Abstract: In the field of fire safety engineering, there is a growing interest in understanding structural resistance under natural fire conditions, in which the fire is non-stationary and burns non-uniformly. One approach that shows much promise is the coupling of a computational fluid dynamics (CFD) simulation to a structural model. Although computationally demanding, CFD codes are well-established for fire safety applications and can accurately represent the characteristics of spreading fires. Modeling structural performance under these conditions may lead to an improved understanding of the fire resistance of buildings with large open floor plans, in which flashover conditions are highly improbable.

The coupling of a CFD code to a structural code, however, presents a number of challenges related to the transfer of data between the fire, heat transfer, and structural models, primarily due to disparities in spatial and temporal scales in the models. A framework for overcoming these differences in scale is proposed. In particular, data from a high-resolution fire simulation is transferred to a low-resolution heat transfer model using newly formulated subcycling and data homogenization algorithms. The heat transfer analysis is conducted using a new class of “macro” heat transfer elements that efficiently model the 3D heat transfer to the structure. The macro heat transfer elements are purposely formulated to be compatible with beam and shell elements that are currently used in the mechanical analysis of structures in fire. Verification studies indicate that the proposed simulation framework allows the structural resistance to be predicted at a modest computational cost in relation to the fire simulation.

Biosketch: Ann Jeffers is an Assistant Professor in the Department of Civil and Environmental Engineering at the University of Michigan. She earned her B.S. in Civil Engineering from the University of Pittsburgh in 2004 and her M.S. and Ph.D. in Civil Engineering from Virginia Tech in 2005 and 2009, respectively. Her research lies at the intersections between the fire sciences and structural engineering disciplines, and specifically seeks to establish novel computational methods that bridge the domains of fire science, heat transfer, and structural mechanics. She was named one of ASCE’s New Faces of Civil Engineering in 2012, and she received an NSF CAREER award in 2013 to characterize the influence of traveling fires on the fire resistance of steel-framed buildings. She currently serves on the ASCE Fire Protection Committee and the SFPE Standards Making Committee on the Predicting the Thermal Performance of Fire Resistive Assemblies, and she led a task group within SFPE to develop a suite of heat transfer verification cases for fire safety applications that will appear in the forthcoming standard.