BS EN 1520:2011

BSI Standards Publication

Prefabricated reinforced components of lightweight aggregate concrete with open structure with structural or non-structural reinforcement

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 1520:2011. It supersedes BS EN 1520:2002 which is withdrawn.

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.

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

ISBN 978 0 580 59023 8

ICS 91.100.30

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2011.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1520

March 2011

ICS 91.100.30

Supersedes EN 1520:2002

English Version

Prefabricated reinforced components of lightweight aggregate concrete with open structure with structural or non-structural reinforcement

Composants préfabriqués en béton de granulats légers à structure ouverte avec des armatures structurales et non-structurales

Vorgefertigte Bauteile aus haufwerksporigem Leichtbeton und mit statisch anrechenbarer oder nicht anrechenbarer Bewehrung

This European Standard was approved by CEN on 5 February 2011.

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

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 1520:2011: E

Contents

Figures

Tables

Foreword

This document (EN 1520:2011) has been prepared by Technical Committee CEN/TC 177 “Prefabricated reinforced components of autoclaved aerated concrete or lightweight 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of an identical text or by endorsement, at the latest by September 2011, and conflicting national standards shall be withdrawn at the latest by December 2012.

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

This document supersedes EN 1520:2002.

Among others, the following changes have been made compared to EN 1520:2002:

— terms and definitions have been updated;

— the order of clauses has been changed;

— lightweight aggregate concrete parameters have been adapted;

— normative references for reinforcement steel have been updated;

— properties and requirements of components have been adapted, e.g. acoustic properties, thermal resistance;

— evaluation of conformity has been adapted;

— Annex A and Annex ZA have been adapted;

— the standard has been editorially edited.

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 Directive 89/106/EEC.

For relationship with EU Directives, 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;

— the procedure to be used where alternative procedures are given in this European Standard.

It may contain

— decisions on the application of informative annexes;

— references to non-contradictory complementary information to assist the user to apply this European Standard.

There is a need for consistency between this document for construction products and the technical rules for works. That means all the information accompanying the CE Marking of the construction products should clearly mention which Nationally Determined Parameters have been taken into account.

EN 1520 describes the design principles and requirements for safety, serviceability and durability of prefabricated components of lightweight aggregate concrete with open structure and with structural or non-structural reinforcement. The design of the components is based on the limit state concept used in conjunction with partial safety factors.

EN 1520 is intended to be used together with Eurocodes EN 1990, EN 1991 and EN 1998.

Numerical values for partial safety factors and other reliability parameters are recommended as basic values that provide an acceptable level of reliability. They have been selected assuming that an appropriate level of workmanship and of quality management applies.

This European Standard gives values with notes indicating where national choices may be made. Therefore, the National Standard implementing EN 1520 should be used with a national application document containing all Nationally Determined Parameters to be used for the design of prefabricated components of lightweight aggregate concrete with open structure and with structural or non-structural reinforcement to be constructed in the relevant country.

National choice is allowed in EN 1520 through the following clauses:

4.3	A.5.2
5.1.1.1	A.6
5.3.5	A.6.1
5.3.7	A.6.2
5.4.3	A.6.3.3.3
5.5.1	A.8.1.4
5.6.2	A.8.2.1.2
5.6.4.2	A.8.2.2.2
7.3	A.9
A.3	B.3.2
A.4.1	B.3.3
A.4.2	B.4.3.1
A.4.3	B.4.3.3
A.5.1	Annex C

Regulatory classes are only given for "Reaction to fire" and "Resistance to fire". All other classes used in this European Standard, i.e. density classes and strength classes, are technical classes.

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

1 Scope

This European Standard is for prefabricated components of lightweight aggregate concrete (LAC) with open structure and with structural or non-structural reinforcement intended to be used in building construction

a) for structural elements:

- loadbearing wall components (solid, hollow core or multilayer);
- retaining wall components (solid) with or without surcharge loading;
- roof components (solid, hollow core or multilayer);
- floor components (solid, hollow core or multilayer);
- linear components (beams or piers).

b) for non-structural elements:

- non-loadbearing wall components (e.g. for 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.

NOTE 1 In addition to their loadbearing and encasing function, components can also be used to provide fire resistance, sound insulation and thermal insulation.

Components covered by this European 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);
- fixtures;
- finishes for external components, such as tiling.

NOTE 2 LAC components can be used in noise barriers if they are designed to fulfil also the requirements of EN 14388.

2 Normative references

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

EN 206-1:2000, *Concrete — Part 1: Specification, performance, production and conformity*

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 dimension of prefabricated reinforced components made of autoclaved aerated concrete or lightweight aggregate concrete with open structure*

EN 992, *Determination of the dry density of lightweight aggregate concrete with open structure*

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

EN 1354, *Determination of compressive strength of 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 1364-1, *Fire resistance tests for non-loadbearing elements — Part 1: Walls*

EN 1365-1, *Fire resistance tests for loadbearing elements — Part 1: Walls*

EN 1365-2, *Fire resistance tests for loadbearing elements — Part 2: Floors and roofs*

EN 1365-3, *Fire resistance tests for loadbearing elements — Part 3: Beams*

EN 1365-4, *Fire resistance tests for loadbearing elements — Part 4: Columns*

EN 1521, *Determination of flexural strength of lightweight aggregate concrete with open structure*

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 1745, *Masonry and masonry products — Methods for determining design thermal values*

EN 1793-1, *Road traffic noise reducing devices — Test method for determining the acoustic performance — Part 1: Intrinsic characteristics of sound absorption*

EN 1793-2, *Road traffic noise reducing devices — Test method for determining the acoustic performance — Part 2: Intrinsic characteristics of airborne sound insulation*

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

EN 10025-1, *Hot rolled products of structural steels — Part 1: General technical delivery conditions*

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

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

EN 12354-1, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms*

EN 12354-2, *Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 2: Impact sound insulation between rooms*

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 12667, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Products of high and medium thermal resistance*

EN 12939, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Thick products of high and medium thermal resistance*

EN 13055-1, *Lightweight aggregates — Part 1: Lightweight aggregates for concrete, mortar and grout*

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 test data from fire resistance tests, excluding ventilation services*

EN ISO 140-3, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 3: Laboratory measurements of airborne sound insulation of building elements (ISO 140-3:1995)*

EN ISO 140-6, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 6: Laboratory measurements of impact sound insulation of floors (ISO 140-6:1998)*

EN ISO 354, *Acoustics — Measurement of sound absorption in a reverberation room (ISO 354:2003)*

EN ISO 717-1, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation (ISO 717-1:1996)*

EN ISO 717-2, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation (ISO 717-2:1996)*

EN ISO 1182, *Reaction to fire tests for products — Non-combustibility test (ISO 1182:2010)*

EN ISO 1716 *Reaction to fire tests for products — Determination of the gross heat of combustion (calorific value) (ISO 1716:2010)*

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2009)*

EN ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method (ISO 6946:2007)*

EN ISO 10456, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values (ISO 10456:2007)*

EN ISO 12572, *Hygrothermal performance of building materials and products — Determination of water vapour transmission properties (ISO 12572:2001)*

EN ISO 15148, *Hygrothermal performance of building materials and products — Determination of water absorption coefficient by partial immersion (ISO 15148:2002)*

ISO 80000-1, *Quantities and units — Part 1: General*

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
lightweight aggregate
LWA
aggregate of mineral origin having a particle density not exceeding 2 000 kg/m^3 (2,00 Mg/m^3) or a loose bulk density not exceeding 1 200 kg/m^3 (1,20 Mg/m^3)

3.1.2
lightweight aggregate concrete
LAC
concrete with an open structure having an oven-dry density of not more than 2 000 kg/m^3 and made with aggregates consisting entirely or partly of lightweight aggregates (LWA)

3.1.3
loadbearing component
component which carries permanent, variable or accidental actions

NOTE Components exposed mainly to wind loads or acting as part of fire resisting walls are considered to be loadbearing.

3.1.4
non loadbearing component
component that mainly supports its own weight and does not contribute to the stability of the works

3.2 Symbols

3.2.1 General symbols

A area

b width of component

d effective depth of cross-section

E modulus of elasticity

e eccentricity

f strength

h overall depth or thickness of cross-section or of component

I moment of inertia

i radius of inertia

k coefficient, factor

l length, height of wall component, span length of a roof or floor component

M bending moment

N axial compression force

t time

V shear force

γ partial safety factor, confidence level

ε strain

σ normal stress

τ shear stress

3.2.2 Subscripts

a anchorage

c concrete parameter, compression

comp component

cr critical

d design value

dry dry state

eff effective value

fl flexural

g declared value

h horizontal

hum in the moist state

k characteristic value

M material

m mean, mandrel

R resistance

S section

s steel parameter, shear; drying shrinkage

t tension

u ultimate (in the ultimate limit state ULS)

w welded, web (shear reinforcement), weak axis

y yield value (for steel)

0 effective value

3.2.3 Symbols used in this European Standard

A_{c} area of the lightweight aggregate concrete section; area of compression zone of the cross-section

A_{c0} partially loaded area

A_{s1} area of tension reinforcement

A_{s2} cross-sectional area of compressive reinforcement

A_{sw} area of shear reinforcement

a dimension of a support perpendicular to the plane of the wall, width of a cavity in hollow core components

a_0 minimum support length

b width of component

b_d width of hollow cores in hollow core wall components

b_i width of solid concrete web between hollow cores of hollow core wall components

b_r width of circumferential solid concrete shell of hollow core wall components

b_0 minimum residual cross-sectional width of a slab

b_v width of the vertical solid web of hollow core components (Figure 4)

b_w minimum width of the section over the effective depth, minimum width of the section in the compression zone

C_{Rd} parameter for shear capacity

c_d concrete cover

d effective thickness of a cross-section

E_{cm} mean value of the modulus of elasticity of LAC

E_{red} $=0{,}6E_{cm}$ reduced modulus of elasticity of LAC taking into account the effects of creep

E_s modulus of elasticity of reinforcement steel

e basis of natural logarithm (= 2,718)

e_a additional eccentricity of the longitudinal action due to geometrical imperfections

e_c additional eccentricity due to creep

e_g declared eccentricity at the top of a vertical component perpendicular to its plane, i.e. the eccentricity used in the operational testing

e_m first order eccentricity due to transverse load

e_N eccentricity of the longitudinal action in the plane of the component

e_0 first order eccentricity of the longitudinal action

e_{tot} total eccentricity of the design axial compression force N_d

e_1 resulting first order eccentricity of the longitudinal load perpendicular to the plane of the component, taken as the sum of e_0 and e_a

e_2 resulting second order eccentricity

f_{cd} design value of the compressive strength of LAC

f_{ck} characteristic compressive strength of LAC

$f_{ck,g}$ declared characteristic compressive strength of LAC

$f_{c,n}$ required minimum compressive strength of a test set with $n \geq 6$ test specimens

$f_{c,3}$ required minimum compressive strength of each test set of three consecutive test specimens

f_k characteristic value of strength parameters

f_{min} required minimum strength

$f_{m,n}$ mean value of n strength results

$f_{t,fld}$ design value of flexural strength of LAC

$f_{t,flk}$ characteristic flexural strength of LAC

f_u moisture conversion coefficient

f_{yd} design value of the yield strength of the steel

f_{yk} characteristic value of the yield strength of the steel

f_{ywd} design value of the yield strength of the shear reinforcement

f_{ywk} characteristic value of the yield strength of the shear reinforcement

f_1 load increasing factor recognizing the effect of second order theory

H_{fd} additional horizontal force due to inclination of the components and effects of second order theory

h overall thickness of roof or floor component or beam, design thickness of a pier or wall

h_f thickness of outer or inner concrete layer of hollow core wall components

h_1 thickness of the top layer of a hollow core or multilayer slab

h_2 thickness of the bottom layer of a hollow core or multilayer slab

h_w overall thickness of a component in the direction of the weak axis; height of the shear reinforcement

I_c moment of inertia of the compressive zone

i_c radius of inertia of the compression zone of the cross-section

i_w radius of inertia in the direction of the weak axis

K_n statistical coefficient for determination of characteristic strength (λ is used in EN 206-1)

k factor for the shear strength

k_s column factor

k_{sg} column factor for operational testing

L distance of stiffening walls or other stiffening elements between each other

l span length or height

l_a anchorage length

l_h horizontal length of a wall

l_e is the clear height of the backfill

$l_{h,eff}$ effective horizontal length of a wall

$l_{h,g}$ declared horizontal length of the component, i.e. the horizontal length of the component used in operational testing

l_s shear span (distance of a point load or line load from the axis of the support reaction)

l_0 effective height with respect to buckling, buckling length

l_{0g} declared wall or pier height, i.e. the height used in operational testing

l_w height of wall component

M bending moment

M_h bending moment resulting from horizontal actions

M_{Rd} design bending resistance of component

M_{Rk} characteristic bending capacity of component

M_{R1} minimum bending capacity

M_{R2} maximum bending capacity

N axial compression force in the section under consideration

N_{ba} vertical loading below the considered horizontal joint

N_{bc} vertical loading above the considered horizontal joint

N_{cr} critical axial design compression force determined for the eccentricity e_a

N_d design axial compression force

N_{Rd} resisting design axial compression force

N_{Rg} declared resisting axial compression force

N_{Rk} characteristic resisting axial compression force

N_{Sd} design value of axial compression force in the section

n number of test specimens in a sample, number of test results

n_{Sdmax} upper value of the design axial compression force per unit of length, determined at half height of the backfill, see Figure A.5

n_{Sdmin} is the lower value of the design axial compression force per unit of length, determined at half the height of the backfill

R percentage of reinforcement = ratio of the cross-sectional area of transverse reinforcement to that of the longitudinal reinforcement, in percent

S slenderness ratio

s spacing of the shear reinforcement bars

s_d diffusion-equivalent air layer thickness

s_n standard deviation of n test results

T	tensile splitting force at top of hollow core wall component or pier due to centric loading
V_{Rd}	contribution of the LAC to design shear resistance of a component
V_{Rd1}	design shear resistance of a component without shear reinforcement
V_{Rd2}	design shear crushing resistance (maximum shear force that can be carried without crushing of the notional concrete compressive struts)
V_{Rd3}	design shear resistance of a component with shear reinforcement
V_{Rd4}	design shear resistance of components under predominantly centric or eccentric longitudinal forces
V_{Rk}	characteristic value of shear resistance
V_{Sd}	design shear force in the section
V_{wd}	contribution to the design shear resistance from any vertical shear reinforcement
v_{mind}	minimum shear strength
w	water absorption coefficient
x	neutral axis depth
z	height of the shear zone, lever arm of internal forces
α	reduction factor for long term effects on the compressive strength of LAC
α_{a2}	inclination of the components according to national rules
α_2, α_6 α_7	factors for anchorage lengths
β	coefficient for the situation of C in the strain diagram according to Figure A.3; coefficient for the determination of the buckling length (Table A.2 and Equation (A.25))
γ_B	partial safety factor for transversely loaded components for brittle failure
γ_{comp}	partial safety factor for component (general)
γ_C	partial safety factor for concrete (also for LAC)
γ_D	partial safety factor for transversely loaded components for ductile failure
γ_M	partial safety factor for material (general)
γ_S	partial safety factor for reinforcement steel
γ_W	partial safety factor for longitudinally loaded components for brittle failure
ε_{cu}	ultimate compressive strain of LAC
ε_{s1}	strain of tensile reinforcement
ε_{s2}	strain of compression reinforcement
ε_{suk}	characteristic value of ultimate steel strain
η_1	coefficient according to Equation (2)
η_2	coefficient according to Equation (5a) or Equation (5b)

θ angle of compressive struts

λ thermal conductivity

λ_{10dry} thermal conductivity in the dry state, determined at a mean test temperature of 10 °C

λ_d design value of thermal conductivity in the moist state, at a moisture content μ_m

μ_m moisture content, related to mass

ν efficiency factor (see Equation (A.14))

ρ dry density of LAC

ρ_1 reinforcement ratio

ρ_3 reduction factor for design shear capacity in the case of short anchorage length

ρ_w shear reinforcement ratio

σ_{cd} design value of concrete compressive edge stress

σ_{sd} design stress of anchored bar at the end of the overlap

τ_{Rd} basic shear strength

τ_{Rk} characteristic shear strength

φ factor taking into account the extent of bending as a function of the type of support of a cellar wall

$\varphi_{LAC}(\infty, t_0)$ design value of final creep coefficient of LAC

ϕ diameter

ϕ_m diameter of mandrel

ϕ_s diameter of reinforcing bar

3.3 Abbreviations

FPC factory production control

ITT initial type testing

LC lightweight concrete

LWA lightweight aggregate

LAC lightweight aggregate concrete with open structure

RH relative humidity

SLS serviceability limit state

ULS ultimate limit state

3.4 Units

Units shall be used in accordance with ISO 80000-1.

For calculations, the following units are recommended:

- forces and loads: kN, kN/m, kPa (= kN/m^2);
- density: kg/m^3;
- unit weight: kN/m^3;
- stresses and strengths, modulus of elasticity: MPa (= N/mm^2 or MN/m^2);
- moments (bending...): kNm.

4 Properties and requirements of materials

4.1 Constituents

4.1.1 General

LWA shall comply with EN 13055-1.

The constituent materials of LAC shall comply with EN 206-1:2000, 5.1.

4.1.2 Release of dangerous substances

LAC components shall not release critical levels of dangerous substance in their intended use.

The manufacturer shall ensure from suppliers product safety data sheets that the emission of dangerous substances from constituent materials is not higher than defined in Community law and in national provisions applicable in the place of use.

4.2 Lightweight aggregate concrete parameters

4.2.1 Dry density

4.2.1.1 General

The dry density, determined in accordance with EN 992, shall be given, either as a declared mean value or as a declared density class.

4.2.1.2 Declared mean density

The manufacturer may declare the density as a mean value. The tolerances on the declared mean value are specified in Table 1. The declared mean value of dry density of LAC shall be at least 400 kg/m³ and not greater than 2 000 kg/m³.

Table 1 — Tolerances on declared mean dry density of LAC

Dry density in kilograms per cubic metre

Declared mean dry density	≤ 1 000	> 1 000
Maximum deviation between actual mean value in sample and declared mean value	50	100
Maximum deviation between individual values in sample and declared mean value	100	150

4.2.1.3 Declared density class

The manufacturer may declare the dry density in accordance with the density classes in Table 2. The mean value shall be within the indicated limits, but individual values may exceed the indicated limits by up to 50 kg/m^3.

Table 2 — Density classes of LAC

Density class	0,5	0,6	0,7	0,8	0,9	1,0	1,2	1,4	1,6	1,8	2,0
Mean dry density kg/m^3	≥ 400 ≤ 500	> 500 ≤ 600	> 600 ≤ 700	> 700 ≤ 800	> 800 ≤ 900	> 900 ≤ 1 000	> 1 000 ≤ 1200	> 1 200 ≤ 1 400	> 1 400 ≤ 1 600	> 1 600 ≤ 1 800	> 1 800 ≤ 2 000

4.2.2 Characteristic strength values

The characteristic value f_k of strength parameters of LAC or LAC components, as compressive strength or flexural strength of the material or the strength from functional testing of components according to Annex B, shall be determined from the mean value $f_{m,n}$ and the standard deviation s_n of n test results according to Table 3. The K_n-values, depending on the number n of test results, shall be taken from Table 4.

Table 3 — Determination of the characteristic strength f_k and required minimum strength f_{min}

Number of results n	$n < 6$	$6 \leq n \leq 9$	$n \geq 10$
Characteristic strength f_k	0,8 $f_{m,n}$	$f_{m,n} - K_n$x s_n	
Required minimum strength f_{min}	≥ 0,90 f_k	≥ 0,75 f_k	≥ 0,67 f_k

4.2.3 Compressive strength

4.2.3.1 General

The compressive strength of LAC shall be given either as a declared characteristic compressive strength according to 4.2.3.3 or as a declared strength class according to 4.2.3.4.

4.2.3.2 Characteristic compressive strength

The characteristic compressive strength is derived from the strength of cores with an equal length and diameter or of cubes, both with a minimum dimension of 100 mm, which are taken from prefabricated components and tested according to EN 1354. These are the reference test specimens.

If test specimens with smaller dimensions taken from prefabricated components are used for the verification of the compressive strength, the results shall be converted by multiplication by the reduction factors specified in Table 5, unless other factors derived from tests are available.

If cast test specimens are used, the strength results of these test specimens, converted to the strength of cores with a diameter of 100 mm and equal length (or of 100 mm cubes, giving the same value) shall be at least 1/0,85 times higher than that required from test specimens with the above dimensions extracted from prefabricated components.

For the purpose of conversion, the strength of cast test specimens shall be multiplied by the conversion factors in Table 6, unless other factors derived from tests are available.

4.2.3.3 Declared characteristic compressive strength

If the manufacturer declares the characteristic compressive strength $f_{ck,g}$, the actual characteristic compressive strength f_{ck}, determined from test results, shall be equal to or greater than the declared value, and the minimum individual value f_{min} shall fulfil the requirements of Table 3. The declared characteristic compressive strength of LAC shall be at least 2 MPa and not higher than 25 MPa.

4.2.3.4 Declared strength class

If the manufacturer declares the compressive strength in terms of a declared strength class, the actual compressive strength determined in accordance with EN 1354 (converted to the strength of the reference test specimens when appropriate, see 4.2.3.2) shall fulfil the requirements of Table 7.

Table 4 — Statistical coefficient K_n for determination of characteristic strength

Number of test results n	Statistical coefficient K_n
6	1,87
7	1,77
8	1,72
9	1,67
10	1,62
11	1,58
12	1,55
13	1,52
14	1,50
≥ 15	1,48

Table 5 — Reduction factors for compressive strength of cores with indicated diameter and equal length or of cubes with indicated edge length

Diameter of cores or edge length of cubes mm	Reduction factor for compressive strength
> 100	1,00
90	0,98
80	0,96
70	0,94
60	0,92
50	0,90
40	0,88

Table 6 — Conversion factors for conversion of test results of cast test specimens to the strength of reference test specimens (drilled cores of 100 mm diameter and length or 100 mm cubes)

Shape and size of cast test specimen	Conversion factor
Cubes - 150 mm	1,00
Cubes - 200 mm	1,05
Cylinders 150 mm/300 mm, depending on strength MPa	
2	1,05
4	1,05
6	1,06
8	1,07
10	1,08
12	1,10
15	1,12
20	1,15
25	1,18

Table 7 — Strength classes and strength requirements for LAC

Compressive strengths in megapascals

Strength class	LAC 2	LAC 4	LAC 6	LAC 8	LAC 10	LAC 12	LAC 15	LAC 20	LAC 25
f_{ck}	2	4	6	8	10	12	15	20	25
$f_{c,3}$ [a]	≥ 4	≥ 7	≥ 9	≥ 11	≥ 13	≥ 15	≥ 18	≥ 24	≥ 29
$f_{c,n}$ [b]	$\geq f_{ck} + K_n \times s_n$ [d]								
f_{cmin} [c] for $n < 6$	≥ 1,5	≥ 3,5	≥ 5,5	≥ 7,0	≥ 9,0	≥ 11	≥ 14	≥ 19	≥ 24
f_{cmin} [c] for $6 \leq n \leq 9$	≥ 1,5	≥ 3,0	≥ 4,5	≥ 6,0	≥ 7,5	≥ 9,0	≥ 12	≥ 17	≥ 22
f_{cmin} [c] for $n \geq 10$	≥ 1,5	≥ 3,0	≥ 4,0	≥ 5,5	≥ 7,0	≥ 8,0	≥ 11	≥ 16	≥ 21

[a] Required mean compressive strength of each test set of three consecutive test specimens.

[b] Required mean compressive strength of a test series with $n \geq 6$ test specimens. The K_n-values, depending on the number n of test specimens, shall be taken from Table 4.

[c] Minimum individual value of compressive strength of a test series of n test specimens.

[d] s_n is the standard deviation of compressive strength of a test series with n test results.

4.2.4 Flexural strength and uniaxial tensile strength

The flexural strength may be estimated as follows:

$$f_{t,flk} = 0,42\, f_{ck}^{2/3} \times \eta_1 \tag{1}$$

$$\eta_1 = 0,4 + 0,6\, (\rho / 2\,200) \text{ for } \rho > 1\,400 \text{ kg/m}^3 \tag{2a}$$

$$\eta_1 = 0,78 \text{ for } \rho \leq 1\,400 \text{ kg/m}^3 \tag{2b}$$

and the uniaxial tensile strength may be estimated as follows:

$$f_{t,k} = 0,1\, f_{ck}^{2/3} \tag{3}$$

where

$f_{t,flk}$ is the characteristic flexural strength of LAC, in megapascals;

$f_{t,k}$ is the characteristic uniaxial tensile strength of LAC, in megapascals;

ρ is the mean value of the dry density of LAC, in kilograms per cubic metre;

f_{ck} is the characteristic compressive strength of LAC according to 4.2.3, in megapascals.

The flexural strength may also be obtained by testing according to EN 1521 and the characteristic value determined according to 4.2.2.

4.2.5 Stress-strain diagram

The idealised stress-strain diagram for LAC consists of a linear relationship between stress and strain up to a compressive strain of 0,002 at design strength level, continuing at a constant stress level up to the ultimate limit state for the strain, the ultimate strain value depending on the dry density of the LAC (see A.4.2 and Figure A.1).

