Earthquake engineering research in the UK

Edmund Booth, consulting engineer and member of the Institution's Research Panel presents a round up of research activity of interest to practitioners

Dating back to the days of Robert Mallet (1810 – 1881) and John Milne (1850 – 1913), the UK has a long tradition of research into earthquake resistant design and this continues today. A recent report1 by the UK Society for Earthquake and Civil Engineering Dynamics (SECED) on how to enhance utilisation of seismic research by the UK consulting industry found a wide range of relevant research at 13 centres. One recommendation of the SECED report was that SECED should commission a web-based directory of UK-based academic research centres and researchers engaged in seismic research, and the SECED committee has decided to fund this project, which is expected to be completed by the end of next year. The directory will be searchable by topic, and the intention is that it will make it easier for practitioners facing a particular problem in seismic engineering to find academic personnel with relevant expertise. For further details, please contact the secretary of SECED at the Institution of Civil Engineers (tel: 020 7665 2238 email: secretary@seced.org.uk).

A snapshot of some current projects at various centres, which may be of interest to practitioners follows. Strong motion and seismic hazard studies, steel, steel-concrete and historic masonry buildings structures, energy dissipating devices and earthquake field reconnaissance are all featured.

a) Imperial College

Work on seismic demand continues under the leadership of Dr Julian Bommer, focusing on earthquake hazard assessment and the characterisation of seismic ground motion for engineering analysis and for design codes. Topics of current focus in this area include the influence of duration on inelastic structural response, the selection and scaling of acceleration time-histories for dynamic analysis, and the definition of input for displacement-based seismic design. Research on structural aspects of earthquake engineering is headed up by Dr Ahmed Elghazouli with major projects on the seismic behaviour and design of braced steel frames and steel-concrete composite structures, both involving analytical modelling and dynamic testing. Another current area of research in this field is the vulnerability assessment of existing reinforced concrete buildings, with case studies focusing on design practice in several Mediterranean countries. Collaborative work between the Engineering Seismology and Structural Earthquake Engineering groups is focused on the development of earthquake loss estimation models.

Imperial College, under Professor Nick Ambraseys, has been involved for a number of years in the production of a European database of strong motion records, produced to a common format by collaboration between a number of European centres. The second volume of the database is now available. These records may be of particular use to practitioners involved in the analysis of structures in seismic areas of Europe.
For further details, contact Dr Ahmed Elghazouli (email: a.elghazouli@ic.ac.uk).

b) University of Bath

While dynamics research at Bath on new built construction concentrates on reducing and controlling vibration, the large majority of the existing building stock proves highly vulnerable to major earthquakes and represents a life threat for many communities worldwide. Following on from reconnaissance missions in earthquake stricken areas in collaboration with EEFIT (see item (d)), the earthquake engineering research group at Bath University has carried out extensive work on the assessment of seismic vulnerability of historic masonry buildings (see Fig 1). This research activity has led to the development of a procedure called FaMIVE (Failure Mechanism Identification and Vulnerability Evaluation), which has been applied to a number of real case studies in India, Nepal, Italy, Turkey and Portugal. The procedure is based on a limit state analysis approach and uses plasticity theory, modified to be applicable to masonry, in order to quantify the most likely collapse mechanism and associated collapse load factor for on street façades of ordinary residential historic masonry houses. The vulnerability of a given sample is then calculated using a probabilistic approach and identifying a number of typical fragility curves for the sample, depending on construction and structural details surveyed *in situ*. The application to

