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Impact of construction details on OSB-sheathed cold-formed steel framed shear walls

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ABSTRACT

The objective of this paper is to explore and characterize the impact of practical construction details on the cyclic performance of cold-formed steel framed shear walls sheathed with Oriented Strand Board. The specific construction details explored are motivated from a two-story, ledger-framed, cold-formed steel archetype building that is the focus of a larger effort to advance seismic performance-design for light steel frame construction. This larger effort in cold-formed steel (CFS) research is funded primarily by the National Science Foundation — Network for Earthquake Engineering Simulation (NSF—NEES) effort and is known as the CFS—NEES project. The archetype structure is known as the CFS—NEES building. Shear walls in real construction, such as the CFS—NEES building, have details that differ from shear walls tested and provided for strength prediction in standards such as AISI-S213. Key differences include: (a) ledger (rim track) members attached across the interior face of the studs; (b) OSB panel seams, both horizontal and vertical, may not be aligned with the chord studs or only blocked with strap; (c) interior gypsum board is in place; (d) field studs may have a different thickness or grade from the chord studs; and other differences. In this work, these highlighted differences (a–d) are specifically explored in a series of shear wall tests loaded via cyclic (CUREE) protocols to determine their hysteretic performance. The test results are compared with AISI-S213 and hysteretic material characterizations utilizing an elastic–plastic model and a model capable of exhibiting pinching in the hysteretic loops.

1. Introduction

Today, light (cold-formed) steel framing is regularly employed as the load bearing members in low- and mid-rise buildings. Common lateral force resisting systems for light steel construction consist of cold-formed steel (CFS) framing members with wood-sheathing, steel sheet-sheathing, or strap bracing and appropriate boundary detailing [1]. In an effort to advance performance-based seismic design of light steel framed construction a National Science Foundation — Network for Earthquake Engineering Simulation (NSF—NEES) effort known as the CFS—NEES project has recently detailed a two-story archetype building [2] that is the focus of the studies presented here. The shear walls in the building utilize back-to-back chord studs and OSB sheathing and reflect modern engineering practices and preferences in CFS structural framing. The details of the shear walls deviate from tested configurations in AISI-S213 in that (a) a ledger or rim track is attached to the interior face of the walls, (b) a gypsum board is attached to the interior face of the walls, (c) OSB panel seams do not always fall at stud or track locations and thus strapping must be used for shear transfer in the walls, and (d) the field studs do not always match the grade or thickness of the chord studs. These deviations represent current construction preferences and framing methods and are not currently accounted for in AISI-S213.

CFS framed shear walls have seen significant study. Notably, based on the work of Serrette [3–5] the North American standard for cold-formed steel framing: lateral design (AISI S213) provides nominal strength for three different types of sheathing: 1.19 cm [15/32 in.] “Structural 1” sheathing, 1.11 cm [7/16 in.] Oriented Strand Board (OSB), and 0.46–0.69 mm [0.018–0.027 in.] steel sheet. Tabled values are based on maximum aspect ratio, fastener spacing at the panel edge, and stud and track thickness. More recently, Rogers [6–10] has developed a large multi-year shear wall testing program. Among the many aspects studied is the significance of the cyclic loading protocol including comparisons between Sequential Phased Displacement (SPD) and the Consortium of Universities for Research in Earthquake Engineering (CUREE) protocol [11]. In general, the dominant failure modes involved the sheathing-to-steel connection and a combination of fastener pull-through, tear-out, and bearing. A large variety of different sheathing materials and details have been explored and results were summarized by Cobeen [12]. However, the impact of ledger track, panel seams, and

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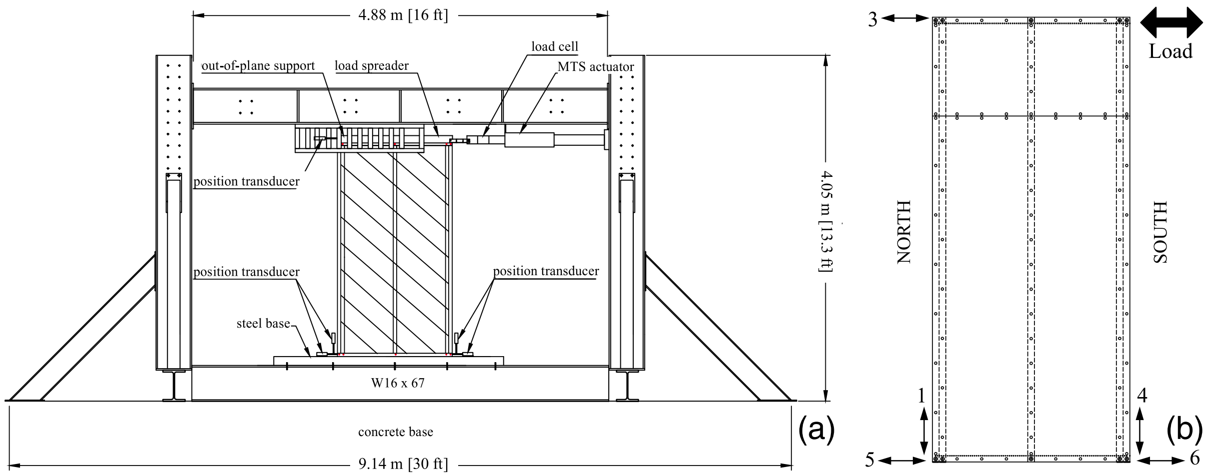

