November 3, 2017

10 CFR 54
Docket No. 50-443
SBK-L-17180

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Seabrook Station

Supplement 58 – Revised Alkali-Silica Reaction Aging Management Program

References:

1. NextEra Energy Seabrook LLC, letter SBK-L-10077, "Seabrook Station Application for Renewed Operating License," May 25, 2010 (Accession Number ML101590099).

2. NRC, "Request for Additional Information for the Review of the Seabrook Station License Renewal Application (CAC NO. ME4028)," March 29, 2017 (Accession Number ML17088A614).

3. NextEra Energy Seabrook LLC, letter SBK-L-17155, "Supplement 58 - Response to Request for Additional Information for the Review of the Seabrook Station License Renewal Application – Building Deformation Analyses Related to Concrete Alkali-Silica Reaction," October 3, 2017 (Accession Number ML17277B519).

In Reference 1, NextEra Energy Seabrook, LLC (NextEra Energy Seabrook) submitted an application for a renewed facility operating license for Seabrook Station Unit 1 in accordance with the Code of Federal Regulations, Title 10, Parts 50, 51, and 54.

In Reference 2, the NRC requested additional information to complete the review of the application related to Alkali-Silica Reaction (ASR) and Building Deformation Monitoring Programs.

NextEra Energy Seabrook, LLC

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In Reference 3, NextEra Energy Seabrook submitted letter SBK-L-17155, responding to the Request for Additional Information (RAI) in Reference 2. Within SBK-L-17155, NextEra Energy Seabrook committed to providing a revised License Renewal Application Appendix A – Updated Final Safety Analysis Report by November 3, 2017.

Enclosure 1 provides revised License Renewal Application (LRA) Appendix A - Updated Final Safety Analysis Report Sections A.2.1.31 for Structures Monitoring, A.2.1.31A for Alkali-Silica Reaction and A.2.1.31B for Building Deformation.

Enclosure 2 provides revised LRA Appendix B Sections B.2.1.31 for Structures Monitoring, B.2.1.31A for Alkali-Silica Reaction (ASR) and B.2.1.31B for Building Deformation Aging Management Programs.

To facilitate understanding, the changes are explained, and where appropriate, portions of the LRA are repeated with the change highlighted by strikethroughs for deleted text and bolded italics for inserted text. These revisions supersede the respective previously submitted sections to the LRA.

This letter contains no new or revised Commitments.

If there are any questions or additional information is needed, please contact Mr. Edward J. Carley, Engineering Supervisor - License Renewal, at (603) 773-7957.

If you have any questions regarding this correspondence, please contact Mr. Kenneth Browne, Licensing Manager, at (603) 773-7932.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on November 3rd, 2017.

Sincerely,

NextEra Energy Seabrook, LLC

Eric McCartney
Regional Vice President - Northern Region

Enclosures:

Enclosure 1 - Revised Seabrook Station License Renewal Application Updated Final Safety Analysis Report Sections A.2.1.31 for Structures Monitoring, A.2.1.31A for Alkali-Silica Reaction and A.2.1.31B for Building Deformation.

Enclosure 2 - Revised Seabrook Station License Renewal Application Appendix B Sections B.2.1.31 for Structures Monitoring, B.2.1.31A for Alkali-Silica Reaction (ASR) and B.2.1.31B for Building Deformation Aging Management Programs.

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Enclosure 1 to SBK-L- 17180

Revised Seabrook Station License Renewal Application Updated Final Safety Analysis Report Section A.2.1.31 for Structures Monitoring, Section A.2.1.31A for Alkali-Silica Reaction (ASR) and Section A.2.1.31B for Building Deformation

A.2.1.31 STRUCTURES MONITORING PROGRAM

The Structures Monitoring Program includes the Masonry Wall Program and the Inspection of Water Control Structures Associated with Nuclear Power Plants Program.

The Structures Monitoring Program is implemented through the plant Maintenance Rule Program, which is based on the guidance provided in NRC Regulatory Guide 1.160 "*Monitoring the Effectiveness of Maintenance at Nuclear power Plants*" and NUMARC 93-01 "*Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*", and with guidance from ACI 349.3R, "*Evaluation of Existing Nuclear Safety-Related Concrete Structures*". The Structures Monitoring Program was developed using the guidance of these three documents. The Program is implemented to monitor the condition of structures and structural components within the scope of the Maintenance Rule, such that there is no loss of structure or structural component intended function.

A.2.1.31A ALKALI-SILICA REACTION (ASR) MONITORING

The plant specific ASR ~~Monitoring~~ ***Aging Management*** Program manages cracking due to expansion and reaction with aggregates of concrete structures within the scope of License Renewal. The potential impact of ASR on the structural strength and anchorage capacity of concrete is a consequence of strains resulting from the expansive gel.

The Structures Monitoring Program and Section XI Subsection IWL Program perform visual inspections of the concrete structures at Seabrook ***Station*** for indications of the presence of alkali-silica reaction (ASR). ASR involves the formation of an alkali-silica gel which expands when it absorbs water. This expansion is volumetric in nature but is most readily detected by visual observation of cracking on the surface of the concrete. This cracking is the result of expansion that is occurring in the in-plane directions. Expansion is also occurring perpendicular (through the thickness of the wall) to the surface of the wall, but cracking will not be visible in this direction from the accessible surface. Cracking on the surface of the concrete is typically accompanied by the presence of moisture and efflorescence. Concrete affected by expansive ASR is typically characterized by a network or "pattern" of cracks. Micro-cracking due to ASR is generated through forces applied by the expanding aggregate particles and/or swelling of the alkali-silica gel within and around the boundaries of reacting aggregate particles. The ASR gel may exude from the crack forming white secondary deposits at the concrete surface. The gel also often causes a dark discoloration of the cement paste surrounding the crack at the concrete surface. If "pattern" or "map" cracking typical of concrete affected by ASR is identified, an evaluation will be performed to determine further actions.

ASR is primarily detected by non-intrusive visual observation of cracking on the surface of the concrete. The cracking is typically accompanied by the presence of moisture and efflorescence. ASR may also be detected or confirmed by removal of concrete cores and subsequent petrographic analysis.

Monitoring of crack growth is used to assess the in-plane expansion associated with ASR and to specify monitoring intervals. A Combined Cracking Index (CCI) is established at thresholds at which structural evaluation is necessary (see table below). The Cracking Index (CI) is the summation of the crack widths on the horizontal or vertical sides of 20-inch by 30-inch grid on the ASR-affected concrete surface. The horizontal and vertical Cracking Indices are averaged to obtain a Combined Cracking Index (CCI) for each area of interest. A CCI of less than the 1.0 mm/m can be deemed acceptable with deficiencies (Tier 2). Deficiencies determined to be acceptable with further review are trended for evidence of further degradation. The change from qualitative monitoring to quantitative monitoring occurs when the Cracking Index (CI) of the pattern cracking equals or is greater than 0.5 mm/m in the vertical and horizontal directions. Concrete crack widths less than 0.05 mm cannot be accurately measured and reliably repeated with standard, visual inspection equipment. A CCI of 1.0 mm/m or greater requires structural evaluation (Tier 3). All locations meeting Tier 3 criteria will be monitored for in-plane expansion ***(via CCI), through-thickness expansion (via*** borehole extensometers***), and volumetric expansion (using CCI and extensometer measurements)*** on a ½ year (6-month) inspection frequency. All locations meeting the Tier 2 structures monitoring criteria will be monitored on a 2.5 year (30-month) frequency. CCI correlates well with strain in the in-plane directions and the ability to visually detect cracking in exposed surfaces making it an effective initial detection parameter. In the event ASR monitoring results indicate a need to amend either the monitoring program acceptance criteria or the frequency of monitoring, NextEra Energy Seabrook will take such action under the Operating Experience element of the Alkali-Silica Reaction ***Aging Management*** ~~Monitoring~~ Program.

Tier	**Structures Monitoring Program Category**	**Recommendation for Individual Concrete Components**	**Criteria**
3	Unacceptable (requires further evaluation)	▪ Structural Evaluation ▪ Implement enhanced ASR monitoring, such as through-wall expansion monitoring using Extensometers.	1.0 mm/m or greater Combined Cracking Index (CCI)
2	Acceptable with Deficiencies	Quantitative Monitoring and Trending	▪ 0.5 mm/m or greater CCI ▪ CI of greater than 0.5 mm/m in the vertical and horizontal directions.
		Qualitative Monitoring	Any area with visual presence of ASR (as defined in FHWA-HIF-12-022) accompanied by a CI of less than 0.5 mm/m in the vertical and horizontal directions.
1	Acceptable	Routine inspection as prescribed by the Structural Monitoring Program	Area has no indications of pattern cracking or water ingress- No visual symptoms of ASR

The Alkali-Silica ~~Reaction Monitoring~~ ***Aging Management*** Program was initially based on published studies describing screening methods to determine when structural evaluations of ASR affected concrete are appropriate. Large scale destructive testing of concrete beams with accelerated ASR has confirmed that parameters being monitored are appropriate to manage the effects of ASR and that an acceptance criterion of 1 mm/m provides sufficient margin with regard to the effect of ASR expansion on structural capacity.

For heavily reinforced structures, in-plane expansion is limited. CCI ~~has been~~ ***was*** observed in the large scale test programs to plateau at a relatively low level of accumulated strain ~~(approximately 1 mm/m)~~. While CCI remains useful for the detection and monitoring of ASR at the initial stages, an additional monitoring parameter in the out-of-plane direction is required to monitor more advanced ASR progression. ASR expansion in the out-of-plane direction will be monitored by borehole extensometers installed in drilled core bore holes. In the selected locations, cores will be removed for modulus testing to establish the level of through-thickness expansion to date. Instruments (extensometers) will be placed in the resulting bore holes to monitor expansion in this direction going forward. ***Measured in-plane expansion and through-thickness expansion will be used to determine volumetric expansion.*** ~~so the~~ ***Expansion measurements will be used to maintain the*** limits specified below ~~are maintained~~.

Structural Design Issue	Criteria[1]
Flexure & reinforcement anchorage	See FP#101020 - Section 2.1 for limit on through-thickness expansion
Shear	See FP#1010***5***~~2~~0 – ***Appendix B*** ~~Section 2.1~~ for limit on ***volumetric*** through-thickness expansion
Anchor bolts and structural attachments	See FP#101020 - Section 2.1 for limit on in-plane expansion

A.2.1.31B BUILDING DEFORMATION MONITORING

The Building Deformation ~~Monitoring~~ ***Aging Management*** Program is a plant specific program implemented under the existing Maintenance Rule Structures Monitoring Program. Building Deformation is an aging mechanism that may occur as a result of other aging effects of concrete. Building Deformation at Seabrook ***Station*** is primarily a result of the alkali silica reaction (ASR) but can also result from swelling, creep, and shrinkage. Building deformation can cause components within the structures to move such that their intended functions may be impacted.

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[1] Expansion Limit Criteria is considered proprietary to NextEra ***Energy*** Seabrook. FP #101020 MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," July 2016, ***and FP#101050 MPR-4273, Revision 0, "Seabrook Station – Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction" were*** ~~was~~ previously submitted to the NRC in SBK~~L~~-L-16071; 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; Dated August 1, 2016

The Building Deformation ~~Monitoring~~ ***Aging Management*** Program uses visual inspections associated with the Structures Monitoring Program and cracking measurements associated with the Alkali-Silica Reaction program to identify buildings that are experiencing deformation. The first inspection is a baseline to identify areas that are exhibiting surface cracking. The surface cracking will be characterized and analytically documented. This inspection will also identify any local areas that are exhibiting deformation. The extent of surface cracking will be input into an analytical model. This model will determine the extent of building deformation and the frequency of required visual inspections.

For building deformation, location-specific measurements (e.g. via laser target and gap measurements) will be compared against location-specific criteria to evaluate acceptability of the condition.

Structural evaluations will be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained. Evaluations of structures will validate structural performance against the design basis, and may use results from the large-scale test programs, as appropriate.

Evaluations for structural deformation will also consider the impact to functionality of affected systems and components (e.g. conduit expansion joints). NextEra Energy Seabrook will evaluate the specific circumstances against the design basis of the affected system or component. Structural evaluations will be used to determine whether additional corrective actions (e.g., repairs, additional inspections and/or analysis) to the concrete or components are required. Specific criteria for selecting effective corrective actions will be evaluated on a location-specific basis.

Enclosure 2 to SBK-L- 17180

Revised Seabrook Station License Renewal Application Section B.2.1.31 for Structures Monitoring, Section B.2.1.31A for Alkali-Silica Reaction (ASR) and Section B.2.1.31B for Building Deformation

B.2.1.31 STRUCTURES MONITORING PROGRAM

Program Description

The Seabrook Station Structures Monitoring Program (SMP) is an existing program that will be enhanced to ensure provision of aging management for structures and structural components including bolting within the scope of this program. The Structures Monitoring Program is implemented through the Seabrook Station Maintenance Rule Program, which is based on the guidance provided in NRC Regulatory Guide 1.160, Revision 2, *"Monitoring the Effectiveness of Maintenance at Nuclear Power Plants"* and NUMARC 93-01, Revision 2,*" Industry Guidance for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*", and with guidance from ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures". The Seabrook Station Structures Monitoring Program was developed using the guidance of these three documents to monitor the condition of structures and structural components within the scope of the Maintenance Rule, such that there is no loss of structure or structural component intended function.

The Seabrook Station Structures Monitoring Program includes periodic visual inspection of structures and structural components for the detection of aging effects specific for that structure. These inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found. A structure found in a harsh environment is defined as one that is in an area that is subject to outside ambient conditions, very high temperature, high moisture or humidity, frequent large cycling of temperatures, frequent exposure to caustic materials, or extremely high radiation levels. For structures in these harsh environments, the inspection is conducted on a five year basis (plus or minus one year due to outage schedule and two inspections within ten years). Structures not found in areas qualifying as a harsh environment are classified as being in a mild environment, and are inspected on a ten year basis (plus or minus one year due to outage schedule and two inspections within twenty years).

Individuals conducting the inspection and reviewing the results are qualified per the Seabrook Station Structures Monitoring Program, which is in accordance with the requirements specified in ACI 349.3R-96, *"Evaluation of Existing Nuclear Safety related Concrete Structures"*. Individuals conducting the inspection and reviewing the results are to possess expertise in the design and inspection of steel, concrete and masonry structures. These individuals must either be a licensed Professional Engineer experienced in this area, or will work under the direction of a licensed Professional Engineer experienced in this area.

