SeabrookLANPEm Resource

From: Debbie - Gmail <grinnelldebbie2@gmail.com>
Sent: Tuesday, November 01, 2016 1:01 PM
To: Poole, Justin
Subject: [External_Sender] FW: C-10 and UCS cover letter with Paul Brown's comments on Seabrook ASR LAR
Attachments: Justin NRC wDW.docx; Justin NRC wDW2.docx

Hi Justin,

The final attachment (Justin NRC wDW2.docx) I am sending to you has a signature that is lined up better. It is a only final change.

Debbie

From: Debbie - Gmail [mailto:grinnelldebbie2@gmail.com]
Sent: Tuesday, November 01, 2016 10:24 AM
To: 'Poole, Justin'
Subject: C-10 and UCS cover letter with Paul Brown's comments on Seabrook ASR LAR

Hello Justin,

The C-10 Research and Education Foundation (C-10) and the Union of Concerned Scientists (UCS) have attached recently a cover letter with our concrete expert, Paul Brown Ph.D.’s commenst on Seabrook’s ASR license amendment request.

If you have any questions, please contact me.

Thank you,

Debbie

Debbie Grinnell
C-10 Foundation

Hearing Identifier: Seabrook_LA_NonPublic
Email Number: 324

Mail Envelope Properties (001201d23461$84d80f70$8e882e50$)

Subject: [External_Sender] FW: C-10 and UCS cover letter with Paul Brown's comments on Seabrook ASR LAR
Sent Date: 11/1/2016 1:00:54 PM
Received Date: 11/1/2016 1:01:16 PM
From: Debbie - Gmail

Created By: grinnelldebbie2@gmail.com

Recipients:
"Poole, Justin" <Justin.Poole@nrc.gov>
Tracking Status: None

Post Office: gmail.com

Files	**Size**	**Date & Time**
MESSAGE	732	11/1/2016 1:01:16 PM
Justin NRC wDW.docx	325108	
Justin NRC wDW2.docx	345172	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Union of Concerned Scientists

C-10 Research & Education Foundation — Safe Sustainable Energy

October 21, 2016

Justin C. Poole
Project Manager, Seabrook Station
Plant Licensing Branch 1-2
Division of Operating Regulation
Office of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Mr. Poole,

By letter dated August 1, 2016 (ADAMS Accession No. ML16216A250), NextEra Energy Seabrook LLC (NextEra) submitted a license amendment request seeking Nuclear Regulatory Commission (NRC) approval of proposed revisions to its current licensing basis to address concrete degradation due to alkali-silica reaction (ASR).

C-10 Research and Education Foundation Inc. (C-10) and the Union of Concerned Scientists (UCS) have been researching and monitoring the Seabrook nuclear plant's ASR concrete degradation issue since it was publicly reported by the NRC more than 5 years ago.

In 2011, Seabrook was the first nuclear plant in the United States to discover ASR degradation, including its presence in the reactor's seismic Category 1 structures. The NRC had no technical or regulatory basis to address, monitor, or regulate this unique form of concrete degradation. NextEra and the NRC have since acknowledged that in addition to ASR's potential effects on the capacity of concrete structures, the expansion effects from ASR have imposed additional consequences not accounted for in their original design.

In response to the public safety concerns about the discovery of ASR and the industry's lack of expertise on this issue, C-10 and UCS engaged Dr. Paul W. Brown, an ASR concrete expert, to advise our organizations on this critical subject. In addition to having worked for the National Institute of Standards and Technology (NIST) Dr. Brown was a contributor to *Codes and Standards for Nuclear Plant Concrete for Nuclear Power Plants* and is serving on the American Concrete Institute (ACI) ASR Task Group.

Since 2012, Dr. Brown's commentaries on a variety of NextEra's published documents outlining their assumptions, processes, research and findings on ASR at Seabrook have been submitted by UCS and C-10 to the NRC. In addition, the NRC Advisory Committee on Reactor Safeguard (ACRS) invited Dr. Brown to speak at the Structural Analysis/Plant License Renewal on September 19, 2014. Recently, we asked Dr. Brown to comment on NextEra's

public documents in support of its license amendment request (LAR). His "*Commentary on Seabrook Station License Amendment Request 16-03"* is reproduced below.

