

Aggregates —

Part 9: Guidance on the use of European test method standards

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Foreword

This Published Document has been prepared under the direction of Subcommittee B/502/6, Tests for aggregates. It is one of nine parts that give guidance on the use and application of a series of European Standards for aggregates. These European Standards were prepared by CEN/TC 154, Aggregates, and have been adopted as British Standards. Conflicting British Standards relating to aggregates will be withdrawn at the latest by June 2004.

This part of PD 6682 gives guidance on the use of the following package of European Standards, prepared by CEN/TC 54, that specify test methods for aggregates.

- BS EN 932, *Tests for general properties of aggregates.*
- BS EN 933, *Tests for geometrical properties of aggregates.*
- BS EN 1097, *Tests for mechanical and physical properties of aggregates.*
- BS EN 1367, *Tests for thermal and weathering properties of aggregates.*
- BS EN 1744, *Tests for chemical properties of aggregates.*
- BS EN 13179, *Tests for filler aggregate used in bituminous mixtures.*

This package includes European Standards that supersede conflicting parts of BS 812. The parts of BS 812 that are superseded by European Standards in this package are listed in Annex A and will be withdrawn on 1 June 2004.

NOTE Users of the different parts of BS 812 should contact BSI Customer Services for confirmation of their withdrawal.

Guidance on the other European Standards in the series for aggregates is given in the following parts of PD 6682.

- *Part 1: Aggregates for concrete — Guidance on the use of BS EN 12620.*
- *Part 2: Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas — Guidance on the use of BS EN 13043.*
- *Part 3: Aggregates for mortar — Guidance on the use of BS EN 13139.*
- *Part 4: Lightweight aggregates for concrete, mortar and grout — Guidance on the use of BS EN 13055-1.*
- *Part 5: Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications excluding concrete, mortar and grout — Guidance on the use of BS EN 13055-2.¹⁾*
- *Part 6: Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction — Guidance on the use of BS EN 13242.*
- *Part 7: Armourstone — Guidance on the use of BS EN 13383 (all parts).*
- *Part 8: Aggregates for railway track ballast — Guidance on the use of BS EN 13450.*

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

This Published Document is not to be regarded as a British Standard.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 29 and a back cover.

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¹⁾ Both BS EN 13055-2 and PD 6682-5 are in preparation.

Introduction

This Published Document provides guidance on the use of a package of European Standards specifying test methods for aggregates. The guidance is aimed primarily at potential UK users of the test methods, but will also be of interest to all in the UK associated with the use of aggregates throughout Europe.

Most of the European test methods for aggregates are based on national test methods from European countries, including UK test methods specified in British Standards. This part of PD 6682 gives a description of each of these European test methods along with guidance on their relevance and familiarity to UK users.

Some general features of the European Standards for aggregates are outlined in Clause 2. These features make fundamental changes to the way in which aggregates are specified and tested in the UK. Clauses 3 to 8 give guidance on each of the European test method standards for aggregates, BS EN 932, BS EN 933, BS EN 1097, BS EN 1367, BS EN 1744 and BS EN 13179, with the scope of each European Standard reproduced in full.

For European test methods that are based on British Standards, only a brief description of the test method is given along with guidance about any changes that have been introduced and how they affect UK users. Some of the European test methods are similar, in part or in name, to existing British Standard test methods, however the differences are significant enough to necessitate a more detailed description of the test and how its implementation affects UK users.

For European test methods that are relatively new to the UK and are likely to be widely used in the future, a detailed description of the test methods is given in an attempt to anticipate the effects of the introduction of these new test procedures. Other tests, which are also unfamiliar to UK users but are not likely to be widely used in the UK, are described only for completeness.

1 Scope

This part of PD 6682 gives guidance on the use of each of the European test method standards for aggregates, BS EN 932, BS EN 933, BS EN 1097, BS EN 1367, BS EN 1744 and BS EN 13179. These specify tests for the following properties of aggregates:

- a) general;
- b) geometrical;
- c) mechanical and physical;
- d) thermal and weathering;
- e) chemical;
- f) filler aggregate used in bituminous mixtures.

