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Testing concrete

Part 211: Procedure and terminology
for the petrographic examination of
hardened concrete



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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 30 November 2016. 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.

Information about this document

The Applied Petrography Group (APG) set up a working party to develop a guidance document relating to the petrographic examination of hardened concrete. This guidance document was published on the Applied Petrography Group website as *APG Special Report 2* [1].

Further discussions around this document between members of the APG and other interested persons in the UK and abroad has led to the development of this part of BS 1881.

Use of this document

It has been assumed in the preparation of this part of BS 1881 that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

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.

Requirements in this standard are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause J.1.1, which states, “Requirements should be expressed using wording such as: ‘When tested as described in Annex A, the product shall ...’”. This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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.

Introduction

BS 1881-211 gives a method for the petrographic examination of hardened concrete.

When applied to concrete samples, petrographic examination refers to a detailed study primarily carried out by visual and optical microscopy and the documentation of observations derived from that examination. The documented report might contain observations only, or could also include conclusions and recommendations for those requesting the study.

It is not intended that such an examination would form part of the routine assessment of the suitability of hardened concrete products. However, the procedures can provide unique and valuable information regarding the ingredients, properties and condition of hardened concrete samples. Such findings can be used in isolation, or as part of a broader programme of investigative studies.

In all cases, the procedures outlined are intended to be performed by an appropriately qualified concrete petrographer or, where specialist support procedures are used, an appropriately qualified materials technologist.

In certain cases, other analytical techniques, including but not limited to, chemical analysis, scanning electron microscopy and X-ray diffraction, might be desirable to augment the petrographical examination.

1 Scope

This British Standard describes procedures and terminology for the examination of hardened concrete and mortar. The procedures are intended to be performed by an appropriately qualified or experienced concrete petrographer.

The principal application of the method described requires the use of a polarizing petrological microscope for the examination of concretes containing Portland and other cements. The petrographic procedures outlined are applicable to the examination of samples of all types of hardened hydraulic cement-based materials, including concrete, mortar, grout, cement and gypsum-based plaster, render, terrazzo, and similar materials.

NOTE In this British Standard, the material for examination is designated as "concrete", even though the commentary is also applicable to the other mixtures, unless the reference specifically excludes a material other than concrete.

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 480-11, *Admixtures for concrete, mortar and grout — Test methods — Part 11: Determination of air void characteristics in hardened concrete*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 macroscopic examination

initial examination of the sample in hand specimen with the aid of a hand lens or stereomicroscope in order to determine the general features of the concrete

3.2 microscopic examination

examination of a prepared thin section using transmitted plane and crossed polarized light in order to provide microstructural information

3.3 thin section

slice of concrete impregnated with dyed resin and mounted on a glass slide

NOTE 1 The concrete is ground to a thickness of between 20 μm and 30 μm , and is sufficiently thin for light to be transmitted through it.

NOTE 2 Customarily thin sections have an area of (50 $\times$ 70) mm.

4 Principle

Petrographical examination involves the visual recognition of the constituents within the concrete to determine the condition of the various materials, to address concerns relevant to wider investigations of a structure, or to facilitate laboratory investigations. A petrographical examination is important to highlight features within the concrete that might already, or might later, influence the behaviour of the material under service conditions. A nomenclature is provided in Annex A.

5 Apparatus

5.1 Apparatus for the examination of samples

5.1.1 Hand lens or stereoscopic microscope, capable of magnifications up to $\times$ 40.

5.2 Apparatus for the petrographic examination of concrete samples

5.2.1 Polarizing petrological microscope, capable of high-resolution at magnifications up to $\times$ 500 and fitted with a digital camera and a means of calibrating the scale of images.

5.2.2 Point-counting apparatus, for use with the petrological microscope, e.g. an electrical or mechanical stage linked to a counting device, such that operation of any one of the counters automatically moves the thin section one further step along the traverse.

5.2.3 Image analysis software (if required).

5.3 Apparatus for detailed study

5.3.1 Petrological microscope, with appropriate filters and light source providing the ability to carry out fluorescence observations in transmitted light.

NOTE Fluorescence requires an ultraviolet light source with appropriate safety provisions.

5.3.2 Petrological microscope, with the facility to work in reflected as well as transmitted light.

NOTE For many manufacturers, objective lenses are designed specifically for this purpose.

5.3.3 Air void characteristics measurement equipment, for the measurement of the air void characteristics of hardened concrete in accordance with BS EN 480-11.

