BRITISH STANDARD

BS EN
680:2005

Determination of the drying shrinkage of autoclaved aerated concrete

The European Standard EN 680:2005 has the status of a British Standard

ICS 91.100.30

BSI
British Standards

National foreword

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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, which has the responsibility to:

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Summary of pages

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 680

December 2005

ICS 91.100.30

Supersedes EN 680:1993

English Version

Determination of the drying shrinkage of autoclaved aerated concrete

Détermination du retrait de séchage du béton cellulaire autoclavé

Bestimmung des Schwindens von dampfgehärtetem Porenbeton

This European Standard was approved by CEN on 26 October 2005.

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Foreword

This European Standard (EN 680:2005) has been prepared by Technical Committee CEN/TC 177 "Prefabricated reinforced components of autoclaved aerated concrete or light-weight aggregate concrete with open structure", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2006, and conflicting national standards shall be withdrawn at the latest by June 2006.

This document supersedes EN 680:1993.

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

1 Scope

This Euopean Standard specifies a method for measuring the relative length changes due to drying (drying shrinkage) of autoclaved aerated concrete manufactured according to EN 771-4 or prEN 12602. The shrinkage characteristics determined according to this method are the following: The conventional reference value of drying shrinkage is the relative length change between two specified moisture contents. The total value of drying shrinkage is the relative length change due to drying from the saturated state until reaching constant length under specified climatic conditions. Other drying shrinkage values may be determined between other parameters to meet other specified national requirements.

2 Normative references

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

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

EN 771-4, *Specification for masonry units — Part 4:Autoclaved aerated concrete masonry units*

prEN 12602, *Prefabricated reinforced components of autoclaved aerated concrete*

3 Principle

Prismatic test specimens are cut from products from new production. For conditioning they are saturated in water at (20 ± 2) °C for a period of at least 72 h and then stored in sealed plastic for a period of (24 ± 2) h. Subsequently they are dried in air at (20 ± 2) °C and (45 ± 5) % relative humidity (drying period under reference shrinkage storage conditions) until constant length is reached.

At the end of the conditioning period and in suitable time intervals during the drying period the length changes and the mass of the test specimens are determined.

Finally, the test specimens are dried to constant mass at (105 ± 5) °C in order to determine the dry density of the autoclaved aerated concrete and to enable the calculation of the moisture content of the test specimens at each measuring date from the difference between the mass in the actual moist state and the dry mass.

A graph relative length change versus moisture content is plotted, and from the curve the conventional reference value of drying shrinkage, $\varepsilon_{cs,ref}$, is determined as the relative length change between the two moisture contents 30 % by mass and 6 % by mass.

Where the total value of drying shrinkage is required, the relative length change of the test specimens from the end of the conditioning period until reaching constant length under reference shrinkage storage conditions at (20 ± 2)° C and (45 ± 5) % relative humidity shall also be measured.

4 Apparatus

a) saw with rotating carborundum or diamond blade or other equipment for cutting test specimens;

b) balance, capable of determining the mass of the test specimens to an accuracy of 0,1 %;

c) callipers, capable of reading the dimensions of the test specimens to an accuracy of 0,1 mm;

d) container, for immersion of the test specimens under water;

e) temperature and moisture controlled room or cabinet, capable of maintaining a temperature of (20 ± 2) °C and a relative humidity of (45 ± 5) % for storing the test specimens during the drying period and for performing the measurement of length changes (see note);

f) measuring apparatus (comparator) for measuring length changes of test specimens.

Any suitable measuring apparatus may be used provided the following requirements are met:

— Length changes shall be measured in the longitudinal axis of the test specimens.

— Positive contact shall be established with the gauge plugs attached in the centres of the end faces of the test specimens.

— Measurements shall be performed with an accuracy of $\Delta L/L \leq 10^{-5}$, where ΔL is the variation in gauge length and L is the initial length of the test specimens between the gauge plugs.

— Measuring apparatus shall have sufficient range to allow for variations in the actual length of various test specimens.

