NEUP Nuclear Energy University Programs
U.S. Department of Energy

Effect of Gamma Irradiation on the Microstructure and Mechanical Properties of Nano-modified Concrete

PI: Florence Sanchez – Vanderbilt University

Collaborators: David Kosson – Vanderbilt University
NSUF Primary Technical Lead: Kurt Terrani – Oak Ridge National Laboratory

Program: NEET-NSUF-2

ABSTRACT:

Scope and Objectives. Access to the Gamma Irradiation Facility in the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory is sought to perform gamma irradiation of nano-modified concretes (i.e., concretes containing nano-particles) as part of the development of a superior concrete for the long-term storage of used nuclear fuel (UNF). Specifically, access to the test reactor facility will be used to simulate decades of radiation dose to study the effects of gamma irradiation on the microstructure and mechanical properties of concrete containing nano-silica and nano-halloysite. The effort addresses the NE research needs in the development of radiation resistant materials, in particular a superior concrete for use in UNF storage. The project specifically addresses current knowledge gaps of the effect of gamma irradiation on the performance of concrete, and cement-based materials in general, including nano-modified concrete formulations and conventional concrete formulations, in dry state conditions.

Project description. Control and nano-modified concretes will be irradiated in dry state conditions using dose rates of 7×10^6 to 1.6×10^7 rad/hr until a total dose of *ca*. 40 MGy is reached. Gamma irradiation testing will be performed in an inert atmosphere at two different temperatures (35°C ± 5°C and 100°C ± 10°C). Post irradiation exposure, state-of-the-art experimental characterizations across multiple length scales (nano to macro), including solid phase mineralogy, nanoindentation, and traditional mechanical testing will be integrated to elucidate key aspects of the performance of nano-modified and conventional concretes under gamma irradiation influence and the subsequent effect on the material mechanical performance.

Major Deliverables. Deliverables include (i) experimental datasets of the effects of gamma irradiation on the microstructure and mechanical properties for two nano-particle types and mix formulations of nano-modified concretes and conventional concretes; and (ii) nano-particle type and mix formulation that demonstrate maximum synergy for a gamma resistant concrete for dry storage systems.

Outcomes and Impact. The project will advance a key component of nuclear waste storage systems through the understanding of the effect of gamma irradiation on improved concrete materials capable of the conditions needed for safe storage of nuclear waste and will extend the scientific knowledge and understanding of fundamental aspects of gamma irradiation damage in concrete materials in dry state conditions. The outcomes from this project are expected to impact material effectiveness in storage applications over extended periods of time in severe radiation conditions and to advance the state of knowledge and understanding in the field of nuclear waste storage and more generally the performance of cement-based materials in nuclear applications.

Collaborators. The research team brings a unique combination of expertise in multiscale experimental characterization of the performance and durability of advanced cement-based materials and nanotechnology in concrete, performance of cementitious materials in nuclear applications, and radiation damage in materials.