The Institution of Structural Engineers

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2012 MSc Research Grant Scheme

Project title: The effect of directionality of ground motion on moment-resisting space frame models

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Aims of research: The strength of horizontal earthquake ground shaking varies with orientation, and yet is typically condensed into a single response spectrum for seismic design. This obscures the difference between ground motions that are highly polarised (strong in one direction) and those that are more orientation-independent. Different structures are affected by this polarisation to different degrees, and this effect needs quantifying for use in seismic codes. Initial work has been carried out on this topic at UCL and Arup on simple bridge pier models. The aim is to extend these early studies to more complicated structures, such as moment-resisting space frames.

Description of method: This work will extend the methodology from previous UCL/Arup studies, documented in the MSc thesis of Padilla (2010), to reinforced concrete (RC) space frame models. Two suites of ground motion records were developed as part of these earlier studies, using the program RspMatchBi, with each suite characterised by different orientation dependence and seismic demand: (i) orientation-independent, matched to the expected geometric mean spectrum; (ii) orientation-dependent, with a strong and weak axis of shaking. The student will develop 3D fibre analysis models of space frames using earthquake engineering simulation software, which is able to describe the response of beams and columns under bidirectional loading. Failure criteria will be defined, based on strain limits in concrete and reinforcing bars. Ground motions will be applied to the model in 9 degree increments. For each ground motion, iteration will be performed to determine a scaling factor for the ground motion such that “failure” (with respect to the strain limits defined above) occurs in 50% of orientations. Frames with shared corner columns (which are loaded by strong shaking in each of two orthogonal directions) will be compared with frames with independent columns in the moment frames. Other parameter studies will be carried out on varying the height of the frame, and the relative stiffness and strength in each direction. Results will be summarised in a directionality factor that can be used to increase or reduce code demands for different types of structural system, analogous to the directionality factor for wind effects that is already included in the US loadings standard, ASCE 7-10. Results will also be compared with those found in the earlier studies based on simpler models. This work will be submitted to the SECED Young Engineers Conference in 2012.

Benefits to structural engineering: Present codes do not take into account the way in which different structures respond to bidirectional ground motions. In the US loadings standard (ASCE 7-11), the effect is considered for wind loading with a directionality factor, Kd. The aim of this study would be to produce a similar factor that applies for seismic ground motion, that is a function of the arrangement of the lateral-load resisting system. Quantifying this effect would also provide information to architects and engineers about which arrangements of structural components are more or less effective at resisting bidirectional earthquake loading.

Proposed finish date: 09/2012