BRITISH STANDARD

BS 812-109: 1990

Testing aggregates —

Part 109: Methods for determination of moisture content

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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Brick Development Association
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Contents

Foreword

This Part of BS 812 has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee, and is a revision of clause **7** of BS 812-2:1975, which is withdrawn by amendment. It forms part of a general revision of the 1975 edition of BS 812. As each of the tests, or collection of related tests, is revised it is intended to issue it as a separate Part or Section of this standard.

In the case of the definitive, oven-drying method for the determination of the moisture content, only editorial changes have been made to the procedure described in the previous edition of clause **7** of BS 812-2:1975. However, in the case of the subsidiary methods, although the modified drying method has been retained under the title of the high temperature method, the siphon-can and buoyancy methods have been omitted as they are rarely used. In their place methods based respectively on the use of a microwave oven and on the reaction of water in the aggregate with calcium carbide have been introduced. These tests are of more limited application than the oven-drying method but are easier to carry out and provide rapid results. In the case of the calcium carbide method, the test procedure has been added as an appendix because of limited availability of information on the apparatus.

It is intended that other British Standards should call up BS 812 test methods as the basis of 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 the relevant test methods.

Reference should be made to BS 812-101 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 the following three methods for the determination of the moisture content of aggregates:

a) oven-drying method (definitive method);

b) high temperature method;

c) microwave-oven method for fine aggregate only.

It also describes the calcium carbide method in appendix A.

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 Principles

3.1 The oven-drying method provides a measure of the total water present in a sample of aggregate and is the definitive procedure. The method comprises placing a test portion in a container and drying it at a temperature of 105 ± 5 °C until it reaches constant mass. Moisture content is determined by difference in mass and expressed as a percentage of the dry mass.

3.2 Three other methods are also included.

NOTE 1 Two of these are based on the use of rapid drying methods and are basically variants of the oven-drying method but certain problems, which are described, may arise with their use which can lead to erroneous results being obtained.

They cannot be regarded as definitive methods, but in favourable circumstances can give adequate results for quality control purposes in a fraction of the time taken by the oven-drying method (see note 2).

NOTE 2 The results of the precision trials described in appendix B showed that the precision of the subsidiary methods for moisture content is not much worse than that of the definitive, oven-drying method. For fine aggregates the subsidiary methods gave similar results to those given by the definitive method, i.e. they did not appear to be biassed. For the slag, the high temperature method showed a tendency to give lower results than the oven-drying method. It is thus important for the subsidiary methods to be calibrated against oven-drying for the full range of materials encountered in practice.

3.3 The third subsidiary method included as appendix A relies on the reaction of water in the aggregate with calcium carbide to evolve acetylene, the amount of which can be assessed by the pressure it generates.

4 Sampling

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

5 Preparation of test portions

Reduce the laboratory sample by the procedures described in clause **6** of BS 812-102:1989 to produce a test portion of mass not less than the mass given in Table 1 appropriate to the nominal size of the aggregate.

Table 1 — Minimum mass of test portion for moisture content determination

Nominal size of aggregate	Minimum mass of test portion
mm	kg
63	15
50	10
40 to 20	5
20 to 10	2
10 to 5	1
less than 5	0.5

NOTE Some loss of water by evaporation is inevitable during sampling and sample reduction. Precautions should be taken to minimize evaporation losses by carrying out all operations as expeditiously as possible and by storing the samples in airtight containers at all intermediate stages.

6 Definitive, oven-drying method

6.1 Apparatus

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

6.1.1 *Balance(s),* of suitable capacity, readable to 0.1 % of the mass of the test portion.

NOTE In general two balances, one of approximately 5 kg capacity readable to 1 g and the other of approximately 500 g capacity readable to 0.1 g will suffice. If aggregate of larger than 40 mm nominal size is to be tested a balance of 25 kg capacity readable to 10 g will also be required.

6.1.2 *Container(s),* airtight, non-corrodible, of capacity suitable to the mass of the test portion.

NOTE If it is more convenient an open top container may be used to cool the test portion using an air-tight cabinet.

6.1.3 *Ventilated oven,* thermostatically controlled to maintain a temperature of 105 ± 5 °C.

6.1.4 *Scoop*

NOTE A convenient size is about 200 mm long and 120 mm wide; see Figure 1 of BS 812-102:1989.

