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Corrigendum No. 1

Testing aggregates —

Part 123: Method for determination of alkali-silica reactivity — Concrete prism method

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Committees responsible for this British Standard

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British Geological Survey
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Department of the Environment, Transport and the Regions — Represented by the Building Research Establishment
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Foreword

This British Standard has been prepared under the direction of Technical Committee B/502. It specifies a method for the measurement of expansion of concrete produced by alkali-silica reaction involving specific aggregate combinations, and is based on the measurement of the length change of concrete prisms containing a high level of alkali that are made from the aggregate under test.

This test method was originally published as DD 218:1995, which is withdrawn.

Annex A is informative, annex B is normative and annex C is informative.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 11, a blank page, an inside back cover and a back cover.

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1 Scope

This British Standard specifies a method of measuring the expansion of concrete produced by alkali-silica reaction involving specific combinations of aggregates.

The method is designed as an accelerated laboratory test for a specific combination of aggregates and is not considered to be a performance test for concrete.

NOTE Aggregates are usually tested in the same combination as when they are actually used. When the aggregate combination to be used is not decided, however, the test sample of aggregate is tested in combination with both an inert aggregate and an aggregate geologically similar to itself in proportions specified in the method. This procedure provides a generally satisfactory assessment of the aggregate by accommodating any pessimum value which it may possess.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the cited publication referred to applies.

BS 12, *Specification for Portland cement.*

BS 410, *Specification for test sieves.*

BS 812-2, *Testing aggregates — Part 2: Methods for the determination of density.*

BS 812-100, *Testing aggregates — Part 100: General requirements for apparatus and calibration.*

BS 812-101, *Testing aggregates — Part 101: Guide to sampling and testing aggregates.*

BS 812-102:1989, *Testing aggregates — Part 102: Methods for sampling.*

BS 812-117, *Testing aggregates — Part 117: Method for determination of water-soluble chloride salts.*

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

BS 1881-108:1983, *Testing concrete — Part 108: Method for making test cubes from fresh concrete.*

BS 1881-131, *Testing concrete — Part 131: Methods for testing cement in a reference concrete.*

BS EN 196-6, *Methods of testing cement — Part 6: Determination of fineness.*

BS EN 196-21:1992, *Methods of testing cement — Part 21: Determination of chloride, carbon dioxide and alkali content of cement.*

3 Terms and definitions

For the purposes of this part of BS 812, the terms and definitions given in BS 812-100, BS 812-101 and BS 812-102 apply.

4 Principle

Concrete test prisms are prepared from the aggregate combination under test, and stored for a period of 52 weeks in conditions which would promote any potential alkali-silica reaction. During this time measurements are made at intervals to determine whether any expansion has occurred.

In order to promote the development of any expansive forces and to ensure that slowly reacting aggregates are detected in the 52-week period, the test is accelerated by:

a) formulating the concrete to possess a higher than average cement and alkali content;

b) storing the prisms at high humidity and a comparatively high temperature (38 °C) to increase the rate of the chemical reaction.

NOTE If expansion exceeding an agreed or specified limit is recorded in the test, or atypical expansion is obtained in routine monitoring of an aggregate source, the individual test specimen exhibiting the highest expansion may be examined to confirm that alkali-silica reaction is the main cause of that expansion. Suitable procedures are to be found in *The Diagnosis of Alkali-Silica Reaction* [1].

5 Sampling

The samples of coarse and fine aggregates used for the test (the laboratory samples) shall be taken in accordance with the procedure specified in BS 812-102:1989, clause **5**.

NOTE The recommendations given in BS 812-102 are primarily intended for sampling from a stockpile of aggregate. Where aggregate is being sampled from a quarry it is important to ensure that the samples obtained for use in the test are satisfactorily representative of the sources concerned.

6 Apparatus

6.1 General

All apparatus shall conform to the general requirements of BS 812-100.

6.2 *Sample divider*, of size appropriate to the maximum particle size to be handled, or alternatively, a flat shovel and a clean, flat, hard surface (e.g. a metal tray), for use in quartering.

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

6.3 *Test sieves*, conforming to BS 410, of the size and apertures appropriate to the nominal size of aggregates to be tested.

6.4 *Balance*, of minimum capacity 5 kg, readable to 1 g.

6.5 *Balance*, of minimum capacity 100 g, readable to 0.01 g.

6.6 *Four steel moulds*, with cavities suitable for casting concrete prisms of lengths (250 ± 50) mm. No two cavities shall differ in length by more than 5 mm and the cross-sections shall be (75 ± 2) mm by (75 ± 2) mm. The moulds shall have the facility for casting stainless steel reference studs into the mid-points of the end faces of the prisms.

The reference studs shall be mounted inside the mould before casting the prisms. The studs shall either have smooth conical recesses into which a 6 mm ball may be located, as shown in Figure 1, or shall provide a 3 mm radius hemispherical bearing, as shown in Figure 2.

NOTE The use of stainless steel grade 316 S11, as specified in BS 970-1:1991, or a grade of similar quality, is recommended for the manufacture of reference studs.

6.7 *Length comparator*, incorporating a measuring device with graduations not greater than 0.002 mm and having a maximum error of ±0.002 mm. The arrangement of the comparator and the range of displacement of the gauge shall be such that specimens can be inserted and removed without damage or undue pressure to the prisms, reference studs or measuring device.

NOTE 1 To allow for typical variations of the prisms and the reference rod, a minimum range of displacement of the measuring device of 15 mm is recommended.

The gauge shall be mounted rigidly in a vertical orientation in a stoutly constructed measuring frame.

NOTE 2 An example of a measuring frame incorporating a mechanical gauge is shown in Figure 3. Similar devices utilizing digital or electronic gauges may be used.

