INL/MIS-23-71318-Revision-0

NRIC ACTI Overview CARD Conference Feb 2023

February 2023

Bradley John Tomer

Changing the World's Energy Future

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

INL/MIS-23-71318-Revision-0

NRIC ACTI Overview CARD Conference Feb 2023

Bradley John Tomer

February 2023

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

National Reactor Innovation Center
Advanced Construction Technology Initiative

Modular Construction Panel

ASME CARD 2023

February 23, 2023

NRIC is a DOE-NE program, launched in FY2020

NRIC
National Reactor Innovation Center

NRIC Accelerates Nuclear Reactor Demonstrations

- Authorized by the Nuclear Energy Innovation Capabilities Act (NEICA)
- Partner with industry to bridge the gap between research and commercial deployment
- Leverage national lab expertise and infrastructure
- Manage demonstrations to success

NRIC INL

Empowering Innovators

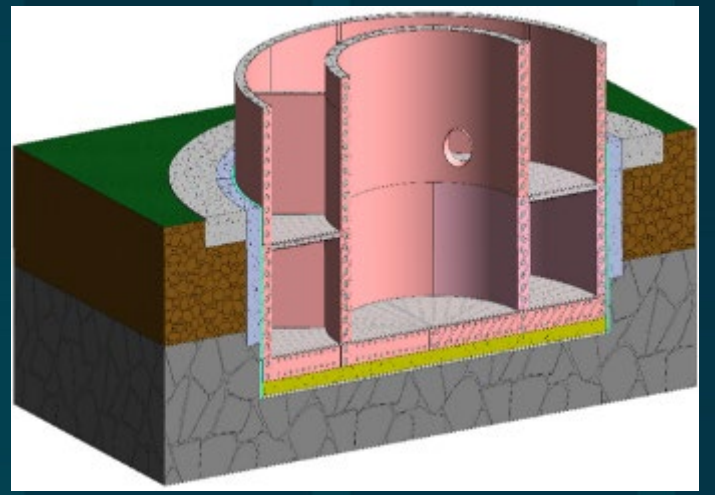
- Demonstration Test Beds
- Experimental Facilities
- Virtual Test Bed
- Cost and Markets

- Planning Tools
  - NRIC Resource Team
  - NEPA guidance
  - Demonstration Resource Network (https://nricmapping.inl.gov/)
  - Siting Tool for Advanced Nuclear Development

NRIC INL

Advanced Construction Technology Initiative (ACTI)

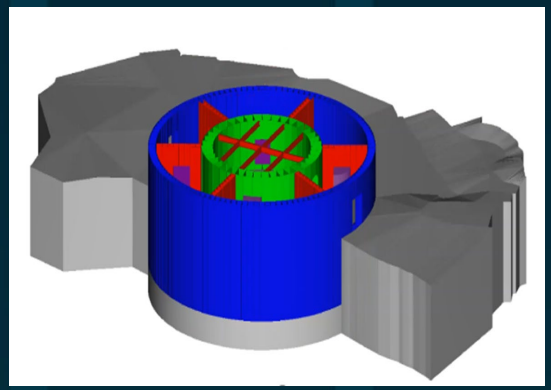
- Purpose -
  - Demonstrate advanced construction technologies/processes that can significantly improve economics and schedule duration of nuclear build projects for SMRs
  - Enable commercial deployment by 2030
    - Partner with industry to learn by doing
    - Collaborate with Nuclear Regulatory Commissions
- General Electric Hitachi Nuclear
  - Technology Areas:
    - Vertical shaft excavation techniques
    - Steel Bricks™- Steel Concrete Composite Modules
    - Advanced monitoring & digital twin technology
  - Two Phase Project:
    - Phase I: Prototype and test Steel Bricks™, optimize design of demonstration
      - Started Jan 2022 with ~ DOE-NE 70% and GEH Team 30% cost share
    - Phase 2: Scaled demo unit construction, testing and decommissioning
      - 2 or 3 years, subject to availability of funds and successful Phase I



NRIC INL

Steel Bricks is a trademark of Modular Walling Systems Holdings Limited (MWS)

