

Estimation of Seismicity Parameters for India

S. T. G. Raghukanth

Indian Institute of Technology Madras

INTRODUCTION

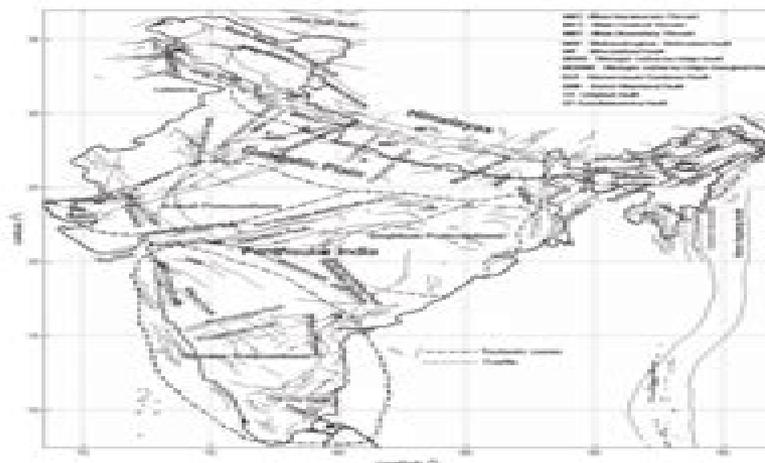
India has long been affected by damaging earthquakes. The recent Khillari (30 September 1993), Jabalpur (22 May 1997), Chamoli (29 March 1999), and Bhuj (26 January 2001) earthquakes have increased awareness of the need for earthquake disaster mitigation in India. The Khillari, Jabalpur, and Bhuj earthquakes, which caused severe damage to life and property, occurred in peninsular India, which is traditionally considered free from earthquakes. Thus, no part of India is free from seismic hazard.

The approach of seismic hazard estimation in India has been to follow the code IS-1893 (2002) brought out by the Bureau of Indian Standards. The code divides this vast country of some three million square meters into four zones. The hazard level is specified in terms of a standard response spectrum shape scaled by the zone factor, which is the expected peak ground acceleration (PGA) value. This PGA value is fixed as 0.1g (Zone II), 0.16 g (Zone III), 0.24 g (Zone IV), and 0.36 g (Zone V). These values have been fixed based on the observed damage patterns of past earthquakes. As is well documented, the Indian subcontinent suffers from interplate as well as intraplate earthquakes. The geological disposition of the faults and the seismogenicity of the southern part of India is much different from that in the Gangaic plain and the Himalayan region (Figure 1). The Geological Survey of India (GSI 2000) brought out a detailed *Seismotectonic Atlas of India*, which indicates that at any point 20–25 faults could be contributing to ground motion. Thus, it would be preferable to assess the future hazard at a city or a project site in a better fashion than just taking the PGA values of IS-1893. Moreover, the code does not specify the confidence levels associated with the four zonal values (Raghukanth and Iyengar 2006). The spatial and temporal uncertainty of seismic sources has been ignored in this zonal map.

Because the engineering design of structures has to ensure the future safety of such structures and their occupants, design values must be based on expected future ground motions and not on a few past observations. The uncertainty of the seismic phenomenon cannot be overlooked in arriving at the design basis spectrum. Sophisticated hazard analysis methods have been developed in the past four decades that account for the line or areal nature of sources near a construction site and also for variation about the mean of the response spectrum. This leads to probabilistic seismic hazard analysis (PSHA) and uni-

form hazard response spectrum (UHRS) methods that have gained importance in addressing the spatial variability in the seismic hazard of important cities in seismically active regions (Cornell 1968). PSHA that addresses engineering safety issues with quantifiable risk levels has become the norm, even for ordinary buildings, in many countries in the form of probabilistic seismic hazard maps (IBC 2003, USNRC 1997).

The three basic inputs required in PSHA are the earthquake recurrence relationships, knowledge of the tectonic features with which the earthquakes could be associated, and ground motion models. The location of major active faults, folds, shear zones, and lineaments in India are broadly known (GSI 2000; Gupta 2006). Ground-motion models for various tectonic regions of India are also available (Sharma 1998; Iyengar and Raghukanth 2004; Raghukanth and Iyengar 2007; Raghukanth and Somala 2009). Kaila *et al.* (1972) divided India into a $2^{\circ} \times 2^{\circ}$ grid and estimated the recurrence relations for the whole country by utilizing 14 years of seismicity data from 1954 through 1967 with magnitudes greater than 4. The derived relations provided a preliminary understanding of the seismicity, but the sparse database, and adopting this



▲ Figure 1. Seismotectonic map of India.

