BRITISH STANDARD

BS EN
1367-1:2000

Test for thermal and weathering properties of aggregates —

Part 1: Determination of resistance to freezing and thawing

The European Standard EN 1367-1:1999 has the status of a British Standard

ICS 91.100.15

National foreword

This British Standard is the official English language version of EN 1367-1:1999. It is included in a package of European Standards declared by CEN/TC 154.

The UK participation in its preparation was entrusted by Technical Committee B/502, Aggregates, to Subcommittee B/502/6, Test methods, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 12, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 February 2000

ISBN 0 580 32540 7

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1367-1

November 1999

ICS 91.100.20

English version

Tests for thermal and weathering properties of aggregates - Part 1: Determination of resistance to freezing and thawing

Essais pour déterminer les propriétés thermiques et l'altérabilité des granulats - Partie 1: Détermination de la résistance au gel-dégel

Prüfverfahren für thermische Eigenschaften und Verwitterungsbeständigkeit von Gesteinskörnungen - Teil 1: Bestimmung des Widerstandes gegen Frost-Tau-Wechsel

This European Standard was approved by CEN on 16 April 1999.

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Contents

		Page
Foreword		3
1	Scope	4
2	Normative references	4
3	Definitions	4
4	Principle	5
5	Apparatus	5
6	Sampling	5
7	Test specimens	5
8	Procedure	7
9	Calculation and expression of results	8
10	Test Report	9
Annex A (informative)	Precision	10
Annex B (informative)	Guidance note for very severe freeze-thaw conditions	11
Annex C (informative)	Bibliography	12

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 154, Aggregates, the Secretariat of which is held by BSI.

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 May 2000, and conflicting national standards shall be withdrawn at the latest by December 2003.

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

This European Standard is one of a series of tests for thermal and weathering properties of aggregates as listed below:

EN 1367-2	Tests for thermal and weathering properties of aggregates - Part 2: Magnesium sulfate test
prEN 1367-3	Tests for thermal and weathering properties of aggregates - Part 3: Boiling test for "Sonnenbrand basalt" and disintegration of steel slag
EN 1367-4	Tests for thermal and weathering properties of aggregates - Part 4: Determination of drying shrinkage
prEN 1367-5	Tests for thermal and weathering properties of aggregates - Part 5: Determination of resistance to thermal shock

Test methods for other properties of aggregates will be covered by parts of the following European Standards:

EN 932	Tests for general properties of aggregates
EN 933	Tests for geometrical properties of aggregates
EN 1097	Tests for mechanical and physical properties of aggregates
EN 1744	Tests for chemical properties of aggregates
EN 13179	Tests for filler aggregate used in bituminous mixtures.

1 Scope

This European Standard specifies a test method which provides information on how an aggregate behaves when it is subjected to the cyclic action of freezing and thawing.

NOTE The stresses on aggregates due to frost depend, amongst other factors, on the degree of water saturation as well as the rate of cooling.

The results provide a means for assessing an aggregate's resistance to this form of weathering.

The test is applicable to aggregates having a particle size between 4 mm and 63 mm.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 932-1, *Tests for general properties of aggregates — Part 1: Methods for sampling*

EN 932-2, *Tests for general properties of aggregates — Part 2: Methods for reducing laboratory samples*

EN 932-5, *Tests for general properties of aggregates — Part 5: Common equipment and calibration*

EN 933-2, *Tests for geometrical properties of aggregates — Part 2: Determination of particle size distribution — Test sieves, nominal size of apertures*

EN 1097-2, *Tests for mechanical and physical properties of aggregates — Part 2: Methods for the determination of the resistance to fragmentation.*

3 Definitions

For the purposes of this European Standard the following definitions apply.

3.1
test specimen
sample used in a single determination when a test method requires more than one determination of a property

3.2
laboratory sample
reduced sample derived from a bulk sample for laboratory testing

3.3 constant mass
successive weighings after drying at least 1 h apart not differing by more than 0,1 %

NOTE In many cases constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven at (110 ± 5) °C. Test laboratories can determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

4 Principle

Test portions of single sized aggregates, having been soaked in water at atmospheric pressure, are subjected to 10 freeze-thaw cycles. This involves cooling to -17,5 °C under water and then thawing in a water bath at about 20 °C. After completion of the freeze-thaw cycles, the aggregates are examined for any changes (crack formation, loss in mass and, if appropriate, changes in strength).

