EN 206:2013 – fit for purpose?

The debate surrounding the revision of EN 206 continues. Alasdair N Beal of Thomasons responds to comments from Chris Clear in *Concrete* June.

I am grateful to Chris Clear[1] for taking the time to offer a detailed response to my paper 'Concrete specification and testing – is EN 206 fit for purpose?'[2]. However, there are some problems.

It was actually the 1965 amendment to CP 114[3] which introduced statistical acceptance criteria for cube tests, not CP 110:1972[4]. The CP 114 rules required ten sets of four test results to be considered against the following criteria, with standard deviation calculated from the 40 results and taken as not less than 3.5MPa:

1. no more than two results in 40 below the specified strength
2. no set of four to have a range exceeding 4 × designed standard deviation
3. no more than one set of four to have average strength less than (specified strength + 4/3 × standard deviations)
4. no set of four to have average strength less than (specified strength + 1 × standard deviation).

Whatever their theoretical merits, the CP 114 rules were found to be hopelessly impractical, so CP 110 adopted simpler rules based on sets of four results and reintroduced a minimum strength requirement: (i) mean of four tests to be at least (f_{cu} + 0.82 × standard deviation) and (ii) no individual test result to fall below 0.85f_{cu}. BS 5328[5] simplified the rules further still: (i) mean of four tests to be at least (f_{cu} + 3MPa) and (ii) no individual test to fall below (f_{cu} – 3MPa).

I was told by Joe Dewar, then director of the British Ready-Mixed Concrete Association, that by the 1980s most engineers treated the 'mean of four' rule as a 'warning light', so only batches falling below (f_{cu} – 3MPa) were rejected. In effect, engineers had reverted to a simple 'minimum strength' criterion (3MPa below the nominal 'characteristic' strength) and abandoned the complex statistical rules of the 1960s and 1970s. The reasons for this were simple: 'mean of four' is impractical and can lead to unnecessary rejection of good concrete.

Statistical and probability calculations can be useful for producers managing quality control, who use low sampling rates and check large volumes of concrete. However, they are not suitable for customers deciding whether to accept concrete delivered to site, typically using a sampling rate between 1/2 and 1/5. Unfortunately, BS EN 206:2013[6] fails to take this into account and seems to have been written almost entirely from a producers' point of view.

If, as Dr Clear claims, the risk of unsatisfactory concrete from a well-run plant is 'non-existent', this would be academic but in practice things can go wrong, so a customer needs to be able to check whether defective concrete has been delivered to his site – and work out what to do if it is. EN 206's refusal to allow customers to test cubes singly, like producers, gives the impression that it is trying to deter customer testing by pushing the cost up.

Dr Clear states that 'a concrete technologist with a rudimentary understanding of statistics' would not be surprised about EN 206 rejecting C25/30 concrete if five test results give results of 30, 34, 31, 32 and 33MPa. However, a concrete technologist with a deeper understanding of statistics would know that within-batch strength variation is much lower than the between-batch variations described by Dr Clear, so if all the batches have been tested, all of the concrete delivered at least equals the specified strength. The producer could be warned that he is 'sailing close to the wind' but rejecting the concrete (as recommended by EN 206) would make no sense at all.

There are similar difficulties with Dr Clear's analysis of my three examples based on concrete from non-certified producers. In his example 1 ((xi) in my Table), he backs the EN 206 view that a batch of C25/30 concrete should be rejected if it produces three tests of 33, 34 and 34MPa. However, again we know that as within-batch strength variation is low, the concrete all exceeds the specified strength. Why should a customer reject it – and why should the producer accept such a decision?

In his example 2 (my (xii)), I am pleased Dr Clear agrees that it would be unwise to accept 50 batches of concrete on the basis of three test results of 26, 36 and 40MPa. The problem here is that the EN 206 acceptance criteria do not take into account sampling rate.

In Dr Clear's example 3 (my (xiii)), he argues that if tests on five batches of C25/30 concrete from a certified plant gave results of 30, 34, 40, 32 and 33MPa, they would 'pass' the EN 206 criteria for a certified plant. However, in my example the concrete was from a non-certified plant and even though all batches were tested (as recommended by Dr Clear) and gave satisfactory results, under EN 206 all of the concrete would be rejected. Again it makes no sense.

Is EN 206 fit for purpose? Unfortunately, on this evidence the answer appears to be 'no'. ●

Alasdair N Beal
Thomasons

References

1. CLEAR, C. EN 206:2013 is fit for purpose. *Concrete*, Vol.48, No.5, pp.11–14, June 2014.
2. BEAL, A.N. Concrete specification and testing – is BS EN 2016 fit for purpose?. *Concrete*, Vol.48, No.3, pp.35–36, April 2014.
3. BRITISH STANDARDS INSTITUTION, CP 114. *The structural use of reinforced concrete in buildings*. BSI, London, amended 1965.
4. BRITISH STANDARDS INSTITUTION, CP 110. *Code of practice for the structural use of concrete, Part 1 Design, materials and workmanship*. BSI, London, 1972.
5. BRITISH STANDARDS INSTITUTION, BS 5328. *Methods for specifying concrete, including ready-mixed concrete*. BSI, London, 1976.
6. BRITISH STANDARDS INSTITUTION, BS EN 206. *Concrete – Specification, performance, production and conformity*. BSI, London, 2013.

