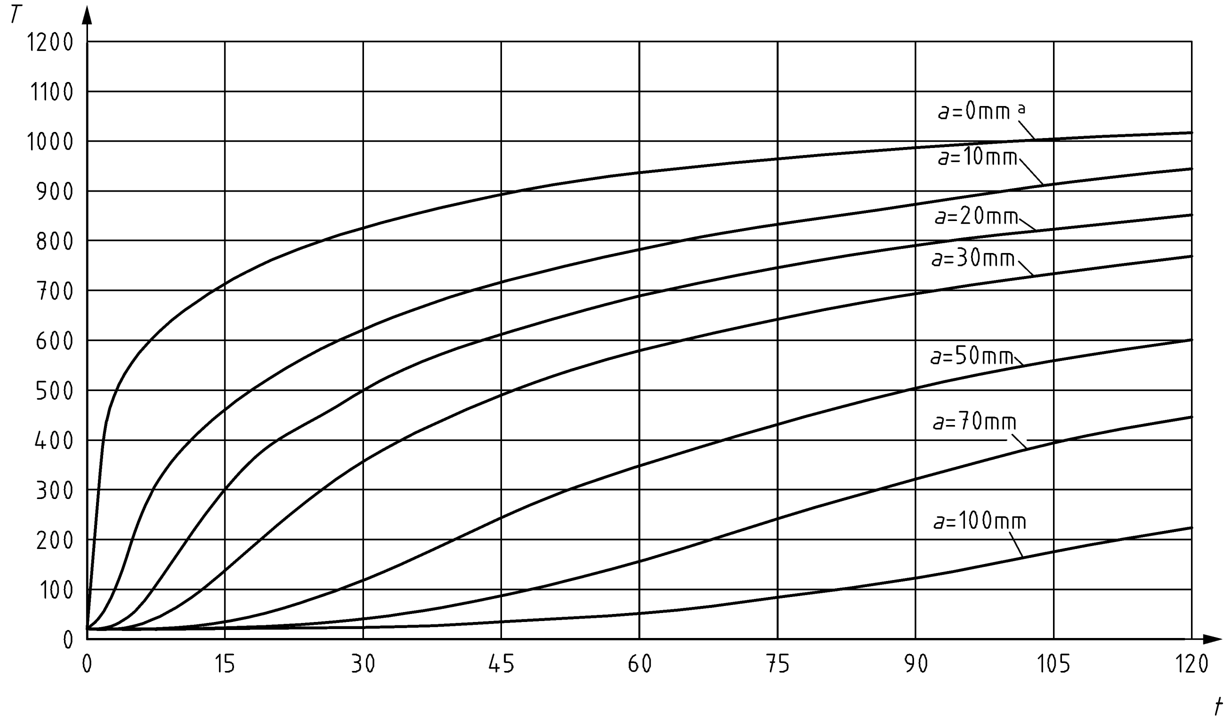
Temperature profiles of AAC wall, floor and roof components and AAC beams

CC.1 Basis of temperature profiles

(1) The temperature profiles have been determined by calculation. They have been verified by tests in different countries. The calculations are based on the assumptions indicated in CC.4.

CC.2 Temperature profiles for AAC wall, floor and roof components

(1) Typical temperature profiles for AAC wall, floor and roof components with a mass related moisture content of ≥ 2 % are presented in Figures CC.1 to CC.4 for different AAC densities. Curves are valid for fire resistance times up to 120 min and are based on standard fire exposed on one side. The temperature profiles of a point inside a component are calculated using 250 mm thickness for AAC component but they are also applicable for other component thicknesses.



Key

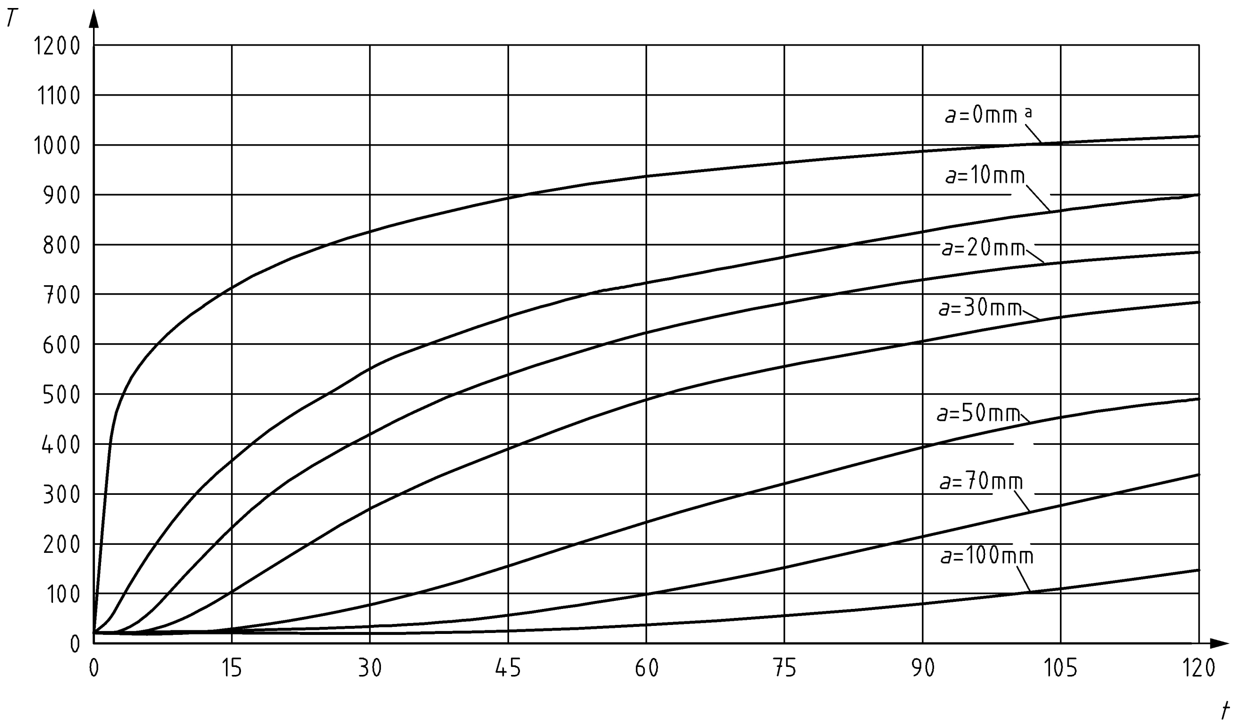
a distance from the exposed surface

t time in min

T Temperature in °C

NOTE Standard temperature-time curve (see C.1.3.14)

Figure CC.1 — Temperature profiles for AAC wall, floor and roof components with a dry density of 300 kg/m^3



Key

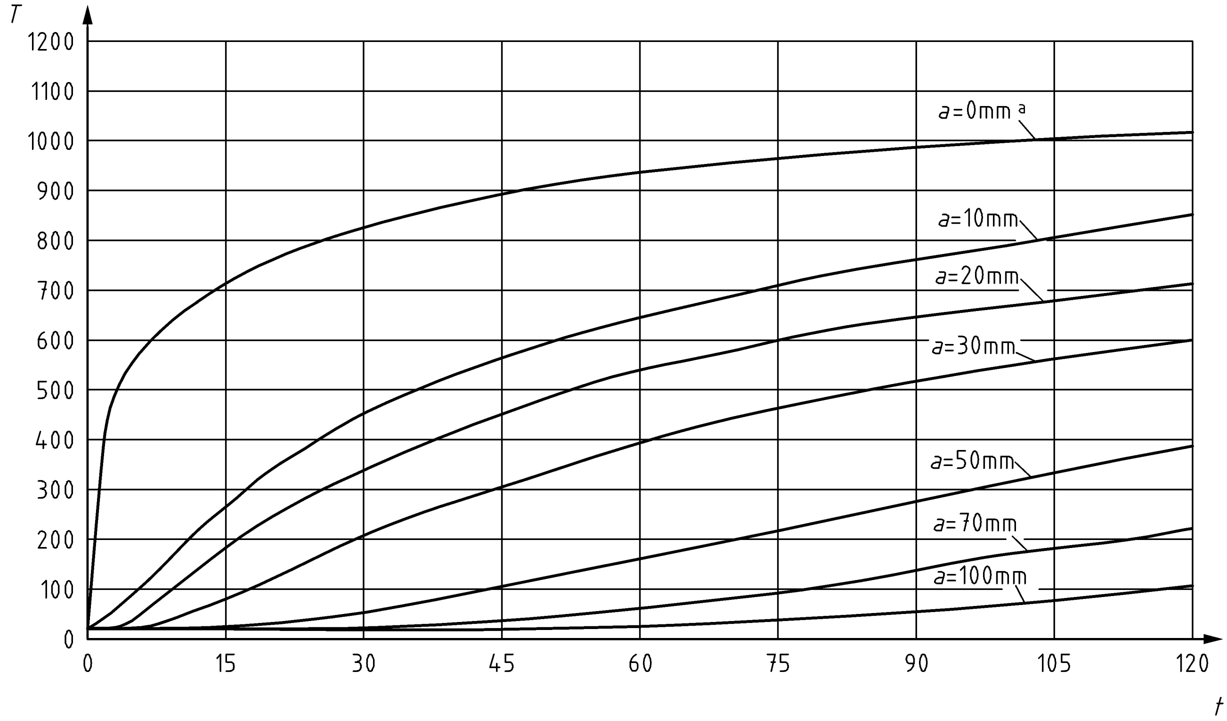
a distance from the exposed surface

t time in min

T Temperature in °C

NOTE Standard temperature-time curve (see C.1.3.14)

Figure CC.2 — Temperature profiles for AAC wall, floor and roof components with a dry density of 400 kg/m^3



Key

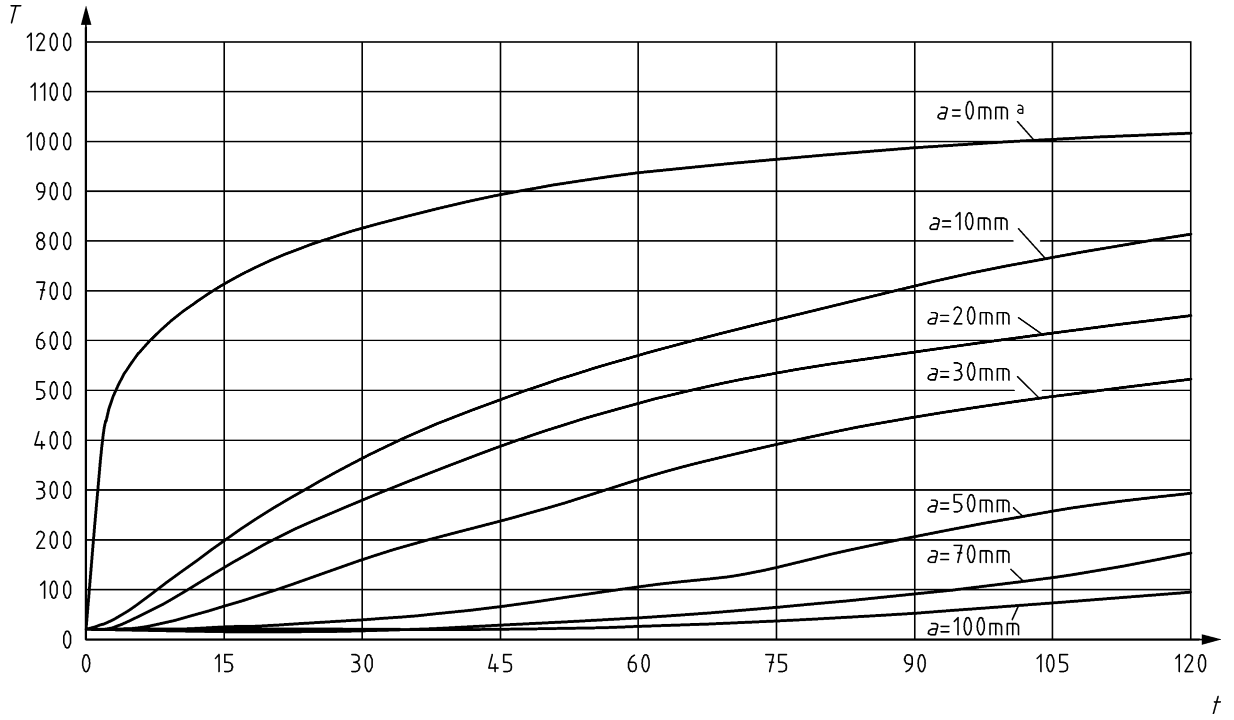
a distance from the exposed surface

t time in min

T Temperature in °C

NOTE Standard temperature-time curve (see C.1.3.14)

Figure CC.3 — Temperature profiles for AAC wall, floor and roof components with a dry density of 500 kg/m^3



Key

a	distance from the exposed surface
t	time in min
T	Temperature in °C

NOTE Standard temperature-time curve (see C.1.3.14)

