British Standard

BRITISH STANDARD

BS 5328-3:1990

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Concrete —

Part 3: Specification for the procedures to be used in producing and transporting concrete

ICS 91.100.30

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee (CAB/-) to Technical Committee CAB/4, upon which the following bodies were represented:

Association of Lightweight Aggregate Manufacturers
Association of Metropolitan Authorities
Association of Quality Pulverised Fuel Ash Suppliers
British Aggregate Construction Materials Industries
British Cement Association
British Civil Engineering Test Equipment Manufacturers' Association
British Precast Concrete Federation
British Ready Mixed Concrete Association
Building Employers' Confederation
Cement Admixtures Association
Cementitious Slag Makers Association
Concrete Society
County Surveyors' Society
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Department of Transport
Department of Transport (Transport and Road Research Laboratory)
Electricity Association
Federation of Civil Engineering Contractors
Institute of Concrete Technology
Institution of Civil Engineers
Institution of Highways and Transportation
Institution of Structural Engineers
Institution of Water and Environmental Management
Royal Institution of Chartered Surveyors
Sand and Gravel Association
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Contents

Foreword

This Part of BS 5328 has been prepared under the direction of the Cement, Gypsum, Aggregates and Quarry Products Standards Policy Committee. This Part, together with BS 5328-1, BS 5328-2 and BS 5328-4, is a revision of BS 5328 :1981, which is withdrawn, and forms a comprehensive standard for the specification of concrete to which codes of practice and contractual documents can refer. It includes recommendations originating from, and complementing clauses in, BS 8110-1.

As this standard involves selection by the specifier from a number of options and, in certain circumstances, agreement on requirements between the purchaser and producer, any requirement for compliance with BS 5328 or any claim of compliance with it has to be qualified by reference to the selection and to any such agreements.

This standard covers the methods for specifying and producing concrete as a construction material up to the point of delivery into the construction. The standard is now in four Parts:

Part 1.	Guide to specifying concrete
Part 2.	Methods for specifying concrete mixes
Part 3.	Specification for the procedures to be used in producing and transporting concrete
Part 4.	Specification for the procedures to be used in sampling, testing and assessing compliance of concrete

Part 1 provides guidance to the specifier and purchaser of concrete on the selection of requirements for materials and concrete mixes. Part 2 provides a choice of methods by which the purchaser can convey the selected requirements to the producer. Part 3 specifies for the producer the procedures to be used in producing and transporting the concrete. Part 4 specifies the procedures to be used by the purchaser in sampling, testing and assessing concrete for compliance.

This standard provides methods for specifying concrete mixed on site or in a precast concrete factory and for the purchase and supply of ready-mixed concrete. It takes account of the distinct and different responsibilities of the purchaser and the producer. There are a number of instances in which the purchaser has to select from the various options given in this standard in order to specify the concrete required. The purchaser is responsible for passing on to the producer the requirements of the specifying body, e.g. the engineer's or architect's specification, together with any additional requirements. Throughout this standard the terms 'specify' and 'specification' are used in relation to both sets of requirements. There may be occasions where it is advantageous for economic or technical reasons to propose changes to the specification. In such cases the producer and purchaser should agree the proposed amendments for approval and sanction by the specifying body.

Precautions need to be taken when working with cement and wet concrete and attention is drawn to these in BS 5328-3 and BS 5328-4.

This standard covers concrete produced by normal methods, but it does not apply to precast concrete products where British Standard specifications contain the specification of the concrete. Many of the requirements of the standard, e.g. the use of materials and the control of production, apply equally to precast concrete and to in situ concrete. However, some of its requirements concerning the responsibilities of the purchaser and producer may not apply in the case of precast concrete. The specification of designated mixes is unlikely to be appropriate for factory produced precast concrete products.

Amendment number 4 takes account of the recent consensus reached by experts on provisions to resist damaging ASR in the UK. These recommendations are published in BRE Digest 330:1999. The technical content of this amendment has been derived from these recommendations.