Additional test methods, specific to particular end uses, are not discussed in this part of PD 6682. These tests are specified in BS EN 13055-1:2002, Annex A and Annex B, for lightweight aggregates for concrete, mortar and grout; BS EN 13055-2:2000²⁾, Annex A and Annex B, for lightweight aggregates for unbound and bound applications; BS EN 13383-2 for armourstone and BS EN 13450:2002, Annex A, Annex C, Annex D, Annex E, Annex F and Annex G for railway ballast.

2 Overview of European Standards specifying test methods for aggregates

2.1 Test sieves

BS EN 932, BS EN 933, BS EN 1097, BS EN 1367, BS EN 1744 and BS EN 13179 specify the use of perforated plate square hole test sieves conforming to ISO 3310-2 for aperture sizes of ≥ 4 mm. For sieves with an aperture size of < 4 mm, they specify the use of woven wire test sieves conforming to ISO 3310-1.

NOTE 1 ISO 3310-1:2000 and ISO 3310-2:1999 are published in the UK as BS 410-1:2000 and BS 410-2:2000.

NOTE 2 The series of European Standards for aggregates specifies sieve size ranges for use in the description of aggregate sizes. Many of these European sieves with an aperture size of ≥ 4 mm are identical to those specified in existing British Standards on aggregates, however some new sieves will be required in the UK because they are not specified in existing British Standards. All British woven wire sieves with an aperture size < 4 mm need to be replaced because all the European sieves with an aperture of < 4 mm differ from those specified in existing British Standards for aggregates.

²⁾ In preparation.

2.2 Aperture sizes of test sieves

BS EN 932, BS EN 933, BS EN 1097, BS EN 1367, BS EN 1744 and BS EN 13179 specify the use of test sieves with aperture sizes ranging from 0.063 mm to 125 mm.

BS EN 933-2 requires that test sieves for aggregate tests are selected from the R 20 series specified in ISO 565. The R 20 series of aperture sizes has a step ratio of consecutive aperture sizes of 1.12.

BS EN 933-2 also requires that particle size distributions include, in addition to any other necessary aperture sizes, appropriate sieves between 0.063 mm and 125 mm with a step ratio of 2. This involves the series: 0.063 mm, 0.125 mm, 0.250 mm, 0.500 mm, 1 mm, 2 mm, 4 mm, 8 mm, 16 mm, 31.5 mm, 63 mm and 125 mm.

2.3 Particle size fraction d_i/D_i

Particle size fractions are specified using the designation d_i/D_i representing the sieve aperture D_i through which all the particles in the fraction pass and the sieve aperture d_i on which they are all retained.

Some of the tests for geometrical properties of aggregates involve a preliminary sorting into size fractions d_i/D_i where $D_i \leq 2d_i$, i.e. single size fractions.

2.4 Fines

The fines content is defined as the percentage by mass that passes the 0.063 mm sieve rather than the 0.075 mm sieve used in current British Standards for aggregates.

2.5 Oven drying temperature

The specified temperature for oven drying of aggregate samples is $(110 \pm 5)^\circ\text{C}$ rather than the current UK practice of $(105 \pm 5)^\circ\text{C}$.

2.6 Drying to constant mass

Constant mass is defined in the European Standards for aggregates as successive weighings, after drying, at least 1 h apart, not differing by more than 0.1 %.

The test procedure for the determination of water content of aggregates, as specified in BS EN 1097-5:1999, Clause 7 includes specific requirements for how to achieve constant mass. However, all of the European test method standards that require the determination of constant mass, state that in many cases constant mass can be achieved after a test portion has been dried for a predetermined time in a specified oven at $(110 \pm 5)^\circ\text{C}$. Test laboratories may determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

3 Guidance on the use of BS EN 932 — Tests for general properties of aggregates

3.1 Guidance on the use of BS EN 932-1 — Methods for sampling

3.1.1 Scope of BS EN 932-1

BS EN 932-1 specifies methods for obtaining samples of aggregates from deliveries, preparation and processing plants including stocks.