6.1.5 *Means of reducing the laboratory sample,* either a sample divider of size appropriate to the maximum particle size to be handled, or, alternatively a flat shovel and a clean, flat, hard horizontal surface, e.g. a metal tray for use in quartering.

NOTE A suitable divider is the riffle box shown in Figure 2 of BS 812-102:1989.

6.1.6 *Thermometer,* covering the range 100 °C to 110 °C.

6.2 Procedure

6.2.1 Clean a container, with its lid if fitted, dry it and then weigh it (M_1). Place the test portion prepared as described in clause **5** in the container by means of the scoop, replace the lid and re-weigh the whole (M_2).

6.2.2 Remove the lid, place the container, lid, and test portion in the oven and dry at a temperature of 105 ± 5 °C maintaining this temperature until the test portion has reached a constant mass.

NOTE Normally 16 h to 24 h is a sufficient period.

6.2.3 Remove the container and test portion from the oven then either replace the lid or place it in an air-tight cabinet and allow the whole to cool for 0.5 h to 1 h, after which weigh again (M_3).

6.2.4 Carry out and record all weighings to an accuracy of 0.1 % of the mass of the test portion.

6.3 Calculation and expression of results

Calculate the moisture content as a percentage of the dry mass from the following equation.

$$\text{moisture content} = \frac{(M_2 - M_3)}{(M_3 - M_1)} \times 100\ \%$$

where

M_1 is the mass of dry container and its lid in g;

M_2 is the mass of the container, lid, and wet test portion in g;

M_3 is the mass of the container, lid, and dry test portion in g.

Express the value of moisture content to the nearest 0.1 % of the dry mass of the test portion.

NOTE The percentage by wet mass may also be calculated from this method if specifically required. In this case the moisture constant (percentage by wet mass) is calculated from the following equation:

$$\text{moisture content} = \frac{(M_2 - M_3)}{(M_2 - M_1)} \times 100\ \%$$

7 Modified drying methods

7.1 General

When rapid results are required for quality control or other purposes any method of drying which drives off water without affecting the aggregate may be used. However it is essential that temperature in excess of 500 °C be avoided. Flint and slag aggregates tend to spall and calcium carbonate aggregates decompose at high temperatures.

NOTE When modified methods are used for quality control purposes, the tester should be experienced in the interpretation of the test results. The test results may differ from those obtained by the definitive method.

7.2 High temperature method

7.2.1 *Apparatus*

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

7.2.1.1 *Balance,* of adequate capacity and accuracy and of such a type as to permit weighing of the test portion and/or the tray.

7.2.1.2 *Means of heating the test portion,* e.g. a radiant heater or hotplate.

7.2.1.3 *Shallow tray,* suitable for the mass of aggregate being heated.

7.2.1.4 *Spatula,* or other implement for stirring the test portion during drying.

7.2.2 *Procedure*

7.2.2.1 Select the mass of the test portion of aggregate to be tested having regard to the purpose for which the result is required and the consequent need for the test portion to be representative of a bulk quantity. Prepare the test portion in accordance with clause **5**.

NOTE Normally a mass of approximately 1 kg is suitable for coarse aggregates and 0.5 kg for fine aggregates.

7.2.2.2 Weigh the test portion (M_1), place it in the tray and heat it, taking care to ensure that the aggregate does not reach a temperature where spitting or decomposition could occur.

NOTE A convenient method of detecting overheating of the aggregate is by the use of small pieces of white paper mixed with the aggregate. Overheating is indicated if the paper turns brown.

7.2.2.3 During heating stir the test portion frequently with the spatula to ensure even exposure of the aggregate to the air and the source of heat. Keep the spatula in the tray until the test portion is dry to avoid loss of solid material.

7.2.2.4 When the test portion is considered to be dry, cool and weigh it and record the mass. Return it to the tray, heat it again for a further 5 min and reweigh it. The test portion shall be regarded as dry when the difference between consecutive weighings does not exceed 0.1 % of the last recorded mass. Continue the cycles of heating and weighing until this condition is achieved and record the final mass as M_2.

7.2.3 *Calculation and expression of results*

Calculate the moisture content as a percentage of the dry mass from the following equation.

$$\text{Moisture content} = \frac{(M_1 - M_2)}{M_2} \times 100\ \%$$

Express the value of moisture content to the nearest 0.1 % of the dry mass of the aggregate.

