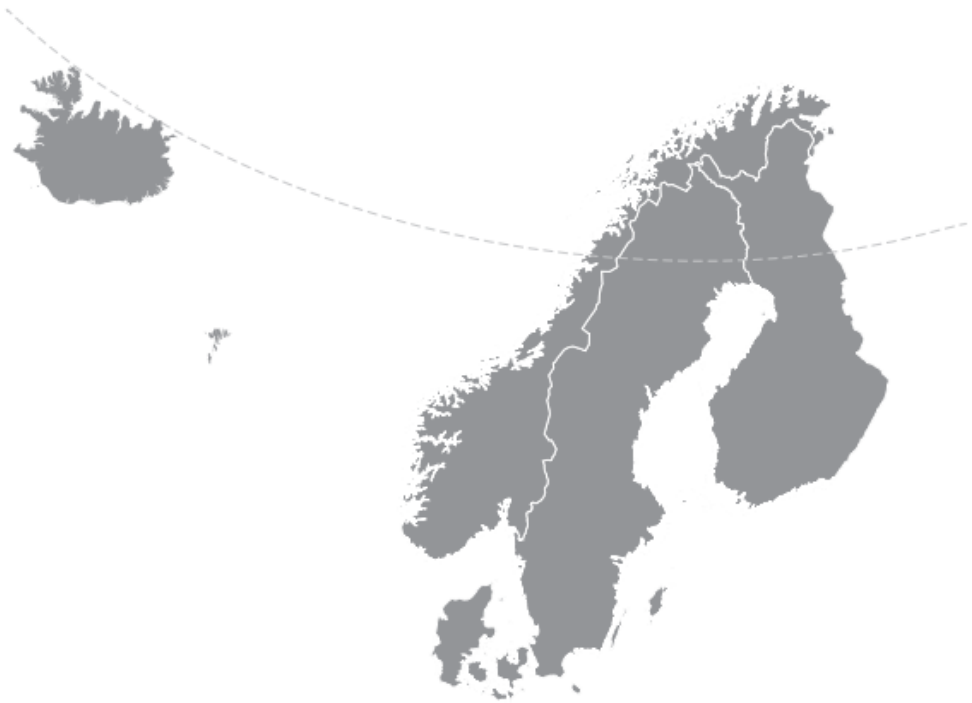
Nordic Concrete
Research

Proceedings of the XXIII Nordic Concrete Research Symposium
Aalborg, Denmark 2017



NCF Nordic Concrete Federation

NORDIC CONCRETE RESEARCH

Proceedings of

XXIII Nordic Concrete Research Symposium

Aalborg, Denmark

21-23 August, 2017

Edited by:
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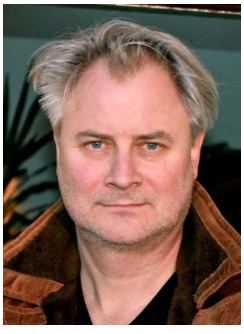
Publisher:
NORSK BETONGFORENING
Postboks 2312, Solli
N-0201 Oslo
Norway

The RILEM approach to mitigate alkali aggregate reactions (AAR) in concrete



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ABSTRACT
Development and assessments of test methods, to avoid deleterious AAR in concrete, have been the focus of three previous RILEM Technical Committees (TC) in the period 1989 to 2014. The 4th RILEM TC on AAR, TC 258-AAA, was established in 2014, and will until 2019 focus on the following Work Packages: WP1- Performance based testing concepts; WP2 - Relationship between results from laboratory and field and the establishment of field exposure sites; WP3 - Testing of potential alkalis released from certain types of aggregates and measurement of internal concrete alkali content; WP4 - Verification of alkalis released from aggregates.

Key words: Alkali Aggregate Reactions, Cement, Concrete, Durability, Testing.

