British Standard

Tests for general properties of aggregates —

Part 6: Definitions of repeatability and reproducibility

The European Standard EN 932-6:1999 has the status of a British Standard

ICS 91.100.15

National foreword

This British Standard is the English language version of EN 932-6:1999. It is included in a package of European Standards declared by CEN/TC 154 and will supersede BS 812-101:1984, which will be withdrawn on 2003-12-01.

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 subcommittee 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 11 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 September 1999

ISBN 0 580 32539 3

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 932-6

May 1999

ICS 01.040.91; 91.100.20

English version

Tests for general properties of aggregates — Part 6: Definitions of repeatability and reproducibility

Essais pour déterminer les propriétés générales des granulats —
Partie 6: Définitions de la répétabilité et de la reproductibilité

Prüfverfahren für allgemeine Eigenschaften von Gesteinskörnungen —
Teil 6: Definitionen von Wiederholpräzision und Vergleichpräzision

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.

CEN
European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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

Ref. No. EN 932-6:1999 E

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 November 1999, 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 standard forms part of a series of tests for general properties of aggregates. Test methods for other properties of aggregates will be covered by parts of the following European Standards:

EN 933, *Tests for geometrical properties of aggregates*;

EN 1097, *Tests for mechanical and physical properties of aggregates;*

EN 1367, *Tests for thermal and weathering properties of aggregates;*

EN 1744, *Tests for chemical properties of aggregates;*

EN 13179, *Tests for filler aggregate used in bituminous mixtures.*

The other parts of EN 932 will be:

Part 1: Methods for sampling;
Part 2: Methods for reducing laboratory samples;
Part 3: Procedure and terminology for simplified petrographic description;
Part 5: Common equipment and calibration.

Contents

1 Scope

This European Standard gives definitions of repeatability and reproducibility adapted from ISO 5725–1 to the specific situation of sampling and testing aggregates.

These adjustments have been made because test portions or test specimens of aggregates are usually not identical to each other as specified in ISO 5725–1.

2 Definitions

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

2.1 sampling and sample reduction definitions

2.1.1
test portion
sample used as a whole in a single test

2.1.2
test specimen
sample used in a single determination of a property when a test method requires more than one determination of a property

2.1.3
sampling error
difference between the properties of a batch and a bulk sample that arises during the process of taking a bulk sample from the batch

2.1.4
bulk sample reduction error
difference between the properties of a bulk sample and a laboratory sample that arises during the process of reducing the bulk sample to a laboratory sample

2.1.5
laboratory sample reduction error
difference between the properties of a laboratory sample and a test portion that arises during the process of reducing the laboratory sample to a test portion

2.1.6
between-laboratory testing variation
variation that arises between test results from different laboratories because of differences between operators, apparatus, reagents, calibrations and environments

2.1.7
within-laboratory testing variation
variation that arises between test results from the same laboratory when the operator, apparatus, reagents, calibrations and environments are not changed

2.1.8
variation between single determinations
variation that arises between single determinations that are used to calculate one test result

2.2 repeatability definitions

2.2.1
critical range
W_c
value less or equal to which the range of *n* single determination a_1, ..., a_n made to obtain a test result is expected to lie within a probability of 95 % (see Figure 1)

NOTE This is the range when a test method requires *n* single determinations of a property, the test result being the average of *n* single determinations. The single determinations can be averaged to the test result if their range does not exceed the critical range Wc.

