NRR-PMDAPEm Resource

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To: Browne, Kenneth
Cc: Thomas, Christine; Brown, Victoria - Seabrook Station Licensing Dept
Subject: Site Visit Plan
Attachments: Seabrook ASR LAR June Site Visit - final.pdf

Ken,

The staff has put together its plan for the site visit during the first week of June. Included is an attachment with the topics that the staff would like to focus on during the trip.

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Plan for Site Visit to Seabrook Regarding Alkali-Silica Reaction (ASR) LAR Review

Dates: June 5, 2017 to June 9, 2017

NRC Participants:
D. Hoang, Structural Engineer
B. Lehman, Structural Engineer
G. Thomas, Sr. Structural Engineer
R. Morante, Consultant Engineer, BNL
J. Braverman, Consultant Engineer, BNL
J. Poole, Project Manager
B. Wittick, Chief

Background

By letter dated August 1, 2016, and supplemented by letter dated September 30, 2016, NextEra Energy Seabrook (NextEra or the licensee) submitted a license amendment request (LAR) to revise the current licensing basis for Seabrook Station, Unit 1 (Seabrook) to adopt a methodology for the analysis of seismic category I structures with concrete affected by alkali-silica reaction (ASR). The proposed amendment would revise the Seabrook Updated Final Safety Analysis Report (UFSAR) to include new methods for analyzing seismic category I structures affected by ASR. In January 2017, the staff opened an audit to review the final complete calculations, and other supporting documentation, that implement the proposed methodology. In that audit it was stated that one of the tools the staff would use is a site visit.

Purpose of the Site Visit

The NRC participants plan to review the calculations and analyses, and supporting documentation that implement the new method for analyzing seismic category I structures affected by ASR, and conduct related walkdowns as needed. This will allow the staff to gain a better understanding of the unique, first-of-a-kind methodology and ensure the methodology is being applied as described in the LAR.

During the staff's review of the application, as well as its review of documents provided as part of the overall audit via the portal, the staff has developed some specific topics to focus on during the site visit. They have been included as a separate attachment. Note that while addressing these topics, new issues and need for additional information may be identified by the staff.

Logistics

NextEra will make relevant information available and will provide rooms and space as necessary. The NRC staff plans on performing the entrance meeting on the afternoon of Monday June 5th, followed by a site walkdown tour to get the staff familiar with the current state of ASR manifestations at the site. At the end of each day, a brief meeting will be held to go over current status and upcoming activities. On Friday June 9th, an exit meeting will be held to lay out what items have been accomplished and any new issues that have been identified.

Licensee Contact: Licensing Manager: Kenneth Browne (603) 773-7932

List of Documents Requested:

Note: Please provide hard copy and electronic copy if feasible

- LAR Submittal and Supplement along with Attachments
- "Criteria Document for Analysis and Evaluation of Seismic Category I Structures at Seabrook Station" (Document # 160268-CD-01, Revision 1, 1/12/17, FP101083)
- Latest Revision of UFSAR Chapter 3, Sections 3.7, 3.8, and 3.9
- "Criteria Document for Evaluation and Design Confirmation of As-Deformed Containment Enclosure Building at Seabrook Station in Seabrook, NH" (Document # 150252-CD-03, Revision 0, 7/27/16)
- "Evaluation of Containment for ASR Effects" (Document # 160268-CA-04, Revision 0, 2/14/17, FP101113)
- "Computation of Load Factors for ASR Demands for Seismic Category I Structures Other Than Reactor Containment" (Document # 160268-CA-01, Revision 0, 7/26/16, FP101042)
- "Impact of ASR on Structures" (Document # MPR-3727, Revision 1, May 2012, FP100716)
- "Seismic Response Computation Summary and Examples" (2182058.01 RG 1.92, 2/10/17)
- Smaoui, N., Bissonnette, B., Berube, M., and Fournier, B., Stresses induced by alkali–silica reactivity in prototypes of reinforced concrete columns incorporating various types of reactive aggregates, Canadian Journal of Civil Engineering , Volume 34, 2007 [Reference 1.11 in Enclosure 6 (MPR-4273) of LAR submittal dated 8/1/16]
- Test Reports for MPR/FSEL Test Programs: MPR-3722 (FP 100718), MPR-4262 (FP100994) and MPR-4231 (FP 100972) [References 4.1, 4.2 & 4.3 in Enclosure 6 (MPR-4273) of LAR submittal dated 8/1/16]
- References 6.1, 6.4 & 6.5 in Enclosure 6 (MPR-4273) of LAR submittal dated 8/1/16
- Documentation of latest measured in-plane expansion and through-thickness expansion data at all locations [Tier 3] where extensometers have been installed to date.

