

Concrete admixtures —

Part 1: Specification for accelerating and retarding water-reducing admixtures

ICS 91.100.10; 91.100.30

Cooperating organizations

The Cement, Gypsum, Aggregates and Quarry Products Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

| | |
|--|---|
| Association of Consulting Engineers | Department of Transport* |
| Association of County Councils | Federation of Civil Engineering Contractors* |
| Association of District Councils | Gypsum Products Development Association |
| Association of Metropolitan Authorities | Institute of Quarrying |
| Autoclaved Aerated Concrete Products Association | Institution of Civil Engineers* |
| British Precast Concrete Federation Ltd.* | Institution of Highway Engineers |
| British Quarrying and Slag Federation | Institution of Municipal Engineers |
| British Railways Board | Institution of Public Health Engineers |
| British Ready Mixed Concrete Association* | Institution of Structural Engineers* |
| British Steel Industry | Institution of Water Engineers and Scientists |
| Cement Admixtures Association* | National Federation of Building Trades Employers* |
| Cement and Concrete Association* | Natural Environment Research Council (Institute of Geological Sciences) |
| Cement Makers' Federation* | Royal Institute of British Architects |
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| Concrete Society Limited* | Sand and Ballast Hauliers and Allied Trades Alliance |
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| Department of the Environment (PSA)* | Stone Federation |
| Department of the Environment (Transport and Road Research Laboratory) | |

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

| | |
|--|------------------------------------|
| Brick Development Association | Mortar Producers' Association Ltd. |
| British Ceramic Research Association | Plasterers' Craft Guild |
| Electricity Supply Industry in England and Wales | |

This British Standard, having been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee, was published under the authority of the Board of BSI and comes into effect on 26 February 1982

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Foreword

This Part of this British Standard has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Committee and is based on an initial draft provided by the Cement Admixtures Association. This Part of this standard incorporates such recommendations of other organizations as the Technical Committee felt were appropriate, and is based on the results of cooperative tests carried out in accordance with earlier drafts of this Part. Particular attention has been given to the use of test methods already covered in BS 1881 and BS 4551.

This Part of the standard is concerned only with accelerating water-reducing admixtures and retarding water-reducing admixtures. Mortar plasticizers are covered in BS 4887. The requirements for accelerating admixtures, retarding admixtures and water-reducing admixtures which were previously covered by BS 5075-1 have been superseded by the issue of BS EN 934-2 and BS EN 934-6.

Where existing British Standards and specifications call up accelerating admixtures, retarding admixtures and water-reducing admixtures meeting the requirements of BS 5075-1, products with an existing certificate showing compliance with that standard can still be accepted. Products which have been tested to the requirements of BS EN 934-2 should also be accepted as showing technically equivalent performance.

Where standards and specifications call up BS EN 934, it is recommended that for an interim period, BS 5075 certification should continue to be accepted as technically equivalent.

Retarding superplasticizing admixtures are covered by BS 5075-3 and admixtures for mortar are covered by BS 4887. All other types of admixture for concrete are now covered by BS EN 934-2.

BS 5075-1:1974 is superseded by this Part and is therefore now withdrawn.

Major changes are made to this Part of this British Standard by Amendment No. 3 subsequent to the publication of BS EN 934-2.

This Part of this standard deals primarily with the water content, the strength and the rate of stiffening and hardening of normal concretes. The effects of admixtures on other properties or on special concretes are not covered and should be the subject of assurances from the vendor.

This Part of this standard requires that the chloride ion content of all admixtures be declared so that the user will be fully aware of the chloride ion content that will be introduced into the concrete by any particular admixture.

Some guidance on the use of admixtures was considered to be important and has been included as Appendix F, which also indicates the desirability of the purchaser carrying out trials of the admixture with the specific materials and conditions of the given concrete work before actually introducing the admixture into a functional concrete mix at the site.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

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1 Scope

This Part of this British Standard specifies the requirements and methods of test for accelerating and retarding water-reducing admixtures, which may be used to modify one or more properties of hydraulic cement concrete: the workability, the rate of stiffening and hardening, and the strength.

2 References

The titles of the standards publications referred to in this standard are listed on the in the Bibliography.

3 Definitions

For the purposes of this Part of this British Standard the definitions given in BS 2787 and the following apply.

3.4

accelerating water-reducing admixture

a material that combines the functions of an accelerating admixture and a normal water-reducing admixture

3.5

retarding water-reducing admixture

a material that combines the functions of a retarding admixture and a normal water-reducing admixture

NOTE 3.4 and 3.5. The performance requirements for these categories are defined according to their specified test requirements in Table 1.

4 Sampling

An admixture to be tested in accordance with the requirements of this Part of this standard shall be sampled by the appropriate method described in Appendix A.

5 Performance requirements

Admixtures shall comply with the performance requirements, appropriate to the type of admixture, detailed in Table 1.

For the purpose of acceptance testing, a representative sample of admixture, as defined in the appropriate subclause in Appendix A, shall be subjected to the tests detailed in Table 1 and shall comply with the relevant requirements specified therein.

Concrete mixes for these tests shall be prepared and tested in accordance with Appendix B and Appendix C.

Each pair of test mixes A and B containing the admixture shall be compared with a control mix made on the same day under the same conditions and the average result obtained from two such comparisons shall be taken to assess compliance with the specified test requirements.

Consignments of this admixture which have the same description, given as in 7.3 a) and b), need not be tested individually for acceptance. If any characteristic of the admixture given in 7.3 a) and b) is changed new acceptance tests shall be carried out and the designation as given in clause 10 b) shall be changed.

NOTE 1 Although the purpose of the tests is to verify compliance with the specified requirements, the results will also serve to demonstrate the effect of the admixture on certain properties of the concrete; it will be seen that, for some types of admixture, certain tests are not applicable.

NOTE 2 For the purposes of acceptance testing, the manufacturer¹⁾ or his agent may be required by the purchaser to demonstrate compliance with the test requirements. The manufacturer is responsible thereafter for ensuring, by his control of production, that consignments of admixture maintain, on delivery, the performance of the sample originally tested for acceptance.

6 Admixture uniformity tests and requirements

Any batch of admixture shall have the same composition, given as in 7.3 b), as that of the admixture tested for acceptance. To check this uniformity of composition, a sample of the batch taken in accordance with Appendix A shall be tested in accordance with Appendix D and Appendix E and it shall satisfy the requirements given in Table 2.

¹⁾ The term "manufacturer" throughout this standard includes the supplier where appropriate.

