Nonlinear Static Seismic Response of a Building Equipped with Hybrid Cross-Laminated Timber Floor Diaphragms and Concentric X-Braced Steel Frames

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Summary:

Simplified seismic design procedures mostly recommend the adoption of rigid floor diaphragms when forming a building's lateral force-resisting structural system. While rigid behavior is compatible with many reinforced concrete or composite steel-concrete floor systems, the intrinsic stiffness properties of wood and ductile timber connections of timber floor slabs typically make reaching a such comparable in-plane response difficult. Codes or standards in North America widely cover wood-frame construction, with provisions given for both rigid and flexible floor diaphragms designs. Instead, research is ongoing for emerging cross-laminated-timber (CLT) and hybrid CLT-based technologies, with seismic design codification still currently limited. This paper deals with a steel-CLT-based hybrid structure built by assembling braced steel frames with CLT-steel composite floors. Preliminary investigation on the performance of a 3-story building under seismic loads is presented, with particular attention to the influence of in-plane timber diaphragms flexibility on the force distribution and lateral deformation at each story. The building complies with the Italian Building Code damage limit state and ultimate limit state design requirements by considering a moderate seismic hazard scenario. Nonlinear static analyses are performed adopting a finite-element model calibrated based on experimental data. The CLT-steel composite floor in-plane deformability shows mitigated effects on the load distribution into the bracing systems compared to the ideal rigid behavior. On the other hand, the lateral deformation always rises at least 17% and 21% on average, independently of the story and load distribution along the building's height.

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