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New standards for pavement concrete

By Dr Chris A Clear, BRMCA technical director and chair of the BSI committee for concrete

December 2012 saw the publication of the long-awaited amendment A1 to the British Standard for Concrete[1]. This amendment introduces principal changes with respect to current guidance for pavement quality concrete (PQC) and minimising the risk of alkali-silica reaction (ASR).

Pavement-quality concrete

Part of the requirements for PQC is for it to resist freezing and thawing. Table A.8 of Part 1 of the Standard entitled 'Limiting values for composition of concrete to resist freezing and thawing (XF exposures)' has been revised to enhance performance. XF3 and XF4 are the high saturation freezing and thawing exposure classes, generally horizontal elements that include pavements. XF3 is where de-icing agents are not used and XF4 is where either de-icing agents are used or the element is exposed to seawater. The revised requirements are summarised in Table 1.

PQC is also required to resist abrasion from vehicular transport and for this reason the requirements for the designated concretes PAV1 and PAV2 have been revised. PAV1 is the designated concrete considered suitable for house drives and domestic parking, and PAV2 is the designated concrete considered suitable for heavy-duty external paving exposed to use by rubber-tyred vehicles. RC40/50XF is a high strength concrete made with freeze thaw resisting aggregate but is not air entrained. Table 2 is a summary of the revisions.

A large part of the difference between the requirements for PAV2 and PAV1 is that PAV1 is assumed not to be exposed to de-icing agents. This assumption has been questioned in the light of the large amounts of de-icing salt used on domestic driveways in 2010, and this is a topic that may be reviewed when the Standard undergoes its full revision in 2014.

Alkali silica reaction

Guidance for minimising the risk of damaging alkali-silica reaction (ASR) in new concrete construction is set out in a BRE Digest 330[2], and this has been referred to in the British Standard for Concrete. However, it is appropriate for the guidance to be included within the British Standard to help ensure the requirements are not overlooked and this is the basis of the ASR part of the BS 8500 Amendment 1.

Essentially there are no technical differences between the BRE Digest 330 guidance and that now included as Appendix D of Part 2 of the Standard[1], where the requirement is to define a maximum alkali content of the concrete depending on the reactivity of the aggregate. The requirements are summarised in Table 3.

Table 1: BS 8500 revised limiting values for composition and properties of concrete to resist freezing and thawing (XF exposure)

Exposure Class	Min. strength class	Max. w/c ratio	Min. cement or combination content (kg/cu m) for 20 mm max. aggregate size	Cements and combinations	Alternative designated concrete
XF3	C25/30*	0.60	280	Most common cement and combination types permitted but IVB-V is excluded and CIII with more than 55% ggbs may not be suitable for PQC	PAV1 and RC40/50XF
XF4	C28/35*	0.55	300		PAV2 and RC40/50XF

* Min. air content of 4.0%, 4.5%, 5.5% or 6.5% with aggregate of 40 mm, 20 mm, 14 mm and 10 mm max aggregate size respectively.

Table 2: Summary of revised requirements for designated concretes subject to freezing and thawing

Concrete designation	Min. strength class	Default slump class	Max. w/c ratio	Min. cement or combination content (kg/cu m) for 20 mm max. aggregate size	Cement and combination type
RC40/50XF	C40/50	S3	0.45	340	CEM I, IIA, IIB-S, IIB-V, and IIIA with a max. 55% ggbs
PAV1	C25/30*	S2	0.60	280	
PAV2	C32/40*	S3	0.45	340	

* Min. air content of 4.0%, 4.5%, 5.5% or 6.5% with aggregate of 40 mm, 20 mm, 14 mm and 10 mm max aggregate size respectively.

Table 3: Recommended limits for alkali content to minimise the risk of damaging ASR in new concrete construction

Aggregate type or combination	Alkali content of concrete, kg Na_2O equivalent/ cu m
Low reactivity	5.0
Normal Reactivity	3.5
High reactivity	2.5*

*There is an option to test high reactivity aggregate whereby the derived limit may be 2.0, 2.5, 3.0 or 3.5 depending on the measured 2 year expansion

References

1. BRITISH STANDARD INSTITUTION. Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier. BS 8500-1:2006+A1:2012, incorporating corrigendum No. 1. 31 December 2012. Part 2: Specification for constituent materials and concrete. BS 8500-2: 2006+A1:2012, incorporating corrigendum No. 1. 31 December 2012.
2. BUILDING RESEARCH ESTABLISHMENT. Alkali-silica reaction in concrete. Detailed guidance for new construction. BRE Digest 330: Part 2: 2004.

