INTERAGENCY AGREEMENT	1. IAA NO. NRC-HQ-60-14-I-0004	PAGE 1 OF 2

2. ORDER NO.	3. REQUISITION NO. RES-14-0066	4. SOLICITATION NO.

5. EFFECTIVE DATE 03/31/2014	6. AWARD DATE 03/31/2014	7. PERIOD OF PERFORMANCE 03/31/2014 TO 05/31/2018

8. SERVICING AGENCY	9. DELIVER TO
NATIONAL INSTITUTE OF STANDARDS TECHNOLOGY ALC: DUNS: 929956050 +4: NATIONAL INSTITUTE OF STANDARDS TECHNOLOGY US DEPARTMENT OF COMMERCE 100 BUREAU DRIVE MS 8602 GAITHERSBURG MD 20899-0001 POC Sharon Rinehart TELEPHONE NO. 301-975-5876	JACOB PHILIP MAIL STOP CSB C2 A7 11555 ROCKVILLE PIKE ROCKVILLE MD 20852

10. REQUESTING AGENCY	11. INVOICE OFFICE
ACQUISITION MANAGEMENT DIVISION ALC: 3100001 DUNS: 040535809 +4: US NUCLEAR REGULATORY COMMISSION ONE WHITE FLINT NORTH 11555 ROCKVILLE PIKE ROCKVILLE MD 20852-2738 POC Jeffrey R. Mitchell TELEPHONE NO. 301-287-0955	US NUCLEAR REGULATORY COMMISSION ONE WHITE FLINT NORTH 11555 ROCKVILLE PIKE MAILSTOP O3-E17A ROCKVILLE MD 20852-2738

12. ISSUING OFFICE	13. LEGISLATIVE AUTHORITY
US NRC - HQ ACQUISITION MANAGEMENT DIVISION MAIL STOP 3WFN-05-C64MP WASHINGTON DC 20555-0001	Energy Reorganization Act of 1974 14. PROJECT ID 15. PROJECT TITLE

16. ACCOUNTING DATA
2014-X0200-FEEBASED-60-60D002-11-6-213-V6446-251B

17. ITEM NO.	18. SUPPLIES/SERVICES	19. QUANTITY	20. UNIT	21. UNIT PRICE	22. AMOUNT
	Agreement Number: NRC-HQ-60-14-I-0004 The Nuclear Regulatory Commission and the National Institute of Standards and Technology hereby enter into this Agreement for the project entitled "Structural Performance of Nuclear Power Plant (NPP) Concrete Structures Affected by Alkali-Silica Reaction (ASR)." Master IAA: N/A				
00001	Authorized Agreement Ceiling Line Item Ceiling$5,671,000.00 Incrementally Funded Amount: $650,000.00 Continued ...				5,671,000.00

23. PAYMENT PROVISIONS	24. TOTAL AMOUNT $650,000.00

26a. SIGNATURE OF GOVERNMENT REPRESENTATIVE (SERVICING)	26a. SIGNATURE OF GOVERNMENT REPRESENTATIVE (REQUESTING)

25b. NAME AND TITLE	25c. DATE	26b. CONTRACTING OFFICER	26c. DATE
Jason Averill Acting Chief Div 731	5-6-14	JEFFREY R. MITCHELL	3/31/2014

TEMPLATE - ADM001

SUNSI REVIEW COMPLETE MAY 2 2 2014 ADM002

The initial apportionment of $650,000.00 shall be used for Phase 1. This increment includes partial funding for Task 1 in the amount of $425K for partial funding of Subtask 1a and partial funding for Task 4 in the amount of $225K for partial funding of Subtask 4a.

Notwithstanding the agreement effective dates and period of performance start dates stated elsewhere in the agreement, the effective date of the agreement and start date of the period of performance are the last date of signature by the parties.

The following documents are hereby made part of this Agreement:
Attachment No. 1: Statement of Work
Attachment No. 2: NRC/NIST Standard Terms and Conditions

ADVANCE PAYMENT IS AUTHORIZED

NRC REQUIRES MONTHLY FINANCIAL STATUS REPORTS

The total amount of award: $5,671,000.00. The obligation for this award is shown in box 24.

STATEMENT OF WORK FOR INTERAGENCY AGREEMENT WITH NIST

PROJECT TITLE: **Structural Performance** of **Nuclear Power Plant (NPP) Concrete Structures Affected by Alkali-Silica Reaction (ASR)**

CO-PRINCIPAL INVESTIGATOR: Fahim Sadek, Kenneth Snyder, and H.S. Lew

NRC CONTRACTING OFFICER'S REPRESENTATIVE: NAME: Jacob Philip
PHONE: 301-251-7471

BACKGROUND

Regulatory Context:

In August 2010, concrete cracking, typical of alkali-silica reaction (ASR) degradation of concrete was identified in some locations of the Seabrook Station Control Building – B Electrical Tunnel in portions of the building below grade and below the ground water table. The tunnel had also been experiencing infiltrating ground water. Petrographic examination of concrete cores extracted from the tunnel confirmed the presence of ASR. Compressive strength testing of the concrete cores indicated a 47 percent reduction in average concrete modulus of elasticity and a 22 percent reduction in compressive strength compared to test cylinders cast during construction. During construction of the Seabrook Station, the Seabrook Station licensee asserts that for concrete structures, low alkali Portland cement was used and that aggregates routinely passed ASTM reactivity and expansion tests, ASTM C227 and ASTM C289, the standards in place at that time. However, ASR induced degradation is still occurring. The Seabrook Station licensee has confirmed ASR degradation in four additional below-grade safety-related structures. The Seabrook Station licensee plans to submit a comprehensive plan for condition assessment, additional tests, long-term monitoring and condition management, and structural appraisal under design loads of the ASR-affected structures and the development of an adequate aging management program. This is the first nuclear power plant (NPP) in the United States to confirm the presence of concrete degradation by ASR; however, it has been detected in nuclear power plants in other countries, and it is possible that other U.S NPPs may experience this degradation mechanism.