Each stud locator of the comparator shall have a stainless steel hemisphere which can be placed into the reference studs in the test prisms. Alternatively, if reference studs which provide hemispherical bearings are used, the comparator shall have recessed conical cups which can be located onto the studs.

NOTE 3 Attention is drawn to the need to ensure the long term stability and accuracy of comparators. In particular, mechanical gauges should be checked for evidence of wear, and electrical gauges for drift.

6.8 *Reference length gauge rod*, with ends machined to match the shape of the reference studs in the prisms. For example, for use with the recessed studs, the rod shall have smooth conical recesses; for studs with the hemispherical bearing, the rod shall have hemispherical ends of 3 mm radius.

The rod shall be made from material which has a coefficient of linear thermal expansion, in the range 0 °C to 100 °C, of not more than 2×10^{-4} % per °C.

NOTE 1 The material known as "Invar" which is a nickel-iron alloy containing about 36 % nickel, has been found to be satisfactory.

NOTE 2 The gauge length of the rod slowly diminishes with time as the contact surfaces wear. It is therefore recommended that a second similar rod be stored for use as a primary standard for periodically checking the regular rod, or for use as a spare if necessary.

The gauge length of the rod shall not differ from the mean gauge length of the four prisms by more than 5 mm.

6.9 *Concrete mixing equipment*, as specified in BS 1881-131.

6.10 *Vibrating table*, as specified in BS 1881-108:1983, **3.3**.

6.11 *Containers*, for maintaining a high relative humidity around the wrapped prisms during storage.

NOTE A suitable design of container is shown in Figure 4.

6.12 *Twill-weave cotton cloth*, (240 ± 30) g/m^2 dry, at least 10 mm wider, but not more than 20 mm wider, than the length of the prisms.

6.13 *Polyethylene lay flat tubing*, 500 gauge, 180 mm wide.

6.14 *Polyethylene bags*, 500 gauge, approximately 500 mm × 250 mm.

6.15 *Temperature-controlled room or cabinet*, capable of being maintained at a temperature of (38 ± 2) °C throughout its storage space.

6.16 *Temperature-recording equipment*, capable of keeping a record of the temperature at one point within the storage facility (see **6.14**).

6.17 *Temperature-controlled room*, capable of being maintained at a temperature of (20 ± 2) °C and at a relative humidity of not less than 50 %.

6.18 *Ventilated oven*, thermostatically controlled at a temperature of (110 ± 5) °C, for drying the aggregate.

6.19 *Nine maximum/minimum thermometers*.

6.20 *Steel rule*, graduated in millimetres.

7 Materials

7.1 *Potassium sulfate*, of analytical reagent quality.

7.2 *High-alkali Portland cement*, with a certified alkali content[1]).

NOTE For testing other than reference and referee testing, cement to the following specification may be used as an alternative to the certified reference cement. Portland cement conforming to BS 12, having a total alkali content, expressed as equivalent sodium oxide (the sum of the contents of Na_2O and 0.658 K_2O), of not less than 0.8 % and not more than 1.0 % as determined in accordance with BS EN 196-21:1992, clause **7** (see **9.3**).

> WARNING Safety precautions should be taken when preparing and handling test prisms made from mixes prepared from Portland cement. In particular, eyes should be protected during all mixing operations and gloves worn during mixing and whenever the test prisms are handled.

7.3 *Deionized water*.

7.4 *Mixing water*, of potable quality.

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[1]) A reference cement with a certified alkali content can be obtained from Building Research Establishment, Garston, Watford, WD2 7JR.

