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Testing aggregates

Part 3. Methods for determination of mechanical properties

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Association of London Borough Engineers and Surveyors
Department of the Environment (Building Research Establishment)

Natural Environment Research Council—Institute of Geological Science



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Foreword

This British Standard has been prepared, under the authority of the Road Engineering Industry Standards Committee, using metric dimensions as part of the national policy to change to the metric system. BS 812 was first published in 1938 and subsequently revised in 1943, 1951, 1960 and 1967.

Guidance on sampling and testing aggregates, including procedures for assessing the precision of methods of test, is given in BS 812 : Part 101. Other Parts of BS 812 published are as follows.

- Part 102 Methods for sampling
- Part 1 Methods for determination of particle size and shape
- Part 2 Methods for determination of physical properties
- Part 4 Methods for determination of chemical properties.

In this Part of the standard changes have been introduced to simplify the determination of the aggregate abrasion value and to improve the precision of the determination of the polished-stone value by comparing the test value with the polished-stone value of a stone of known stability. The change to rational metric dimensions has affected most of the apparatus detailed in this Part of the standard and the metric sizes of aggregates now regarded as standard may not give the same results as those obtained by earlier methods.

The test for the determination of crushing strength of cylinders cut from rock, included in earlier editions of this standard, has been omitted from this revision because experience has shown the repeatability and reproducibility of the results to be very poor and also because a more reliable assessment of the performance of aggregates can be obtained from the other tests for mechanical

properties.

Information on any other methods of test that are thought suitable for extensive use, or suggestions for improvement of the specified methods, are welcomed and will be considered when it becomes desirable again to revise the standard.

In particular views would be welcomed on the need to retain both the aggregate crushing value and the ten per cent fines value tests. The latter was introduced in 1960 to provide a method which is applicable to all aggregates because the aggregate crushing value may yield anomalous results for softer materials, having values of 30 or higher.

Attention is drawn to the companion standard BS 3681 'Methods for the sampling and testing of lightweight aggregates for concrete'.

The Enderby control stone and the pneumatic tyre used in the method given in clause 10 for determination of the polished stone value are no longer in production. An alternative modified method is therefore given in clause 11 which uses a new control stone and a solid rubber tyre both of which are readily available. In order to improve consistency, supplies of the new control stone are to be obtained from a stockpile held by the Transport and Road Research Laboratory, Old Wokingham Road, Crowthorne, Berks RG11 6AU. Either of the methods given in clauses 10 and 11 may be used and can be expected to give comparable results. The alternative method is basically the same as that given in clause 10 except that some differences have been introduced to accommodate the new control stone and the solid rubber tyre. Clause 10 will be withdrawn as soon as there is evidence that the stocks held by some test laboratories of the Enderby control stone and pneumatic tyre used in that clause have been exhausted. While the addition of the alternative modified method has become urgent because the Enderby control stone and pneumatic tyre used in clause 10 are in short supply, a fuller revision is planned and comments relating to an improved test are invited.

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British Standard

Testing aggregates

Part 3. Methods for determination of mechanical properties

1. Scope

This Part of the standard specifies methods for the determination of the aggregate impact value, aggregate crushing value, ten per cent fines value, aggregate abrasion value and polished-stone value of aggregates.

The tests are intended for use in obtaining assurance that material complies with specified requirements, for research, production control or assessment of variation and are done on certain size fractions

2. References

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

3. Reporting

3.1 General. The report shall affirm that the tests were done in accordance with this standard. Any departure from the specified test procedure shall be described with reasons for the departure and, if possible, estimates of its effect on the test results. The report shall also include details of any special processing of the sample, other than that required by the test methods, carried out in the laboratory. For example, crushing to provide larger quantities of smaller sizes or the separation of constituents from an as-dug gravel.

3.2 Certificate of sampling. The report shall affirm that a certificate of sampling was received with the sample and shall declare all the information given on the certificate. If a certificate was not received this shall be stated in the report.

4. Significance of the results

The distribution of the results of any test on any material stems from a number of contributing factors. In assessing the significance of the results the repeatability and reproducibility of the test should be recognized. Estimates of these are given in appendix A and should be used in assessing test results.

5. General

All the tests in this Part of the standard are carried out on certain size fractions which normally have to be sieved out from the laboratory sample. Where such a fraction constitutes less than 15% of the

total sample the results may not be representative. The aggregate impact test, aggregate crushing test and the ten per cent fines test are likely to be affected to a greater extent than the aggregate abrasion test and polished-stone test where flaky particles are separated in preparing the test sample. Under such circumstances the following recommendations should provide a more representative test sample:

- (a) where general assurance about a given source of aggregate is required a further sample of a different grade and containing more than 15% of the required size should be obtained and tested;
- (b) where a particular consignment is to be tested for impact value, crushing value or ten per cent fines value, a non-standard size should be tested.

