

October 8, 2026

Hon. Ho K. Nieh, Chairman
Hon. David A. Wright, Commissioner
Hon. Bradley R. Crowell, Commissioner
Hon. Matthew J. Marzano, Commissioner
Hon. Douglas W. Weaver, Commissioner
By email to Jody C. Martin, Secretary of the Commission at hearing.docket@nrc.gov

SUBJECT: *Request for Commission Intervention and Oversight of Alkali-Silica
Reaction Testing for Seabrook Station Unit 1, Docket No. 50-443*

1. Introduction and Summary

C-10 Research and Education Foundation (“C-10”) respectfully requests you, the Commissioners of the U.S. Nuclear Regulatory Commission (“NRC” or “Commission”), to fulfill a commitment made in 2019 by your predecessors to “step in and provide direction” to your agency Staff if needed for the adequate regulatory oversight of dangerous concrete degradation caused by alkali-silica reaction (“ASR”) at NextEra Seabrook, LLC’s (“NextEra’s”) Seabrook nuclear power plant.¹ Your oversight and direction are greatly needed at this moment to ensure that both NextEra and the Staff make an informed and effective response to the recent discovery that ASR is progressing more rapidly and extensively than predicted by NextEra ten years ago, such that it is projected to exceed the limit in NextEra’s renewed operating license before the license expires in 2050.²

¹ *NextEra Seabrook, L.L.C.* (Seabrook Station, Unit 1), CLI-19-07, 90 N.R.C. 1, 11 (2019) (hereinafter “Commission Decision CLI-19-07”) (“If it appears that we need to step in and provide direction in the future, we will not hesitate to act.”). We also invoke your 2021 commitment to your Congressional overseers to “continue to monitor potential concerns with ASR at Seabrook” as part of your “regulatory responsibilities.” Letter from Christopher T. Hanson, NRC Chairman, to Hon. Edward J. Markey, U.S. Senate (June 10, 2021) (ML21139A161). *See also* letter from Hon. Edward J. Markey and Hon. Elizabeth Warren, U.S. Senate, to Hon. Christopher T. Hanson, NRC Chairman (Dec. 10, 2021), <https://www.markey.senate.gov/imo/media/doc/2021.12.10%20Seabrook%20Independent%20Investigation.pdf>. (website last visited Oct. 5, 2026).

² Letter from Matthew R. Young, NRC, to NextEra re: Seabrook Station – Integrated Inspection Report 050003443/2023001, Encl. at 9 (May 11, 2023) (ML23129A193) (“The inspectors noted that several of the extensometer locations were projected to exceed the licensed through-thickness expansion limit before the expiration of renewed Seabrook operating license in 2050, but based on current rates, the projected time to exceedance is greater than 10 years.”). *See also* Advisory Committee on Reactor Safeguards (“ACRS”) Letter to NRC Chairman David A. Wright re: Report on the Safety Aspects of the Alkali-Silica Reaction Phenomenon at the Seabrook Nuclear Power Station at 1 (Sept. 23, 2025) (ML25254A200) (hereinafter “ACRS 9/23/25 Letter”) (“Seabrook is currently operating under the large-scale testing program (LSTP) boundaries that may potentially be exceeded in the future.”).

Our request is based on the attached expert Declaration and supporting Technical Assessment by Victor E. Saouma, Ph.D., a highly qualified expert in ASR.³ Dr. Saouma previously testified before the Atomic Safety and Licensing Board (“ASLB”) regarding significant inadequacies in NextEra’s application for a license amendment approving NextEra’s ASR assessment and monitoring program.⁴ The focus of the hearing was the Large-Scale Test Program (“LSTP”) conducted between 2014 and 2018 by Ferguson Structural Engineering Laboratory (“FSEL”) at the University of Texas in Austin, for the purpose of supporting NextEra’s ASR assessment and monitoring program.⁵ Dr. Saouma is familiar with the body of U.S. and international research on ASR, and has consistently monitored efforts by NextEra to assess and monitor ASR at Seabrook since 2018.

In addition, we rely on the ACRS’ advice to you, following their recently completed four-year review of ASR at Seabrook (2021-2025), to apply “knowledge learned from tests performed on ASR since the original LSTP testing.”⁶ Aside from LSTP1, every major research program that has investigated the structural effects of ASR in a nuclear context used shear walls or geometry-specific shear panels as the test specimen. LSTP1 was also anomalous in its treatment of control specimens. Rather than using time-matched companion specimens in which ASR was suppressed, NextEra used a control methodology that did not provide an equivalent contemporaneous baseline, confounding the effects of ASR with aging and other time-dependent effects. Dr. Saouma is unaware of any major ASR structural research program reviewed in his Technical Assessment that has used such an approach to establish the effect of ASR on structural response. When those programs are examined carefully, a consistent pattern emerges: across all programs using geometry-representative specimens and properly controlled test programs, ASR causes a reduction in structural capacity, not an increase as erroneously inferred by NextEra and the Staff from the LSTP1 results.⁷

³ See Attachment, Declaration of Victor E. Saouma, Ph.D., ¶¶ 6-18 (Oct. 7, 2026) (hereinafter “Saouma Declaration”). Dr. Saouma’s Curriculum Vitae is attached to his Declaration as Exhibit 1. Dr. Saouma’s expert report, *ASR Research Program Gaps and Structural Test Evidence: A Unified Technical Assessment* (Oct. 7, 2026) (hereinafter “Saouma Technical Assessment”), as attached to his Declaration as Exhibit 2.

⁴ See *NextEra Seabrook, L.L.C.* (Seabrook Station, Unit 1), LBP-20-09, 92 N.R.C. 58 (2020) (“ASLB Decision LBP-20-09”).

⁵ We will refer to the 2014-18 initial round of the LSTP as “LSTP1” and any planned or contemplated future repetition of the LSTP as “LSTP2.”

⁶ ACRS 9/23/25 Letter at 1. While the ACRS characterizes the consideration of post-LSTP1 testing information as merely “beneficial” (*id.*), we respectfully submit, as set forth in Dr. Saouma’s Declaration and Technical Assessment, that it is essential for the reasonable protection of public health and safety. Further as discussed in Section 5(d) below, the ACRS lacked a factual basis for its underlying conclusion that NextEra’s program for assessment and monitoring of ASR at Seabrook already provides “confidence that Seabrook can be operated safely.”

⁷ See Section 5(a) below.

As discussed in Section 5(c) below, we are gravely concerned that NextEra appears to plan a repetition of LSTP1, without applying this large body of currently available scientific evidence -- a significant portion yielded by NRC-sponsored research and testing -- showing that the methods of LSTP1 are unsuitable and inadequate to assess or predict the behavior of ASR in shear walls of critical safety structures such as the Containment Enclosure Building ("CEB"). The LSTP1 beam tests yielded results that were not only predictable -- and conveniently favorable -- but actually unconservative.

Because it is methodologically deficient and unconservative, LSTP1 should not be replicated for Seabrook. Nevertheless, based on C-10's understanding of recent comments by the NRC's inspection Staff, NextEra plans to essentially duplicate the flawed testing methods of LSTP1 in a future LSTP2. The NRC Staff, for its part, has made no commitment to ensure that a future LSTP2 uses demonstrably superior -- and indeed, essential -- methods for ASR testing. Further, the Staff's continued acceptance of the LSTP1 results over the past decade, without applying the large and growing body of scientific evidence that unequivocally shows its deficiencies, raises significant concerns about the rigor of their future oversight of an LSTP2.

As discussed in Section 6 below, we ask you to intervene to ensure that, before undertaking any further ASR testing, both NextEra and the Staff consider the substantial body of research and test results concerning ASR in specimens genuinely representative of a CEB. We also ask you to ensure that NextEra and the Staff will update the outdated methodologies used in LSTP1. Finally, Dr. Saouma advises that at a minimum, the Commission should require the Staff to ensure that any supplemental testing program will use geometry-representative squat shear wall or shear panel specimens, fully instrument the reinforcement with strain gauges, employ time-matched lithium-suppressed companion controls, and develop a validated expansion prediction model calibrated to Seabrook concrete mixtures.⁸

It is our understanding that preparation of an ASR testing protocol is a time-consuming process. Therefore, we ask the Commissioners to intervene now, in order to ensure that this preparation time can be spent in a way that maximizes safety, effectiveness, and efficiency. In this context, we note our reasonable expectation that the next licensing action taken by NextEra for Seabrook Station related to the ASR issue will be on or near 2030, when NextEra either (1) applies to have the Seabrook Station ASR-expansion limits increased to allowed continued operation for the most degraded structures that are nearing the current limits; and/or (2) applies for an additional extended license term to 2070. At either juncture, NextEra will need to submit new testing results for ASR to demonstrate that safety structures will be safe and operable to that extended license expiration date.

⁸ Saouma Technical Assessment at 18.

2. About ASR and its Significance for Seabrook

Colloquially known as “concrete cancer,” ASR is a type of alkali-aggregate reaction that can degrade concrete structures by causing them to crack and weaken.⁹ ASR “may impact the material properties of concrete, which could affect the load-bearing capacity of the structure.”¹⁰ Thus, the NRC must ensure that ASR does not compromise the load-bearing capacity of Seismic Category I structures such as the Seabrook CEB, including their ability to resist design-basis seismic loads.¹¹

3. Clarification of Nature of C-10’s Demands Upon the Commission

At the outset, we wish to clarify the nature of our demands in relation to the NRC’s licensing and enforcement regulations and processes. This letter does not constitute an enforcement petition pursuant to 10 C.F.R. § 2.206. Rather, it seeks action on a previously made commitment by the Commissioners, as set forth in Commission Decision CLI-19-07, to take ASR related supervisory action at Seabrook if warranted. C-10 respectfully submits that the conditions warranting intervention, as set forth by the Commission in CLI-19-07, exist now: at this pivotal moment when NextEra is preparing ASR tests that may affect the safety of Seabrook’s operation for decades to come, the NRC Staff is no longer “actively engaged in gaining an enhanced understanding of the [ASR] phenomenon.”¹² To the contrary, the Staff is disregarding a body of ASR research results -- including recently-published results of NRC-sponsored research -- that unequivocally demonstrates the inadequacy of the Staff’s established “strategies for addressing ASR-related degradation” at Seabrook.¹³ By failing to adopt or apply this significantly “enhanced understanding” of ASR, the Staff exposes public health and safety to an unacceptable and unnecessary level of risk -- now and potentially far into the future.¹⁴

Nor does C-10 seek to re-open the 2019 license amendment proceeding before the ASLB on the adequacy of LSTP1 to support NextEra’s ASR assessment and monitoring program, or to otherwise revisit the ASLB’s decision in LBP-20-09. Instead, our demands build on the progress made in that proceeding. We also seek to rectify significant contemporaneous errors that were not brought to the attention of the ASLB or the parties by NextEra or the NRC Staff during that proceeding. And C-10 seeks to ensure that any future enforcement or licensing action related to ASR at Seabrook takes into account the significant increase in technical knowledge of ASR’s effects on shear concrete structures that has been gained since the 2019 hearing.

⁹ Commission Decision 19-07, 90 N.R.C. at 3.

¹⁰ *Id.*

¹¹ *Id.*, 90 N.R.C. at 4 (“[S]eismic Category I structures must remain functional during a safe shutdown earthquake.”).

¹² Commission Decision 19-07, 90 N.R.C. at 11.

¹³ *Id.*

¹⁴ See discussion in Section 6 and note 36 below.

Finally, over the past three years, C-10 has made every reasonable effort to inform the NRC Staff and the ACRS of our concerns that the NRC's regulatory approach to ASR at Seabrook is deficient for failure to consider the significant safety implications of recent ASR testing, related to which Dr. Saouma has submitted multiple papers and made multiple presentations to the NRC Staff and the ACRS.¹⁵ He has also obtained peer review of his analysis.¹⁶ Yet, the NRC Staff has consistently dismissed his concerns. Unfortunately, the Staff's dismissal fails to support the Staff's criticisms or comply with basic scholarly standards.¹⁷ Thus, we bring our concerns to the Commission now.

4. Relevance of 2019 Hearing on NextEra's License Amendment Request

In 2019, the ASLB conducted an adjudicatory hearing regarding C-10's legal challenge to the sufficiency of NextEra's ASR assessment and monitoring program to satisfy NRC regulations and the safety standards of the Atomic Energy Act. Dr. Saouma testified as an expert witness for C-10, the Intervenor. C-10's chief complaint was that LSTP1 used scientifically flawed specimens and calculation methods and thus underestimated the expansion rates of ASR.

C-10's intervention yielded new license conditions requiring NextEra to monitor control extensometers (*i.e.*, measure, record, and project ASR expansion rates) every six months rather than every ten years as NextEra had proposed.¹⁸ Had C-10's intervention not occurred, NextEra and the NRC would almost certainly be unaware that some structures may be outside the allowed ASR degradation expansion limits by as early as 2034, which is sixteen years prior to the end of the 2050 extended license period.

Further, while the ASLB did not require NextEra to re-do LSTP1, it nevertheless recognized the gravity of the safety risk posed by ASR to Seabrook safety structures. Thus, it is a matter of significant concern that neither NextEra nor the Staff gave any testimony about existing National Institute of Standards and Technology ("NIST") guidance for testing of shear concrete walls, nor did they discuss the relevance of testing of ASR-affected shear walls that was then underway at NIST under contract with the NRC. Most egregiously, it was the ACRS who alerted the ASLB to the NIST tests, but inaccurately represented that the tests were complete and that they supported the results of LSTP1.¹⁹

Thus, it is thanks to C-10's intervention, Dr. Saouma's testimony, and the ASLB's Decision LBP-20-09 that the NRC is now aware that ASR is progressing more rapidly at Seabrook than predicted by NextEra. Yet, ASLB Decision 20-09 has no precedential value with respect to its ruling on the adequacy of LSTP1 because it does not reflect the full range of relevant

¹⁵ See Saouma Declaration, ¶¶ 28-39.

¹⁶ See *id.*, ¶¶ 36, 39.

¹⁷ *Id.*, ¶¶ 38.

¹⁸ ASLB Decision LBP-20-09, 92 N.R.C. at 144-46, 218.

¹⁹ See Section 5(d) below.

information that was available to NextEra and the Staff at the time, nor is it up-to-date with respect to subsequently completed research and testing.

5. Grounds for Commission Intervention and Action

Approximately ten years have now passed since NextEra applied to the NRC for a license amendment that would approve a program for assessing and monitoring ASR at Seabrook. During that decade, actions by NextEra and oversight by the NRC Staff have fallen far short of the reasonable level of comprehensiveness and rigor required to ensure adequate protection of public health and safety. In addition, oversight by the ACRS as the NRC's "watchdog" has been inexplicably misleading and inadequate. Finally, recent statements by NextEra and the NRC Staff raise the reasonable concern that NextEra is poised to repeat the demonstrably inadequate LSTP1 without significant pushback from the Staff. Thus, it is time for the Commission to "step in and provide direction."²⁰

a. NextEra and NRC Staff failures

From the start, as set forth in the attached Saouma Declaration and Technical Assessment, NextEra and the NRC Staff failed to follow -- or even address -- NRC-sponsored guidance for the testing of ASR-infected concrete, NISTIR 7937, "Alkali-Silica Reaction Degradation of Nuclear Power Plant Concrete Structures: A Scoping Study" (2013) ("NISTIR 7937"). Instead of testing shear walls demonstrably representative of the CEB on a scientific basis, as directed by NISTIR 7937, NextEra tested ASR-infected concrete beams.²¹ NextEra did not acknowledge the existence of NISTIR 7937, let alone submit any justification for its failure to follow NIST's guidance. LSTP1 was also methodologically deficient in its treatment of control specimens. A valid assessment of ASR effects requires time-matched companion specimens of the same concrete in which ASR is suppressed, so that aging and other time-dependent effects are not confounded with ASR. The LSTP1 control methodology did not provide such an equivalent contemporaneous baseline.

Based on the LSTP1 tests of concrete beams, NRC Staff approved NextEra's ASR assessment and monitoring program in its Safety Evaluation for the proposed license amendment.²² Like NextEra, the Staff did not acknowledge the existence or applicability of NISTIR 7937, even though NIST had prepared the guidance for the NRC's Office of Nuclear Reactor Research.²³ Nor did the Staff question or otherwise address the legitimacy of NextEra's failure to follow the guidance.

²⁰ Commission Decision 19-07, 90 N.R.C. at 11.

²¹ See Technical Assessment, § 3 (citing NISTIR-7937, "Alkali-Silica Reaction Degradation of Nuclear Power Plant Concrete Structures: A Scoping Study" (2013) ("NISTIR-7937")).

²² NRC Safety Evaluation Related to Amendment No. 159 to Facility Operating License No. NPF-86 (March 1, 2019) (ML18362A370).

²³ See NISTIR 7937, cover page.

Throughout the following decade, NextEra and the Staff failed to take into account the results of relevant ASR testing, including NRC-sponsored ASR testing, on shear concrete walls typical of Seismic Category 1 structures like the Seabrook CEB. These test results -- including tests conducted by NIST and Dr. Saouma on equally representative shear panels -- showed that the results of NextEra's tests on ASR-affected beams cannot validly be extrapolated to the behavior of wall-type structures, particularly the cylindrical reinforced-concrete shell of the CEB at Seabrook. Those beam-test results provide an unjustifiably optimistic -- and therefore unconservative -- assessment of the CEB's shear capacity. Reliance on them could consequently jeopardize public safety and the environment.²⁴

Instead, NextEra and the Staff continued to rely on NextEra's demonstrably faulty program for assessing and monitoring ASR in concrete safety structures at Seabrook. Only in 2020, after NextEra's program was challenged by C-10 in the 2019 license amendment hearing, did the ASLB wisely impose additional rigorous monitoring requirements on NextEra.²⁵ However, the ASLB did not overrule NextEra's fundamentally erroneous assumption that ASR's strengthening effect on concrete beams would be representative of its effects on structures such as the shear walls of the CEB.²⁶ But at that time, as discussed above in Section 4, the ASLB was not fully informed by NextEra or the Staff of relevant ASR testing on shear walls, nor were all of these test results available. Further, as discussed in Section 5(d) below, the ACRS even gave the ASLB unsupported and erroneous assurances that NIST had completed ASR testing that reinforced the results of LSTP1.

**b. ASR testing on shear walls consistently shows
that ASR reduces structural capacity.**

²⁴ See Technical Assessment, Table 1 at page 12. As further explained by Dr. Saouma:

NextEra's laboratory tests disregarded the foundational principle of experimental mechanics that each test specimen should be as representative of the prototype as laboratory scale and resources allow. Where the prototype is a large-diameter cylindrical reinforced concrete shell subjected to in-plane membrane shear under lateral seismic loading -- as in the Seabrook [CEB] -- the appropriate test article is a squat shear wall or geometry-specific shear panel. Both should be representative of that behavior, and not an out of plane shear beam as tested by the LSTP.

Id. at 5.

²⁵ See LBP-20-09, 92 N.R.C. 58, 188 (2020) ("ASLB Decision LBP-20-09"). In that proceeding, Dr. Saouma provided expert testimony on behalf of C-10, the Intervenor.

²⁶ We note that at the time of the ASLB's decision, the only NRC-sponsored testing of shear walls that was complete was a test program at the University of Colorado, conducted by Dr. Saouma. Dr. Saouma's tests were completed in 2017. As he testified to the ASLB, his tests of ASR in shear walls showed a weakening effect. NIST's test results, which were consistent with Dr. Saouma's results, were not published until 2022. See NIST Technical Note 2180 (Task 3) (2022). Structural Performance of Alkali-Silica Reaction-Affected Reinforced Concrete Shear Walls.

Since the time of the ASLB's decision, aside from LSTP1, every major ASR research program that has investigated the structural effects of ASR in a nuclear context used shear walls or geometry-specific shear panels as the test specimen.²⁷ When those programs are examined carefully, a consistent pattern emerges: across all programs using geometry-representative specimens and properly controlled mixes, ASR causes a reduction in structural capacity, not an increase as erroneously inferred by NextEra and the Staff from the LSTP1 results.

c. NextEra appears poised to repeat LSTP1 without considering the results of ASR tests on concrete shear walls.

In order to account for the unanticipated expansion of ASR beyond the threshold established in NextEra's operating license, NextEra must now do additional laboratory testing of ASR-infected specimens.²⁸ Unfortunately, however, NextEra appears poised to repeat their ten-year record of disregard for information that is and should remain central to their inquiries. As stated by the NRC Staff to C-10 Executive Director Sarah Abramson, NextEra has informed the Staff that it intends to repeat or approximate the same non-representative laboratory tests, non-time-matched control methodology, and unvalidated and scientifically unjustified application of beam-test results to wall-type structures that it relied on to support its current ASR assessment and monitoring program. While the Staff has informed Ms. Abramson of its own intention to conduct a prior review of NextEra's plans for the second round of ASR testing under the NRC's policy for "[ROP Action Matrix Deviations](#)," we are concerned by the Staff's failure, over the past decade, to recognize or apply the significant body of new understanding that has been gained by NRC-sponsored and international research and testing.²⁹

d. ACRS has not adequately or accurately fulfilled its watchdog role.

In this context, we also raise to your attention that the ACRS, your watchdog arm relied on for their review of highly technical licensing issues, may have undermined the vigor of the Staff's oversight by erroneously asserting, in its December 14, 2018 letter to the Commissioners regarding NextEra's LAR, that NRC-sponsored ASR research by NIST and "large Canadian and European programs" had "produced similar results to the LSTP."³⁰ In fact, NIST had not

²⁷ See Saouma Technical Assessment at 5 (noting that aside from the Seabrook LSTP1 testing program, every major research program conducted since 2016 -- Canadian, Japanese, NRC-funded American -- used shear walls or shear panels and found adverse structural effects).

²⁸ Seabrook Station, Unit No. 1 – License Amendment No. 159 (March 11, 2019) (ML18204A291). See also Transcript, Advisory Committee on Reactor Safeguards, Subcommittee on Plant Operations and License Renewal at 32 (Apr. 17, 2025) (ML25134A252) (Travis Daun, NRC Staff, stating that confidence in the safety of operation is only possible "up to the expansion that [NextEra] tested;" otherwise, "we don't know.").

²⁹ In addition, we are concerned by the ACRS' less-than-forceful recommendation that consideration of this new information would be "beneficial" rather than clearly stating that it is necessary for protection of public health and safety. See Section 5(d) below.

³⁰ ACRS Letter to NRC Chairman Svinicki at 4 (December 14, 2018) (ML18348A951) ("ACRS 12/14/18 Letter"). In Decision LBP-20-09, the ASLB cited this letter as support for NextEra's

produced any research results at that time, and the results that NIST subsequently produced in 2021 were *not* consistent with the LSTP. As noted by Dr. Saouma, while the LSTP and NIST used different geometries, they reached opposite conclusions about the effects of ASR on concrete structures.³¹

Notably, in the 9/23/25 ACRS letter to the Commissioners, summarizing its “multi-year” and “extended” review of NextEra’s measures for addressing ASR at Seabrook, the ACRS did not correct this unsupported assertion.³² Problematically, the ACRS “reaffirmed” the conclusions of the ACRS’ 12/14/18 letter -- which, without explicit exception, included the erroneous and undocumented conclusion that NIST and other research programs yielded results “similar to the LSTP.” Given the importance of the ACRS’ opinions to the NRC’s decision-making process, the misrepresentation of preliminary NIST results to the ACRS in 2018 should be acknowledged and corrected.

As discussed above, we are also concerned that the ACRS’ 9/23/25 Letter, while acknowledging that additional knowledge has been gained since 2018, describes consideration of that knowledge as merely beneficial rather than necessary for protection of public health and safety.³³ It is imperative that the Commission clarify for the Staff that application of this new knowledge is essential for protection of public health and safety.³⁴ We also note that the only conclusions that are clearly stated by the ACRS, using the language of the Atomic Energy Act regarding its minimum statutory safety standard, are repetitions of the ACRS’ unsupported 2018 assertion, based on then-non-existent NIST test results, that LSTP1 was adequate and that Seabrook is and will be safe to operate now and for an extended period.³⁵

6. Conclusion and Request for Relief

We respectfully submit that the Commission has serious cause for concern that NextEra’s next steps will fail to effectively assess or respond to the safety risks ASR poses, with consequences not just for the current license renewal term that expires in 2050, but also for a second license

license amendment application seeking approval of its ASR assessment and monitoring program. 92 N.R.C. at 96 n.206.

³¹ See Saouma Technical Assessment, § 4 and NIST Technical Note 2180 (Task 3).

³² ACRS 9/25/25 Letter at 1. See also Saouma Technical Assessment, § 5.

³³ *Id.* at 1 (emphasis added).

³⁴ See *Union of Concerned Scientists*, 824 F.2d 108, 118-19 (D.C. Cir. 1987), distinguishing between the minimal safety requirements of the Atomic Energy Act and discretionary measures that go beyond satisfaction of that standard.