It is necessary for the purchaser to take into account the requirements of specialized codes of practice and any influences of the construction process. Provisions are made in this standard for the inclusion of any special requirements.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its 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 to iv, pages 1 to 9 and a back cover.

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Sidelining in this document indicates the most recent changes by amendment.

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Introduction

This Part of BS 5328 gives the basic requirements to be observed by the producer, who supplies concrete specified in accordance with this standard, during the manufacture of the concrete, including the standards for the plant and the use of quality control procedures. The technical requirements for the transport and delivery of ready-mixed concrete apply also when a contractor produces concrete at a central plant and transports it by vehicles to the point of use on site.

Purchasers ordering in accordance with this standard are advised to specify quality assurance requirements for materials or for concrete in their purchasing contracts to assure themselves that products specified in accordance with BS 5328 consistently achieve the required level of quality. Purchasers of ready-mixed concrete are advised to specify certification meeting the requirements of National Accreditation Council for Certification Bodies, Category 2 for product conformity. They are similarly advised to specify that, where they are available, constituent materials should be obtained from suppliers operating quality systems in accordance with BS 5750.

1 Scope

This Part of BS 5328 specifies the procedures to be followed when producing and transporting concrete that has been specified in accordance with BS 5328-2. It does not apply when the concrete is produced or transported according to the requirements of another British Standard.

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

2 Definitions

For the purposes of this Part of BS 5328 the definitions given in BS 5328-1 and BS 6100 apply.

3 Information to be provided by the producer

3.1 Before any concrete is supplied

When requested, the producer shall provide the purchaser with the following information before any concrete is supplied:

a) the nature and source of each constituent material including, for any concrete to be exposed to design chemical classes DC-2, DC-3, DC-3*, DC-3**, DC-4, DC-4*, DC-4**, DC-4m, DC-4m* or DC-4m**, information on the aggregate carbonate range of the aggregate combination;

b) the source of supply of concrete and any proposed alternative sources;

c) the proposed proportions or quantity of each constituent per cubic metre of fully compacted concrete;

d) details of admixtures to be used as in **3.3** (not permitted in standard mixes);

e) evidence of suitability of proposed mix proportions to meet the specified requirements as in **3.4** and **3.5** (designed mixes only);

NOTE For designated mixes, the certification body is responsible for checking the evidence of the suitability of the mix proportions.

f) certification of quality assurance;

g) the method used to minimize damaging ASR and as appropriate:

i) details of service record;

ii) verification of conformity, see **3.9** of BS 5328-4:1990;

iii) relevant manufacturers' guaranteed alkali limit or declared alkali content;

h) any other relevant information.

3.2 During the production of concrete

3.2.1 *Changes in status of quality assurance of materials*

When information has been requested by the purchaser under **3.1**, the producer shall provide the purchaser with any change in the status of quality assurance of materials during the period of concrete production.

3.2.2 *Changes in materials*

On request, the producer shall provide the purchaser with details of any proposed changes in the source or nature of any of the constituent materials during the period of concrete production.

3.2.3 *Changes in mix composition*

On request, the producer shall provide the purchaser with details of the following changes made during the period of production:

a) changes greater than 20 kg/m^3 in the cement content from that last declared;

b) where cements or combinations are used containing ground granulated blastfurnace slag (ggbs) limestone or pulverized-fuel ash (pfa) as a main constituent, changes in any agreed proportions except where changes are to ensure compliance with the relevant cement standard.

Any such changes shall not take the cement content or free water/cement ratio outside any specified limits.

3.2.4 *Cement, ggbs and pfa*

When requested, the producer shall provide the purchaser with the following:

a) a certificate stating that the cement complies with the appropriate British Standard;

b) a certificate stating that the ggbs or pfa complies with the appropriate British Standard.

3.2.5 *Changes in concrete quality assurance*

When the producer has provided the purchaser with information on certification of quality assurance, the purchaser shall be kept informed of any change in the status of certification.

