# BRE Digest 330: Alkali–silica reaction in concrete – the case for revision, Part II

**In Part I[1] the case for review of UK guidance on ways to minimise the risk of damaging alkali–silica reaction (ASR) in concrete was made. It went on to consider current issues for the specification of cement alkalis; composite cements and combinations; and alkali contributions from aggregates. This Part will consider the guidance on recycled aggregates and the treatment of alkalis from sources other than cement and aggregates before reviewing the potential publication routes for updated guidance.**

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BRE Digest 330: Part 2[2] differentiates between the various recycled aggregates. It separates recycled concrete aggregate and recovered aggregates from the general group of recycled aggregate arising from the reprocessing of inorganic material previously used in construction. It sets down rules for the use of recycled concrete and recovered aggregates, which appear to have been satisfactory in practice.

Increased pressure on construction sites to improve sustainability and reduce waste has prompted a further examination of the case for use of recycled aggregate. An investigation at Dundee University, Concrete Technology Unit, undertaken for WRAP[3] has confirmed the high variability in properties of recycled aggregate. Various constituents were shown to be expansive although the terms of the project prohibited the time necessary for further investigation to confirm whether this was ASR or some other mechanism. Various constituents also were shown to contribute alkali, as determined in accordance with the RILEM method[4] discussed in Part I.

Users of recycled aggregate have confirmed their variable composition and the impossibility, economically, of separating out potentially deleterious constituents. In this situation the classification as potentially 'highly reactive' aggregate remains a necessary precaution.

**Recommendation 7:** That the Digest 330 requirements on recycled aggregate, recycled concrete aggregate and recovered (reclaimed) aggregates be retained.

## The classification and alkali limit applicable to aggregates

Classification of aggregates in Digest 330, Part 1 requires that petrographic examination of aggregates should conform to BS 812-104[5]. A new European Standard, BS EN 932-3: *Procedure and terminology for simplified petrographic description*[6], has since been published. It is questionable whether this is a suitable alternative since it appears little more than a standardised labelling procedure intended to ensure that a logical geological description is given to the aggregate in question. It is suggested that the use of BS 812-104 with only a single test could be adequate and this should be considered further.

Digest 330: Part 2 describes the class of aggregates considered to be 'highly' reactive, included in which are those described as greywacke and greywacke-type. It is known that these aggregate types vary considerably in their reactivity and refers to the testing protocol[7] for their classification.

There is limited data on the testing of greywacke aggregate to this protocol, making it difficult to reassess their classification as a generic rock type. Testing of various sources of Scottish greywacke at Dundee University, Concrete Technology Unit, projects for the assessment of efficiency of fly ashes in minimising ASR, have confirmed the variability in reactivity with some samples exceeding the expansion limits in the protocol. The use of greywacke aggregates in the north-east of Ireland is being examined to check whether any general guidance can be deduced.

**Recommendation 8:** That the procedure in Digest 330 for classification of aggregates for alkali reactivity be reviewed and simplified where possible.

**Recommendation 9:** That greywacke and greywacke-type aggregates continue to be classified as 'highly' reactive unless proved otherwise by testing to the protocol.

## Alkali from other sources

According to Digest 330; Part 2, alkalis from other sources are to include those from "aggregate, admixture, etc", excluding "alkali contributed by recycled concrete aggregates". The limit of 0.60kg $Na_2O_{eq}/m^3$ is described as "a conservative approach" as the information on how these alkalis affect the mechanisms involved was limited.

At the time this limitation was imposed the limit was adequate to cover alkali introduced as salt from marine aggregates and the admixtures available were not in wide use.

The sustainability of concrete relies on using aggregate from all available sources, including marine, and it is not always a sustainable use of fresh water to remove salt from them completely. The contribution of alkali from marine aggregate remains one to be taken into account.

Concrete technology has developed over the 20 years since this limit on alkalis from other sources was introduced. In particular the use of high-performance admixtures with significant content of alkali has become commonplace. Their use is restricted by this limit, suggesting that a more logical treatment of this alkali is required.

The more conservative approach to alkalis from admixtures compared to those from recycled concrete aggregate has no technical basis. There is now more experience in the inclusion of additional admixture alkali from the Irish Republic[8] where, although the basis for control of ASR is similar to that in Digest 330, alkalis from admixtures are not limited other than by the overall limit on concrete.

