The Institution of Structural Engineers

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2011 MSc Research Grant Scheme

Project title: Calibration of non-linear response history analysis results with observed structural damage in the 2010 Maule (Chile) Earthquake

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Aims of research: Earthquake engineering researchers somewhat facetiously describe earthquakes as full scale shake table experiments, and yet it is difficult to obtain a complete set of useful data, including material strengths, building geometries, earthquake ground motion and structural damage. As part of EEFIT fieldwork following the 2010 Maule Earthquake in Chile, the applicant obtained a large body of data for an apartment building in Talca. The main aim of this research is to compare the expected damage calculated using nonlinear response history analysis and numerical damage indices from the literature with real observations of damage following an earthquake.

Description of method: As part of EEFIT fieldwork following the 2010 Maule Earthquake in Chile, the applicant obtained a large body of data relating to an 18-storey apartment building located in downtown Talca, including structural drawings, material specifications, and photos of damage taken immediately after the event. Like most modern midrise and highrise construction in Chile, the building structural system comprised reinforced concrete (RC) shear walls, and there was little observable structural damage, with the exception of significant spalling in lintel beams above many apartment doorways. Damage photos included a photo of lintel beams above every doorway, labelled with apartment number for referencing with building plans. The University of Chile has also recently released earthquake ground motion data from the earthquake, including a free-field recording from Talca.

The project will involve building a nonlinear structural model of the building in appropriate analysis software (such as Perform3D, OpenSees, or Ruaumoko). Due to the long duration of the earthquake ground motion (2-3 minutes of strong ground shaking) it will be necessary to model the strength and stiffness degradation of RC elements under multiple cycles of response. Nonlinear response history (time history) analysis of the building model will be carried out, using the Talca recording as input. Numerical damage indices from the literature will be evaluated for each of the RC shear walls and lintel beams, and will be compared with photos of structural damage.

Additional response history analyses will also be carried out for other ground motions which are similar in intensity to the Talca recording (to assess the sensitivity of the response to the ground motion selected) and for ground motions compatible with the Chilean code demand for the area (to assess building compliance with expected code performance). The work will draw preliminary conclusions about Chilean seismic design practice based on the obtained results.

Benefits to structural engineering: The study will ideally provide “experimental” validation of nonlinear response history analysis methods and numerical measures of damage from the literature. The work will also put the report from the EEFIT field team into perspective – very little observed damage in modern construction may be seen as a success story for Chilean seismic design practice, but this needs to be evaluated with respect to the levels of earthquake ground motion that were experienced, and the expected performance in a potentially larger design earthquake. This will inform not just the Chilean seismic community, but international researchers, practitioners and code developers.

Proposed finish date: 09/2011