Non-Destructive Evaluation for Large-Scale, ASR-Activated, Concrete Mockups

Call for Participation

Submitted to

NDE Researchers

From

Principal Investigators
Yann Le Pape (lepapeym@ornl.gov)[1,2] and Z. John Ma (zma2@utk.edu)[2]

[1]Oak Ridge National Laboratory
[2]Department of Civil and Environmental Engineering
University of Tennessee, Knoxville (UTK)

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Introduction and Background

Alkali-silica reaction (ASR) is a chemical reaction in either concrete or mortar between hydroxyl ions of the alkalis (sodium and potassium) from hydraulic cement (or other sources), and certain siliceous rocks and minerals present in some aggregates. The reaction product, an alkali-silica gel, is hygroscopic having a tendency to absorb water and swell, which under certain circumstances, leads to abnormal expansion and cracking of the concrete. This phenomenon affects the durability and performance of concrete structures severely. Because of that, ASR has been recognized as one of the most deleterious phenomena in concrete as it can cause significant loss of mechanical properties and cracking in concrete structures.

The challenge now exists in evaluating the degree of the ASR damage in existing structures so that informed decisions can be made toward mitigating ASR progression and damage. Reliable methods and tools are needed in order to evaluate the condition of ASR affected structures. This evaluation may include tests to determine the loss of mechanical properties, internal damage within structures, micro and macro cracks already developed, and the degree of expansion that has already occurred. Several techniques are currently available for characterizing ASR damage in real structures, which are a combination of in-situ monitoring and laboratory testing. In-situ monitoring of surface crack widths is a common technique that has been used to study the progress of ASR. However, this method can take up to three years to obtain reliable data. On the other hand, laboratory tests such as the modified stiffness damage test (SDT) and petrographic examination require extracting cores from structures. The representation of cores to overall structure is still questionable because cores provide insight to damage within a localized section within the concrete. In addition, the number of cores that can be extracted from a structure is very limited due to the destructive nature of the testing. As a result, non-destructive evaluation (NDE) is gaining popularity since it provides quick results without affecting the integrity of concrete structures. Several NDE techniques have been used to characterize ASR damage in concrete such as ultrasonic wave velocity (UPV), impact echo (IE), electrical resistivity, spectral analysis of surface wave (SASW), surface wave transmission (SWT), non-linear acoustic technique (NLAT) and full-scale dynamic testing (to name a few).

Oak Ridge National Laboratory (ORNL) and The University of Tennessee, Knoxville (UTK) have constructed three large concrete specimens in order to research the effects of stress confinement on the development of damage in concrete structures due to ASR. Another primary objective of this research is to determine a reliable nondestructive evaluation technique that accurately assesses ASR damage within large-scale concrete structures. To accomplish this objective, ORNL and UTK are extending a **Call for Participation** in order to provide multiple researchers the opportunity of testing a wide array of NDE methods within this research project while also benefitting the research program by identifying suitable NDE methods to evaluate ASR affected-concrete structures.

Objectives and Goals

The objectives and goals for the participation in this study are:

1. To provide a medium for NDE researchers and invite them to assess the effectiveness and reliability of new and available NDE techniques.
2. To study and capture the progress and damage of ASR in large scale specimens at different ASR stages using NDE techniques.
3. To evaluate the ability of NDE to predict damage in typical field structures.
4. To evaluate the loss of mechanical properties that occur during ASR progression using NDE techniques.
5. To study the difference in the behavior of the confined and unconfined ASR specimen using NDE techniques.

