British Standard

BRITISH STANDARD

BS 812-110: 1990

Testing aggregates —

Part 110: Methods for determination of aggregate crushing value (ACV)

Committees responsible for this British Standard

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

Aggregate Concrete Block Association
Association of Consulting Engineers
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Contents

Foreword

This Part of BS 812 has been prepared under the direction of the Cement, Gypsum, Aggregate and Quarry Products Standards Policy Committee, and is a revision of clause **7** of BS 812-3:1975, which is withdrawn. It forms part of a general revision of the 1975 edition of BS 812. As each of the tests, or collection of tests is revised, it will be issued as a separate Part or Section of this standard.

The method described in this revision has not been changed technically from that given in BS 812-3:1975, but has been amended editorially to align it with other Parts in this series.

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

Some of the tests in other Parts of BS 812 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 extensive testing is justified.

Reference should be made to BS 812-101:1984 for general guidance on testing aggregates, precision of test methods and variance arising from sampling errors.

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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 describes a method for the determination of the aggregate crushing value (ACV) which gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load.

The method is applicable to aggregates passing a 14.0 mm test sieve and retained on a 10.0 mm test sieve. For other size fractions, a recommended method is described in appendix A.

The method is not suitable for testing aggregates with an aggregate crushing value higher than 30, and in such cases the method for ten per cent fines value described in BS 812-111 is applicable.

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 Part of BS 812 the definitions given in BS 812-100, BS 812-101 and BS 812-102 apply.

3 Principle

A test specimen is compacted in a standardized manner into a steel cylinder fitted with a freely moving plunger. The specimen is then subjected to a standard loading regime applied through the plunger. This action crushes the aggregate to a degree which is dependent on the crushing resistance of the material. This degree is assessed by a sieving test on the crushed specimen and is taken as a measure of the aggregate crushing value (ACV).

4 Sampling

The sample used for the test (the laboratory sample) shall be taken in accordance with the procedure described in clause **5** of BS 812-102:1989.

5 Apparatus

NOTE All apparatus should comply with the general requirements of BS 812-100.

5.1 *A steel cylinder,* open-ended, of nominal 150 mm internal diameter with plunger and baseplate of the general form and dimensions shown in Figure 1 and given in Table 1. 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.

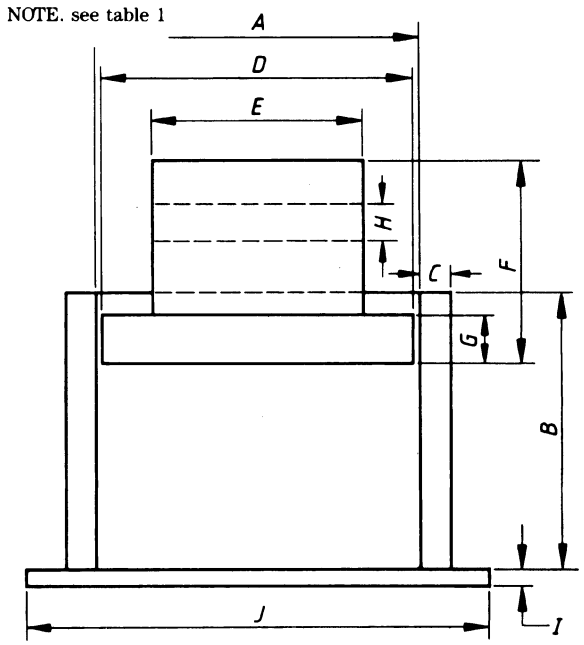

Figure 1 — Outline form of cylinder and plunger apparatus for the aggregate crushing value

Table 1 — Principal dimensions of cylinder and plunger apparatus

Component	Dimensions (see Figure 1)	Nominal 150 mm internal diameter of cylinder	Nominal 75 mm internal diameter of cylinder (see appendix A)
		mm	mm
Cylinder	Internal diameter, *A*	154 ± 0.5	78.0 ± 0.5
	Internal depth, *B*	125 to 140	70.0 to 85.0
	Minimum wall thickness, *C*	16.0	8.0
Plunger	Diameter of piston, *D*	152 ± 0.5	76.0 ± 0.5
	Diameter of stem, *E*	< 95 to ≤ *D*	> 45.0 to ≤ *D*
	Overall length of piston plus stem, *F*	100 to 115	60.0 to 80.0
	Minimum depth of piston, *G*	not less than 25.0	not less than 19.0
	Diameter of hole, *H*	20.0 ± 0.1	10.0 ± 0.1
Baseplate	Minimum thickness, *I*	10	10
	Length of each side of square, *J*	200 to 230	110 to 115

5.2 *A tamping rod,* made out of straight iron or steel bar of circular cross section, 16 ± 1 mm diameter and 600 ± 5 mm long, with both ends hemispherical.