TECHNICAL CONTEXT

The **alkali–silica reaction** (**ASR**) in concrete can occur over time between the highly alkaline cement paste and reactive non-crystalline (amorphous) silica, which is found in many common aggregates. *This reaction causes the expansion of the altered aggregate by the formation of a* swelling gel of Calcium Silicate Hydrate (CSH). This gel increases in volume with water and exerts an expansive pressure inside the material, which may cause spalling and loss of strength of the concrete. The time dependent structural capacity of the ASR affected concrete structure needs to be assessed for making licensing decisions for the 20 year license renewal of NPP's.

OBJECTIVE

The objective of this research study is to develop a technical basis and regulatory guidance for NRC staff to evaluate ASR-affected concrete structures. The research will assess the structural performance of ASR-affected concrete structures for design basis static and dynamic loading and load combinations through its service life, including the period of extended operation for the 20 year license renewal period.

Overall the research outcome is a methodology to determine, for an existing ASR-affected structure;

1. Current structural capacity to resist static and dynamic loads, and
2. An estimate of future structural capacity to resist static and dynamic loads.

In brief, a testing procedure will be developed that will yield data on material and mechanical properties of concrete for performing a structural evaluation of ASR-affected structures. A methodology will also be developed for estimating the extent of the reaction over time, whereby a relationship can be established between the extent of the expansion due to ASR and the changes in mechanical properties of the concrete structures.

TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED

This project should be conducted by experts in the field of structural engineering and concrete materials degradation behavior. The proposed servicing agency NIST is nationally and internationally recognized as being the most qualified and experienced in the performance of concrete materials and the structural design of concrete structures.

SCOPE OF WORK

The scope of the proposed research shall include, but not be limited to:

1. Identifying and evaluating method for managing the effects of ASR to maintain intended functionality
2. Identifying criteria to assess the state of the ASR with respect to structural performance
3. Identifying and evaluating methods for determining the state and severity of the ASR degradation, and for predicting the rate at which the reaction is progressing
4. Identifying the effects of ASR on the capacity of anchorages
5. Identifying and evaluating methods for determining the impact of ASR on the mechanical properties of reinforced concrete as they relate to the static and dynamic performance of structure
6. Identifying parameters to be measured and the criteria to be used to determine when the ACI 349 code provisions and other related standards and codes may not be valid
7. Formulating numerical models for the formation of ASR and for evaluation of the performance of ASR-affected concrete
8. Quantifying the change in transport processes through ASR-affected concrete and identifying how it may affect other degradation mechanisms such as corrosion of the steel reinforcement

9. Identifying standard test methods for new construction that may improve the effectiveness of reducing the likelihood of ASR.

The specific tasks for this research are to address the time dependent structural performance of ASR affected structures subject to static and dynamic loads for periods through the license renewal period of 20 years. The goal of the research is to help NRC staff gain a better understanding of and formulate an agency position on the effects of ASR on NPP concrete structures. This will help NRC staff with updating the GALL (Generic Aging Lessons Learned) Report used in license renewal applications.

Task 1: Assessing In-Situ Mechanical Properties of ASR-Affected Concrete

Duration of Task/Dollar Cost: Three years, FY14, FY15, FY16 $1,564,000

Objective:

To establish the relationship between expansion due to ASR and (1) concrete mechanical properties and (2) surface cracking of concrete, and to evaluate the effectiveness of stirrups (i.e., hoop reinforcement) in confining expansion of concrete due to ASR.

Approach:

NIST will perform the following three separate subtasks to achieve the objectives of this task. All three subtasks will utilize three large concrete block specimens (approximately 4 ft wide x 6 ft high x 10 ft long) made with three different reactive aggregates. The details of the concrete mix design and ASR acceleration procedures will be developed in collaboration with NRC. These blocks will have tri-axial strain gauges embedded at selected locations to measure internal expansion of concrete due to ASR and overall expansion of the blocks using an optical instrument system. In addition, a control block specimen (approximately 4 ft wide x 6 ft high x 6 ft long) will also be cast using non-reactive material for comparison purposes. Cores will be removed from the block specimens, and compressive and tensile tests under confinement pressure will be performed to determine the mechanical properties of the concrete as the ASR reaction progresses. Advanced computational modeling of the concrete blocks will be conducted to correlate the state of strain at the center of the block with surface cracking at various levels of reaction/expansion. The modeling results will be validated using measurements and observations from the test blocks. The testing and analysis of Task 1 will provide protocols for (1) estimating the extent of ASR, (2) estimating the resulting volume expansion and corresponding internal pressure development, (3) performing expansion analysis of the concrete specimen, and (4) estimating the mechanical properties of ASR-affected concrete structural members.

Task 1a: Measurement of in-situ mechanical properties

- Cast large-scale non-ASR reactive (one) and ASR-reactive (three) reinforced concrete blocks. These blocks will be instrumented as outlined above, and will be confined by reinforcing bars (hoops) to evaluate the effect of the confinement on ASR expansion.

