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Spring 2013

Concrete Today

The magazine of the British Ready-Mixed Concrete Association

BRMCA British Ready-Mixed Concrete Association

Mineral Products Association


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Having a minimal impact on the environment was always going to be a high priority for the Environment Agency's HQ, Horizon House, in Bristol. The concrete for the post-tensioned frame was locally sourced and certified to the responsible sourcing standard BES 6001. With a BREEAM rating of 85%, the best for an office in the UK, this is a truly sustainable building. This is worth talking about.
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Quality concrete

Who is responsible for the quality of concrete supplied to a construction site? In most cases it is the ready-mixed concrete supplier who takes responsibility for the quality of the concrete as delivered, but in most cases the concrete is supplied by a responsible ready-mixed concrete supplier. These suppliers not only use tried and tested materials, and a documented quality system, but also have product conformity certification issued by an accredited third party.

The article entitled *Quality assured ready-mixed concrete* explains this in more detail. Unfortunately there are irresponsible suppliers of ready-mixed concrete who will claim their material meets the client's specification, often in the knowledge that busy engineers and contractors do not have the time to verify their claims. The message is that if an engineer or contractor uses poor quality concrete in a structure they will bear the cost if there is a premature failure, and so it is their responsibility to select quality assured concrete as supplied by BRMCA Members.

The first articles *Quality assured ready-mixed concrete* and *Specifying quality reinforcement* emphasise the importance of conformity assessment, a real demonstration that the product being supplied actually meets the requirements specified or claimed. *Customer service excellence* covers just how good concrete can be while *New standards for pavement concrete* does what it says on the can. *Specifying concrete admixtures* sets the scene for recent developments to improve the fresh and hardened properties of concrete, where the importance of early strength is covered in *Early concrete strength to cut capital congestion* and *Post-tensioned concrete*.

Chris A Clear is Technical Director of the British Ready-Mixed Concrete Association (BRMCA) and nominated Chairman of the BSI Committees 'Concrete' and 'Concrete production and testing'.

We are grateful for the valuable contributions of CARES, The Cement Admixtures Association and Post Tensioning Association to this publication, and indeed our industry.

BRMCA – British Ready-Mixed Concrete Association
Gillingham House
38-44 Gillingham Street
London
SW1V IHU
Tel: +44 (0) 20 7963 8000
Fax: +44 (0) 20 7963 8001
www.brmca.org.uk

Cover image: BRMCA members fully support the MPA's Cycle Safe campaign and want to be at the forefront of helping to improve road safety

Printed by URBAN Design & Print, Essex

Quality assured ready-mixed concrete

By Chris A Clear, technical director, BRMCA

For a list of Companies holding BSI Kitemark Certification go to www.kitemark.com, click on the 'Find it' tab, enter 'BS EN 206-1 and BS 8500' into the 'Business (Company, Service or Licensee number)' box and then press 'search'.

For a list of Companies holding QSRMC Certification go to www.qsrmc.co.uk and select 'QSRMC'.

October 2012 sees publication of the amended version of the British Standard for Concrete, BS 8500[1]. Essentially the amendment addresses three important issues:

- Clarification of product conformity certification.
- Requirements for demonstrating that the risk of damaging alkali silica reaction is minimised.
- Revised guidance for pavement quality concrete subject to freezing and thawing.

Product conformity certification

Conformity assessment and accreditation are important parts of the nation's quality infrastructure. This is confirmed by the department for Business, Innovation and Skills (BIS) which is responsible for activity in this area and has produced guidance entitled *Conformity Assessment and Accreditation Policy in the United Kingdom*[2].

Conformity assessment is the demonstration that product being supplied actually meets the requirements specified or claimed. Concrete is generally specified by a wide range of requirements including designation, strength class, consistence class, minimum cement content, maximum water/cement ratio and other aspects in accordance with BS 8500. For this reason conformity assessment requires technical expertise and, to be completely objective, should be carried out by a body independent of any party interested in the outcome of the assessment. This is United Kingdom Accreditation Service (UKAS) accredited third party conformity assessment and in the UK the third party should be either the Quality Scheme for Ready-Mixed Concrete (QSRMC) or as an equivalent, the BSI Kitemark Scheme for Ready-mixed concrete.