3.3 Information on admixtures

When requested under **3.1**, the producer shall provide the purchaser with the following information:

a) the typical dosage and details of the effects of underdosage and overdosage;

b) the generic type(s) of the main active constituent(s) in the admixture;

c) whether or not the admixture contains chlorides and, if so, the chloride content of the admixture expressed as a percentage of chloride ion by mass of admixture;

d) whether or not the admixture leads to the entrainment of air when used at the proposed dosage;

e) where more than one admixture is used, data on their interaction and compatibility.

3.4 Suitability of proposed mix proportions to meet a specified strength (designed mixes only)

3.4.1 *General*

When evidence is requested, as in item e) of **3.1** of the adequacy of the proposed mix proportions to meet the specified strength, this generally shall be:

a) data from previous production of concrete using the materials and plant which will be used to produce the concrete, confirming that the proposed mix proportions satisfy the criteria given in **3.4.2**; or

b) where no satisfactory data exist under item a), data from trial mixes confirming that the proposed mix proportions satisfy the requirements of **3.4.3**.

Sampling and testing shall be carried out by the methods described in the relevant Parts of BS 1881.

3.4.2 ***Proposals based on previous production data***

When based on previous production data, the mean 28 day compressive strength calculated from n cube results, from separate batches of concrete, shall exceed the specified characteristic strength by:

$$k\sigma\left\{0.86 + \sqrt{\left(\frac{2}{n}\right)}\right\}$$

where

k is a statistical constant, not less than 1.64;

σ is the standard deviation estimated from n results, but not less than 3 N/mm^2;

n is the number of test results, not less than 10 and not greater than 100. A test result may be a single result or the mean of two or more results from cubes of the same sample.

When n exceeds 100, the mean strength shall exceed the specified characteristic strength by k, in which k shall be not less than 1.64 and s shall be not less than 3 N/mm^2.

Previous production data for use in calculating these criteria shall be 28 day compressive strength results from separate batches of concrete sampled at random over an immediately prior period exceeding 1 month and not exceeding 1 year, using the materials and plant which are proposed for the work.

3.4.3 ***Proposals based on trial mixes***

When trial mixes are required, by item b) of **3.4.1**, the number of laboratory and/or site mixed batches shall be specified or agreed between the purchaser and producer using the materials which are proposed for the work. The workability of each of the trial batches shall be the same as the proposed supply within the tolerances given in **3.5** of BS 5328-4:1990. Three cubes shall be made from each batch for test at 28 days. The average compressive strength of the three cubes tested at 28 days shall exceed the specified characteristic strength by at least 10 N/mm^2.

3.5 Suitability of proposed mix proportions to meet a specified maximum free water/cement ratio (designed mixes only)

When evidence is requested that the proposed mix proportions will provide concrete of the required workability, a producer shall provide evidence from his previous production and/or previous trial mixes using the same constituent materials and operating within the limits of the maximum free water/ cement ratio specified.

When a maximum free water/cement ratio has been specified and laboratory trial mixes are required, the suitability of the proposed mix shall be tested by preparing two batches in a laboratory in accordance with BS 1881-125 with cement and aggregates known from past records of the suppliers of the materials to be typical of those proposed.

The specified maximum free water/cement ratio of both trial batches shall not be exceeded when their workability is the same as that which is proposed to be used in the work.

4 Production of concrete

4.1 General

The purchaser shall be afforded all reasonable opportunity and facility to inspect the constituent materials and the manufacture of concrete and to take samples or to make tests. All such inspection, sampling and testing shall be carried out with the minimum of interference with the process of manufacture and delivery.

NOTE Designated mixes can only be supplied from plants that hold current product conformity certification based on product testing and surveillance coupled with approval of their quality system and therefore additional inspections by the purchaser will not normally be necessary.

4.2 Supervision, inspection and personnel

The design of mixes, the supervision of the production of the concrete and materials testing shall be carried out by experienced engineers, concrete technologists or technicians.