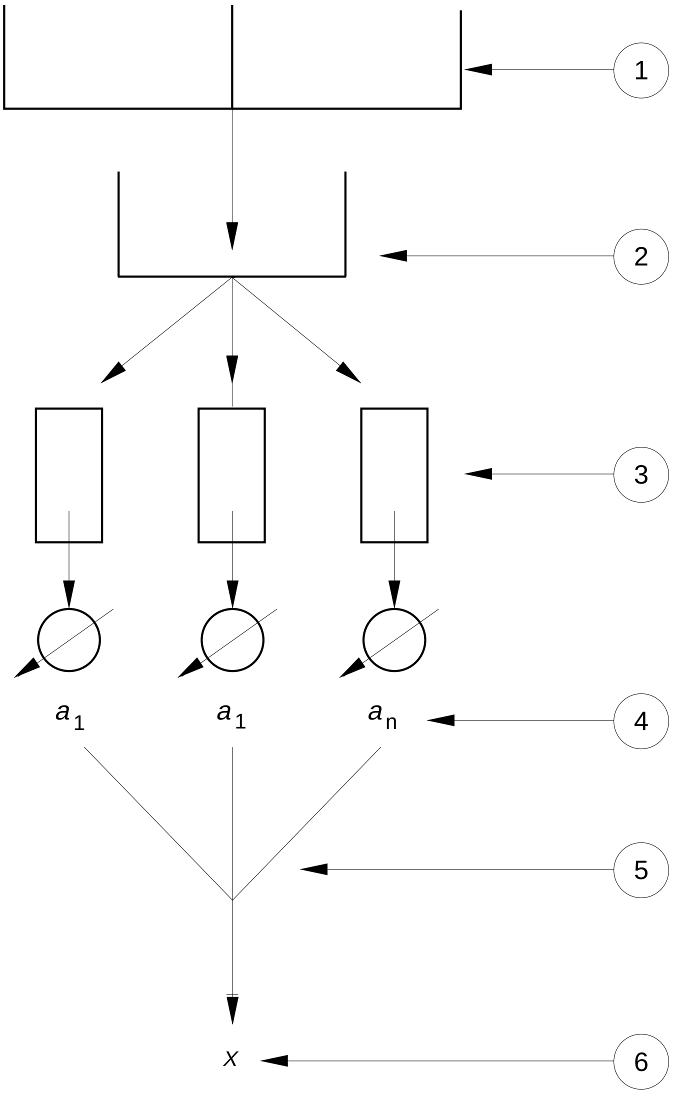
W_c is calculated by the following equation:

$$W_c = f(n) \cdot \sigma_a$$

where

$f(n)$ is a factor, the values of which are given in Table 1;

σ_a is the standard deviation of single determinations.



1 Laboratory sample
2 Test portion
3 Test specimens
4 Determinations
5 Averaging determinations
6 Test result

NOTE The determinations can only be averaged to a test result

$$X = \frac{(a_1 + ...a_n)}{n} \text{ if } (a_{max} - a_{min}) \leq W_c = f(n) \cdot \sigma_a$$

Figure 1 — Calculation of a test result from *n* determinations a_1, ... a_n

Table 1 — Values for *f*(*n*)

n	*f*(*n*)
2	2,8
3	3,3
4	3,6
5	3,9
6	4,0

2.2.2
repeatability *r* conditions
conditions where test results are obtained with the same test method on identical test portions of aggregate, in the same laboratory, by the same operator, using the same equipment and within short intervals of time

NOTE 1 For repeatability *r* conditions to be achieved in practice a number of identical test portions of aggregate should be manufactured.

NOTE 2 "The same operator" — it is acceptable if a team of operators works together, each taking on the responsibility for a particular stage of a test.

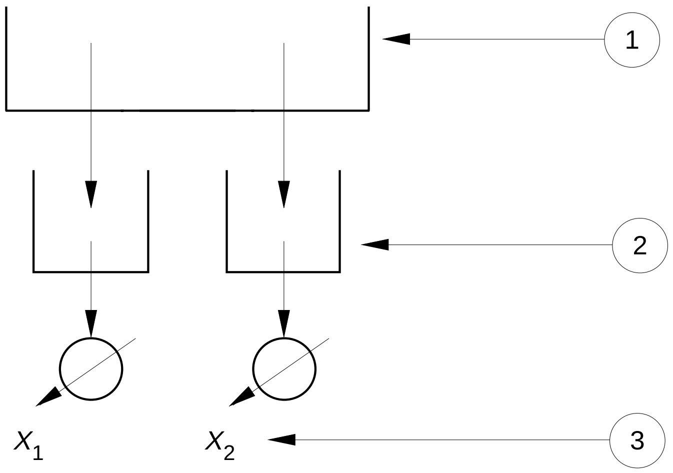
NOTE 3 "A short interval of time" — with aggregate tests that take weeks or months to complete, test results are obtained under repeatability conditions if the tests start within a short interval of time of each other and finish within a short interval of time of each other.

2.2.3
repeatability r_1 conditions
conditions where test results are obtained with the same test method on different test portions of the same laboratory sample of aggregate, in the same laboratory, by the same operator, using the same equipment and within short intervals of time (see Figure 2)

NOTE 1 The subscript "$_1$" is added to indicate that the laboratory sample reduction error contributes to the variations measured under r_1 conditions. Laboratory sample reduction error always occurs in practical situations when test portions are obtained from laboratory samples so that then r_1 conditions, not *r* conditions, apply.

NOTE 2 "The same operator" — it is acceptable if a team of operators works together, each taking on the responsibility for a particular stage of a test.

NOTE 3 "A short interval of time" — with aggregate tests that take weeks or months to complete, test results are obtained under repeatability conditions if the tests start within a short interval of time of each other and finish within a short interval of time of each other.



