Technical information

Portland-Fly Ash Cement
(CEM II/B-V 42,5N)
PROPERTIES & APPLICATIONS

Blue Circle **PHEONIX® CEMENT**

This document summarises the general properties and applications of Phoenix® Cement and is intended to be read in conjunction with the Tarmac Phoenix® product data sheet. 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 relevant Tarmac Health and Safety data sheet.

DESCRIPTION

Phoenix is the Tarmac Cement brand name for bulk Portland-fly ash cement. This type of cement is designated in the British Standard for cement (BS EN 197-1(1)) as:BS EN 197-1: CEM II/B-V 42,5N.

This designation covers cement containing between 65 and 79% Portland cement clinker, 21 to 35% siliceous fly ash and 0-5% minor additional constituents. Phoenix contains a minimum of 25% fly ash and is cement strength class 42,5 with normal (N) early strength development.

Phoenix is manufactured at a number of sites in the UK, either by controlled blending or inter-grinding the various constituents in such a way as to produce a homogeneous product. It is subject to the same rigorous production control as other BS EN 197-1 cements with independent third party verification and carries a CE Mark. Phoenix has been available within the UK for more than 25 years and has been used successfully in many prestige construction projects.

PROPERTIES

The properties of Phoenix are very similar to those of conventional Portland cement (CEM I), but there are some differences that need to be recognised.

TEN REASONS FOR USING PHOENIX

1. Quality-assured CE marked product.
2. Lower embodied CO2 than CEM I portland cement.
3. Single-point ordering (compared with using seperate ash portland cement).
4. Enhanced sulfate resistance.
5. Reduces risk of Alkali-Silcia Reaction.
6. Reduced mixing times (compared with using separate ash and Portland cement).
7. Manufactured by Tarmac, the UK's largest cement producer.
8. Improves pumpability.
9. Enhanced resistance to chloride ingress.
10. Strength gain after 28 days.

FRESH CONCRETE

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

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

Perhaps the most noticeable feature of concrete containing Phoenix is that it will appear darker in colour than Portland cement concrete.

The setting time of Phoenix concrete will be increased by up to 2 hours, this may be even more pronounced in cold weather. Whilst this can be advantageous in large concrete pours, it may be more critical in other applications such as power-floated floors.

HARDENED CONCRETE

The strength development of Phoenix concrete is slower at early ages (less than 7 days) than for Portland cement concrete proportioned to achieve the same 28-day strength. However, the concrete will continue to gain strength after 28 days provided it is properly cured.

The in situ strength of Phoenix concrete, particularly in thick sections, will also often be significantly higher than for Portland cement concrete. It should be noted that the rate of heat generation and peak temperatures generated by Phoenix concrete are lower than for equivalent Portland cement concrete.

This property is often utilised for construction of large concrete elements (see Mass concrete/large concrete elements). For concrete of a given strength class ('grade') and similar aggregates, the elastic modulus is similar to Portland cement concrete although creep may be reduced.

DURABILITY

Alkali-silica reaction (ASR)

The measures to be taken in order to minimise the risk of ASR are described fully in the current British Standard for concrete; BS 8500[(2)].

The fly ash content (>25 per cent) of Phoenix reduces the effective alkali content of the cement and the declared mean alkali content is only 0.60 per cent Na20 eq. This compares with 0.75 per cent Na20 eq for Tarmac bulk Portland cements (CEM I).

In practice, this means that higher cement contents can be used, without increasing the risk of ASR, if Phoenix is incorporated in concrete compared with using Portland cement (see below). Cement contents are usually limited to a maximum of 550 kg/m³ except for highly specialised applications.

Portland Cement (kg/m³)	Maximum allowable cement content (kg/m³)	
	Pheonix	Tarmac CEM I
Low	550	550
Normal	550	415
High	415	330

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

Consequently, when high cement contents are required to achieve good structural strength, using Phoenix enables the concrete producer to balance this with minimal risk of ASR.

Resistance to sulfate attack and aggressive ground

Due to its fly ash content (>25 per cent), Phoenix qualifies for the '+SR' suffix of BS 8500 and BRE Special Digest 1[(3)] and is thus designated as: CEM II/B-V+SR.

Phoenix is suitable for use in all ground conditions where Sulfate Resisting Portland Cement CEM I-SR 0, CEM I-SR 3 would be used and it is subject to exactly the same limits on minimum cement content and water/cement ratio (see below). It should be noted that whilst the use of Phoenix in Design Chemical class DC-4m is not permitted, these ground conditions, combining high levels of sulfate with high levels of magnesium, rarely exist in nature.