Batchermen and mixer-drivers shall receive instruction on the use of concrete batch data, the mode of operation of the equipment, particularly the control of the water content as described in **4.7** and the completion of the concrete delivery ticket, where appropriate.

Caution. When cement is mixed with water, alkali is released. Take precautions to avoid dry cement entering the eyes, mouth and nose when mixing cement or concrete by wearing suitable protective clothing. If cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash wet concrete off the skin immediately.

4.3 Selection of materials and design of concrete mixes

4.3.1 *General*

The materials shall be selected and the concrete mix designed to meet the requirements specified by or agreed with the purchaser.

4.3.2 *Adjustments to standard mixes*

The producer shall select the appropriate mix proportions for the specified standard mix from Table 5 of BS 5328-2:1997 and shall make adjustments to the specified values to obtain the correct yield as described in the footnote to Table 5 of BS 5328-2:1997 and for the characteristics of the aggregates to be used.

Where several sizes of single-sized coarse aggregates are used, they shall be combined in such proportions that the combined grading falls within the limits given in BS 882 or BS 1047 for graded aggregate of the appropriate nominal size except that a tolerance of up to 5 % is permissible. This tolerance shall be divided between the sieves within the total of 5 %. The producer shall adjust the percentage of fine aggregate in the mix according to the characteristics of the particular aggregates to be used.

NOTE A range of fine aggregate proportions is given in Table 5 of BS 5328-2:1997. Lower proportions are generally applicable to finer gradings, smoother textures or rounded shapes. Higher proportions are generally applicable to coarser gradings, rougher textures or angular shapes. For all grades, small adjustments in the percentages of fine aggregates may be required depending on the properties of the particular aggregates used.

For standard mixes ST4 and ST5 the overlapping ranges reflect the overlapping grading limits C, M and F in BS 882. The higher proportions are applicable to the coarser end of each grading limit and to mixes of higher workability. It is advisable to check that the proportion of fine aggregate given will produce satisfactory concrete if the grading of the fine aggregate approaches the coarser end of grading limits C or the finer end of grading limits F.

The actual batch weights shall be calculated to suit the size of the batch required from the values given in Table 5 of BS 5328-2:1997. Allowance shall be made for a moisture content typical of the aggregates being used.

4.4 Inspection on delivery, storage and handling of materials

4.4.1 *General*

At the point of delivery of the material, the supplier shall provide the purchaser with a delivery ticket identifying the material. The material shall be inspected for agreement with the description on the ticket and for freedom from visible damage or contamination.

4.4.2 *Cement, ggbs and pfa*

Separate storage shall be provided for different types of cement, ggbs and pfa which shall be clearly identified. Separate storage for cements of different strength classes is only necessary where the standard strength class or sub-class is specified.

Neither high alumina cement complying with BS 915 nor supersulphated cement complying with BS 4248 shall be mixed with any other type of cement.

NOTE 1 Careful storage is essential for supersulphated cement since it deteriorates rapidly in poor storage conditions.

Bins or silos shall be weatherproof and permit free flow and efficient discharge of their contents. Each bin or silo shall be fitted with an independent regularly cleaned filter or other method of dust control sufficient to allow the delivery to be maintained at the correct pressure.

NOTE 2 It may be necessary to aerate pfa to ensure free flow.

Bagged cement shall be stored in such a manner that it will not become damp either from the weather or from the ground. The store shall be managed so that the cement is used in the same order as it is delivered.

Cement that has been adversely affected by damp or other causes shall not be used.

4.4.3 *Aggregates*

Each nominal size and type of aggregate shall be stored separately.

Storage and handling shall be arranged to avoid contamination, minimize segregation and prevent intermingling with adjacent material. Adequate drainage shall be provided.

4.4.4 *Admixtures and pigments*

Admixtures and pigments shall be stored in accordance with the manufacturer's instructions and attention shall be given to preserving the legibility of identifying labels.

