EXPERIMENTAL, NUMERICAL, AND ANALYTICAL STUDIES
ON THE SEISMIC RESPONSE OF STEEL-PLATE CONCRETE COMPOSITE
SHEAR WALLS

ABSTRACT

The seismic performance of rectangular steel-plate concrete (SC) composite shear walls is assessed for application to buildings and mission-critical infrastructure. The SC walls considered in this study were composed of two steel faceplates and infill concrete. The steel faceplates were connected together and to the infill concrete using tie rods and headed studs, respectively. The research focused on the in-plane behavior of flexure- and flexure-shear-critical SC walls.

An experimental program was executed in the NEES laboratory at the University at Buffalo and was followed by numerical and analytical studies. In the experimental program, four large-size specimens were tested under displacement-controlled cyclic loading. The design variables considered in the testing program included wall thickness, reinforcement ratio, and slenderness ratio. The aspect ratio (height-to-length) of the four walls was 1.0. Each SC wall was installed on top of a re-usable foundation block. A bolted baseplate to RC foundation connection was used for all four walls. The walls were identified to be flexure- and flexure-shear critical. The progression of damage in the four walls was identical, namely, cracking and crushing of the infill concrete at the toes of the walls, outward buckling and yielding of the steel faceplates near the base of the wall, and tearing of the faceplates at their junctions with the baseplate.

A robust finite element model was developed in LS-DYNA for nonlinear cyclic analysis of the flexure- and flexure-shear-critical SC walls. The DYNA model was validated using the results of the cyclic tests of the four SC walls. The validated and benchmarked models were then used to conduct a parametric study, which investigated the effects of wall aspect ratio, reinforcement ratio, wall thickness, and uniaxial concrete compressive strength on the in-plane response of SC walls.

Simplified analytical models, suitable for preliminary analysis and design of SC walls, were developed, validated, and implemented in MATLAB. Analytical models were proposed for monotonic and cyclic simulations of the in-plane response of flexure- and flexure-shear-critical SC wall piers. The model for cyclic analysis was developed by modifying the Ibarra-Krawinler Pinching (IKP) model. The analytical models were verified using the results of the parametric study and validated using the test data.