³⁵ See *id.* at 1:

We reaffirm the Committee’s December 14, 2018 and December 19, 2018 conclusions that the programs and commitments to manage age-related degradation and the ASR condition through NextEra’s License Amendment Request 16-03 and license renewal application provide confidence that Seabrook can be operated safely.

renewal term if NextEra submits an application.³⁶ And it would be an unconscionable waste of the millions of dollars spent by the NRC on NIST's guidance and on ASR testing programs by NIST and Dr. Saouma if the NRC were to permit NextEra to repeat or approximate the LSTP1 beam test for the next phase of ASR testing.³⁷

For NextEra, in its planning for further ASR testing, to disregard the results of crucial NRC-sponsored technical guidance and the results of years of NRC-sponsored ASR testing is unacceptable and unsafe. In Dr. Saouma's expert opinion, Seabrook is now operating without the complete technical basis needed to demonstrate continued structural adequacy of its safety-related concrete structures.³⁸ Unless fundamental changes are made to the next phase of ASR testing at Seabrook, this dangerous deficiency will not merely remain uncorrected; it will persist and become increasingly consequential as ASR expansion and associated cracking continue. The longer corrective action is delayed, the greater the accumulated deterioration, the more uncertain the remaining structural safety margins, and the greater the potential risk to the surrounding population. Absent such changes, this unacceptable condition could persist throughout the next 24 years, until the renewed operating license expires in 2050, and potentially through a further extension to 2070. Of equal concern, NRC acceptance of a methodologically deficient testing approach at Seabrook could create a precedent for future ASR investigations, in which subsequent programs relying on the same or similar methods may be afforded unwarranted credibility based on prior regulatory acceptance rather than on independent scientific validity. Such an outcome would risk institutionalizing a flawed methodology and could undermine confidence in the scientific rigor of future NRC evaluations.

Accordingly, we ask you to intervene and give direction to the NRC Staff to require NextEra to design new ASR tests that are consistent with NIST guidance and with the testing procedures of recent ASR tests by NIST and other institutions. In addition, any final test program should be subjected to peer review by internationally recognized independent experts on ASR and/or experimental mechanics. We also request that you ask the ACRS to investigate the inaccurate statement in their 2018 Letter.

The Commission should also require the Staff to ensure that any supplemental testing program will use geometry-representative squat shear wall or shear panel specimens, instrument the

³⁶ Pursuant to NRC regulation 10 C.F.R. § 54.17(c), the earliest date on which NextEra could apply for subsequent license renewal is 2030, twenty years before its renewed license is due to expire. It is reasonable to expect that at that time, NextEra would present the results of its latest round of ASR tests in support of its subsequent license renewal application, and that those test results would be considered. As a results, the next round of ASR tests conducted by NextEra could be crucial to the NRC's safety findings for operating Seabrook until 2070 — 44 years from now.

³⁷ Saouma Declaration, ¶ 5 (stating that unmodified repetition of LSTP1 would be "a costly and dangerous mistake.").

³⁸ Saouma Declaration, ¶ 47.

reinforcement with strain gauges, employ time-matched lithium-suppressed companion controls, and develop a validated expansion prediction model calibrated to Seabrook concrete mixtures.³⁹

Finally, Dr. Saouma wishes to inform the Commissioners of his availability to serve as a *pro bono* technical advisor to NextEra and the NRC Staff in planning further ASR tests that comply with NIST's guidance and that build on the results of NIST Technical Note 2180 (Task 3). If the NRC wishes to engage Dr. Saouma for such consultation, he can best be reached by email at saouma@colorado.edu.

Sincerely,



Diane Curran
Counsel for C-10

Cc: NextEra Seabrook, L.L.C.
Anna Bradford, Director, NRC Office of Nuclear Reactor Regulation
Travis Daun, NRC Senior Resident Inspector, Seabrook Station
Seamus Flanagan, NRC Resident Inspector, Seabrook Station
Niklas Floyd, NRC Senior Reactor Inspector, Region 1
Gregory Halnon, Chair of ACRS
Senator Edward Markey (MA)
Senator Elizabeth Warren (MA)
Senator Jeanne Shaheen (NH)
Senator Maggie Hassan (NH)
Congressman Christopher Pappas (NH)
Congresswoman Maggie Goodlander (NH)
Congressman Seth Moulton (MA)

Attachment: Declaration of Victor E. Saouma, Ph.D. (Oct. 7, 2026) and Exhibits 1 through 4 to his Declaration.

³⁹ *Id.* at 18.

**ATTACHMENT TO C-10
LETTER TO NRC COMMISSIONERS
(Oct. 8, 2026)**

Declaration of Victor E. Saouma, Ph.D
(Oct. 7, 2026)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE COMMISSION

In the Matter of	)	
NextEra Energy Seabrook, LLC	)	Docket No. 50-443
(Seabrook Station, Unit 1)	)	October 7, 2026

DECLARATION OF VICTOR E. SAOUMA, Ph.D

Under penalty of perjury, Victor E. Saouma declares as follows:

Introduction and Purpose of My Declaration

1. My name is Victor E. Saouma. I am Professor Emeritus of Civil Engineering at the University of Colorado in Boulder. I am also the Managing Partner of X-Elastica, a small consulting firm based in Boulder, Colorado. The work of X-Elastica focuses on the nonlinear seismic analysis of complex concrete and reinforced concrete structures, those suffering of chemical deterioration in particular. A copy of my Curriculum Vitae is attached to my declaration as **Exhibit 1**.
2. I have been retained by the C-10 Research and Education Foundation (C-10) to provide my professional evaluation of the current state of knowledge of NextEra Seabrook, LLC (NextEra) and the U.S. Nuclear Regulatory Commission (NRC) regarding alkali-silica reaction (ASR) at the Seabrook nuclear power plant. ASR is a specific form of alkali-aggregate reaction (AAR), the broader class of deleterious reactions between alkalis in cement paste and reactive aggregate constituents.
3. As discussed in my attached expert report, *ASR Research Program Gaps and Structural Test Evidence: A Unified Technical Assessment* (Oct. 7, 2026) (hereinafter “Technical Assessment”) (**Exhibit 2**), this point in time is significant for three reasons.
 - (a) First, approximately ten years have passed since NextEra applied to the NRC for approval of a program for assessment and monitoring of ASR in Seabrook safety structures, including Seismic Category I structures such as the Containment Enclosure Building (CEB). It is also approximately ten years since completion of the Large-Scale Test Program (LSTP), a three-year program of testing of ASR-affected concrete beams by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas (Austin). NextEra based its ASR assessment and monitoring program on the results of the LSTP. At this decade milestone, it is appropriate – and indeed essential – to review lessons learned from the LSTP, including guidance that was missed or ignored at the time of the LSTP as well as significant developments in the understanding of ASR’s behavior in nuclear power plant structures since then. Taken alone or together, the missed prior guidance and subsequent technical developments show that the LSTP was not an adequate technical basis for assessing the seismic resistance of the Seabrook CEB, nor for predicting the future progression of ASR and its structural consequences in that safety-related structure.

- (b) Second, recent ASR monitoring results indicate that some Seabrook structures are trending to exceed the upper bound of the expansion range evaluated in the LSTP, as early as 2034. This discovery is significant, because it shows that the LSTP was not a reliable predictor of how fast ASR would progress at Seabrook.
 - (c) And third, the discovery that ASR is progressing more rapidly than predicted by NextEra and the NRC is significant because it triggers a requirement for additional laboratory testing of ASR-affected specimens.
4. Before proceeding with further testing, it is important to revisit the inadequacies of the LSTP, including inadequacies that were visible at the time and inadequacies that have been demonstrated by the significant body of research and testing – some sponsored by the NRC at great cost – that have been published since 2017. This includes test results showing that the specific LSTP testing approach is not a reliable technical basis for predicting ASR's structural effects on the seismic performance of the Seabrook CEB's cylindrical reinforced-concrete shell.
 5. Unfortunately, NextEra appears to be preparing to repeat or approximate the LSTP, in disregard of the significantly increased understanding of ASR's behavior that has been developed over the past ten years. As discussed in my Technical Assessment, to carry through with a reprise of the LSTP, without modifying the tests to take that new information into account, would be a costly and dangerous mistake. NextEra would waste resources for a result that is likely to be misleadingly optimistic and therefore dangerous to the public and the environment. The NRC should take great care to ensure that the next set of tests does not repeat the mistakes of the LSTP.

My Background and Qualifications

6. I am *Professeur des Universités* in France, and have been a visiting Professor at the Swiss Federal Institute of Technology (Lausanne), January-June 1990; 1997-1998, and Sept.-Dec. 2011. I was also a visiting Professor, (typically 1 summer month): at the *Université de Toulouse* (2009), *Politecnico de Catalunya*, (2007, 2010); and *Ecole Normale supérieure de Cachan*, (1992, 1994, 2007). I was an invited Professor for two years (2003-2004) at the *Politecnico di Milano*.
7. I am qualified by training and experience in the fields of [AAR](#), [Fracture Mechanics](#), [numerical simulations of dams and nuclear reactors](#), probabilistic based safety assessment, seismic analysis, chloride diffusion experimental mechanics and structural testing.
8. I have received three degrees in Civil Engineering: a Ph.D. from Cornell University in 1980, an M.E. from Cornell University in 1977, and a B.E. from the American University of Beirut in 1977.
9. I am a leading international expert in the field of AAR. I have developed what is probably the most widely referenced and copied model for AAR (in Abaqus, Vector3, Grizzly/Moose at the Idaho National Laboratory and LS-Dyna by the National Institute for Standards and Technology (NIST) as well as in China, Switzerland, and Canada. My research has encompassed material

and structural testing, theoretical and computational models, numerical simulations of dams and nuclear reactors. I published a book on Numerical Modeling of AAR; and I have published over 30 papers on AAR, chloride diffusion, Seismic Analysis and Stochastic Analyses.

10. In the Fall of 2025, I organized and co-taught with three other international leaders a short course [Management of Alkali Aggregate Affected Structures; Analysis, Performance & Prediction](#) to 50 participants from 17 countries.
11. In the spring of 2026, I published [The Four Books of Structural Analysis, From the History of Mechanics to Modern Computational Methods](#), a four-volume approximately 3,300 page treatise on structural analysis. This book is available online at no cost.
12. In addition, I have published extensively on related topics, including fracture mechanics, risk-based assessment of bridges and dams, chloride diffusion, and experimental dynamics, and have edited a book on the latter subject. More recently, I made substantial contributions to the preparation of a report for the Electric Power Research Institute (EPRI) on the numerical modeling of nuclear concrete containment vessels.

My experimental and computational work includes large-scale testing of concrete fracture properties for EPRI; dynamic centrifuge testing of dam models in Japan; real-time hybrid simulation—a sophisticated form of dynamic structural testing—for the National Science Foundation (NSF); experimental investigations of alkali-silica reaction (ASR), including expansion, its effects on shear strength, and expansion under varying environmental and loading conditions, for the Nuclear Regulatory Commission (NRC); and three-dimensional numerical simulation of ASR-induced expansion in dams for the Bureau of Reclamation.

13. I am the former Director and Principal Investigator of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), NSF Center on Fast Hybrid Test at the University of Colorado, Boulder (2006-2009).
14. I have served as President of [FraMCoS](#) (Fracture Mechanics of Concrete), a scientific organization focusing on the fracture and cracking of concrete (and organized FraMCoS IX).
15. I was the Chair of International Union of Laboratories and Experts in Construction Materials, Systems and Structure (RILEM's) Technical Committee 259-ISR for Prognosis of deterioration and loss of serviceability in structures affected by alkali-silica reactions. This committee sought to expand our knowledge in the prognosis of structures affected by ASR, and to develop a benchmark problem to validate numerical codes that assess ASR.
16. I have also served as a member of the Materials Aging and Degradation (MAaD) External Review Committee (ORNL, Light Water Reactor Sustainability R&D Program); a member of the Expanded Proactive Materials Degradation Analysis Expert Panel (PMDA) for concrete in nuclear reactors; and Reviewer of the French research program MACENA (associated with VeRCoRs).
17. I have conducted research on ASR for the Swiss Dam Safety office, the Tokyo Electric Power Service Company, Oak Ridge National Laboratory, the NRC, and the U.S. Bureau of Reclamation.

18. I also spent four years conducting research for the Electric Power Research Institute on the applicability of fracture mechanics to concrete dams; and nine years conducting research for the Tokyo Electric Power Service Company on the seismic response of dams (numerical and experimental).

My ASR Research and Testing on Behalf of the NRC

19. In 2014 and 2017, the NRC awarded me a \$703,000 contract to provide support for “Experimental and Numerical Investigation of Alkali Silica Reaction in Nuclear Reactors.” The initial grant award is posted on the NRC’s ADAMS Publicly Available Records System (PARS) Library (“ADAMS”) at ML14274A265. As stated at page 4 of the grant award, the impetus for my proposed research stemmed from “the apparent challenge confronting the NRC in assessing safety issues pertaining to the Seabrook nuclear power plant which suffers from Alkali Silica Reaction (ASR), and in particular NRC request that the licensee determines the long term safety of the plant within the framework of ML121250588 (2012).” (ML121250588 is the NRC’s “Seabrook Alkali-Silica Reaction Issue Technical Team Charter.” The Charter’s purpose is to “provide coordination of the onsite inspections, in-office technical reviews, and other associated evaluation and assessment activities involving NextEra’s review and resolution of the ASR issues at Seabrook Station.”).
20. In December 2017, I submitted a four-volume report on my research:
 - (a) Vol. 1-A: Design of an AAR Prone Concrete Mix for Large Scale Testing (93 pages)
 - (b) Vol. 1-B: AAR Expansion; Effect of Reinforcement, Specimen Type, and Temperature (123 pages)
 - (c) Vol. 1-C: Effect of AAR on Shear Strength of Panels (90 pages)
 - (d) Vol. 2: Diagnosis & Prognosis of AAR in Existing Structures (210 pages)
 - (e) Vol. 3-a: Risk Based Assessment of the Effect of AAR on Shear Walls Strength (25 pages)
 - (f) Vol. 3-b: Probabilistic Based Nonlinear Seismic Analysis of Nuclear Containment Vessel Structures with AAR (216 pages)
 - (g) Final Summary Report (23 pages)

My Final Summary Report is posted on ADAMS at ML19044A772. I also made an oral in-person presentation to the NRC near completion of my project.

21. For the record, I have not received a response to my report from the NRC.

NIST ASR Research and Testing on Behalf of the NRC

22. In 2014, in addition to my research contract, the NRC also entered an Interagency Agreement with NIST regarding “Structural Performance of Nuclear Power Plant (NPP) Concrete Structures Affected by Alkali-Silica Reaction (ASR).” As described in the Statement of Work, the objective of this research study was “to develop a technical basis and regulatory guidance for NRC staff to evaluate ASR-affected concrete structures. The research will assess the structural performance of ASR-affected concrete structures for design basis static and dynamic loading and load combinations through its service life, including the period of extended operation for the 20 year license renewal period.”
23. The NIST Grant Statement of Work also promised the development of a new methodology for assessing ASR in nuclear plants:

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

In addition, a significant component of the NIST study was the conduct of shear capacity testing in shear walls containing ASR. Thus, the NIST Grant included “Task 3: Seismic Response Characteristics of ASR-Affected Concrete Structural Member,” whose “Objective” was to “develop a methodology for assessing the degradation of seismic resistance of structural members and systems due to ASR.” By testing shear walls, NIST more closely approximated the concrete walls of the Seabrook containment building than testing of ASR in concrete beams, on which NextEra would subsequently base a license amendment request (“LAR”) for NRC approval of its ASR monitoring program.

24. To carry out Task 3, NIST proposed to use the following “Approach:”

To avoid sustaining serious damage due to seismic excitation, structures are designed such that the lateral displacement of vertical members (such as columns and walls) and the end rotation of horizontal members (such as beams and girders) should not exceed the specified allowable values. If the stiffness and energy-absorbing capacity are reduced due to ASR, the response of structural members to earthquake excitation may exceed the design limits, thereby making the structure susceptible to serious damage or collapse during the design level earthquake. At the present time, seismic analysis procedures for nuclear power plant structures subjected to ASR degradation are not available in the open literature. NIST will carry out cyclic loading tests of 3/4-scale normal (one) and ASR-affected (three) concrete shear walls to assess the effects of ASR on strength and stiffness. Such tests will yield information on the effects of ASR degradation on the energy absorption properties of concrete shear walls. The cyclic loading protocol for these tests and the reinforcing ratio and details

for shear walls will be developed in collaboration with NRC to ensure applicability to NPPs.

25. NIST published the results of Task 3 in 2022 in NIST Technical Note 2180: Weigand, et al., *Structural Performance of Nuclear Power Plant Concrete Structures Affected by Alkali-Silica Reaction (ASR); Task 3: Assessing Cyclic Performance of ASR-Affected Concrete Shear Walls* (Jan. 2022). NIST Technical Note 2180 confirmed the conclusion of my own research and testing for NRC that ASR degrades the condition of shear concrete walls.
26. As summarized in § 4.1.1.4.1.1 of my Technical Assessment, NIST tested four reinforced concrete shear wall specimens at $h_w/l_w = 2.0$ under reversed cyclic lateral loading. The control specimen used the same reactive concrete mix as the reactive specimens, dosed with lithium nitrate to suppress ASR, and was aged and tested alongside the ASR specimens — providing the most rigorous material comparison in any program to date and, unlike the LSTP, eliminating the confounding effect of normal concrete maturation gain.
27. The results of NIST’s testing of ASR shear walls, as reported in NIST Technical Note 2180, showed a significant degradation of shear capacity. In particular:
 - (a) NIST reported a 30% reduction in compressive strength; 70% reduction in modulus of elasticity; and 40% reduction in splitting tensile strength in ASR-affected concrete at approximately 0.23–0.25% expansion. These material degradation effects caused statistically significant reductions of 26% in normalized yield moment capacity and 11% in peak flexural capacity, with the normalized yield moment M_y/M_n falling below 1.0 for all three reactive specimens.
 - (b) NIST concluded explicitly that ACI 318 capacity calculation procedures are unconservative for ASR-affected walls — a conclusion that is independent of wall aspect ratio because it rests on material degradation that is present in any ASR-affected concrete structure.

My Work on Behalf of C-10 Research and Education Foundation

28. Since 2018, I have been retained by C-10 to evaluate work done by NextEra, NextEra’s consultants, and the NRC technical staff regarding the presence of ASR in concrete at the Seabrook nuclear power plant; and the effect of ASR on the integrity of the concrete, including the containment. In the course of my review, I evaluated both public and proprietary documents regarding NextEra’s investigations. (While I have reviewed proprietary information in the course of my work for C-10, neither this Declaration nor my Technical Assessment contains any proprietary information.) I also applied the insights of my work under the NRC contract described above in ¶¶ 19-20.
29. On Feb. 12, 2019, I prepared a report for C-10 entitled “Concerns Regarding the Structural Evaluation of Seabrook Nuclear Power Plant.” C-10 submitted my report to the NRC Commissioners in support of their Emergency Petition for Exercise of Commission’s Supervisory Authority to Reverse No Significant Hazards Determination and Immediately Suspend License Amendment and License Renewal Decisions (Feb. 13, 2019) (ML19044A768) (hereinafter

“2019 Emergency Petition”). My report explained the basis for my expert opinion that the LSTP and related finite analysis were substandard and inadequate to support any conclusion that the ability of the Seabrook containment to withstand a design basis earthquake had not been unduly compromised by the presence of ASR.¹

30. Without addressing the merits of my criticisms and concerns, the Commission denied C-10’s Emergency Petition in *NextEra Seabrook, L.L.C.* (Seabrook Station, Unit 1), CLI-19-07, 91 N.R.C. 1 (2019).
31. Since the Commission’s decision in 2019, nothing has changed my expert opinion that the manner in which NextEra’s consultants have analyzed the impact of ASR on Seabrook and developed an ASR monitoring program is seriously deficient and thereby poses an unacceptable risk to public health and safety. Subsequent developments, including NIST Technical Note 2180 and other testing results, have further confirmed my opinion.
32. In 2019, I submitted written and testimony to the NRC’s Atomic Safety and Licensing Board (ASLB) regarding significant inadequacies in NextEra’s application for approval of a license amendment containing a program for assessment and monitoring of ASR at Seabrook. The hearing was held on Sept. 24 through 27 in Newburyport, Massachusetts. While the ASLB generally approved NextEra’s license amendment, it imposed significant additional monitoring requirements on NextEra in response to my testimony. *See NextEra Seabrook, L.L.C.* (Seabrook Station, Unit 1), LBP-20-09, 92 N.R.C. 58 (2020).
33. At the time of the ASLB hearing on NextEra’s license amendment application, NIST Technical Report 2180 had not been published, nor had the results of similar testing programs other than my own been published. Since then, however, as reflected in § 4.1.4 of my Technical Assessment, every major research program aside from the LSTP that has investigated the structural effects of ASR in a nuclear context used shear walls or geometry-specific shear panels as the test specimen. When those programs are examined carefully, a consistent pattern emerges that directly contradicts the LSTP finding: across all programs using geometry-representative specimens and properly controlled mixes, no program reproduced the LSTP’s strengthening result. The two programs employing time-matched, lithium-suppressed controls — NIST and my own — measured reductions in capacity (on the order of 11–26% and 20%, respectively), while the remaining programs found no strength increase together with adverse effects on stiffness, ductility, and energy dissipation. Under these circumstances, it would be an unconscionable waste of the NRC’s resources to permit NextEra to repeat or approximate the LSTP for the next phase of ASR testing.
34. NIST Technical Note 2180 further confirmed the conclusion of my own research and testing: that ASR degrades concrete shear capacity and, as a consequence, reduces the seismic resistance of the Seabrook CEB’s cylindrical reinforced-concrete shell.

¹My February 12, 2019 expert report was submitted as a proprietary document. At the same time, C-10 also submitted a non-proprietary summary of my report (ML19044A773). A publicly available redacted version of my complete report was prepared in 2019 and is posted on ADAMS at ML19254F151.

35. I discussed the significance of the NIST study for Seabrook Station in my *White Paper, Assessment of NIST Shear Wall Tests and Their Relevance for Seabrook Safety* (Apr. 30, 2025) (ML25121A280, pdf p. 172). To summarize the findings of that White Paper:
- (a) NextEra predicted an increase in shear strength in ASR-affected structures based on beam tests from the LSTP. Although this increase was not necessarily relied upon for explicit numerical credit, the claimed LSTP strengthening (or non-degradation) result materially influenced the regulatory basis for the ASR monitoring program. In contrast, NIST's shear-wall tests at $h_w/l_w = 2.0$ (intermediate aspect ratio) — a more appropriate configuration — showed a decrease in strength, demonstrating the inapplicability of LSTP results and raising serious concerns about the adequacy of NextEra's assessment and monitoring program.
 - (b) This disparity between the NIST and LSTP results was foreseeable. The selection of out-of-plane beam-shear tests to predict CEB behavior reflected a fundamental misunderstanding: cylindrical shells resist lateral loads primarily through membrane action (in-plane shear) with minimal bending — not beam flexure, which captures out-of-plane shear. Tests should have been performed on specimens which capture in-plane shear failure, as consistently done by other researchers studying cylindrical shells. Given its prior research on CEB shear behavior (e.g., Cornell/MIT projects), the NRC had the knowledge and responsibility to recognize that the proposed NextEra beam test was fundamentally non-representative.
 - (c) Moreover, it appears NextEra did not conduct an adequate literature review; chemical prestressing effects, long documented (e.g., Ahmed, Burley, and Rigden, 1998), show that reinforced concrete beams can exhibit apparent increases in shear capacity under certain restrained test conditions, even as ASR degrades the concrete's material properties.
 - (d) NextEra relied on the empirical equation $E = 57,000\sqrt{f'_c}$ (MPR-ML16279A050, 2017) to relate compressive strength to elastic modulus. However, NIST found the experimental data widely scattered, not clustering around the equation. This scatter highlights the need to explicitly account for uncertainties. NIST's findings thus invalidate the procedure developed in (NRC-ML18226A205, 2018) for inferring past expansion.
36. My April 2025 White Paper was peer-reviewed by Dr. Jacky Mazars, Prof. Emeritus, Polytechnic Institute, Grenoble Alpes University (France) (pdf p. 201) (*see Exhibit 3*) and by Dr. Stein Sture, Prof. Emeritus, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder (U.S.) (*See Exhibit 4*).
37. In May 7, 2025, I presented my April 2025 White Paper and a power point summarizing my findings. *See* Presentation to ACRS re: Assessment of NIST Shear Wall Tests and Their Relevance for Seabrook Station Safety (May 7, 2025) (Meeting Transcript, ML25121A280, pdf pp. 172-206).
38. At a subsequent ACRS full committee meeting on September 3, 2025, George Thomas of the NRC Staff gave a power point presentation responding to my April 2025 White Paper (ML25261A269, pdf pp. 117-28). At the same meeting, I presented my response to Dr.