5.3 *A balance,* of at least 3 kg capacity, readable and accurate to 1 g.

5.4 *Test sieves,* with square-hole perforated plate, of sizes 14.0 mm and 10.0 mm and a woven wire 2.36 mm test sieve.The test sieves shall comply with BS 410.

5.5 *A well-ventilated oven,* thermostatically controlled at a temperature of 105 ± 5 °C.

5.6 *A compression testing machine,* capable of applying any force up to 400 kN and which can be operated to give a uniform rate of loading so that this force is reached in 10 min (see **7.2**). The machine shall comply with the requirements of BS 1610 for a grade 1 or a grade 2 machine.The machine may be used with or without a spherical seating.

NOTE Although the maximum force applied to this test is 400 kN it may be more convenient to use a compression testing machine capable of applying any force up to 500 kN as is required for the ten per cent fines test described in BS 812-111.

5.7 *A cylindrical metal measure,* for measuring the test samples, of sufficient rigidity to retain its form under rough usage and having an internal diameter of 115 ± 1 mm and an internal depth of 180 ± 1 mm

5.8 *A rubber mallet.*

5.9 *A metal tray,* of known mass large enough to contain 3 kg of aggregate.

5.10 *A brush,* with stiff bristles.

6 Preparation of test portions and specimens

6.1 Reduce the laboratory sample using the procedures described in clause **6** of BS 812-102:1989 to produce a test portion of sufficient mass to produce three test specimens of 14 mm to 10 mm size fraction.

NOTE A single test specimen is that quantity of material required to fill the cylinder (see **7.1** and Table 2).

Table 2 — Guide to minimum mass of test portions required to obtain a suitable mass of material to determine the aggregate crushing value

Grading of the aggregate	Minimum mass of the test portion[a]
mm	kg
All-in aggregate 40 max. size	60
All-in aggregate 20 max. size	45
Graded aggregate 40 to 5	40
Graded aggregate 20 to 5	25
Graded aggregate 14 to 5	15

[a] For normal density aggregates.

6.2 Thoroughly sieve the entire surface dry test portion on the 14 mm and 10 mm test sieves to remove the oversize and undersize fractions. Divide the resulting 14 mm to 10 mm fraction to produce three test specimens each of mass such that the depth of the material in the cylinder is approximately 100 mm after tamping as described in **7.1** (see note 1).

NOTE 1 The appropriate quantity of aggregate may be found conveniently by filling the cylindrical measure in three layers of approximately equal depth. Tamp each layer 25 times, from a height of approximately 50 mm above the surface of the aggregate, with the rounded end of the tamping rod. Level off using the tamping rod as a straightedge.
NOTE 2 Mechanical sieving should only be used for aggregates which do not degrade under this action.

6.3 Dry the test specimens by heating at a temperature of 105 ± 5 °C for a period of not more than 4 h. Cool to room temperature and record the mass of material comprising the test specimens before testing.

7 Procedure

7.1 Place the cylinder of the test apparatus in position on the baseplate and add the test specimen in three layers of approximately equal depth, each layer being subjected to 25 strokes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface. Take care to ensure that the plunger does not jam in the cylinder.

7.2 Place the apparatus, with the test specimen prepared as described in **6.3** and plunger in position, between the platens of the testing machine and load it at as uniform a rate as possible (see note) so that the required force of 400 kN is reached in 10 min ± 30 s.

NOTE When, during the early stages of the test, there is a significant deformation, it may not be possible to maintain the required loading rate and variations in the loading rate may occur especially at the beginning of the test. These variations should be kept to a minimum with the principal object of completing the test in the overall time of 10 min ± 30 s.

7.3 Release the load and remove the crushed material by holding the cylinder over a clean tray of known mass and hammering on the outside of the cylinder with the rubber mallet until the particles are sufficiently disturbed to enable the mass of the specimen to fall freely on to the tray.

NOTE If this fails to remove the compacted aggregate other methods may be used but take care not to cause further crushing of the particles.