— Means shall be provided for checking the measuring apparatus at each measuring date against an invariable reference.

g) gauge plugs, to be applied on the end faces of the test specimens, made of corrosion-resistant metal and shaped in such a way that a reliable positive contact with the measuring apparatus used is ensured.

h) ventilated drying oven, capable of maintaining a temperature of (105 ± 5) °C.

NOTE The room according to e) need not necessarily be humidity-controlled. Alternatively, during the drying period, the test specimens may be stored in a closed container under the specified climatic conditions. For the reference conditions the specified relative humidity of (45 ± 5) % in the container can be obtained by means of saturated potash solution (KCO_3).

5 Test specimens

5.1 Sample

The sample for the preparation of the test specimens shall be taken in such a manner that it is representative of the production to be investigated.

In the case of prefabricated reinforced components the test specimens are prepared from the components themselves. Alternatively, they may be taken from prefabricated nonreinforced components of the same mould.

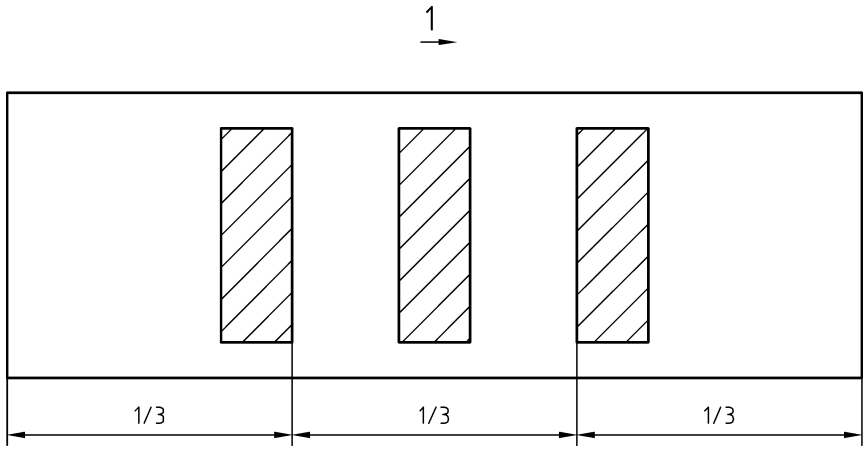
5.2 Shape and size of the test specimens

The test specimens shall be prisms with a cross-section of 40 mm × 40 mm and a length to suit the length of the measuring apparatus, but not less than 160 mm.

5.3 Number of test specimens

The test set, taken from either prefabricated reinforced components, from prefabricated nonreinforced components of the same mould or from nonreinforced masonry units, shall consist of three test specimens.

Whenever possible, one test specimen shall be prepared from the upper third, one from the middle and one from the lower third of the component or of the masonry unit in the direction of rise of the mass during manufacture (see Figure 1).



Key

1 Direction of rise

Figure 1 — Sampling scheme

5.4 Preparation of test specimens

The test specimens shall be cut by means of a rotating carborundum blade or other equipment. They shall not contain any reinforcement. All surfaces shall be plane and clean.

The longitudinal axis of the test specimens taken from a reinforced component or from an unreinforced component of the same mould shall be perpendicular to the direction of rise and preferably in the longitudinal direction of the reinforced component. The longitudinal axis of the test specimens taken from unreinforced masonry units shall be perpendicular to the direction of rise and preferably in the vertical direction of the unit corresponding to the height of the unit.

Test specimens may be prepared from samples which have previously been used for other tests, provided that they are cut at least 150 mm from an area where visible damage or changes to the normal structure and appearance have occurred.

Gauge plugs according to 4g) for measuring length changes shall be firmly attached to the centres of the end faces of the test specimens using an adhesive such that the adhesive does not influence the result.

NOTE For the determination of the moisture content of the autoclaved aerated concrete according to 7.2 it is necessary to know the mass of the gauge plugs and of their fixation (adhesive).

5.5 Measurement of dimensions of test specimens and determination of their volume

The initial dimensions of the test specimens shall be measured to an accuracy of 0,1 mm, using callipers.

Width and thickness shall be measured – between the longitudinal middle axes of opposite longitudinal surfaces – near both ends and in the middle of the length.