Table 1(a) — Performance requirements and tests for test mix concrete A

| Property | Type of admixture | |
|---|-----------------------------|--------------------------|
| | Accelerating water-reducing | Retarding water-reducing |
| Compacting factor (see C.3) relative to control mix concrete | At least 0.03 above | At least 0.03 above |
| Stiffening times (see C.4) for 0.5 N/mm ² for 3.5 N/mm ² | — | — |
| Minimum compressive strength as % of control mix concrete (see C.5) at 24 h at 7 days at 28 days | 125 — 90 | — 90 90 |

Table 1(b) — Performance requirements and tests for test mix concrete B

| Property | Type of admixture | |
|---|---|---|
| | Accelerating water-reducing | Retarding water-reducing |
| Compacting factor (see C.3) relative to control mix concrete | Not more than 0.02 below | Not more than 0.02 below |
| Stiffening time (see C.4) for 0.5 N/mm ² for 3.5 N/mm ² | More than 1 h At least 1 h less than control mix | At least 1 h longer than control mix — |
| Minimum compressive strength as % of control mix concrete (see C.5) at 24 h at 7 days at 28 days | 125 — 110 | — 110 110 |

NOTE The strength requirements take into account the usual variations in cube testing and the limited increase in air content allowed with the test mix concretes.

Table 2 — Admixture uniformity test requirements

| Characteristic | Test reference | Requirement |
|--------------------------|----------------|---|
| Dry material content | D.1 | (a) For liquid admixtures: to be within 3 % (<i>m/m</i>) of the value stated by the manufacturer. (b) For solid admixtures: to be within 5 % (<i>m/m</i>) of the value stated by the manufacturer. |
| Ash content ^a | D.2 | To be within 1.0 % (<i>m/m</i>) of the value stated by the manufacturer. |
| Relative density | D.3 | For liquid admixtures: to be within 0.02 of the value stated by the manufacturer. |
| Chloride ion content | Appendix E | To be within 5 % of the value stated by the manufacturer or within 0.2 % (<i>m/m</i>), whichever is the greater. |

^a As admixtures containing chloride give very variable results for ash content this test and requirement may be waived for admixtures which contain more than 1.0 % (*m/m*) of chloride ion.

7 Information to be provided by the manufacturer

7.1 Information concerning the admixture.

The following information shall be provided by the manufacturer in a printed form.

- The name, trade mark or other means of identification of the manufacturer.
- The trade designation of the product, i.e. brand name, reference number and/or letter.
- The description of the material, i.e. accelerating or retarding water-reducing admixture.

7.2 Information concerning the admixture acceptance tests. The following information shall be provided by the manufacturer in a printed form if requested.

- The name and location of the test laboratory where admixture acceptance and uniformity tests were made and the date of testing.
- The sources of the cement (works of manufacture) and aggregates (quarry or pit, or for material dredged from seas, estuaries or rivers, the locality).
- The quantity of admixture used in the test mix concretes.
- The values of compacting factor, water/cement ratio and cement content for each batch of the control and test mix concretes.
- The percentage water reduction for test mix concrete B.
- The stiffening times to reach resistances to penetration of 0.5 N/mm² and 3.5 N/mm² for mortars sieved from each control and test mix concrete.
- The air content of each batch of the control and test mix concretes.

h) The ratio of the average compressive strength of the cubes from each of the test mix concretes A and B to the average compressive strength of the cubes from the control mix concrete at each appropriate age. This ratio is to be expressed as a percentage for each set of control and two test mix concretes at the appropriate ages required by this standard for the different types of admixtures.

7.3 Additional information. The following information shall be provided by the manufacturer in a printed form.

- Physical state (i.e. liquid or solid) and colour.
- Composition.

- Generic type of main active constituent(s), e.g. lignosulphonate, organic hydroxy-carboxylic acid or carbohydrate.
- Dry material content.
- Ash content.
- Relative density of liquid admixtures.
- Chloride ion content, expressed as a percentage by mass of total admixture.

c) Chloride content relative to the cement mass contributed by the recommended dosage or dosages expressed as a percentage by mass of chloride ion.

d) Packaging, recommended storage conditions, maximum storage time before use, and special precautions at extremes of temperature, including instructions regarding liquids which have become frozen. Where any special requirements on storage life apply, they shall be stated in the words:

“This admixture shall not be taken to comply with the requirements of BS 5075-1:1982 after (date).”

e) instructions for use and any necessary safety precautions, e.g. if caustic, toxic or corrosive.

- f) Any known incompatibility with other admixtures or with certain types of cement etc.
- g) The manufacturer's recommended dosage or dosages.
- h) Effects of underdosage and overdosage.
- i) The number and year of this Part of this British Standard, i.e. BS 5075-1:1982 [see footnote to clause 10 h)].

8 Manufacturer's compliance certificate

The manufacturer shall provide a certificate stating that the admixture, at the time of delivery, complied with the requirements of this Part of this standard. The manufacturer shall also provide the results of any uniformity tests which relate to current supplies of the admixture.

9 Manufacturer's storage certificate

The manufacturer shall provide a certificate confirming that the storage recommendations have been followed for the admixture.

10 Marking

When admixtures are supplied in containers they shall be clearly marked with the following information. When the material is supplied into a bulk container at the point of delivery, the same information shall be provided on a clearly printed label handed over at the time of delivery.

- a) The name, trade mark or other means of identification of the manufacturer.
- b) The trade designation of the product, i.e. brand name, reference number and/or letter (see clause 5).
- c) The description of the material, i.e. accelerating or retarding water-reducing admixture.
- d) Chloride ion content.
 - 1) The chloride ion content expressed as a percentage by mass of total admixture.
 - 2) The chloride content relative to the cement mass contributed by the recommended dosage or dosages expressed as a percentage by mass of chloride ion.

- e) A summary of storage requirements including any special requirements on storage life as indicated in 7.3 d) which shall be clearly marked in the words:

"This admixture shall not be taken to comply with the requirements of BS 5075-1:1982 after (date)."

- f) Instructions for use and any necessary safety precautions, e.g. if caustic, toxic or corrosive.
- g) The manufacturer's recommended dosage or dosages.
- h) The number and year of this Part of this British Standard, i.e. BS 5075-1:1982²⁾.

²⁾ Marking BS 5075-1:1982 on or in relation to a product is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification to support such claims should be addressed to the Director, British Standards Institution, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ in the case of certification marks administered by BSI or to the appropriate authority for other certification marks.

Appendix A Methods of sampling admixtures

A.1 General. Take samples of admixtures in the appropriate manner given in **A.2** to **A.5**. In all steps of the sampling procedure, minimize the exposure of the material to the atmosphere so as to avoid appreciable uptake of moisture or carbon dioxide, or the evaporation of moisture.

A.2 Sampling of powdered materials from packages. Each sample shall represent not more than 1 t of solid admixture. Sample six packages or 1 % of the number of packages, whichever is the greater, or, where the total number of packages does not exceed six, all the packages. Ensure that the packages sampled are evenly distributed throughout the consignment.