Transfer any particles adhering to the inside of the cylinder, to the baseplate and the underside of the plunger, to the tray by means of a stiff bristle brush. Weigh the tray and the aggregate and determine the mass of aggregate used (M_1) to the nearest gram.

7.4 Sieve the whole of the test specimen on the tray on the 2.36 mm test sieve until no further significant amount passes during a further period of 1 min. Weigh and record the masses of the fractions passing and retained on the sieve to the nearest gram (M_2 and M_3 respectively). If the total mass of the two individual fractions (M_2 plus M_3) differs from the initial mass (M_1) by more than 10 g, discard the result and repeat the complete procedure using a new test specimen.

NOTE 1 In all of the procedures described in **7.3** and **7.4** take care to avoid loss of fines and overloading the sieves.
NOTE 2 Mechanical sieving should only be used for aggregates which do not degrade under its action.

7.5 Repeat the whole procedure described in **7.1** to **7.4** with a second test specimen.

8 Calculation and expression of results

8.1 Calculate the aggregate crushing value (ACV) expressed as a percentage to the first decimal place, of the mass of fines formed to the total mass of the test specimen from the following equation:

$$ACV = \frac{M_2}{M_1} \times 100$$

where

M_1 is the mass of the test specimen (in g);

M_2 is the mass of the material passing the 2.36 mm test sieve (in g).

8.2 Calculate the mean of the two results to the nearest whole number. Report the mean as the aggregate crushing value, unless the individual results differ by more than 0.07 times the mean value. In this case repeat the test on two further specimens, calculate the median of the four results to the nearest whole number, and report the median as the aggregate crushing value.

NOTE The median of four results is calculated by excluding the highest and the lowest result and calculating the mean of the two middle results.

9 Precision

9.1 A precision experiment was carried out involving 14 laboratories. Details of the experiment and the precision data are given in appendix B.

9.2 Uses of precision data are described in clause **5** of BS 812-101:1984.

10 Test report

The report shall affirm that the aggregate crushing value was determined in accordance with this Part of BS 812 and whether or not a certificate of sampling is available. If available, a copy of the certificate of sampling shall be provided. The test report shall contain the following additional information:

a) sample identification and sample description;

b) the aggregate crushing value (ACV).

Appendix A Recommended method for determining the aggregate crushing value of other size fractions

A.1 General

A.1.1 When required, or if the definitive size fraction passing the 14 mm test sieve and retained on a 10 mm test sieve is not available, tests may be made on aggregates of other sizes larger than the definitive size, up to a size which passes a 28.0 mm test sieve, using the apparatus in clause **5**.

Alternatively, tests may be made on aggregates smaller than the definitive size down to a size which is retained on a 2.36 mm test sieve, using either the same apparatus or that described in **A.2** which is referred to as the smaller apparatus.

A.1.2 Owing to the non-homogeneity of aggregates the results of tests on non-definitive size fractions are not likely to be the same as those obtained from standard tests. In general, the smaller sizes of aggregate will give a lower aggregate crushing value and the larger sizes a higher value, and the relationship between the values obtained will vary from one aggregate to another. However, the results obtained with the smaller apparatus have been found to be slightly higher than those with the standard apparatus and the errors for the smaller sizes of aggregate tested in the smaller apparatus are therefore compensatory.

A.2 Apparatus

A.2.1 *General.* The apparatus is either as described in clause **5** or when testing aggregate smaller than 10 mm in particle size, as described in **A.2.2** to **A.2.7**.

A.2.2 *A steel cylinder,* open-ended with plunger and baseplate, generally as described in **5.1** with a nominal internal diameter of 75 mm. The general form of dimensions of the cylinder and of the plunger are shown in Figure 1 and given in Table 1.

A.2.3 *A tamping rod,* made out of straight steel of circular cross section, 8 mm diameter and 300 mm long. One end shall be rounded.

A.2.4 *A balance,* of at least 500 g capacity and accurate to 0.2 g.

A.2.5 *Test sieves,* of appropriate sizes as given in Table 3. The test sieves shall comply with BS 410.

A.2.6 *A compression testing machine,* generally as described in **5.5** except that it shall be capable of applying a force of 100 kN, and of being operated to give a uniform rate of loading so that this force is reached in 10 min (see note to **7.2**).

