

Testing aggregates —

Part 104: Method for qualitative and quantitative petrographic examination of aggregates

Confirmed November 2011

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/502 Aggregates, to Subcommittee B/502/6 Test methods, upon which the following bodies were represented:

- British Aggregate Construction Materials Industries
- British Civil Engineering Test Equipment Manufacturers' Association
- British Steel Industry
- County Surveyors' Society
- Department of Trade and Industry (National Measurement Accreditation Service)
- Department of Transport
- PSA Projects Ltd.
- Sand and Gravel Association Ltd.
- Coopted members

This British Standard, having been prepared under the direction of Technical Committee B/502, was published under the authority of the Standards Board and comes into effect on 15 September 1994

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The following BSI references relate to the work on this standard:
Committee reference B/502
Draft for comment 88/13739 DC

ISBN 0 580 22643 3

Amendments issued since publication

Amd. No.	Date	Comments

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Foreword

This Part of BS 812 has been prepared under the direction of Technical Committee B/502, Aggregates, and gives a method for the petrographic examination of aggregates.

It is not intended that such an examination should form part of the routine assessment of the suitability of aggregates. However, there may be circumstances in which petrographic examination will be the only satisfactory means of assessment. In other cases it can enhance and clarify results obtained from other forms of assessment.

In some cases a less rigorous examination of aggregates may be sufficient and it is recommended that the qualitative examination given in clause 7 is used. Any such decision is, however, a matter for agreement between the client and the body undertaking the petrological examination and as such is outside the scope of this standard.

It has been assumed in the drafting of this Part of BS 812 that the execution of its provisions is entrusted to appropriately qualified people, experienced in aggregate petrography, and with access to an appropriately equipped laboratory. In certain special cases, other analytical techniques (including chemical analysis, X-ray diffraction and scanning electron microscopy) may provide useful additional information, but these are outside the scope of this standard.

Work on testing procedures for aggregates is being carried out in Europe under the auspices of CEN/TC 154, Aggregates. The method described in this Part of BS 812 is included in the programme of work of CEN/TC 154. It is envisaged that a European Standard, based on this method, will be published in due course.

Selected references on petrographic examination additional to those referenced in the text are included in annex C.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, 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 describes a general method for the examination of samples of coarse or fine aggregates to determine petrographic composition and to assist in the assessment of those aggregates for potential suitability for the intended use. The results relate only to the sample received at the laboratory and not necessarily to the deposit from which the samples are derived. The method is applicable to the determination of the proportion of any recognizable mineral or rock type, irrespective of the amount of such material, in the sample.

The major application of the method described is in the examination and assessment of processed aggregates.

2 References

2.1 Normative references

This Part of BS 812 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 812 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This Part of BS 812 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 812, the definitions given in BS 812-101, BS 812-102, BS 6100-5.2 and BS 6100-6.3 apply, together with the following.

3.1

alteration

mineralogical changes imposed upon a rock or rock body by secondary geological activity

NOTE Altered rocks thus contain secondary minerals which may or may not be detrimental to the properties of those rocks. In petrographic examination geological alteration should be distinguished from “weathering” (see 3.8).

3.2

microcrystalline

composed of crystals so fine that they can be resolved only under a microscope

NOTE The term is often confused with “cryptocrystalline” but may be distinguished by the fact that a cryptocrystalline texture is so fine-grained that it specifically requires a high power microscope to resolve individual crystals. Thus the term “microcrystalline” indicates a relatively coarser grain size than “cryptocrystalline” and does not necessarily require a high power microscope to resolve the individual crystals.

3.3

monomictic

aggregates essentially comprising particles of one rock or mineral type

3.4

petrography

the systematic description of rocks, usually in hand-specimen and thin section

NOTE The petrographic examination of aggregates comprises a description of that aggregate in terms of the constituent rock (or discrete mineral) types.

3.5

polymictic

aggregate comprising particles of many different rock or mineral types

3.6

qualitative examination

an examination in which some or all of the constituents of a sample are identified and described, but the proportions of those constituents are not established

3.7

quantitative examination

an examination in which the amounts and proportions of one or more constituents of a sample are determined

3.8

weathering

the process by which rocks are broken down and decomposed by the actions of external agencies such as wind, rain, temperature changes, plants and bacteria

NOTE In petrographic examination “weathering” should be distinguished from “alteration”.

4 Principle

4.1 The method involves the visual recognition and quantification of rock and mineral constituents of an aggregate sample to determine the petrographic composition.

NOTE It is assumed that the analyst is competent to recognize unambiguously the relevant mineral constituents in the sample.

4.2 The laboratory sample is first subjected to a qualitative examination. Duplicate representative test portions are then prepared and subjected to a more detailed examination, employing both macroscopical and microscopical techniques. Methods are given to quantify the petrographic composition of the aggregate sample. These procedures allow for the thorough and statistically reliable petrographic examination of an aggregate sample.

5 Sampling

5.1 The laboratory sample shall be taken in accordance with the procedures described in clause 5 of BS 812-102:1989.

5.2 The minimum size of the laboratory sample aggregate shall be as given in Table 1.

NOTE 1 The minimum sample sizes given in Table 1 take precedence over the recommendations of clause 5 of BS 812-102:1989 for this procedure.