Design chemical class	Min cement content (kg/m³)	Min cement content (kg/m³)
DC-1	-	-
DC-2	320	0.55
DC-2z	320	0.55
DC-3	380	0.40
DC-3z	340	0.50
DC-4	380	0.35
DC-4z	360	0.45
DC-4m	N/A	N/A

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RESISTANCE TO CARBONATION

For concrete of a given strength class, BS 8500 recognises that concrete containing CEM II/B-V cement, ie Phoenix, has equivalent resistance to carbonation to concrete containing other cement types in all carbonation classes (XC1, XC2, XC3/4).

RESISTANCE TO CHLORIDES

Phoenix is inherently more resistant to the ingress of chloride ions than Portland cement. This applies both to chlorides originating in de-icing salts and chlorides from seawater and increases the corrosion protection of the concrete to the embedded reinforcement. In BS 8500, this is recognised by permitting the use of a concrete of a lower strength class for a given cover to reinforcement.

The following illustration is extracted from BS 8500-1 Table A.5 for concrete exposed to chloride class XS1 and intended for a working life of at least 100 years.

Nominal cover to reinforcement (mm)	Minimum concrete strength class	
	Pheonix concrete	CEM I concrete
35+Δc	Not permitted	Not permitted
40+Δc	C 35/45	Not permitted
45+Δc	C 32/40	Not permitted
50+Δc	C 28/35	Not permitted
55+Δc	C 25/30	Not permitted
60+Δc	C 25/30	Not permitted
65+Δc	C 25/30	C 35/45

RESISTANCE TO FREEZING AND THAWING

Once again, BS 8500 considers that concrete made with Phoenix (CEM II/B-V) has equivalent resistance to freezing and thawing as concrete of the same grade made with other cement types. For exposure to severe conditions, air-entrained concrete is the preferred option. Air-entrained Phoenix concrete is possible to produce practically, but care needs to be taken in the selection of admixtures (see Compatability with admixtures).

CONCRETE MIX DESIGN

Concrete mix design using Phoenix cement is based on exactly the same principles as for concrete containing Portland cement(4). There are however, certain slight differences that should be recognised. Trial mixes are strongly recommended.

WORKABILITY AND WATER CONTENT

The fly ash component of Phoenix acts as a lubricant and reduces the amount of water required to produce a given slump. Typically the water reduction in the region of up to 10 litres/m3 can be expected. The use of Phoenix can also improve the pumpability of concrete, both by its lubricating effect, and by reducing any tendency for water to separate from the concrete in the pump line and cause blockages. The fly ash particles in Phoenix are typically finer than those of Portland cement. This leads to a more cohesive (low bleed) concrete which is generally advantageous, but it is important that concrete is not too cohesive (see Yield) as it can lead to problems with finishing (see also Slabs and floors).

STRENGTH AND CEMENT CONTENT

For a given water/cement ratio, Phoenix will achieve a lower 28-day compressive strength than Portland cement. Therefore, to achieve a specific concrete strength, the water/cement ratio must be reduced. Effectively, this means that the cement content for a given water content should be increased. Typically around 10% (but in isolated cases up to 15%) more Phoenix would be required when compared with Portland cement. It should be noted that the Phoenix concrete will however gain more strength after 28 days than the equivalent Portland cement concrete. Because of this strength gain after 28 days, there may be instances where specification of a 56-day strength could be appropriate. This would then lead to possible economies in cement content. Trial mixes are recommended to determine the 28 to 56 day strength gain.

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APPLICATIONS

Concrete containing Phoenix cement is appropriate for a wide range of construction applications.

GENERAL CONSTRUCTION

Correctly proportioned Phoenix concrete is suitable for most forms of general construction but proper attention must be paid to the curing process. The extended setting time and slow early strength development of Phoenix concrete requires extended curing and formwork striking times. This is particularly important for thin concrete elements (where heat loss to the environment is high) and construction in cold weather.

SLABS AND FLOOR

Slab construction, especially in hot or windy conditions, requires particular attention. Concrete made with Phoenix will remain plastic for longer times than Portland cement concrete and is generally quite cohesive. The extended setting time increases the time during which plastic cracking can occur(5) and the low bleed may increase the risk of plastic shrinkage cracking in particular. Adjusting the concrete mix to reduce the fines content (see Yield) or using a coarser sand will prevent the mix becoming too cohesive, allowing some bleed water to reach the surface. The importance of effective curing of exposed surfaces, as a means of minimising cracks, cannot be overemphasised.