Take sub-samples from the selected sample packages by one or more of the following procedures, as appropriate.

Where packages contain less than 500 g, take the whole of the contents of a package.

Where packages contain 500 g or more, use either of the following methods; the method given in a) is the preferred method but if a sampling tube is not available use the method given in b).

- a) Insert a sampling tube, which takes a core not less than 25 mm in diameter, into the package so that it takes a core of the material from substantially the entire length of the package.
- b) Empty one of the packages to be sampled on to a clean dry surface and mix the material. Take at least three portions of not less than 125 g each from different parts of the heap.

Repeat the procedure with each of the other packages to be sampled and thoroughly mix the sub-samples obtained to form one bulk sample.

Reduce this bulk sample to about 1 kg, either by coning and quartering or by use of a sample splitter. Place the sample in one or more airtight labelled containers.

A.3 Sampling of liquids from containers. Each sample shall represent not more than 5 000 litres of liquid admixture. Sample six containers or 1 % of the number of containers, whichever is the greater, or, where the total number of containers does not exceed six, all the containers. Ensure that the containers sampled are evenly distributed throughout the consignment.

Agitate the containers to disperse all lightly settled material. Disregard all deposits which are not readily brought into suspension by such agitation.

Without delay, take sub-samples from the selected containers by one or more of the following procedures, as appropriate.

Where containers hold less than 0.5 litre, take the whole of the contents of a container.

Where containers hold 0.5 litre or more, take 0.5 litre of the liquid in each container, combine the sub-samples obtained in this way and mix them thoroughly to form one bulk sample.

Thoroughly mix the bulk sample and take a final sample of not less than 1 litre. Place this in one or more clean bottles, labelled and tightly stoppered.

A.4 Sampling bulk materials. No requirement is specified in this standard for sampling from single packages or containers whose contents exceed 1 t of solid admixture or 5 000 litres of liquid admixture. The method of sampling in such cases will depend upon the circumstances, but the sample size shall be sufficient to represent the product to be tested.

NOTE Additional guidance on sampling may be found in BS 6000 and BS 6001.

A.5 Particulars of sample. Record the date, place and method of sampling, the identity and quantity of the consignment represented by the sample and the name(s) of the supervisor(s) present.

Appendix B Preparation of concrete for admixture acceptance tests

B.1 General. Prepare the concrete for the admixture acceptance tests using the constituents, mix proportions and procedure given in **B.2** to **B.5**. Use identical cement and aggregates for all mixes in a series being compared.

To compare the properties of concrete with and without the addition of the admixture, make duplicate batches of test mix concrete A, and of test mix concrete B where appropriate, and duplicate batches of control mix concrete.

B.2 Constituents

B.2.1 Cement. The cement shall be a reference Portland cement which is an ordinary Portland cement that has been specially selected for the purpose of admixture acceptance tests and shall comply with the requirements of BS 12. It shall be identified as “CAA/BS 5057-1 Reference Portland Cement” and shall be stored in a sealed container.

NOTE The cement can be obtained from the Cement Admixtures Association, 38A Tilehouse Green Lane, Knowle, West Midlands B93 9EY.

B.2.2 Aggregates. The aggregates shall be in an oven-dry condition. The coarse aggregate shall be an uncrushed gravel complying with BS 882. It shall consist of 20 mm and 10 mm single-sized materials. Neither of the sizes shall have a flakiness index higher than 35 % when tested in accordance with BS 812-105.1 nor a 10 % fines value less than 50 kN when tested in accordance with BS 812-111.

The fine aggregate shall be an uncrushed sand complying with BS 882 except that the grading of the sand as used shall comply with Table 3. The sand shall be obtained from a source that is known to be free from organic matter and it shall have a content of acid-soluble matter of less than 5 % when tested in accordance with clause 7 of BS 4550-6:1978.

Table 3 — Fine aggregate grading limits

| BS 410 sieve | | Mass passing BS sieve |
|--------------|-----|-----------------------|
| mm | µm | % |
| 10 | | 100 |
| 5 | | 90 to 100 |
| 2.36 | | 85 to 100 |
| 1.18 | | 75 to 100 |
| | 600 | 60 to 79 |
| | 300 | 12 to 40 |
| | 150 | 0 to 12 |

B.2.3 Admixture. The admixture shall be in the appropriate condition recommended by the manufacturer for general use in practice.

B.3 Mix proportions

NOTE It is advisable to prepare trial mixes to ensure that the control mix concrete complies with the requirements given in B.3.1 for compacting factor, cement content and air content.

B.3.1 Control mix concrete. The proportions, by mass, of the oven-dry aggregate shall be: 45 parts of 20 mm to 10 mm coarse aggregate: 20 parts of 10 mm to 5 mm coarse aggregate: 35 parts of fine aggregate. The cement content of the fully compacted concrete shall be $300 \pm 5 \text{ kg/m}^3$. The water content of each batch shall be such as to produce a concrete having a compacting factor in the range 0.88 to 0.90 when determined in accordance with C.3.

The air content shall not be more than 2.0 % when tested in accordance with C.2.

B.3.2 Test mix concrete A. Test mix concrete A shall contain the admixture at the manufacturer's recommended dosage rate. It shall be of the same composition as the control mix and the water content shall include the quantity of water contributed by the admixture.

The air content determined in accordance with C.2 shall not be more than 2.0 % higher than that of the corresponding control mix concrete and in any case not more than a total of 3.0 %.

B.3.3 Test mix concrete B. Test mix concrete B shall contain the admixture at the manufacturer's recommended dosage rate. It shall be of the same composition as the control mix except that the total water/cement ratio (including the quantity of water contributed by the admixture) shall be adjusted to give a water reduction of 8.0 % (unless otherwise specified) relative to the control mix concrete.

The relation between the percentage water reduction and the water/cement ratio, w/c , is given by:

w/c of test mix concrete B =

$$w/c \text{ of control mix} \times \frac{(100 - \text{percentage reduction})}{100}$$

= w/c of control mix $\times 0.92$ (unless otherwise specified)

The air content, determined in accordance with C.2, shall not be more than 2.0 % higher than that of the corresponding control mix concrete and in any case not more than a total of 3.0 %.

B.4 Type of mixer. The concrete shall be mixed in a pan mixer. In operation, the mixer shall be filled to between 50 % and 90 % of its nominal batch capacity.

NOTE Each batch of control or test mix concrete will require approximately 100 kg or 40 litres of concrete for the full range of tests. A pan mixer with a nominal batch capacity of 50 litres will generally be most suitable. Guidance on the quantities required for each test on a batch of concrete is given in Table 4.

