Construction Materials
Volume 169 Issue CM3

Editorial
Sims

ice | proceedings

Proceedings of the Institution of Civil Engineers
Construction Materials 169 June 2016 Issue CM3
Pages 117–118 http://dx.doi.org/10.1680/jcoma.2016.169.3.117

ice
Institution of Civil Engineers
publishing

Editorial

Ian Sims PhD
Director, RSK Environment Ltd (Materials & Structures), Hemel Hempstead, UK

The dominance of Portland cement concrete as the world's pre-eminent structural material developed during the 19th century and continued throughout the 20th century and retains that position today. However, the material had a 'guilty secret' that was only revealed by research in the USA during the 1930s; in some circumstances, an expansive reaction can gradually occur between aggregate constituents and alkaline hydroxides from the cement, causing damage to the hardened concrete within structures (Stanton, 1940). This has become known as 'alkali–aggregate reaction' (AAR), or most commonly and more specifically, 'alkali–silica reaction' (ASR). This AAR family of mechanisms is by no means the most frequently encountered threat to concrete durability or the serviceability of structures, but it can be a serious issue when it occurs and it has certainly continued to fascinate concrete research scientists and engineers ever since its first published description, some 76 years ago.

This themed issue of our journal and the next issue (published in August 2016) together provide a structured, up-to-date overview of AAR, 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 takes place in São Paolo, Brazil, in July 2016.

This issue comprises the first seven of fourteen papers, with the other seven being in published in the next issue (Issue 4). 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 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

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 may be expected at the 15th ICAAR in Brazil and readers who cannot or could not attend the conference may wish to obtain a copy of the Proceedings (see http://ibracon.org.br/icaar/).

After graduating as a geologist in London in 1972, I was introduced to the 'guilty secret' of AAR as I commenced PhD research into the chemical instability of some concrete in the UK. This project covered a range of mechanisms, but unbeknown to me at the time, it would be AAR that would come to dominate my professional life in construction materials consultancy. Over more than 40 years, I have been privileged to witness practising engineers and applied scientists getting to grips with AAR worldwide. I believe we now understand the several reactions, including how to recognise them in existing structures and manage the situation, but crucially also including how to determine any possible AAR potential in new works and take effective precautionary measures. However, challenges remain, especially as appreciation of the potential threat from AAR is not universally or equally appreciated everywhere in the world (Sims and Poole, 2016), and we are still finding types of structure that behave exceptionally. Overall, the prospects are encouraging for both a declining incidence of AAR damage and successful approaches to management and/or repair of affected cases.

The opening paper in this issue (Andiç-Cakir *et al.*, 2016) provides an introduction to AAR in the context of the series of ICAARs, from the first small meeting in Denmark in 1974, through to the much larger gatherings in more recent years. An indication of the rapid global spread of the recognition of AAR is illustrated by an interesting world map that is doubtlessly already out of date, while examples are provided of some key AAR developments.

Leemann *et al.* (2016) take a close look at the ASR mechanism and reaction products, variously using optical and electron microscopy, and suggest that better understanding of those issues will improve modelling and the application of accelerated tests for predicting the behaviour of structures. Further explanation of microstructural models of AAR is provided by Dunant and Scrivener (2016), who have demonstrated that the formation of microcracks within aggregates is the key degradation process in ASR. These authors propose a resultant micro-modelling technique that can be used to predict and assess the behaviour of full-scale AAR-affected concrete structures.

Ultimately, of course, it is all about the effect of AAR on concrete structures, and Shayan (2016) describes how this starts with microscopic cracking, which gradually brings about degradation of the mechanical properties of concrete and structural elements; Shayan further explains how AAR damage can cause the concrete to become vulnerable to other deteriorative mechanisms.

De Rooij (2016) provides a user-friendly, enjoyable and experienced guide to the practical diagnosis of AAR in structures (see also Godart *et al.*, 2013). The author explains the value of a 'dedicated' desk study prior to site inspection of the structure in question, before giving helpful guidance on the taking of suitable samples and their subsequent petrographic examination and allied testing.