The station SMP identifies plant equipment impacted or potentially impacted by building deformation through baseline and periodic walkdowns of the structures. The as-found conditions of the items of interest are evaluated and recommendations for repair or periodic monitoring are established in accordance with the Corrective Action Program.

Detection of aggressive subsurface environments will be completed through the sampling of groundwater. This procedure monitors groundwater for chloride concentration, sulfate concentration and pH on a 5 year basis

The Structures Monitoring Program will include an external surface inspection of the aboveground steel tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B, and 1-AB-TK-29. This inspection will inspect the paint or coating for cracking, flaking, or peeling.

Examination of inaccessible areas, such as buried concrete foundations, will be completed during inspections of opportunity or during focused inspections. An evaluation of these opportunistic or focused inspections for buried concrete will be performed under the Maintenance Rule Program every 5 years (if no opportunistic inspection was performed during a 5-year period, a focused 5 year inspection is required) to ensure that the condition of buried concrete foundations on site is characterized sufficiently to provide reasonable assurance that the foundations on site will perform their intended function through the period of extended operation. ***To date Seabrook Station has performed numerous opportunistic inspections of buried concrete structures to confirm the characterization of ASR affected structures (e.g. switchyard generator step up transformer pit inspections in 2014, and Unit 2 Circulating Water Vault in 2015).*** Additional inspections may be performed in the event that an opportunistic or focused inspection or visible portions of the concrete foundation reveal degradation and will be entered into the Corrective Action Program (CAP).

Concrete structures were constructed equivalent to recommendations in ACI 201.2R, *"Guide for Making a Condition Survey of Concrete in Service"*. Loss of material due to leaching of calcium hydroxide is considered to be an aging effect requiring management for Seabrook Station. There have been indications of leaching in below grade concrete in Seabrook Station structures. Leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Resistance to leaching is enhanced by using a dense, well-cured concrete with low permeability. These structures are designed in accordance with ACI 318 and constructed in accordance with ACI 301 and ASTM standards. Nevertheless, Seabrook Station manages loss of material due to leaching of calcium hydroxide with visual inspection through the Structures Monitoring Program.

Seabrook Station has scheduled specific actions to determine the effects of aggressive chemical attack due to high chloride levels in the groundwater. Seabrook Station has scheduled concrete testing during the second and third quarter of 2010. An evaluation will be performed based on the results of the testing and a determination of the concrete condition which may lead to additional testing or increased inspection frequency. Testing of concrete may consist of the following:

a. concrete core samples

b. penetration resistance tests

c. petrographic analysis of the concrete core samples

d. visual inspection of rebar as they are exposed during the concrete coring

NextEra Energy Seabrook will evaluate the results of the testing and, if required, undertake additional corrective actions in accordance with the Structures Monitoring Program CAP.

The Seabrook Station Structures Monitoring Program does not credit protective coatings for management of aging effects on structures and structural components within the scope of this program.

There are no preventative actions specified in the Seabrook Station Structures Monitoring Program, which includes implementation of NUREG-1801 XI.S5, XI.S6, and XI.S7. These are monitoring programs only.

The parameters monitored in the Seabrook Station Structures Monitoring Program are in agreement with ACI 349.3R-96 and ASCE 11-90, "*Structural Condition Assessment of Buildings*".

Concrete deficiencies are classified using the criteria specified in the Seabrook Station Structures Monitoring Program, which is based on the guidance provided in ACI 201.1R-2, "*Guide for Making a Condition Survey of Concrete in Service*".

As noted in the Seabrook Station response to NRC IN 98-26, *"Settlement Monitoring and Inspection of Plant Structures Affected by Degradation of Porous Concrete Subfoundations"*, porous concrete was not used in the construction of building sub-foundations at Seabrook ***Station***.

Monitoring of structures and structural components in the scope of the Seabrook Station Structures Monitoring Program is performed in compliance with Regulatory Position 1.5 of NRC Regulatory Guide 1.160 The condition of all structures within the scope of this program is assessed on a periodic basis as specified by 10 CFR 50.65. Structures that do not meet their design basis at the time of inspection due to the extent of degradation, or that may not meet their design basis at the next normally scheduled inspection due to further degradation without intervention are entered into the Corrective Action Program and evaluated for corrective action and/or additional inspections as delineated in 10 CFR 50.65(a)(1). In addition, structures may also be scheduled for follow-up inspections following the completion of any corrective actions to that structure.

The condition of any structure subject to additional inspections or corrective actions is recorded through Seabrook Station Structures Monitoring Program reports to provide a basis for scheduling additional inspections and any required corrective actions in the future, as specified the Seabrook Station Structures Monitoring Program.

Structures that are determined to be acceptable under the Maintenance Rule structural inspections are monitored as specified in 10 CFR 50.65(a)(2).

Evaluations of a structure's condition assess the extent of any degradation of the structural member in accordance with industry standards and the judgment of the qualified individuals performing the inspections.

The acceptance guidelines in the Seabrook Station Structures Monitoring Program are a three-tier hierarchy similar to that described in ACI 349.3R-96, which provides quantitative degradation limits. Under this system, structures are evaluated as being acceptable, acceptable with deficiencies, or unacceptable. Evaluations of a structure's condition are completed according to the guidelines set forth in the Seabrook Station Structures Monitoring Program.

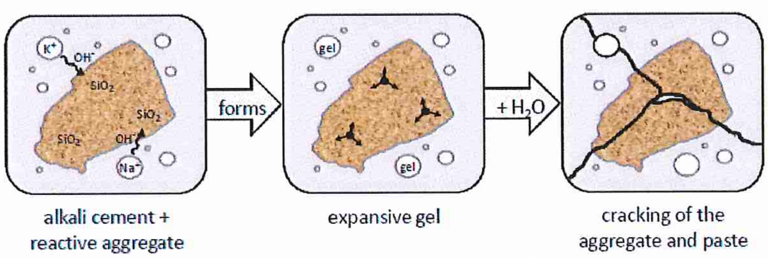
B.2.1.31A ALKALI-SILICA REACTION

PROGRAM DESCRIPTION

The Alkali-Silica Reaction ***(ASR)*** Aging Management Program ***(AMP)*** is a new plant specific program being implemented under the existing Maintenance Rule Structures Monitoring Program that will manage the aging effects related to Alkali-Silica Reaction of each structure and component subject to an Aging Management Review, so that the intended function(s) will be maintained consistent with the current licensing basis for the period of extended operation.

Alkali-Silica Reaction

Alkali-Silica Reaction ~~(ASR)~~ is an aging mechanism that may occur in concrete under certain circumstances. It is a reaction between the alkaline cement and reactive forms of silicate material (if present) in the aggregate. The reaction, which requires moisture to proceed, produces an expansive gel material. This expansion results in strains in the material that can produce micro-cracking in the aggregate and in the cement paste. The potential impact of ASR on the structural strength and anchorage capacity of concrete is a consequence of strains resulting from the expansive gel. These strains produce the associated cracking. Because the ASR mechanism requires the presence of moisture in the concrete, ASR has been predominantly detected in groundwater impacted portions of below grade structures, with limited impact to exterior surfaces of above grade structures.



ASR Expansion Mechanism

Impact of Confinement

Reinforcing steel, loads on the concrete structure (i.e., deadweight of the structure itself), and the configuration of the structure provide confinement that restrains in-situ expansion of the gel and limits the resulting cracking in concrete.

Since the impact of ASR on mechanical properties relates to the extent of cracking, restraint of the expansion limits the reduction of in-situ mechanical properties and overall degradation of structural performance. There is a prestressing effect that occurs when reinforcement restrains the expansion caused

by ASR. This effect is similar to concrete prestressing or analogous to pre-loading a bolted joint.
The concrete prestressing effect is only present when the concrete is confined. If the concrete is removed from the stress field, the concrete prestressing effect is lost. For example, a core taken from a reinforced concrete structure that has been affected by ASR will lose the confinement provided by the reinforcement and concrete surrounding the sample, and therefore is no longer representative of the concrete within its structural context.

Seabrook Station Concrete
The concrete mix designs used in original construction at Seabrook ***Station*** utilized an aggregate that was susceptible to ASR, which was not known at the time. Although ~~the~~ testing was conducted in accordance with the ASTM C289 standard~~s~~, the ~~standard~~ ***test method*** was subsequently identified as limited in its ability to predict long term ASR for moderate to low reactive aggregates. ASTM C289 has since been withdrawn.

In 2009, Seabrook ***Station*** tested seasonal groundwater samples to support the development of a License Renewal Application. The results showed that the groundwater had become aggressive and ***NextEra Energy*** Seabrook initiated a comprehensive review of possible effects to in-scope structures.

A qualitative walkdown of plant structures was performed and the "B" Electrical Tunnel was identified as showing the most severe indications of groundwater infiltration. Concrete core samples from this area were removed, tested for compressive strength and modulus of elasticity, and subjected to petrographic examinations. While the results showed that both compressive strength and modulus of elasticity had declined, the structure ***was*** ~~were~~ determined to be within ***its*** design basis and ***therefore*** remain***ed*** ~~operable~~ ***able to perform its design function***. The results of ~~the~~ petrographic examinations ~~also showed that~~ ***on*** the ***core*** samples ~~had experienced~~ ***identified*** Alkali-Silica Reaction (ASR). This discovery ~~initiated~~ ***prompted*** an Extent of Condition evaluation. Because the ASR mechanism requires the presence of moisture or very high humidity in the concrete, ASR has been predominantly detected in portions of below-grade structures, with limited impact to exterior surfaces of above grade structures.

Large-Scale Testing Program
The structural assessment of ASR-affected structures at Seabrook Station considered the various limit states for reinforced concrete and applied available literature data to evaluate structural capacity. This evaluation identified gaps in the publicly available test data and the applicability to the reinforcement concrete at Seabrook ***Station***. The limited available data for shear capacity and reinforcement anchorage for ASR-affected reinforced concrete with two-dimensional reinforcement mats were not representative of Seabrook Station. This conclusion was driven largely by the facts that the literature data for reinforcement anchorage were from a test method that ACI indicates is unrealistic

and the literature data for shear capacity were from test specimens only inches in size. Additionally, no data were available on anchor bolt capacity on reinforced concrete with two dimensional reinforcement mats like Seabrook Station.

The need for Seabrook ***Station***-specific testing was driven by limitations in the publicly available test data related to ASR effects on structures. Most research on ASR has focused on the science and kinetics of ASR, rather than engineering research on structural implications. Although structural testing of ASR-affected test specimens has been performed, the application of the conclusions to a specific structure can be challenged by lack of representativeness in the data (e.g., small-scale specimens; poor test methods; different reinforcement configuration). The large-scale test programs undertaken by NextEra Energy Seabrook provided data on the limit states that were essential for evaluating seismic Category I structures at Seabrook Station. The data produced from these programs were a significant improvement from the data in published literature sources, because test data across the range of ASR levels were obtained using a common methodology and identical test specimens. The results were used to assess ***the impact of ASR on*** structural limit states and ~~to inform the assessment of~~ ***on selected*** design considerations[2]***. This assessment supports use of the test results in structural calculations.***

The large-scale test programs included testing of specimens that reflected the characteristics of ASR-affected structures at Seabrook Station. Tests were completed at various levels of ASR cracking to assess the impact on selected limit states. The extent of ASR cracking in the test specimens was quantified by measuring the expansion in the in-plane and through-thickness ~~specimen~~ dimensions. The in-plane dimension refers to measurements taken in a plane parallel to the underlying reinforcement bars. There was no reinforcement in the ~~test specimen~~ through-thickness direction (perpendicular to the in-plane direction). ASR expansion measurements were ~~monitored~~ ***taken*** throughout ***the*** test ***programs***~~ing~~. The test programs ~~all relevant limit states except compression (i.e.,~~ assessed flexur***al capacity***~~e~~ and reinforcement anchorage, shear ***capacity***, and ***capacity of*** anchor bolts and structural attachments to concrete~~)~~. The results of the ***shear and reinforcement anchorage*** test program***s*** demonstrated that ***there was*** no ***adverse effect on structural performance*** ~~no of~~ ***in*** the***se*** ~~assessed~~ limit states ~~are reduced by ASR~~ when ASR expansion levels ~~in plant structures are~~ ***were*** below those ~~observed~~ ~~evaluated~~ in the ***test specimens*** ~~large scale test programs~~***. The results of the anchor test program demonstrated that there was no adverse effect on anchor capacity except at high levels of ASR expansion.***

The effect of ASR on compressive strength was not assessed in the large-scale test program. An evaluation of compression using existing data from published literature sources was performed. The evaluation concluded that ASR expansion

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[2] ***FP #101020 MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," July 2016***

in reinforced concrete results in compressive load that should be combined with other loads in design calculations. However, ASR does not reduce the structural capacity of compression elements.

The specimens used in the large-scale test programs experienced levels of ASR that bound ASR levels currently found in Seabrook ***Station*** structures (i.e., are more severe than at Seabrook ***Station***), but the number of available test specimens and nature of the testing prohibited testing out to ASR levels where there was a clear change in limit state capacity. Because there ~~is~~ ***are*** no~~t~~ testing data for these more advanced levels of ASR, periodic monitoring of ASR at Seabrook is necessary to ensure that ~~the conclusions of the large scale test program remain valid- that~~ the level of ASR does not exceed that ~~considered under the~~ ***observed in the*** test programs***, which ensures that the conclusions of the large-scale test program remain applicable.***

The overall conclusion from analyses of structural limit states is that limit state capacity is not degraded when small amounts of ASR expansion are present in structures. Presently, the ASR expansion levels in Seabrook ***Station*** structures are below the levels at which limit state capacities are reduced.

One of the objectives of the test program was to identify effective methods for monitoring ASR. The program concluded that monitoring the in-plane and through-thickness expansion is effective for characterizing the significance of ASR in structures. A Combined Cracking Index (CCI) methodology based on crack width summation was shown to be effective for in-plane expansion monitoring. Snap ring borehole extensometers (SRBEs) provided accurate and reliable measurements for monitoring through-thickness expansion.

Results from the large-scale testing program are ~~also~~ used to support evaluations of structures subjected to deformation. These evaluations are discussed in the Building Deformation ~~Monitoring~~ ***Aging Management*** Program in LRA Section B.2.1.31B.