4.2.6 Modulus of elasticity

The modulus of elasticity may be estimated as follows:

$$E_{cm} = 10\,000\, f_{ck}^{1/3} \times \eta_2 \qquad (4)$$

where

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

f_{ck} is the characteristic compressive strength according to 4.2.3, in megapascals;

η_2 is a coefficient according to Equation (5a) or Equation (5b);

$$\eta_2 = (\rho / 2\,200)^2 \quad \text{for } \rho > 1\,400 \text{ kg/m}^3 \qquad (5a)$$

$$\eta_2 = 0{,}64\,(\rho / 2\,200) \quad \text{for } \rho \leq 1\,400 \text{ kg/m}^3 \qquad (5b)$$

where ρ is the mean value of the dry density, in kilograms per cubic metre.

The modulus of elasticity may also be obtained by testing according to EN 1352.

4.2.7 Poisson's ratio

For design purposes, Poisson's ratio for elastic strains may be taken as 0,2. If cracking is permitted in concrete in tension, Poisson's ratio may be taken as 0,0.

4.2.8 Coefficient of thermal expansion

For design purposes, the coefficient of thermal expansion may be taken as 8×10^{-6} K^{-1}.

4.2.9 Drying shrinkage

The mean value of the drying shrinkage may be taken as 0,75 mm/m for a component with a thickness of at least 75 mm exposed to an environment with a relative humidity of (45 ± 5) %. Alternatively, the mean value of drying shrinkage may be determined by testing.

NOTE The tests can be carried out in accordance with EN 1355 as described for the shrinkage measurements on unloaded control specimens, with the following deviations:

— Three test specimens should be used.

— They should be cut from a prefabricated component two days after casting.

— Until cutting of the test specimens, the prefabricated component should be protected against moisture loss and stored at (20 ± 2) °C.

— Cutting and preparation of the test specimens (measurement, attachment of the gauge plugs etc.) should be such that changes of the moisture content and the temperature of the LAC are avoided as far as possible.

— Without further conditioning of the test specimens, the gauge points should be attached immediately after cutting of the test specimens, and the zero reading of the measuring device for the length changes shall be taken as early as possible.

— Strain readings are recommended after 1, 2, and 7 d storage in an environment at (20 ± 2) °C and (60 ± 5) % or (45 ± 5) % relative humidity and then at appropriate intervals until the shrinkage is less than or equal to 0,02 o/oo per week. The reading on day 2 is considered as the zero reading.

— Drying shrinkage $\varepsilon_{cs,t}$ is defined as the total strain (length change divided by the gauge length) of the unloaded control specimens from the zero reading at 2 days until the considered time *t* and should be indicated in the test report for each individual test specimen and as the mean value of the three test specimens.

— It is recommended to illustrate the development of drying shrinkage by a curve representing the mean value of the three test specimens;

end of note.

Alternatively, drying shrinkage may be tested in accordance with standards approved in the place of use of the LAC-components.

4.2.10 Creep

For design purposes the final creep coefficient may be taken as φ_{LAC} (∞,t_0) = 2,0. More accurate values may be obtained by tests according to EN 1355 and may be declared as mean values.

4.2.11 Thermal conductivity

4.2.11.1 General

The thermal conductivity λ_{10dry} of LAC shall be stated along with the dry density. In the case of multilayer components consisting of different materials the design thermal conductivity and the dry density of each material shall be stated. Design thermal conductivity values may be either calculated from measurements carried out on test specimens or taken from tables and corrected for moisture in accordance with 4.2.11.7.

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

4.2.11.2 Procedure for determination of dry thermal conductivity by testing

Where tests are carried out, the procedure according to 4.2.11.3 to 4.2.11.6 shall be followed.

4.2.11.3 Test method

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

4.2.11.4 Test specimens

The 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.

4.2.11.5 Conditioning of test specimens

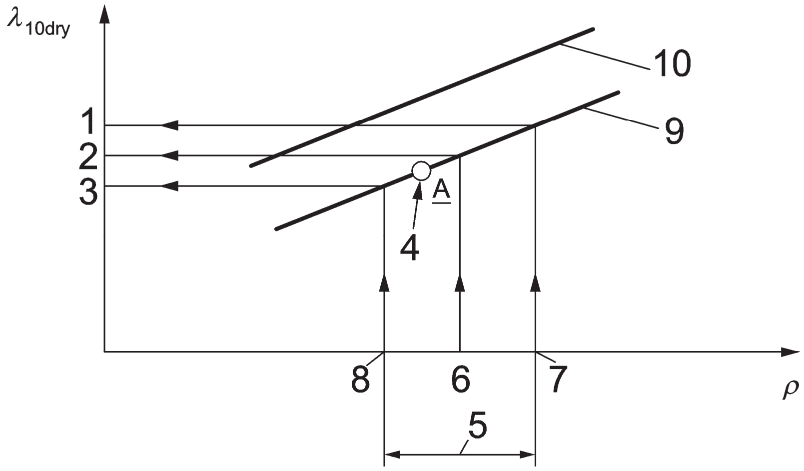
The test specimens shall be conditioned to constant mass at (23 ± 2) °C and (50 ± 5) % RH. Constant mass is considered to be obtained when the difference between two consecutive weighings, 24 h apart, does not exceed 0,2 %.

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

4.2.11.6 Determination of dry mean value and limit values

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 5.1.5. The dry density of each of the three specimens shall be determined in accordance with EN 992, and the mean value of the three results shall be calculated.

A graph of thermal conductivity λ_{10dry} (W/mK) and dry density ρ (kg/m^3) is plotted using the tabulated values given in 4.3.11.7. The mean measured λ_{10dry} value is plotted against the corresponding measured mean dry density (see point A in Figure 1). A curve parallel to the line representing the tabulated values is drawn through this point. From this curve the mean and the limit values of the thermal conductivity can be determined as a function of the mean dry density of the product and the 10 % and 90 % fractile of the manufactured dry product density with a confidence level of γ= 90 % according to EN ISO 10456.



Key
1 upper limit
2 mean value
3 lower limit
4 point A: average of test results
5 manufactured dry density range
6 mean manufactured dry density
7 90 % of production
8 10 % of production
9 parallel curve through point (A)
10 curve representing tabulated values

Figure 1 — Determination of dry thermal conductivity λ_{10dry}

4.2.11.7 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 8 for the dry state.

Table 8 — Dry thermal conductivity λ_{10dry} of LAC for 50 % and 90 % of production, with a confidence level γ= 90 % (compiled according to EN 1745)

Mean dry density [a] kg/m³	Thermal conductivity λ_{10dry} W/mK 50 %	90 %
400	0,10	0,12
500	0,12	0,15
600	0,16	0,18
700	0,19	0,21
800	0,22	0,25
900	0,26	0,28
1 000	0,30	0,32
1 100	0,34	0,36
1 200	0,39	0,41
1 300	0,43	0,46
1 400	0,48	0,51
1 500	0,53	0,56
1 600	0,60	0,63
1 700	0,67	0,70
1 800	0,76	0,80
1 900	0,86	0,90
2 000	0,96	1,00

NOTE 1 Intermediate values can be obtained by interpolation.

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

[a] See Figure 1.

4.2.12 Water vapour permeability

The design value of the water vapour resistance factor may be taken as 5 or 15, respectively. The lower value shall be taken 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.

4.2.13 Water tightness

Due to its open structure LAC is normally highly permeable for water, and the components made of this material are therefore not watertight. Where water tightness is required, e.g. for exterior walls or roofs, the components shall be protected against penetration of water, e.g. by suitable rendering, coating, cladding, or finishes.

4.3 Reinforcement steel

In general the reinforcement in LAC components consists of reinforcement steel (i.e. bars, coiled rods, and welded fabrics).

Reinforcement steel shall comply with EN 10080 or with the relevant clauses of EN 10025-1 and/or EN 10025-2 (for plain smooth bars).

NOTE Reinforcement steel can be identified in the National Application Document (NAD) by the technical class with the product number according to the product specification xxx (national specification).

5 Properties and requirements of components

5.1 General

5.1.1 Mechanical resistance

5.1.1.1 General

All relevant structural properties of a product shall be evaluated for both the ultimate and the serviceability limit states. The use of design methods according to Annex A or Annex B shall be declared by the manufacturer as a design method specified in 5.1.1.2, 5.1.1.3 and 5.1.1.4.

NOTE Actions and partial 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.

5.1.1.2 Design by calculation

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

5.1.1.3 Design by calculation and physical testing

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

- use of alternative design methods;
- 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.

5.1.1.4 Design by testing

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 4.2.2).

5.1.2 Deflections

The deflections of roof or floor components or beams under a given action can 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).

5.1.3 Acoustic properties

5.1.3.1 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 140-3 and expressed as single number quantity for rating according to EN ISO 717-1 (reference method).

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 are applicable to elements of any size having the same or better specification.

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

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

5.1.3.2 Impact sound insulation

When required, the impact sound insulation of floors constructed of components shall be measured according to EN ISO 140-6 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 are applicable to floors having the same or better specification but of any size.

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

5.1.3.3 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.

5.1.4 Reaction to fire and resistance to fire

5.1.4.1 Reaction to fire

If the content of organic material is less than 1 % by mass or volume (whichever is the more onerous) LAC is classified as Euroclass A1 without the need for testing.

LAC components containing 1 % or more of organic material by mass or volume shall be tested for reaction to fire and then classified according to EN 13501-1.

5.1.4.2 Resistance to fire

When resistance to fire of LAC components is required, it shall be classified on the basis of test results and shall be declared by the manufacturer.

Components shall be tested and classified according to 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.

5.1.5 Design thermal resistance and design thermal conductivity

In order to determine the thermal performance of the roof, floor or wall in which the components are used, it is necessary to determine their design thermal resistance. The design thermal resistance shall be calculated in accordance with EN ISO 6946 using the dimensions of the components, including any voids (e.g. hollow cores), in conjunction with the design thermal conductivity.

Table 9 — Basic values for moisture content and moisture conversion coefficient of LAC (compiled according to EN ISO 10456)

Dry density of LAC kg/m³	Moisture content μ_m (mass by mass) at 23 °C / 50 % RH	 23 °C / 80 % RH	Moisture conversion coefficient f_u
400 to < 799	0,02	0,03	2,6
799 to 2 000	0,02	0,03	4,0

In the case of LAC with a foamed matrix, the moisture contents in Table 9 shall be multiplied by a factor of 2,5.

The design value of thermal conductivity λ_d is derived from the dry thermal conductivity λ_{10dry} (see Table 8) by correction for moisture according to Equation (6) taking into account the moisture content μ_m of the LAC to be expected in end use conditions and the moisture conversion coefficient f_u (see Table 9).

$$\lambda_d = \lambda_{10dry} \; e^{f_u \mu_m} \qquad (6)$$

where

- e is the basis of natural logarithms (2,718);
- λ_d is the design thermal conductivity in the moist state, at a moisture content μ_m, in watts per metre Kelvin;
- λ_{10dry} is the thermal conductivity in the dry state, in watts per metre Kelvin (see NOTE);
- μ_m is the moisture content in the moist state, mass by mass (see Table 9);
- f_u is the moisture conversion coefficient, mass by mass (see Table 9).

Moisture correction may also be established by measurements at specified conditions. Equation (6) can be used for the correction to zero moisture content of the test results for thermal conductivity as required in 4.2.11.6.

NOTE The thermal performance is obtained by using the mean thermal conductivity λ_{10dry} (50 %).

5.2 Types of components

5.2.1 General

Prefabricated components according to this European Standard are subdivided into loadbearing and non-loadbearing components according to the types listed in Table 10.

Table 10 — Types of components

Designation	Notation[a]
Loadbearing wall component (solid) Loadbearing wall component (hollow core) Loadbearing wall component (multilayer)	WLS WLH WLM
Non-loadbearing wall component (solid) Non-loadbearing wall component (hollow core) Non-loadbearing wall component (multilayer)	WNS WNH WNM
Retaining wall components (solid)	WRS
Roof component (solid) Roof component (hollow core) Roof component (multilayer)	RLS RLH RLM
Floor component (solid) Floor component (hollow core) Floor component (multilayer)	FLS FLH FLM
Beam (solid) Beam (hollow-core) Pier (solid)	BLS BLH PLS
Cladding component (solid)	CNS
Box culvert (hollow core)	BNH
Component for noise barriers	NB

[a] W = wall, L = loadbearing, S = solid, H = hollow core, M = multilayer, N = non-loadbearing, R = retaining wall or roof, F = floor, B = beam or box culvert or barrier, P = pier, C = cladding, NB = noise barrier

If required, the notation may additionally indicate use of structural (RS) or non-structural reinforcement (NS) as e.g. WLS-RS or WLS-NS.

5.2.2 Roof and floor components

Roof and floor components are manufactured as

— solid LAC components having the same density throughout;

— hollow core LAC components having longitudinal holes in the core section;

— multilayer components comprising one layer of LAC and one or more layers of LAC of another composition or of another type of concrete;

— LAC components of the above types but with openings and/or fitting pieces.

5.2.3 Wall components

Wall components are manufactured as

— solid LAC components having the same density throughout;

— hollow core LAC components having longitudinal holes in the core section;

— multilayer LAC components comprising of one layer of LAC and one or more layers of LAC of another composition or of another type of concrete;

— LAC components of the above types but with openings and/or fitting pieces.

If necessary, parts of the component, such as highly stressed window piers or beams, may be made of other materials, such as lightweight aggregate concrete with closed structure, normal weight concrete or steel. Assessment of thermal insulation, fire resistance, and other essential characteristics of the component likely to be affected shall be carried out including these parts of the component.

5.2.4 Beams and piers

LAC beams and piers are manufactured with the same density throughout with a solid cross-section, however, beams used as lintel wall plates may be manufactured with hollow-core cross section,

5.2.5 Other prefabricated components

Other types of LAC components are manufactured for special applications, such as noise barriers or small box culverts.

5.3 Detailing, technical requirements, and declared properties

5.3.1 Detailing

When required, the manufacturer shall provide drawings containing sufficient information enabling the verification of the mechanical strength of the component. These drawings shall include at least the following: plans, elevations, necessary cross-sections with reinforcement details.

NOTE 1 This is usually not necessary if the components are designed for a specific application (taking into account the partial safety factors valid in the place of use and the actual load situation).

When required, the manufacturer should provide instructions for the transport and lifting of components.

NOTE 2 General guidance for the design and use of lifting devices may be found in CEN/TR 15728 “Design and use of inserts for lifting and handling of precast concrete-elements”, however, the specific properties of the LAC should be taken into account.

5.3.2 Dimensions and tolerances

The essential dimensions (length or height, thickness, and width) shall be determined in accordance with EN 991 and shall be declared by the manufacturer (see NOTE).

On delivery the deviations of the dimensions (individual values) of the components from the declared dimensions shall not exceed the following values:

— thickness ± 5 mm;

— length, height, width ± 8 mm.

Wall components with vertical loads shall not deviate from planeness of the surfaces by more than 5 mm when measured with a straight-edge over a length of 2 m in the loadbearing direction.

For horizontally spanning wall components intended to be laid dry, the maximum deviation from planeness of loadbearing surfaces shall not exceed 2 mm in the transverse direction and 4 mm in the longitudinal direction.

The testing of the planeness of the longitudinal edges can be performed by means of a straight-edge made of steel or aluminium, which shall have a length of at least 2 m, and a set of feeler gauges, capable of measuring to an accuracy of 0,1 mm. The straight-edge is repeatedly placed over the length of the diagonals of the surface to be measured and the deviation of the surface of the component to the straight edge is determined. In the case of concave curvature the maximum distance from the straight edge shall be measured. In the case of a convex surface the straight edge shall be placed on the surface in such a way that the maximum distances from the surface are approximately the same on both sides of the point of contact. The distances shall be measured and rounded to the nearest 0,1 mm. The deviation of nominal plane loadbearing surfaces from parallelism is calculated from the maximum difference between the individual values of the measured widths of the component.

The deviation of nominally rectangular components from squareness in their plane, determined in accordance with EN 991, shall not exceed the values indicated in Table 11.

Table 11 — Maximum permissible deviation from squareness in the plane of components

Width of component m	**Deviation** mm/0,5 m
≤ 1,0 > 1,0	3 2

NOTE Components are generally rectangular and of uniform thickness. Tongued and grooved edge profiles or other jointing systems can be provided.

5.3.3 Mass of the components

The dry mass and the mass including the delivery moisture content of the components shall be stated as mean values.

5.3.4 Deflections

When required, deflections shall be checked by calculation or by testing.

5.3.5 Strength of joints

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 can be determined by calculation, according to the national provisions.

5.3.6 Minimum requirements

Components shall fulfil a number of additional requirements, depending on the component type (see 5.4 to 5.5).

5.3.7 Reinforcement detailing

The structural reinforcement shall have sufficient bond or anchorage in the component in order for the component to perform as intended.

The detailing of the reinforcement shall be sufficient to identify the bond or anchorage system used in the components, just as the minimum support depth shall be declared.

NOTE The bond or anchorage system used and the minimum support depth declared can be based on results from the initial type-testing or from documented experience. Additional requirements can be stated by the designer or in National Documents.

5.4 Additional requirements for roof and floor components and beams

5.4.1 Minimum dimensions

The thickness h of roof or floor components shall be at least 60 mm. The total height h of beams shall be at least 100 mm.

In the case of hollow core slabs (see Figure 2) the thickness of the top layer (h_1) shall be at least h/4. The thickness of the bottom layer (h_2) shall be at least h/5. The minimum residual cross-sectional width, after subtracting the total width of the cavities, $b_0 = b - \Sigma a$, shall be at least b/3.

5.4.2 Minimum requirements for structural reinforcement

5.4.2.1 General

Components shall have sufficient reinforcement to avoid brittle bending failure, by ensuring that the characteristic bending capacity of the cracked cross-section is above the characteristic bending capacity of the uncracked cross-section. This shall be verified either by calculation or by testing.

Beams are usually designed as simply supported components with shear reinforcement, except for beams over openings in walls, which may be produced without shear reinforcement.

Roof and floor components are usually designed as simply supported components, reinforced in one direction and without shear reinforcement. The percentage of reinforcement (ratio R of the cross-sectional area of the transverse reinforcement to that of the longitudinal reinforcement, expressed in percent) shall be at least that specified in Table 12.

Table 12 — Minimum percentage of reinforcement R

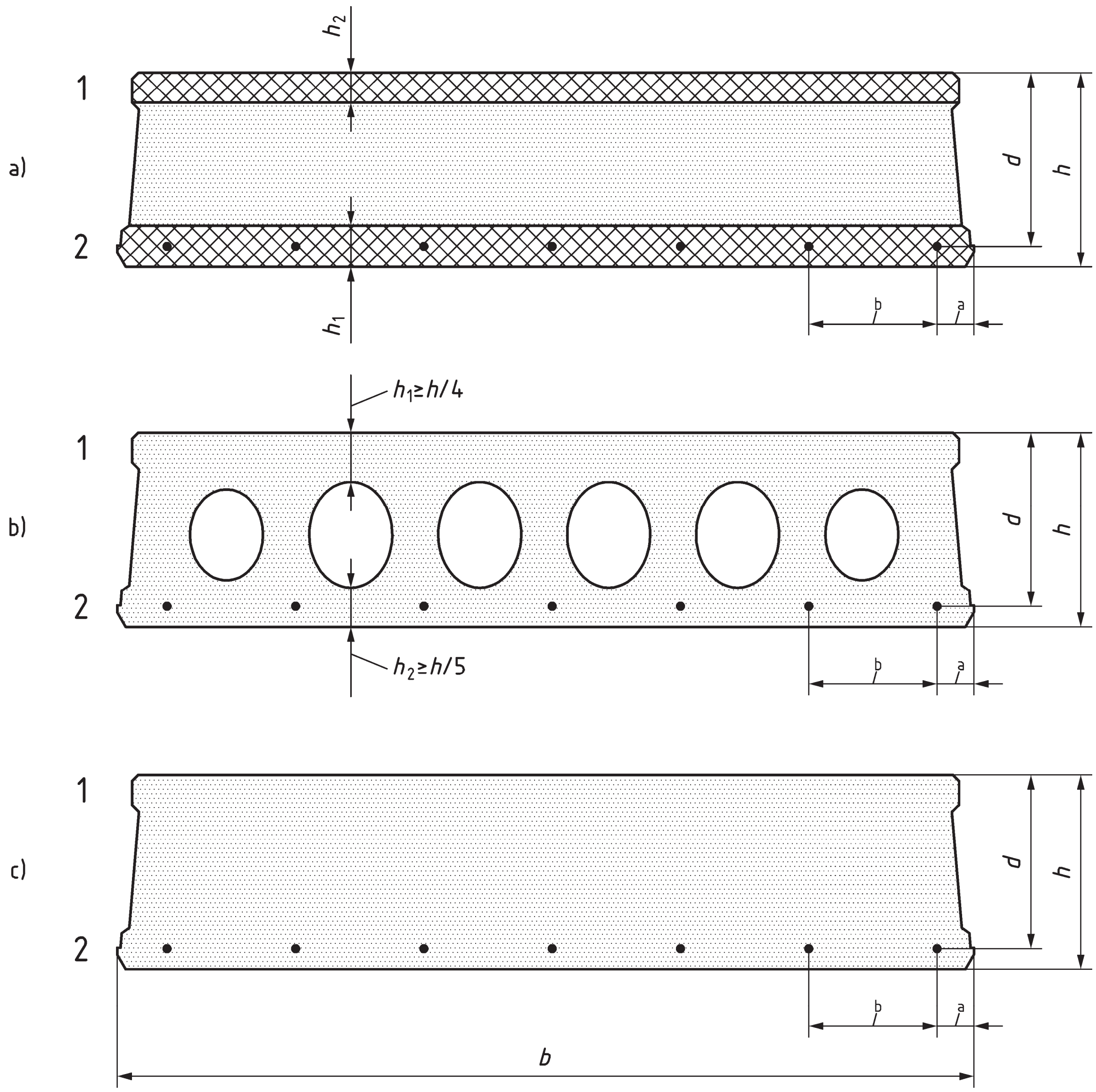
Strength class	Width b of the component		
	$b \leq 625$ mm	625 mm < $b \leq 1250$ mm	1250 mm < b
LAC 2 to LAC 6	0 %	20 %	20 %
LAC 8 to LAC 12	0 %	10 %	20 %
LAC 15 to LAC 25	0 %	0 %	20 %

In the case of uniformly distributed live loads with characteristic values over 3,5 kN/m^2 the minimum percentage of reinforcement shall be increased by 10 percentage points. The minimum percentage of reinforcement required shall, however, not exceed 20 % in any case. The transverse reinforcement below concentrated loads needs special considerations.

5.4.2.2 Bar spacing

The spacing between two adjacent longitudinal bars in slabs shall not exceed twice the thickness h of the component or 200 mm, whichever is the lower value, see Figure 2. The distance to the longitudinal edges of the component shall not be greater than half this distance.

Each component shall contain at least three longitudinal bars, except for components with a width less than 300 mm, where two bars are sufficient. In the case of hollow core slabs, the longitudinal bars shall be arranged in the web area and not be near the cores unless a check of the slab-type connection of the tension chord and the web has been performed and transverse reinforcement is provided. The minimum value of the concrete cover to the voids shall be selected analogously to the value for exterior surfaces.



Key

1 top
2 bottom

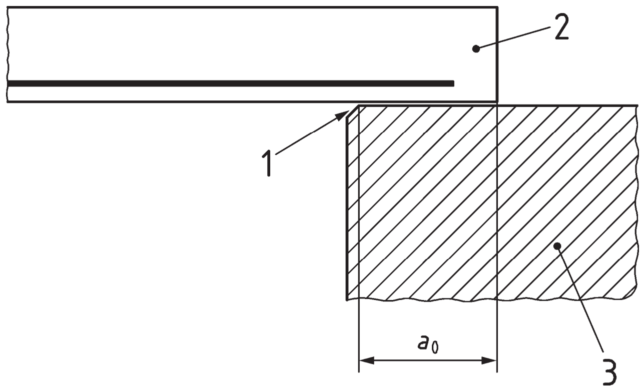
NOTE The distance between longitudinal reinforcement bars shall be
**) not more than 200 mm and not more than 2h
*) not more than 100 mm and not more than h

Figure 2 — Examples of multilayer slab, hollow core slab and solid slab
(With respect to transverse reinforcement, see 5.4.2.1)

5.4.3 Support length

The manufacturer shall declare the minimum support length a_0 when relevant.

Longitudinal bars shall continue from one support to the next without lap splices.



Key

1 splay
2 roof/floor component
3 support

Figure 3 — Support length a_0

NOTE The minimum support length required for the component is declared by the manufacturer, however, the actual support length can depend on the structural design and national requirements.

5.5 Additional requirements for wall components

5.5.1 General

The values for the minimum component dimensions will be specified in the national application document. Guideline values are given in 5.5.2.

5.5.2 Walls with non-structural reinforcement

The minimum wall thickness is as follows:

— structural walls in general $h \geq$ 70 mm;

— non-structural walls $h \geq$ 50 mm;

— structural hollow core walls $h \geq$ 100 mm;

— non structural hollow core walls $h \geq$ 65 mm.

For loadbearing door and window piers, a minimum cross-section of 50 000 mm^2 is required, the minimum width being at least 250 mm. In the case of a cross-section of 25 000 mm^2 and a width of 150 mm, piers shall be reinforced structurally with 2 longitudinal 10 mm diameter bars on each side.

