Technical information

Portland Limestone Cement
(CEM II/A-LL 42,5N/52,5N)
PROPERTIES & APPLICATIONS

PORTLAND LIMESTONE CEMENT

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 Tarmac 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 Tarmac Cement Health and Safety data sheet for Common cements.

1. DESCRIPTION

PLC is the Tarmac Cement brand name for bulk Portlandlimestone 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. Tarmac PLC typically contains around 10-15% limestone and is class 52,5 or 42,5 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'). Tarmac bulk PLC, produced at our Aberthaw works*, is designated as: BS EN 197-1 CEM II/A-LL 52,5N Tarmac 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be noted that prior to the introduction of EN 197-1 in 2000, there was already a British Standard (BS 7583:1996, now withdrawn) for this type of cement.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 CO2 of a PLC is around 85% of a typical CEM I(2)

*Tarmac Cement also produces a CEM II/A-LL 42,5N cement at Tunstead works, containing around 15% 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 C3S by increasing nucleation and also modifies the C3A 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) and 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% Na2O eq) is lower than for a Portland cement (currently 0.75% Na2O eq) due to the inherently low alkali content of the limestone component. (See table 1).

Table 1

Aggregate reactivity	Maximum allowable cement content (kg/m³)*	
	Tarmac PLC	Tarmac CEM I
Low	>550	>550
Normal	485	465
High	345	335

*Assumes no alkali contribution from sources other than the cement

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).

Table 2

Design	Maximum allowable cement content (kg/m³)*			
Chemical class	CEM I	PLC*	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 concrete containing 20mm max size aggregate

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.

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3.4 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.

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

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.

REFERENCES

1. BS EN 197-1. Cement. Composition, specifications and conformity criteria for common cements.
2. BCA, CSMA, UKQAA. Embodied CO2 of factory-made cements and combinations. Fact Sheet 18 [P2].
3. Moir, G. Gaining acceptance. International Cement Review, March 2003, pp68-70.
4. Matschei, T. et al. The role of calcium carbonate in cement hydration. Cement & Concrete Research, (37), 2007, pp551-558.
5. BRE Digest 330 Part 2. Alkali-silica reaction in concrete: Detailed guidance for new construction.
6. BS 8500. Concrete. Complementary British Standard to BS EN 206. Part 1: Method of specifying and guidance for the specifier. Part 2: Specification for constituent materials and concrete.
7. BRE Special Digest 1. Concrete in aggressive ground.
8. BS 5628-3. Code of practice for the use of Masonry. Materials and components, design and workmanship (withdrawn).
9. BS EN 998-1. Specification for mortar for masonry.
10. UK National Annex to Eurocode 6: Design of Masonry structures. Part 1.1: General rules for reinforced and un-reinforced masonry structures.
11. BS EN 8204-1+A1. Screeds, bases and in situ floorings. Concrete bases cementitious levelling screeds to receive floorings.
12. BS 8204-2+A2. Screeds, bases and in situ floorings. Concrete wearing surfaces.

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