1 Laboratory sample
2 Test portions
3 Test results

NOTE X_1 and X_2 are compatible and can be averaged if $(X_1 - X_2) \leq r_1$.

Figure 2 — Repeatability r_1 conditions

2.2.4
repeatability *r* or r_1 standard deviation
standard deviation of test results obtained under repeatability *r* or r_1 conditions denoted by σ_r or σ_{r_1}

NOTE 1 The different sources of variation contained in σ_r or σ_{r_1} are given in Table 2.

NOTE 2 σ_{r_1} measures the within-laboratory testing variation and additionally the laboratory sample reduction error.

2.2.5
repeatability value *r* or r_1
value less or equal to which the absolute difference between two test results, obtained under repeatability *r* or r_1 conditions, is expected to be within a probability of 95 %

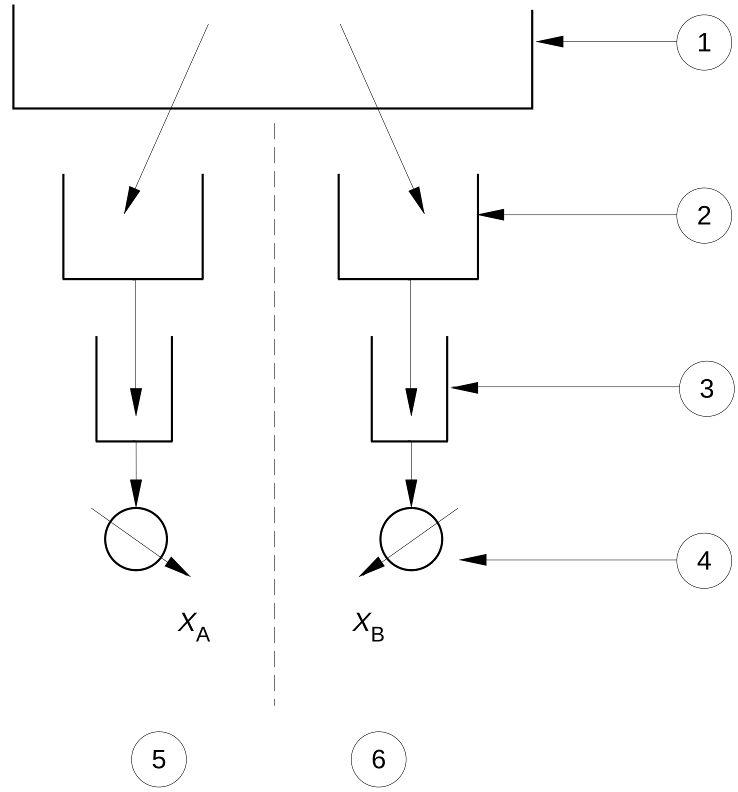
2.3 reproducibility definitions

2.3.1
reproducibility *R* conditions
conditions where test results are obtained with the same test method on identical test portions of aggregate, in different laboratories, by different operators using different equipment

NOTE For reproducibility *R* conditions to be achieved in practice a number of identical test portions of aggregate should be manufactured.

2.3.2
reproducibility R_1 conditions
conditions where test results are obtained with the same test method on test portions of different laboratory samples of the same bulk sample, in different laboratories, by different operators using different apparatus (see Figure 3)

NOTE The subscript "$_1$" indicates, as for repeatability r_1 conditions that sample reduction errors contribute to the variations measured under *R* conditions.



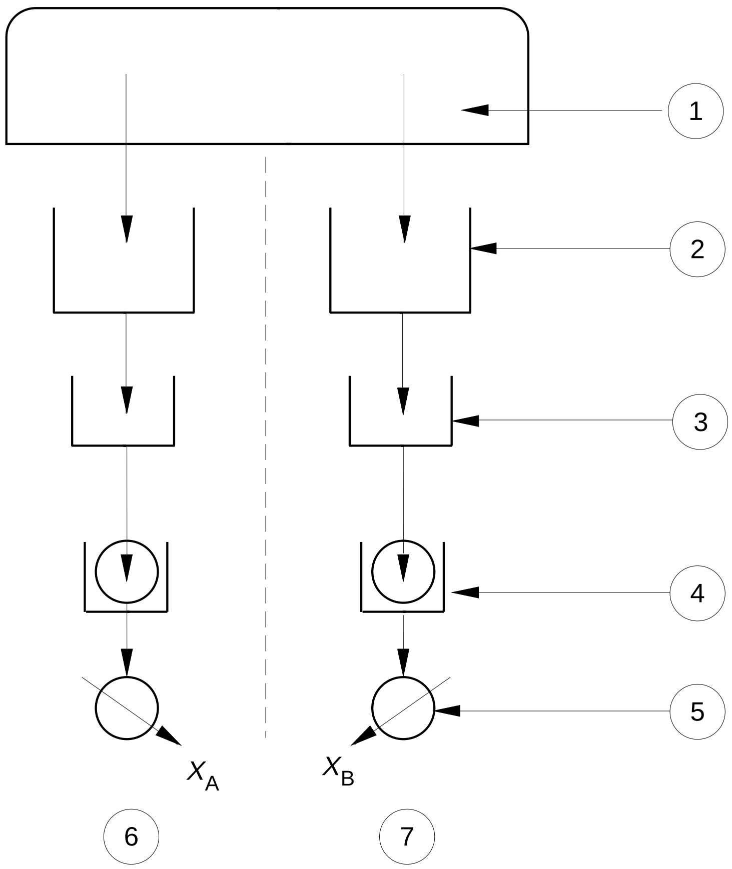
1 Bulk sample
2 Laboratory sample
3 Test portions
4 Test results
5 Laboratory A
6 Laboratory B

