British Standard

BRITISH STANDARD

BS 812-101:1984

Testing aggregates —

Part 101: Guide to sampling and testing aggregates

UDC [625.07+691.22]:620.1

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement Gypsum Aggregates and Quarry Products Standards Committee (CAB/-) to Technical Committee CAB/2 upon which the following bodies were represented:

Aggregate Concrete Block Association
Association of Consulting Engineers
Association of Consulting Scientists
Association of Lightweight Aggregate Manufacturers
Brick Development Association
British Aggregate Construction Materials Industries
British Ceramic Research Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation Limited
British Ready Mixed Concrete Association
Calcium Silicate Brick Association Limited
Cement and Concrete Association
Cement Makers' Federation
Chartered Institute of Building
Concrete Society
County Surveyors' Society
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Department of the Environment (Transport and Road Research Laboratory)
Department of Transport
Electricity Supply Industry in England and Wales
Federation of Civil Engineering Contractors
Greater London Council
Institute of Concrete Technology
Institution of Civil Engineers
Institution of Highways and Transportation
Institution of Public Health Engineers
Institution of Structural Engineers
Institution of Water Engineers and Scientists
Mortar Producers' Association Limited
National Federation of Terrazzo-mosaic Specialists
Natural Environment Research Council (Institute of Geological Science)
Royal Institute of British Architects
Sand and Gravel Association Limited
Society of Chemical Industry
Coopted member

This British Standard, having been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 July 1984.

The following BSI references relate to the work on this standard:
Committee reference CAB/2
Draft for comment 83/12686

ISBN 0 580 13878 X

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

Foreword

This Part of this British Standard, prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee is a revision of clause 4 and appendix A of BS 812-1:1975, which are withdrawn by amendment. The remainder of the 1975 edition is being revised and as each of the tests, or collection of related tests is revised it is intended to issue it as a separate Part or Section of this standard.

It is intended that other British Standards should call up BS 812 test methods as the basis of compliance. Nevertheless, it is *not* intended that all aggregates should be subjected regularly to all the listed tests. Specifications in other standards should call up only relevant test methods.

Some of the tests in other Parts of this standard are of limited application, and advice on the use of simpler tests is given, for example when they can be used for a preliminary sorting of aggregates to see whether more expensive testing is justified.

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, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 812 gives general guidance on sampling and testing aggregates and procedures for assessing the precision of the tests described in other Parts of this standard.

2 Definitions

For the purposes of this Part of BS 812 the definitions given in BS 812-102, together with the following apply. Other statistical terms have the meanings defined in BS 5532.

2.1 repeatability

NOTE A lengthy discussion of this term is given in BS 5497. Briefly, repeatability is a measure of the within-laboratory variability of the results from a test method.

2.1.1
repeatability r[1)]

the value below which the absolute difference between two single test results obtained with the same method on identical test material under the same conditions (same operator, same apparatus, same laboratory and a short interval of time) may be expected to lie with a probability of 95 %

2.1.2
repeatability r_1[1)]

the value below which the absolute difference between two single test results obtained with the same method using different test portions of the same laboratory sample under the same conditions (same operator, same apparatus, same laboratory, and a short interval of time) may be expected to lie with a probability of 95 %

2.2 reproducibility

NOTE A lengthy discussion of this term is given in BS 5497. Briefly, reproducibility is a measure of the between-laboratory variability of the results of a test method.

2.2.1
reproducibility R[1)]

the value below which the absolute difference between two single test results obtained with the same method on identical test material under different conditions (different operators, different apparatus, different laboratories and/or different time) may be expected to lie with probability of 95 %

2.2.2
reproducibility R_1[1)]

the value below which the absolute difference between two single test results obtained with the same method using different test portions of the same laboratory sample under different conditions (different operators, different apparatus, different laboratories and/or different time) may be expected to lie with a probability of 95 %

2.2.3
reproducibility R_2[1)]

the value below which the absolute difference between two single test results obtained with the same method using different laboratory samples from the same batch under different conditions (different operators, different apparatus, different laboratories and/or different time) may be expected to lie with a probability of 95 %

2.3
single test result

the value obtained by applying a standard test method fully, once

NOTE A single test result may be a value derived from tests on a number of specimens, or the mean value of a number of observations, or the result of a calculation from a set of observations, as specified by the standard test method. The standard test method may require one or more test portions to be tested to obtain a single test result.

