Investigations into Alkali-Aggregate Reaction in Concrete Structures

by

Chintha Kusumlatha Pathirana

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Research Supervised
by
Dr. A.P.N. Somaratna
and
Mr. H. Abeyruwan

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF PERADENIYA
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Abstract

Alkali Aggregate Reaction (AAR) is a chemical reaction taking place in concrete between alkalis in pore solution of cement paste and reactive phases in aggregates, with mechanical implications. It causes the concrete concerned to undergo expansion with time, resulting in premature cracking of concrete, and unwarranted deformations in structures which could shorten their service lifetime. In Sri Lanka, so far there has been no documented evidence of systematic investigations on AAR in structures. Nevertheless there are a few old concrete structures which are still being used, but showing symptoms similar in nature to those of AAR. Since characteristics of aggregate mainly contribute to AAR a substantial part of the present study is devoted to investigate the potential alkali-silica reactivity of Sri Lankan aggregates. In this study, the standard tests, ASTM C289 - 07 for potential alkali-silica reactivity of aggregates (chemical method) and ASTM C295 - 07 for petrographic examinations, have been performed on samples collected from numerous locations spreading over Sri Lanka, representing a wide range of morphological types of coarse and fine aggregates. Based on the results of these tests, as the next step, ASTM C1260 – 7 for the potential alkali reactivity of aggregates (mortar-bar method) was performed on selected samples. Based on the results, a new parameter named, 'Potential Reactivity Index' (PRI), has been proposed as an index to rank slowly reactive aggregates. The degree of reactivity has been quantified by extending the rapid chemical test covered by ASTM C289. A correlation was established between the expansion of aggregates and PRI. The degradation of concrete was assessed by ultrasonic and acoustic tests. The results of ultrasonic pulse velocity and

resonant frequency testing have shown that the dynamic modulus of elasticity of the concretes is affected by AAR.

If AAR takes place in an existing concrete structure it might become necessary to implement remedial measures which can vary from blocking moisture ingress to introducing stress-relief cuts in concrete. To initiate remedies, the presence of AAR in a structure has to be detected. Then the progress of AAR along with its potential for causing structural distress needs to be predicted. To understand the structural implications of AAR, computer simulations can be performed. The present study uses a methodology for using a general purpose finite element program package to simulate AAR numerically. AAR is considered as a thermal equivalent expansion process, in which the expansion of the concrete due to the equivalent temperature rise is equal to the expansion due to AAR. A computer code has been developed for this purpose and validated using analytical solutions to several benchmark problems. A real structure under alkali-aggregate reaction, found in literature has been analyzed using the proposed numerical procedure.