British Standard

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Specification for aggregates from natural sources for concrete

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Committees responsible for this British Standard

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Association of Consulting Engineers
British Aggregate Construction Materials Industries
British Cement Association
British Geological Survey
British Precast Concrete Federation
British Ready Mixed Concrete Association
British Steel Industry
Building Employers' Confederation
County Surveyors' Society
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Department of Transport
Sand and Gravel Association

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Contents

Foreword

This British Standard has been prepared under the direction of Technical Committee B/502 Aggregates. This edition introduces technical changes but it does not reflect a full review or revision of the standard which will be undertaken in due course. This standard supersedes BS 882:1983, which is withdrawn.

Terminology included in this edition reflects the preliminary work being undertaken on a European Standard, under the auspices of the European Committee for Standardization (CEN), by CEN/TC 154, Aggregates, which will supersede this edition in due course. “Fine aggregate” is replaced by “sand”, which now refers to natural uncrushed, partially crushed and crushed rock material. “Fines” replaces “clay, silt and fine dust” and refers to any solid material passing a 75 μm sieve.

New grading requirements are introduced for coarse aggregates containing 2 mm to 10 mm fractions with the inclusion of limits for material passing a 14 mm sieve. This ensures a reasonable fraction of the aggregate will be retained between the 20 mm and 14 mm sieves and eliminates the anomaly that some nominal 14 mm aggregates previously complied with the 20 mm grading requirements.

Changes in test methods since the 1983 edition are reflected. The difference in results for mechanical properties dependent on the moisture condition of the aggregate is eliminated by linking limits to tests on oven-dry materials.

Another example reflects the change in the test for fines content to the washing and sieving method and limits have been correspondingly increased. Attention is also drawn to the importance of performance characteristics where doubt exists in place of fixing particular limits for fines contents.

The appendices give further consideration to provision of information by the supplier and advice on user concerns. Appendix A is expanded to include provision of information on request from tests in accordance with BS 812 for acid soluble sulphate contents and drying shrinkage. Additionally in several cases the time period is reduced from which test results are to be provided. Appendix B identifies the potential damaging effect of mundic mine waste specifically in Cornwall and Devon. Finally Appendix C includes tighter guideline limits on chloride content in the total combined aggregate whilst stressing the need to calculate the chloride content of the concrete mix from the total of the measured values for each of the constituents.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 9 and a back cover.

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0 Introduction

When specifying aggregates in compliance with this standard, there may be a need to specify or approve certain additional quality requirements or narrower grading limits within one of those inTable 4 for sands, to suit special applications, for example, the production of concrete having an especially fine finish or suitable for very severe conditions of exposure. Certain machine-formed concrete or precast products may also require aggregate gradings outside those given in Table 3, Table 4 and Table 5. In these cases appropriate grading should be agreed between the purchaser and the supplier. When narrower grading limits are required, sands should be obtained from sources which demonstrate from test data no more variability than a grading width (see Appendix A). Guidance is given in Appendix B on special factors to be considered in the selection of aggregates for which limits cannot be specified and determined by testing the aggregate itself in accordance with an accepted method of test. Guidance on chloride content is given in Appendix C.

In general it will not be necessary to test each aggregate for all of the requirements specified in this standard. Consideration of the nature of the aggregate and its source will normally indicate which characteristics will need periodic examination, particularly in respect of those properties for which different requirements are given for specific uses. The suitability of an aggregate for the required use can be assessed initially by reference to data provided by the supplier in accordance with Appendix A.

Some variation in the measured quality of material from any source can be expected due to sampling and testing in addition to the variability of the material itself. Data provided in accordance with Appendix A may not be strictly applicable to the material in a single sample or consignment.

1 Scope

This British Standard specifies the quality and grading requirements for aggregates obtained by processing natural materials for use in concrete. (For lightweight aggregates, see BS 3797.)

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

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

2.1
aggregate
a granular material obtained by processing natural materials

2.2
coarse aggregate
aggregate mainly retained on a 5.0 mm BS 410 test sieve and containing no more finer material than is permitted for the various sizes in this specification.

NOTE Coarse aggregate may be described as gravel (uncrushed, crushed or partially crushed) as defined in **2.2.1**, or as crushed rock as defined in **2.2.2**, or as blended coarse aggregate as defined in **2.2.3**.

