STEEL MODULES OF STEEL-PLATE COMPOSITE SLABS WITH DIAPHRAGM PLATES - BEHAVIOR, ANALYSIS, AND DESIGN

ABSTRACT

Steel-plate composite (SC) structures have gained widespread adoption in the safety-related nuclear structures and are being actively considered for integration into small modular reactors (SMRs) and advanced reactors (ARs) due to their enhanced structural efficiency, safety, and expedited construction timelines. SC structures allow for parallel construction, with steel modules fabricated off-site simultaneously with on-site erection, thereby reducing overall construction duration. These steel modules, comprising of steel faceplates, shear studs, and tie bars, function as stay-in-place formwork during concrete placement, further minimizing construction time. Extensive research has been conducted over the past two decades on the structural behavior, analysis, and design of SC structures. However, research on the behavior and design of empty SC modules before and during concrete casting has been limited. For empty SC slab modules, which are similar to SC walls but oriented horizontally, no prior research has been performed. Additionally, there is a need to study the behavior of empty SC slab modules with diaphragm plates (SC-DP), which are potential alternatives to typical SC slab modules.

This research presents the results of numerical and analytical investigations conducted to: (1) evaluate the behavior of steel modules of SC slabs, (2) evaluate the influence of diaphragm plates on the behavior of steel modules of SC-DP slabs, and (3) assess the feasibility of unshored construction in SC slab modules. Mechanics-based model (MBM) equations were developed to predict the effective shear stiffness and midspan deflections in the steel modules of SC slabs and SC-DP slabs. The results indicate that tie bars in typical SC slab modules undergo significant shear deformations due to Vierendeel truss action, leading to unfavorable midspan deflections. The use of diaphragm plates in place of tie bars resulted in significantly higher stiffness and reduced deflections, making SC-DP slabs a feasible option for constructing larger unsupported spans. The research concludes by providing design equations and design recommendations for the steel modules of SC slabs, and SC-DP slabs.