Properties and Applications of Bulk PLC

(Portland Limestone Cement, CEM II/A-LL 52,5N) for use in In-Situ Concrete

LAFARGE
bringing materials to life ™

This document summarises the general properties and applications of PLC cement for use in in-situ concrete (Although much of the information is also relevant to the production of concrete products). It is intended to be read in conjunction with the Lafarge Cement product datasheet. However, it is not exhaustive and for more detailed advice, or where the properties of concrete are critical, specialist publications should be consulted.

For Health and Safety information please refer to the Lafarge Cement Health and Safety datasheet for Portland-limestone cement.

1. Description

PLC is the Lafarge Cement brand name for bulk Portland-limestone cement. This generic type of cement is designated in the British Standard for cement (BS EN 197-1[1]) as BS EN 197-1: CEM II/A-LL or BS EN 197-1: CEM II/A-L. This designation covers cement containing between 80 and 94% Portland cement clinker, 6 –20% limestone and 0-5% minor additional constituents.

Lafarge cement **PLC** typically contains around 10-15% limestone and is class 52,5 with normal (N) early strength development. The 'LL' suffix indicates that the limestone component is of high purity, with a level of total organic carbon below 0.20% *(If the organic content of the limestone is between 0.20% and 0.50%, the suffix 'LL' is replaced by 'L').*

Lafarge bulk PLC, produced at our Aberthaw works*, is designated as:

BS EN 197-1 CEM II/A-LL 52,5N

Lafarge **PLC** is manufactured by inter-grinding the various constituents to produce a homogeneous product. It is subject to the same rigorous production control as all other BS EN 197-1 cements with independent third-party verification and carries a CE Mark.

It should be noted that prior to the introduction of EN 197-1 in 2000, there was already a British Standard (BS 7583:1996, now withdrawn) for this type of cement. Portland-limestone cements have therefore been available in the UK for around 15 years. Portland-limestone cements also have a long history of widespread use elsewhere in Europe, having first been standardised in Spain in 1960[3].

The reduced clinker content of **PLC** relative to CEM I, combined with the widespread availability of limestone increases the sustainability of the cement. The embodied CO_2 of a **PLC** is around 85% of a typical CEM I[2]

** Lafarge Cement also produces a CEM II/A-LL 42,5N cement at Hope works, containing around 18% limestone. For more information on the properties and applications of this product, please contact the Technical Helpdesk (0845 812 6232)*

2. Properties

The properties of **PLC** are very similar to those of conventional Portland cement (CEM I) and in most circumstances the two cements are interchangeable, but there are some differences in properties that need to be recognised.

2.1 Fresh concrete

At the same cement content, concrete containing **PLC** will have a slightly reduced water demand and hence the slump at a given water/cement ratio will generally be slightly higher than for a Portland cement concrete.

At constant slump however, the concrete will appear to be cohesive and bleeding will be reduced. The rate of slump loss is also slower.

Perhaps the most noticeable feature of concrete containing **PLC** is that it will appear slightly lighter in colour than Portland cement concrete. The setting time of **PLC** concrete is not significantly different to Portland cement.

2.2 Hardened concrete

Contrary to popular belief, the limestone component of **PLC** is not simply an inert filler[3,4]. It is thought that the finely divided limestone accelerates the hydration of C_3S by increasing nucleation and also modifies the C_3A hydration to form a stable monocarboaluminate phase. There is also a physical space filling effect leading to a reduction in porosity in the hardened cement paste.

The overall result is that, despite its lower clinker content, the early age strength development of **PLC** is similar to that of Portland cement and higher than that of Portland cement/fly ash or Portland cement/slag blends. At 7 and 28 days, the strength of concrete containing **PLC** will generally be similar to concrete containing Portland cement of the same strength class. However, with some aggregate combinations a 5% increase in cement content (relative to CEM I) may be appropriate. As with all concrete, particular attention to curing is needed for concrete containing **PLC** in order to develop the full potential properties of the cement.

Hardened concrete made with **PLC** will be lighter in colour and will often have a smoother surface finish than Portland cement concrete, making it particularly suitable for visual concrete elements. This is a result of the preferential grinding of the limestone in the production process leading to a finer particle size distribution in the final cement.

3. Durability

3.1 Alkali-Silica Reaction (ASR)

The measures to be taken in order to minimise the risk of ASR are described fully in BRE Digest 330[5]. This document is also referenced by the current British Standard for concrete; BS 8500[6].

PLC is treated in the same way to Portland cement. It has a declared mean alkali content based on the total alkali content of the cement, which is used to calculate its contribution to the alkalis in concrete. However, this declared value (currently 0.72 % Na_2O eq) is lower than for a Portland cement (currently 0.75 % Na_2O eq) due to the inherently low alkali content of the limestone component. (See table 1 above).

3.2 Resistance to sulfate attack and aggressive ground

Provisions for concrete to resist sulfate attack and other forms of aggressive ground are given in BS 8500 and BRE Special Digest 1[7]. **PLC** is restricted to use in DC-1 and DC-2 conditions, as indeed is Portland cement (CEM I), but with different limits on water/cement ratio and cement content. (See table 2 below).

