The fifteenth Mallet–Milne lecture

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Received: 10 January 2016 / Accepted: 13 January 2016 / Published online: 3 April 2016
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The biennial Mallet–Milne Lecture is organised by the Society for Earthquake and Civil Engineering Dynamics (SECED) in memory of the two founding fathers of engineering seismology; Robert Mallet and John Milne. Whilst it may be ironic that two men widely credited with instigating the scientific study of earthquakes should hail from an area of such low seismicity as the British Isles, it is consistent with the UK's pioneering role in science generally during the Victorian era. SECED aims to continue that tradition by encouraging the UK scientific and engineering community to remain disproportionately active in this field and the Mallet–Milne lectures are a key element in this.

The aim of the lecture series is to capture the experience of an eminent seismologist or earthquake engineer, giving them a platform to pass on those key elements that have characterised and formulated a distinguished career. The quality and variety of the lectures over the course of the series has achieved this objective handsomely with the subject matter covering the full range of specialisms that make up the broad disciplines of seismology and earthquake engineering whilst the geographical diversity of the speakers has ensured that experience has been drawn from across the globe.

Five of the lectures in the series have been dedicated to seismology and seismic hazard assessment. Indeed, the inaugural lecture was entitled 'Engineering Seismology' and was presented by Professor Nicholas Ambraseys of Imperial College, London in 1987. This described a new approach to the assessment of liquefaction potential and re-evaluation of twentieth century seismicity in Turkey. In the lecture Professor Ambraseys emphasised the importance of field observations and measurements to provide data for proper earthquake risk management. In the fifth Mallet–Milne lecture 'From Earthquake Acceleration to Seismic Displacement', Professor Bruce Bolt of the University of California at Berkeley discussed the destructive nature of near-field ground motions containing high energy pulses. The eighth Mallet–Milne lecture 'Living with Earthquakes: Know Your Faults',

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was presented by Dr. James Jackson of Cambridge University who addressed the identification and characterisation of active geological faults. Dr. Jackson illustrated the advances made in the determination of source parameters for earthquakes, in the understanding of the relationship between crustal deformations and geomorphology and in the developments of technology for measuring the deformation of the earth's surface. More recently, in the thirteenth lecture in the series, 'The Practice of Earthquake Geology: Career-Changing Events and Life Stories', Lloyd Cluff of the Pacific Gas and Electric Company, California, related a lifetime of field reconnaissance studies and of developing seismic hazard techniques and risk assessments for critical facilities around the world, including the Trans-Alaska Pipeline, Aswan Dam and Diablo Canyon Nuclear Power Plant. Finally, in the fourteenth Mallet–Milne lecture in 2013, Roger Musson of the British Geological Survey gave a remarkable overview of the contribution of British seismologists and engineers to the study of earthquakes in 'A History of British Seismology', which was particularly fitting as it coincided with the centenary of John Milne's death in 1913.

Directly following the determination of the seismology and seismic hazard comes the need to understand the local ground response, foundation behaviour and the potential for soil-structure interaction. This area of earthquake engineering has been covered by two of the Mallet–Milne speakers. In the seventh Mallet–Milne lecture, 'The Road to Total Earthquake Safety', Professor Cinna Lomnitz of the National Autonomous University of Mexico addressed the dynamics of seismic wave propagation, the response of soft soils and the coupling of ground response with structural response. The tenth Mallet–Milne lecture, presented by W.D Liam Finn, Anabuki Professor of Foundation Geodynamics, Kagawa University, Japan and Professor Emeritus at the University of British Columbia, focused more specifically on the design of foundations. 'A Study of Piles during Earthquakes: Issues of Design and Analysis' presented a critical overview of engineering practice for evaluating the response of pile foundations during earthquakes.

Moving on from the ground motion, the structural response of buildings subject to seismic excitation has been the subject of four of the Mallet–Milne lectures. In the third Mallet–Milne lecture 'Reduction of Vibrations', Professor Geoffrey Warburton of Nottingham University illustrated how the hazard, hence the risk, can be mitigated by engineering intervention through the application of dampers, base isolation and active control to limit the forces on structures subjected to earthquake loading. The next lecture in 1993 entitled 'Simplicity and Confidence in Seismic Design' was delivered by Professor Tom Paulay of the University of Canterbury, Christchurch, New Zealand. He used his extensive design experience to address the concepts that can be employed to ensure the predictable seismic response of reinforced concrete buildings. Explicit rules aimed at "telling the structure how to behave" through the selection and detailing of 'structural fuses' to protect more brittle elements of the structure were comprehensively presented. The issue of expected and actual behaviour of buildings was revisited in 1997 by Professor Roy Severn of the University of Bristol in the Sixth Mallet–Milne lecture. 'Structural Response Prediction Using Experimental Data', drew upon Professor Severn's lifetime experience in the dynamic testing of large structures around the world and the application of the results to earthquake engineering. The ninth lecture in the series was given by Nigel Priestley, Emeritus Professor of Structural Engineering of the University of California at San Diego, and co-director of the Rose School in Italy, in which he presented a challenge to the status quo in 'Revisiting Myths and Fallacies in Earthquake Engineering'. In the lecture he examined the fundamental principles for the seismic design of structures and concluded that in many cases, current practices, often embodied in design codes, were based on unrealistic concepts and approximations. In preference, he outlined progress towards the

development of simple and rational seismic design procedures based on displacement rather than strength considerations.