C-10 and UCS have reviewed Dr. Brown's analysis and urge the NRC to deny NextEra's license amendment request for Seabrook until it (1) carries out appropriate tests and uses them to justify the applicability of the results from the University of Texas project to Seabrook structures, (2) develops a specific system for monitoring Seabrook structures to assess the future progress of ASR, and (3) develops a specific plan for responding to the future progress of ASR in Seabrook structures.

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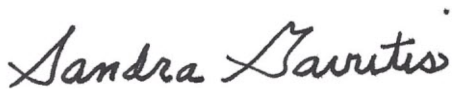

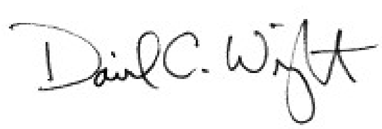

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Commentary on Seabrook Station
License Amendment Request 16-03

P.W. Brown, Ph.D.
Sept. 30, 2016

Statement of Purpose

The purpose of this paper is to comment on the public documents provided to the Nuclear Regulatory Commission by NextEra Energy in support of its license amendment request (LAR) for Seabrook Station.

The reviewed documents include: **"Seabrook Station License Amendment Request 16-03: Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction"** (August 1, 2016, 10 CFR 50.90, Docket No. 50-443, SBK-L-16071) and enclosures 2, 3, 4, 7, and 8 of that document. These documents are available online at the NRC website. Enclosures 1, 5, and 6 are marked "Proprietary" and are not publicly available (although Enclosure 7 is a non-proprietary version of Enclosure 1).

Summary

The public version of NextEra Energy's LAR 16-03 has been written in such general terms, as a practical matter only general comments can be advanced. Principal among this is that this document in no way makes a convincing argument that the data generated can actually be applied to the performance of the Seabrook structures. Rather, it reads like a tautology in which general statements are made without reference or technical support.

The primary rationale cited in the LAR for performing specific tests (or for not testing) is provided in part by a study of the performance of Texas bridges where two damage mechanisms are occurring. And the rationale for not testing also treats ASR-affected concrete structures as being comprised of materials exhibiting homogeneous properties regardless of their proximity to reinforcement. Neither is the case for Seabrook structures. Consequently, assessments/predictions of the responses of Seabrook structures to ASR, which are made in the absence of direct physical testing of concrete from those structures, are questionable.

Detailed comments

The paper is organized into comments on five general issues that are raised by the statements in the NextEra documents.

1. Concrete Expansion under Constraint

It appears that the central argument being advanced by NextEra to support a license amendment is that ASR, in a highly reinforced concrete, does not result in a significant loss of structural capacity – at least under the conditions of the tests carried out at the University of Texas. While there is no basis to question the results obtained in these particular tests, there is a strong basis to question their relevance to the Seabrook facility. This is for a variety of reasons.

Firstly, **there is no basis to compare compressive strength of the ASR-attacked concrete in the test blocks to that in the actual Seabrook facility.** Early results obtained by NextEra showed a significant diminution in cylinder strengths. Subsequent to that, no further strength testing was carried out. This is a significant limitation because the degradation phenomenon is converting a homogeneous material to a heterogeneous one. NextEra admits to this. While the course of ASR in unrestrained samples will be to eventually introduce networks of cracks, the course of ASR in highly reinforced concrete will be to produce a concrete fabric wherein aggregate is embedded in a clay-like paste with minimal mechanical properties.