3.3 Resistance to carbonation

For concrete of a given strength class, BS 8500 recognises that for a given concrete strength class, concrete containing CEM II/A-L (or LL) cement ie: **PLC** has equivalent resistance to carbonation to concrete containing other cement types in all carbonation classes (XC1, XC2, XC3/4).

3.4 Resistance to chlorides

BS 8500 considers that for concrete of the same strength class **PLC** has equivalent resistance to chlorides as Portland cement.

3.5 Resistance to Freezing and Thawing

Once again, BS 8500 considers that concrete made with **PLC** (CEM II/A-L (orLL)) has equivalent resistance to freezing and thawing as concrete of the same strength class made with other cement types. For exposure to severe conditions, air-entrained concrete is always the preferred option.

4. Concrete Mix Design

Concrete mix design using **PLC** cement concrete is not significantly different to that for Portland cement concrete.

4.1 Workability and water content

Slightly less water is required for the same slump, when using **PLC** compared to CEM I.

Table 1

Aggregate Reactivity	Maximum Allowable Cement Content (kg/m3) *** Lafarge PLC	Lafarge CEM I
Low	>550	>550
Normal	485	465
High	345	335

**** Assumes no alkali contribution from sources other than the cement*

Table 2

Design Chemical Class	Min Cement Content (kg/m3)*** CEM I	PLC*	Max water/cement ratio*** CEM I	PLC*
DC-1	-	-	-	-
DC-2	340	360	0.50	0.45
DC-2z	320	320	0.55	0.55
DC-3 and above	-Not Permitted			

** For PLC of strength class 42,5 or 52,5*

**** For concrete containing 20mm max size aggregate*

4.2 Strength and cement content

The appropriate cement content for concrete of a given 28 day cube strength and slump should be determined from trial mixes.

The cement content may differ from that of an equivalent Portland cement (CEM I) concrete in certain circumstances. In particular, where a high strength concrete is required, the cement content may be slightly higher than for CEM I.

The early age strength of the **PLC** concrete will however, be similar to, or slightly higher than CEM I concrete of the same 28 day strength.

4.3 Compatibility with admixtures

PLC is compatible with most commercially available concrete admixtures, including air-entraining admixtures.

5. Applications

5.1 General construction

Concrete containing **PLC** cement is appropriate for a wide range of above-ground construction applications and can generally be used wherever Portland cement (CEM I) concrete would be used (for both in situ and precast work). As mentioned earlier, the light colour and smooth surface finish of **PLC** concrete makes it particularly suitable for architectural concrete elements. **PLC** concrete pumps easily and can be slipformed.

5.2 Mortar and Screeds

Current standards[8,9,10] permit the use of **PLC** in masonry mortars. It may also be used in levelling screeds and concrete bases that will subsequently receive flooring[11] as well as in directly finished concrete wearing courses[12]. However, it is not permitted in cementitious wearing screeds[12]. As with all screeds, particular attention to curing is needed for screeds containing **PLC**.

Table 2

1	Cement – Part 1: Composition, specifications and conformity criteria for common cements. BS EN 197-1, 2000: BSI
2	Embodied CO2 of factory made cements and combinations. Fact Sheet 18[P2], BCA/CSMA/UKQAA: 2009
3	Moir G. Gaining acceptance. International Cement Review, March 2003,66-70
4	Matschei T.et al. The role of calcium carbonate in cement hydration. Cement & Concrete Research, (37) 551-558, 2007
5	Alkali – Silica reaction in concrete: Detailed guidance for new construction. BRE Digest 330 Part 2, 2004: Building Research Establishment
6	Concrete – Complementary British Standard to BS EN 206-1 Part 1: Method of specifying and guidance for the specifier. BS 8500-1, 2006: BSI Part 2: Specification for constituent materials and concrete. BS 8500-2, 2006: BSI
7	Concrete in aggressive ground. BRE Special Digest 1, 2005: BSI
8	Code of practice for use of masonry –Materials and components, design and workmanship. BS 5628 –3, 2005: BSI (now withdrawn)
9	Specification for mortar for masonry – Part 1: Masonry mortar. BS EN 998-1, 2010: BSI
10	UK National Annex to Eurocode 6:Design of Masonry structures- Part 1.1: General rules for reinforced and un-reinforced masonry structures. NA to BS EN 1996-1-1, 2005: BSI
11	Screeds bases and in-situ floorings – Concrete bases and cement sand levelling screeds to receive floorings – Code of practice. BS 8204-1+A1, 2009: BSI
12	Screeds bases and in-situ floorings – Concrete wearing surfaces – Code of practice. BS 8204-1+A2, 2011: BSI

For further information

Technical helpline
Tel: 0845 812 6232
E-mail: info@uk.lafarge.com

Customer services
Tel: 0845 812 6300
E-mail:
customerservice@uk.lafarge.com

LAFARGE CEMENT UK LTD
Portland House
Bickenhill Lane
Solihull, Birmingham
B37 7BQ
Tel. 0845 812 6400
Fax 0845 812 6200
www.lafarge.co.uk