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Reliability of cold-formed steel framed shear walls as impacted by variability in fastener response

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ABSTRACT

The objective of this paper is to examine the reliability of cold-formed steel framed shear walls with a particular emphasis on walls sheathed with wood structural panels. A sheathed cold-formed steel framed shear wall is a system consisting of studs, tracks, and sheathing often with bridging and/or blocking, connected with steel-to-steel and sheathing-to-steel fasteners. The shear walls may be integrally connected to foundations, floors, or other shear walls through a variety of means including hold downs, straps, diaphragm chords and collectors. Shear wall lateral resistance in cold-formed steel framed buildings varies because of the randomness in the components and connections that comprise the wall. The interaction between fasteners and sheathing is particularly important because (1) sheathing-to-steel fastener response is the main source of shear wall nonlinearity (2) there is high variability in this fastener response. Although the nominal strengths for different shear wall configurations are stated in current design specifications (e.g., AISI S400), variability of shear walls has not been explicitly considered. Existing resistance factors are extrapolations from steel diaphragm testing. To explore the impact of fastener response variability on shear wall reliability, Monte Carlo simulation of typical cold-formed steel framed wood sheathed shear walls with random fastener input was conducted. Variability in fasteners was determined based on existing physical fastener tests. Statistical properties of shear wall strength, demand capacity ratio of key fasteners, as well as relations between fastener strength and shear wall strength are all explored. Reliability evaluation is provided for four different design methods. The results indicate that shear wall strength benefits from a system effect whereby variability in fastener response is reduced through redistribution resulting in reduced variability in overall shear wall strength. Concomitant with this is a slight decrease, approximately 3%, in the mean system strength that also must be considered.

1. Introduction

Cold-formed steel (CFS) structural systems are commonly used for low and mid-rise construction. In the design of CFS-framed buildings, shear walls are typically used to provide lateral resistance for seismic or wind load (e.g., see Fig. 1). Commonly, wood sheathing, such as oriented strand board (OSB), is screw-fastened to CFS studs and tracks to develop lateral shear stiffness and strength (e.g., see Fig. 2).

As the wall is sheared an incompatibility exists between the CFS framing, which is largely deforming as a parallelogram, and the wood sheathing that remains nearly rectangular and primarily undergoes rigid body translation and rotation because of its large in-plane rigidity. The incompatibility between the deformed frame and sheathing causes a relative displacement that must be accommodated at the fasteners. This displacement causes tilting and bending of the fastener, as well as deformation and damage to the steel and wood sheathing material around the fastener. This damage is the source of yielding and energy dissipation in these systems [1,2] . The resulting overall CFS-framed wood-sheathed shear wall cyclic response exhibits significant hysteresis, degradation, and pinching, as shown in Fig. 3.

CFS-framed wood-sheathed shear walls have been tested extensively. In North America AISI S400-15 [3] (previously AISI S213-07

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Fig. 1. CFS-NEES building and shear wall in it.

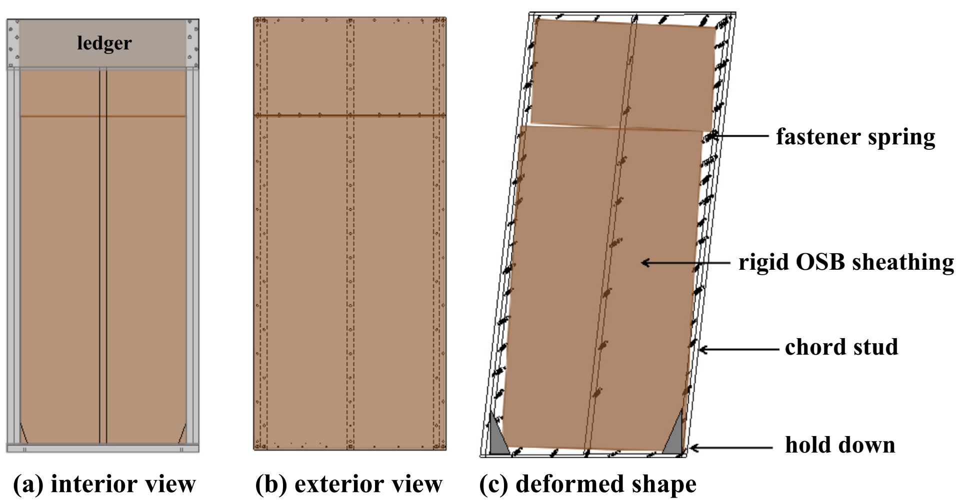

Fig. 2. Typical cold-formed steel framed shear wall in a ledger-framed building.

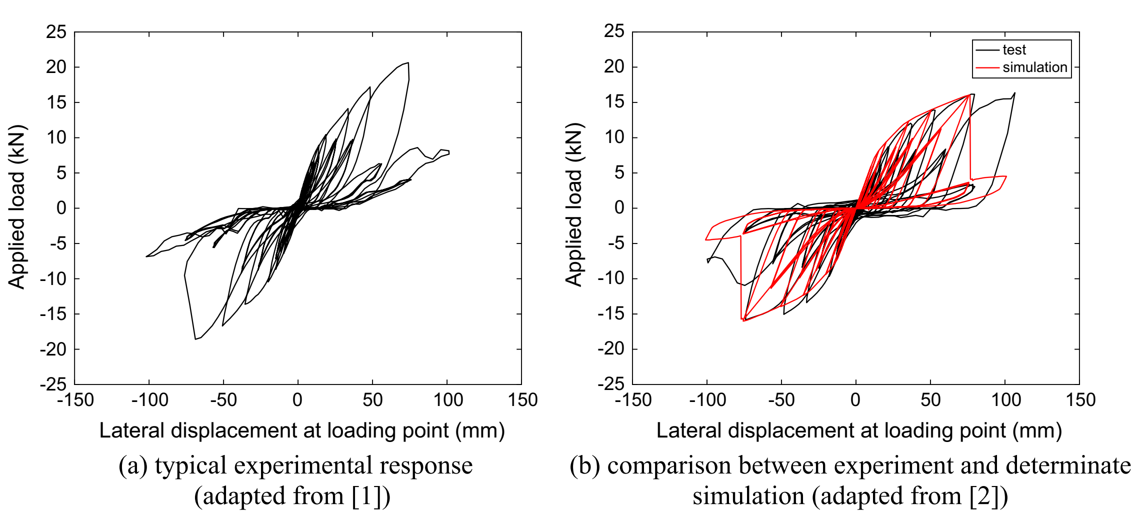

Fig. 3. CFS-framed wood sheathed shear wall cyclic response.