● **Author's reply:**

Concrete quality and Standards

In many ways I wish all engineers were like Alasdair Beal and take a detailed interest in the quality of concrete that may be delivered to a construction site. Only last week a structural engineer phoned me to say that having specified a C32/40 concrete, subsequent examination of site cube results and then in-situ strength assessment indicate an in-situ core strength of around 15MPa. The engineer did not know if the concrete producer had any Product Conformity Certification and was having difficulty because the producer was not responding to telephone calls. The point is that the rules for identity testing of concrete are a backstop to provide the engineer, contractor or producer with a mechanism to check particular loads of concrete, normally because there has been some observed irregularity. Identity testing should not be confused with any specified site quality control, nor should it be confused with the producer's factory production control and conformity assessment.

No amount of identity testing will prevent a rogue supplier delivering concrete with just enough cement such that it goes hard within a day because most of the time this is all its customers require. The real need is to demand more from the concrete supplier before the order is placed, rather than try to catch it out after the concrete is delivered and placed, and where the cost of any remedial work will always greatly outweigh the value of the material supplied.

All BRMCA members have Product Conformity Certification to supply concrete in accordance with EN 206 and BS 8500[1], either to the Quality Scheme for Ready-Mixed Concrete or to the BSI Kitemark Scheme for Ready-Mixed Concrete. The Standards set out the rules under which the concrete is supplied and the accredited third parties carry out audits to ensure the supplier operates in accordance with the rules.

I am also very grateful to Alasdair Beal for the information concerning the CP 114 as amended in 1965. CP 114: 1969 as amended up to July 1977 is the earliest version in my possession. In this version there is a requirement for supervision: "A competent person should be employed whose first duty it will be to supervise all stages in the preparation and placing of concrete. All tests on materials, the making and testing of cubes and the maintenance and calibration of all mixing and measuring plant should be carried out under his direct supervision". In modern times it is accepted that most clients will not cover the cost of direct supervision but a minimum requirement should always be for the concrete supplier to have some form of third-party Product Conformity Certification. ●

Chris A Clear
MPA–BRMCA

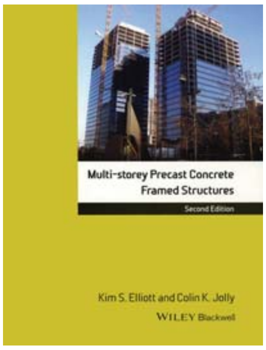
Reference

1. BRITISH STANDARDS INSTITUTION, BS 8500-1. *Concrete. Complementary British Standard to BS EN 206-1. Method of specifying and guidance for the specifier*. BSI, London, 2006+A1:2012.

● **Editor's note:**
Correspondence on this topic is now closed.

BOOK REVIEWS

Multi-storey Precast Concrete Framed Structures



AUTHORS: KIM S ELLIOTT AND COLIN K JOLLY
PUBLISHER: WILEY BLACKWELL, 2013
ISBN: 978-1-4051-0614-6
PRICE: £89, 760PP

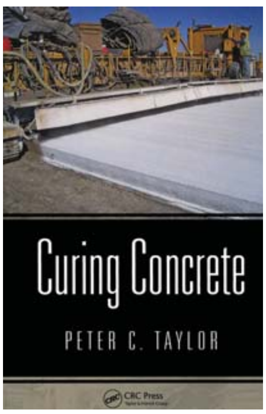
Multi-storey Precast Concrete Framed Structures provides a detailed understanding of the procedures involved in precast structural design. Published in 1996, the first edition was considered to provide a comprehensive treatment of precast concrete-framed structures. It provided an insight into the production and erection of precast elements as well as design methodology including worked examples.

The fully revised second edition has been updated to reflect developments in precast processes and practices. Importantly it includes calculations in accordance with Eurocode 2. Where there are differences between the design procedures of the two prevailing codes, the now superseded BS 8110 *Structural concrete* and its replacement Eurocode EN 1992-1-1, they are explained. In the design examples, the text is presented in two columns to highlight the differences.

Civil and structural engineers, as well as final-year undergraduate and postgraduate students of civil and structural engineering, will all find this book to be a thorough overview of this important construction technology. ●

Richard Day
The Concrete Society

Curing Concrete



AUTHOR: PETER C TAYLOR
PUBLISHER: CRC PRESS, 2013
ISBN: 978-0415779524
PRICE: £80, 215PP

Curing is one of those activities that every civil engineer and construction worker has heard of, but in reality does not worry about that much. In practice, curing is often low on the list of priorities on the construction site, particularly when budgets and programmes are under pressure. Yet the increasing demands being placed on concretes also means that they are possibly less forgiving than in the past. Therefore, any activity that will help improve hydration and hence performance, while reducing the risk of cracking and dusting surfaces, is becoming more important.

This book explains exactly why curing is so important and shows you how best to do it. It covers: The fundamentals of cement hydration; The benefits of curing on concrete performance; Curing in practice; and Measurement and specifications.

The author possibly gets a bit over-enthusiastic when he recommends curing the saw cut faces of sawn joints in ground-supported slabs but otherwise the advice given is sound.

There are numerous examples of how curing (or a lack of it) has affected concrete performance in real-world situations. These include examples from hot and cold climates, as well as those related to high-performance concretes. This book is aimed at construction professionals who want to ensure the quality and durability of their concrete structures and demonstrates that curing is well worth the extra effort and cost. ●

Richard Barnes
The Concrete Society