The fourteenth Mallet–Milne lecture

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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. It is somewhat ironic that two men widely credited with instigating the scientific study of earthquakes should come from the British Isles; an area of low seismicity in world terms. Both Mallet and Milne were relatively unknown in their homeland, yet were held in high esteem in Italy and Japan, respectively, where they made significant contributions to the scientific understanding of earthquakes.

Robert Mallet was born in Dublin in 1810 and graduated in Science and Mathematics from Trinity College, Dublin, at the age of 20. He spent his early career working in his father's foundry business, supplying iron work for construction projects throughout Ireland. Later Mallet's interests turned to geology and earthquakes and he applied his knowledge of mechanics to the interpretation of the earth's movements. In 1835 he enrolled in the British Association for the Advancement of Science which helped to fund much of his research in seismology, publishing 'On the Dynamics of Earthquakes' in 1848 and, with the help of his son, 'The Earthquake Catalogue of the British Association' in 1858, both of which were seminal publications. Following the Great Neapolitan Earthquake of 1857 he travelled to Padula in Italy to study at first hand the devastation of that event. Such were his pioneering skills, he produced for the first time a map showing isoseismal lines to record the severity of the earthquake experienced in different areas, and used the relatively new invention of photography to record the damage; a first in scientific research. The results of his detailed research in Italy were documented in the 'Great Neapolitan Earthquake of 1857: the First Principles of Observational Seismology', published as two volumes in 1862. The publication would come to be considered as a classic work in seismology, and cement Robert Mallet's place in Italian seismological history.

John Milne was born in Liverpool in 1850 and enjoyed an eventful career quite unlike that of any of his peers. He studied at Kings College, London and the Royal School of

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Mines, and following an early career as a mining engineer, was appointed, at the age of 25, as Professor of Mining and Geology at the Imperial University of Tokyo. Following the Yokohama Earthquake of 1880 his attention was drawn to the study of earthquakes, with a view to saving life and property. Milne had an active career in seismology in Japan and was instrumental in establishing the serious scientific study of earthquakes. He is generally credited with the invention of the horizontal pendulum seismograph and producing the first codes of practice for civil engineers in seismic regions. Along with Sir James Alfred Ewing and Thomas Gray (two other British scientists working in Japan) he founded the Seismological Society of Japan in 1880. On leaving Japan in 1895, Milne was awarded the Order of the Rising Sun from the Meiji Emperor; an honour rarely awarded to a foreigner. On his return to the UK, Milne established an observatory at his home in Shide on the Isle of Wight, where he continued his scientific studies. He went on to establish the first global network of seismograph stations under the auspices of the British Association for the Advancement of Science.

The concept of the Mallet–Milne lecture series is to capture a lifetime of experience from eminent professionals who have spent their careers working in the field of seismology or earthquake engineering. This objective has certainly been met over the years with a series of eminent speakers presenting a wide variety of earthquake related topics, ranging from seismology through to detailed design and testing.

Four of the lectures in the series have been dedicated to seismology and seismic hazard assessment. In the first Mallet–Milne lecture (in 1987), ‘Engineering Seismology’ Professor Nicholas Ambraseys of Imperial College, London, 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. In the eighth Mallet–Milne lecture ‘Living With Earthquakes: Know Your Faults’ Dr. James Jackson of Cambridge University 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. In the thirteenth lecture in the series, ‘The Practice of Earthquake Geology: Career-Changing Events and Life Stories’, Lloyd Clough of the Pacific Gas and Electric Company, California, related a lifetime of field reconnaissance studies and 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.

Once the seismology and seismic hazard have been addressed the engineer has to understand the local ground response, foundation behaviour and the potential for soil–structure interaction. Two of the Mallet–Milne speakers have addressed these issues. 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, ‘A Study of Piles During Earthquakes: Issues of Design and Analysis’ was presented by W.D Liam Finn, Anabuki Professor of Foundation Geodynamics, Kagawa University, Japan and Professor Emeritus at the University of British Columbia. Professor Finn presented a critical overview of engineering practice for evaluating the response of pile foundations during earthquakes.