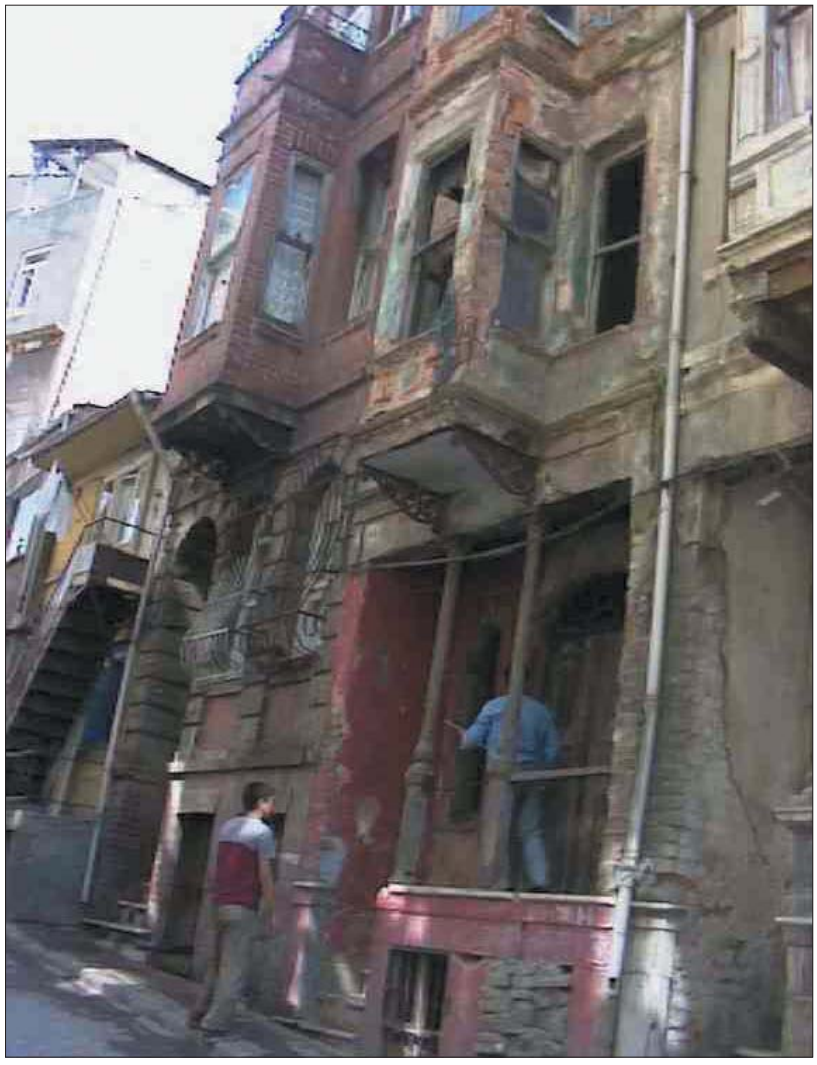

Fig 1. Vulnerable historic masonry building with oriel windows and portico in Istanbul

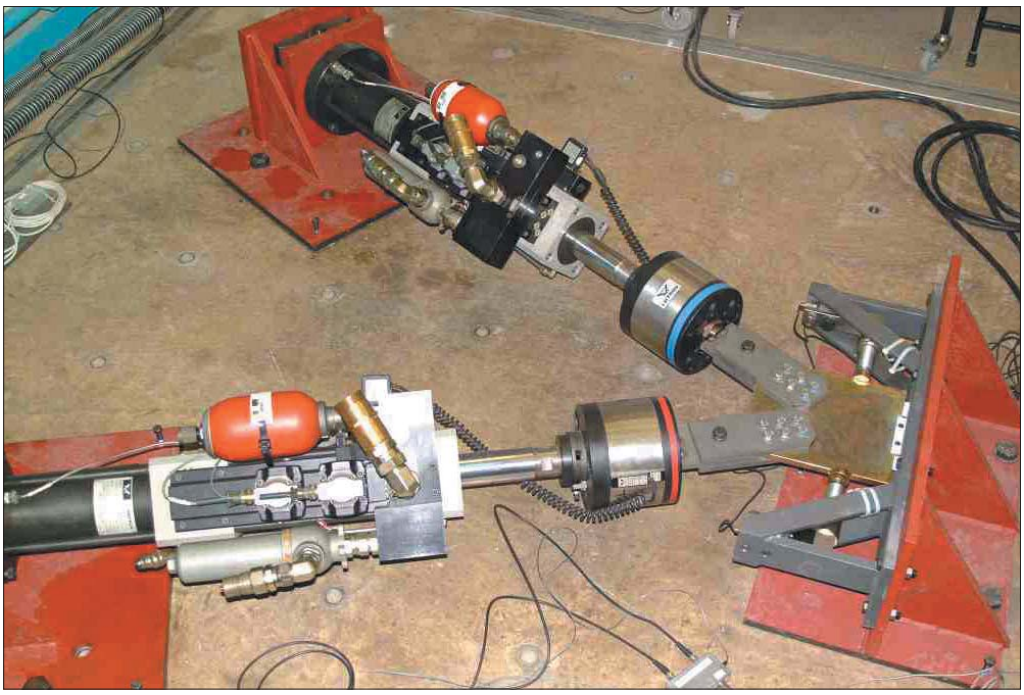

Fig 2. Test rig consisting of two small visco-elastic dampers mounted in a K-braced frame

two historic districts in Istanbul, sponsored by European funding, have led to the definition of damage scenarios.