The specimens will be cast and kept in an environmental chamber (approximately 32 ft wide x 48 ft long x 36 ft high) to maintain proper temperature and humidity.

- Periodically over the period of three years, remove cores from the block specimens and perform compressive and tensile tests under tri-axial condition consistent with the restraint indicated by the imbedded strain gages. The restraint condition will be achieved by testing the core specimen in a pressure-controlled test chamber. This will help determine the tensile and compressive strength of concrete at various levels of expansion.
- Cores will be taken in two orthogonal directions relative to the direction of concrete placement to evaluate the core orientation with respect to the axis of loading in determining the mechanical properties.
- The modulus of elasticity will be determined from both compression and tension tests.

Task 1b: Effect of confinement by stirrups

- The three large block specimens will be fabricated with hoop stirrups placed at different spacing.
- Selected hoop stirrups will be instrumented with strain gages to measure the forces induced by ASR expansion on the stirrups. Change in surface dimensions will be measured periodically along the length of the specimen using an optical measurement instrument. The effect of the confinement due to ASR expansion will be evaluated and compared with numerical model predictions.

Task 1c: Effect of ASR on surface expansion and cracking

- Surface crack formation due to ASR will be measured by means of an optical measurement system. The measurements of surface cracking will be related to internal expansion due to ASR.
- Perform and validate a computational expansion analysis of the reinforced concrete block specimen. The model will correlate the state of strain at the center of the block with surface cracking.

Deliverable

A methodology will be developed for determining the effect of ASR degradation effect on the mechanical properties of in-situ concrete in structural members and the effects of hoop reinforcement in confining expansion of concrete due to ASR.

Task 2: Assessing Bond and Anchorage of Reinforcing Bars in ASR-Affected Concrete

Duration of Task/Dollar Cost: Two Years FY15, FY16 $659,000

Objective:

To develop a methodology for assessing the effects of ASR on bond strength between concrete and steel reinforcement including (1) lap splices in flexural members, and (2) axially loaded reinforcing bars. The methodology will address the degree of loss of anchorage and flexural capacities.

Approach:

NIST will perform the following two sets of tests to assess the deterioration of bond strength in ASR affected concrete structures. Degradation of bond strength will affect the required length of lap splices of tension reinforcement in beams and the required length of embedment of axially loaded reinforcing bars in concrete.

Task 2a: Effect of ASR on lap splices of flexural reinforcement

- Cast 16 rectangular (approximately 14 in wide x 24 in high x 10 ft long) ASR-reactive reinforced concrete beam specimens using one of the three mix designs used for the large block specimens in Task 1. Two additional beam specimens will be cast using non-reactive material as control specimens. All beam specimens will be designed in accordance with the 2011 ACI 318 Building Code. Two different sizes of reinforcing bars will be used. Lap splices will be placed in the constant moment region of four-point loading test setup with and without transverse reinforcement. Spliced reinforcing bars will be instrumented with strain gauges to detect the loss of bond strength. The beams will be cast and kept in the environmental chamber to maintain proper temperature and humidity.
- Perform static four-point loading tests periodically over a period of two years. Results of the tests including load, strain, and deflection measurements will help determine the degradation in bond strength as the ASR reaction takes place.

Task 2b: Effect of ASR on embedment length of reinforcement

- Cast 16 rectangular (approximately 18 in wide x 18 in wide x 30 in high) ASR-reactive block specimens using one of the three mix design used for the large block specimens. A single reinforcing bar will be embedded in the block. Two different sizes of reinforcing bars will be used. Two additional specimens will be cast using non-reactive material as control specimens. The embedment length will be determined by the 2011 ACI 318 Building Code. The specimens will be cast and kept in the environmental chamber to maintain proper temperature and humidity.
- Perform simple pullout tests periodically over a period of two years. The results of the test will include loss of pullout strength as the specimens experience expansion due to ASR effects.

Deliverable:

A procedure will be developed that can be used to assess the loss of bond strength due to ASR.

Task 3: Seismic Response Characteristics of ASR-Affected Concrete Structural Members

Duration of Task/Dollar Cost: Two Years FY16, FY17 $639,000

Objective:

To develop a methodology for assessing the degradation of seismic resistance of structural members and systems due to ASR.

Approach:

To avoid sustaining serious damage due to seismic excitation, structures are designed such that the lateral displacement of vertical members (such as columns and walls) and the end rotation of horizontal members (such as beams and girders) should not exceed the specified allowable values. If the stiffness and energy-absorbing capacity are reduced due to ASR, the response of structural members to earthquake excitation may exceed the design limits, thereby making the structure susceptible to serious damage or collapse during the design level earthquake. At the present time, seismic analysis procedures for nuclear power plant structures subjected to ASR degradation are not available in the open literature. NIST will carry out cyclic loading tests of ¾-scale normal (one) and ASR-affected (three) concrete shear walls to assess the effects of ASR on strength and stiffness. Such tests will yield information on the effects of ASR degradation on the energy absorption properties of concrete shear walls. The cyclic loading protocol for these tests and the reinforcing ratio and details for shear walls will be developed in collaboration with NRC to ensure applicability to NPPs. The following subtasks will be performed:

Task 3a: Effect of ASR on embedment length of reinforcement

- Design and cast four rectangular ¾ scale shear wall specimens; one with non-reactive material as control specimen and three with ASR-reactive material using one of the three mix designs used for the large block specimens in Task 1. The shear walls will be cast and kept in the environmental chamber to maintain proper temperature and humidity.
- Periodically perform loading tests of the specimens which will include vertical (gravity) loads along with cyclic displacement of the shear wall specimens over a period of two years. Results of the tests will include mainly the hysteresis loops of the walls in addition to strains on reinforcing bars and concrete, along with damage patterns. Results will help to determine the effects of ASR on the energy dissipation capacity of shear walls.