PROGRAM ELEMENTS

The following provides the results of the evaluation of each program element against the 10 elements described in Appendix A of NUREG-1800 Rev. 1, *"Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants".*

ELEMENT 1 - SCOPE OF PROGRAM

The ~~Seabrook Station~~ Alkali-Silica Reaction (ASR) ***Aging Management*** ~~Monitoring~~ Program ***(AMP)*** provides for management of aging effects due to the presence of ASR. ***The*** program scope includes concrete structures within the scope of the License Renewal Structures Monitoring Program and License Renewal ASME Section XI Subsection IWL Program. License Renewal concrete structures within the scope of this program include:

Category I Structures

- Containment Building (including equipment hatch missile shield)
- Containment Enclosure Building
- Containment Enclosure Ventilation Area
- Service Water Cooling Tower including Switchgear Rooms
- Control Building
- Control Building Make-up Air Intake Structures
- Diesel Generator Building
- Piping (RCA) Tunnels
- Main Steam and Feed Water East and West Pipe Chase
- Waste Processing Building
- Tank Farm
- Condensate Storage Tank Enclosure
- Emergency Feed Water Pump House Building, including Electrical Cable Tunnels and Penetration Areas (Control Building to Containment)
- Fuel Storage Building
- Primary Auxiliary Building including RHR Vaults
- Service Water Pump House
- Service Water Access (Inspection) Vault
- Circulating Water Pump House Building (below elevation 21'-0)
- Safety Related Electrical Manholes and Duct Banks
- Pre-Action Valve Building

Miscellaneous Non-Category I Yard Structures

- SBO Structure – Transformers and Switch Yard foundations
- Non-Safety-Related Electrical Cable Manhole, Duct Bank Yard Structures foundations
- Switchyard and 345 KV Power Transmission foundations

Non-Category I Structures

- Turbine Generator Building
- Fire Pump House
- Aboveground Exterior Tanks 1-FP-TK-35-A, 1-FP-TK-35-B, 1-FP-TK-36-A, 1-FP-TK-36-B and 1-FP-TK-29 foundations
- Fire Pump House Boiler Building
- Non-Essential Switchgear Building
- Steam Generator Blowdown Recovery Building

- Intake & Discharge Transition Structures

ELEMENT 2 - PREVENTIVE ACTIONS

There are no preventive actions specified in the Seabrook Station Structures Monitoring Program, which includes implementation of NUREG-1801 XI.S5, XI.S6, and XI.S7. These are monitoring programs only. Similarly, the ASR ***AMP*** ~~Monitoring Program~~ does not rely on preventive actions.

ELEMENT 3 - PARAMETERS MONITORED/INSPECTED

The Alkali-Silica Reaction (ASR) ***AMP*** ~~Monitoring Program~~ manages the effects of cracking due to expansion and reaction with aggregates. The potential impact of ASR on the structural performance and anchorage capacity of concrete is a consequence of strains resulting from the expansive gel. The strains consequently produce the associated cracking.

The program focuses on identifying evidence of ASR, which could lead to expansion due to the reaction with aggregates. The program reflects published guidance for condition assessment of structures and incorporates practices consistent with those used as part of the large-scale testing programs.

Initial screening of ASR
Walkdowns of the station are performed on a periodic basis (SMP walkdowns, Systems Walkdowns, etc.). Visual symptoms of deterioration are noted and compared to those commonly observed on structures affected by ASR. Common visual symptoms of ASR include, but are not limited to, "map" or "pattern" cracking and surface discoloration of the cement paste surrounding the cracks. The cracking is typically accompanied by the presence of moisture and efflorescence. The lists of symptoms associated with the initial screening of ASR is consistent with many published documents, including but not limited to the Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures", and the Institution of Structural Engineering document "Structural Effects of Alkali-Silica Reaction: Technical Guidance on the Appraisal of Existing Structures."

Inspection of inaccessible areas of concrete will be performed during opportunistic or focused inspections for buried concrete performed under the Maintenance Rule every 5 years. The concrete materials used to produce the concrete placed in inaccessible areas were the same as the concrete materials used to produce the concrete placed in accessible areas. Thus, the performance and aging of inaccessible concrete would be the same as the performance and aging of accessible concrete.

Since the concrete mix and aggregates used at Seabrook Station ~~is~~ ***are*** consistent between structures, it is assumed unless demonstrated otherwise that ***pattern cracking observed during walkdowns is from*** ASR ~~can be present~~. Petrographic examination can be performed on a concrete specimen to aid in confirming the proposed diagnosis arrived upon from visual inspection of the concrete surface. Typical petrographic features of ASR generally consist of the following:

- Micro-cracking in the aggregates and/or cement paste
- Reaction rims around the aggregates.
- Silica gel filling cracks or voids in the sample.
- Loss of cement paste-aggregate bond.

Expansion

For ASR-affected surfaces at Seabrook Station, NextEra Energy Seabrook will monitor the effects of ASR expansion by obtaining measurements in both the in-plane (X&Y directions) and through-thickness directions (Z-direction). Specifically, ***NextEra Energy*** Seabrook will be monitoring the Combined Cracking Index (CCI) for in-plane expansion and extensometer measurements for through-thickness expansion. ***In addition, NextEra Energy Seabrook will use the CCI data and through-thickness expansion measurements to determine volumetric expansion.*** Expansion from ASR results in cracking and a change to the material properties of the concrete, and eventually requires an evaluation to ensure adequate structural performance.

Expansion is a readily quantifiable parameter and an effective method for determining ASR progression. Expansion measurements at Seabrook ***Station*** can be easily obtained in the in-plane directions. The Cracking Index (CI) is a quantitative assessment of cracking present in the cover concrete of affected structures. A CI measurement is taken on accessible surfaces exhibiting the typical ASR symptoms. The CI is the summation of the crack widths on the horizontal or vertical sides of a section of the ASR-affected concrete surface of predefined dimensions. Seabrook ***Station*** uses a grid size of 20 inches by 30 inches. The CI in a given direction is converted and reported in units of mm/m.

The CIs are used to establish the Combined Cracking Index (CCI). The CCI estimates expansion on a concrete surface using measurements of crack widths along a pre-determined length or grid. The CCI is calculated by summing the crack widths crossing all reference grid lines and dividing the result by the sum of all gridline lengths. Criteria used in assessment of expansion is expressed in terms of CCI and based on recommendations provided in MPR-3727, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments" and supported by the test programs. The test programs indicated that direction of expansion is not significantly affected by the reinforcement when expansion is at or below approximately 1 mm/m. Beyond this expansion level, the two-dimensional reinforcement mats provide confinement in the in-plane directions, and through-thickness expansion dominates.

Data analysis from the large-scale test program has been completed and thresholds established based on the test reports. The thresholds are based on the structure as a whole so if localized extensive ASR or macro cracking is experienced in particular areas of the structure, then the entire structure is assumed to be susceptible to similar degradation. The overall methodology for using in-plane ***expansion,*** ~~and~~ through-thickness expansion***, and volumetric expansion*** values for various aspects of the monitoring program is ~~summarized as follows:~~ ***discussed below.***

Initial screening for ASR will be performed using CCI only. CCI values exceeding 1 mm/m will trigger additional actions. CCI is a relatively simple, non-destructive method for monitoring cracking that appropriately characterizes expansion until expansion reorients in the direction of least restraint (i.e., the through-thickness direction at Seabrook Station).

Anchor Performance Monitoring Parameter

For anchor performance, the large scale test programs show that ASR does not have an effect until in-plane expansion reaches a sufficiently high level. Therefore, if the CCI exceeds a specified threshold, additional evaluation must be performed to justify continued acceptability of the anchors.

This approach is based on the fact that anchor performance is sensitive to in-plane expansion, but not through-thickness expansion. In-plane expansion creates micro-cracks parallel to the axis of an anchor, mainly in the concrete cover. These micro-cracks perpendicular to the concrete surface have the potential to provide a preferential failure path within a potential breakout cone, leading to degraded anchor performance.

Through-thickness expansion has the potential to create micro-cracks perpendicular to the axis of an anchor. These potential micro-cracks that open parallel to the concrete surface do not provide a preferential failure path to result in degraded anchor performance. An anchor loaded in tension would compress the through-thickness expansion and close any potential micro-cracks within the area of influence of that anchor. Without a 'short-circuit' of the breakout cone, through-thickness expansion is a non-factor in anchor performance.

Crack Width Summation

Crack width summation is a simple methodology for initial assessment of ASR-affected components and is recommended by publicly available resources.

ASR produces a gel that expands as it absorbs moisture. This expansion exerts a tensile stress on the surrounding concrete which strains the concrete and eventually results in cracking.

The engineering strain in a structural member at the time of crack initiation (ε_{cr}) is equivalent to the tensile strength of the concrete divided by the elastic modulus ($\varepsilon_{cr} = \sigma_t / E$). The Cracking Index quantifies the extent of the surface cracking. The total strain in the concrete can be approximated as the sum of the strain at crack initiation plus the cracking index ($\varepsilon \approx \varepsilon_{cr}$ + CI). Figure 1 depicts a concrete specimen with rebar being put in tension resulting in cracking.
Concrete has little strain capacity; therefore, in ASR-affected concrete, the crack widths comprise most of the expansion (ΔL). As a result, the Cracking Index provides a reasonable approximation of the total strain applied to the concrete after crack initiation, because strain in the un-cracked concrete between cracks is minimal.

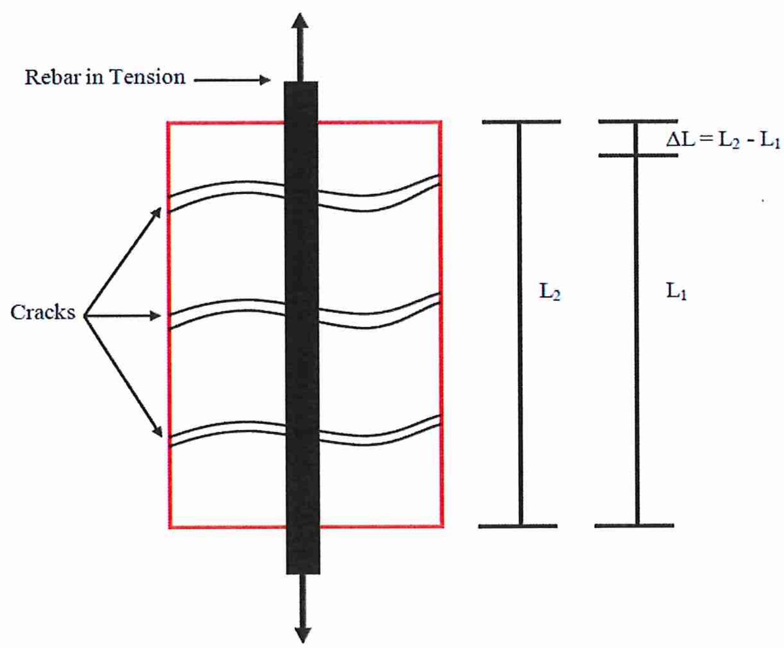


Figure 1 - Concrete Specimen put in Tension

For surfaces where horizontal and vertical cracking indices are similar (e.g., where there is equivalent reinforcement in both directions), a Combined Cracking Index (CCI) that averages the horizontal and vertical Cracking Indices can consolidate the expansion assessment to a single parameter. The CCI is also used to measure the effects of associated rebar strain.

Change in Elastic Modulus and Extensometer Measurements

The large scale test program show***ed***~~s~~ that ~~out of plane~~ through-thickness expansion dominates for structures with two-dimensional reinforcement mats ***in the in-plane directions*** (like ~~seen~~ ***structures*** at Seabrook Station).

Data from the structural testing programs ~~have~~ show***ed***~~n~~ that expansion in the in-plane direction plateau***ed***~~s~~ at low expansion levels, while expansion in the through-thickness direction continu***ed***~~s~~ to increase. ***Based on this observation,*** Seabrook ***Station*** will install the extensometers in Tier 3 and other selected locations to measure expansion in the through-thickness direction. This approach will enable measuring expansion for a given concrete structural member from the time the extensometer is installed and going forward. To calculate the total expansion, ***NextEra Energy*** Seabrook will determine expansion from original construction until the time the extensometers are installed ***and then add the*** ~~(preinstrument +~~ extensometer measurement~~s)~~.

The method to determine the total ASR induced through-thickness expansion at each instrument location at Seabrook ***Station*** is to ~~use a~~ determine~~d~~ ~~pre instrument~~ expansion ***at the time the extensometer is installed*** based on the reduction in modulus of elasticity.

The foundation of the approach for determining expansion in the through-thickness direction prior to installing an extensometer is the universal agreement among published sources that elastic modulus decreases with ASR progression. NextEra Energy Seabrook could have used the literature data to produce a generic correlation between reduction of elastic modulus and expansion, but instead elected to pursue a more precise relationship that was more representative of Seabrook Station. The correlation relating through-thickness expansion to elastic modulus is based exlusively on data from the MPR/FSEL test programs, which has several important advantages:

- ***All data are from cores removed from reinforced concrete that has a reinforcement configuration that is comparable to Seabrook Station. Accordingly, the test data reflect ASR development is a stress field that was more representative of an actual plant structure than literature data, which are typically based on unconfined cylinders.***

- ***The cores were obtained from test specimens that have a concrete mixture design that is as representative of Seabrook Station as practical.***

- ***The test programs were conducted under a Nuclear Quality Assurance program that satisfies the requirements of 10 CFR 50, Appendix B.***

~~A correlation relating expansion to reduction in elastic modulus was developed from the large scale testing program data. This correlation is applicable to reinforced concrete structures at Seabrook. The elastic modulus was chosen because the large scale test program showed it to be the most sensitive and most repeatable material property. The test data used to generate the correlation were obtained from the test specimens that were designed to be as representative as practical of the concrete at Seabrook, including the reinforcement detailing. Additionally, comparison against literature data shows that the correlation follows a trend that is consistent with other published studies.~~

The extensometer measurements will provide direct measurements of through-thickness expansion going forwards. The measurements are the parameter to be monitored. The elastic modulus will not be monitored going forward. Pre-instrument expansion is calculated initially to establish expansion to date and is not repeated ***(except for the purpose of studies to corroborate applicability of the correlation, which are discussed in the license renewal commitments).***

Volumetric Expansion

To support that concrete at Seabrook Station is appropriately represented by the specimens from the large scale test programs, NextEra Energy Seabrook will also monitor volumetric expansion using the CCI data and extensometer data.