Thomas, which is set forth in my *White Paper, Technical Response to NRC's Rebuttal of My Analysis of NIST ASR Findings for Seabrook Safety* (Aug. 31, 2025) (Meeting Transcript ML25121A280, pdf pp. 129-148). To summarize the concerns raised in my White Paper, I found that the NRC Staff's response had failed to meet basic scholarly standards in approving NextEra's inappropriate test methodology and NextEra's flawed expansion reconstruction. Further, instead of addressing these fundamental technical concerns, the Staff had deflected them with irrelevant discussions and unsubstantiated assertions.

39. My August 2025 White Paper was peer-reviewed by Dr. Stein Sture. *See Exhibit 4.*

My Current Assessment of ASR at Seabrook and the Inadequacy of the NRC's Regulatory Oversight

40. As set forth in my Technical Assessment, the LSTP is grossly inadequate both to assess ASR-induced degradation of shear capacity — and the resulting loss of seismic resistance — and to predict the future progression and severity of ASR at Seabrook.
41. From the start, the LSTP was inconsistent with NISTIR 7937, ASR testing guidance issued in 2013 by NIST for ASR testing in nuclear plant structures. As set forth in § 3 of my Technical Assessment, these inconsistencies related to large-scale instrumented structural elements (§ 3.1), confined core testing (§ 3.2), and future expansion prediction (§ 3.3). As discussed in my Technical Assessment and as summarized in Table 1, the deficiencies are extensive and significant. Further, there is no indication that NextEra plans to correct those deficiencies.
42. As discussed in §4.1.1 of my Technical Assessment, during the ten years that have passed since NextEra sought NRC approval of its ASR assessment and testing program, the NRC's technical staff have contracted for, and then largely ignored, a significant body of guidance and research by NIST and other institutions. Instead, the Staff has deferred to NextEra on an issue that is novel, complex, and safety-significant — and that, if incorrectly assessed, could compromise the seismic resistance of safety-related structures and thereby put public safety at risk. That deference is particularly difficult to justify where neither NextEra nor its contractors appear to have established recognized technical expertise in ASR through the peer-reviewed literature; to my knowledge, they have not published even one peer-reviewed technical paper on the structural behavior of ASR-affected reinforced concrete. Only in 2020, when NextEra's program was challenged in a licensing hearing before the ASLB, did the NRC impose additional monitoring requirements on NextEra. And even then, the ASLB did not question the fundamental concept of the LSTP's testing concrete beams instead of shear walls.
43. As set forth in § 4.1 and 4.1.1–4.1.3 of my Technical Assessment, NextEra's laboratory tests disregarded the foundational principle of experimental mechanics that each test specimen should be as representative of the prototype as laboratory scale and resources allow. Where the prototype is a large-diameter cylindrical reinforced concrete shell subjected to in-plane membrane shear under seismic loading — as in the Seabrook CEB — the appropriate test article is a shear wall or geometry-specific shear panel representative of that behavior, not an out of plane shear beam. The difference is significant: aside from the Seabrook testing program, every major research program conducted since 2016 (Canadian, Japanese, NRC-funded American) used shear walls or shear panels *and found adverse structural effects*.

44. As discussed in § 4.2 of my Technical Assessment, the LSTP also omitted the single most important instrumentation required to characterize ASR's effects on structural capacity: strain gauges on the longitudinal reinforcement. Direct strain measurements were necessary to quantify the additional (and "parasitic") tensile strain imposed on the steel reinforcement and the corresponding compressive state imposed on the concrete. Those strain changes are the direct mechanical manifestation of the phenomenon described as "chemical prestressing." Yet NextEra invoked that phenomenon only for its asserted beneficial consequence — an apparent increase in shear strength — while failing to recognize its adverse consequences. Thus, the LSTP presented only the supposed benefit of "chemical prestressing," without providing a complete and balanced assessment of both its beneficial and detrimental structural effects.
45. Another methodological deficiency, as set forth in § 4.3 of my Technical Assessment, concerns the LSTP's use of a so-called control specimen. The program did not use an ASR-free, time-matched control; instead, it used a specimen from the same ASR-reactive mix tested shortly after casting, and compared it to nominally identical specimens tested months or years later. That comparison is inherently biased because concrete naturally continues to gain strength with time, whether or not ASR is present.
46. Finally, as discussed in § 5 of my Technical Assessment, the Commission has reason for serious concern that the ACRS, a watchdog arm of the NRC relied on by the agency for their expert review of highly technical licensing issues, may have biased the NRC's review process in 2018 by making an undocumented and unsupported claim that NRC-sponsored ASR research by NIST and "large Canadian and European programs" had "produced similar results to the LSTP." In fact, NIST had not produced any research results at that time, and the results that NIST subsequently produced in 2022 were *not* consistent with the LSTP. The ACRS did not correct this unsupported assertion in 2025, when it reported to the NRC Commissioners on a "multi-year review" of NextEra's measures for addressing ASR at Seabrook. Given the importance of the ACRS' opinions to the NRC's decision-making process, the ACRS' incorrect and misleading assertion should be acknowledged and corrected, and the ACRS should be required to address the substantial body of research that contradicts its 2018 assertion.

Conclusion and Recommendations

47. In my expert opinion, Seabrook is now operating without the complete technical basis needed to demonstrate continued structural adequacy of its safety-related concrete structures. This situation compromises the seismic qualification of Category I safety structures like the CEB.
48. Unless major changes are made to the next phase of ASR testing at Seabrook, and unless the NRC draws the necessary technical and regulatory conclusions from those test results, this unacceptable situation is likely to continue for the next 24 years, through a renewed operating license term that does not expire until 2050 – or possibly until 2070 if Seabrook's operating license is renewed for a second term.
49. From the beginning, the LSTP was inconsistent not only with NRC-funded NIST guidance, but also with the then-existing state of the art in ASR assessment, structural testing, and experimental mechanics. It was therefore deficient in design, instrumentation, and controls. These

deficiencies fatally undermined the credibility of NextEra's assertion that the LSTP showed ASR would have a strengthening effect on concrete in Seabrook safety-related structures, including the cylindrical reinforced-concrete shell of the CEB.

50. Further, both NextEra and the NRC Staff have disregarded the fact that the two other independent NRC-funded ASR testing programs that used representative geometry and rigorous controls — including the NIST testing conducted for the NRC at considerable expense — found adverse structural effects, thereby contradicting NextEra's assertion that ASR would have a strengthening effect.
51. The ACRS's 2018 endorsement of the LSTP was factually unsubstantiated and may have biased decisions by both the NRC Staff and the ASLB. While subsequent ASR testing, including testing conducted by NIST and myself, conclusively demonstrated that this endorsement was incorrect, the ACRS repeated the endorsement in 2025 without addressing the contradictory research results.
52. Given the persistent failures in regulatory oversight by both the Staff and the ACRS over the past ten years, I believe it is necessary at this time for the Commissioners to step in and take measures to correct the Staff's continuing disregard for NIST's guidance and the results of multiple research programs into the effects of ASR on concrete shear walls such as are used in the Seabrook CEB. I would also urge the Commissioners to seek accountability from the ACRS for its erroneous and misleading statements in support of the LSTP.
53. The Commission should direct the NRC Staff to undertake a prospective review of NextEra's plans to conduct another round of ASR testing. That prospective review should include an independent assessment by qualified external experts in ASR-affected reinforced concrete, nonlinear structural behavior, and the seismic performance of nuclear safety-related structures. This review should apply the guidance of NISTIR 7937, as well as the results of ASR testing on shear walls that has been conducted since 2016. Thus, it is extremely important that any supplemental testing program for ASR at Seabrook must use geometry-representative squat shear wall or shear panel specimens, instrument the reinforcement with strain gauges, employ time-matched lithium-suppressed companion controls, and develop a validated expansion prediction model calibrated to Seabrook concrete mixtures.
54. I wish to offer the Commission my own expert services as a consultant on these matters. I will provide my services voluntarily, at no charge to the NRC or NextEra.

The statements of fact in this declaration and in my report are true and correct to the best of my knowledge, and the opinions stated therein are based on my best professional judgment.

Executed in Accord with 10 CFR 2.304(d) by:



Victor E. Saouma

Dated: October 7, 2026

EXHIBIT 1 TO SAOUMA DECLARATION

Saouma Curriculum Vitae

VICTOR E. SAOUMA

Last Updated: April 2026

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Retired Dec 2023; *all post retirement activities are on my web site.*

Professional Experience

- *Professeur des universités*, France, 2012-
 - Visiting Professor, Swiss Federal Institute of Technology (Lausanne), Civil Engineering (Sept. Dec. 2011).
 - Former Director and Principal Investigator of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), NSF Center on Fast Hybrid Test at the University of Colorado, Boulder; 2006-2009.
 - Visiting Professor, (typically 1 summer month): *Université de Toulouse* (2009), Politecnico of Catalunya, (2007, 2010); Ecole Normale Supérieure de Cachan, (1992, 1994, 2007);
 - Visiting Professor, *Politecnico di Milano*, Department of Structural Engineering, 2003-2004.
 - Visiting Professor, Swiss Federal Institute of Technology (Lausanne), Civil Engineering (January-June 1990); Material Science Department, 1997-1998.
 - Professor (1995 to present), Associate Professor (1988-1995), Assistant Professor (1984-1988), Department of Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder.
 - Assistant Professor, Department of Civil Engineering, University of Pittsburgh, Pittsburgh, PA, Sept. 1981-Dec. 1983.
 - Research Associate, Department of Civil Engineering, Princeton University, Princeton, N.J., Oct. 1980 - Aug. 1981.
-

Relevant Committee Memberships

- President, 2013-2016, (and Fellow) of the *International Association of Fracture Mechanics for Concrete and Concrete Structures* ([IA-FraMCOs](#)).
 - Chairman, 2015-2019, of the [RILEM committee](#) on *Prognosis of deterioration and loss of serviceability in structures affected by alkali-silica reactions*.
 - Past Member of the *Materials Aging and Degradation* (MAaD) External Review Committee (ORNL, Light Water Reactor Sustainability R&D Program).
 - [Member](#), 2010-2014, of the *Expanded Proactive Materials Degradation Analysis Expert Panel* (PMDA) for concrete in nuclear reactors; Nuclear Regulatory Commission.
 - Past: In connection with the VerCoRs study (1/3 model of a reactor containment building to be tested by *Electricite de France*, EdF): Member of the Scientific Committee of MACENA, *Managing confinement structures in the event of an accident*.
 - Member of the Scientific Committee of OECD/NEA/CSNI CAPS ASCET - *Assessment of Structures subject to Concrete Pathologies*.
-

Education

- Cornell University, Ph.D. in Civil Engineering, September 1980.
 - Cornell University, M.E. in Civil Engineering, January 1977.
 - American University of Beirut, B.E. in Civil Engineering, June 1975.
 - Lycée Chateaubriand, Rome, Baccalaureat Série Scientifique, 1971.
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Research Interests

- Nonlinear (static and dynamic) analysis of major structures (nuclear containers, dams) due to aging or severe load.
 - Computational and experimental (fracture) mechanics.
 - [Alkali Silica Reactions](#).
 - [Real time hybrid simulation](#).
 - Large scale and innovative laboratory testing.
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Teaching

Undergraduate:

Statics
Strength of Material
Structural Analysis
Reinforced Concrete
Computer Literacy for Undergraduates
Matrix Structural Analysis
Structural Analysis for Architects

Graduate:

Continuum Mechanics
Computer Graphics
Finite Elements
Fracture Mechanics
Nonlinear Structural Analysis of Frames
Advanced Reinforced Concrete
Prestressed Concrete

Publications

Books

1. Saouma, V.E. *The Four Books of Structural Analysis* (2026), 3,000 pp., trilingual (EN/FR/ES); freely available for download.
 2. Saouma, V.E. and Hariri-Ardebili, M. (2020) *Aging, Shaking and Cracking of Infrastructures; From Mechanics to Concrete Dams and Nuclear Structures*, Springer-Nature.
 3. Saouma, V.E. (Ed.) (2020) *Diagnosis & Prognosis of AAR Affected Structures*, Springer-Nature.
 4. Saouma, V.E. (2013) *Numerical Modeling of AAR*, 320 pages, Taylor& Francis;
 5. Saouma, V. and Sivaselvan, M. (Eds) (2008) *Hybrid Simulation: Theory, Implementation and Applications*
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Archival Publications

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<https://doi.org/10.1016/j.engstruct.2020.111709>
99. Saouma, V.E., Hariri-Ardebili, M.A., Graham, L., 2020, **A Stochastic Computational Method for Global Behavior of Alkali-Silica Reaction.** *Cement Concrete and Research*, Vol. 132, 106032.
<https://doi.org/10.1016/j.cemconres.2020.106032>
98. Saouma, V. and Hariri, M. (2019) **Integrative Experimental and Numerical Study of ASR Affected Nuclear Concrete Containment**, *Materials and Structures*, Vol. 53, No. 1.
<https://doi.org/10.1617/s11527-019-1433-y>

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96. Saouma, V.E. and Hariri-Ardebili, M.A., 2019, **Seismic capacity and fragility analysis of an ASR-affected nuclear containment vessel structure**, *Nuclear Engineering and Design*, Vol 346, pp. 140-156, <https://doi.org/10.1016/j.nucengdes.2019.02.011>
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94. Hariri-Ardebili, M.A.. and Seyed-Kolbadi, S.M. and Saoumaa, V.E. and Salamon, J. and Rajagopalan, B. (2018) **Random Finite Element Method for the Seismic Analysis of Gravity Dams**, Vol. 71, pp. 405-420
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93. Liaudata,J. and Carol, I. and Lopez, C. and Saouma, V. (2018) **ASR Expansions in Concrete under Triaxial Confinement** *Cement and Concrete Composites*, Feb., pp 160-170
<https://doi.org/10.1016/j.cemconcomp.2017.10.010>
92. Saouma, V. and Hariri-Ardebili, and Merz, C. (2018) **Risk-Informed Condition Assessment of a Bridge with Alkali Aggregate Reaction**, *ACI Structures Journal*, Vol. 115, pp. 475-487.
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Major Conference Organizer

- 9th International Conference of the International Association of Fracture Mechanics of Concrete and Concrete Structures, IA-FraMCoS, Berkeley, CA, June 2016 (235 participants, 205 presentations, 32 countries) <http://framcoss.org/FraMCoS-0.php>
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Special Reviewed Publication

25. Hariri-Ardebili, M. and Saouma, V. (2019) **Long Term Assessment of Dams Suffering from Alkali Aggregate Reaction State of the Art Review**, Bureau of Reclamation report No. XX
24. Saouma, V. and Hariri-Ardebili, M. **Road Map for the Structural Assessment of Concrete Dams Suffering from ASR; Application to Seminole Dam**, Bureau of Reclamation report No. XX
23. Saouma, V. (Editor) & Fournier, B. and Katayama, T. and Leemann, A. and Lothenbach, B. and Martin, R.P. and Menéndez, E. and Sanchez, L. and Sellier, A. and Wood, J. **Diagnosis & Prognosis of AAR in Existing Structures** Technical Report to be Published by RILEM
22. Saouma, V., Spark, R. and Graff, D. (2017) **Design of an AAR Prone Concrete Mix for Large Scale Testing**, NRC Grant NRC-HQ-60-14-G-0010.
21. Saouma, V., Howard, D., Graff, D., and Hariri, M. (2017) **AAR Expansion; Effect of Reinforcement, Specimen Type, and Temperature**, NRC Grant NRC-HQ-60-14-G-0010.
20. Saouma, V., Graff, D., Howard, D. and Hariri, M. (2017) **Effect of AAR on Shear Strength of Panels**, NRC Grant NRC-HQ-60-14-G-0010.
19. Saouma, V. and Hariri, M. (2017) **Risk Based Assessment of the Effect of AAR on Shear Walls Strength**, NRC Grant NRC-HQ-60-14-G-0010.
18. Saouma, V. and Hariri, M. (2017) **Probabilistic Based Nonlinear Seismic Analysis of Nuclear Containment Vessel Structures with AAR**, NRC Grant NRC-HQ-60-14-G-0010.
17. Saouma, V. (2017) **Structural Modeling of Nuclear Containment Structures**, Special publication by Electric Power Research Institute (EPRI).
16. Hariri-Ardebili, M., Saouma, V., LePape, Y. (2016) **Independent Modelling of the Alkali-Silica Reaction: Mock-up Test Block**, Report ORNL/TM-2016/537
15. Saouma, V., Hariri-Ardebili, Puatatsananon, W., and Le Pape, Y. (2015) . **Preliminary Results on the Alkali-Silica Reaction in Massive Reinforced Concrete Structures: Numerical Simulations of Coupled Moisture Transport and Heat Transfer and Structural Significance of Internal Expansion**, ORNL/TM-2014/489
14. Saouma, V., Hariri-Ardebili, M., and Le Pape, Y. (2015) **Effect of Alkali-Silica Reaction on Shear Strength of Reinforced Concrete Structural Members**, ORNL/TM-2015/588.
13. Graves, H., Le Pape, Y., Naus, D., Rashid, J., Saouma, V., Sheikh, A., Wall, J. [Expanded Material Degradation Assessment \(EMDA\), Volume 4: Aging of Concrete](#) *Technical Re-*

port NUREG/CR7153, Vol. 4; ORNL/TM-2013/532.

12. Saouma, V.E. and Sivaselvan, M.V. (Eds.) (2008) **Hybrid Simulation; Theory, Implementation and Applications**, Taylor & Francis.
11. Bourdarot, E., Mazars, J., and Saouma, V.E. (Eds.), **Fracture and Failure of Concrete Dams**, Balkema, 1994.
10. Reich, R. and Saouma, **Fracture Mechanics Analysis of Gravity Lock Monolith**, *Engineering Technical Letter, No. ETL 1110-2-344*, US Army Corps of Engineers Civil Works, Engineering Division, Nov. 1992.
9. Plizzari, G., Saouma, V.E., and Waggoner, F., **Sperimentazione in Centrifuga di Dighe a Gravita in Calcestruzzo**, *Studi e Ricerche*, Vol. 13, Scuola di Specializzazione in Costruzioni in C.C., Fratelli Pesenti, Politecnico di Milano, pp. 359-394, 1992.
8. Saouma, V.E., and Brühwiler, E., **Engineering and Design Fracture Mechanics Analysis of Concrete Hydraulic Structures**, *Engineering Technical Letter, No. ETL 1110-2-8003*, US Army Corps of Engineers Civil Works, Engineering Division, Nov. 1991.
7. Saouma, V.E., Dungan, R., and Morris, D., (Eds.), **Proceedings of the International Conference on Dam Fracture**, GS-7491, Electric Power Research Institute, Palo-Alto, Sept. 1991.
6. Saouma, V.E., **Innovative Analysis and Design Procedures for Concrete and Arch Dams**, in *Jubilee Volume commemorating the retirement of Prof. L. Serafim*, Coimbra, Portugal, Oct. 1991.
5. Saouma, V.E., Ayari, M.L., and Boggs, **Static and Dynamic Fracture Mechanics of Concrete Dams**, in *Fracture Mechanics of Concrete Structures, From Theory to Applications*, L. Elfgren Editor, pp. 336-354, Chapman and Hall, 1989.
4. **Computer Application in Concrete Technology**, ACI, SP106, 1988.
3. Saouma, V.E., Ayari, M.L., and Boggs, H., **Fracture Mechanics of Concrete Gravity Dams**, in *Fracture of Concrete and Rock*, S. Swartz, and S. Shah Editors, pp. 311-333, Springer-Verlag, 1989, (Translated into Chinese).
2. Saouma, V.E., Sikiotis, E.S., **On the Optimization of Partially Prestressed Concrete Beams**, in *Partial Prestressing, From Theory to Practice* M.Z. Cohn, Ed., PP. 411-425, Martinus Nijhoff Publ., 1986.
1. Ingraffea, A.R., Saouma, V.E., **Numerical Modelling of Discrete Crack Propagation in Reinforced and Plain Concrete**, in *fracture Mechanics of Concrete, Structural Application and Numerical Calculation*, G.C. Sih, and A. de Tomaso, Editors, Martinus Nijhoff Publ., 1984.

Consulting Activities

1. Seoul National University; Structural Evaluation of Hanbit Nuclear Power Plant Number 4, S. Korea. (2020)
2. C-10 (*pro-bono*) in the matter of C-10 vs NextEra Energy Seabrook, LLC) Docket No. 50-443, ASLBP No. 17-953-02-LA-BD01. Wrote the emergency petition, multiple motions, direct and verbal testimony.
3. Pressurized cracks in concrete offshore structures, Shell Norway (through Reinertsen).

4. Review of Detensioning Plans for CR-3 (Progress Energy) through Structural Integrity.
5. Cracking of Crystal River nuclear reactor containment vessel (Progress Energy) through Performance Improvement International, San Diego.
6. Weidlinger & Assoc., New-York. Rebuttal report of a fracture mechanics based explanation for the fatal parking garage collapse at the Tropicana casino resort in Atlantic City, NJ.
7. Tokyo Electric Power Service Company, Tokyo, Japan.
8. New-York City Department of Environmental Protection (through Gannett Flemming), Gilboa Dam.
9. Cracking in solid rocket propellants, Bayern-Chemie GmbH, Aschau/Inn, Germany
10. Iran Water Power Company (Karun 4 dam), Tehran, Iran.
11. Edison Ellettricità, Turin, Italy.
12. Electricité de France, Paris
13. Obayashi Corporation, Japan
14. Tokyo Electric Power Service Company, Japan
15. US Bureau of Reclamation
16. Hilti Corporation, Lichtenstein.
17. Schnabel Engineering, Denver, CO
18. Swiss Dam Safety Authority, Berne, Switzerland
19. ISMES, Bergamo, Italy
20. ESI, Paris, France
21. PCS Mining, Saskatoon, Canada.
22. ACS Martin, L. A., CA
23. Hanna Mining, Cleveland, OH
24. General Dynamics, Fort-Worth TX
25. TERRA-TEK INC., Salt-Lake City, UT
26. CTICM, Paris, France
27. Southern Utility Company
28. US Army Corps of Engineers

Funded Research

Principal Investigator			
Jan. 2018- Dec. 2020	Long Tern Assessment of Dams Suffering from Alkali Aggregate Reaction	US Bureau of Reclamation	\$592,327
May. 16- Sept. 16.	Independent Modeling of the Alkali-Silica Reaction Mock-Up Test Block	Oak Ridge National Laboratory	\$ 60,000
Oct. 14 - Sept. 17	Experimental and Numerical Investigation of Alkali-Silica Reactors	Nuclear Regulatory Commission	\$ 703,197

May 16-Dec 16	Report on Numerical Modeling of Nuclear Structures	Electric Power Research Institute	\$35,000
Jan. 15 - Aug. 15	Alkali-Silica Reaction in Nuclear Power Plants	Oak Ridge National Laboratory	\$ 36,000
Jan. 14 - Jan. 14	Alkali-Silica Reaction in Nuclear Power Plants	Oak Ridge National Laboratory	\$ 138,000
Oct 12 - Dec 12	Developing Corporate Performance-Based Seismic Design Guideline Works	Enerjisa, Turkey	\$48,500
Oct. 09 - Dec. 10	Unconventional Fracture Tests for Crystal River Project	Progress Energy	\$130,000
Oct. 08- Nov. 09	Development of Finite Element Code Mercury	NEESinc	\$120,000
Jul. 08 - Mar. 10	3D Nonlinear Dynamic Analysis of Dams; Software Development and Technical Support.	Tokyo Electric Power Service Company	\$1,000,000
Jul. 07 - Mar. 10	AAR Expansion in Concrete under Triaxial Confinement.	Tokyo Electric Power Service Company	\$120,000
September 07	NEESinc	Workshop Organization at CU-NEES	\$7,500
Jul. 06 - Mar. 07	AAR Expansion in Concrete under Triaxial Confinement.	Tokyo Electric Power Service Company	\$64,000
Jul. 06 - Mar. 07	Life Prediction of AAR Affected Structures	Tokyo Electric Power Service Company	\$20,000
Jul. 06 - Mar. 07	3D Nonlinear Dynamic Analysis of Dams; Software Development and Technical Support.	Tokyo Electric Power Service Company	\$150,000
Jul. 06	Integration of Fast Hybrid Testing with a Cluster of 124 CPU	University of Colorado (Prof. Cai, Co-Pi)	\$28,000
Jan. 06-Sep. 09	Operation and Maintenance of the Colorado NEES Site	National Science Foundation	\$949,063
Nov. 05 - Mar. 06	Nonlinear Fracture Mechanics of Solid Rocket Propellant	Bayern-Chemie GmbH, Aschau/Inn, Germany	—
Jun. 05 - Mar. 06	Nonlinear Simulation of an AAR Affected High Voltage Transmission Tower	Tokyo Electric Power Service Company	\$20,000
Dec-04 - Mar. 05	Numerical Simulation AAR Deterioration in a High Voltage Transmission Tower	Tokyo Electric Power Service Company	\$ 10,000
Jan. 03 - Dec. 04	Cyclic Response of Concrete Joints	Italian Ministry of Research	38,000 Euro
Mar. 02 - Dec.02	Generation of a 3D Finite Element Mesh for a Nuclear Reactor Panel	Electricité de France	10,000 Euro
Jan-02-Dec-04	Numerical Investigation of Alkali-Aggregate Reactions in Dams	FOWG, Switzerland	CHF 100,000

Aug. 02 - Mar. 07	Static and Dynamic Dam Safety Investigation Using Fracture Mechanics	Tokyo Electric Power Service Company	\$ 891,599
Aug. 00 - Jul. 02	Static and Dynamic Dam Safety Investigation Using Fracture Mechanics	Tokyo Electric Power Service Company	\$ 635,423
Jun. 00 - May 02	Deterioration of Reinforced Concrete; A Fracture Mechanics Approach	National Science Foundation	\$ 128,000
Jan.94 - Aug. 94	Mixed Mode Testing of Rock/Concrete Interfaces	Electric Power Research institute	\$ 57,000
Aug. 93 - Jul. 94	Development of Instructional Workbenches for Small Scale Structural Testing	Univ. of Colorado	\$ 20,000
Jan. 93 - Dec. 93	Large Scale Mixed Mode Testing of Rock/Concrete Interfaces	Electric Power Research Institute	\$ 171,312
Jan. 90 - Dec. 91	Uplift Pressure in Dam Cracks under Seismic Loading, and 3D Fracture Analysis of Concrete Gravity Dams	Electric Power Research Institute, and Pacific Gas and Electric	\$ 150,000
Jun. 89 - May 92	Fracture Mechanics of Concrete Dams: Part II From Theory to Applications; Static Case.	Electric Power Research Institute	\$ 592,000
May 89 - Aug. 90	Effect of Uplift Pressure on Fracture Characterization of Concrete: Design and Evaluation of Testing Procedure	Electric Power Research Institute	\$ 41,857
Jul. 88	Donation of two Apollo DN3500 workstations	Apollo Computer	\$ 54,000.
Feb. 88 - Jan. 89	Design and Checking Automation of Reinforced Concrete Structures	U.S. Army Corps of Engineers	\$ 60,037.
Feb. 88 - Jan. 89	Load Module Development for 3DSAD	U.S. Army Corps of Engineers	\$ 42,493.
Dec. 87 - Feb. 88	Integrated Computer Aided Design of Complex Structures	General Dynamics, Advanced Analysis Group	\$ 21,000.
Dec. 87 - Jun. 88	Implementation of a Distributed Finite Element Based Structural Optimization Program on a CRAY/XMP	Cray Research	Computer and Technical Support
Jun. 87 - Nov. 88	Fracture Mechanics of Concrete Dams	Electric Power Research Institute	\$ 131,809
Dec. 86 - Sep. 87	Elasto-Plastic Fracture Mechanics of Welded Plates	National Bureau of Standards	\$ 9,594.
Sep. 86 - Jun. 87	Instructional Expert System for ACI Code Provisions	University of Colorado	\$ 3,998.