Figure CC.4 — Temperature profiles for AAC wall, floor and roof components with a dry density of 600 kg/m^3

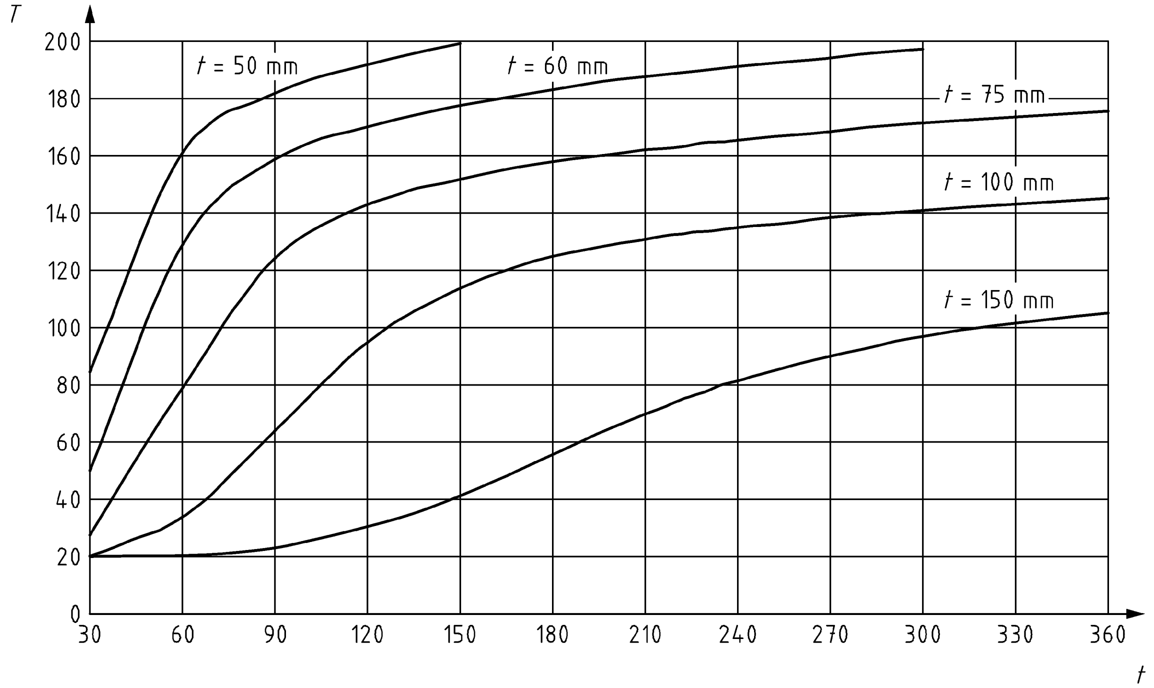
(2) Figure CC.5 gives the temperature profiles of the non exposed face of a component for the determination of the criteria I of the classification to fire, for dry densities 300 kg/m^3 to 600 kg/m^3.

CC.3 Temperature profiles for AAC beams

(1) Figure CC.5 shows how the temperature profiles represent the temperature in the cross section of beams taking symmetry into account.

(2) Typical temperature profiles for AAC beams with a mass related moisture content of ≥ 2 % are presented in Figures CC.6 to CC.13 for different AAC densities.

Curves are given for fire resistance times 30 min, 60 min and 90 min and are based on standard fire exposure exposed on 3 sides. The temperature profiles are calculated for beams with a width of 150 mm and a height of 200 mm and for beams with a width of 300 mm and a height of 400 mm. Linear interpolation and also extrapolation are permitted for other beam sizes.

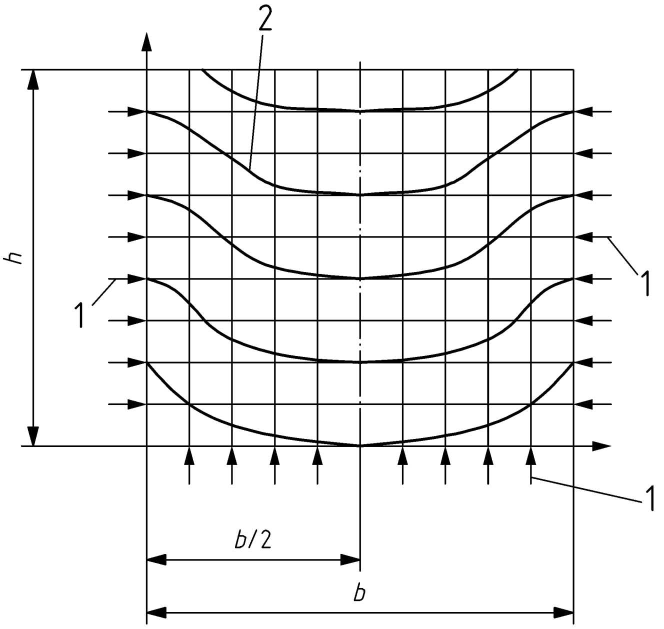


Key

t time in min

T Temperature in °C

Figure CC.5 — Temperature profiles of the non exposed face of component for the determination of the criteria of the classification to fire, for a dry density of 300 and 600 kg/m³

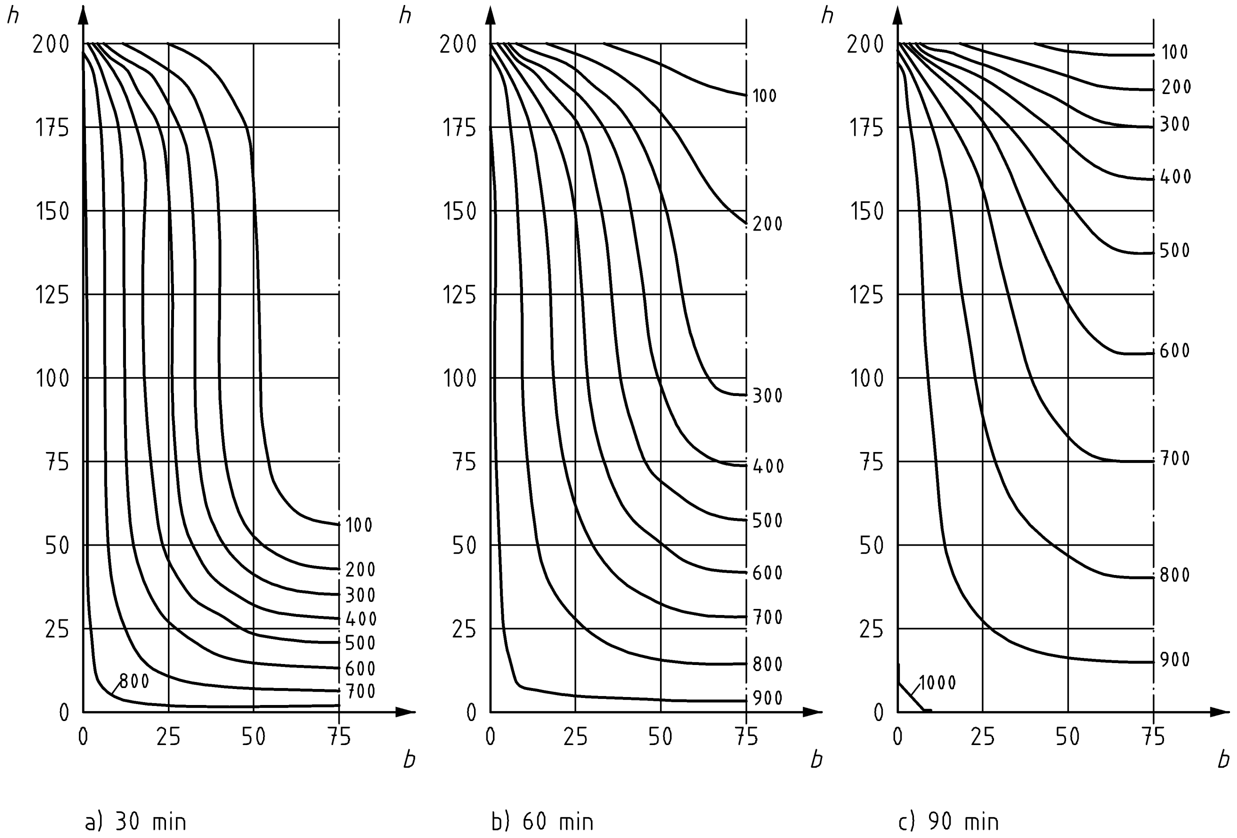


Key

1 sides exposed to standard fire

2 temperature profiles in °C

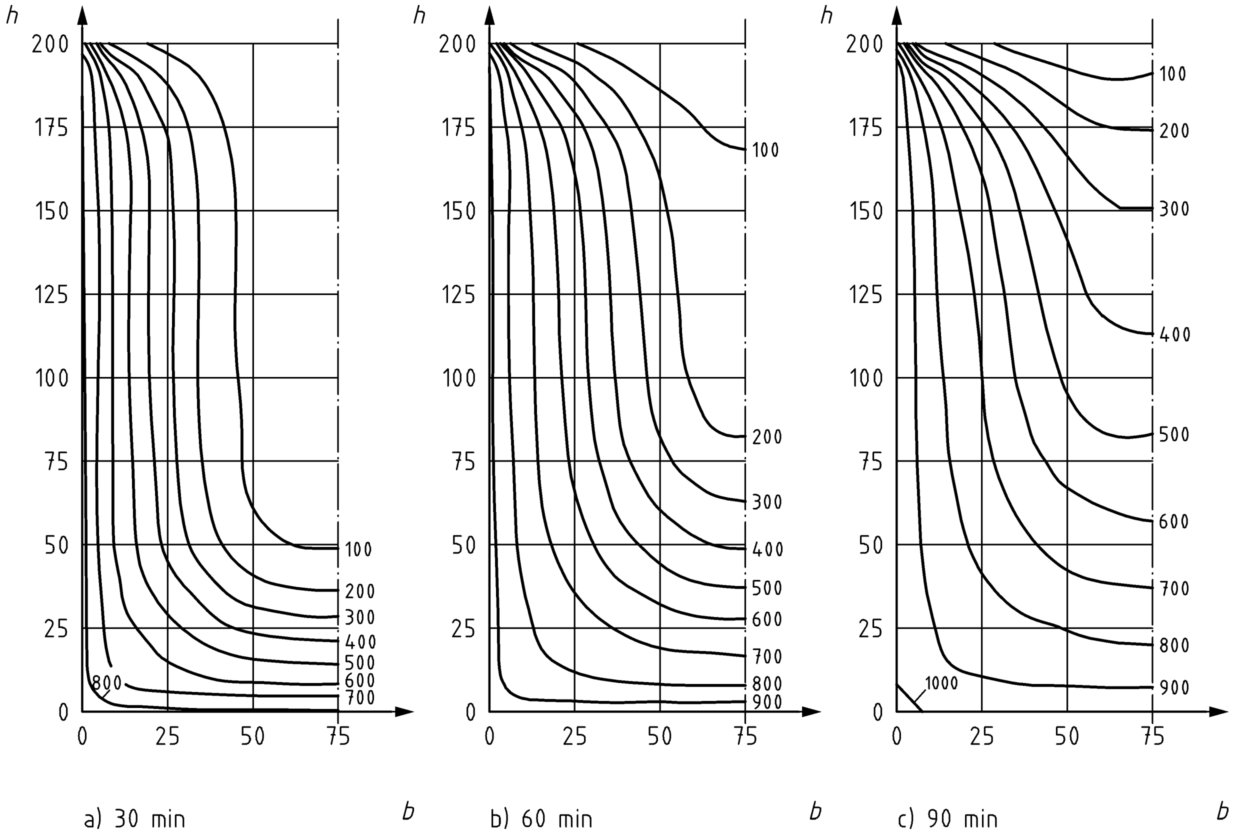
Figure CC.6 — Temperature profiles in °C for AAC-beams (*b* × *h* = 150 mm × 200 mm) with a dry density of 300 kg/m³, exposed on three sides to standard fire