Four of the Mallet–Milne speakers have addressed various issues associated with the structural response of buildings subject to seismic excitation. 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 fourth Mallet–Milne lecture 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” were presented in a comprehensive fashion. The issue of expected and actual behaviour of buildings was revisited in the Sixth Mallet–Milne lecture in 1997. Professor Roy Severn of the University of Bristol presented ‘Structural Response Prediction Using Experimental Data’, drawing on his lifetime experience in the dynamic testing of large structures around the world and the application of the results to earthquake engineering. In the ninth lecture in the series Nigel Priestley, Emeritus Professor of Structural Engineering of the University of California at San Diego, and co-director of the Rose School in Italy, presented ‘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.

Earthquakes can of course have devastating effects on societies across the world and three of the Mallet–Milne lecturers have presented an holistic view of the risks involved. In the second Mallet–Milne lecture, ‘Coping With Natural Disasters’, Professor George Housner of the California Institute of Technology addressed the challenges and perspectives of the International Decade for Natural Disaster Reduction. He considered not only seismic hazards, but also other natural events like 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 a retrospective on 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 twelfth Mallet–Milne lecture, ‘The Seismic Future of Cities’, Dr. Roger Bilham of the University of Colorado, Boulder, looked forward to 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 fourteenth Mallet–Milne lecture is particularly poignant as it coincides with the centenary of John Milne’s death in 1913. In recognition of the continuing legacy of British seismologists and engineers to the study of earthquakes, the fourteenth Mallet–Milne lecture is ‘A History of British Seismology’, presented by Dr. Roger Musson of the British Geological Survey (BGS). Dr. Musson is a graduate of Queens University, Belfast, and Edinburgh University, and is currently Head of Seismic Hazard and Archives at the BGS. He is a Fellow of

the Geological Society of London, a Fellow of the Royal Astronomical Society, and a Member of the Seismological Society of America, the Earthquake Engineering Research Institute, and the American Geophysical Union. He has published widely in the field of seismology and seismic hazard and was Chairman of the ESC Working Group on Macroseismology.

Whilst earthquakes may be as old as history, it is still surprising to learn from Roger's lecture that the oldest theoretical writing on earthquakes in Britain dates back to the end of the twelfth century, and perhaps even more surprising that the first attempt in Britain to make a proper scientific study of an earthquake was as early as 1666. If you look into the development of any branch of scientific study you will invariably find periods when perfectly plausible theories have been promulgated by learned scholars and practitioners, only to be proven with time to be entirely false. When we are dealing with seemingly random natural processes like earthquakes it is hardly surprising that some of the early writers on the subject matter should fall victim to the same phenomenon. We learn from Roger's review of these early works how hard it was to make accurate deductions from very limited observational data.

Those familiar with the works of Robert Mallet and John Milne will be well aware of the major contribution that they made to the early advancement of the science of seismology. Perhaps less well known is that around the same time, what was almost certainly the world's first local network of seismic instruments was being deployed in Perthshire, Scotland, using inverted pendulum instruments invented by James Forbes. Roger's lecture gives us a fascinating insight into the work of these early pioneers through the macroseismic recording of earthquakes in the nineteenth century to the network of seismograph stations instigated by the by the Institute of Geological Sciences (now the British Geological Survey) in the 1970s.

Hosting the Mallet–Milne lecture and arranging the publication of the manuscript is a significant financial undertaking for SECED, and in this respect we are extremely grateful for the contribution from our sponsors for the 2013 event; the Institution of Civil Engineers, the Gray–Milne Fund, and the British Geophysical Association.

SECED is pleased that the Editors of the Bulletin of Earthquake Engineering have agreed to publish the Fourteenth Mallet–Milne lecture in its entirety. The Mallet–Milne lecture has traditionally been published in hardcopy format, but this year for the first time, the lecture will be available as an 'open access' publication, which means that it will be free to download from Springer's website. It will of course also be available in hard copy. Making the publication available as open access will significantly increase the readership and dissemination of knowledge worldwide. Together with the previous Mallet–Milne lectures we are confident that this will prove to be a valuable resource for seismologists and earthquake engineers for years to come.

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