1. INTRODUCTION

1.1 Alkali Aggregate Reactions

Alkali Aggregate Reactions (AAR) can be defined as chemical reactions between the alkalis hydroxides (sodium and potassium) in the pore solution of concrete and certain minerals in the aggregate. The product of the AAR is a hygroscopic gel that expands upon hydration and may introduce cracking in the surrounding concrete, thereby reducing the mechanical properties of concrete and structure service-life and increasing cost for society. The incubation time needed before AAR damage starts ranges from a few months to several decades, much depending on aggregate type, binder type and exposure climate.

1.2 Background of the previous work in RILEM

The 3rd RILEM[1] Technical Committee (TC 219-ACS)[2] on AAR was established in 2007. The TC ended its activities in 2014. Initial work, since 1989, by the first two RILEM TCs, 191-ARP and its predecessor TC 106, concentrated on the assessment of the alkali-reactivity potential of aggregates. However, in recognition that damaging expansion involves interaction between all the main components of a concrete mix, the 3rd TC 219-ACS also focused on the assessment of the effect of the cement/binder on AAR, i.e. performance testing. It was prepared several documents/recommendations, published as:

- **AAR-6.1** (diagnosis & prognosis) – RILEM note book publication [1]
- Literature review on performance testing - SINTEF Report [2]

The central recommendations were published in a special issue of "Material and Structures" [3]:

- **AAR-0** Overview Guide
- **AAR-1.1** Petrographic Examination Method
  - Rapid classification of aggregates based on point counting in thin sections.
- **AAR-2** Accelerated Mortar Bar Test (AMBT; 80°C, 1N NaOH, 14 days)
  - Rapid classification of aggregates based on mortar bar expansion.
- **AAR-3** Concrete Prism Test (CPT; 38°C, 100 % RH, 52 weeks)
  - Potential alkali-reactivity of aggregate combinations based on expansion of concrete prisms (Application 1: AAR-3.1, high alkali content). The method also allows determination of the alkali threshold of an aggregate combination (Application 2: AAR-3.2)
- **AAR-4.1** Accelerated Concrete Prism Test (ACPT; 60°C, 100 % RH, 20 weeks)
  - Potential alkali-reactivity of aggregate combinations based on expansion of concrete prisms with a high alkali content.
- **AAR-5** Screening test for carbonates (AMBT; 80°C, 1N NaOH, 14 days)
  - Rapid screening test for alkali carbonate reactive aggregates.
- **AAR-7.1, 7.2 and 7.3** (ASR specification)
  - ASR specifications for mitigation of ASR.

The "petrographic atlas" (**AAR-1.2**) was published separately as a RILEM book in "Material and Structures" [4].

2 THE NEW RILEM TC 258-AAA – link to a Norwegian R&D project

The new, 4th TC on AAR (TC 258-AAA)[3] started in October 2014, and is chaired by Professor Børge Johannes Wigum (HeidelbergCement Northern Europe, Norway), and the secretary is Dr Jan Lindgård (SINTEF, Norway).

The main purpose of this new RILEM TC is to develop and promote a performance based testing concept for the prevention of deleterious Alkali Silica Reactions (ASR) in concrete (the issue Alkali Carbonate Reaction, ACR, is not included in this TC). Strong emphasis will be put on publishing the new methods develop as RILEM recommendations and on the implementation these methods and recommendations as national- and international standards.

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[1] RILEM – International union of laboratories and experts in construction materials, systems and structures

[2] RILEM Technical Committee 219-ACS. Alkali-Aggregate Reactions in Concrete Structures (2007-2014)

[3] Avoiding alkali aggregate reactions in concrete - Performance based concept (2014-2019).

2.1 The Work Packages (WPs)

WP1 - Performance testing and accelerated testing in laboratory.
Development of performance test methods to document the mitigating effect of supplementary materials such as fly ash or slag etc., or the use of a low alkali levels in the mix. Thus, a much wider selection of aggregates can be used safely while increasing the sustainability of the concrete and aggregate industry. Although some performance tests have been in use for many years, there is still a necessity to improve and validate more reliable test methods, including arranging international inter-laboratory trials. WP1 is headed by Dr Terje F. Rønning, (*HeidelbergCement Northern Europe, Norway*).

