BRITISH STANDARD

BS 1881 :
Part 130 : 1996

Testing concrete

Part 130. Method for temperature-matched curing of concrete specimens

ICS 91.100.30

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/1, Concrete production and testing, upon which the following bodies were represented:

Association of Lightweight Aggregate Manufacturers
Association of Metropolitan Authorities
British Aggregate Construction Materials Industries
British Cement Association
British Civil Engineering Test Equipment Manufacturers
British Iron and Steel Producers' Association
British Precast Concrete Federation
British Ready Mixed Concrete Association
Building Employers' Confederation
Cement Admixtures Association
Cementitious Slag Makers' Association
Concrete Society
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Highways Agency
Institute of Concrete Technology
Institution of Structural Engineers
Institution of Water and Environmental Management
National House Building Council
Quality Ash Association
Sand and Gravel Association
Society of Chemical Industry

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 November 1996

Amendments issued since publication

Amd. No.	Date	Text affected

The following BSI references relate to the work on this standard:
Committee reference B/517/1
Draft for comment DD 92

ISBN 0 580 25890 4

Contents

Foreword

This Part of BS 1881 has been prepared by Subcommittee B/517/1. It describes a method for temperature-matched curing of concrete specimens and is based on the method described in DD 92 : 1984.

During the period between fresh concrete in an element setting, and it being subjected to working loads, an estimate of the in situ strength may be required for a number of reasons. Some of the more common are:

– to provide information on the gain of concrete strength in cold conditions;

– to determine the striking time for vertical and soffit formwork;

– to determine the time at which prestressing operations may be started

– to determine the time at which a member may be subjected to all or part of the working load;

– to provide information on the effects of temperature on the long term strength of the concrete.

The in situ cube strength (as defined in BS 6089) differs from the standard strength of water-stored cubes cured at 20 °C (as defined in BS 1881 : Part 111) for a number of reasons. These include:

– variations in mix proportions within or between batches;

– differences in compaction;

– differences in moisture conditions during curing;

– differences in temperature history.

This test procedure only addresses the difference in temperature history.

The temperature history of concrete in an element will depend on the types and quantities of cement, the thermal properties of the concrete, the size and shape of the section, the insulating properties of the formwork, the ambient temperature conditions and the concrete placing temperature. From the foregoing, it can be seen that standard cubes may not give a reliable indication of the concrete strength in the element particularly at early ages, where large differences in temperature history can occur between cubes stored at 20 °C, and the concrete in the element. An alternative method is therefore needed for estimating the early-age strength of the concrete in the element under consideration.

Several methods are in use, but these vary considerably in accuracy and appropriateness for the following reasons.

– Tests conforming to BS 1881 : Part 207 : 1992 are only suitable for estimating the concrete strength near to the surface as they are dependent on impact, penetration resistance, or rupture of the concrete surface. However, this is the concrete that is protecting the reinforcement and it is often the most highly stressed part of the cast section.

– Cubes cured alongside the cast section provide a safe and reasonable means by which the strength of the cast section can be estimated only if the cast section is thin and not insulated. In larger cast sections, cubes cured alongside will substantially underestimate the early-age strength of the cast section.

– By matching the temperature of water in a curing bath to the rise and fall of temperature in a concrete element, cubes cured in the bath are subjected to the same temperature history as the concrete at a selected point in the element. When tested for strength, these cubes should give a more accurate estimate of the concrete strength at a selected point in the element at the time of testing. This method of curing cubes is termed 'temperature-matched curing'.

A feature of using temperature-matched curing is that a record is obtained of the rise and fall in concrete temperature due to the hydration of the cement. Depending on the particular conditions, the control of early-age thermal cracking may require conformity to a maximum peak temperature, a maximum fall from peak temperature to mean ambient temperature and/or a maximum temperature difference. Where the heat of hydration of the concrete causes the temperature to exceed 70 °C, the properties of the concrete may be affected. In order to assess the possibility of damage to concrete by any of the above phenomena, recording the temperature at various locations in the structure is often advantageous. Such an investigation may be undertaken either in conjunction with, or independently of temperature-matched curing. Annex A of this Part of BS 1881 describes how such temperature histories should be recorded.

Specification

1 Scope

This Part of BS 1881 describes the method for curing concrete cubes so that they follow the concrete temperature at a pre-selected position in a concrete element.