Sep. 86 - Aug. 87	Expert System Development for R/C Beam Design Checking; Part I.	U.S. Army Corps of Engineers	\$ 99,820.
Aug. 86 - Dec. 86	Finite Element Simulation of Rock Hydrofracture near a Subsurface Cavity	U.S. Army Corps of Engineers	\$ 7,200.
Sep. 85 - Aug 86	Engineering Research Equipment Grant: Network of High Performance "Computational Workstations" (Co P.I. K. Willam. C. Gustafson) Matching Fund	National Science Foundation University of Colorado	\$ 76,400. \$ 50,000.
Feb. 86 - Sep. 86	An Automated Model for the Load Definition Module of the 3DSAC CDAMS Program	U.S. Army Corps of Engineers	\$ 13,000.
Oct. 85 - Sep. 86	Implementation of an Integrated Fatigue Life Prediction Program on a Cray	General Dynamics, Fort-Worth, TX	\$ 47,000.
Sep. 85 - May 86	Application of Artificial Intelligence to Reinforced Concrete Design	CRCW, Univ. of Colorado	\$ 2,500.
Sep. 85 - Aug. 86	Fracture Mechanics of Concrete Dams	Bureau of Reclamation	\$ 9,995.
Aug. 85 - Dec. 85	Numerical and Experimental Studies on Bitt Cutter Performance	PCS Mining, Saskatchewan	\$ 17,000.
Oct. 83 - Nov. 85	Partially Prestressed Concrete Beam Optimization	National Science Foundation; Research Initiation Grant	\$ 47,967.

Co-Principal Investigator			
Apr 89 - Mar 91	Brittle-Ductile Failure Mechanics of Mortar and Concrete (Co P.I. K. Willam & S. Sture)	US-AFOSR	\$ 137,971.
	Personal Contribution 33.3%		\$45,990
Jul. 88 - Jan. 91	Load Prediction and Structural Response of Bridges (Co-P.I. G. Goble, D. Frangopol, J. Dow)	Federal Highway Agency	\$ 800,000.
	Personal Contribution 10%		\$80,000
Jun. 88 - May 89	Simulation of Progressive Failure in Solids and Structures (Co-P.I. K. Willam, S. Sture)	National Science Foundation	\$ 191,000.
	Matching Fund	University of Colorado	\$ 15,000.
	Personal Contribution 25%		\$51,500
Oct. 87 - Sep. 89	Simple Load Capacity Tests for Bridges to Determine Load Posting Levels (Co P.I. G. Goble, D. Frangopol)	Pennsylvania Department of Transportation	\$ 220,572.
	Personal Contribution 33%		\$72,788

Aug. 87 - Jul. 88	Brittle-Ductile Failure Mechanics of Mortar and Concrete (Co P.I. K. Willam & S. Sture) Personal Contribution 15%	US-AFOSR	\$ 50,000. \$7,500
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Wrote final proposal for the establishment of the **Bechtel Computer Aided Design Laboratory**, \$1,000,000.

Short Courses

1. [Management of Alkali Aggregate Affected Structures; Analysis, Performance](#) (50 participants from 17 countries).
2. Fracture Mechanics; University of Rome (Roma 3), July 2011
3. Fracture Mechanics; Polytechnic University of Catalunya, Summer 2010.
4. Short course on AAR, Paris, October 2009.
5. Workshop on Dam Research Needs, Boulder Sept. 2007
6. Workshop on Fast Hybrid Simulation, Boulder Aug. 2007
7. Alkali Aggregate Reactions in Massive Concrete Structures; Boulder, CO, April 2007
8. Workshop on Fast Hybrid Simulation, Boulder Nov. 2006
9. Alkali Aggregate Reactions in Massive Concrete Structures; Boulder, CO, April 2005
10. Alkali Aggregate Reactions; and Dynamic Analysis of Dams; International Center for Structure mechanics (CISM), Udine, December 2004.
11. Nonlinear Dynamics of Concrete Dams, 4 hours in a Course at the Politecnico of Milan on Nonlinear Dynamic Analysis of Structures, July 2004.
12. *Recent Advances in Engineering for Concrete Dams*, with Dungar, R., and Boggs, H.; 58 Participants from 14 countries, Sept. 9-10 1991 Boulder CO.

Invited Papers

18. Saouma V. and Hariri, M. (2018) **Probabilistic Cracking, Ageing and Shaking of Concrete Dams**, International Symposium on Dam Safety, Istanbul Turkey.
17. Saouma, V. (2016) **Size Effect: From Irwin to Bažant and Mandelbrot**, invited paper to the first Bažant Workshop at the 9th triennial Conference organized by the International Association for Fracture of Concrete and Concrete Structures, Berkeley, June 2016.
16. Saouma, V. (2013) **Application of the Cohesive Crack Models to Concrete, Ceramics and Polymers** Keynote Lecture at the 8th triennial Conference organized by the International Association for Fracture of Concrete and Concrete Structures, Toledo, April 2013.
15. Saouma, V. and Puatatsananon, W. **Chemo-Mechanical Model for Alkali-Silica Reaction**, 1st International Conference on Numerical Modeling Strategies for Sustainable Concrete, Aix-en-Provence, May 2012.
14. Saouma, V., Uchita, Y., Yagome, Y. **Research needs in Seismic Safety of Dams**, *Proceedings of the 4th US-Japan Workshop on Advanced Research on Dams*, Technical Memorandum No. 4075, Public Works Research Institute, Tsukuba, Japan, pp. 279–293 May, 2007.
13. Saouma, V. **Advanced Joint Modelling**, in *NW-IALAD, European network on Dam Engineering*, Barcelona, November, 2004.
12. Saouma, V. **Nonlinear Dynamics of Concrete Joints; from Theory to Dam Applications**, in *NW-IALAD, European network on Dam Engineering*, Zurich, Sept. 2004.
11. Saouma, V. and Chang, S.Y., **Numerical Simulation of Reinforced Concrete Deterioration due to Steel Corrosion, Freezing-Thawing and Mechanical Load Effects** in *Life-Cycle Performance of Deteriorating Structures: Assessment, Design and Management*, Special Publication of ASCE, Eds., D.M. Frangopol, E. Bruhwiler, M.H. Faber, and B. Adey, 2003
10. Saouma, V.E. and Uchita, T., **3D Nonlinear Dynamic Analysis of Concrete Dams**, *ICANCEER International Conference on Advances and New Challenges in Earthquake Engineering Research*, Harbin, PRC, Aug. 2002
9. Saouma, V.E., **Numerical Simulation of Concrete Deterioration**, *NSF Workshop*, Prague, July 2002
8. Saouma V. E., Červenka J., **Finite Element Analysis of R/C Structures A Hybrid Approach**, *US Japan Seminar on Post-Peak Behavior of Reinforced Concrete Structures Subjected to Seismic Loads* Lake Yamanaka, Oct. 25-29, 1999.
7. Saouma V. E., Červenka J., Slowik V., & Chandra Kishen J. M., **Mixed mode fracture of rock-concrete interfaces**, *US-Europe Workshop on Fracture and Damage of Quasi-Brittle Materials: Experiment, Modeling and Computer Analysis*, Prague, Czech Republic, Sep. 21-23, 1994.
6. Saouma, V.E., **Fracture Mechanics of Concrete Dams**, Keynote Speaker at the *Fracture Mechanics for Hydroelectric Power Systems Symposium*, Vancouver, September

- 1994.
5. Saouma, V.E., **Size Effects and Fractal Analysis of Concrete; Byproducts of a Dam Fracture Research Project**; *Int. Conference on Size Effect* Sendai Japan, Nov. 1993.
 4. Reich, R., Červenka, J., Plizzari, G., and Saouma, V., **Implementation and Validation of a Nonlinear Fracture Model in a 2D/3D Finite Element Code**, *First Bolomey Workshop*, ETH, Zurich, July 1992.
 3. Saouma, V., Červenka, J., Keating, S., Reich, R., and Waggoner, F., **Fracture Mechanics of Concrete Dams**, *Int. Conference on Fracture Mechanics of Concrete Structures*, Breckenridge, CO, June 1992.
 2. Saouma, V.E., Reich, R., **Fracture Mechanics Analysis of Lock and Dam 27**, *US Army Corps of Engineers Structures Conference*, Jacksonville, July 1991.
 1. Saouma, V.E., Ayari, M., and Boggs, H., **Fracture Mechanics of Concrete Gravity Dams**, *Fracture of Dams*, Session, International Conference on Fracture of Concrete and Rock, Houston, June 1987, Springer-Verlag, pp.311-333.
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Refereed Conference Proceedings

50. Y. Le Pape, V. Saouma, Z. J. Ma, J. V. Cabage, M. Guimaraes, K.G. Field, C.H. Mattus, D.J. Naus, J.T. Busby, **Significance of Alkali-Silica Reaction in Nuclear Safety-Related Concrete Structures**, Fontevraud 8 - Contribution of Materials Investigations and Operating Experience to LWRs' Safety, Performance and Reliability France, Avignon - 2014, September 14-18
49. Puntel, E. and Saouma, V. **Experimental Behaviour of Concrete Joint Interfaces Under Reversed Cyclic Loading**, in *Analytical Models and New Concepts in Concrete and Masonry Structures*, AMCM'2008, Lodz, Poland, June 2008.
48. Uruchida, S., Yagome, Y., Kubota, K., Uchita, Y., Saouma, V., **Experimental Investigation of Dynamic Uplift in Concrete Gravity Dams**, 10th ICOLD Annual Meeting Symposium, St Petersburg, June 2007
47. Al-Mahaidi, R., Pham, H.B., Saouma, V., **Discrete-Smeared Crack Finite Element Mechanisms in RC Members**, 8th International Symposium on Fiber Reinforced Polymer Reinforcement for Concrete Structures, FRPRCS-8, Patras, July 2006
46. Pham, H.B., Al-Mahaidi, R., Saouma, V., **Modelling of CFRP-Concrete Bond Using Smeared and Discrete Cracks**, International Symposium on Bond Behaviour of FRP in Structures (BBFS 2005), Chen and Teng (eds.), 2005
45. Saouma, V., Perotti, L. **Alkali Aggregate Reactions in Dams; Stress Analysis and Long Term Predictions**, American State Dam Safety Official (ASDSO) Conference on Dam Safety, New Orleans, Sept. 2005.
44. Uruchida, S., Shimpo, T., Uchita, Y., Yagome, Y., Saouma, V. **Dynamic Centrifuge Analysis of Concrete Gravity Dam**, 73rd Annual Meeting of ICOLD, Teheran, IRAN, paper No. 085-04, 2005
43. Puntel, E., Bolzon, G., Saouma, V., **Numerical and Experimental Investigation of Joints Subjected to Cyclic Loading**, International Conference on Fracture Mechanics,

- Torino, page 396, March 2005.
42. de Sanctis, F., Saouma, V. Viggiani, G. and Denarie, E. **Fracture Mechanics Characterization of Fine-Grained Tuff** EURO-Conference on Rock Physics and Geomechanics, Postdam, 20-23 Sept. 2004.
 41. Noguchi, H., and Saouma, V., **An Investigation of Freeze-Thaw in Dam Concrete; Experimental and Numerical Study**, in Proceedings of Concrete Under Severe Conditions, Oh, B.H. Editor, Korea Concrete Institute, pp. 506-513, 2004
 40. Camata G., Spacone E. and Saouma V., **Nonlinear modeling of debonding failure of RC structural members strengthened with FRP laminates**, Proceedings of 6th International Symposium on Fibre-Reinforced Polymer (FRP) Reinforcement for Concrete Structures (FRPRCS-6), Singapore, July, 2003.
 39. Camata G., Spacone E. and Saouma V., **Modeling FRP strengthened reinforced concrete structural members using nonlinear finite elements**, fib-Symposium Concrete Structures in Seismic Regions, May 6-9, Athens, 2003.
 38. Camata G., Spacone E. and Saouma V., **Nonlinear Fracture mechanics analysis of brittle failure modes of post-strengthening aged/damaged Reinforced Concrete structural members with Fiber Reinforced Polymer materials**, proceedings of Bond in Concrete - from research to standards, Budapest, November 2002.
 37. Hansen E.J. and Saouma, V.E., **Numerical Simulation of Reinforced Concrete Deterioration**, *FRAMCOS-3 Proceedings*, pp 1655-1668, Mihashi and Rokugo Eds., AEDIFICATIO publishers, 1998.
 36. Shinmura, A. and Saouma, V.E., **The Study of Water Leakage Through Fracture in Reinforced Concrete**, *FRAMCOS-3 Proceedings*, pp 1677-1686, Mihashi and Rokugo Eds., AEDIFICATIO publishers, 1998.
 35. Plizzari, G., Saouma, V.E, and Slowik, V., **Comportamento del Calcestruzzo Fessurato in Presenza di Carichi Ciclici di Ampiezza Variabile**, Gruppo Italiano Frattura, (IGF 11), pp. 297-306, Brescia, 1995.
 34. Slowik, F., Kishen, C., Saouma, V., and Morris, D., **Rock/Concrete Cracks; Myths and Realities**, WaterPower 1995, San-Francisco, July 1995.
 33. Červenka, J., Saouma, V. and Morris, D., **MERLIN: a 2D/3D Finite Element Program for Safety Assessment of Cracked Dams**, WaterPower 1995, San-Francisco, July 1995.
 32. Plizzari, G., and Saouma, V., **Linear or Nonlinear Fracture Mechanics of Concrete?** Proceedings of the 2nd International Conference on Fracture Mechanics for Concrete and Concrete Structures (FraMCoS2), Wittmann, F.H. (Ed.), Zurich, July 1995.
 31. Slowik, F. and Saouma, V., **Transient Fluid Fracture Interaction**, Proceedings of the 2nd International Conference on Fracture Mechanics for Concrete and Concrete Structures (FraMCoS2), Wittmann, F.H. (Ed.), Zurich, July 1995.
 30. Červenka, J., and Saouma, V., **Discrete Crack Modeling in Concrete Structures**, Proceedings of the 2nd International Conference on Fracture Mechanics for Concrete and Concrete Structures (FraMCoS2), Wittmann, F.H. (Ed.), Zurich, July 1995.
 29. Červenka, J., Boggs, H., Plizzari, G., and Saouma, V., **Non-Linear Analysis of Joint Behavior Under Thermal and Hydrostatic Loads for an Arch Dam**, *Third Benchmark Workshop on Numerical Analysis of Dams*, ICOLD, Paris, Spetember, 1994, Vol 1,

- pp. 255-277.
28. Červenka, J., Boggs, H., Plizzari, G., and Saouma, V., **Evaluation of Critical Uniform Temperature Decrease of a Cracked Buttress Dam**, *Third Benchmark Workshop on Numerical Analysis of Dams*, ICOLD, Paris, Spetember, 1994, Vol 2, pp. 467-485.
 27. Reich, R., Červenka, J., and Saouma, V., **MERLIN: A Computational Environment for 2D/3D Discrete Fracture Analysis**, Proceedings of the EURO-C 1994 Conference on Computational Modelling of Concrete Structures, 1994.
 26. Slowik, V., and Saouma, V., **Investigation on Cracking of Concrete with Applications to the Seismic Safety of Dams**, Proceedings of the EURO-C 1994 Conference on Computational Modeling of Concrete Structures, 1994.
 25. Saouma, V.E., Boggs, H., and Morris, D., **Safety Assessment of Concrete Dams Using Fracture Mechanics**, Q.68, R.84, Proceedings of the 18th ICOLD (International Commission on Large Dam) Conference, pp. 1415-1435, Durban 1994.
 24. Perrone, C., Songer, A.D., and Saouma, V., **A Hypermedia-Based Framework for an Integrated Civil Engineering Curriculum**, American Society of Engineering Education, Gulf-Southwest Annual Meeting, Austin, TX, 1993
 23. Songer, A.D., Perrone, C., and Saouma, V., **aHyper CE: Computer Aided Instruction for the Introduction to Civil and Architectural Engineering**, American Society of Engineering Education, Gulf-Southwest Annual Meeting, Austin, TX, 1993
 22. Saouma, V., Červenka, J., Keating, S., Reich, R., and Waggoner, F., **Fracture Mechanics of Concrete Dams**, Proceedings of the Int. Conference on Fracture Mechanics of Concrete Structures, Elsevier Applied Science, pp. 404-412, 1992.
 21. Reich, J., Cervenka, J., and Saouma, V., **Computational Fracture Mechanics of Concrete**, ASCE Specialty Conference in Computational Mechanics, Texas, 1992.
 20. Reich, R., Cervenka, and Saouma, V.E., **Numerical Techniques for 2D and 3D Nonlinear Fracture Mechanics Based Analysis of Dams**, Proceedings of the Int. Conf. on Dam Fracture, pp. 163-182, Boulder CO. Published by Electric Power Research Institute, GS-7491, Palo-Alto, Sept. 1991.
 19. Saouma, V.E., Brühwiler, E., Keating, S., Ryan, J., and Schulz, J., **Innovative Fracture Testing Techniques for Dam Engineering**, Proceedings of the Int. Conf. on Dam Fracture, pp. 459-475, Boulder CO. Published by Electric Power Research Institute, GS-7491, Palo-Alto, Sept. 1991.
 18. Brühwiler, E., and Saouma, V.E., **Water Fracture Interaction in Cracked Concrete Dams**, Proceedings of the Int. Conf. on Dam Fracture, pp. 551-567, Boulder CO. Published by Electric Power Research Institute, GS-7491, Palo-Alto, Sept. 1991.
 17. Saouma, V.E., Brühwiler, E., Boggs, H., and Morris, D., **A Comprehensive Investigation of Fracture Mechanics of Concrete Dams**, Workshop on Application of Fracture Mechanics to Dam Engineering, Locarno, Sept. 17-18, 1990
 16. Brühwiler, E., and Saouma, V.E., **Fracture Testing of Rock by the Wedge Splitting Test**, Proceedings of the 31st US Rock Mechanics Symposium, June 1990, Golden CO, pp. 287-294
 15. Saouma, V., Dambowy, J., and Commander, B., **Automated Design of R/C Structures from Graphics to Expert Systems**, Proceedings of the second *Int. Conference on Computer Aided Analysis and Design of Concrete Structures*, pp. 479-489, Zell-Am-

- See, Pineridge Press, Vol. 1, N. Bicanic and H. Mang Ed.
14. Saouma, V.E., Broz, J.J., Boggs, H.L., and Brühwiler, E. **A Comprehensive Investigation of Fracture Mechanics of Concrete Dams**, *International Symposium on Analytical Evaluation of Dam Related Safety Problems, Theme A: Concrete Dams-Fracture Problems*, ICOLD 57th Executive Meeting, Copenhagen, July 1989.
 13. Saouma, V.E., Doshi, S., Jones, M.S., Sikiotis, E.S., **Research in Computer Aided Design of Reinforced Concrete at the University of Colorado**, *Proceedings of the ACI Symposium on Usage of Computers*, San Antonio, 1987.
 12. Saouma, V.E., Droz, P., **Mixed Mode Blunt Crack Instability Using a Path Independent Contour Integral**, *Proceedings of the 8th Int. Conf. on Structural Mechanics in Reactor Technology*, Brussels, Aug. 1985.
 11. Saouma, V.E., **Computer Graphics Aided Simulation of Crack Propagation**, *Proceedings of the XIII International Finite Element Congress*, Baden Baden, W. Germany, Nov. 19-20, 1984.
 10. Saouma, V.E., and Sikiotis, E.S., **Interactive Computer Graphics in the Design of Reinforced Concrete Buildings**, *Proceedings of the Int. Conf. on Computer Aided Analysis and Design of Concrete Structures*, pp. 937-950, Pineridge Press, 1984.
 9. Saouma, V.E., Jones, M.S., Jones, R.A., **CAI of Structural Analysis and CAE Laboratory Development**, *Proceedings of the National Conference on University Programs in Computer Aided Engineering, Design, and Manufacturing*, Lehigh University, 1984, pp. 179-185.
 8. Saouma, V.E., and Sikiotis, E.S., **Application of Partial Prestressing Optimization**, *NATO/ARW Partial Prestressing: From Theory to Practice*, M.Z. Cohn, Editor, Paris 1984.
 7. Saouma, V.E., and Sikiotis, E.S., **Interactive Graphics Nonlinear Constrained Optimization**, *NASA CP 2335, Research in Structures and Dynamics*, 1984, pp. 143-157.
 6. Saouma, V.E., and Kleinosky, M.J., **Finite Element Simulation of Rock Cutting: a Fracture Mechanics Approach**, *Proceedings of the 25th U.S. Symposium on Rock Mechanics*, Northwestern University, Evanston IL, June 1984, pp. 792-799.
 5. Saouma, V.E., **Computer Graphics Simulation of Crack Propagation**, *Proceedings of the Third International Conference on Numerical Methods in Fracture Mechanics*, Swansea, U.K., pp. 219-233, March, 1984, Pineridge Press.
 4. Saouma, V.E., and Zatz, I.J., **An Automated Finite Element Procedure for Fatigue Crack Propagation Analyses**, *paper No. AIAA 83-0841, Proc. of the 24th AIAA/ASME/ASCE/AHSSDM Conference*, Lake Tahoe, Nevada, June 1983, pp. 196-204.
 3. Saouma, V.E., and Ingraffea, A.R., **Discrete Crack Modelling in Reinforced Concrete**, *Proc. of the Engineering mechanics Specialty Conference*, ASCE, Purdue University, June 1983, pp. 1005-1008.
 2. Saouma, V.E., and Hoelzeman, R. **Computer Graphics Aided Instruction of Structure**, *Proc. of the Eighth Conference on Electronic Computation*, Houston, Texas, Feb. 1983, pp. 209-222.
 1. Saouma, V.E., and Ingraffea, A.R., **Fracture Mechanics Analysis of Discrete Cracking**, *Proc. of the IABSE Colloquium on Advanced Mechanics of Reinforced Concrete*,

Delft, 1981.

