

# T.T. SOONG STUDENT LECTURE SERIES

The "T. T. Soong Student Lecture Series" recognizes Prof. Soong's outstanding research accomplishments and contributions to the field of structural and earthquake engineering over the course of his 48-year career at the University at Buffalo.

## Control of Inelastic Structures by Weakening and Damping

### Abstract

Control of structures can be achieved by adding suitable control devices such as actively controlled actuators, strengthening and stiffening elements, and/or adding passive damping devices. However, the control demands often require reducing the induced forces in structures, and eliminating essential structural elements and masses that contribute to generating inertial forces during earthquakes. Recently, Reinhorn and his colleagues developed design and implementation concepts that weaken the structural system and reduce 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 when introduced into 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 a concept requires particular attention to 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, the theoretical and experimental verification of the concept using simulated earthquakes in the laboratory, and the development of design procedures using active control theories.



### Andrei M. Reinhorn, Ph.D., PE

**Professor Emeritus, University at Buffalo, State University of New York**

Andrei M. Reinhorn is a professor emeritus at the University at Buffalo (UB) who 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 UB spanning over thirty years. Professor 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 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 the 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, The Structural Engineering and Earthquake Simulation Laboratory (SEESL) at UB.

Professor Reinhorn was awarded the 2011 ASCE Nathan M. Newmark Medal. He has received numerous other awards, including the 2007 SUNY Chancellor's Award for Excellence in Scholarship and Creative Activity, 2006 UB "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://civil.eng.buffalo.edu/~reinhorn/>

**Date: Friday, April 5, 2013 Time: 12:00 PM – 2:00 PM**

**Location: 140 Ketter Hall, North Campus, University at Buffalo**

**Webcast: <http://civil.eng.buffalo.edu/webcast>**

**Technical Questions: [seeslwebcast@gmail.com](mailto:seeslwebcast@gmail.com) Refreshments will be served!**



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