UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of NEXTERA ENERGY SEABROOK, LLC (Seabrook Station, Unit 1)	Docket No. 50-443-LA-2 ASLBP No. 17-953-02-LA-BD01

Hearing Exhibit

Exhibit Number: NRC090

Exhibit Title: Staff Testimony in Response to Exhibit INT030

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NRC STAFF TESTIMONY OF ANGELA BUFORD, BRYCE LEHMAN, AND GEORGE THOMAS IN RESPONSE TO EXHIBIT INT030

Q.1. Please state your name, occupation, and by whom you are employed.

A.1. This information is provided in A.1a–A.1c of Exhibit NRC001-R.

Q.2. Please describe the nature of your responsibilities on behalf of the U.S. Nuclear Regulatory Commission.

A.2. This information is provided in A.2a–A.2c of Exhibit NRC001-R.

Q.3. Please explain what your duties have been in connection with the NRC Staff review of the NextEra Energy Seabrook, LLC license amendment request (LAR) to revise the Seabrook Station, Unit No. 1 Updated Final Safety Analysis Report (UFSAR) (NRC007) to include a methodology to demonstrate that Seabrook structures with alkali-silica reaction (ASR) continue to meet the design codes for original construction (INT010 (nonproprietary); INT089[1] (proprietary)).[2]

A.3. This information is provided in A.3a–A.3c of Exhibit NRC001-R.

[1] The Staff does not cite Exhibit INT011 because it includes highlighting that is not a part of the original document.

[2] NextEra supplemented the LAR on September 30, 2016 (NRC010), October 3, 2017 (NRC013), December 11, 2017 (NRC014), and June 7, 2018 (NRC015). Separately, on May 18, 2018, in updating its license renewal application for Seabrook, NextEra provided revised versions of MPR Associates (MPR) reports previously submitted as LAR supplements (NRC016).

Q.4. What is the purpose of this testimony?

A.4. Pursuant to the Board's order of September 16, 2019,[3] the purpose of this testimony is to respond to INT030, the supplemental rebuttal testimony of the C-10 Research and Education Foundation's (C-10) expert witness, Dr. Victor Saouma.

Q.5. In INT030, Dr. Saouma discusses a "corroboration study." To what do you understand him to be referring?

A.5. The large-scale test program (LSTP) at the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin established limits in the through-thickness direction for ASR expansion. The ASR expansion monitoring program developed for Seabrook based on the LSTP involves, in part, monitoring through-thickness expansion at Seabrook to ensure that it remains within these limits. Through-thickness expansion, however, cannot be measured at Seabrook until an extensometer is installed and, even then, the extensometer only measures expansion from the time of its installation. In order to calculate the through-thickness expansion that had occurred up to the time of the extensometer's installation, NextEra used LSTP data to develop a curve to correlate normalized[4] elastic modulus and through-thickness expansion. NextEra compared this curve to literature data and noted that the trend from the literature data compared favorably with the curve.

In order to obtain the normalized elastic modulus for application of the correlation curve to determine through-thickness expansion to date of Seabrook structures, it is necessary to

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[3] Order (Granting C-10's Motion for Leave to File Supplemental Rebuttal Testimony) (Sept. 16, 2019) (unpublished) (ML19259B318).

[4] A normalized property is the ratio of the concrete material property measured at a different expansion level (i.e., the time of extensometer installation) to that measured 28 days after construction.

know the original (i.e., 28-day) modulus of the impacted Seabrook concrete; however, elastic modulus was not measured during Seabrook's construction. Therefore, NextEra provided two approaches by which the original modulus could be determined—(1) use the equation from American Concrete Institute (ACI) 318-71, Section 8.3.1 (NRC049 at 22) to estimate the modulus based on the measured 28-day compressive strength of concrete cylinders cast at the time of Seabrook construction or (2) use reference Seabrook cores representative of original construction and not impacted by ASR. Because both approaches can introduce uncertainty, NextEra applied a "reduction factor" to the normalized modulus term of the correlation curve, which would conservatively result in overestimating the through-thickness expansion to date in Seabrook structures.

The Staff determined that, based on considerations of statistical measures of goodness of fit, the correlation curve is reasonable because it accounts for a large majority of the variance in the LSTP data, as well as similar trends seen in the existing literature data. However, the Staff included as a license condition that NextEra perform a confirmatory corroboration study of the curve on Seabrook structures to provide additional assurance of the continued applicability of the curve. The corroboration study is required to cover at least 20 percent of extensometer locations on Seabrook ASR-affected structures and to use the approach provided in Appendix C of Report MPR-4273, Revision 1. It is required to be completed no later than 2025, with a follow-up study 10 years thereafter, and NextEra is required to notify the NRC each time a study is completed.

Based on these considerations, the Staff found NextEra's proposed method for determining through-thickness expansion to date to provide reasonable assurance of adequate protection of public health and safety.

Q.6. Dr. Saouma argues that the calculation of through-thickness expansion to date carries “substantial uncertainties” because, in part, it relies on the equation from ACI 318-71 to estimate the original modulus based on the 28-day compressive strength (INT030 at 1). What is your response to this?