Lectures, Conference Presentations

96. Risk & Reliability Assessment of NCVS Subjected to AAR & Seismic Excitation; A Holistic Approach. Nuclear Regulatory Commission. Oct. 2017.
95. Aging and Shaking of Nuclear Containment Structures; Advanced Modelling. University of Grenoble/EdF Nov. 2017
94. Numerical Modeling of Alkali Silica Reaction, National Institute of Standards and Technology, Gaithersburg, April, 2015.
93. Ageing, Shaking and Cracking of Concrete Infrastructures, Swiss Federal Institute of technology, Lausanne, March 2015.
92. On Alkali Aggregate Reactions in Nuclear Power Plants, Nuclear Regulatory Commission, June, 2014.
91. Real Time Hybrid Simulation; Do we Still Need Shake table Tests; Universite de Grenoble, June 2014
90. Real Time Hybrid Simulation; Do we Still Need Shake table Tests; ETH Zurich, June 2014
89. Modeling of Alkali Silica Reaction; Oak Ridge National Laboratory, September 2013.
88. Nonlinear Analysis of Concrete Dams, Universidad de los Andes, Bogota Colombia. May 2013
87. Real Time Hybrid Simulation, Universidad de los Andes, Bogota Colombia. May 2013
86. Potential Applications of Real Time Hybrid Simulation in Aerospace Industry, presentation at Dassault Systemes, Paris, France, 2012
85. Potential Applications of Real Time Hybrid Simulation to *Electricite de France*, Cachan, May 2012
84. Aging, Shaking, and Cracking of Infrastructures: Dams and Nuclear Containment Vessels. Swiss Federal Institute of Technology, Lausanne, Nov. 2011.
83. On Nonlinear Analysis of Nuclear Reactor Containment Vessels; Food for Thought. Nuclear Regulatory Commission, October 2011.
82. Numerical Simulation of Alkali Aggregate Reaction in Nuclear Power Plants, Nuclear Regulatory Commission, October 2011.
81. Real Time Hybrid Simulation, Workshop on Adaptive Discretization and Applications, Roma 3, Italy, June 2011
80. Nonlinear Analysis of Dams, Special Seminar in Roma 3, Italy, June 2011
79. Dynamic Analysis of Reinforced and Massive Concrete Structures; Universita Federico II, Naples, Italy, May 2011
78. Real Time Hybrid Simulation vs Shake Table Tests, UCLA, Jan. 2011.
77. Real Time Hybrid Simulation vs Shake Table Tests, University of Washington, April 2011.
76. Real Time Hybrid Simulation in Reinforced Concrete; *Mécanique de l'Endommagement Appliquée au béton et aux structures en béton; Workshop en l'honneur de Jacky Mazars*, June 2010.

75. Real Time Hybrid Simulation vs. Shake Table Test' National Institute of Standards and Testing (NIST), Nov. 2010.
74. Nonlinear Dynamic Modeling of Concrete dams, XXXIV Jornadas Sudamericana de Ingenieria Estructural, San Juan, Argentina, Sept. 2010.
73. Cracking of Concrete; From Material Characterization to Structural Analysis; Oak Ridge National Laboratory; 1st Annual Coordinated Nuclear Materials Research Meeting; July 2010.
72. Nonlinear Analysis of Concrete Dams, Vattenfall, Sweden, May 2009.
71. Hybrid Simulation of reinforced Concrete Structures, University of Toulouse, May 2009
70. Nonlinear analysis of concrete Dams, Univesity of Roma (3), March 2009.
69. Numerical Modelling of alkali-Aggregate Reactions, University of Toulouse, March 2009.
68. CU-NEES Fast Hybrid Testing Facility, 6th NEES Annual Meeting in Portland, June 2008.
67. Concrete Dams; Aging, Cracking and Shaking. Delft Technical University, May 2008
66. Hybrid Simulation Research at CU-NEES, presented at the French Atomic Energy Commission, Saclay, France 2007
65. Modelling AAR with Merlin, ICOLD Workshop on Chemical Expansion in Concrete, Granada, 2007
64. Modeling of Alkali-Aggregate Reactions in Concrete, Swiss Federal Institute of Technology, Lausanne, July 2007.
63. Hybrid Testing at CU-NEES, LMS Corporation, Louvin, Belgium, July 2006.
62. Hybrid Testing Perspective, Central Research Institute of the Power Industry (CRIEPI), Abiko, Japan June 2006.
61. Seismic Analysis of Concrete Dams, Shimizu Laboratory, Tokyo, June 2006
60. Discrete Crack Models in Fracture Mechanics, Ecole des Mines, Sophia-Antepolis, France, July 2005.
59. 3D Nonlinear Dynamics Analysis of Concrete Dams. EPFL, Lausanne, March 2005.
58. Alkali Aggregate Reactions in Concrete Dams, US Bureau of Reclamation, March 2005
57. Nonlinear Finite Element Modeling of CFRP; *SIKA Research Group*, Zurich, November 2004.
56. Advanced Analysis of Dams; *ENDESA*, Barcelona, November 2004.
55. Nonlinear Analysis of Concrete Dams; *Korean Water Company (KOWACO)*, Seoul, June, 2004.
54. Dynamic Analysis of Arch Dams; From Theory to Applications. *Ministry of Water Resources*, Teheran, Iran, June 2004.
53. Theory of Dynamic Analysis of Arch Dams. *Sharif University*, Teheran, June 2004.
52. Nonlinear Dynamic Analysis of Dams; *Department of Applied Mathematics, Politecnico di Milano (MOX)*, May, 2004
51. Numerical Simulation of Alkali Aggregate Reaction in Concrete Dams, US Bureau of Reclamation, April 2004.
50. Dam Engineering Challenges; Seismic and AAR Analysis; *Accademia Nazionale dei Lincei*, Rome March 2004
49. Dam Engineering Newest Challenges; *University of Rome, La Sapienza* Oct. 2003

48. Numerical Simulation of Concrete Deterioration, *Italcementi*, Bergamo, July 2003.
47. Fracture Mechanics of FRP Reparation, *University of Lecce*, July 2003.
46. 3D Nonlinear Dynamic Analysis of Dams, *University of Grenoble*, March 2003.
45. Deterioration of Reinforced and Massive Concrete; *University of Grenoble*, March 2003.
44. Numerical Simulation of Concrete Deterioration, *Swiss Federal Institute of Technology*, Lausanne, July 2002
43. 3D Nonlinear Dynamic Analysis of Concrete Dams, Tsinghua University, Beijing, PRC, Aug. 2002
42. Fracture Mechanics of Concrete Dams, China Yangtze Three Gorges Project Development Corp., and China Three Gorges University, Yichang, PRC, Aug. 2002
41. 3D Nonlinear Dynamic Analysis of Concrete Dams, China Institute of Water Resources and Hydropower Research (IWHR), Beijing, PRC, Aug. 2002
40. Numerical Simulation of Concrete Deterioration, *University of Venice*, June 2001.
39. Fracture Mechanics of Dams, *Politecnico of Milan*, June 2001.
38. Fracture Mechanics of Dams, *Tokyo Electric Power Company (TEPCO)*, Tokyo, Japan, October 1999.
37. Reflections on, and Applications of Fracture Mechanics in Concrete. *Politecnico di Milano*, Dec. 1998.
36. Fiber Optics Based Determination of Strains Around the Fracture Process Zone in Concrete WST. *Swiss Federal Institute of Technology*, Lausanne December 1998.
35. Dynamic Uplift Pressures in Dams under Earthquakes, *Swiss Federal Institute of Technology*, Zurich June 1998.
34. Numerical Simulation of Concrete Bridge Deck Deterioration, *Prof. Z. Bažant's 60th Birthday Anniversary Workshop* in Prague, March 1998
33. Applications of Fracture Mechanics in Structural Engineering, *University of Leipzig*, Nov. 1997.
32. Fracture Mechanics of Concrete Dams, *ENEL/CRIS Milan Italy*, Nov. 1997.
31. Numerical Simulation of Concrete Bridge Deck Deterioration, *Ecole Normale Supérieur de Cachan*, France, Oct. 1997.
30. 4th International Benchmark Workshop on Numerical Analysis of Dams, (Organized by ICOLD), Madrid, Sept. 1996 (Round Table)
29. Fracture Mechanics of Concrete Dams, *Central Research Institute of the Japanese Electric Power Industry*, Chiba, Japan, Nov. 5. 1993.
28. Fracture Mechanics of Concrete, *Obayashi Construction Company*, Tokyo, Japan, Nov. 4, 1993.
27. Water Fracture Interaction in Concrete, *Norwegian Institute of Technology (NTH)*, Trondheim, Norway, July 1993.
26. Fracture Mechanics of Concrete, *University of Rome, La Sapienza*, July 1992.
25. Fracture Mechanics Research on Dam Cracking; *B.C. Hydro*, Vancouver; Oct. 16, 1992.
24. Fracture Mechanics of Concrete Dams, *Universidad Politecnica de Madrid*, July 1992.
23. Fracture Mechanics of Concrete Dams, *Ecole Normale Supérieure de Cachan*, Paris, France, March 1992.
22. Int. Conference on Fracture of Concrete, Breckenridge, CO 1992.

21. Fracture Mechanics of Concrete, *ISMES*, Bergamo, July 1990.
20. Fracture of Dams, *Tsinghua University*, Beijing, April 1990.
19. Fracture Mechanics of Concrete Dams, *Institute of Water Conservancy and Hydroelectric Power Research*, Beijing, April 1990.
18. Fracture of Concrete, *Swiss Cement Industry Research institute*, Wildegg, March 1990.
17. Fracture Mechanics of Dams, *Laboratoire Central des Ponts et Chaussées*, Paris, March 1990.
16. Fracture Mechanics of Concrete Dams, *ACRES International*, Niagara Falls, Canada, Dec. 7-8 1989.
15. Fracture Mechanics of Concrete Dams, *University of California*, Berkeley, Nov. 6 1989.
14. Fracture Mechanics of Concrete, *Colorado State University*, April 1989.
13. Fracture Mechanics of Concrete Gravity Dams, *Bureau of Reclamation*, Denver, March 1989.
12. Fracture Mechanics of Concrete Gravity Dams, *Northwestern University*, March 1989.
11. Fracture Mechanics of Concrete Gravity Dams, *EPRI Electric Power Advisory Group*, Chattanooga, TN, March 1989.
10. Fracture Mechanics of Concrete Gravity Dams, *Polytechnic of Madrid*, November, 1987.
9. Fracture Mechanics of Concrete Gravity Dams, *CRIS/ENEL*, July 1987, Milan, Italy.
8. Fracture Mechanics of Anisotropic Rock cutting, *Dowell-Schlumberger Research laboratory*, Tulsa, OK.
7. Computer Graphics in Structural Design, *King Faisal University*, Saudia-Arabia, march 18-23, 1986.
6. Some Engineering Applications of Fracture Mechanics, *Waterways Experimental Station*, Vicksburg, MS. Sept. 20-24, 1985.
5. Development of a mixed smeared and discrete crack model for concrete and geomaterial, *Dept. of Civil Engineering, Swiss Federal Institute of Technology*, Lausanne, Switzerland, June 1-15, 1983, June 1-15, 1984.
4. Finite Element Simulation of Crack Propagation, *Eidgenoessisches Institut fuer Reaktorforschung (EIR)*, Schaffhausen, Switzerland, July 30, 1982.
3. Finite Element Modeling of R/C using fracture mechanics, *Istituto Sperimentale Modelli e Strutture (ISMES)*, Bergamo, Italy, July 1982.
2. Finite Element Simulation of Crack Propagation *Swiss Federal Institute of Technology*, lausanne, Switzerland, July 9, 1982.
1. Automated Nonlinear Finite Element Analysis of Reinforced Concrete; a Fracture Mechanics Approach, *Swiss Federal Institute of Technology*, Zurich, Switzerland, June 21, 1981.

Supervised Dissertations

Ph.D.:

12. Golsa Mahdavi **Nonlinear Transient Analysis of an AAR affected Dam** 2020-2022.
13. Hariri, Mohammad **Innovative Numerical Modeling of Concrete Dams**, 2012-2015

12. Kang, Dae-Hung **Computational Environment for Real Time Hybrid Simulation**, 2010.
11. Puntel, Eric **Experimental and numerical investigation of the monotonic and cyclic behaviour of concrete dam joints**, Politecnico di Milano 2004.
10. Puatatsananon, Wiwat **Numerical Simulation of Coupled Chemical-Mechanical Deterioration of Concrete**, 2002
9. Chandra, K., **Interface Cracks: Fracture Mechanics Studies leading towards Safety Assessment of Dams**, May 1996.
8. Červenka, J., **Discrete Crack Modeling in Concrete Structures**, 1994.
7. Reich, R., **On the Marriage of Fracture Mechanics and Mixed Finite Element Methods: An Application to Concrete Dams**, 1993.
6. Prinaris, A., **Flow Processes in Nonlinear Material Modelling Synthesis and Homogenization**, 1990.
5. Gamal-El-Din, **Fractal Dimensions and Fracture Properties of Cracked Concrete**, 1990.
4. Ayari, M., **Static and Dynamic Fracture Mechanics of Concrete Gravity Dams**, 1988
3. Sikiotis, E., **Innovative Techniques in Structural Optimization**, 1987

M.S.:

35. Yuichiro Gakuhari **Sensitivity and Uncertainty Analyses of a Dam with AAR**
34. Graff, D. **Shear Strength of AAR Affected Concrete**, 2017
33. Spark R. **Shear Strength Deterioration due to ASR**, 2016
32. Prusinski, K. **Pushover Analysis of a Bridge Pier**, 2015
31. Sonavane, T. **Analysis of Arches**, 2014
30. Georg, R. **Historical Analysis of Arches and Modern Shells**, 2014
29. Stanko, Scott **Contributions to Real Time Hybrid Simulation Modeling**, 2012.
28. Segura, Christopher **Hybrid Simulation; Modeling and Testing**, 2011.
27. Basbolat, E. **Post-Processor to the Mercury Software for Hybrid Simulation**, Dec. 2010.
26. Nasr, K. **Coupled Fracture and Combustion in Solid Rocket Propellants**, May 2010.
25. Perotti, L. **Alkali Aggregate Reactions in Concrete Dams**, Politecnico di Milano, June 2004.
24. Ruolo, Dora **Interface Crack Joints Under Cyclic Loads**, Politecnico di Milano, Jan. 2004
23. Chang, P., **Finite Element/Fracture Mechanics Simulation of Heterogeneous Materials**, 2002.
22. Gillan, Chad **Centrifuge Testing of Concrete Dams**, Aug. 2002
21. Puatatsananon, Wiwat **Probabilistic Fracture Mechanics**, Aug. 1998
20. Hansen, Eric, **Rate Deterioration Investigation of Bridge Decks Based on Diffusion/Fracture Mechanics Numerical Study**, Aug. 1997.
19. Fox, Kristen, **Fracture Mechanics Analyses of Anchor Bolts**, Aug. 1996.

18. Ostrander, Keith, **Applications of Fiber Optics in the Strain Measurement of Structures**, Aug. 1996.
17. Shinmura, A., **Fluid Fracture Interaction in Pressurized Reinforced Concrete Vessels**, 1995
16. Roh, Y., **Numerical Simulation of Fluid Flows in Cracked Concrete**, 1995
15. Winkler, L. **Development of a Workbench of Mechanics, Materials and Structures Experiment**, 1994
14. Hermanrud, J. (CS), **Development of a Three Dimensional Finite Element Post-Processor**, 1993
13. Wigner, W., **Three Dimensional Fracture Mechanics Analysis of an Arch Dam**, 1993.
12. Dewey, R. **Uplift Modelling for Fracture Mechanics Analysis of Concrete Gravity Dams**, 1993.
11. Waggoner, F., **Centrifuge Testing of Concrete Gravity Dams**, M.S. Aug., 1992.
10. Ryan, J., **Effect of Bi-Axial Confinements on Fracture Properties of Concrete, Laboratory and Field Tests**.
9. Broz, J. **Experimental Fracture Mechanics of Concrete Dams**, 1989.
8. Commander, B., **An Improved Method of Bridge Evaluation: Comparison of Field Test Results with Computer Analysis**, 1989.
7. Dambowy, J., **A Knowledge Based Expert System for the ACI Building Code**, 1989.
6. Doshi, S., **Knowledge Based Expert System for Reinforced Concrete Design Checking**, 1987.
5. Jones, M., **A Prototype Hybrid Expert System for Structural Design**, 1987.
4. Sikiotis, E., **Computer Graphics Aided Design of Reinforced Concrete Frames**, 1983.
3. Flango, R., **Graphical PreProcessor for Steel and Concrete Orthogonal Building Frames**, 1983.
2. Murad., M., **Partially Prestressed Concrete Beam Optimization**, 1983
1. Schwemmer, S., **Numerical Evaluation of the Quarter Point Singular Element**, 1983

Foreign Jury Member

1. Andreea Carpiuc-Prisacari (2016) (PhD Candidate; Ecole Normale Supérieure de Cachan (France), *Experimental database with full-field measurements for mixed-mode crack propagation in concrete: comparison between experimental and numerical results*.
2. Kharazi, M. PhD Candidate; Ecole Normale Supérieure de Cachan (France); Rapporteur of her PhD Thesis *Une méthodologie de modélisation pour l'évaluation de l'étanchéité des enceintes de confinement des centrales nucléaires* (A Model for the permeability assessment of nuclear reactor confinement vessel), 2014
3. Raguenau, Frederic *These d'habilitation a la Recherche*, France, Oct. 2006.
4. Berthet-Rambaud, Philippe, *Structures Rigides Soumises aux Avalanches et Chutes de Blocs: Modélisation du Comportement Mécanique et Caractérisation de l'Interaction "Aléa-Ouvrage"*, Doctoral Thesis, Université de Grenoble, July 2004.

5. Bournazel, Jean Pierre, *Contribution a l'Etude du Caractere Thermomecanique de la Maturation du Beton*, Doctoral Thesis, Ecole Normale Superieure, Cachan, July 1992.
 6. Jouhari, M., *Dynamic Crack Growth with Internal Uplift Pressures*, Ecole Nationale des Ponts et Chaussees, Paris, France, 1992.
-

Lecture Notes Manuscripts

1. [Structural Engineering; Analysis & Design](#), 664 pages
2. [Structural Concepts and Systems for Architects](#), 265 pages
3. [Reinforced Concrete](#) 175 pages
4. [Computer Literacy for Undergraduates](#), 233 pages
5. [Finite Element Analysis of Frames](#), 280 pages
6. [Finite Element Analysis](#), 280 pages
7. [Advanced Mechanics of Materials](#), 280 pages
8. [Fracture Mechanics](#), 474 pages

Those notes can be downloaded from my personal web page <http://civil.colorado.edu/~saouma/Lecture-Notes>

Technical Reports

Over 100 Technical Reports written to sponsors.

Software Development

Mercury An Optimized Nonlinear Finite Element Code for Real Time Hybrid Simulation.

MERLIN 3D Nonlinear Finite Element Program, (1991-Present), Funded by Electric Power Research Institute (EPRI), and Tokyo Electric Power Service Company (TEPSCO).

Spider , a general purpose Windows/Open-GL based finite element graphical postprocessor. (1991-Present), Funded by Electric Power Research Institute (EPRI), and Tokyo Electric Power Service Company (TEPSCO).

KumoNoSu a general purpose 3D finite element generator particularly suited for cracked structures, reinforced concrete, and dam structures, (1999-present), Funded by Tokyo Electric Power Service Company (TEPSCO).

Beaver Program for the automation of the layout of double curvature arch dams

PARSIFAL (Particle Simulator for Analysis), a 2D/3D generator for heterogeneous materials with particle collision detection,(2002-Present), Funded by National Science Foundation

SIMSAR (Simulation of Silica Aggregate Reactions) in concrete, (2002-2003), Funded by Swiss Dam Safety Agency.

CDAP (Concrete Deterioration Analysis Program), coupled nonlinear multiphysics simulation of heat, moisture, chloride and carbon diffusion in concrete, (2002-Present), Funded by National Science Foundation.

Society Membership

1. Fellow and President (2013-2016) of the International Association for Fracture Mechanics of Concrete and Structures (FRAMCOS)
 2. (Founding member) Swiss Society of Living Organ Donors (*Association Suisse des Donneurs Vivants d'Organe*)
 3. American Concrete Institute
-

Committee Member

1. ACI 349 Concrete Nuclear Structures
 2. ACI 446 Fracture mechanics of Concrete
 3. ACI-ASCE Committee 447, Finite Element Analysis of Reinforced Concrete Structures.
 4. RILEM TC-259-ISR Committee; Prognosis of Deterioration and Loss of Serviceability in Structures Affected by Alkali-Silica Reactions (Chair).
 5. RILEM TC-258-AAA Avoiding alkali aggregate reactions in concrete - Performance based concept
 6. Member International Association of Fracture Mechanics of Concrete Structures (IA-FramCoS), President.
-

Reviewer for

1. National Science Foundation
2. American Concrete Institute
3. ASCE, J. of Engineering Mechanics
4. ASCE J. of Structural Engineering
5. ASCE J. of Engineering Materials
6. ASME Journal of Applied Mechanics
7. International Journal of Solids and Structures
8. International J. of Numerical Methods in Engineering
9. Journal of the American Ceramic Society

10. Journal of Earthquake Engineering and Structural Dynamics
 11. Cement and Concrete Research
 12. Int. Journal of Fracture Mechanics
 13. Engineering Fracture Mechanics
 14. National Science and Engineering Research Council, Canada
 15. Italian Ministry of Research and University (MIUR)
 16. European Journal of Earthquake Engineering
 17. European Journal of Mechanics
 18. Indian Society of Earthquake Technology Journal
 19. Swiss National Research Council
-

Session Chairman

1. Chairman session “Structural applications and sustainability: Nuclear structures and storages”, International Conference on Numerical Modeling Strategies for Sustainable Concrete Structures (SSCS), 2012 in Aix en Provence, France;
2. Chairman Plenary Lecture session (P. Rossi), International Conference on Numerical Modeling Strategies for Sustainable Concrete Structures (SSCS), 2012 in Aix en Provence, France;
3. Chairman of the “Thermal and vapor effects and cracking” session in the Conference on Concrete Structures Under Severe Conditions (CONSEC07), Tours, June 2007.
4. 39th US Japan Joint Panel Meeting on Wind and Seismic Effects (by Invitation only), Tsukuba, Japan, 2007.
5. Co-Chairman, WG-3 “Dissemination of Knowledge, Education and Training in a Distributed Environment”, *2nd World Forum on Collaborative Research in Earthquake Engineering An Invitational Workshop*, Ispra, March 2007.
6. Chairman, Session 4, CONSEC 04 Fourth International Conference on Concrete under Severe Conditions of Environment and Loading, Seoul, June 2004
7. Chairman, Session 8, Size Effect, Fracture Mechanics of Concrete Structures, Cachan May, 2001.
8. Chairman Session VIII, , Europe-US Workshop on Fracture and Damage in Quasibrittle Structures, Prague Sept. 1994.
9. Chairman, Session 2-B, International Conference on Fracture Mechanics of Concrete Structures, Breckenridge, CO, June 1992.
10. Chairman, Session on Fracture of Dams, ACI Convention, 1991.
11. Chairman, Session II, International Workshop on Application of Fracture Mechanics to Dam Engineering, Lucarno Switzerland, Sept. 1990.