ACTI Team Members & Roles



- General Electric Hitachi Nuclear Energy (GEH)
- EPRI – Digital Twin, and NDE techniques
- Nuclear Advanced Manufacturing Research Centre (NAMRC) – Advanced Sensor
- University of North Carolina @ Charlotte (UNCC) – Digital Twin
- Purdue University – Steel-Concrete Composite prototype testing
- Modular Walling Systems Holdings Limited (MWS) – Steel Brick ™
- Caunton Engineering & Aecon – Steel Brick™ Fabricators
- Black & Veatch – Boring Technology, Construction, & Site Selection
- Tennessee Valley Authority (TVA) – Industry Partner
- Ontario Power Generation & Duke Power – SME's
- NRC Rotational Employees

NRIC INL

Vertical Shaft Construction

- Reduce costs associated with excavation,
  - Potential to reduce the amount of excavation and engineered backfill needed by 1 million cubic feet
  - Demonstration project includes:
    - Secant and pile construction
    - Inspections, and testing of safety-related backfill
- Conceptual design for scaled demo structure
  - Diameter of 110 feet
  - Shaft depth 20 feet
  - Height above grade 6 feet
- Sensors will be installed to measure impacts of construction activities to provide empirical data

NRIC INL

Steel Brick™ Concept

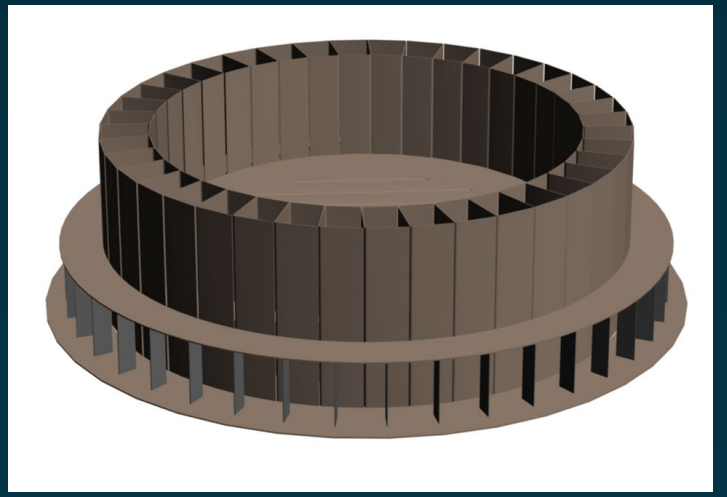
Next generation Steel Concrete Composite modules, for Seismic Category 1 structures installed in a radial configuration

Steel Brick™ Fabricated at Shop

Concurrent wall fab and excavation
Reduced schedule duration

Steel Brick™ Modules
Shipped to site

Reduced onsite work
Improved quality
Less rework

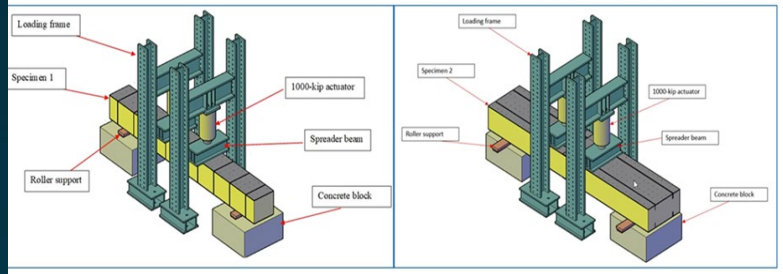


Assembled in field, outside of pit, lowered into pit

NRIC INL

- Steel Brick™ prototypes at Purdue from Caunton Engineering.
- Filled with Concrete and imperfections for Stress Testing and Non-Destructive Examination
- Measure strength of splices/connections - generate data for digital twin and regulator acceptance as containment application