The test method consists of soaking at atmospheric pressure and storage in water for thorough water absorption (see **8.1**) and exposure to frost action under water (see **8.2**).

5 Apparatus

5.1 All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

5.2 Ventilated drying oven, with forced circulation of adequate capacity. The oven shall be capable of being controlled at (110 ± 5) °C.

5.3 Balance, with an accuracy of ± 0,1 g, of adequate capacity.

5.4 Low temperature cabinet, (upright or chest) with air circulation. A manual method of control may be used, provided the correct cooling curve, as shown in Figure 1, is adhered to. In the case of a dispute, the automatic control shall be used.

5.5 Cans, made from seamless drawn or welded corrosion-resistant sheet metal, with a thickness of about 0,6 mm, having a nominal capacity of 2 000 ml, an internal diameter of 120 mm to 140 mm, and an internal height of 170 mm to 220 mm are suitable. Cans shall be covered by suitable lids.

For lightweight aggregates, cans shall be suitably ballasted.

5.6 Test sieves, conforming to EN 933-2.

5.7 Water, distilled or de-ionized.

6 Sampling

Sampling shall be carried out in accordance with EN 932-1.

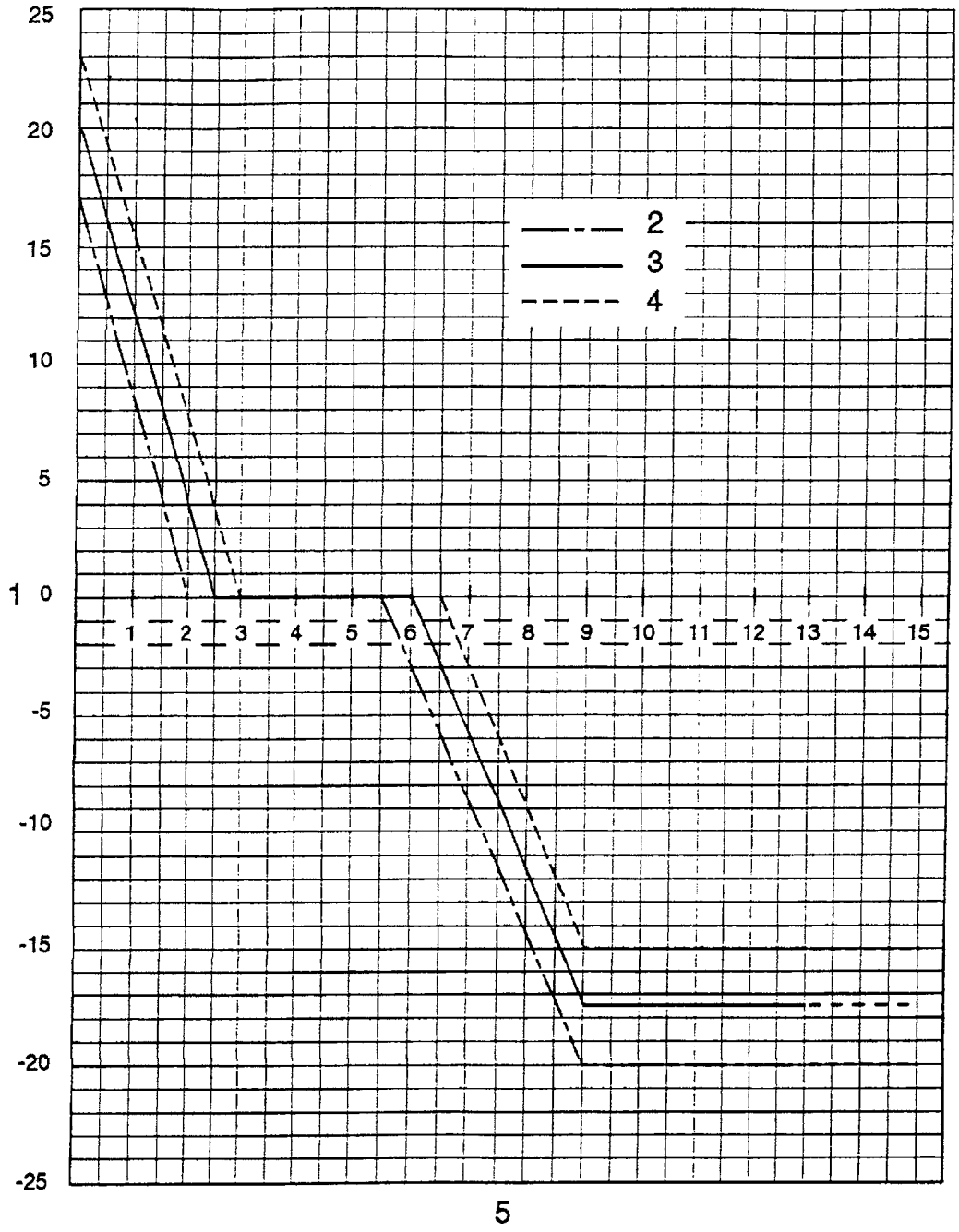
7 Test specimens

7.1 General

Three individual test specimens shall be used. The test specimens shall be obtained in accordance with EN 932-2 by sample reduction from production single sized aggregates from which oversized and undersized aggregates have been removed.

NOTE If it is intended to carry out a strength test after the freeze-thaw cyclic loading, this test should be performed on an appropriate grading sieved out from the laboratory sample, in accordance with EN 1097-2.

In order to do this, a laboratory sample should be taken of twice the mass required for the strength test (see Table 1), plus an allowance for waste. This laboratory sample should then be split into two approximately equal parts. The first part should be used for fragmentation and density tests, without being subjected to the freeze-thaw cycling, and the second part should be subjected to the freeze-thaw cyclic test.



1 Temperature in °C
2 Lower limit
3 Control
4 Upper limit
5 Time in hours

Figure 1—Temperature curve in the centre of the filled can (reference measuring point) located in the middle of the cabinet

7.2 Size of test specimens

The preferred size fraction shall be within the range 8 mm to 16 mm, but if required, any of the sizes listed in Table 1 may be used.

The quantities for each of the three individual test portions are specified in Table 1, and deviations of ± 5 % are permissible.

Table 1 — Mass of test portions required for the freeze-thaw cyclic test