4.4.5 *Water*

Water shall be protected from contamination.

4.5 Batching

Cement, ggbs and pfa shall be measured by mass in one of the following ways:

a) by weighing, using a separate weighing device from that provided for the aggregates;

b) for cement, by using whole bags as provided by the manufacturer.

When permission is given by the purchaser, the following aggregates shall be measured either by mass or by volume:

1) aggregates for concretes of grades C7.5 and C10;

2) aggregates for concrete of grade C15, other than lightweight aggregates;

3) the lightweight coarse aggregate component only in concrete of grade C15 and higher;

4) aggregates for standard mixes ST1, ST2 and ST3.

In all other cases, aggregates shall be measured by mass, using a weighing device.

When weighing aggregate(s), allowance shall be made for the mass of the water in the aggregate(s).

Water shall be measured by volume or by mass.

Admixtures and pigments shall be used in accordance with the manufacturers' instructions. Solid admixtures and pigments shall be measured by mass. Liquid or paste admixtures shall be measured by mass or by volume. To ensure uniform dispersion, the measured dosage shall be discharged, preferably in a single shot, into the water prior to mixing or at the same time as the water is added. When certain admixtures, e.g. superplasticizers, are added subsequent to the mixing of the concrete; the concrete shall be adequately remixed to ensure uniformity.

The accuracy of the measuring equipment shall be within ±3 % of the quantity of cement, water or total aggregates being measured and within ±5 % of the quantity of admixture or pigments being used.

All measuring equipment shall be maintained in a clean and serviceable condition. The weighing devices shall be zeroed daily, checked for accuracy monthly and calibrated quarterly.

4.6 Mixing

The mixer shall comply with BS 1305 where applicable. The mixing time shall be not less than that used by the mixer manufacturer in assessing its performance or as determined by trials.

Mixers, except continuous mixers, shall be emptied before being charged with a new batch of concrete. Mixers shall not be loaded in excess of the manufacturer's rated capacity, which shall be displayed on the mixer in terms of the volume of mixed concrete.

Each batch of concrete shall be inspected prior to discharge.

4.7 Control of water content and workability

The water content of concrete shall be regulated by controlling its workability or by measuring and combining the moisture contents of the constituent materials. Batchermen and mixer-drivers shall be made aware of the appropriate responses to variations in concrete consistence of a particular mix caused by normal variations in aggregate moisture content or grading. The total amount of water added to the mix shall be recorded.

NOTE When water content is controlled by the assessment of the workability, the relationship between water content and workability for the materials used should be available.

4.8 Quality control

The producer shall implement procedures of supervision, inspection, testing, maintenance and calibration to ensure that the specified characteristics of the concrete will be achieved.

4.9 Temperature of fresh concrete

4.9.1 *Work in cold weather*

The temperature of the fresh concrete at the time of delivery into the construction shall be not less than 5 °C, unless any other value is specified, or permitted, by the purchaser.

When the required temperature is achieved by heating the mixing water and aggregates, the water shall not be heated above 80 °C. If the water is heated above 60 °C, it shall be mixed with the aggregate before coming in contact with the cement.

When working in cold weather, the mixing plant, aggregates and mixing water shall be free from snow, ice and frost.

4.9.2 *Work in hot weather*

The temperature of the fresh concrete at the time of delivery into the construction shall not exceed 30 °C unless any other value is specified, or permitted, by the purchaser.

4.10 Transport of concrete

4.10.1 *General*

Concrete shall be transported from the mixer to the point of placing as rapidly as practicable by methods that will maintain the required workability and will prevent segregation, loss of any constituents or ingress of foreign matter or water. The concrete shall be deposited as close as practicable to its final position to avoid rehandling or moving the concrete horizontally by vibration.