NOTE The percentage by wet mass may also be calculated from this method if specifically requested.

7.3 Microwave oven method; normally limited to fine aggregates

NOTE This method is not applicable to some materials (see note 2 to **7.3.2.2**).

7.3.1 *Apparatus*

The apparatus shall be as described in **6.1** except that the oven and airtight non-corrodible containers shall be replaced by a well ventilated microwave oven and non-metal containers of sufficient capacity to hold the mass of the test portion.

NOTE 1 Currently available microwave, ovens are unlikely to have a sufficient capacity to hold the mass of test portions given in Table 1 for coarse aggregates.

NOTE 2 Metal containers cannot be used as they reflect microwaves. Materials such as porcelain and borosilicate glass which heat-up under the influence of microwaves and not just by conduction from the aggregate are preferable; this reduces the possibility of water vapour condensing on the cooler walls of the container before being carried away by air circulation.

7.3.2 *Procedure*

7.3.2.1 Carry out preliminary trials to ascertain the time required to dry the test portions and to establish whether or not the aggregate under test is adversely affected by microwave radiation such as becoming excessively hot.

7.3.2.2 Follow the procedure described in **6.2**. Take note of the fact that as microwave drying is used, the period of drying will vary from that in **6.2**.

NOTE 1 The microwave oven should be used in accordance with the manufacturer's instructions.

NOTE 2 Most siliceous and calcareous aggregates can be dried satisfactorily in a microwave oven but flints, slag and some calcareous aggregates have a tendency to shatter and therefore cannot be tested by the microwave oven method. Materials such as pulverized fuel ash, colliery spoil or aggregates derived from them are not suitable as any carbonaceous matter remaining in them will ignite in the microwave oven.

7.3.3 *Calculation and expression of results*

Calculate the moisture content as described in **6.3** and express the value to the nearest 0.1 % of the dry mass of the aggregate.

8 Precision

8.1 A precision experiment was carried out involving 13 laboratories. Details of the experiment and the precision data obtained are given in appendix B.

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

9 Test report

The test report shall affirm that the moisture content 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 include the following additional information:

a) sample identification;

b) the moisture content as a percentage of the dry mass of the test portion;

c) the method used for the determination of the moisture content i.e. the definitive oven-drying method or whichever of the subsidiary methods was used.

NOTE Normally the subsidiary methods will be used only for site control purposes.

Appendix A Recommendations for determination of moisture content using the calcium carbide method

A.1 General

Calcium carbide will react with water in an aggregate to produce acetylene according to the following equation.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2.$$

If the reaction is allowed to occur under laboratory conditions in a closed container the pressure of acetylene in the container is a measure of the moisture content of the aggregate. This method can be used as a rapid method of determining moisture content of aggregates.

A.2 Apparatus

A.2.1 *Calibrated calcium carbide pressure moisture meter*

NOTE Calcium carbide pressure moisture meters are commercially available and should be calibrated in accordance with the manufacturer's instructions. For information on the availability of this apparatus, apply to Enquiry Section, British Standards Institution, Linford Wood, Milton Keynes, MK14 6LE, enclosing a stamped addressed envelope for reply.

A.2.2 *Balance,* of 2 kg minimum capacity readable to 0.1 g.

A.2.3 *Steel balls,* to aid the mixing process.

A.2.4 *Cleaning brush and a cloth.*

A.2.5 *Scoop,* for measuring the calcium carbide reagent.

A.3 Reagent

A.3.1 *Calcium carbide,* finely pulverized, of a grade capable of producing acetylene gas in the amount of at least 0.15 m^3 per kilogram of carbide.

NOTE The reagent produces a dangerous gas when it comes into contact with water. It should therefore always be stored in an air-tight container and suitable precautions taken when handling it.

A.4 Procedure

NOTE Only a general procedure is given as the test should always be carried out in accordance with the procedure recommended by the manufacturer.

A.4.1 Place the calcium carbide and the steel balls in the larger chamber of the moisture tester.