Table 4 — Approximate quantities of concrete required for each admixture acceptance test on a batch

| Test | Quantity of concrete | |
|-----------------------------------|----------------------|-----------|
| | kg | litres |
| Air content | 15 | 6 |
| Compacting factor | 50 | 20 |
| Stiffening time | 3 to 12 | 1.25 to 5 |
| Compressive strength (6 cubes) | 15 | 6 |

B.5 Mixing procedure

B.5.1 General. Prepare two identical batches of control mix concrete and two identical batches of test mix concrete A, and of test mix concrete B if appropriate for the particular category of admixture (see Table 1), in the same mixer using the same procedure. Arrange the mixing so that a set of a control mix and associated test mix concrete batches A, and B if appropriate, is produced on the same day. Weigh the cement, aggregates and water.

B.5.2 Mixing control mix concrete. Place the aggregates in the mixer, add approximately half the mixing water and mix the material for 2 min. After standing for 8 min, with the pan covered to minimize evaporation, restart the mixer and add the cement gradually during the next 30 s. Add the remainder of the mixing water during the next 30 s and mix the concrete for a further 3 min.

B.5.3 Mixing test mix concretes A and B. Adopt the mixing procedure described above but disperse the admixture in the second addition of water.

Appendix C Admixture acceptance tests on the control mix and test mix concretes

C.1 General. Use the same test procedure, in detail, for each of the concrete mixes. Carry out the tests required by the standard in accordance with the instructions given in C.2 to C.5. Where compaction of the concrete is necessary, this is accomplished by mechanical vibration using an identical method and procedure each time.

C.2 Air content. Determine the air content of each batch of the control and test mix concretes A and B to the nearest 0.1 %, in accordance with BS 1881-106 using mechanical vibration. Carry out the test between 30 min and 45 min after the completion of mixing. Cover the concrete to prevent evaporation of water and leave it undisturbed between the completion of mixing and the start of the test. Determine the air content on a single sample of the fresh concrete. Discard the concrete sample after the test. Where the limits in B.3.1, B.3.2 or B.3.3 are exceeded, change the batch or source of one or more constituents and repeat the test procedure.

C.3 Compacting factor, plastic density and cement content. Determine the compacting factor in accordance with BS 1881-103 with the following modifications. Determine the compacting factor of each batch of the control and test mix concretes A and B in duplicate on separate samples of the concrete. Determine the partially-compacted mass between 10 min and 15 min after the completion of the mixing, filling the hopper immediately prior to opening the trap door, and determine the fully compacted mass immediately thereafter. Use mechanical vibration to obtain full compaction of the concrete layers. The compacting factor is the ratio of the mean partially-compacted mass to the mean fully-compacted mass. Calculate the plastic density and cement content of the fresh concrete in accordance with BS 1881-103 from the mean fully-compacted mass.

C.4 Stiffening times

C.4.1 General. Determine the times from completion of mixing of the concrete for mortar sieved from each batch to reach resistances to penetration of 0.5 N/mm² and 3.5 N/mm², using the apparatus and procedure given in C.4.2 and C.4.3, on appropriate mixes prepared on the same day.

NOTE One set of results for each batch of concrete is sufficient. **C.4.2 Apparatus**³⁾. The following apparatus is required.

C.4.2.1 Full tolerance perforated plate test sieve, 5.00 mm aperture, complying with the requirements of BS 410.

C.4.2.2 Self-indicating platform scale, preferably with a tare device, reading to at least 15 kg with graduations not greater than 100 g.

C.4.2.3 Containers, rigid, water-tight, non-absorptive, non-oiled and at least 75 mm in diameter and 50 mm to 100 mm deep. Sufficient containers are needed to provide an area of surface large enough for the required number of penetrations of the rod.

NOTE It may be found advantageous to use disposable containers.

C.4.2.4 Stop-clock.

³⁾ Whilst the apparatus described in C.4.2 is to be used for reference purposes, the resistance to penetration of the sieved mortar may also be determined using apparatus described in ASTM C403, 1977 "Time of setting of concrete mixtures by penetration resistance", provided that the same apparatus is used throughout.

C.4.2.5 Brass rod, 65 mm long and 6.175 ± 0.025 mm in diameter, with one end ground flat perpendicular to the axis of the rod. At 25 ± 0.25 mm from this end the diameter shall be turned down to 4.5 ± 0.5 mm for the remaining 40 mm. A brass washer, approximately 20 mm in external diameter, shall be slipped over the narrow end of the brass rod and rest on the shoulder formed by the change in diameter of the rod.

C.4.2.6 Clamp and stand, for the brass rod, such that the brass rod is held vertically by the narrow end with the washer well clear of the clamp. The clamp shall be mounted in a stand, such as a lever-type drill-stand, that enables the rod to be lowered vertically in a controlled and steady manner over a distance of at least 40 mm.

The stand shall be firmly fixed to a bench so that the lower end of the brass rod, in its raised position, is about 6 mm above the rim of the container when this is placed on the platform scale.

NOTE This apparatus is the same as that required for the stiffening time test in BS 4551.

C.4.3 Procedure

C.4.3.1 Separation of mortar and filling of containers. Separate the mortar from the concrete by sieving through the 5.00 mm test sieve on to a non-absorptive surface. Remix the mortar using a hand trowel and fill the containers to within 10 mm of the top of the container in about ten increments, tapping the container on the bench four times after each addition. Complete the filling within 15 min of the completion of mixing of the concrete.

C.4.3.2 Storage conditions. Cover the filled containers to prevent the evaporation of water, and keep them at 20 ± 2 °C. Do not remove the bleed water.

C.4.3.3 Times of determination of resistance to penetration. Determine the resistance to penetration at hourly intervals up to a resistance of 1 N/mm^2 and thereafter at half-hourly intervals until a resistance of 4 N/mm^2 is reached.

C.4.3.4 Resistance to penetration. At the appropriate times place the container on the platform scale and remove the cover. Position the container so that the mortar surface beneath the brass rod is at least 20 mm from the rim of the container or from the position of any previous penetration. Adjust the scale-tare device or record the mass of the filled container. Slowly lower the brass rod into the mortar until the brass washer just touches the surface; at this moment note the scale reading, in kilograms, and correct it if necessary, for the mass of the filled container.

C.4.3.5 Treatment of the test results. Calculate the resistance to penetration in newtons per square millimetre, at various test times, by dividing the recorded reading in kilograms by three.

NOTE This simple calculation is made possible by using a brass rod with an end area of 30 mm^2 , and by assuming that the reading in kilograms is equivalent to a force of 10 N, which is sufficiently accurate for the purpose of this test.

Estimate the times to reach resistances to penetration of 0.5 N/mm^2 and 3.5 N/mm^2 by linear interpolation between the results immediately above and below these values. Report the results to the nearest 15 min.