NOTE 2 The sample should be accompanied by a certificate of sampling as required in clause 9 of BS 812-102:1989.

Table 1 — Minimum size of laboratory sample

Maximum particle size mm	Minimum mass kg
50	200
40	100
20	13
≤ 10	2

5.3 The aggregate samples shall be taken from processed material at a suitable stage of production.

NOTE 1 All aggregate sources exhibit some variability. It is therefore important to ensure that an adequate and well defined sampling scheme is used.

NOTE 2 Particular sampling difficulties may be encountered with crushed rock aggregate sources that exhibit varying degrees and intensities of veining, weathering and other exceptional non-uniformly distributed features. Special procedures may be necessary which are outside the scope of this standard.

NOTE 3 The sampling methods described are intended primarily for the examination of processed aggregates. The overall resource evaluation of a quarry, quarry site or rock mass is outside the scope of this standard.

NOTE 4 It is important that the laboratory sample should be neither oven-dried nor wetted until the qualitative examination has been initiated.

6 Apparatus

6.1 *Sieves*, conforming to BS 410, of appropriate mesh size.

6.2 *A sample divider*, appropriate to the maximum size of sample to be handled, as described in 4.5 of BS 812-102:1989.

6.3 *A low-power microscope*, capable of magnifications up to $\times 40$.

NOTE Stereoscopic and zoom facilities are desirable.

6.4 *Apparatus and machinery suitable for the manufacture of 30 μm thick geological thin sections*. Sand samples and some coarse aggregates will also require materials and apparatus suitable for resin consolidation prior to manufacture of the thin section.

NOTE General guidance on the equipment required for making geological thin sections, and the various procedures to be employed, is given in Allman and Lawrence [1].

6.5 *A petrographic (i.e. polarizing) microscope*, capable of high-resolution at magnifications up to $\times 500$.

6.6 *Point-counting apparatus for use with the petrographic microscope*, e.g. an electro-mechanical stage linked to a counting device, such that operation of any one of the counters automatically moves the thin section one further step along the traverse.

6.7 *Balances*, for various mass ranges each capable of weighing the test portion to an accuracy of 0.1 %. (See Table 2.)

7 Qualitative examination of the laboratory sample

7.1 Aggregate type

Examine the laboratory sample to ascertain the general character of the aggregate, including its moisture condition, and record the approximate maximum particle size and whether it is natural or crushed. Make preliminary visual estimates of the proportions of constituents of interest.

NOTE The moisture condition of the sample should be a subjective assessment of whether the sample is dry, damp or wet.

Distinguish between natural sand or gravel aggregates, aggregates produced by crushing rock and artificial aggregates and record any observations. When aggregates have been produced in part by the crushing of coarse gravels or boulder deposits, or when aggregates, especially sand, have been produced by blending natural and crushed rock materials, state that the aggregate type is blended (see BS 6100-6.3 for definitions of different types of aggregates).

7.2 Particle description

Describe the general character of the aggregate particles in terms of nominal maximum size, grading, shape and surface texture. Note in particular the presence of any fine material and any particle coatings or encrustations before the sample is wetted.

NOTE 1 Guidance on the terminology used in describing particle shape and surface texture is given in Neville [2].

NOTE 2 To carry out the particle examination and description it may be necessary first to examine the sample as received and then wash it in order to make the required observations and comments.

7.3 Petrographic description

Identify and record the main rock (or mineral) types using the terms and definitions given in appendix A of BS 812-102:1989. When the rock type is uncertain (for example in fine-grained rocks), distinguish the types on the basis of visual appearance including colour, grain size and any other distinctive features. In a polymictic aggregate, when possible, indicate the rock type that is clearly dominant. Consider the petrographic composition in relation to the particle size distribution and state if there is a petrographic differentiation according to particle size.

8 Preparation of the test portions for quantitative evaluation

8.1 General

Quantitative evaluation of the petrographic composition of an aggregate involves selecting test portions from the laboratory sample, sieving the test portions into size fractions and assessing the composition of each size fraction by hand separation and weighing of subsamples, or point-counting in the case of material finer than 1.18 mm. The test portion mass required to achieve a specified relative error depends on the grading and composition of the aggregate under examination. The procedures are designed to give large enough test portions for the relative error of estimates of the proportions of constituents to be $\pm 10\%$ or better when duplicate test portions are examined. If a constituent is present as a small proportion it may be impractical to examine test portions large enough to give a relative error of $\pm 10\%$, and in such circumstances a larger error then has to be accepted.

8.2 Minimum mass of test portion

The test portion mass shall be not less than the minimum mass shown in Table 2 for the size of aggregate being examined.

NOTE The procedures given in annex B include a calculation of the 95 % confidence limits for estimated proportions as a function of the actual proportions found and the actual test portion masses used.

The test portion masses given in Table 2 should lead to a relative error of $\pm 10\%$ for constituents present at a level of 20 %.

