Springer Natural Hazards

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Preface

The destructive potential of earthquakes depends on their magnitude and the placement of the hypocenter. Worldwide efforts in establishing seismological and geophysical networks has increased considerably and data centers provide information that is essential to identify earthquake locations, understand the physics of the earthquakes and faulting mechanisms, as well as studies on site effects and earthquake recurrence. These types of studies play a key role in mitigating earthquake hazards and planning emergency response. However, recent earthquakes demonstrated the risks to modern societies, especially in terms of health, safety, and economic viability. The study of earthquakes combines science, technology, and expertise in infrastructure and engineering in an effort to minimize human and material losses when their occurrence is inevitable. Although probably the most important, direct shaking effects are not the only hazard associated with earthquakes, other effects such as landslides, liquefaction, and tsunamis have also played important part in destruction produced by earthquakes. Most earthquake-related deaths are caused by the collapse of structures, and the construction practices play a tremendous role in the death toll of an earthquake.

As an example among the others, in the Messina area (southern Italy), more than 120,000 people perished in an earthquake (M = 7.2) that struck the region in 1908, mainly killed due to the easily collapsible structures that dominated both the major cities and villages of the region. A larger earthquake that struck San Francisco three years earlier had killed fewer people (about 700) because building construction practices were less vulnerable and predominantly made by wood. In both areas, these events played a key role in the future of the region. Recently, on January 12, 2010, disaster struck Haiti and its economy, as well as its surrounding nations. Death totals topped 200,000, and reliable industries and structures were destroyed, leaving the nation in a tough situation. It remains clear that the earthquake that has recently stuck Haiti has had a catastrophic impact on Haiti, leaving its economy in shambles. In the last decades, other important examples of catastrophic events are the great Sumatra earthquake (December 26, 2004) and the Japan earthquake (March 11, 2011) associated also with tsunamis of notable energy that caused

Fig. 1 The children drawing presented in this figure has the aim to illustrate the effects of earthquakes on society as seen by children affected by such catastrophic phenomenon

several casualties and damage to both residential buildings and industrial facilities (e.g., Fukushima Daiichi nuclear power plant).

Such catastrophic events take an unimaginable toll on children and their families as demonstrated, for example, by the 2008 Sichuan Province and 2005 Pakistan earthquake. In such disaster management contexts, family members as well as health care and school personnel are the first-line responders and are natural sources of continued social support as children recover. Such kind of natural disasters can really impact on children and consequently on our societies. The children drawing presented in Fig. 1 has the aim to illustrate the effects of earthquakes on society (the word "PRIMA" stands for before, while the word "DOPO" stands for after). The drawing has been realized by one, the children hosted in the Mirandola camp (during the 2012 Emilia seismic sequence, Italy). Such camp was also used by few research teams (I took part in one of them) conducting real-time monitoring and data collection in the epicentral area.

The chapters in this book are devoted to various aspects of earthquake research and analysis of their impact on modern and past societies. In the following a brief outline of each contribution is given.

A Description of Seismicity Based on Non-extensive Statistical Physics: A Review

The manuscript by Vallianatos et al. opens this book tackling the problem of the physics of earthquakes which still has many questions that have not yet been answered since the phenomenon is subjected to many uncertainties. In this chapter, the authors review some fundamental properties of earthquake physics (in the geodynamic

laboratory scale) and how these are derived by means of non-extensive statistical physics with the main goal to understand aspects of the underlying physics that lead to the evolution of the earthquake phenomenon.

Recognition of periAdriatic Seismic Zones Most Prone to Next Major Earthquakes: Insights from a Deterministic Approach

Mantovani et al. describe the short-term development of tectonic processes which is closely related to major decoupling earthquakes at plate boundaries. Each of these events triggers a perturbation of the strain field which propagates in the surrounding area and may increase the probability of earthquakes in tectonic zones or may even cause further seismicity when the fault involved is close to failure. This implies that in a given tectonic context, the past distribution of strong shocks can significantly influence the location of the next seismic events. In this work, the authors discuss on how the above interpretation may have influenced the spatiotemporal distribution of major shocks in the central Mediterranean region, with particular regard to the periAdriatic zones. It is argued that the regularity patterns of seismicity so far identified may provide significant information on the possible location of the next strong earthquakes in the Italian peninsula. The results of this analysis suggest that the probability of next strong shocks is higher for the northern periAdriatic zones, with particular regard to the northern Apennines, than in the southern zones (southern Apennines and Calabria). Present knowledge does not allow to give this kind of information for some Italian zones (mainly Sicily, Apulia, and northwestern Italy), for which significant regularity patterns of seismicity have not been recognized yet.