Dimensions in millimetres

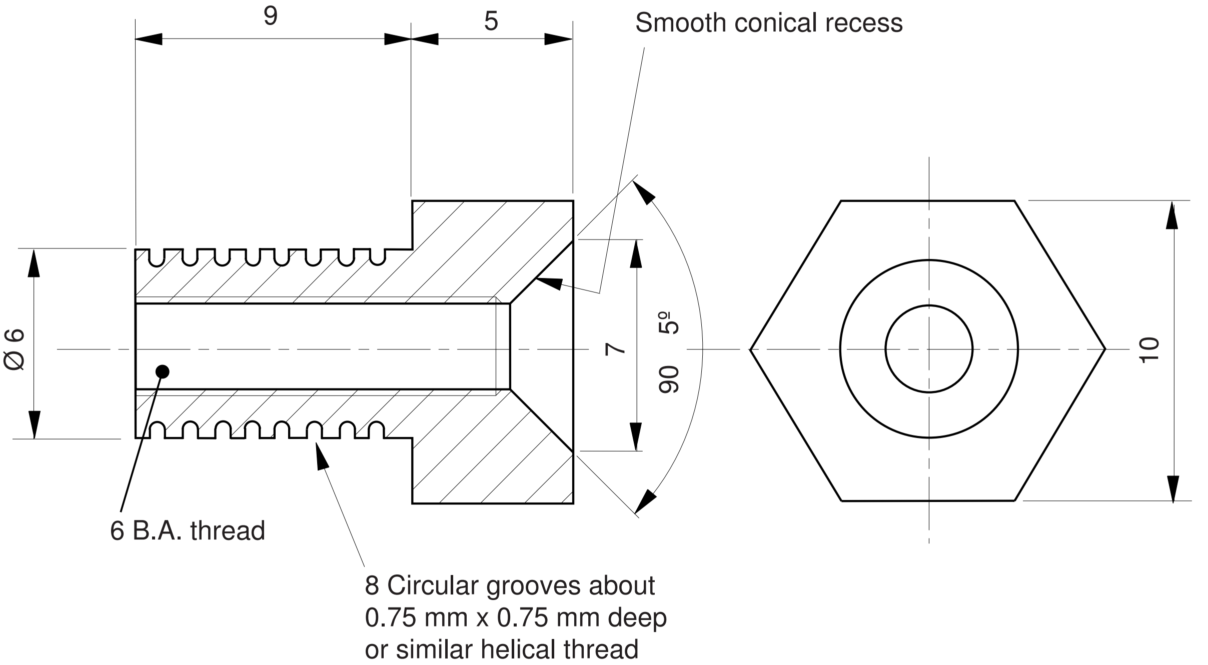

Figure 1 — Example of stainless steel reference stud

Dimensions in millimetres

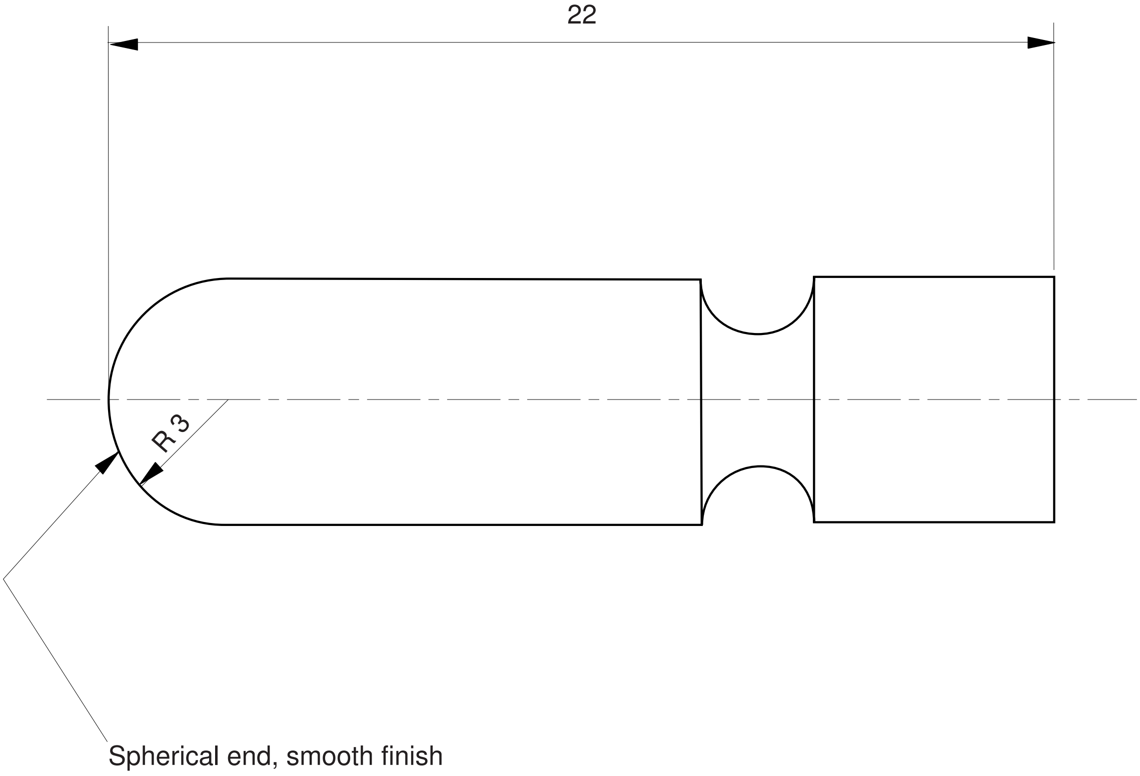

Figure 2 — Example of reference stud providing hemispherical bearing

Dimensions in millimetres

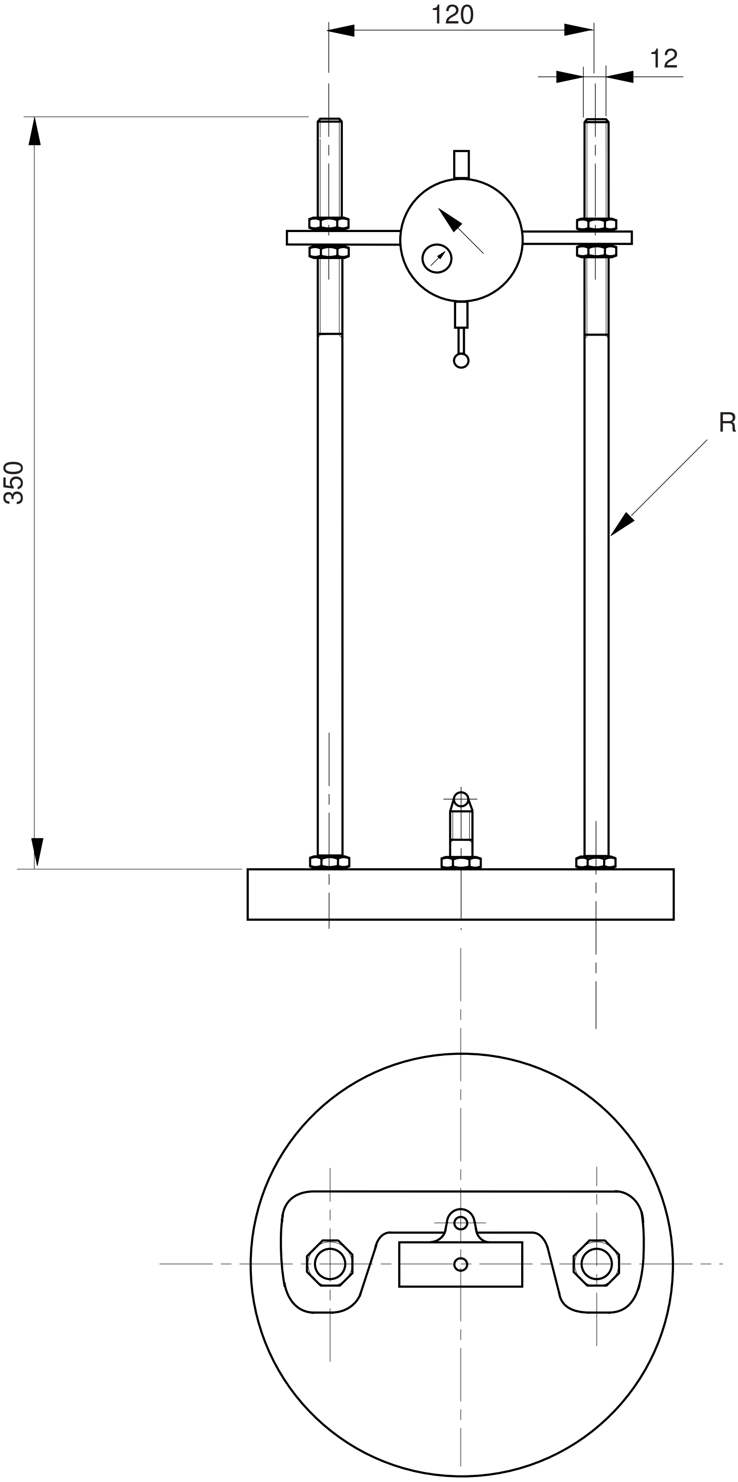

Figure 3 — Example of length comparator

Dimensions in millimetres

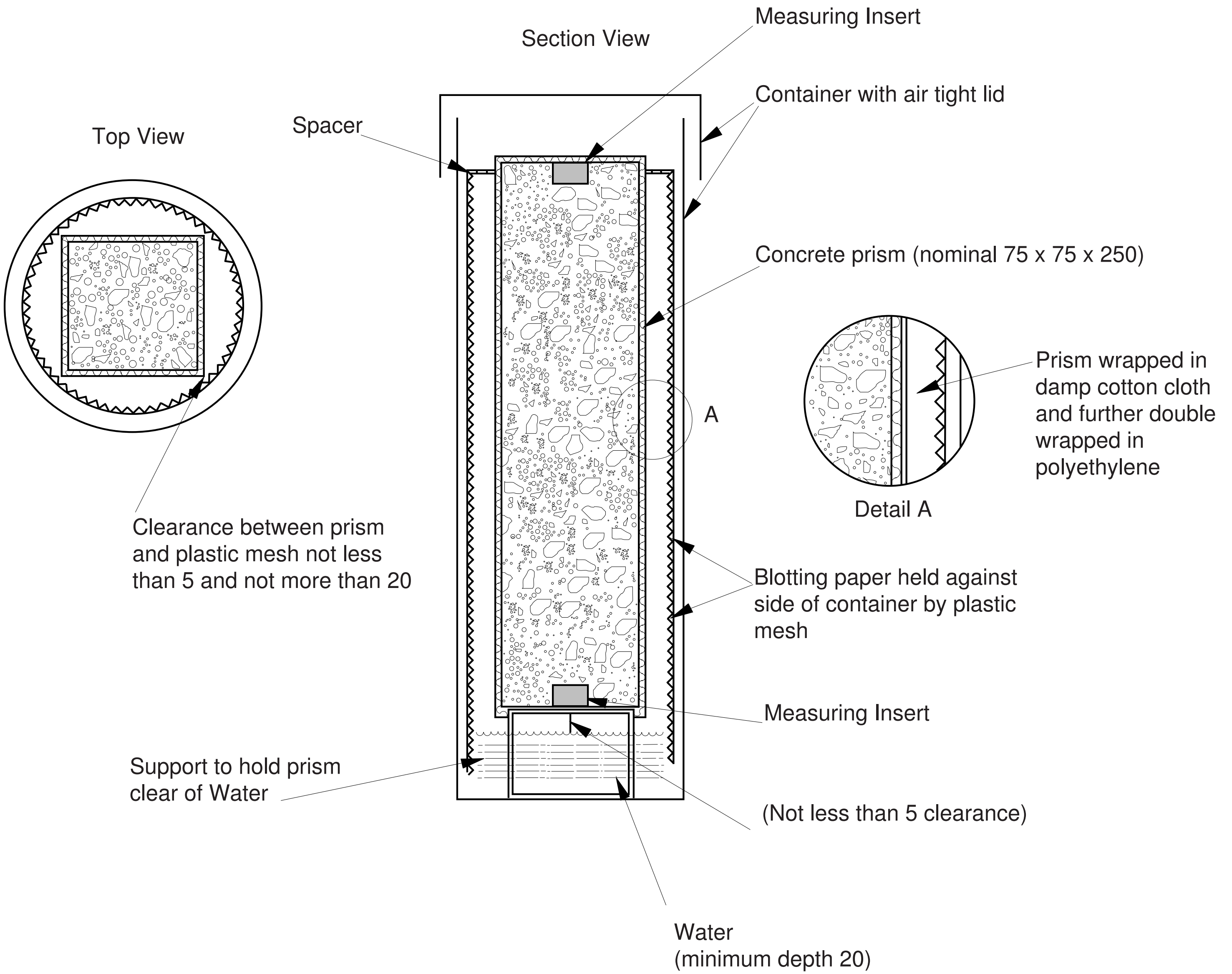

Figure 4 — Container to provide humid environment around concrete prism

8 Preparation of aggregate test portions

8.1 If the chloride ion content of the aggregate, determined in accordance with BS 812-117, exceeds 0.01 %, wash the aggregate test portions twice, in each case using a fresh quantity of deionized water of twice the mass of the aggregate portion. Agitate the aggregate with the first quantity of water for a few minutes, and then decant the water; then soak the aggregate in the second quantity of water for 24 h before decanting and drying. Stir the aggregate at least twice during the soaking period.

8.2 Oven-dry the laboratory samples of aggregate at a temperature of (110 ± 5) °C for (24 ± 2) h.

8.3 Sieve the oven-dried laboratory sample of coarse aggregate into four fractions by means of sieves having apertures of 20 mm, 10 mm, and 5 mm. Weigh each of the four fractions and calculate the percentages of oversized and undersized materials which shall be excluded from the test portions.

