Erasmus Mundus
www.msc-sahc.org

SHORT COURSE

Seismic assessment and improvement of unreinforced masonry buildings
Comportamento e reforço sísmico de edifícios de alvenaria

Prof. Jason Ingham

University of Auckland, New Zealand

Guimarães, February 2, 2012

Lisbon, February 7, 2012

Objective

Unreinforced masonry (URM) buildings are both the oldest and most cherished buildings of many communities, and the class of buildings that are repeatedly shown to be most seismically vulnerable in an earthquake. Generally iconic or important publicly owned URM buildings attract funds that enable sophisticated inspections and associated computer modelling to be undertaken. However, such buildings represent a small proportion of the entire buildings stock and there is a requirement to be able to rapidly perform seismic assessment and retrofit of regular, less iconic URM buildings if their performance in an earthquake is to be improved.

Prof. Jason Ingham was the Principal Investigator of a large research project tasked with generating new knowledge on the seismic assessment and retrofit of unreinforced masonry buildings, with findings reported in the form of an industry user guide suitable for use by professional structural engineers. This user guide was being disseminated to practitioners at the time of the Canterbury (New Zealand) earthquakes in early 2011, and has since been widely used in the assessment of damaged buildings. Prof. Ingham was also the principal researcher responsible for collecting data on the performance of all forms of masonry buildings in the Canterbury earthquake swarm.

After participating in this Course, you will be able to:

- Define the seismic loads in masonry buildings and elements
- Assess the seismic safety of masonry building components
- Define adequate strengthening measures

Who should attend?

Design Engineers, Site Engineers, Contractors, Local Authorities, Research Engineers and Graduate Students.

Fees, Dates and Location

The fee for the participation in the 1-day course is 125 euro (until January 16) and 175 euro (after January 16). For MSc and PhD students a 60% reduction applies upon submission of a valid certificate. For enrolment and further information please contact:

- Guimarães: Ms. Paula Teixeira, phone (+351 253510218), fax (+351 253510217), email (sec.estruturas@civil.uminho.pt).
- Lisbon: FUNDEC – Mrs. Fernanda Correia / Ms. Vanessa Silva, phone (+351 218418042), fax (+351 218418193), email (fundec@civil.ist.utl.pt).

Dates:	Guimarães, February 2, 2012, 9:00-12:30 / 14:00-17:30 Lisbon, February 7, 2012, 9:00-12:30 / 14:00-17:30
Duration:	1 day, 7 hours
Location:	Guimarães, Universidade do Minho (Room to be announced) Lisbon, Instituto Superior Técnico (Room to be announced)

Course Outline

Part 1: Earthquake observations

The findings from the Canterbury earthquakes will be compared with other earthquakes worldwide, to emphasise damage modes to unreinforced masonry buildings that repeat themselves, plus report observations that are specific to various building components. Particular attention will be given to the performance of seismically retrofitted masonry buildings, to outline the adequacy or deficiency observed in various improvement techniques.

Part 2: Material properties

The properties of the bricks, mortar and timber of unreinforced masonry buildings vary greatly. For projects with a limited budget it may be necessary to establish suitable design values based upon brief site inspections. Details will be presented on a range of available techniques, with attention given to the properties of fired clay bricks and lime mortar. Typical values for stone masonry used in Portugal will also be given.

Part 3: Loads on building components

Most masonry buildings have flexible timber diaphragms, and the structural dynamic characteristics of such buildings are generally poorly understood. For a given design spectra, information will be presented on how to attribute seismic loads to the in-plane and out-of-plane loaded walls, to determine the loads on diaphragms and wall-diaphragm connections, and to determine the loads on parapets.

Part 4: Seismic assessment of in-plane loaded masonry frames

The in-plane loaded walls provide the principal rigidity to an earthquake loaded URM building. These walls may be treated as equivalent frames, with the capacity of piers and spandrels investigated. Several failure modes exist for these elements dependent on their geometry, axial load, and materials properties. A procedure to assess the capacity of masonry frames will be presented.

Part 5: Seismic assessment of timber diaphragms

Timber diaphragms exhibit a surprisingly complex behaviour when loaded in-plane in an earthquake, with their deformation being attributable to both flexure and shear. Methods for determining the stiffness and the strength of timber diaphragms will be presented.

Part 6: Seismic assessment of out-of-plane loaded walls

Out-of-plane loaded walls are perhaps the most vulnerable component of a URM building. A variety of techniques have previously been developed to predict the performance of such walls. These methods will be discussed and the procedure now adopted in the New Zealand user guide will be presented in detail.

Part 7: Seismic assessment of parapets

All parapets in URM buildings should be restrained or can be expected to fail when loaded in a moderate sized earthquake. The procedure used to assess the vulnerability of masonry parapets will be presented.

Part 8: Principles of heritage conservation

Guidelines exist for the appropriate strategy for implementation of seismic improvements in a manner that minimises the impact on the heritage attributes of the building. These guidelines will be presented.

Part 9: Stiffening and strengthening diaphragms

Stiffening and strengthening of timber diaphragms is frequently necessary in order to control out-of-plane wall deformations at diaphragm level. The use of added sheet overlays or underlays has been shown to be cost effective and extremely effective. Details will be provided.

Part 10: Connections

One of the principal deficiencies of URM buildings is the lack of mechanical anchorages between structural elements, and particularly wall-diaphragm connections. Details will be presented for through-bolt or anchor plate type connections and for adhesive anchors set into the masonry.

Part 11: Post-tensioning masonry walls

Post-tensioning of masonry is not a particularly common technique, but has been repeatedly shown in past earthquakes to provide excellent response. The post-tensioning extends the known characteristics of masonry structures, which are that they perform well in compression. Details regarding post-tensioning will be presented.

Part 12: Strengthening masonry walls using surface bonded and near surface mounted materials

The general method for strengthening masonry walls is to add supplementary material, using either surface bonded techniques or near surface mounted techniques. Fibre reinforced polymers have become one of the most accepted supplementary materials because of their high stiffness and strength and their low added mass, but other composite materials are also available such as textile reinforced mortars and fibre reinforced shotcrete mortars. Design procedures for these various wall reinforcement techniques will be presented.

Instructor

Dr. Jason Ingham did his BE and ME at The University of Auckland, followed by a PhD at the University of California at San Diego, USA. Supervised by Professor Nigel Priestley and Professor Freider Seible he investigated the seismic response of elevated concrete freeway frames and funded by the California Department of Transportation (Caltrans). Dr. Ingham joined The University of Auckland as a staff member in 1995 and undertook an MBA in 2004.

For the last 6.5 years he has led the largest ever structural engineering project to be undertaken in New Zealand. The project has been a collaboration between the University of Auckland and the University of Canterbury and within the project he has supervised 12 doctoral students investigating aspects of the seismic assessment and improvement of unreinforced masonry buildings. This research has resulted in the authoring of a national document on the subject that has been disseminated through professional seminars to structural designers nationwide. The document is also a teaching resource for post-graduate students. More recently New Zealand has had two large earthquakes which have resulted in substantial damage to unreinforced masonry buildings in the city of Christchurch. Prof. Ingham has been closely involved in the immediate post-earthquake assessment of these buildings, and he is closely involved in the repair process for some buildings and in experimental opportunities to test some of the damaged buildings that are to be scheduled for demolition.