Book review

Analysis of Hardened Concrete: A Guide to Tests, Procedures and Interpretation of Results

Working Group of the Concrete Society. The Concrete Society, Camberley, Surrey, UK, 2014, ISBN 978-1-904482-82-6, £75.00 (with a 40% discount for Concrete Society members), 76 pp.

Concrete remains the world's most abundant and most important construction material. There is a continuing need for specialists to be able to assess its composition as a hardened product, perhaps as part of a condition survey to evaluate its ability to continue in service, or sometimes with new materials subject to concern over compliance, or otherwise as part of an investigation into disappointing performance or even failure. Such work has never been easy, but the UK was in the forefront of developing and standardising techniques to provide indicative results for the key aspects of concrete composition, including cement content and original water/cement ratio.

The original Technical Report 32 (TR 32), published by the Concrete Society in 1989, was based on fundamental techniques developed in the 1950s and 1960s, as had previously been described by Figg and Bowden in a milestone Building Research Establishment report entitled *The Analysis of Concretes* (published in 1971). In the 25 years since that original TR 32, new and improved analytical techniques have been developed and/or become more accessible. At the same time, however, concrete composition has become enormously more complex, including wide ranges of cements and cementitious additions, plus the now commonplace usage of chemical admixtures and combinations thereof, all of which at least complicate and sometimes frustrate the reliable back-analysis of concrete. So an authoritative update of TR 32 will be most welcome in the UK and further afield. It is encouraging to note that John Figg is listed among the six corresponding members who helped the 16-strong working group chaired by Jeremy Ingham.

Report TR 32 was always intended to provide practical guidance for those undertaking analyses and others needing to interpret the findings. This principle continues in the new edition, whose 76 pages are dominated by substantial sections on the 'Determination of concrete constituents' (Section 3, 19 pages) and the 'Determination of concrete properties' (Section 4, 21 pages), supported by a short section on sampling and preparation (Section 2, four pages), a thorough listing of references (seven pages), plus other sources of information (two pages) and the method for micrometric analysis (Appendix C, two pages). In this context, the word 'properties' is largely shorthand for quantifying the various constituents, such as cement, mix water (as water/cement ratio), air voids and various important chemical components (e.g. chlorides, sulfates, alkalis); however, there is also a section on depth of carbonation. In addition, there are helpful but short appendices providing a glossary of terms (Appendix A, two pages) and guidance on health and safety (Appendix B, three pages).

These components of the practical guidance are all well written and well presented, and are appropriately but not abundantly illustrated by largely colour photographs, a few diagrams and plenty of helpful, clear tables. Sections 3 and 4 have obviously been carefully and sometimes extensively updated, for example to include the latest position on the use of the various BS 1881 analysis methods in view of the multifarious constituents

possibly present, and the range of chemical admixtures now likely to be encountered and how they might be detected. In terms of the water/cement (or water/binder) ratio determination, techniques developed since 1989 are thoroughly described and discussed, including the now widely applied fluorescence microscopy method and a research approach using scanning electron microscopy.

The accuracy and precision of the various procedures for quantifying the key compositional characteristics of concrete, such as cement (or binder) content and original water/cement ratio, have long been an uncertain and sometimes controversial issue, even before the increasing complexity of concrete composition created still greater difficulties. Some work on the repeatability and reproducibility of the cement content determination method was fully described in the 1989 version of TR 32 (and is summarised in this new second edition) and has since been repeatedly cited even though those values were obtained using reference samples of the constituents, as these data are very rarely available in practical cases. No systematic trials of the physicochemical method for original water/cement ratio had ever been carried out, although some suggested estimates had been referenced. In these circumstances, therefore, it was laudable that the new working group should decide to include a programme of trials in their work, which was carried out in two stages between 2012 and 2013 and is described in their substantial Appendix D (11 pages), not 'Appendix F' as unfortunately stated in the Acknowledgements!

In short, the trial, which included the two existing BS 1881 methods, for cement content and original water/cement ratio using the physicochemical technique, provided disappointing results for these two long-established procedures. Obviously this was an important finding, and perhaps was not that surprising to many, with the conclusion given in Appendix D being rather carefully worded as the 'trials indicate that there is significant doubt regarding the accuracy of the BS 1881-124 analysis procedures when applied to contemporary concrete'. Moreover, in the relevant section of Chapter 4, it is somewhat bleakly declared in bold print that 'the BS 1881-124 water/cement ratio method did not appear to be sufficiently accurate to provide useful data to the end user'. However, these publicised, even highlighted, negative findings need to be considered alongside the caveat that also appears in the conclusion to Appendix D, that 'the limitations of the trial must be noted, particularly in terms of its relatively small scale', followed by recommendations for 'a much larger research trial'. As the trials undertaken were recognised to be limited and small scale, with no trials at all being applied to the alternative non-standard methods described, some readers might question the wisdom of publishing the findings before undertaking the recommended larger trial.

Notwithstanding this reviewer's discomfort regarding the trials presented in Appendix D, this new edition of Concrete Society TR 32 is a worthy successor to the long-serving previous edition, and everyone involved in the analysis of hardened concrete, whether as an analyst or investigator, or as an owner or construction operative, is recommended to obtain a copy and keep it to hand. It is to be hoped that somebody will soon take up the significant challenge of arranging a suitably detailed trial, to reliably clarify the confidence with which the various techniques can be usefully applied to various types and conditions of concrete.

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