12. Chairman, Session Xb, Int. Conf. on Computer Aided Analysis and Design of Concrete Structures, Zell-Am-See, Austria, April 1990.
 13. Chairman, Session H2, Fracture and Strain Softening I, 8th Int. Conf. on Structural Mechanics in Reactor Technology, Brussels, August 1985.
 14. Chairman, Process Zone Session, International Conference on Fracture Mechanics of Concrete and Rock, Vienna, July 1988.
-

Conference Advisory Panels

1. Member of the Scientific Committee for CONSEC 2016 (Concrete under Severe Conditions).
2. International Conference on Numerical Modeling Strategies for Sustainable Concrete Structures (SSCS), 2012 in Aix en Provence, France; Member of the scientific Committee.
3. FramCos-8, Toledo (Spain) 2013, Member of Scientific Board.
4. FramCos-7, Seoul 2010, Member of Scientific Board.
5. Fifth International Conference on Concrete under Severe Conditions Environment and Loading, Tours, France, (2007) Member of the Scientific Committee.
6. FramCos-6, Cagliari 2007, Member of Scientific Board.
7. ICFXI International Conference on Fracture mechanics, Torino, 2005.
8. CONSEC 04 Fourth International Conference on Concrete under Severe Conditions of Environment and Loading, Seoul, June 2004
9. Third International Conference on Fracture Mechanics of Concrete Structures (FRAMCOS-3), Gifu Japan, Oct. 1998.
10. Fracture Mechanics for Hydroelectric Power Systems Symposium, Vancouver September 1-2, 1994
11. International Workshop on Dam Fracture and Damage, Chambéry, France, March 16-18, 1994, **Co-Organizer** with Mazars and Bourdarot.
12. International Workshop on Size Effect in Concrete Structures, Sendai, Japan, Oct. 31-Nov. 2, 1993.
13. International Conference on Computational Contact Mechanics, Southampton, UK, Sept. 1993.
14. International Conference on *Fracture Mechanics of Concrete Structures*, Coordinator, Breckendridge, CO 1992.
15. International Conference on *Dam Fracture*, **Co-Organizer** with R. Dungar, Boulder CO, Sept. 11-13, 1991. 100 Participants from 18 countries.
16. International Workshop on *Application of Fracture Mechanics to Dam Engineering*, **Co-Organizer** with R. Dungar and F. Whittmann, Lucarno Switzerland, Sept. 17-18, 1990.
17. International Conference on *Micromechanics of Failure of Quasi-Brittle Materials*, New-Mexico, June 1990.
18. Second International Conference on *Computer Aided Analysis and Design of Concrete Structures*, Zell Am See (Austria), April 1990.
19. International Conference on *Fracture of Rock and Concrete*, Houston, June 1987.

Host for External Visitors

1. Antoine Tixier, Ecole Normale Supérieure de Cachan, February-July 2010
2. Etienne Burdet, Ecole Normale Supérieure de Cachan, April-July 2009.
3. Gregory Lebon, Ecole Normale Supérieure de Cachan, April-July 2006.
4. Al-Mahaidi, Riadh, Monash University Australia, 9 months, 2000-2001.
5. Linner, Jens, Chalmers University, 2 months 1995.
6. Slovik, V., ETH, Zurich, 2 years, 1992-94
7. Dave Dollar, US Bureau of Reclamation, Denver (1991-1992, part time)
8. Plizzari, G., University of Brescia/ISMES, Italy, Research Associate, 12 Months, 1991-1992
9. Thiel, F., Ecole Central/Framatome, Paris, France, VSN, 16 months, 1991-1992.
10. Brühwiler, E., ETH Zurich, Switzerland, Research Associate 2 years, 1989-1990.
11. Kim, I., Pusan University, S. Korea, Sabbatic leave, 1 year, 1988.

Contents

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EXHIBIT 2 TO SAOUMA DECLARATION

Saouma Technical Assessment

**ASR Research Program Gaps and Structural Test Evidence:
A Unified Technical Assessment**

*Prepared for C-10 Research and Education Foundation
Amesbury, Massachusetts*

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Submitted to:

Commissioners, U.S. Nuclear Regulatory Commission

October 7, 2026

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1 Introduction and Summary

Ten years have passed since NextEra Seabrook LLC (NextEra) applied to the U.S. Nuclear Regulatory Commission (NRC) for approval of a program for assessment and monitoring program of alkali-silica reaction (ASR)¹ in concrete safety structures at its Seabrook Unit 1 nuclear power station (Seabrook) (NextEra-ML16216A240, 2016).

Relying on the Large-Scale Test Program (LSTP), a series of laboratory tests conducted by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin on ASR-affected concrete beams (which I will call “LSTP1”), NextEra asserted that ASR would have a strengthening effect on Seabrook concrete and would progress very slowly over multiple decades. Thus, NextEra asserted that monitoring intervals could be lengthy and there was little cause for alarm (NextEra-ML16216A240, 2016).

However, within less than a decade after NextEra’s prognostication, measurements of ASR expansion at Seabrook demonstrate that some structures are trending to exceed the upper bound of the expansion range of the LSTP by as early as 2034 (U.S. Nuclear Regulatory Commission, 2023). Under NextEra’s license, this high expansion rate triggers a requirement for additional analysis (U.S. Nuclear Regulatory Commission, 2019). And both the NRC and NextEra have recognized that the existing test data cannot be extrapolated to the current and projected future expansion without additional testing at higher expansion levels, (U.S. Nuclear Regulatory Commission, 2023) (Advisory Committee on Reactor Safeguards, 2024, p.221).

Although NextEra has not formally or publicly disclosed its plans for further laboratory testing, it is the author’s understanding, based on representations made by NRC Staff members to C-10’s Executive Director, Sarah Abramson, that the company is preparing to repeat LSTP1. In other words, NextEra apparently intends to test one or more ASR-affected concrete beams. While some parameters may be modified, NextEra does not appear to propose changing the LSTP in the respect most relevant to the safety of the Seabrook nuclear plant: the program would still test out-of-plane shear behavior in beams, rather than the more representative structural configuration of squat shear walls, which is needed to capture the in-plane shear behavior widely recognized as representative of Seismic Category I concrete structures.

It is also my understanding, based on statements by the same NRC Staff members to Ms. Abramson, that the Staff intends to conduct a prior review of NextEra’s plans for the second round of the LSTP (which I will call “LSTP2”). Such a prior review is permitted by the NRC’s policy for “ROP Action Matrix Deviations,” and indeed was exercised in 2012 in order to “provide increased resources for the oversight of the Seabrook Station related to the degradation of safety-related

¹ASR is an irreversible concrete degradation phenomenon that can severely compromise the physical properties of concrete and, consequently, significantly reduce a structure’s load-carrying capacity, particularly under seismic demands.

concrete structures because of [ASR].”²

In my expert opinion, given the serious errors committed by NextEra in LSTP1, the NRC Staff’s proposal to conduct a prior review of LSTP2 is prudent and even necessary. But the Staff should not embark on a review of any proposed LSTP2 without carefully considering the errors that were made in LSTP1 that rendered it inadequate to adequately forecast the extent and progress of ASR at Seabrook. These errors included (a) NextEra’s and FSEL’s failure to follow explicit guidance by the National Institute of Standards and Technology (NIST) that existed at the time of LSTP1; and (b) NextEra’s and the NRC Staff’s disregard or dismissal of the significant body of ASR test results issued during the past ten years which demonstrates that the results of LSTP1 were not applicable to shear walls such as those found in the containment enclosure building (CEB), a seismic Category 1 structure.

For these reasons, the review of any proposed LSTP2 should include an independent assessment by qualified external experts in ASR-affected reinforced concrete, nonlinear structural behavior, and seismic performance of nuclear safety-related structures. This is not merely a matter of preference. It is consistent with sound engineering practice and with the NRC’s own obligation to verify the acceptability of industry proposals independently of the licensee, particularly where the issue is technically complex, safety-significant, and not readily resolved by routine regulatory inspection.

Such independent review is especially warranted here because LSTP1 was relied upon to support consequential conclusions about the future behavior of Seabrook’s safety-related concrete structures, yet those conclusions have since proven inadequate or inapplicable to the governing structural configuration. Based on past experience, neither NextEra nor the NRC Staff has sought meaningful outside expertise on the central structural question: whether ASR-affected Category I concrete structures at Seabrook can maintain adequate shear capacity, particularly under in-plane seismic demands. An external review may be inconvenient, and its conclusions may not align with the preferences of either the licensee or the Staff, but that is precisely the value of independent expert scrutiny.

However, in light of the Staff’s concerning lack of interest over the past ten years in applying either the NIST guidance that existed at the time of LSTP1 or the lessons that have been learned through ASR testing of shear concrete walls, I believe it is necessary for the Commission to step in for the purpose of ensuring that the Staff’s review is fully informed by relevant guidance and by the research and tests that have been conducted over the past 10 years – including research by NIST and others that was contracted by the NRC.

²*Id.* According to the NRC’s policy for deviations from the ROP Action Matrix:

The NRC determines its regulatory response in accordance with an Action Matrix that provides for a range of actions commensurate with the significance of the performance indicator (PI) and inspection results as described in IMC 0305, “Operating Reactor Assessment Program.” The NRC recognizes that there may be rare instances in which the regulatory actions dictated by the Action Matrix may not be appropriate. In these instances, the Agency may deviate from the Action Matrix to either increase or decrease Agency action when approved by the Executive Director for Operations.

Finally, the Commission should inquire into an early erroneous and misleading representation by the Advisory Committee on Reactor Safeguards (ACRS) regarding the adequacy of LSTP1, which may have biased both the NRC Staff and the Atomic Safety and Licensing Board (ASLB). The ACRS' failure to fulfill its responsibility to provide an independent and thorough review is extremely concerning in light of the fact that ASR in nuclear plants is a relatively new phenomenon for which the NRC had no regulations or guidance prior to the discovery of ASR at Seabrook in 2009, nor does it have any even at this date.

This report has four major sections regarding ASR at Seabrook:

- §3 From the start, LSTP1 was inconsistent with ASR testing guidance issued in 2013 by the National Institute of Standards and Technology (NIST) for ASR testing in nuclear plant structures (NIST, 2013). NextEra has given no indication that it plans to correct those deficiencies. NextEra's laboratory tests disregarded the foundational principle of experimental mechanics that each test specimen should be as representative of the prototype as laboratory scale and resources allow. Where the prototype is a large-diameter cylindrical reinforced concrete shell subjected to in-plane membrane shear under seismic loading—as in the Seabrook CEB—the appropriate test article is a shear wall or geometry-specific shear panel representative of that behavior, not an out-of-plane shear beam. The difference is significant: aside from the Seabrook testing program, every major research program conducted since 2016 (Canadian, Japanese, NRC-funded American) used shear walls or shear panels *and found adverse structural effects*.
- §4 This section raises the concern that in the ten years that have passed since NextEra sought NRC approval of its ASR assessment and testing program, the NRC Staff have contracted for and then ignored significant ASR research and testing by NIST and other institutions, including research and testing sponsored by the NRC, which showed that the methods used in LSTP1 were inappropriate to model ASR's behavior in the Seabrook CEB and other shear walls. Only in 2020, when NextEra's program was challenged in a licensing hearing before the Atomic Safety and Licensing Board, did the NRC impose additional monitoring requirements on NextEra (Atomic Safety License Board, 2020)³ And even then, the ASLB did not question the fundamental concept of LSTP1's testing concrete beams instead of shear walls. (*Id.*)
- §5 The Commission should be concerned that the ACRS, a watchdog arm of the NRC relied on by the agency for their expert review of highly technical licensing issues, may have biased the NRC's review process in 2018 by making an undocumented and unsupported claim that NRC-sponsored ASR research by NIST and "large Canadian and European programs" had "produced similar results" to LSTP1, (Advisory Committee on Reactor Safeguards, 2018, p. 4). In fact, NIST had not produced any research results at that time, and the results

³In that proceeding, the author testified as an expert witness for the Intervenor, C-10. See §2 below.

that NIST subsequently produced in 2021 were *not* consistent with LSTP1.⁴ The ACRS did not correct this unsupported assertion in 2025, when it reported to the NRC Commissioners on a “multi-year review” of NextEra’s measures for addressing ASR at Seabrook (Advisory Committee on Reactor Safeguards, 2025). Given the importance of the ACRS’ opinions to the NRC’s decision-making process, the ACRS’ incorrect and misleading assertion should be acknowledged and corrected, and the ACRS should be required to address the substantial body of research that contradicts its 2018 assertion.

§6 This section presents the report’s conclusions. In the author’s expert opinion, Seabrook is now operating without the complete technical basis needed to demonstrate continued structural adequacy of its safety-related concrete structures. Unless major changes are made to the next phase of ASR testing at Seabrook, this unacceptable situation is likely to continue for the next 24 years, through a renewed operating license term that does not expire until 2050. Even more concerning, based on recent statements by NextEra officials, the company may seek a second license renewal term, allowing operation until 2070. A repetition of LSTP1 would be grossly inadequate to justify continued operation of Seabrook for even a fraction of such a lengthy renewal term.

2 About the Author

Victor E. Saouma, with over 40 years of research experience, including nearly 20 years devoted to Alkali Silica Reaction (ASR), has made significant contributions to the field. His ASR research encompasses 11 major funded projects, two books [Aging, Shaking, and Cracking of Infrastructures: From Mechanics to Concrete Dams and Nuclear Structures](#) (Saouma and Hariri-Ardebili, 2021), [Numerical Modeling of Alkali Aggregate Reaction](#) (Saouma, 2013), 9 major reports, 9 short courses, and 13 peer-reviewed papers.

He chaired an international committee through RILEM (International Meeting of Laboratories and Experts of Materials, Construction Systems, and Structures), focusing on the [diagnosis and prognosis of structures affected by ASR](#). He served as the editor of a RILEM report comprising over 450 pages and contributions from 30 leading researchers [Diagnosis & Prognosis of AAR Affected Structures; State-of-the-Art Report of the RILEM Technical Committee 259-ISR](#) (Saouma, 2020) underscoring his expertise.

He is a past President and Fellow of the [International Association of Fracture Mechanics for Concrete and Concrete Structures](#) and is, accordingly, well-versed in concrete cracking issues. He has advised the Tokyo Electric Power Company (TEPCO) on the nonlinear dynamic analysis of large arch dams and on ASR-related problems affecting massive reinforced concrete structures. He conducted shear tests for TEPCO and for the Electric Power Research Institute (EPRI).

⁴See Section 5 below.

He was a key contributor to EPRI's report *Structural Modeling of Nuclear Containment Structures*.

Saouma's research on ASR has been funded by various organizations, including the Nuclear Regulatory Committee, Oak Ridge National Laboratory, and the Bureau of Reclamation, the Tepco Electric Power Company, and the Swiss Federal Office of Energy (SFOE). His technical reports are available [online](#).

His research interests extend to theoretical, numerical, and experimental fracture mechanics, chloride diffusion in concrete, real-time hybrid simulation (Saouma and Sivaselvan, 2014), and centrifuge testing of dams.

His international collaborations include France, Spain, Switzerland, Italy, and Japan.

In addition to his scientific expertise, Saouma is a trained civil engineer. He has taught linear and nonlinear structural analyses as well as reinforced and advanced reinforced concrete design, providing him with a broad perspective on engineering challenges.

In studying ASR over fifteen years, he has observed that ASR is an extraordinarily complex and nefarious reaction. Although it has been recognized since the 1940s, the emergence of structures suffering from this phenomenon has become more evident only recently (as it may take many years to manifest itself). Consequently, ASR has attracted the attention of researchers from many disciplines: chemists, mineralogists, geologists, material scientists, mechanics, experimentalists, and, notably, structural engineers. No single discipline can independently provide a definitive answer to the questions posed by ASR. However, those who adopt a comprehensive perspective are best positioned to offer informed opinions.

In 2019, on behalf of the C-10 Research and Information Foundation (C-10), he served as an expert witness in a license amendment proceeding before the U.S. Nuclear Regulatory Commission (NRC), (NRC-ML19312B609, 2019), concerning the state of ASR at the Seabrook nuclear power plant. His testimony resulted in the implementation of stronger measures for monitoring the state of ASR over a 20-year license renewal term.

Given his diverse research background, encompassing theoretical, experimental, numerical, and field work, as well as his leadership role in addressing ASR globally, he is well-positioned to evaluate the adequacy of the work conducted at Seabrook Nuclear Power Plant.

3 NIST 2013 Scoping Study vs. Actual LSTP

In April 2013, with funding from the NRC, NIST published NISTIR 7937, "Alkali-Silica Reaction Degradation of Nuclear Power Plant Concrete Structures: A Scoping Study" (NIST, 2013). The report identified knowledge gaps "on how to control alkali-silica reactivity, how to predict future development of cracks, and how to predict the performance of concrete structures affected by alkali-

silica reaction,” and proposed a technical plan for closing those gaps. As discussed below, however, LSTP1 did not follow NIST’s guidance in a number of significant respects.

3.1 Large-Scale Instrumented Structural Elements

3.1.1 What NIST recommended

1. “Cast large-scale ASR-reactive reinforced concrete elements representative of common structural components.” (NIST, 2013, p. 23). Note that while the scoping study did not suggest a particular geometry, it described earthquake-vulnerable concrete components in a nuclear plant as consisting of “vertical members (such as columns and walls) and the end rotation of horizontal members (such as beams and girders).” (NIST, 2013, p. 26).
2. Embed triaxial strain gauges at selected locations within those large-scale ASR-reactive reinforced concrete elements.
3. Perform an expansion analysis to infer the degree of internal restraint and confinement produced by reinforcement and structural continuity.
4. Use the measured strain field to characterize the in-situ restraint state — recognizing that ordinary unconfined core tests may not be representative of the strength that exists in massive reinforced structures affected by ASR.

3.1.2 What LSTP1 did — and did not do

1. LSTP1 failed to satisfy NIST’s recommendation to cast large-scale ASR-reactive reinforced concrete elements representative of common structural components. Instead, it tested beams exclusively. The LSTP included no shear wall specimens, despite NIST’s explicit identification of walls as earthquake-vulnerable vertical members. (NIST, 2013, p. 26). As demonstrated in §4.1.1 below, the structural behavior of beams under out-of-plane one-way shear is fundamentally different from that of walls under in-plane membrane shear; test results from one cannot be reliably extrapolated to the other.
2. **No direct characterization of the three-dimensional strain/restraint state.** The LSTP1 beam specimens were not instrumented in a manner that directly characterized the full three-dimensional strain field or the internal restraint state, as contemplated by the NIST framework. Instead, the program relied primarily on measured in-plane expansion, through-thickness expansion, volumetric expansion, and correlations between modulus reduction and expansion. Those measurements may describe the amount and direction of expansion in the test specimens, but they do not directly establish the internal restraint state that would be needed to verify whether, where, or to what extent any asserted ASR-induced “chemical

prestressing” mechanism was actually operative in a manner representative of Seabrook’s massive reinforced concrete structures.

3. **No representative structural confinement or NIST-type expansion analysis.** Although the LSTP1 beams contained reinforcement mats that provided some in-plane restraint, they did not reproduce the structural confinement, continuity, boundary conditions, and load path of massive reinforced concrete walls or containment-type structures at Seabrook. Nor did LSTP1 perform or report the type of expansion/restraint analysis contemplated by NIST, namely an analysis using measured strain fields to infer the degree of internal restraint and confinement. MPR later developed methods for estimating through-thickness and volumetric expansion and for comparing Seabrook structures to the LSTP specimens, but that is not the same as analytically reconstructing the restraint state in the prototype structures themselves. Thus, the asserted applicability of LSTP1 to Seabrook rested on expansion comparisons and modulus-expansion correlations, rather than on a direct demonstration that the relevant restraint and confinement conditions were representative.⁵
4. **No measured strain field; in-situ restraint state never characterized:** Because no triaxial strain gauges were embedded and no expansion analysis was performed, the measured strain field that NIST identified as the essential basis for characterizing the in-situ restraint state — and for assessing whether ordinary unconfined core tests are representative — was never obtained. LSTP1’s foundational claim of specimen representativeness therefore rests on assertion rather than measurement.

Taken together, these omissions are not isolated technical shortcomings — they are the very measurements and analyses that NIST identified as the prerequisites for establishing that a test program’s specimens are representative of in-situ conditions. Without shear wall specimens, LSTP1 provides no data on the structural components most critical to seismic performance at Seabrook. Without triaxial strain gauges, the internal restraint state was never measured. Without lateral confinement and a computational expansion analysis, the degree of internal restraint was never quantified. And without a characterized strain field, LSTP1’s foundational claim — that its beam specimens replicate the restraint conditions of the Seabrook CEB — is an unsubstantiated assertion.

A regulatory finding of structural adequacy cannot be grounded in a test program that

⁵The fact that the LSTP1 beams contained ordinary reinforcement should not be confused with representative structural confinement. Reinforced concrete beams commonly include transverse reinforcement or stirrups, and that ordinary beam reinforcement is not the same as the restraint provided by structural continuity, boundary conditions, massive wall geometry, or surrounding concrete in an actual nuclear safety-related structure. Moreover, the critical test region in which the ASR/AAR-induced cracking was allowed to develop was intentionally left without stirrups, because the test was designed to evaluate material/section behavior rather than the behavior of a fully representative structural system. In that critical region, there was therefore no transverse restraint from stirrups and no structural restraint comparable to that present in the Seabrook prototype structures.

systematically omitted the instrumentation and analyses that the governing technical authority prescribed as the basis for any such conclusion.

3.2 Confined Core Testing

3.2.1 What NIST recommended

- Remove cores from the large-scale instrumented elements after ASR exposure.
- Perform compressive and tensile tests on those cores under triaxial restraint consistent with the restraint state indicated by the embedded strain gauges.
- Conduct a computational expansion analysis to guide the ideal orientation of extracted cores.
- Translate the structural restraint observed in the large-scale element into quantified material properties under representative confinement conditions.

3.2.2 What LSTP1 did — and did not do

- Tested cores, but without confinement: LSTP1 tested cylinders and cores for compressive strength, elastic modulus, limited tensile properties, and petrography — but without triaxial restraint.
- Argued against confined core testing: The LSTP1 report contends that once a core is removed from its structural context, the prestressing effect of confinement is lost and the core is no longer representative of in-situ performance. While internally consistent, this argument does not constitute implementation of the NIST-recommended confined core test framework.

LSTP1 therefore adopted only one branch of the NIST concept: large-scale reinforced structural testing intended to preserve confinement. The second branch — instrumented strain-field inference followed by separate triaxially restrained core testing — was not implemented.

NextEra’s and the NRC Staff’s failure to follow or even acknowledge (NIST, 2013) is both inexplicable and inexcusable. This report was published in April 2013, well before the commencement of LSTP1 in “late 2013.” *See* NRC (2025). Less than a year before publication of (NIST, 2013), the NRC had set up a “Seabrook Alkali-Silica Reaction Technical Team” (SAITT) with the objective, among other things, of “ensur[ing] the adequacy of technical methods used by the licensees in determining adequate margin (including testing, samples), (NRC, 2012). The Charter for the SAITT provided for consultation with the Office of Nuclear Reactor Research (RES), where Dr. Jacob Philip has “developed and managed research” in ASR since 2012 and also serves as NIST’s project manager for ASR. Dr. Philip is listed on the cover of (NIST, 2013) as program director.

3.3 Future Expansion Prediction

3.3.1 What NIST recommended

- Adopt a sigmoidal expansion-versus-time framework as the conceptual basis for predicting future ASR progression.
 - **Step 1** — Accelerated residual expansion tests: Use laboratory-accelerated tests (e.g., ASTM C1260, ASTM C1293) to establish a relationship between accelerated residual expansion values and the asymptotic ultimate expansion value on the sigmoid curve.
 - **Step 2** — First-order kinetic model: Develop a first-order kinetic model incorporating temperature and moisture dependence to estimate future expansion as a function of time, coupled to mechanical property relationships to predict future structural capacity.
- Caution against near-linear extrapolations of past monitoring trends as a substitute for a validated predictive model, particularly for structures requiring extended periods of safe operation.

3.3.2 What LSTP1 did — and did not do

- **Comprehensively characterized residual shear capacity** at various measured expansion levels. **But --**
 - **Did not develop any expansion prediction model:** No accelerated residual expansion tests, sigmoidal curve construction, or first-order kinetic modeling was performed for the Seabrook concrete mixtures.
 - **Provided no methodology** for determining where on the sigmoid curve the Seabrook structures currently reside, or how much additional expansion remains. This gap was explicitly identified by NIST (2013) three months before LSTP1 commenced.

Table 1 summarizes the aspects in which LSTP1 complied or failed to comply with the guidance of NIST (2013).

Table 1: Compliance of the LSTP with the NIST Technical Framework (NISTIR 7937).
Amber $\sim$ = partially addressed; Salmon $\times$ = not implemented.

What NIST Recommended (NISTIR 7937)	What the LSTP Did — or Did Not Do	Complied?
Large-scale ASR-reactive reinforced concrete elements representative of structural components	Large-scale non-representative out-of-plane shear beams	$\sim$
Triaxial strain gauges embedded in large-scale elements to measure internal restraint state	Instrumentation limited to expansion monitoring (crack width, embedded pins, z-frame, borehole extensometers); no triaxial strain gauges	$\times$
Computational expansion analysis to estimate internal restraint and guide core orientation	No computational expansion analysis of this type reported	$\times$
Confined core tests under triaxial restraint consistent with in-situ confinement state	Cores tested unconfined (compressive strength, modulus, petrography only); LSTP argues confinement is lost when core is removed (misleading and out of context)	$\times$
Sigmoidal expansion-versus-time framework with accelerated residual expansion tests	No sigmoidal expansion model or accelerated residual expansion tests developed for Seabrook concrete	$\times$
First-order kinetic model for predicting future expansion as a function of temperature and moisture	No predictive kinetic model developed	$\times$
Geometry-representative structural test specimens (shear walls or shear panels for nuclear structures)	Beams used exclusively for shear testing — the only program in the international record to do so	$\times$
Time-matched non-reactive companion specimens as controls (lithium-suppressed, same mix, same age)	“Control” specimen from same reactive mix tested at $\sim$ 30 days (before ASR developed); reactive specimens tested up to 2.5 years later	$\times$

4 Other Major Flaws

4.1 Geometry

The author has determined that there are major flaws in the geometry adopted by LSTP1. A foundational principle of experimental mechanics is that each test specimen should be as representative of the prototype as laboratory scale and resources allow. Where the prototype is a large-diameter cylindrical reinforced concrete shell subjected to in-plane membrane shear under seismic loading — as in the Seabrook CEB — the appropriate test article is a shear wall or geometry-specific shear panel representative of that behavior, not an out-of-plane shear beam.