In the event of neither of these options proving possible it may be necessary to test the original fraction. The report shall state the fact when a further sample was obtained, when a non-standard size was tested or when the test was made on a fraction containing less than 15% of the laboratory sample.

6. Determination of aggregate impact value

6.1 General. The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slowly applied compressive load. With aggregate of aggregate impact value higher than 30 the result may be anomalous. Also, aggregate sizes larger than 14 mm are not appropriate to the aggregate impact test.

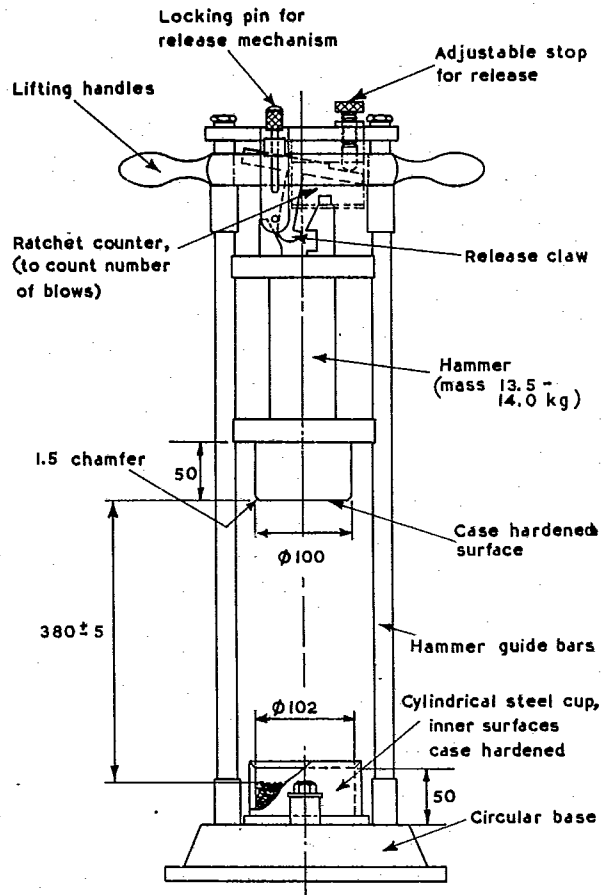
The standard aggregate impact test shall be made on aggregate passing a 14.0 mm BS test sieve and retained on a 10.0 mm BS test sieve. If required, or if the standard size is not available, smaller sizes may be tested but owing to the non-homogeneity of aggregates the results are not likely to be the same as those obtained from the standard size. In general, the smaller sizes of aggregate will give a lower impact value but the relationship between the values obtained with different sizes may vary from one aggregate to another.

6.2 Sampling. The sample for this test shall be taken in accordance with Part 102 of this standard.

6.3 Apparatus. The following apparatus is required.

6.3.1 An impact testing machine of the general form shown in figure 1 and complying with the following.

(a) Total mass not more than 60 kg nor less than 45 kg.



Dimensions are in millimetres

NOTE. As a temporary measure, apparatus complying with the requirements of BS 812 : 1967 (now withdrawn) shall be deemed to comply with this requirement.

Figure 1. Aggregate impact test machine

The machine shall have a circular metal base weighing between 22 kg and 30 kg, with a plane lower surface of not less than 300 mm diameter, and shall be supported on a level and plane concrete or stone block or floor at least 450 mm thick. The machine shall be prevented from rocking either by fixing it to the block or floor or by supporting it on a level and plane metal plate cast into the surface of the block or floor.

(b) A cylindrical steel cup having an internal diameter of 102 mm and an internal depth of 50 mm. The walls shall be not less than 6 mm thick and the inner surfaces shall be case hardened. The cup shall be rigidly fastened at the centre of the base and be easily removed for emptying.

(c) A metal hammer weighing 13.5 kg to 14.0 kg the lower end of which shall be cylindrical in shape, 100.0 mm diameter and 50 mm long, with a 1.5 mm chamfer at the lower edge, and case hardened. The hammer shall slide freely between

vertical guides so arranged that the lower (cylindrical) part of the hammer is above and concentric with the cup.

(d) Means for raising the hammer and allowing it to fall freely between the vertical guides from a height of 380 ± 5 mm on to the test sample in the cup, and means for adjusting the height of fall within 5 mm.

(e) Means for supporting the hammer whilst fastening or removing the cup.

NOTE. Some means for automatically recording the number of blows is desirable.