As the consequential cost of concrete not meeting its specified requirements will outweigh the basic materials cost many clients make third party conformity assessment certification mandatory.

The BS 8500 definition for product conformity certification has been revised, and includes a number of explanatory notes, as shown in the box (right). There is an industry view that this definition for product conformity certification does not adequately define accreditation, and that the definition should be more explicit.

Alkali silica reaction

A new Annex D to BS 8500: Part 2 gives the rules of application for use by producers to ensure that the risk of damaging alkali-silica reaction is minimised. This replaces earlier references to BRE Digest 330[3] wherein the historical basis for the rules can still be found.

Freezing and thawing

In response to the unusually severe winters of 2009/10 and 2010/11 the requirements have been changed to improve performance of concrete under exposure to high water saturation freezing and thawing, with and without de-icing agents, such as that used in external pavements.

Extract from BS 8500:2012[1]

Product conformity certification is based on product testing and surveillance, and issued by an accredited third-party certification body in accordance with a documented quality system.

NOTE 1 Users of this part of BS 8500 are advised to consider the desirability of quality system assessment and registration against BS EN ISO 9001 by an accredited third-party certification body. Many certification bodies have this as a requirement of their product conformity certification. Further information on the provisions for assessment, surveillance and certification of production control can be found in BS EN 206-1:2000, Annex C.

NOTE 2 Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

NOTE 3 Attention is drawn to the Department for Business, Innovation & Skills policy document, *Conformity assessment accreditation policy*.

References

1. British Standards Institution. BS 8500 Concrete — Complementary British Standard to BS EN 206-1 —
Part 1: 2006+A1 2012 Method of specifying and guidance for the specifier
Part 2: 2006+A1 2012 Specification for constituent materials and concrete
BSI, London, September 2012.
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Specifying quality reinforcement

By Ben Bowsher, chief executive, UK CARES

CARES
Pembroke House
21 Pembroke Road
Sevenoaks
Kent TN13 1XR
Tel: 01732 450000
Fax: 01732 455917
e-mail: general@ukcares.com
www.ukcares.com

The efficient use of reinforcement depends on the steel and associated products possessing the correct properties, accurate processing (eg straightening from coil, cutting and bending, welding and coupling) and correct fixing. Increasingly it must also be sourced from a company operating according to accepted principles of sustainability.

The mechanical properties of reinforcing steel are determined principally by the steel producer. This is important for steel bars and consequently certification of steel bar producers has grown in importance; almost all the UK usage of reinforcing bars is now CARES approved.

CARES certification

Over the years, CARES has created certification requirements for all key products and services associated with reinforcing steel and certificates for each of these as required. CARES certification is now positively specified in the UK by such as the National Concrete Specification, the National Building Specification and the Specification for Highway Works. Work continues within CARES to ensure that newer requirements are met – and wherever possible certification is made available, such as in the area of responsibly sourced materials.

The schemes offered by CARES and others are designed to provide the quality link in the supply chain from steel producer to site. However, CARES believes that there remain a number of firms outside this or any such product-related certification scheme. As a result, many clients and contractors are not receiving the security of product conformance they have come to expect and sometimes believe they are getting.

Processing of reinforcing steels

Reinforcement processors are responsible for ensuring that:

- The material/product possesses the correct properties
- The material/products are sourced in a sustainable way
- The process is performed in order to meet customer requirements
- There is full traceability

A processor of reinforcing steel must ensure that purchased material and products comply with specified requirements. CARES-approved reinforcement processors do this by buying only from sources acceptable to CARES, thereby negating the need for further inspection and testing. Consequently, contractors using suppliers registered by CARES may also rely on this system. Failure to use such suppliers and, instead, to use suppliers not suitably certificated would put the onus of satisfaction on to the contractor. CARES certification is often part of the specification and therefore this situation should not arise in these cases. It sometimes does, however, and contractors should use purchasing and receipt inspection procedures which act to ensure that the specification is properly implemented in practice.