5.5.3 Walls with structural reinforcement

5.5.3.1 Solid walls

The minimum dimensions of solid wall components shall be the same as for walls with non-structural reinforcement. Their minimum width b shall at least be 500 mm. Individual fitting components with widths of 500 > $b \geq$ 200 mm are acceptable.

5.5.3.2 Hollow core walls

(1) Infill panels that only support their own weight and which are exposed to wind may be designed as hollow core panels with reinforcement on both sides. Their thickness h shall be at least 120 mm and their width b at least

500 mm, and they shall also comply with the dimensional requirements given in 5.4.1 and Figure 2b. The anchorage of the reinforcement is deemed sufficient if it complies with A.9, (2)a) or A.9 (2)b).

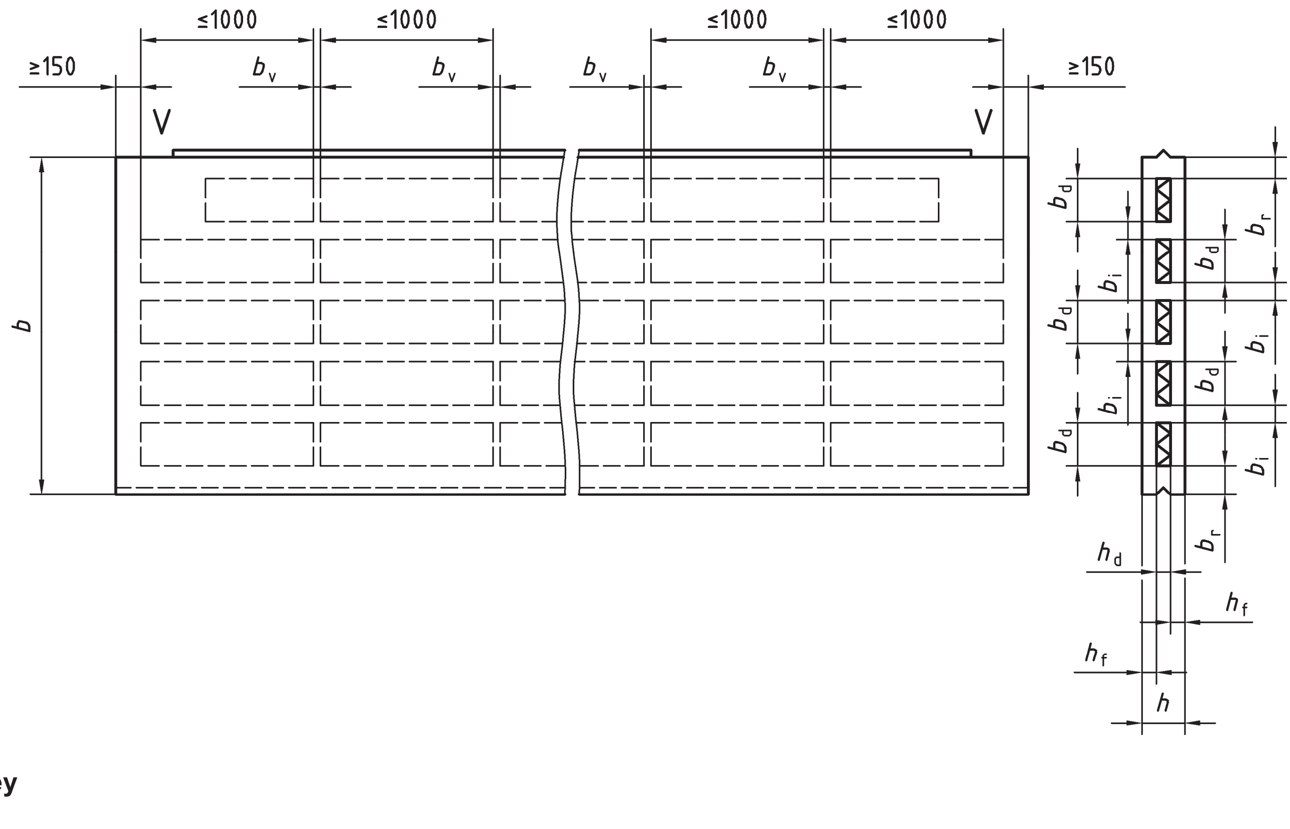
(2) Walls loaded horizontally (e.g. by wind or earth pressure) and vertically by their own weight and by additional loads can be manufactured as solid walls or hollow core walls. For solid walls, the same minimum dimensions as for non-reinforced walls shall apply. The dimensions of horizontally or vertically spanning hollow core wall components shall be in accordance with Figure 4. Their width shall be at least 500 mm and their thickness at least 200 mm. Their longitudinal edges shall be profiled in order to ensure shear transfer across the joints. For wall components with openings the width (i.e. the dimension in vertical direction) f of the parts forming lintels (e.g. above doors or windows) may be less than 500 mm if they are adequately designed for the loads acting on them.

(3) Along the longitudinal and transverse edges, a circumferential solid concrete shell shall be provided with a width b_r of at least 150 mm. Within the zone of embedded anchoring devices additional solid areas should be provided. The anchorage shall be fitted with due care. A schematic design is shown in Figure 4 with the following limits:

— $h_f \geq 75$ mm;

— $b_0 = b - \Sigma b_d \geq b/3$.

Dimensions in millimetres



Key

$b_v \geq 50$ mm
$b_r \geq 150$ mm
$b_d \leq 250$ mm
$b_i \geq 100$ mm

Figure 4 — Basic design of hollow core wall components

5.6 Durability

5.6.1 General

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

Components shall not be exposed to environmental conditions they cannot withstand for their design life, and the protection of the reinforcement against corrosion shall be considered in order to ensure the loadbearing capacity of the components and to avoid spalling of the concrete cover caused by corroding reinforcement. Under certain conditions protection of the surface of the components can be necessary in order to avoid deterioration of the LAC.

The influence of long-term effects on the compressive strength of LAC and the loadbearing behaviour of components is taken into account in design by calculation by means of the α–factor (see A.4.2) and in design by testing by means of increased partial safety factors γ_{comp} (see B.3.3).

If of relevance, the long-term deformations due to creep (see 4.2.10) and shrinkage (see 4.2.9) of the LAC shall be considered.

5.6.2 Minimum cover with regard to bond

For bond the minimum cover on structural reinforcement, including stirrups, shall be at least 1,5 times the maximum aggregate size and at least the maximum bar diameter (or equivalent diameter of bundled bars, respectively), but not less than 10 mm in order to ensure adequate crack-distribution and anchorage of reinforcement.

5.6.3 Exposure classes related to environmental conditions

In Table 13 exposure classes from EN 206-1:2000, Table 1, which may be applied for LAC components are combined with environmental descriptions covering the use of LAC components. The manufacturer shall declare for which of these exposure classes his product is suitable.

Table 13 — Description of permissible exposure classes with respect to risk of reinforcement corrosion

Aggressivity of environment	Exposure class	Description of environment	Examples where exposure classes can occur
Passive	X0	Very dry	Inside buildings with very low humidity
	XC1	Dry	Dwellings, including kitchens, bathrooms and laundry rooms Offices
Moderate	XC2	Wet, rarely dry	Foundations subject to long-term contact with water
	XC3	Moderate humidity	Commercial kitchens and bathrooms Interior surfaces in storage rooms and in stables open to the atmosphere
	XC4, XF1	Moderate humidity or alternating wet and dry, without chlorides	External walls not exposed to airborne chlorides
Severe	XD1, XF2, XS1	Moderate humidity or alternating wet and dry, in combination with chlorides	External walls exposed to airborne chlorides, e.g. noise barriers or external walls of buildings along roads or external surfaces in marine environment
	XD3		External walls exposed to spray containing chlorides, e.g. noise barriers or external walls of buildings along roads

5.6.4 Corrosion protection of reinforcement

5.6.4.1 General

When corrosion of reinforcement can cause damage to the components or loss of structural safety, the reinforcement shall be protected by one of the following methods:

- embedding the reinforcement in a zone of normal concrete or lightweight concrete with closed structure (see 5.6.4.2);
- hot dip galvanizing of the steel (see 5.6.4.3);
- use of stainless steel (see 5.6.4.4);
- corrosion protective coating of the steel (see 5.6.4.5).

5.6.4.2 Embedding in a zone of normal concrete or of lightweight concrete with closed structure (LC-concrete)

Embedding in a zone of normal concrete or lightweight concrete with closed structure may be used in environmental classes X0, XC1, XC2, XC3, XC4, XD1, XF1, XF2 and XS1.

The reinforcement shall be completely embedded in normal concrete or in lightweight concrete with closed structure as defined in EN 206-1 and in relevant National Application Documents. The minimum concrete cover for corrosion protection is specified in Table 14. However, in the case of embedding of the reinforcement in LC-concrete, the concrete cover shall be at least the maximum grain size of the lightweight aggregate + 5 mm, except for the exposure classes X0 and XC1.

Table 14 — Embedding in a zone of normal concrete or LC-concrete with closed structure - Minimum concrete cover in millimetres

Aggressivity of environment	Passive	Moderate		Severe
Exposure classes	X0, XC1	XC2, XC3	XC4, XF1	XD1, XF2, XS1
Minimum cover of concrete with closed structure in mm	10	20	25	35

The minimum concrete cover shall be increased by the additive safety margin $\Delta c_{min,dur}$.

NOTE The value of $\Delta c_{min,dur}$ for use in a country can be found in its national application document. The recommended value is 0 mm.

5.6.4.3 Hot dip galvanizing of the steel

Hot dip galvanizing of the steel may be used in environmental classes X0, XC1, XC2, XC3, XC4, XD1, XD3, XF1, XF2 and XS1.

The hot dip galvanizing shall be carried out in accordance with EN ISO 1459, EN ISO 1460 and EN ISO 1461 with a zinc cover of not less than 100 µm and not more than 200 µm. The temperature in the zinc bath shall be between 440 °C and 460 °C during the galvanizing process.

The minimum concrete cover for zinc coated reinforcement steel is specified in Table 15.

If the water absorption through the surface is not prevented by other means, the outside of exterior walls in exposure classes XC4, XD1, XF1, XF2 and XS1 shall be protected by a layer of water resistant and water vapour permeable mineral render with a minimum thickness of 1 cm. The water absorption coefficient of the mineral render, determined according to EN ISO 15148, shall be $w \leq 0{,}5$ kg/m²h^{0,5} and its diffusion-equivalent air layer thickness, determined according to EN ISO 12572, shall be $s_d \leq 2$ m.

In addition the surface of components exposed to spray containing chlorides (exposure class XD3) shall be protected by a water repellent emulsion paint coating applied to the render. The water absorption coefficient of the coating, determined according to EN ISO 15148, shall be $w \leq 0{,}5$ kg/m²h^{0,5} and the sum of the diffusion-equivalent air layer thickness, determined according to EN ISO 12572, of the render and the additional coating shall be $s_d \leq 2$ m.

Joints shall be sealed to prevent penetration of spray or water from the atmosphere. The integrity of the joints shall be inspected during the whole service life of the structure. Accumulation of condensate within the component shall be avoided. The end faces of components shall not be sealed to enable any precipitated water to escape.

Table 15 — Minimum concrete cover in millimetres for hot dip galvanized reinforcement steel

Aggressivity of environment	Passive	Moderate	Severe
Exposure classes	X0 XC1	XC2, XC3, XC4 [a d] XF1[d]	XD1[d], XD3 [e], XS1[c d] XF2[d]
Minimum LAC cover [b] in mm	30	30	30

a Not suitable for components in contact with alternating water levels.

b Minimum mean dry density of the surrounding LAC > 700 kg/m³ or minimum density class 0,8, respectively.

c Not for buildings with a distance to the coast line of less than 100 m.

d Only in connection with a layer of water repellent plaster (see above).

e Only in connection with a layer of water repellent plaster with additional water repellent emulsion paint coating.

5.6.4.4 Use of stainless steel

Stainless steel may be used in all exposure classes listed in Table 13. The stainless steel shall be in accordance with EN 10088. The material number to be chosen depends on the national regulations at the intended place of use.

The minimum concrete cover shall comply with 5.6.4.2.

5.6.4.5 Use of a corrosion protective coating

This method may be used in exposure classes X0, XC1, XC2, XC3, XC4, XF1 and XF2.

The reinforcement shall be completely covered by the coating. The recipe of the coating and the application procedure shall be documented in the FPC. The efficiency of the coating shall be verified by testing according to EN 990.

Examples of corrosion protective coatings are:

— cement based coatings;

— anti corrosive paintings.

Table 16 — Minimum concrete cover in mm with regard to durability and test method to pass by initial type-test and FPC for bars with a corrosion protective coating

Aggressivity of environment	Passive	Moderate	Severe
Exposure classes	X0, XC1	XC2,XC3, XC4, XF1	XF2
Minimum LAC cover, in mm	10	20	30
Test method according to EN 990	Method 2 or 3	Method 2 or 3	Method 2 or 3

Evaluation of results of tests according to EN 990

Corrosion protective coating according to 5.6.4.5 is considered to be suitable if it passes at least one of the alternative short term tests (method 2 or method 3) in EN 990. In case of dispute, method 2 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 corrosion (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 steel surface of each individual bar;

or

— if the corroded surface area does not exceed by more than 5 % that 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.

5.6.5 Freeze-thaw resistance

When the components are exposed to freeze-thaw conditions according to exposure classes XF1 and XF2, the manufacturer shall declare freeze-thaw resistance according to the experience in the place of use of the components until an appropriate European Standard for testing the freeze-thaw resistance is available.

6 Evaluation of conformity

6.1 Introduction

The scheme for the evaluation of conformity for structural components shall include the following tasks:

a) initial type-testing (see 6.2);

b) factory production control (see 6.3);

c) initial inspection of the factory and of factory production control (see 6.4);

d) continuous surveillance, assessment and approval of factory production control (see 6.5).

The scheme for the evaluation of conformity for non-structural components, shall include the following tasks:

— initial type-testing (see 6.2);

— factory production control (see 6.3).

For both structural and non-structural components the manufacturer shall demonstrate that factory production control is performed, to ensure that the components produced conform to the requirements specified in Clause 4 and Clause 5 in accordance with the performance values declared by the manufacturer.

6.2 Initial type-testing of the component

6.2.1 General

Initial type-testing (ITT) is defined as the complete set of tests or other procedures (e.g. calculation) described in this European Standard, to determine the performance of samples of products representative of the product type, for the mandated characteristics.

Where a manufacturer produces the same product on more than one production line or unit, or in more than one factory, there may be no need to repeat ITT for these different production lines or units (the manufacturer takes responsibility for ensuring that the products are indeed the same). The need to repeat ITT depends on whether the production equipment used in the factory, and/or the production line or unit, might influence the performance declarations forming part of the CE marking.

The manufacturer may entrust the ITT or parts of it to any party equipped and qualified to undertake correct ITT for the product concerned, provided that all rules relevant for the attestation of conformity will be properly applied.

Appropriate initial type-testing shall be carried out at the commencement of production of a new type of product manufactured in accordance with this European Standard or whenever a significant change occurs in respect of an existing product.

Significant changes in the manufacturing process (e.g. new processing equipment, new type of raw materials) may have the consequence that an established product has to be considered as a new product that is subject to initial type-testing. When only some of the aspects specified in this European Standard differ, then the initial type-testing may be restricted to those aspects concerned.

In the case of products differing from established products only in aspects that do not influence the properties specified in this European Standard, then these do not constitute new products and therefore are not subject to initial type-testing.

For the purpose of initial type-testing, the properties in Table 17 shall be determined to demonstrate compliance with the manufacturers declared values. The results of initial type-testing shall be recorded.

The manufacturer shall declare the values for the relevant properties.

As long as the product remains unchanged, there is no need to repeat the ITT.

NOTE For the purpose of this clause, a new type of product is defined as a group of components whose essential properties are significantly different from the same properties of any other group, e.g. compressive strength and/or density for components with a certain thickness within a strength and/or density class.

6.2.2 Sharing of results from ITT

A manufacturer may use ITT results obtained by someone else (e.g. by another manufacturer, as a common service to manufacturers, or by a product developer), hereafter called ‘other party ITT results’, to justify his own declaration of conformity 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 characteristics relevant for performance;

— in addition to any information essential for confirming that the product has such same characteristics, the other party who has carried out the ITT testing concerned or has had it carried out, has expressly accepted to transmit to the manufacturer the results and the test report to be used for the latter’s ITT, 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 ITT results accepts remaining responsible for the product being in compliance with all the provisions of the CPD, including both the design and the manufacture of the product;

— he ensures that the product has the same characteristics relevant for performance as the one that has been subjected to ITT, 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 ITT and

— he keeps available a copy of the ITT report that 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.

6.3 Factory production control

6.3.1 General

The manufacturer shall establish and maintain a documented factory production control system including the quality objectives. The system shall enable product traceability and be capable of enabling confirmation that the products manufactured conform to this European Standard.

The factory production control system shall consist of the following written procedures and/or instructions concerning all

a) inspections and tests and the utilisation of the results to control equipment, raw or incoming materials and the production process;

b) inspections and tests on the finished product itself.

The results of inspection and tests shall be recorded.

The testing regime for raw material properties and finished products including test frequencies shall be included in the factory production control manual.

6.3.2 Process control

6.3.2.1 Raw materials

The manufacturer shall define the acceptance criteria of raw materials (including reinforcing materials) either from tests carried out by the manufacturer or the raw materials supplier and the procedures that he operates to ensure that these are met.

All delivery notes for incoming materials shall be checked to ensure that the specification is correct. A visual inspection shall be made to ensure that the materials delivered conform to the delivery note.

On the first delivery of LWA from a new source a check for grading by sieve analysis and a check of loose bulk density shall be made.

6.3.2.2 Production process

Relevant features of the plant and production process shall be defined giving the frequency of the inspections and tests on equipment and on work in progress together with the values or criteria required. Actions to be taken when control values or criteria are not achieved shall be given. Weighing, measuring and production equipment shall be calibrated for accuracy. The frequency of calibration shall be given in the factory production control manual.

6.3.3 Finished products

6.3.3.1 Tests on finished products

The factory production control system incorporates a sampling plan according to the factory production control manual. The minimum frequency of sampling and testing shall conform to Tables 18 and 19. The results of sampling and testing shall be recorded and statistical analysis of test results shall be carried out, where appropriate.

In the absence of any statistical data derived from a factory production control system, the tabulated information in Table 18 and Table 19 shall be used by the manufacturer as a basis for establishing the sampling plans and the testing frequencies. The sampling plans depend upon the production type and composition, the manufacturing process, size, output and complexity.

6.3.3.2 Alternative tests

When an alternative test is used, the test and procedure together with its correlation with the reference test shall be recorded.

6.3.3.3 Test equipment

Test equipment shall be calibrated at regular intervals to ensure the required accuracy.

6.3.3.4 Identification and traceability

The stock control system of manufactured products shall be given in the factory production control manual. This shall include the methods of treating non-conforming products (see 6.6).

Delivery documentation shall allow traceability of the products.

6.4 Initial inspection of the factory and the factory production control

6.4.1 Information to be supplied

When required, the manufacturer shall make available full details of his factory production control system to the body responsible for the inspection.

When the factory production control is subject to an initial inspection, the manufacturer shall provide information on the factory production control and the equipment to be used to produce the LAC components.

6.4.2 Inspection

The manufacturer shall provide the body responsible for the inspection with the necessary means to

a) confirm that the factory production control manual complies with the requirements of 6.3;

b) assess that the production equipment is in accordance with the factory production control manual and in relation to providing the ability to meet the requirements of this EN;

c) assess that the laboratory equipment is in accordance with the factory production control manual and is suitable for factory production control.

NOTE A particular inspection could be necessary for a new type of LAC component in an existing factory.

6.4.3 Reports

A report of the inspection shall be prepared.

6.5 Surveillance, assessment and approval of the factory production control

6.5.1 Inspection tasks

When required, the body responsible for inspection shall carry out continuous surveillance, assessment and acceptance of the factory production control operated by the manufacturer. Any major change in the factory production control shall be reported by the manufacturer to the body responsible for inspection at least within one month of its implementation.

The body responsible for inspection shall verify that factory production control complies with the requirements of 6.3.

6.5.2 Frequency of inspections

Inspections shall be carried out at least once per year.

6.5.3 Reports

A report shall be prepared after each inspection carried out to verify compliance with 6.3.

6.6 Actions to be taken in the event of non-conformity

The manufacturer shall immediately determine the affected quantity, take appropriate action to prevent their dispatch and inform any affected customer if such component has been released. In addition, the manufacturer shall immediately determine the causes of such non-conformity, take corrective actions and undertake a management review of all factory production control procedures. All such actions and findings shall be appropriately recorded.

The reports following surveillance, assessment, and acceptance of the factory production control (see 6.5.3) shall form the basis for any decisions/actions to be taken and shall be considered on a case by case basis.

Table 17 — Initial type-testing of the LAC components

Property	Type of Testing	Type of component [a]									Reference test/ inspection
		For structural use					For non structural use				
		WLS WLH WLM	WRS	RLS, FLS RLH, FLH RLM, FLM	BLS BLH	PLS	CNS	WNS WNH WNM	BNH	NB	
Density	LAC [h]	x	x	x	x	x	x	x	x	x	EN 992
Compressive strength	LAC [h]	x	x	x	x	x	x		x	x	EN 1354
Flexural strength	LAC [h]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	EN 1521
Modulus of elasticity	LAC [h]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	EN 1352
Creep	LAC [h]	x [b]	x [b]	x [b]	x [b]	x [b]					EN 1355
Reinforcement cover	Component	x	x	x	x	x	x	x	x	x	Physical measurement
Corrosion protection	Component	x [e]	x [e]	x [e]	x [e]	x [e]	x [e]	x [e]	x [e]	x [e]	EN 990
Durability against freeze-thaw	LAC [h]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]		x [b]	x [b]	[i]
Dimensions	Component	x	x	x	x	x	x	x	x	x	EN 991
Steel: -yield strength -tensile strength	Steel	x	x	x	x	x	x	x	x	x	EN 10080 EN ISO 6892-1 or checking of the certificate when relevant (see 4.2.2)
Loadbearing capacity under transverse load	Component		x	x	x						EN 1356
Loadbearing capacity under predominantly longitudinal load	Component	x				x	x			x	EN 1740
Drying shrinkage	LAC [h]	x [d]	x [d]	x [d]	x [d]	x [d]	x [d]	x [d]	x [d]	x [d]	EN 1355, values obtained on shrinkage specimens
Thermal conductivity	LAC [h]	x [c]		x [c]	x [c]	x [c]					EN 12664, EN 12667 or EN 12939 (EN 992 for density in case of tabulated λ-value)
Resistance to fire	Component	x	x	x	x	x	x	x		x	EN 1364-1 EN 1365-1 EN 1365-2 EN 1365-3 EN 1365-4
Reaction to fire	Component	x [f]	x [f]	x [f]	x [f]	x [f]	x [f]	x [f]	x [f]	x [f]	EN ISO 1182 EN ISO 1716
Airborne sound reduction	Component	x [b]		x [b]			x [b]	x [b]		x [b]	EN 1793-2 [g] EN ISO 140-3 EN ISO 717-1 EN 12354-1
Impact sound reduction	Component			x [b]							EN ISO 140-6 EN ISO 717-2 EN 12354-2
Sound absorption coefficient	Component	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]		x [b]	EN 1793-1 [g] EN ISO 354
Joint strength	Component	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	x [b]	EN 1739 EN 1741
Shear resistance between layers of multilayer components	LAC [h]	x [h]	x [h]	x							EN 1742

[a] Type of component: Notation according to Table 10.
[b] Only if used in design on the basis of a declared value derived from measurements.
[c] Not necessary when thermal conductivity values are obtained from approved tables.
[d] Not necessary when drying shrinkage is taken as 0,75 mm/m according to the first sentence of 4.2.9.
[e] Only necessary for structurally reinforced component, where reinforcement is embedded in LAC.
[f] Reaction to fire test is only necessary if the content of organic material is higher than 1 % by mass or volume (whichever is higher).
[g] Only for road traffic noise reducing devices.
[h] Where the same material is used in a range of components, it is only necessary to test the material for one type of component.
[i] According to test method valid at the place of use of the components.

