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Testing concrete –

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

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 6, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 1881 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 January 2013. It was prepared by Subcommittee B/517/1, *Concrete production and testing*, under the authority of Technical Committee B/517, *Concrete*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 1881 supersedes BS 1881-130:1996, which is withdrawn.

Relationship with other publications

BS 1881 is published in the following parts:

- BS 1881-113, *Method for making and curing no-fines cubes*;
- BS 1881-119, *Method for determination of compressive strength using portions of beams broken in flexure (equivalent cube method*);
- BS 1881-122, *Method for determination of water absorption*;
- BS 1881-124, *Methods for analysis of hardened concrete*;
- BS 1881-125, *Method for mixing and sampling fresh concrete in the laboratory*;
- BS 1881-128, *Method for analysis of fresh concrete*;
- BS 1881-129, *Method for the determination of density of partially compacted semi-dry fresh concrete*;
- BS 1881-130, *Method for temperature matched curing of concrete specimens*;
- BS 1881-131, *Methods for testing cement in a reference concrete*;
- BS 1881-201, *Guide to the use of non-destructive methods of test for hardened concrete*;
- BS 1881-204*, Recommendations on the use of electromagnetic covermeters*;
- BS 1881-206, *Recommendations for determination of strain in concrete*;
- BS 1881-207, *Recommendations for the assessment of concrete strength by near-to-surface tests*;
- BS 1881-208, *Recommendations for the initial surface absorption of concrete*;
- BS 1881-209, *Recommendations for the measurement of dynamic modulus of elasticity of concrete*;
- DD 216, *Determination of chloride content of fresh concrete*.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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 cannot confer immunity from legal obligations.

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Introduction

During the period between fresh concrete in an element hardening, and it being subjected to working loads, an estimate of the in-situ strength might be required for a number of reasons, these include:

- 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 pre-stressing operations may be started
- to determine the time at which a member may be subjected to all or part of the working load; and
- to provide information on the effects of temperature on the long term strength of the concrete.

The in-situ cube or cylinder strength (as defined in BS 6089) differs from the standard strength of water-stored cubes or cylinders cured at 20 °C (as defined in BS EN 12390-2) for a number of reasons, including:

- variations in mix proportions within or between batches;
- differences in compaction;
- differences in moisture conditions during curing; and
- differences in temperature history.

This test procedure only addresses the difference in temperature history.

The temperature history of concrete in an element depends 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. Because of this, standard cubes or cylinders might 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 or cylinders 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 EN 12504-2 and BS EN 12504-3 are only suitable for estimating the concrete strength near to the surface as they are dependent on impact, resistance, or rupture of the concrete surface. However, as this is the concrete that protects the reinforcement, it is often the most highly stressed part of the cast section.
- Specimens 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, specimens cured alongside 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, specimens 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 specimens 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 specimens 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 might 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 might 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 describes how such temperature histories can be recorded.

1 Scope

This part of BS 1881 describes the method for curing concrete cubes or cylinders 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 Normative References

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 12350-1, *Testing fresh concrete – Part 1: Sampling*

BS EN 12390-1, *Testing hardened concrete – Part 1: Shape, dimensions and other requirements for specimens and moulds*

BS EN 12390-2, *Testing hardened concrete – Part 2: Making and curing specimens for strength tests*

BS EN 12390-3, *Testing hardened concrete – Part 3: Compressive strength of test specimens*

3 Terms and definitions

For the purposes of this part of BS 1881, the terms and definitions given in BS EN 12350-1 apply.

4 Apparatus

4.1 *Cube or cylinder moulds*, conforming to BS EN 12390-1 (as appropriate to the maximum aggregate size in use) together with a cover plate.

NOTE The function of the cover plate is to prevent concrete being washed from the specimen 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 specimen 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 for concrete*, accurate to ±1 °C, compatible with and forming part of the control equipment described in **4.8**, for monitoring the temperature of the concrete at the location at which the in-situ strength is to be estimated.

4.6 *Temperature sensor for water bath*, accurate to ±1 °C, compatible with and forming part of the control equipment described in **4.8**.

4.7 *Recorder(s)*, capable of recording the outputs from the temperature sensors located in the water bath and concrete continuously, or at intervals not exceeding 15 min in the first 24 h of curing, and 30 min thereafter.

4.8 *Control equipment*, capable of maintaining the temperature of the water bath to ±2 °C when compared with the concrete temperature, and capable of functioning satisfactorily up to temperatures of 80 °C.

NOTE 1 Provided the quantity of water in the bath does not exceed 150 L, natural cooling of an un-lagged 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 temperature sensor in the water bath should be located well away from heating element.

*NOTE 3 Advice on methods suitable for recording temperatures is given in **A.4**.*

5 Method

5.1 Positioning the concrete temperature sensor(s)

5.1.1 Agree the position(s) at which the temperature sensor(s) are to be placed within the element with the person(s) requesting that the test is carried out.

5.1.2 Position the sensor at the selected location preferably before placing the concrete, or within 30 min of placing.

5.1.3 Ensure that when the chosen position (see **5.1.1**) is near an external face, the tip of the sensor is at least 25 mm and preferably 50 mm away from any formed or exposed surface.

NOTE When assessing formwork striking times or the time for starting pre-stressing or loading for example, the location chosen should be representative of the cooler parts of the element. This is to ensure that the matched cubes/cylinders give the required strength.

5.2 Sampling and curing

5.2.1 Take a representative sample of the concrete being placed in the element in accordance with BS EN 12350-1.

5.2.2 Cast at least four specimens from this concrete into in accordance with BS EN 12390-2.

5.2.3 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.

5.2.4 Ensure that the initial temperature of the water bath is within ±1 °C of the concrete temperature.

5.2.5 Switch on the control and recording equipment at least 30 min before the concrete temperature sensor is covered with concrete.

5.3 Strength testing

5.3.1 At the required ages, remove at least two specimens, de-mould and test them immediately for compressive strength in accordance with BS EN 12390-3.

5.3.2 Record the results individually for each specimen.

6 Report

6.1 General

The report shall state 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 control equipment used was in accordance with **4.8**.

6.2 Information to be included in the test report

The report shall include the following*:*

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 test specimens;

f) nominal size of test specimens;

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

h) strength of cubes/cylinders in N/mm² (see **5.3**);

i) a note of any malfunctions of the equipment;

j) calibration status of the test equipment;

k) any deviations from this standard; and

l) documentation of the sampling method, if available.

NOTE 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; and

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

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

The positioning of any additional temperature sensors should be agreed with the person(s) requesting that the test is carried out 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 can 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 so that they avoid direct sunlight.

A.3 Accuracy

Measurements from any additional temperature sensors should be accurate to ±1 °C.

A.4 Frequency of logging

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

Bibliography

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6089, *Assessment of in-situ compressive strength in structures and pre-cast concrete components – Complementary guidance to that given in BS EN 13791*

BS EN 12504-2, *Testing concrete in structures – Non-destructive testing – Part 2: Determination of rebound*

BS EN 12504-3, *Testing concrete in structures – Part 3: Determination of pull-out force*

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