Title: SEISMIC RESISTANT DESIGN OF CONNECTIONS WITH THE USE OF PERFORATED BEAMS

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The 1994 Northridge and 1995 Kobe earthquakes had destructive effects and proved that welded steel moment frames were generally prone to premature brittle failure. This is an area of high concern for engineers since, in particular for the 1994 Northridge earthquake; there was great damage for what was regarded as being a moderate event with a 6.8 Richter scale magnitude and duration of ground motion shaking of about 10 seconds. Brittle damage was generally confined in the vicinity of welds of beam-to-column connections and had occurred in old and short as well as new and tall buildings. This mobilized studies which were conducted by the Federal Emergency Management Agency (FEMA) and the SAC Joint Venture with reports ranging from FEMA 350 to 355F with main aim to develop reliable, practical and cost-effective design guidelines, specifications and standards of practice in order to reduce the earthquake hazards of steel moment-frame structures. Alternative solutions were considered (FEMA 350, EC8: Part 3) by reinforcing connections or having a Reduced Beam Section (RBS) to achieve the *"weak beam-strong column"* mechanism which will enable the development of an internal plastic hinge within the beam acting as a ductile seismic fuse.

Today, it is estimated that around 35% of steel-framed buildings incorporate long spans in excess of 12m. This guidance note reminds signers of the benefits of long span construction. In the 1990s the cellular beam, which replaced the castellated beam, gained prominence. Cellular beams are now estimated to have an 80% share of the long span UK market. This dominance is due to several factors including: (i) Compared to the other long span alternatives, the fabrication content is significantly less, (ii) Asymmetric cellular beams allow greater design economy, (iii) Regular service holes allow greater flexibility for service integration, (iv) Reduction of the material volume without reducing the structural strength, (v) the potential to span longer without being heavier while they comply with the serviceability requirements, and (vi) fewer columns and consequently foundations. There has been a lot of research on perforated beam webs with the geometry of the perforation ranging from circular, hexagonal, to even elliptically-based shapes. However, very limited research has been conducted up to date regarding the design limitations of seismic resistant connections when such perforated beams are used. Moreover, the use of perforated sections to address the *"weak beam-strong column"* concept has been attempted with positive and reliable results.

This study presents an extensive step-by-step analysis of a partially restrained extended end-plate beam-to-column connection, with single or multiple circular web perforations introduced along the length of the beam while subjected to the cyclic loading proposed by SAC protocol from FEMA-350 (2000). The parameters introduced in the parametric

study were the distance from the face of the column, S, and the web opening spacing, S_o, with closely and widely spaced web openings. The potential of adding periodical web openings along the entire length of the beam was also examined. The design of such reduced web section (RWS) connections should be based on the articulate decision of the first opening's distance from the face of the column. It is concluded that using large isolated perforations is an effective way of improving the behavior of connections enhancing their ductility, rotational capacity and their energy dissipation capacity. Moreover, the connections with novel openings outperform the conventional ones; therefore, they can be suitably used in the aseismic design of steel frames.

Biography

Konstantinos Tsavdaridis is the Director of the research group focuses on steel and steel-concrete composite structures. He holds an MEng from City University London and an MSc (DIC) from Imperial College, London. His research expertise is in structural product development that embraces resilience and sustainability, particularly the development of innovative structural systems and members, and testing large-full scale structures. He has published more than 60 scientific articles, journal publications, technical reports and international conference papers. He is a member of the American Society of Civil Engineers, Professional Chartered Civil Engineer and registered at the European Federation of National Engineering Associations.