The aim of sampling is to obtain a bulk sample that is representative of the average properties of the batch.

The methods specified in BS EN 932-1 are also suitable for obtaining sampling increments that may be tested separately.

Methods to be used for sample reduction are also given.

The methods specified in BS EN 932-1 are based on manual procedures. Mechanical or automatic sampling and sample reduction may also be used. Criteria for the design and the assessment of such equipment are given in BS EN 932-1:1997, Annex A.

The methods specified in BS EN 932-1 are limited to civil engineering purposes.

3.1.2 Summary of method

BS EN 932-1 specifies procedures for sampling from specific types of location, e.g. conveyors, silos, belt and chute discharges, sampling stockpiles, etc., with informative examples of equipment such as sampling scoops, frames, tubes, spears, etc.

BS EN 932-1 also covers the reduction of bulk samples for the production of laboratory samples, nominating rotary sample dividers as the preferred means of sample reduction and giving examples of such dividers for both coarse and fine aggregate sizes. However, operational procedures for the use of rotary sample dividers are included only in BS EN 932-2, which specifies methods for reducing laboratory samples for the production of test portions.

Sample reduction by fractional shovelling and the use of random numbering techniques are also specified in BS EN 932-1. These methods are not specified in the current British Standard for aggregate sampling, BS 812-102.

BS EN 932-1 notes that sampling from stockpiles should, wherever possible, be avoided but includes a method for sampling from flat-topped sampling stockpiles. Guidance on sampling from conical and prismatically shaped stockpiles is given informatively in BS EN 932-1:1997, Annex C.

Guidance on the measurement of sampling variation is given informatively in BS EN 932-1:1997, Annex B. This information provides the user with a procedure that checks whether the number of sampling increments taken is adequate for subsequent test methods.

3.1.3 Relationship to equivalent British Standards

BS EN 932-1:1997 partially supersedes BS 812-102:1989, which will be withdrawn on 1 June 2004.

3.1.4 Implications for the UK

BS EN 932-1 significantly expands on BS 812-102 by covering a wide range of techniques and equipment for sampling aggregates.

BS 812-102, Appendix A gives guidance on petrological description. In the series of European Standards for aggregates, a procedure and terminology for petrographical description is specified in BS EN 932-3.

The description of particle shape and surface texture in BS 812-102 is not included in similar detail in BS EN 932-1, but BS EN 932-3 requires “brief information” to be given about shape, roundness and surface texture of aggregate particles.

3.2 Guidance on the use of BS EN 932-2 — Methods for reducing laboratory samples

3.2.1 Scope of BS EN 932-2

BS EN 932-2 specifies methods for reducing laboratory samples of aggregates to test portions, when the test portion mass is:

- a) specified by a lower limit on the mass;
- b) specified by a tolerance around a target mass;
- c) determined precisely by the requirements of a test method.

3.2.2 Summary of method

Each of the European test method standards for aggregates specifies a quantity of material to be tested (a test portion) in one of three ways listed in 3.2.1. BS EN 932-2 gives methods of preparing test portions to meet each of these different types of test method.

For tests relating to 3.2.1 a), BS EN 932-2:1999, 6.2 specifies a test portion mass yield of 100 % to 150 % of the minimum mass specified by the test method. BS EN 932-2:1999, 6.2 specifies sample reduction by rotary sample divider, riffle box, fractional shovelling or quartering. However, it does not recommend sample reduction by quartering for wide gradings.

For tests relating to 3.2.1 b), BS EN 932-2:1999, 6.3 specifies a test portion mass yield that is within 15 % of the mass specified by the test method. BS EN 932-2:1999, 6.3 specifies sample reduction by rotary sample divider, riffle box or fractional shovelling.

For tests relating to both 3.2.1 a) and b), BS EN 932-2:1999, 6.2 and 6.3 notes that rotary sampling is the preferred procedure for sample reduction.