2.2.1
gravel

a) **uncrushed gravel**
coarse aggregate resulting from the natural disintegration of rock

b) **crushed gravel**
coarse aggregate produced by crushing gravel

c) **partially crushed gravel**
coarse aggregate produced from a mixture of crushed and uncrushed gravel

2.2.2
crushed rock
coarse aggregate produced by crushing rock

2.2.3
blended coarse aggregate
coarse aggregate produced by the controlled blending of gravel and crushed rock

2.3
sand

aggregate mainly passing a 5.0 mm BS 410 test sieve and containing no more coarser material than is permitted for the various gradings in this specification

NOTE Sand may be described as uncrushed or partially crushed as defined in **2.3.1**, as crushed gravel sand as defined in **2.3.2**, as crushed rock sand as defined in **2.3.3**, or as blended sand as defined in **2.3.4**.

2.3.1
uncrushed or partially crushed sand

a) **uncrushed**

sand resulting from the natural disintegration of rock

b) **partially crushed**

sand produced from a mixture of uncrushed sand and crushed sand resulting from the crushing of associated particles during product processing

2.3.2
crushed gravel sand

sand produced by crushing gravel

2.3.3
crushed rock sand

sand produced by crushing rock

2.3.4
blended sand

sand produced by the controlled blending of two or more of the types of sand defined in **2.3.1**, **2.3.2** or **2.3.3**

2.3.5
fines

any solid material passing a 75 μm BS 410 sieve

2.4
all-in aggregate

aggregate consisting of a mixture of coarse aggregate and sand. It may be produced without separating into coarse and fine fractions, or it may be produced by combining coarse aggregate and sand

2.5
heavy duty concrete floor finishes

concrete made with specially selected aggregate of a hardness, surface texture and particle shape suitable for use as a wearing finish, for floors

2.6
pavement wearing surfaces

concrete made with specially selected aggregate of a hardness, surface texture and particle shape suitable for use in concrete pavements and similar surfaces

3 Sampling and testing

Sampling and testing of aggregates shall be carried out in accordance with the requirements of the appropriate Parts of BS 812.

4 Quality requirements

4.1 General

Aggregate for concrete shall consist of any types of coarse aggregate and/or any types of sand or of all-in aggregate, as defined in clause **2**.

Aggregate supplied as a mixture of different sizes or types shall be proportioned and mixed in such a way as to ensure reasonable consistency.

NOTE Layer loading of lorries with different sizes or types of materials is unlikely to give the required consistency.

4.2 Flakiness index

When determined in accordance with BS 812-105.1, the flakiness index of the combined coarse aggregate shall not exceed 50 for uncrushed gravel and 40 for crushed rock or crushed gravel.

NOTE 1 For special circumstances, e.g. for pavement wearing surfaces, a lower flakiness index may be specified.

NOTE 2 Information on the general factors affecting durability of concrete is given in BS 5328-1 and BS 8110.

4.3 Shell content

When determined in accordance with BS 812-106, the shell content shall not exceed the values given in Table 1.

Table 1 — Limits on shell content

Size	Limits on shell content (%)
Fractions of 10 mm single size, or of graded or all-in aggregate that are finer than 10 mm and coarser than 5 mm	20
Fractions of single sizes or of graded or all-in aggregate that are coarser than 10 mm	8
Aggregates finer than 5 mm	No requirement

4.4 Mechanical properties

When determined in accordance with **6.4** and **7.4** of BS 812-111:1990, the oven-dry 10 % fines value shall not be less than the appropriate value in Table 2. As an alternative to the 10 % fines test, the aggregate impact value may be carried out in accordance with BS 812-112. The oven-dry aggregate impact value shall not exceed the appropriate value given in Table 2.

Table 2 — Limiting values on mechanical properties for different types of concrete

Type of concrete	10 % fines value (min.) kN	Alternatively, aggregate impact value (max.) %
Heavy duty concrete floor finishes	150	25
Pavement wearing surfaces	100	30
Others	50	45

4.5 Acid soluble sulphate content

When requested, the producer shall provide the acid soluble sulphate content of the aggregate determined in accordance with BS 812-118.

NOTE BS 5328-1 and BS 8110-1 give guidance on the acid soluble sulphate content of the concrete from all mix constituents.