The length L shall be measured along the longitudinal middle axes of two opposite longitudinal surfaces.

The volume V of the test specimens shall be calculated by multiplying the mean values of thickness, width, and length measurements.

5.6 Conditioning of test specimens

After their preparation, the test specimens shall be saturated with moisture by water storage for a period of at least 72 h at (20 ± 2) °C. For this purpose they shall be stored during the first 24 h with one third of their thickness, during the second 24 h with two thirds of their thickness and during the last 24 h totally under water. Subsequently the test specimens shall be stored at this temperature in sealed plastic for 24 h to achieve even distribution of moisture.

6 Testing procedure

6.1 Drying storage in a climate at (20 ± 2) °C and (45 ± 5) % relative humidity and determination of length changes and variations of mass

In order to avoid faulty readings due to the presence of dirt, the gauge plugs shall be wiped carefully before each measurement.

The first reading of the gauge length (L_{c0}) and of the invariable reference ($L_{inv,0}$) and the first determination of the mass (m_0) of the test specimens shall be made after conditioning according to 5.6.

Subsequently, the test specimens shall be gradually dried by storing in air at (20 ± 2) °C and a relative humidity of (45 ± 5) %. During this period, they shall be placed on a grid with enough clear space around each other, enabling sufficient circulation of air around test specimens.

To enable drawing of the graph shown in Figure 2 at least five readings of the gauge length, the length of the invariable reference and accompanying weighings of the test specimens shall be executed at suitable time intervals.

When required and in addition to the conventional reference value of drying shrinkage, the total drying shrinkage can be determined by recording the length change from the beginning to the end of the reference shrinking storage conditions and when the test specimens have reached constant length at 20°C and 45 % relative humidity.

The last readings of the length change and the associated weighings shall be excecuted:

— after 21 days storage in the specified standard climate, and

— after 28 days storage in the specified standard climate.

If the relative length change between 21 days and 28 days increases by more than 0,02 mm/m, the shrinkage storage shall be continued and additional measurements and weighings shall be carried out until the increase of length change within 7 days does not exceed this value.

6.2 Drying of test specimens at (105 ± 5) °C

In order to determine the dry density and the moisture content of the autoclaved aerated concrete the test specimens shall be dried after the completion of the shrinkage test. For this purpose they shall be placed in a ventilated drying oven at (105 ± 5) °C until constant mass is attained. Immediately after removal from the drying oven, the mass of the individual test specimens shall be determined. The mass of the test specimens is considered constant if, after 24 h of further drying, it has not changed by more than 0,2 %. Subsequently, the gauge plugs shall be detached, and the mass of the individual test specimens shall again be determined.

7 Test results

7.1 Calculation of relative length change

The relative length change, ε_{csi}, in millimetres per metre, between time t_0 and time t_i is calculated as follows:

$$\varepsilon_{csi} = \frac{\Delta L_c}{L_c} \times 1\,000 = \frac{(L_{c0} - L_{ci}) - (L_{inv,0} - L_{inv,i})}{L_c} \times 1000 \quad (1)$$

where:

ΔL is the variation in gauge length according to 6.1 (first measurement of the test specimen at the end of conditioning period L_{c0}, minus measurement of the test specimen L_{ci} at time t_i, minus variation in length of the measuring, $L_{inv,0} - L_{inv,i}$ between time t_0 and time t_i), in millimetres;

L_c is the initial length of the autoclaved aerated concrete test specimen (without gauge plugs), in millimetres (mean value of the two length measurements according to 5.5);

L_{c0} is the reading of the measuring apparatus at the test specimen at date t_0 (at the end of conditioning period);

L_{ci} is the reading of the measuring apparatus at the invariable reference at date t_i;

$L_{inv,0}$ is the reading of the measuring apparatus at the invariable reference at date t_0;

$L_{inv,i}$ is the reading of the measuring apparatus at the invariable reference at date t_i;

The relative length change of each individual test specimen and the mean value at each measuring date shall be expressed to the nearest 0,01 mm/m.