For tests relating to **3.2.1 c)**, BS EN 932-2:1999, Clause **11** specifies the reduction of laboratory samples by a two-stage process. First using a method specified in BS EN 932-2:1999, **6.2** to produce a subsample in excess of the required mass, followed by a technique to further reduce the subsample to the mass required for the test procedure.

Sample reduction with crushing to reduce the particle size and procedures for obtaining duplicate test portions are also included in BS EN 932-2.

3.2.3 Relationship to equivalent British Standards

BS EN 932-2:1999 partially supersedes BS 812-102:1989, which will be withdrawn on 1 June 2004.

3.2.4 Implications for the UK

BS EN 932-2 specifies, in more detail than existing British Standards, the manner in which laboratory samples are reduced to test portions for use in test methods.

3.3 Guidance on the use of BS EN 932-3 — Procedure and terminology for simplified petrographic description

3.3.1 Scope of BS EN 932-3

BS EN 932-3 specifies a basic procedure for the petrographic examination of aggregates for the purposes of general classification. The procedure is not suitable for the detailed petrographical study of aggregates for specific end uses.

NOTE The examination should be carried out by a qualified geologist (petrographer), with experience of materials used in civil engineering.

This European Standard covers only natural aggregates, sand and gravel or crushed rock aggregate as well as their source materials.

3.3.2 Summary of method

BS EN 932-3 is intended for the general classification of rocks and aggregates rather than detailed petrographic study for specific end uses.

BS EN 932-3 specifies the minimum mass to be “delivered for examination”. BS EN 932-3 also specifies examination methods for both rock and aggregate samples.

For the examination of aggregate samples, BS EN 932-3 specifies that, in addition to petrographic identification, a description of particle shape, roundness and surface texture is required. BS EN 932-3 also specifies that, for aggregate samples, the degree of weathering and the presence of any exterior coating on the surface of the grains shall be noted.

3.3.3 Relationship to equivalent British Standards

BS EN 932-3:1997 partially supersedes BS 812-102:1989, which will be withdrawn on 1 June 2004.

3.3.4 Implications for the UK

BS EN 932-3 expands on the simplified procedure for petrographic description in BS 812-102:1989, Appendix A.

BS EN 932-3 requires “brief information” to be given about the surface characteristics of aggregate particles, though not in similar detail as in BS 812-102:1989, Appendix C.

The series of European Standards for aggregates does not include a method for qualitative and quantitative petrographic examination. BS 812-104 describes such a method and as such will remain in use in the UK.

3.4 Guidance on the use of BS EN 932-5 — Common equipment and calibration

3.4.1 Scope of BS EN 932-5

BS EN 932-5 specifies general requirements for common equipment, calibration procedures and reagents for the testing of the properties of aggregates.

3.4.2 *Summary of method*

BS EN 932-5 is based on, and closely follows, the requirements specified in BS 812-100.

BS EN 932-5, 5.5.2 informatively references the International Organization for Legal Metrology (OILM) classification of weights. BS EN 932-5 adopts the OILM classification of weights for the purposes of calibrating and checking measuring instruments.

3.4.3 *Relationship to equivalent British Standards*

BS EN 932-5:2000 supersedes BS 812-100:1990, which will be withdrawn on 1 June 2004.

3.4.4 *Implications for the UK*

BS EN 932-5 simplifies some of the requirements of BS 812-100 and redefines the method for calibration and the methods for checking ovens and test sieves.

3.5 Guidance on the use of BS EN 932-6 — Definitions of repeatability and reproducibility

3.5.1 *Scope of BS EN 932-6:1999*

BS EN 932-6 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, contrary to what is specified in ISO 5725-1, test portions or test specimens of aggregates are not usually identical to each other.

3.5.2 *Summary of method*

BS EN 932-6 gives definitions of sampling errors, sample reduction errors and testing variations and definitions of repeatability and reproducibility conditions.