Note X_A and X_B are compatible and can be averaged if $(X_A - X_B) \leq R_1$.

Figure 3 — Reproducibility R_1 conditions

2.3.3
reproducibility R_2 conditions
conditions where test results are obtained with the same test method on different bulk samples of a batch, in different laboratories, by different operators using different apparatus (see Figure 4)

NOTE The subscript "$_2$" indicates that sampling errors and sample reduction errors contribute to the variations measured under R_2 conditions.



1 Batch
2 Bulk samples
3 Laboratory samples
4 Test portions
5 Test results
6 Laboratory A
7 Laboratory B

NOTE X_A and X_B are compatible and can be averaged if $(X_A - X_B) \leq R_2$.

Figure 4 — Reproducibility R_2 conditions

2.3.4
reproducibility R, R_1 or R_2 standard deviation
standard deviation of test results obtained under reproducibility R, R_1 or R_2 conditions, denoted by σ_R or σ_{R_1} or σ_{R_2}

NOTE The different sources of variation contained in σ_R, σ_{R_1} and σ_{R_2} can be seen in Table 2.

Table 2 — Sources of variation measured by repeatability r or r_1 and reproducibility R, R_1 or R_2

Sources of variation	r	r_1	R	R_1	R_2
Sampling error					✓
Bulk sample reduction error				✓	✓
Laboratory sample reduction error		✓		✓	✓
Between-laboratory testing variation			✓	✓	✓
Within-laboratory testing variation	✓	✓	✓	✓	✓

2.3.5
reproducibility value R, R_1 or R_2
value less or equal to which the absolute difference between two test results, obtained under reproducibility R, R_1 or R_2 conditions, is expected to lie within a probability of 95 %

NOTE Sampling errors are included in R_2, but not in R_1. Sampling errors always occur in practical situations when batches are sampled. If parties want to compare results it is recommended that they obtain the results under R_1 conditions.

3 Equations relating repeatability and reproducibility limits to standard deviations

3.1 Standard deviations

A standard deviation is associated with each of the sources of error or variation listed in clause **2** (see Table 3).

Table 3 — Standard deviations

Source of error or variation	Standard deviation
Sampling error	σ_S
Bulk sample reduction error	σ_{SRB}
Laboratory sample reduction error	σ_{SRL}
Between-laboratory testing variation	σ_L
Within-laboratory testing variation	σ_r
Variation between single determinations	σ_a

3.2 Equations

$$\sigma_{r1} = \sqrt{\sigma_{\mathrm{r}}^2 + \sigma_{\mathrm{SRL}}^2}$$

$$\sigma_{R} = \sqrt{\sigma_{\mathrm{r}}^2 + \sigma_{\mathrm{L}}^2}$$

$$\sigma_{R1} = \sqrt{\sigma_{\mathrm{r}}^2 + \sigma_{\mathrm{L}}^2 + \sigma_{\mathrm{SRL}}^2 + \sigma_{\mathrm{SRB}}^2}$$

$$\sigma_{R2} = \sqrt{\sigma_{\mathrm{r}}^2 + \sigma_{\mathrm{L}}^2 + \sigma_{\mathrm{SRL}}^2 + \sigma_{\mathrm{SRB}}^2 + \sigma_{\mathrm{s}}^2}$$

where

r is 2,8 × σ_{r}
r_1 is 2,8 × σ_{r_1}
R is 2, 8 × σ_{R}
R_1 is 2, 8 × σ_{R_1}
R_2 is 2, 8 × σ_{R_2}

Annex A (informative)
Bibliography

ISO 5725–1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*.

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