6 Sampling and preparation of test specimens

The number of specimens required depends on the purpose of the examination; for deterioration investigations, all regions of a structure or element that exhibit different types of distress or exposure conditions shall be sampled. Additionally, at least one control core specimen shall be taken from an adjacent region, in the same member, where no deterioration is visible. Ideally for quality assurance or quality control purposes, a sample shall be taken for a selected volume of the concrete produced for a project.

Suitable specimens are diamond-cut core samples, lump samples or cast cube/cylinder/prisms; the type of specimen submitted for examination shall depend on the nature of the task and the structure from which it is to be taken. The size shall be appropriate for the scope of work. Care shall be exercised if using specimens that might be too small to allow comparison of a chosen region of deterioration with that of surrounding non-deteriorated concrete.

For all specimens, the following information (where available) shall be recorded, either on the core/lump sample or on a sampling sheet:

- a) unique site reference;
- b) date of sampling;
- c) photographs of the location of the core or cut specimen;
- d) reason for sampling location;
- e) age of structure;
- f) exposure conditions
- g) method employed to extract specimen;
- h) vertically or horizontally cut specimen;
- i) arrow on the profile of the specimen indicating direction towards outer face;
- j) arrow on the end of the specimen indicating way-up on specimens from a vertical surface; and
- k) mix design.

Specimens shall only be deemed fit for purpose if, when related to the scope of work, they are of sufficient size and number, are uncontaminated, and are from appropriate locations. Any deficiencies in the specimen sizes shall be recorded and the observations stated as preliminary or inconclusive. In such cases, it shall be recorded that the report relates specifically to the specimens received and that any extrapolation is clearly identified.

Care shall be taken when sampling not to wash out any deposits that might be present or induce any new cracking or damage to a specimen. The outer surface shall also be protected from damage during sampling as many features of interest are contained within this zone.

Specimens shall be wrapped in cling-film and placed in labelled sealed polythene bags before being placed into rigid containers suitable for secure transportation.

NOTE For early age concrete samples, it might be appropriate to wrap samples in moist paper towels placed in a sealed plastic bag to prevent premature drying of actively hydrating cement. This is not necessary for most concrete of 1 month or older.

Specimens shall be adequately padded and placed in a rigid container for shipping to prevent mechanical damage in transit.

7 Preparation of thin and polished thin sections

7.1 General

One or more thin sections shall be prepared depending on the size of the sample, the features observed and the purpose of the examination.

NOTE 1 Details of the technique needed to prepare a thin section is given in Annex B and supplementary techniques are given in Annex C.

A thin section is a portion of material mounted on a slide and mechanically reduced to a thin slice (0.025 ± 0.005) mm in thickness, and normally protected by a slide cover. For special purposes (observations with reflected light microscope for the determination of opaque minerals or microprobe analysis), polished blocks, slabs, sections or polished thin sections shall be prepared. Polished blocks and polished thin sections shall have one side polished with alumina polishing paste (5 μm to 12 μm grade) and diamond paste (6 μm , 3 μm and 1 μm). The polished side shall remain uncovered.

The thin section shall typically measure approximately (70 × 50) mm, but larger or smaller sections may be used as appropriate.

NOTE 2 Smaller thin section sizes might require additional thin sections to be prepared to ensure that the total area of thin section available for study is representative of the sample.

7.2 Preparation of thin sections

COMMENTARY ON 7.2

This subclause provides a description of a method for thin section preparation commonly employed in the UK. However, many other procedures and types of equipment are available. For guidance on the apparatus and machinery to be used, see Annex D.

For all methods employed, the following precautions shall be taken.

- a) Excessive heating involving temperatures of >45 °C shall be avoided during the thin section preparation.
- b) Exposure to air shall be minimized as carbonation can take place very rapidly in freshly ground and polished concrete surfaces, and carbonation results in the loss of valuable information in the finished thin section.
- c) Exposure to water shall be kept to a minimum in order to avoid secondary hydration and the loss of water-soluble compounds from the hardened cement paste.

7.3 Preparation of polished specimens

Large-area polished surfaces can be examined with a binocular microscope to obtain valuable information about the concrete. As large an area of the specimen as is possible shall be provided – ideally representing the full length of the core or area of cut surface and including the parts of the specimen not examined in thin section. The method of polishing shall typically involve the use of glass or cast iron lapping plates and abrasive slurry, finishing with a surface ground, and polished using alumina polishing pastes ending at 12 μm grade or finer.