Construction Materials
Volume 169 Issue CM4
Editorial
Sims

ice | proceedings

Proceedings of the Institution of Civil Engineers
Construction Materials 169 August 2016 Issue CM4
Pages 179–181 http://dx.doi.org/10.1680/jcoma.2016.169.4.179

ice
Institution of Civil Engineers
publishing

Editorial

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This themed issue (CM4) of our journal and the previous issue (CM3, June 2016) together provide a structured, up-to-date overview of alkali–aggregate reaction (AAR) in concrete, with invited authors addressing aspects in which they are acknowledged international specialists. Since 1974, the progress of understanding AAR has been periodically reviewed by an International Conference on AAR (ICAAR) and these themed issues are timed to coincide with the latest of these conferences, the 15th ICAAR, which took place in Sao Paolo, Brazil, in July 2016.

This issue comprises the final seven of 14 papers, with the other seven having been published in CM3. In sequence, all of these papers and their subjects may be summarised as follows

Issue 3 (June 2016)

1. ICAARs 1974–2016
2. Types of AAR reactions and products
3. Physical models for alkali–silica reaction (ASR)
4. Effects of AAR on concrete and structures
5. Diagnosis of AAR
6. Appraising structures affected by AAR
7. Assessing aggregates for AAR potential

Issue 4 (August 2016)

8. Minimising the risk of AAR
9. Performance testing and exposure sites
10. AAR in dams and hydro-projects
11. Alkali-release from aggregates in concrete
12. Mitigation and repair of AAR-affected structures
13. Enigma of 'so-called' alkali–carbonate reaction
14. Rilem technical committees on AAR

As explained in my Editorial for CM3 in June, each of these papers is deliberately concise to achieve a compact overview of a complex subject, but also contains references to key publications in which more exhaustive information may be found, when required. Further progress was made during the 15th ICAAR in Brazil and readers who could not attend the conference might wish to obtain a copy of the Proceedings (see http://ibracon.org.br/icaar/).

The opening paper in this issue (Nixon *et al.*, 2016) explains the many preventative options that are available for minimising the risk of AAR damage in new concrete structures. These are essentially based on eliminating at least one of the three key factors necessary for AAR: a) sufficient alkalis, b) reactive aggregate combination and c) sufficient water. Of these, it is frequently not feasible to eliminate water, and natural aggregates are difficult to assess reliably for reactivity and in any case are unpredictably variable in character. Accordingly, it is often found most convenient to adopt strategies for reducing or controlling concrete alkali contents and, in this endeavour, there is an increasing preference for using mineral additions or 'supplementary cementitious materials' (SCMs) as part of the binder. The authors define the considerations that indicate the level of precaution required in a given case, including aggregate reactivity, type of construction and the expected exposure conditions, describing slightly differing approaches in various regions.

Over the years there have been many attempts to invent the ideal laboratory test for predicting AAR, but most are at best indicative and can be misleading, with the longer-term expansion tests being generally regarded as the most dependable for identifying potentially deleterious aggregate combinations. Even then, it has become apparent that the behaviour of laboratory specimens can be quite different from that of the same concrete in real structures and in-service conditions. Thus, there has long been an enduring desire for a genuine performance test (of the actual project concrete mix) that can achieve a reliable representation of likely structural behaviour in an acceptably short time. Lindgård *et al.* (2016) address progress with this ambition, describing the steady progress of the International Union of Laboratories and Experts in Construction Materials, Systems and Structures – universally known by the acronym of its lengthy title in French, Rilem – towards this goal and the parallel development of external exposure sites around the world, wherein laboratory-scale work is being compared with the actual behaviour of larger elements in realistic conditions.