Guidance on recording the temperature history at other positions in a concrete element is also given.

2 References

2.1 Normative references

This Part of BS 1881 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 1881 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 1881 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this Part of BS 1881 are listed on the inside back cover, but reference should be made to the latest edition.

3 Definitions

For the purposes of this Part of BS 1881, the definitions given in BS 1881 : Part 101 : 1983 apply.

4 Apparatus

4.1 *Cube moulds*, 100 mm or 150 mm (as appropriate to the maximum aggregate size in use), conforming to BS 1881 : Part 108 : 1983, together with cover plates.

NOTE. The function of the cover plate is to prevent concrete being washed from the cube surface by the circulating water, but not necessarily to provide a complete seal. Mould bases make suitable cover plates.

4.2 *Water bath (or curing tank)*, of sufficient capacity to contain at least four cube moulds.

4.3 *Water heater*, capable of raising the temperature of the water in the filled bath at a rate of 10 °C/h.

4.4 *Agitating device*, for circulating the water in the bath to ensure an even temperature distribution.

4.5 *Temperature sensor*, accurate to ± 1 °C, compatible with and forming part of the control equipment described below, for monitoring the temperature of the concrete at the location at which the in situ strength is to be estimated.

4.6 *Temperature sensor*, accurate to ± 1°C, compatible with and forming part of the control equipment described below, for monitoring the temperature of the water bath.

4.7 *Recorder*, capable of recording the outputs from the above temperature sensors continuously, or at intervals not exceeding 15 min in the first 24 h of curing, and 30 min thereafter.

4.8 *Control equipment*, recorded by the water bath sensor to within ± 1 °C when compared with that recorded by the concrete temperature sensor.

NOTE 1. Provided the quantity of water in the bath does not exceed 150 l, natural cooling of an unlagged bath is usually sufficient to keep its temperature the same as that measured at the concrete temperature sensor whilst the concrete temperature is falling.

NOTE 2. The operator of the equipment should undertake appropriate checks (e.g. third party calibration, or comparison with alternative equipment) to ensure that the temperature sensors are within the accuracy required by **4.5** and **4.6**.

NOTE 3. The temperature sensor in the water bath should be located well away from heating element.

NOTE 4. The equipment should function satisfactorily up to temperatures of 80 °C.

NOTE 5. Advice on methods suitable for recording temperatures is given in **A.4.**

5 Method

5.1 Positioning the concrete temperature sensor

Take care when selecting the location for the concrete temperature sensor. Position the sensor at the selected location preferably before placing the concrete, or within 30 min of placing. Ensure that when the chosen position is near an external face, the tip of the sensor is at least 25 mm away from any formed or exposed surface.

NOTE 1. Typical locations for the temperature sensors are 50 mm deep into the concrete:

- near to the face of a vertical surface;
- near to the upper exposed face of a horizontal surface;
- when using applied heat, on the side opposite the applied heat or, when heat is uniformly applied, the centre of the element.

NOTE 2. When assessing formwork striking times or the time for starting prestressing or loading for example, the location chosen should be representative of the cooler parts of the element. This will ensure that the matched cubes give a safe strength.

NOTE 3. Care should be taken in the routing of the connecting cable for the concrete temperature sensor, to minimize the risk of damage during and after the placing of the concrete.

5.2 Sampling the concrete

Take a representative sample of the concrete being placed in the element using the method described in BS 1881 : Part 101 : 1983 for concrete sampling on site, or BS 1881 : Part 125 : 1986 for sampling in the laboratory. Cast at least four cubes from this concrete into moulds using the method described in BS 1881 : Part 108 : 1983. Wipe the top edge of each mould clean and apply the cover plate. Place the filled moulds immediately into the water bath immersing them completely. Ensure that the initial temperature of the water bath is within + 1 °C to − 5 °C of the concrete temperature.

5.3 Curing

Switch on the control and recording equipment as soon as the concrete temperature sensor is covered with concrete.

5.4 Strength testing

At the required ages, remove at least two cubes, demould and test them immediately for compressive strength in accordance with the method given in BS 1881 : Part 116 : 1983. Report the results individually.

6 Report

6.1 General

The report shall confirm that the test specimens were cured in accordance with this Part of BS 1881, and in particular that inspection of the temperatures recorded from the sensors indicates that the requirement of **4.8** has been conformed to. The report shall state whether or not a certificate of sampling and specimen preparation is available. If available, a copy of each certificate shall be provided.