Key

a), b), c) fire resistance time

Figure CC.7 — Temperature profiles in °C for AAC-beams (*b* × *h* = 150 mm × 200 mm) with a dry density of 400 kg/m^3, exposed on three sides to standard fire



a) 30 min

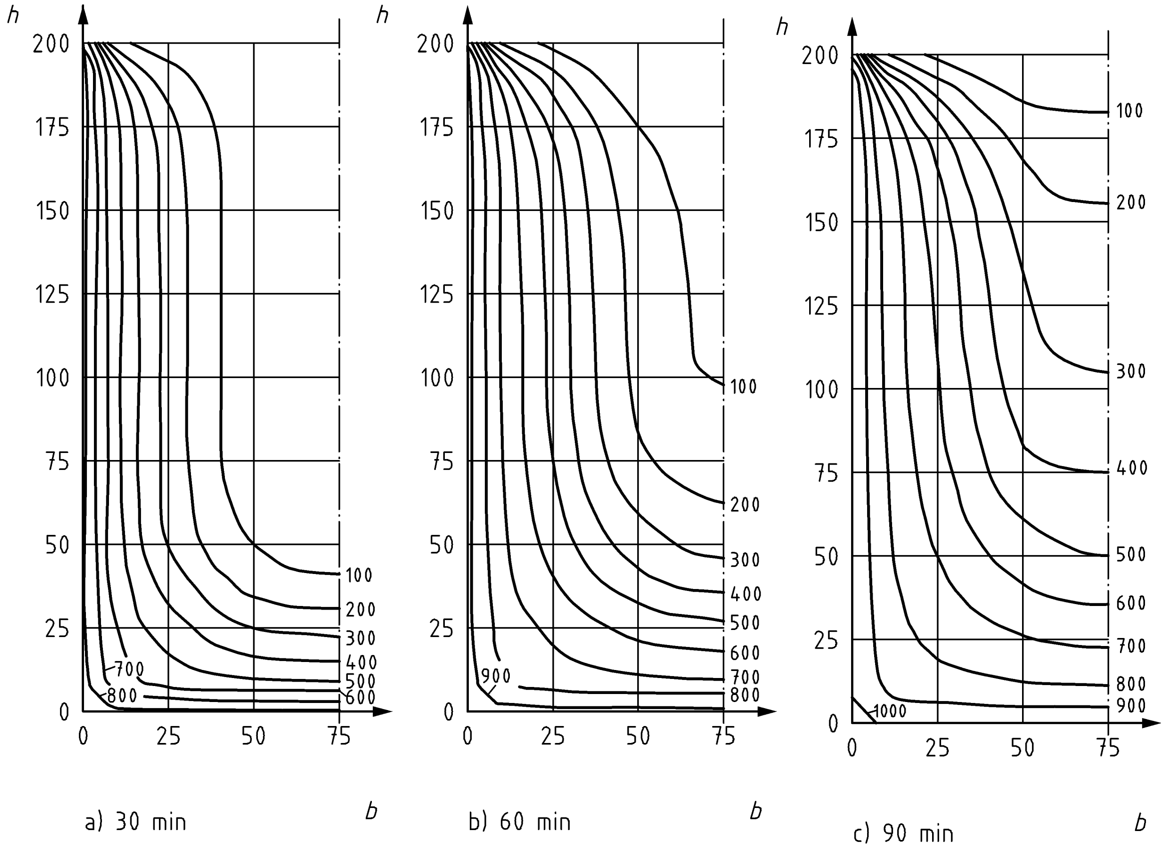
b) 60 min

c) 90 min

Key

a), b), c) fire resistance time

Figure CC.8 — Temperature profiles in °C for AAC-beams (*b* × *h* = 150 mm × 200 mm) with a dry density of 500 kg/m^3, exposed on three sides to standard fire



a) 30 min

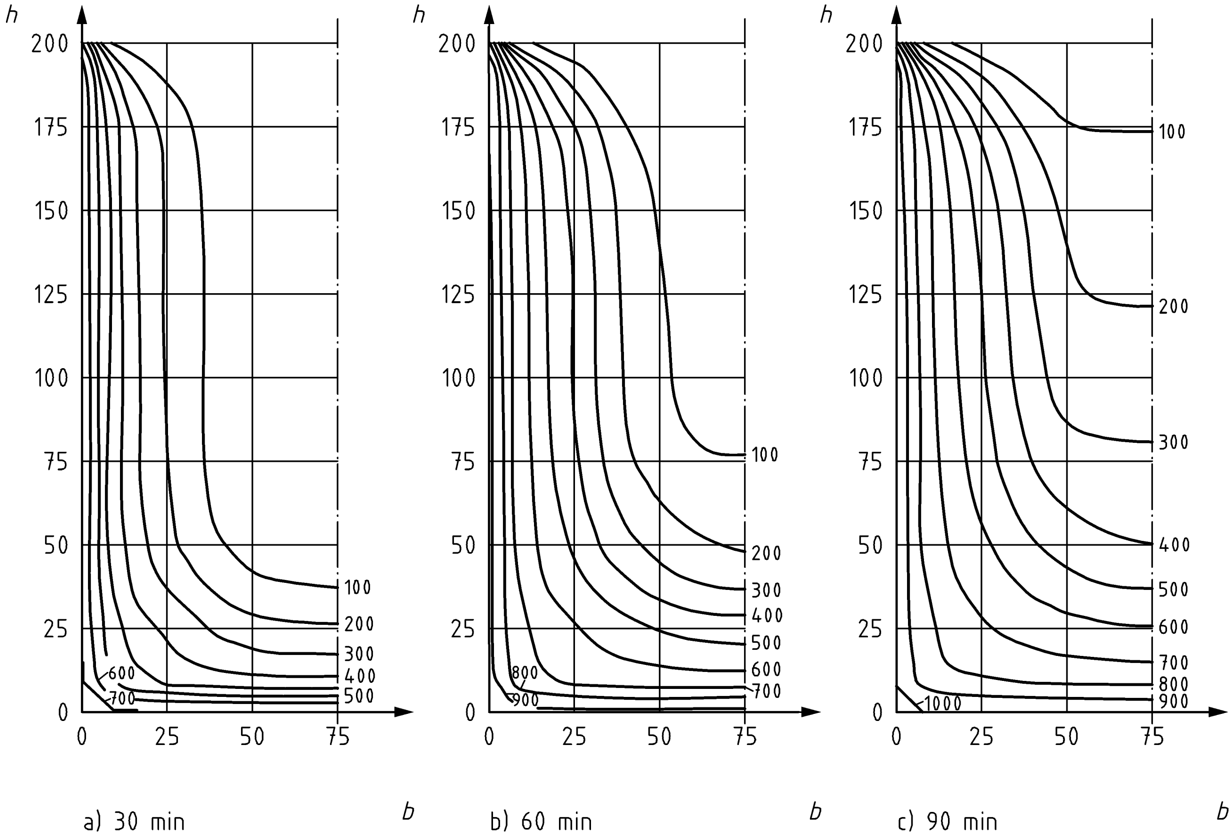
b) 60 min

c) 90 min

Key

a), b), c) fire resistance time

Figure CC.9 — Temperature profiles in °C for AAC-beams (*b* × *h* = 150 mm × 200 mm) with a dry density of 600 kg/m^3, exposed on three sides to standard fire



a) 30 min

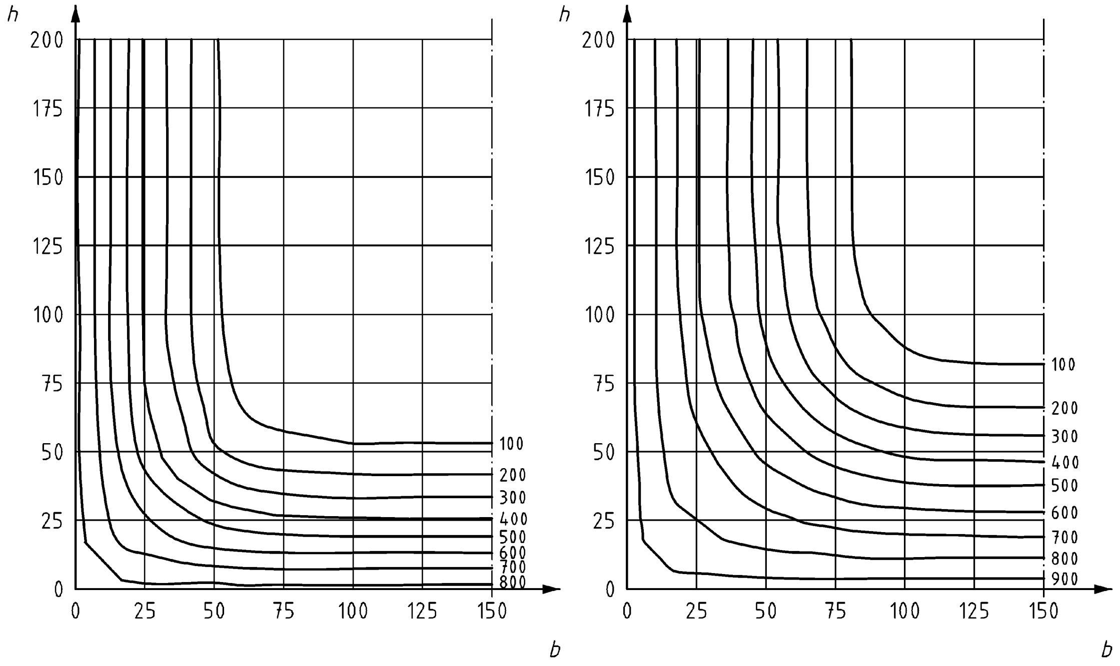
b) 60 min

c) 90 min

Key

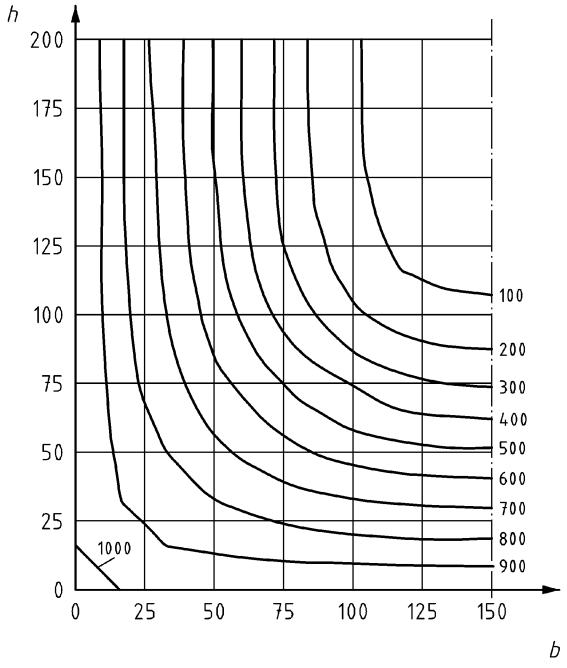
a), b), c) fire resistance time

Figure CC.10 — Temperature profiles in °C for AAC-beams ($b \times h$ = 300 mm × 400 mm) with a dry density of 300 kg/m^3, exposed on three sides to standard fire



a) 30 min

b) 60 min

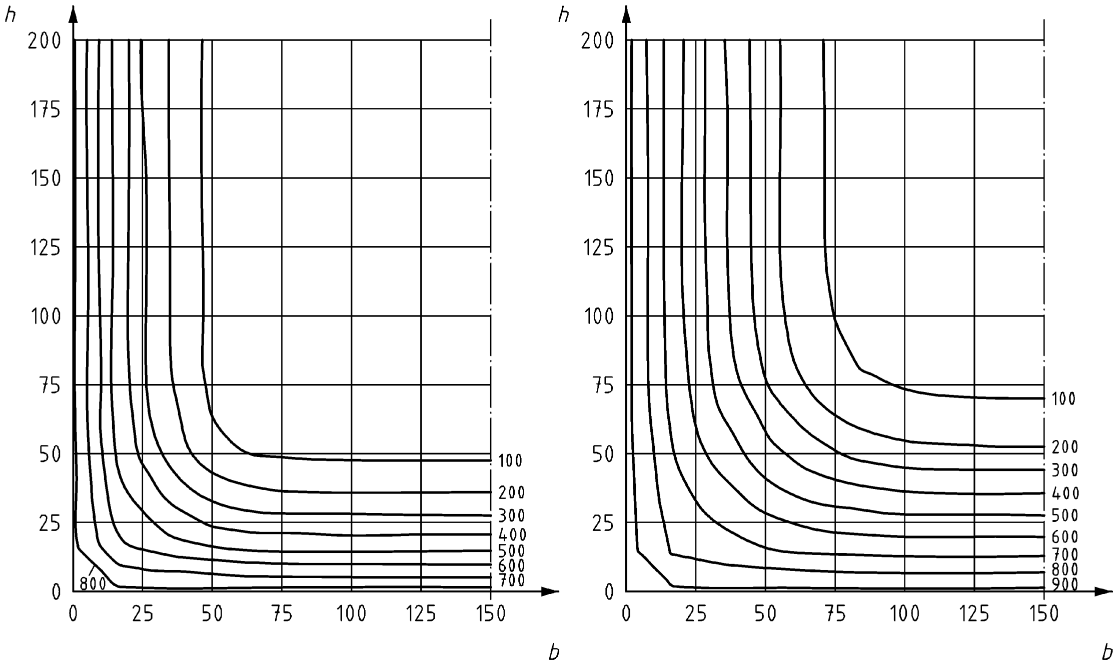


c) 90 min

Key

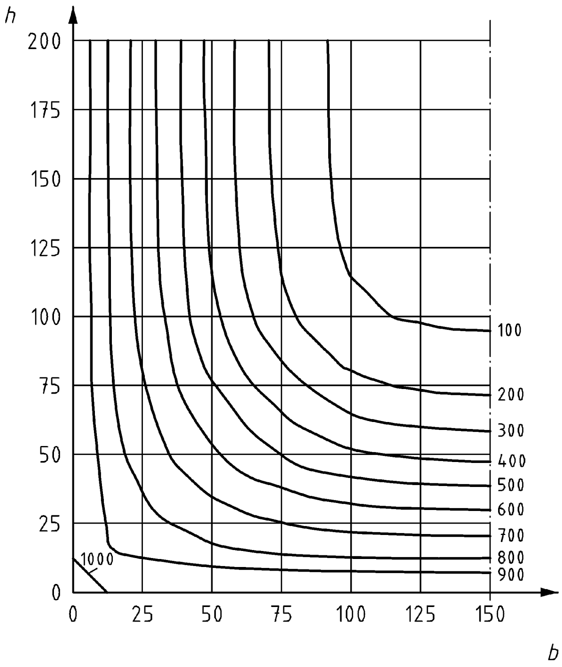
a), b), c) fire resistance time

Figure CC.11 — Temperature profiles in °C for AAC-beams (*b* × *h* = 300 mm × 400 mm) with a dry density of 400 kg/m^3, exposed on three sides to standard fire