CARES schemes

The various CARES schemes for reinforcing steel and related products are accredited by UKAS and are based on an initial assessment and regular inspections of manufacturing and site processing. Both initial assessment and subsequent inspections are conducted to test the operation of the quality system and product conformity against the relevant specification or product standard.

The principal CARES requirements applied to reinforcement processors are:

- Material and product sourcing
- Establishing conformity
- Maintaining traceability
- A quality system to ensure compliance with the CARES requirements
- Quality plans for special non-standard requirements
- Control of procedure and work instructions
- Documented complaints procedures
- Regular internal reviews of the quality system

Of the above requirements, traceability merits further explanation.

Traceability

In the case of the reinforcing steel itself, CARES requires that cast identity be retained up to the cutting and bending operation: records permit the cut and bent bars or sheets of fabric, ready for fixing, to be traced back to the cast or casts from which they have been fabricated. This is achieved by recording the cast/bundle numbers against each bar/fabric schedule in the delivery and is retained in the internal documentation. Consequently the cast/bundle numbers are not passed on to the contractor, but can be referred to when required. This procedure makes requests for copies of test certificates by contractors or engineers of limited value and they could be usefully eliminated.

CARES accreditation

CARES has faithfully recognised the principles of impartiality, integrity and technical competence since it began operating in 1984, and it maintains its commitment to supporting government policy in this regard, ensuring that it applies those conformity assessment principles set out in the paper of the Department for Business Innovation and Skills (BIS), *Conformity Assessment and Accreditation Policy in the United Kingdom*.

Despite all of the above, there remains a small residue of reinforcement processors (fabricators) who sometimes incorrectly claim to hold CARES approval or more commonly claim not to need approval, because they use only steel or related products from CARES approved sources. This claim is not valid, as material or products from a CARES approved producer, passing through the hands of a non-approved processor, loses approved status.

CARES regularly updates a list of approved firms on its website (www.ukcares.com), importantly including the scope of certification achieved. If in doubt, consult this list or alternatively ask for further information about CARES by contacting the address above.

CARES Identification System

Country or Regional Grouping is as follows:-

Germany	1 rib
Belgium, Netherlands, Luxembourg	2 ribs
France	3 ribs
Italy	4 ribs
United Kingdom, Eire	5 ribs
Scandinavia	6 ribs
Spain, Portugal	7 ribs
Greece, Turkey	8 ribs
Outside Europe	9 ribs

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Customer service excellence

By Steve Crompton, Chairman, British Ready-Mixed Concrete Association

Quality assured ready-mixed concrete is available across the whole of the UK from over 850 sites where the average delivery distance is typically no more than six radial miles.

Even during the present downturn in the construction industry the UK demand for ready-mixed concrete was over 15,300,000 cu m in 2011. By its very nature ready-mixed concrete is the ultimate just-in-time material, manufactured to a wide range of specified requirements for both fresh and hardened characteristics such as setting time, strength and durability. Meeting these requirements competitively is what ultimately defines excellence in customer service.

BRMCA encourages excellence in customer service and is keen to share examples of best practice, so that even higher levels can be consistently achieved. This is the ambition behind the BRMCA Award for Excellence in Customer Service, as presented at the 2012 Concrete Society Awards in London.

The Award for Excellence in Customer Service recognises and celebrates ready-mixed companies who provide a high-quality efficient and professional service. Projects are featured from both winners and those shortlisted for the award. The projects also provide a showcase for the technical expertise of the BRMCA members and their commitment to delivering solutions to meet client needs. Judges were particularly impressed with entries with the widest range of positive feedback from customers.

2012 Winner: Lafarge Readymix

This year's winning entry from Lafarge Readymix impressed the judges with a stunning commendation which praised the technical solution, delivery, management and excellent quality of surface finish.

