UNIVERSITY OF MACAU
FACULTY OF SCIENCE AND TECHNOLOGY
DEPARTMENT of CIVIL & ENVIRONMENTAL ENGINEERING

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"Nonlinear Modal Analysis and Superposition of Structural Responses for Seismic Applications"

by

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Abstract

Buildings constructed in the seismic regions are vulnerable to earthquake activities and are required to be designed such that its seismic capacity must exceed the corresponding seismic demand with sufficient ductility. While design codes and standards have been developed to establish the seismic capacity in design, estimating the seismic demand in nonlinear structures has always been a challenging task mainly because of the lack of scientific measurement tools. Nonlinear dynamic analysis is believed to be the most accurate method of computing the seismic demand, but it requires earthquake time histories that are uncertain and difficult to predict. At the same time, using only one earthquake time history in the analysis typically does not give a good representation of the broad spectrum of frequency contents due to uncertainties in earthquake ground motions. In

order to predict the seismic demand accurately, nonlinear dynamic analysis always requires a large number of earthquake time histories in the computation, resulting in a huge computational effort and making the analysis impractical in the design process. Therefore, a fast analysis method with high accuracy to predict the maximum seismic demand is needed.

In this presentation, a brief introduction to the National Earthquake Hazards Reduction Program will first be given. Then a fast analysis algorithm based on modal superposition of nonlinear response is proposed. Because linear modal superposition has found great acceptances in performance-based seismic engineering, it is here extended to the nonlinear domain by using the force analogy method, where the change in stiffness after yielding is replaced by a change in displacement. Geometric nonlinearity will be incorporated in the analysis using nonlinear stability functions. State space method is used to explicitly calculate the dynamic responses of each modal single-degree-of-freedom system. Through the combination of the force analogy method, stability functions, state space method, and modal superposition, both nonlinear response history analysis (NRHA) and nonlinear response spectra analysis (NRSA) are performed and results will be presented to contain both accuracy and efficiency.

Biography

Dr. Kevin Wong is a Research Structural Engineer at the National Institute of Standards and Technology (NIST), a part of the Department of Commerce and the Federal Government in the United States. His research interests include earthquake engineering and structural dynamics, nonlinear analysis, stability, structural control, and energy dissipation. His job at NIST is to conduct research for the National Earthquake Hazards Reduction Program (also known as NEHRP) in advancing the measurement science technology in performance-based seismic engineering. Prior to joining NIST, he was an Assistant Professor at the University of Utah for 4 years and at the Nanyang Technological University in Singapore for 6 years. He has published over 30 journal papers, over 30 conference papers, and 1 book titled "Structural Dynamics for Structural Engineers". He received his master and Ph.D. degrees from the University of California, Los Angeles (UCLA).

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