C.5 Compressive strength. For each batch of the control and test mix concretes A and B, prepare six 100 mm test cubes between 45 min and 60 min after the completion of mixing. Make, using mechanical vibration to produce full compaction of the concrete, cure and test the cubes in accordance with BS 1881-108, BS 1881-111 and BS 1881-116, testing three cubes at each appropriate age as given in Table 1. If one result within the set of three obtained on specimens tested at the same age varies by more than ± 5 % from the average of the set, discard the result and recalculate the average of the remaining results. If more than one result varies by more than ± 5 % from the average, discard the set of results and repeat the tests on the concrete. Calculate the ratio of the average compressive strength of the three cubes at each appropriate age from test mix A, and B where appropriate, to the average compressive strength of the three cubes from the control mix at the same age as a percentage, to the nearest 1 %.

Appendix D Admixture uniformity tests

D.1 Dry material content

D.1.1 Principle. The water content of the admixture is determined by distilling a mixture of it with a carrier liquid completely immiscible with and lighter than water, and collecting and measuring the volume of the evolved water. The dry material content is then calculated by difference.

D.1.2 Reagents. The following reagents are required.

D.1.2.1 Toluene, analytical reagent quality, as carrier liquid.

D.1.2.2 Kieselguhr powder (as selected for suitability as a filter aid).

D.1.3 Apparatus. The following apparatus is required.

NOTE The apparatus is essentially the Dean and Stark apparatus specified in BS 756.

D.1.3.1 Distillation flask, 250 ml capacity, with a short neck and a 34/35 ground-glass socket joint.

D.1.3.2 Condenser, of the glass water-cooled reflux type, as shown in Figure 3 of BS 756:1952.

D.1.3.3 Spray tube, as shown in Figure 4 of BS 756:1952.

D.1.3.4 Graduated receiver, type 1, of 7.5 ml or 2 ml capacity, as shown in Figure 5 and Figure 6 of BS 756:1952. For most purposes the 7.5 ml receiver is suitable, but for water contents less than about 10 % (dry material contents greater than about 90 %) the 2 ml receiver shall be used.

An appropriate ground-glass reduction adaptor may be employed to connect the receiver to the distillation flask, or, preferably, each receiver may be fitted with a 34/35 cone joint.

NOTE It is also convenient to use PTFE (polytetrafluoroethylene) sleeves on all ground-glass joints to facilitate dismantling of the apparatus after each test.

D.1.4 Procedure. Before assembling the apparatus for the test, thoroughly clean all the glass components and then dry them in an oven at 105 °C to 110 °C.

NOTE 1 The inner tube of the condenser may also conveniently be dried by rinsing with pure acetone.

For liquid admixtures, weigh, to the nearest 0.01 g, an 8 g to 10 g representative sample of admixture into the dry distillation flask containing about 10 g of Kieselguhr powder which has previously been dried at 105 °C to 110 °C. Using a small test tube (e.g., 75 mm × 12 mm) as a pestle and a rubber-tipped glass rod as the handle, mix the admixture thoroughly into the Kieselguhr powder. Add about 50 ml of toluene from a measuring cylinder and after mixing again leave the test tube in the distillation flask. Attach the receiver to the condenser and the distillation flask, lubricating each joint with a few drops of toluene, and pour a further 50 ml of toluene into the apparatus via the condenser tube.

Insert a loose plug of cottonwool in the condenser tube and heat the distillation flask by means of an electric heating mantle, or other suitable form of heat, so that condensate falls from the end of the condenser at a rate of 2 to 5 drops per second.

NOTE 2 if required, one or two glass or porcelain beads, or other suitable material may be added to the distillation flask to promote even boiling.

Continue heating until the volume of water collected in the receiver shows no increase during a period of 1 h, a refluxing time varying from 1 h to 4 h usually being required with different admixtures. Detach any globules of water from the condenser wall by washing down with toluene by means of the spray tube, or by rubbing with a copper wire.

NOTE 3 A copper wire may also be used to dislodge any droplets of water adhering to the sides of the receiver, as well as to correct a faulty meniscus.

Allow the contents of the collecting tube of the receiver to cool to room temperature and then record the volume of water collected.

For solid admixtures, use the same procedure but without the addition of Kieselguhr powder.

D.1.5 Calculation. Take the mass of 1 ml of water at room temperature as 1 g and calculate the dry material content on the original mass of the sample taken. Report the results as a percentage to the nearest 0.1 %.

$$\text{Dry material content} = 100 - \frac{100 V}{W}$$

where

V is the volume of water collected, in ml

W is the mass of sample taken, in g

D.2 Determination of ash content

D.2.1 Principle. The ash content, which gives an indication of inorganic constituents, is determined by igniting the admixture at 600 °C to remove any organic material.

D.2.2 Apparatus. The following apparatus is required.

D.2.2.1 Crucible, porcelain or silica, squat form, 15 ml to 30 ml capacity with a lid.

D.2.2.2 Desiccator, containing magnesium perchlorate (dried).

D.2.2.3 Balance, capable of weighing to the nearest 0.001 g.

D.2.2.4 Muffle furnace.

D.2.3 Procedure. Ignite the crucible and lid at 600 ± 25 °C for 15 min to 30 min. Transfer to the desiccator, allow to cool for 30 min and weigh the crucible with its lid to the nearest 0.001 g. Add about 1.0 g of solid or liquid admixture to the crucible, cover with the lid, and reweigh.

In order to minimize the risk of mechanical loss on heating, first wet the sample of any solid admixture with a few millilitres of water, then remove the bulk of the water from the sample of solid or liquid admixture by placing the crucible (without lid) under an infra-red heating lamp, or on a steam bath, or in an air oven at about 90 °C, and finally transfer the crucible to a muffle furnace at room temperature and heat gradually so that the temperature reaches 300 °C in 1 h and 600 °C in a further 2 h to 3 h. Maintain the temperature of the furnace at 600 ± 25 °C for 16 h to 24 h. Remove the crucible from the furnace and allow to cool, covered with its lid, in the desiccator. After cooling for 30 min, weigh the crucible plus lid and contents to the nearest 0.001 g.

D.2.4 Calculation. Calculate the ash content of the admixture on the original mass of the sample taken. Report the result as a percentage to the nearest 0.1 %.

$$\text{Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

where

W_1 is the mass of crucible plus lid, in g

W_2 is the mass of crucible plus lid and sample, before igniting, in g

W_3 is the mass of crucible plus lid and sample, after igniting, in g

D.3 Relative density of liquid admixtures

D.3.1 Apparatus. The following apparatus is required.

D.3.1.1 Hydrometer, of appropriate nominal range, complying with the requirements of BS 718 for the M50 series and for use with liquids of medium surface tension.

D.3.1.2 Graduated cylinder, 500 ml capacity, complying with the requirements of BS 604.