NOTE If a submitted aggregate sample contains oversized or undersized materials in excess of the limits given in BS 882, it is recommended that the suitability of the sample be reviewed with the supplier or client, as appropriate, before proceeding with the test.

Reduce the four fractions by the procedure specified in BS 812-102:1989, clause **6**, to produce test portions of > 10 mm aggregate of approximate mass 5 kg, and of < 10 mm aggregate of approximate mass 3.5 kg, plus further portions of 2 kg and 1 kg respectively, for density determination.

8.4 Sieve the oven-dry sample of fine aggregate into two fractions, using a sieve having 5 mm apertures. Weigh each fraction and calculate the percentage oversize.

NOTE If a submitted aggregate sample contains oversized material in excess of the limit given in BS 882, it is recommended that the suitability of the sample as being representative be reviewed with the supplier or client, as appropriate, before proceeding with the test.

Reduce the two fractions by the procedure specified in BS 812-102:1989, clause **6**, to produce a test portion of approximate mass 3.5 kg, plus a further portion of 500 g mass for density determination.

8.5 Determine the relative densities of the aggregates in accordance with BS 812-2. Determine the water absorptions in accordance with BS 812-2, but for the 20 mm to 10 mm fractions and the 10 mm to 5 mm fractions use a value for the water absorbed in 10 min.

The particle densities and water absorptions are determined on aggregate portions which have had the < 63 µm fraction removed by washing.

9 Mix design

9.1 Specific combinations of aggregates

If a specific combination of aggregates (see note 1) is required for a mix design for a particular construction, combine the aggregates in the proportions specified for the construction mix.

If the aggregate proportions are not yet established, use those given in Table 1.

In either case, the mix shall be prepared using the cement and water proportions given in Table 1.

NOTE 1 It is considered unlikely that minor adjustments to the proportions of the fractions of aggregates from the same sources will significantly influence the concrete prism test results. Re-testing is not normally justified when the proportions of aggregates are modified slightly from those originally designed and tested.

NOTE 2 Volume proportions are specified in order to maintain a constant amount of cement (and hence alkali) per unit volume of aggregate when aggregates of different relative density are tested. Allowance for the water absorption of the aggregate is made in order to achieve a constant free water content.

Table 1 — Mix proportions by volume for cement and dry aggregates

Material	Proportion % by volume
Cement	22.2
Coarse aggregates	
< 10 mm	22.0
> 10 mm	16.5
Fine aggregates	16.5
Water (free)	22.8

9.2 Other circumstances

9.2.1 *Fine aggregate*

If only a fine aggregate is supplied for test, test the aggregate in the proportions set out in Table 1 in both the following combinations:

a) in combination with a coarse aggregate from the same or geologically similar source;

b) in combination with a non-reactive coarse aggregate[2].

The grading of a fine aggregate shall be within the grading range appropriate to its normal production for use as a concreting aggregate.

9.2.2 *Coarse aggregate*

If only a coarse aggregate is supplied for test, test the aggregate in the proportions set out in Table 1 in both the following combinations:

a) in combination with a fine aggregate from the same or geologically similar source;

b) in combination with a non-reactive fine aggregate[2].

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[2] Suitable non-reactive, coarse and fine aggregates are available from Building Research Establishment, Garston, Watford, WD2 7JR.

9.3 Adjustment of the alkali content of the mix

9.3.1 Adjust the alkali content of the mix, prepared as specified in clause **11**, by adding potassium sulfate to the mixing water to produce a mix having the same alkalinity as a mix prepared from a cement having an alkali content of (1.00 ± 0.05) % sodium oxide equivalent. Calculate the mass of potassium sulfate required from the formula:

$$M = C \cdot \left(\frac{1-s}{35.56}\right) \qquad (1)$$

where:

M is the mass of potassium sulfate in grams (g), to the nearest 0.01 g;

C is the cement content of the mix in grams (g);

s is the sodium oxide equivalent of the cement, expressed as a percentage.

9.3.2 Record the equivalent sodium oxide content of the cement, and the mass of potassium sulfate added to the mixing water per 100 g of cement.

10 Temperature and humidity conditions

10.1 Use Table 2 to find the correct temperature and humidity of the laboratories and storage chambers used during the test.

Table 2 — Temperature and humidity requirements

Stage	Temperature °C	Relative humidity %
Mixing	20 ± 5	> 50
First 24 h of storage in moulds	20 ± 2	> 90[a]
Demoulding	20 ± 5	> 50
The next 6 days after demoulding	20 ± 2	> 96[b]
From 7 days age to completion of test	38 ± 2	> 96[b]
Length measurements	20 ± 2	> 50

[a] To be achieved by the measures specified in **11.3.**

[b] These values refer to the relative humidity immediately around the prisms and may be achieved by the means specified in clause **12**.

10.2 Keep a record of the temperature at one point within the room or cabinet used for storing the test prisms at (38 ± 2) °C. Use this record to set the controls on the thermostat and heater so that, according to this record, the temperature varies within a range centred on 38 °C, i.e. so that the heater cuts in when the temperature (in °C) falls to $(38 - T_A)$ and cuts out when the temperature (in °C) rises to $(38 + T_B)$. T_A and T_B are each no more than 2 °C, and differ by no more than 0.5 °C.

NOTE 1 Acceptable methods of keeping a record are:

a) a calibrated temperature probe linked to a chart recorder;

b) a calibrated temperature probe linked to a data logger or personal computer that records the maximum and minimum temperature each day;

c) a calibrated maximum/minimum thermometer that is read and re-set on at least three days a week.

NOTE 2 Temperatures outside the tolerance of ±2 °C are allowed for no more than a 48 h period, providing the temperature tolerance is not exceeded by more than ±4 °C. These variations to the procedure cannot be accepted more than four times during a 52-week cycle.

