ABSTRACT

Steel-plate Composite with Diaphragm Plate (SC-DP) – an advanced modular construction technology, is now being adopted for use in compact reactors. It is important to assess the performance of critical infrastructures subjected to dynamic loadings. This study investigates the structural response of SC-DP structures subjected to missile impact and in-plane shear (seismic) loading. The research addresses a critical gap in understanding the multi-hazard performance of SC-DP structures, which are increasingly used in protective and safety-related infrastructure such as nuclear facilities and high-security buildings.

A comprehensive experimental program was designed to evaluate the local damage mechanism. Laboratory-scale SC-DP specimens were fabricated and subjected to high-velocity missile impact tests, simulating accidental or deliberate projectile strikes. The experiments made a qualitative and quantitative assessment of failure mechanisms. The results demonstrated the enhanced resistance of SC-DP systems due to the presence of diaphragm plates in conjunction with steel faceplates.

A testing program for in-plane shear loading was designed to evaluate the performance of the SC-DP structure when subjected to lateral loads, as would occur during seismic events. The experimental behavior was characterized by moment-displacement relationships, observed failure mechanisms, and the impact of simultaneous thermal loading.

Numerical simulations using finite element models were developed and validated against experimental results, allowing for a detailed analysis of stress distributions, damage evolution, as well as the local missile impact effects and global in-plane shear effects on the SC-DP structures. The research compared existing design methods to observed SC-DP behavior under extreme loads, establishing safety margins and enhancing understanding of their resilience and failure mechanisms in multi-hazard scenarios. The results offer practical guidance for designing critical infrastructure subjected to impactive and in-plane shear forces.