Volumetric expansion is the sum of expansion in each of the principal directions, as shown in the equation below.

$$\varepsilon_v = \varepsilon_1 + \varepsilon_2 + \varepsilon_3$$

Where:

ε_v ***= volumetric expansion***
ε_1 ***= principal strain (e.g., in the length direction)***
ε_2 ***= principal strain (e.g., in the height direction)***
ε_3 ***= principal strain (e.g., in the depth direction)***

Because Seabrook Station uses combined cracking index (CCI) to characterize in-plane expansion, this equation is re-written as follows:

$$\varepsilon_v = 2 \times (0.1 \times CCI) + \varepsilon_{TT}$$

Where:

ε_v ***= volumetric strain, %***
CCI = combined cracking index, mm/m
ε_{TT} ***= through-thickness expansion, %***

Structural Limit States

The applicable design codes provide methodologies to calculate structural capacities for the various limit states and loading conditions applicable to Seabrook Station. Each relevant limit state was evaluated using published literature and the results of the MPR/FSEL large-scale test programs that used specimens designed and fabricated to represent reinforced concrete at Seabrook Station. The following guidance applies for structural evaluations of ASR-affected concrete structures at Seabrook Station:

- Flexure/Reinforcement Anchorage - Based on the MPR/FSEL large-scale test program results, structural evaluations should consider that there has been no adverse impact on flexural capacity and reinforcement anchorage (development length) performance, provided that through-thickness expansion is at or below bounding conditions of the large scale testing and expansion behavior is comparable to the test specimens, ***including through-thickness and volumetric expansion.***

- Shear – Based on the MPR/FSEL large-scale test program results, structural evaluations should consider that there has been no adverse impact on shear capacity, provided that through-thickness expansion is at or below bounding conditions of the large scale testing and expansion behavior is comparable to the test specimens, ***including through-thickness and volumetric expansion.***

- Anchors and Embedments – Based on the MPR/FSEL large-scale test program results, structural evaluations should consider that there is no adverse effect to post-installed or cast in place anchor/embedment capacity, provided that in-plane expansions remain at or below limits established by large scale testing. Through-thickness expansion is not relevant for anchor/embedment capacity.

ELEMENT 4 - DETECTION OF AGING EFFECTS

Monitoring walkdowns are performed on a periodic basis. The Structures Monitoring Program (SMP) walkdowns identify areas that show symptoms of ASR being present. The SMP includes periodic visual inspection of structures and components for the detection of aging effects specific for that structure. The inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found. A structure found in a harsh environment is defined as one that is in an area that is subject to outside ambient conditions, very high temperature, high moisture or humidity, frequently large cycling of temperatures, frequent exposure to caustic materials, or extremely high radiation levels. For structures in these harsh environments, the inspection is conducted on a five (5) year basis (plus or minus one year due to outage schedule and two inspections within ten years. Structures not located in an area qualifying as a harsh environment are classified as being in a mild environment, and are inspected on a ten (10) year basis (plus or minus one year due to outage schedule and two inspections within twenty years).

In-Plane Expansion

As previously discussed in Element 3, Seabrook ***Station*** uses the CCI methodology to monitor the expansion of ASR affected areas in the in-plane direction. ~~A CCI is established at thresholds at which structural evaluation is necessary. The~~ CCI of less than 1.0 mm/m can be deemed acceptable with deficiencies (Tier 2). Deficiencies determined to be acceptable with further review are trended for evidence of further degradation. A CCI of 1.0 mm/m or greater requires structural evaluation (Tier 3). All locations meeting Tier 3 will be monitored via CCI on a ½ year (6-month) inspection frequency. All locations meeting Tier 2 will be monitored on a 2.5 year (30-month) frequency. In the event ASR monitoring results indicate a need to amend either the monitoring program acceptance criteria or the frequency of monitoring, NextEra Energy Seabrook will take such action under the Operating Experience element of the Alkali-Silica Reaction ~~Monitoring~~ ***Aging Management*** Program. ***(Structural calcuations that support the Structural Deformation AMP may indicate that more frequent CCI monitoring (e.g., semiannually) may be appropriate for locations that have CCI of less than 1.0 mm/m (Tier 1 or 2). NextEra Energy Seabrook will perform in-plane expansion monitoring at whichever interval is more frequent.)***

Seabrook ***Station*** has established reference grids that track the CCI of ASR affected areas. These grids are 20" x 30" and consist of three parallel vertical lines and two parallel horizontal lines. Measurement ~~referenced~~ points (gage points) are installed at the intersections of horizontal and vertical lines of the reference grid to allow for long-term monitoring of potential ongoing expansion. The CI is obtained from measurements of crack widths along a set of lines drawn on the surface of a concrete member. Expansion is documented by measuring the increase in the length of the lines used to determine the CI (distance between gage points). A pocket-size crack comparator card and an optical comparator are used to take the measurements.

The location of the CCI reference grid is established in the area that appears to exhibit the most-severe deterioration due to ASR (accessibility and structure geometry also factor into the decision making progress on where to establish a grid). At Seabrook ***Station*** the axes of the reference grid/grids are parallel and perpendicular to the main reinforcement of the associated reinforced concrete member.

CCI correlates well with strain in the in-plane directions and the ability to visually detect cracking in exposed surfaces making it an effective initial detection parameter. CCI's limitation for ~~heavily~~ reinforced structures ***at Seabrook Station*** is that in-plane expansion (and therefore CCI) ~~has been~~

~~observed to~~***will*** plateau at a relatively low level of accumulated strain***.*** ***This behavior was demonstrated*** in test specimens from the MPR/FSEL large scale testing program***s***. No ***adverse*** structural impacts from ASR ***were observed*** ~~have been seen~~ at these plateau levels in the large scale testing program. While CCI ~~remains~~ ***is*** useful for the detection and monitoring of ASR at the initial stages, an additional monitoring parameter in the ~~out-of-plane~~ ***through-thickness*** direction is required to monitor more advanced ASR progression. The difference between the in-plane expansion and the through-thickness expansion is due to the reinforcement detailing and the resulting difference in confinement between the in-plane and through-thickness direction. Through thickness expansion is less confined due to the fact that there is no reinforcement in that direction, therefore, expansion occurs preferentially in the through-thickness direction. Similarly, for unreinforced concrete backfill, expansion occurs in all directions.

~~Out of Plane~~ *Through-Thickness* Expansion

The need for ~~out of plane~~ ***through-thickness*** expansion monitoring is triggered by a CCI exceeding 1 mm/m. The expansions of the test specimens in the MPR/FSEL large-scale test programs were significantly more pronounced in the through-thickness direction (i.e. perpendicular to the reinforcement mats) than the in-plane directions (i.e. on the faces of the specimens parallel to the reinforcement mats).

~~Elastic Modulus~~ *Pre-Instrument Expansion*

To determine expansion to date at a location selected for instrument installation, Seabrook ***Station*** ~~will be~~ remov***es***~~ing~~ concrete cores at the location in which the instruments ~~will be~~ ***are*** installed and tests them for compressive strength and elastic modulus. Using the methodology from MPR-4153, the elastic modulus values are used to determine pre-instrument expansion in the through-thickness direction.

~~Concrete cores will be removed from all Tier 3 locations for material property testing.~~ Cores removed for ***material*** property testing ~~will~~ have the approximate dimensions of 4" diameter × 8" length and ~~will be~~ ***are*** tested in accordance with ASTM C39 for Compressive Strength and C469 for Elastic Modulus. The cores ~~will be~~ ***are*** taken perpendicular to the reinforcement mat.

The cores are ~~A~~ visual***ly*** examin***ed***~~ation~~ ***to*** confirm there is no mid-plane crack or edge-effect cracking.

Snap-Ring Borehole Extensometer

Seabrook ***Station*** ~~will~~ install***s*** Snap-Ring Borehole Extensometers (SRBEs) at the station to monitor through-thickness expansion. The ***MPR/FSEL*** ~~Large Scale~~ test~~ing~~ program evaluated performance of the SRBEs, along with two other instrument types, in a test specimen representative of the concrete at Seabrook Station over a one-year period. The SRBE provided accurate measurements of through-thickness expansion throughout the test program and did not exhibit any problems related to reliability. The test program involved cycles of extended exposure to high temperature and humidity, which bounds the conditions expected at Seabrook Station.

The SRBE consists of a graphite rod that is held in place by an anchor placed in the borehole. Measurements are performed by using a depth micrometer to measure the distance from a reference anchor at the surface of the concrete to the end of the graphite rod. The SRBE design contains no electronics and does not require calibration. ~~Therefore,~~ ***F***ailure of the SRBE is unlikely. In the event that an SRBE did fail (e.g., an anchor broke loose), Seabrook ***Station*** could install another SRBE nearby to the failed location and continue expansion monitoring. This will not result in significant loss of data.

A SRBE ~~will be~~ ***is*** installed in a core bore at each Tier 3 location. The elastic modulus ~~will be~~ ***is*** only ~~be~~ determined at the time of core removal to determine pre-instrument expansion to date. Additionally, mid-plane or edge-effect cracking ~~will be~~ ***is*** visually observed at the time of core removal. SRBE monitoring ~~will be~~ is conducted on a six month frequency.

<u>Volumetric Expansion</u>

Although the test programs identified through-thickness expansion as the most sensitive correlating parameter, ASR expansion can also be characterized in terms of volumetric expansion. To support that concrete at Seabrook Station is appropriately represented by the specimens from the large scale test programs, NextEra Energy Seabrook also monitors volumetric expansion by using the CCI and extensometer measurements to calculate volumetric expansion at each monitoring location where an extensometer is installed. Volumetric expansion is determined at each monitoring interval (i.e., every six months for Tier 3 locations). An advantage of the volumetric expansion parameter is that it accounts for expansion in all three principal directions, which will address slight variation among in-plane expansion values at different locations throughout Seabrook Station.

ELEMENT 5 - MONITORING AND TRENDING

The progression of ASR degradation of the concrete is an important consideration for assessing the long term implications of ASR and specifying monitoring intervals. The most reliable means for establishing the progression of ASR degradation is to monitor expansion of the *in situ* concrete. Results of walkdowns are initially reviewed by a licensed Professional Engineer (PE) or qualified person to determine whether the symptoms shown have potential to be ASR and if CCI measurements are needed.

In-Plane and ~~Out of Plane~~ *Through-Thickness* Expansion
For anchor capacity, shear capacity, and reinforcement anchorage, ***NextEra Energy Seabrook*** uses in-plane expansion (CCI) and ~~out of plane~~ ***through-thickness*** expansion (modulus + SRBE measurements) to ~~compare with~~ ***apply*** the test results from the ***MPR/FSEL*** ~~Large Scale~~ test~~ing~~ program.

ASR is a slow progressing phenomenon. ***NextEra Energy*** Seabrook will consider the rate at which a location is approaching the CCI and expansion limits and take appropriate action to ensure continued structural adequacy.

Volumetric Expansion
For shear capacity and reinforcement anchorage, NextEra Energy Seabrook uses volumetric expansion to compare observed ASR progression at the plant with the test specimens from the MPR/FSEL large scale testing programs.

ASR is a slow progressing phenomenon. NextEra Energy Seabrook will consider the rate at which a location is approaching the CCI and expansion limits and take appropriate action to ensure continued structural adequacy.

ELEMENT 6 - ACCEPTANCE CRITERIA

Identification of the typical symptoms indicative of ASR generates the need to initially start monitoring the area using CCI. For the structures subject to ASR monitoring, rebar strain as a result of ASR induced stresses and ASR induced stresses in combination with design bases loads will be verified to be within code allowable limits.

In-Plane *Expansion for Initial Screening*
A Combined Cracking Index (CCI) is established at thresholds at which structural evaluation is necessary (see table below). The Cracking Index (CI) is the summation of the crack widths on the horizontal or vertical sides of 20-inch by 30-inch grid on the ASR-affected concrete surface. The horizontal and vertical Cracking Indices are averaged to obtain a Combined Cracking Index (CCI) for each area of interest. A CCI of less than the 1.0 mm/m can be deemed acceptable with deficiencies (Tier 2). Deficiencies determined to be

acceptable with further review are trended for evidence of further degradation. The change from qualitative monitoring to quantitative monitoring occurs when the Cracking Index (CI) of the pattern cracking equals or is greater than 0.5 mm/m in the vertical and horizontal directions. Concrete crack widths less than 0.05 mm cannot be accurately measured and reliably repeated with standard, visual inspection equipment. A CCI of 1.0 mm/m or greater requires structural evaluation (Tier 3). All locations meeting Tier 3 criteria will be monitored via CCI (in-plane expansion) and borehole extensometers (through-thickness expansion) on a ½ year (6-month) inspection. All locations meeting the Tier 2 structures monitoring criteria will be monitored on a 2.5 year (30-month) frequency. CCI correlates well with strain in the in-plane directions and the ability to visually detect cracking in exposed surfaces making it an effective initial detection parameter. Tier 1 structures do not display signs of ASR and are monitored consistent with the Structures Monitoring Program. In the event ASR monitoring results indicate a need to amend either the monitoring program acceptance criteria or the frequency of monitoring, NextEra Energy Seabrook will take such action under the Operating Experience element of the Alkali-Silica Reaction ~~Monitoring~~ ***Aging Management*** Program.

Tier	**Structures Monitoring Program Category**	**Recommendation for Individual Concrete Components**	**Criteria**
3	Unacceptable (requires further evaluation)	▪ Structural Evaluation ▪ Implement enhanced ASR monitoring, such as through-wall expansion monitoring using Extensometers.	1.0 mm/m or greater Combined Cracking Index (CCI)
2	Acceptable with Deficiencies	Quantitative Monitoring and Trending	▪ 0.5 mm/m or greater CCI ▪ CI of greater less than 0.5 mm/m in the vertical and horizontal directions.
		Qualitative Monitoring	Any area with visual presence of ASR (as defined in FHWA-HIF-12-022) accompanied by a CI of less than 0.5 mm/m in the vertical and horizontal directions.
1	Acceptable	Routine inspection as prescribed by the Structural Monitoring Program	Area has no indications of pattern cracking or water ingress. No visual symptoms of ASR.

Criterion of 1mm/m distinguishes between Tier 2 and Tier 3 locations in relation to CCI. The large scale test program shows agreement between embedded pins and CCI, therefore ensuring CCI is acceptable. A structural evaluation is needed when the CCI reaches what is classified as Tier 3 (CCI > 1 mm/m). The structural evaluation should reflect the current expansion levels of the structure.

For ASR-affected structures within the scope of the Building Deformation AMP, the structural evaluation for building deformation fulfills the requirement in the ASR AMP for structural evaluation of Tier 3 structures. For ASR-affected structures that are within the scope of the ASR AMP but not within the scope of the Building Deformation AMP, a structural evaluation that considers the effects of ASR may not exist at the time it reaches Tier 3. In such cases, it will be necessary to perform the evaluation.