The six diving boards at an Aquatics Centre in London provided a real challenge to the designers and contractor, but these were all met by the performance qualities of Agilia™ vertical self-compacting concrete. Furthermore, the understated yet complex structures were delivered to a fixed deadline.

After several weeks of laboratory and site trials beginning in March 2010 a suitable mix was agreed and in total over 600 cu m was supplied through the night in continuous pours to avoid cold joints and help deliver a perfect finish. Together with high quality formwork and site management with an eye for perfection, the architectural aspiration was delivered.

Highly Commended: Atomic Weapons Establishment (AWE), Burghfield supplied by Tarmac (West)

The new warhead assembly/disassembly facility is in a security enclave isolated from the rest of the Burghfield site. Safety and security is obviously paramount and the use of smartphones, networked computers, email, internet, digital cameras and electronic recording devices are all strictly prohibited from the site.

The six 'major' single continuous pours, the last of which was 2,408 cu m, required an immense amount of planning. The materials required on site included 6,000 tonnes of aggregate, six tippers to move aggregates, 12 truck mixers, admixture tankers, thirty-seven cement and ggbs tankers and four tractor units together with nine fully stocked heated mains water tanks.

This entry was shortlisted in recognition of the BRMCA member more than meeting the rigorous customer requirements despite tight logistical constraints. Proof of this success is winning subsequent contracts from the client.

Highly Commended: Oaklands Farm, Shropshire supplied by Tudor Griffiths

The size and timing of this pour, in addition to the relationship between customer and ready mixer warrants this projects place in the shortlist. The largest poultry house in the country required the 'laying' of 600 cubic metres of concrete in six hours.

Utilising fifteen of their truck mixers, Tudor Griffiths completed these massive pours in the allotted time, with sufficient time to power-finish the two 4,000 sq m floors.

Highly Commended: Druids Lane Bus Terminus, Birmingham supplied by CEMEX Readymix

Part of the Birmingham PFI, a 25-year contract to maintain the city's infrastructure funded by private investment, the site in Druids Lane required a pavement solution that would be able to perform with heavy point loads, as well as oil spillages and hot bus tyres.

CEMEX Readymix, with their Surfacing division, were tasked to provide a material which could be installed and trafficked rapidly in order to minimise disruption, as well as to provide a durable surface and prevent any future disruption issues to the public transport system.

The CEMEX solution accepted by the client was a full depth construction using Roller Compacted Concrete. This was supplied from CEMEX's Weeford Plant and laid using plant otherwise used for installing asphalt.

The production and installation of the Roller Compacted Concrete was completed on schedule and the use of this technology as a cost-effective, durable solution for public and private pavements continues to grow.

This entry was shortlisted in recognition of the specialist knowledge applied to the project and of the success in meeting the client's needs for long-term performance, cost effectiveness and programme delivery.

Previous winners

2011 East Kent Access Phase 2, Brett Concrete
2010 Drax Power Stations, Tarmac
2009 New Tyne Tunnel, Bardon Concrete

For more information about these winning projects visit www.brmca.org.uk

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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.
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the Sign of Quality

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.

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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

Early concrete strength to cut capital congestion

By Dr Chris A Clear, technical director of the British Ready-Mixed Concrete Association (BRMCA)

Table 1: Minimum strength of reinstatement materials required for opening the highway to traffic

Reinstatement material	Compressive strength class* 7 day	Compressive strength class* 28 day	Minimum cube strength for opening traffic**, N/mm sq	Target laboratory cube strength at opening, N/mm sq
Concrete	-	C32/40	25	32
	-	C20/25	20	25
Concrete or Cement Bound Granular Material (CBGM) B	-	C16/20	15	19
	-	C12/15	10	13
Foamed concrete	-	C8/10	7	9
	-	C5/6	4	6
	C3/4	-	2.8	3.6
	C1.5/2	-	1.4	1.8

* Strength class minimum characteristic cylinder/cube strength
** Based on values given in HD 27/04

The Mayor of London and Transport for London (TfL) have introduced a targeted lane rental scheme that allows TfL to charge companies a daily fee for undertaking roadworks on London's busiest roads at the busiest times. This scheme should encourage more efficient working and reduce disruption from roadworks.