D.3.1.3 Thermometer, complying with the requirements of BS 1704 covering the range -5 °C to 105 °C and calibrated for 100 mm immersion, e.g. thermometer with schedule mark GP105C/1.0/100.

D.3.2 Procedure⁴⁾ Adjust the temperature of the admixture, if necessary, to be 20 ± 5 °C. Transfer the admixture carefully to a clean 500 ml graduated cylinder avoiding the formation of air bubbles in the liquid. Hold the hydrometer by the top of the stem and insert it into the liquid in the cylinder. Release the hydrometer when approximately in the equilibrium position and, when it has reached equilibrium, read the scale at the bottom of the meniscus for transparent liquids or where the meniscus merges with the stem of the hydrometer for opaque liquids. Report the relative density to the nearest 0.002.

Appendix E Determination of the chloride ion content of admixtures

E.1 General. In order to provide a standard method that will be applicable to all admixtures, a potentiometric titration method has been adopted for the determination of chloride ion content. The method involves making two equal additions of standard sodium chloride solution to a solution of the admixture and, after each addition, titrating the total chloride with silver nitrate solution, using a silver electrode to detect each end-point potentiometrically. By means of this procedure, well defined end-points are obtained for admixtures with a very low chloride ion content, and at the same time the silver nitrate solution is standardized and allowance can be made for the added chloride.

NOTE Alternative methods of determining the chloride ion content may also be suitable for some admixtures and, if shown to be of equivalent accuracy, any such method may be used. In the event of dispute, however, the potentiometric method described in this appendix is to be considered as the standard reference method.

E.2 Reagents. The following reagents are required. All reagents shall be of analytical reagent quality and distilled or deionized water shall be used throughout.

E.2.1 Ammonium nitrate, saturated solution in water.

E.2.2 Nitric acid, concentrated, 70 % (m/m) (16 mol/l).

E.2.3 Sodium chloride, 0.1 mol/l, standard reference solution, prepared by dissolving 5.845 g of sodium chloride (dried at 150 °C for 2 h) in water and diluting to 1 litre in a volumetric flask.

E.2.4 Silver nitrate, 0.1 mol/l, non-standardized volumetric solution, prepared by dissolving 17.0 g of silver nitrate in water and diluting to 1 litre.

E.3 Apparatus. The following apparatus is required.

E.3.1 Potentiometer or pH meter.

E.3.2 Silver electrode.

E.3.3 Salt-bridge container, filled with saturated ammonium nitrate solution, and incorporating an appropriate liquid junction preferably of the ground-glass sleeve type.

E.3.4 Calomel reference electrode, to fit inside the above salt-bridge container.

NOTE Items **E.3.3** and **E.3.4** may be dispensed with if a reference mercury-mercurous sulfate-alkali sulfate electrode is employed instead. As a further alternative, any combination electrode purposely manufactured for chloride determination may be used in place of items **E.3.2**, **E.3.3** and **E.3.4**.

⁴⁾ The procedure described in **D.3.2** is sufficiently accurate for use in the uniformity test methods, but it is recommended that BS 718 should be referred to if further advice is required.

E.4 Procedure. Weigh, to the nearest 0.01 g, a 10 g to 12 g representative sample of admixture into a 250 ml beaker, and add 50 ml of water followed by 2 ml of concentrated nitric acid. If the sample does not dissolve completely filter through a rapid filter paper⁵⁾ and wash the residue with water.

NOTE When the admixture contains less than about 0.6 % (*m/m*) chloride ion, take all of the solution for chloride ion determination, but for higher chloride ion contents make the solution up to a known volume with water in a volumetric flask and for analysis pipette a suitable volume to contain up to about 70 mg of chloride ion.

Using indicator test paper, check that the solution is acid, adding more nitric acid if necessary, and dilute to approximately 150 ml with water. Add, by pipette, 10 ml of the sodium chloride solution and immerse the silver electrode and the liquid junction of the salt-bridge container in the solution. Connect the electrodes to the potentiometer or pH meter and titrate slowly with the silver nitrate solution, keeping the admixture solution constantly stirred by means of a magnetic or other suitable mechanical stirrer. Record the potential and corresponding burette readings at frequent intervals and, as the end-point approaches and the potential increases more rapidly, add the titrant in quantities of, e.g., 0.1 ml to 0.4 ml. Continue the titration for a further 1 ml to 2 ml beyond the end-point. Add, by pipette, a further 10 ml of the sodium chloride solution to the admixture solution and continue the titration with the silver nitrate solution using the same procedure as before.

E.5 Calculation. If *E* is the potential in millivolts and *V* is the corresponding number of millilitres of silver nitrate solution added, obtain the end-point of each titration by calculating the change in potential for successive titration values ($\Delta E/\Delta V$ as m V/ml), and then plot $\Delta E/\Delta V$ against each respective mean volume of silver nitrate solution on a graph with $\Delta E/\Delta V$ values as ordinates and volumes of silver nitrate solution added as abscissae; the maximum value of $\Delta E/\Delta V$ indicated by the curve gives the end-point.

Calculate the chloride ion content on the original mass of sample taken for the determination. Report the results as a percentage by mass of chloride ion to the nearest 0.2 %.

$$\text{Chloride ion content} = \frac{3.546(2V_1 - V_2)}{W(V_2 - V_1)} \quad (1)$$

where

V_1 is the volume of silver nitrate solution required by the sample and 10 ml of the standard reference 0.1 mol/l sodium chloride solution, in ml

V_2 is the volume of silver nitrate solution required by the sample and 20 ml of the standard reference 0.1 mol/l sodium chloride solution, in ml

W is the mass of sample taken, in g

NOTE To obtain the equivalent anhydrous calcium chloride content of the admixture, multiply the chloride ion content by 1.565.

The following example shows the calculation of chloride ion content using the experimental data given in Table 5 and shown graphically in Figure 1.

From Figure 1, $V_1 = 12.60$ and $V_2 = 22.65$, and substituting these values into equation (1) :

$$\begin{aligned} \text{Chloride ion content} &= \frac{3.546(25.20 - 22.65)}{11.58(22.65 - 12.60)} \% \\ &= \frac{3.546 \times 2.55}{11.58 \times 10.05} \% \\ &= 0.08 \% (\equiv 0.12 \% \text{ anhydrous calcium chloride}) \\ &= 0.0 \% \text{ chloride ion to the nearest } 0.2 \% \end{aligned}$$

⁵⁾ A Whatman No. 1 or similar filter paper is suitable.