a) 30 min

b) 60 min

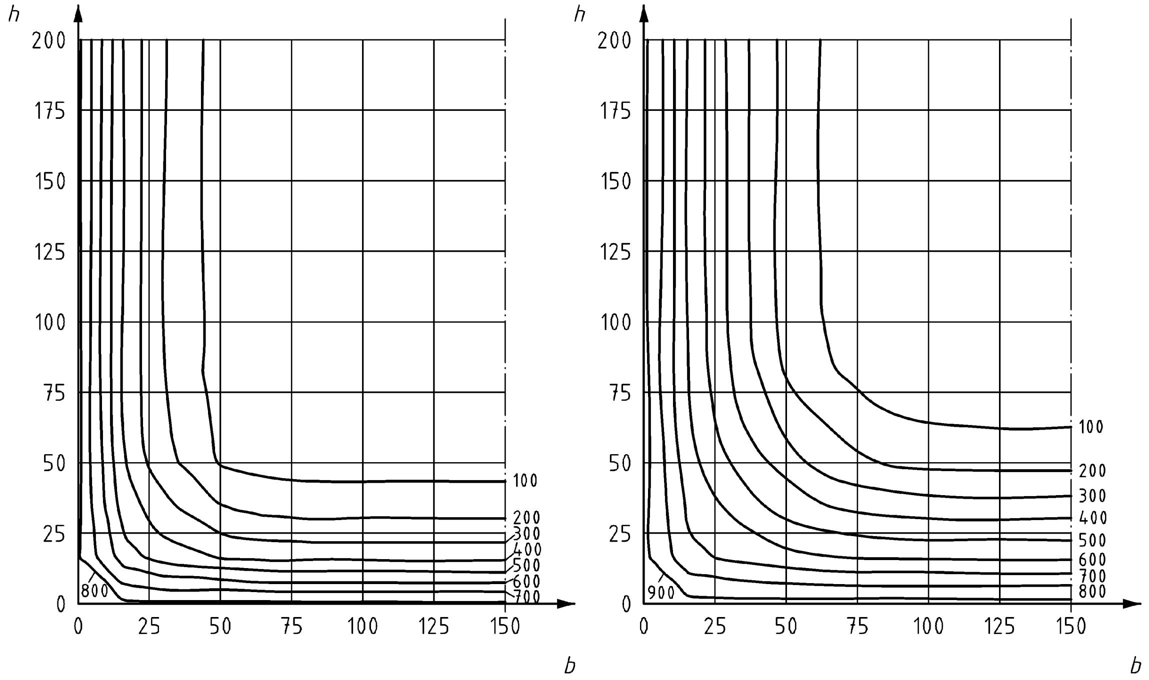


c) 90 min

Key

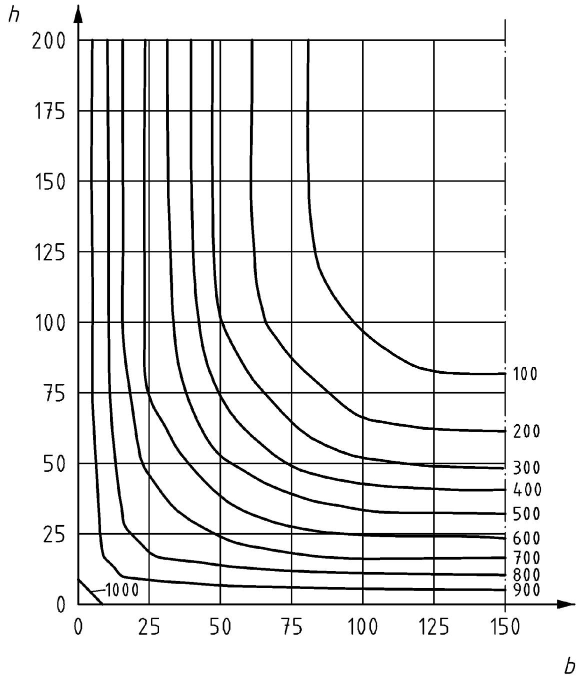
a), b), c) fire resistance time

Figure CC.12 — Temperature profiles in °C for AAC-beams ($b \times h$ = 300 mm × 400 mm) with a dry density of 500 kg/m^3, exposed on three sides to standard fire



a) 30 min

b) 60 min



c) 90 min

Key

a), b), c) fire resistance time

Figure CC.13 — Temperature profiles in °C for AAC-beams (*b* × *h* = 300 mm × 400 mm) with a dry density of 600 kg/m^3, exposed on three sides to standard fire

CC.4 Calculation assumptions

The calculations are based on the following assumptions:

a) Coefficient of heat transfer:	fire exposed surface	25 W/m^{2}K
	non exposed surface	9 W/m^{2}K
b) Emissivity	of fire	$\varepsilon_f = 1{,}0$ [7]
	of the surface	$\varepsilon_m = 0{,}7$ [8]
c) Mass related moisture content:	2 %	

d) Standard temperature time curve [7]

e) Thermal conductivity λ in W/mK

Table CC.1

Temperature in °C	Density in kg/m^3				
	300	400	500	600	700
20	0,085	0,100	0,120	0,140	0,160
300	0,110	0,124	0,142	0,156	0,176
600	0,181	0,182	0,186	0,201	0,221
≥ 900	0,268	0,267	0,269	0,275	0,295

f) Density ρ

$$\rho(T) = \rho(20\,°\text{C}) = \text{const.}$$

g) Specific heat c_p in J/kgK for a mass related moisture content of 2 %

Table CC.2

Temperature in °C	Density in kg/m^3				
	300	400	500	600	700
0	1 084	1 092	1 100	1 101	1 102
99,9	1 084	1 092	1 100	1 101	1 102
100,1	1 882	1 890	1 898	1 899	1 900
200	1 022	1 030	1 038	1 039	1 040
1200	1 022	1 030	1 038	1 039	1 040

h) Calculation program

Finite Element Program: FIRES-T [10]

i) Correction function

The temperatures calculated with FIRES-T were modified with a correction function according to [11].

Annex CD
(normative)

Resistance to fire tabulated data for walls with mechanical impact

(1) Minimum dimensions and minimum axis distances should not be less than the values given in Table CD.1 for resistance to fire REI-M and EI-M. Table CD.1 is valid on the condition that the requirements for the minimum amount of reinforcement for AAC components given in Table CD.2 are fulfilled.

(2) To avoid excessive thermal deformation and subsequent failure of integrity between walls, the ratio of clear height of wall to wall thickness (L/h) should not exceed 40 for vertical non-loadbearing wall components and 30 for vertical loadbearing wall components.

Table CD.1 — Minimum wall thickness and minimum axis distance a_{min} of AAC walls with mechanical impact supported on at least two opposite ends; AAC dry density 450 kg/m^3 to 700 kg/m^3 with structural or non structural reinforcement for resistance to fire REI-M and EI-M

Standard fire resistance	**Minimum wall thickness/ minimum axis distance a_{min}** mm/mm	
	Minimum density 450 kg/m^3	**Minimum density 550 kg/m^3**
REI-M 30	200/30	200/20
REI-M 60	200/30	200/20
REI-M 90	200/40	200/30
REI-M 120	250/40	250/30
REI-M 180	300/60	300/50
EI-M 30	200/30	175/20
EI-M 60	200/30	175/20
EI-M 90	200/30	175/20
EI-M 120	240/30	240/30
EI-M 180	240/30	240/30

Table CD.2 — Minimum amount of reinforcement for AAC components used in walls with mechanical impact

Minimum amount of tensile reinforcement [a] **depending on the thickness *h* and the length *L* of AAC component**			
Length L	d ≥ 175 mm	d ≥ 200 mm	d ≥ 225 mm
mm	mm^2/m	mm^2/m	mm^2/m
≤ 4 000	≥ 102	≥ 102	≥ 102
4 000 – 5 000	≥ 131	≥ 112	≥ 102
5 000 – 6 000	≥ 190	≥ 162	≥ 146
6 000 – 7 000	≥ 258	≥ 220	≥ 195
7 000 – 7 600	-	≥ 252	≥ 222
7 600 – 8 000	-	≥ 265	≥ 245

[a] Tensile reinforcement for the mechanical action (M).

Annex D
(informative)

Recommended values for partial safety factors

NOTE The partial safety factors and reliability level are determined according to national regulations (see national application document). The following values are recommended for use.

D.1 General

The safety values are determined according to national regulations (see national application document). In the absence of national safety evaluation principle the systems and classes in D.2 and D.3 are recommended for use.

NOTE The safety level on material parameters is set to obtain a reliability level of $\beta = 4{,}7$. The safety factors for loads as given in EN 1990 may be used to obtain that reliability level.

D.2 Ultimate Limit States (ULS)

(1) The partial safety factor is $\gamma_\mathrm{M} = \begin{cases} \gamma_\mathrm{s}, \gamma_\mathrm{C} & \text{for desing by calculation} \\ \gamma_\mathrm{comp} & \text{for design by testing} \end{cases}$

The partial safety factor for the material may be defined as:

$$\gamma_\mathrm{M} = k_{\gamma 1} \cdot k_{\gamma 2} \cdot k_{\gamma 3} \tag{D.1}$$

where

$k_{\gamma 1}$ takes into account the failure type;

Table D.1 — Safety parameter for failure type

Failure type	Ductile	Brittle
$k_{\gamma 1}$	1,00	1,20

$k_{\gamma 2}$ takes into account the accuracy of the material parameter in construction determined on the basis of the controlled material parameter. As for example full scale testing gives “good” accuracy, and properties derived from small scale testing compared to the real construction have a “normal” safety factor level.

Table D.2 — Safety parameter for accuracy when determining the material parameter

Accuracy of material parameter	Good	Normal
$k_{\gamma 2}$	1,00	1,10

$k_{\gamma 3}$ takes into account the variation.

$$k_{\gamma 3} = e^{\left(3{,}04 V_\mathrm{R} - 1{,}64 V_\mathrm{f}\right)} \tag{D.2}$$

where

$V_R = \sqrt{V_m^2 + V_G^2 + V_f^2}$ is the summarized coefficient of variation of the property;

V_m is the coefficient of variation for model uncertainty of component resistance;

V_G is the coefficient of variation for geometry;

V_f is the coefficient of variation for material strength.

(2) The variation can be determined in each case by the manufacturer.

In Table D.3 the coefficient of variation for geometry is taken as $V_G = 0{,}02$, which corresponds to the tolerances given in this European Standard. The coefficient of variation V_m is 0,05 for steel and 0,10 for AAC in design by calculation. The coefficient of variation V_m in design by testing is $V_m = 0{,}05$ for direct application testing of components. For extended application testing of components the coefficient of variation is $V_m = 0{,}10$, see the definition in B.1.

The coefficient of variation V_f is 0,05 for steel and 0,10 for AAC in design by calculation. The coefficient of variation V_f in design by testing is $V_f = 0{,}05$ for structurally reinforced components and $V_f = 0{,}10$ for non-structurally reinforced components.

Table D.3 — Safety parameters depending on variation

V_G (geometry)	0,02	0,02	0,02	0,02
V_m (model)	0,05	0,05	0,10	0,10
V_f (material)	0,05	0,10	0,05	0,10
$k_{\gamma 3}$	1,15	1,20	1,30	1,31

Table D.4 — Partial safety factors

Partial safety factor γ_M		**Design by calculation**		**Design by testing γ_{comp}**	
		γ_S	γ_C	**Direct application [a]**	**Extended application [a]**
Structurally reinforced [b] component	Reinforcing steel γ_S	1,15 (1,0 ▪ 1,0 ▪ 1,15)	-	-	-
Structurally reinforced [b] component	Ductile bending failure [c] γ_c / γ_{comp}	-	1,44 (1,0 ▪ 1,1 ▪ 1,31)	1,15 (1,0 ▪ 1,0 ▪ 1,15)	1,30 (1,0 ▪ 1,0 ▪ 1,30)
Structurally reinforced [b] component	Brittle failure γ_c / γ_{comp}	-	1,73 (1,2 ▪ 1,1 ▪ 1,31)	1,38 (1,2 ▪ 1,0 ▪ 1,15)	1,56 (1,2 ▪ 1,0 ▪ 1,30)
Non-structurally reinforced [b] component	Brittle failure γ_c / γ_{comp}	-	1,73 (1,2 ▪ 1,1 ▪ 1,31)	1,44 (1,2 ▪ 1,0 ▪ 1,2)	1,57 (1,2 ▪ 1,0 ▪ 1,31)

[a] Direct and extended application is defined in Annex B B.1.