Fig. 1. (a) Drawing of test rig with sensor locations and (b) shear wall with load and position transducer locations (numbers 1 through 6).

grade and thickness of the field studs has not been studied. The test program presented herein broadens the field to include the impact of practical construction details, consistent with multi-story CFS buildings, on shear wall response.

2. Test program

The complete test program is detailed in the CFS—NEES research report RR03 [13] and a summary of the testing is provided here.

2.1. Test setup

The structural testing frame at the University of North Texas was employed for shear wall testing (Fig. 1(a)). Sensors were placed at the bottom and top of the shear wall (Fig. 1(b)) to monitor lateral displacements and uplift. The specimens were anchored to the test rig at several locations along the base, detailed in Fig. 2. Fig. 2 also notes the location of the hold downs relative to the anchors.

2.2. Methodology

Both monotonic and cyclic tests are performed under displacement control. Monotonic tests follow ASTM E564-06 [14]. This protocol requires a preload of approximately 10% of the estimated ultimate load to be applied and held for 5 min to seat all connections. The preload is then removed and the specimen is loaded to one-third of the estimated ultimate load. Again, the specimen is loaded and unloaded, this time to two-thirds of ultimate load. The loading continues in this manner until ultimate load is attained.

For cyclic loading, the CUREE protocol was employed in accordance with ASTM E2126. A constant cyclic frequency of 0.2 Hz was chosen for the cyclic test as well as a reference displacement based on the results from monotonic tests. Fig. 3 depicts the CUREE protocol used for this test series.

2.3. Specimen design

The baseline specimen consisted of either 1.22 m × 2.74 m [4 ft × 9 ft] or 2.44 m × 2.74 m [8 ft × 9 ft] walls framed with 600S162-54 (345 MPa [50 ksi]) studs spaced 0.61 m [24 in.] on center and connected with No. 10 flathead screws to 600T150-54 (345 MPa [50 ksi]) track (member nomenclature per AISI-S200-07). Studs were spaced at 0.61 m [24 in.] on center and braced with continuous rolled channel (CRC) as detailed in Fig. 4. Chord studs consisted of back-to-back studs assembled with pairs of No. 10 flathead screws spaced every 30.5 cm [12 in.]. Simpson Strong-Tie S/HDU6 hold downs were attached on the inward face at the bottom of the chord studs. Twelve No. 14 fasteners attached the hold downs to the chord studs.

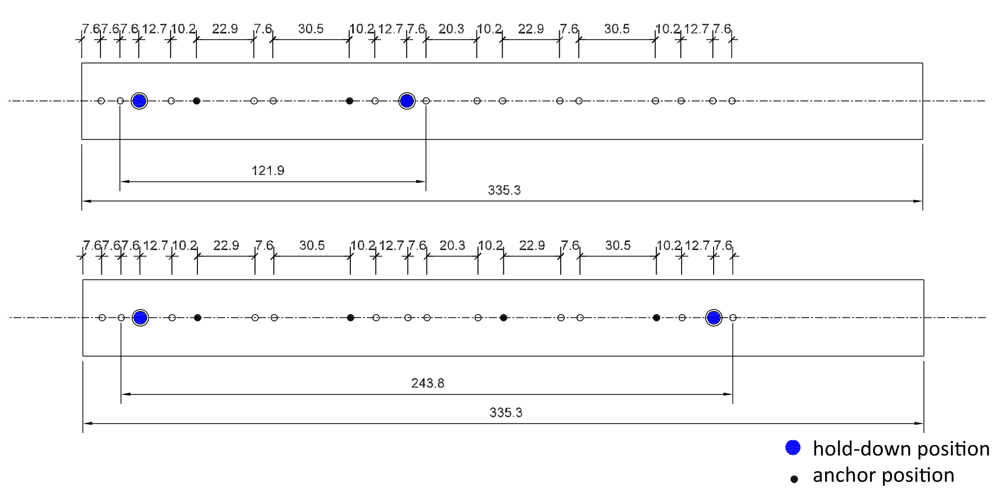

Fig. 2. Shear wall anchor and hold down position for 1.22 m × 2.74 m shear walls (top) and 2.44 m × 2.74 m shear walls (bottom). All units are in centimeters.