Questions for the Seabrook ASR LAR Site Visit (June 5-9, 2017)

100-40-40 Follow-up Questions / Clarifications

1. The calculation provided a description and two examples of how the 100-40-40 method was applied for combining the 3 directional responses, to determine the maximum expected response for a single load component (e.g., in-plane shear and moment). The results for the 24 combinations include 2 (+ and -) that match the result from the RG 1.92 method.

   However, also included in the Load Combination is H_e, defined as the "dynamic soil load". The 100-40-40 method was also applied to H_e. Since the vertical component of H_e is zero, it becomes 100-40. There are 24 H_e combinations, but only 12 are unique. These are combined with the results of the 100-40-40 method applied to the seismic inertial loads, for each of the 24 combinations.

   From the examples, H_e is identified uniquely in the N, S, E, and W directions. The magnitudes in the two opposite seismic directions are significantly different in some cases. In Section 3.2 Example Computation B, $H_{e.south.M11}$ = -3407 lbf-in/in while $H_{e.north.M11}$ = -39 lbf-in/in. The effect of H_e may in some cases reduce the total seismic-induced element forces. Therefore, the staff needs to gain a better understanding of how the dynamic soil pressure load was calculated and applied to the structure.

   Describe how the dynamic soil pressure load (H_e) was calculated and applied to the structure.

2. The calculation provided a description and two examples of how the 100-40-40 method was applied for combining the 3 directional responses, to determine the maximum expected response for a single load component (e.g., in-plane shear and moment).

   However, it is not clear how the 100-40-40 method is applied when there is a multiple load interaction effect, such as satisfaction of the axial force plus moment interaction equations used for design of concrete sections. Consistent with the examples presented, the expected maximum axial force (F) would be calculated separately, the expected maximum moment (M) would be calculated separately, and then 4 permutations (+F/+M; +F/-M; -F/+M; -F/-M) would be evaluated using the interaction equations.

   Provide an example demonstrating how multiple forces (e.g., axial and moment) are combined; if the method is different from that described above provide the technical basis for its acceptability.

Questions Related to ASR Load Factors

1. Table 1 in SG&H Calculation 160268-CA-01, "Computation of Load Factors for ASR Demands for Seismic Category I Structures Other Than Containment" lists the values of parameters used in the load factor calculations, for Severity Zones 1 through 4. Explain why the coefficient of variation (COV) for Severity Zone 1 is significantly larger than for the other severity zones. If it was in line with the other zones (approx. 0.2), how would this affect the calculation of the Severity Zone 1 ASR Load Factor for the static load combination?

2. The CEB evaluation report indicates that the crack indices (CIs) for the CEB are essentially in Severity Zone 1 (0-0.5mm/m). Setting the Threshold Factor to 1.2 apparently leaves very little margin for additional ASR strain (0.6mm/m max.). Based on the projected rate of ASR growth in the CEB, how long will it take to use up the margin? What is the next step, once the margin is exhausted?

