

Factory-made composite cements

Introduction

Factory-made composite cements have been available in the UK for over 30 years but until recently have been supplied into fairly localised markets. Now, however, a range of types is available across the UK which incorporate limestone, fly ash or blastfurnace slag as secondary constituents. These factory-made composite cements are supplied variously by BCA Member Companies for use in bulk or packed in bags.

This Fact Sheet describes the composition, properties and performance of factory-made composite cements in order to increase awareness and to demonstrate where their use is already permitted in a wide range of end-use applications.

What are factory-made composite cements?

Used here the term factory-made composite cement means any cement type that conforms to BS EN 197-1 [1] (or BS EN 197-4 [2]) other than CEM I. They comprise Portland cement clinker combined (interground or blended) with one or more additional inorganic constituents plus an optimised amount of set-regulator ('gypsum'). So, factory-made composite cements are collectively, types CEM II, CEM III, CEM IV and CEM V and are identified by name in Table 1. Such a use of the term 'composite' aligns with the UK concrete sector's traditional understanding but is wider than is implied by the cement standard itself wherein two particular cements, CEM II/M and CEM V, include the word 'composite' in their names.

Table 1. Types of factory-made composite cements included in BS EN 197-1

CEM II	Portland-slag cement (S)	Portland-silica fume cement (D)	Portland-pozzolana cement (P, Q)	Portland-fly ash cement (V, W)	Portland-burnt shale cement (T)	Portland-limestone cement (L, LL)	Portland-composite cement (M)
CEM III	Blastfurnace cement						
CEM IV	Pozzolanic cement						
CEM V	Composite cement						

NOTE 1. Note that types CEM II/M and CEM V include the word 'composite' in their names but the expression 'factory-made composite cements', as used here, is not restricted to these two types.

NOTE 2 The capital letters in brackets denote the specific type of secondary constituent permitted in the cement; their meaning is defined in BS EN 197-1 for common cements.

Factory-made composite cements are the manufactured alternatives to the additions/mixer combinations used in concrete and are available across the full range of standardised strength classes. They are appropriately formulated to cover the scope of possible applications either as general purpose building cements, typically packed in bags, or for use in more structural applications and typically, but not exclusively, supplied in bulk.

Which factory-made composite cements do BCA Member Companies actually make?

BCA Member Companies market their factory-made composite cements under a variety of brand names. However, even within a given company, brand names may differ for the same cement where it is supplied both in bulk and packed in bags. Nevertheless, the 'standard designations' (generic descriptions in product standards) are always included on delivery documents and bags. The factory-

made composite cements that BCA Member Companies currently make (2006) are identified in Table 2.

Table 2. BCA Member Company factory-made composite cements (2006)			
Types	Standard designation		
	Notation (types of cement)		Strength classes of current production
CEM II	Portland-limestone cement	CEM II/A-L and II/A-LL	32,5 R, 42, 5 N and 52,5 N
	Portland-fly ash cement	CEM II/A-V	32,5 R and 42,5 N
		CEM II/B-V	32,5 N, 32,5 R and 42,5 N
CEM III	Low early strength blastfurnace cement	CEM III/A	42,5 L

NOTE 1. The letters 'A' and 'B' in notations for CEM II cements indicate the range of proportions of the secondary constituent. 'A' indicates from 6% to 20%, whereas 'B' indicates from 21% to 35%, all by mass.

NOTE 2. The letter 'A' [and 'B' and 'C', if used] in notations for CEM III cements indicates the range of proportions of the secondary constituent. 'A' indicates from 36% to 65% by mass [whereas 'B' would indicate from 66% to 80% and 'C' would indicate from 81% to 95%].

NOTE 3. In strength classes, the letter N denotes ordinary early strength, the letter R denotes high early strength and the letter L denotes low early strength.

Properties/performance of factory-made composite cements

Portland cement CEM I has an enviable record of successful performance as 'the' global binder. Its properties are understood and it is robustly fit-for-purpose in concretes, mortars and grouts in all but the most demanding environments. However, in general, the appropriate specification/use of factory-made composite cements can deliver performance equal to that of concrete containing CEM I cement and under certain conditions, can improve on the durability performance achieved. Furthermore, in the case of use in masonry mortars, within the generality of exposure conditions, factory-made composite cements can achieve the same level of performance on a one-to-one volume basis as a CEM I cement within the same traditional volume mix proportions [see BCA Fact Sheet 13].

Some particular examples of improved properties/performance of use of factory-made composite cements in concrete are given in Table 3.