7.2 Calculation of moisture content

The mass related moisture content μ_{mi}, in percent, at each measuring date t_i is calculated as follows:

$$\mu_{mi} = \frac{m_i - m_d}{m_d - m_{plug}} \times 100 \quad (2)$$

where:

m_i is the mass of the moist test specimen at the measuring date t_i, in kilograms;

m_d is the mass of the test specimen after drying at (105 ± 5) °C, in kilograms;

m_{plug} is the mass of the gauge plugs (including the adhesive), in kilograms.

The mass related moisture content of each individual test specimen and the mean value at each measuring time shall be expressed to the nearest 0,1 %.

7.3 Determination of the conventional reference value of drying shrinkage

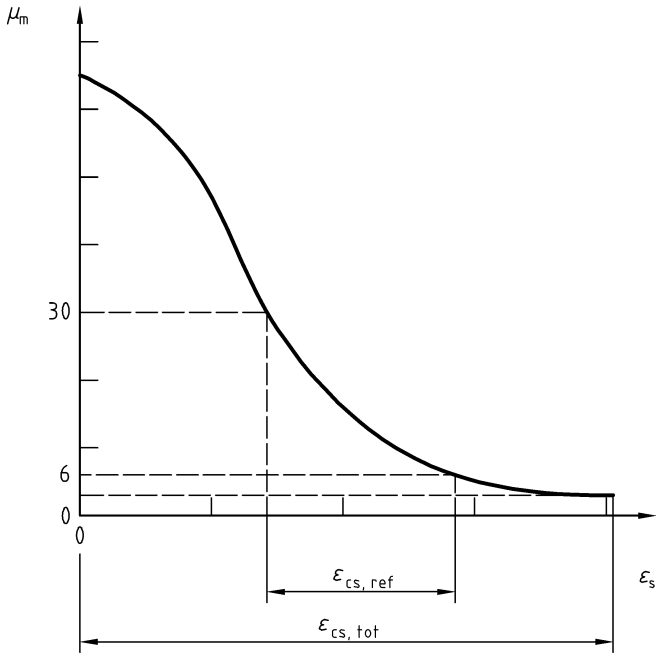
The mean values of relative length change, $\varepsilon_{cs,i}$ and moisture content, μ_{mi}, for each measuring date t_i are plotted in a graph and connected by a curve (see Figure 2).

The conventional reference value of drying shrinkage, $\varepsilon_{cs,ref,,}$ is determined from the curve as the difference of the relative length change ε_{cs} between the moisture contents μ_m = 30 % by mass and μ_m = 6 % by mass.

$\varepsilon_{cs,ref}$, representing the mean value of the three test specimens, shall be expressed to the nearest 0,01 mm/m.

7.4 Determination of the total value of drying shrinkage

If the total drying shrinkage is required, this shall be calculated, using equation (1); calculated as the relative length change between the end of the conditioning period at time t_0 and the finalisation of the shrinkage storage at time t_e.



Key

μ_m mass related moisture content
ε_{cs} relative length change

Figure 2 — Principle for determination of $\varepsilon_{cs,ref}$

7.5 Calculation of the dry density

In analogy to EN 678 the dry density of the autoclaved aerated concrete is calculated as the ratio between the mass of the test specimens (without gauge plugs) dried according to 6.2 and their volume calculated according to 5.5.

8 Test report

The test report shall include the following:

a) identification of the product;

b) date of manufacture or other code;

c) place of testing, testing institute and person responsible for testing;

d) number and date of issue of this European Standard;

e) dry density of each individual test specimen and mean value;

f) relative length change, ε_{csi}, and mass related moisture content, μ_{mi}, of individual test specimens and mean values for the different measuring dates;

g) graph according to Figure 2, where the mean values of ε_{csi} are plotted as a function of the mean value of μ_{mi};

h) conventional reference value of drying shrinkage $\varepsilon_{cs,ref}$;

i) if required, the total value of drying shrinkage $\varepsilon_{cs,tot}$;

j) if necessary, observations on the appearance of the test specimens (e. g. unusual poresize distribution).

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