A similar approach is being applied to evaluating the seismic vulnerability of existing low engineered masonry infilled reinforced concrete frames, such as the one that caused the widespread casualties in Turkey, India, and more recently Algeria. The number of parameters that define the problems is very large, and their variability great, as real cases differ substantially and in different ways, from the codified guidelines. Research work follows two parallel activities; one based on 3D non linear push over analysis of infilled frames with a predefined set of irregularities, relating mainly to geometry, the second one looking at range of existence of different failure modes in relation to various combinations of material parameters.

Another important resource for practitioners is the World Housing Encyclopedia, an Internet based database at www.world-housing.net, sponsored by the Earthquake Engineering Research Institute and the International Association for Earthquake Engineering in the USA. This lists typical building construction types and assesses their likely seismic performance. Dr D'Ayala of University of Bath is the European editor. *For further details, please contact Dr Dina D'Ayala (email: absdfda@bath.ac.uk)*

c) University of Oxford

Earthquake engineering research at Oxford is led by Dr Martin Williams and Dr Tony Blakeborough. Their main interests are in the assessment of structural response to earthquakes and the development of new earthquake-resistant construction techniques. Both numerical modelling and laboratory testing are used, the latter based around a novel experimental technique which has been developed, known as real-time substructure testing.

A particular area of current interest is the use of energy dissipators in seismic design and retrofit. In dissipative design, the aim is to concentrate the energy absorption in purpose-designed dissipative elements, thus limiting (or possibly preventing entirely) damage to the main structure. Many different dissipative devices exist or have been proposed, including viscous devices, friction mechanisms, rubber dissipators and yielding elements, which absorb energy through sacrificial plastic deformation. However, comparatively few have been rigorously tested. At Oxford a variety of devices using the real-time substructure method are being tested, in which a physical test on the device itself is coupled to a numerical analysis of the surrounding structure. By linking the physical test and numerical model together via a real-time feedback loop, it is possible to create an accurate simulation both of the device behaviour (including rate-dependent effects) and of its influence on the overall structural response. Fig 2 shows a test on an assembly consisting of two small visco-elastic dampers mounted in a K-braced frame. The frame is modelled numerically and servo-hydraulic actuators simulate the forces and deformations imposed on the device by the main braces.
For further details, please contact Dr Martin Williams (email: martin.williams@eng.ox.ac.uk).

d) EEFIT

The UK Earthquake Engineering Field Investigation Team (EEFIT) was established in 1982 as a joint academic/industry body with the aim of carrying out regular investigations of earthquakes. The purpose is two fold; to report on what lessons may be learned, and to provide learning opportunities for less experienced members of the field missions. EEFIT is self-financing but receives administrative support from the Institution of Structural Engineers.

The field missions are broadly split 50/50 between university and industry members. Academic members are normally able to obtain funding from the Engineering and Physical Sciences Research Council, who have been consistent supporters of the objectives of EEFIT. Industry members are funded by their employers, and the willingness of industry to carry these costs over the past 20 years is an encouraging vote of confidence in the value of EEFIT's efforts and the real training benefits to be gained. Since 1983, reports have been published on 19 destructive earthquakes worldwide.

Most recently, EEFIT hosted an evening meeting on the Bam, Iran, earthquake of December 2003 (see Fig 3), with presentations by Halcrow and University of Westminster who had conducted field missions. se

Further details may be found on the EEFIT website at www.eefit.org.uk, or by contacting Berenice Chan (email: mail@eefit.org.uk) at the Institution of Structural Engineers.

Fig 3. Non-engineered mud brick arch structure after the Bam, Iran earthquake

REFERENCES

1. SECED Working Party The Implementation in the UK of Earthquake Engineering Research. SECED August 2001, (www.seced.org.uk/rwp/report.pdf)