Numerical simulation of the behaviour of a gusset plate connections under cyclic loading

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ABSTRACT

In the current design practise, concentrically braced frames (CBFs) are designed and detailed to dissipate the energy through brace yielding in tension and inelastic buckling in compression under the strong shaking. To ensure the brace yielding in tension, the current seismic provisions require the axial capacity of the gusset plate connection should exceed the axial capacity of the brace. In addition, AISC (2002) provisions require for special concentric braced frames (SCBFs) to provide the $2t_g$, where t_g is the gusset plate thickness, linear clearance in the gusset plate in order to accommodate brace to buckle in out of plane of the frame. Such a linear clearance rule results in a relatively large gusset plates and the resulting gusset plate connection could be uneconomical. The out of plane buckling geometry requirement is not met with the Eurocode provisions and it could results the mixed buckling mode of in plane and out plane buckling of braces and lead to form the plastic hinges in the brace ends and provide additional demand to the welds in the connections. Non of the codes take in to account the phenomenon that when a braced frame bay deforms horizontally, into a parallelogram shape, the tension brace gusset plates could undergo compression buckling due to the initial orthogonal angle between the beam and column becoming acute and it leads to tear the gusset plate due to the tension brace pulling on the gusset plate.

So in this study we investigate the influence of the gusset plate and the framing elements, designed according to EC3-EC8 (2003) and AISC (2002) provisions, on the seismic performance of CBFs and presentes the proposals for the optimum gusset plate connection design by numerical simulation to the full scale sub-assemblages using detail finite element models in MIDAS FEA software. At the beginning, detailed FE model of a tested single brace specimen connected to rectangular gusset plate was developed to obtain the appropriate value for initial imperfection through the comparison to experimental results and to investigate the effective angle of stress distribution at the gusset plate. Later, the sub-assemblages including the top and bottom beams, gusset plate connection at each end of the brace and columns, to represent the single bay in the ground storey of the 4 storey CBF building, was developed to explore the influence of the frame details such as the beam to column connection, out of plane geometry requirement, the brace angle and the gusset plate thickness. The results shows that the proper detailing of the gusset plate connection can improve the performance of the CBFs. Further global performances of the detailed finite element models are compared to performance of the equivalent stick model using OpenSees programme in order to validate the stick model response.