Specifying concrete admixtures

By John Dransfield, Cement Admixtures Association

BS EN 934-2, defines admixtures for concrete as "material added during the mixing process of concrete in a quantity not more than 5 per cent by mass of the cement content of concrete, to modify the properties of the mix in the fresh and/or hardened state". BS EN 934-2 categorises the admixture type and associated performance requirements and has recently been modified to incorporate viscosity modifying admixtures. This now gives 12 admixture types defined in the standard, although this article will only focus on the two most commonly used types: water-reducing admixtures (WRA) and high range water-reducing admixtures (HRWRA) (also referred to as superplasticising admixtures).

Dispersion technology

WRAs and HRWAs are mainly composed of four generic chemistries: lignosulfonates (LNS), melamine sulfonates (SMC), napthalene sulfonates (BNS) and the more modern polycarboxylic ethers (PCEs). The LNS-based products are still the most cost effective at S2 consistence levels but rapidly lose any advantage at the consistence class increase above and beyond S3.

Lignosulphonate/napthalene blends can offer an extremely cost effective improvement over pure lignosulphonates, however, the continuing advances in the efficiency of PCEs increasingly makes PCEs the more logical choice.

The most innovative superplasticizer admixtures, based on third and fourth generation PCE polymers, combine the ability to provide substantial water reductions, with or without extended slump life, simply by modifying the dosage. The broad breadth of their water reduction capabilities stretches from 10 per cent to upwards of 40 per cent at equal workability.

Reducing costs and carbon footprint

Specifiers want materials that meet economic and environmental needs and are looking to specify sustainable concretes[1]. The use of admixture technology in concrete mix designs creates cost-effective, high-performance, sustainable, easy-to-place concrete.

In the past, increasing the cement and water content was seen as the best way to improve its workability – however, the use of admixtures tackles the workability issue and, at the same time, reduces concrete's carbon footprint by decreasing the amount of cementitious materials needed.

More flowable concretes such as self-compacting concretes (SCC) can only really be created using PCE-based admixtures. Such concretes can be placed with reduced manpower and have less potential for defects and cracking. They also allow speedier pours for more efficient construction time. All of these factors are of major importance to reduce cost and improve speed. If SCC is at the far end of the spectrum then S4 and S5 consistence concrete, using PCE-based admixtures, comes into its own as a clear, viable alternative to S2 with no negative cost implications.

The Shard. Admixtures were utilised to deliver the quality of finish and speed of curing to support fast-trackworking without sacrificing other performance properties

High-rise construction

Pumping is undoubtedly the most efficient method of delivering concrete in high-rise construction.

Supplying concrete that can be pumped a significant distance in height or length can be potentially problematic. The concrete mix design must be correctly proportioned and the constituent materials carefully selected, to allow the concrete to flow easily and uniformly through the pipe – not too cohesive but with a consistence that allows easy placement at the point of delivery.[2]

High-rise applications, which tend to use high-strength concrete, will tend to contain higher quantities of blastfurnace materials such as ground granulated blast-furnace slag (GGBS), crushed rock fines or fly ash with typical consistence levels of S4 to F6.[3] The major challenge of pumping concrete in high-rise situations is achieving a balance between friction and flow. Should the fines content be high (over 180 litres per cu m), the frictional resistance would be too great and this would significantly increase the potential for the concrete to block the pump line, a polycarboxylic ether (PCE) based superplasticiser brings performance to the mix that would negate such risks.

A suitable admixture for pumped concrete is one that reduces the water content, pipe friction and segregation tendencies under pressure, without increasing inter-particle stresses.[4] The admixture ensures the all-important grout fraction is evenly distributed in the line to prevent friction and subsequent segregation that would occur if excess water were present.

In less demanding circumstances, viscosity modifying agents can overcome segregation, these are normally used in conjunction with superplasticising admixtures to maintain or increase the fluidity.[5]

When faced with high-rise, high-strength, high-quality surface finish requirements, careful selection of the type and quantity of the powder fraction in combination with admixture performance is essential to ensure a successfully balanced mix.

References

1. The Concrete Centre, Specifying Sustainable Concrete, TCC, 2011
2. Neville, A.M., Properties of Concrete, 3rd edn, Longman Group, 1982, pp 238-9
3. Neville, A.M., Properties of Concrete, pp. 239-40
4. The Manual & Advisory Safety Code for Concrete Pumping of the BCPA, "Concrete for Pumping", pp 56-58
5. Concrete Society Digest No. 1, Pumping Concrete, prepared by: Laing Design and Development Centre

The CAA represents the UK admixture manufacturers, ensuring high levels of quality, support and information to users. For more information on the Cement Admixtures Association visit www.admixtures.org.uk