Table 18 — Factory production control, testing of the finished product LAC components for structural uses

Property	Type of testing	Type of component [a] WLS WLN WLM	WRS	RLS, FLS RLH, FLH RLM, FLM	BLS BLH	PLS	Reference test/ inspection	Frequency	Remarks
Density	LAC [c]	x	x	x	x	x	EN 992	Every 250 m³ or twice per month	For each LAC type
Compressive strength	LAC [c]	x	x	x	x	x	EN 1354	Every 250 m³ Or twice per month	For each LAC type
Flexural strength	LAC [c]	x [b]	x [b]			x [b]	EN 1521	Twice per year	For each LAC type
Steel - tensile strength - yield strength	Steel	x	x	x	x	x	EN ISO 6892-1 or checking of the certificate when relevant (see 4.2.2)	Each delivery	
Reinforcement cover	Component	x	x	x	x	x	Physical measurement	Once per week	
Durability against corrosion (of reinforcement)	Component	x	x	x	x	x	EN 990	Once per year	Visual inspection, only relevant when reinforcement is not embedded in dense concrete and stainless steel is not used
							Visual inspection	Once per day	
Dimensions	Component	x	x	x	x	x	EN 991	Once per week	
Loadbearing capacity under transverse load	Component		x	x	x		EN 1356	Every 1 000 units or twice per month	Only relevant in the case of design by testing
Loadbearing capacity under predominantly longitudinal load	Component	x	x			x	EN 1740	Every 1 000 units or twice per month	Only relevant in the case of design by testing
Detailing	Component	x	x	x	x	x	EN 991, visual inspection, physical measurement	Once per week	See 5.3.1, dimensions, concrete cover, number, diameter, and position of reinforcing bars
Drying shrinkage	LAC	x [d]	x [d]	x [d]			EN 1355, values obtained on shrinkage specimens	Once per year	

Table 18 *(continued)*

Property	Type of testing	Type of component [a]					Reference test/ inspection	Frequency	Remarks
		WLS WLH WLM	WRS	RLS, FLS RLH, FLH RLM, FLM	BLS BLH	PLS			
Thermal resistance	Com-ponent [c]	x [e]	x [e]	x [e]	x [e]	x [e]	EN 12664 EN 12667 or EN 12939	Once per year	Calculation from thermal conductivity and dimensions
Resistance to fire	LAC, Component	x	x	x	x	x	See relevant parameters (density, compressive strength, dimensions)	See relevant parameters	
Reaction to fire	LAC	x [f]	x [f]	x [f]	x [f]	x [f]			
Water vapour permeability	Component	x [g]			x [g]	x [g]	Suitability of coating when required	Once per year	Highly permeable due to open structure
Water permeability	Component	x [g]			x [g]	x [g]	Suitability of coating when relevant	Once per year	Highly permeable due to open structure. If required to be protected
Durability against freeze-thaw	Component	x [f]	x [f]	x [f]	x [g]	x [g]	Freeze-thaw test [i] or suitability of coating when required	-	In exposure classes XF1 and XF2 to be protected unless the freeze-thaw resistance of the LAC has been verified by tests [i]
Direct airborne sound insulation	Component	x [h]		x [h]	x [h]	x [h]	Control of dry density according to EN 992	See density	
Impact sound insulation	Component			x [h]			Control of relevant material properties and dimensions	See relevant properties	
Release of dangerous substances	LAC	x	x	x	x	x		-	See note in ZA.1

NOTE It is not possible to assess the airborne sound reduction and the impact sound insulation on individual components.

[a] Type of component: Notation according to Table 10.
[b] Only if required design is based on results of flexural tests.
[d] Not necessary when drying shrinkage is taken as 0,75 mm/m according to the first sentence of 4.2.9.
[e] Only if used in design on the basis of a declared value.
[f] Only for exposed applications.
[g] For application in external walls.
[h] Only when the product is intended also for acoustical applications.
[i] According to the test method valid at the place of use of the component.

Table 19 — Factory production control, testing of the finished product, LAC components for non-loadbearing uses

Property	Type of testing	Type of component [a]				Reference test/ inspection	Frequency	Remarks
		CNS	WNS WNH WNM	BNH	NB			
Density	LAC [b]	x	x	x	x	EN 992	Every 250 m³ or twice per month	Relevant for properties such as thermal conductivity, anchorage of reinforcement, etc. For each LAC type
Compressive strength	LAC [b]	x	x	x	x	EN 1354	Every 250 m³ or twice per month	For each LAC type
Flexural strength	LAC [b]	x [c]			x [c]	EN 1521	Twice per year	For each LAC type
Ultimate tensile strength and yield strength	Steel	x [d]	x [d]	x [d]	x [e]	Checking of the certificate	Each delivery	
Reinforcement cover	Component	x [e]	x [d]	x [e]	x [e]	Physical measure-ment	Once per week	
Durability against corrosion (of reinforcement)	Component	x [e]	x [d]	x [e]	x [e]	EN 990	Once per year	Visual inspection, only relevant when reinforcement is not embedded in dense concrete and stainless steel is not used
						Visual inspection	Once per day	
Dimensions	Component	x	x	x	x	EN 991	Once per week	
Loadbearing capacity under transverse load	Component	x			x	EN 1356	Every 1 000 units or twice per month	Only relevant in the case of design by testing

Table 19 *(continued)*

Property	Type of testing	Type of component [a]				Reference test/ inspection	Frequency	Remarks
		CNS	WNS WNH WNM	BNH	NB			
Loadbearing capacity under predominantly longitudinal load	Component	x				EN 1740	Every 1 000 units or twice per month	Only relevant in the case of design by testing
Water vapour permeability	Component	x [g]	x [g]		x	Suitability of coating when required	Once per year	Highly permeable due to open structure
Water permeability	Component	x [g]	x [g]		x	Suitability of coating when required	Once per year	Highly permeable due to open structure. If required to be protected
Durability against freeze-thaw	Component	x [h]		x [h]	x	Freeze-thaw test [k] or suitability of coating when required	Once per year	In exposure classes XF1 and XF2 to be protected unless the freeze-thaw resistance of the LAC has been verified by tests.
Reaction to fire	Component	x [h]	x [h]		x	-	-	Euroclass A1, only by initial type-testing
Resistance to fire (in the end use conditions)	Component	x	x		x	Control of relevant properties (density and dimensions)	See density	
Thermal resistance	Component	x [i]	x [i]			Control of dry density and dimensions	See density	Calculated from thermal conductivity and dimensions
Direct airborne sound insulation index	Component	x [j]	x [j]			Control of dry density	See density	Related to the weight of the component per m²
Sound absorption coefficient	Component				x	EN ISO 354	-	Only at initial type-testing
Release of dangerous substances	LAC	x	x	x		-	-	See note in ZA.1

NOTE It is not possible to assess the airborne sound insulation index on individual components.

a Type of component: Notation according to Table 10.
b Where the same material is used in a range of components it is only necessary to test the material for one type of component.
c Only if required design is based on results of flexural tests.
d Only in case of horizontal and imposed loads.
e Only in case of reinforced component.
g For external walls.
h Only for exposed applications.
i Only when the product is intended also for thermal applications.
j Only when the product is intended also for acoustical applications.
k According to the test method valid at the place of use.

7 Basis for design

7.1 Design methods

The structural design may either be based on calculation (Annex A) and/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 principles of EN 1992-1-1.

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; by wind, snow and ice; by thermal actions; by vehicular loading on parking floors;

— accidental:

impact, explosions, actions due to fire.

NOTE The actions are based on EN 1990 and EN 1991 (all parts). The actions for use in a country can be found in its national regulations.

8 Marking, labelling and designation

8.1 Standard designation

Prefabricated components of LAC with structural or non structural reinforcement shall be identified by at least the following designations:

a) number of this European Standard;

b) type of component (abbreviations see Table 10);

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

d) declared dry density of the LAC (expressed as a mean value or as a 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;

k) exposure class;

l) intended use.

A coding system which summarizes one or more requirements of this European Standard can be used. The explanation of any coding system used shall be provided.

EXAMPLE 1 Loadbearing wall component (solid) [300 × 2 500 × 2 650] conforming to this European Standard of strength class LAC 10, density class 1,2, reaction to fire according to Euroclass A1, resistance to fire 60 min, thermal conductivity λ_{10dry} = 0,39 W/mK (p = 50 %).

EN 1520 - WLS/ LAC 10/1,2/A1/REI 60/0,39/300 × 2 500 × 2 650

EXAMPLE 2 Beam [240 × 250 × 2 750] conforming to this European Standard of declared characteristic compressive strength 7,0 MPa, declared dry density 950 kg/m³, reaction to fire Euroclass A1, resistance to fire 90 min.

EN 1520 - BLS /7,0 MPa/950 kg/m³/A1/R 90/10 kN/m/240 × 250 × 2 750

EXAMPLE 3 Loadbearing wall component (solid) [300 × 2 500 × 2 650] conforming to this European Standard of strength class LAC 10, density class 1,2, reaction to fire according to Euroclass A1, resistance to fire 60 min, thermal conductivity λ_{10dry} = 0,39 W/mK (p = 50 %).

EN 1520 - WLS/LAC 10/1,2/Code

Code: A1/REI 60/0,39/300 × 2 500 × 2 650

8.2 Additional information on accompanying documents

The manufacturer may give further information in product literature or on accompanying commercial documents, on for instance the following:

a) background information on design (e.g. design according to Annex A and/or Annex B);

b) bond;

c) mass of the component;

d) direct airborne sound reduction index;

e) impact sound pressure level;

f) environmental class;

g) drying shrinkage;

h) thermal expansion;

i) creep;

j) tolerances and squareness.

NOTE For CE marking and labelling see ZA.3 of Annex ZA.

Annex A
(normative)

Design of components by calculation

A.1 Introduction

The design of components 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 LAC.

Design values to be used can be determined according to the provisions of this annex, using the relevant partial safety factors.

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

A.2 General

(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 and

— requirements and analytical models for which no alternative is permitted unless specifically stated.

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

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

(5)P In this annex Application Rules are marked by a number in brackets 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)P Nominal dimensions, including those tolerances, which lead to the most unfavourable result, shall be used in the calculations.

(8) A.4 to A.7 describe general calculation procedures that may be used for components subjected to bending, shear, or axial compression. A.8 gives specific rules applicable to the different types of components.

(9)P More detailed analyses may be carried out on the basis of the design assumptions given in A.4.1.

NOTE The design of the components requires also a thorough consideration of the overall stability and stiffness of the entire building. If the stiffness and the stability of the structure are not obvious, analytical verification of the stability of both horizontal and vertical stiffening members is necessary. In the case of high deformability of the stiffening members allowance should be made for the influence of their deformations on the effects of actions (second order effects).

A.3 Partial safety factors

Partial safety factors are determined according to national application documents.

NOTE An example is given in informative Annex C.

A.4 Ultimate limit state – Design for bending and combined bending and axial compression

A.4.1 Design assumptions

(1)P The design assumptions in a) to j) given below shall be used.

a) Plane sections remain plane.

b) The strain in the reinforcement is the same as that in the surrounding LAC.

c) The flexural strength of LAC is generally ignored. It may be taken into account in wall components for bending as a result of wind actions in combination with vertical actions.

d) The stresses in LAC in compression are derived from the design stress-strain diagram given in Figure A.1.

e) The stresses in the reinforcement are derived from the design stress-strain diagram given in Figure A.2.

f) Deformations and second order effects are calculated using the mean values of the material properties (such as E_{cm} according to 4.2.6). For cross-sectional design, the design values of the material properties are used.

g) For cross-sections subject to centrally loaded longitudinal compression, the compressive strain of LAC is limited to 0,002.

h) For cross-sections not fully in compression, the limiting compressive strain of LAC is given by Equation (A.1). In intermediate situations, the strain distribution is defined by assuming that the compressive strain is 0,002 at a level (ε_{cu} - 0,002)/ε_{cu} of the height of the section from the most compressed face.

i) The adoption of the above assumptions leads to the range of potential strain diagrams shown in Figure A.3.

j) The effect of longitudinal reinforcement present in the compression zone is not 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.

NOTE The use of the flexural strength in bending is described in the national application document as indicated in A.6.3.3.3.

A.4.2 Stress-strain diagram for LAC

(1)P The stress-strain diagram for LAC for cross-sectional design is shown in Figure A.1, where the ultimate compressive strain ε_{cu} is given by the equation

$$\varepsilon_{cu} = 0{,}003\ 5\ \eta_1 \geq 0{,}002 \qquad \text{(A.1)}$$

where

η_1 = 0,40 + 0,60 ρ / 2 200 (see Equation (2a));

ρ is the dry density of LAC, in kilograms per cubic metre.

The design value of the compressive strength of LAC is defined by

$$f_{cd} = f_{ck} / \gamma_C \qquad \text{(A.2)}$$

where

f_{cd} is the design value of the compressive strength of LAC, in megapascals;

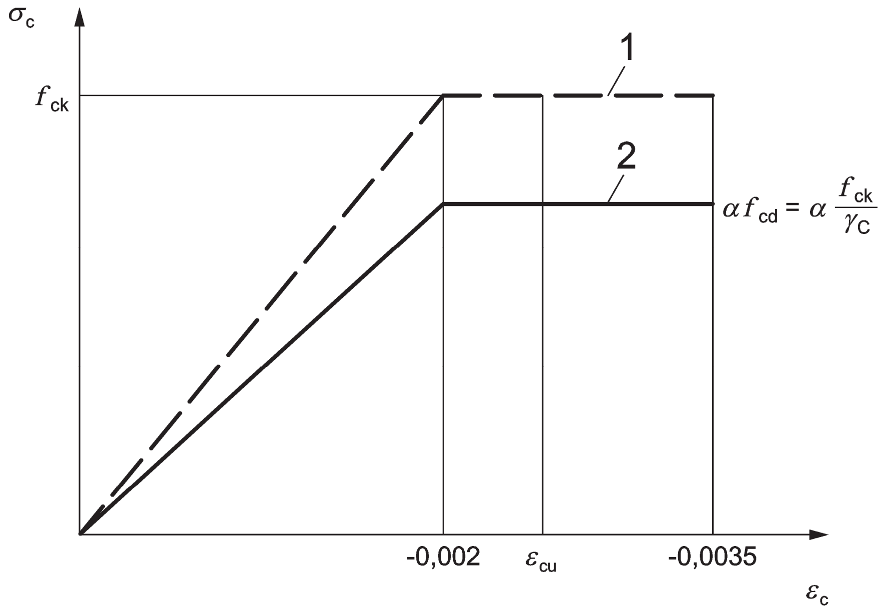
f_{ck} is the characteristic compressive strength of LAC, in megapascals;

γ_C is the partial safety factor for concrete (also for LAC) according to A.3.

NOTE 1 The value of γ_C for use in a country can be found in its national application document. The recommended values for use are given in Table C.1.

(2)P Giving allowance for long term effects on the compressive strength of LAC the design strength is multiplied by the coefficient α.

NOTE 2 The value of α for use in a country can be found in the national application document. The recommended value of α is 0,85. In cases where the compression zone decreases in width in the direction of the extreme compression fibre α is recommended to be reduced to 0,80.



Key

1 idealized diagram
2 design diagram

Figure A.1 — Bi-linear stress-strain diagram for LAC in compression for cross-sectional design

A.4.3 Stress-strain diagram for reinforcement steel

(1)P The design value f_{yd} of the yield strength of reinforcement steel is defined by:

$$f_{yd} = f_{yk}/\gamma_S \quad (A.3)$$

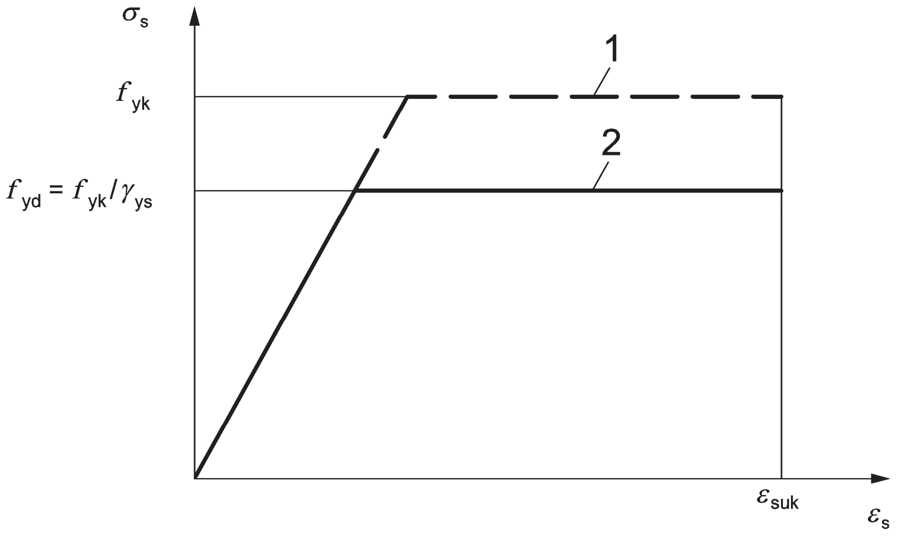
where

f_{yk} is the characteristic yield strength of reinforcement steel;

γ_S is the partial safety factor for reinforcement steel.

NOTE The value of γ_S for use in a country can be found in its national application document. Recommended values are given in Table C.1.

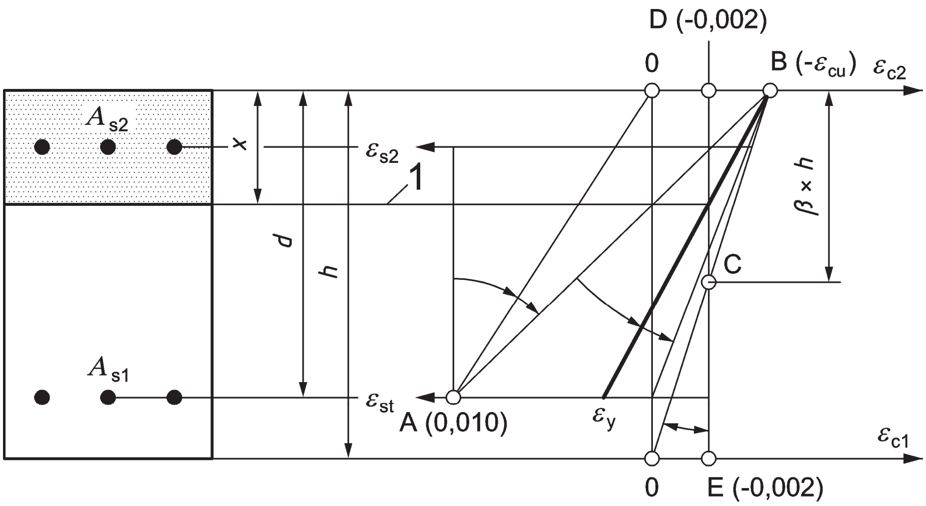
(2) The design stress-strain diagram for reinforcement steel is given in Figure A.2. Other established stress-strain diagrams may be used. E_s is the modulus of elasticity of reinforcement steel (e.g. 2 x 10^5 MPa).



Key

1 idealized diagram
2 design diagram

Figure A.2 — Design stress-strain diagram for reinforcement steel



Key

1 neutral axis

The value of β is equal to (ε_{cu} - 0,002)/ε_{cu}, where ε_{cu} is calculated from Equation (A.1).

Figure A.3 — Possible strain diagrams in the ultimate limit state

A.5 Ultimate limit state induced by shear

A.5.1 Shear design for components predominantly under transverse load not requiring shear reinforcement

(1)P The following conditions shall be met:

$$V_{Ed} < V_{Rd1} \quad \text{(A.4a)}$$

$$V_{Ed} < V_{Rd2} \quad \text{(A.4b)}$$

where

V_{Ed} is the design shear force in the section;

V_{Rd1} is the design shear resistance of a component without shear reinforcement;

V_{Rd2} is the design shear crushing resistance (maximum shear force that can be carried without crushing of the notional concrete compressive struts), which is given by Equation (A.14).

The design shear force does not need to be checked at a distance of less than $d/2$ from the support. A reduction of concentrated loads near the support is not allowed.

NOTE 1 The value of V_{Rd1} can be estimated by Equation (A.5) or Equation (A.10) as specified in the national application document.

(2) The design shear resistance V_{Rd1} may be estimated as:

$$V_{Rd1} = C_{Rd} k \cdot \eta_1 (100\ \rho_1 f_{ck})^{1/3} b_w d \tag{A.5a}$$

with a minimum of

$$V_{Rd1} = v_{mind}\ b_w d \tag{A.5b}$$

where

C_{Rd} is a parameter for shear capacity;

k is a factor for the shear strength, see Equation (A.8);

η_1 is a coefficient according to Equation (A.9);

ρ_1 is the reinforcement ratio $\rho_1 = A_{s1}/(b_w\ d) \leqq 0{,}02$;

f_{ck} is the characteristic compressive strength of LAC, in megapascals;

A_{s1} is the cross-sectional area of the longitudinal reinforcement, anchored as described in A.9, in square millimetres;

b_w is the minimum width of the cross-section over the effective depth, in millimetres;

d is the effective depth of the cross-section, in millimetres;

v_{mind} is the minimum shear strength of LAC, in megapascals.

NOTE 2 The values of C_{rd} and v_{mind} can be found in the national application document. Recommended values are:

$$C_{Rd} = 0{,}145 / \gamma_C \tag{A.6}$$

$$v_{mind} = 0{,}03 \cdot k^{3/2} \cdot f_{ck}^{½} \tag{A.7}$$

$$k = 1 + (200/d)^{½} \leq 2{,}0 \tag{A.8}$$

$$\eta_1 = 0{,}40 + 0{,}60 \rho / 2\ 200 \tag{A.9}$$

where

γ_C is the partial safety factor for LAC;

f_{ck} is the characteristic compressive strength of LAC, in megapascals;

ρ is the dry density of LAC, in kilograms per cubic metre.

(3) The design shear resistance V_{Rd1} may be estimated as:

$$V_{Rd1} = \tau_{Rd}\ k\ (1{,}2 + 40\ \rho_1)\ b_w\ d \tag{A.10}$$

$$\tau_{Rd} = \tau_{Rk} / \gamma_C \qquad \text{(A.11)}$$

$$\tau_{Rk} = 0,125\, f_{t,flk} \qquad \text{(A.12)}$$

$$k = 1,6 - d/1000 \geq 1 \qquad \text{(A.13)}$$

where

τ_{Rk} is the characteristic shear strength of LAC, in megapascals;

k is a factor for the shear strength, see Equation (A.13);

ρ_1 is the reinforcement ratio $\rho_1 = A_{s1}/(b_w\, d) \leqq 0,02$;

τ_{Rd} is the design shear strength of LAC, in megapascals;

γ_C is the partial safety factor for LAC;

A_{s1} is the cross-sectional area of the longitudinal reinforcement, anchored as described in A.9, in square millimetres;

b_w is the minimum width of the cross-section over the effective depth, in millimetres;

d is the effective depth of the cross-section, in millimetres;

$f_{t,flk}$ is the characteristic flexural strength of LAC (see 4.2.4), in megapascals.

(4) The design shear crushing resistance V_{Rd2} is given by:

$$V_{Rd2} = 0,5\ \eta_1\, b_w\, z\ \nu\, f_{ck} / \gamma_C \qquad \text{(A.14)}$$

where

η_1 is a coefficient according to Equation (A.9);

b_w is the minimum width of the cross-section over the effective depth, in millimetres;

z is the height of the shear zone, which is taken as the distance between the centres of the compression zone and the longitudinal reinforcement (lever arm of internal forces), in metres. This may be set to $0,9d$ in normal designs, but not more than the height (h_w) of the shear reinforcement;

d is the effective depth of the cross-section, in metres;

h_w is the height of the shear reinforcement, in metres;

ν is the efficiency factor, which shall be taken as 0,6;

f_{ck} is the characteristic compressive strength of LAC, in megapascals;

γ_C is the partial safety factor for LAC.

A.5.2 Shear design for components predominantly under transverse load requiring shear reinforcement

(1)P The following conditions shall be met:

$$V_{Ed} < V_{Rd3} \qquad \text{(A.15a)}$$

$$V_{Ed} < V_{Rd2} \qquad \text{(A.15b)}$$

where

V_{Ed} is the design shear force in the section;

V_{Rd2} is the design shear crushing resistance (maximum shear force that can be carried without crushing of the notional concrete compressive struts), which is given by Equation (A.14);

V_{Rd3} is the design shear resistance of the component with shear reinforcement.

The design shear force does not need to be checked at a distance of less than $d/2$ from the support. A reduction of concentrated loads near the support is not allowed.

NOTE 1 The value of V_{Rd3} can be estimated by Equation (A.16) or Equation (A.17) as specified in the national application document.

(2)P For beams with vertical shear reinforcement (ladder-type), the shear resistance V_{Rd3} is

$$V_{Rd3} = (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot\theta \quad \text{(A.16)}$$

where

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

s is the spacing of the shear reinforcement bars, in metres;

z is the height of the shear zone, which is taken as the distance between the centres of the compression zone and the longitudinal reinforcement (lever arm of internal forces), in metres. This may be set to $0{,}9d$ in normal designs, but not more than h_w;

h_w is the height of the shear reinforcement, in metres;

f_{ywd} is the design yield strength of the shear reinforcement ($f_{ywd} = f_{ywk}/\gamma_S$), in megapascals;

f_{ywk} is the characteristic value of the yield strength of the shear reinforcement, in megapascals;

γ_S is the partial safety factor for reinforcement steel;

θ is the angle of the compression struts.

The shear reinforcement shall fulfil the minimum requirements in (4).

The angle θ of the compression struts shall be limited.

NOTE 2 The limiting values of $\cot\theta$ can be found in the national application document. The recommended limits are $1 \leq \cot\theta \leq 2{,}5$.

(3)P For beams with vertical shear reinforcement (ladder-type), the shear resistance V_{Rd3} is

$$V_{Rd3} = V_{Rd1} + V_{wd} \quad \text{(A.17)}$$

where V_{Rd1} is the design shear resistance of a component without shear reinforcement given by Equation (A.10) and V_{wd} is estimated by Equation (A.18) as

$$V_{wd} = 0{,}8\ (A_{sw}/s)\ z\ f_{ywd} \quad \text{(A.18)}$$

where

A_{sw} is the area of shear reinforcement, in square millimetres;

s is the spacing of the shear reinforcement bars, in metres;

z is the height of the shear zone, which is taken as the distance between the centres of the compression zone and the longitudinal reinforcement (lever arm of internal forces), in metres. This may be set to $0{,}9d$ in normal designs, but not more than $h_{w;}$.

d is the effective depth of the cross-section, in metres;

h_w is the height of the shear reinforcement, in metres;

f_{ywd} is the design yield strength of the shear reinforcement ($f_{ywd} = f_{ywk}/\gamma_S$), in megapascals;

f_{ywk} is the characteristic value of the yield strength of the shear reinforcement, in megapascals;

γ_S is the partial safety factor for reinforcement steel.