[b] Structural and non-structural reinforced component, see 3.1.3.

[c] AAC is ductile in action with structural reinforcement, as for example in bending failure·

D.3 Serviceability Limit States (SLS)

The partial safety factor γ_M for the SLS should be taken as $\gamma_M = \gamma_C = \gamma_S = 1{,}0$ for evaluation by calculation or $\gamma_M = \gamma_{comp} = 1{,}0$ for evaluation by testing, respectively.

Annex E
(informative)

Recommendations for the consideration of prestress in the design of prefabricated reinforced AAC components

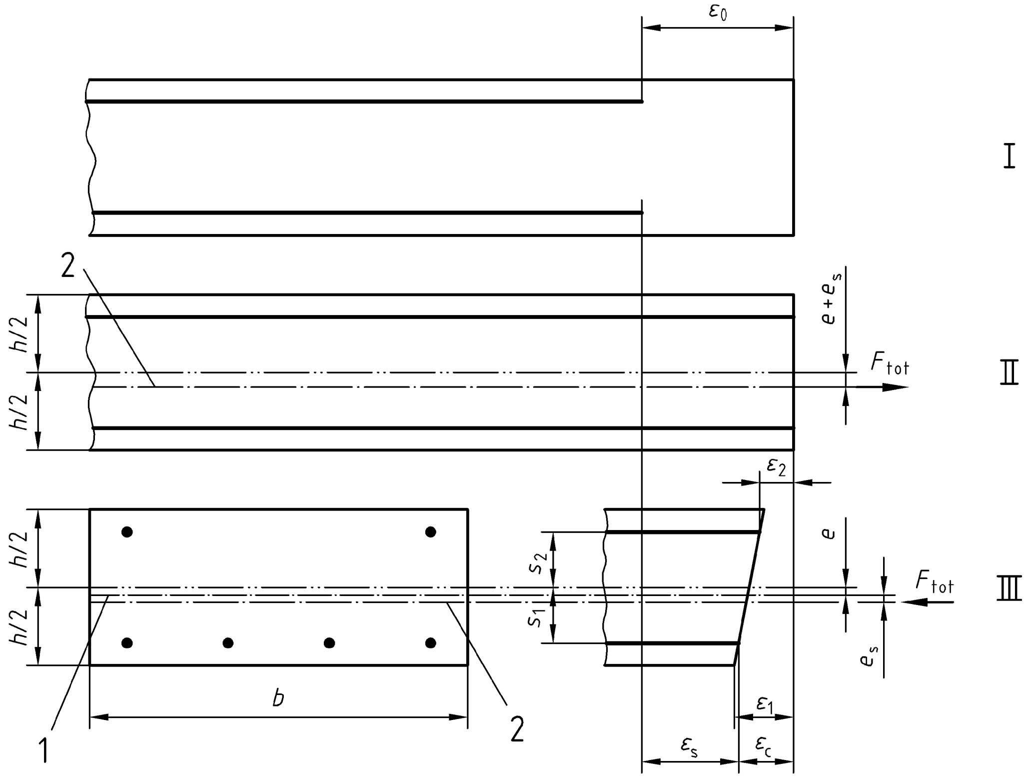
E.1 Calculation of prestrain from test results

E.1.1 General

The value of prestrain (ε_0) shown in Figure E.1 is not depending on cross-section values and can be used in design. It is defined as the difference in length between AAC and reinforcing steel when relative displacements are not prevented. It can be considered as a property which depends on raw materials, type of corrosion protection coating the and autoclaving process.

The computation of prestrain presented in this annex is only valid for components in which the tensile forces in the reinforcement are developed by bond or by the transverse bars and the development length is less than 15 % of the length of the component, at each end.

The effect of a prestrain (ε_0) on a given cross-section is analysed in accordance with Figure E.1.



Key

1	centre of gravity of reinforced cross section
2	centre of gravity of reinforcement
Phase I:	Relative movements are free and stresses are zero.
Phase II:	The prestrain (ε_0) is neutralised by means of an external force (F_{tot}) affecting the reinforcement only.
Phase III:	Interaction between AAC and reinforcement is established and external counterforce (F_{tot}) which affects the whole cross-sections is introduced. The total of external forces is now zero.

Figure E.1 — Analysis of prestress by means of an assumed external force

E.1.2 Symbols

Part of the symbols are given in Figure E.1.

A_{s1} is the cross-sectional area of bottom (tension) reinforcement;

A_{s2} is the cross-sectional area of top (tension) reinforcement;

E_{cm} is the mean modulus of elasticity of AAC (see 4.2.7);

$E_{cm,t}$ is the modulus of elasticity of AAC reduced due to creep before measurement of steel stress;

$E_{cm,t} = E_{cm} / (1 + \varphi_0)$

The creep coefficient φ_0 can be calculated using the equation $\varphi_0 = \varphi_1\ t^{0,2}$ where t is the time between manufacture and measurement, in days. In the absence of more accurate data, φ_1 can be taken as 0,1 if t is less than 60 *d.*

E_s is the modulus of elasticity of reinforcing steel (200 000 MPa);

$n = E_s / E_{cm,t}$ when ε_0 is calculated from steel or initial camber measurements, see E.1.4;

f_{s0m} is the measured mean steel stress of the AAC component according to EN 1738 (corresponding to strain value ε_s in Figure E.1);

a_0 is the measured initial camber of the AAC component according to EN 1738;

L is the length of the AAC component of which the initial camber is measured.

E.1.3 Cross-section values of AAC components

The moment of inertia (I) is

$$I = bh^3 / 12 + n\left(A_{s1}s_1{}^2 + A_{s2}s_2{}^2\right) - A_t e^2 \tag{E.1}$$

where

$$A_t = b\,h + n\,(A_{s1} + A_{s2}) \tag{E.2}$$

$$e = n\,(A_{s1}\,s_1 - A_{s2}\,s_2) / A_t \tag{E.3}$$

The bottom section modulus W_1 and the top section modulus W_2 are:

$$W_1 = I / (h / 2 - e) \text{ and } W_2 = I / (h / 2 + e) \tag{E.4}$$

The distance e_s between the centre of gravity of reinforcement and reinforced cross section is:

$$e_s = \{[A_{s1}\,(h / 2 + s_1) + A_{s2}\,(h / 2 - s_2)] / (A_{s1} + A_{s2})\} - e - h / 2 \tag{E.5}$$

E.1.4 Calculation of prestrain ε_0 from steel measurement

The external force F_{tot} is given by Formula (E.6).

$$F_{tot} = \varepsilon_0\,(A_{s1} + A_{s2})\,E_s \tag{E.6}$$

The compression strains in the bottom and the top fibre of AAC are:

$$\varepsilon_1 = F_{tot}\,(1 / A_t + e_s / W_1) / E_{cm,t} \tag{E.7}$$

$$\varepsilon_2 = F_{tot}\,(1 / A_t - e_s / W_2) / E_{cm,t} \tag{E.8}$$

The tensile strain in the steel is:

$$\varepsilon_{st} = \varepsilon_0 - \varepsilon_c \tag{E.9}$$

where

$$\varepsilon_c = \varepsilon_1 - (\varepsilon_1 - \varepsilon_2) \cdot (h/2 - s_1) / h \tag{E.10}$$

The measured prestrain (ε_0) can now be calculated by resolving the Formula (E.11)

$$f_{s0m} = \varepsilon_{st}\,E_s = (\varepsilon_0 - \varepsilon_c)\,E_s \tag{E.11}$$

E.2 Cross-sectional analysis of a AAC component in SLS if prestress is taken into account

The symbols and cross-sectional values used are in accordance with E.1.2 and E.1.3.

The loss of prestress due to creep is taken into account by using the long term modulus of elasticity of AAC

$$E_{cm,\infty} = E_{cm} / (1 + \varphi) \tag{E.12}$$

where φ is the final creep coefficient assumed has 1,0 unless declared by the manufacturer.

Thus $n = E_{\text{cm},\infty} / E_\text{s}$ is used when calculating cross-sectional values of the AAC component.

The effect of shrinkage is taken into account by using the design prestrain value, $\varepsilon_{0\text{d}}$, which can be determined as follows:

$$\varepsilon_{0\text{d}} = \varepsilon_{0\text{m}} - \varepsilon_{0\infty} \tag{E.13}$$

where

$\varepsilon_{0\text{m}}$ is the declared mean short-term prestrain in accordance with 4.1.1;

$\varepsilon_{0\infty}$ is the final drying shrinkage value of the component as given in 5.2.3, Table 9.

If the properties of corrosion protection coating are such that slip occurs between reinforcement and AAC, the loss of prestress due to slip should be determined and taken into account.

The resulting prestress force, F_p, is given by the Formula (E.14):

$$F_\text{p} = \varepsilon_{0\text{d}} \, (A_{\text{s}1} + A_{\text{s}2}) \, E_\text{s} \tag{E.14}$$

The location of F_p is the same as the location of F_tot in Figure E.1.

The extreme fibre stresses of AAC,σ_1, and, σ_2, are calculated as follows:

$$\sigma_1 = F_\text{p} / A_\text{t} - F_\text{p} e_\text{s} / W_1 \tag{E.15}$$

$$\sigma_2 = F_\text{p} / A_\text{t} + F_\text{p} e_\text{s} / W_2 \tag{E.16}$$

(compression negative, tension positive).

E.3 Splitting forces due to prestress

End cracks might be caused by splitting forces due to high prestress. Normally there is no risk of cracking if the following condition is satisfied:

$$E_\text{s} h_1 \rho_1 \left(1 - 8\sqrt{\rho_1}\right) \varepsilon_0 / \left(f_{\text{ct,flk}} c\right) \leq 1{,}5 \tag{E.17}$$

where

E_s is the modulus of elasticity of steel (200 000 MPa);

h_1 is the overall depth of the cross-section;

ρ_1 is the reinforcement ratio;

ε_0 is the short-term prestrain;

$f_{\text{ct,flk}}$ is the characteristic flexural tensile strength of AAC;

c is the effective length of the zone from the end of the component in which the splitting stresses are supposed to act; normally assumed as 75 mm.

E.4 Methods to prevent end cracks due to prestress

In components where prestress might cause end cracks, transverse reinforcement can be provided to withstand splitting forces. Various types of connections between the two reinforcement mats at the end of the components can be used depending on the magnitude of the splitting force. The magnitude of the splitting force can be calculated by using recognized methods.

Annex F
(informative)

Statistical methods for quality control

(1) To establish a statistical basis for quality control of the characteristic values in accordance with 4.2.3, the following guidance can be used.

NOTE The expressions presented here, which use Bayesian procedure with “vague” prior distributions, lead almost to the same result as classical statistics with a confidence level equal of 0,75.

(2) Compliance can be demonstrated by determining the mean value of test results and comparing this with the declared value. The acceptance rule is given by:

$$m_x \geq X_{gi} / X_{0i} + k_n \cdot s_x \qquad \text{(F.1)}$$

where

X_{0i} is the expected mean value of the examined property (strength, loadbearing capacity, etc.), established by the manufacturer based on initial type testing and experience. In the case of extended application X_{0i} may be a function determined on the basis of a model covering the range of products;

X_{gi} is the declared value for the specimen tested, see Formula (F.2);

k_n is the control parameter, the values are given in Table F.1;

$m_x = \frac{1}{n}\sum \bar{x}_i$ is the mean value of $\bar{x}_i$ for the *n* specimens tested;

$\bar{x}_i = \frac{X_i}{X_{0i}}$ is the stochastically variable which is examined;

X_i is the actual measured test result.

The declared value X_{gi} is determined on the basis of an expected value X_{0i} by:

$$X_{gi} \leq \bar{x}_k X_{0i} \qquad \text{(F.2)}$$

where

$\bar{x}_k = m_x\left(1 - k_s V_x\right)$ is the characteristic value of $\bar{x}_i$ for the *n* specimens tested.

If the coefficient of variation V_x is known, for instance from evaluation of previous tests in a comparable situation, the coefficient k_s is determined by Table F.2 for known variation.

If the coefficient of variation is unknown, it has to be estimated from the sample.

$$s_x = \sqrt{\frac{1}{n-1}\sum\left(\bar{x}_i - m_x\right)^2} \text{ is the standard deviation;} \qquad \text{(F.3)}$$

$$V_x = \frac{s_x}{m_x} \text{ is the coefficient of variation;} \qquad \text{(F.4)}$$

k_s is then taken from Table F.2 for unknown variation.

