Geotechnical, Geological and Earthquake Engineering

Fabio Taucer
Roberta Apostolska *Editors*

Experimental Research in Earthquake Engineering

EU-SERIES Concluding Workshop

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Preface

The construction of earthquake resistant buildings was based for centuries on the observation of earthquake damage to the built environment and the adoption of corrective measures during reconstruction. As a result, the areas affected by earthquake disasters have served as large fields for testing construction practice, albeit in an uncontrolled way. The advent of laboratory-controlled experiments, in combination with field observations, allowed during the last decades a fast advancement towards what we know today as modern earthquake engineering, which required experimental tests to be representative of real conditions in the field. It meant the use of full-scale specimens, accurate control of boundary conditions and reliable readings of response, which implied continuous evolution of the infrastructure supporting the experimental tests, still today one of the main challenges in earthquake engineering.

Shaking tables and reaction frames/walls coupled with hydraulic actuators have been in use for more than half a century for carrying out experimental tests in earthquake engineering. This has permitted the development of new design procedures and innovative technologies for earthquake protection, as well as the calibration of numerical models. In Europe, experimental testing has been at the fore-front of pre-Normative research in support of the European standards for construction, in particular of EN 1998 (Eurocode 8: Design of structures for earthquake resistance), through the participation of smaller scale labs, mostly for testing of sub-assemblages and components, up to large laboratories for full-scale validation and demonstration tests. Geotechnical centrifuges have also been used in earthquake engineering for studying wave propagation and soil-structure interaction phenomena, for both surface and embedded structures.

In an effort towards capitalizing on the existing infrastructures in Europe for experimental testing in earthquake engineering, the European Commission financed the SERIES Project (Seismic Engineering Research Infrastructures for European Synergies, www.series.upatras.gr) under grant agreement n° 227887 of the Research Infrastructures Programme in the Seventh Framework Programme. The project was coordinated by Prof Michael N. Fardis of the University of Patras. It aimed at fostering a sustainable culture of co-operation among all research infrastructures, by taking advantage of their complementarities while at the same time bringing the less advanced infrastructures to the levels of the most advanced ones. A major part

of the project was devoted to transnational access of users to a world-class portfolio combining Europe's largest facility for pseudo-dynamic testing, four diverse shake tables and two centrifuges. The project also envisioned joint research activities towards new fundamental technologies and innovative techniques, promoting efficient and joint use of the research infrastructures.

In this volume, experts from Europe, USA and China present their work in the three areas addressed by the SERIES Project: networking, transnational access and joint research activities. The networking activities include the development of a public distributed database of past, present and future test results, distributed testing capabilities, hybrid simulation, telepresence, and protocols for qualification of Research Infrastructures. The results of transnational access activities are presented for a number of projects among the 27 carried out at the seven large-scale infrastructures of SERIES, ranging from the retrofit of existing to the design of new reinforced concrete, steel, masonry and wood structures, as well as soil-structure interaction and wave propagation. The joint research activities explored novel techniques for better control of fast tests or special applications, new sensing and instrumentation systems, data assimilation in equipment-specimen models for better test control and optimisation of testing campaigns, as well as experimental studies of soil-structure interaction.

The SERIES concluding workshop on "Earthquake Engineering Research Infrastructures" was held at the Joint Research Centre of the European Commission at Ispra, Italy on May 28–30, 2013, jointly with the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES, USA). The workshop attracted a large audience to listen to renowned experts from around the world presenting close to 55 invited contributions. The event was dedicated to the memory of Prof Roy Severn, who established and led the EQUALS facility at the University of Bristol and co-ordinated seismic infrastructure projects which preceded SERIES in past Framework Programmes, notably ECOEST I and II and ECOLEADER.

We gratefully acknowledge the support of Ms Claudia Carniel from the Joint Research Centre, and Ms Vassia Vayenas and Dr Dionysis Biskinis from the University of Patras for their contribution to the organisation of the SERIES Workshop at Ispra.

In Memory of Prof Roy Severn

Professor Roy Severn CBE FREng FICE initiated and led the formation of the strong network of European earthquake engineering laboratories that has underpinned European research in this field for nearly 25 years, leading to EU funded projects including ECOEST1, ECOEST2, ECOLEADER, CASCADE, FUDIDCOEEF and SERIES. All these projects promoted the development and application of large scale shaking table, reaction wall and centrifuge experiments, enabling a large number of EU researchers to access a network of world class facilities. The resulting research has led to many advances and has underpinned the development of Eurocode 8.

