

Cements

Published October 2000
Reprinted October 2004

One of a series of publications produced in conjunction with the following organizations, and part-funded by DETR.

Association of Concrete Industrial Flooring Contractors
Association of Lightweight Aggregate Manufacturers
British Cement Association
British Standards Institution
Building Research Establishment
Cement Admixtures Association
Cementitious Slag Makers Association
Concrete Industry Alliance
Concrete Society
Glanville Consultants
Institute of Concrete Technology
Ove Arup & Partners
Quarry Products Association
Ready-mixed Concrete Bureau
RMC Readymix Ltd
L M Scofield Ltd
United Kingdom Quality Ash Association

A full list of the publications in this series is given on the back page.

INTRODUCTION

This publication provides information on the types and properties of cements that have been, or are being, standardized in Europe for implementation in national standards in CEN member countries. It provides guidance on the circumstances when it may be necessary to specify a type or class of cement to a concrete producer.

The types of cement used in concrete have been, or are being, standardized in the BS EN 197 series, *Cement – Composition, specifications and conformity criteria*:

Part 1: *Common cements*;

Part 3: *Low heat common cements*;

Part 4: *Sulfate-resisting cements*.

Although these product standards give limited guidance on how to use the cements, many are traditional to the UK, but previously supplied under different BS numbers, notation and titles. Table 1 on page 3 indicates the previous British Standard that contains the closest specification to each BS EN 197-1 cement notation and identifies the BS EN 197-1 cements that are currently manufactured in the UK.

In fact, although BS EN 197-1 has already been published by BSI, in practice UK cement manufacturers will only begin to supply common cements to this new harmonised (CE marking) standard from 1 April 2001. Only from that date does it become legally permissible to affix the CE marking to conforming cements.

The new BS EN will provide an opportunity for using more types of cement than previously, but the use in UK concrete of unfamiliar types will still need appropriate validation before being adopted in national specifications.

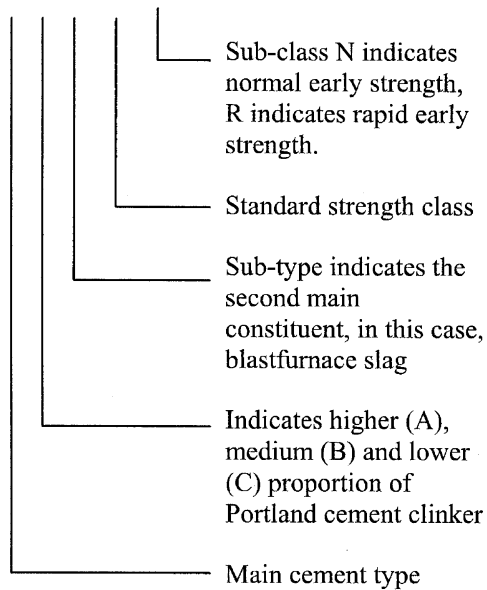
TYPES OF CEMENTS

Notation for cements

Cements standardized to BS EN 197-1 cover a range of five main types, from CEM I (Portland cement) to CEM V (composite cement). The notation applied to them indicates: the main cement type; the proportion of Portland cement clinker; the second main constituent; the standard (i.e. 28-day) strength class and the rate of early strength gain.

For example, a particular Portland-slag cement to BS EN 197-1 is denoted by:

CEM II/A-S 42.5 N



Cements standardized in other parts of the BS EN 197- series, will tend to adopt the principles of the BS EN 197-1 notation but not necessarily the detail.

Constituents of cements

The possible constituents of factory-produced cements, corresponding to the various cement types in BS EN 197-1 described in Table 1 are:

- main constituent, e.g. Portland cement clinker;
- second main constituent, e.g. fly ash, blastfurnace slag, limestone, silica fume;
- minor additional constituent, e.g. fly ash, blastfurnace slag, limestone, natural pozzolana;
- set regulator, i.e. calcium sulfate;
- additives, e.g. grinding aids, air-entraining agents, pigments.