2.4
sampling error

the error in a single test result arising from known and acceptable deficiencies in both the sampling and sample reduction operations in obtaining a laboratory sample from a batch

2.5
sample reduction error

the error in a single test result arising from known and acceptable deficiencies of the sample reduction operation in obtaining the test portion or test portions from a laboratory sample

2.6
variance

a measure of dispersion based on the mean squared deviation from the arithmetic mean

[1)] According to the above definitions, r_1 and R_1 make allowance for sample reduction errors whereas r and R do not. In addition R_2 makes allowances for sampling errors. With many aggregate tests it is not possible to carry out repeat tests on identical material so that r_1, R_1 and R_2 are the measures of variability which will be of use in practice.

3 General

Attention is drawn to the aim of sampling by the principal method given in Part 102 of this standard, i.e. to obtain a sample representative of the average quality. For other purposes it may be necessary to use a modified procedure. Special sampling procedures, for example to allow for the determination of the presence and quantity of occasional contaminants, are given in other Parts, when appropriate.

Particular emphasis is placed on the need for proper reporting, and each test method requires a report including a certificate of sampling, (see BS 812-102). The test(s) have to be done in accordance with the relevant Part(s) and the reports have to affirm this. If any departure from specified sampling or test procedures is found to be necessary this has to be made clear on the report together with reasons and, if possible, an estimate of the effects. The report should also include details of any special processing of the sample, other than that required by the test methods, carried out in the laboratory, e.g. crushing to provide larger quantities of smaller sizes, or the separation of constituent sizes from a graded or blended aggregate.

Each report should include all the information specified in the report clause in the appropriate Part including precision estimates.

Because the precision of testing has important consequences, the estimates of repeatability and reproducibility given have been established using the full procedures and recommendations of BS 5497 modified only as necessary to take account of the special nature of aggregates or the particular test methods (see clause **5**).

Aggregates may contain, or during handling, processing or testing may generate particles or fumes that could be injurious to health. It is essential that, in addition to ensuring that test equipment is properly guarded, appropriate precautions are taken such as by the use of goggles, dust masks, dust containing and extracting facilities, or fume cupboards.

4 Significance of test results

The applicability of test results depends on several factors and their interactions, e.g. the methods used for sampling and sample reduction, the number of samples taken, the precision of the test method, the extent to which a test simulates reality. All these are capable of producing important effects often as great as real variations in the materials.

Some tests described in BS 812 are not accurate measures of well defined properties but are included as useful preliminary tests. This is to encourage a reduction in the mis-application of expensive and time consuming, but more accurate, methods which are not always justified. Information on the use of such preliminary tests is given in the appropriate Parts of the standard.

Many of the tests described in BS 812 give a measure of the comparative behaviour of materials under the specified test regime. It is not necessarily implied that the results give a realistic indication of the behaviour of the material in practice. Guidance on the interpretation of test results is given in the appropriate Parts.

Precision estimates of the test procedures are given in the appropriate Parts of the standard. Their application to the setting of compliance limits, data screening, and monitoring of laboratories is discussed in clause **5**.

5 Precision of test methods

5.1 General. This clause describes how the precision estimates given in other Parts of this British Standard may be used, and gives a method, involving tests on duplicate laboratory samples, which may be used to measure the variability arising from sampling errors.

5.2 Symbols. The symbols used in this clause are as follows:

N	a number of batches;
a, b	single test results obtained on the same laboratory sample;
A, B	laboratory samples from the same batch;
D	the difference between two single test results obtained on the same laboratory sample;
M	the mean value of two single test results obtained on the same laboratory sample;
$\bar{x}$	overall mean of data;
V_S	variance arising from sampling errors;
V_{Sr}	variance arising from sample reduction errors;
V_L	variance arising from between-laboratory differences;
V_r, V_{r1}	repeatability variances;
V_R, V_{R1}, V_{R2}	reproducibility variances;

r, r_1	repeatability, measures of within-laboratory variability;
R, R_1, R_2	reproducibility, measures of between-laboratory variability.

5.3 Relationships. Table 1 shows the relationships between repeatability and reproducibility and their variances, and also how the sampling, sample reduction and laboratory variances contribute to the repeatability and reproducibility variances.

