Shock and Vibration 14 (2007) 469–470
IOS Press

Book Review

Izuru Takewaki, *Critical Excitation Methods in Earthquake Engineering,* Elsevier BV, Oxford and Amsterdam, ISBN 13: 978-0-08-045309-5 and 10: 0-08-045309-0, 2006 (296 pp.)

What could go wrong with the structure that is dynamically excited? To answer this inquiry it is most instructive to know its maximum response within the class of excitations. The excitation that produces the maximum response is called a critical excitation and came into being some 40 years ago.

Critical excitation methods in earthquake engineering have its origin in the works by Drenick (2nd Joint United States-Japan Seminar on Applied Stochastics, Washington, D.C., 1968) and Shinozuka (J. Engng. Mech. Div. ASCE 1970). While these works are formulated in a simple mathematical form and contain a fairly large safety margin to recorded ground motions, their influence on the later development of seismic critical excitation methods are extremely extensive and noticeable.

This important monograph begins with a concise explanation of these pioneering works by Drenick and Shinozuka to provide readers with the fundamental concepts and significance of critical excitation problems. This reviewer had an opportunity to hear Professor Drenick deliver his exciting lecture in 1976, in Southampton, England. I made a note on the conference Flyer: “A very important method for highly responsible structures”. Subsequently, a special chapter was incorporated into the book on convex modeling of uncertainty that this reviewer co-authored with Professor Ben-Haim.

Professor Takewaki ought be congratulated that he took upon himself to further extend the Drenick-Shinozuka methodology. In Chapter 1 of this monograph, the subsequent development of the critical excitation methods in earthquake engineering is explained in detail. In Chapter 2, a new probabilistic approach for SDOF and MDOF models is described in terms of a probabilistic input model and an objective function as a stochastic response. Chapter 3 deals with the extension of the method in Chapter 2 to non-proportionally damped structural models by using the state-space approach. In Chapter 4, an acceleration response at the top of a building is treated as the objective function of a new class of critical excitation methods.

One of the most difficult problems in the field of critical excitation may be the problem in which elastic-plastic behaviors are included. A parametric approach to this difficult problem is explained in Chapter 5 with the help of the stochastic equivalent linearization technique.

While the envelope function of the input motion has been specified up to Chapter 5, the critical envelope function of the input motion is searched in Chapter 6. A mathematical programming technique is used to solve the problem numerically. In Chapter 7, a more complicated problem is tackled for finding a robust design under the structure-dependent critical excitation. While the member stiffness of the structure has been specified in the previous chapters, the member stiffness itself is found in the problem in Chapter 7 for safer and more efficient design. This design problem is highly nonlinear and its solution needs elaborate treatment.

Chapters 8–11 include the earthquake input energy as the objective function of the critical excitation methods. In Chapter 8, a velocity power (time integration of squared ground motion velocity) in addition to an acceleration power (time integration of squared ground motion acceleration) is treated as a new constraint on the input motion. The author makes it clear that most of recorded ground motions are bounded appropriately by two bounding curves derived from the two constraints on acceleration and velocity powers. It is shown subsequently that the approach by the earthquake input energy is suitable for expressing complicated phenomena of soil-structure interaction problems.

The author concludes in Chapter 12 that the earthquake energy input rate can be a suitable measure of global stiffness of a structure and a new critical excitation method can be developed in the critical excitation problem including the earthquake energy input rate as the objective function.

Throughout the book, a unified technique is used and explained that the critical excitation problem dealing with time-dependent quantities can be solved by the interchange of the order of the double maximization procedures with respect to time and frequency. This concept is simple and epoch-making for extremely sensitive structures like nuclear reactors, hospitals, government facilities, embassies, super high-rise buildings, and the like.

This monograph is concise and thought-provoking. Many useful references are collected together with cutting-edge advancement in the text itself. This monograph will be proved to be the most valuable resource for researchers and structural engineers working in uncertain structural design environments under earthquakes in particular, and in natural disasters in general, as well as man-made disasters.

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