Deliverable:

A methodology for assessing the loss of stiffness and of energy absorption capacity of structural members and assemblies will be developed.

Task 4: Estimating the Degree of Reaction in ASR Affected Concrete and the Corresponding Expansion

Duration of Task/Dollar Cost: Three Years FY14, FY15, FY16 $1,130,000

Objective:

To develop methodology for estimating the degree of internal expansion due to ASR.

Approach:

Task 4 will be completed in three phases. In the first phase, the most promising quantitative method will be used to identify and quantify the reactive phases and the amount of reaction product. No standardized test method exists, so a new test method has to be developed. Initially, the method will be used to quantify easily identifiable reactive phases. In the second phase, the method will be validated on mortar samples made with natural fine aggregates that are more difficult to quantify. In the third phase, the procedure will be expanded to account for the sampling challenge of quantifying the amount of reaction product in concrete.

The degree of the reaction will be determined by comparing the volume of reactive phases to the volume of reaction product. By analyzing samples throughout the degradation process, one can estimate a "conversion factor" between volume of reaction product and equivalent volume of initial reactive phases. Companion expansion samples will be used to validate the assertion that the degree of reaction is a useful estimator for the "degree of expansion".

The most promising phase identification and quantification method are based on hyper-spectral analysis of scanning electron microscope (SEM) images. The SEM can be used to identify textural features in backscattered electron imaging (BEI) mode, and can be coupled with an X-ray detector to perform a microprobe analysis of the chemical composition at each pixel of the image. The microscopist analyzes the image and chemical data to identify training sets of pixels that represent the best examples of a particular phase. In hyper-spectral analysis, the entire X-ray energy spectrum at each pixel is used to classify all the pixels in the image. NIST has scientist at the forefront of the use of these techniques applied to cementitious materials.

Although these techniques are powerful and show great promise, the expectations for the precision of the method must be tempered by the challenges involved. There is no guarantee that method will work for all reactive phase types. Moreover, the sampling challenge involved with quantifying the volume fraction of reaction product in concrete will be substantial. The goal of the Task is to have a method that can reliable estimate the degree of reaction to the nearest quartile.

Task 4a: Identification and Characterization of Expansive Materials and Mixtures

- Identify and collect samples of highly reactive aggregate materials
    - Use industrial glasses for high reactivity
    - Use natural aggregates with easily-identifiable reactive phases
- Develop trial mixtures
    - Cast mortar bars, mortar cubes, and concrete prisms
    - Subject to high humidity and high temperature
    - Measure expansion over time
- Develop a concrete mixture
    - Compare the expansion of the test mixtures
    - Identify suitable mixtures for reinforced concrete testing
- Analyze aggregates to quantify reactive phase(s) fraction
- Develop test method to quantify phase(s) in hydrating mortars
    - Cast reactive mortar bars: expose to elevated temperature and pH
    - Measure expansion over time
    - Quantify reactive phases and reaction products
        - SEM Microscopy: hyperspectral analysis

Task 4b: Procedure Refinement on Mortars

- Use the Task 4a mortar bars with natural aggregate
- Cast reactive concrete prisms (in preparation for Task 4c)
- Cast reactive mortar bars
    - Measure expansion over time
    - Quantify reactive phases and reaction products
        - SEM Microscopy: hyperspectral analysis
- Validate the procedure for estimating the degree of the reaction for natural aggregates
- Validate the monotonic relationship between reaction and expansion

Task 4c: Procedure Refinement on Concretes

- Analyze prisms from Task 4b and from the Task 1 concrete prisms
- Quantify the reactive phases using hyper-spectral analysis
- Identify a sampling procedure for quantifying reaction products
- Validate procedure for estimating the degree of reaction

Deliverable:

A method outlining how to estimate the degree of the reaction in ASR affected concrete will be published.

Task 5: Predicting Future and Ultimate ASR Expansion in ASR-Affected Concrete

Duration of Task/Cost: Three Years FY15, FY16, FY17 **$1,127,000**

Objective:

To develop test methods for determining the ultimate degree of reaction for use on existing concrete structures.

Approach:

Although the relationship between degree of reaction and expansion should be monotonic, the specific relationship will probably be unique for each concrete mixture. Therefore, an estimate for the degree of reaction by itself cannot be used to estimate the ultimate extent of expansion. On could, however, estimate the ultimate extent of reaction experimentally. Moreover, knowledge of how fast the reaction will occur could be estimated from a few critical parameters. Therefore, with knowledge of the ultimate degree of reaction and an estimate for how fast the reaction will progress could get an estimate for how long before a critical degree of expansion is reached.

The Task is developed in three phases. In the first phase, a first-order model is developed for the primary factors influencing the rate of the reaction, including the degree of reaction. In the second phase, a test is developed for estimating the ultimate degree of reaction. The outcomes of the first and second phase will be developed using mortar bars. In the third phase, the first-order model and the test for the ultimate expansion will be validated using concrete specimens.