The code letters used to indicate the sub-type and thus the second main constituent are:

- S – blastfurnace slag
- D – silica fume;
- P – natural pozzolana;
- Q – natural calcined pozzolana;
- V – siliceous fly ash (e.g. pfa);
- W – calcareous fly ash (e.g. high-lime fly ash);
- T – burnt shale;
- L – limestone;
- M – two or more of the above.

Table 1: Types of cement and their composition in BS EN 197-1

British Standard		Cement	BS EN 197-1 cement notation	Clinker content, %	Content of other main constituents, %	BS EN-197-1 cements, UK manufactured	
To be withdrawn	To co- exist						
BS 12	BS 4027	Portland cement	CEM I	95 – 100	–	✓	
–	BS 146	Portland-slag cement	CEM II/A-S	80 – 94	6 – 20		
			CEM II/B-S	65 – 79	21 – 35	✓	
–	–	Portland-silica fume cement	CEM II/A-D	90 – 94	6 – 10		
–		Portland- pozzolana cement	CEM II/A-P	80 – 94	6 – 20		
			CEM II/B-P	65 – 79	21 – 35		
			CEM II/A-Q	80 – 94	6 – 20		
			CEM II/B-Q	65 – 79	21 – 35		
BS 6588		–	Portland-fly ash cement	CEM II/A-V	80 – 94	6 – 20	
				CEM II/B-V	65 – 79	21 – 35	✓
–		–	Portland-burnt shale cement	CEM II/A-W	80 – 94	6 – 20	
				CEM II/B-W	65 – 79	21 – 35	
–		–	Portland-burnt shale cement	CEM II/A-T	80 – 94	6 – 20	
				CEM II/B-T	65 – 79	21 – 35	
–		BS 7583	Portland- limestone cement	CEM II/A-L	80 – 94	6 – 20	
				CEM II/A-LL	80 – 94	6 – 20	✓
				CEM II/B-L	65 – 79	21 – 35	
	CEM II/B-LL			65 – 79	21 – 35		
–	–	Portland- composite cement	CEM II/A-M	80 – 94	6 – 20		
			CEM II/B-M	65 – 79	21 – 35		
–	BS 146	Blastfurnace cement	CEM III/A	35 – 64	36 – 65	✓	
BS 4246	–		CEM III/B	20 – 34	66 – 80	✓	
			CEM III/C	5 – 19	81 – 95		
–	–	Pozzolanic cement	CEM IV/A	65 – 89	11 – 35		
–	BS 6610		CEM IV/B	45 – 64	36 – 55		
–	–	Composite cement	CEM V/A	40 – 64	36 – 60		
			CEM V/B	20 – 39	61 – 80		

NOTE

See the National Foreword and National Annex to BS EN 197-1 for the time-scale and reasons for the withdrawal or continued co-existence of current British Standards and the BS EN.

PROPERTIES OF CEMENTS

Strength classes for cement

The standard strength class of a cement categorizes its performance in terms of the BS EN 196, *Methods of testing cement. Part 1: Determination of strength test for compressive strength in N/mm² (MPa), at an age of 28 days.* Each class spans a "conformity band" of 20 N/mm² (MPa), defined by upper and lower limits as shown in Table 2. These limits are characteristic rather than absolute and permit up to 5% of test results to fall below the lower limit by not more than 2.5 N/mm² (MPa) and up to 10% to exceed the upper limit. The lower characteristic value defines the strength class. Cements are also tested at ages of 2 days or 7 days, depending on the strength class, to establish whether they are of normal or high early strength sub-class.

Table 2 Strength classes for cement

Compressive strength, N/mm ² (MPa)				
Strength class	Early strength		Standard strength	
	2 days	7 days	28 days	
32.5N	–	≥ 16.0	≥ 32.5	≤ 52.5
32.5R	≥ 10.0	–		
42.5N	≥ 10.00	–	≥ 42.5	≤ 62.5
42.5R	≥ 20.00			
52.5N	≥ 20.00	–	≥ 52.5	–
52.5R	≥ 30.00			

Other properties of cements

In addition to strength, cements to BS EN 197-1 have to satisfy a number of other requirements, including initial setting time, soundness (as indicated by expansion) and a number of chemical properties. Examples are shown in Table 3.