Equations that relate repeatability and reproducibility limits to standard deviations are also included.

3.5.3 *Relationship to equivalent British Standards*

BS EN 932-6:1999 supersedes BS 812-101:1984, which will be withdrawn on 1 June 2004.

3.5.4 *Implications for the UK*

The guidance given in BS 812-101, on general aspects of aggregate sampling and testing and on the significance and precision of test results, is not expressed in similar detail in BS EN 932-6.

4 Guidance on the use of BS EN 933 — Tests for geometrical properties of aggregates

4.1 Guidance on the use of BS EN 933-1 — Determination of particle size distribution — Sieving method

4.1.1 *Scope of BS EN 933-1*

BS EN 933-1 specifies a method, using test sieves, for the determination of the particle size distribution of aggregates. It applies to aggregates of natural or artificial origin, including lightweight aggregates, up to 63 mm nominal size, but excluding filler.

NOTE The determination of the grading of fillers is specified in BS EN 933-10.

4.1.2 *Summary of method*

BS EN 933-1 specifies that the test portion is washed to remove fine particles passing a 0.063 mm sieve. After drying, the remaining material is separated on a series of sieves of decreasing aperture sizes and the particle size distribution is calculated from the percentages by mass retained on each sieve.

4.1.3 *Relationship to equivalent British Standards*

BS EN 933-1:1997 supersedes BS 812-103.1:1985, which will be withdrawn on 1 June 2004.

4.1.4 Implications for the UK

The test procedure specified in BS EN 933-1 is based on the traditional UK method of washing and dry sieving, albeit using sieves of a different series.

The requirements of BS EN 933-1 for the minimum test portion masses and the maximum loading limits of sieves are not identical to BS 812-103.1.

In the UK, aggregates are washed by agitating the test portion with water in a container. However, it should be noted that elsewhere in Europe, whilst aggregates are washed in the same way, the washing process is often completed directly on the guarded 0.063 mm sieve rather than decanting only the wash water and suspended fines. Either process is permitted in BS EN 933-1 with a note that overloading and overflowing should be avoided.

4.2 Guidance on the use of BS EN 933-2 — Determination of particle size distribution — Test sieves, nominal size of apertures

4.2.1 Scope of BS EN 933-2

BS EN 933-2 specifies nominal aperture sizes and shape for woven wire cloth and perforated plate in test sieves used for test methods for aggregates.

It applies to aggregates of natural or artificial origin including lightweight aggregates.

4.2.2 Summary of method

BS EN 933-2 does not contain a test method, but sets out requirements for test sieves used in the testing of aggregates. The key BS EN 933-2 requirements are listed below.

- a) Test sieves shall have square apertures.
- b) Sieves with an aperture size of <4 mm shall be woven wire test sieves conforming to ISO 3310-1.
- c) Sieves with an aperture size of ≥ 4 mm shall be perforated plate square hole test sieves and shall conform to ISO 3310-2.

NOTE ISO 3310-1 and ISO 3310-2 are published in the UK as BS 410-1:2000 and BS 410-2:2000 respectively.

A standard set of sieves from the R 20 series specified in ISO 565 is listed. These sieves are required to be included when carrying out a particle size distribution, in addition to any other required sieves.

4.2.3 Relationship to equivalent British Standards

BS EN 933-2:1999 does not supersede any British Standard.

4.2.4 Implications for the UK

The UK practice of using perforated plate square hole sieves rather than woven wire sieves for larger aperture sieves is retained by BS EN 933-2.

NOTE Further guidance on the implications of BS EN 933-2 on sieve use in the UK is given in 2.1.

4.3 Guidance on the use of BS EN 933-3 — Determination of particle shape — Flakiness index

4.3.1 Scope of BS EN 933-3

BS EN 933-3 specifies the procedure for the determination of the flakiness index of aggregate and applies to aggregates of natural or artificial origin, including lightweight aggregates.

The test procedure specified in BS EN 933-3 is not applicable to particle sizes of <4 mm or >80 mm.