Yet the test program appears to have specifically attempted to avoid establishing the extent of this heterogeneity both on local mechanical properties and on microstructure. In particular the program has avoided carrying out widely accepted tests the results of which could be readily understood. Variations in compressive and splitting tensile strengths as functions of orientation and depth within the test block could have easily been done. This could have readily been accompanied by establishing cement paste microhardness values along with petrographic analyses. Such data could have been obtained from Seabrook structures and would have permitted a reasonable translation of the results on the test blocks to the actual structure. It would also provide data points against which future test results could have been compared – a step which seems critical if the objective is to permit the prediction of the future responses of Seabrook structures to ASR.

The local expansive response of concrete to ASR will be influenced by the distribution of reinforcing steel. It is usual to install grids of rebar (mats) near the external surfaces (tops and bottoms of slabs and vertical surfaces for walls). The extent of reinforcement in the third dimension is generally much lower. This appears to be the distribution used for the University of Texas experiments. This selection is based on the assumption that the mats of reinforcement will inhibit expansion in the two dimensions parallel to them. Based on this assumption, the criterion which has been established for assessing the behavior of the test specimens or of the Seabrook structures themselves is to measure the though-wall dimensional changes. This is new and novel. Based on reading these documents, from which virtually all data were redacted, an acceptable level of expansion in the through-wall direction was noted. However, no justification for this is provided.

In addition, while extensiometers are being installed, they can only provide information as to the overall dimensional change; they cannot determine the specific locations of

expansion. Consequently, very localized and intensely damaging expansion could occur in planes parallel to the planes of the walls which would not result in a significant through-wall dimensional change. In other words, it is possible that a monolithic wall could be damaged in such a fashion that it is converted into three distinct segments—a center segment and two segments adjacent to the reinforcement—which would act independently of each other.

The redaction of data from these documents is problematic. The statement at the top of Enclosure 1,*"The information to be redacted includes details of test programs that MPR conducted and results from the test programs. Release of this information would concede intellectual property. Release of this information would also constitute a loss of competitive advantage relative to others engaged in similar test programs or engaged in assessment of structural impacts of alkali silica reaction."* is entirely inconsistent with the stated goal of the report to advance the body of knowledge of the effects of ASR under conditions of restraint.

This is an extraordinary point of view. It is difficult to understand how withholding pertinent information, which would allow an independent assessment of the test results used support the claims of NextEra, could reasonably be interpreted in this way. It is usual to actually submit such results for peer review to provide a basis for consensus among the relevant scientific community.

1. **Mechanism of ASR**

The understanding of ASR as stated in this NextEra report is superficial to the point of being misleading.

ASR gel is not a compound of fixed composition. It has a variable monovalent cation-to-calcium ratio and a compositionally dependent viscosity. A high ratio produces a gel which is fluid and will accommodate to the pores and voids. As this ratio decreases the gel becomes sufficiently viscous that osmotic effects can place stress on the surrounding concrete. A local source of restraint can, for some period of time, minimize dimensional instability and cracking. However, restraint does not stop the progress of the reaction.

The course of ASR in restrained samples is known to initially cause pore filling, resulting in densification, which will for some period of time counteract the loss of structural capacity. This has been observed in other expansive forms of concrete deterioration, such a sulfate attack.

However, eventually cracking does occur with an abrupt loss of mechanical properties. Not having carried out the above-cited tests severely limits the ability to predict such a possible change in behavior or, more relevantly, provide a firm basis to assert that abrupt changes in structural capacity will not occur during the operating life of the facility.

Thus, no basis has been provided to support the implicit assumption made in this report, namely, that a linear extrapolation of the performance based on University of Texas testing, is appropriate.

It is also being argued in support of LAR approval that the expansive reaction in highly reinforced structures can be regarded as the equivalent of prestressing. However, the tensile strength range for prestressing steel is 1725-1860 MPa while that of rebar is no greater than 690 MPa. This is far from equivalence. A logical extension of this argument suggests that the properties of the concrete *per se* really don't matter.

2. Structural Consequences of ASR

A key element of the work carried out by NextEra has been to attempt to discredit compressive testing of core samples that was carried out relatively shortly after ASR had been reported.