4.10.2 *Time of transport*

Concrete shall be discharged from the delivery vehicle within 2 h after the time of loading, when concrete is transported in truck mixers or agitators, or within 1 h after the time of loading when non-agitating equipment is used unless a shorter time is specified or a longer time permitted by the purchaser. The time of loading shall start from the first contact between cement and aggregates or, when these are surface dry, between cement and added water.

NOTE A longer time after loading may be appropriate in cool, humid weather or when ggbs, pfa or retarding admixtures have been used, but a shorter time may be essential in hot weather with rich mixes, or where accelerating admixtures have been used.

4.10.3 *Transport of centrally-batched concrete*

The technical requirements for the transport and delivery of ready-mixed concrete given in **4.10.4** shall also apply when centrally batched concrete is transported by road vehicles to the point of use on site.

4.10.4 *Transport and delivery of ready-mixed concrete*

4.10.4.1 *Quantity of concrete*

The basis of supply shall be by the cubic metre of fresh, fully compacted concrete. The volume of a given batch of concrete shall be calculated from the total mass of the batch divided by the mass per cubic metre of fresh, fully compacted concrete determined in accordance with BS 1881-107. The total mass of the batch shall either be calculated as the sum of the masses of all materials used including water or be determined from the gross and tare weights of the vehicle on a weighbridge.

NOTE Compaction by the method described in BS 1881-107 is not appropriate for semi-dry concrete mixes.

4.10.4.2 *Transport of concrete*

Concrete shall be transported in a truck mixer unless the purchaser agrees to the use of non-agitating vehicles. When non-agitating vehicles are used, the mixed concrete shall be protected from gain or loss of water.

4.10.4.3 *Additional water*

No water, other than any amount required to produce the specified workability, shall be added to the truck mixer drum before discharge unless specifically required and signed for by the purchaser. The water added shall be recorded on the delivery ticket.

4.10.4.4 *Delivery ticket*

Before discharging the concrete at the point of delivery, the supplier shall provide the purchaser with a delivery ticket for each batch of concrete on which is printed, stamped or written the following minimum information:

a) the name or number of the ready-mixed concrete depot;

b) the serial number of the ticket;

c) the date;

d) the truck number;

e) the name of the purchaser;

f) the name and location of the site;

g) the grade or mix description of the concrete;

h) the specified workability;

i) the minimum cement content, if specified;

j) the type and, if specified, the standard strength class or sub-class of the cement or combination;

k) the limiting proportions of ggbs or pfa, if specified;

l) the maximum free water/cement ratio, if specified;

m) the nominal maximum size of aggregate;

n) the type or name of admixture, if included;

o) the quantity of concrete in cubic metres;

p) the time of loading.

The following information shall be added to the delivery ticket on site:

q) the time of completion of discharge;

r) the water added to meet the specified workability;

s) the extra water added at the request of the purchaser of the concrete, or his representative, and his signature.

NOTE Space should be provided for any additional items.

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Publications referred to

BSI publications

BRITISH STANDARDS INSTITUTION, London

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

BS 915, *Specification for high alumina cement.*

BS 1047, *Specification for air-cooled blastfurnace slag aggregate for use in construction.*

BS 1305, *Specification for batch type concrete mixers.*

BS 1881, *Testing concrete.*

BS 1881-107, *Method for determination of density of compacted fresh concrete.*

BS 1881-125, *Methods for mixing and sampling fresh concrete in the laboratory.*

BS 4248, *Specification for supersulphated cement.*

BS 5328, *Concrete.*

BS 5328-1, *Guide to specifying concrete.*

BS 5328-2, *Methods for specifying concrete mixes.*

BS 5328-4, *Specification for the procedures to be used in sampling, testing and assessing compliance of concrete.*

BS 5750, *Quality systems.*

BS 6100, *Glossary of building and civil engineering terms.*

Other publications

[1] BRE Digest 330[1)] Alkali-silica reaction in concrete, 1999

[1)] Available from CRC Ltd, 151 Rosebery Avenue, London EC1R 4QX or online from www.brebookshop.com.

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