Forecasting Moderate Earthquakes in Northern Algeria and Morocco

In this work, Peláez et al. studied the correlation between locations of $M_W \geq 5.0$ earthquakes and locations of $5.0 > M_W \geq 4.0$ events for northern Algeria and Morocco. A preliminary study shows that it can be observed a relatively good agreement between locations for these two data sets, that is, minor earthquake locations could be used to forecast future places where will happen moderate and moderate to strong earthquakes. They propose a time-independent forecasting model based on the spatially smoothed seismicity rate of $M_W \geq 4.0$ earthquakes. Finally, a time-independent forecasting model is proposed from the computation of $M_W \geq 5.0$ and $M_W \geq 6.0$ earthquake probabilities considering that seismicity follows both a Poisson process and the Gutenberg–Richter magnitude–frequency relationship.

An Earthquake Catalogue (2200 B.C. to 2013) for Seismotectonic and Seismic Hazard Assessment Studies in Egypt

Sawires et al. aim at preparing new and up-to-date unified and Poissonian earthquake catalogue for Egypt including the focal mechanism solution data, so that the earthquake information can be reached from a single source. A catalogue for earthquakes that occurred in Egypt and its vicinity during the period 2200 B.C.–2013 was compiled for achieving a unified magnitude scale. Data were obtained from different sources, local, regional, and international. Earthquake magnitudes are reported in different scales and come from a variety of sources. The initial compiled catalogue comprised a total of 64,613 earthquakes (historical and instrumental events). In addition, a focal mechanism solution database was collected. This database contains 688 fault plane solutions gathered from different published and unpublished sources, covering the time period from 1940 until the end of 2013.

For establishing a common magnitude, namely an equivalent moment magnitude M_W, two new relationships correlating M_S and m_b with M_W were derived.

Probabilistic Seismic Hazard Assessment for Romania

In this study, Vacareanu et al. focus on the probabilistic seismic hazard assessment for Romania using the latest seismicity data and ground motion prediction models. In the first step, an evaluation of the applicability of several ground motion prediction models for seismic sources in Romania is performed on a database which consists of over 300 strong ground motions recorded in Romania, Bulgaria, and Moldova during ten Vrancea subcrustal earthquakes. The testing procedure employed in this study uses several goodness-of-fit measures. A sensitivity analysis for the probabilistic seismic hazard assessment (PSHA) results for four cities in Romania (Bucharest, Focsani, Iasi, and Craiova), located in the forearc of the Carpathian Mountains, is presented. The results provide the basis for defining the computation hypothesis and corresponding weights assigned to the logic tree branches for the PSHA for Romania. The scope is to provide a refined input for the implementation of the seismic action according to the requirements of EN 1998-1.

Practicality of Monitoring Crustal Deformation Processes in Subduction Zones by Seafloor and Inland Networks of Seismological Observations

As well as the 2011 Tohoku earthquake, there will be other megathrust earthquakes around Japan in the future. These earthquakes will surely have a strong effect on various aspects of society, including economic, psychological, infrastructural, and survival problems. In this chapter, Ariyoshi and Kaneda review the progress of studies on monitoring seismic changes in crustal deformation and seismic activity by comparing simulation results for the Tokai and Tonankai earthquakes in order to discuss the validity of modeling of subducting plates and the detectability of preseismic changes based on seafloor and inland observation networks for disaster mitigation. Since leveling change due to shallower VLF swarms is so local as to be incoherent, removal of the moving-averaged data from the data stacked by four nearby observation points in the same node of Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) may be useful to detect the short-term local leveling change. This developed oceanfloor observation is expected as short-term forecasting so as to reduce economic loss reasonably.

Neo-deterministic Definition of Seismic and Tsunami Hazard Scenarios for the Territory of Gujarat (India)

Magrin et al. present a neo-deterministic definition of earthquake hazard scenarios. A reliable and comprehensive characterization of expected seismic ground shaking is essential to improve building codes, particularly for the protection of critical infrastructures and for land use planning. So far, one of the major problems in classical methods for seismic hazard assessment consisted in the adequate characterization of the attenuation models, which may be unable to account for the complexity of the medium and of the seismic sources and are often weakly constrained by the available observations.