The shear reinforcement shall fulfil the minimum requirements in (4).

(4) The minimum shear reinforcement ratio ρ_w for beams shall be at least

$$\rho_{w,min} = 0{,}08 f_{ck}^{1/2} / f_{yk} \tag{A.19}$$

where

$$\rho_w = A_{sw} / (s \cdot b_w) \tag{A.20}$$

and where

f_{ck} is the characteristic compressive strength of LAC, in megapascals;

f_{yk} is the characteristic yield strength of the reinforcement steel, in megapascals;

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

s is the spacing of the shear reinforcement measured along the longitudinal axis of the member, in millimetres;

b_w is the width of the web of the beam, in millimetres.

Using reinforcement steel with yield strength f_{yk} = 500 MPa will lead to the following minimum percentages of shear reinforcement shown in Table A.1:

Table A.1 — Minimum percentages of shear reinforcement $\rho_{w,min}$ for reinforcement steel with f_{yk}= 500 MPa

Characteristic compressive strength of LAC f_{ck} MPa	$\rho_{w,min}$ %
2	0,023
4	0,032
6	0,039
8	0,045
10	0,051
12	0,055
15	0,062
20	0,072
25	0,080

The shear reinforcement shall be vertical and welded to the longitudinal reinforcement. Welding and anchorage shall be verified according to A.9.

(5) The value of the characteristic value of the yield strength of the shear reinforcement f_{ywk} should be limited.

NOTE 3 The limiting value of f_{ywk} can be found in the national application document. The recommended value is $f_{ywk} \leq$ 400 MPa.

A.5.3 Shear design for components under predominantly longitudinal compression forces, e.g. walls and piers

(1)P Only the portions of the cross-section which remain without tensile stresses under the relevant load combination in the ultimate limit state are considered to be capable of resisting concrete stresses due to shear.

(2)P The design shear resistance is:

$$V_{Rd4} = \tau_{Rd}\, b_w\, x / 1{,}5 \quad \text{(A.21)}$$

$$\tau_{Rd} = 0{,}125\, f_{t,flk} / \gamma_C \quad \text{(A.22)}$$

where

τ_{Rd} is the basic shear strength of LAC, in megapascals;

b_w is the minimum width of the section in the compression zone, in millimetres;

x is the neutral axis depth $x \leq h$; calculated using first order theory, in millimetres;

$f_{t,flk}$ is the characteristic flexural strength of LAC (see 4.3.4), in megapascals;

h is the overall depth of the cross-section, in millimetres;

γ_C is the partial safety factor for LAC.

In cross-sections where the zone of decompression in the ultimate limit state extends further than to the centre of the cross-section it shall be verified that:

$$N_{Sd} / V_{Sd} \geq 2{,}0 \quad \text{(A.23)}$$

where

N_{Sd} is the design axial compression force in the section;

V_{Sd} is the design shear force in the section.

A.6 Ultimate limit state induced by structural deformation (buckling)

A.6.1 General

(1)P When determining the loadbearing capacity of slender LAC 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 are given in A.6.2 and A.6.3. They are both suitable for designing vertical loadbearing LAC components which can be classified as slender isolated columns or walls and are mainly loaded by a central or eccentric longitudinal load and possibly also by a transverse load (e.g. horizontal wind load, earth pressure).

(3)P The slenderness ratio S of the components shall not exceed the values indicated in Figure A.4,

where

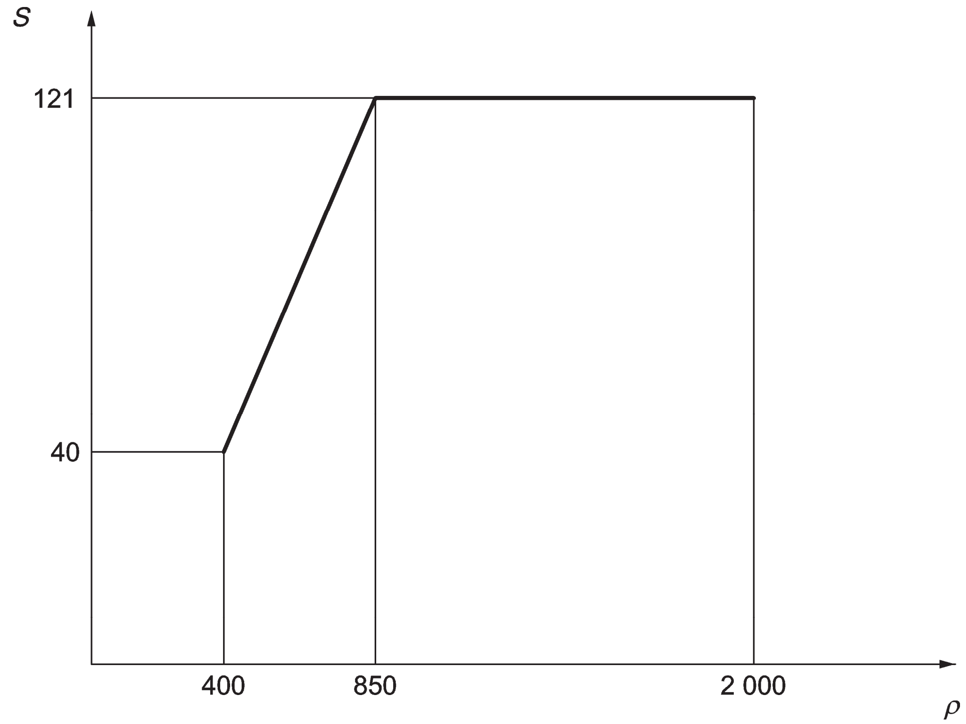
S is the slenderness ratio; $S = l_0/i_w \leq 121$;

l_0 is the buckling length of the component, in metres. The buckling length (effective height with respect to buckling) will depend on the support conditions, as shown in Table A.2;

i_w is the radius of inertia in the direction of the weak axis (i_w = 0,289h for rectangular solid cross-sections), in metres;

h is the overall thickness of the component, in metres;

ρ is the mean value of the dry density of the LAC, in kilograms per cubic metre.



Key

S slenderness ratio
ρ mean dry density of LAC

Figure A.4 — Limits of slenderness ratio S of loadbearing walls and piers

NOTE The use of the design methods according to the different methods of this subclause (A.6.2, A.6.3 or A.6.4) in a country is specified in the national application document. The national application document can limit the use of these components for different structural applications such that e.g. different minimum thicknesses are required or different maximum slenderness limits are specified for certain structural applications.

A.6.2 Method based on the Euler formula

(1)P The resisting design axial compression force N_{Rd} shall be determined as the loadbearing capacity of that part of the cross-section, which can be regarded as centrally loaded, i.e.:

$$N_{Rd} = k_s \cdot \alpha \cdot f_{cd} A_c \quad \text{(A.24)}$$

where

k_s is the column factor according to Equation (A.25);

α is the long term factor according to A.4.2;

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

A_c is the area of the compression zone of the cross-section;

$$k_s = \frac{1}{1 + \frac{f_{ck}}{E_{cm}\pi^2} \cdot \left(\frac{l_0}{i_c}\right)^2} \qquad \text{(A.25)}$$

where

E_{cm} is the mean value of the modulus of elasticity of LAC according to 4.2.6;

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

l_0 is the buckling length of the component equal to $\beta \cdot l_w$, where β depends on the support conditions as shown in Table A.2.

β is a coefficient for the determination of the buckling length (see Table A.2);

l_w is the height of the wall component;

i_c is the radius of inertia of the compression zone of the cross-section, i.e. $i_c = (I_c/A_c)^{½}$;

I_c is the moment of inertia of the compression zone of the cross-section;

A_c is the area of the compression zone of the cross-section.

For rectangular cross-sections or cross-sections with other shapes that can be converted into equivalent rectangular cross-sections the following may be used:

$A_c = l_h (h - 2e_1)$ (A.26)

$i_c = (h - 2e_1)/\sqrt{12}$ (A.27)

where

h is the design thickness of the component, which for a solid wall is equal to the thickness of the wall;

e_1 is the first order eccentricity perpendicular to the wall taken as the sum of the first order eccentricity of the longitudinal load in the middle third of the height of the wall (e_0) and the additional eccentricity of the longitudinal compression force due to geometrical imperfection (e_a). The geometrical imperfection shall be taken as 1/500 of the total component height.

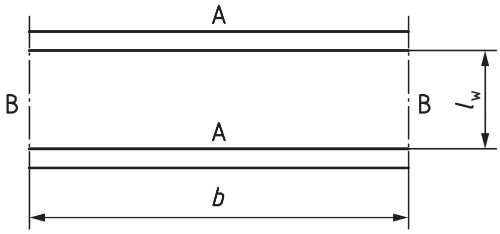
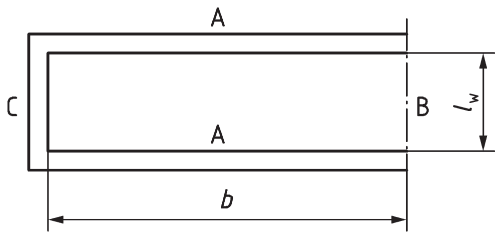
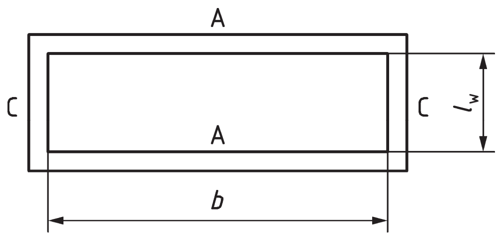
l_h is the effective horizontal length of the cross-section.

The cross-sections at the top and bottom of the wall need to be checked for crushing in the case of larger bending moments at the top or bottom, than the moment in the middle third of the wall. This is checked by using the Equation (A.24) with k_s=1,0.

NOTE 1 The national application document can limit the use of the components with respect to slenderness and loadbearing capacity.

(2) For the determination of the buckling length $l_0 = \beta \cdot l_w$ (coefficient β see Table A.2) a multi-sided support of a wall should be assumed only if the wall is erected without in-plane joints between the supporting walls.

Table A.2 — Coefficient β for the determination of the buckling length l_0 at different boundary conditions
(used in Equation (A. 25), $l_0 = \beta \cdot l_w$)

Lateral restraint	Sketch	Expression	Factor β	
Along two edges			β =1,0 for any ratio of l_w/b	
Along three edges		$\beta = \frac{1}{1+\left(\frac{l_w}{3b}\right)^2}$	b/l_w 0,2 0,4 0,6 0,8 1,0 1,5 2,0 5,0	β 0,26 0,59 0,76 0,85 0,90 0,95 0,97 1,00
Along four edges		If $b \geq l_w$ $\beta = \frac{1}{1+\left(\frac{l_w}{b}\right)^2}$ If $b < l_w$ $\beta = \frac{b}{2l_w}$	b/l_w 0,2 0,4 0,6 0,8 1,0 1,5 2,0 5,0	β 0,10 0,20 0,30 0,40 0,50 0,69 0,80 0,96
Key	A… floor slab B… free edge C… transverse wall			

NOTE 2 The information in Table A.2 assumes that the wall has no openings with a height exceeding 1/3 of the wall height l_w or with an area exceeding 1/10 of the wall area. In walls laterally restrained along 3 or 4 sides with openings exceeding these limits, the parts between the openings should be considered as laterally restrained along 2 sides only and be designed accordingly.

NOTE 3 The information in Table A.2 assumes that the wall is restrained sufficiently by transverse walls and that mechanical joints connect the restrained wall and the transverse walls. Requirements for transverse walls and mechanical joint need to be considered by the designer, just as guidance or rules can be found in national documents or in EN 1992-1-1.

A.6.3 Modified model column method

A.6.3.1 General

(1)P When determining the loadbearing capacity account shall be taken of the effect of slenderness and of any moments and eccentricities occurring and their influence on the buckling of wall components.

(2)P In the case of eccentric compression in the plane of the structure, components shall be analysed for buckling about the weak axis.

(3)P For structures which are sufficiently restrained in the horizontal direction account may be taken of compressive stresses together with stresses due to any transverse action acting at the same time. This is obtained by analyzing the cross-sections with the largest resultant action eccentricity within the middle third of the height of the components. When determining the resulting eccentricity account shall be taken of action eccentricities, prebuckling, and transverse action about both main axes.

(4)P For combinations of actions with only vertical loads or for combinations of actions with predominantly vertical loads, walls shall normally be designed using the declared LAC compressive strength. In cases where the declaration includes a declared component strength, the loadbearing capacity may be determined on this basis.

A.6.3.2 Effect of slenderness

A.6.3.2.1 Total eccentricity

(1)P The total eccentricity is estimated as

$$e_{tot} = e_0 + e_m + e_a + e_2 + e_c \quad \text{(A.28)}$$

where

- e_0 is the first order eccentricity of the longitudinal load within the middle third of the height of the wall component;
- e_m is the first order eccentricity caused by bending due to the horizontal load estimated as $e_m = M_h / N_d$, where M_h is the design value of the bending moment due to the transverse load and N_d is the design value of the axial compression load;
- e_a is the eccentricity due to the geometrical imperfections, which may be set to 1/500 of the total component height;
- e_2 is the second order eccentricity;
- e_c is the eccentricity due to creep, which may be set to zero for short-term loads and to $0{,}002 l_0 \varphi_{LAC} (e_0/h)^{½}$ for long-term loads.

A.6.3.2.2 Second order eccentricity

(1)P The second order eccentricity of a non-structurally reinforced cross-section may be taken as

$$e_2 = (N_d / (N_{cr} - N_d))(e_0 + e_a + e_m + e_c) \quad \text{(A.29)}$$

where

- N_d is the design axial compression force;
- N_{cr} is the critical axial design compression force determined in accordance with Equation (A.24) assuming the eccentricity equal to e_a.
- e_0 is the first order eccentricity of the longitudinal load within the middle third of the height of the wall;
- e_a is the eccentricity due to the geometrical imperfections, which may be set to 1/500 of the total component height;
- e_m is the first order eccentricity caused by bending due to the horizontal load estimated as $e_m = M_h / N_d$, where M_h is the design value of the bending moment due to the transverse load and N_d is the design value of the axial compression load;
- e_c is the eccentricity due to creep, which may be set to zero for short-term loads and to $0{,}002 l_0 \varphi_{LAC} (e_0/h)^{½}$ for long-term loads;
- l_0 $= \beta \cdot l_w$ is the buckling length;

β is the coefficient for the determination of the buckling length (see Table A.2);

l_w is the height of the wall component;

φ_{LAC} is the creep coefficient of LAC;

h is the overall thickness of the component in the direction of the weak axis.

A.6.3.3 Design of critical cross-section for compression and bending

A.6.3.3.1 General

(1) The effect of slenderness and transverse loading is taken into account by using e_{tot} (see A.6.3.2) as the eccentricity of the design axial compression force. The critical cross-section is designed for the design axial compression force N_d and the bending moment $M_d = N_d e_{tot}$, where e_{tot} is the total eccentricity according to Equation (A.28).

A.6.3.3.2 Structurally reinforced cross-section

(1)P Estimations shall be based on design assumptions and diagrams in A.4. The reinforcement in the compression zone shall not be taken into account.

A.6.3.3.3 Non-structurally reinforced cross-section

(1)P Linear elastic stress distribution of LAC shall be assumed.

NOTE 1 The loadbearing capacity can be estimated according to point (2) or (3) according to the decisions in the national application document.

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

Partially cracked cross-sections ($0{,}4h \geq e_{tot} > h/6$):

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

$$\sigma_{cd} = 2\,N_d / (3\,l_{h,eff}\,(h/2 - e_{tot})) \leq f_{ck}/\gamma_C \tag{A.30}$$

Uncracked cross-sections ($e_{tot} \leq h/6$):

$$\sigma_{cd} = N_d / (l_{h,eff}\,h) + 6\,M_d / (l_{h,eff}\,h^2) \leq f_{ck}/\gamma_C \tag{A.31}$$

where

N_d is the design axial compression force;

$l_{h,eff}$ is the effective horizontal length of the wall, column or pier;

h is the design thickness;

e_{tot} is the total eccentricity of the design axial compression force according to Equation (A.28);

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

γ_c is the partial safety factor for LAC;

M_d is the design bending moment.

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

It shall be verified that the design edge stresses on the tensile side (σ_{td}) and on the compressive side (σ_{cd}) are as follows:

$$\sigma_{td} = -N_d / (l_{h,eff}\, h) + 6M_d /(l_{h,eff}\, h^2) \leq f_{t,flk} / \gamma_C \quad \text{(A.32a)}$$

$$\sigma_{cd} = N_d /(l_{h,eff}\, h) + 6M_d /(l_{h,eff}\, h^2) \leq f_{ck} / \gamma_C \quad \text{(A.32b)}$$

where the symbols are the same as in Equation (A.31).

If the characteristic flexural strength $f_{t,flk}$ is determined by testing according to EN 1521, this value shall, in the absence of more accurate data, be multiplied by a factor α.

NOTE 2 The value of α can be found in the national application document. The recommended value is 0,8.

A.6.4 Simplified design method for cellar walls subjected to earth pressure loading

(1) For storey-high solid walls being subjected to direct plate bending stress only by active earth pressure (cellar walls) and having a rectangular cross-section, a simplified verification method may be applied if the following conditions are met:

a) The clear height of the cellar wall is l_w ≤ 2,6 m and the wall thickness is h ≥ 240 mm.

b) The cellar ceiling acts as a diaphragm and is able to absorb and transfer the bearing force resulting from the earth pressure.

c) At the bottom of the wall the horizontal bearing force from the earth pressure can be absorbed and transferred.

d) The characteristic value of the live load q_k on the ground surface within the area of influence of the earth pressure on the cellar wall is ≤ 5 kN/m^2 (see Figure A.5).

e) The ground surface does not rise; the height of the backfill l_e is not larger than the height of the wall l_w.

f) There is no hydrostatic pressure acting on the wall.

g) At its base the wall stands on a mortar bed for its entire cross-section.

h) The span of the supported ceilings is l ≤ 6 m, unless the bending moments from the angle of rotation of the ceiling is limited by structural measures, e.g. centring strips. For ceilings spanning in two directions, the shorter one of the two spans shall be selected for l.

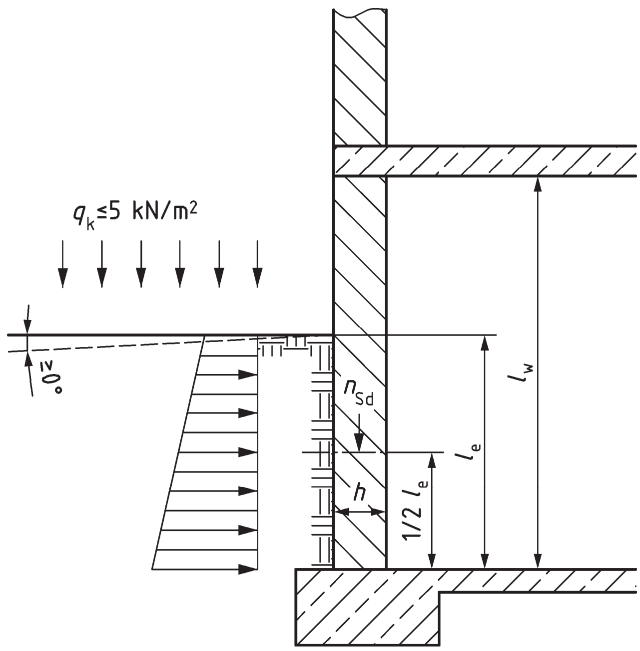


Figure A.5 — Design loads for cellar walls

The loadbearing capacity of the wall subjected to earth pressure is considered as verified if the following conditions are fulfilled:

$n_{Sdmax} \leq 0,25 \cdot h \cdot f_{ck}/\gamma_C$ (A.33a)

$n_{Sdmin} \geq \varphi \cdot \gamma_e \cdot l_e^2 \cdot l_w/h$ (A.33b)

where

n_{Sdmax} is the upper value of the design axial compression force per unit of length, determined at half height of the backfill, see Figure A.5;

n_{Sdmin} is the lower value of the design axial compression force per unit of length, determined at half the height of the backfill;

l_w is the clear height of the cellar wall;

l_e is the clear height of the backfill;

h is the wall thickness;

γ_e is the design value of the dead load of the backfill material;

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

γ_C is the partial safety factor for non-reinforced LAC-components;

φ is a factor taking into account the extent of bending as a function of the type of support of the cellar wall.

The factor φ is

- for walls with two-sided support (at top and bottom): φ = 1/20;
- for walls with four-sided support not containing any in-plane joints between the restraining walls, the factor φ may be taken into account as follows:
  - walls with $L \geq 2\ l_w$: φ = 1/20;
  - walls with $L \leq l_w$: φ = 1/40;
  - For $l_w < L < 2\ l_w$ linear interpolation may be applied;

L is the distance of stiffening walls or other stiffening elements between each other.

A.7 Serviceability limit states

A.7.1 Serviceability limit state of cracking

(1)P Calculation of crack widths in order to ensure sufficient corrosion protection of the structural reinforcement is not necessary for LAC-components where the corrosion protection is achieved according to 5.6.4.3, 5.6.4.4 and 5.6.4.5.

(2)P Calculation of crack width in order to ensure sufficient corrosion protection is not necessary for roof and floor components, which fulfil the requirements in 5.6.

A.7.2 Serviceability limit state of deformation

A.7.2.1 General

(1)P The deformation of a member of a structure shall not be such that it adversely affects its performance or appearance.

(2)P Appropriate limiting values of deflection taking into account the nature of the structure, finishes, partitions and fixings and the function of the structure shall be used in structural design.

(3)P The following states of deformation shall be checked under realistic conditions or assumptions:

— long-term deformations due to a permanent or quasi - permanent combination of actions;

— active deformations, i.e. such deformations that can cause damage to other structural components or be detrimental to the use of the components.

(4)P Deflections of roof and floor components and beams shall be limited in such a way that harmful effects are prevented.

A.7.2.2 Design assumptions

(1)P The design assumptions given below shall be used:

— Plane sections remain plane.

— The strain in the reinforcement is the same as in the surrounding LAC.

— Stresses in the LAC and in the reinforcement are derived from the characteristic values of the material properties.

— Deformations are calculated on the basis of the mean values of the material properties (such as E_{cm} according to 4.2.6). The modulus of elasticity of LAC is reduced to allow for creep when calculating deformations due to permanent or quasi-permanent actions.

A.8 Components requirements

A.8.1 Roof and floor components

A.8.1.1 Field of application

(1)P Roof and floor components (see 5.4 and Figure 2) are designed as one-way spanning, simply supported

— solid components;

— hollow core components;

— multilayer components.

(2)P Loadbearing cantilevered components (i.e. balconies etc.) shall be designed.

(3)P Special measures shall be introduced in case of predominantly dynamic loading (traffic ramps, vibration from heavy machinery, seismic actions etc.) or large concentrated loads. These measures include the use of shear reinforcement, transverse reinforcement, not using LAC with low density or low strength etc.

(4)P Longitudinal edges shall be designed in such a way that shear forces can be transferred between adjoining components.

(5)P Characteristic bending capacity of a cracked cross-section shall be greater than the characteristic bending capacity of an uncracked cross-section in order to avoid brittle failure by providing a minimum content of reinforcement. For this control measure the tensile strength in an uncracked cross-section shall be taken as the flexural strength of LAC according to 4.2.4.

A.8.1.2 Structural design

(1)P The span is defined as the distance between the support reactions.

(2)P For assembly and service purposes a point load of 1,0 kN in the centre of the span shall be assumed.

(3)P Reduction of the compression zone (e.g. by chases) shall be taken into account in the design of components.

A.8.1.3 Shear joints

(1)P The transfer of in-plane shear forces from one component to another may be verified by demonstrating that the design shear forces in the joint do not exceed the design shear resistance of the joint.

(2)P The joint strength shall be established, either by calculation or by testing according to EN 1741.

A.8.1.4 Punching

(1)P The punching shear capacity shall be verified according to the requirements in the national application document.

A.8.2 Wall components

A.8.2.1 Components with non structural reinforcement

A.8.2.1.1 Structural design

(1)P Wall components shall transfer their loads storey by storey. They can be storey-height panels or with horizontal joints within the storey-height. If there are horizontal joints within the storey height, these shall be completely filled with mortar.

(2)P The structural design of the wall components shall fulfil the requirements of A.6. In addition the overall stability of the building shall be verified.

(3)P Shear transfer due to shear wall action may not be taken into account across beams within wall components unless special precautions are taken.

A.8.2.1.2 Chases

(1)P Horizontal or inclined chases shall be taken into account in the structural analysis. However, vertical chases with a depth of not more than 30 mm or one-sixth of the wall thickness and at least 1,0 m apart may be ignored in the structural analysis.

(2)P The sum of the widths of permitted chases without structural analysis shall not exceed 20 % of the horizontal length of the wall.

