Cruciform finite elements for the modelling of steel joints in frame analysis

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The development of the component method for the characterization of steel joints (Eurocode 3) has lead to the use of mechanical models, composed of springs and rigid bars for frame analyses. However, this adds complexity, numerical overhead —consequence of the large number of degrees of freedom— and possible round off errors (due to the rigid bars) in the solution process.

With the aim of avoiding these problems generalized cruciform finite elements with 4 nodes and 12 degrees of freedom (for the 2D case) are proposed. These cruciform elements are also suitable for semi-rigid connections and can be used for the global analysis of semi-rigid steel frames. The elements are capable of modelling rectangular, trapezoidal and double rectangular web panels, arising in internal joints with beams of different depth.

The characteristics of these elements (stiffness and resistance) are generated from the mechanical models by means of an efficient displacement based modal approach. All the forces and moments coming from the adjacent beams and columns concur at the joint, therefore, the complete force field in the panel zones is known with no need for a transformation parameter β (EC3-Part 1.8 [2]). In addition, since the real dimensions of the joint are being considered, the eccentric moments are automatically taken into account. Also, the interaction between the deep and the shallow sides of column double panels are taken into account. Numerical simulations are carried out that show the validity and efficiency of the proposed approach.