However, models for predicting the path of ASR in reinforced structures have been described in in papers including "On Mechanical Degradation of Reinforced Concrete Affected by Alkali-Silica Reaction" by Winnicki and Pietruszczak in *The Journal of Engineering Mechanics* (Vol 134, 2008), which specifically cites the need to carry out compressive testing if the response of reinforced concrete to ASR is to be predicted. **While a variety of models have been developed to predict the mechanical consequences of ASR, none have been referenced in this LAR**. This is an important limitation of the analysis in the NextEra analysis. The above cited model is particularly relevant because it specifically addresses reinforced concrete.

A second limitation of the validity of the analyses cited in the NextEra LAR is that it largely ignores the effects of dimensional instability. This is in spite of the fact that a seal failure detected in 2014 was found to be the result of "relative building movement" [LAR section 2.1.1 of Enclosure 1]. In a September 21, 2016 letter to the NRC commenting on the LAR, David Lochbaum has cited examples where a concrete dam has expanded by several feet due to ASR. While these are mass concrete structures and are not extensively reinforced, this observation is relevant. Even in the absence of a significant loss of tensile capacity, dimensional changes would be likely to have adverse impacts on the performance of mechanical equipment and conduits used to transport fluids.

More pertinent to the observations of Mr. Lochbaum is the finding cited in section 3.3 of Enclosure 1 of the LAR that the concrete fill at the Seabrook site is susceptible to ASR. Behavior of fill concrete would be analogous to the behavior of mass concrete such as that in a dam. Expansion of fill concrete could significantly impact structures in apposition to it.

Section 3.3 of Enclosure 1 also states the stresses produced by ASR may be mitigated by creep of concrete. However, it is far from clear that the dimensional changes associated with creep are beneficial.

Section 3.3.2 discusses the evaluation of the effects of ASR in terms of a 3-stage process where ever more detailed finite element analyses will be carried out. However, there is no discussion of remediation measures that will be taken in response to stage 3 findings.

Section 3.5.1 discusses maintaining ASR expansion limits below limits described in a proprietary reference. **This presupposes that NextEra has at its disposal means to mitigate expansion. There is no such means.** Table 4 in Enclosure 1 defines various expansion limits. More generally, throughout the LAR various (redacted) values are presented for limits on dimensional instabilities. Yet these values seem to be entirely arbitrary. There is no meaningful discussion supporting the basis for the definition of specific expansion limit values as cited in Table 4. Nor is there any discussion of remedial measures that will be taken should the limiting values in Table 4 be approached.

Table 1 of Section 3.2 *Impact of ASR on Seabrook Structures* cites the potential consequences of ASR to be structural limit states for: Flexural and reinforcement anchorage development, shear, compression, anchor bolts and structural attachments to concrete based on the testing carried out at the University of Texas. There appears to be a significant shortcoming here: the interpretation of the results of UT testing appears not to be based on a comparison of the performance of reinforced test blocks with unreinforced control samples on which expansion and strength measurements could have been made. **Thus, there is no basis to compare the actual extent of ASR to the extensive sets of data from the literature.**

The University of Texas study does rely on and generalizes the data from a study of bridges in Texas that were being degraded by a combination of ASR and delayed ettringite formation (DEF). However, these are two distinct deterioration reactions, one of which affects the aggregate and the other affects the cement paste portion of the concrete. No attempt was made to deconvolute the relative contributions of each these expansive mechanisms and the results of the bridge study were stated only in the most general of terms. **Consequently, based on available information no real basis has been given that would provide confidence that the results of the UT testing can be meaningfully translated to the performance of Seabrook concrete.** This is essentially admitted in section 3.2.1 of Enclosure 1.

3. Effects of ASR on Anchorage

Section 3.2.2 of Enclosure 1 describes the testing of anchorage systems (bolts and attachments) and states that minimal loss in capacity was observed. This is not unexpected. The LAR narrows its discussion to in-plane expansion. However, expansion will not be homogeneous and the primary concern for anchorage systems embedded in a material which is not expanding homogeneously would not be the loss anchorage capacity. Rather, it would be the tendency for the deflection of the bolts and anchors themselves placing stresses to the attached components.