Table F.1 — Control factor k_n as a function of samples n with a fractile value of 5 % (p = 0,95) and a confidence level of γ approximately 0,75 (using bayesian procedures with “vague” prior distribution) and under the assumption that the safety level (Annex D) is based on a summarized variation of V_R = 0,10

k_n for known variation									
V_x	n = 3	4	5	6	8	10	20	30	∞
0,025	0,89	0,83	0,80	0,77	0,74	0,72	0,68	0,67	0,64
0,05	1,39	1,33	1,30	1,27	1,24	1,22	1,18	1,17	1,14
0,075	1,56	1,50	1,47	1,44	1,41	1,39	1,35	1,34	1,31
0,10	1,64	1,58	1,55	1,52	1,49	1,47	1,43	1,42	1,39
0,15	1,72	1,66	1,63	1,60	1,57	1,55	1,51	1,50	1,47
0,20	1,77	1,71	1,68	1,65	1,62	1,60	1,56	1,55	1,52
0,25	1,79	1,73	1,70	1,67	1,64	1,62	1,58	1,57	1,54
k_n for unknown variation									
V_x	n = 3	4	5	6	8	10	20	30	∞
0,025	2,37	1,63	1,33	1,18	1,00	0,92	0,76	0,73	0,64
0,05	2,87	2,13	2,83	1,68	1,50	1,42	1,26	1,23	1,14
0,075	3,04	2,30	2,00	1,85	1,67	1,59	1,43	1,40	1,31
0,10	3,12	2,38	2,08	1,93	1,75	1,67	1,51	1,48	1,39
0,15	3,20	2,46	2,16	2,01	1,83	1,75	1,59	1,56	1,47
0,20	3,25	2,51	2,21	2,06	1,88	1,80	1,64	1,61	1,52
0,25	3,27	2,53	2,23	2,08	1,90	1,82	1,66	1,63	1,54

Table F.2— Coefficient k_s as a function of samples n with a fractile value of 5 % (p = 0,95) and a confidence level γ approximately 0,75 (using bayesian procedures with “vague” prior distribution)

n	**3**	**4**	**5**	**6**	**8**	**10**	**20**	**30**	**∞**
k_s for known variation	1,89	1,83	1,80	1,77	1,74	1,72	1,68	1,67	1,64
k_s for unknown variation	3,37	2,63	2,33	2,18	2,00	1,92	1,75	1,73	1,64

Annex G
(normative)

Factory production control of stainless reinforcing steel based on at least three samples – Minimum acceptance criteria for individual values and corresponding mean values

Minimum acceptance criteria are given concerning the characteristics 0,2 % proof strength $R_{p0,2}$, tensile strength R_m, percentage total elongation at maximum force A_{gt} and ratio tensile strength/proof strength R_m / $R_{p0,2}$ of the finished reinforcing bars or de-coiled products based on at least three samples.

Acceptance criteria are in accordance with EN 10080 or EN 10088-5 whichever is relevant. Deviation of the different values is assumed to be based on known variation.

Batch is accepted based on at least three steel samples when the control is performed according to F.1.

Annex H
(informative)

Methods for declaring the mechanical and fire resistance performances in ENs for structural elements

H.1 Declaration methods

Manufacturers may declare both in the DoP and in the CE marking the mechanical resistance and fire resistance characteristics of the structural elements/components (or structural kits) covered by the scope of this standard accordance with one of the methods given in this Annex in accordance with the business model chosen.

H.2 Method M1

Declaration of data allowing the subsequent determination of the mechanical and fire resistance performances by reference to both:

— detailed graphic information on the geometrical features (dimensions and detailed cross sections, including tolerances and arrangement of constituent products, where relevant) of the structural product or structural kit, and

— properties of the structural material(s) and of the structural constituent(s), if any, used so that these may enable the purchaser (or the end user) the assessment and verification of the mechanical and fire performance characteristics (including aspects of durability and serviceability) of the structural elements/components or the structural kits. before their final use

There is no design method applied. The standard should allow this possibility.

NOTE 1 The information in the DoP and accompanying the CE marking includes specific reference to the geometrical features of the structural element, or the structural kit, and to the characteristics of the structural material(s) and the structural constituent(s), if any, used and not the mechanical and the fire resistance performances of the structural product or the structural kit as such.

NOTE 2 This declaration method may be applied to structural products or kits manufactured in long series, (e.g. off-the-shelf or catalogued structural products) grouped into product families, according to the manufacturer's specification and placed on the market, (e.g. for retail or made available in a web page) when the final place of destination is not known and the manufacturer finds it difficult to provide information on the mechanical and fire performance of his/her products without knowing the final structural requirements and conditions of use.

NOTE 3 The responsibility of the manufacturer is limited to the manufacturing of the structural product as well as to the declared geometrical features of the product and of the mechanical and fire related characteristics of the material(s) used allowing a subsequent calculation of such performance characteristics if necessary.

H.3 Method M2

Declaration of the mechanical and fire resistance performance characteristics (including applied NDPs, safety factors, load values and assumptions, etc.) of the structural element or the structural kit (with the results expressed as characteristic values or design values), determined by the manufacturer applying the calculation methods given in the EN Eurocodes and referred to in this European standard or given herein.

The design method is the Eurocodes. The standard should allow this possibility. Additional information, relevant for the design of the structural elements/components and structural kites using Eurocodes (e.g.

Nationally Determined parameters) for placing the products on different national markets, may be obtained in the Eurocodes National Annexes or through the National Product Contact Points for Construction.

NOTE 1 The information in the DoP and accompanying the CE marking includes specific reference to the performance of the mechanical and fire resistance characteristics based on calculation results based on Eurocodes.

NOTE 2 This declaration method may be applied to structural products or structural kits manufactured in long series, (e.g. off-the-shelf or catalogued structural products) grouped into product families, according to the manufacturer's specification and placed on the market, (e.g. for retail or made available in a web page) when the final place of destination is not known but the manufacturer wishes to provide information of the mechanical and fire performance, under certain assumptions, of his/her products using the calculation methods given in the specific EN Eurocodes are used.

NOTE 3 The responsibility of the manufacturer covers the declared mechanical performance characteristics including the fitness of the materials used.

H.4 Method M3a

Declaration of the mechanical and fire resistance performance by reference, in an unambiguous way, to both:

- the design documentation of the structural element(s), or the structural kit(s), (drawings, material specifications, etc.) provided by the client; and
- the production documentation prepared by the manufacturer on the basis of the relevant design documentation.

In addition, reference has to be made in the declaration to the specific position of the structural element, or structural kit in the works.

This European standard provides appropriate indications in 8.2 regarding the content of the production documentation.

The design method is he one chosen by the client or the designer of the works. The standard should allow this possibility.

NOTE 1 The information in the DoP and accompanying the CE marking does not refer to the mechanical and fire resistance performance characteristics of the structural element(s), or the structural kit(s,) but to the above mentioned documentation since the values of the characteristics are part of the design documentation provided by the client.

NOTE 2 This declaration method may be applied when the intended place of destination is known, the design documentation of the product prepared by the designer of the works of destination is made available to the manufacturer by the client and the manufacturer has to elaborate only the relevant production documentation.

NOTE 3 The responsibility of the manufacturer is limited to the manufacturing of the product in accordance with the production documentation, its adequacy to the design documentation and the fitness of the materials and constituent products used.

H.5 Method M3b

Declaration of the mechanical and fire resistance performance by reference, in an unambiguous way, to both:

- the design documentation prepared by the manufacturer, on the basis of data (e.g. drawings, including specific geometric details, loads, safety factors, etc.) provided by the client and using the design method (EN Eurocodes, or others) required in the contract by the client; and
- the production documentation prepared also by the manufacturer on the basis of the relevant design documentation.

In addition, reference has to be made in the declaration to the construction works of destination.

This European standard provides in 8.2 and 8.3 appropriate indications regarding the content of both the design and the production documentation, respectively.

The design method is the one established in the order or contract and chosen by the client or the designer of the works. The standard should allow this possibility.

NOTE 1 The information in the DoP and accompanying the CE marking does not refer directly to the mechanical and fire resistance performance of the structural element(s), or of the structural kit(s) but to the above mentioned documentation since the values of these characteristics are part of the design documentation provided by the manufacturer.

NOTE 2 This declaration method is relevant when the intended place of destination is known and the manufacturing order requires design and production documentations of the product to be prepared by the manufacturer for a specific works of destination.

NOTE 3 The responsibility of the manufacturer covers the design and manufacturing of the product, its adequacy to the design and production documentation and the fitness of the materials used.

Annex ZA
(informative)

Relationship of this European Standard with Regulation (EU) No.305/2011

(When applying this standard as a harmonized standard under Regulation (EU) No. 305/2011, manufacturers and Member States are obliged by this regulation to use this Annex)

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under standardization request M100 “Precast Concrete Products” given to CEN and CENELEC by the European Commission (EC) and the European Free Trade Association (EFTA).

When this European Standard is cited in the Official Journal of the European Union (OJEU), under Regulation (EU) No 305/2011, it shall be possible to use it as a basis for the establishment of the Declaration of Performance (DoP) and the CE marking, from the date of the beginning of the co-existence period as specified in the OJEU.

Regulation (EU) No 305/2011, as amended, contains provisions for the DoP and the CE marking.

Table ZA.1.1 — Relevant clauses for structural loadbearing wall components

Construction Product(s): Loadbearing wall components (WL) as covered in the scope of this European Standard Intended use(s): Structural						
Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
Compressive strength (of concrete), flexural strength (of concrete)		4.2.3, 4.2.4 4.2.5	—	All methods	Declared value in MPa or declared strength class	
Density		4.2.2.2, 4.2.2.3	—	All methods	Declared values in kg/m^3 or declared density class	
Ultimate tensile strength and yield strength (of steel)		4.3	—	All methods	Declared values in MPa	
Water vapour permeability (for external walls)		4.2.14	—	All methods	Declared factor or value in –	
Mechanical resistance	In case of verification by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant	5.1.1 (Annex A) 7.1 (Annex A)	—	Method M1	Declared geometry and materials properties as above	Method of design: by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
	In case of verification by testing: Loadbearing capacity	5.1.1 (Annex B) 7.1 (Annex B)	—	Method M1	Declared geometry and materials properties as above	
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	

Construction Product(s): Loadbearing wall components (WL) as covered in the scope of this European Standard
Intended use(s): Structural

Essential Characteristics	Clause(s) in this European Standard	Regulatory classes	Notes, units	
			Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works
Detailing	5.2.1, 5.2.7	—	All methods	Significant production drawings if required; declared tolerance class
Drying shrinkage (in end use conditions)	4.2.10, 5.2.3	—	All methods	Declared value from testing or tabulated value, in mm/m
Durability against: freeze–thaw (only for exposed applications)	5.3.1, 5.3.4	—	All methods	Declared freeze/thaw resistance
Durability against: corrosion	5.3.1, 5.3.3	—	All methods	Coating of reinforcement bars
Reaction to fire (only for exposed applications)	5.1.3.1	Euro-classes	All methods	Declared class
Resistance to fire (in the end use conditions)	5.1.3.2	RE, REI, REI-M	All methods	
Thermal resistance (only when the product is intended also for thermal applications)	4.2.13, 5.1.4	—		Declared value in $(m^2 \cdot K)/W$ or λ_{10dry} in $W/(m \cdot K)$
Direct airborne sound insulation index (only when the product is intended also for acoustical application)	5.1.2.1	—		Declared value in dB
Release of dangerous substances	4.1.2	—	All methods	
Rigidity of joints	5.2.6	—	All methods	Declared value

Table ZA.1.2 — Relevant clauses for retaining wall components

<table>
<tr><td colspan="7">Construction Product(s): Retaining wall components (WR) as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Essential Characteristics</td><td>Clause(s) in this European Standard</td><td>Regulatory classes</td><td colspan="3">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength (of concrete),
flexural strength (of concrete)</td><td>4.2.3,
4.2.4
4.2.5</td><td>—</td><td>All methods</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.2.2,
4.2.2.3</td><td>—</td><td>All methods</td><td colspan="2">Declared values in kg/m^3 or declared density class</td></tr>
<tr><td colspan="2">Ultimate tensile strength and yield strength (of steel)</td><td>4.3</td><td>—</td><td>All methods</td><td colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="6">Mechanical resistance</td><td rowspan="4">In case of verification by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant</td><td rowspan="4">5.1.1 (Annex A)
7.1 (Annex A)</td><td rowspan="4">—</td><td>Method M1</td><td>Declared geometry and materials properties as above</td><td rowspan="6">Method of design:
by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.</td></tr>
<tr><td>Method M2</td><td>Declared values in kNm, kN, kN/m, etc., as relevant</td></tr>
<tr><td>Method M3a</td><td>Design documentation elaborated by the client</td></tr>
<tr><td>Method M3b</td><td>Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works</td></tr>
<tr><td rowspan="2">In case of verification by testing:
Loadbearing capacity</td><td rowspan="2">5.1.1 (Annex B)
7.1 (Annex B)</td><td rowspan="2">—</td><td>Method M1</td><td>Declared geometry and materials properties as above</td></tr>
<tr><td>Method M2</td><td>Declared values in kNm, kN, kN/m, etc., as relevant</td></tr>
</table>

