The Institution of Structural Engineers

International HQ
11 Upper Belgrave Street
London SW1X 8BH
United Kingdom
tel: +44 (0)20 7235 4535
fax: +44 (0)20 7235 4294
mail@istructe.org
www.istructe.org

2013/14 Undergraduate Research Grant Scheme

Project title: Optimisation of column-beam connections using beam web perforation

University: University of Leeds

Supervisor: Konstantinos Tsavdardis

Student: tba

Aims of research:
The Northridge and Kobe earthquakes back in the 90's taught us some good lessons regarding the aseismic design of steel structures. Welded steel connections proved unsatisfactory and novel alternatives that can implement the strong column – weak beam capacity design principle, enhancing the overall performance were pursued. Inspired by the subsequent Reduced Beam Section (RBS) solutions for beam-column connections and the material efficiency achieved in perforated steel beams, the current work attempts to find the best option of earthquake resistant beam-column connections for when the means of beam weakening comes in the shape of variously perforating the beam sections.

Description of method:
The latest trend of earthquake resistant design comes by the name of performance based design. To achieve this, knowledge on the individual behaviour of components together with details on the way they are interlinked is of great importance. Following this rationale, the current research endeavour attempts to examine through a combined analytical experimental study a large number of variations for beam-column connections, where beams are perforated locally close to their attachment to the column. The shape of beam openings, and their geometric arrangement was previously shown for ordinary perforated beams to have a large influence on both dynamic characteristics and load capacity. Yet, no similar work exists for connections intended for earthquake resistant structures. Novel shapes along with more conventional (e.g. circular) web openings will be considered, while notions of topology optimisation will be used in order to recover the most efficient connection. Factors that will be included in the parametric study concern the distance between the opening and the column, the web opening area, the column to beam joining technique (i.e. bolts, welding, etc) and different loading combinations.
The project will be assigned to a team of two students with one of them responsible for the analytical/modelling part and the other responsible for model testing. The modelling will be performed using the nonlinear Finite Element programme ANSYS and the optimisation using Altair's Hyperworks. All required software licences are already available within the University of Leeds. Comparison metrics will focus on the available ductility, yield initiation, and ultimate capacity while cyclic loading will be performed in order to indirectly assess the damping capacity of the connections. Modal analysis will try to asses any minor impacts on the vibration frequencies. Experiments will be performed on a solid beam-column connection and the final optimised output in order to complement and validate the numerical work.

Benefits to structural engineering:
On the way towards more cost effective structures with better response characteristics and a deeper understanding on their performance details, this research will attempt to provide another elegant yet unexplored solution concerning the design of aseismic beam-column connections. Principals of optimisation, although implicit in any engineering field are rarely practiced in a strict non empirical way. The current study alongside other aims intends to encourage practicing engineers to use novel tools readily available in design nowadays. The work will be further developed with the aim to make an impact on design guidelines and recommendations.

Proposed finish date: May 2014