

# **Balanced alkali limit in cement for alkali-silica reaction risk-free concrete production**

**by Cibele Sanchez Roboredo**

Thesis submitted in fulfilment of the requirements for  
the degree of

**Master of Engineering (Research)**

under the supervision of Vute Sirivivatnanon and Paul  
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University of Technology Sydney  
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June 2020

## CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Cibele Sanchez Roboredo declare that this thesis is submitted in fulfilment of the requirements for the award of Master Degree by Research, in the School of Civil & Environmental Engineering, Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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*A thesis submitted in partial fulfilment of the requirements  
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*in*

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*by*

**Cibele Sanchez Roboredo**

*to*

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## ABSTRACT

The effect of alkali concentration on the alkali-silica reaction (ASR) is presented in the context of balance alkali content in ASR risk assessed concretes. In order to investigate the effect of alkali concentration on ASR, the reactivity of the non-reactive micro-diorite aggregate and reactive greywacke aggregate, classified by the Australian Standard AS 1141.60.2 were investigated. Slurry tests in the presence and absence of calcium hydroxide (CH), dissolution tests to monitor the rate of release of alkali, calcium, silica and aluminium ions into solution and mortar bar and paste tests were carried out as a function of alkali concentration of the immersion solution with and without the addition of the supplementary cementitious material (SCM) fly ash.

Aggregate reactivity in ground aggregate slurry tests as a function of pH and temperature demonstrated that reactivity of ASR increased with temperature, pH and reactivity of the aggregate. The relative reactivity of these aggregates was further confirmed by dissolution tests showing that the rate of dissolution of silica, in particular, increased with aggregate reactivity. The dissolution test for fly ash also showed significant reactivity with respect to the rate of silica dissolution.

Slurry tests in the presence and absence of CH showed that, in the presence of CH, the rate of reaction increased markedly, demonstrating the importance of calcium ions on ASR gel formation. Under the experiment conditions, fly ash happened to consume more calcium which indicates high reactivity. The degree of consumption of CH did not increase with pH. This lack of dependence on the pH was ascribed to diminishing solubility of calcium ions with increased pH and suggests that the composition of the ASR gel formed is dependent on the pH of the solution.

Accelerated mortar bar tests (AMBT, AS 1141.60.1) were carried out as a function of alkali concentration with and without fly ash addition. Expansion rates were observed to increase with aggregate reactivity and with pH. The addition of the Australian fly ash class F significantly reduced expansion suggesting that fly ash acts in mitigation of ASR through competitive reaction inhibiting the progression of the aggregate reaction.

Ground aggregate slurry and mortar bar and paste tests showed increased reaction with pH and reactivity of the silica components present in aggregates. Reduced alkali concentration simply reduced the reaction rate. The continuing reaction even at low alkali concentrations suggests that ASR occurs irrespective of the pH. The potential for deleterious ASR is, however,

dependent on the action of the silica gel formed on the concrete and therefore further work is required into the complete mechanism of ASR to complement the current study.





## **DEDICATION**

I would like to dedicate my work to my parents Delmonte Roboredo and Roseli Sanchez Roboredo, to whom I owe all my achievements. Mom and Dad, I have been tremendously blessed to have you and your unconditional love and support throughout my life. I would not have any achievements in my life without your continuous support. I am also very blessed to have two lovely sisters, Carolina and Catia, who were always on my side even when so far away. Of course I have to thank my beautiful and lovely niece Valentine for the most beautiful smile in my life that always cheers me up. I always had dreams, and with my family, my dreams are becoming achievements!

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## LIST OF PUBLICATIONS

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