Test Setup and Specimen Drawings



Picture of East Side of Test Setup

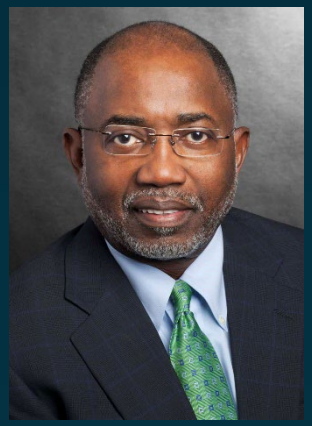
NRIC INL HITACHI

Digital Twin

- State of the art replica of the structure to integrate sensor data, artificial intelligence, machine learning, and data analytics. Cradle to grave monitoring
- EPRI, University of North Carolina Charlotte, Nuclear AMRC
- Organizes all project data by component and by life-stage
  - Each module with its own rich information, models and sensors
    - Flow of information through the modules - Back and Forth
    - Ability to query, investigate, assess conditions of individual Steel Bricks™ in the structure.
  - Semi-automated procedures to update Building Information Modeling & Finite Element Analysis models from field measurements
  - Procedures to stream data from the field for real-time decision-making via wireless transmission of sensor data
  - Long-term monitoring combining structural models with:
    - Earth pressure sensors (lateral stress)
    - LiDAR scans of base, shaft walls and ground surface

NRC Collaboration

- Congress recognized the importance of agency coordination in the Nuclear Energy Innovation Capabilities Act
- DOE/NRC MOU to "coordinate DOE and NRC technical readiness and sharing of technical expertise and knowledge on advanced nuclear reactor technologies and nuclear energy innovation, including reactor concepts demonstrations, through the [NRIC]."
  - NRIC Rotations



Fred Sock
Office of Nuclear Regulatory Research

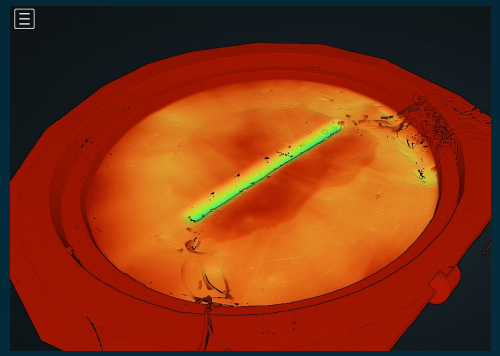
Allen Fetter
Office of Nuclear Reactor Regulation

- Monthly Coordination Calls – DOE/NRC/NRIC

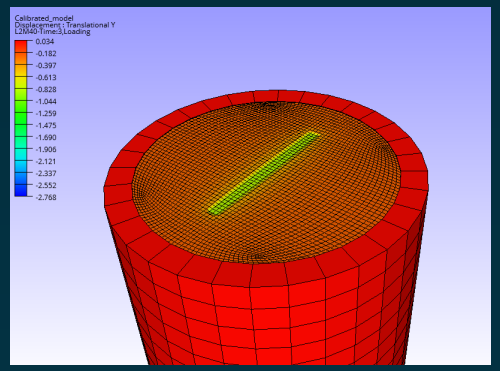
NRIC INL

ACTI Phase 2 Scope

- Select US fabricators of Steel Brick™
- Fabricate Steel Brick™ and sub-assemblies and ship to site for final assembly into modules and rings
- Site mobilization and completion of all required permits
- Excavate vertical shaft
- Install demonstration-scale Steel Brick™ containment and reactor building
- Deploy the sensors and Digital Twin
- Test the structure and collect data
- Perform regulator type of inspections
- Issue reports and lessons learned at various stages of construction and testing



Point Cloud & Sensor Data Update Models for Better Decision-Making in Construction



The successful outcome of NRIC ACT Project is that at the end of Phase 2 the technical readiness level of the demonstrated technology shall be TRL-6 or above

NRIC INL

Benefits of Program

- Bridge the gap between development and commercialization
  - Providing funding to mature technology readiness and reduce risks to participants for first of a kind build
  - Facilitate partnership between technology developers, end users, national labs, universities, regulators, industrial participants
- Learn by doing reduces risks associated with first commercial build
  - Types of materials standardly available in the US vs Europe
  - Optimize design for assembly
  - Establish construction procedures – welding, lifting, NDE, etc.
  - Sequencing of operations
- Builds confidence with regulators, construction entities, and trades
- Develop supply chain

NRIC INL

Thank you!

NRIC INL