(3)P Without structural analysis chases shall not be positioned less than 1,5 times the thickness from the edges of wall components. Chases shall be formed by inserting battens in the formwork or by machining. Chasing of completed walls by chiselling is not permitted.

(4) Additional information or requirements for chases or for walls with chases can be found in national application documents.

A.8.2.1.3 Openings

(1)P Verification of the loadbearing capacity of the beams over the openings in wall components shall be carried out according to A.4 and A.5.

(2)P Verification of loadbearing capacity is not required if all of the following conditions are met:

— clear width of opening ≤ 1,5 m;

— beams cast monolithically and forming an integral part of wall components;

— floor loads from one side only;

— design value of imposed floor loads ≤ 2,75 kN/m^2;

— no concentrated loads on the beam;

— dimensions and reinforcement are in accordance with Table A.3.

Table A.3 — Required dimensions of beams without verification of loadbearing capacity

<table>
<tr><th>Clear width of wall opening
m</th><th>Direction of floor span</th><th>Minimum height
mm</th><th>Minimum width
mm</th><th>Minimum Reinforcement</th></tr>
<tr><td>≤ 1,00</td><td rowspan="2">Perpendicular to beam</td><td>200</td><td rowspan="3">120</td><td rowspan="3">2 bars,
$A_s \geq 300$ mm²</td></tr>
<tr><td rowspan="2">> 1,00
≤ 1,50</td><td>400</td></tr>
<tr><td>Parallel to beam</td><td>300</td></tr>
</table>

For beams with a width below 120 mm, verification of loadbearing capacity is not required if the other requirements in Table A.3 are fulfilled and loads are reduced in proportion to the actual width of the wall.

A.8.2.2 Components with structural reinforcement

A.8.2.2.1 General structural design

(1)P The structural design of the wall components shall fulfil the requirements of A.4 and A.5. The reinforcement in the compressive zone of the cross-section shall not be taken into account.

(2) Wall components which are placed between or in front of different loadbearing systems generally are fixed horizontally at their smaller edges or corners. They are predominately loaded horizontally by e.g. wind loads or earth pressure and vertically by their dead weight, the dead weight of the components above them and/ or additional loads, e.g. by roofs or floors. The components can span horizontally or vertically.

(3)P Horizontally spanning components shall be supported in the vertical direction, either continuously, e.g. on foundation, or on single supports, e.g. corbels of the main loadbearing system. In the latter case the components are acting as a beam for vertical loading and as a slab for horizontal loading.

A.8.2.2.2 Solid walls

(1)P The transfer of the horizontal support forces into the overall loadbearing structure shall be verified also taking into account their increase due to second order effects and unintended inclination of the components.

(2)P For wall components arranged in horizontal position, placing one component on the other, the effect of unintended inclination - depending on the imperfections of production and execution - on the horizontal support forces and the bending moments of the components shall be taken into account according to Figure A.6 and Equation (A.34).

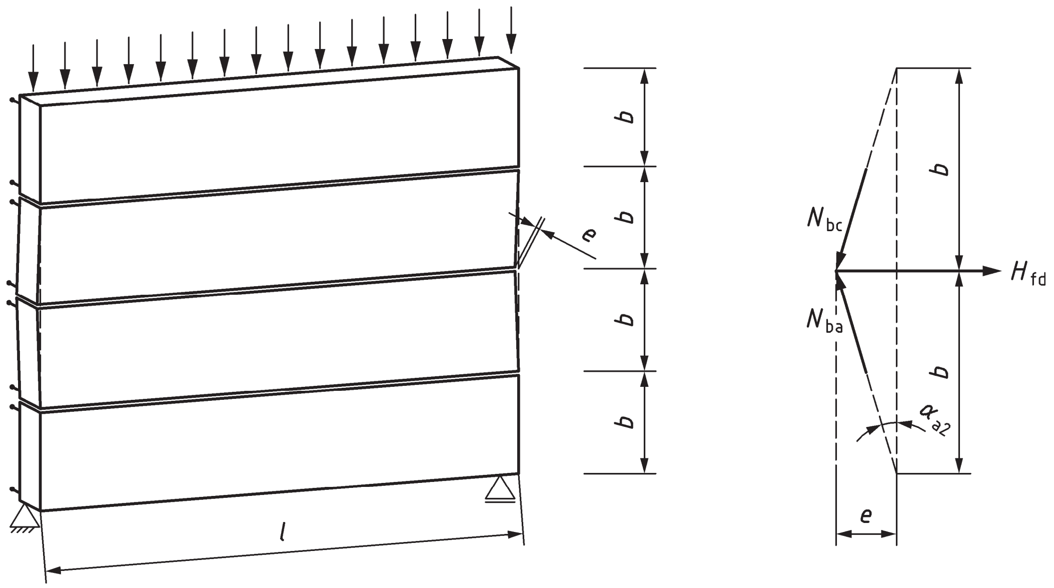


Figure A.6 — Additional horizontal force H_{fd} due to inclination of the components and effects of second order theory

$$H_{fd} = (N_{bc}+N_{ba})\cdot\alpha_{a2}\cdot f_1 \quad \text{(A.34)}$$

where

H_{fd} is the additional horizontal force due to unintended inclination of the components and effects of second order theory;

N_{bc} is the vertical loading above the considered horizontal joint;

N_{ba} is the vertical loading below the considered horizontal joint;

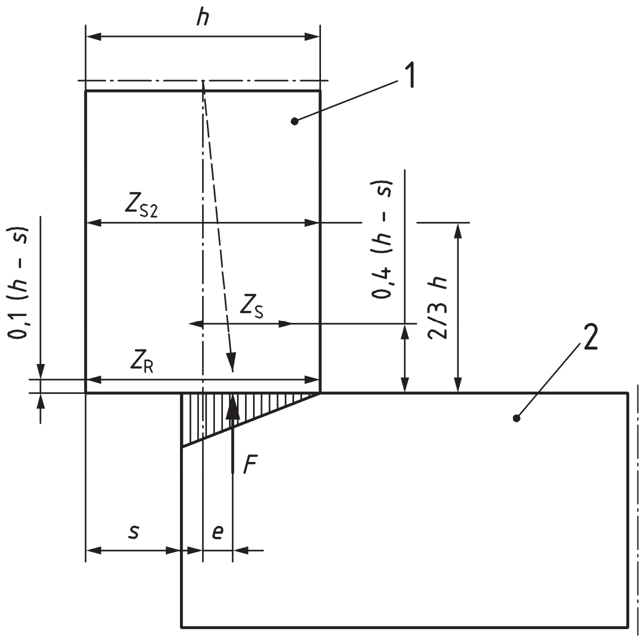
α_{a2} is the unintended inclination of the components according to national rules;

f_1 is the load increasing factor recognizing the effect of second order theory.

(3)P For the verification by means of the second order theory the effect of creep of the LAC and of the cracking of the component may be taken into account by assuming a reduced modulus of elasticity E_{red} =0,6E_{cm}, with E_{cm} according to 4.2.6, Equation (4). Furthermore it shall be verified, that the bending stress due to the characteristic horizontal loading, e.g. wind loading does not exceed the flexural strength of the LAC. Otherwise, the modulus of elasticity shall be further reduced on the basis of testing or calculation.

(4)P For horizontally spanning wall components intended to be laid dry, the maximum wall height shall be not more than 8 m and the horizontal joints shall be profiled and designed according to 5.5.3.

(5)P If walls are not supported over their entire thickness, the loadbearing capacity and the transfer of the additional forces onto the anchoring devices shall be verified. These forces shall be determined assuming a linear stress distribution in the joint. The maximum permissible oversail is 0,4 h, where h is the thickness of the wall component. The tensile splitting forces arising in accordance with Figure A.7 shall be absorbed either by the tensile strength of the LAC or by sufficiently anchored reinforcement. The anchorage of the reinforcement shall be verified by testing according to the national application document. The design tensile strength shall be calculated on the basis of Equation (3) in 4.2.4, with a partial safety factor γ_C for non-reinforced LAC and shall be reduced by the factor 0,8 to recognize long-term effects.



Key

1 wall component
2 foundation

Figure A.7 — Tensile splitting forces in wall components with oversail *s*

(6)P When determining the resisting axial compression stress for components being supported over their entire thickness the design edge compressive stress σ_{Sd} shall not be lower than the resisting design compressive stress σ_{Rd} according to Equation (A.35).

$$\sigma_{Sd} < \sigma_{Rd} = 0{,}9\ \alpha{\cdot}f_{ck}/\gamma_C \qquad \text{(A.35)}$$

where

α is the factor taking into account long-term effects, $\alpha = 0{,}8$;

γ_C is the partial safety factor for non-reinforced LAC.

(7)P If the wall components are not supported over their entire thickness, the design edge compressive stress σ_{Sd} in the horizontal joint shall be limited according to Equation (A.36), assuming a linear distribution of the compressive stresses.

$$\sigma_{Sd} < \sigma_{Rd} = 0{,}5 f_{ck}/\gamma_C \qquad \text{(A.36)}$$

(8)P Horizontally spanning wall components shall be designed with a thickness of $h \geq L/40$ where L is the horizontal span length.

A.8.2.2.3 Hollow core walls

(1)P The provisions described in A.8.2.2.1 and A.8.2.2.2 are also valid for hollow core walls. However the relevant geometrical values in accordance with 5.5.3.2 and the additional requirements given in this subclause shall be taken into account.

(2)P The vertical load transfer shall be designed according to Equation (A.24) taking into account the effective minimum cross section of the hollow core component. The total eccentricity shall be limited to $e_t = h / 6$.

(3)P In addition to (2) the cross-sectional resistance N_{Rd} shall be limited to the plastic resistance of one of the two loadbearing shells with the thickness h_f and the length *l* of the component in accordance with Equation (A.37), see Figure 4.

$$N_{Rd} \leq \alpha \cdot f_{cd} \cdot h_f \cdot l \quad \text{(A.37)}$$

(4)P For the design for the tensile splitting forces occurring in the top and bottom area of the wall components due to the hollow cores, the uniaxial tensile strength may be calculated according to Equation (3). Higher compressive strength values than f_{ck}= 10 MPa shall not be taken into account, however. For the determination of the design value of the uniaxial tensile strength, the partial safety factor γ_C for non-reinforced LAC shall be used. Figure A.8 shows the forces at the top of a hollow core wall component in the case of uniformly distributed compression load. If there are any deviations from these load positions, this shall be taken into account in the design.

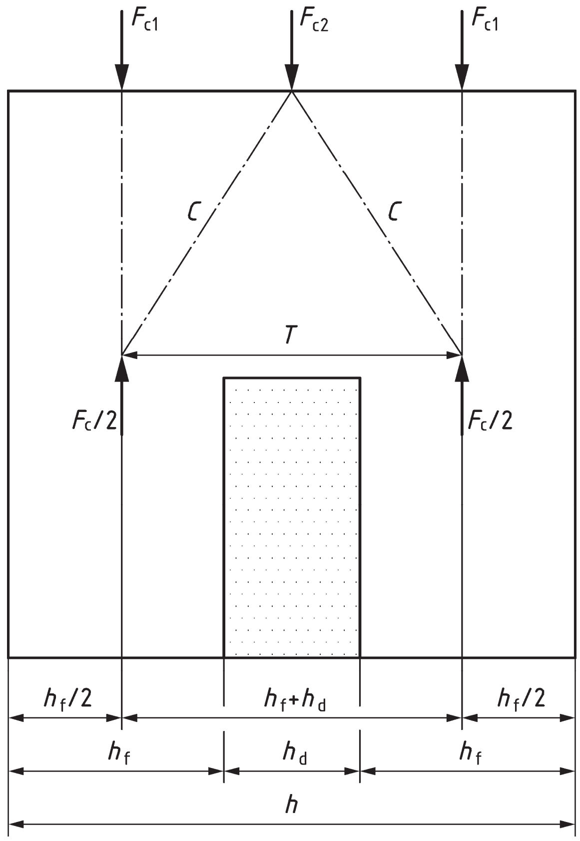


Figure A.8 — Tensile splitting forces at the top of a hollow core wall component

(5)P Vertical line loads, e.g. from continuously supported floor or roof slabs shall be transferred by structural measures to the centre plane of the wall. In the direction of the wall thickness tensile splitting reinforcement for absorbing the resulting tensile force $T \geq 0{,}25\ F$ according to Figure A.9, shall be inserted in the solid LAC shell of the hollow core wall component directly below the supported floor or roof.

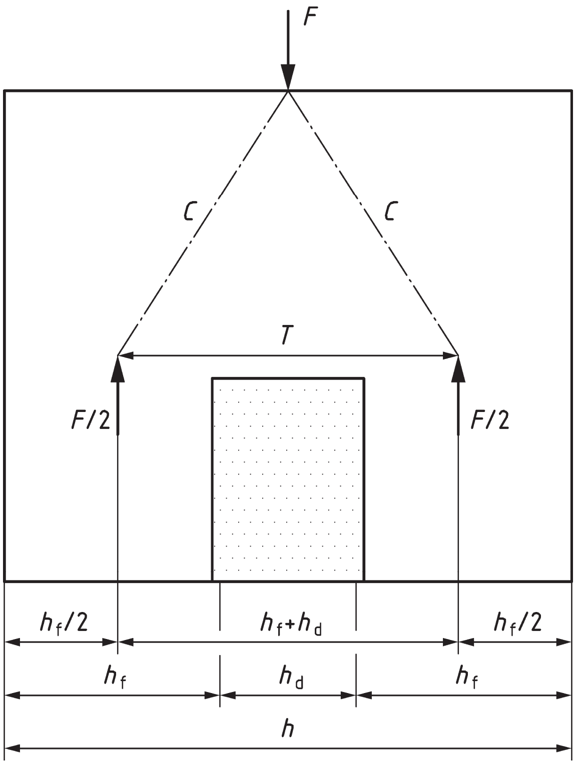


Figure A.9 —Tensile splitting force *T* due to centric loading

(6)P When applying concentrated vertical point loads, a load spread angle of 60° in the longitudinal direction of the component shall be assumed. No hollow cores shall be present within the load application area up to the point, where adjacent load spread triangles overlap. Within the loaded area a reinforcement to resist a horizontal tensile force of $T \geq 0{,}25\ F$ shall be inserted in transverse and longitudinal direction. As an alternative to a load distribution under 60° the solid LAC shell at the top of the upper hollow core wall component may be designed as a continuous reinforced ringbeam loaded by the force F. In this case the width b_v of the massive vertical LAC webs between the hollow cores shall be ≥ 150 mm, see Figure (4).

(7)P Unlike solid wall components, the maximum permissible oversail is 0,2 h, otherwise the same provisions as for solid walls apply. An adequately anchored transverse reinforcement shall be provided in the lower shell of the component at the bottom of the wall and designed for the tensile splitting forces in accordance with Figure A.7. Alternatively, when using a 30 cm high solid LAC beam at the base of the component, the tensile splitting forces can be covered by the design tensile strength of the LAC. The vertical webs between the hollow cores shall be designed, for the shear force resulting from eccentricity in combination with the tensile splitting force Z_{s2} according to Figure A.7.

A.8.2.2.4 Lintel wall plates of solid and hollow core components

(1)P The vertical loads resulting from the dead weight and imposed loads from supported lintel wall plates and/or additional loads, e.g. from roofs, shall be made to act centrally by suitable means.

(2)P The effects of diaphragm and plate action shall be combined.

(3)P The vertical components of the shear force shall be covered by vertical shear reinforcement in the form of shear ladders in accordance with A.5. In order to prevent splitting of the components due to the welded joints of the shear ladders, the minimum lateral concrete cover within the anchorage zone of the welded joints shall not be reduced within the zone of the hollow cores. The reinforcement needed for horizontal loads, as e.g. wind loads, shall be placed symmetrically in the two outer shells. The greater cross-sectional area of the reinforcement shall apply.

(4)P No hollow cores shall be arranged within the anchorage zone of the longitudinal reinforcement.

(5)P The anchorage of the horizontal tensile beam-reinforcement for the vertical loads shall be designed in accordance with A.9 (2) e). Alternatively the anchorage may be designed with anchoring devices, recognizing the partial area compression and the tensile splitting forces.

(6)P By suitable means, e.g. suitable slip planes in the support zone, shall be ensured that no obstructed longitudinal movement resulting from temperature, shrinkage etc. will occur.

A.8.2.2.5 Chases

The relevant requirements of A.8.2.1.2 apply.

A.8.3 Components for noise barriers

A.8.3.1 Field of application

(1) Components for noise barriers (according to 5.2.5) are for external applications (e.g. along roads) and are not building components. They are loaded only by their dead load and by direct wind forces.

A.8.3.2 Structural design

(1)P The relevant requirements of A.8.1 apply.

(2)P Noise barrier components exposed to wind loads shall be designed according to A.4 and A.5.

A.9 Detailing of reinforcement

(1)P Structural reinforcement shall have sufficient bond or anchorage in the component.

NOTE Systems of bond or anchorage approved in a country can be found in its national application document.

(2) Examples for systems for achieving bond or anchorage are listed below:

a) By anchoring all smooth reinforcing bars in roof or floor components as indicated in Figure A.10. The diameter of the bars and the amount of reinforcement used shall not exceed the limits in Table A.4. The characteristic yield strength of the reinforcement steel used in design shall not be taken as greater than 220 MPa.

   In the end zone bars shall be covered on all sides with not less than 10 mm of concrete with closed structure for a length of at least 500 mm.

   If the anchoring length is less than 50 mm, the design shear capacity of the component shall be reduced by a factor ρ_3 according to Equation (A.38).

   $$\rho_3 = (l_a / 25 - l_a^2 / 2\,500) \qquad \text{(A.38)}$$

   where

   l_a is the anchoring length, in millimetres.

b) By using welded steel fabric mats without hooks or bends with at least one transverse bar lying behind the front edge of the support. The distance between the transverse bars shall not exceed 250 mm. The characteristic yield strength of the steel shall not exceed 500 MPa, the maximum bar diameter shall not exceed 8 mm, and the amount of reinforcement shall not exceed 0,25 % of the cross-sectional area of the component. Welded steel fabric mats shall be covered on both sides by at least 10 mm of concrete having a dry density of at least 1 200 kg/m^3. The loadbearing capacity of the welded joints in the anchorage zone shall be verified as follows: The 5 % quantile of the population of the shear strength S determined in accordance with EN 1737 shall reach at least the following values:

   $S = 0{,}35\ A_{s1}\ f_{yk}$ for $f_{yk} = 500$ MPa

   $S = 0{,}50\ A_{s1}\ f_{yk}$ for $f_{yk} = 235$ MPa

   where

   A_{s1} is the cross sectional area of the thicker steel bar of the welded joint;

   f_{yk} is the characteristic steel strength of the bar.

If stainless steel is used, the relevant national requirements shall be taken into account

Verification of the loadbearing capacity of the welded connection:

$$F_{bdt} = S \leq 16\, A_s\, f_{cd}\, \phi_t \,/\, \phi_l \qquad \text{(A.39)}$$

where

F_{bdt} is the loadbearing capacity of the anchorage of a welded transverse bar;

S is the ultimate shear strength of the welded joint;

A_s is the cross sectional area of the bar to be anchored;

f_{cd} is the design concrete strength;

ϕ_t is the nominal diameter of the transverse bar;

ϕ_l is the nominal diameter of the bar to be anchored, $\phi_t \leq 8$ mm.

c) By using ribbed bars in roof or floor components as shown in Figure A.11, with the characteristic yield strength of the reinforcement used in design not being taken to be higher than 550 MPa, and the diameter of the bars used in design not exceeding 12 mm. The bars shall be covered on all sides by at least 10 mm of concrete having a dry density of at least 1 200 kg/m^3. The anchorage length l_a shall always be at least 45 mm.

d) By securing at least 200 mm support length for beams with spans of up to 2,5 m reinforced with ladder reinforcement. The ladder reinforcement shall have transverse bars welded to the tensile reinforcement with at least one transverse bar over the support. The ratio between the cross-sectional area of the transverse bars over the support and the cross-sectional area of the tensile reinforcement shall be greater than 0,2. The characteristic yield strength of the steel shall not exceed 550 MPa, the bar diameter shall not exceed 10 mm, the cover shall be at least 10 mm and the characteristic compressive strength of the concrete shall be at least 6 MPa. The loadbearing capacity of the welded joints in the anchorage zone shall be verified as described in A.9 b).

e) Having the anchorage of the flexural reinforcement in beams designed as part of shear ladders with a minimum of two transverse bars over the support, with an anchorage length $l_b > 30\,\phi$, where ϕ is the diameter of the bars. The welding (bar sizes, diameters, spacing and concrete cover) shall comply with EN 1992-1-1, Figure 8.5. Alternatively ribbed reinforcement bars with a straight length of $l_b = 30\,\phi$ above the support and additional end hooks may be used to serve as well anchored flexural reinforcement, when in addition two stirrups enclose the longitudinal tension reinforcement above the support. The diameter of the stirrups shall be not less than $0{,}4\phi$. In both cases, the bars shall be encased in at least 10 mm of concrete with a dry density of not less than 1200 kg/m^3 and a compressive strength of not less than 6 MPa.

f) By using non-structural reinforcement meshes consisting of straight ribbed bars with the overlap length of at least 400 mm and at least one mesh, the diameter of the bars not being larger than 6 mm and embedded in concrete with a characteristic compressive strength of at least 6 MPa with a cover of at least 30 mm.

g) By using structural reinforcement mesh consisting of straight, ribbed bars in wall components, the mesh having an overlap of at least one mesh and an overlap length l_o of at least

$$l_o \geq \alpha_2 \alpha_6 \alpha_7 \cdot (2\phi/9) \cdot (\sigma_{sd} / f_{t,fld}) \geq l_{o,min} \qquad \text{(A.40)}$$

$$l_{o,min} = \max\{0{,}067 \alpha_6 \phi\, \sigma_{sd} / f_{t,fld} ; 15\phi ; 200 \text{ mm}\} \qquad \text{(A.41)}$$

where

α_2 = 1 - 0,15· $(c_d - \phi)/\phi$, but not less than 0,7 and not more than 1,0;

α_6 = 1,5;

α_7 = 1,5;

$f_{t,fld} = f_{t,flk} / \gamma_{C}$;

and

c_d is the concrete cover;

$f_{t,fld}$ is the design value of the flexural strength of LAC;

$f_{t,flk}$ is the characteristic flexural strength of LAC;

ϕ is the bar diameter;

σ_{sd} is the design stress of the anchored bar at the end of the overlap ($\leq f_{yd}$);

f_{yd} is the design value of the yield strength of the reinforcement steel.

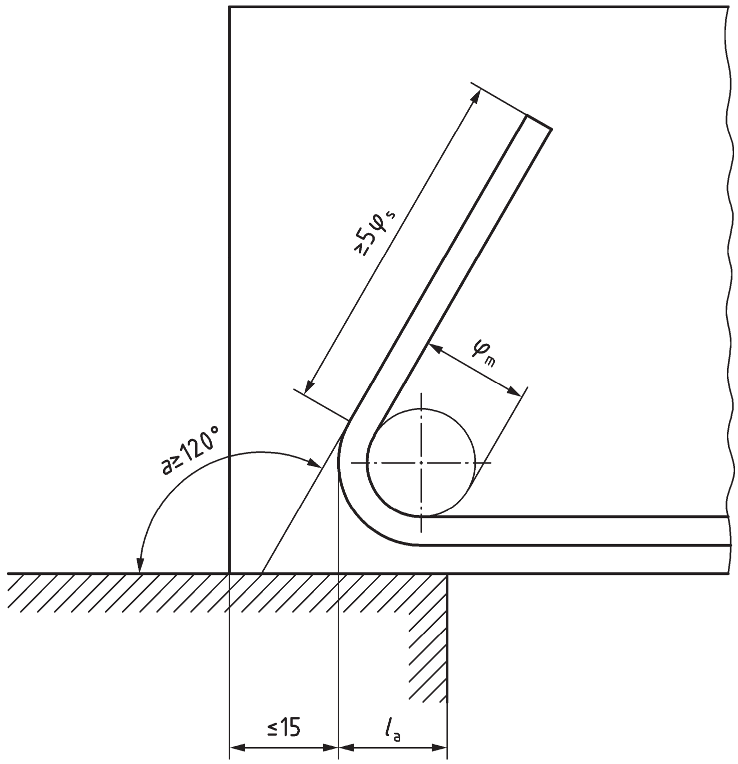
The anchorage length may be reduced if the structural reinforcement mesh is welded, the weld strength is declared and the reduction is verified by testing.

h) By using other values or anchorage arrangements. Such other values shall be based on full-scale tests according to EN 1356 applying the load in such a way as to ensure shear or anchorage failure. These shall always include limitations on density or strength of the concrete, yield strength of reinforcement steel and diameter of the bars, and a maximum amount of reinforcement in the components. Long-term behaviour shall be taken into account.