Geophysical Characterization of Liquefied Terrains Using the Electrical Resistivity and Induced Polarization Methods: The Case of the Emilia Earthquake 2012

Nasser describes liquefaction of a shallow, water-saturated sand and silty sand layer which has resulted in the damage of several buildings as well as of roads and sidewalks during the Emilia–Romagna earthquake (northern Italy, May 20, 2012). In fact, massive surface fracturing, sand upwelling, sand volcanoes, limited blister

formation, and lateral spreading liquefaction features took place immediately after the main shock.

Working Strategies for Addressing Microzoning Studies in Urban Areas: Lessons from the 2009 L'Aquila Earthquake

Vessia et al. present working strategies for addressing microzoning studies in urban areas presenting the results through lessons learned from the 2009 L'Aquila earthquake. This is a crucial approach for mitigating risk in prone earthquake areas, and several efforts have been done in the past years by the Department of Civil Protection. This also may help the authorities in estimating economic losses due to the strong earthquakes and comparing the results with losses that occurred in the last decades.

Earthquake-Induced Reactivation of Landslides: Recent Advances and Future Perspectives

In this chapter, Martino presents a nice description of seismic-induced landslide. Earthquake-induced reactivation of landslides is a focus topic in the risk management as severe damages and losses were caused so far from seismically triggered slope failures. Slope stability conditions under seismic action were studied since several decades by pseudostatic approaches as well as by sliding block methods that follow the Newmark approach. These last ones were more recently upgraded by flexible block approaches to provide a more constrained evaluation of earthquake-induced displacements, i.e., by considering the landslide mass resonance during the seismic shaking. Nevertheless, these approaches cannot take into account the very complex interactions between seismic waves and slope pointed out by several case histories that are reported in the literature. Such interactions can be simulated by more sophisticated stress–strain numerical models. Nonetheless, to carry out these simulations, it is necessary to provide very strong constraints to both the geological setting of the slope and the local seismic response. In this regard, a fundamental contribution derives from detailed engineering–geological reconstructions as well as in-site geophysical measurements. Very recent studies experienced theoretical approaches for pointing out the significance of some physical parameters, such as the ratios of characteristic periods related to the seismic wave properties and to the landslide mass geometry, to provide a more exhaustive prevision of earthquake-induced landslide displacements.

Resilience, Vulnerability and Prevention Policies of Territorial Systems in Areas at High Seismic Risk

Teramo et al. present aspects of the seismic vulnerability and resilience of an urban system through a multidimensional and interdisciplinary approach addressed to an effective prevention policy and sustainable territory planning. In particular, in their study, they analyze the actual capability of a territorial system to face the effects of a strong earthquake on the basis of targeted territorial, seismic, health, social, and legal indicators. Specific applications aimed at emergency management and rescue coordination are moreover proposed through the territory monitoring with innovative wireless sensor networks that ensure unexpected effectiveness levels.

Numerical Study of the Seismic Response of a Mid-Rise RC Building Damaged by 2009 Tucacas Earthquake

In this chapter, Vielma et al. present the results of the numerical simulation related to a reinforced concrete framed building who suffered light damage by the 2009 Tucacas Earthquake (6.4 Mw). The building was designed according to the current Venezuelan codes, splitting the structure into three different modules in order to avoid the negative effects of in-plane irregularities and represent a typical mid-rise building located on high seismic-prone areas. In order to improve the original seismic design of the building, a new building was proposed using an innovative energy-based procedure. The set of dynamic analyses was used in order to formulate a new procedure for the determination of fragility curves. Results show that the new procedure is suitable in order to predict the damage state which the building may reach when it is subjected to a strong earthquake, and therefore, it can be really useful for construction practices in order to ensure the life of the population and to reduce the seismic vulnerability.

Analysis of Seismic Vulnerability of Rural Houses in China

Jue et al. present a detailed analysis of seismic vulnerability of rural houses in China. This represents a key point because most of seismic disasters in China have taken place in rural areas. The damage of dwelling houses has been the biggest cause of casualties and asset loss, which causes enormous impact on rural societies and economic systems. In this paper, the seismic vulnerability of counties was assessed with regard to the structural features of rural houses, measured by the number and ratio of potentially damaged houses in the case of seismic disasters.

Finite Element Modelling for Seismic Assessment of Historic Masonry Buildings

Betti et al. discuss on use of the finite element modelling technique for assessment of seismic vulnerability of historic masonry buildings. In particular, two representative case studies are presented: a masonry church and an old residential building. The aim of the chapter is to outline that advanced numerical analyses can provide significant information to understand the actual structural behavior of ancient buildings under seismic loading. A clear understanding of the structural behavior, based on sophisticated tools of structural analysis, can reduce the extent of remedial measures in the restoration of ancient buildings through a reliable strengthening.