One way to help minimise the amount of time that works disrupt traffic is to clarify the early age strength requirement of concretes, and other cement bound materials, used for the reinstatement of openings in highways. This was an aim of a project funded by the Department for Transport (DfT) and Transport for London (TfL) entitled 'Reducing Congestion from Highway Works'.

It is up to highway owners and their designers to specify the compressive strength class of concrete or other cement bound material required for reinstatement. Using HD 27/04[1] it is possible to determine the minimum cube strength required from the reinstatement material to open the highway to traffic, as shown in Table 1.

Reducing the curing period

One of the most frequently used materials for highway reinstatement is a C16/20 concrete or CBGM B concrete as a base layer in a composite road. This material is usually subject to a 'deemed to satisfy' curing period of seven days before trafficking, and this is where there is scope to reduce the time the highway is closed for reinstatement.

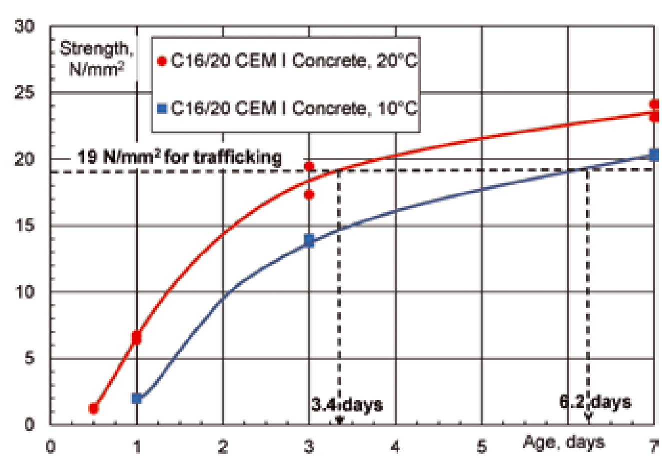
From Table 1 the minimum cube strength required for a C16/20 before trafficking is 15 N/mm sq, deemed equivalent to a 19 N/mm sq measured on laboratory cured cubes. Figure 1 shows the relationship between compressive cube strength of laboratory cured specimens of a C16/20 CEM I concrete or CBGM B with age, at both 20 deg C and 10 deg C. The 28-day target mean strength for a C16/20 is around 30 N/mm sq, where with CEM I as the binder the 7-day strength is expected to be 24 N/mm sq. That is around 80 per cent of the 28-day strength. Where a cement is used that includes 30 per cent fly ash or 50 per cent ggbs only around 70 per cent of the 28-day strength is normally achieved. Using the 20 deg C line from Figure 1 it is evident that a C16/20 only requires up to 3.5 days to reach the required strength, and only where the curing temperature is reduced to 10 deg C does the time required increase to just over six days.

At a depth of around 1.2 m the ground temperature is typically from a minimum 4 deg C in March to a maximum of 17 deg C in September[2]. Therefore, 10 deg C is a reasonable estimate for unfavourable conditions, accepting that as cement bound materials generate heat on hydration they will be warmer than the surrounding ground temperature. It may be argued that a seven-day curing period for reinstatement material is safe and is useful guidance for where there is no urgency. Where it is important to re-open the highway, to reduce congestion and save cost, then there is potential to reduce the curing period to that required to achieve the necessary in-situ strength. As shown in the Figure 1 example the curing time could be reduced to less than four days for CEM I C16/20 under favourable conditions.

A practical solution is for the reinstatement contractor to adopt in-situ testing to demonstrate that the required strength has been achieved, rather than just accept overly conservative deemed to satisfy rules for curing time.

For further information see www.trl.co.uk/reducingcongestionfromhighwayworks/

Fig 1: Relationship between strength of C16/20 CEM I concrete and age



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Post-Tensioned Concrete

Material efficiency and structural performance

Ben Ume, Chairman of the Post-Tensioning Association (PTA)

The practice of post-tensioning (PT) allows the full utilisation of the high compressive strength of concrete. A prestress force is applied to a concrete member using high strength steel strand and specialised anchorage assemblies. The strand is profiled through the concrete slab and counteracts a portion of the applied loads to give an extremely efficient structure.

