Nonlinear 1D component based and 3D continuum-based finite element analysis of hybrid timber-steel beam to column connections

F. Nouri[†], H. Valipour[†*]

[†]University of New South Wales, f.nouri@unsw.edu.au
[‡] University of New South Wales, h.valipour@unsw.edu.au

Current study deals with numerical simulation of steel-timber hybrid frames. A 3D continuum finite element model developed in ABAQUS is proposed to simulate the behaviour of steel-timber composite beam to column connections with double web angles under negative bending moments. Inelastic behaviour of timber is captured by a multi-surface continuum damage mechanics constitutive law implemented in a UMAT subroutine. The adopted timber material model used in the current study considers the anisotropic behaviour of timber and accounts for the hardening behaviour of timber in compressions perpendicular to the grain direction, i.e. radial and tangential directions, as well as the brittle failure of timber under shear and tension. For the sake of simplicity and reduction of computational costs, timber is treated as a transversely isotropic material. Crack band model in conjunction with a specific meshing strategy are used to alleviate mesh sensitivity of the problem. Also, contact and geometrical nonlinearities are considered along with the nonlinear response of the steel profiles, bolts and connectors. In addition, a component-based 1D finite element model developed in OpenSees is utilised to capture the nonlinear response of joints, where action of each component is modelled by using a zero-length spring. Results of simulation for both finite element models show a good agreement with results of experiments conducted on joints. Sample results of simulations and their correlation with the experimental results are shown in Fig. 1.

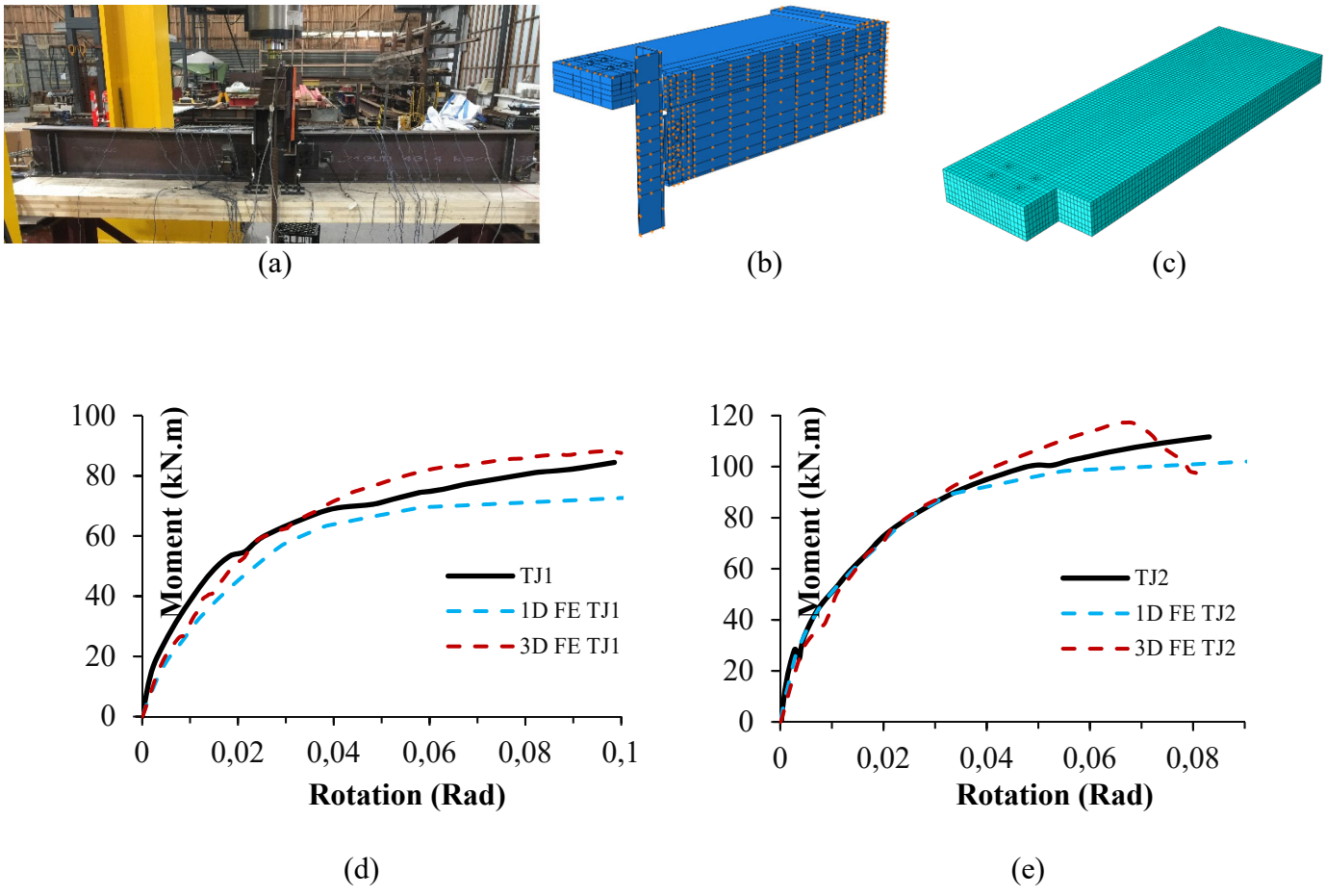

Figure 1: FE modelling (a) tested specimen (b) 3D Continuum model (c) meshing outline of CLT slab (d) results of FE simulation TJ1 (d) results of FE simulation TJ2

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