Earthquake-Resistant and Thermo-Insulating Infill Panel with Recycled-Plastic Joints

Modern buildings should be endowed with features that allow people to carry out their activities in a sustainable environment and with a high level of safety. The major concern of this work refers to one peculiar aspect that recently is gaining the attention of designers and construction companies: the role of infill panels. There is now an increasing consensus on how these non-structural elements should be carefully designed, both to increase their thermo-insulating capacity and to adapt their earthquake performance to the most recent standards. The solution was found in an innovative constructive system for infill panels, in which the traditional hollow-core masonry blocks are connected, rather than with the traditional mortar layers, through joints made from recycled plastic. The constructive system has the advantage of a rapid assemblage, which reduces the construction times, and allows the insertion of insulating panels that reduce the thermal conductivity to very low levels. Therefore, it will be extremely important for the developments of our modern societies.

Base Isolation and Translation of a Strategic Building Under a Preservation Order

Monti et al. in this chapter deal with a retrofitting intervention on a strategic building. In particular, the seismic retrofitting of a strategic building owned by the Italian Highway Company, built in the 1950s, is presented. The structure is endowed with mushroom-shaped columns with hollow section at the *pilotis* floor, which makes them particularly vulnerable to shear. In order to retrofit the frame, it was decided to design a seismic isolation system at the base of the building, by

inserting the isolation devices under the existing columns at the *pilotis* floor. The main benefit of this solution is the possibility to operate exclusively at the ground level, without interrupting the work activities at the upper floors. In general, from the social standpoint, the example presented in this chapter could serve as pilot study that can help in planning the retrofitting of residential building without displacing the occupants to different locations while working on the building.

Lessons from the Wenchuan Earthquake

A strong earthquake like the Wenchuan earthquake on May 12, 2008, in China causes huge losses in human lives and property damages in a short time. Nevertheless, the losses after the main shock are very serious as well, because of the disaster chain, which is often underestimated in its consequences. For this reason, reconstruction projects have been carried out after the earthquake with varying degrees of success. This paper deals with a number of issues that occurred after the Wenchuan earthquake, from which certain lessons can be learned. Inappropriate planning has relocated towns and villages along the active fault zone in seismic risk zones. A safe distance of the buildings from the active fault zones was not respected in all reconstruction projects. The amount of loose source material on the slopes for debris flows after the earthquake was underestimated, leading to ineffective design of hazard control projects. The level of newly designed roads, bridges, and tunnels turned out to be too low due to an underestimation of the rise of the riverbeds in the main valleys. Areas with a high hazard for flooding and debris flows were ignored in the planning of new built-up areas.

Lessons Learned from the Recent Earthquakes in Iran

Although the understanding of the reasons and impacts of natural disasters and models to compute the frequency and severity of disastrous earthquakes has improved, a slight increase can be seen in the earthquake deaths as a percentage of the total global deaths. Iran, like other developing counties, suffers earthquake causalities and economic damages. The residences and other constructions in Iran especially in small villages and towns are generally built without considering seismic design regulations, so they are highly vulnerable. Comparing yearly earthquake death rates among Iran, Japan, and USA during three different periods revealed that while Japan and USA have been reduced their yearly rates, Iran's status has been worsening. Among the principal causes of high death toll and economic losses in Iran, one can refer to building collapse, changes in land use, increases in the concentration of people and capital in high-risk areas, fast and uncontrolled urbanization, the persistence of extensive urban and rural poverty, the depreciation of the region's environment resulting from the mismanagement of

natural resources, ineffective public policies, and lagging and misguided investments in infrastructures. Among the important lessons learned from the recent earthquakes in Iran are fundamental earthquake hazard reduction needs to engage national consciousness at all levels of society, public education, solving the problems in the natural disaster preparedness system, and deficiencies in current construction practice.

"The Impact of the Great 1950 Assam Earthquake on the Frontal Regions of the Northeast Himalaya"

In this paper, Devi and Bora discuss the great 1950 Assam earthquake which caused widespread devastation throughout the frontal regions of northeast Himalaya and it is classified as the 10th largest earthquake of the twentieth century. The ground cracked and fissured, bridges and rail lines were destroyed, and riverbeds silted up. Immediately after the shock, several tributaries of Brahmaputra River were blocked by landslips caused by the violent shaking of the earthquake causing drastic flooding afterward. This great earthquake, destructive in Assam and Tibet (China), was an important earthquake event since the introduction of seismological observation stations. This earthquake changed topographical features in the eastern syntaxis and caused havoc in the frontal region of northeast Himalaya, making drastic impact on human civilization.