3. From Table 13 of the CEB evaluation report, the CIs for the CEB above grade (el. 30’ to el. 119’) are 0.16mm/m in both hoop and meridional directions. For analysis purposes, Region 4 is defined completely around the circumference (360 deg.), and between el. 20’ and el. 119’. A value of 0.10 mm/m is assigned to this region. The ASR strain in this region is assumed to be axisymmetric, and will cause a slight increase in radius of the CEB, based on w = hoop strain x radius. For 0.10 mm/m strain, w = 0.0001 x 948” = 0.0948”. In the CEB evaluation report, radial displacements on the order of +/-1” are reported at el. 50’. This result apparently is taken from the analysis for the unfactored static load combination. What is difference between the displacement calculated in the ANSYS ASR-only analysis and the displacement calculated in the ANSYS unfactored static load combination analysis? Identify the contribution of each load component of the combination to the total displacement.

4. Section 1.4.3 of the SG&H Report 160268-R-01, “Development of ASR Load Factors for Seismic Category I Structures”, indicates that the lowest ASR Severity Zones (I, II, and III) are established to align with the criteria for “Tier 1: Acceptable with Deficiencies – Qualitative Monitoring Required.” However, Table 1 - ASR Severity Zones (in the same report), indicates:
   a) Zone I corresponds to Seabrook Structural Monitoring Program (SMP) ASR Crack Criteria for “Tier 2 Qualitative,”
   b) Zone II corresponds to Tier 2 Quantitative, and
   c) Zones III and IV correspond to Tier 3.

   Explain the apparent inconsistencies between the text in Section 1.4.3 and Table 1 for ASR Severity Zones I, II, and III.

5. The largest load factor for the ASR load is 2.0, which is applicable to the static load combination. As a result, the static load combination is often the governing load combination in the current evaluation. The ASR load factor is a function of the k_{ASR} parameter, which is the ratio of the factored ASR load demands to the total factored load demands. SG&H Calculation 160268-CA-01, “Computation of Load Factors for ASR Demands for Seismic Category I Structures Other Than Containment”, indicates that k_{ASR} = 0.4 is selected for Severity Zone I. The report also indicates that using 0.4 is conservative because this represents nearly doubling the original factored design demands. The basis for stating that 0.4 represents nearly doubling the original factored design demands is not evident. Provide a discussion justifying the use of 0.4 as a conservative value. Also, were the actual loads calculated for ASR reviewed to determine whether the use of k_{ASR} = 0.4 is reasonable?

6. In Table 5 of the CEB Evaluation Report by SG&H 150252-CA-02, Rev. 0, “Evaluation and Design Confirmation of As-Deformed CEB,” a load factor of 1.4 is applied to the swelling load S_w, in all load combinations. It is not clear why the same load factor of 1.4 for S_w is used in all load combinations, while the other load factors vary depending on the particular load combination. Further, S_w is not included as a load (with an appropriate associated load factor) in any of the load combinations indicated in UFSAR markup

Tables 3.8-1, 3.8-14, and 3.8-16; it is not clear why the S_w load considered in the analysis is not included in the referenced UFSAR markup load combination tables.

Load factors assigned to each load in the design basis and codes is influenced by the degree of accuracy to which the load effect can be calculated, the variation that might be expected in the load during the lifetime, the probability of the all loads in combination occurring at the same time, and to account for variability in the structural analysis used to compute moments and shears. For the unusual load combinations, Seabrook LAR UFSAR markup Tables 3.8-1, 3.8-14, and 3.8-16 show a load factor of 1.0 associated with the ASR load (S_a); however, there is a higher degree of subjectivity, uncertainty and variability associated with estimating the internal ASR loads which are known to exist when compared to the other loads which are external and well defined in the design basis.

a. Clarify why the same load factor of 1.4 for S_w is used in all load combinations in Table 5 of the CEB Evaluation Report by SG&H 150252-CA-02, while the other load factors vary depending on the particular load combination
b. Clarify why S_w is not included as a load (with an appropriate associated load factor) in any of the load combinations indicated in UFSAR markup Tables 3.8-1, 3.8-14, and 3.8-16.
c. Justify why a load factor of 1.0 associated with the ASR load (S_a) is appropriate for "unusual" load combinations in the design basis (e.g., combinations involving extreme or severe environmental or abnormal loads) given that, relative to the other loads in the combinations, there is high degree of subjectivity, uncertainty and variability associated with estimating internal ASR loads and high degree of certainty (100 percent confidence) that it exists.