Table 3: Other properties of cements

Standard strength class	32.5	42.5	52.5
Initial setting time*	≥ 75 min	≥ 60 min	≥ 45 min
Expansion*	≤ 10 mm	≤ 10 mm	≤ 10 mm

*Tested according to BS EN 196-3, *Determination of setting time and soundness.*

CEMENTS WITH SPECIAL PROPERTIES

Sulfate-resisting cements

A European Standard EN 197-4 is being developed that will probably cover a number of types of sulfate-resisting cements and, when published and implemented in the UK, will require the withdrawal of BS 4027, *Specification for sulfate-resisting Portland cement.* Until then, BS 4027 remains current and also provides a route to the selection of low-alkali (LA) cement.

Low heat cements

Three European Standards are being prepared to cover a number of types of cements with low heat characteristics. The first, EN 197-3, *Composition, specification and conformity criteria for low heat common cements,* will be a general standard that sets classes of heat of hydration applicable to any 'Portland type' cement. When implemented, this will require the withdrawal of BS 1370, *Specification for low heat Portland cement.* The next one in the group will cover low early strength, low heat cements (strength classes, 32.5L, 42.5L and 52.5L). The final one will cover mass concrete, low heat cements of strength class 22.5L.

WHEN TO SPECIFY THE CEMENT

he draft BS 8500 gives the range of cements suitable for use in defined exposure classes. The specifier may further restrict this choice, but emphasis should be placed on establishing the appropriate concrete specification, leaving the producer to select a cement from BS 8500 that will economically achieve the required performance. If restrictions are placed on the producer's choice of cement type, then it is essential that the concrete specification takes the likely effects into account, otherwise conflicting requirements can occur.

Specification of designed or designated concrete

The draft BS 8500 provides a list of suitable cement types for each exposure class or designation, for both designed and designated concretes. Further restriction of these lists of cements is only necessary if, for example, the following are required:

- white or coloured concrete;
- control of temperature rise or gradient in the concrete;
- control of rate of gain of strength of the concrete;
- special concrete finishes.

Specification of standardized prescribed concrete

The draft BS 8500 provides a list of suitable cement types for standardized prescribed concrete and, as previously, further restriction is usually unnecessary. When cements of strength class 32.5 are used, the required cement content is automatically increased by 10%.

Specification of prescribed concrete

The specifier assumes responsibility for the choice of materials, their proportions (except water) and the consistence class. The producer is responsible for producing concrete to those proportions. The specifier is also responsible for the resulting performance of the hardened concrete. Thus for prescribed concrete the specification contains the type and the standard strength class of the cement. Naturally, the local availability of materials should be checked.

FURTHER READING

The other publications from this series will be helpful. Visit www.cementindustry.co.uk and click 'information'/'library'/'BCA publications' to check availability and for free download.

Standards for fresh concrete – a composite of BS EN 206-1 and BS 8500

Specifying concrete to BS EN 206-1/BS 8500:

Concrete for normal uses

Concrete resistant to chemical attack

Guide to the selection of concrete quality and cover for reinforcement for normal concrete structures

Examples of the specification of designated concrete

Examples of the specification of designed concrete

Guidance on additional requirements for designed concrete

Lightweight concrete

Visual concrete

Coloured concrete

Concrete for industrial floors

Specifying constituent materials for concrete to BS EN 206-1/BS 8500:

Cements

Additions

Admixtures

European replacements for British Standards: Concrete and its constituent materials

Specifying constituent materials for concrete to BS EN 206-1/BS 8500: Cement

45.307

First published 2000

ISBN 0 7210 1565 4

Price group A

© British Cement Association 2000

Published by the British Cement Association on behalf of the supporting organizations.

British Cement Association
Riverside House, 4 The Meadows Business Park
Station Approach, Blackwater
Camberley, Surrey GU17 9AB
Telephone 01276 608700
Facsimile 01276 608701
www.cementindustry.co.uk

All advice or information from the British Cement Association is intended for those who will evaluate the significance and limitations of its contents and take responsibility for its use and application. No liability (including that for negligence) for any loss resulting from such advice or information is accepted. Readers should note that all BCA publications are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.