

Preface

Damages due to catastrophic earthquakes are huge. Over a million and half people have been killed during the most catastrophic ten earthquakes that have occurred since 1900. Still, the number of victims and material damage due to earthquakes has permanently been growing although, according to statistics, the number of catastrophic earthquakes per annum is constant. For example, the Haiti earthquake with magnitude $M = 7$ that occurred in 2010 took 316,000 human lives, destroyed and damaged 97,294 and 188,383 houses, respectively. It was the deadliest earthquake that has ever occurred. Such an increase of number of victims and damages has mostly been due to intense urbanization resulting in an increased density of population in the seismically active belts of the Earth.

Since the seismic hazard cannot be reduced, the seismic risk related to civil structures can be decreased in a number of ways. One of the basic measures of reduction of such risk is permanent development of new methods of analysis of structures for the effect of earthquakes as well as constant improvement of seismic design regulations in seismic regions. The technique of health monitoring of structures (HMS) that has lately been applied in civil structures is also one of the methods contributing to reduction of seismic risk.

HMS is mostly applied in aeronautics and mechanical engineering. The application of HMS in civil structures still lags behind its application in the above mentioned disciplines. The earliest application of this technique in structural engineering is traced back to the seventies of the last century when mass measurement of dynamic characteristics of full-size structures begun by use of the ambient and force vibration techniques. With the invention of the first strong motion instruments and parallel to their installation on ground, a certain number of buildings were instrumented for the purpose of measuring their dynamic response with the triggering of these instruments by stronger earthquakes. However, all these measurements are associated with a certain time period. Continuous real-time measurements of behavior of structures has been enabled later, as a result of the development of fast data acquisition systems and real-time transmitting of data to centres for monitoring of structures. Most of this book is dedicated to modern real-time HMS.

In order to stress out the extent of damage that can be caused by earthquakes, the first chapter of the book deals with the phenomena and the damage due to the series of earthquakes that took place in Christchurch in New Zealand in 2010 and 2012. The remaining chapters of the book deal with some topical themes related to HMS and earthquake effect.

The second chapter contains a review of application of HMS in the past, current state of the art in this field as well as considerations as to improvements to be made regarding instrumentation of new buildings for health monitoring.

A description of use of dynamic artificial neural networks and wavelet signal analysis for intelligent processing of signals and damage identification is given in the third chapter. The analyses of signals and detection of damage are demonstrated via application to an aerospace structure thermal protection system panel and a four-storey benchmark building frame structure. In the next chapter, a rationale is given as to why it is useful to use smart wireless sensor networks for instrumentation of structures. It is explained how these should be properly distributed. Further on, their advantages over other sensors are given.

The fifth chapter displays the use of the concept of mechanical impedance of structures which is similar to the concept of electrical impedance of electrical circuits. The electrical impedance produced by piezo-impedance transducers bonded to structures enables good evaluation of damage to structures. The assumed approach is proved by a frame model tested on a seismic shaking table.

The application of health monitoring in buildings is presented in the next four chapters.

Chapter 6 deals with the variation of the stiffness characteristics of the Sheffield University Arts Tower during its retrofitting obtained by the installed system for monitoring of vibrations.

The technique of real-time damage detection in buildings and its application in practice are presented in Chap. 7. Examples of earthquake damage detection in buildings of different structural systems and number of storeys are also given. The possibility of application of this technique in a larger number of structures in a single area is explained. An accent is given on the possibility of mapping damages to all structures in a given location. It is shown that the results can be displayed within minutes of a triggering event in a summary format. Chapters 9 and 10 show the analysis of time history records obtained for instrumented buildings in Chile during the earthquakes that took place in 2010. The ninth chapter contains analyses of records obtained on two instrumented buildings due to the earthquake, which affected the central part of Chile on 27 February 2010. The records point to nonlinear behaviour of these structures resulting in modification of their dynamic characteristics. The tenth chapter shows the behaviour of Vina Del Mar building during the period of frequent aftershocks that occurred between May 2 and July 14, 2010. Autoregressive with exogenous input (ARX) time series model was used to verify if a structure was damaged due to the mentioned events.

An HMS system based on automated operational modal analysis and its application to an arch bridge is described in Chap. 10. In the next, the eleventh chapter, a real-time health monitoring system consisting of 700 sensors is presented.

The functioning of this system is demonstrated through monitoring data during very long, long, middle and short distance earthquakes.

The last two chapters deal with observation and analysis of seismic shaking table tests. The first test presented in Chap. 12 refers to a base isolated reservoir. Horizontal nonlinear behaviour of isolators is also presented. The second test shown in the last chapter refers to testing of a model of a pipe line system to define its behaviour under dynamic loading as a basis for health monitoring of full scale thermal power plant pipeline systems.

The editor and the authors of the presented chapters hope that this book will contribute to a more frequent application of health monitoring systems in structures for the purpose of real-time detection of damages due to earthquakes.



<http://www.springer.com/978-94-007-5181-1>

Earthquakes and Health Monitoring of Civil Structures

Garevski, M. (Ed.)

2013, XII, 331 p., Hardcover

ISBN: 978-94-007-5181-1