This principle is well-established as early as 1980. Buyukozturk, Connor, and Leombruni (1980) examined shear transfer in reinforced concrete nuclear containment structures and explicitly demonstrated that in-plane membrane shear transfer through aggregate interlock and dowel action is the primary load-carrying mechanism in cylindrical shells under seismic loading. Their analysis emphasized that the appropriate test specimen for nuclear containment structures *must reproduce in-plane shear transfer*. Critically, they identified three concrete-dependent mechanisms governing this transfer: (1) aggregate interlock across crack faces, (2) tensile resistance at crack tips, and (3) dowel action of reinforcement across cracked planes. All three mechanisms are directly degraded by ASR-induced micro-cracking and concrete property loss. The LSTP’s exclusive use of beam specimens to assess nuclear containment shear capacity represents a departure from this established principle of geometry-representative testing, not an advancement of it.

4.1.1 Why the CEB Governing Seismic Demand is In-Plane Membrane Shear, Not Out-of-Plane Shear

For the Seabrook CEB under lateral seismic loading, the governing shear mechanism is in-plane membrane shear flow distributed around the circumference of the cylindrical shell — not the out-of-plane, one-way beam shear tested in LSTP1. This distinction is fundamental. Saouma and Hariri-Ardebili (2020) showed that, for a nuclear concrete containment (NCC) subjected to lateral seismic loading, the dominant shell action at the azimuths approximately $\pm 90^\circ$ from the direction of ground motion is in-plane membrane shear, whereas out-of-plane shear is associated with the 0° and 180° azimuths. The in-plane shear at the critical azimuths is resisted by the combined hoop and meridional reinforcement of the shell — the structural configuration associated with the in-plane wall-panel shear limit, not the one-way beam-shear limit. Because the CEB cylindrical shell carries seismic demand primarily through in-plane membrane shear action, any structural test intended to assess the effect of ASR on Seabrook’s safety-related concrete structures must reproduce that in-plane shear mechanism. A beam test that exercises out-of-plane one-way shear does not reproduce it and therefore cannot serve as the experimental basis for regulatory conclusions about the CEB.

4.1.2 NRC Justification for Out-of-Plane Shear

NRC Staff have argued that testing out-of-plane shear was appropriate because ACI 318 specifies a lower shear-strength expression for one-way shear — the concrete contribution (V_c), commonly associated with $(0.17\sqrt{f'_c})$ in SI units — than for in-plane wall-panel shear, commonly associated with $(0.83\sqrt{f'_c})$. On that basis, Staff appear to reason that out-of-plane shear is the governing, and therefore conservative, case. That reasoning is analytically incorrect as applied to the CEB under seismic loading.

4.1.3 Author's Criticism

The values $(0.17\sqrt{f'_c})$ and $(0.83\sqrt{f'_c})$ do not represent two competing shear capacities for the same failure mechanism, at the same location, under the same loading condition. The former is the concrete contribution to one-way shear in a beam-type member, typically without transverse shear reinforcement in the critical region. The latter is an in-plane shear-stress limit for a reinforced wall panel resisting membrane shear through horizontal and vertical reinforcement. These provisions address different failure planes, different structural configurations, and different load-resisting mechanisms. Selecting the governing seismic failure mode of a cylindrical shell merely by comparing the numerical coefficients in two different ACI provisions⁶ is therefore mechanically unsound.

Moreover, the Staff's argument is internally inconsistent. If out-of-plane shear is deemed governing because the ACI one-way shear limit is lower, and if that limit depends on concrete tensile/fracture properties that are degraded by ASR, then ASR should reduce the out-of-plane shear capacity. That is precisely what the University of Colorado tests found: an approximately 20% reduction in unreinforced specimens representative of the material-dominated out-of-plane shear mechanism. Thus, under either framing, the experimental record supports a reduction in capacity, not the strengthening effect inferred from LSTP1.

4.1.4 NIST and the International Research Community Tested Shear Walls or Shear Panels — and Found Different Results

With the exception of LSTP1, every other major research program that has investigated the structural effects of ASR in a nuclear context used shear walls or geometry-specific shear panels as the test specimen. LSTP1 stands alone in its use of beam specimens. When programs other than LSTP1 are examined carefully, a consistent pattern emerges that directly contradicts the LSTP1 finding: across all programs using geometry-representative specimens and properly controlled mixes, ASR causes a reduction in structural capacity, not an increase.

⁶The numerical coefficients should not be compared in isolation. They arise in different code provisions, for different member types, reinforcement configurations, and failure mechanisms. A lower coefficient in a beam-shear expression does not establish that beam shear is the governing seismic mechanism in a cylindrical shell.

4.1.4.1 NIST Task 3 Shear Wall Program (Technical Note 2180, 2022) — NRC-funded (Inter-Agency Agreement No. NRC-HQ-60-14-I-0004):

4.1.4.1.1 Findings NIST tested four reinforced concrete shear wall specimens at $h_w/l_w = 2.0$ under reversed cyclic lateral loading. The control specimen used the same reactive concrete mix as the reactive specimens, dosed with lithium nitrate to suppress ASR, and was aged and tested alongside the ASR specimens — providing the most rigorous material comparison in any program to date and, unlike the LSTP, eliminating the confounding effect of normal concrete maturation gain.

In (NIST, 2022), NIST reports: 30% reduction in compressive strength; 70% reduction in modulus of elasticity; and 40% reduction in splitting tensile strength in ASR-affected concrete at approximately 0.23–0.25% expansion. These material degradation effects caused statistically significant reductions of 26% in normalized yield moment capacity and 11% in peak flexural capacity, with the normalized yield moment M_y/M_n falling below 1.0 for all three reactive specimens.

NIST concludes explicitly that ACI 318 capacity calculation procedures are unconservative for ASR-affected walls — a conclusion that is independent of wall aspect ratio because it rests on material degradation that is present in any ASR-affected concrete structure.

4.1.4.1.2 NIST Shear Wall Results Are Applicable to the CEB — and a Squat Wall Test Would Have Shown the Same or Greater Reduction It has been suggested that the NIST specimens, with their intermediate height-to-length aspect ratio of $h/l = 2.0$ (characteristic of walls that fail in a combined flexural-shear mode), are not representative of the Seabrook CEB and that their findings therefore cannot be applied to the CEB seismic assessment. This objection does not withstand scrutiny — and the argument can be turned: had NIST tested squat walls instead, the finding of ASR-induced strength reduction would almost certainly have been at least as large, and very likely larger.

The CEB is a large-diameter cylindrical shell with no intermediate floor diaphragms. Under lateral seismic loading, the full overturning moment and base shear are carried from dome to base mat by the shell wall acting as a single cantilever, without redistribution through intermediate diaphragm action. The effective shear span ratio of this cantilever — the ratio of overturning moment to base shear at the critical base section — produces an effective aspect ratio for the CEB that is intermediate between the Habibi squat specimens ($h_w/l_w = 1.1$) and the NIST intermediate specimens ($h_w/l_w = 2.0$).

Neither tested geometry is a perfect analogue of the CEB cylindrical shell. NIST itself states that interpolation or extrapolation beyond the tested parameter range is not yet appropriate. But this cuts both ways: the applicant cannot invoke the NIST aspect ratio as a reason to dismiss the NIST findings without simultaneously conceding that no available data certifies the CEB's safety.

The NIST findings that are most directly applicable to the CEB are not aspect-ratio dependent. The finding that ACI 318 overestimates the yield moment capacity of ASR-affected walls — with $M_y/M_n < 1.0$ for all three reactive specimens — rests on ASR-induced pre-straining of longitudinal bars and on concrete material degradation: 30% reduction in compressive strength f'_c , 70% reduction in modulus of elasticity E_c , and 40% reduction in splitting tensile strength f_t .

These are properties of the material, not the structural geometry. They are present in the Seabrook CEB concrete regardless of the effective aspect ratio of the shell. The conclusion that ACI 318 capacity calculation procedures are unconservative for ASR-affected concrete applies to the CEB's code-based capacity evaluation irrespective of whether the governing failure mode is flexural, shear, or combined.

The 70% reduction in E_c deserves particular emphasis in the context of a cylindrical shell structure. Shell membrane stiffness and bending stiffness are both proportional to E_c . A 70% reduction in E_c materially alters the natural period of the CEB, changes the circumferential distribution of seismic demand around the shell, and reduces the buckling resistance of the compression side under combined gravity load and seismic overturning moment. None of these consequences are captured in any capacity assessment that does not explicitly account for the in-situ modulus degradation of the ASR-affected concrete.

The second part of the argument is equally important: had NIST tested squat walls ($h/l \approx 1.0$ or less), the finding of ASR-induced strength reduction would not have been smaller — it would have been the same or larger. The reason is rooted in the mechanics of shear transfer. In squat walls, where shear dominates over flexure, the concrete contribution to shear resistance depends most heavily on: (i) aggregate interlock across diagonal cracks, (ii) the tensile resistance of the concrete at the tips of diagonal cracks, and (iii) the dowel action of reinforcement crossing crack planes.

ASR degrades all three of these mechanisms directly. It pre-opens cracks before any load is applied, reducing aggregate interlock from the outset. It reduces splitting tensile strength by 40% — the NIST-measured value — which governs the very crack-tip resistance that limits diagonal tension failure. And it reduces the compressive strength and stiffness of the concrete struts that carry diagonal compression in the web.

In a flexure-dominated wall (high aspect ratio), a portion of the lateral load is resisted by the moment couple in the boundary elements — a mechanism that depends primarily on the longitudinal reinforcement yield strength, which ASR does not directly degrade. The concrete-dependent shear mechanisms are proportionally less critical.

In a shear-dominated squat wall, there is no such partial escape to a steel-dominated mechanism: the concrete-dependent shear mechanisms carry the load, and ASR has degraded all of them. The NIST result — statistically significant strength reduction in a flexure-shear specimen — is therefore a conservative lower bound on the reduction that would be expected in a shear-dominated squat

wall or in the membrane shear transfer of a cylindrical shell.

The absence of squat wall test data with properly controlled ASR specimens is not a reason to discount the NIST findings. It is a reason to regard them as an underestimate of the true concern.

This reasoning is reinforced by Habibi’s own finding (Habibi, Sheikh, Vecchio, and Panesar, 2018). Even in Habibi’s squat walls — the geometry most favorable to the “chemical prestress” argument, with high confinement from I-shaped boundary columns — the net effect of ASR was not a strength increase: it was no significant change in peak strength but a 30% reduction in ductility and energy dissipation. If the beneficial prestress mechanism were dominant in squat wall geometry, Habibi would have found a strength increase. It did not. The NIST intermediate-aspect-ratio result and the Habibi squat-wall result together bracket the behavior across aspect ratios: both show adverse structural effects, neither shows the strength increase claimed by the LSTP.

4.1.4.2 Habibi et al. (2018) — Canadian Nuclear Safety Commission: Although the Habibi, Sheikh, Vecchio, and Panesar (2018) study is the single shear-wall reference most frequently invoked by the NRC and by NextEra to support the claim that ASR does not reduce wall strength, a careful reading of the original paper and of the subsequent OECD/NEA ASCET benchmark reports (Phases II and III) shows that the study cannot credibly bear the regulatory weight that has been placed on it. The program is too small, too imperfectly documented, and too adversely affected by its own design choices to support any general claim about the structural effects of ASR on nuclear shear walls.

First, the program is underpowered. Only five walls were tested, of which only three were ASR-reactive, and the reactive specimens spanned a narrow range of expansion levels. A sample of this size cannot reliably detect moderate strength loss, and the absence of a clear peak-strength difference between reactive and control specimens is therefore not, by itself, evidence that no strength loss occurred.

Second, the test articles themselves are not representative of the CEB. Habibi’s specimens were squat walls ($h_w/l_w \approx 1.1$) with I-shaped boundary columns providing very high geometric confinement — a configuration that maximizes the apparent “chemical prestress” benefit of ASR and minimizes the visibility of concrete degradation. Neither the aspect ratio nor the boundary-element detailing corresponds to the cylindrical shell wall of the Seabrook CEB.

Third, the specimens had a documented detailing deficiency. The transverse reinforcement used 45-degree hooks that do not meet the seismic detailing requirements of (ACI 318, 2019). Specimens with substandard detailing cannot reliably distinguish capacity degradation caused by ASR from capacity limitations caused by the detailing itself, and such specimens are excluded from the ACI 445-B wall strength database for exactly this reason.

Fourth — and most consequential — two OECD Nuclear Energy Agency reports (OECD Nuclear Energy Agency, 2019; OECD Nuclear Energy Agency, 2022), which attempted to blind-

benchmark the Habibi results with international finite-element teams, identified substantive experimental and documentation uncertainties. These include questions about whether the recorded displacement properly represented wall deformation, whether the lower beam may have experienced uplift, and whether actuator force and A-frame displacement were adequately resolved as separate time histories.

OECD Nuclear Energy Agency (2019) sates that even after follow-up questions to the University of Toronto team, aspects of the loading protocol and axial-load measurement remained unclear, and that the numerical modeling had to be revised to incorporate bottom-beam-to-floor contact and bottom post-tensioned bolts — support conditions that were not adequately represented in the original test documentation.

These are not minor details: if the base restraint and the measured deformations are uncertain, then the reported load-deformation response cannot be treated as a clean measure of intrinsic wall strength.

Fifth, even taking the Habibi results at face value, the program reported approximately a 30% reduction in ductility and energy dissipation in the ASR-reactive specimens. Both quantities are directly relevant to seismic performance; a wall that has lost 30% of its ductility and energy-dissipation capacity cannot reasonably be described as structurally unaffected by ASR, regardless of whether its peak lateral resistance has changed.

Taken together, these limitations mean that Habibi, Sheikh, Vecchio, and Panesar (2018) is not a reliable basis for inferring that ASR does not reduce shear-wall strength in safety-related nuclear structures. It is a small, imperfectly documented study of a non-representative geometry with a documented detailing deficiency, and its own results show adverse effects on ductility and energy dissipation. The frequency with which it is invoked in the regulatory record is not proportionate to the evidentiary weight it can actually carry. At most, Habibi supports the narrow proposition that in this particular set of squat walls, a clear reduction in peak lateral resistance was not observed — a much weaker proposition than the one for which it is routinely cited.

4.1.4.3 University of Colorado – NRC-funded (Grant No. NRC-HQ-60-14-G-0010):

The University of Colorado program (Saouma and Hariri-Ardebili, 2020), funded by the NRC in parallel with the NIST program, tested sixteen large-scale shear panels scaled to represent a nuclear concrete containment (NCC) of 20 m radius at 0.56 scale — scaled shear panels, not beams, with geometry and boundary conditions designed to reproduce the shell of a nuclear concrete containment. Non-reactive companion specimens were cast from the same reactive aggregate and cement with lithium nitrate added to suppress ASR, and both sets were aged and tested at matching ages — the comparison methodology LSTP1 did not employ. Lateral confining traction representative of the vertical stress at the selected elevation within the NCC was applied, and strain gauges were placed on the reinforcement, permitting the ASR-induced strains in the steel and concrete to be

quantified rather than assumed. Under these representative conditions, ASR caused a reduction of approximately 20% in shear strength for both reinforced (structural) and unreinforced (material) specimens at approximately 0.6% average expansion. No strength increase was observed.

A subsequent probabilistic nonlinear seismic analysis of a full-scale NCC found that a relatively low ASR expansion of 0.3% reduced seismic capacity by approximately 20%. The authors conclude explicitly: “ASR will reduce the intrinsic shear capacities of concrete (as determined both experimentally and numerically) and the seismic response of an NCC.”

4.1.4.4 Sawada et al. (2021) — Japanese nuclear industry (Kajima Corporation):

The program addressed in (Sawada, Takaine, Okayasu, Nimura, and Shimamoto, 2021) represents the methodological gold standard for geometry-specific ASR structural testing of nuclear shear walls. The program used geometry-specific specimens ($h_w/l_w \approx 0.67$), controlled reactive aggregate with measured expansion prism data, variable constraint conditions, comprehensive monitoring throughout exposure, and rigorous nonlinear FEM validation explicitly incorporating ASR expansion strain and degraded material properties — the methodological standards the LSTP failed to meet.

Specimens were exposed to ASR free expansion of approximately $2100\text{--}2800 \times 10^{-6}$, far exceeding any other program. The findings: initial stiffness reduced by ASR; deformation angle at maximum strength smaller under severe constraint; ultimate strength not enhanced. No strength increase was observed at any level of expansion or constraint condition — directly refuting the claim that ASR-induced pre-stress provides a net structural benefit under representative nuclear shear wall conditions.

It should be noted that the Sawada reference specimen (No. 0) was taken from a prior study by Oyamoto et al. (2017) using different materials, limiting direct experimental comparison. The supplementary numerical analysis correcting for this limitation (the No. 0' comparison) confirms the adverse effects on stiffness and deformation capacity. The University of Colorado and NIST programs, which used time-matched same-mix reactive and lithium-suppressed companion specimens, provide the more materially rigorous result. Sawada is the methodological standard for protocol and instrumentation; the NRC-funded programs provide the cleaner structural comparison.

4.1.4.5 Summary: The Convergent Evidence from Five Programs

Table 2 summarizes the five programs constituting the full experimental record on ASR effects on nuclear structural performance. The pattern is unambiguous: the only program finding strength increase is the one with the least representative geometry, no strain-gauge instrumentation on the reinforcement, and no time-matched control — its “control” specimen was tested at 30 days from the same reactive mix, before ASR had developed, and is accordingly confounded by normal concrete maturation gain.

Both NRC-funded programs — operating independently under parallel inter-agency agreements — find strength reduction. To aid interpretation, each column heading below is followed by a brief explanation of why that attribute governs the evidentiary weight of the program.

Column notes: **Program/Funding** identifies the test program and its sponsor; NRC-funded independent programs carry the greatest evidentiary weight for U.S. regulatory purposes. **Specimen type** governs which failure mode is tested—shear walls and shear panels reproduce the in-plane membrane shear demand of the CEB, while beams do not. **Confinement** controls whether the “chemical prestress” artifact is suppressed; without representative lateral confinement, ASR can appear to strengthen concrete for non-structural reasons. **Mix control** determines whether reactive vs. control comparisons isolate the effect of ASR itself—a proper control is a non-reactive companion cast from an equivalent mix, aged under equivalent conditions, and tested at the same age as the reactive specimen. **ASR effect on strength** is the quantitative result; convergence across multiple independent programs is the strongest form of experimental evidence. **Key limitation/note** lists methodological caveats a regulator must weigh when relying on the program—narrow limitations constrain how far the result can be generalized.

4.2 Omission of Strain Gages

LSTP1 also omitted the single most important instrumentation required to characterize ASR effects on structural capacity: strain gauges on the longitudinal reinforcement.⁷ The purported benefit of ASR in a restrained reinforced concrete member is a putative tensile prestrain imposed on the steel by the expanding concrete — often described as a “chemical prestress.” Quantifying that tensile prestrain in the steel, and the corresponding compressive state imposed on the concrete, requires direct strain measurement.

The LSTP1 specimens were not so instrumented. As a result, the very mechanism alleged to be responsible for any apparent strength increase cannot be confirmed or disproven from the LSTP1 data. The detrimental effect of ASR on the steel (additional sustained tension) and on the concrete (sustained compression combined with internal cracking from gel expansion) was therefore neither measured nor reported.

In a test program commissioned to inform regulatory decisions about the safety of an operating nuclear facility, the omission of the measurement that would have resolved the central mechanistic question is, at minimum, a significant methodological deficiency.

4.3 Unreliability of the Control Specimen

A second methodological deficiency concerns LSTP1’s use of a control specimen. The Reinforcement Anchorage Test Program described in (MPR Associates, Inc., 2018) §5.3.1, used a single “control” specimen cast for that program and tested approximately 30 days after fabrication — that is, before meaningful ASR development had occurred. The remaining reinforcement-anchorage specimens were allowed to develop ASR and were then evaluated relative to the performance of that early-age control specimen.

This comparison does not isolate the effect of ASR. It necessarily superimposes the effect of ASR on the normal maturation gain of concrete. Concrete continues to gain compressive strength, tensile strength, and stiffness well beyond 28 or 30 days. Using a representative ACI-based estimate, compressive strength could reasonably increase on the order of 10–25 percent between 30 days and later-age testing. Because concrete shear strength varies approximately with $(\sqrt{f'_c})$, a 15 percent increase in compressive strength would correspond to approximately a 7 percent increase in nominal shear strength from ordinary aging alone, even if ASR provided no beneficial effect whatsoever. A more refined estimate could be developed if the exact concrete mixture proportions, curing history, and strength-gain data were publicly available, but the public materials do not provide the full information needed for such a calibration.

Accordingly, a reactive specimen tested after long-term accelerated ASR conditioning is being compared against a control from the same general test program tested at a much younger and weaker age. Any apparent “no loss” or “gain” in the ASR specimen therefore includes whatever strength and stiffness the concrete acquired through normal hydration over the intervening period. This is not a true control in the methodological sense required for safety-critical regulatory conclusions.

⁷The omission of the reinforcing bars strain gages is not to be confused by the omission of internal strain gages suggested by the scoping study.

Table 2: Comparison of ASR shear-strength test programs

Color key: outlier (strength increase claimed) convergent evidence (direct strength reduction) partial/qualified evidence (no peak-strength effect, other degradation)

Column notes: **Specimen type** governs which failure mode is tested—shear walls and shear panels reproduce the in-plane membrane shear demand of the CEB, while beams do not. **Confinement** controls whether the “chemical prestress” artifact is suppressed; without representative lateral confinement, ASR can appear to strengthen concrete for non-structural reasons. **Mix control** determines whether reactive vs. control comparisons isolate the effect of ASR itself—a proper control is a non-reactive companion cast from an equivalent mix, aged under equivalent conditions, and tested at the same age as the reactive specimen. **ASR effect on strength** is the quantitative result; convergence across multiple independent programs is the strongest form of experimental evidence. **Key limitation/note** lists methodological caveats a regulator must weigh when relying on the program—narrow limitations constrain how far the result can be generalized.

Specimen type	Confinement	Mix control	ASR effect on strength	Key limitation / note
LSTP1				
<i>NextEra</i>				
Beams, no shear reinf.	None	No time-matched control. “Control” specimen from the same reactive mix tested at ~30 days, before ASR developed; reactive specimens tested up to ~2.5 years later. Comparison confounded by normal concrete maturation gain.	Increase claimed, ~no reduction	Wrong geometry; no strain gauges on reinforcement to quantify “chemical prestress”; pseudo-control at 30 days biases result toward no degradation; not reproduced by any subsequent program; finding is an artifact of test conditions.
Saouma (2020)				
<i>NRC Grant NRC-HQ-60-14-G-0010</i>				
Shear panels, NCC-scaled	Yes—lateral, representative of NCC	Excellent—same aggregates, lithium control	~20% reduction, both reinf. and un-reinf.	Geometry scaled to NCC; both in-plane and out-of-plane tested; 3D nonlinear seismic analysis performed.
NIST Task 3 (Technical Note 2180, 2022)				
<i>NRC Inter-Agency NRC-HQ-60-14-I-0004</i>				
Shear walls, $h_w/l_w = 2.0$	Yes—axial gravity	Excellent—lithium control, same mix	11–26% strength reduction; ACI 318 unconservative	Material findings geometry-independent; code conclusions directly applicable to CEB capacity evaluation.
Sawada et al. (2021)				
<i>Japanese utilities</i>				
Shear walls, $h_w/l_w = 0.67$	None	Poor—reference from prior study	No increase; stiffness and deformation reduced	Methodological gold standard for protocol; result qualified by mixed reference concrete; no benefit observed at 10× the LSTP expansion level.
Habibi et al. (2018)				
<i>Canadian NSC</i>				
Squat walls, $h_w/l_w = 1.1$	Yes—axial	Moderate	No peak strength effect; 30% ductility reduction	45°-hook detailing deficiency; small sample, 5 walls, 3 reactive; documented experimental uncertainties, ASCET Phase II/III; I-shaped confinement not representative of CEB; not in ACI 445-B database; frequently cited by NRC beyond what the evidence supports.