5.4 Uses of repeatability

5.4.1 *General.* Pairs of single test results obtained under appropriate repeatability conditions from the same laboratory sample are required. If the intention is to consider the results of the tests without a contribution from sample reduction error, steps should be taken to ensure that sample reduction error does not contribute to differences between pairs of results. In this case the differences would be compared with r. This is possibly only when the test portion is not changed by the test method and thus can be used again for the second test. Alternatively, if the intention is to consider results that include sample reduction errors, each test portion should be obtained from its laboratory sample by a separate sample reduction operation. In this case the differences would be compared with r_1.

5.4.2 *Data screening.* This procedure will be appropriate when the tests can be repeated in a reasonable time and at a reasonble cost. A pair of single test results should be rejected and the tests repeated if the difference between them exceeds r or r_1.

5.4.3 *Laboratory monitoring.* When the same test is carried out regularly in a laboratory it is recommended that pairs of single test results should be obtained and the differences compared with r or r_1 to check the standard of testing in the laboratory. 20 or more pairs of test results are sufficient to allow a reliable assessment to be made.

5.5 Uses of reproducibility

5.5.1 *Laboratory comparisons.* If it is required to carry out a comparison of two laboratories assuming no sampling errors, the laboratories should use test portions obtained from the same laboratory sample, and the difference between the two single test results should be compared with R_1.

When two laboratories apply the same test method to different laboratory samples of the same batch of material, the difference between their two single test results should be compared with R_2. If the differences is greater than R_2, the following should be investigated.

a) The test procedures, including sample reduction, and the apparatus used in both laboratories should be examined thoroughly to eliminate errors, and the tests repeated on the same laboratory samples.

b) The sampling procedure should be reviewed and the tests repeated using new bulk samples.

c) Where the aggregate presents sampling problems (as in the case of aggregate prone to severe segregation and sampled from heaps), the value of R_2 should be recalculated using a value of V_S obtained either by examining available data on similar aggregate or from tests on duplicate laboratory samples of the aggregate as described in **5.7**.

5.5.2 *Specification limits.* The achievable precision of a test method should be taken into consideration when fixing specification limits using R_2, which includes allowances for sampling errors and sample reduction errors.

5.6 Uses of variance arising from sampling errors

5.6.1 *General.* In some circumstances it may be necessary to assess sampling error. This will require tests to be carried out using the particular test method for which the results are required.

5.6.2 *Sampler monitoring.* The proficiency of a sampler can be checked by requiring him to take duplicate bulk samples. This should be done during the course of normal sampling, but not necessarily all at one time. The sampler should carry out the tests described in **5.7** using aggregate to which an established value of V_S is applicable. If the value of V_S which he obtains is larger than the established value, then the sampling procedures may need to be reviewed.

5.6.3 *Sampling method suitability.* The tests described in **5.7** are carried out using the aggregate for which it is required to assess the suitability of the standard method of sampling. If the value of V_S obtained is larger than the value given in the appropriate Part of this British Standard for the test method being used, then the method of sampling should be improved (e.g. by taking a larger number of increments), or the value of R_2 should be revised.

Table 1 — Relationships

Relationship	Equation	Variances involved			
		Initial sampling	Sample reduction	Test method	Between laboratory
Repeatability and reproducibility	$r = 2.8\sqrt{V_r}$			✓	
	$r_1 = 2.8\sqrt{V_{r1}}$		✓	✓	
	$R = 2.8\sqrt{V_R}$			✓	✓
	$R_1 = 2.8\sqrt{V_{R1}}$		✓	✓	✓
	$R_2 = 2.8\sqrt{V_{R2}}$	✓	✓	✓	✓
Sampling and sample reduction error	$V_{r1} = V_r + V_{Sr}$		✓	✓	
	$V_{R1} = V_R + V_{Sr}$		✓	✓	✓
	$V_{R2} = V_R + V_S + V_{Sr}$	✓	✓	✓	✓
Laboratory variability	$V_R = V_r + V_L$			✓	✓
	$V_{R1} = V_{r1} + V_L$		✓	✓	✓
	$V_{R2} = V_{r1} + V_L + V_S$	✓	✓	✓	✓

NOTE V_S measures the variance of those sampling errors which are random in nature. Any systematic sampling errors, which might occur if a sampler fails to follow the sampling procedure given in BS 812-102 and does not obtain representative samples, will increase between-laboratory differences.

