MPA Cement Fact Sheet 14a

Modern cements (Packed)

What are modern cements?

'Cement' is the basic 'glue' that binds together all the components of concrete which, in turn, is the most widely used construction material on earth. But what is cement? And what are 'modern cements'?

Traditionally, 'cement' has meant 'ordinary Portland cement (OPC)' to most professional and occasional users in UK. Although re-named 'Portland cement CEM I' in 2000, it still dominates bulk supply (see Fact Sheet 14b) from the factory for use, either as the sole 'glue' or in combination with other cementitious materials, in construction and civil engineering. Factory supply into the UK bagged market is, however, significantly different where major changes since 2006 have led to a market which is now CEM II-dominated; CEM II cements are types variously described as 'lower carbon' or 'factory-made composite' cements. The expression 'modern cements' is, however, used herein to describe all the major Portland-type cements (CEM I to CEM V) potentially available to the UK market, with those actually supplied by MPA Cement's four member companies specifically identified.

The introduction of even more 'new', or unfamiliar, cements is almost inevitable. Economic and regulatory changes together with an increasing commitment from all stakeholders to sustainable development are all drivers-for-change in cement process, composition and performance. In consequence, specifiers, concrete producers and construction workers alike are now encountering different types of cement with differing properties.

Portland cement CEM I

To provide a reference point, we first need to know how Portland cements are made. The manufacture of the basic material, Portland cement CEM I, involves precise blending of limestone or chalk, with clay or shale (quarried and finely-ground) then heating the resultant mixture in a rotary kiln to 1450ºC. At that temperature, a chemical change takes place and the raw materials turn into a hard, nodular solid known as clinker. After cooling, the clinker is ground in a ball, or roller, mill to produce cement powder. Approximately five percent gypsum (calcium sulfate) is also inter-ground in order to control the setting time of the product. The overall process is energy-intensive and much CO_2 is emitted during the chemical changes in the kiln but the production of CEM I clinker, and cement, is essential because it is a basic constituent of all CEM II, CEM III, CEM IV and CEM V cements.

A library could be filled with the books and research material written about the manufacture, properties, uses and sustainability credentials of CEM I Portland cement; suffice it to say that it provides the multiple 'benchmarks' against which all other cements tend to be compared. Although patented almost 200 years ago, it is yet 'modern' in the sense that it has undergone continual development, has demonstrated remarkable

adaptability/robust performance and its continued use in everyday concreting around the world means that it still forms the 'bedrock' of the built environment.

The demands for 'sustainable development', however, have placed an increased responsibility on the construction sector to continuously improve existing processes, products and practices, and to innovate in order to reduce both energy used in service and embodied energy in products together with reduced emission of greenhouse gases during manufacture. It is these drivers, coupled with the realities/logistics of a mature supply-chain together with the overarching requirement to provide products appropriately 'fit-for-purpose' into the wide range of end-use applications, that has led to the current market mix of modern CEM I and 'low carbon' factory-made composite cements. Within this market mix, it is undoubtedly the case that CEM I cement is readily available throughout UK in bulk delivery but has become rather more difficult to source in bags, displaced in large measure, by 'low carbon' CEM II cements.

Low carbon, CEM II, III, IV and V packed cements

Low carbon, factory-made cements have been available in the UK for over 90 years but until 2006 had been supplied in bulk into fairly localised markets. Now, however, a range of types of packed cement is available across the UK that incorporates limestone or fly ash as secondary constituents. These factory-made cements are supplied variously by MPA Cement's Member Companies.

Used here the term low carbon cement means any cement type that conforms to BS EN 197-1 [1] other than CEM I. They comprise Portland cement clinker combined (inter-ground or blended) with one or more additional inorganic constituents plus an optimised amount of set-regulator ('gypsum'). They are 'low carbon' because they contain lower proportions of cement clinker; they are collectively, types CEM II, CEM III, CEM IV and CEM V and are identified generically, along with CEM I, by standard name in Table 1.

Table 1. Types of modern cement including low carbon, factory-made composite cements standardised in BS EN 197-1

Type		Standard name						
CEM I		Portland cement						
Low carbon, factory-made composite cements	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.

Which low carbon, packed cements do MPA Cement's Member Companies market?

MPA Member Company low carbon packed cements identified by brand name

MPA Cement's Member Companies market their low carbon, factory-made composite cements under a variety of brand names and those currently manufactured (2014) by MPA Cement's members are given in Table 2.

