Defense Announcement

Computational Modeling of Delayed Progressive Collapse of Reinforced Concrete Building Structure

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There has been ever-increasing interest over the past couple of decades in improving our understanding of the mechanisms responsible for the progressive collapse of structures. Existing design recommendations and analyses are largely limited to instantaneous (time-independent) collapse. However, recent experiments revealed that reinforced concrete (RC) structures may be susceptible to *delayed* collapse, thus prompting the consideration of time-dependent material behavior as part of progressive collapse analysis and design. A reduced order computational model for delayed collapse behavior of RC structures is introduced in this work, in which the potential damage zones that evolve within the structure are treated as cohesive elements. The constitutive model of the cohesive element accounts for viscoelastic deformation and time-dependent damage accumulation of the concrete, along with hardening plasticity and time-dependent slippage of the steel reinforcement. The remaining part of the structure is treated as a viscoelastic continuum. The model is first applied to simulate the pushdown experiment on a RC frame subassemblage under displacement-controlled loading. The deformation and failure mechanisms are in good agreement with experimental observations. The model is then used to investigate the behavior of the subassemblage in a ``static fatigue scenario" in which the load is monotonically increased to a prescribed level and is then held constant until ultimate structural failure results from the assumed time-dependent responses of the concrete material and concrete-rebar interface. The corresponding timescale of the delayed failure is on the order of hours, a result which has important implications not only for the analysis and design of RC structures against progressive collapse, but also for the safety of first responders who enter structures that may collapse within that period of time.