MASS CONCRETE/LARGE CONCRETE ELEMENTS

The low heat evolution of concrete made with Phoenix is a significant advantage for the construction of mass concrete elements or other large concrete elements. Typically, the standard EN 196-9 heat of hydration (J/g) of Phoenix is around 15%t lower than for Portland cement. The use of a reduced heat cement helps to reduce the risk of early age thermal cracking. For more detailed guidance, consult CIRIA report C 660[(6)]. The lower bleeding of Phoenix concrete is also helpful in deep sections as a means of reducing plastic settlement cracking.

CONCRETE ELEMENTS FOUNDATIONS

The reduced heat characteristics discussed above, when combined with the sulfate resisting properties of Phoenix concrete, make it particularly useful for constructing massive concrete foundations.

As discussed in the section Resistance to chlorides, concrete made using Phoenix cement has enhanced resistance to chloride ion penetration and reinforcement corrosion. This gives it advantages for construction of concrete elements exposed to seawater.

MORTARS AND SCREEDS

Current standards [(7,8)] also permit the use of Phoenix in masonry mortars. It may also be used in screeds and concrete bases which will subsequently receive flooring [(9)] but is not permitted in cementitious wearing screeds (note: concrete made with Phoenix is permitted in directly-finished concrete wearing courses [(10)]). Attention to proper curing is required for screeds to ensure that full performance is developed.

GROUTS

Phoenix is suitable for use in most general-purpose grouts, subject to any restrictions in the project specification. However, it should be noted that BS EN 447[(11)] restricts the cement type in grouts for pre-stressing tendons to Portland cement unless regulations in the place of use permit the use of other EN 197-1 cements.

FOAMED CONCRETE

Tarmac Phoenix is compatible with most pre-mixed foams; and the fly ash content of the cement concretes has little effect on the air content and resulting density (due to the high levels of surfactant being employed and the stability of the foam).

For other production methods please contact our technical helpdesk.

Trial mixes are always recommended to ensure that the flow, density and strength of the foamed concrete meet the desired requirements.

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FORMWORK REMOVAL

The early-age strength development of Phoenix concrete is slower than that of Portland cement concrete. Consequently, formwork removal should be delayed until the concrete has developed sufficient strength to resist collapse, deformation or damage to the concrete. This will be particularly important in cold weather. Guidance on the minimum time before striking formwork may be available in the project specification or in standards such as BS 8110 (table 6.2). Once formwork has been removed it is advisable to protect the newly exposed surfaces from drying (see above).

TESTING

Test cubes made from Phoenix concrete should be representative of the concrete delivery. It is important that once made they are protected from drying and stored at a temperature of 20 ± 5ºC. Care should also be taken not to move the cubes, once setting has occurred, until stripping (at 24 hours). Once stripped, cubes should be immediately transferred to moist storage.

The use of temperature matched curing techniques could be considered for critical elements in a structure.

MAKING GOOD

No special procedures are required for Phoenix concrete, but it should be noted that the colour of the concrete may change in the first few weeks after casting owing to continued cement hydration.

SPECIAL USES

This information sheet covers most conventional construction applications of Phoenix concrete. However for further advice on using Phoenix concrete in specialist applications, please contact the: Tarmac Cement & Lime technical helpdesk (see below for details).

ACKNOWLEDGEMENTS

This information sheet is based, in part, on the information contained in the United Kingdom Quality Ash Association (UKQAA) Best Practice Guide No:1 – The placing and compaction of concrete containing PFA/Fly Ash. 2004. www.ukqaa.org.uk.

HEALTH AND SAFETY

Contact between cement powder and body fluids (eg, sweat and eye fluids) may cause irritation, dermatitis or burns. For further information, including control of soluble hexavalent chromium, refer to the Tarmac Cement & Lime Health and Safety information sheet for Common Cements.

REFERENCES

1. BS EN 197-1. Cement. Composition, specifications and conformity criteria for common cements.
2. BS 8500. Concrete. Complementary British Standard to BS EN 206-1. Part 1: Method of specifying and guidance for the specifier. Part 2: Specification for constituent materials and concrete.
3. BRE Special Digest 1. Concrete in aggressive ground.
4. BRE. Design of normal concrete mixes. Second edition.
5. Concrete Society. Technical Report 22. Non-structural cracks in concrete.
6. Bamforth, P. Early-age thermal crack control in concrete. CIRIA report C660.
7. BS 5628-3. Code of practice for the use of Masonry. Materials and components, design and workmanship (withdrawn).
8. BS EN 998-1. Specification for mortar for masonry.
9. BS EN 8204-1+A1. Screeds, bases and in situ floorings. Concrete bases and cementitious levelling screeds to receive floorings.
10. BS 8204-2+A2. Screeds, bases and in situ floorings. Concrete wearing surfaces.
11. BS EN 447. Grout for prestressing tendons. Basic requirements.

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