Control of Seismic Response of Structures using Protective Devices

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Abstract

Control of structures can be done by adding suitable control devices such as actively controlled actuators, strengthening and stiffening elements, and/or adding passive damping devices. The control demands often require reducing however the induced forces in structures and eliminating essential structural elements and masses that contribute to generating inertial forces during earthquakes. Recently the speaker and his colleagues developed design and implementation concepts which weaken the structural system reducing the induced forces at the expense of increased deformations, while correcting and controlling such increases with supplemental damping. This results in an improved behavior, in particular when applied to existing structures, as well as introduced in the new construction. The concept and implementation was studied by the author's team theoretically using control methods and experimentally using structural models with weakening, or softening, devices and simulated earthquakes. The implementation of such concept requires particular attention and balance of safety and stability. The presentation will introduce the concept, the development of weakening components (such as rocking columns), the innovation of true negative stiffness devices and the development of design procedures using active control theories. While the active control theory requires active means of implementation, the control requirements are realized by-en-large using passive systems (such as dampers, or braces) and only adjusted by active means in special applications. For this design approach, the presentation will initiate the audience to the optimal control theories and their applications.

Andrei M. Reinhorn *is a retired professor (emeritus) at University at Buffalo and was involved in education, research and consulting in structural dynamics with applications to earthquake engineering, wind effects and extreme loads engineering. He is a graduate of the Technion – Israel Institute of Technology (BS 1968, PhD 1978) followed by an academic career at University at Buffalo - State University of New York - for over thirty years. Prof Reinhorn conducted research in evaluation and design of building structures experiencing inelastic deformations near collapse. He also developed modeling and solution techniques for structural control and base-isolated structures. Computational platforms 3D-BASIS and IDARC developed by him and his coworkers are widely used by academics and design professionals around the world. He pioneered experimental structural control that brought the experimentation from small scale laboratory implementations to the full scale real-life realization of controlled structures using active tendon systems in Japan. He was one of the pioneers in defining the disaster resilience of communities and its quantification, using basic principles of process control. Most recently he developed new approaches to analysis of structures using State Space Approach (SSA) and Mixed Lagrangian Formulation (MLF). He developed integrated computing and experimentation methods, which are in the forefront of hybrid simulation techniques. As one of its designers and founders, he directed one of the largest laboratories in the US for structural engineering and earthquake simulations (SEESL) located at University at Buffalo.*

Professor Reinhorn was awarded the 2011 ASCE-Nathan M. Newmark Medal. He has received numerous other awards including 2007 SUNY Chancellor's Award for Excellence in Scholarship and Creative Activity, 2006 UB – University at Buffalo "Exceptional Scholar" Sustained Achievement Award, 2005 ASCE/CERF Charles Pankow Award for Innovation, and 1998 AGC-Build San Diego Award., for work related to applications of structural control. More information can be found at [*http://civivl.eng.buffalo. edu/~reinhorn/*](http://civivl.eng.buffalo.edu/~reinhorn/)