Seismic Vulnerability of Structures
Philippe Guéguen, Editor
Wiley, Hoboken, NJ (2013),
344 pp., hardbound, 149.95 USD,
ISBN 978-1-84821-524-5

An eleven page well written and interesting introduction begins this seven-chapter book, each chapter written by a different author. Included in this illustrated book is an index and bibliographies at the end of each chapter.

Seismic Vulnerability of Structures, in general, deals with assessment methods for individual structures (mostly buildings) in urban areas. (Older buildings, the majority of buildings in our established cities, have not been designed for earthquake effects and, in fact, there is probably no documentation carefully describing their design or construction.) This book is concerned with improving the evaluation of risk of seismic activity.

The issue of seismic vulnerability is essentially important because of the density of our cities and the structural shape and large size of the many structures that make up any city. Had the populations been spread out over the countryside, the destructive effect of earthquakes would be much less than now. Of course, with the approximately 50,000 earthquakes per year that occur, very few result in significant destruction and deaths because of locations and severity of the resulting ground motion often is in remote areas. There is a fundamental problem that makes estimation of seismic vulnerability difficult: the prediction of when and where and what magnitude of any earthquake is just about impossible now although, when it does occur, locations affected can often be determined, although usually with too short a warning to the populations.

Chapter 1 is on seismic vulnerability of existing buildings: empirical methods, based on probabilistic or deterministic approaches that are developed from historical data. Inherent in structural response is the nonlinearity—both in the form of possible large displacements and non-viscous friction (joints, skins, facades) of multi-degree-of-freedom structures. Included in the chapter is treatment of masonry and reinforced concrete buildings.

Chapter 2 deals with mechanical methods including fragility curves. The authors discuss "pushover analysis" where a building is subject to lateral forces, monotonically increasing, until a predefined displacement occurs. This is an incremental, essentially non-linear analysis. The chapter discusses how to develop this "push-over" curve. The chapter also includes a good explanation of fragility curves.

Chapter 3 discusses seismic vulnerability in Greece. The author includes analysis of existing unreinforced masonry and reinforced concrete buildings almost as a case history approach including the development of fragility curves.

Chapter 4 concerns experimental methods. This includes in-situ recording and eventual analysis of structural vibration and perhaps the most valuable chapter for readers of this journal. Then based on experimental data, existing buildings are modeled. Included is a discussion when the linear elastic limit of structures is reached and the yield strength is exceeded and the system becomes non-linear (at least in that aspect.)

Chapter 5 treats numerical modeling: if the building is modeled as a collection of bars (beams and columns), plates, and shells. Some of those bars may be non-linear elements (like concrete which only works in compression) and the numerical model is quite complex and non-linear. Also, the element's properties may, at best, be estimated which makes analysis much more subject to uncertainty.

Chapter 6 considers risk analysis used in Switzerland: useful for a review of one country's approach, a country not subject to large scale earthquakes. The author gives an example of a seven story "bar shaped" building (like the UN building in New York), modeled as a column with seven masses, a 7-DOF system. The effects of simplifications of this structure are discussed. This chapter is most useful to get an indication of an approach to evaluate vulnerability.

Chapter 7 talks about preliminary evaluation of vulnerability of existing bridges; at first glance, bridges are simple structures: a series of beams in tension or compression and perhaps plates but of course there are curved bridges, and bridges on foundations that could move in any direction. The seismic event can cause the bridge to unseat, to rupture its columns, to move or compress the abutment, and to liquefy the foundation. This chapter discusses all of these and presents vulnerability criteria for different bridge designs.

The book is highly technical and chock full of equations, not to be used alone, but to be used together with the text in the accompanying references. Lots of acronyms make reading slightly difficult, but all chapters are well written and self-contained. Most readers of this Journal will not come up against strong seismic vibrations in their work but if one wants to gain an understanding of the current science, and difficulty of evaluating the vulnerability of structures to earthquakes, this is an excellent read. I recommend this book for that reason.

Richard J. Peppin
Engineers for Change, Inc.
PeppinR@ASME.org