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Estimation of Seismicity Parameters Using a Computer A. I. Zakharova,1986-01 *Estimation of Seismicity Parameters Using a Computer* A. I. Zakharova,1986 **Seismic Source Method of Seismic Hazard Analysis and EQZONE Computer Code Manual** Yankee Atomic Electric Company,1985 **National Earthquake Hazards Reduction Program, Summaries of Technical Reports Volume XXXII** Geological Survey (U.S.),1991 **Practice of Earthquake Hazard Assessment** DIANE Publishing Company,1993 Summarizes probabilistic seismic hazard assessment as it is practiced in various countries throughout the world 59 reports are included covering 88 countries which comprise about 80% of the inhabited land mass of the Earth Over 100 maps **Life Cycle Analysis and Assessment in Civil Engineering: Towards an Integrated Vision** Robby Caspeele,Luc Taerwe,Dan Frangopol,2018-10-31 This volume contains the papers presented at IALCCE2018 the Sixth International Symposium on Life Cycle Civil Engineering IALCCE2018 held in Ghent Belgium October 28 31 2018 It consists of a book of extended abstracts and a USB device with full papers including the Fazlur R Khan lecture 8 keynote lectures and 390 technical papers from all over the world Contributions relate to design inspection assessment maintenance or optimization in the framework of life cycle analysis of civil engineering structures and infrastructure systems Life cycle aspects that are developed and discussed range from structural safety and durability to sustainability serviceability robustness and resilience Applications relate to buildings bridges and viaducts highways and runways tunnels and underground structures off shore and marine structures dams and hydraulic structures prefabricated design infrastructure systems etc During the IALCCE2018 conference a particular focus is put on the cross fertilization between different sub areas of expertise and the development of an overall vision for life cycle analysis in civil engineering The aim of the editors is to provide a valuable source of cutting edge information for anyone interested in life cycle analysis and assessment in civil engineering including researchers practising engineers consultants contractors decision makers and representatives from local authorities U.S. Geological Survey Open-file Report ,1992 National Earthquake Hazards Reduction Program ,1993 **National Earthquake Hazards Reduction Program, Summaries of Technical Reports Volume XXXIII** ,1992 **Bollettino di geofisica teorica ed applicata** ,1988 **Computers, Control & Information Theory** ,1986 *Geographical Information Systems in Assessing Natural Hazards* Alberto Carrara,Fausto Guzzetti,2013-04-17 The 16 contributions to Geographical Information Systems in Assessing Natural Hazards report on GIS investigations into landslides floods volcanic eruptions earthquakes and groundwater pollution hazards Current methods for predicting extreme events are critically discussed the emphasis being on the intrinsic complexity of this type of operation requiring many spatial data long historical records and sound models of the physical processes involved Within this context the potentials and limitations of GIS are addressed in terms of data acquisition spatial data structures and modelling for simulation of the causal phenomena Geographical Information Systems in Assessing Natural Hazards will help investigators in

both public and private institutions to evaluate the actual effectiveness of GIS in coping with natural disasters and to develop new strategies for projects aimed at the assessment and mitigation of the effects of such catastrophic events

Probabilistic Earthquake Hazard Assessment for Fiji Trevor Jones,1998 Mechanical Engineering ,1987

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Family Dwellings W. Rinehart,Sylvester Theodore Algermissen,Mary Gibbons,1976 **Statistical Methods for**

Earthquake Hazard Assessment and Risk Analysis G. R. Dargahi-Noubary,2000 Hazard assessment and risk analysis of natural disasters requires detailed analysis of the available information The raw material of such investigations are the past data which are often incomplete and insufficient Due to the nature of the problem statistical methods have been increasingly used in hazard assessment and risk analysis of disasters such as earthquakes high speed winds and floods Although most of the classical theories have been utilized for this purpose there are still many important areas which have not received enough attention This book is devoted to description of some statistical theories and methods and discussion of their relevance to hazard assessment of natural disasters in general and earthquakes in particular Except for introductory material different chapters of the book are made independent from each other whenever possible This is done in the expense of covering the same material in several places In doing so our goal was to make it easier for readers who seek to learn and apply a particular method Also to facilitate this theories utilized are described in detail in the corresponding chapters

The IGS File of Seismic Activity and Its Use for Hazard Assessment Paul W. Burton,Institute of Geological Sciences (Great Britain),1978 Proceedings of the Fifth International Conference on Seismic Zonation Association française du génie parasismique,Earthquake Engineering Research Institute,1996

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