10.3 The temperature distribution of the room or cabinet used for storing the test specimens at (38 ± 2) °C shall be verified at least once a year and after any major repair or replacement of heater elements and/or thermostat. The room or cabinet shall be filled with specimens to at least 50 % of capacity during the verification procedure.

NOTE A suitable procedure is given in annex A. Other procedures may be used provided that it can be demonstrated that they give sufficiently accurate data.

11 Preparation of test prisms

11.1 Proportioning the concrete

Prepare the constituents in accordance with clause **9**, using oven-dried aggregates. Calculate the batch weights (see note) using the values for aggregate relative density [oven-dried at (110 ± 5) °C] and water absorption determined in accordance with **8.5**. If the relative density of the cement is not already known, determine it by the method given in BS EN 196-6.

NOTE For the preparation of four test prisms each measuring 250 mm × 75 mm × 75 mm (see **11.3**) a 7 l mix is needed. A proforma for calculating the batch masses for a 7 l mix is given in annex B.

11.2 Mixing

11.2.1 Add the required amount of potassium sulfate to half the mixing water (see **9.3**), ensuring that all the potassium sulfate is dissolved.

11.2.2 Place the aggregates in the mixing pan, add that half of the mixing water which does not contain the dissolved potassium sulfate, and mix the material for 2 min. Allow the mix to stand for 8 min with the pan covered to minimize evaporation; then re-start the mixer and add the cement gradually during the next 30 s. Add the remainder of the mixing water containing any dissolved potassium sulfate during the next 30 s and mix the concrete for a further 3 min.

11.3 Casting

Cast four test prisms from each mix. Compact the concrete into the moulds in two layers of approximately equal depth, by the method specified in BS 1881-108 for compacting test cubes, using the vibrating table.

After compacting the concrete, smooth the surfaces of the prisms with a trowel and immediately cover the prisms with flat, impervious sheets (e.g. thin rubber, polyethylene, or steel) making contact with the upper edges of the moulds. Place the covered moulds inside a polyethylene bag containing (10 ± 1) ml of water, and close the end of the bag. Cure the bagged prisms for (24 ± 0.5) h in a place free from vibration and in conditions which will prevent loss of moisture, either:

a) in a moist curing room or cabinet with a relative humidity greater than 90 %;

b) wrapped completely with polyethylene or other impervious sheeting, and placed under damp matting or any other suitable material.

NOTE 1 The preferred method of storing prisms during the first 24 h of curing is that described in a).

NOTE 2 It is important to minimize loss of water during this initial hardening stage in order to reduce the risk of shrinkage cracks forming in the specimens.

Whichever method of moist air storage is used, maintain the temperature of the storage room or cabinet at (20 ± 2) °C.

12 Storage and measurement

12.1 On the day that the prisms are cast, place the comparator and its reference rod in the room, maintained at (20 ± 2) °C, in which measurements are to be made. For all subsequent measurements, place the comparator and its reference rod in the measuring room the day before measurements are to be made in order to allow the instruments to assume the temperature of the room's atmosphere. Carry out all measurements on the prisms at a temperature of (20 ± 2) °C.

12.2 Demould the prisms at (24 ± 0.5) h. Designate one end of each prism as the top and mark this end with a number for identification. Keep this end uppermost during all subsequent measurements. Immediately examine each prism and record any signs of plastic shrinkage cracks, or any other defects. Measure the length of each prism to the nearest 1 mm with a steel rule, and record these as the initial lengths l_a, l_b, l_c and l_d.

12.3 Immediately after measuring the initial lengths of the prisms, take a comparator reading on each prism by the following method.

Clean the ends of the reference rod and the contact surfaces of the comparator. Mark one end of the rod. Place the rod in the comparator with the marked end uppermost, slowly rotate the rod, and record the minimum reading of the gauge to the nearest 0.002 mm. Take this as the initial reference reading, r_0.

NOTE If a digital electronic device with a zeroing facility is used, there is no need to record any reference readings, r_0 etc.

Clean the prisms' reference studs and then place each prism in turn in the comparator. Slowly rotate the prism and record the minimum reading of the gauge to the nearest 0.002 mm. Take this as the reading for the prism, a_0. Similarly, determine the gauge readings b_0, c_0, and d_0 respectively for the other three prisms.

Calculate the difference between the readings a_0 and r_0 and take this as the initial measurement A_0 of the first prism. Similarly calculate the initial measurements B_0, C_0, and D_0 of the other three prisms.

12.4 For each prism, cut a piece of the cotton cloth 640 mm long and 10 mm wider than the length of the prism. Saturate each cloth with deionized water (typically 80 ml is required for a cloth 260 mm wide) and wrap one piece around the four large faces of each prism in two layers. Place the wrapped prisms into single pieces of the polyethylene tubing cut to the same length as the prisms. Smooth each tube around the cloth and secure with stout rubber bands.

NOTE No wrapping is applied to the end faces of the prisms.

Place the wrapped prisms in polyethylene bags. Pour 5 ml of deionized water over the upper end face of each prism and seal the bags. Place each bagged prism in a container (see **6.10**) and ensure that it contains water to a depth of at least 20 mm. Store at (20 ± 2) °C until the next measurement, which shall be at seven days after mixing.

12.5 When the 7-day measurements are due, remove each prism from its polyethylene bag, but leave the wrapping and rubber bands undisturbed. Clean the reference studs and take comparator readings on the reference rod and the four prisms by the procedures given in **12.3**. Record the readings r_1 from the reference rod, and a_1, b_1, c_1 and d_1 from the prisms at 7 days. Calculate the 7-day measurements A_1, B_1, C_1 and D_1 from the difference between r_1 and the four prism readings.