If a structural evaluation has already been performed to evaluate building deformation, plant personnel will verify that the in-plane expansion included in the structural evaluation bounds the as-found condition. If necessary, the existing evaluation will be updated to bound the as-found condition and provide margin for future expansion.

It is noted that the Tiers are intended for (1) initial screening of structures, (2) determination of when to install extensometers, and (3) determination of the base monitoring frequency.

Once a structural evaluation is performed for building deformation, the monitoring frequency will be established based on the most stringent criteria. For example a Stage 2 Building Deformation Evaluation that is monitored on a 30 month frequency may have Tier 3 CCI location monitored on a six month frequency and a Stage 3 Building Evaluation that is monitored on a 6 month frequency may have Tier 2 CCI locations that will also be monitored on a 6 month frequency.

In-Plane Expansion for Anchor Bolts and Structural Attachments
A specific in-plane expansion acceptance criterion[3] was established for anchor capacity by the large scale test program test reports, and is presented in FP#101020 Section 2.1. Maintaining this limit is assured by periodically measuring in-plane expansion in areas affected by ASR.

~~**Out of Plane**~~ ***Through-Thickness Expansion***
In areas in which the CCI is classified as Tier 3, the expansion due to ASR will be monitored in the through-thickness direction as well. Specific acceptance criteria have been established by the large scale test program test reports, and are ***presented in FP#101020, Section 2.1*** ~~summarized in the Table below~~. Maintaining these limits is assured by periodically measuring through-thickness expansion in areas affected by ASR.

~~Effect of ASR on Structural Limit States~~

~~**Structural Design Issue**~~	~~**Criteria**[4]~~
~~Flexure & reinforcement anchorage~~	~~See FP#101020 - Section 2.1 ***for through-thickness expansion limit***~~
~~Shear~~	~~See FP#101020 - Section 2.1 ***for through-thickness expansion limit***~~
~~Anchor bolts and structural attachments~~	~~See FP#101020 - Section 2.1 ***for in-plane expansion limit***~~

[3] Expansion Limit Criteria are considered proprietary to NextEra Energy Seabrook. FP #101020 MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," July 2016, was previously submitted to the NRC in SBK-L-16071; 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; Dated August 1, 2016

[4] ~~Expansion Limit Criteria is considered proprietary to NextEra EnerySeabrook. FP #101020 MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on the Structural Design Evaluations," July 2016, was previously submitted to the NRC in SBL-L-16071; 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; Dated August 1, 2016~~

Volumetric Expansion

In areas in which the CCI is classified as Tier 3, the expansion due to ASR will be monitored in the through-thickness direction as well. Specific acceptance criteria have been established by the large scale test program test reports, and are summarized in FP#101050, Appendix B. Maintaining these limits is assured by periodically measuring through-thickness expansion in areas affected by ASR.

ELEMENT 7 - Corrective Actions

Evaluations will be performed under the ***NextEra Energy*** Seabrook Corrective Action Program (CAP) and an appropriate analysis will be performed to evaluate against the design basis of that structure. The NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 7 Corrective Actions.

ELEMENT 8 - CONFIRMATION PROCESS

The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 8 Confirmation Process.

ELEMENT 9 - ADMINISTRATIVE CONTROLS

The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 9 Administrative Controls.

ELEMENT 10 - OPERATING EXPERIENCE

The primary source of OE, both industry and plant specific, was the ***NextEra Energy*** Seabrook ~~Station~~ Corrective Action Program documentation. The ***NextEra Energy*** Seabrook ~~Station~~ Corrective Action Program is used to document review of relevant external OE including INPO documents, NRC communications and Westinghouse documents, and plant specific OE including corrective actions, maintenance work, orders generated in response to a structure, system or component deficiencies, system and program health reports, self-assessment reports and NRC and INPO inspection reports.

Newly Identified Operating Experience (OE)

NextEra Energy Seabrook will update the Aging Management Program for any new plant-specific or industry OE. This includes ongoing industry studies performed both nationally and internationally. Research data taken from these studies will be used to enhance the ASR program, if applicable. In addition NextEra ***Energy*** Seabrook has submitted a License Amendment Request to the Commission in accordance with 10CFR50.90 to incorporate a revised methodology related to ASR material properties and building deformation analysis for review and approval. NextEra ***Energy Seabrook*** will incorporate changes related to this LAR submittal as necessary to maintain alignment of the aging management program to the current license basis.

Groundwater Operating Experience

Historically, NextEra Energy Seabrook has experienced groundwater infiltration through cracks, capillaries, pore spaces, seismic isolation joints, and construction joints in the below grade walls of concrete structures. Some of these areas have shown signs of leaching, cracking, and efflorescence on the concrete due to the infiltration. During the early 1990's an evaluation was conducted to assess the effect of the groundwater infiltration on the serviceability of the concrete walls. That evaluation concluded that there would be no deleterious effect, based on the design and placement of the concrete and on the non-aggressive nature of the groundwater.

In 2009, NextEra ***Energy Seabrook*** tested seasonal groundwater samples to support the development of a License Renewal Application. The results showed some of the groundwater to be aggressive. Ground water testing performed in November 2008 and September 2009 found pH values between 6.01 and 7.51, chloride values between 19 ppm and 3900 ppm, and sulfate values between 10 ppm and 100 ppm. Aggressive chemical attack becomes a concern when environmental conditions exceed threshold values (Chlorides > 500 ppm, Sulfates >1500 ppm, or pH < 5.5). Based on determination of aggressive ground water and observed efflorescence on the concrete surface, NextEra ***Energy Seabrook*** initiated a comprehensive review of possible effects to concrete of in-scope structures.

ASR Identification OE

In 2009, NextEra ***Energy Seabrook*** performed a qualitative walkdown of plant structures and the "B" Electrical Tunnel was identified as showing the most severe indications of groundwater infiltration. Concrete core samples from this area were removed, tested for compressive strength and modulus of elasticity, and subjected to petrographic examinations. The results showed that both compressive strength and modulus of elasticity were less than the expected values, which is symptomatic of ASR. The results of the petrographic examinations also showed that the samples had experienced Alkali-Silica Reaction (ASR).

NextEra ***Energy Seabrook*** initiated an extent of condition evaluation and concrete core samples were taken from five additional areas of the plant that showed characteristics with the greatest similarity to the "B" Electrical Tunnel. Additional concrete core samples were also taken from an expanded area around the original concrete core samples in the "B" Electrical Tunnel.

Tests on these core samples confirmed that the original "B" Electrical Tunnel core samples show the most significant ASR. For the five additional areas under investigation, final results of compressive strength and modulus testing indicate that the compressive strength in all areas is greater than the strength required by the design of the structures. Modulus of elasticity was in the range of the expected value except for the Diesel Generator, Containment Enclosure Buildings, Emergency Feedwater Pumphouse, and the Equipment Vaults, which were less than the expected value in localized areas.

Evaluation of the affected structures concluded that they are fully capable of performing their safety function but margin had been reduced. Material property results from cores removed from a reinforced concrete structure do not properly represent the actual structural performance because the structural context is lost. However, the areas are potentially subject to further degradation of material properties due to the effects of ASR.

Confirmation of Overall Expansion Behavior

NextEra Energy Seabrook will perform several actions to confirm that expansion behavior at the plant is consistent with the specimens from the MPR/FSEL Large Scale Test Programs. These actions assess similarity of expansion behavior in terms of trends between directions and expansion levels ~~(in-plane, through-thickness, volumetric).~~ The actions also include corroborating the correlation of normalized modulus versus through-thickness expansion derived from the MPR/FSEL testing against plant data. This AMP may be updated as necessary to account for any findings from these checks, which are described in the table below.

Objective	Approach	When
Ongoing Monitoring ***(See AMP Elements 3 through 6)***		
Expansion within limits from test programs	Compare measured in-plane expansion (ε_{xy})***,*** ~~and~~ through-thickness expansion (ε_z)***, and volumetric expansion (ε_v)*** at the plant to limits from test programs	Intervals as specified in AMP
Lack of mid-plane crack	Inspect cores removed from ASR-affected structures (and boreholes) for evidence of mid-plane cracks	When cores are removed to install extensometers or for other reasons.
Periodic Confirmation of Expansion Behavior		
Lack of mid-plane crack	Review of records for cores removed to date or since last assessment	Periodic assessments • At least 5 years prior to the Period of Extended Operations (PEO) • Every 10 years thereafter
Expansion initially similar in all directions but becomes preferential in z-direction	Compare ε_{xy} to ε_z using a plot of ε_z versus Combined Cracking Index (CCI)	
Expansions within range observed in test programs	Compare measured ε_{xy}, ~~and~~ ε_z ***and ε_v*** at the plant to limits from test programs to check margin for future expansion	
	~~Compare measured volumetric expansion to range from beam test~~	

	programs and check margin for future expansion	
Corroborate modulus-expansion correlation with plant data ***(A secondary objective of these studies is to provide additional data to confirm that expansion behavior at the plant is comparable to the test specimens.)***	For ***20% of the*** 3 extensometer locations with pre-instrument ε_z in the observed expansion range : • Remove cores for modulus testing at extensometer locations with more significant changes in extensometer readings. • Compare $\Delta\varepsilon_z$ determined from the modulus-expansion correlation with $\Delta\varepsilon_z$ determined from the extensometer ***and the original modulus result*** ***A detailed explanation of this approach is provided in MPR-4301-Seabrook Station License Renewal and License Amendment - Input for Requests for Additional Information Responses Regarding Aging Management for Alkali-Silica Reaction (SBK-L-17155).***	At least 5 years prior to PEO (initial study) and 10 years thereafter (follow-up study).

EXCEPTIONS TO NUREG-1800

None

ENHANCEMENTS

- Implement the Alkali-Silica Reaction (ASR) Monitoring
- Revise the ***NextEra Energy*** Seabrook Structural Monitoring Procedure EDS 36180 to include Alkali-silica reaction description, aging effects, inspection criteria, acceptance criteria.
- Revise the ***NextEra Energy*** Seabrook ASME Section XI, Subsection IWL Program ES1807.031 to include Alkali-silica reaction aging effects.

CONCLUSION

To manage the aging effects of cracking due to expansion and reaction with aggregates in concrete structures, the existing Structures Monitoring Program, B.2.1.31, and ASME Section XI, Subsection IWL Program, B.2.1.28 have been augmented by this plant specific Alkali-Silica Reaction (ASR) ***Aging Management*** ~~Monitoring~~ Program ***(AMP),*** B.2.1.31A.

Routine inspections are performed by the Structures Monitoring and the ASME Section XI, Subsection IWL Program. Areas that have no visual presence of ASR are considered "acceptable" (Tier 1). An area with a Combined Cracking Index (CCI) of less than 1.0 mm/m is deemed "acceptable with deficiencies" (Tier 2). An area with a CCI of 1.0 mm/m or greater is deemed "unacceptable" and requires further evaluation (Tier 3). In addition, an area that meets Tier 3 requirements will be monitored for through-thickness expansion in addition to CCI. ***In such areas, the through-thickness expansion and CCI values will be used to determine volumetric expansion.***

Evaluations will be performed under the ***NextEra Energy*** Seabrook Corrective Action Program (CAP) and an appropriate analysis will be performed to evaluate against the design basis of that structure.

The ***NextEra Energy*** Seabrook ~~Station~~ ASR ***AMP*** ~~***Monitoring Program***~~ provides reasonable assurance that the effects of aging of in-scope concrete structures due to the presence of Alkali-Silica reaction will be managed to ensure the structures continue to perform their intended function consistent with the current licensing basis for the period of extended operation.

B.2.1.31B BUILDING DEFORMATION

PROGRAM DESCRIPTION

The Building Deformation ~~Monitoring~~ ***Aging Management*** Program ***(AMP)*** is a new plant specific program being implemented under the existing Maintenance Rule Structures Monitoring Program. Building Deformation is an aging mechanism that may occur as a result of other aging effects of concrete. Building Deformation at Seabrook ***Station*** is primarily a result of the alkali silica reaction (ASR) described in LRA section B.2.1.31A but can also result from swelling, creep, and shrinkage. Building deformation can cause components within the structures to move such that their intended functions may be impacted.

The Building Deformation ~~Monitoring~~ ***Aging Management*** Program uses visual inspections associated with the Structures Monitoring Program and cracking measurements associated with the Alkali-Silica Reaction program to identify buildings that are experiencing deformation. The first inspection is a baseline to identify areas that are exhibiting surface cracking. The surface cracking will be characterized and analytically documented. This inspection will also identify any local areas that are exhibiting deformation. The extent of surface cracking will be input into an analytical model. This model will determine the extent of building deformation and the frequency of required visual inspections.

For building deformation, location-specific measurements (e.g. via laser target and gap measurements) will be compared against location-specific criteria to evaluate acceptability of the condition.

Structural evaluations will be performed on buildings and components affected by deformation as necessary to ensure that the structural function is maintained. Evaluations of structures will validate structural performance against the design basis, and may use results from the large-scale test programs, as appropriate.

Evaluations for structural deformation will also consider the impact to functionality of affected systems and components (e.g., conduit expansion joints). NextEra ***Energy Seabrook*** will evaluate the specific circumstances against the design basis of the affected system or component. Structural evaluations will be used to determine whether additional corrective actions (e.g., repairs) to the concrete or components are required. Specific criteria for selecting effective corrective actions will be evaluated on a location-specific basis.

PROGRAM ELEMENTS

The following provides the results of the evaluation of each program element against the 10 elements described in Appendix A of NUREG-1800 Rev. 1, *"Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants".*

ELEMENT 1 - SCOPE OF PROGRAM

The ***NextEra Energy*** Seabrook Building Deformation ~~Monitoring~~ ***Aging Management*** Program provides for management of the effect of building deformation on concrete structures and associated components within the scope of license renewal. Program scope includes components within the scope of license renewal contained in concrete structures within the scope of the Structures Monitoring Program and License Renewal ASME Section XI Subsection IWL Program. Concrete structures within the scope of this program include:

Category I Structures

- Containment Building (including equipment hatch missile shield)
- Containment Enclosure Building
- Containment Enclosure Ventilation Area
- Service Water Cooling Tower including Switchgear Rooms
- Control Building
- Control Building Make-up Air Intake Structures
- Diesel Generator Building
- Piping (RCA) Tunnels
- Main Steam and Feed Water East and West Pipe Chase
- Waste Processing Building
- Tank Farm
- Condensate Storage Tank Enclosure
- Emergency Feed Water Pump House Building, including Electrical Cable Tunnels and Penetration Areas (Control Building to Containment)
- Fuel Storage Building
- Primary Auxiliary Building including RHR Vaults
- Service Water Pump House
- Service Water Access (Inspection) Vault
- Circulating Water Pump House Building (below elevation 21'-0)
- Safety Related Electrical Manholes and Duct Banks
- Pre-Action Valve Building

Non-Category I Structures

- Intake & Discharge Transition Structure

ELEMENT 2 - PREVENTIVE ACTIONS

There are no preventive actions specified in the ***NextEra Energy*** Seabrook ~~Station~~ Structures Monitoring Program, which includes implementation of NUREG-1801 XI.S5, XI.S6, and XI.S7. These are monitoring programs only. Similarly, the Building Deformation ~~Monitoring~~ ***Aging Management*** Program does not rely on preventive actions.