A simplified, first-order model approach is used to predict the magnitude of future expansion in ASR affected concrete. For each identify parameter (temperature, alkalinity, reactive phase volume fraction, etc.), identify a simple expression (power law, exponential, etc.) with a minimum of parameters, with the overall model being the product of each expression. The resulting model will not be precise, but it should be able to help guide engineering judgment as to whether a critical loss in capacity is imminent or well into the future. As such, it could help to inform decisions whether to modify future inspection schedules.

Moreover, expansion data from standardized tests indicates that the expansion curve for a specimen has the appearance of a sigmoidal curve. Given that the primary factors (temperature, alkalinity, volume fraction of reactive phase, etc.) are constant, the rate of the expansion is also a function of the degree of the reaction. Therefore, the success of this Task depends upon the success of Task 4 in developing a method to determine the ASR degree of reaction.

The test method for the ultimate degree of reaction will be developed for use on existing concrete structures.

Task 5a: Primary Factors: Temperature, Alkalinity, Volume Fraction

- Identify a very reactive aggregates: industrial glasses and natural
- Cast reactive mortar bars:

  - Use different reactive phase volume fractions
  - Use different total alkalinity in the mixture
  - Expose to different temperatures
- Measure expansion and degree of reaction
- Identify first-order relationships for each of the experimental factors:
  - temperature, alkalinity, and reactive phase volume fraction
- Identify a model for incorporating the degree of reaction
- Estimate model parameters for each relationship

Task 5b: Ultimate Expansion:
- Cast reactive mortar prisms
- Measure expansion over time
- Cut thin slabs
  - Expose to elevated temperature and alkalinity
  - Measure subsequent expansion
- Related prism ultimate expansion to thin slab ultimate expansion

Task 5c: (simultaneous with Task 4c) Validation in Concrete:
- Cast reactive concrete prisms
  - Vary the temperature, alkalinity, and reactive phase volume fraction
- Measure expansion over time
  - Expose to different temperatures
- Cut thin slabs and estimate ultimate expansion
- Validate the first order model for reaction rate and the method for estimating the ultimate expansion

Deliverable:

A method outlining how to estimate the future rate of the ASR reaction and the ultimate expansion will be published.

Task 6: ASR Effects on Transport of Ions through Concrete and its Potential for Causing Other Degradation Mechanisms in Concrete

Duration of Task/Dollar Cost: Two Years FY16, FY17 **$552,000**

Objective:

To develop a methodology for assessing the expected service life of ASR affected concrete.

Approach:

ASR will affect the remaining service life of concrete. The primary cause of this effect is the cracking that results from the expansion. The cracks act as "superhighways" for transporting water liquid/vapor (which can accelerate the ASR) and dissolved ionic species that can initiate other degradation reactions like corrosion of the steel reinforcement. Conversely, if the concrete is restrained (by steel reinforcement) and there is an absence of cracking, one would not expect any significant change in the transport or the service life. Therefore, quantifying the effects of ASR on the remaining service life of the concrete requires a means of quantifying the effects of the cracks on transport. Moreover, a relative change in the transport coefficient translates into a corresponding relative change in the remaining service life; doubling the transport coefficient will roughly halve the remaining service life.

Fortunately, the transport coefficient is roughly proportional to the concrete conductivity. Specifically, the formation factor (an important service life transport parameter) can be approximated by the ratio of the pore solution conductivity to the bulk conductivity. Therefore, a relative change in the measured bulk conductivity would suggest a correspondingly proportional change in the transport coefficient. Moreover, there appears to be a strong relationship between steel reinforcement corrosion rate and concrete resistivity [Hornbostel et al., *Cement and Concrete Composites*, Vol. 39, 60-72 (2013)]. Although the relationship is not universal, it could be incorporated into a monitoring program that uses concrete resistivity measurements.

Fortunately, monitoring and measuring the bulk conductivity of concrete is relatively straightforward. A pair of metallic electrodes can be embedded into the concrete and an impedance analyzer can be used to determine the bulk resistance between the two electrodes. Although the conversion between resistance and resistivity requires a geometrical conversion factor, because only relative changes in resistivity are needed, relative changes in the measured resistance will translate to directly to relative changes in the resistivity.

An important technical challenge is determining the location of the electrodes. The electrodes could be placed on opposite sides of a concrete element, with the intent of obtaining the overall resistivity. In practice, however, this approach is not optimal. Affected concrete often lacks access to the external (exposed) surface. Moreover, it is the conductivity of the concrete that lies between the steel reinforcement and the exposed surface that is the most relevant to changes in the service life. Therefore, a reliable method will require a means of making electrical contact with the embedded steel reinforcement.

Task 6a: Identifying Strategies for Critical Concrete Resistivity

- Cast reactive mortar bars and (reinforced) prisms
- Expose to a moist environment
- Monitor the resistivity, chloride ingress, and the corrosion rate of the specimens
- Develop a field procedure for concrete resistivity
- Relate changes in resistivity to the service life parameters:
    - The time to the onset of a corrosion current
    - The subsequent corrosion current

Task 6b: Field Testing and Validated Transport Through Cracks

- Cast reactive reinforced concrete blocks
- Expose to moisture and chloride solution
- Map the chloride ingress
- Compare the results to the predicted results

