EQUIVALENT VISCOUS DAMPING FOR CLT INFILLED STEEL MOMENT FRAME STRUCTURES

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ABSTRACT

A performance based design method; in particular the direct displacement based design (DDBD) procedure utilizes equivalent viscous damping expression to represent the effect of energy dissipative capacity of a structural system (Priestley et al. 2007). Several equations for the equivalent viscous damping have been developed for different structural systems (e.g., Sullivan 2013; Wijesundara et al. 2011). However, the previous studies have not addressed the timber-steel hybrid systems. In this paper, equivalent viscous damping equation for timber-steel hybrid system is proposed, where Cross Laminated Timber (CLT) shear panels are used as infill in steel moment resisting frames. The CLT panel in the proposed hybrid system is connected to the frame by steel brackets that are nailed to the CLT walls and bolted to the steel frame as shown in Figure 1(Schneider et al. 2013). A gap is also considered between the edge of the CLT wall and the steel members to allow for construction tolerances and to accommodate deformation of brackets (Dickof et al. 2013).

The proposed hybrid system is modeled in Opensees finite element software (UCB 2010). The CLT panel incorporated in this model as linear elastic shell element and Pinching4 Opensees material model was used for brackets in parallel with the Elastic Perfectly Plastic Gap (EPPG) material.

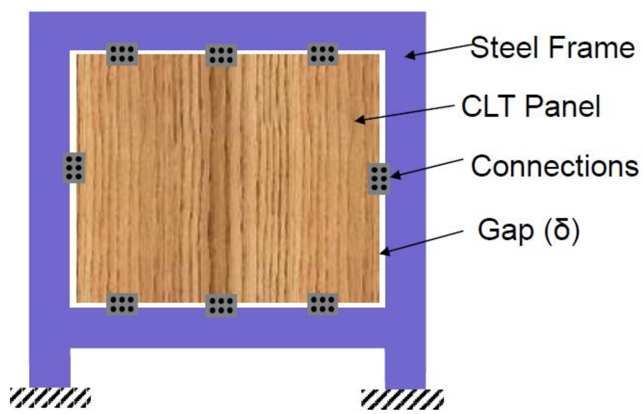

Figure 1: *Timber-steel hybrid system with steel frame and CLT infill walls*

The steel frame elements were created using a combination of the linear and nonlinear displacement beam-column elements. Since the CLT panel is relatively stiff, the energy dissipation is accomplished through the ductile behaviour of brackets that mainly depends on the magnitude of confinement gap provided. To determine the effect of gap on the ductility of the hybrid system, monotonic pushover analysis was done for the proposed system. An initial gap of 10 mm provided for the construction tolerance and another five sets of gap magnitudes (i.e., 20 mm, 40 mm, 60 mm, 80 mm, and 100 mm) used to assess the effect on ductility of the system. Following this, the above hybrid system models were studied under cyclic loading protocol. Figure 2 shows the hysteresis response of the proposed system for the considered six gap magnitudes. The obtained results show that hysteretic behaviour is changing as the gap varies.

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Moreover, from the results the area under the curve has significantly increased as the gap increases.

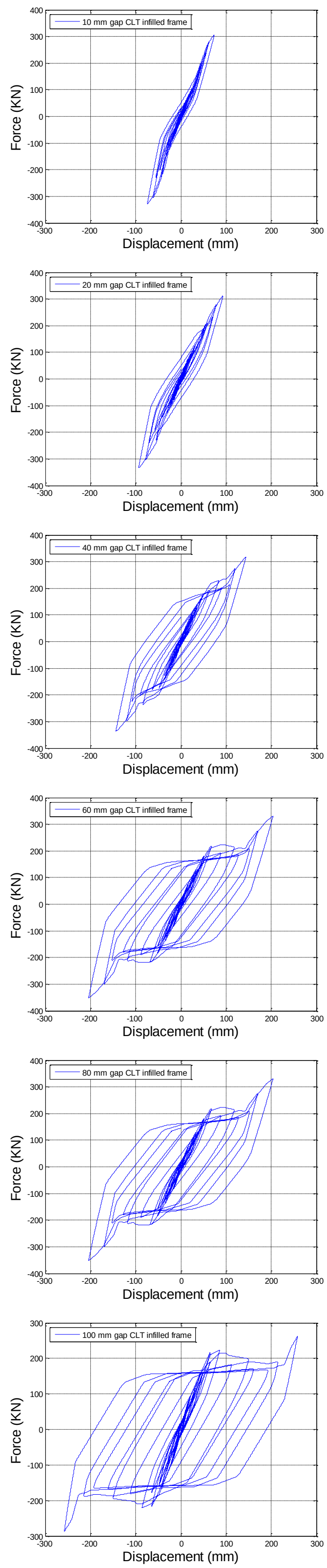

Figure 2: *Hysteretic response of proposed system for various gaps*

The equivalent viscous damping values for of each model were calculated using the area based approach. The calculated ductility and equivalent viscous damping values are in the range 1.07-7.76 and 7.3-23.7%, respectively. Following this, least square regression was used to estimate the coefficients of the proposed equations. A curve representing the relation between equivalent viscous damping and ductility is depicted in Figure 3. This figure shows the proposed equation is in good agreement with other hysteretic rules.

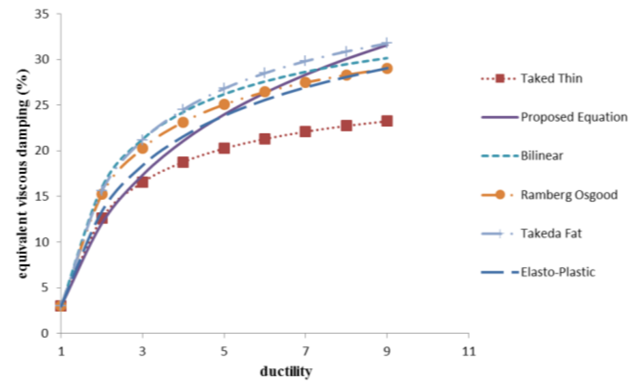

Figure 3: *Equivalent damping vs. ductility*

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