Special Issue on Computational Simulation in Structural Engineering

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Over the past two decades, considerable progress has been made in developing computational tools to simulate the response of structural systems to various loading conditions arising from natural and/or artificial hazards. In many cases, the potential hazards that an existing structural system will face are more numerous than those considered in its initial design, particularly for older structures. For example, resistance to tsunami loads is now a consideration for many coastal bridges, whereas blast resistance has become essential for protecting buildings located in urban areas or at critical government facilities. Assessing structural capacity for these hazards carries significant computational challenges, in addition to the challenges that arise from the constantly evolving and uncertain hazards for which existing structural systems were designed.

This special issue of the *Journal* contains 22 technical papers and one forum paper that reflect original research and technological advancements in simulating structural response to a wide variety of hazards using a wide variety of techniques. The technical papers fall in to five broad categories, as follows: (1) collapse simulation, (2) simulation techniques, (3) earthquake resistance, (4) uncertainty modeling, and (5) multiphysics simulation; however, it will be clear when reading the special issue that significant overlaps exist among myriad subsets of the papers described briefly herein.

Five papers address the simulation of structural collapse, as follows: (1) Li and El-Tawil investigate the robustness of a seismically designed steel moment-resisting frame buildings using three-dimensional (3D) nonlinear models, (2) Karamanci and Lignos investigate modeling issues relevant to collapse capacity assessment of special concentrically braced frames (SCBFs) in seismically active regions, (3) Björnsson and Krishnan compare competing simulation methodologies for the benchmark problem of a water tank that collapses under strong seismic excitation, (4) Main outlines procedures for computational assessment of structural robustness and applies these procedures to 3D models of prototypical midrise moment-resisting frame buildings, and (5) Burton and Deierlein develop computational models suited to simulating the seismic collapse of nonductile reinforced concrete frame buildings with infill walls.

Four papers tackle a wide variety of techniques in computational simulation, as follows: (1) Shahidi and Pakzad propose a procedure to fit proper response surface models that replace the finite element (FE) model in model updating applications, (2) Cho and Porter present a platform for nonlinear analysis of real-scale RC structures that requires only a few material properties and no problem-dependent parameters or calibrations, (3) Terzic and Stojadinovic evaluate the postearthquake functionality of a typical California highway overpass using hybrid simulation, and (4) Whyte and Stojadinovic also use hybrid simulation to examine the impact of loading sequence on the behavior of thick squat RC walls designed for radiation shielding and blast and fire resistance.

Four papers highlight applications of computational simulation for earthquake resistant systems, as follows: (1) Chen et al. investigate the feasibility of using a portal frame as a substitute for shear walls in multistory light wood frame buildings, (2) Lucchini et al. propose a robust design method for tuned mass damper building systems that considers uncertainties of both the building properties and the input seismic excitation, (3) Vemuru et al. develop a nonlinear model that is capable of simulating accurately the dynamic response of elastomeric bearings at all displacement ranges, particularly beyond the stability limit, and (4) Dao and Ryan use computational simulation of a full-scale base-isolated steel moment-resisting frame building to show that a well-calibrated superstructure model is not required in order to predict the displacement of the isolation system.

Four papers investigate reliability, optimization, and the modeling of uncertainty, as follows: (1) Hoffman and Richards identify several obstacles to obtaining true optimal solutions with genetic algorithms (GAs) when using nonlinear time history analysis of tall buildings and then discuss three modifications that improve the efficiency and reliability of the GA, (2) Ribeiro et al. evaluate structural robustness under cascading main shock-after shock events by comparing the reliability index under the cascading events to the index obtained for only the main shock, (3) Vamvatsikos combines previously disparate techniques in order to develop an improved algorithm for seismic performance uncertainty estimation via incremental dynamic analysis (IDA) and progressive accelerogram-wise Latin hypercube sampling, and (4) in the final paper of this group, Pillai et al. develop a framework for time-variant reliability analysis of posttensioned, segmental concrete bridges subjected to corrosion.

Five papers focus on multiphysics simulations of structural systems, as follows: (1) Fragiacomo et al. model the long-term behavior of wood-concrete composite beams in order to capture their time-dependent behavior due to naturally changing ambient environmental conditions, (2) Chen et al. develop a simplified thermomechanical coupling model that is able to predict the time-dependent lateral deflection of cold-formed steel wall systems subjected to fire, (3) Bewick and Williamson present computational models for steel stud wall systems that account for experimentally observed failure modes under blast loading, (4) Macorini and Izzuddin propose an advanced mesoscale partitioned modeling strategy for simulating the response of unreinforced masonry walls to blast loading, and (5) Yim et al. present an integrated multiscale, multiphysics methodology for source-to-site simulation of tsunami generation, wave propagation, and coastal runup to subsequent coupled structural response to fluid impact loads.

In the one forum paper, El-Tawil et al. summarize current trends and future research needs in computational simulation of gravity-induced progressive collapse of steel frame buildings.

The aforementioned 23 papers meet the goals of informing and advancing computational simulation techniques in structural engineering that will lead to new avenues of investigation and future research.

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