DELIVERABLES/SCHEDULES AND/OR MILESTONES

Task #	Every 6 months after start of project	Every 6 months after start of project	End of Task	NUREG/CR Draft report
1	Technical Letter Report detailing progress/findings on each Task to date.	NIST Presentation to NRC staff on the 6 monthly Technical Letter Report.	Technical Letter Report	Draft NUREG/CR report (in proper format) on the entire project spanning all the tasks provided to the NRC 2 months before end date of project
2			Technical Letter Report	
3			Technical Letter Report	
4			Technical Letter Report	
5			Technical Letter Report	
6			Technical Letter Report	

Tentative Allocation of Resources, Phase 1

Phase 1: Planned Duration approximately 18 months from date of acceptance

Apportionment of Initial $650K for a Proposed NRC Project
"Structural Performance of Nuclear Power Plant Concrete Structures
Affected by Alkali-Silica Reaction"

Task 1a: Assessing In-Situ Mechanical Properties of ASR-Affected Concrete (425K)

(1) Labor (direct + overhead): $160K

(2) Materials (including overhead): $260K
Testing equipment and data acquisition systems ($180K)

Expendable gages, sensors, and test specimens ($80K)

(3) Travel (including overhead): $5K

Deliverable (Task 1a – Phase 1):

NIST will prepare a report for NRC which includes: (1) detailed design of four test specimens including (a) longitudinal reinforcement, and (b) transverse reinforcement to evaluate confinement effect; (2) instrumentation plan including (a) strain measurement of reinforcing bars, (b) tri-directional internal concrete stain measurement, (c) strain measurement of surface concrete, (d) internal concrete temperature measurement, and (e) internal concrete moisture content measurement (f) crack measurement of surface concrete; (3) specimen construction and curing; (4) procedure for taking core samples and storing under controlled environment; and (5) procedure for testing concrete cores for compressive and tensile strengths. The report will also include the concrete mix design for each of the four specimens based on the results of Task 4a – Phase 1.

Task 4a: Estimating the Degree of Reaction in ASR-Affected Concrete and the Corresponding Expansion (225K)

(1) Labor (direct + overhead): $88K

(2) Other Direct (12-month contract including overhead): $125K

(3) Materials (including overhead): $7K

(4) Travel (including overhead): $5K

Deliverable (Task 4a – Phase 1):

NIST will prepare a report for NRC that summarizes the data and information that was used to develop the mixtures for the reinforced concrete experiments:
(a) the properties of the expansive materials that have been identified; (b) the expansion and strength data from the trial mixtures; (c) the identification of suitable concrete mixtures; and (d) a set of three concrete mixtures having *low*, *medium*, and *high* degrees of expansion.

Every six months, NIST will submit a report summarizing work progress and accomplishments.
(A) This is the value NRC will receive from Phase 1 (defined by the specific work to be undertaken and the specific deliverables to be provided in exchange for this increment of funds).
(B) NRC will derive value from the completion of Phase 1 irrespective of any other work on this project ever being done in the future.

REPORTING REQUIREMENTS

In addition to the reports described under, "Deliverables/Schedules and/or Milestones', NIST shall comply with the following reporting requirements.

Monthly Letter Status Report

A Monthly Letter Status Report (MLSR) is to be submitted to the NRC Project Manager by the 20th of the month following the month to be reported with copies provided to the following:

Richard Correia	Division Director	Mail Stop: CSB 4A-07M	Richard.Correia@nrc.gov
Chon Davis	Management Analyst	Mail Stop: CSB 4A-07	Chon.Davis@nrc.gov
William R. Ott	Branch Chief	Mail Stop: C-2 C-07	William.Ott@nrc.gov
Jacob Philip	Civil/Geotechnical Engr.	Mail Stop: C-2 C-07	Jacob.Philip@nrc.gov
Acquisition Management Division			ContractsPOT.Resource@nrc.gov

The MLSR will identify the title of the project, the Agreement Number, the Principal Investigator, the period of performance, the reporting period, summarize each month's technical progress, list monthly spending, total spending to date, and the remaining funds and will contain information as directed in NRC Management Directive 11.8, Exhibit 5 (dated March 2, 2007). Any administrative or technical difficulties which may affect the schedule or costs of the project shall be immediately brought to the attention of the NRC COR.

MEETINGS AND TRAVEL

NIST shall budget for a total of 20 individual travel trips, over the course of the Agreement within the US (and a few abroad).

NRC-FURNISHED MATERIAL

N/A

CONTRACTING OFFICER'S REPRESENTATIVE (COR)

Technical direction will be provided by the COR, Jacob Philip, who can be reached at:

Mail Stop: (C-2 C-07)
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555-0001
Phone: (301) 251-7471

Fax: (301) 251-7410
Email: (Jacob.philip@nrc.gov)

Technical direction includes interpreting technical specifications, providing needed details, and suggesting possible lines of inquiry. Technical direction must not constitute new work or affect overall project cost or period of performance.

CONTACTS

For NIST: Administrative Point of Contact:	For U.S. NRC: Administrative Point of Contact:
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NRC-HQ-60-14-I-0004 Attachment No. 2

NRC/NIST STANDARD TERMS AND CONDITIONS

RESEARCH QUALITY

The quality of NRC research programs are assessed each year by the Advisory Committee on Reactor Safeguards. Within the context of their reviews of RES programs, the definition of quality research is based upon several major characteristics:

Results meet the objectives (75% of overall score)
- Justification of major assumptions (12%)
- Soundness of technical approach and results (52%)
- Uncertainties and sensitivities addressed (11%)

Documentation of research results and methods is adequate (25% of overall score)
- Clarity of presentation (16%)
- Identification of major assumptions (9%)

It is the responsibility of NIST to ensure that these quality criteria are adequately addressed throughout the course of the research that is performed. The NRC Contracting Officer's Representative (COR) will review all research products with these criteria in mind.