Archaeoseismology in Sicily: Past Earthquakes and Effects on Ancient Society

This work presents a review of archeological evidence of strong earthquakes occurring in Sicily at the time of Greek and Roman colonization, a period of considerable political, economic, and social instability. In this historical context, the earthquake effects may have been obscured or overlooked to some extent, and consequently, the documentary information on ancient earthquakes, when available, is often sparse and lacking objectivity. The studied cases combine historical and archaeological data together with the evidence of structural damage to archaeological sites. Looking into past, the vocation of archaeoseismology lies in the identification of past seismic events and particularly what the ancient society knew on earthquakes and what kind of seismic effects produced on buildings and sites.

The Earthquakes of Southern Italy from the 18th to the 20th Centuries

In this chapter, Catalani present the earthquakes of southern Italy from the eighteenth to the twentieth centuries. In this period, the high density of population in southern Italy, the characteristics of the territory (mainly mountainous with malarial planes along the coast), and the economic system based on the land had pushed the southern communities to adapt to their territory, finding forms of appropriate use and exploitation of the land itself. Even the building industry had adapted to the territory. However, these people had also learned how to cope with the worst effects of earthquakes. Nevertheless, it is not possible to understand the importance of earthquakes in Italy completely and in particular in the southern regions, if only we consider them as natural phenomena. Earthquakes have surely contributed to the physical alteration of the landscape, just like other natural forces (such as wind, rain, and changes in temperature) together with human activities. However, over the centuries, the earthquake has been marked as a dynamic element of the "cultural landscape." This is because all catastrophic events, therefore even earthquakes, mark the life of communities and become part of their historical memory. Communities build settlements, organize their economy, and establish their social relationships upon which these disastrous events then take effects.

Earthquake and People: The Maltese Experience of the 1908 Messina Earthquake

In this paper, Borg and colleagues describe the perception in the Maltese archipelago of the devastating earthquake that struck southern Italy along the Messina Strait. As a result, the cities of Messina along Sicily's coast and Reggio di Calabria were completely destroyed causing more than 120,000 fatalities and left many without shelter. The 1908 earthquake had a significant impact on buildings and people and local communities which were displaced. The Maltese experience of the Messina 1908 earthquake relied on communication which reached Malta after the event. The chapter discusses information on the building deficiencies and damage, limitations of communication infrastructure during that period, and limits to timely emergency response to support the population and emergency action at the beginning of the twentieth century.

A Web Application Prototype for the Multiscale Modelling of Seismic Input

A Web application prototype is described, aimed at the generation of synthetic seismograms for user-defined earthquake models. The Web application's graphical user interface hides the complexity of the underlying computational engine, which is the outcome of the continuous evolution of sophisticated computer codes, some of which saw the light back in the middle 1980s. With the Web application, even the non-experts can produce ground shaking scenarios at the local or regional scale in very short times, depending on the complexity of the adopted source and medium models, without the need of a deep knowledge of the physics of the earthquake phenomenon. Actually, it may even allow neophytes to get some basic education in the field of seismology and seismic engineering, due to the simplified intuitive experimental approach to the matter. One of the most powerful features made available to the users is indeed the capability of executing quick parametric tests in near real time, to explore the relations between each model's parameter and the resulting ground motion scenario. The synthetic seismograms generated through the Web application can be used by civil engineers for the design of new seismic-resistant structures, or to analyze the performance of the existing ones under seismic load.

Rapid Response to the Earthquake Emergencies in Italy: Temporary Seismic Networks Coordinated Deployments in the Last Five Years

The rapid deployment of a dense temporary network of seismic stations, soon after the occurrence of a damaging earthquake, is an essential action to improve the seismic monitoring and the quality of the studies on the aftershock sequence. Having seismic waves recorded with a dense seismic network can greatly improve the detection of earthquakes and the estimation of hypocenter parameters. Since 1990, the National Institute of Geophysics and Volcanology (Italian: IstitutoNazionale di Geofisica e Vulcanologia (INGV)) manages a portable seismic network structure: an instrumental pool to deploy dense seismic networks for scientific experiments and to monitor aftershocks after the occurrence of damaging earthquakes. Today, this pool includes about 100 seismic stations which, if necessary, can be integrated in the real-time seismic surveillance system of INGV. The real-time data contribute to the monitoring of the seismicity in the epicentral area, and the off-line analysis of the recorded seismograms allows the imaging of the fault system geometry and kinematics. The chapter presents the INGV portable seismic network, its history, and the current coordination projects with other Italian