If a constituent is present at a level lower than 20 %, and a relative error of $\pm 10\%$ is required, then the test portion mass shall be determined from Figure 1 or from the following equation:

$$M = 0.0002 (100 - P) \frac{(D_{\max})^3}{P} \quad (1)$$

where

M is the minimum mass of each test portion (in kg);

P is the estimated proportion of constituent of interest [in % (m/m)];

$D_{\max}$ is the maximum particle size (in mm).

Example. If a constituent of interest is present at the 2 % level, Figure 1 shows that the test portion mass should be increased by approximately an order of magnitude over that given in Table 2 to achieve the required relative error of $\pm 10\%$.

Table 2 — Minimum mass of each test portion required to give a relative error of $\pm 10\%$ for an estimated proportion of a constituent of interest of 20 %, when using duplicate test portions

Maximum particle size mm	Minimum mass of test portion kg
50	100
40	51
20	6.4
10	0.8

8.3 Oversize material

If the amount of oversized material, in a test portion of either a coarse or aggregate sand, falls outside the grading limits of BS 882, the test portion shall be examined as submitted, without adjusting its grading.

8.4 Fine material in coarse aggregate

Material finer than 5 mm in a coarse aggregate shall not be included in the calculation of the composition of the coarse aggregate. If the composition of such material is required, first separate the coarse and fine fractions of the laboratory sample using a 5.00 mm sieve, then prepare duplicate test portions of the material passing the 5.00 mm sieve and examine in accordance with 9.2.

8.5 “All-in” aggregates

For “all-in” aggregates, first separate the coarse and fine fractions of the laboratory sample using a 5.00 mm sieve, then prepare duplicate test portions of each fraction in accordance with the appropriate procedures for either coarse aggregates or sand given in clause 9.

8.6 Particle petrography in coarse aggregate

If, in exceptional circumstances, it is necessary to determine the proportion of a mineral contained within the particles of a coarse aggregate, then the test portions shall be crushed and a subsample taken from each. At each stage of the crushing and sample reduction procedures the test portion masses shall be not less than that permitted by equation (1). The subsamples shall be examined in accordance with 9.2.

NOTE 1 As an aid in achieving this, use the estimated proportion of the constituent of interest P and draw a line representing equation (1) on log/log paper, with M as one axis and D as the other. This graph may then be used to choose a convenient series of crushing and sample reduction stages, always keeping to the side of the line corresponding to a test portion mass in excess of that given by equation (1).

NOTE 2 All sample reduction or subsampling operations should use recognized methods such as rotary samplers or fractional shovelling.

8.7 Washing and drying of test portions

8.7.1 Wash the test portions with tap water to remove adhering dust and loose particle coatings. Retain a portion of the removed dust for possible future examination and analysis.

NOTE When a test portion is to be analysed for water-soluble salts, retain a portion of the unwashed laboratory sample.

8.7.2 Dry and weigh each test portion.

8.8 Determination of the required masses to be analysed

8.8.1 For coarse aggregates, sieve into size fractions using 50.0 mm, 37.5 mm, 20.0 mm, 10.0 mm and 5.00 mm sieves. Determine the mass of each size fraction m_i in kilograms to an accuracy of 0.1 % (m/m) of the test portion. Calculate the mass of each size fraction for analysis using the method given in annex A.

8.8.2 For sand, sieve into size fractions using 10.0 mm, 5.00 mm, 2.36 mm, and 1.18 mm sieves, and determine the mass of each fraction in grams to 0.1 % of the test portion (m/m).

Calculate the mass of each size fraction for analysis, and the number of points to count in thin sections, using the method given in annex A.

8.8.3 Repeat 8.8.1 or 8.8.2 using the second test portion.

8.8.4 The calculations of required test portion mass given in annex A assume a particle density of 2 600 kg/m³. An appropriate adjustment to the required test portion mass shall be made for aggregates with densities that differ substantially from this value.

NOTE Density variations of less than ± 10 % from 2 600 kg/m³ can usually be neglected.

9 Quantitative examination of a test portion

9.1 Coarse aggregate

9.1.1 From each size fraction take an appropriate sample for analysis (see annex A), hand separate and weigh the constituent rock or mineral varieties, principally on the basis of visual differentiation. Avoid unnecessary subdivisions into groups of purely nomenclatural interest. The rock and mineral names given in appendix A of BS 812-102:1989 shall be used. The use of other terms shall be avoided as far as possible. Descriptive terms, such as the colour and grain size, shall be placed (when needed) in brackets after the rock or mineral name together with any appropriate comments on alteration or weathering. A category “others” may be included provided that a definition or description is given of the materials in it. Ill-defined categories such as “miscellaneous” or “unknown” shall not be used.

9.1.2 Thin sections, when required, shall be made of selected particles of each constituent to verify rock types and investigate very fine-grained constituents and secondary minerals.

When thin sections are not prepared (see note 1) this shall be stated in the test report.

NOTE 1 Thin sections are usually prepared to investigate the composition of the samples. Agreement should be reached between parties when the preparation of thin sections for such a purpose is considered unnecessary.

NOTE 2 If required, the approximate composition of a coarse aggregate by volume may be calculated from the composition determined by mass using published values of relative density for the rock and mineral constituents concerned.