5.7 Measurement of variance arising from sampling errors

5.7.1 *General.* This procedure allows the variance arising from sampling errors to be measured by a single operator on a single nominal type of aggregate. It gives a measure of the variance due to sampling errors which is comparable with the values of V_S, given in other Parts of this British Standard, which were obtained in precision trials.

5.7.2 *Procedure.* The procedure requires duplicate bulk samples to be taken from at least nine batches of aggregate and a pair of single test results to be obtained from each bulk sample. Select batches of the type and grading for which the results are required. The number of batches is denoted by N. Using the sampling method to be assessed, take a bulk sample (A) and then a second bulk sample (B) from each batch. Reduce each bulk sample to the size of a laboratory sample using the method described in BS 812-102. Produce from each laboratory sample the test portion or portions required to obtain a single test result (*a*), using the sample reduction method described in the appropriate Part of this standard, and then re-combine the remainder of the laboratory sample and produce the test portion or portions required to obtain a second single test result (*b*), using the same method. Carry out the tests using the procedure from the appropriate Part of this standard and record the results in a table as shown in Table 3.

Where particle size is the property under consideration, record the characteristic of each test portion as the mass percentage (to the nearest 0.5 % or less) passing the test sieve given in Table 2.

Table 2 — Characteristic test sieve

Aggregate size	Characteristic test sieve
> 20 mm	[a]
5 mm to 20 mm	10 mm
< 5 mm	600 μm
Filler	150 μm

[a] A convenient test sieve is one which passes 10 to 50 mass percentage of the aggregate.

5.7.3 *Calculations.* From each pair of single test results from each bulk sample, calculate the mean (M_A or M_B) and the difference (D_A or D_B) as given in Table 3, without rounding any value. Calculate:

$$\bar{x} = \sum (M_A + M_B)/(2N)$$

$$V_{r1} = \sum (D_A^2 + D_B^2)/(4N)$$

$$V_S = \left\{ \sum (M_A + M_B)^2/(2N) \right\} - 0.5\ V_{r1}$$

$$r_1 = 2.8\sqrt{V_{r1}}$$

If this calculation yields a negative value for V_S, report V_S as zero.

Record the variance V_S to three significant figures as the measure of the variance arising from sampling errors. If the value of r_1 is greater than the value given for r_1 in the appropriate Part of this British Standard then the sample reduction and/or the testing have not been carried out to an adequate proficiency and this value of V_S is unreliable, and it is advisable to check the sample reduction and testing procedures and then repeat the sampling and testing described in **5.7.2**.

5.7.4 *Worked example.* From the data in Table 3, $N = 9$, and

$\bar{x} = 20.8$

$\sum (D_A^2 + D_B^2) = 68$

$\sum (M_A - M_B)^2 = 219.5$

So that

$V_{r1} = 68/36 = 1.89$

$V_S = (219.5/18) - 0.5\ (1.89) = 11.2$

$r_1 = 3.8$

Table 3 — Sieve tests on coarse aggregate. % passing 10 mm

Batch	Bulk sample A				Bulk sample B				A–B difference
	Single test results		Mean	Difference	Single test result		Mean	Difference	
	a	*b*	M_A	D_A	*a*	*b*	M_B	D_B	$M_A - M_B$
1	17	20	18.5	3	20	20	20	0	1.5
2	17	19	18	2	25	21	23	4	5
3	27	30	28.5	3	17	17	17	0	11.5
4	23	22	22.5	1	17	18	17.5	1	5
5	29	26	27.5	3	25	27	26	2	1.5
6	18	19	18.5	1	15	13	14	2	4.5
7	18	18	18	0	17	16	16.5	1	1.5
8	25	23	24	2	26	27	26.5	1	2.5
9	18	18	18	0	19	21	20	2	2

blank

Publications referred to

BS 812, *Testing aggregates*.
BS 812-102, *Methods for sampling*.
BS 5497, *Precision of test methods*.
BS 5497-1, *Guide for the determination of repeatability and reproducibility for a standard test method*.
BS 5532, *Statistics — Vocabulary and symbols*.

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