Table 2. Brand names for MPA Cement Member Company packed cements (2014)

Cement type (by standard designation)	Brand names			
	CEMEX	Hanson	Hope	Lafarge Tarmac
Portland (CEM I)	*Rugby High Strength*	*High Strength 52,5N*	*Currently, Hope does not produce packed cements*	*Procem*
				Ferrocrete
				Portland Max
Portland-fly ash (CEM II/B-V)	*Rugby⁺ Cement*	*Sulfate-Resisting*		*General Purpose*
	Rugby⁺ Sulfate			*Sulfacrete*
Portland-limestone [CEM II/A-L(-LL)]	*Rugby⁺ Premium**	*Cement (General Purpose)*		*General Purpose*
		*Multicem**		*Mastercrete**
				Buxton Cement

* Contains an integral air entraining admixture

In addition, 'standard designations' (generic descriptions in product standards) are always included on delivery documents and/or bags (see Table 1 for the basic notation).

Identification of, and market for, packed cements in UK

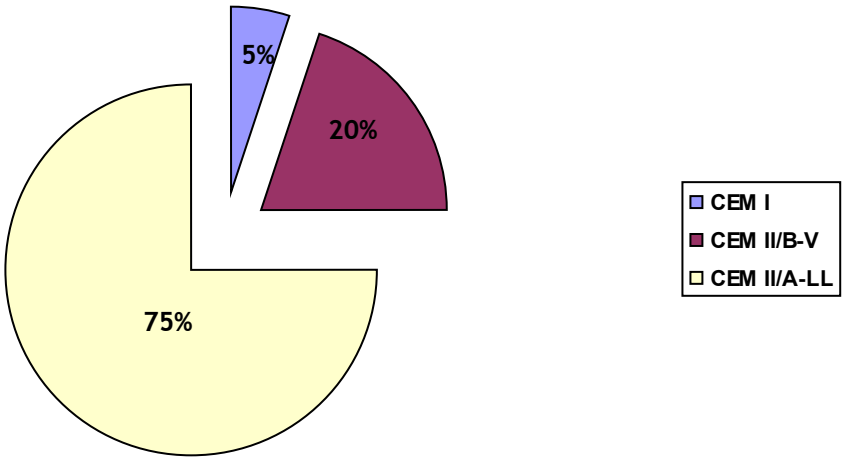
Since 2006, there has been a major shift in the UK market for packed cement, away from CEM I Portland cement (formerly known as OPC) and towards more sustainable CEM II cements where a proportion of the clinker is replaced by alternative, low carbon, cementitious materials.

Typical packed cement formulations currently available are:

- CEM I: Portland cement
- CEM II/B-V: Portland-fly ash cement (21 - 35% fly ash)
- CEM II/A-L (LL): Portland-limestone cement (6 - 20% limestone) *

* May also include air entraining admixtures

In 2010, the UK market for packed cements was divided as given in the figure below and MPA Cement Member Company brand names for these bagged cements are as given above in Table 2:



Interaction of modern (CEM II) cements with mortar admixtures

Mortar admixtures (plasticisers, waterproofers etc.) developed for CEM I Portland cement may not give the same level of performance with the new types of packed cement designated CEM II. It is apparent that admixture manufacturers, especially those not also supplying the bulk cement market, may not be aware of this change in the packed cement profile or have not re-evaluated their products for relative performance and reformulated as necessary.

Users of admixtures for mortar or concrete should check the admixture labelling to ensure that the product states that it is suitable for use with CEM II or with 'all types of cement' and follow the manufacturers instructions for use. Trial mixes are usually encouraged but if the user is in doubt he should make trial mixes and/or contact the admixture manufacturer for advice.

If they have not already done so, admixture manufacturers should consider reformulating their products in order to match the available cement types because it is most unlikely that the UK packed cement market will return to the previous, CEM I Portland cement dominated position.

MPA Cement members will be pleased to provide samples of cement and/or technical advice as appropriate; see Table 3 for contact names:

Table 3. Contact names in MPA Cement's Member Companies (2014)

Company	Contact	E-mail	Tel
CEMEX Cement	Richard Boult	richardguy.boult@cemex.com	01788 517252
Hanson Cement	Simon Chudley	simon.chudley@hanson.biz	01724 282211
Hope Cement	Jo Cantwell	joanne.cantwell@hopeconstructionmaterials.com	0845 520 1888
Lafarge Tarmac Cement	Bill Price	bill.price@uk.lafarge.com	0845 812 6296

Properties/performance of low carbon, packed cements

Performance

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 low carbon packed cements can deliver performance equal to that of concrete or mortar etc. containing CEM I cement and under certain conditions, can improve on the durability performance achieved.