4. Behavior Over Time and Monitoring

Monitoring is discussed in such general terms that NextEra could do almost nothing and comply with the commitments cited in its LAR. For example, there is no discussion as to where through-thickness extensiometers will be placed, how many will be placed, the criteria for selecting their locations and the correlation of those data with any other testing, such as direct mechanical property determinations.

The monitoring is based on a rigid timetable for which no basis was given. If the purpose is to avoid catastrophic failure of structures or related components such as piping systems and anchorage systems then a sensible approach is to also integrate a response to the data into that schedule.

Prepared under contract from the Union of Concerned Scientists

Union of Concerned Scientists

C-10 Research & Education Foundation · Safe Sustainable Energy

October 21, 2016

Justin C. Poole
Project Manager, Seabrook Station
Plant Licensing Branch 1-2
Division of Operating Regulation
Office of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Washington, DC 20555-0001

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Sincerely,

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Executive Director
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44 Merrimac St.
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(978) 465-6646
sandra@c-10.org

Dr. David Wright, Co-Director
Global Security Program
Union of Concerned Scientists
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P.W. Brown, Ph.D.
Sept. 30, 2016

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Section 3.5.1 discusses maintaining ASR expansion limits below limits described in a proprietary reference. **This presupposes that NextEra has at its disposal means to mitigate expansion. There is no such means.** Table 4 in Enclosure 1 defines various expansion limits. More generally, throughout the LAR various (redacted) values are presented for limits on dimensional instabilities. Yet these values seem to be entirely arbitrary. There is no meaningful discussion supporting the basis for the definition of specific expansion limit values as cited in Table 4. Nor is there any discussion of remedial measures that will be taken should the limiting values in Table 4 be approached.

Table 1 of Section 3.2 *Impact of ASR on Seabrook Structures* cites the potential consequences of ASR to be structural limit states for: Flexural and reinforcement anchorage development, shear, compression, anchor bolts and structural attachments to concrete based on the testing carried out at the University of Texas. There appears to be a significant shortcoming here: the interpretation of the results of UT testing appears not to be based on a comparison of the performance of reinforced test blocks with unreinforced control samples on which expansion and strength measurements could have been made. **Thus, there is no basis to compare the actual extent of ASR to the extensive sets of data from the literature.**

The University of Texas study does rely on and generalizes the data from a study of bridges in Texas that were being degraded by a combination of ASR and delayed ettringite formation (DEF). However, these are two distinct deterioration reactions, one of which affects the aggregate and the other affects the cement paste portion of the concrete. No attempt was made to deconvolute the relative contributions of each these expansive mechanisms and the results of the bridge study were stated only in the most general of terms. **Consequently, based on available information no real basis has been given that would provide confidence that the results of the UT testing can be meaningfully translated to the performance of Seabrook concrete.** This is essentially admitted in section 3.2.1 of Enclosure 1.

3. Effects of ASR on Anchorage

Section 3.2.2 of Enclosure 1 describes the testing of anchorage systems (bolts and attachments) and states that minimal loss in capacity was observed. This is not unexpected. The LAR narrows its discussion to in-plane expansion. However, expansion will not be homogeneous and the primary concern for anchorage systems embedded in a material which is not expanding homogeneously would not be the loss anchorage capacity. Rather, it would be the tendency for the deflection of the bolts and anchors themselves placing stresses to the attached components.

4. Behavior Over Time and Monitoring

Monitoring is discussed in such general terms that NextEra could do almost nothing and comply with the commitments cited in its LAR. For example, there is no discussion as to where through-thickness extensiometers will be placed, how many will be placed, the criteria for selecting their locations and the correlation of those data with any other testing, such as direct mechanical property determinations.

The monitoring is based on a rigid timetable for which no basis was given. If the purpose is to avoid catastrophic failure of structures or related components such as piping systems and anchorage systems then a sensible approach is to also integrate a response to the data into that schedule.

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