6.3.2 BS test sieves of aperture sizes 14.0 mm, 10.0 mm and 2.36 mm, for a standard test. For tests on aggregate sizes smaller than the standard, the appropriate aperture sizes of sieves shown in table 1 shall be used (see 7.1.3.1 of Part 1 of this standard).

6.3.3 A cylindrical metal measure of sufficient rigidity to retain its form under rough usage and with an internal diameter of 75 ± 1 mm and an internal depth of 50 ± 1 mm.

6.3.4 A straight metal tamping rod of circular cross section, 10 mm diameter, 230 mm long, rounded at one end.

6.3.5 A balance of capacity not less than 500 g, and accurate to 0.1 g.

6.4 Preparation of the test sample. The material for the standard test shall consist of aggregate passing a 14.0 mm BS test sieve and retained on a 10.0 mm BS test sieve and shall be thoroughly separated on these sieves before testing. For smaller sizes the aggregate shall be prepared in a similar manner using the appropriate sieves given in table 1. The quantity of aggregate sieved out shall be sufficient for two tests.

The aggregate shall be tested in a surface-dry condition. If dried by heating, the period of drying shall not exceed 4 h, the temperature shall not exceed 110°C and the samples shall be cooled to room temperature before testing.

The measure shall be filled about one third full with the aggregate by means of a scoop, the aggregate being discharged from a height not exceeding 50 mm above the top of the container. The aggregate shall then be tamped with 25 blows of the rounded end of the tamping rod, each blow being given by allowing the tamping rod to fall freely from a height of about 50 mm above the surface of the aggregate and the blows being evenly distributed over the surface. A further similar quantity of aggregate shall be added in the same manner and a further tamping of 25 blows given. The measure shall finally be filled to overflowing, tamped 25 times and the surplus aggregate removed by rolling the tamping rod across, and in contact with, the top of the container, any aggregate which impedes its progress being removed by hand and aggregate being added to fill any obvious depressions. The net mass of aggregate in the measure shall be recorded (mass A) and the same mass used for the second test.

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6.5 Test procedure. Rest the impact machine, without wedging or packing, upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

Fix the cup firmly in position on the base of the machine and place the whole of the test sample in it and compact by a single tamping of 25 strokes of the tamping rod as above.

Adjust the height of the hammer so that its lower face is 380 ± 5 mm above the upper surface of the aggregate in the cup and then allow it to fall freely on to the aggregate. Subject the test sample to a total of 15 such blows, each being delivered at an interval of not less than 1 s. No adjustment for hammer height is required after the first blow.

Then remove the crushed aggregate by holding the cup over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cup and the underside of the hammer to the tray by means of a stiff bristle brush. Sieve the whole of the sample in the tray, for the standard test, on the 2.36 mm BS test sieve until no further significant amount passes in 1 min. When testing sizes smaller than the standard separate the fines on the appropriate sieve given in the 'for separating fines' column in table 1.

Weigh the fractions passing and retained on the sieve to an accuracy of 0.1 g (mass *B* and mass *C* respectively), and if the total mass *B* + *C* is less than the initial mass (mass *A*) by more than 1 g, discard the result and make a fresh test.

Repeat the whole procedure starting from the beginning of 6.5 using a second sample of the same mass as the first sample.

6.6 Calculations. The ratio of the mass of fines formed to the total sample mass in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

$$\text{Percentage fines} = \frac{B}{A} \times 100$$

where

A is the mass of surface-dry sample (g);

B is the mass of fraction passing the sieve for separating the fines (g).

6.7 Reporting of results. The mean of the two results shall be reported to the nearest whole number as the aggregate impact value.

If a non-standard size of aggregate is tested, the size shall be reported.

Table 1. Particulars of BS test sieves for testing standard and non-standard sizes of aggregate as described in clauses 6, 7 and 8

Sample size	Nominal aperture sizes of BS test sieves complying with the requirements of BS 410 (full tolerance)		
	for sample preparation passing	retained	for separating fines
Non-standard	mm	mm	mm μm
	28.0	20.0	5.00 –
	20.0	14.0	3.35 –
Standard	14.0	10.0	2.36 –
Non-standard	10.0	6.30	1.70 –
	6.30	5.00	1.18 –
	5.00	3.35	– 850
	3.35	2.36	– 600

NOTE. Aggregate sizes larger than 14.0 mm are not appropriate to the aggregate impact test.

7. Determination of aggregate crushing value

7.1 General. The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. With aggregate of an aggregate crushing value higher than 30 the result may be anomalous, and in such cases the ten per cent fines value (clause 8) should be determined instead.

The standard aggregate crushing test shall be made as described in 7.3 to 7.7 on aggregate passing a 14.0 mm BS test sieve and retained on a 10.0 mm BS test sieve. If required, or if the standard size of aggregate is not available, the test shall be made according to 7.8.