Maximum aggregate size mm	Mass or volume of aggregate required	
	Normal aggregate g	Lightweight aggregate (bulk volume) ml
4 to 8	1 000	500
8 to 16	2 000	1 000
16 to 32	4 000[1)]	1 500
32 to 63	6 000[1)]	-
[1)] Additional cans will be necessary.		

7.3 Preparation of test specimens

The test specimens shall be washed and adherent particles removed. They shall be dried to constant mass at (110 ± 5) °C, allowed to cool to ambient temperature and weighed immediately (M_1).

For lightweight aggregates, dry to constant mass.

Weighing shall be carried out to the following accuracies:

- aggregates up to 16 mm size, to ± 0,2 g;
- aggregates above 16 mm size, to ± 0,5 g.

8 Procedure

8.1 Soaking

The test specimens prepared in accordance with **7.3** shall be stored at atmospheric pressure for (24 ± 1) h in the cans specified in **5.5** at (20 ± 3) °C, in distilled or demineralized water, the water covering the test portions by at least 10 mm for the full 24 h period of soaking.

8.2 Exposure to freezing under water

Check that the water level in each can is still at least 10 mm above the top of the test specimen and place the lids on the cans. Place the covered cans containing the test specimens in the cabinet, ensuring that the distance between the cans and the sidewalls of the cabinet is not less than 50 mm and the cans are not touching, in order that the heat is extracted from them as uniformly as possible from all sides.

Using the temperature at the centre of a covered can, situated in the centre of the cooled area, as the reference measuring point of temperature, regulate the cabinet so that the temperature follows a cooling curve inside the limits as shown in Figure 1.

Subject the samples in the cabinet to a series of 10 freeze-thaw cycles as follows.

a) Reduce the temperature from (20 ± 3) °C to 0 °C in (150 ± 30) min and hold at 0 °C for (210 ± 30) min.

b) Reduce the temperature from 0 °C to (-17,5 ± 2,5) °C in (180 ± 30) min and hold at (-17,5 ± 2,5) °C for a minimum of 240 min

NOTE: If it is necessary to interrupt the test during the freezing cycle or when under manual control, for example at weekends, the cans should be kept at (-17,5 ± 2,5) °C. A total interruption of up to 72 h is possible.

c) At no stage allow the air temperature to fall below -22 °C.

d) After the completion of each freezing cycle thaw the cans by immersion in water at approximately 20 °C. Thawing shall be considered to be completed when the temperature has reached (20 ± 3) °C.

e) After the completion of each thawing phase hold the cans in water at (20 ± 3) °C for a maximum of 10 h. Each freeze-thaw cycle shall be completed within 24 h.