ELEMENT 3 - Parameters Monitored/Inspected

A three stage process will be used to initially screen for deformation and to analyze the effects on structures for the self-straining loads from ASR expansion, creep, shrinkage, and swelling. Each stage of the process would have increasing levels of rigor. The analysis and evaluation of each structure may begin at any of the three stages. If initial review of a structure determines that a structure cannot be qualified in a particular evaluation stage due to high ASR expansion, low margin in the structural design, or any other limitation that excludes the structure form being qualified at that stage; the structure can be evaluated at a higher stage evaluation that employs more rigor. Ultimately the structure is classified according to the stage in which it is qualified to meet the design code requirements and monitored accordingly. For example, a stage 2 structure is qualified using a Stage 2 evaluation and thresholds are monitored to stage 2 thresholds.

<u>Review, Acquisition, and Assessment of Deformation Data</u> - The initial step in the deformation analysis process involves reviewing existing data and performing additional field surveys of structures. Since ASR was initially identified at Seabrook ***Station*** in 2009, NextEra ***Energy Seabrook*** has gathered visual inspection data and obtained ASR expansion measurement data for each structure through the Structures Monitoring Program. Data also were collected in walkdowns to identify potential interactions between deformed structures and plant components. Recently, seismic gap measurements were obtained for building deformation. Collectively, the ASR expansion and building deformation measurement data can be used to analytically determine the deformed shape of each structure.

NextEra ***Energy Seabrook*** will initially review the data obtained for each structure to determine if additional measurements are needed to characterize the deformed shape of the structure. A review of the structure and associated data determines which of the three stages is appropriate to analyze each structure. The stage of analysis and the amount of field data required for each building depends on the following considerations:

- The design margins of the undeformed structure when design basis loads are applied;
- The locations where design margins are a minimum;
- The magnitude of ASR expansion and deformation measured in the structure;
- The orientation and complexity of deformation measurements, and;
- The complexity of the structure.

The review of data assesses that there are sufficient data to characterize structure deformation corresponding to the stage of analysis used to evaluate the structure. If the data assessment concludes that more data are necessary to characterize ASR expansion in the structure, then additional data will be obtained in the form of Crack Index (CI) measurements in ASR affected areas, identification/measurements of expansion induced cracks, measurements between points on the structure, and/or measurements relative to adjacent structures (e.g., seismic gap measurements).

The amount of data needed for the analysis increases with the stage of analyses being performed to qualify each structure. The Stage 1 analysis is based on maximum ASR strain measured by Crack Index (CI) measurements performed at locations with most pattern cracking based on visual inspection for a structure or a region of the structure. The amount of CI data that are needed increases when a structure is evaluated for a higher stage of analysis. A Stage 3 analysis includes a sufficient number of CI measurements to accurately calculate the mean ASR strain in a region of a structure. The number of CI measurements for a region will be determined through one of the following approaches:

- For large regions, a number of CI measurements are selected such that additional CI measurements would not cause a significant change to the computed mean ASR strain.
- For small regions, the number of CI measurement grids will be based on the ratio of measured area to the total area.

  Alternatively, the mean ASR strain can be computed using a smaller number of CI measurements if close-up visual inspection of the region affirms that the collected measurements are representative of the region. A Stage 2 analysis uses a quantity of data that is between those described for Stages 1 and 3. Other data such as seismic gap measurements, displacement, deformations, width of structural cracks (if any), and overall expansion for structure are used with graded approach based on the stage of analysis.

Quantify ASR Demands – A finite element model (FEM) will be developed for Stage 2 or 3 analyses in ANSYS that represents the undeformed shape of each structure. The dimensions of the model will be based on design drawings. The model will include all relevant portions of the structure and its foundation. ASR expansion is simulated in the FEM by expanding (i.e., straining) the modeled concrete material at locations where evidence of ASR is observed in the actual structure. The magnitude and distribution of the ASR expansion applied to the FEM is selected to match field measurements and observations. Creep, shrinkage, and swelling that have occurred since each structure was erected could also affect building long term deformation. Although the deformation caused by these long-term conditions is small, these mechanisms are considered in each analysis to more accurately quantify the deformation caused by ASR and long-term loadings. Once the creep, shrinkage, swelling, and ASR expansion are applied to the FEM along with the static deadweight of the structure as a body force, a deformed shape is produced. The deformed shape determined from FEM is compared to the various measurements of the actual deformed shape obtained in the Review, Acquisition and Assessment phase.

Because of inhomogeneity of concrete in structures and the level of detail used to model ASR-affected regions, it may be necessary to adjust the concrete expansion imposed in the ASR-affected regions of the model or make refinements to the shape of ASR regions, while remaining consistent with field measurements, to correlate the predicted shape and extent of deformation with the actual measurements from the structure. If the actual deformed shape of a structure differs from the shape simulated by the FEM, then there may be additional loads on the structure that account for the differences. If the deformed structure cannot be accurately predicted using the FEM and the available measurements, additional measurements will be obtained and the process of verifying the deformation analysis model will be repeated.

Analysis of ASR-Impacted Structure – The overall objective of the deformation analysis is to assess each structure's capacity to withstand design basis loads in conjunction with the ASR expansion loads. Once the FEM is verified by comparing the simulated deformations and strains to measurements of the actual structure, the magnitude of ASR expansion in the affected areas of the structure is amplified by a factor to account for potential future ASR expansion. Then the original design load demands are added to ASR load demands based on the load combinations specified in Seabrook ***Station*** UFSAR Tables 3.8-1, 3.8-14, and 3.8-16. In Stage 3 evaluations, the original design demands are recomputed by applying the associated loads to the FEM. In other stages, the original design demands are generally taken from original design calculations. The results from these analyses are compared to ACI 318-71 or ASME Section III acceptance criteria, as appropriate.

Establish Parameters Monitored and Threshold Limits – The specific locations where ASR exists in each structure and the critical areas where the margin to

Licensing Basis structural design code and design basis acceptance criteria are most limiting influence the locations and types of measurements that are used to monitor each structure. The results from the deformed structure analysis will be reviewed to identify the critical areas for meeting the structural acceptance and seismic gap criteria and the ASR regions that influence the calculated results in the critical areas. Monitoring parameters will be identified and their locations specified based on the review.

Field inspections shall be performed to obtain observations and measurements that can be used to quantify ASR loads applied to each structure. A list of observations and measurements that may be recorded during field inspection is provided in Table 1. A document review shall be performed for each structure. Documents that are necessary to review include design drawings and design criteria. Other additional documents shall also be reviewed as needed in order to perform susceptibility evaluations. All documents reviewed shall be the latest available revision. A list of documents that may be reviewed is provided in Table 2.

The number of monitoring locations and the types of measurements taken will be influenced by the sensitivity of the results to the level of expansion or deformation in these regions as well as the size and shape of ASR-affected areas in the structure.

Table 1. Field Observations and Measurements for Deformation Evaluations

	Parameter	Description
	Cracking suspect of ASR (visual observations)	Qualitative visual observations made of cracking that exhibits visual indications of ASR and ASR-related features, using industry guidelines
	Cracking not suspect of ASR (visual observations)	Qualitative visual observations made of cracking that do not exhibit indications of ASR. These cracks may be structural (i.e. caused by stresses acting on the structure) or caused by shrinkage or other mechanisms aside from ASR.
	Other structural or material distress (visual observations)	Qualitative visual observations made of structural distress, such as buckled plates, broken welds, spalled concrete, delaminated concrete, displacement at embedded plates, damage to coatings, and chemical staining.
	Crack index	Quantitative measurement of in-plane cracking on a concrete structural component using the cracking index measurement procedure
	In-plane strain rate	Quantitative measurement of length between two points installed on a concrete component using a removable strain gage. In-plane expansion is computed as the change in length between measurements recorded at different times.

	Through-thickness expansion	Quantitative measurement of the thickness of a concrete component using an extensometer device. Through-thickness expansion is computed as the change in thickness between measurements recorded at different times.
	Through-thickness strain rate	Calculated value based on measurements of through-thickness expansion over a period of time.
	Individual crack widths/lengths	Quantitative measurement of individual crack widths using either a crack card, an optical comparator, or any other instrument of sufficient resolution. Such measurements shall be accompanied by notes, sketches, or photographs that indicate the pattern of the cracks and their length. Also included in this category are tools that quantify the change in crack widths, such as mountable crack gages, extensometers, and invar wires
	Seismic isolation joints	Quantitative measurement of the width of seismic joints that separate two adjacent structures. Also included in this category are qualitative observations of distress in seals covering or filling isolation joints, such as tears, wrinkles, and bubbles.
	Structure dimensions	Quantitative measurement of a structure's dimensions or the distance between two adjacent structures. Included in this category are measurements of plumbness of walls, levelness of slabs, and bowing/bending of members.
	Equipment/conduit offsets	Quantitative measurement or visual observation of building deformation through the misalignment of equipment and/or the deformation of flexible conduit joints.

Table 2. Document Review for Building Deformation Evaluations

		Documents	**Description**
Review Necessary		Structural design drawings and specifications	Structural design drawings, including excavation drawings, backfill drawings, and adjacent structure drawings as needed
		Original structural design criteria	Structural design criteria, including the Updated Final Safety Analysis Report (UFSAR), documenting loads, load combinations, and strength acceptance criteria for which the structure was originally designed

		Structural design calculations	Structural design calculations documenting the underlying assumptions of the original structural design and original design demands and capacities.
Review As Needed		Construction documentation	Construction documents, drawings, and photos documenting construction stages, concrete placement, etc. This category also includes as-built drawings and survey data following construction.
		Documentation of structural and material tests	Existing documentation of testing, including petrography, that has been performed on the structure or the materials of the structure.

Stage 1 – Susceptibility Screening Evaluation: Each of the seismic Category I structures are screened for susceptibility to structural deformation caused by ASR using existing field data and conservative hand calculations.

Stage 2 – Analytical Evaluation: An analytical evaluation is performed for structures that the Stage 1 Susceptibility Screening Evaluation identifies as susceptible to deformation, but do not satisfy ACI 318-71 acceptance criteria. A finite element model of the structure is used to estimate structural demands due to self-straining loads, while all other demands are taken from existing design calculations. Additional field data is obtained to provide input to the analysis. The evaluation verifies compliance with ACI 318-71 using the same criteria as the original design.

Stage 3 – Detailed Evaluation: A detailed design confirmation calculation is performed when the Stage 2 Analytical Evaluation concludes that some area of a structure does not satisfy ACI 318-71 acceptance criteria or when the structure has sufficient deformation that may impact demands computed in the original design. The detailed evaluation uses the Stage 2 finite element model to compute demands due to self-straining loads as well as all other design loads. In the Stage 3 evaluation, consideration is given to cracked section properties, self-limiting secondary stresses, and the redistribution of structural demands when sufficient ductility is available.

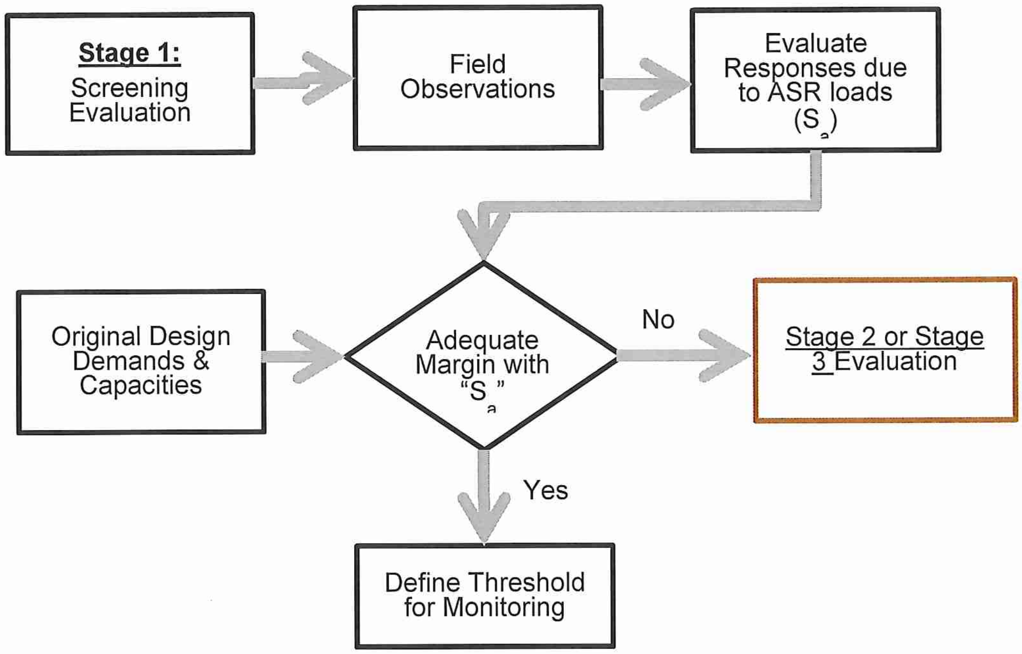
All three stages of the evaluation process use the original design acceptance criteria given in the UFSAR Chapter 3 including separation of structures by seismic gaps. Each analysis stage will determine threshold monitoring limits to define the monitoring frequency and criteria for re-evaluating structures with deformation. The threshold monitoring limits are described below.

Stage 1: Susceptibility Screening Evaluation
NextEra ***Energy Seabrook*** has conducted walkdowns of selected in scope structures and plant equipment to identify items of interest and evaluate the items through the Corrective Action Program for their impact on plant operations. NextEra ***Energy Seabrook*** will perform future walkdowns for all in scope structures. Inspection data from these walkdowns and other measurements obtained for ASR-affected structures will be reviewed to determine if deformation is occurring and to identify potential locations and directions of movement or deformation. The data that will be collected includes measurements of relative building movements, equipment misalignments, and concrete cracking indexes. ASR monitoring grids, which are used to measure the strain in reinforced concrete, were installed on structures throughout the facility. The monitoring grids were installed at the most severe locations for ASR cracking, and therefore, provide a conservative estimate of the strain in the structure. After reviewing existing field data, a walkthrough inspection will be performed to verify field conditions and determine if ASR expansion only affected localized regions of the structure or whether the structure has experienced global deformation of structural members. Field data that are older than three years old shall be verified during this walkthrough inspection.