Construction Product(s): Retaining wall components (WR) as covered in the scope of this European Standard

Intended use(s): Structural

Essential Characteristics	Clause(s) in this European Standard	Regulatory classes	Notes, units	
			Method M3a	Design documentation elaborated by the client
			Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works
Detailing	5.2.1, 5.2.7	—	All methods	Significant production drawings if required; declared tolerance class
Drying shrinkage (in end use conditions)	4.2.10, 5.2.3	—	All methods	Declared value from testing or tabulated value, in mm/m
Durability against: freeze–thaw (only for exposed applications)	5.3.1, 5.3.4	—	All methods	Declared freeze/thaw resistance
Durability against: corrosion	5.3.1, 5.3.3	—	All methods	Coating of reinforcement bars
Reaction to fire (only for exposed applications)	5.1.3.1	Euro-classes	All methods	Declared class
Resistance to fire (in the end use conditions)	5.1.3.2	RE, REI	All methods	
Thermal resistance (only when the product is intended also for thermal applications)	4.2.13, 5.1.4	—		Declared value in $(m^2 \cdot K)/W$ or λ_{10dry} in $W/(m \cdot K)$
Release of dangerous substances	4.1.2	—	All methods	
Rigidity of joints	5.2.6	—	All methods	Declared value

Table ZA.1.3 — Relevant clauses for roof components

<table>
<tr><td colspan="7">Construction Product(s): Roof components (RF) as slabs as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Essential Characteristics</td><td>Clause(s) in this European Standard</td><td>Regulatory classes</td><td colspan="3">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength (of concrete),
flexural strength (of concrete)</td><td>4.2.3,
4.2.4
4.2.5</td><td>—</td><td>All methods</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.2.2,
4.2.2.3</td><td>—</td><td>All methods</td><td colspan="2">Declared values in kg/m^3 or declared density class</td></tr>
<tr><td colspan="2">Ultimate tensile strength and yield strength (of steel)</td><td>4.3</td><td>—</td><td>All methods</td><td colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="6">Mechanical resistance</td><td rowspan="4">In case of verification by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant</td><td rowspan="4">5.1.1 (Annex A)
7.1 (Annex A)</td><td rowspan="4">—</td><td>Method M1</td><td>Declared geometry and materials properties as above</td><td rowspan="6">Method of design:
by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.</td></tr>
<tr><td>Method M2</td><td>Declared values in kNm, kN, kN/m, etc., as relevant</td></tr>
<tr><td>Method M3a</td><td>Design documentation elaborated by the client</td></tr>
<tr><td>Method M3b</td><td>Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works</td></tr>
<tr><td rowspan="2">In case of verification by testing:
Loadbearing capacity</td><td rowspan="2">5.1.1 (Annex B)
7.1 (Annex B)</td><td rowspan="2">—</td><td>Method M1</td><td>Declared geometry and materials properties as above</td></tr>
<tr><td>Method M2</td><td>Declared values in kNm, kN, kN/m, etc., as relevant</td></tr>
</table>

<table>
<tr><td colspan="7">Construction Product(s): Roof components (RF) as slabs as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Essential Characteristics</td><td>Clause(s) in this European Standard</td><td>Regulatory classes</td><td colspan="3">Notes, units</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td>Method M3a</td><td>Design documentation elaborated by the client</td><td rowspan="2"></td></tr>
<tr><td>Method M3b</td><td>Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works</td></tr>
<tr><td colspan="2">Detailing</td><td>5.2.1,
5.2.7</td><td>—</td><td>All methods</td><td colspan="2">Significant production drawings if required; declared tolerance class</td></tr>
<tr><td colspan="2">Drying shrinkage
(in end use conditions)</td><td>4.2.10,
5.2.3</td><td>—</td><td>All methods</td><td colspan="2">Declared value from testing or tabulated value, in mm/m</td></tr>
<tr><td colspan="2">Durability against: freeze–thaw
(only for exposed applications)</td><td>5.3.1,
5.3.4</td><td>—</td><td>All methods</td><td colspan="2">Declared freeze/thaw resistance</td></tr>
<tr><td colspan="2">Durability against: corrosion</td><td>5.3.1,
5.3.3</td><td>—</td><td>All methods</td><td colspan="2">Coating of reinforcement bars</td></tr>
<tr><td colspan="2">Reaction to fire
(only for exposed applications)</td><td>5.1.3.1</td><td>Euro-classes</td><td>All methods</td><td colspan="2">Declared class</td></tr>
<tr><td colspan="2">Resistance to fire
(in the end use conditions)</td><td>5.1.3.2</td><td>RE, REI</td><td>All methods</td><td colspan="2"></td></tr>
<tr><td colspan="2">Thermal resistance
(only when the product is intended also for thermal applications)</td><td>4.2.13,
5.1.4</td><td>—</td><td></td><td colspan="2">Declared value in $(m^2 \cdot K)/W$ or
λ_{10dry} in $W/(m \cdot K)$</td></tr>
<tr><td colspan="2">Direct airborne sound insulation index (only when the product is intended also for acoustical application)</td><td>5.1.2.1</td><td>—</td><td></td><td colspan="2">Declared value in dB</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>—</td><td>All methods</td><td colspan="2"></td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.2.6</td><td>—</td><td>All methods</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1.4 — Relevant clauses for floor components

Construction Product(s): Floor components (RF) as slabs as covered in the scope of this European Standard

Intended use(s): Structural

Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
Compressive strength (of concrete), flexural strength (of concrete)		4.2.3, 4.2.4 4.2.5	—	All methods	Declared value in MPa or declared strength class	
Density		4.2.2.2, 4.2.2.3	—	All methods	Declared values in kg/m^3 or declared density class	
Ultimate tensile strength and yield strength (of steel)		4.3	—	All methods	Declared values in MPa	
Mechanical resistance	In case of verification by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant	5.1.1 (Annex A) 7.1 (Annex A)	—	Method M1	Declared geometry and materials properties as above	Method of design: by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
	In case of verification by testing: Loadbearing capacity	5.1.1 (Annex B) 7.1 (Annex B)	—	Method M1	Declared geometry and materials properties as above	
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	

Construction Product(s): Floor components (RF) as slabs as covered in the scope of this European Standard

Intended use(s): Structural

Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
Detailing		5.2.1, 5.2.7	—	All methods	Significant production drawings if required; declared tolerance class	
Drying shrinkage (in end use conditions)		4.2.10, 5.2.3	—	All methods	Declared value from testing or tabulated value, in mm/m	
Durability against: freeze–thaw (only for exposed applications)		5.3.1, 5.3.4	—	All methods	Declared freeze/thaw resistance	
Durability against: Corrosion		5.3.1, 5.3.3	—	All methods	Coating of reinforcement bars	
Reaction to fire (only for exposed applications)		5.1.3.1	Euro-classes	All methods	Declared class	
Resistance to fire (in the end use conditions)		5.1.3.2	RE, REI	All methods		
Thermal resistance (only when the product is intended also for thermal applications)		4.2.13, 5.1.4	—		Declared value in $(m^2 \cdot K)/W$ or λ_{10dry} in $W/(m \cdot K)$	
Direct airborne sound insulation index (only when the product is intended also for acoustical application)		5.1.2.1	—		Declared value in dB (either by testing or by calculation)	
Release of dangerous substances		4.1.2	—	All methods		
Rigidity of joints		5.2.6	—	All methods	Declared value	

Table ZA.1.5 — Relevant clauses for linear components

Construction Product(s): Linear components (BL, PL) as covered in the scope of this European Standard

Intended use(s): Structural

Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
Compressive strength (of concrete), flexural strength (of concrete)		4.2.3, 4.2.4 4.2.5	—	All methods	Declared value in MPa or declared strength class	
Density		4.2.2.2, 4.2.2.3	—	All methods	Declared values in kg/m^3 or declared density class	
Ultimate tensile strength and yield strength (of steel)		4.3	—	All methods	Declared values in MPa	
Mechanical resistance	In case of verification by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant	5.1.1 (Annex A) 7.1 (Annex A)	—	Method M1	Declared geometry and materials properties as above	Method of design: by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
	In case of verification by testing: Loadbearing capacity	5.1.1 (Annex B) 7.1 (Annex B)	—	Method M1	Declared geometry and materials properties as above	
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	

Construction Product(s): Linear components (BL, PL) as covered in the scope of this European Standard

Intended use(s): Structural

Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
Detailing		5.2.1, 5.2.7	—	All methods	Significant production drawings if required; declared tolerance class	
Durability against: corrosion		5.3.1, 5.3.3	—	All methods	Coating of reinforcement bars	
Reaction to fire (only for exposed applications)		5.1.3.1	Euro-classes	All methods	Declared class	
Resistance to fire (in the end use conditions)		5.1.3.2	R	All methods		
Release of dangerous substances		4.1.2	—	All methods		

Table ZA.1.6 — Relevant clauses for non-loadbearing wall and sound barrier components

Construction Product(s): Non-loadbearing wall components (WN) and sound barrier components (SB) as covered in the scope of this European Standard Intended use(s): Non-structural						
Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
Compressive strength (of concrete), flexural strength (of concrete)		4.2.3, 4.2.4 4.2.5	—	All methods	Declared value in MPa or declared strength class	
Density		4.2.2.2, 4.2.2.3	—	All methods	Declared values in kg/m^3 or declared density class	
Ultimate tensile strength and yield strength (of steel)		4.3	—	All methods	Declared values in MPa	
Water vapour permeability (for external walls)		4.2.14	—	All methods	Declared factor or value in g·m/(MN·s)	
Mechanical resistance	In case of verification by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant	5.1.1 (Annex A) 7.1 (Annex A)	—	Method M1	Declared geometry and materials properties as above	Method of design: by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
	In case of verification by testing: Loadbearin	5.1.1 (Annex B) 7.1 (Annex B)	—	Method M1	Declared geometry and materials properties as above	

Construction Product(s): Non-loadbearing wall components (WN) and sound barrier components (SB) as covered in the scope of this European Standard

Intended use(s): Non-structural

Essential Characteristics	Clause(s) in this European Standard	Regulatory classes	Notes, units	
g capacity			Method M2	Declared values in kNm, kN, kN/m, etc., as relevant
			Method M3a	Design documentation elaborated by the client
			Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works
Detailing	5.2.1, 5.2.7	—	All methods	Significant production drawings if required; declared tolerance class
Drying shrinkage (in end use conditions)	4.2.10, 5.2.3	—	All methods	Declared value from testing or tabulated value, in mm/m
Reaction to fire (only for exposed applications)	5.1.3.1	Euro-classes	All methods	Declared class
Resistance to fire (in the end use conditions)	5.1.3.2	E, EI, EI-M	All methods	
Thermal resistance (only when the product is intended also for thermal applications)	4.2.13, 5.1.4	—		Declared value in $(m^2 \cdot K)/W$ or λ_{10dry} in $W/(m \cdot K)$
Direct airborne sound insulation index (only when the product is intended also for acoustical application)	5.1.2.1	—		Declared value in dB
Release of dangerous substances	4.1.2	—	All methods	
Rigidity of joints	5.2.6	—	All methods	Declared value

Table ZA.1.7 — Relevant clauses for non-loadbearing cladding components

Construction Product(s): Cladding components (CN) as covered in the scope of this European Standard Intended use(s): Non-Structural						
Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
Compressive strength (of concrete), flexural strength (of concrete)		4.2.3, 4.2.4 4.2.5	—	All methods	Declared value in MPa or declared strength class	
Density		4.2.2.2, 4.2.2.3	—	All methods	Declared values in kg/m^3 or declared density class	
Ultimate tensile strength and yield strength (of steel)		4.3	—	All methods	Declared values in MPa	
Water vapour permeability (for external walls)		4.2.14	—	All methods	Declared factor or value in g·m/(MN·s)	
Mechanical resistance	In case of verification by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant	5.1.1 (Annex A) 7.1 (Annex A)	—	Method M1	Declared geometry and materials properties as above	Method of design: by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
	In case of verification by testing: Loadbearing capacity	5.1.1 (Annex B) 7.1 (Annex B)	—	Method M1	Declared geometry and materials properties as above	
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	

Construction Product(s): Cladding components (CN) as covered in the scope of this European Standard

Intended use(s): Non-Structural

Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
Drying shrinkage (in end use conditions)		4.2.10, 5.2.3	—	All methods	Declared value from testing or tabulated value, in mm/m	
Durability against: freeze–thaw (only for exposed applications)		5.3.1, 5.3.4	—	All methods	Declared freeze/thaw resistance	
Durability against: corrosion		5.3.1, 5.3.3	—	All methods	Coating of reinforcement bars	
Reaction to fire (only for exposed applications)		5.1.3.1	Euro-classes	All methods	Declared class	
Resistance to fire (in the end use conditions)		5.1.3.2	E, EI, EI-M	All methods		
Thermal resistance (only when the product is intended also for thermal applications)		4.2.13, 5.1.4	—		Declared value in $(m^2 \cdot K)/W$ or λ_{10dry} in $W/(m \cdot K)$	
Direct airborne sound insulation index (only when the product is intended also for acoustical application)		5.1.2.1	—		Declared value in dB	
Release of dangerous substances		4.1.2	—	All methods		
Rigidity of joints		5.2.6	—	All methods	Declared value	

