



BSI Standards Publication

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

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 It supersedes BS EN 1520:2002 which is withdrawn.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.

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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.

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Contents

	Page
Foreword.....	7
1 Scope	10
2 Normative references	10
3 Terms, definitions, symbols and abbreviations	13
3.1 Terms and definitions	13
3.2 Symbols	13
3.2.1 General symbols	13
3.2.2 Subscripts	14
3.2.3 Symbols used in this European Standard	14
3.3 Abbreviations	19
3.4 Units	19
4 Properties and requirements of materials	20
4.1 Constituents	20
4.1.1 General.....	20
4.1.2 Release of dangerous substances.....	20
4.2 Lightweight aggregate concrete parameters	20
4.2.1 Dry density	20
4.2.2 Characteristic strength values	21
4.2.3 Compressive strength	21
4.2.4 Flexural strength and uniaxial tensile strength.....	23
4.2.5 Stress-strain diagram	23
4.2.6 Modulus of elasticity	24
4.2.7 Poisson's ratio	24
4.2.8 Coefficient of thermal expansion	24
4.2.9 Drying shrinkage.....	24
4.2.10 Creep	25
4.2.11 Thermal conductivity.....	25
4.2.12 Water vapour permeability.....	27
4.2.13 Water tightness	27
4.3 Reinforcement steel	27
5 Properties and requirements of components.....	28
5.1 General.....	28
5.1.1 Mechanical resistance.....	28
5.1.2 Deflections.....	28
5.1.3 Acoustic properties	28
5.1.4 Reaction to fire and resistance to fire	29
5.1.5 Design thermal resistance and design thermal conductivity	29
5.2 Types of components.....	30
5.2.1 General.....	30
5.2.2 Roof and floor components.....	31
5.2.3 Wall components	31
5.2.4 Beams and piers	31
5.2.5 Other prefabricated components	31
5.3 Detailing, technical requirements, and declared properties	31
5.3.1 Detailing.....	31
5.3.2 Dimensions and tolerances	31
5.3.3 Mass of the components.....	32
5.3.4 Deflections.....	32
5.3.5 Strength of joints	32
5.3.6 Minimum requirements	32
5.3.7 Reinforcement detailing.....	32
5.4 Additional requirements for roof and floor components and beams.....	33
5.4.1 Minimum dimensions	33

5.4.2	Minimum requirements for structural reinforcement	33
5.4.3	Support length	34
5.5	Additional requirements for wall components	35
5.5.1	General.....	35
5.5.2	Walls with non-structural reinforcement.....	35
5.5.3	Walls with structural reinforcement	35
5.6	Durability	36
5.6.1	General.....	36
5.6.2	Minimum cover with regard to bond.....	37
5.6.3	Exposure classes related to environmental conditions	37
5.6.4	Corrosion protection of reinforcement	38
5.6.5	Freeze-thaw resistance	40
6	Evaluation of conformity.....	40
6.1	Introduction	40
6.2	Initial type-testing of the component.....	41
6.2.1	General.....	41
6.2.2	Sharing of results from ITT.....	41
6.3	Factory production control.....	42
6.3.1	General.....	42
6.3.2	Process control.....	42
6.3.3	Finished products.....	42
6.4	Initial inspection of the factory and the factory production control	43
6.4.1	Information to be supplied.....	43
6.4.2	Inspection.....	43
6.4.3	Reports	43
6.5	Surveillance, assessment and approval of the factory production control	43
6.5.1	Inspection tasks.....	43
6.5.2	Frequency of inspections	43
6.5.3	Reports	44
6.6	Actions to be taken in the event of non-conformity	44
7	Basis for design	50
7.1	Design methods	50
7.2	Limit states	50
7.3	Actions.....	50
8	Marking, labelling and designation.....	51
8.1	Standard designation	51
8.2	Additional information on accompanying documents	52
Annex A	(normative) Design of components by calculation.....	53
Annex B	(informative) Design of components by testing	81
Annex C	(informative) Recommended values for partial safety factor.....	87
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	88
Bibliography		109