In the susceptibility screening process, conservative estimates of deformations and strains based on the field data are used to estimate demands caused by self-straining loads for critical locations in the structure. Self-straining loads include four components: ASR, creep, shrinkage, and swelling. Based on guidance in ACI 318-71, creep, shrinkage and swelling are included with the dead load. The ASR demands (identified as "Sa" herein) are factored and then combined with demands due to design loads for critical load combinations in the current licensing basis. An evaluation is performed using strength acceptance criteria as described in the current licensing basis.

For screening evaluations that conclude a structure fully complies with the strength acceptance criteria, the critical locations of the structure are re-evaluated for a higher level of ASR demand to determine the maximum allowable, factored self-straining loads at which the structure meets the design acceptance criteria. A set of monitoring elements (consisting of strain measurements, deformation measurements, seismic gap measurements, and/or other quantifiable behaviors) is established along with threshold limits for each monitoring element. The threshold limits are defined as the maximum measurement for each monitoring element that results in a factored self-straining load equal to the factored self-straining load at the structural design limit (with factored design basis loads included). The threshold limit for the monitoring elements defined in Stage 1 is equal to the set of monitoring element measurements that produce a factored ASR demand that is 90% of the factored self-straining load at the acceptance limit. If a structure monitoring element measurement obtained from walkdowns and other monitoring activities exceeds the monitoring threshold limit, then a Stage 2 Analytical Evaluation is required.

A structure is classified as Stage 1 if the Susceptibility Screening Evaluation concludes that the structure satisfies the strength acceptance criteria and the structure monitoring element measurements are less than the Stage 1 threshold limits. The Susceptibility Screening Evaluation for Stage 1 structures is summarized in a calculation package that supplements the original design calculation. The calculation package also documents the set of monitoring measurements and the threshold limits for the monitoring process. The monitoring measurements and the threshold limits are incorporated into the ***NextEra Energy*** Seabrook Structures Monitoring Program to periodically assess the condition of structures and verify that the structure meets the design acceptance criteria.



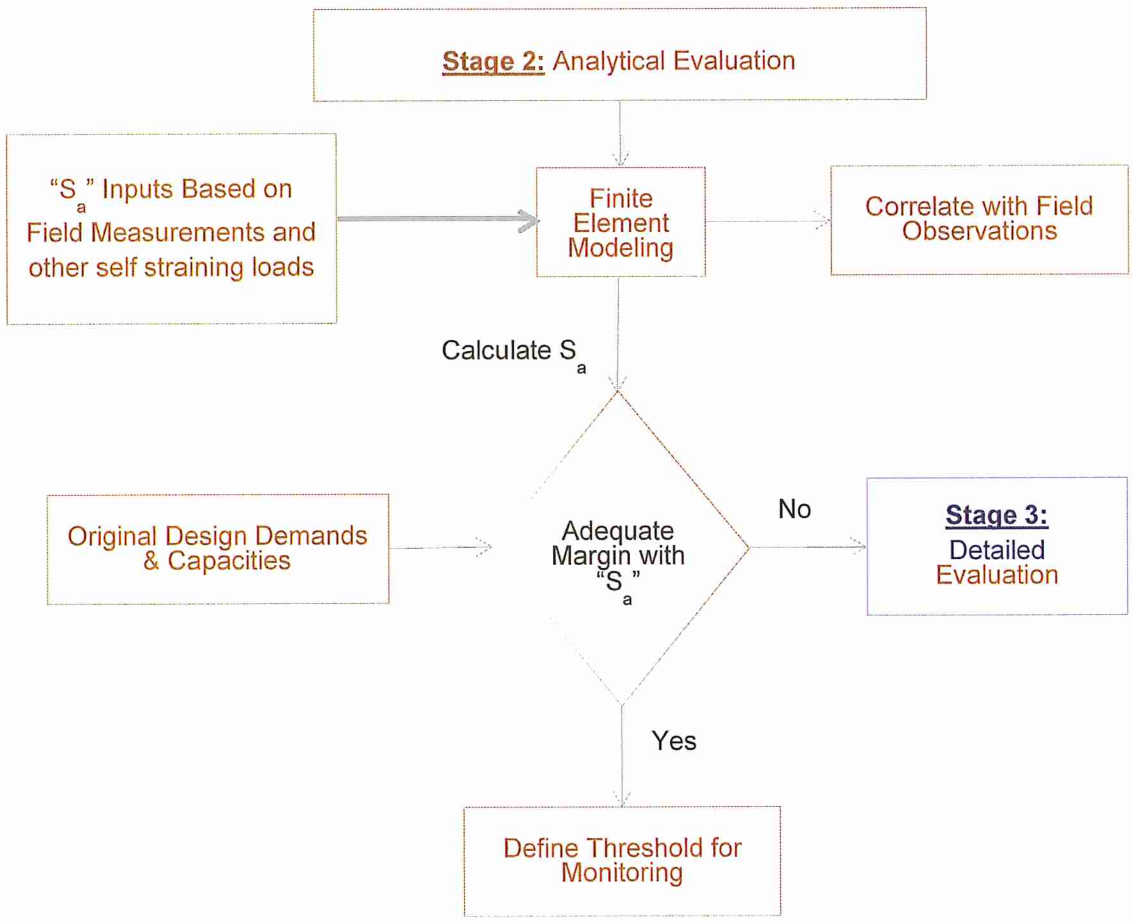
Stage 2: Analytical Evaluation
For structures that cannot be shown to meet the ACI 318-71 acceptance criteria using the conservative methods of the Susceptibility Screening Evaluation or monitoring measurements indicate high Sa demands, an Analytical Evaluation is required. The Analytical Evaluation uses more accurate methods to quantify demands due to self-straining loads. Also, additional inspections are performed to measure structural strains and deformations at a broader range of critical locations of the structure. These measurements would be used to compute the self-straining loads with more accuracy than possible using the inputs from the Susceptibility Screening Evaluation process.

An ANSYS finite element model (FEM) of the structure is created based on design drawings and uncracked design section properties. The model is initially benchmarked to the original design analysis of the structure with only the current licensing basis loads. The FEM is then calibrated such that the deformations and strains due to unfactored sustained loads and self-straining loads are consistent with field measurements. The FEM is used to compute the structural demands due to ASR loads (Sa). The self-restraining demands from finite element analysis are factored and then combined with demands due to factored design loads from the original design calculations for the load combinations described in the current licensing basis. The structural demand in critical regions of the structure are evaluated using strength acceptance criteria described in the current licensing basis. The methods used for the Stage 2 analysis are unchanged from the original design analyses with the exception of accounting for the self-straining loads in the analysis and the use of the ANSYS software program for computing the sustained and self-straining loads.

Structures that satisfy the Analytical Evaluation acceptance criteria are re-evaluated for a higher level of Sa to compute the maximum allowable self-straining loads on the structure. The maximum allowable loads correspond to the maximum, factored self-straining loads at which the structure meets the design acceptance criteria. A set of monitoring measurements are identified and threshold limits are set for each measurement based on the maximum allowable self-straining load. The threshold limits for each monitoring element defined in Stage 2 are determined by scaling all measurements proportionally such that a factored self-restraining demand equal to 95% of the value at the design acceptance limit is achieved.

A structure is classified as Stage 2 if the Analytical Evaluation concludes that the structure satisfies the strength acceptance criteria and the structure monitoring element measurements are less than the Stage 2 threshold limits. The Analytical Evaluation calculation for Stage 2 structures supplements the original design calculation. The monitoring measurements, measuring locations, and threshold limits for monitoring are also included in the supplement to the calculation.

Monitoring elements may include strain measurements, measurements of the relative displacement between structures, component specific measurements (e.g. gap measurements) and other quantifiable parameters. The threshold limits are defined as the maximum allowable measurement for each monitoring parameters that limits the self-straining loads to some fraction of the maximum allowable self-straining load. The monitoring measurements and the threshold limits are used to periodically assess the condition of structures and verify that the structure meets the design acceptance criteria.

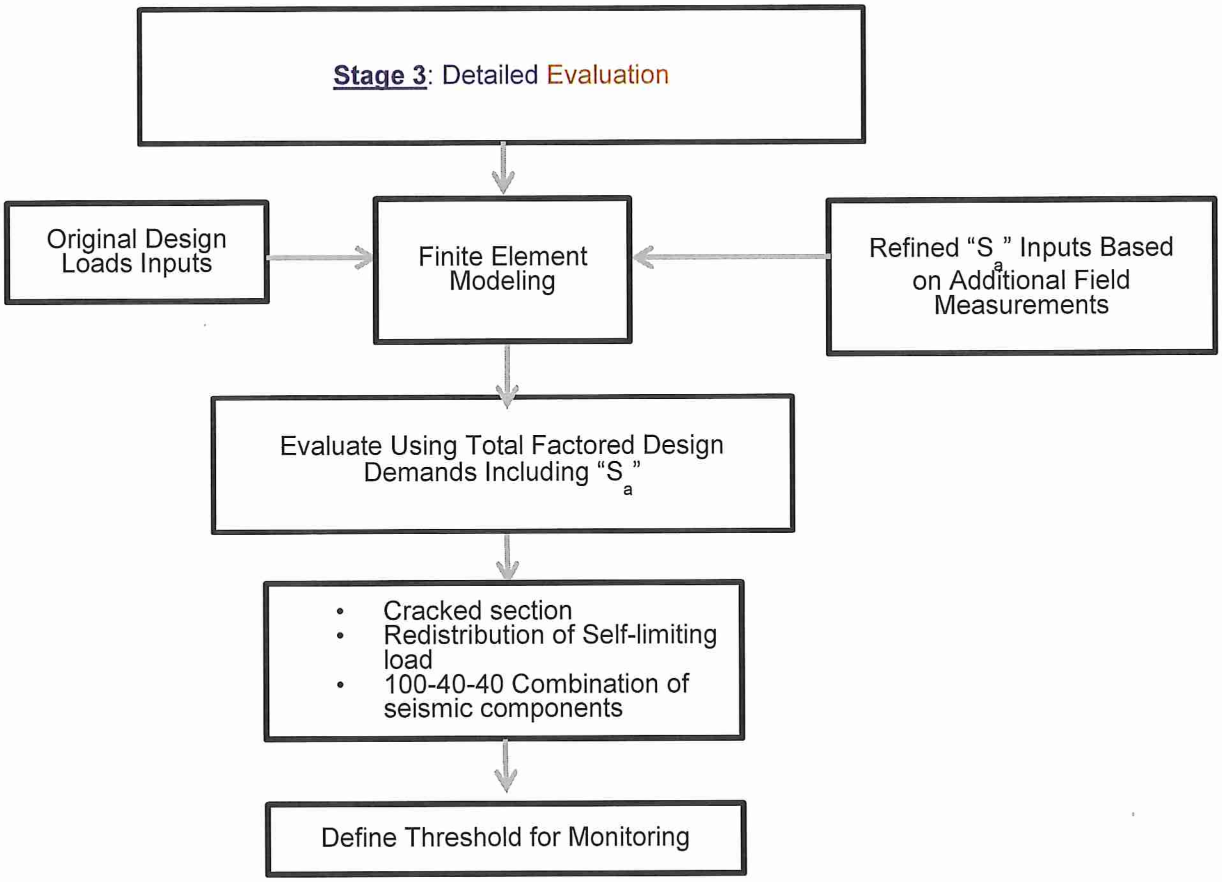


Stage 3: Detailed Evaluation

Structures that do not meet the acceptance criteria of the Stage 2 Analytical Evaluation are analyzed by a Detailed Evaluation. In the Detailed Evaluation, Sa demands and the loads from creep, shrinkage and swelling are recomputed using the Stage 2 FEM. Structural demands due to design loads are recomputed by applying design demands (i.e. wind, seismic, hydrostatic pressure, etc.) to the FEM. A detailed structural evaluation is performed for all load combinations described in the licensing basis. The structure is evaluated using strength acceptance criteria described in the current licensing basis. Consideration is given to force and moment redistribution in regions with localized overstresses and sufficient ductility. In the Stage 3 evaluation, consideration is given to cracked section properties, self-limiting secondary stresses, and the redistribution of structural demands when sufficient ductility is available. The 100-40-40 percent rule in NRC Regulatory Guide 1.92, Revision 3, is used as an alternative to the SRSS method for combining three directional seismic loading in the analysis of seismic, Category I structures that are deformed by the effects of ASR.

Structures that meet the acceptance criteria of the Detailed Evaluation are re-evaluated for a higher level of self-straining load to establish the threshold limits for each monitoring element measurement. A similar process is used as described in the Stage 2 Analytical Evaluation above. The threshold limit for each monitoring element defined in Stage 3 is equal to the limit for the monitoring element measurement that produces a factored Sa load at the design acceptance limit.

The Detailed Evaluation is summarized in a design calculation package that will supersede the original design calculation. The calculation package documents the set of monitoring measurements and the threshold limit of the monitoring measurements for the structures monitoring program to verify that the structure to meets the design acceptance criteria.



