Special Issue: Commemorating 10 Years of Research since 9/11

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This special issue of the *Journal of Structural Engineering* commemorates 10 years since the attacks of September 11, 2001, by focusing on research that was motivated by the impacts of events of that day. Primarily, in response to the collapse of the World Trade Center towers, the damage and collapse of neighboring structures and the damage to the Pentagon, national organizations and structural engineers have performed substantial amounts research in the area of progressive collapse with an emphasis on the response of structures to extreme loads. The ultimate objective of this research is to provide the means to design more robust and redundant structures that can resist progressive collapse under extreme loads, such as blast, impact, and fire, by considering both member and system response to extreme events and increasing the database of experimental results. This special issue focuses on some recent research in these areas. The papers and their list of references combined are a rich source of information and a state-of-the-art representation of structural engineering for extreme loads.

The first seven papers in this issue focus on the topic of resiliency and robustness. Although the Department of Defense (DoD) has been focused on collapse prevention since before 9/11, they have done significant research since that event. The first paper, by Stevens et al., highlights the work that lead to development of the Unified Facilities Criteria (UFC) 4-023-03, Design of Buildings to Resist Progressive Collapse.

Both experimental and analytical investigations of progressive collapse are considered in the next three papers. Sadek et al. focus on steel and concrete moment frames with a focus on beam column subassemblages in the event of a column removal. Sasani et al. present results of an experimental and analytical investigation of an 11-story concrete structure with initial damage. Williams and Williamson look experimentally and analytically at the topic of concrete bridges subjected to blast.

The next three papers look more at the analytical and probabilistic side of progressive collapse. El-Tawil investigates the impact of modeling decisions on the analytical response of a 10-story steel structure and highlights the importance of the floor system in the analysis. Xu and Ellingwood look specifically at whether pre-Northridge steel moment frames meet UFC requirements for structural integrity using probabilistic modeling of the connections. Kanno and Ben-Haim consider structural redundancy and its effects on robustness of the structure by considering concepts of strong and weak redundancy.

The events of 9/11 pointed to large knowledge gaps in the response of structures to fire; and since then, the number of researchers and publications in this field have grown. One example is a paper by Braxtan and Pessiki, who developed the first set of experiments that examine the structural effects of removed fire protection in a fire following an earthquake. In addition to describing the experiments, finite-element analyses show how spray fire protection damage on the steel beams adjacent to the steel column causes an increase in temperatures in the column.

Columns are integral to stability in a building; and in the case of fire, the columns can develop unanticipated moments and thus respond as beam-columns, which are subject to both axial loads and moments. Varma et al. tested several steel wide-flange columns under combined axial load and moment conditions to determine their fundamental moment-curvature responses at elevated temperatures and different axial load levels. Other steel wide-flange columns were tested to determine their inelastic buckling behavior and axial load-displacement responses at elevated temperatures.

Columns on a building perimeter respond as beam-columns in a fire because of the thermal gradient that induces moment in the rotationally restrained column. Quiel et al. present a two-pronged procedure to predict the behavior of the perimeter column, considering both the individual member response (including thermal gradients) and the global response (including the interactions of adjacent members). This closed-form procedure predicts the perimeter column response (demand) and capacity.

Steel beams acting compositely with concrete slabs contribute significantly to the load-carrying capability of floor systems under fire. But how much does the slab contribute to the load-carrying capacity, what are the failure mechanisms, and under what conditions is the slab most beneficial? To begin to address some of these questions, Varma et al. experimentally investigated the structural behavior of thin composite floor systems subjected to combined gravity loads and fire loading. They studied parameters such as shear connection types, fire scenarios, and fire protection scenarios to evaluate the effects of each on fire performance.

The companion papers by Cashell et al. study the ultimate behavior of lightly reinforced concrete floor slabs under extreme loading conditions. Particular emphasis is given to examining the failure conditions of idealized composite slabs which become lightly reinforced in a fire situation because of the early loss of the steel deck. The first paper focuses on experiments that were conducted at ambient temperature and represent an essential step toward quantifying the behavior under elevated temperature conditions. The second paper describes numerical simulation of the tests and suitable analytical models for predicting various failure conditions in slabs, including the condition of elevated temperature.

This special issue is a joint effort of the Fire Protection and Structural Members Committees of the Structural Engineering Institute (SEI) Technical Activities Division. These two committees; and the Committees on Blast, Progressive Collapse, Composite Construction and Connections; were instrumental in developing the pool of authors and reviewers for this issue. We are most thankful to the reviewers, who under tight time constraints, made careful evaluations of the submitted manuscripts and provided valuable feedback. We would also like to thank Dr. Sherif El-Tawil, chief editor, for his support and efforts, as well as the ASCE production offices for their extra attention to this issue as we approached deadlines.