A.2.7 *A cylindrical metal measure,* generally as described in **5.6** except that it shall have an internal diameter of 57 mm ± 1 mm and an internal depth of 90 mm ± 1 mm.

A.3 Preparation of test portions and specimens

Follow the procedure described in clause **6**, using the appropriate sieves as described in Table 3, according to size of the fraction under test. For a test portion with a grading of less than 10 mm maximum size, a minimum mass of 1 kg is required.

With the smaller apparatus, the quantity of the test specimen is such that the depth of material in the cylinder (**A.2.2**) is 50 mm after tamping with the smaller rod (**A.2.3**).

NOTE The appropriate quantity of the test specimen may be found conveniently by using the smaller measure and tamping rod.

A.4 Procedure

Follow the procedure given in clause **7** except that, when using the smaller apparatus, use the smaller tamping rod and apply the load up to a total force of 100 kN. Take particular care with the larger sizes of aggregate to ensure that the plunger does not jam in the cylinder. Sieve the material removed from the cylinder on the appropriate sieve given for separating fines in Table 3.

A.5 Calculation and expression of results

Follow the general procedure described in clause **8**.

A.6 Test report

The test report shall contain the information specified in clause **10** with additionally, the size of the aggregate tested, and if smaller than the definitive apparatus, the nominal size of the cylinder used in the test.

Table 3 — Particulars of test sieves for testing other size fractions of aggregates

Size fraction	Nominal aperture size of test sieve complying with BS 410			
	For preparation of test specimens		For separating fines	
	Passing	Retained		
	mm	mm	mm	μm
Larger than	28.0	20.0	5.00	—
standard	20.0	14.0	3.35	—
Standard	14.0	10.0	2.36	—
Smaller than	10.0	6.30	1.70	—
standard	6.30	5.00	1.18	—
	5.00	3.35	—	850
	3.35	2.36	—	600

Appendix B Details of the evaluation of precision data

B.1 The precision data given in Table 4 were determined from an experiment conducted in 1989/90 involving 14 laboratories. The experiment was designed, and the data analysed, following the principles set out in BS 5497-1. The materials used were from 4 t stockpiles. Laboratory samples of approximately 125 kg were taken in accordance with BS 812-102, and one laboratory sample of each material was sent to each laboratory. Two test portions were prepared from each laboratory sample for the determination of the aggregate crushing value. (The same materials were also used for the precision experiments recorded in BS 812-111 and BS 812-112).

B.2 The tests for outliers given in BS 5497-1 were applied to the data. No data were found to be outliers.

B.3 Variation due to the preparation of the samples (V_s) in the precision trial may be assumed to be small so that R_1 will be similar to R_2. The definitions of repeatability r_1 and reproducibility R_1 and R_2 and of the variances V_{r1}, V_s and V_L are given in BS 812-101. The values given in Table 4 apply when a test result is obtained as the average of two determinations of the aggregate crushing value on sub-samples of the same test portion, when both determinations comply with the check on the masses given in **7.4**.

Table 4 — Precision values for the determination of aggregate crushing value

Material	Mean value of the data	Repeatability r_1	Reproducibility R_2	$\sqrt{V_{r1}}$	$\sqrt{(V_L + V_S)}$
Argillaceous limestone (A)	27	2.8	6.1	1.0	1.9
Blast-furnace slag (B)	35	0.5	4.2	0.2	1.5
Carboniferous limestone (C)	19	0.8	2.9	0.3	1.0
Igneous rock (I)	16	1.3	3.4	0.5	1.1
Mixed gravel (M)	21	1.5	3.6	0.5	1.2

Publications referred to

BS 410, *Specifications for test sieves.*

BS 427, *Methods for Vickers hardness test.*

BS 427-1, *Testing of metals.*

BS 427-2, *Verification of the testing machine.*

BS 812, *Testing aggregates.*

BS 812-100, *General requirements for apparatus and calibration.*

BS 812-101, *Guide to sampling and testing aggregates.*

BS 812-102, *Methods of sampling.*

BS 812-111, *Methods for determination of the ten percent fines value (TFV).*

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

BS 1610, *Materials testing machines and force verification equipment.*

BS 1610-1, *Specification for the grading of the forces applied by materials testing machine.*

BS 1610-2, *Specification for the grading of equipment used for the verification of the forces applied by materials testing machines.*

BS 5497, *Precision of test methods.*

BS 5497-1, *Guide for the determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.*

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London
W4 4AL