# Preface

Engineers are always interested in the worst-case scenario. The seismic design of buildings should ensure structural safety against the worst possible future earthquakes. The features of this monograph are:

(1) Consideration of elastic–plastic behavior of building structures in the critical excitation method for improved building-earthquake resilience,
(2) Consideration of uncertainties of structural parameters in structural control and base-isolation for improved building-earthquake resilience, and
(3) New insights into structural design of super high-rise buildings under long-period ground motions (case study on tall buildings in mega cities in Japan during the 2011 off the Pacific coast of Tohoku earthquake on March 11).

This book consists of two parts. The first part deals with the characterization and modeling of worst or critical ground motions on inelastic structures. The second part of the book focuses on investigating the worst-case scenario for passively controlled and base-isolated buildings.

Chapter 1 provides an overview of the effects of historic and recent strong earthquake ground motions on building structures and associated life loss.

Chapter 2 provides comprehensive information about the most recent and devastating Tohoku earthquake of moment magnitude 9.0 which hit off the pacific coast of eastern Japan on 11 March 2011. This earthquake and the tsunami following it left severe damage to building structures and caused nearly 20,000 of losses of life.

As is well known, the robust design of buildings for future earthquake loads requires reliable understanding of the ground motion characteristics. Accordingly, Chaps. 3 and 4 report on the characteristics of near-field (near-fault) ground motions with pulse-like acceleration. Furthermore, these two chapters provide simple mathematical models for this class of ground motions and associated structural response. Chapter 3 deals with the simulation of near-field ground motions with pulse-like acceleration while a critical excitation of multiple sequences for inelastic responses is discussed in Chap. 4.

Chapters 5–7 deal with the characterization and modeling of earthquake ground motion of multiple sequences. Recently, this class of ground motions was clearly observed during the 2011 off the Pacific coast of Tohoku earthquake on March 11. This research subject is new and has not received adequate attention from researchers. For instance, most seismic codes specify design ground motions as single events. However, moderate ground motion with repeated acceleration sequences could lead to more severe damage to structures than a single sequence of strong ground motion. The worst-case scenario is studied within the deterministic and probabilistic frameworks. Characteristics of earthquake ground motion of repeated sequences are made clear in Chap. 5 while critical ground motion sequences are discussed in Chap. 6. In Chap. 7, responses of elastic–plastic structures to nonstationary random acceleration sequences are investigated and the reliability of such structures is evaluated.

A practical problem always arises in the design of buildings against earthquake loads. It is always difficult to select a suite of suitable earthquake records from a large set of records as input to the nonlinear time-history analysis of structures. Chapter 8 provides deterministic and probabilistic measures that can be used to identify unfavorable accelerograms. This chapter provides simple concepts which can be utilized to select a suit of appropriate earthquake records for nonlinear time-history analysis of structures.

Chapters 9 and 10 deal with the worst-scenario of earthquake loads on inelastic structures with special emphasis on the type of seismic waves of the ground motion and damage quantification using damage indices.

Chapter 11 deals with the worst-case scenario for bidirectional ground motions. Most of the current seismic-resistant design codes are based on the simulation of building response under uni-directional earthquake input. However, bidirectional input is inevitable for the reliable design of columns.

Chapters 12 and 13 tackle the worst-case scenario for passively controlled buildings. The structural member stiffness and strength of buildings are uncertain due to various factors resulting from randomness, material deterioration, temperature dependence, etc. The passive damper systems are also uncertain depending on various sources. The concept of sustainable building design under such uncertain structural-parameter environment may be one of the most challenging issues to be tackled recently. By predicting the response variability accurately, the elongation of service life of buildings may be possible.

Chapter 14 focuses on the worst-case scenario for base-isolated buildings. The stiffness and damping of the base-isolation system and the stiffness of the superstructure are selected as uncertain parameters. An efficient methodology is explained to evaluate the robustness (variability of response) of an uncertain base-isolated building.

The book closes with Chap. 15 on current challenges and future directions on design of building structures with greater earthquake resilience.

The importance of the worst-scenario approach for improved earthquake resilience of buildings and nuclear reactor facilities has been recognized and demonstrated by the recent great earthquake (March 11, 2011) in Japan. Such understanding is of extreme significance especially for large or important structures.

The word ‘unexpected incident’ is often used in Japan after the 2011 great earthquake. It may be true that the return period of this class of earthquakes at the same place could be 500–1,000 years and the use of this word may be acceptable to some extent from the viewpoint of the balance between the construction cost and the safety level. However, the critical excitation method is expected or has a potential for enhancing the safety level of building structures against undesirable incidents drawn from this irrational concept in the future. One of the most important and challenging missions of structural engineers may be to narrow the range of such unexpected incidents in building structural design. Redundancy, robustness, and resilience are expected to play important roles in such circumstances.

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