6.2 Information to be included in the test report

6.2.1 *Essential information*

The following information shall be included in the test certificate:

a) identification of the concrete element in the structure;

b) location of the concrete temperature sensor within the element;

c) method of curing of the element, e.g. time of retention of shutters, additional measures;

d) date and time of commencement of test;

e) identification marks on the cubes or test specimens;

f) nominal size of cubes or type of test specimens;

g) age of specimens in days (if less than 3 days, in hours);

h) strength of cubes in N/mm^2 (see **5.4**);

i) a note of any malfunctions of the equipment;

j) calibration status of the test equipment.

6.2.2 *Additional information*

The following information should be made available if requested at the time of issuing instructions for the test:

a) appearance of the test sample;

b) temperature history of the element recorded by the concrete temperature sensor;

c) maturity at testing, stating what maturity function was used.

Where temperature histories are required as part of the report, advice on the presentation of the data is given in **A.6**.

Annex

Annex A (informative)

Recording the temperature history of a concrete element

A.1 General

In addition to the temperatures monitored by the temperature-matched curing system, it is often desirable to monitor and record the temperature history in various other positions of large concrete elements. This may be achieved by the use of additional temperature sensors connected to a suitable recorder.

A.2 Additional temperature sensors

A.2.1 The positioning of any additional temperature sensors should be agreed in advance with due consideration to the data required and its application.

Fixing the measuring tip of sensors to reinforcement should be avoided as conduction of heat through the reinforcement may give false readings of the temperature of the concrete. Thermocouples for example should be attached such that the measuring junction is placed at least 25 mm from the reinforcement.

For recording ambient air temperatures, sensors should be positioned to avoid direct sunlight.

A.2.2 The guidance in NOTE 3 of **5.1**, concerning cable routing, should be followed.

A.3 Accuracy

A.3.1 Measurements from any additional temperature sensors should be accurate to $\pm$ 1 °C.

A.3.2 The operator should undertake appropriate precautions (for example third party calibration, or comparison with alternative equipment) to ensure that the indicated readings from any additional temperature sensors conform to **A.3.1**.

A.4 Frequency of logging

If continuous recording equipment (e.g. a chart recorder) is not used, the frequency of recording temperatures should be agreed in advance. Time intervals should be appropriate to the rate of change of concrete temperature expected and the duration of recording.

Experience has shown that recording temperatures at 30 min intervals produces an acceptably smooth temperature history curve. Shorter intervals may be necessary with rapid hardening cements, fast track construction methods, or with the application of accelerated curing methods.

A.5 Recording data

A variety of methods are available for recording the outputs from the temperature sensors. Typical forms of data storage are as follows:

a) papertape (as printed numbers or punched tape);

b) paper chart in a chart recorder (as a trace);

c) computer disk (digital, in a format suitable for any further processing);

d) magnetic tape or data cassette.

A.6 Presentation of data

After any necessary processing, presentation of the data should include the date and time of commencement of the concrete pour, the pour reference number, and the location of all the temperature sensors.

The data should be presented, in tabular or graphical form as required, for all the temperature sensors. Tabulated data should show all the recorded temperatures, without editing. A graphical presentation of the data should show temperature (vertical scale) against time (horizontal scale), and may include either all the recorded data, or if appropriate, only selected representative results.

List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 1881 :	*Testing concrete*
BS 1881 : Part 101 : 1983	*Method of sampling fresh concrete on site*
BS 1881 : Part 108 : 1983	*Method for making test cubes from fresh concrete*
BS 1881 : Part 116 : 1983	*Method for determination of compressive strength of concrete cubes*
BS 1881 : Part 125 : 1986	*Methods for mixing and sampling fresh concrete in the laboratory*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 1881 :	*Testing concrete*
BS 1881 : Part 111 : 1983	*Method of normal curing of test specimens (20 °C method)*
BS 1881 : Part 207 : 1992	*Recommendations for the assessment of concrete strength by near-to-surface tests*
BS 6089 : 1981	*Guide to assessment of concrete strength in existing structures*
DD 92 : 1984	*Method for temperature-matched curing of concrete specimens*

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ISBN 0 580 25890 4