

ABSTRACT

In safety-related nuclear structures, steel-plate composite (SC) walls are often used in combination with reinforced concrete (RC) walls or foundations. The design demands need to be transferred between the two different structural systems through appropriate connections without connection failure, which is often associated with brittle failure mode. This study presents a design procedure developed for mechanical connections between SC and RC walls. This procedure implements the full-strength connection design approach as per *Specifications for Safety-Related Steel Structures for Nuclear Facilities*, AISC N690-18, which requires connections to be stronger than the weaker of the connected walls. The study also presents the results from experimental and numerical investigations conducted to verify the structural performance of the full-strength SC wall-to-RC wall mechanical connection.

The experimental program involved testing six mechanical connections comprising four full-scale and two scaled specimens. The four specimens subjected to out-of-plane moment (OOPM) and out-of-plane shear (OOPV) represented a unit cell of a typical wall in a nuclear facility. The remaining two specimens subjected to in-plane shear (IPV) were scaled (1:3) to facilitate testing using the existing loading setup. Two specimens were tested for each loading scenario. The two specimens per loading case were differentiated by longitudinal rebar-to-baseplate connection plans: coupler (C) and double nut (DN). The performance, strength, ductility, and failure mode of the proposed mechanical connection were evaluated based on the experimental observations.

The observed governing failure mode of all test specimens was either RC wall flexural yielding or RC wall shear failure. The connection region steel plates (tie plates, wing plates, and baseplates) remained within their elastic range until failure ensuring energy dissipation away from the connection region. Additionally, the wing plates and baseplates strains remained comparatively lower than the tie plate strain values. This was attributed to the contribution of concrete during the force transfer between the two structural elements indicating that the proposed connection design procedure is suitable and conservative for SC wall-to-RC wall mechanical connections.

Three-dimensional (3D) finite element models (FEM) were developed and benchmarked against the experimental data to gain an additional insight into the connection behavior. Parametric

studies were conducted to compensate for the limited experimental database and evaluate the influence of design parameters such as wall thickness and RC wall longitudinal reinforcement layers on the performance of the designed mechanical connection. Numerically predicted results compared favorably with experimental observations. The recommended design procedure is intended to help designers consider mechanically connecting SC-RC walls where non-contact lap splicing is not feasible and in an attempt to utilize the potential for accelerated construction time and enhanced structural performance of SC walls.