12.6 Immediately after each measurement replace the wrapped prism in its polyethylene bag. Pour 5 ml of deionized water over the upper end of the prism before sealing the bag. Check that there is at least the 20 mm minimum depth of water in the containers and place the bagged prisms inside. Fit the caps. Store the containers in the cabinet or room maintained at (38 ± 2) °C, until the prisms are required for further measurement.

12.7 24 h before making further measurements (see **12.8**), remove the prisms, inside their containers, from the room or cabinet and allow them to cool to (20 ± 2) °C.

When the prisms are returned to the storage room or cabinet, their positions shall be changed according to a cycle that ensures that each prism is moved from top to bottom, from side to side, and from front to back of the room or cabinet during the 52 weeks of storage.

12.8 At the end of periods two weeks, four weeks, 13 weeks, 26 weeks, 39 weeks and 52 weeks after mixing (see notes), remove the prisms from their containers and take comparator readings on the reference rod and the four prisms by the procedures given in **12.3**. Re-bag and store the prisms as described in **12.6**. Record the readings r_2, a_2, etc. and r_4, a_4, etc. for 2 weeks and 4 weeks respectively, and so on. Calculate the corresponding measurements A_2, B_2, etc. and A_4, B_4, etc.

NOTE 1 If measurements are to be continued beyond 52 weeks, intervals between successive measurements should not exceed 13 weeks, except for the tolerance allowed in note 2.

NOTE 2 The casting day should be chosen so that readings can be made precisely at 7 days and at 2 weeks after casting. Subsequent readings can, exceptionally, vary from the set date by up to 2 days.

NOTE 3 Maintenance of a consistently high humidity within each concrete specimen is critical to obtaining good reproducibility in this test method. It is important therefore that the measurement of each prism is carried out without delay, so that the wrapped prisms are outside their sealed bags for the shortest possible time, thus avoiding excessive drying from the bare end faces.

NOTE 4 If the mean expansion of the prisms between 39 weeks and 52 weeks is greater than 0.010 % of initial measurement, they should continue to be stored under the stipulated conditions and comparator readings should be taken after a further 13 weeks. This procedure should be repeated every 13 weeks until the mean expansion between successive readings is less than 0.010 %, or until an agreed mean cumulative expansion of the four prisms is exceeded.

12.9 Should any prism, when measured in the comparator, show a shrinkage relative to its initial reading at 24 h, that prism shall be discarded and all its readings disregarded. If two prisms show such shrinkage at any stage or stages, all four prisms shall be discarded and the test repeated.

13 Calculation and expression of results

Calculate the increase in length of each prism for each period of measurement, from the difference between A_0, B_0, etc. and the appropriate values, A_n, B_n, etc. where n is 1, 2, 4, 13, etc.. Calculate and report each difference as a percentage of the initial length of the corresponding prism to the nearest 0.01 %. For example, at 4 weeks age the percentage length change h_{a4} of the first prism is given by:

$$h_{a4} = \frac{A_4 - A_0}{l_a} \times 100 \qquad (2)$$

where:

A_4 is the comparator measurement of the prism at 4 weeks age;

A_0 is the initial comparator measurement of the prism;

l_a is the initial length of the prism.

Record this length change to the nearest 0.01 %.

Also calculate the mean length change of the four prisms for each measurement age. For example, at 4 weeks age the mean percentage length change m_4 is given by:

$$m_4 = \frac{h_{a4} + h_{b4} + h_{c4} + h_{d4}}{4} \qquad (3)$$

where h_{a4}, h_{b4}, h_{c4} and h_{d4} are the percentage length changes of the four prisms at 4 weeks age.

Record this mean length change to the nearest 0.005 %.

NOTE Estimates of the repeatability and reproducibility of this method and of the variability due to sampling are given in annex C.

14 Test report

The report shall affirm that the test for measuring the expansions produced by alkali-silica reaction was carried out in accordance with this British Standard and whether or not a certificate of sampling of the fine and/or coarse aggregates used is available. If available, a copy of the certificate shall be provided. The test report shall contain the following additional information:

a) the date of manufacture of specimens;

b) the origin, identification and date of sampling (if available) of aggregates and cement;

c) the aggregate combination tested and proportions by mass of aggregates;

d) details of the amounts, if any, of oversized or undersized materials rejected;

e) the chloride content of the aggregate;

f) the equivalent alkali content of the cement and the amount of potassium sulfate added per 100 g of cement;

g) the percentage length change of each of the four specimens at each measuring age;

h) the mean length change for the set of four specimens, to the nearest 0,005 %;

i) any noteworthy changes in the appearance of the specimens, such as cracking or surface deposits, and the ages at which they were first observed.

If only a fine aggregate or only a coarse aggregate has been tested, give the following information for items g) and h):

1) the percentage length change of all eight specimens at each measuring age;

2) the mean length change of the four specimens containing aggregate from the same or geologically similar source, to the nearest 0.005 %;

3) the mean length change of the four specimens containing the non-reactive aggregate, to the nearest 0.005 %.

Annex A (informative)

Procedure for checking the uniformity of the temperature within the room or cabinet used for storing the test prisms at (38 ± 2) °C

The procedure requires nine calibrated maximum/minimum thermometers.

One of these (thermometer A) should be located close to the sensor of the device used in **10.2** to keep a temperature record.

Four should be located in the upper one-third of the usable space, and four in the lower one-third of the usable space. Each should be at least 75 mm from the sides of the room or cabinet.

Re-set the maximum/minimum indicators, then leave the nine thermometers in position for 24 h.

The room or cabinet should be considered to have a satisfactory temperature profile if, after this period:

a) no thermometer gives a minimum reading more than 2 °C below the minimum reading on thermometer A;

b) no thermometer gives a maximum reading more than 2 °C above the maximum reading on thermometer A.

Annex B (normative)

Proforma for calculating batch masses

Table B.1 gives a proforma for calculating batch weights for a concrete mix from volume proportions. A 7 l mix is used as an example in this table.