Table 3 — Coarse aggregate

Sieve size	Percentage by mass passing BS sieves for nominal sizes							
	Graded aggregates			Single-sized aggregate				
mm	40 mm to 5 mm	20 mm to 5 mm	14 mm to 5 mm	40 mm	20 mm	14 mm	10 mm	5 mm[a]
50.0	100	—	—	100	—	—	—	—
37.5	90 to 100	100	—	85 to 100	100	—	—	—
20.0	35 to 70	90 to 100	100	0 to 25	85 to 100	100	—	—
14.0	25 to 55	40 to 80	90 to 100	—	0 to 70	85 to 100	100	—
10.0	10 to 40	30 to 60	50 to 85	0 to 5	0 to 25	0 to 50	85 to 100	100
5.0	0 to 5	0 to 10	0 to 10	—	0 to 5	0 to 10	0 to 25	45 to 100
2.36	—	—	—	—	—	—	0 to 5	0 to 30

[a] Used mainly in precast concrete products.

4.6 Carbonate content

When requested, information shall be provided on the carbonate content of the coarse aggregates and/or sand determined in accordance with BS 812-104 and/or chemical analysis in accordance with BS EN 196-21. The sample to be used for the BS EN 196 test (the laboratory sample) shall be taken in accordance with the procedure specified in clause **5** of BS 812-102:1989. The carbonate content shall be expressed as equivalent calcium carbonate content in accordance with the recommendations in BRE Special Digest 1.

5 Grading

5.1 Coarse aggregate

When determined in accordance with BS 812-103.1 using test sieves of the sizes given in Table 3, complying with BS 410, full tolerance, the grading of the coarse aggregate shall be within the appropriate limits given in Table 3.

5.2 Sand

5.2.1 *General*

When determined in accordance with BS 812-103.1, using test sieves of the sizes given in Table 4 complying with BS 410, full tolerance, the grading of the sand shall comply with the overall limits given in Table 4. Additionally, not more than one in ten consecutive samples shall have a grading outside the limits for any one of the gradings C, M or F, given in Table 4.

5.2.2 *Heavy duty concrete floor finishes*

For heavy duty concrete floor finishes, the sand shall comply with C or M given in Table 4.

Table 4 — Sand

Sieve size	Percentage by mass passing BS sieve			
	Overall limits	Additional limits for grading		
		C	M	F
10.00 mm	100	—	—	—
5.00 mm	89 to 100	—	—	—
2.36 mm	60 to 100	60 to 100	65 to 100	80 to 100
1.18 mm	30 to 100	30 to 90	45 to 100	70 to 100
600 µm	15 to 100	15 to 54	25 to 80	55 to 100
300 µm	5 to 70	5 to 40	5 to 48	5 to 70
150 µm	0 to 15[a]	—	—	—

NOTE Individual sands may comply with the requirements of more than one grading. Alternatively some sands may satisfy the overall limits but may not fall within any one of the additional limits C, M or F. In this case and where sands do not comply with Table 4 an agreed grading envelope may also be used provided that the supplier can satisfy the purchaser that such materials can produce concrete of the required quality.

[a] Increased to 20 % for crushed rock fines, except when they are used for heavy duty floors.

5.3 All-in aggregate

When determined in accordance with BS 812-103.1 using test sieves of the sizes given in Table 5 complying with BS 410, full tolerance, the grading of all-in aggregate for concrete shall be within the appropriate limits given in Table 5.

Table 5 — All-in aggregate

Sieve size	Percentage by mass passing BS sieves for nominal sizes			
	40 mm	20 mm	10 mm	5 mm[a]
50.0 mm	100	—	—	—
37.5 mm	95 to 100	100	—	—
20.0 mm	45 to 80	95 to 100	—	—
14.0 mm	—	—	100	—
10.0 mm	—	—	95 to 100	100
5.00 mm	25 to 50	35 to 55	30 to 65	70 to 100
2.36 mm	—	—	20 to 50	25 to 100
1.18 mm	—	—	15 to 40	15 to 45
600 µm	8 to 30	10 to 35	10 to 30	5 to 25
300 µm	—	—	5 to 15	3 to 20
150 µm	0 to 8[b]	0 to 8[b]	0 to 8[b]	0 to 15

[a] Used mainly in precast concrete products.
[b] Increased to 10 % for crushed rock sand.

5.4 Fines

When determined in accordance with **7.2.1** of BS 812-103.1:1985, the amount of material passing the 75 µm sieve shall not exceed the quantities given in Table 6.

