

ABSTRACT

Zhang, Kai. Ph.D., Purdue University, May 2014. Compression Behavior and Partial Composite Action of SC Composite Walls in Safety-Related Nuclear Facilities. Major Professor: Amit H. Varma.

Steel-plate reinforced concrete (SC) composite walls typically consist of thick concrete walls with two exterior steel faceplates. The concrete core is sandwiched between the two steel faceplates, and the faceplates are attached to the concrete core using shear connectors, for example, ASTM A108 steel headed shear studs. The shear connectors and the concrete infill enhance the stability of the steel faceplates, and the faceplates serve as permanent formwork for concrete placement. SC composite walls were first introduced in the 1980's in Japan for nuclear power plant (NPP) structures. They are used in the new generation of nuclear power plants (GIII+) and being considered for small modular reactors (SMR) due to their structural efficiency, economy, safety, and construction speed.

Steel faceplates can potentially undergo local buckling at certain locations of NPP structures where compressive forces are significant. The steel faceplates are usually thin (0.25 to 1.50 inches in Customary units, or 6.5 to 38 mm in SI units) to maintain economical and constructional efficiency, the geometric imperfection and locked-in stresses induced during construction make them more vulnerable to local buckling. Accidental thermal loading may also reduce the compressive strength and exacerbate the

local buckling potential of SC composite walls. This dissertation presents the results from experimental and analytical investigations of the compressive behavior of SC composite walls at ambient and elevated temperature. The results are used to establish a compactness limit to prevent local buckling before yielding of the steel faceplates and to develop a design approach for calculating compressive strength of SC composite walls with non-slender and slender steel faceplates at ambient and elevated temperature.

Composite action in SC walls is achieved by the embedment of shear connectors into the concrete core. The strength and stiffness of shear connectors govern the level of composite action. This level of partial composite action can influence the behavior and stiffness of SC composite walls. This dissertation presents analytical investigations of the level of partial composite action and its influence on the flexural stiffness of SC walls. The results are used to propose design criteria for steel headed shear studs, such as their size, spacing, and strength.