UFSAR Section 3.8.5 Question: In Enclosure 1 of the 8/1/16 LAR submittal, the proposed changes to UFSAR in Section 2.2 and UFSAR markup pages in Attachment 1 of the LAR do not include any change to UFSAR Section 3.8.5 "Foundations." Since foundations of Category 1 structures used the same reactive aggregate in its concrete, how are foundations evaluated for ASR and why is there no proposed changes to UFSAR Section 3.8.5?

Impact of In-plane E\expansion exceedances on structural capacity: Provide latest measured in-plane expansion and through-thickness expansion data at all locations extensometers have been installed to date. The results of the MPR/FSEL large-scale test program seems to suggest that, for structures with 2D rebar mats and no through-thickness reinforcement, in-plane expansion would be more significant with regard to impact on structural capacity than through-thickness expansion. Address implications of exceedances (deviation) in in-plane expansion beyond the plateau levels observed on MPR/FSEL test specimens with regard to impact on structural capacity in shear, flexure and rebar anchorage.

Integrated Effect of Microcracking and Building Deformation on Structural Capacity (limit states of flexure/rebar anchorage, shear): The proposed building deformation analysis methodology addresses the response (determines structural demands) of ASR-affected structures under design basis load combinations including ASR load. The MPR/FSEL Large-Scale Test Program (LSTP) in part addressed the impact of ASR micro-cracking on structural capacity (limit states of shear, flexure/rebar anchorage) for structures with 2D reinforcement (no through-thickness reinforcement). Section 4.3 and Assumption JA11 in Section 5.1 of CEB Calculation 150252-CA-02, states: "ASR expansion impacts the total demand on reinforced concrete elements, but does not reduce the resistance (capacity) of reinforced concrete elements so long as strain does not exceed the limits [specifically states out-of-plane expansion] defined in Ref. 16 (MPR-4273)." Building deformation or global manifestations of ASR can lead to macro-cracking (e.g., wide, discrete, through-wall cracks) or other effects that were not seen in the MPR/FSEL test specimens at the time of load tests, and therefore the test results do not reflect impact of such effects on structural capacity. How is the impact on structural capacity of integrated effects of ASR micro-cracking and global manifestations (e.g., macro-cracking), which are not mutually exclusive, addressed in the proposed method of evaluation of ASR-affected structures?

Compressive Strength Verification

Section 3.2.3 of the LAR notes that adjustments to Seabrook design code methodologies are unnecessary if ASR through-thickness expansion levels remain below limits established during the MPR/FSEL structural testing. The design evaluations of the ASR-affected structures use the ACI 318 code equations, which are a function of specified minimum concrete compressive strength (f_c') that is required to be achieved or exceeded based on cylinder or core tests, to determine structural capacity for various limit states. Section 3.1.1 of the LAR states, in part, that [t]he margin between the specified compressive strength used in design and the value expected from the concrete mix ensures there is a low probability of measuring a compressive strength value after construction below the specified value. ASR has the potential to reduce the compressive strength of concrete based on cylinder or core tests; however, as a backstop against excessive structural deterioration, there is no provision in the LAR to periodically validate that the specified (minimum) concrete compressive strength used in the design calculations of ASR-affected structures exists or is exceeded.

Will the specified minimum concrete compressive strength used in the design calculations of ASR-affected structures be periodically validated, as a backstop against structural degradation?