Table 6 — Fines

Aggregate type	Percentage by mass passing 75 µm sieve (max.)
Uncrushed, partially crushed, or crushed gravel coarse aggregate	2
Crushed rock aggregate	4
Uncrushed, partially crushed or crushed gravel sand	4
Crushed rock sand	16 (9 for use in heavy duty floor finishes)
Gravel all-in aggregate	3
Crushed rock all-in aggregate	11

NOTE The nature of the fines can vary between different aggregates. The limits given above are appropriate for most aggregates found in the UK. Evidence of performance in use or the result of trial mixes may be used to justify the adoption of higher or lower limits.

Appendix A
Information to be provided by the supplier

When requested, the supplier shall provide any of the following information for the purpose of initial assessment of the suitability of an aggregate for a particular use. Test result information shall be determined in accordance with the relevant Parts of BS 812.

a) *Source of supply:*

1) name and location of quarry or pit (grid reference);

2) county or region;

3) for materials dredged from the seas, estuaries or rivers, the address of the wharf at which they were landed.

b) *Aggregate type.*

c) *Typical properties:*

1) shape;

2) surface texture;

3) flakiness index;

4) 10 % fines value;

5) aggregate impact value;

Data provided from test results is to be not more than five years old for properties 1) to 5).

6) carbonate content:
For carbonate content the supplier, on request, shall also provide all available recent test data.

7) particle density;

8) water absorption values;

Data provided from test results is to be not more than one year old for properties 7) and 8).

9) grading;

10) fines;

11) shell content;

12) acid soluble sulphate content;

Data provided from test results is to be not more than 3 months old for properties 9), 10), 11) and 12). The grading of sand is to be described and if the sand is substantially less variable than either C, M or F of Table 4, the supplier may state the grading envelope within which 90 % of test results may be expected to fall.

13) chloride ion content;

Data provided is to be from the most recent series of weekly test results for property 13). If, however, the supplier can show that the typical chloride content of the processed material is less than 0.01 % then annual testing will be sufficient.

14) drying shrinkage.

For aggregate sources in which the aggregate shrinkage is consistently less than 0.05 % the data from the test results are to be no more than 5 years old provided the essential character of the material does not change.

For aggregate sources in which the aggregate shrinkage is consistently 0.05 % or greater, the data from test results is to be no more than 1 year old.

The supplier is to notify the purchaser of any changes in production likely to affect the validity of the information given.

NOTE The time periods given above are not intended to be used for purposes of assessing compliance with this standard.

Appendix B
Special considerations

Reference should be made to the appropriate British Standard code of practice for advice on the quality of aggregate to be specified for making concrete according to its type and use. Particular attention should be given to the following in addition to complying with the appropriate requirements of this standard.

a) If there is reason to suspect the presence of material that could accelerate or retard the hydration of cement to an unacceptable degree or cause undue air entrainment, the possible effects should be determined by performance tests on concrete made with the aggregate in question, unless evidence of general performance is available which is satisfactory to the purchaser. Such tests should be carried out in accordance with the requirements of the appropriate Parts of BS 1881. The details of such concrete tests, including mix proportions, type of cement, type and grading of any reference aggregate, the properties of concrete to be determined, the age of test and criteria of acceptance should be agreed between the purchaser and the supplier before the tests are started.

b) Where appearance is an essential feature of the concrete, aggregates should be selected having regard for their freedom from materials such as iron pyrites or particles of coal that could mar the surface. In such cases the only guide is a knowledge of the source and of similar work that has been carried out with the aggregate in question.

c) No simple tests for the durability and resistance to frost or wear of concrete can be applied; hence experience of the properties of concrete made with the type of aggregate in question and a knowledge of their source are the only reliable means of assessment.

NOTE 1 Advice on alkali-aggregate reaction is given in BS 5328-1, BS 8110-1, Concrete Society Technical Report No. 30 and BRE Digest 330.

NOTE 2 Advice on drying shrinkage is given in BS 5328-1, BS 8110-1 and BRE Digest 357.

NOTE 3 Deterioration of building blocks and some other concrete made using mine waste generally known as mundic has occurred in Cornwall and Devon. This is apparently caused by the instability of some pyritic and/or slaty rock constituents. Further information is given in "Advice on certain unsound rock aggregates in concrete in Cornwall and Devon", Department of the Environment, London, February 1991.