Charlwood and Sims (2016) describe the special case of dams and hydro-electric projects, which sometimes exhibit AAR damage in circumstances that would not be expected to cause problems in smaller structures; moreover the movements sometimes take longer to become apparent and/or then continue for longer. This different and persistent consequence of AAR, sometimes in apparent synergistic combination with other deteriorative mechanisms, has not yet been fully explained, but seems likely to relate to the long-term release of additional alkalis from some types of aggregate and possibly to the recycling of alkalis as earlier reaction products become recrystallised. These authors, as consultants for some new dam and hydro projects, have been frustrated by a failure in some cases to learn lessons and apply remedies from events and experience elsewhere.

One of these issues is considered in detail by Menéndez *et al.* (2016), who describe the search for a method that can evaluate the potential contribution of additional alkalis from a particular aggregate combination. It seems clear that certain rock-forming minerals, notably some feldspars and micas, can release alkalis within concrete, and that these alkalis can then participate in AAR; the challenge lies in finding a test method that quantifies this property in a way that reliably predicts the problem and enables suitable precautions to be adopted. Recommendations are indicated for a suitable accelerated test, but more work is needed to resolve the contrast between alkali release in quick tests and that which can occur in concrete over the lifetime of a structure.

AAR in concrete leads to damaged structures and engineers expect to be able to repair and rehabilitate damaged structures, or at least to manage affected infrastructure, to maintain serviceability in advance of longer-term solutions. Folliard *et al.* (2016) summarise an example of on-going field trials carried out on a range of AAR-affected highway structures in eight states of the USA. Various mitigating options were included in the trials, all aimed at arresting the AAR by either excluding moisture (surface-applied sealants and coatings, including some fibre-reinforced wraps) or stabilising existing reaction products (lithium solutions). Silane-based materials were found to be the most effective, while the lithium options were ineffective in practice, owing to inadequate penetration, even when applied using an electrochemical system.

Ever since the late 1950s, the now familiar ASR has apparently had an expansive sister mechanism that affects dolomitic carbonate aggregates, known as the ‘alkali–carbonate reaction’ (ACR). This gave rise to a scientific controversy, because while the original concrete examples in Canada were undoubtedly damaged by expansion, similar examples of dolomitic reaction rim formation elsewhere in the world were often not accompanied by expansion. Katayama *et al.* (2016) explain this ‘enigma’ and describe the careful research that finally revealed the truth about ‘so-called’ ACR. Notwithstanding the dramatic reaction rims that can be formed around dolomitic limestone aggregate particles owing to dedolomitisation, any expansion is actually caused by cryptocrystalline quartz ‘hidden’ within the fine-grained rock texture; ACR is actually ASR!

This Editor has recently had the honour and pleasure of co-editing an updated version (Sims & Poole, 2016) of Swamy’s book, *The Alkali–Silica Reaction in Concrete* (Swamy, 1991). Swamy’s original book summarised the position with ASR about 25 years ago, but also included chapters about the experience with ASR in various countries, each written by a regional specialist. This unique aspect of the book has been greatly developed in the new edition and now includes a near-complete world coverage. Although this exercise has demonstrated that AAR, now seen to be more or less synonymous with ASR, affects us all to varying extents, it is slightly disappointing to note that, some 76 years since ASR was first described by Stanton (1940), it remains an active problem and one that is being separately and variously confronted in different countries and regions.

In the final paper of this pair of themed issues, Wigum *et al.* (2016) describe an on-going endeavour to harmonise the world, at least insofar as AAR/ASR is concerned. Rilem set up a technical committee for AAR in 1988 and this work continues under the chairmanship of Professor Børge Wigum since 2014. The latest Rilem recommendations to date may be found in Godart *et al.* (2013; 2017) for AAR diagnosis and appraisal, plus Nixon and Sims (2016) and Fernandes *et al.* (2016) for AAR tests and specifications. Wigum *et al.* (2016) take the story forward, forecasting the development of an international ‘performance-based testing concept’ by about 2019.

I hope that readers will enjoy reading and using these papers as much as I have appreciated the honour of editing these themed issues and summarising the excellent contributions in this particular issue.

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