It systematically biases the comparison toward a finding of no ASR-induced degradation, because age-related strength gain is allowed to mask whatever deterioration ASR may have caused.

Put differently, the true structural effect attributable to ASR is not the reported apparent change relative to the early-age control specimen, but the reported apparent change minus the age-related maturation gain. Thus, an apparent gain of only a few percent is entirely consistent with no real ASR benefit at all, and may in fact conceal a net ASR-induced loss.

A proper control would require time-matched nonreactive companion specimens — cast from an equivalent mix, conditioned and aged under equivalent conditions for the same duration, and tested at the same age — so that the only material variable between the two sets of specimens would be ASR. LSTP1 did not produce such companion specimens. One possible approach would have been to use otherwise comparable companion specimens in which ASR was suppressed, for example by lithium admixture or other accepted mitigation measures, and to test those specimens at the same ages as the reactive specimens.

For this reason, the LSTP1 control specimen cannot support the conclusion that ASR had no adverse effect, much less that ASR produced a strengthening effect.

5 Erroneous, Unsupported and Misleading Statements by the ACRS

5.1 The ACRS's Misleading and Unsupported 2018 Assertion

In its 2018 letter to NRC Chairman Svinicki (Advisory Committee on Reactor Safeguards, 2018), the ACRS asserted, under the heading “Independent ASR Research,” that:

[A] large body of ASR research similar to the LSTP is ongoing, including domestic research sponsored by the NRC's Office of Nuclear Regulatory Research at the National Institute of Standards, as well as large Canadian and European programs. *These programs have produced similar results to the LSTP, observing increased structural capacity in highly-constrained, ASR-affected structures.* Also noteworthy is the fact that the National Institute of Standards program (and others) chose a similar approach of fabricating prototypical, structural-sized test samples, with concrete produced to artificially accelerate ASR.

Advisory Committee on Reactor Safeguards (2018)

The ACRS letter does not cite any specific NIST report, publication, or data source in support of the assertion that domestic and international research yielded results that were consistent with the LSTP and showed increased structural capacity in highly-constrained, ASR-affected structures.

5.1.1 The Factual Impossibility of the ACRS Assertion at the Time It Was Made

The ACRS letter is dated December 14, 2018. The NIST shear wall test program — the structural testing program of which the ACRS purported to describe the “results” — had been funded by the NRC under Inter-Agency Agreement No. NRC-HQ-60-14-I-0004 in 2014 and was still in progress at the time the ACRS letter was issued. The structural test results from that program were not published until 2022, nearly four years after the ACRS letter (NIST, 2022). This chronology has two immediate consequences:

- The ACRS could not have been reporting on the results of the NIST structural test program, because no such results existed in the public record at the time the letter was written. The ACRS's use of the past tense (“have produced similar results”) was not supported by any NIST publication in existence in December 2018. At best, the ACRS was characterizing expected or anticipated results of an ongoing program; at worst, it was attributing to NIST a conclusion that NIST itself had not yet reached and had no basis to reach.
- The only NIST publication on ASR in nuclear structures in existence in December 2018 was (NIST, 2013), *i.e.*, “Alkali-Silica Reaction Degradation of Nuclear Power Plant Concrete Structures: A Scoping Study.” That report presented no structural test results — it was a gap analysis and a research roadmap, one that explicitly identified the absence

5.1 The ACRS's Misleading and Unsupported 2018 Assertion

of a validated predictive expansion model as a critical deficiency in the regulatory treatment of ASR-affected NPP structures. Nothing in (NIST, 2013) could possibly have been described as “similar results to the LSTP, observing increased structural capacity.”

There is therefore no NIST document in existence as of December 2018 that supports the ACRS characterization. The assertion was factually unsupportable at the time it was written.

It is also a matter of concern that the ACRS wrote another letter to the NRC Commissioners in 2025, in which it reiterated its 2018 conclusion that the LSTP adequately represented the condition of ASR at Seabrook (Advisory Committee on Reactor Safeguards, 2025). In that letter, the ACRS made no attempt to correct its previous erroneous statement that NIST had produced research results consistent with the LSTP.

5.1.2 What NIST Actually Found When Its Results Were Published

When NIST did publish its structural test results (NIST, 2022), the findings directly contradicted both LSTP's and the ACRS's assertion that ASR has a strengthening effect on highly-constrained concrete. NIST reported the following effects in ASR-affected reinforced concrete shear walls with material-controlled comparison specimens:

- 30% reduction in concrete compressive strength.
- 70% reduction in concrete modulus of elasticity.
- 40% reduction in concrete splitting tensile strength.
- Statistically significant 26% reduction in normalized yield moment capacity and 11% reduction in peak flexural capacity, with normalized yield moment M_y/M_n falling below 1.0 for all three reactive specimens; and
- An explicit conclusion is that ACI 318 capacity calculation procedures are unconservative for ASR-affected walls.

These findings are the opposite of “increased structural capacity in highly-constrained, ASR-affected structures.” The NIST results, as actually published, do not corroborate the LSTP — they contradict it.

5.1.3 The Subsequent NRC Staff Position Is Irreconcilable with the 2018 ACRS Letter

At the September 3, 2025 meeting of the ACRS Full Committee, NRC Senior Civil Engineer George Thomas, PhD, PE (NRR/DEX), stated that “The NIST Study was generic ASR research and not specific to Seabrook, whereas the Large-Scale Test Program (LSTP) conducted by NextEra was Seabrook-specific.” (Thomas, 2025, p. 118).

This staff position cannot be reconciled with the 2018 ACRS letter. If, as Dr. Thomas asserted in 2025, the NIST program is “generic” and “not specific to Seabrook,” then the ACRS's 2018 invocation of that same NIST program as corroboration of the LSTP and the Seabrook LAR was unwarranted. Conversely, if the ACRS was correct in 2018 that the NIST program is sufficiently similar in approach to the LSTP to constitute corroborating evidence, then the NIST findings — including the conclusion that ACI 318 is unconservative for ASR-affected walls — apply to Seabrook with equal force.

The NRC cannot simultaneously: (i) rely on the 2018 ACRS letter's invocation of the NIST program to validate the LSTP-based Seabrook safety case, and (ii) treat the actual NIST findings as too generic to apply to Seabrook when those findings prove adverse. The regulatory record must be corrected to reflect the fact that the NIST test results are indeed applicable to Seabrook shear walls, and indeed were designed for the purpose of providing needed information about the effects of ASR on shear walls.

6 Conclusions

The following findings, organized by section, establish that LSTP1 does not constitute an adequate technical basis for regulatory decisions about ASR-affected structures at Seabrook, and that the NRC’s institutional record contains irreconcilable contradictions on this point.

6.1 §3 — NIST Framework vs. LSTP

- §3.1 — Large-scale instrumented elements. LSTP1 cast large-scale specimens but omitted triaxial strain gauges and performed no computational expansion analysis. Its claim of specimen representativeness cannot be verified from the data produced (§2.1).
- §3.2 — Confined core testing. LSTP1 rejected the NIST-recommended triaxially restrained core test framework entirely, providing no experimental substitute for characterizing the in-situ confinement state.
- §3.3 — Expansion prediction. LSTP1 developed no sigmoidal expansion model, no accelerated residual expansion tests, and no kinetic model for Seabrook concrete. It provides no basis for predicting where on the expansion curve Seabrook structures currently reside — a gap now acute given that monitored expansion has already exceeded the upper bound of the LSTP1 test range.

6.2 §4 — Non-Representative Test Geometry

- §4.1 — Beam geometry. Under seismic loading, the CEB is governed by in-plane membrane shear at the $\pm 90^\circ$ azimuths, resisted by combined hoop and meridional reinforcement. LSTP1 is the only program in the international record to use beam specimens — which exercise out-of-plane one-way shear — to assess nuclear structural ASR. Every other major program (Canadian, Japanese, NRC-funded American) used shear walls or shear panels and found adverse structural effects.
- §4.2 — Omission of reinforcement strain gauges. The “chemical prestress” mechanism — the purported source of any apparent strength increase — was never quantified. The central mechanistic question the LSTP was commissioned to resolve was left unresolved.
- §4.3 — Non-representative control. The LSTP1 control specimen was tested at 30 days — before ASR had developed — while reactive specimens were tested up to 2.5 years later. Normal concrete maturation gain (estimated at ~7% in shear strength) systematically biases the result toward no degradation. No time-matched, lithium-suppressed companion specimens were produced.

6.3 §5 — The 2018 ACRS Letter

- §5.1.1 — The ACRS asserted in December 2018 that NIST structural tests corroborated LSTP1. Those results did not exist: NIST Technical Note 2180 was not published until 2022 (NIST, 2022). No NIST publication in existence in December 2018 reported structural test data of any kind.
- §5.1.2 — When NIST published its results in 2022, they directly (NIST, 2022) contradicted LSTP1: 30% reduction in compressive strength, 70% reduction in elastic modulus, 40% reduction in splitting tensile strength, statistically significant reductions of 11–26% in structural capacity, and an explicit conclusion that ACI 318-71 (1971) is unconservative for ASR-affected walls.
- §5.1.3 — NRC staff’s 2025 characterization of the NIST program as “generic” and “not specific to Seabrook” is irreconcilable with the 2018 ACRS invocation of that same program as direct corroboration of the LSTP. The NRC cannot simultaneously invoke NIST to validate the LSTP and dismiss NIST’s adverse findings as inapplicable. The regulatory record must be corrected.

6.4 Overall

Seabrook is operating without the complete technical basis needed to demonstrate continued structural adequacy of its safety-related concrete structures under design-basis seismic loading. LSTP1 was deficient in design, instrumentation, and controls. In establishing LSTP1, NextEra and the NRC Staff disregarded existing NIST guidance (NIST, 2013) and fundamental scientific principles. And since then, they have disregarded the fact that every independent program using representative geometry and rigorous controls found adverse structural effects. The ACRS's 2018 endorsement (Advisory Committee on Reactor Safeguards, 2018) of LSTP1 was factually unsubstantiated and has since been contradicted by the evidence it invoked. The ACRS should correct its misstatement and address the significant body of research that contradicts it, including research by NIST and the author.

Under the circumstances, the Commission should step in and supervise the establishment of the next round of ASR tests for Seabrook. At a minimum, any supplemental testing program must use geometry-representative shear wall or shear panel specimens, instrument the reinforcement with strain gauges, employ time-matched lithium-suppressed companion controls, and develop a validated expansion prediction model calibrated to Seabrook concrete mixtures.

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EXHIBIT 3 TO SAOUMA DECLARATION

Mazars Peer Review

Peer review of the technical white paper authored by Professor emeritus Victor
E. Saouma (Univ. of Colorado – Boulder)

*By Prof. emeritus Jacky Mazars (Polytechnic Institute –Grenoble Alpes
University, France)*

Some words About Prof. J. Mazars

Being from the same generation as V. Saouma, I, like him, have over 40 years of experience in research on concrete and concrete structures, mainly focused on analyzing damage to materials caused by mechanical effects and the effects of time. The objective is to analyze the risk in extreme situations for structures when they are subjected to earthquakes, explosions, impacts or other environmental actions.

Background : Doctor from Paris University, Professor at ENS Paris-Saclay then at INP Grenoble (currently emeritus).

Scientific advisor:

- at Electricité De France (EDF) : Vercors research program performed around a mock-up of a Nuclear Enclosure Building and Co-chairman of TINCE'23 (Technological Innovations in Nuclear Civil Engineering -Paris-Saclay 2023) and in this capacity Guest Editor of a special issue TINCE of the European Journal of Environmental and Civil Engineering (Vol. 28, n°13, Nov. 2024)
- at OXAND group providing consultancy and software solutions to help clients optimize their Asset and infrastructures

Committee and expertise - Civil Engineering expert at : ANR France, FRS Belgium, NSRC Canada, NCN Poland; Advisory Board on Structural Earthquake Engineering - European Commission (JRC Ispra Italy), Committee on Testing methods in Fracture Mechanics (RILEM). He was member of several institution: ASCE, ACI, RILEM, AFPS.... and led numerous collaborations: Associated Prof. at Univ. Sherbrooke (Canada), invited Prof at UC Berkeley, Northwestern Univ. and several university in Europe (UK, Italy, Spain, Switzerland & France).

Scientific responsibilities : in France CEOS.fr research program - ARVISE program and in Earthquake Engineering CASSBA, CAMUS, CAMUS 2000 programs – in Europe PREC8, ICONS, SAFERR, ECOEST, LESSLOSS all in the field of Earthquake Engineering.

Scientific production : About 80 peer-review papers and contribution to books chapters and 8 books acting as editor or author including : “Damage and Cracking of Concrete Structures” from J. Mazars & S. Grange – ISTE-WILEY 2022.

Peer review of the technical white paper authored by Dr. Victor E. Saouma

This white paper (WP) aims to alert the relevant authorities to a questionable analysis of the effects of Alkali Silica Reaction (ASR) on the Seabrook power plant.

Based on this WP, four questions are asked by C-10 Research and Education Foundation, which are answered below.

1- Is the paper review technically sound ?

The answer is clearly “yes”. Professor Saouma is a respected figure in the international scientific community, and the presentation of his skills and expertise in the WP confirms this (15 years devoted to ASR, 11 major funded projects, 2 books, dozens of rapport and peer-reviewed papers and the chairmanship of an international RILEM committee on the subject). He is also a leader in the field of concrete structure behavior and has served as president of the International Association of Fracture Mechanics for Concrete and Concrete Structures (FramCoS), he has advised the Tokyo Electric Power Company (TEPCO-Japan) and was a key contributor to EPRI’s report “Structural Modeling Of Nuclear Containment Structures”. All of this involves numerous collaborations particularly in Europe and, as mentioned above, Japan.

The subject addressed by the WP is the result of his position as an expert witness with C-10 since 2019, as he indicates “His testimony resulted in the implementation of stronger measures for monitoring the state ASR over 20-year license renewal term” and then he is well positioned to evaluate the adequacy of the work conducted at Seabrook NPP.

2- Does the white paper make valid scientific arguments ?

In my opinion there are two key points in the arguments put forward in the WP :

a/ the fact of relying on results from tests carried out on a type of structure that is not representative of the situation in which a Containment Enclosure Building (CEB) is, when it is subjected to ASR and a seismic type loading. The resulting problem is that the results contradict those obtained elsewhere on shear walls representative of in-plane loading (the situation experienced by the CEB), whereas the beam test carried out by NextEra is representative of out-of-plane loading.

Tables 1 & 2 of the WP are clear on this subject :

Results on RC beam (NextERA) : no reduction of shear capacity in ASR-affected concrete

Results on shear walls (NIST) : the presence of ASR caused a # 20% reduction in the shear strength

It should be noted, however, that while this downward trend is confirmed by tests carried out at the University of Colorado (-22%), it is not confirmed by tests carried out in Japan

(Kajima), which did not find a significant decrease, or by tests carried out at the University of Toronto, which found a slight increase in this resistance. All of this confirms that the conclusion drawn from the NextEra's tests is incorrect and that this point should be further investigated.

That said, it is also the use of NextEra's results that poses problems. In summary, the idea is to consider that after the ASR effect, a new concrete with modified mechanical characteristics is obtained and that it is sufficient to use the ACI 318 formulas to move forward, particularly in estimating ASR expansion, which is a major indicator for predicting the behavior of CEB over time.

To fully understand the subject of concrete damage, its internal microstructure is modified by expansions and microcracks and no longer reacts in the same way to traditional stresses. This is reflected in particular in the tests carried out and presented in Figure 5 by a wide dispersion of results, which has a significant impact on the determination of past expansion (Figure 7). The wide dispersion of results leads us to say that conclusions that do not take this wide dispersion into account will produce erroneous results. As stated in the WP "the relationship between compressive strength and elastic modulus cannot be reliably captured by a single equation" (equation (1) in the WP).

3- Are Dr. Saouma's conclusions supported by scientific evidence?

The answer here is also "yes". The WP is the result of an analysis based on the experience and expertise of a man of culture on the topic of ASR, but also on many others subjects (he is very knowledgeable about finite element structural analysis, and his presentation in the WP on the particularities of membrane action (Appendix B) is that of a man experienced in the theme).

His analysis is based on a rich and solid bibliographic knowledge from institutions recognized for the quality of their work.

Thus, in the conclusions presented on page 10 of the WP, I fully endorse what is said :

a/ on "LSTP erroneous test configuration", especially on the points 1 (on the NextEra's tests), the point 4 (the non-use of the membrane theory) and point 5 (the failure to take into account the biaxial confinement present in the CEB).

b/ on "Relevance of NIST report on shear strength", especially on point 1 related to the shear strength of ASR-concrete, which is a major point.

c/ on "Relevance of NIST tests on past expansion". I totally agree with points 1 (inapplicability of the ACI Code equation relating compressive strength to elastic modulus) and 2 (the NextEra's procedure to estimate past expansion) and I confirm Dr. Saouma's opinion on the fact that the current structural monitoring program is fundamentally flawed and presents a significant safety risk (point 3).

4- Do you see a weak link in Dr. Saouma's argumentation?

Following on from what I said above (Q 1, 2 and 3) I can only answer "no" to this question, and I would add that, in my opinion, the arguments developed in the WP and the conclusions drawn from them lead, in my view, to the need to revisit the studies carried out on the basis of the NextERA trials and to incorporate the results of other experiments more suited to the context in order to move forward with a new analysis.

And above all, it is important to be very vigilant when transferring the observed effects to structural calculations, for which the ASR-related risk analysis must be based on nonlinear finite element calculations, which are the only method capable of accurately determining the consequences of ASR development in this plant. In any case, that is what we would try to do in Europe.

Dr. Jacky Mazars, August 2025

A handwritten signature in black ink, appearing to be 'J. Mazars', with a large loop on the left and a long horizontal stroke extending to the right.

EXHIBIT 4 TO SAOUMA DECLARATION

Sture Peer Review

Peer Review of Technical-Scientific White Papers

Prepared by Professor Emeritus Victor Saouma

Department of Civil, Environmental, and Architectural Engineering
University of Colorado Boulder

By Professor Emeritus Stein Sture
Laboratory for Atmospheric and Space Physics
University of Colorado Boulder

A. Summary of Professor Stein Sture's background and credentials

Prof. Stein Sture's academic background and research contributions over a period of over 50 years are in broad fields of geomechanics, structural mechanics and materials, and computational mechanics. His main contributions in the areas of experimental and analytical mechanics of brittle and ductile solids such as concrete, are described in over 50 peer reviewed papers and over 30 research reports. He has authored and co-authored over 320 peer reviewed publications in all categories and over 80 research reports. With regard to concrete and other brittle, quasi-brittle and ductile and composite materials his research activities has been supported by AFOSR, ARO, DOE, ONR, NASA, etc. He has served on executive, steering, advisory, technical – scientific, etc. committees of ASCE, NATCAM, IUTAM, DOE, USNCTAM, USNCCM, etc. His main work is in constitutive modeling and fracture processes of a broad range of materials and structural systems subjected to low and high levels of stress or loads.

Stein Sture served as Vice Chancellor for Research at the University of Colorado at Boulder, between 2005-2015. He also served as Interim Provost and Executive Vice Chancellor for Academic Affairs also at the University of Colorado at Boulder for several years. He served as Interim Dean (2005–2006) and Dean of the Graduate School between 2007 and 2009. He also holds the position of Huber and Helen Croft Endowed Professor in the Department of Civil, Environmental, and Architectural Engineering in the College of Engineering and Applied Science. He has been a faculty member at CU Boulder since 1980. He also served as Associate Dean for Research in the College of Engineering and Applied Science (2002-2005), chair of the Department of Civil, Environmental, and

Architectural Engineering for nearly six years (1990-1991; 1993-1998). Between 1976 and 1980 he was on the faculty at Virginia Polytechnic Institute and State University. He received his education in public schools in Oslo, Norway, a degree in engineering mechanics at the Schous Institute of Technology, Oslo, and MS, PhD degrees at the University of Colorado, Boulder. His fields of expertise are in the areas of experimental and analytical modeling in solid mechanics, geomechanics, structural mechanics, computational geotechnics, and geotechnical engineering. He has advised and graduated 38 PhD and 47 MS thesis students. He has authored or co-authored 320 peer reviewed publications and 80 research reports. Between 1985 and 1986 he was a visiting professor at the Norwegian University of Science and Technology in Trondheim, and the University of Oxford, United Kingdom, where he is Jenkin Fellow in Engineering Sciences.

Dr. Sture's scholarly contributions are mainly in the areas of constitutive modeling of cementitious composites and geomaterials; nonlinear analysis of soil-structure interaction systems including earthquake-induced soil liquefaction mechanisms; modeling of bifurcation instabilities and localized deformations in single phase as well as fluid saturated porous media; development of explicit and implicit integration techniques for elastic-plastic pressure sensitive materials; large deformation analysis; and, fracture mechanics related to weakly cemented materials. Dr. Sture has presented many plenary or keynote lectures at national and international conferences, and a large number of invited lectures. He has served as a consultant to numerous public and private organizations including Exxon Production Research Co., Shell Oil Development Co., Federal Aviation Administration, Lockheed-Martin Corp., Structural Reliability Technology, Inc., URS, United Nations Development Program, among others.

He has served as editor of three major journals, including editor in chief of ASCE's Journal of Engineering Mechanics, and editor of the International Journal of Numerical and Analytical Methods in Geomechanics (John Wiley & Sons). He has served as organizer and general chair of seven major national and international scientific and engineering conferences. He served as a member of the U.S. National Committee for Theoretical and Applied Mechanics. He is a Distinguished Member of the American Society of Civil Engineers; Fellow of the Engineering Mechanics Institute, and Fellow of the U.S. Association for Computational Mechanics. He served on NASA's Human Exploration and Operations Research Committee, among others.

B. Peer Review of Technical-Scientific White Paper by Professor Emeritus Victor Saouma

The purpose of the White Paper (WP) is to bring attention to shortcomings and potentially inadequate analysis and interpretations of Alkali Silica Reaction (ASR) in all main reinforced and plain concrete structural systems and subsystems at the Seabrook Nuclear Power Plant. The main concern with ASR is substantial reduction in structural integrity mainly in terms of strength and stiffness, which would make Seabrook Power Plant dysfunctional and inoperable. Professor Saouma has addressed very serious concerns. The following sections will address specific questions and topics.

Are the two analyses from Dr. Saouma scientifically sound ? Specific considerations:

- (1) Is the White Paper on the NIST Study relevant to the Seabrook Station, and
- (2) Is the Technical Response to the Nuclear Regulatory Commission (NRC) presentation technically sound ?

1. Is the White Paper on the NIST Study Relevant to the Seabrook Station ?

Yes, the two analyses conducted by Dr. Saouma are definitively relevant to circumstances and conditions at the Seabrook Station. Dr. Saouma is a highly regared researcher, educator and scholar in the USA and international technical-scientific communities working on the safety and integrity of important and sensitive concrete structures subjected to both static and dynamic conditions. Dr. Saouma has devoted decades of his professional career to understanding and mitigating the effects of Alkali Silica Reactions. He has written extensively on this topic in the open journal and conference literature and he has made many professional presentations and lectures at national and international conferences and committee meetings. His many contributions, committee assignments and leadership positions have been described in earlier reports and white papers relevant to this case. As has been stated previously “his testimony resulted in the implementation of stronger measures for monitoring the state (of) ASR over 20-year license renewal term”. Dr. Saouma is definitely an expert regarding assessing the structural concrete work conducted at the Seabrook Nuclear Power Plant.

2. Is the Technical Response to the Nuclear Regulatory Commission (NRC) presentation technically sound ?

Yes, the answer is in the affirmative – Yes. Previous assessments, evaluations and white papers clearly describe or outline without ambiguity Dr. Saouma’s findings.

C. Does Dr. Saouma present valid scientific arguments ?

Previous reports and white paper have clearly described Dr. Saouma's scientific arguments, where he has carefully argued behavior of laboratory shear wall simulations that were not representative of Seabrook Station structures, especially loading conditions and general boundary conditions of the laboratory test structures. As related in previous assessments involving ASR effects. It is quite clear that the presence of ASR has severe detrimental effects on integrity and operation of the structure.

D. Do you identify any weaknesses in his (Dr. Saouma's) reasoning ?

As indicated earlier Dr. Saouma is one of few high-level experts in ASR effects on concrete structures. He is mmethodical, well organized, and principled in his work and assessments. I know of very few engineers and scientists of Dr. Saouma's caliber, overall knowledge, and integrity. His white paper presentations, statements and conclusions are unambiguous, exceptionally clear and well stated, and very well organized. I see no weaknesses in Dr. Saouma's reasoning or conclusions.

Dr. Stein Sture, February 12, 2026.