Finally in this issue, Godart and Wood (2016) contribute their combined long experience of appraising AAR-affected structures, based upon a detailed Rilem report that is in preparation for publication next year (Godart *et al.*, 2017). Site monitoring, core expansion and other test procedures are critically evaluated and schemes are described (derived and developed from ISE (1992; 2010)) for determining expansion indices and severity rating of structural elements.

A search for the most effective means of identifying reactive aggregates dates back as far as the first realisation of AAR, and Fernandes *et al.* (2016a) describe the system devised over many years by Rilem Technical Committees (Nixon and Sims, 2016). These authors explain the initial role of petrographical examination of aggregates, complemented by a recently published petrographic atlas of reactive rock types and textures (Fernandes *et al.*, 2016b). They then consider the various screening and concrete prism expansion tests, including the crucial quest for a performance test that could perhaps eventually be applied to particular or project concrete mixes.

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. We shall meet again for the second part in the August 2016 issue of *Construction Materials.*

REFERENCES

Andiç-Cakir Ö, Poole AB and Ideker JH (2016) ICAAR 1974–2016 conferences for examination of AAR in concrete. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 119–127, http://dx.doi.org/10.1680/jcoma.15.00074.

De Rooij M (2016) Diagnosis of alkali–aggregate reaction in practice. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 154–161, http://dx.doi.org/10.1680/jcoma.15.00069.

Dunant CF and Scrivener KL (2016) Physically based models to study the alkali–silica reaction. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 136–144, http://dx.doi.org/10.1680/jcoma.15.00073.

Fernandes I, Andiç-Cakir Ö and Hooton D (2016a) Assessing aggregates for alkali–aggregate reaction potential. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 172–178, http://dx.doi.org/10.1680/jcoma.15.00060.

Fernandes I, Ribeiro MdA, Broekmans MATM and Sims I (eds) (2016b) *Petrographic Atlas: Characterisation of Aggregates Regarding Potential Reactivity to Alkalis. RILEM TC 219-ACS Recommended Guidance AAR-1.2, for Use with the RILEM AAR-1.1 Petrographic Examination Method.* Springer, Dordrecht, the Netherlands, pp. 202.

Godart B, de Rooij M and Wood JGM (eds) (2013) *Guide to Diagnosis and Appraisal of AAR Damage to Concrete in Structures. Part 1 Diagnosis (AAR-6.1).* RILEM State-of-the-Art Reports, Volume 12, Springer, Dordrecht, the Netherlands, pp. 101.

Godart B and Wood JGM (2016) Appraising structures affected by the alkali–aggregate reaction. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 162–171, http://dx.doi.org/10.1680/jcoma.15.00068.

ISE (Institution of Structural Engineers) (1992) *Structural Effects of Alkali–Silica Reaction: Technical Guidance on the Appraisal of Existing Structures.* ISE, London, UK.

ISE (Institution of Structural Engineers) (2010) *Structural Effects of Alkali–Silica Reaction: Technical Guidance on the Appraisal of Existing Structures. Addendum, April 2010.* ISE, London, UK.

Leemann A, Katayama T, Fernandes I and Broekmans MATM (2016) Types of alkali–aggregate reactions and the products formed. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 128–135, http://dx.doi.org/10.1680/jcoma.15.00059.

Nixon PJ and Sims I (eds) (2016) *Rilem Recommendations for the Prevention of Damage by Alkali–Aggregate Reactions in New Concrete Structures, RILEM Technical Committee 219-ACS.* RILEM State-of-the-Art Reports, Volume 17, Springer, Dordrecht, the Netherlands, pp. 176.

Sims I and Poole AB (eds) (2016) *Alkali–Aggregate Reaction in Concrete: a World Review* (2nd edition of Swamy RN (ed) (1992) *The Alkali-Silica Reaction in Concrete*), Taylor & Francis, London, UK, pp. 400.

Shayan A (2016) Effects of alkali–aggregate reaction on concrete and structures. *Proceedings of the Institution of Civil Engineers – Construction Materials* **169(3)**: 145–153, http://dx.doi.org/10.1680/jcoma.15.00076.

Stanton TE (1940) Expansion of concrete through reaction between cement and aggregate. *Proceedings of American Society of Civil Engineers* **66(10)**: 1781–1811.