4.3.2 Summary of method

Test portions are first sorted by sieving into a specific series of particle size fractions.

Each particle size fraction is then sorted by sieving on a bar sieve with parallel slot openings of a width specified for that particle size fraction.

Flaky particles are those which can pass through the slots in the bar sieve.

The flakiness index is calculated as the sum of the masses of the flaky particles in each size fraction as a percentage of the total mass tested.

4.3.3 Relationship to equivalent British Standards

BS EN 933-3:1997 supersedes BS 812-105.1:1989, which will be withdrawn on 1 June 2004.

4.3.4 Implications for the UK

BS EN 933-3 categorizes a particle as flaky if its minimum dimension is less than half its upper sieve size (D), as defined by the particle size fraction in which it falls. In terms of the BS 812-105.1 definition, this is effectively equivalent to 0.56 of the particle's mean sieve size.

Limits for flakiness index values for coarse aggregates intended for use in concrete or in bituminous mixtures are specified in BS EN 12620 and BS EN 13043 respectively. The flakiness index test specified in BS EN 933-3 produces lower flakiness index values than the test specified in BS 812-105.1, therefore the limits specified for flakiness in BS EN 12620 and BS EN 13043 are lower than those specified in the existing British Standards for concrete and bituminous mixtures, BS 882 and BS 63.

Test equipment for BS 812-105.1 is not suitable for testing in accordance with BS EN 933-3.

4.4 Guidance on the use of BS EN 933-4 — Determination of particle shape — Shape index

4.4.1 Scope of BS EN 933-4

BS EN 933-4 specifies a method for the determination of the shape index of coarse aggregates. It applies to aggregates of natural or artificial origin, including lightweight aggregates.

The test method specified in BS EN 933-4 is applicable to particle size fractions d_i/D_i where $D_i \leq 63$ mm and $d_i \geq 4$ mm.

4.4.2 Summary of method

Test portions are first sorted by sieving into one or more single particle size fractions, dependent upon the grading of the aggregate under test. Size fractions with few particles are discarded.

The length and thickness of particles in each remaining size fraction is assessed and particles with a length (L) to thickness (E) ratio of >3 are separated and weighed. These particles are classified as non-cubical.

The method suggests that most non-cubical particles with an L/E significantly different from 3 can be identified visually and separated from the test portion. However, a particle slide gauge, with jaws set at a ratio of 3 to 1, is to be used when necessary.

The shape index is calculated as the sum of the masses of the non-cubical particles in each size fraction as a percentage of the total mass tested.

4.4.3 Relationship to equivalent British Standards

BS EN 933-4:2000 does not supersede any British Standard.

4.4.4 Implications for the UK

Users of this method of characterizing particle shape in mainland Europe have suggested that shape index values often correlate with values of flakiness index.

The series of European Standards on aggregates give the option to determine the shape index value in accordance with BS EN 933-4, only when required by the aggregate user. However, it is unlikely that requirements for the determination of the shape index value will be specified for end uses in the UK for aggregates conforming to this series of European Standards on aggregates. In addition, UK producers are unlikely to routinely provide test data based on this procedure.

It should be noted that the shape index value measured in accordance with BS EN 933-4 is fundamentally different from the elongation index determined in accordance with BS 812-105.2.

4.5 Guidance on the use of BS EN 933-5 — Determination of percentage of crushed and broken surfaces in coarse aggregate particles

4.5.1 Scope of BS EN 933-5

BS EN 933-5 specifies a method for the determination of the percentage of particles with crushed and broken surfaces in a sample of natural coarse aggregate. It applies to gravel or mixed aggregate containing gravel.

The test method specified in BS EN 933-5 is applicable to particle size fractions d_i/D_i where $D_i \leq 63$ mm and $d_i \geq 4$ mm.

NOTE For aggregate sizes with $D > 63$ mm and/or $d < 4$ mm the test may be carried out on particle size fractions d_i/D_i where $D_i \leq 63$ mm and $d_i \geq 4$ mm.