Example

An example of the process of determining threshold limits for subsequent monitoring (if required for a particular structure) is described below. For the containment enclosure building, seismic gap measurements and annulus width measurements can be used to monitor deformation of the structure. Specific locations are chosen and threshold limits are set for these locations to ensure license renewal intended functions are met. The calculation of these threshold limits is defined and evaluated using the following equations:

$$\overline{TM} \leq TL$$

$$\overline{TM} = \sum_{i=0}^{n} \left| d_{n,field} - d_{n,design} \right| \times \left(\frac{1}{n}\right)$$

$$TL = \sum_{i=0}^{n} \left[\left| d_{n,baseline} - d_{n,design} \right| \times k_{n,thf} \right] \times \left(\frac{1}{n}\right)$$

$$k_{n,thf} = \frac{d_{n,FEA,1.2}}{d_{n,FEA,baseline}}$$

Where:

$\overline{TM}$ = Average deformation for locations in threshold measurement set

TL = Threshold Limit

n = Number of measurement locations in threshold measurement set

$d_{n,field}$ = Field measurement of threshold measurement n at time of monitoring

$d_{n,design}$ = Design dimension of threshold measurement n

$d_{n,baseline}$ = Field measurement of threshold measurement n at time when TL is established and CEB evaluation is performed

$d_{FEA,1.2}$ = Radial deformation of the CEB at location of threshold measurement n due to unfactored sustained loads plus unfactored self-straining loads with a 1.2 threshold factor

$d_{n,FEA,baseline}$ = Radial deformation of the CEB at location of threshold measurement n due to unfactored sustained loads plus unfactored self-straining loads without threshold factor amplification

For each threshold measurement, a method will be established to perform the measurement in a repeatable way. It is particularly important to perform the measurement in a well-defined location; otherwise, seemingly small deviations in the concrete surfaces can have a significant impact on the repeatability of the threshold measurements. For some of the locations in the containment enclosure building, a repeatable measurement method has already been established and a baseline measurement has been obtained. Other locations have been measured in the past, but have not been measured in a suitably repeatable way for continued monitoring. Once a suitable baseline measurement is established for all locations in the each structure, then the average threshold limit can be computed. An example projected value of the threshold limit is provided in Table below. It should be noted that the values in the table are presented as an example and are not intended to be applicable to actual locations.

Example Threshold Limits

Measurement ID	1	2	3	4
Measurement Type	Seismic Gap	Seismic Gap	Annulus Width	Annulus Width
Measurement Azimuth	180	305	220	240
Measurement Elevation	+5.5 ft	+21 ft	+9 ft	+9 ft
Relative-to Structure	CB	Personnel Hatch	CB	CB
Direction of deformation	Inward	Inward	Inward	Inward
Measurement taken from Inside or Outside of Annulus	Inside	Outside	Inside	Inside
Baseline Measurement Date and Report Reference	April 2016 [XX]	April 2016 [XX]	April 2016 [XX]	April 2016 [XX]
$d_{n,baseline}$, in.	1.5	1.97	51.00	52.00
$d_{n,design}$, in.	3.0	3.0	54.00	54.00
Baseline Measurement, in. $\lvert d_{n,baseline} - d_{n,design} \rvert$	1.50	1.03	3.00	2.00
$d_{n,FEA,baseline}$, in.	-0.34	-0.65	-1.01	-0.41
$d_{n,FEA,1.2}$, in.	-0.34	-0.69	-1.18	-0.48
$k_{n,thf}$	1.01	1.05	1.17	1.17
Local Threshold Limit, in. $\lvert d_{n,baseline} - d_{n,design} \rvert \times k_{n,thf}$	1.52	1.08	3.51	2.34
Average of Baseline Measurements			**1.88 in.**	
Threshold Limit (based on projected baseline values)			**2.11 in.**	

Summary

In summary, the process will classify affected structures into one of three categories: (1) structures with minimal amounts of deformation that do not affect the structural capacity as determined in the original design analysis; (2) structures with elevated levels of deformation that are shown to be acceptable using Finite Element Analysis (FEA) but still meeting the original design basis requirements when ASR effects are included; and (3) structures with significant deformation that are analyzed and shown to meet the requirements of the code of record using the methods described herein.

This approach is consistent with guidance in ACI 349.3R-1996 used to establish the inspection criteria for the Structures Monitoring Program. The ASR deformation categories do not necessarily correspond to the criteria used to characterize ASR cracking in structures that is discussed in LRA section B.2.1.31A. That is, a Stage 2 structure does not necessarily have ASR cracking that is classified as Tier 2. Structures will be monitored based on the most limiting parameter for monitoring from either the ASR ~~Monitoring~~ ***Aging Management*** Program or the Building Deformation ~~Monitoring~~ ***Aging***

Management Program. The building deformation monitoring frequency for structures for each Stage is summarized in Table 3.

Table 3 Structure Deformation Monitoring Requirements

Stage	Deformation Evaluation Stage	Monitoring Interval
1	Screening assessment	3 years
2	Analytical Evaluation	18 months
3	Detailed Evaluation	6 months

The monitoring frequencies in Table 3 are based on guidelines developed for inspecting transportation structures with ASR degradation. The guidance recommends inspections from six months to 5 years depending on the age of the damage to the structure and the rate of change in degradation. The interval for recording monitoring elements for deformation for each structure can be increased to the interval in the next lower Stage (i.e., Stage 3 to Stage 2 and Stage 2 to Stage 1) if no change in measurements are observed for 3 years. Stage 1 structures that have shown no change in deformation for 10 years may increase the inspection interval to once every 5 years. Structures that show no evidence of building deformation will continue to be inspected with a frequency as established by the Structures Monitoring Program.

Components Impacted by Structural Deformation
With deformation, an aging effect of concern is component functionality and structural interferences. Condition walkdowns are performed with a focus on safety-related components such as pumps, valves, conduits, piping etc. The identification of items of interest is entered into the ***NextEra Energy*** Seabrook Corrective Action Program (CAP) to be dispositioned for impact on plant structures. Specific features to look for include, but are not limited to, the following:

- Distorted flexible couplings
- Non-parallel pipe/conduit/HVAC joints
- Gaps, distortions, or tears in seals
- Crimped tubing
- Distorted support members/structural steel
- Distorted/bent anchor bolts
- Offset rod hangers
- Support members exceeding minimum clearance
- Cracked welds
- Support embedment plates – not flush with walls
- Misaligned pipe flanges
- Misaligned pipes in penetrations

- Roof membranes and weather seals degraded
- Electrical box, panel, or fitting distorted

Component specific features may indicate irreversible deformation of the affected component or irreversible plastic deformation of the structure such as rebar yielding or rebar slip. If these features are observed, then they will be documented in the corrective action process so that future monitoring walkdowns will observe the same features. Inspections of these features are in addition to the installed monitoring elements such as strain measurements and measurements of the relative deformation between structures. All of these measurements will be performed at the frequency described in Table 1.

The walkdowns will be performed in accordance with the Structures Monitoring Program and ASME Section XI, Subsection IWL Program documents. ***NextEra Energy*** Seabrook will update the walkdown guidance documents as necessary to accommodate new Operating Experience (OE) identified during the walkdowns.

ELEMENT 4 - Detection of Aging Effects

As discussed in Element 3 baseline walkdowns to identify the potential effects caused by building deformation will be performed. The results of the baseline walkdowns will be used to determine the key assumptions in the structural analysis in addition to determining the monitoring frequencies for equipment impacted by building deformation. Subsequent monitoring will be performed as part of future Structures Monitoring Program (SMP) walkdowns. The inspection frequencies identified by Table 1 will be applied in locations where symptoms of deformation are identified; otherwise, the inspection frequency will follow the requirements of the SMP. The SMP includes periodic visual inspection of structures and components for the detection of aging effects specific for that structure. The inspections are completed by qualified individuals at a frequency determined by the characteristics of the environment in which the structure is found.

ELEMENT 5 - Monitoring and Trending

Once the inspection frequencies are determined as described by Element 3, visual inspections will be used to monitor and trend future building deformation. Any new indications of building deformation will be placed in the Corrective Action Program, and evaluations will be performed to determine if inspection frequencies should be changed to ensure that future effects of degradation would be identified before loss of components' intended function.

ELEMENT 6 - Acceptance Criteria

A systematic approach to evaluation of structures and components impacted by ASR expansion and building deformation is utilized. A structural model is developed where ASR induced expansion is applied to the structure developing force, moments, and displacements that are attributed to the effects of ASR. The added load due to ASR is then combined with other CLB loads (deadweight, wind, hydrostatic, seismic, etc.). Resultant load combinations are then evaluated to validate compliance with structural design code requirements

Specific quantitative criteria to ensure component-intended functions will be maintained under all design conditions and is condition and location specific. Field observations of distorted/misaligned components and local structural deformation indicated by strain measurements or relative building movements are evaluated utilizing the existing acceptance criteria or design code specified for the design function of the component.

NextEra ***Energy Seabrook*** will determine appropriate criteria based on the walkdown results and the particular geometry and configuration in the area of interest. The criteria will include margin to trigger action prior to loss of intended function whether that action is an additional inspection or repair/replacement of the component.

ELEMENT 7 - Corrective Actions
Structural evaluations are performed to ensure impacted structures are in compliance with the Current Licensing Basis are documented in the Corrective Action Program. The NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 7 Corrective Actions. (Ref: LRA A.1.5 and B.1.3.)

ELEMENT 8 - Confirmation Process
The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 8 Confirmation Process.

ELEMENT 9 - Administrative Controls
The FPL/NextEra Energy Quality Assurance Program and Nuclear Fleet procedures will be utilized to meet Element 9 Administrative Controls.

ELEMENT 10 - Operating Experience

Building Deformation – Containment Enclosure Building (CEB)
In late 2014, a walkdown was performed to investigate a concern from the NRC that water, leaking from SB-V-9, was leaking into the Mechanical Penetration (Mech Pen) area though building seals. The walkdown documented that a Mechanical Penetration area seal was found torn. The damaged seal was a vertical seismic gap seal between the Containment Enclosure Building (CEB) and the Containment Building (CB). It was then stated that the condition of the seal and other local evidence indicated that the damage to the seal appeared to be caused by relative building movement and not seal degradation (i.e. shrinkage or material deterioration).

Following the discovery mentioned above, Engineering identified that the damage to the seal was caused by CEB outward radial deformation. ***NextEra Energy*** Seabrook engaged an engineering firm to perform visual assessments of accessible areas surrounding the CEB to determine the behavior of the CEB, whether the CEB movement is localized or widespread, and if other plant structures or components had been impacted. A Cause and Effect Diagram was prepared to understand the physical phenomena occurring with the CEB. Parametric studies using a linear finite element model of the CEB with boundary conditions modeling parameters appropriate for estimating structural deflections and deformed shapes were performed. The results were compared to in-situ field measurements taken between structures and at seismic isolation joints between various structures. The deformation patterns simulated by finite element analysis (FEA) were generally similar to field measurements. The results of the FEA showed that the deformation of the CEB was most likely due to Alkali-Silica Reaction (ASR) expansion in the concrete when combined with the expected creep and swelling of the concrete. The root cause to the event was determined to be the internal expansion (strain) in the CEB concrete produced by ASR in the in-plane direction of the CEB shell and ASR expansion in the backfill concrete coincident with a unique building configuration. The Root Cause Evaluation identified that there are many different symptoms of building deformation. These include:

- Conduit, duct, or piping seismic connection deformation
- Gate or door misalignment
- Seismic gap seal degradation
- Seismic gap width variations
- Fire seal degradation

(Note: above list is not intended to be all inclusive)

As a result walkdowns were performed to identify the above symptoms that may have been missed during the ~~Structural~~ ***Structures*** Monitoring Program Walkdowns that were conducted prior to this discovery. The items identified were entered ***NextEra Energy*** Seabrook's Corrective Action Program.

Building Deformation – RHR & FSB
NextEra Energy Seabrook is currently evaluating observations of expansion resulting in building deformation in the Residual Heat Removal (RHR) Equipment Vault and the Fuel Storage Building (FSB). Because the evaluation of the RHR Equipment Vault and the FSB are ongoing and the observed deformation has not yet been conclusively attributed to ASR, the walkdown guidance has not been updated to reflect observations in these locations.

Plant Specific Operating Experience

AR 02044627 notes that the as-measured width of seismic isolation gaps is less than the nominal value of 3 inches specified on concrete drawings for isolation between structures. There are a total of 93 as-measured gaps less than 3 inches between the following abutting structures: Containment Building, Containment Enclosure Building, Mechanical Penetration Area, West Main Steam and Feed Water Pipe Chase, Electrical Penetration Area and Emergency Feed Water Pump House. Initial finite element analysis completed determined that the deformation is attributed to ASR expansion and creep. The compensatory measure implemented requires measuring seismic isolation gaps every six months.

AR 2114299 documents that a seismic isolation joint located on an expansion boot near ductwork in the Containment Enclosure Building is vertically misaligned by approximately 2". The boot appeared to be in good shape***; it was*** ~~and~~ not dry or cracking. The AR determined that the cause of the misalignment is building deformation of the Containment Enclosure Building. The engineering evaluation concluded that the displaced ducts resulted in some slipping of the expansion joint material relative to the clamp at the areas of highest relative movement and that there is reasonable assurance that the joint material would most likely slip rather than tear or elongate during a seismic event. The condition was found acceptable as is and no loss of intended function was identified.

AR 02107225 documents a deformed and misaligned flexible coupling on a conduit located in the West Pipe Chase area. Based on a field walkdown, the coupling was misaligned by 1.75" which is greater than the established 1.25" acceptable limit. The cause of the misalignment was building deformation. Therefore, engineering analysis was performed to ensure that the enclosed cable can continue to perform its safety function. Even though the cable could continue to perform its safety function, the flexible conduit was repaired to restore design margin.

AR 02129621 documents the seismic gap between Containment and the CEB horizontal cantilevered concrete shield block at Azimuth 230 elevation 22' is less the ~~the~~ minimum required seismic gap of .277 inches. The cause of the reduced gap was building deformation. An engineering analysis was performed to ensure that the structural remains operable while steps are taken to restore to design requirements.

Newly Identified Operating Experience (OE)

NextEra Energy Seabrook will update the Aging Management Program for any new plant-specific or industry OE. This includes ongoing industry studies performed both nationally and internationally. Research data taken from these studies will be used to enhance the Building Deformation ~~Monitoring~~ ***Aging Management*** Program, if applicable. In addition NextEra ***Energy*** Seabrook has submitted a License Amendment Request to the Commission in accordance with 10CFR50.90 to incorporate a revised methodology related to ASR material properties and building deformation analysis for review and approval. NextEra ***Energy Seabrook*** will incorporate changes related to this LAR submittal as necessary to maintain alignment of the aging management program to the current license basis.

EXCEPTIONS TO NUREG-1800
None

ENHANCEMENTS
Implement the Building Deformation (BD) Monitoring Program
The ***NextEra Energy*** Seabrook Structural Monitoring Procedure EDS 36180 will be revised to include building deformation aging effects, inspection criteria, and acceptance criteria.

CONCLUSION
To manage the aging effects of building deformation due to ASR, swell, creep, and expansion, the existing Structures Monitoring Program and ASME Section XI, Subsection IWL Program, have been augmented by this plant specific Building Deformation ~~Monitoring~~ ***Aging Management*** Program. This program will perform baseline inspections to determine the extent of deformation, input the inspection results into an analytical model, and use this model to determine the projected rate of future deformation, and set inspection frequencies both to ensure that the calculated deformation rate is valid, and the established monitoring frequencies ensure that intended functions for structures and components will be maintained.