Preface

Over the last quarter of a century, Japan has experienced two major earthquake disasters: the 1995 Kobe earthquake and the 2011 Tohoku earthquake. Huge loss of human lives and vast damage to structures resulted from serious failure by scientists and engineers, including the author, endeavoring to mitigate natural disasters. The mistakes we made must not be repeated. Thoroughly and systemically, we must draw broad lessons from the two calamities and take steps to deal effectively with future earthquakes and tsunamis.

It is said that the large rupture between tectonic plates, which caused the 2011 earthquake, might have changed the stress condition of the Japanese archipelago. This, it is further assumed, may accelerate the triggering of earthquakes in the regions along the Nankai Trough, i.e., Tokai, Tonankai, and Nankai earthquakes, and the northern Tokyo Bay earthquake. Our urgent task is to reveal the vulnerability of the country and local communities to future natural hazards and to prepare accordingly.

For the reduction of the loss of human lives and property and for the creation of a safe society, we have to firstly regain the reliance of the people on science and technology related to natural disaster mitigation. Also essential are the endeavors of experts in the natural sciences and the humanities, all of whom must actively strive to advance interactive communication.

About 1 month after the 2011 Tohoku earthquake, as the chair of the Civil Engineering and Architectural Committee organized by the Science Council of Japan, I requested the presidents of 22 academic societies to organize a liaison committee for a multidisciplinary and comprehensive survey of lessons from the earthquake and tsunami disaster. What is needed from us is close cooperation and coordination of the academic societies to analyze the cause of the disaster, to contribute to restoration and reconstruction of the affected area, and to scientifically and technologically mitigate the destructive effects of future natural disasters.

During the last half-century, natural disasters, such as earthquakes, tsunamis, storms, and floods, have been increasing. Unfortunately, we the Japanese people painfully experienced the 2011 earthquake and tsunami disaster, but we learned many lessons from this disaster. We must share with the world the practical lessons we have learned. In that endeavor, the national government, local governments, research organizations, universities, and NPOs must all, each at its own level, strive to move forward.

With the participation of many architects, civil engineers, and researchers in engineering fields, I organized a non-profit organization named "Engineers without Borders, Japan (EWBJ)" in 2000. It has provided technological assistance for developing measures to deal with natural disasters in Asian countries such as Indonesia, Pakistan, and Bangladesh with aid for the restoration and revitalization of communities and disaster-related education for children. The EWBJ continues to expand its endeavors for the creation of a safe and secure world.

After my university graduation in 1966, I worked for Taisei Corporation, then at Tokai University, and subsequently at Waseda University. I have continued in each organization to conduct research on practical work in the field of earthquake disaster-prevention engineering. With the aim of further contributing to the development of the earthquake engineering and its related fields, this book summarizes and generalizes what I have learned over the years.

In Chap. 1, I focused on the increase of natural disasters due to vulnerability of societies and global climate change in Japan as well as around the whole world, and analyzed the reasons of this increase. I have continuously conducted field surveys whenever an earthquake disaster occurred and have given advice and technical assistance for the reconstruction of the affected areas in the world. Sections 1.2 and 1.3 summarize the results of those field surveys.

The Great Kanto Earthquake in 1923 provided the impetus for development of earthquake-resistance design in Japan. The technology has developed, with lessons being drawn from each subsequent earthquake and infrastructures being reinforced. The principles and strategies of enhancement of earthquake resistance of societies, along with reinforcement technology of existing structures, are outlined in Chap. 2. At the same time, in order to make the content of the book more accessible to young readers, the essentials of the dynamic analysis method are explained.

Chapters 3 and 4 describe, respectively, the mechanisms of liquefaction and liquefaction-induced large ground displacement, along with their induced damage to various kinds of structures and lifeline facilities. Countermeasures to prevent damage of structures are also introduced. Chapter 4 focuses in particular on 11 examples of liquefaction-induced ground displacements and the damage during past earthquakes, both in Japan and abroad. The data are mostly drawn from the outcomes of U.S.–Japan joint research on liquefaction and its effects on lifeline systems.

Chapter 5 discusses the dynamic behaviors of underground structures by earthquake observations and numerical analyses of an underground tank, undersea tunnels, and a rock tunnel. Most of this research was done during my work at Taisei Corporation. The earthquake observations revealed that the deformation of underground structures was governed by the strain of the surrounding ground. Based on this finding, the response displacement method was proposed for the earthquake-resistant design for underground structures.

It has been predicted that an earthquake directly below the Tokyo area and large earthquakes along the Nankai Trough in the Pacific Ocean would cause serious damage to the central part of Japan. In Chap. 6, several issues which are increasing the danger of these earthquakes and the measures to reduce the damage are discussed.

It was Dr. S. Okamoto, Dr. K. Kubo, and Dr. C. Tamura, professor emeriti of the University of Tokyo, who first cleared the path that led me to become a scholar in the field of earthquake disaster prevention engineering. Prof. Okamoto guided me in how to conduct empirical research based on experimentation and observation. Prof. Kubo provided countless opportunities for me to conduct research into liquefied soil flow and lifeline earthquake engineering. Prof. Tamura always supported me in my research at University of Tokyo, even after graduation. Here I wish to express my deep thanks to these illustrious scholars.

Finally, in regard to the publication of this book, I extend my gratitude to colleagues at Taisei Corporation, Tokai University, and Waseda University with whom I have continued to work; to the associates who took part in surveys and research; and to the staff members of my laboratory who contributed to the compilation of this book. In particular, I am also indebted and grateful to research associate Dr. D. Guo and my graduate students I. Kato, N. Tonsho, and R. Nakamachi, as well as our laboratory secretaries R. Matsunaga and T. Nagata, for providing outstanding support in arranging the text and the various charts. Last but not least, I express my highest appreciation to my wife Noriko and my family for their deep understanding and support for my research work.

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