7.2 Sampling. The sample for this test shall be taken in accordance with Part 102 of this standard.

7.3 Apparatus. The following apparatus is required for the standard test.

7.3.1 An open ended steel cylinder of nominal 150 mm internal diameter with plunger and base-plate, of the general form and dimensions shown in figure 2. The surfaces in contact with the aggregate shall be machined and case hardened, or otherwise treated, so as to have a hardness value of not less than 650 HV, in accordance with BS 427, and shall be maintained in a smooth condition.

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7.3.2 A straight metal tamping rod of circular cross section, 16 mm diameter and 450 mm to 600 mm long. One end shall be rounded.

7.3.3 A balance of at least 3 kg capacity and accurate to 1 g.

7.3.4 BS test sieves of sizes 14.0 mm, 10.0 mm and 2.36 mm (see 7.1.3.1 of Part 1 of this standard).

7.3.5 A compression testing machine capable of applying a force of 400 kN and which can be operated to give a uniform rate of loading so that this force is reached in 10 min. The machine shall comply with the requirements of BS 1610 for a grade A or a grade B machine. The machine may be used with or without a spherical seating.

7.3.6 A cylindrical metal measure (optional) for measuring the sample, of sufficient rigidity to retain its form under rough usage and having an internal diameter of 115 mm and an internal depth of 180 mm

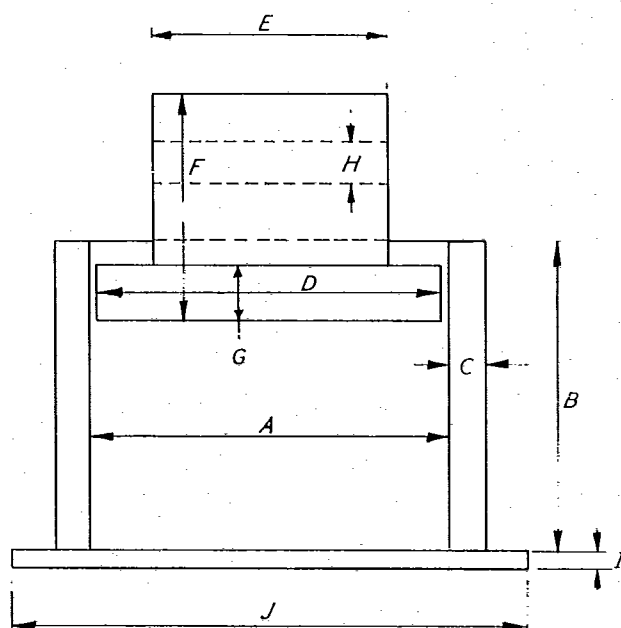
7.4 Preparation of test sample. The material for the standard test shall consist of aggregate passing the 14.0 mm BS test sieve and retained on the 10.0 mm BS test sieve and shall be thoroughly separated on these sieves before testing. The quantity of aggregate sieved out shall be sufficient for two tests

The aggregate shall be tested in a surface-dry condition. If dried by heating the period of drying shall not exceed 4 h, the temperature shall not exceed 110 °C and the aggregate shall be cooled to room temperature before testing.

The quantity of aggregate for one test shall be such that the depth of the material in the cylinder shall be 100 mm after tamping as described in 7.5.

The appropriate quantity may be found conveniently by filling the cylindrical measure in three layers of approximately equal depth, each layer being tamped 25 times from a height of approximately 50 mm above the surface of the aggregate with the rounded end of the tamping rod and finally levelled off, using the tamping rod as a straight edge.

The mass of material comprising the test sample shall be determined (mass *A*).



Key to dimensions

Letter symbol	Dimensions for	Nominal 150 mm internal diameter of cylinder	Nominal 75 mm internal diameter of cylinder
A	Cylinder		
	Internal diameter	mm 154 ± 0.5	mm 78.0 ± 0.5
B	Internal depth	125 to 140	70.0 to 85.0
C	Wall thickness	≤ 16.0	≤ 8.0
D	Plunger		
	Diameter of piston	152 ± 0.5	76.0 ± 0.5
E	Diameter of stem	95 to 155	45.0 to 80.0
F	Overall length of piston plus stem	100 to 115	60.0 to 80.0
G	Depth of piston	≤ 25.0	≤ 19.0
H	Diameter (nominal) of hole	20.0	10.0
I	Baseplate		
	Thickness (nominal)	6	6
J	Length of each side of square	200 to 230	110 to 115

NOTE. As a temporary measure, apparatus complying with the requirements of BS 812:1967 (now withdrawn) shall be deemed to comply with this requirement.

Figure 2. Outline form and principal dimensions of cylinder and plunger apparatus for aggregate crushing test