Table A.4 — Limits of reinforcement in roof and floor components for design by calculation (plain steel, with characteristic yield strength $f_{yk} \leq 220$ MPa)

Characteristic compressive strength of LAC f_{ck} MPa	**Maximum bar diameter** ϕ_s mm	**Maximum cross-sectional area of reinforcement** A_s mm²/m
2	8	453
4	10	785
6	10	943
8	12	1 357
≥ 10	14	1 847

Dimensions in millimetres



Key

ϕ_m ≥ 2,5 ϕ_s
ϕ_s: diameter of reinforcing bar
l_a: available anchorage length

Figure A.10 — Anchorage of smooth reinforcing bars

Dimensions in millimetres

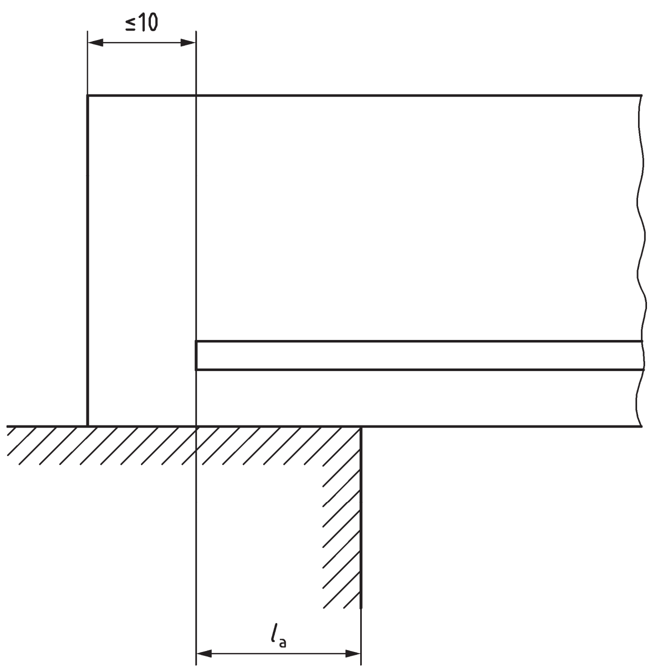


Figure A.11 — Anchorage of ribbed reinforcing bars

A.10 Partially loaded areas

(1)P For a partially loaded area A_{c0} the resistance N_{Rd} for compression forces shall be determined as follows:

$$N_{Rd} = f_{ck} A_{c0}/\gamma_C \quad (A.42)$$

where

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

A_{c0} is the area under compression;

γ_C is the partial safety factor of the LAC.

(2)P Unless the transverse tensile forces arising in the zone subject to compression are carried by reinforcement, a partial safety factor of γ_C for non-reinforced LAC shall be used.

Annex B
(informative)

Design of components by testing

B.1 Introduction

Design values to be used can be determined according to the provisions of this annex, using the relevant partial safety factors.

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

B.2 General

(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 and

— requirements and analytical models for which no alternative is permitted unless specifically stated.

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

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

(5)P In this annex Application Rules are marked by a number in brackets not followed by the letter P.

(6)P In this annex it is assumed that the characteristic loadbearing capacities, type of failure in ultimate limit state, and/or other characteristic properties of the component subject to control by continuous testing or initial type-testing are declared.

(7)P For structural components representative for current production control test results may be utilised to establish the statistical basis for the characteristic values in accordance with this European Standard.

(8)P Design methods based entirely on declared characteristic material properties are specified in Annex A.

(9)P Design by testing may replace design by calculation for one or more of the properties of the components if the design is performed in accordance with the requirements in this annex. The actual combination of design methods in relation to the component range shall be stated by the manufacturer.

NOTE Guidance for design by testing can be found in EN 1991-1.

B.3 Safety evaluation

B.3.1 General

(1)P Evaluation of the safety of the component in design may be taken into account by using partial safety factors for limit states.

(2)P In analysis of ultimate limit states the partial safety factor shall consider any relevant safety aspects, 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 during performance testing.

B.3.2 Brittle and ductile failure

B.3.2.1 General

(1)P The safety aspects of type of failure during performance testing are taken into account by different partial safety factors.

NOTE With respect to partial safety factors see B.3.3 and Annex C.

(2)P For transversely loaded components it is necessary to differentiate between ductile and brittle failure in accordance with EN 1356.

B.3.2.2 Transversely loaded components

(1)P Ductile failure: Ductile failure shall be assumed when at least one of the following states is achieved:

- failure of the component due to yielding of the reinforcement;
- failure after appearance of cracks distributed in a pattern appropriate to the applied load;
- deflection before failure ≥ (3/200) L, where L is the span length (between the centres of supports, (see Figure B.1).

(2)P Brittle failure: In all other cases the failure shall be assumed to be brittle.

B.3.2.3 Longitudinally loaded components

(1)P Failure of longitudinally loaded components shall always be considered as brittle.

B.3.3 Partial safety factors

(1)P The partial safety factors are determined according to national application documents.

NOTE Examples are given in Annex C.

B.4 Ultimate limit states

B.4.1 General

(1)P It shall be verified that the design capacity determined in accordance with this section is higher than or equal to the design effects of the actions applied.

(2)P Where, in practice, the application of loads differs from the test situation, it shall be shown by calculation that the maximum design effects of actions result in an equal or higher safety level than that derived from the test results.

(3) Guidance for extending test results to components of other sizes and of similar load cases to those tested can be supplied by the manufacturer.

B.4.2 Transversely loaded components

B.4.2.1 Loadbearing capacity

(1)P The loadbearing capacity of transversely loaded components shall be determined in accordance with EN 1356. The loadbearing capacity shall be given either as uniformly distributed load or as separate values for bending and shear capacity.

(2)P For all types of failure the loadbearing capacity shall be determined in relation to the applied load at failure.

(3)P Bending and shear capacity may be calculated from the test results and position of applied loads in the test. These capacities may be used for any loading situation where the load is symmetrical with respect to the longitudinal centre line of the component.

(4)P To determine the characteristic shear capacity, other positions of line loads to those used to determine the bending capacity, may be chosen. For uniformly distributed actions, the shear span (see Figure B.1) may be assumed to be one quarter of the length.

(5)P For loading situations where line and point loads occur simultaneously, the characteristic value for shear resistance of a component may be fully utilised for all shear spans less than that tested, provided that the number, diameter and position of transverse bars in the anchorage zone are the same.

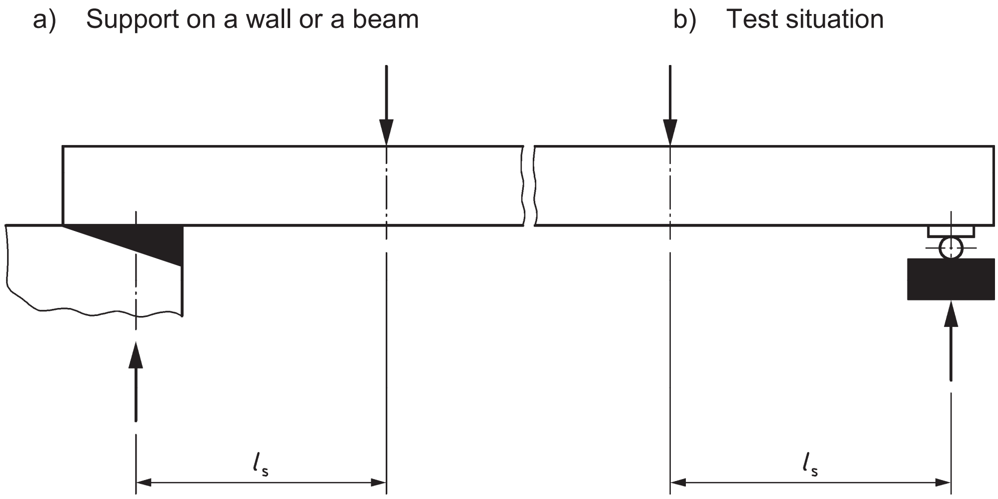


Figure B.1 — Definition of shear span l_s

B.4.2.2 Design values for bending capacity 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.4.2.1.

NOTE With respect to partial safety factors γ_{comp} see Table C.2 in Annex C.

The design value of bending capacity shall be calculated as follows:

$$M_{Rd} = M_{Rk} / \gamma_{comp} \quad \text{(B.1)}$$

where

M_{Rk} is the declared characteristic value of bending resistance calculated from the test series including the dead weight and with loads positioned normally at the outer quarter points of the span;

γ_{comp} is the partial safety factor for loadbearing capacity of the component.

The design value of the shear resistance shall be calculated as follows:

$$V_{Rd} = V_{Rk} / \gamma_{comp} \quad \text{(B.2)}$$

where

V_{Rk} is the characteristic value of shear resistance calculated from the test series including the dead load and with loads applied in the required positions.

B.4.2.3 Design criteria

(1)P In order to fulfil the required safety level the support length for transversely loaded components shall be at least that used in performance testing.

(2)P Holes, grooves or chases are only allowed without detailed analysis if a performance test with the same or more critical dimensions and locations of holes, grooves or chases has been conducted.

B.4.3 Longitudinally loaded components

B.4.3.1 Loadbearing capacity

(1)P The loadbearing capacity of longitudinally loaded components shall be determined in accordance with EN 1740. In the case of asymmetric reinforcement the eccentricity shall be chosen so that it affects the weakest side unfavourably.

(2)P The loadbearing capacity by stated characteristic values, N_{Rk}, and also the corresponding eccentricity (at top and bottom) used in the tests shall be determined and declared.

NOTE The value of γ_{comp} can be found in the national application document. Recommended values are given in Table C.2.

B.4.3.2 Design criteria

(1)P When determining loadbearing capacity, the column-effect and any moments and eccentricities occurring which influence buckling of longitudinally loaded components shall be taken into account.

(2)P Horizontal or inclined chases shall be taken into account in the structural design. However, vertical chases with a depth of not more than 30 mm or one-sixth of the wall thickness and at least 1,0 m apart may be ignored. The sum of the permitted chase widths without verification of their influence on the loadbearing capacity shall not exceed 20 % of the horizontal wall length.

(3)P The design thickness h of a homogeneous wall shall not be greater than the stated thickness.

(4)P The declared resistance of components from type-testing or performance testing is not applicable for sections or piers of width less than the normal dimension used in testing.

(5)P The loadbearing capacity of smaller sections may be taken from the section ratio adjusted by a shape factor.

B.4.3.3 Design loadbearing capacity for centric and eccentric compression forces

(1)P If the thickness and the eccentricity of the component under consideration differs from that used in the tests, the design loadbearing capacity may be determined from Equation (B.3) if the following two conditions are met:

$e_1 \leq (2/3)\, e_g$ and

$0{,}85\, l_{0g} \leq l_0 \leq 1{,}15\, l_{0g}$

(2) The resisting design longitudinal compression force may be determined from:

$$N_{Rd} = (N_{Rk} / \gamma_{comp}) \times (d - 2e_1) / [d - (4/3)e_g] \times (l_{h,eff} / l_{h,g}) \times (k_s / k_{sg}) \tag{B.3}$$

where

l_0 is the effective height of the wall, depending on the support conditions;

d is the design thickness (for a solid wall $d = h$ where h is the wall thickness);

e_1 is the first order eccentricity perpendicular to the wall taken as the sum the first order eccentricity of the loads (e_0) and the additional eccentricity of the longitudinal compression force due to geometrical imperfections (e_a). The geometrical imperfection may be set to 1/500 of total component height;

e_g is the declared eccentricity at the top of the component perpendicular to its plane i.e. the eccentricity used in the testing;

l_{0g} is the declared pier or wall height, i.e. the height used in operational testing;

$l_{h,eff}$ is the effective horizontal length of the component equal to $l_h - 2e_N$;

l_h is the horizontal length of the component;

e_N is the eccentricity of the longitudinal compression force in the plane of the component;

$l_{h,g}$ is the declared horizontal length of the component, i.e. the horizontal length of the component used in the testing;

N_{Rk} is the characteristic resisting longitudinal compression force of the component for eccentric (e_g) compression;

γ_{comp} is the partial safety factor for loadbearing capacity of the component

and where, unless otherwise established (see Equation (A.25)), k_s and k_{sg} may be taken as follows:

$$k_s = \frac{1}{1 + 12 \cdot 10^{-4} \left(\frac{l_0}{d - 2 e_1} \right)^2} \quad \text{(B.4)}$$

$$k_{sg} = \frac{1}{1 + 12 \cdot 10^{-4} \left(\frac{l_{0g}}{d - \frac{4}{3} e_g} \right)^2} \quad \text{(B.5)}$$

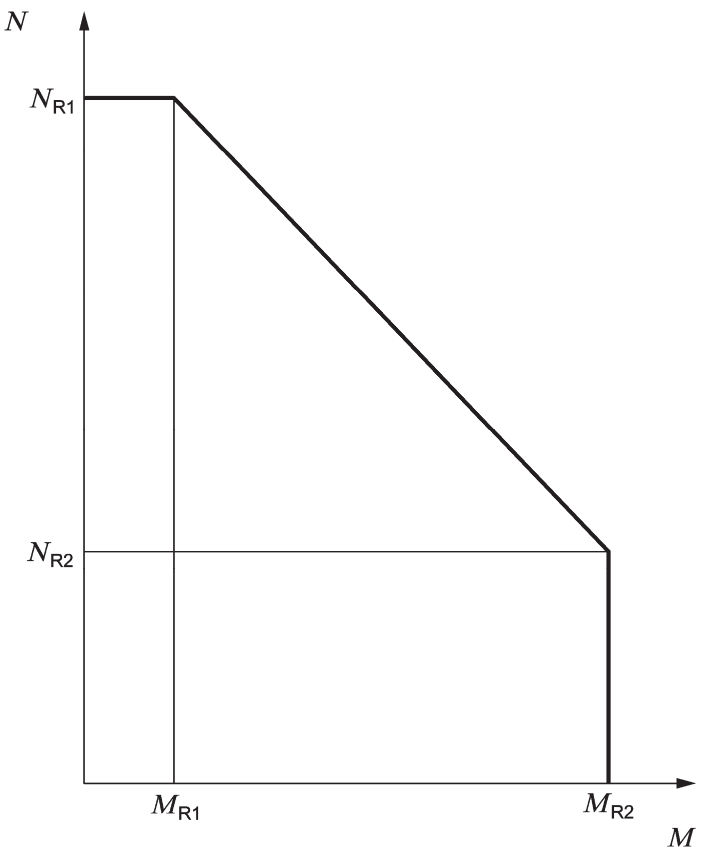
NOTE The value of γ_{comp} for use in a country can be found in its national application document. The recommended values for use are given in Table C.2.

B.4.4 Components simultaneously loaded transversely and longitudinally

B.4.4.1 General

(1)P Component design for simultaneously acting transverse forces and longitudinal compression forces may be based on a simplified *N/M* interaction diagram (see Figure B.2) obtained for a cross-section of a component. The diagram depends upon variables like reinforcement, compressive strength, and cross-section of components.

(2)P In cases where the cross-section of the component is constant, this diagram is valid for the entire length of the component, except for the range of the tensile forces in the reinforcement. In this range the allowable bending moment shall be reduced.



N_{R1} is the resisting longitudinal compression force for pure longitudinal loading according to B.4.3.3;

N_{R2} is the resisting longitudinal compression force for simultaneous longitudinal and transverse load, calculated and then verified by test in accordance with EN 1740 (the test shall continue until bending capacity M_{R2} has been reached);

M_{R1} is the minimum bending capacity for bending moments from eccentricities under longitudinal loading according to B.4.3.1;

M_{R2} is the maximum bending capacity in the absence of longitudinal loading according to B.4.2.1.

Figure B.2 — Simplified N/M interaction diagram of the cross-section, representing results of three test series

B.4.4.2 Loadbearing capacity

(1)P The loadbearing capacity of components loaded both transversely and longitudinally shall be determined in accordance with EN 1356 and EN 1740.

B.5 Serviceability limit states

B.5.1 Elastic deformations

(1)P Elastic deformations under service loads are indicated in the test report (see EN 1740 or EN 1356, respectively).

(2)P The manufacturer shall, on request, present the values for deflections of roof and floor components and beams.

B.5.2 Time dependent deformations

(1)P Time dependent deformations may be estimated using elastic deformation and nominal values for the creep factor and drying shrinkage (see Clause 4).

Annex C
(informative)

Recommended values for partial safety factor

C.1 General

The partial safety factors and reliability levels from national application documents can be used. The following values are recommended in the absence of national values.

C.2 Ultimate limit states (ULS)

If no other values are specified, the partial safety factors γ_M according to Table C.1 can be used for evaluation by calculation and the partial safety factors γ_{comp} according to Table C.2 can be used for design by testing.

Table C.1 — Partial safety factors γ_M for material properties

Partial safety factors γ_M			**ULS**	**Accidental actions**
Reinforcement steel		γ_S	1,15	1,00
LAC	Reinforced components	γ_C	1,40	1,20
	Plain or lightly reinforced components	γ_C	1,70	1,40

Table C.2 — Partial safety factors γ_{comp} for components

Partial safety factor γ_{comp} [a]		**ULS**	**Accidental actions**
Transversely loaded components	Ductile failure γ_D	1,20	1,10
	Brittle failure γ_B	1,50	1,20
Longitudinally loaded components [b]	Brittle failure γ_W [c]	1,80	1,40
	Brittle failure γ_W [d]	2,40	1,70

[a] The partial safety factor should be selected for the recognized type of failure in the test. If different failure modes are reached in a test series or if the results from two or more test series are used for interpolation, the highest relevant partial safety factor should be chosen.

[b] Failure in longitudinally loaded components is always considered brittle.

[c] Design cases, where creep is not important.

[d] Design cases, where creep is important.

C.3 Serviceability limit states (SLS)

The partial safety factor for the SLS can be taken as γ_M = 1,0 for design by calculation or γ_{comp} = 1,0 for design by testing, respectively.

Annex ZA
(informative)

Provisions for the CE marking of prefabricated components of lightweight aggregate concrete with open structure with structural or non-structural reinforcement under the EU Construction Product Directive

ZA.1 Clauses of this European Standard addressing the provisions of EC Construction Products Directive

This European Standard and this Annex ZA have been prepared under Mandate M100 "Precast Concrete Products", as amended and given to CEN by the European Commission and the European Free Trade Association.

The clauses of this European Standard shown in this annex meet the requirements of this Mandate given under the EC Construction Product Directive (89/106/EEC).

Compliance with this Annex ZA confers a presumption of the fitness for use of prefabricated reinforced components of lightweight aggregate concrete with open structure covered by this European Standard (see Clause 1 and Table 13) for its intended use(s) indicated herein; reference should be made to the information accompanying the CE-Marking.

WARNING — Other requirements and other EU Directives, not affecting the fitness for intended use(s), can be applicable to falling within the scope of this European Standard.

NOTE 1 In addition to any specific clauses relating to dangerous substances contained in this European Standard, there can be any other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply.

NOTE 2 An informative database of European and national provisions on dangerous substances is available at the Construction web site on EUROPA (accessed through http://ec.europa.eu/enterprise/construction/cpd-ds/.

This annex establishes the conditions for the CE marking of prefabricated reinforced components of lightweight aggregate concrete with open structure intended for the uses indicated in Table ZA.1a to Table ZA.1h and shows the relevant clauses applicable:

This annex has the same scope as Clause 1 of this European Standard and is defined by Table ZA.1a to Table ZA.1h.

Table ZA.1a — Harmonised clauses for loadbearing wall components

<table>
<tr><td colspan="6">Construction Product(s): Loadbearing wall components (WLS, WLH, WLM) as covered in the scope of the European Standard

Intended use(s): Structural</td></tr>
<tr><td colspan="2">Requirements/characteristics from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength (of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ 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 colspan="2">Declared values in MPa</td></tr>
<tr><td colspan="2">Water vapour permeability (for external walls)</td><td>4.2.12</td><td>-</td><td colspan="2">Declared factor or value in g·m/(MN·s)</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1 (Annex A), 7.1, Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design

Design by calculation (Annex A)

or

Design by testing (Annex B)

<u>should be declared.</u></td></tr>
<tr><td>in case of design by testing:
Loadbearing capacity</td><td>5.1.1 (Annex B), 7.1, Annex B</td><td>-</td><td>Declared value in kN, kNm or kN/m²</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2 or 5.5</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Durability against:
freeze-thaw (only for exposed applications)</td><td>5.6.4</td><td>-</td><td colspan="2">In exposure classes XF1 or XF2 to be protected unless the freeze-thaw resistance of LAC has been verified by tests.</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euroclasses</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>RE, REI, REI-M</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Thermal resistance (only when the product is intended also for thermal applications)</td><td>4.2.11, 5.1.5</td><td>-</td><td colspan="2">Declared value in m²·K/W or λ_{10dry} in W/mK based on thermal resistance</td></tr>
<tr><td colspan="2">Direct airborne sound insulation index (only when the product is intended also for acoustical application)</td><td>5.1.3.1</td><td>-</td><td colspan="2">Declared value in db(A)</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.3.5</td><td>-</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1b — Harmonised clauses for retaining wall components

<table>
<tr><td colspan="6">Construction Product(s): Retaining wall components (WRS) as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Requirements/
characteristic
from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength
(of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³
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 colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1
(Annex A),
7.1, Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
<u>should be declared.</u></td></tr>
<tr><td>In case of design by testing:
Loadbearing capacity</td><td>5.1.1
(Annex B),
7.1, Annex B</td><td>-</td><td>Declared value in kN, kNm or kN/m²</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2 or 5.5</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Durability against:
freeze-thaw (only for exposed applications)</td><td>5.6.4</td><td>-</td><td colspan="2">In exposure classes XF1 or XF2 to be protected unless the freeze-thaw resistance of LAC has been verified by tests.</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euroclasses</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>RE, REI</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Thermal resistance (only when the product is intended also for thermal applications)</td><td>4.2.11, 5.1.5</td><td>-</td><td colspan="2">Declared value in m²·K/W
or
λ_{10dry} in W/mK based on thermal resistance</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.3.5</td><td>-</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1c — Harmonised clauses for roof components

<table>
<tr><td colspan="6">Construction Product(s): Roof components (RLS, RLH, RLM) as slabs as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Requirements/
Characteristic
from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength (of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ 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 colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation: Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1 (Annex A), 7.1, Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
should be declared.</td></tr>
<tr><td>In case of design by testing: Loadbearing capacity</td><td>5.1.1 (Annex B), 7.1, Annex B</td><td>-</td><td>Declared value in kNm or kN/m²</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2, 5.4</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Durability against:
freeze-thaw (only for exposed applications)</td><td>5.6.4</td><td>-</td><td colspan="2">In exposure classes XF1 or XF2 to be protected unless the freeze-thaw resistance of the LAC has been verified by tests</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euroclasses</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>RE, REI</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Thermal resistance (only when the product is intended also for thermal applications)</td><td>4.2.11, 5.1.5</td><td>-</td><td colspan="2">Declared value in m²·K/W</td></tr>
<tr><td colspan="2">Direct airborne sound insulation index (only when the product is intended also for acoustical application)</td><td>5.1.3.1</td><td>-</td><td colspan="2">Declared value in db A</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.3.5</td><td>-</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1d — Harmonised clauses for floor components

<table>
<tr><td colspan="6">Construction Product(s): Floor components (FLS, FLH, FLM) as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Requirements/ Characteristic from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength (of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ 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 colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1 (Annex A), 7.1, Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
should be declared.</td></tr>
<tr><td>In case of design by testing:
Loadbearing capacity</td><td>5.1.1 (Annex B), 7.1, Annex B</td><td>-</td><td>Declared value in kNm or kN/m²</td></tr>
<tr><td colspan="2">Loadbearing capacity (in case of verification by testing)</td><td>5.1.1, 7.1, B.2, B.3.1, B.3.2.1, B.4.1, B.4.4</td><td>-</td><td colspan="2">Declared value in kNm or kN/m²</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2, 5.4</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Durability against:
freeze-thaw (only for exposed applications)</td><td>5.6.4</td><td>-</td><td colspan="2">In exposure classes XF1 or XF2 to be protected unless the freeze-thaw resistance of the LAC has been verified by tests.</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euroclasses</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>RE, REI</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Thermal resistance (only when the product is intended also for thermal applications)</td><td>4.2.11, 5.1.5</td><td>-</td><td colspan="2">Declared value in m²·K/W or λ_{10dry} in W/mK based on thermal resistance</td></tr>
<tr><td colspan="2">Direct airborne sound insulation index impact noise transmission index (only when the product is intended also for acoustical application)</td><td>5.1.3.1
5.1.3.2</td><td>-</td><td colspan="2">Declared value (either by testing or by calculation)</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.3.5</td><td>-</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1e — Harmonised clauses for linear components

<table>
<tr><td colspan="6">Construction Product(s): Linear components (BLS, PLS) as covered in the scope of this European Standard
Intended use(s): Structural</td></tr>
<tr><td colspan="2">Requirements/
Characteristic
from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength
(of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ 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 colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1
(Annex A),
7.1, Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
should be declared.</td></tr>
<tr><td>In case of design by testing:
Loadbearing capacity</td><td>5.1.1
(Annex B),
7.1, Annex B</td><td>-</td><td>Declared value in kNm or kN/m (beams) or kN (piers)</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2, 5.4 or 5.5</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euroclasses</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>R</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
</table>