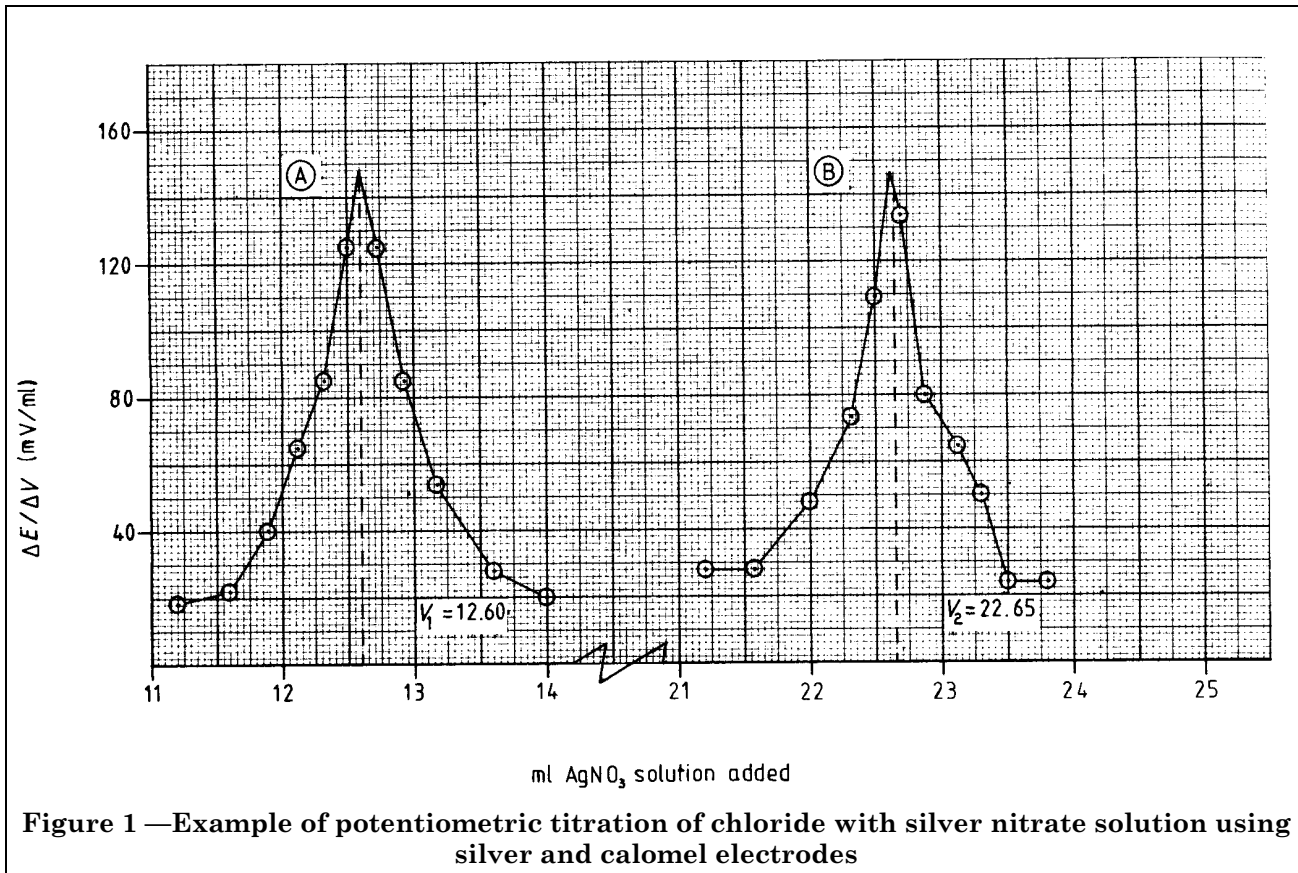


Figure 1—Example of potentiometric titration of chloride with silver nitrate solution using silver and calomel electrodes

Table 5—Example of experimental data for the determination of the chloride ion content of an admixture

| A. 11.58 g admixture + 10 ml 0.1000 mol/l sodium chloride solution | | | B. 11.58 g admixture + 20 ml 0.1000 mol/l sodium chloride solution | | |
|--|-----|---------------------|--|-----|---------------------|
| Silver nitrate solution | E | $\Delta E/\Delta V$ | Silver nitrate solution | E | $\Delta E/\Delta V$ |
| ml | mV | mV/ml | ml | mV | mV/ml |
| 11.00 | 216 | 18 | 21.00 | 213 | 28 |
| 11.40 | 223 | 23 | 21.40 | 224 | 28 |
| 11.80 | 232 | 40 | 21.80 | 235 | 48 |
| 12.00 | 240 | 65 | 22.20 | 254 | 75 |
| 12.20 | 253 | 85 | 22.40 | 269 | 110 |
| 12.40 | 270 | 125 | 22.60 | 291 | 135 |
| 12.60 | 295 | 125 | 22.80 | 318 | 80 |
| 12.80 | 320 | 85 | 23.00 | 334 | 65 |
| 13.00 | 337 | 55 | 23.20 | 347 | 50 |
| 13.40 | 359 | 28 | 23.40 | 357 | 25 |
| 13.80 | 370 | 20 | 23.60 | 362 | 25 |
| 14.20 | 378 | | 24.00 | 372 | |

Appendix F Notes on the use of accelerating and retarding water-reducing admixtures

F.1 General. Admixtures are used to modify the properties of plastic or hardened concrete. The benefits to be derived from any admixture are, however, contingent on proper use and knowledge of any side effects or potential hazards that may arise. Admixtures are never to be regarded as a replacement for good concreting practice and are never to be used indiscriminately.

F.2 Site trials. The general behaviour or performance of an admixture in concrete should be reflected by the data obtained from the admixture acceptance tests. The specific effects produced by any admixture will, however, depend to some extent on the particular concrete and circumstances of use. The performance of the admixture should be evaluated preferably by site trials with the specific materials and conditions of the given concrete work in order to establish the admixture dosage which will produce the required effect without adverse effects on any other properties of the concrete.

Site trials should also be carried out to ensure that the admixture dosage is the optimum for the relevant temperature conditions. Once such an admixture dosage, which may be different from that used in the material acceptance tests, has been decided by these site trials it should be accurately controlled in order to ensure uniformity of behaviour.

F.3 Dispensing. Dispensing equipment should be sufficiently accurate to deliver within 5 % of the specified dosage rate in successive batches of concrete and it should be cleaned and checked at regular intervals to ensure correct functioning. To obtain satisfactory performance, the admixture should be distributed uniformly throughout the batch of concrete during its initial mixing, and this is best achieved either by introducing the admixture in solution in a major part of the mixing water or by adding the admixture coincidentally with the mixing water, as, for example, by injection into the water line. Solid admixtures should be added in accordance with the directions of the manufacturer. Admixtures should not be added during the transportation, placing or consolidation of the concrete. The effects of some admixtures on setting times and water reduction in concrete may vary with the time of their addition during the batching and mixing operations, and a standard mixing sequence for the admixture should therefore be used. Admixture manufacturers will readily give advice concerning suitable dispensing equipment and satisfactory methods for introducing their products into concrete. One type of admixture should not be employed with any other admixture unless the two admixtures have been shown by tests to be compatible and not detrimental to the concrete.