NOTE 4 Advice on the thaumasite form of sulfate attack is given in the BRE Special Digest 1.

d) As no test is available at present for determining clay as an adherent coating or as lumps in aggregate, no limits have been specified at present in this standard.

Appendix C
Guidance on the chloride content of aggregates

Marine aggregates and some inland aggregates can contain chlorides. Chlorides can also be contained in other constituents of concrete. It is the responsibility of the concrete mix designer to calculate the total chloride content of a concrete mix from the chloride contents of the various constituents and to ensure that an appropriate maximum value is not exceeded. Such maximum values are given in BS 5328-1, BS 8110-1 and other relevant codes of practice.

Table 7 gives guidance on chloride contents for combined aggregates for four categories of concrete. The use of combined aggregates within the limits in Table 7 will in most circumstances result in concrete complying with BS 5328-1 and BS 8110-1, but this needs to be confirmed by calculation, using measured chloride values for each of the constituents. Reference is made to combined aggregates because individual aggregates containing levels of chloride in excess of and below those of Table 7 can be blended to produce a combined aggregate having a satisfactory chloride content.

NOTE Information on levels of chloride in marine aggregates is available from suppliers under BACMI/SAGA Marine Dredged Aggregate Certification Scheme.

Table 7 — Limits for chloride content of aggregates

Type and use of concrete	Chloride ion content expressed as percentage by mass of combined aggregate
Prestressed concrete and heat-cured concrete containing embedded metal	0.01
Concrete containing embedded metal made with cement complying with BS 4027	0.03
Concrete containing embedded metal and made with cement complying with BS 12, BS 146, BS 1370, BS 4246, BS 6588, BS 6610 or combinations with ground granulated blastfurnace slag (ggbs) or pulverized-fuel ash (pfa)	0.05
Other concrete	No limit

Publication(s) referred to

BS 12:1996, *Specification for Portland cement.*

BS 146:1996, *Specification for Portland blastfurnace cements.*

BS 410:2000, *Test sieves — Technical requirements and testing.*

BS 812, *Testing aggregates.*

BS 812-102:1989, *Methods for sampling.*

BS 812-103.1:1985*, Method for determination of particle size distribution — Sieve tests.*

BS 812-104:1994*, Method for qualitative and quantitative petrographic examination of aggregates.*

BS 812-105.1:1989*, Method for determination of particle shape — Flakiness index.*

BS 812-106:1985, *Methods for determination of shell content in coarse aggregate.*

BS 812-111:1990, *Methods for determination of ten per cent fines value (TFV).*

BS 812-112:1990, *Methods for determination of aggregate impact value (AIV).*

BS 812-118:1988, *Methods for determination of sulphate content.*

BS 1370:1979, *Specification for low heat Portland cement.*

BS 1881, *Testing concrete.*

BS 3797:1990, *Specification for lightweight aggregates for masonry units and structural concrete.*

BS 4027:1996, *Specification for sulfate-resisting Portland cement.*

BS 4246:1996, *Specification for high slag blastfurnace cement.*

BS 5328, *Concrete.*

BS 5328-1:1997, *Guide to specifying concrete.*

BS 6588:1996, *Specification for Portland pulverized-fuel ash cements.*

BS 6610:1996, *Specification for Pozzolanic pulverized-fuel ash cement.*

BS 8110, *Structural use of concrete.*

BS 8110-1:1997*, Code of practice for design and construction.*

BS EN 196*, Methods of testing cement.*

BS EN 196-21*, Determination of the chloride, carbon dioxide and alkali content of cement.*

Building Research Establishment (BRE) Digest No 330 (revised 1991) — *Alkali aggregate reactions in concrete.*

Building Research Establishment (BRE) Digest No 357 (January 1991) — *Shrinkage of natural aggregates in concrete.*

Building Research Establishment (BRE) Special Digest 1 (August 2001) — *Concrete in aggressive ground.*

Department of the Environment, London — Advice on certain unsound rock aggregates in concrete in Cornwall and Devon (February 1991).

The Concrete Society Technical Report No 30[1)] (October 1987) — Alkali silica reaction, minimising the risk of damage to concrete. Guidance notes and model specification.

[1)] Available from the Concrete Society, Framewood Road, Wexham, Slough SL3 6PJ.

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