A.4.2 Take a test portion of the aggregate of known mass (not less than 100 g) and place it in the cap of the tester. With the pressure vessel in an approximately horizontal position, insert the cap in the pressure vessel and seal the unit by tightening the clamp, taking care that no carbide comes into contact with the aggregate until a complete seal is achieved. Then raise the moisture tester to a vertical position so that the aggregate falls into the pressure vessel.

A.4.3 Shake the instrument vigorously in a rotary motion so that the calcium carbide can react with all the available free water. Continue shaking for at least 1 min and leave sufficient time to allow dissipation of the heat generated by the chemical reaction.

A.4.4 When the needle on the pressure dial stops moving read the dial while holding the instrument in a horizontal position at eye level. Record the dial reading.

A.4.5 With the cap of the instrument pointed away from the operator slowly release the gas pressure. Empty the pressure vessel and examine the material for lumps. If the sample is not completely pulverized, repeat the test using a new test portion.

NOTE It is essential that the top of the instrument is pointed away from the operator.

A.5 Calculation and expression of results

The dial reading is the percentage of moisture by wet mass (x). Convert this to the percentage of moisture by dry mass y from the following equation:

$$y = \frac{x}{1 - \left(\frac{x}{100}\right)} \text{ \% \%}$$

where

x is the moisture content as a percentage of the wet mass.

Record the result.

Appendix B Details of the evaluation of the precision data

B.1 The precision data were determined from an experiment conducted in 1988 to 1989 involving 13 laboratories. The experiment was designed, and the data analysed, following the principles set out in BS 5497-1. The moisture content of aggregates is dependent on storage conditions and it would have been difficult to ensure that no loss of moisture occurred between the preparation of the samples and their testing by the participating laboratories. For this reason the precision experiment was confined to the determination of repeatability (r_1) and no attempt was made to measure reproducibility (R_1 and R_2).

B.2 The materials used were from 10 t to 20 t stockpiles. Laboratory samples of approximately 100 kg mass were taken in accordance with BS 812-102, and two laboratory samples were sent to each laboratory. Two test portions were prepared from each laboratory sample for each method of determination of moisture content. The materials were as shown in Table 2.

Table 2 — Materials used in the evaluation of precision data

Materials		Portion
A	Gritstone	20 mm single-size
B	Limestone	40 mm single-size
C	Limestone fines	< 5 mm
D	Flint gravel	5 mm to 20 mm
E	Sand	BS 882 type M
F	Blastfurnace slag	14 mm single-size

Tests with the microwave oven method and the calcium carbide method were confined to the two fine aggregates C and E.

B.3 The tests for outliers given in BS 5497-1 were applied to the data. Three of the 13 laboratories reported one or more results for the definitive oven-drying method which were shown to be outliers by these tests. Four of the 13 laboratories reported one or more results for the high temperature method which were shown to be outliers by these tests. Two of the 9 laboratories which used the microwave oven method reported data which were shown to be outliers. The data for the 10 laboratories that used the calcium carbide method did not contain any outliers. The moisture contents ranged from nearly zero for the coarse aggregates A and B to about 7 % for the sand E.

B.4 The results of the trials are given in Table 3. The definition of repeatability r_1 may be found in BS 812-101. The values given in Table 3 apply when a test result is obtained from applying the test method once to a single test portion.

Table 3 — Precision values for the determination of moisture content

Method	r_1
	%
105 °C oven-drying	$0.11 + 0.079\ \bar{x}$
High temperature	$0.12 + 0.111\ \bar{x}$
Microwave oven	$0.07 + 0.091\ \bar{x}$
Calcium carbide	$0.00 + 0.111\ \bar{x}$
NOTE $\bar{x}$ is the mean of the data.	

B.5 The results of the precision trials showed that the precision of the subsidiary methods for moisture content is not much worse than that of the definitive oven-drying method. For fine aggregates the subsidiary methods gave similar results to those given by the definitive method, i.e. they did not appear to be biased. For the slag, the high temperature method showed a tendency to give lower results than the oven-drying method. This was attributed to the failure of some participants to heat test portions long enough to achieve constant mass.

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Publications referred to

BS 812, *Testing aggregates.*

BS 812-2, *Methods for determination of physical properties*[1)].

BS 812-3, *Methods for determination of mechanical properties*[1)].

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

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

BS 812-102, *Methods for sampling.*

BS 882, *Specification for aggregates from natural sources for concrete.*

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.*

[1)] Referred to in the foreword only.

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