Table 3. Examples of improved properties/performance using factory-made composite cements in UK concrete permitted by BS 8500 (in comparison with the use of Portland cement CEM I)			
Property /performance	Benefit	Notation (type of cement)	
Workability	Improved workability	Factory-made composite cements in general	
Bleeding	Reduced bleeding	Factory-made composite cements in general	
Heat of hydration	Reduced heat of hydration leading to a reduced risk of early thermal cracking	Blastfurnace cement	CEM III/A
			CEM III/B
Sulfate-resistance	Increased resistance to both the conventional (ettringite) and the thaumasite (TSA) forms of sulfate attack	Portland-fly ash cement	CEM II/B-V (+SR)*
		Pozzolanic cement	CEM IV
		Blastfurnace cement	CEM III/A
CEM III/B			

Chloride ingress	Decreased rate of chloride ingress leading to a reduced risk of corrosion of reinforcement	Blastfurnace cement	CEM III/B
Alkali silica reaction	Reduced risk of damaging ASR	Portland-fly ash cement	CEM II/B-V
		Blastfurnace cement	CEM III/A CEM III/B
<p>* (+SR) means 'sulfate-resisting' and that the CEM II/B-V cement contains at least 25% by mass of fly ash.</p> <p>NOTE. The meaning of the letters 'A' and 'B' in notations for CEM II or CEM III types of composite cements is the same as described in the notes to Table 2.</p>			

The complete specification of factory-made composite cements (together with their mixer combination counterparts) is beyond the scope of this Fact Sheet but, in the case of concrete, can be found in BS 8500-2 [3]. In the case of specification of factory-made composite cements for use in masonry mortars, a fuller description can be found within BCA Fact Sheet 13, its references and associated guidance documents.

Implications of factory-made composite cements for the specifier and concrete producer

Factory-made composite cements can be manufactured either by inter-grinding or blending. These operations are, as are all others, under factory control. In particular, the proportioning of the constituents is under the responsibility of the cement maker and is subject to factory production control procedures and audit testing leading to CE marking under a system of attestation of conformity (AoC) of 1+ (see BCA Eurocemts Information Sheet No. 1). This gives a specifier confidence, in a transparent and easily traceable manner, that the correct composition has been achieved.

In addition, the cement maker has a range of measures at his disposal with which to optimise the properties and performance of his composite cements in the fresh wet and hardened states. These measures include:

- optimising the gypsum/sulfate content to regulate setting without compromising strength development;
- using additives to reduce water demand or to improve early strength;
- ensuring compatibility at source between the individual constituents;
- and, if necessary, modifying clinker composition to optimise performance.

Potential benefits for the concrete producer in using a factory-made composite cement, include:

- factory production control of proportions and CE marking;
- ensured homogeneity of constituents;
- reduced batching time;
- single point ordering;
- possible reductions in required storage capacity.

It must be acknowledged, though, that the fixed proportions of factory-made composite cements may lead to some reduction in a concrete producer's overall flexibility. However, it is possible for a cement maker to adopt a 'winter' and 'summer' formulation, within the compositional limits of a particular factory-made composite cement.

Structures in which factory-made composite cements have been used

Although by no means exhaustive, a few examples of where factory-made composite cements have already been used in the UK are given in Table 4.

Type of cement	Name/types of structure or application	Location in UK
Portland-fly ash cement	Falkirk Wheel	Falkirk
	Channel Tunnel Rail Link	Kent
	Thames Crossing tunnel segments	Woolwich
	Wind farms	[Several locations]
	Water infrastructure	
	Industrial floors	[Several locations]
Ready-mixed concrete	[Several locations]	
Portland-limestone cement	Falmouth College of Arts	Cornwall
	Ready-mixed concrete	S W England
Low early strength blastfurnace cement	Ready-mixed concrete, precast concrete blocks and precast concrete pavers	[Several locations]

What does the future hold for factory-made composite cements?

In mainland Europe, factory-made composite cements have, over the past 40 years, captured a significant and increasing market, estimated to be about 68% in 2004 [4]. In the UK in the same year the equivalent market share was around 5%. BCA Member Companies have recently (during 2006) introduced a new range of CEM II factory-made composite cements to the UK market. These are principally packed products using fly ash, blastfurnace slag or limestone as the secondary constituent. The cement industry expects that the use of factory-made composite cements will continue to grow as specifiers and users become more aware of their properties, performance and availability.

Where can I find out more?

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References

- [1] British Standards Institution. BS EN 197-1, *Cement-Part 1: Composition, specifications and conformity criteria for common cements*
- [2] British Standards Institution. BS EN 197-4, *Cement-Part 4: Composition, specifications and conformity criteria for low early strength blastfurnace cements*
- [3] British Standards Institution. BS 8500-2, *Concrete – Complementary standard to BS EN 206-1, Part 2 Specification for constituent materials and concrete*
- [4] CEMBUREAU (European Cement Association) statistics, 2005

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