NEW STANDARDS FOR CONTRACTORS WHO PREPARE NUREG-SERIES MANUSCRIPTS

The U.S. Nuclear Regulatory Commission (NRC) began to capture most of its official records electronically on January 1, 2000. The NRC will capture each final NUREG-series publication in its native application. Therefore, please submit your final manuscript that has been approved by your NRC COR in both electronic and camera-ready copy.

The final manuscript shall be of archival quality and comply with the requirements of NRC Management Directive 3.7 "NUREG-Series Publications." The document shall be technically edited consistent with NUREG–1379, Rev. 2 (May 2009) "NRC Editorial Style Guide." The goals of the "NRC Editorial Style Guide" are readability and consistency for all agency documents.

All format guidance, as specified in NUREG-0650, Revision 2, will remain the same with one exception. You will no longer be required to include the NUREG-series designator on the bottom of each page of the manuscript. The NRC will assign this designator when we send the camera-ready copy to the printer and will place the designator on the cover, title page, and spine. The designator for each report will no longer be assigned when the decision to prepare a publication is made. The NRC's Publishing Services Branch will inform the NRC COR for the publication of the assigned designator when the final manuscript is sent to the printer.

For the electronic manuscript, the Contractor shall prepare the text in Microsoft Word, and use any of the following file types for charts, spreadsheets, and the like.

File Types to be Used for NUREG-Series Publications	
File Type	File Extension
Microsoft®Word®	.doc
Microsoft® PowerPoint®	.ppt
Microsoft®Excel	.xls
Microsoft®Access	.mdb
Portable Document Format	.pdf

This list is subject to change if new software packages come into common use at NRC or by our licensees or other stakeholders that participate in the electronic submission process. If a portion of your manuscript is from another source and you cannot obtain an acceptable electronic file type for this portion (e.g., an appendix from an old publication), the NRC can, if necessary, create a tagged image file format (file extension.tif) for that portion of your report. Note that you should continue to submit original photographs, which will be scanned, since digitized photographs do not print well.

If you choose to publish a compact disk (CD) of your publication, place on the CD copies of the manuscript in both (1) a portable document format (PDF); (2) a Microsoft Word file format, and (3) an Adobe Acrobat Reader, or, alternatively, print instructions for obtaining a free copy of Adobe Acrobat Reader on the back cover insert of the jewel box.

DISSEMINATION OF PROJECT INFORMATION/PUBLICATION REQUIREMENTS

Prior to any dissemination, display, publication, presentation, or release of papers, articles, reports, summaries, or abstracts developed under the NRC/NIST Agreement, NIST/NIST Laboratory shall submit them to the NRC for review and comment. NRC shall have a review and comment period of at least [60] days, after which both an NRC and NIST/NIST Laboratory representative at the lowest management level, shall attempt to resolve any differing viewpoints or statements which are the subject of NRC objection. If the matter cannot be resolved at that level, the issue shall be brought up to the next management level in both organizations until an agreement can be reached or it reaches the Office Director level. In the event resolution cannot be achieved, the NIST/NIST Laboratory will not publish the work as a NUREG/CR, but publish as a NIST/ NIST Laboratory report without reference to NRC, the NRC office name or COR's name on the report.

ACQUIRED MATERIAL, EQUIPMENT, OR SOFTWARE (PROPERTY)

In accordance with Management Directive 11.8, Part V, Section F, the Servicing Agency's proposal must include a description of the property required for project performance that has an estimated acquisition cost of $500 or more. The proposal must also identify the potential development of NRC-funded software with a useful life of 2 years or more and a development cost of $500 or more during the project. NRC-funded software is software specifically developed for NRC by the laboratory and is generally the deliverable for the project.

After the NRC reviews the list of property and NRC-funded software included in the Servicing Agency's proposal, any questions regarding the acquisition of property or the development of NRC funded software will be addressed with the laboratory during negotiations. After negotiating project terms and conditions, NRC shall issue an "Interagency Agreement," authorizing the work and approving acquisition of property or development of NRC-funded software.

The Servicing Agency shall submit a written request to the NRC COR for approval to develop additional NRC-funded software or purchase additional property with an estimated acquisition cost of $500 or more after work initiation. The NRC COR shall approve or disapprove the acquisition or development of any additional items in writing.

The Servicing Agency shall report property, including software, with an acquisition cost of $500 or more in the monthly letter status report in the month the property or software was acquired. The Servicing Agency shall provide a copy of all monthly letter status reports to the regular distribution. The Servicing Agency shall provide the information listed in Management Directive 11.8, Part V, Section C, for each item reported as appropriate, in the monthly letter status report.

ORGANIZATIONAL CONFLICT OF INTEREST REPRESENTATION AND DISCLOSURE

NIST recognizes that Section 170A of the Atomic Energy Act of 1954, as amended, requires that NRC be provided with disclosures on potential conflicts when NRC obtains technical, consulting, research and other support services. NIST further recognizes that the assignment of NRC work to another Agency must satisfy NRC's conflicts standards. In accordance with 42 U.S.C.§ 2210a, NIST has disclosed present and currently planned agreements and arrangements with others (meaning, persons and Government agencies as defined in 42 U.S.C. § 2014 including NRC licensees, vendors, industry groups or research institutes that represent or are substantially comprised of nuclear utilities) and represents that NIST is presently not involved in situations or relationships with others in the same/similar technical area as the NRC project scope of work identified in this interagency agreement that would either (a) preclude NIST from being able to provide impartial, technically sound, or objective advice or assistance in light of other activities or relationships with others, or (2) give NIST an unfair competitive advantage with respect to present and currently planned agreements and arrangements with others.

