Ultra-High-Performance Concrete and Advanced Manufacturing Methods for Modular Construction

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Program: NEET: Advanced Methods for Manufacturing

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ABSTRACT:

The Advanced Methods for Manufacturing Program seeks to conduct research in developing high performance concrete (HPC) products, and their fabrication and manufacturing methods to enhance modular construction techniques. With high strength and dense microstructure, HPC is expected to facilitate rapid construction with thinner and lighter modules, and can withstand harsh environments and mechanical loads. While previous research on HPC has been limited to mixture laboratory development stage, which often requires special high temperature and high pressure treatment as well as unconventional mixing method, our goal is to develop cost-effective ultra-high performance concrete (UHPC) products with 150 MPa (22 ksi) concrete compressive strength without special temperature and pressure treatment, high durability, large-scale process-ability with controlled quality, which can be rapidly fabricated and assembled for modular construction of new nuclear power plants.
To achieve the overarching goal of developing innovative UHPC materials and methods to manufacture components faster and with better quality, in order to improve factory assembly of plant modules, the following objectives are defined.

1) Develop a new class of self-consolidating, ultra-high strength, and durable concrete materials (UHPC) that can be *readily* and *reliably* applied to modular construction. Quality control guidelines will be developed.
2) Experimentally establish a database of UHPC material mechanical properties, and long-term durability properties.
3) Develop a steel plate/UHPC module connected with cross ties, in which the structural integrity is ensured.
4) Understand the UHPC and steel interaction especially bonding and corrosion issues.
5) Examine the module's structural performance by large-scale testing and finite element simulation.

To achieve these objectives, this project pulls together a research team with various expertise in concrete material science, steel-concrete interaction, large-scale structural testing method, concrete durability and degradation, advanced sensing technology, and nuclear power plant construction and operations. The proposed research fits in the workscope of Advanced Method for Manufacturing (NEET-1), with focus on "assembly and material innovation to enhance modular building techniques such as advances in high strength concrete and rebar, and inspection equipment."