Table B.1 — Proforma for calculating batch masses for a 7 l concrete mix from volume proportions

Material	Volume of material in mix	Volume for 7 l mix	Relative density[a]	Batch masses for 7 l mix	Water absorption	Absorbed water for 7 l mix
	%	l		G	%	g
Cement	22.2	1.554	D_c	$M_c = D_c \times 1\ 554$		
Aggregate: 20 mm to10 mm (nominal)	22.0	1.540	D_{20}	$M_{20} = D_{20} \times 1\ 540$	A_{20}	$W_{20} = \dfrac{M_{20} \times A_{20}}{100}$
Aggregate: 10 mm to 5 mm (nominal)	16.5	1.155	D_{10}	$M_{10} = D_{10} \times 1\ 155$	A_{10}	$W_{10} = \dfrac{M_{10} \times A_{10}}{100}$
Aggregate: fine	16.5	1.155	D_s	$M_s = D_s \times 1\ 155$	A_s	$W_s = \dfrac{M_s \times A_s}{100}$
Free water	22.8	1.596		1 596		
Total absorbed water						$W_{20} + W_{10} + W_s$
Total added water				$1\ 596 + W_{20} + W_{10} + W_s$		

Key

D_c	is the density of the cement (g/cm^3), determined in accordance with BS EN 196-6:1992;
D_{20}	is the relative density on an oven-dry basis of 20 mm to 10 mm aggregate, determined in accordance with BS 812-2:1995;
D_{10}	is the relative density on an oven-dry basis of 10 mm to 5 mm aggregate, determined in accordance with BS 812-2:1995;
D_S	is the relative density on an oven-dry basis of fine aggregate, determined in accordance with BS 812-2:1995;
M_c	is the total batch weight for the cement (g);
M_{20}	is the total batch weight for 20 mm to10 mm aggregate (g);
M_{10}	is the total batch weight for 10 mm to 5 mm aggregate (g);
M_S	is the total batch weight for fine aggregate (g);
A_{20}	is the percentage water absorption on a mass basis of 20 mm to 10 mm aggregate;
A_{10}	is the percentage water absorption on a mass basis of 10 mm to 5 mm aggregate;
A_s	is the percentage water absorption on a mass basis of fine aggregate;
W_{20}	is the mass of absorbed water for 20 mm to 10 mm aggregate (g);
W_{10}	is the mass of absorbed water for 10 mm to 5 mm aggregate (g);
W_s	is the mass of absorbed water for fine aggregate (g).

[a] The density value used for cement is the particle density (g/cm^3).

Annex C (informative)

Precision

C.1 The precision data given in Table C.1 were determined from an experiment conducted in 1991 to 1992, involving 12 laboratories. Each laboratory was provided with two laboratory samples of each aggregate fraction, and made two concrete batches using each laboratory sample, and two prisms from each concrete batch (i.e. they tested eight prisms for each aggregate combination). The aggregate combinations tested were:

X Chert fine aggregate from south-west England + limestone coarse aggregate;

Y Trent Valley fine and coarse aggregates;

Z Thames Valley fine and coarse aggregates.

The reference cement specified in **7.2** was used for all the tests. The prisms were stored at 38 °C and tested after 52 weeks.

C.2 The data for aggregate combination Z from two laboratories contained outliers which were excluded from the calculation of repeatability and reproducibility.

C.3 The repeatability limits r_0 and r_1 (as defined in Table C.1) which are to apply to expansion measurements (%) at ages earlier than 52 weeks may be calculated from the following equations:

$$r_0 = 0.40\,E$$

$$r_1 = 0.17\,E + 0.003$$

where

E is the average of the percentage expansions to which the limits are to be applied.

NOTE Modifications to the procedures have been made since these precision data were determined. The precision data given do not apply to the modified test described in this British Standard, which should yield significantly improved reproducibility.

Table C.1 — Precision of the determination of the expansion of concrete prisms

Aggregate combination	Number of laboratories	Average expansion %	Repeatability[a]		Reproducibility[a]	
			r_0 %	r_1 %	R_1 %	R_2 %
X	12	0.278	0.097	0.054	0.155	0.155
Y	12	0.146	0.068	0.026	0.056	0.059
Z	10	0.039	0.017	0.007	0.057	0.059

Key

r_0	is the value below which the range of test results for the percentage expansion of four individual prisms may be expected to lie with a probability of 95 %, when individual prisms are made from the same concrete batch and tested over the same time interval in the same laboratory by the same operator using the same equipment;
r_1	is the value below which the absolute difference between two test results for the average percentage expansion of sets of four prisms may be expected to lie with a probability of 95 %, when the prisms are made from different concrete batches and tested over the same time interval in the same laboratory by the same operator using the same equipment, using the same laboratory samples of the aggregate fractions;
R_1	is the value below which the absolute difference between two test results for the average percentage expansion of pairs of prisms may be expected to lie with a probability of 95 %, when the prisms are made from different concrete batches and tested in different laboratories by different operators using different equipment, but using the same laboratory samples of the aggregate fractions;
R_2	is the value below which the absolute difference between two test results for the average percentage expansion of sets of four prisms may be expected to lie with a probability of 95 %, when the prisms are made from different concrete batches and tested in different laboratories by different operators using different equipment, and using different laboratory samples of the aggregate fractions.

[a] For general definitions of these terms, see BS 5497-1.

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Standards publications

BS 970-1:1991, *Specification for wrought steels for mechanical and allied engineering purposes — Part 1: General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels.*

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

Other documents

[1] BRITISH CEMENT ASSOCIATION. *The Diagnosis of Alkali-Silica Reaction*. British Cement Association Publication 45.042, 1992. (Publication available from the British Cement Association, Century House, Telford Avenue, Crowthorne, Berkshire RG11 6YS.)

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