WP2 - Performance testing and laboratory vs. field; Exposure site.
An important additional tool in validation of the performance testing concept is to make an assessment of the link between accelerated laboratory results and behaviour of these concrete mixtures in real field structures. One main objective is to establish a link between outdoor exposure sites dedicated to AAR investigations and located in different parts of the world in order to generate an international database on the effect of environmental conditions on the kinetics of AAR. WP2 is headed by Prof. Benoît Fournier (*Université Laval, Québec, Canada*).

WP3 - Performance testing; Assessment of detailed alkali inventory in concrete, including internal alkali release from aggregates, recycling of alkali and external alkali supply.
One important “missing link” is how to measure the amount of potential alkalis that might be released from various aggregate types under accelerated laboratory conditions. It is the intention to finalise and validate such a test method. It is also of importance to evaluate the potential internal alkali recycling in the concrete which in some instances have been reported, in addition to assess any alkali contribution from external sources. WP3 is headed by Dr Esperanza Menéndez Méndez (*Institute of Construction Science, “Eduardo Torroja” (CSIC), Spain*).

WP4 - Verification of alkalis released from aggregates. Results of alkali release from aggregates under accelerated laboratory tests need to be verified and calibrated to what happens in real structures. The aim is to compile results from exposure sites and concrete structures worldwide in order to assess the “true” level of alkali released from various aggregates. WP4 is headed by Professor Børge Johannes Wigum, (*HeidelbergCement Northern Europe, Norway*).

2.2 Norwegian research project (2014-2018)

The Norwegian R&D project 236661 "ASR – Alkali-silica reaction in concrete – reliable concept for performance testing" (*abbreviated: "KPN-ASR"*) (*http://www.sintef.no/prosjekter/alkalireaksjoner-palitelig-konsept-for-funksjonspr/*) covers the same topics as RILEM TC 258-AAA. For several sub-topics, a close research co-operation with members of the RILEM TC, in particular leading researchers in Northern America, is established. Moreover, relevant findings in this project are communicated to members of RILEM TC 258-AAA on TC meetings.

3 STATUS OF RILEM TC 258-AAA SPRING 2017

RILEM TC 258-AAA has a wide international membership, which helps to promote the eventual international use of RILEM methods and recommendations. Physical meetings twice a year will still be the centre of its activities and wherever possible this is co-ordinated with major relevant international conferences to facilitate attendance. Members around the world that are not able to travel to the meetings are following the discussions through the extended minutes of the meetings. All relevant documents, including the minutes from the meetings, are available for TC members at the RILEM internal website.

In WP1, the main work is concentrating on the performance testing concept using a 38°C Concrete Prism Test (CPT; based on the Norwegian CPT [5]). Previous CPT procedures (e.g. RILEM AAR-3) included testing of alkali-reactivity of aggregate (AAR-3.1) and the determination of the alkali threshold of an aggregate combination (AAR-3.2). The performance testing concept includes applications for performance assessment of combinations of aggregates and cement/binders at various or specific alkali contents.

The initial work in WP2 has included casting of about 80 concrete cubes (300x300x300 mm) for outdoor storage and monitoring at 10 different exposure sites in Europe and North America (Portugal (2), France, Norway (2), Iceland, Germany, Canada (2) & Texas). The concrete mixtures included ordinary Portland cement and addition of fly ash (20 & 30%), along with control mixtures.

In WP3, a Round-Robin test has been initiated in order to evaluate the draft test procedure for measuring potential amount of releasable alkalis from aggregates. In addition, initial work in WP3 includes the preparation of an outline literature review regarding the alkali inventory in concrete.

In WP4, Post-doc activities in the Norwegian "KPN-ASR" project have developed a draft test method to determine the alkali level in concrete facilitating activities to verify the level of potential alkali release from aggregates in real concrete.

In the past 75 years, we have struggled to understand, control and prevent damage from AAR since it was first reported in concrete. This continuing series of RILEM Technical Committees has helped to harness international co-operation in this struggle for the last nearly 30 years and will continue this work in the future.

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