When using modern low carbon packed cement, users should be aware that the rate of strength gain with time varies with cement type. In general CEM II to CEM V cements have a lower early strength than Portland cement CEM I but tend to gain a higher strength over a longer period. There is, however, an important caveat in that the quality of workmanship is paramount in determining adequate strength and durability of the end-use product, irrespective of the cement type.

Importance of workmanship

Whatever type of packed cement is used, there really is no substitute for good practice and workmanship in ensuring a durable cement-based building product. It is essential to use the correct materials, proportion and mix the materials properly, add the correct amount of water, compact, cure and protect as appropriate. When using low carbon, packed cements (CEM II etc), it is particularly important to ensure that effective curing (days rather than hours) is applied promptly and effectively. Precautions should always be taken to avoid loss of water to the surroundings and to prevent premature drying whether the end-use is: concrete, mortar, screed or render.

Sustainability

As a consequence of continual improvement in process and composition, modern packed cements are more sustainable than previously. Put simply, as clinker content decreases, a cement's contribution to sustainability increases. Clinker production is very energy, and carbon, intensive and even though specific energy consumption and CO_2 emissions are being reduced year-on-year, future reductions will become more difficult to achieve. In consequence, the means for satisfying societal demands for cement, fulfilling environmental obligations and responding to economic imperatives have had to be reconsidered. This has led, where appropriate to the end-use, to the direct reduction of ‘clinker intensiveness’ in factory-made packed cements by the manufacturer using increased quantities of inorganic materials, inter-ground or blended, to produce low carbon CEM II and CEM III cements.

The effects on the embodied CO_2 (CO_2e) of modern cements can be seen in the indicative values for Portland cement CEM I and the range of additions used in UK as constituents of concrete, as reported in MPA Cement Fact Sheet 18 [2]. In addition, CO_2e figures for a range of factory made composite cements and their equivalent combinations are given in MPA Cement Fact Sheet 18. These values are ‘year-specific’ and therefore subject to

change by way of periodic improvement; progress is reported by updating Fact Sheets 18 from time-to-time.

Benefits in use

Some particular benefits of improved properties/performance of use of low carbon, packed cements are described in Table 4.

Table 4. Improved properties/performance of low carbon, packed cements (in comparison with use of CEM I)

Property /performance	Benefit	Notation (type of cement)	
Workability	Improved workability/cohesion	Portland limestone cement	CEM II/A-LL
		Portland fly ash cement	CEM II/B-V
Bleeding	Reduced bleeding	Portland fly ash cement	CEM II/B-V
		Enhanced Portland-limestone cement**	CEM II/A-L(-LL)
Heat of hydration	Reduced heat of hydration leading to a reduced risk of early thermal cracking	Portland-fly ash cement	CEM II/B-V
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)*
Chloride ingress	Decreased rate of chloride ingress leading to a reduced risk of corrosion of reinforcement	Portland-fly ash cement	CEM II/B-V
Alkali silica reaction	Reduced risk of damaging ASR	Portland-fly ash cement	CEM II/B-V
Frost attack	Reduced risk of damage in severe winters	Enhanced Portland-limestone cement**	CEM II/A-L(-LL)

* (+SR) means 'sulfate-resisting' and that the CEM II/B-V cement contains at least 25% fly ash by mass of the 'sum of the main and minor additional constituents' (i.e. total constituents of the cement excluding calcium sulfate).

** Containing integral air entraining agent

How will modern cements develop in the future?

Although it is the operational impacts of a building that are the most significant in terms of the overall sustainability of construction, the embodied environmental impacts of materials/construction units are also subject to comparative rating. This means that manufacturers need to constantly innovate in order to minimise such impacts. In the case of cements, the effect is almost certain to be that the proportion of low carbon, factory-

made composite cements (particularly CEM II and CEM III), as a fraction of total production of modern cements, will continue to increase.

MPA Cement's Members are committed to improving the sustainability credentials of all their cements and supplying them packed (and in bulk).

Where can I find out more?

Contact: C McCague, Tel: +44(0)20 7963 8000, colum.mccague@mineralproducts.org

References

[1] British Standards Institution. BS EN 197-1, *Cement-Part 1: Composition, specifications and conformity criteria for common cements*

[2] MPA Cement (plus CSMA and UKQAA), Fact Sheet 18 *Embodied CO_{2e} of UK cement, additions and cementitious material*

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