Specimens and Materials

Three specimens, corresponding to 136" x 116" x 40" (approx. 3.5 m x 3 m x 1 m) reinforced concrete blocks, have been cast for the purpose of this project and enclosed in an environmental chamber under specific temperature (38 ^{o}C) and relative humidity (95%) conditions to accelerate the ASR-induced expansion. Detailed dimensions and reinforcement details can be found in **Appendix A**. Two specimens (Specimens 1 & 2) have been fabricated using highly reactive aggregates. One of these two specimens was confined (Specimen 1) in a relatively rigid steel frame preventing expansion in the reinforced plane. The second specimen (Specimen 2) is unconfined and free to expand in all direction. The third specimen (Specimen 3), considered as a control specimen, was made with the same reactive aggregates, but the ASR has been mitigated, by incorporating lithium in the mix. All the three specimens have been instrumented with different types of sensors to monitor expansion, temperature, and strain. Each specimen is instrumented with a number of embedded strain transducers measuring strain at select points within the mass of each specimen. Several deformation sensors are both embedded within and attached to the surfaces of the concrete specimens. For Specimen 1, the top and bottom surfaces are accessible for NDE. For Specimens 2 & 3, all surfaces are accessible. A full set of companion cylinders were cast at the day of pouring in order to assess the deterioration of mechanical properties of both stress-confined concrete and freely-expanding concrete as a function of ASR expansion.

Benefits to Participants

Benefits to NDE researchers would be to evaluate the effectiveness and reliability of NDE methods on large-scale mockups in order to predict the reliability of the NDE technique for testing field structures. In addition, the accelerated specimens will be conditioned and monitored for 2 - 3 years; which can provide a setting to study the progress of ASR at different stages by NDE techniques.

Timeline and Schedule

Several NDE researchers are expected to perform testing on the concrete mockups. The environmental chamber operation must be halted in order to provide a workable environment, which may negatively impact the ongoing study. Therefore, it is in the best interest of the project to select proposals for participation that minimize the amount of time in which the curing environment must be disabled. For this reason, researchers are encouraged to minimize research time inside the environmental chamber.

Expected Deliverables

Participants are expected to submit the following details prior to the final approval from ORNL and UTK:

1. Testing plan, duration, and schedule.
2. List of all NDE methods that will be performed.
3. Open access plan to the acquired data.
4. List of participants with contact information.

A detailed suggested proposal guideline follows in Table 1. However, this guideline is not exhaustive so proposals should include any relevant information that would aid in making a knowledgeable choice in deciding which NDE methods should be investigated. A limited number of projects can be granted access to the specimens due to the constraints imposed by the ongoing research endeavor.

Table 1 Proposal Guideline

Proposal Section	**Section should include:**	**Suggested Length**
Evaluation Technique	What evaluation technique are you planning on utilizing? What parameters does this technique measure/observe? How can this technique be used to achieve the objectives of this project? How applicable is this technique for determining ASR damage in nuclear structures? Has this technique been used to assess ASR damage in concrete before? What equipment will you use to perform this NDE?	1 -5 Paragraphs
Timeline of Activities	How much time per visit will you need access to the specimens? What testing frequency would you propose to access the specimens? What would be the desired starting and ending timeline?	1 Paragraph + Schedule
Data Access	Plan detailing how the acquired data will be shared with the research community	1-3 paragraphs
Personnel	Please list all personnel currently expected to participate in this research (Including contact information for the leading investigator).	As needed
References	Include any publications that demonstrate/support the effectiveness of your proposed evaluation technique.	As needed

Selection Criteria

Applications will be reviewed as they are received. Proposals will be unbiasedly accepted based on technical merit. Proposals will also be selected on the following attributes: a) ability to achieve research objectives; b) amount of specimen access time required; c) amount of surface preparation time (less is better), and d) uniqueness of technique/algorithm. The list of NDE researchers already granted access to the concrete specimens is shown in Table 2. This list will be periodically updated as researchers are granted access.

Table 2 List of accepted NDE researchers

Institution	NDE Method
Univ. of South Carolina	Acoustic Emission (AE)
Vanderbilt	Digital Image Correlation (DIC)
University of Minnesota	Linear Array Ultrasound

Submittal of Applications

The deadline for proposal submittal is **February 1, 2017**. However, researchers are encouraged to submit proposals as soon as possible as applications will be reviewed and potentially accepted as they are received.

Proposals should be submitted via email attachment to the principal investigator, John Ma (**zma2@utk.edu**), with email subject containing **"NDE Call for Participation"**.