Post-tensioning involves stressing the tendons after the concrete has been placed and cured. The tendons are cast into ducts or sleeves to allow the strand to slide through the hardened concrete and corrosion protection is normally provided by injecting cement grout or grease. Post-tensioning is used in bridges, floor slabs, silos and many other forms of construction. It can bring significant benefits in terms of economy, construction programme, structural performance and reduction in material usage.

Material efficiency: achieving thinner floor slabs

Post-tensioning has the minimum structural thickness of any floor system. The reduced slab thickness reduces the amounts of concrete and reinforcement required, generating important cost and material savings.

Achieving thinner slabs maximises floor to ceiling height and can even create additional floors within the same building height. Additional savings can be made on the costs of cladding and services.

Minimising the structural thickness of the floor slabs also lowers the self weight of the building, which in turn reduces foundation loadings and yields smaller foundations, further lowering material costs.

Flexibility and adaption: achieving longer spans

Post-tensioned concrete can span further than reinforced concrete and competes economically with steel structures. The longer spans that can be achieved by post-tensioning reduce the number of columns required and give greater layout flexibility and more expansive interiors.

Post-tensioned concrete during construction, Whitmore School, Harrow

Bournville College, part of the redevelopment of the former MG Rover site at Longbridge

As well as affording greater flexibility of internal layout, post-tensioned slabs are able to follow irregular column grids and curves and cope with the complex geometry incorporated within many ambitious structures today.

Flexibility also extends to the ability to carry out future modifications to the slabs. Whether for change of use or to accommodate unforeseen requirements, the creation of penetrations within PT slabs can be carried out easily and safely provided that changes which may affect the existing structure are designed by a competent engineer and carried out by a qualified post-tensioning specialist[1].

Speed of construction

Post-tensioning has a short lead-in time and can be constructed rapidly. Once complete the slabs provide a safe working platform for other trades allowing follow-on trades to commence earlier in the programme.

The reduction in the amount of material required and the subsequent reduced reinforcement congestion, allow the fixing of the systems and the placing of the concrete to be achieved more quickly and easily. Post-tensioning also allows early stripping of formwork, accelerating floor construction.

Significant benefits in the speed of construction make post-tensioning ideally suited to accelerated construction schedules.

Thermal mass and exposed soffits

The reduced cracking of PT slabs makes them ideal for internal fair faced soffits. Surfaces are aesthetically pleasing and offer a durable, low maintenance finish.

The thermal mass properties of concrete, which allow the transfer of heat between the surface of the material and its interior at a rate that matches the daily heating and cooling cycle of the building, are proven and well documented[2]. The exposed soffits of post-tensioned slabs allow full exploitation of the thermal mass properties to help reduce temperature fluctuations, and contribute to savings on heating and costly air-conditioning systems.

Summary

Post-tensioning already leads the way in the US and Australia and the benefits of this solution are now growing in recognition in the UK. With the benefit of material efficiency and consequent cost and carbon savings it is increasingly attractive and with the growth in the number of installers, PT can continue to go from strength to strength bringing benefits to clients, designers and contractors.

[1] PTA Guidance Note GN01: Post-Formed Holes Through Post-Tensioned Slabs, PTA, 2010.
[2] Utilisation of Thermal Mass in Non Residential Buildings, The Concrete Centre, 2007.

Members of the Post-Tensioning Association are directly engaged in the design, manufacturing and/or installing of post-tensioning materials. Visit our website www.post-tensioning.co.uk for a list of members, technical guidance notes and case studies, including the recent winner of the PTA awards.

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BRMCA – British Ready-Mixed Concrete Association
Gillingham House, 38-44 Gillingham Street, London SW1V IHU

Tel: +44 (0)20 7963 8000
Fax: +44 (0)20 7963 8001
www.brmca.org.uk

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