F.4 Temperature. The rate of setting and hardening of concrete will vary with the ambient temperature conditions, and consequently the relative effects produced by admixtures will also be modified by changes in temperature. The dosage of retarding admixtures necessary to produce a given degree of retardation is to be increased as the temperature of the concrete rises (see Figure 2).

For concrete work at low temperatures, the normal precautions taken in cold weather to ensure that the concrete does not freeze are to be observed. The use of accelerating admixtures will help the concrete to reach a strength sufficient to withstand the effects of frost in a reduced time.

F.5 Workability. Admixtures can be used to modify the workability of concrete or to extend the period over which the concrete remains workable, or to reduce the accidental occurrence of cold joints. An appropriate workability test, for example the compacting factor test, can be used at various intervals of time to ensure that the workability required on site is obtained.

There is an approximate relationship between the loss of workability and the stiffening time of concrete, it will in many cases be valuable to relate change in stiffness to time after mixing using either the stiffening time test described in C.4 or an appropriate workability test. This is indicated in Figure 2 where, in the example given, the time at which the compacting factor drops to below the value of 0.75 corresponds approximately to the initial stiffening time. Figure 2 also indicates how, as the ambient temperature increases, the rate of reduction of workability increases and the stiffening time decreases. Effects similar to those found when the ambient temperature changes may also be observed when the temperature of the concrete materials alters due to such factors as the use of hot materials and the frictional heating effects produced by mixing for longer periods in mixers of large capacity.

F.6 Chloride-based admixtures. The presence of chloride in concrete presents potential hazards with some cements or when metals are embedded in concrete and certain precautions are therefore necessary.

On account of this corrosion risk, it is recommended that in admixtures for use in concrete, made with any type of cement, containing prestressing tendons, reinforcement or embedded metal the chloride ion content should not exceed 2 % by mass of the admixture or 0.03 % by mass of the cement when calculated on the mix composition. It is also recommended that the limits given above of chloride ion content should be applied to concrete without embedded metal made with cement which complies with the requirements of BS 4027 and BS 4248. This recommendation does not apply to concrete that is not prestressed or reinforced or that does not contain embedded metal.

F.7 Special cements. Most admixtures can be used with at least some special-purpose cements in the Portland range such as rapid-hardening, white, sulfate-resisting and low heat cements, and a number are compatible with other types of cement such as high alumina and supersulfated cements. In these cases, however, the admixture manufacturer and the cement maker should be consulted before an admixture is used.

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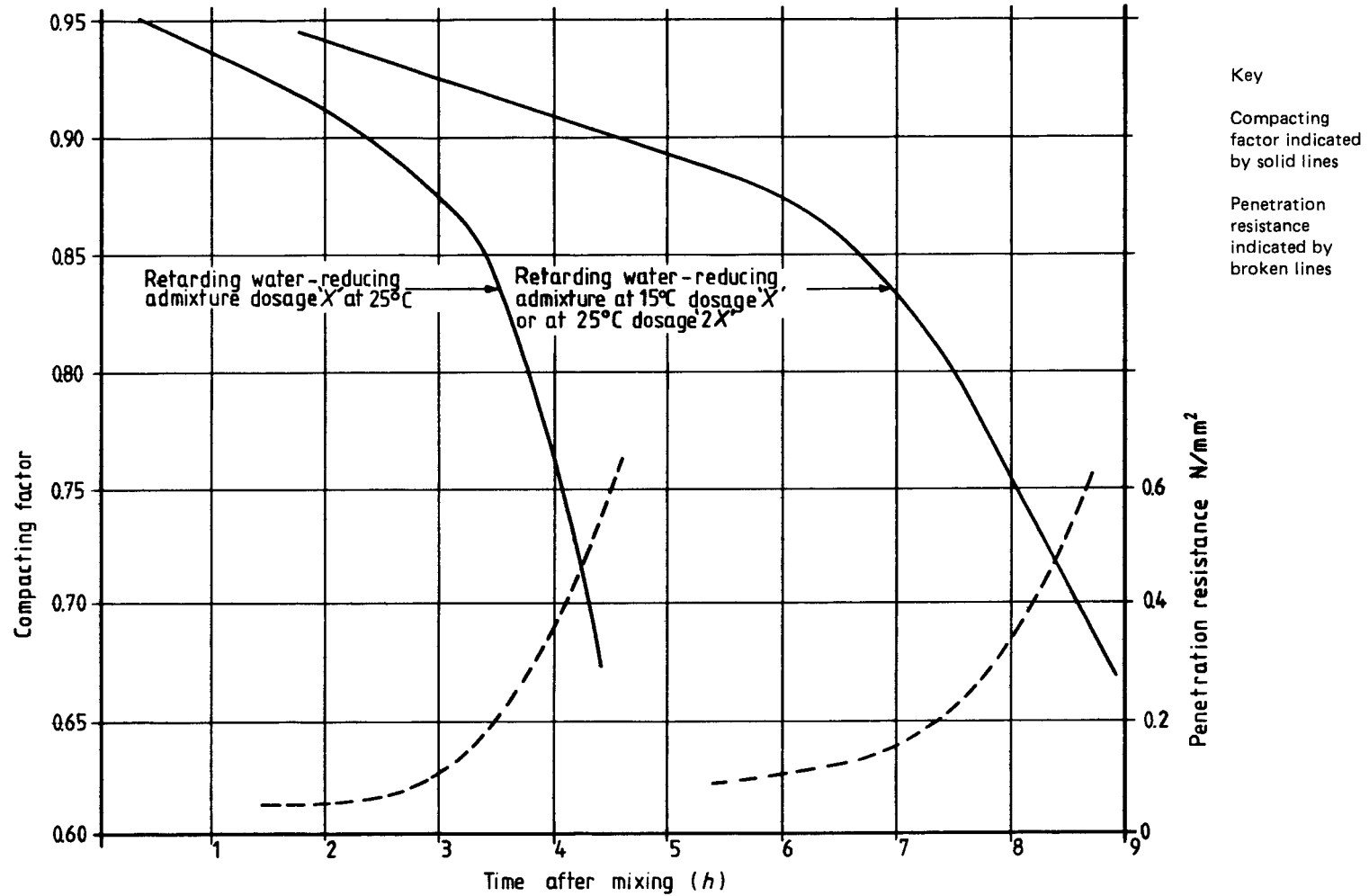


Figure 2 — Typical relationship between compacting factor, penetration resistance (stiffening time) and time, indicating temperature effects (cement content: 300 kg/m^3)

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⁶⁾ Referred to in the foreword only.

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