The exemption from calculations, where the alkali from other sources is below 0.2kg $Na_2O_{eq}/m^3$, remains valid as precision of analysis and resource necessary for continual testing is not justified compared with the minimal risk involved.

Where low alkali cements are used with low and normal reactivity aggregates it is currently assumed that the overall alkali level is self-limiting. If the alkali limit from other sources were to be removed then there could be a risk for some high cement content/high admixture dosage special concretes. Below 500kg/m$^3$ cement the alkali content

*"Various issues relating to the sustainability of concrete and its constituent materials have highlighted the need for an early revision to be undertaken in the guidelines for minimising the risk of damaging alkali–silica reaction in concrete as published in BRE Digest 330."*

will still be self-limiting but above that the risk increases and an overall alkali limit for these combinations should be added to protect such situations.

**Recommendation 10:** That the limitation of alkali from 'other sources' be deleted, other than the exclusion from the overall alkali calculation where it is less than 0.2kg $Na_2O_{eq}/m^3$.

**Recommendation 11:** That a limit of ≤3.5kg $Na_2O_{eq}/m^3$ be introduced for the combination of normal reactivity aggregates with low alkali cement where the cement content exceeds 500kg/$m^3$.

## The appropriate publication medium for UK rules on ASR

While the initial published guidance was produced by an independent, widely representative group chaired by Michael Hawkins and appeared as Concrete Society Technical Report 30(9), the detailed guidance for concrete specification has been published by the Building Research Establishment as Digest 330. The Information Paper modifying the 1999 Digest was drawn up by a working party set up by the BSI Concrete Committee. It is this latter modified 2004 Digest that is called up in the British Standard for concrete, BS 8500-2(10).

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Although the European Standard for concrete, BS EN 206-1(11), refers specifications to minimise the risk of damage due to ASR to national regulations (BS 8500 for the UK), there have been a number of initiatives at the European Standardisation level that impinge on this derogation to national regulations. The request by Lithuania for specification of a 'low' alkali cement has already been referred to; more recently an *ad hoc* group of the CEN concrete, aggregates and cement Technical Committees referred various aspects currently within the scope of Digest 330 to the various CEN Technical Committees for action. These include determination on the effective (or 'reactive' as referred to in UK guidance) alkali content of cements and additions, provision of a common procedure for determination of the effective alkali content of concrete, and monitoring the progress of the RILEM group working on a performance test for concrete.

While this work is progressing, the status of UK national provisions existing only in guidelines issued by a standards-independent body (BRE) will be questioned when it inevitably comes to maintaining national independence on such guidelines. A precedent for this concern comes from the objections raised by CEN on the inclusion of UK cements considered to be sulfate-resisting where the only semi-official basis for selection of cements is BRE Special Digest 1.

Alternatives for consideration are to include key specification matters in the form of official British Standards publications. This could take the form of a full Standard, or a normative annex to BS 8500-2. An informative annex is unlikely to be considered suitable since the specification clauses in the body of the standard are normative. In any of these cases, BRE Digest 330 could continue as the general background and basis for guidance to the national provisions. An appropriate time to do this would be when BS 8500 is revised to reflect the revised European concrete standard.

Whatever the preferred location of definitive UK rules for minimising the risk of damage due to alkali–silica reaction, it is essential that the requirements in all UK publications are aligned. This will require revision of BRE Digest 330 and review of the relevant clauses and annexes in BS 8500 and BS EN 197-1(12). In all cases the need for wide representation of views and experiences is essential.

**Recommendation 12:** That BSI Committee for Concrete, B/517/1, gives consideration to whether the specification clauses for minimising the risk of damaging alkali–silica reaction in concrete should be published in an official British Standards Institution publication and, if so, whether this should be in the form of a normative annex to BS 8500-2.

**Recommendation 13:** That the authorities responsible for the content of BRE Digest 330, BS 8500, and BS EN 197-1 national annex review their content to ensure uniformity in UK rules.

## Concluding remarks

Various issues relating to the sustainability of concrete and its constituent materials as well as developments in admixture and concrete technology have highlighted the need for an early revision to certain requirements in the guidelines for minimising the risk of damaging alkali–silica reaction in concrete as published in BRE Digest 330: 2004. ■

■ **Acknowledgement**:

The author was chief chemist of Castle Cement, a member of The Concrete Society Hawkins Committee and chairman of its alkali limit working party. He is chairman of BSI committee B/516 Cement and building limes.

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