Figures

Figure 1 — Determination of dry thermal conductivity $\lambda_{10\text{dry}}$	26
Figure 2 — Examples of multilayer slab, hollow core slab and solid slab (With respect to transverse reinforcement, see 5.4.2.1).....	34
Figure 3 — Support length a_0	35
Figure 4 — Basic design of hollow core wall components	36
Figure A.1 — Bi-linear stress-strain diagram for LAC in compression for cross-sectional design	55
Figure A.2 — Design stress-strain diagram for reinforcement steel.....	56
Figure A.3 — Possible strain diagrams in the ultimate limit state	56
Figure A.4 — Limits of slenderness ratio S of loadbearing walls and piers	62
Figure A.5 — Design loads for cellar walls	67
Figure A.6 — Additional horizontal force H_{fd} due to inclination of the components and effects of second order theory	72
Figure A.7 — Tensile splitting forces in wall components with oversail s	73
Figure A.8 — Tensile splitting forces at the top of a hollow core wall component.	74
Figure A.9 — Tensile splitting force T due to centric loading	75
Figure A.10 — Anchorage of smooth reinforcing bars	79
Figure A.11 — Anchorage of ribbed reinforcing bars	79
Figure B.1 — Definition of shear span l_s	83
Figure B.2 — Simplified N/M interaction diagram of the cross-section, representing results of three test series	86
Figure ZA 1 — Example of CE marking with Method 1	101
Figure ZA 2 — Example of CE marking with Method 2.....	103
Figure ZA.3 — Example of CE marking with Method 3a.....	105
Figure ZA.4 — Example of CE marking with Method 3b.....	107
Figure ZA.5 — Example of simplified label.....	108

Tables

Table 1 — Tolerances on declared mean dry density of LAC	20
Table 2 — Density classes of LAC	21
Table 3 — Determination of the characteristic strength f_k and required minimum strength $f_{\min}$	21
Table 4 — Statistical coefficient K_n for determination of characteristic strength.....	22
Table 5 — Reduction factors for compressive strength of cores with indicated diameter and equal length of cubes	22

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)	22
Table 7 — Strength classes and strength requirements for LAC	23
Table 8 — Dry thermal conductivity λ_{10dry} of LAC for 50 % and 90 % of production, with a confidence level $\gamma = 90$ % (compiled according to EN 1745)	27
Table 9 — Basic values for moisture content and moisture conversion coefficient of LAC (compiled according to EN ISO 10456)	29
Table 10 — Types of components	30
Table 11 — Maximum permissible deviation from squareness in the plane of components	32
Table 12 — Minimum percentage of reinforcement R	33
Table 13 — Description of permissible exposure classes with respect to risk of reinforcement corrosion	37
Table 14 — Embedding in a zone of normal concrete or LC-concrete with closed structure - Minimum concrete cover in mm	38
Table 15 — Minimum concrete cover in mm for hot dip galvanized reinforcement steel	39
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	40
Table 17 — Initial type-testing of the LAC components	45
Table 18 — Factory production control, testing of the finished product LAC components for structural uses	46
Table 19 — Factory production control, testing of the finished product, LAC components for non-loadbearing uses	48
Table A.1 — Minimum percentages of shear reinforcement $\rho_{w,min}$ for reinforcement steel with $f_{yk} = 500$ MPa	60
Table A.2 — Coefficient β for the determination of the buckling length l_0 at different boundary conditions (used in Equation (A. 25), $l_0 = \beta \cdot l_w$)	64
Table A.3 — Required dimensions of beams without verification of loadbearing capacity	71
Table A.3 — Limits of reinforcement in roof and floor components for design by calculation (plain steel, with characteristic yield strength $f_{yk} \leq 220$ MPa)	78
Table C.1 — Partial safety factors γ_M for material properties	87
Table C.2 — Partial safety factors γ_{comp} for components	87
Table ZA.1a — Harmonised clauses for loadbearing wall components	89
Table ZA.1b — Harmonised clauses for retaining wall components	90
Table ZA.1c — Harmonised clauses for roof components	91
Table ZA.1d — Harmonised clauses for floor components	92
Table ZA.1e — Harmonised clauses for linear components	93
Table ZA.1f — Harmonised clauses for non-loadbearing wall components	94
Table ZA.1g — Harmonised clauses for cladding components	95

Table ZA.1h — Harmonised clauses for small box culvert components 96

Table ZA.2a — Systems of attestation of conformity 97

Table ZA.2b — Assignment of evaluation of conformity tasks (for structural components) under system 2+ 97

Table ZA.2c — Assignment of evaluation of conformity tasks (for non structural or light structural components) under System 4.....98

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 $2\,000\text{ kg/m}^3$ ($2,00\text{ Mg/m}^3$) or a loose bulk density not exceeding $1\,200\text{ kg/m}^3$ ($1,20\text{ Mg/m}^3$)

3.1.2

lightweight aggregate concrete

LAC

concrete with an open structure having an oven-dry density of not more than $2\,000\text{ kg/m}^3$ 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
$f_{t,fd}$	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
$\alpha_2, \alpha_6, \alpha_7$	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
$\lambda_{10\text{dry}}$	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/m²);
- density: kg/m³;
- unit weight: kN/m³;
- stresses and strengths, modulus of elasticity: MPa (= N/mm² or MN/m²);
- 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/m³.