Table ZA.1.8 — Relevant clauses for non-loadbearing small box culvert components

Construction Product(s): Box culvert components (BN) as covered in the scope of this European Standard Intended use(s): Non-Structural						
Essential Characteristics		Clause(s) in this European Standard	Regulatory classes	Notes, units		
Compressive strength (of concrete), flexural strength (of concrete)		4.2.3, 4.2.4 4.2.5	—	All methods	Declared value in MPa or declared strength class	
Density		4.2.2.2, 4.2.2.3	—	All methods	Declared values in kg/m^3 or declared density class	
Ultimate tensile strength and yield strength (of steel)		4.3	—	All methods	Declared values in MPa	
Mechanical resistance	In case of verification by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsion or punching shear strength as relevant	5.1.1 (Annex A) 7.1 (Annex A)	—	Method M1	Declared geometry and materials properties as above	Method of design: by calculation (Annex A) or by testing (Annex B) shall be declared; the bond class (4.4) and the thermal prestress class (4.5) shall be declared.
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	
				Method M3b	Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works	
	In case of verification by testing: Loadbearing capacity	5.1.1 (Annex B) 7.1 (Annex B)	—	Method M1	Declared geometry and materials properties as above	
				Method M2	Declared values in kNm, kN, kN/m, etc., as relevant	
				Method M3a	Design documentation elaborated by the client	

<table>
<tr><td colspan="7">Construction Product(s): Box culvert components (BN) as covered in the scope of this European Standard
Intended use(s): Non-Structural</td></tr>
<tr><td colspan="2">Essential Characteristics</td><td>Clause(s) in this European Standard</td><td>Regulatory classes</td><td colspan="3">Notes, units</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Method M3b</td><td>Design documentation and manufacturing documentation elaborated by the manufacturer with reference to the works</td><td></td></tr>
<tr><td colspan="2">Detailing</td><td>5.2.1,
5.2.7</td><td>—</td><td>All methods</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage
(in end use conditions)</td><td>4.2.10,
5.2.3</td><td>—</td><td>All methods</td><td colspan="2">Declared value from testing or tabulated value, in mm/m</td></tr>
<tr><td colspan="2">Durability against: freeze–thaw (only for exposed applications)</td><td>5.3.1,
5.3.4</td><td>—</td><td>All methods</td><td colspan="2">Declared freeze/thaw resistance</td></tr>
<tr><td colspan="2">Durability against: corrosion</td><td>5.3.1,
5.3.3</td><td>—</td><td>All methods</td><td colspan="2">Coating of reinforcement bars</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>—</td><td>All methods</td><td colspan="2"></td></tr>
</table>

ZA.2 System of Assessment and Verification of Constancy of Performance (AVCP)

The AVCP system(s) of prefabricated reinforced components of autoclaved aerated concrete indicated in Table(s) ZA.1.1 to ZA.1.8, can be found in the EC legal act(s) adopted by the EC: Decisions 95/204/EC (OJ L 129) and 1999/94/EC (OJ L 29).

Micro-enterprises are allowed to treat products under AVCP system 3 covered by this standard in accordance with AVCP system 4, applying this simplified procedure with its conditions, as foreseen in Article 37 of Regulation (EU) No.305/2011.

ZA.3 Assignment of AVCP tasks

The AVCP system(s) of the prefabricated reinforced components of autoclaved aerated concrete as provided in Table(s) ZA.1.1 to ZA.1.8 is defined in Table(s) ZA.3.1 to ZA.3.2 resulting from application of the clauses of this or other European Standards indicated therein. The content of the tasks assigned to the notified body shall be limited to those essential characteristics, if any, as provided for in Annex III of the relevant standardization request and to those that the manufacturer intends to declare.

Taking into account the AVCP systems defined for the products and the intended uses the following tasks are to be undertaken by the manufacturer and the notified body respectively for the assessment and verification of the constancy of performance of the product.

Table ZA.3.1 — Assignment of AVCP tasks for prefabricated reinforced components of autoclaved aerated concrete under system 2+1)

Tasks		Content of the task	AVCP clauses to apply
Tasks for the manufacturer	An assessment of the performance of the construction product carried out on the basis of testing (including sampling), calculation, tabulated values or descriptive documentation of the product	All essential characteristics of Tables ZA.1.1 to ZA.1.5 relevant for the intended use which are declared	6.2
	Factory production control (FPC)	Parameters related to all essential characteristics of Tables ZA.1.1 to ZA.1.5 relevant for the intended use which are declared	6.3
	Testing of samples taken at factory according to the prescribed test plan	All essential characteristics of Tables ZA.1.1 to ZA.1.5 relevant for the intended use which are declared	6.3.2.7
Tasks for the notified factory production control certification body	Initial inspection of the manufacturing plant and of FPC	Parameters related to all essential characteristics of Tables ZA.1.1 to ZA.1.5, relevant for the intended use which are declared. Documentation of the FPC.	6.3.4
	Continuous surveillance, assessment and evaluation of FPC	Parameters related to all essential characteristics of Tables ZA.1.1 to ZA.1.5, relevant for the intended use which are declared. Documentation of the FPC.	6.3.5
1) Applies to wall components (WL), retaining wall components (WR), roof and floor components (RF), beams (BL) and piers (PL).			

Taking into account the AVCP systems defined for the products and the intended uses the following tasks are to be undertaken by the manufacturer for the assessment and verification of the constancy of performance of the product.

Table ZA.3.2 — Assignment of AVCP tasks for prefabricated reinforced components of autoclaved aerated concrete under system 4 1)

Tasks		Content of the task	AVCP clauses to apply
Tasks for the manufacturer	An assessment of the performance of the construction product on the basis of testing, calculation, tabulated values or descriptive documentation of that product	All essential characteristics of Tables ZA.1.6 to ZA.1.8 relevant for the intended use which are declared	6.3
	Factory production control (FPC)	Parameters related to all essential characteristics of Tables ZA.1.6 to ZA.1.8 relevant for the intended use	6.2
1) Applies to cladding components (CN), partition wall components (WN), box culverts (BN) and components for sound barriers (SB).			

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[24] ISO 4356, *Bases for the design of structures — Deformations of buildings at the serviceability limit states*

National Annex NA (informative)

Nationally determined parameters on prefabricated reinforced components of autoclaved aerated concrete

Introduction

This National Annex has been prepared by Technical Committee B/523, Prefabricated components of reinforced autoclaved aerated concrete and lightweight aggregate concrete with open structure. In the UK it is to be used in conjunction with BS EN 12602:2016.

NA.1 Scope

This National Annex gives:

a) the UK decisions for the Nationally Determined Parameters described in the following subclauses of BS EN 12602:2016:

5.1.4	Design thermal resistance and design thermal conductivity
5.3.4	Freeze and thaw resistance
A.3.2 (1), (3)	Stress-strain diagram for AAC
A.3.3 (1)	Stress-strain diagram for reinforcing steel
A.4.1.2 (1)	Components not requiring design shear reinforcement
A.4.1.3.1 (7)	Shear resistance
A.4.1.3.2 (1)	Design steel stress in shear reinforcement
A.4.1.3.3 (1)	Design shear resistance V_{Rd2}
A.5.2 (1)	Method based on Euler formula
A.5.3.3.3 (3)	Non-structurally reinforced cross-section
A.6.3 (1)	Design method for punching shear
A.7 (2), (3)	Primary torsion/combined primary torsion and shear
A.8 (2)	Concentrated forces
A.9.4.1 (5), (6)	Basic considerations (serviceability limit states of deformation)
A.10.2.2 (1)	Design bond strength
A.10.3 (2)	Anchorage
B.3.2.2 (2), (3)	Design values for bending and shear capacity
B.3.3.2 (2)	Design loadbearing capacity
B.3.3.3.2 (1)	Design loadbearing capacity
C.2.2(1)	Design values of material properties
Annex D	Recommended values for partial safety factors;

b) the UK decisions on the status of BS EN 12602:2016 informative annexes; and

c) other clauses requiring national decisions.

NA.2 Nationally Determined Parameters

NA.2.1 Stress-strain diagram for AAC [BS EN 12602:2016, A.3.2 (1), (3)]

In formula A.1 the value of γ_c should be taken from Table D.4 in NA.2.19.

The value for α in Figure A.2 should be taken as 0,85.

NA.2.2 Stress-strain diagram for reinforcing steel [BS EN 12602:2016, A.3.3 (1)]

In formula A.2 the value of γ_s should be taken from Table D.4 in NA.2.19.

NA.2.3 Components not requiring design shear reinforcement [BS EN 12602:2016, A.4.1.2 (1)]

In formula A.6 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.4 Shear resistance [BS EN 12602:2016, A.4.1.3.1 (7)]

In formula A.9 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.5 Design steel stress in shear reinforcement [BS EN 12602:2016, A.4.1.3.2 (1)]

In formulae A.10 and A.11 the values of γ_c and γ_s should be taken from Table D.4 in NA.2.19.

NA.2.6 Design shear resistance V_{Rd2} [BS EN 12602:2016, A.4.1.3.3 (1)]

In formula A.12 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.7 Method based on Euler formula [BS EN 12602:2016, A.5.2 (1)]

In formula A.14 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.8 Non-structurally reinforced cross-sections [BS EN 12602:2016, A.5.3.3.3 (3)]

In formulae A.27, A.28 and A.29 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.9 Design method for punching shear [BS EN 12602:2016, A.6.3 (1)]

In formula A.30 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.10 Primary torsion/combined primary torsion and shear [BS EN 12602:2016, A.7 (2), (3)]

In formulae A.32a, A.32b, A.32c and A.36 of BS EN 12602:2016, the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.11 Concentrated forces [BS EN 12602:2016, A.8 (2)]

In formula A.39 the value of γ_c should be taken from Table D.4 in NA.2.19 and the value for α should be taken as 0,85.

NA.2.12 Basic considerations (serviceability limit states of deformation) [BS EN 12602:2016, A.9.4.1 (5), (6)]

In clause A.9.4.1 (5) the limit value recommended for the calculated sag of roof and floor components subjected to quasi-permanent loads is span/250.

In clause A.9.4.1 (6) the limit value recommended for the deflections that may cause damage to partitions or other elements in contact with the component and occurring after installation of such members ("active" deflection) is span/500.

NA.2.13 Design bond strength [BS EN 12602:2016, A.10.2.2 (1)]

In formula A.46 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.14 Anchorage [BS EN 12602:2016, A.10.3 (2)]

In formula A.48 the value for $Ø_{tot}$ should be the actual outer bar dimension, excluding the corrosion protection coating.

In formula A.48 the value of γ_s should be taken from Table D.4 in NA.2.19.

In formula A.49 the value of γ_c should be taken from Table D.4 in NA.2.19.

NA.2.15 Design values for bending and shear capacity [BS EN 12602:2016, B.3.2.2 (2), (3)]

In formulae B.1 and B.2 the value of γ_{comp} should be taken from Table D.4 in NA.2.19.

NA.2.16 Design loadbearing capacity [BS EN 12602:2016, B.3.3.2 (2)]

In formula B.4 the value of γ_{comp} should be taken from Table D.4 in NA.2.19.

NA.2.17 Design loadbearing capacity [BS EN 12602:2016, B.3.3.3.2 (1)]

In formula B.5 the value of γ_{comp} should be taken from Table D.4 in NA.2.19.

NA.2.18 Design values of material properties [BS EN 12602:2016, C.2.2(1)]

The value of $\gamma_{M,fi}$ = 1,0 should be used as the material safety factor for fire design.

NA.2.19 Recommended values for partial safety factors [BS EN 12602:2016, Annex D]

This clause has been amended to reflect the UK national parameters and gives recommended values for partial safety factors. The following clause numbers refer to the clauses in BS EN 12602:2016.

NA.3 Decisions on the status of informative annexes

BS EN 12602:2016 informative Annexes CB, D, E, F and ZA may be used in the UK. The partial safety factors and the reliability levels should be as per the recommended values given in Annex D.

NA.4 Other clauses requiring national decisions

NA.4.1 Derived density values [BS EN 12602:2016, 4.2.2.4]

The manufacturer’s declared density as described in Clause 4.2.2.3 should be used in preference to derived densities.

NA.4.2 Design thermal resistance and design thermal conductivity [BS EN 12602:2016, 5.1.4]

The design moisture content for AAC is to be taken as 3% by weight for protected conditions and 5% by weight for unprotected conditions.

NA.4.3 Freeze and thaw resistance [BS EN 12602:2016, 5.3.4]

The required number of freeze/thaw cycles is 15. The mean value for the loss in mass should not exceed 5%.

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