NIST further recognizes that the performance of NRC work by NIST must satisfy NRC's conflicts standards and that the obligation to conform to the NRC's conflicts standards continues throughout the duration of this interagency agreement. Accordingly, during the life of this agreement, NIST shall review and promptly disclose its current work and planned work for others (meaning, persons and Government agencies as defined in 42 U.S.C. § 2014 including NRC licensees, vendors, industry groups or research institutes that represent or are substantially comprised of nuclear utilities) in the same/similar technical area as the NRC project scope of work identified in this interagency agreement.

NIST agrees to include provisions effecting the disclosure of any such potential conflicts of interest to NIST in any contracts or other agreements into which NIST enters for assistance in providing the service to NRC. NIST will disclose to NRC any potential conflicts of which it is made aware under the terms of those contracts or other agreements.

Disclosures for current or planned work for NIST or others in the same or similar technical area as the proposed work, are to include the following information: (1) the name of organization; (2) dollar value; (3) period of performance of the work identified; and (4) statements of work for the projects. Within 30 days of NIST disclosure, NRC shall then determine whether a conflict would result and, if one does, determine, after consultation with NIST, the appropriate action NRC or NIST should take to avoid the conflict, or when appropriate under the NRC procedures, waive the conflict. If NIST determines there is no applicable work in the same or similar technical area, it should be stated in its proposal.

TERMINATING THE AGREEMENT

Any party may terminate this agreement by providing 30 days written notice to the other party. If NRC terminates the agreement, NIST is authorized to collect costs incurred prior to cancellation of the order plus any termination costs, up to the total value of the agreement.

COST RECOVERY

NIST will be reimbursed for all cost incurred.

ACCOUNTING INFORMATION

	NIST	***NRC***
Agency Location Code (ALC)	13 06 0001	3100001
Funding Expiration Date (requesting agency)		No –Year Funds
Business Event Type Code (BETC)	COLL	DISB
Business Partner Network Number (BPN)	929956050	040535809
Additional Accounting Classification /Information (Optional)	Funding Agency Code: 1341	Funding Agency Code: 3100

Treasury Account Symbol (TAS) in Central Accounting System (CARS) format:

Component TAS	**SP**	**ATA**	**AID**	**BPOA**	**EPOA**	**A**	**Main**	**Sub**
NIST			013			X	4650	000

NRC			031			X	0200	000

AUTHORITIES

The NRC is acting pursuant to authority conferred in the Energy Reorganization Act of 1974, 42, U.S.C. 5801 et seq. (42 U.S.C. Section 5845 (b), (c), and (e)). Section 205(c) of the Energy Reorganization Act of 1974 (42 U.S.C. 5845(c)(2)) authorizes the NRC to request form other Federal agencies that they furnish, on a reimbursable basis, such research services as the NRC deems necessary for the conduct of its functions.

NIST's programmatic authority for undertaking this work is (Need to cite correct NIST programmatic authority depending on the type of work) 15 U.S.C.272(b)(10), (b)(11), and 272(c)(15).

DISPUTES RESOLUTION

Should disagreements arise on the interpretation of the provisions of this agreement or amendments and/or revisions thereto, that cannot be resolved at the operating level, the areas(s) of disagreement shall be stated in writing by each party and presented to the other party for consideration. If agreement or interpretation is not reached within 30 days, the parties shall forward the written presentation of the disagreement to respective higher officials for appropriate resolution. If a dispute related to funding remains unresolved for more than 30 calendar days after the parties have engaged in an escalation of the dispute, the dispute shall be resolved in accordance with instructions provided in the Treasury Financial Manual (TFM) Volume 1, Part 2, Chapter 4700, Appendix 10, available at http://www.fms.treas.gov/tfm/index.html.

NIST CONTRACTS, GRANTS, AND FELLOWSHIPS

(a.) Will contractors be used to carry out any of the work under this agreement? _x_ ***yes*** ___ ***no.***

NIST contractors and their employees may perform incidental work under this agreement. Intellectual property developed by such contractors/employees is governed by the FAR clauses contained in the NIST contract, which include the right of the contractor to elect to retain ownership of inventions under the Bayh-Dole Act (35 U.S.C. § 200 *et seq.*), and possible contractor ownership of data rights. NIST expects that approximately $***125,000*** will be transferred to contractors to perform incidental work under this agreement, and the parties agree that should this estimate change, the estimate will be revised through an exchange of emails which will be retained in the official agreement file.

(b.) Will students or U.S. citizens working under a NIST financial assistance award made under the authority of 15 U.S.C. § 278g-1 be used to carry out work under the agreement?
___ ***yes*** _x_ ***no.***

If **no**, the following term is incorporated into this agreement:

No students or U.S. citizens working under a NIST financial assistance award made under the authority of 15 U.S.C. § 278g-1 will perform work under this agreement.

(c) Will employees or agents of recipients working under a NIST financial assistance award issued pursuant to this agreement be used to carry out work under the agreement? __ *yes* _x_ ***no***.
If **no**, the following term is incorporated into this agreement:

No employees or agents of recipients working under a NIST financial assistance award will perform work under this agreement.