On completion of the tenth cycle, pour the contents of each can into a test sieve having an aperture size that is half the lower size sieve used to prepare the test specimen (e.g., in the case of the 8 mm to 16 mm fraction, into a test sieve of 4 mm aperture size). Wash and sieve the test specimen on the specified sieve by hand. Dry the residue remaining on the sieve at (110 ± 5) °C to constant mass, cool to ambient temperature and weigh immediately (M_2).

9 Calculation and expression of results

9.1 Determination of the percentage mass loss

Calculate the undersize by combining the residues from the three test specimens, weigh and express the mass obtained as a percentage of the mass of the combined test specimens.

Calculate the result of the freeze-thaw test (F) in accordance with the following equation:

$$F = \frac{M_1 - M_2}{M_1} \times 100 \qquad (1)$$

where

M_1 is the initial dry total mass of the three test specimens, in grams;
M_2 is the final dry total mass of the three test specimens, that is retained on the specified sieve, in grams;
F is the percentage loss in mass of the three test specimens after freeze-thaw cycling.

NOTE A statement on the precision of this test is given in annex A.

9.2 Determination of the strength loss after freeze-thaw cycling

Calculate the difference in percentage between the strength test results of the test portions, with and without freeze-thaw cycling, following the procedures specified in EN 1097-2.

Calculate the percentage strength loss, accurate to 0,1 %, in accordance with either equation (2) or equation (3) as follows:

$$\Delta S_{LA} = \frac{S_{LA_1} - S_{LA_0}}{S_{LA_0}} \times 100 \qquad (2)$$

where

ΔS_{LA} is the percentage strength loss;
S_{LA0} is the Los Angeles coefficient of the test portion without freeze-thaw cycling;
S_{LA1} is the Los Angeles coefficient of the test portion after freeze-thaw cycling.

$$\Delta S_{SZ} = \frac{S_{SZ_1} - S_{SZ_0}}{S_{SZ_0}} \times 100 \qquad (3)$$

where

ΔS_{SZ} is the percentage strength loss;
S_{SZ0} is the impact value of the test portion without freeze-thaw cycling;
S_{SZ1} is the impact value of the test portion after freeze-thaw cycling.

10 Test report

The test report shall include the following information:

a) reference to this European Standard;
b) sampling method if known and marking, type and origin of the laboratory samples;
c) shape, size, gradings and number of laboratory samples;
d) visual observations of the aggregate retained on the specified sieve;

NOTE Any unusual disintegration of the aggregate retained on the sieve should be reported.

e) result of the freeze-thaw test, *F*, expressed to the nearest 0,1 % by mass;
f) date of report and name of test laboratory.

Annex A (informative)

Precision

The following precision data was determined from a cross testing experiment carried out under the CEC DG XII Measurement and Testing Programme (Contract No MAT 1 - CT 93 - 0400 Project No 134 Testing of Industrial Products - Aggregates for Construction) in 1996/1997. 12 laboratories from 8 European countries participated in the cross testing experiment.

The repeatability r_1 and reproducibility R_1 for a homogeneous material for a size fraction 8 mm to 16 mm (passing a 4 mm test sieve) was as follows:

$W_c = 0{,}03 + 0{,}39\,X$ $\quad r_1 = 0{,}04 + 0{,}36\,X$ $\quad R_1 = 0{,}07 + 0{,}62\,X$

The results were interpreted in accordance with ISO 5725:1986.

Annex B (informative)

Guidance note for very severe freeze-thaw conditions

Where it can be demonstrated that the test method specified in this European Standard does not distinguish adequately between aggregates as regards durability in service, it can be necessary to consider the following:

a) the use of a solution of 1 % sodium chloride (NaCl); or

b) the use of a saturated solution of urea.

All other parameters of this European Standard remain the same, other than the adjustment of the freezing point for the cooling curve, see Figure 1.

Until experience with a definitive test method, using one of the above solutions, giving good precision on a wide range of European aggregates is available, the reference freeze-thaw test method is as specified in this standard, using distilled water.

Annex C (informative)

Bibliography

ISO 5725:1986 Precision of test methods - Determination of repeatability and reproducibility for a stand and test method by inter-laboratory tests

BS EN 1367-1:2000

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL