NRC Standards Forum II
Session 3: Innovative Approaches to QA

Optimization and Modernization of QA Requirements for Steel and Composite Construction for Nuclear applications

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Background

The dire need for expanded NUCLEAR baseload capacity has spurred the following industry response/concerns:

- *Reactor vendors have proposed new designs and types of SMRs, ARs, and microreactors (MRs).*
- *The nuclear related manufacturing industries are looking for improved ways to ensure timely, cost-efficient, and defect-free delivery of the various power generation related equipment.*
- *In parallel, the construction industry is busy incorporating improved design/construction practices (especially modular SC construction) to increase schedule performance, reduce field labor requirements, and improve cost certainty.*
- *Existing construction related NQA regime is seen as an impediment – there is a need to develop revamped QA requirements that account for the newer construction practices and use of integrated technology such as digital twins.*
- *Recognizing the market size and magnitude of nuclear construction related challenges, both reactor vendors and the steel construction industry have increasingly embraced SC construction. QA program's must be better tailored for modular steel/composite construction to ensure reactor vendors can receive the qualitative and quantitative benefits!*

Background

In response, the following synergistic developments have occurred in the past two years or so:

- *Through the National Reactor Innovation Center (NRIC), Idaho Nation Lab (INL) launched a broad initiative to explore potential opportunities for simplifying the QA requirements – Purdue Applied Research Institute (PARI) was one of the contributors who supported the INL study.*
- *INL's feasibility study focused on the justification of alternative QA regimes for analysis / design, software use, procurement, manufacturing/fabrication, erection, and general construction activities.*
- *PARI identified many steel and concrete construction related NQA requirements that should be revisited in light of the recent design/construction advances.*
- *In parallel, several steel producers, fabricators, erectors, and concrete suppliers worked with the American Institute of Steel Construction (AISC) and PARI to launch a broad QA modernization/optimization program targeted toward structural steel, steel plate composite, and supporting concrete placement.*
- *INL is in the process of initiating a similar effort for concrete structures.*

SCMN Program Mission

The Steel Construction Modernization in Nuclear (SCMN) R&D program seeks to enhance the United States efforts to commercialize the construction of Gen III+ and IV reactors, including Small Modular Reactors (SMRs), Advanced Reactors (ARs), Microreactors (MRs), and licensed Advanced Light Water Reactors (ALWRs), through modernization and/or optimization of QA/QC practices and reduction in costs related to procurement, fabrication, erection, concrete placement, and other construction activities for safety-related steel and composite structures.

The above initiative could also result in a corollary benefit to help simplify the construction of:

(1) Upcoming new nuclear fuel production facilities;

(2) One-of-a-kind DOE/NNSA nuclear weapon production related facilities; and

(3) DOE facilities related to processing and short-term / long-term storage of nuclear waste.

Program's Goals

The mission of this program shall be met with the following goals:

1. *Leveraging the inherent advantages (modularity, performance, light-weight, strength, and ductility, cost, schedule) of structural steel and steel-plate composite (SC) technology; and*

2. *Addressing, resolving, optimizing, and modernizing nuclear quality assurance and control requirements through research, development, training, workforce development, and development of a nationally recognized trade/quality certification program.*

Industry Threats that will be addressed by the Program

Address various factors that drive up construction costs and schedules, such as:

1. Onerous nuclear quality assurance and quality control requirements, including the need for a graded QA approach that matches new safety classifications (i.e., other than safety-related)
2. Poor constructability due to lack of pre-construction engagement of steel fabricators, suppliers, and erectors in the design stage
3. Review/revaluation/rework needed to resolve non-conformances, flaws, or deviations
4. Shortage of nuclear quality qualified suppliers, approved vendors, certified fabricators
5. Lack of trained, qualified, and certified workforce for nuclear design, detailing, fabrication, erection, construction, and inspection activities

The program will optimize acceptable NQA program requirements for steel and composite structures, reduce field rework, and address construction supply chain issues

A Consortium Approach for the Program

Sponsors for this effort will include different sectors of the nuclear construction industry:

1. Steel Mills, Producers, Plate Manufacturers, and Resellers
2. Concrete Mix Suppliers and Concrete Placement Companies
3. Steel Fabricators and Erectors including Large and Small Vendors
4. EPC – Engineering, Procurement, and Constructors (general contractors)
5. Nuclear Reactors Vendors for SMRs, ALWRs, ARs, MRs, etc.
6. Nuclear fuel producers, nuclear waste processing companies
7. DOE's nuclear enterprise (weapons production facilities, demonstration reactors, etc.)
8. DOE, NRC, and DOD – US government regulators and purchasers in some cases

Expected Program Outcomes

1. Nuclear quality requirements that are based on results driven research, provide value, and are easier to implement by US-based firms and trade organizations
2. Addressing construction deviations, non-conformances for nuclear construction through empirical data, which will define ranges for acceptable tolerances thus reducing NCRs
3. Codification of optimized quality requirements and tolerances in codes and standards manuals
4. Certainty in cost and construction schedules through full-scale construction mockups, adhering to quality requirements, and the allowance of certain construction deviations
5. Full engaged national supply chain for nuclear construction including fabricators, erectors, detailers, etc., to bid on jobs
6. Thoughtful up-skilling of the national construction workforce through classroom and virtual training courses, hands-on work on mockups, and industry-backed certification programs for companies and craft personnel

Execution Approach for a ~2.5-Year Project

- *Identify opportunities for optimization of some existing QA measures as well as modernization of others based on new trends in production of materials, fabrication, modular construction, and erection/construction*
- *Develop a non-binary/graded QA approach based on structure's classification and the performance significance of its specific regions, structural elements/connections, constituent materials, etc.*
- *Determine the research approach and perform the necessary research to validate the proposed QA optimization and modernization measures*
- *Assess impact of construction flaws, deviations, non-conformances, and larger tolerances through testing of specimens and benchmarked analyses (recall that the existing design equations are based on perfect or near-perfect specimens)*
- *Develop training materials, conduct mockups, and implement a national construction-focused certification and credential programs (that could be stackable)*
- *Canvass the concerned committees to embrace the proposed measures*
- *Work with industry stakeholders and regulatory agencies to gain acceptance*

Execution Approach for a ~2.5-Year Project

Some Guiding Principles regarding Judicious Use of Construction related QA and QC Measures

- *QA and QC measures are intended to minimize the prospect of errors, both during production and in the field.*
- *QA measures consist of proactive preventative steps that assure right materials, tools, instruments, and crafts will be used to execute the work.*
- *QC measures consist of in-process inspections/observations that verify the quality of the installed work.*
- *From the standpoint of performance assurance, the following observations can be made:*
  - ✓ *QA measures provide assurance that the structure will deliver its required strength, which is critical for ensuring Essentially Elastic response.*
  - ✓ *QC measures are important for ensuring that the as-constructed structure will have the required energy dissipation capacity since workmanship errors can influence its ductility.*

Therefore, QA measures should be the focus for structures designed to remain essentially elastic; and QC measures should be the focus for structures designed to behave inelastically.

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