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	$0,8 f_{m,n}$	$f_{m,n} - K_n \times s_n$	
Required minimum strength f_{min}	$\geq 0,90 f_k$	$\geq 0,75 f_k$	$\geq 0,67 f_k$

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 $n < 6$	$\geq 1,5$	$\geq 3,5$	$\geq 5,5$	$\geq 7,0$	$\geq 9,0$	≥ 11	≥ 14	≥ 19	≥ 24
f_{cmin}^c for $6 \leq n \leq 9$	$\geq 1,5$	$\geq 3,0$	$\geq 4,5$	$\geq 6,0$	$\geq 7,5$	$\geq 9,0$	≥ 12	≥ 17	≥ 22
f_{cmin}^c for $n \geq 10$	$\geq 1,5$	$\geq 3,0$	$\geq 4,0$	$\geq 5,5$	$\geq 7,0$	$\geq 8,0$	≥ 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:

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

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

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

and the uniaxial tensile strength may be estimated as follows:

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

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:

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

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);

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

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

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 $8 \times 10^{-6} \text{ K}^{-1}$.

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 $(45 \pm 5) \%$. 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 $(20 \pm 2) ^\circ\text{C}$.
- 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 $(20 \pm 2) ^\circ\text{C}$ and $(60 \pm 5) \%$ or $(45 \pm 5) \%$ 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 $\phi_{\text{LAC}}(\infty, t_0) = 2,0$. 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 $\lambda_{10\text{dry}}$ 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. $\lambda_{10\text{dry}}(50\%)$ or $\lambda_{10\text{dry}}(90\%)$).

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 %.

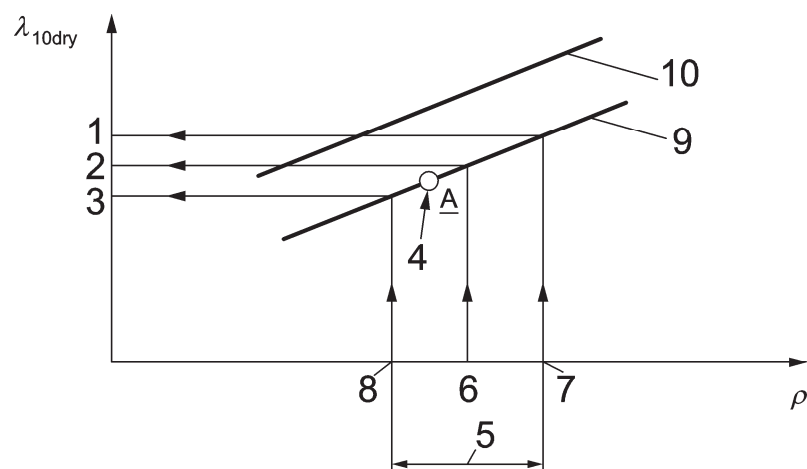
Other test conditions (e.g. oven-dry state) may be used if the correlation between the reference test conditions and the alternative test conditions can be given.

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 $\lambda_{10\text{dry}}$ (W/mK) and dry density ρ (kg/m³) is plotted using the tabulated values given in 4.3.11.7. The mean measured $\lambda_{10\text{dry}}$ 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 $\gamma = 90\%$ 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 $\lambda_{10\text{dry}}$ of LAC for 50 % and 90 % of production, with a confidence level $\gamma = 90$ % (compiled according to EN 1745)

Mean dry density ^a kg/m ³	Thermal conductivity $\lambda_{10\text{dry}}$ 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 $\lambda_{10\text{dry}}(50\%)$.		
^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/m ³	Moisture content μ_m (mass by mass) at		Moisture conversion coefficient f_u
	23 °C / 50 % RH	23 °C / 80 % RH	
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 in the LAC to be expected in end use conditions and the moisture conversion coefficient f_u (see Table 9).

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

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;

$\lambda_{10\text{dry}}$ 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 $\lambda_{10\text{dry}}$ (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)	WLS
Loadbearing wall component (hollow core)	WLH
Loadbearing wall component (multilayer)	WLM
Non-loadbearing wall component (solid)	WNS
Non-loadbearing wall component (hollow core)	WNH
Non-loadbearing wall component (multilayer)	WNM
Retaining wall components (solid)	WRS
Roof component (solid)	RLS
Roof component (hollow core)	RLH
Roof component (multilayer)	RLM
Floor component (solid)	FLS
Floor component (hollow core)	FLH
Floor component (multilayer)	FLM
Beam (solid)	BLS
Beam (hollow-core)	BLH
Pier (solid)	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
$\leq 1,0$	3
$> 1,0$	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	$625 \text{ mm} < b \leq 1250$ mm	$1250 \text{ mm} < b$
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 $3,5 \text{ kN/m}^2$ 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.