

Preface

Objectives

Earthquake engineering is generally considered as an advanced research area in engineering education. Most of the textbooks published in this field cover topics related to graduate education and research. There is a growing need, however, for the use of basic earthquake engineering knowledge, especially, in the earthquake resistant design of structural systems. Civil engineering graduates who are concerned with structural design face the fundamental problems of earthquake engineering more frequently in their professional careers. Hence, an introductory level textbook covering the basic concepts of earthquake engineering and earthquake resistant design is considered as an essential educational instrument to serve for this purpose.

This book aims at introducing earthquake engineering to senior undergraduate students in civil engineering and to master's students in structural engineering who do not have a particular background in this area. It is compiled from the lecture notes of a senior level undergraduate course and an introductory level graduate course thought over the past 12 years at the Middle East Technical University, Ankara, Turkey. Those students who take the course learn the basic concepts of earthquake engineering and earthquake resistant design such as origin of earthquakes, seismicity, seismic hazard, dynamic response, response spectrum, inelastic response, seismic design principles, seismic codes and capacity design. A prior knowledge of rigid body dynamics, mechanics of vibrations, differential equations, probability and statistics, numerical methods and structural analysis, which are thought in the second and third year curriculum of undergraduate civil engineering education, is sufficient to grasp the focus points in this book. Experience from the past 12 years proved that students benefitted enormously from this course, both in their early professional careers and in their graduate education, regardless of their fields of expertise in the future.

The main objective of the book is to provide basic teaching material for an introductory course on structural earthquake engineering. Advanced topics are intentionally excluded, and left out for more advanced graduate courses. The

authors believe that maintaining simplicity in an introductory textbook is a major challenge while extending the coverage to advanced topics is trivial. Hence, the majority of the information provided in the book is deliberately limited to senior undergraduate and introductory graduate levels while a limited number of more advanced topics are included as they are frequently encountered in many engineering applications. Each chapter contains several examples that are easy to follow, and can mostly be solved by a hand calculator or a simple computational tool.

Organization of Chapters

Chapter 1 discusses the basic physical and dynamic factors triggering earthquakes; global tectonics, fault rupture, formation of ground shaking and its effect on the built environment. Measurement of earthquake size and intensity is also defined in this chapter.

Chapter 2 introduces basic elements of probabilistic and deterministic seismic hazard assessment. Uniform hazard spectrum concept is the last topic covered in **Chap. 2**.

Chapter 3 presents dynamic response of simple (single degree of freedom) systems to earthquake ground motions. Analytical and numerical solutions of the equation of motion are developed. Response spectrum, inelastic response and force reduction concepts in seismic design are discussed herein.

Chapter 4 introduces linear elastic earthquake design spectra and the inelastic (reduced) design spectra. This chapter also presents the fundamentals of seismic hazard map concept employed in seismic design codes, particularly in Eurocode 8 and NEHRP provisions, together with ASCE 7 standards.

Chapter 5 develops the dynamic response analysis of building structures under ground shaking. Modal superposition, equivalent lateral load analysis, response spectrum analysis and pushover analysis are presented progressively. Analysis of base isolated structures is also included.

Chapter 6 extends the analysis methods in **Chap. 5** to three-dimensional, torsionally coupled buildings. Basic design principles and performance requirements for buildings in seismic design codes are presented.

Chapter 7 is particularly devoted to the capacity design of reinforced concrete structures in conformance with the modern design codes including Eurocode 8 and ASCE 7. Ductility in concrete and capacity design principles are discussed in detail. This chapter is concluded with a comprehensive example on the design and detailing of a reinforced concrete frame.

Suggestions for Instructors

The material in this book may serve for developing and teaching several courses in the senior undergraduate and graduate levels of civil engineering education during a 13- or 14-week semester of about three lecture hours per week.

Earthquake Engineering at Senior Undergraduate Level

A selected coverage of topics is suggested from the book for an introductory course on earthquake engineering at the undergraduate level. [Chapter 1](#) can be summarized in a week in a slide presentation form. [Chapter 2](#) may also be summarized in a week through describing the fundamentals of seismic hazard analysis methodology. Sections 3.6.3–3.6.7 can be excluded from [Chap. 3](#) in teaching an undergraduate course. [Chapter 4](#) is advised to be given in a practical manner, with more emphasis on defining the design spectra directly according to Eurocode 8 and ASCE 7. Sections 5.8 and 5.9 can also be excluded from [Chap. 5](#). Full coverage of [Chaps. 6](#) and [7](#) is necessary for introducing the basics of earthquake resistant building design.

Earthquake Engineering at Graduate Level

The entire book can be covered in a first course on earthquake engineering at the graduate level. [Chapter 2](#) can be shortened by introducing the classical probabilistic and deterministic hazard assessment methods with emphasis on their elementary components, while step-by-step descriptions of probabilistic and deterministic hazard assessment methods can be ignored. Assuming that the students have already taken structural dynamics, Sects. 3.1, 3.2, 3.4.1 and 3.4.2 can be skipped in [Chap. 3](#). Similarly Sects. 5.1, 5.2 and 5.5 can be excluded from [Chap. 5](#).

Engineering Seismology and Hazard Assessment at Graduate Level

The first four chapters of the book can be good teaching sources for a graduate level engineering seismology course for civil engineering students. The content of the [Chap. 1](#) can be extended by the cited reference text books and can be given to the student in the first 3 weeks of the course. Seismic hazard assessment covered in [Chap. 2](#) can be taught in 4–5 weeks. The instructor can start refreshing the basics of probability before the main subjects in seismic hazard assessment. The elastic

response spectrum concept that is discussed in [Chap. 3](#) can follow the seismic hazard assessment and simple applications on the computation of uniform hazard spectrum can be given to the students from the materials taught in [Chaps. 2](#) and [3](#). The last 2 or 3 weeks of the course can be devoted on the code approaches for the definition of elastic seismic forces that are discussed in [Chap. 4](#).

Basic Earthquake Engineering

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