A.6. The Staff disagrees with Dr. Saouma’s characterization in Figure 22 of Exhibit INT028, referenced in his supplemental rebuttal testimony, that the normal variability of +/- 20 percent in the measured data in ACI 318-71 is a margin of error. Rather, the +/- 20 percent is a reference to the variability of the experimental data on which the ACI 318-71 empirical equation for concrete modulus of elasticity was developed. Section 8.3.1 of ACI 318-71 (NRC049 at 22) states that for normal weight concrete, the modulus of elasticity (E_c) may be considered to be $57,000\sqrt{f'c}$. The code does not require the modulus of elasticity value calculated using the empirical equation to be varied by +/- 20 percent. Therefore, Dr Saouma mischaracterizes normal variability in the data underlying the code equation as a margin of error in the code equation. Additionally, the original elastic modulus for locations of installed extensometers at Seabrook are calculated using the average 28-day compressive strength data available for the location (INT020(P) at 108-09), and not using an individual cylinder test, thereby accounting for variability to obtain a representative modulus for the location and not one that is susceptible to a +/- 20 percent margin of error, as Dr. Saouma asserts.

The Staff also disagrees with Dr Saouma’s conclusion, based on Figure 22, that uncertainties are so large that the correlation equation is unacceptable. The correlation equation was developed as the statistical best-fit (errors minimized) of the representative LSTP data to provide a correlation that could be applied to Seabrook structures. The correlation equation was further adjusted using a normalized modulus reduction factor to account generally for potential uncertainty and to provide a conservative estimate of through-thickness expansion

in the area (not a point location) of the installed extensometer. The Staff further notes that the corroboration study required by the license condition provides additional assurance that the correlation equation will remain representative and valid for Seabrook structures.

Based on the above, Dr. Saouma does not demonstrate that the Staff was wrong to find that the correlation equation provided reasonable assurance.

Q.7. Dr. Saouma argues that the calculation of through-thickness expansion to date does not account for the increase in the compressive strength of concrete over time and that this would cause the calculation to underestimate through-thickness expansion. What is your response to this?

A.7. The increase in the compressive strength of concrete over time is one possible uncertainty associated with estimating the original elastic modulus. The Staff found that the reduction factor applied in NextEra's adjusted correlation equation (INT020(P) at 23-24) adequately addressed uncertainties and yields conservative expansion estimates on a consistent basis. This is further explained in A.8 below.

Q.8. Dr. Saouma asserts that compressive strength after five years can be as much as 20% higher than the value measured at 28 days. Even if this were the case at Seabrook, would this challenge the conservatism of the calculation of through-thickness expansion to date?

A.8. No. As previously stated, the calculation of through-thickness expansion to date includes a reduction factor to account for uncertainties. Even with a 20% increase in compressive strength relative to the 28-day strength after 5 years, as proposed by Dr. Saouma, the reduction factor in NextEra's adjusted correlation equation would bound this uncertainty. This is because applying an increase in compressive strength of a factor of 1.2 (i.e., 20 percent) to the ACI 318-71 equation for elastic modulus, which is a function of the square root of

compressive strength, would result in the initial modulus being higher by a factor of the square root of 1.2, which is 1.095; consequently, the resulting normalized modulus would be lower by a factor of 0.91 (i.e., 1/1.095). The reduction factor in NextEra's adjusted correlation equation is smaller than this value and, therefore, adequately accounts for this uncertainty. There is no "fundamental flaw" in NextEra's approach as claimed by Dr Saouma and his depiction of the adjusted relationship between through-thickness expansion and corrected normalized elastic modulus in Figure 3 of INT030 is not valid.

Q.9. After reviewing all of the information available to you since the issuance of the safety evaluation for the LAR (INT024 (nonproprietary); INT025 (proprietary)), including all of the information provided by C-10 and Dr. Saouma, is it still your expert opinion that the proposed plant-specific method of evaluation for design evaluation of seismic Category I reinforced concrete structures affected by ASR at Seabrook is, as conditioned, acceptable and provides reasonable assurance that these structures will continue to meet the NRC's requirements?

A.9. Yes.

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AFFIDAVIT OF ANGELA BUFORD

I, Angela Buford, do hereby declare under penalty of perjury that my statements in the foregoing testimony are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

Angela Buford
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Execute in Rockville, Maryland
this 20th day of September 2019

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AFFIDAVIT OF BRYCE LEHMAN

I, Bryce Lehman, do hereby declare under penalty of perjury that my statements in the foregoing testimony are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

Bryce Lehman
Structural Engineer
U.S. Nuclear Regulatory Commission
Washington, DC 20555
Telephone: (301) 415-1626
Email: Bryce.Lehman@nrc.gov

Execute in Rockville, Maryland
this 20th day of September 2019

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AFFIDAVIT OF GEORGE THOMAS

I, George Thomas, do hereby declare under penalty of perjury that my statements in the foregoing testimony are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

George Thomas
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Execute in Rockville, Maryland
this 20th day of September 2019