Table ZA.1f — Harmonised clauses for non-loadbearing wall components

<table>
<tr><td colspan="6">Construction Product(s): Non-loadbearing wall components (WNS, WNH, WNM) as covered in the scope of this European Standard
Intended use(s): Non-structural</td></tr>
<tr><td colspan="2">Requirements/
characteristic
from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength
(of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">In case of horizontal and impact loads:
declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ or density class</td></tr>
<tr><td colspan="2">Ultimate tensile strength and yield strength (of steel)</td><td>4.3</td><td>-</td><td colspan="2">In case of horizontal and impact loads:
declared values in MPa</td></tr>
<tr><td colspan="2">Water vapour permeability (for external walls)</td><td>4.2.12</td><td>-</td><td colspan="2">Declared factor or value in g·m/(MN·s)</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1 (Annex A), 7.1 and in case of horizontal and impact loads 7.1, Annex A</td><td>-</td><td>In case of horizontal and impact loads: declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
<u>should be declared.</u></td></tr>
<tr><td>In case of design by testing:
Loadbearing capacity</td><td>5.1.1 (Annex B), 7.1 and in case of horizontal and impact loads 7.1, Annex B</td><td>-</td><td>In case of horizontal and impact loads: declared value in kN/m or kN/m²</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2, 5.5</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euro-classes</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>E, EI, EI-M</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Thermal resistance (only when the product is intended also for thermal applications)</td><td>4.2.11, 5.1.5</td><td>-</td><td colspan="2">Declared value in m²·K/W or λ_{10dry} in W/mK based on thermal resistance</td></tr>
<tr><td colspan="2">Direct airborne sound insulation index (only when the product is intended also for acoustical application)</td><td>5.1.3.1</td><td>-</td><td colspan="2">Declared value in db A</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.3.5</td><td>-</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1g — Harmonised clauses for cladding components

<table>
<tr><td colspan="6">Construction Product(s): Cladding components (CNS) as covered in the scope of this European Standard
Intended use(s): Non-structural</td></tr>
<tr><td colspan="2">Requirements/
Characteristic
from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength (of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">In case of horizontal and impact loads:
declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ or density class</td></tr>
<tr><td colspan="2">Ultimate tensile strength and yield strength (of steel)</td><td>4.3</td><td>-</td><td colspan="2">In case of horizontal and impact loads:
declared values in MPa</td></tr>
<tr><td colspan="2">Water vapour permeability (for external walls)</td><td>4.2.12</td><td>-</td><td colspan="2">Declared factor or value in g·m/(MN·s)</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant (in case of design by calculation)</td><td>5.1.1 (Annex A), 7.1, and in case of horizontal loads Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
should be declared.</td></tr>
<tr><td>Loadbearing capacity (in case of design by testing)</td><td>5.1.1 (Annex B), 7.1, Annex B</td><td>-</td><td>Bending capacity only</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Durability against:
freeze-thaw (only for exposed applications)</td><td>5.6.4</td><td>-</td><td colspan="2">In exposure classes XF1 or XF2 to be protected unless the freeze-thaw resistance of the LAC has been verified by tests.</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Reaction to fire (only for exposed applications)</td><td>5.1.4.1</td><td>Euroclasses</td><td colspan="2">Euroclass A1</td></tr>
<tr><td colspan="2">Resistance to fire (in the end use conditions)</td><td>5.1.4.2</td><td>E, EI, EI-M</td><td colspan="2">-</td></tr>
<tr><td colspan="2">Thermal resistance (only when the product is intended also for thermal applications)</td><td>4.2.11, 5.1.5</td><td>-</td><td colspan="2">Declared value in m²·K/W or λ_{10dry} in W/mK based on thermal resistance</td></tr>
<tr><td colspan="2">Direct airborne sound insulation index (only when the product is intended also for acoustical applications)</td><td>5.1.3.1</td><td>-</td><td colspan="2">Declared value in db A</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant clauses in ZA.1 and ZA.3</td></tr>
<tr><td colspan="2">Rigidity of joints</td><td>5.3.5</td><td>-</td><td colspan="2">Declared value</td></tr>
</table>

Table ZA.1h — Harmonised clauses for small box culvert components

<table>
<tr><td colspan="6">Construction Product(s): Box culvert components (BNH) as covered in the scope of this European Standard
Intended use(s): Non-structural</td></tr>
<tr><td colspan="2">Requirements/
characteristic
from the mandate</td><td>Relevant clause(s) in this European Standard</td><td>Mandated level(s) and/or class(es)</td><td colspan="2">Notes, units</td></tr>
<tr><td colspan="2">Compressive strength
(of concrete)</td><td>4.2.3</td><td>-</td><td colspan="2">Declared value in MPa or declared strength class</td></tr>
<tr><td colspan="2">Density</td><td>4.2.1</td><td>-</td><td colspan="2">Declared value in kg/m³ 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 colspan="2">Declared values in MPa</td></tr>
<tr><td rowspan="2">Mechanical resistance</td><td>In case of design by calculation:
Mechanical strength, expressed in terms of: flexural, tensile, compressive, shear, torsional or punching shear strength as relevant</td><td>5.1.1 (Annex A), 7.1, and Annex A</td><td>-</td><td>Declared value</td><td rowspan="2">Method of design
Design by calculation (Annex A)
or
Design by testing (Annex B)
should be declared.</td></tr>
<tr><td>In case of design by testing:
Loadbearing capacity</td><td>5.1.1 (Annex B), 7.1, and Annex B</td><td>-</td><td>Declared value</td></tr>
<tr><td colspan="2">Detailing</td><td>5.3.1, 5.3.2</td><td>-</td><td colspan="2">Significant production drawings if required</td></tr>
<tr><td colspan="2">Drying shrinkage (in end use conditions)</td><td>4.2.9</td><td>-</td><td colspan="2">0,75 mm/m
or declared value from testing, in mm/m</td></tr>
<tr><td colspan="2">Durability against:
freeze-thaw (only for exposed applications)</td><td>5.6.4</td><td>-</td><td colspan="2">In exposure classes XF1 or XF2 to be protected unless the freeze-thaw resistance of the LAC has been verified by tests.</td></tr>
<tr><td colspan="2">Durability against:
corrosion</td><td>5.6.3</td><td>-</td><td colspan="2">Coating of reinforcement bars or embedding in concrete with closed structure</td></tr>
<tr><td colspan="2">Release of dangerous substances</td><td>4.1.2</td><td>-</td><td colspan="2">See relevant paragraphs in ZA.1 and ZA.3</td></tr>
</table>

The requirement on a certain characteristic is not of application in those Member States where there are no regulations for such characteristic. In this case, manufactures willing to place their products in the market of these Member States are not obliged to determine nor to declare the performance of their products with regard to this characteristic and the option "no performance determined" (NPD) in the information accompanying the CE mark (see ZA.3) can be used.

The NPD option can not be used where the characteristic is subject to a threshold level.

ZA.2 Procedures for the attestation of conformity of products

ZA.2.1 Systems of attestation of conformity

The system of attestation of conformity for the 17 types of prefabricated reinforced components of lightweight aggregate concrete with open structure indicated in Table ZA.1a up to Table ZA.1h is shown in Table ZA.2a for the indicated intended use(s), in accordance with the Commission Decisions of 14 June 1995 (95/204/EC) and of 25 January 1999 (1999/94/EC) published in the Official Journal of the European Communities and given in Annex 3 of the mandate for the product family "Precast normal/ lightweight/autoclaved aerated concrete products".

Table ZA.2a — Systems of attestation of conformity

Product(s)	Intended use(s)	Level(s) or class(es)	Attestation of conformity system(s)
Prefabricated components of lightweight aggregate concrete with open structure and with structural or non-structural reinforcement	For structural use	-	2+
	For non-structural or light structural use ([1])	-	4

System 2+: See Directive 89/106/EEC, Annex III.2(ii), first possibility, including certification of the factory production control by an approved body on the basis of initial inspection of factory and of factory production control as well as of continuous surveillance, assessment and approval of factory production control.

System 4: See Directive 89/106/EEC, Annex III.2(ii), third possibility.

([1]) Light structural use refers to applications that in case of failure are not supposed to cause the collapse of the works or part of them, inadmissible deformations or injury to people (to be defined by Member States).

The attestation of conformity of the structural components in Table ZA.1a up to Table ZA.1e should be based on the evaluation of conformity procedure indicated in Table ZA.2b and Table ZA.2c resulting from application of the clauses of this European Standard indicated therein.

Table ZA.2b — Assignation of evaluation of conformity tasks (for structural components) under system 2+ [a]

Tasks			Content of the task	Evaluation of conformity clauses to apply
Tasks under the responsibility of the manufacturer	Factory production control (FPC)		Parameters related to all characteristics of relevant Table ZA.1	6.3 and 6.6
	Initial type-testing by a notified test lab		Reaction to fire	6.2
	Initial type-testing by the manufacturer		All relevant characteristics in relevant Table ZA.1 (except reaction to fire)	6.2
	Testing of samples taken at the factory		All relevant characteristics of relevant Table ZA.1	6.3 and 6.6
	Certification of FPC by the FPC certification body on the basis of	Initial inspection of factory and of FPC	Parameters related to all relevant characteristics of relevant Table ZA.1	6.3 and 6.4
		Continuous surveillance, assessment and approval of FPC	Parameters related to all relevant characteristics of relevant table ZA.1	6.3 and 6.5

[a] Applies to wall components (WL), retaining wall components (WR), roof and floor components (RF), beams (BL) and piers (PL).

Table ZA.2c — Assignation of evaluation of conformity tasks (for non structural or light structural components) under System 4 [a]

Tasks		Scope of the tasks	Clauses to apply
Tasks for the manufacturer	Initial type-testing	All characteristics in relevant Table ZA.1	6.2 and 6.6
	Factory production control	Parameters related to all characteristics in relevant Table ZA.1	6.3 and 6.6

[a] Applies to cladding components (CN), partition wall components (WN), box culverts (BN) and components for sound barriers (SB).

ZA.2.2 EC Certificate and declaration of conformity

In case of products with system 2+: When compliance with the conditions of this annex is achieved, and once the notified body has drawn up the certificate mentioned below, the manufacturer or his agent established in the EEA should prepare and retain a declaration of conformity, which entitles the manufacturer to affix the CE marking. This declaration should include:

- name and address of the manufacturer or his authorised representative established in the EEA, and the place of production;
- description of the product (type, identification, use, ...) and a copy of the information accompanying the CE marking;
- provisions to which the product conforms (i.e. Annex ZA of this EN);
- particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions);
- the number of the accompanying factory production control certificate;
- name of, and position held by the person empowered to sign the declaration on behalf of the manufacturer or his authorised representative.

The declaration should be accompanied by a factory production control certificate, drawn up by the notified body, which should contain, in addition to the information above, the following:

- name and address of the notified body;
- the number of the factory production control certificate;
- conditions and period of validity of the certificate, where applicable;
- name of, and position held by, the person empowered to sign the certificate.

In case of products with system 4: When compliance with this annex is achieved, the manufacturer or his agent established in the EEA should prepare and retain a declaration of conformity (EC Declaration of conformity), which entitles the manufacturer to affix the CE marking. This declaration should include:

- name and address of the manufacturer, or his authorised representative established in the EEA, and place of production;
- description of the product (type, identification, use,...), and a copy of the information accompanying the CE marking;
- provisions to which the product conforms (i.e. Annex ZA of this EN);
- particular conditions applicable to the use of the product (e.g. provisions for use under certain conditions);

— name of, and position held by the person empowered to sign the declaration on behalf of the manufacturer or of his authorised representative.

The above mentioned declaration and certificate should be presented in the official language or languages of the member state in which the product is to be used.

ZA.3 CE marking and labelling

ZA.3.1 General

The manufacturer or his authorised representative established within the EU or EFTA is responsible for the affixing of the CE marking. The affixing should be done preferably on the component itself. When not possible it can be on the accompanying label or on the accompanying documents, e.g. delivery note.

The manufacturer has the possibility to declare the mechanical resistance of the component using one of the following Methods:

1 Declaring geometrical and material properties of the component, determined according to Clause 4 or Clause 5, sufficient to calculate the mechanical resistance (i.e. load bearing capacity and stiffness) of the component (see ZA.3.2 for Method 1).

2 Declaring the mechanical resistance (i.e. load bearing capacity in ULS and cracking and deflection in SLS) of the component as determined according to 5.1.1 (Annex A or Annex B) with possibly reference to the relevant national application documents defining the Nationally Determined Parameters (see ZA.3.3 for Method 2).

3 a) Declaration of compliance with a given production documents of the component, together with the information on the purchaser and party responsible for the design (see ZA.3.4 for Method 3a).

3 b) Declaration of compliance with a given design specification made by the manufacturer where declaring adequate mechanical resistance against all the loads affecting to the component in a specific part of works. Reference is made to the structural design documents of the component produced (and held) by the manufacturer which are designed based on information (e.g. actions and deflection limits) from a specific part of works according to 5.1.1 (Annex A) taking into account Nationally Determined Parameters given in the national application document of the country of use (see ZA.3.5 for Method 3b).

The CE conformity symbol to affix should be in accordance with Directive 93/68/EEC and should be accompanied by the following information (see examples Figures ZA.1, ZA.2, ZA.3 and ZA.4):

— identification number of the notified body (only for products under system 2+);

— name or identifying mark of the producer;

— registered address of the producer;

— the last two digits of the year in which the marking is affixed;

— number of the certificate of factory production control (only for products under system 2+);

— reference to this European Standard with the date of version

— description of the product: generic name, material, dimensions,…and intended use;

— information on the mandated characteristics or,

— when relevant data and parameters required to determine the mechanical strength and resistance to fire of the product according to the national design codes and provisions in the place of use/destination or

— identification of the party responsible for the design (manufacturer or another party) and of the design calculations and significant production drawings;

- values and, where relevant, level or class to declare for each mandated characteristic as indicated in the relevant clauses in this European Standard in Table ZA.1a up to Table ZA.1h;
- as an alternative, where possible, standard designation can be given. This designation should give information on all the characteristics, if all are not covered, then values for those not covered should be additionally given.
- "No performance determined" for characteristics where this is relevant.

The "No performance determined" (NPD) option can not be used where the characteristic is subject to a threshold level. Otherwise, the NPD option can be used when and where the characteristic, for a given intended use, is not subject to regulatory requirements in the member state of destination.

ZA.3.2 Declaration of geometrical data and material properties

According to this method ,all data that are needed on the component, according to the design method in the country of use to determine the mechanical strength (i.e. load bearing capacity and deflection) of the component, shall be declared. The following information shall be provided in the CE-marking:

- compressive strength of LAC;
- density of LAC;
- ultimate yield strength of reinforcement steel (if relevant);
- geometrical data (critical dimensions and tolerances + amount and location of reinforcement);
- minimum support length;
- environmental classes intended;
- thermal properties (if relevant);
- acoustical properties (if relevant);
- reaction to fire (if relevant);
- resistance to fire (if relevant);
- drying shrinkage (if relevant).
- rigidity of joints (if needed in design);
- conditions for durability: information on corrosion protection of the reinforcement and on the national freeze-thaw resistance test method used (if relevant)

Figure ZA.1 gives an example of CE marking with method 1.

In addition the following information are needed:

For ultimate limit state:

- shear force of welded joints of reinforcement (if needed in design)
- flexural strength (if needed in design)

For serviceability limit state:

- modulus of elasticity
- creep (if needed in design)

NOTE The method 1 can be applied for products off the shelf and catalogue products.

CE	CE conformity marking consisting of the CE symbol given in directive 93/68/EEC
0123-CPD-001	Identification of the notified body
AnyCo Ltd, PO Box 21, B-1050	Name or identifying mark and registered address of the producer
11	Last two digits of the year in which the marking was affixed
0123-CPD-00456	Number of the FPC certificate
EN 1520:2011	Number ant title of European Standard concerned with version date
Prefabricated components of lightweight aggregate concrete with open structure with structural and non-structural reinforcement	Generic name and intended use
Loadbearing wall component (WLS) LAC: Strength class: LAC 10 Density class: 1400 Reinforcement steel mesh: Tensile yield strength: 500 MPa Longitudinal and horizontal reinforcement mesh: A_s .... 50 mm²/m ϕ_s .... 4 mm *a* (axis distance) 250 mm The reinforcement is situated in the middle third of the cross section The component can be used in environmental class: X0, XC1, XC3 The component should be fully supported on its base Dimensions and tolerances (mm): Thickness: 100 ± 5 Height: 2400 ± 8 Length: 4800 ± 8 For detailing, thermal, acoustical, fire behaviour etc see Technical Information: Product Catalogue ABC.2003 – clause ii	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer) NOTE Numerical values are only as example.

Figure ZA.1 — Example of CE marking with Method 1

ZA.3.3 Declaration of product properties

According to this method 2 the declaration shall cover among others the characteristic mechanical resistance (i.e. load bearing capacity, cracking and deflection) of the component designed according to 5.1.1 (Annex A or Annex B) using Nationally Determined Parameters or sets of Nationally Determined Parameters if recommended values are not applicable.

This method 2 determines properties relating to essential requirements "mechanical resistance and stability" and "resistance to fire".

The following information should be provided in the CE-marking:

- compressive strength of LAC;
- density;
- ultimate yield strength of reinforcement steel (if relevant);
- mechanical resistance of the component: Design according to Annex A or Annex B, partial safety factors for LAC and steel used in the calculation and other Nationally Determined Parameters (NDP) used in design;
- serviceability aspects (cracking and deflection in SLS);
- geometrical data (critical dimensions and tolerances/tolerance class + amount and location of reinforcement)
- minimum support length (if relevant);
- environmental classes intended;
- thermal properties (if relevant);
- acoustical properties (if relevant);
- reaction to fire (if relevant);
- resistance to fire (if relevant);
- rigidity of joints (if needed in design);
- drying shrinkage (if relevant);
- conditions for durability: information on corrosion protection of the reinforcement and on the national freeze-thaw resistance test method used (if relevant).

Figure ZA.2 shows an example of CE marking with method 2. It gives a model CE marking inclusive of the information needed to determine, according to design regulation valid in the place of use, the properties related to mechanical resistance and stability, including aspects of durability and serviceability.

NOTE The method 2 is used for the declaration of product properties determined following this European Standard and Eurocodes.

CE	CE conformity marking consisting of the CE symbol given in directive 93/68/EEC
0123-CPD-001	Identification of the notified body
AnyCo Ltd, PO Box 21, B-1050	Name or identifying mark and registered address of the producer
11	Last two digits of the year in which the marking was affixed
0123-CPD-00456	Number of the FPC certificate
EN 1520:2011	Number and title of European Standard concerned with the version date
Prefabricated components of lightweight aggregate concrete with open structure with structural and non-structural reinforcement	Generic name and intended use
Loadbearing wall component (WLS) LAC: Strength class: LAC 10 Density class: .... 1400 Reinforcement steel mesh: Tensile yield strength: ....500 MPa Mechanical resistance (design values): Design according to Annex A: Loadbearing capacity with e_{tot} = yy mm: xx kN/m Material safety factors applied in calculation of mechanical resistance: For LAC .... γ_C = 1,40 For reinforcement steel .... γ_S = 1,15 Resistance to fire REI: .... 60 min Reaction to fire................................Euroclass A1 Thermal resistance ....vvv m²K/W Drying shrinkage (in end use conditions)...................... 0,75 mm/m For geometrical data, detailing, durability, acoustic insulation parameters and other NDPs see the Technical documentation Technical documentation: Position Number .... nnnnnn	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer) NOTE Numerical values are only as example.

Figure ZA.2 ─ Example of CE marking with Method 2

ZA.3.4 Declaration of compliance with given design specification

According to this method, the declaration shall encompass the situation where the component is ordered by another party than the manufacturer. Requirements to the manufacturing of the component are identified in the production documents of the component which are based on information from the design of the component. The structural design and production documents of the component are prepared by the purchaser or by the manufacturer in cooperation with the purchaser.

The following information shall be provided in the CE-marking:

- identification of the production document and the purchaser;
- identification of party responsible on structural design;
- compressive strength of LAC;
- density of LAC
- ultimate yield strength of reinforcement steel (if relevant);
- minimum support length (if relevant);
- environmental classes intended;
- thermal properties (if relevant);
- acoustical properties (if relevant);
- reaction to fire (if relevant);
- resistance to fire (if relevant);
- rigidity of joints (if needed in design);
- drying shrinkage (if relevant);
- conditions for durability: information on corrosion protection of the reinforcement and on the national freeze-thaw resistance test method used (if relevant).

NOTE This method of declaration complies with Method 3a in Guidance Paper L.

Figure ZA.3 shows an example of CE marking with method 3a.

CE	CE conformity marking consisting of the CE symbol given in the directive 93/68/EEC
0123-CPD-001	Identification of the notified body
AnyCo Ltd, PO Box 21, B-1050	Name or identifying mark and registered address of the producer
11	Last two digits of the year in which the marking was affixed
0123-CPD-00456	Number of the FPC certificate
EN 1520:2011	Number and title of European Standard concerned with dated version
Prefabricated components of lightweight aggregate concrete with open structure with structural and non-structural reinforcement	Generic name and intended use
Loadbearing wall component (WLS) Production drawing: 146-65/2010-11-20 Purchaser: Building Company Ltd. Designer: Building Design Company Ltd. LAC: Strength class: LAC 10 Density class: 1400 Reinforcement steel: Tensile yield strength: 500 MPa Resistance to fire .... REI 60 Reaction to fire.. A1 For rigidity of joints, thermal and acoustic behaviour, drying shrinkage and durability see the design specifications. Design Specification: Order Code xxxxxx	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer) NOTE Numerical values are only as example.

Figure ZA.3 ─ Example of CE marking with Method 3a

ZA.3.5 Declaration of compliance with a given design specification covered by the CE-marking

According to this method the declaration shall encompass the mechanical resistance of the component essential for its use based on the purchasers order referring to one or more specified load situations in a specific part of works. The manufacturer shall verify by structural design calculations according to 5.1.1 (Annex A) taking into account Nationally Determined Parameters given in the national application document of the country of use that the component is able to resist all the loads affecting to it in ULS and that the given deflection limits are satisfied in SLS.

The following information shall be provided in the CE-marking:

— identification of the construction works where the component is intended to be used with its position number;

— reference to the structural design documents produced (and held) by the manufacturer with possibly reference to the relevant national application documents defining the Nationally Determined Parameters;

— compressive strength of LAC;

— density of LAC;

— ultimate yield strength of reinforcing steel (if relevant);

— minimum support length (if relevant);

— environmental classes intended;

— thermal properties (if relevant);

— acoustical properties (if relevant);

— reaction to fire (if relevant);

— resistance to fire (if relevant);

— rigidity of joints (if needed in design);

— drying shrinkage (if relevant);

— conditions for durability: information on corrosion protection of the reinforcement and on the national freeze-thaw resistance test method used (if relevant).

NOTE This method of declaration complies with Method 3b in Guidance Paper L.

Figure ZA.4 gives an example of CE marking with method 3b.

CE	CE conformity marking consisting of the CE symbol given in the directive 93/68/EEC
0123-CPD-001	Identification of the notified body
AnyCo Ltd, PO Box 21, B-1050	Name or identifying mark and registered address of the producer
11	Last two digits of the year in which the marking was affixed
0123-CPD-00456	Number of the FPC certificate
EN 1520:2011	Number and title of European Standard concerned with dated version
Prefabricated components of lightweight aggregate concrete with open structure with structural or non-structural reinforcement	Generic name and intended use
Loadbearing wall component (WLS) To be used in a building: - Union street 15 , 001234 Helsinki - Position number 568-G5 Mechanical resistance: - Design document 1234/2010-11-12 LAC: Strength class: LAC 10 Density class: 1,4 Reinforcement steel: Tensile yield strength: 500 MPa Resistance to fire .... REI 60 Reaction to fire.. A1 For rigidity of joints, thermal and acoustic behaviour, drying shrinkage and durability see the design specifications. Design Specification: Order Code xxxxxx	Information on product mandated characteristics including detailing (to be adapted to the specific product by the manufacturer) NOTE Numerical values are only as example.

Figure ZA.4 — Example of CE marking with Method 3b

ZA.3.6 Simplified label

The simplified label can be used in method 1, 2 and 3, provided the detailed information is made available on request.

In the case of simplified label the following information should be added to the CE marking symbol:

— name of identifying mark and registered address of the producer;

— identification number of the unit (to ensure traceability);

— the last two digits of the year in which the marking is affixed;

— number of the EC factory production control certificate;

— reference to this European Standard.

The same identification number should mark, in the accompanying documents, the information related to the unit.

Figure ZA.5 gives a model for the simplified label for CE marking. Other information required by ZA.3.1 shall be given with the accompanying documents

CE	CE conformity marking consisting of the CE symbol given in directive 93/68/EEC
AnyCo Ltd, PO Bx 21, B-1050	Name or identifying mark and registered address of the producer
WLS 123	Identification number of the unit.
11	Last two digits of the year in which the marking is affixed
0123-CPD-0456	Number of the FPC certificate OR
EN 1520:2011	Number of this European Standard with version date

Figure ZA.5 — Example of simplified label

For small elements or for product stamping reasons, the size can be reduced by removing reference to EN and/or to FPC certificate.

In addition to any specific information relating to dangerous substances shown above, the product should also be accompanied, when and where required and in the appropriate form, by documentation listing any other legislation on dangerous substances for which compliance is claimed, together with any information required by that legislation.

NOTE 1 European legislation without national derogations need not be mentioned.

NOTE 2 Affixing the CE marking symbol means, if a product is subject to more than one directive, that it complies with all applicable directives.

Bibliography

EN 1990, *Eurocode — Basis of structural design*

EN 1991-1 (all parts), *Eurocode 1 — Actions on structures*

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

CEN/TR 15728, *Design and Use of Inserts for Lifting and Handling of Precast Concrete — Elements*

Guidance Paper L, *Application and use of Eurocodes*

EN 14388, *Road traffic noise reducing devices — Specifications*

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

...making excellence a habit.™