ABSTRACT

Sener, Kadir C. Ph.D., Purdue University, May 2014. Out-of-Plane Behavior and Design of Steel-Plate Composite (SC) Walls for Safety-Related Nuclear Facilities. Major Professor: Amit H. Varma.

SC walls consist of exterior steel faceplates that are anchored to the concrete infill in between them using shear connectors (or studs). Additionally, the two steel faceplates are connected to each other using tie bars that are embedded in the concrete infill. The out-of-plane behavior of SC walls was evaluated experimentally by conducting one-way bending tests on beam specimens that were representative of strips taken in the longitudinal and transverse directions of full-scale walls. A total of 19 large-scale SC beam specimens were tested. The parameters considered in the experimental investigations were the wall thickness (or beam depth), longitudinal reinforcement ratio, interfacial shear connector type and spacing, transverse shear reinforcement type and spacing, and the presence or absence of stiffeners (ribs) on the steel faceplates.

The experimental results included the load-displacement behavior, section moment-curvature behavior, steel faceplate strains, and tie bar strains for each of the tested specimens, along with the observed cracking patterns and failure modes. The specimen failure modes were categorized as: (i) shear failure, (ii) flexure failure, or (iii) flexural-shear failure depending on experimental observations and measurements.

Section fiber models and detailed 3D finite element models were developed and analyzed to gain additional insights into the out-of-plane behavior and failure of the tested specimens. The results from the numerical analyses were compared with experimental results and observations mentioned above. The benchmarked models were used to predict the behavior of SC beam specimens tested by other researchers.

The experimental databases of SC beam tests conducted in Japan, S. Korea, China, and the US (as part of this study) were compiled. The databases were separated into out-of-plane: (i) shear, and (ii) flexure databases depending on the specimen failure mode. Specimens with flexural-shear failure mode were included in both databases. The out-of-plane shear database was used to evaluate the shear strength design equations from applicable design codes, and to estimate the applicable strength reduction (ϕ) factor. Similarly, the out-of-plane flexure database was used to evaluate the flexural strength design equations from applicable design codes, and to estimate the applicable strength reduction (ϕ) factor.