Roy joined the University of Bristol as a lecturer in 1956, becoming a Pro Vice Chancellor, twice Dean of Engineering, Head of the Department of Civil Engineering and Director of the Earthquake Engineering Research Centre, before retiring in 1995. He was elected President of the Institution of Civil Engineers in 1990–1991.

Roy Severn was born in Hucknall Nottinghamshire on 6th September 1929. He eventually moved with his family to Great Yarmouth, spending his final 6th form year at Great Yarmouth Grammar School.

At the end of the war, in 1947, he read mathematics at the Royal College of Science in London. He played cricket, rugby and soccer and as a direct consequence met Professor Sammy Sparkes of Imperial College when they both played for the

Wasps Rugby Club. Sparkes persuaded Roy that a career in Civil Engineering would be sensible. At that time Roy also met Deryck N. de G. Allen who was later to become his PhD supervisor at Imperial College. Allen was a student of Sir Richard Southwell who was developing numerical relaxation techniques for the solution of large sets of equations. The Consulting Engineers, Binnie, Deacon and Gourley had a commission to design the Dokan Arch Dam near Baghdad. They asked Allen for help so he and Roy took on the task and spent many hours with hand calculators grinding out numerical stress analysis solutions.

In 1956, after National Service with the Royal Engineers, during which he served as a 2nd Lieutenant in Egypt, Cyprus and Aden, Roy was offered a lectureship in civil engineering at Bristol. That same year, the Institution of Civil Engineers set up an Arch Dams Committee, chaired by Sir Angus Paton, to investigate the potential of the emerging finite element technique. Roy was the most junior member of the committee and was allocated the task of developing numerical earthquake response analysis techniques. This was the starting point of earthquake engineering research at the University of Bristol.

Although a mathematician by background, Roy recognised the importance of large scale experimentation and prototype observations in seeding and validating theory and analysis. In 1981, he won the Telford Gold Medal of the Institution of Civil Engineers with Alan Jeary and Brian Ellis of the Building Research Establishment for their pioneering work on forced vibration testing of embankment dams using a novel eccentric mass exciter system. Then, in 1984, Roy became a member of the Civil Engineering Committee of the UK Science and Engineering Research Council. He won the bid from that committee to set up a 15 t capacity, six degree of freedom shaking table capable of testing large structural components and models with simulations of real earthquakes. At the same time, Roy promoted the SERC's initial funding of the UK Earthquake Engineering Field Investigation Team (EEFIT).

In 1990, the European Commission invited Roy to co-ordinate the large earthquake engineering facilities in LNEC (Lisbon), ISMES (Italy), NTU Athens and Bristol in a joint programme to calibrate and improve the performance of shaking tables. This project put Europe's shaking table facilities amongst the best in the world and led to the sequence of EU funded projects listed above. The ELSA reaction wall facility at JRC Ispra, the shaking tables at CEA Saclay and EUCENTRE Pavia, and centrifuges at Cambridge and IFSTTAR Nantes subsequently joined the laboratory network, making their facilities available to researchers from across the EU. Roy continued to co-ordinate this European laboratory-based earthquake engineering research until 2005—some 10 years after his official retirement—leaving behind a thriving, world class, research community that continues to underpin improvements in global earthquake safety.

In 1981, Roy was elected a fellow of Royal Academy of Engineering. In 1992, he was awarded a CBE for services to Civil Engineering. In 1997 he delivered the 6th Mallet-Milne Lecture entitled "Structural Response Prediction Using Experimental Data".

Roy was still working right to the end. His last big project was a book of the history of the Faculty of Engineering at the University. He, very generously, funded its production and donated the royalties to the University to set up a scholarship fund for students.

Roy Severn died on 25 November 2012, aged 83. He is survived by his wife Hilary, daughters Fiona and Elizabeth and his five grandchildren.

The European Research Infrastructures on earthquake engineering will always remember Roy Severn as the initiator of a long and successful period of European research and collaboration. We all acknowledge Roy for his continuous leadership and European spirit.

Bristol, UK — Colin Taylor
Patras, Greece — Michael N. Fardis
Ispra, Italy — Artur V. Pinto
August 2014

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