The devastating effects that earthquakes can wreak on societies across the world have also been addressed in a wider context, rather than focusing purely engineering or seismological considerations. Three of the Mallet–Milne lecturers have presented an holistic view of the risks involved, beginning with the second Mallet–Milne lecture, ‘Coping With Natural Disasters’, by Professor George Housner of the California Institute of Technology. Professor Housner addressed the challenges and perspectives of the International Decade for Natural Disaster Reduction, considering not only seismic hazards, but also other natural events such as floods, windstorms and wildfires, and addressed the need for improved communication of risks including information exchange, warning systems and education programmes. In the eleventh Mallet–Milne lecture, ‘Saving Lives in Earthquakes: Successes and Failures in Seismic Protection from 1960’, Professor Robin Spence of Cambridge University took a broad view of the extent to which earthquake risks to human life have been reduced. He presented an overview of almost half a century of statistics on earthquake casualties, disruption and costs, and made some important observations on changing attitudes towards earthquake risk. In the following lecture in 2009, ‘The Seismic Future of Cities’, Dr. Roger Bilham of the University of Colorado, Boulder, considered the risks associated with the projected doubling of the earth’s population in the next half century. He predicted that earthquakes with large return periods that had little impact on villages and towns in the past would in future be shaking urban agglomerations housing upward of 12 million people. The incorporation of earthquake resistant structures in the development of these megacities was therefore of increasing importance, placing a significant responsibility on the future generations of earthquake engineers to exercise their skill not only from a technical perspective, but from a political one as well.

The fifteenth Mallet–Milne lecture also falls into this category and builds upon the themes of the eleventh and twelfth lectures. In “Earthquake Safety in India: Achievements, Challenges and Opportunities”, Professor Sudhir K. Jain, Director of the Indian Institute of Technology Gandhinagar, gives a comprehensive overview of both those measures that have already been taken, and those that are still urgently needed, to reduce the seismic risk to the heavily populated areas of India. Whilst the focus of the lecture is on the Indian sub-continent, the message is widely applicable across large parts of the developing world.

Professor Jain graduated from the University of Roorkee, and obtained both Masters and Doctoral degrees from the California Institute of Technology, Pasadena during which time he encountered two former Mallet–Milne lecturers, Bruce Bolt and George Housner. Having served on the faculty of the Indian Institute of Technology Kanpur (IITK) since 1984, he is currently seconded to the new Indian Institute of Technology Gandhinagar in Ahmedabad as its Founder Director. Over the course of his career, Professor Jain has published widely in academic journals, has been a consultant for major projects such as bridges, dams and petrochemical pipelines, and has made a tremendous impact on earthquake engineering practice and education in India. He has been instrumental in the development of several important seismic codes in India, and has trained a huge number of professional engineers and college teachers in earthquake engineering through his highly successful continuing education programmes. He set up the National Information Centre of Earthquake Engineering (NICEE) at IITK and developed the National Programme on Earthquake Engineering Education (NPEEE), supported by the Government of India. Both of these initiatives are described in the lecture, being pivotal to the capacity building which is a key element in the effort to reduce the risk to the Indian population from large earthquakes.

Being Director of IIT Gandhinagar has given Professor Jain the opportunity to experiment not only with numerous ideas in curriculum, student affairs and faculty management, but also to introduce innovative techniques to improve the seismic robustness of the buildings in the new campus he is developing, as eloquently described in the lecture.

Professor Jain is the current President of the International Association for Earthquake Engineering (IAEE), having been elected to its Board of Directors in 2000. He also served on the Board of Directors of the World Seismic Safety Initiative from 2002 to 2009 and was elected Fellow of the Indian National Academy of Engineering in 2003. More recently, he was conferred Life Membership by the New Zealand Society for Earthquake Engineering (NZSEE) in 2013.

In the 15th Mallet–Milne lecture at the Institution of Civil Engineers in May 2015, Professor Jain explained the background to the seismic hazard in the Indian sub-continent and the early developments there triggered in response to very large earthquakes, particularly those of 1897 in Assam and 1931 and 1935 in Quetta, as well as the institutionalization of Indian earthquake engineering in the 1950s and 60s, in large part through the influence of A. N. Khosla. However, Professor Jain went on to argue that, despite the progress that has undoubtedly been made towards seismic safety in India, major challenges still remain. He focused particularly upon four aspects: the need to take advantage of windows of opportunity after major earthquakes when political support for improved safety is strongest; increased capacity building extending and augmenting existing initiatives such as the NICEE and NPEEE; new seismically-resilient building typologies that meet local needs in terms of materials, practices and weather conditions; and the urgent need to address several areas of concern including the lack of an effective competence-based licensing system for civil and structural engineers, the general lack of an environment which enables adequate enforcement of building code provisions and the somewhat indiscriminate adoption of trends from developed countries towards seismic safety, without adequate consideration of the local conditions.

Following the success of the open access publication of the fourteenth Mallet–Milne lecture in the *Bulletin of Earthquake Engineering*, SECED are pleased that the editors have once again agreed to publish the fifteenth Mallet–Milne lecture in its entirety, meaning that it will be freely available to download from the Springer website. We are confident that this will be an important addition to the knowledge base provided by the publication of the Mallet–Milne lecture series since 1987 and will be a valuable resource and inspiration, not only to earthquake engineers, but also to administrators and politicians, particularly in the more seismically active regions of the developing world.

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