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NHERI TallWood 10-story Test Nonstructural, Part 3 of 4: Cold-Formed Steel Framed Interior Walls

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ABSTRACT

Nonstructural interior partition walls constructed by cold-formed steel (CFS) may be damaged at small story drift during an earthquake. To avoid these damages, this paper illustrates two types of tracks and six different corner details to accommodate in-plane and out-of-plane movement. A 10-story mass timber structural system with these interior CFS walls will be constructed and tested at an upcoming shaking table test at UC San Diego.

Introduction

Due to the widespread use of cold-formed steel (CFS) framed in nonstructural walls, the damage and economic loss they sustain during an earthquake will be especially important [1]. Damage to some nonstructural components occurs at a small story drift ratio [2]; among these, CFS-framed interior partition walls, constructed floor to floor, are especially sensitive to story drift.

An upcoming 2022 shake table test of a 10-story mass timber building at NHERI@UCSD 2022 provides the opportunity to investigate nonstructural components, and among these various details for interior partition walls. This paper describes the configuration of the interior walls designed to mitigate some of the damage that occurs at intersecting walls in slip-track configurations. Companion papers provide a test overview, and description of other nonstructural components being considered including a curtain wall subassembly [3], three different exterior wall subassemblies [4], and stairs [5].

Literature Review

CFS walls consist of vertical studs spaced 16” or 24” o.c. between top track and bottom tracks, and sheathed with drywall on both sides. Commonly, the studs are connected to the tracks and the tracks are fully connected to the floor slab above and below. The performance of interior partition walls can be improved by isolating partitions walls from the interstory drift. Thus, various slip or sliding track details have been proposed and are used by industry. In the basic detail, studs are not connected to the track at the top of the wall and slip occurs

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between the studs and the track [1]. The slotted track detail (Fig. 1(a)) uses a horizontally slotted top track, with screws not fully tightened to the floor above, to allow the top track to slide relative to the floor in the in-plane direction. To the author's knowledge, the commercial tracks have not been tested seismically. Araya-Letelier et al. [6] proposed a circular slotted track that allowed relative movement in both directions, but this detail has not found favor with practitioners. The double slip track detail (Fig. 1(b)) uses nested tracks at the top. The upper track is connected to the floor slab and the lower track to the studs, so that slip occurs between the two tracks. Furthermore, a ¾'' gap between the two tracks allow for vertical deflection. The double slip configuration was superior to the conventional slip track to hold the wall together under large drift [7].

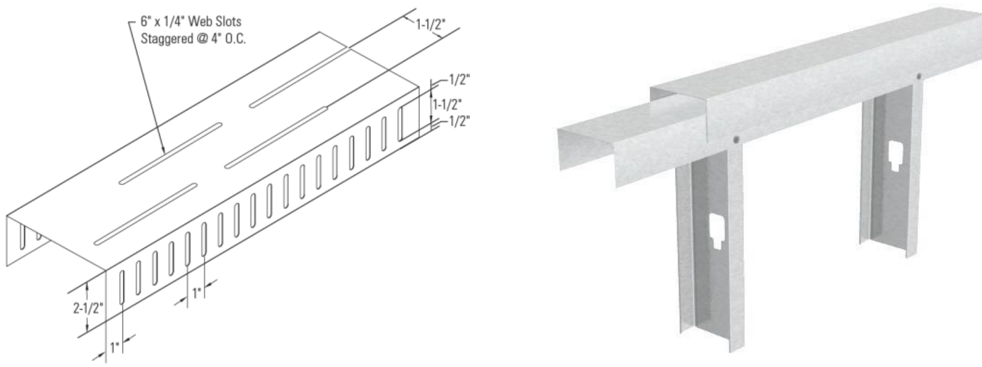

Figure 1. (a) CEMCO's CST Brand Slotted Slip-Track and (b) double slip track

The benefit of slip track is limited due to incompatibilities at intersecting or return walls. A few solutions have been proposed to separate the movement of the intersecting in-plane and out-of-plane wall. These details include corner gap [1, 7], flexible corner [8], and use of thermal expansion joints adjacent to the corner [7]. However, the corner detailing has not been well researched and consensus is lacking. Moreover, connections between shaft walls and conventional partition walls have not been investigated.

Interior Walls Configuration

To advance knowledge about the seismic performance of interior walls and develop solutions to reduce damage at wall intersections, various interior wall subassemblies will be installed on stories 5-9 of the building. First, two types of walls are used throughout the plans: *conventional interior walls* and *shaft walls*. The conventional interior walls are detailed with top slip track connections using either the double slip track (Fig. 2a), or CEMCO's CST Brand Slotted Slip-Track (Fig. 2b). Typical studs and tracks are 362S162-33 and 362T125-33, respectively, and the walls are sheathed with 5/8" thick gypsum board on both sides (Fig. 2c). The shaft wall uses CEMCO's Fire Rated J-Track 4" web and CH studs 4" web with friction connections at the top (Fig. 2d). A 1" thick shaft liner board is friction fit into the rated side of the wall, and the non-rated side is sheathed with two layers of 5/8" gypsum board (Fig. 2d and 2e).

The plan layouts are shown in Figure 3. The residential layouts on stories 5 and 6 (Fig. 3a and 3b) are intended to represent a realistic layout of interior walls on the very limited size floor plan. Story 5 incorporates conventional interior walls that extend to the stairwell from all directions; on this story wall panels will be integrated directly into the stair framing system, as described in [5]. Story 6 has a similar layout to story 5, but includes a shaft wall assembly around the center stair core. Adopting an approach that has not, to the authors' knowledge, been used before in the literature, commercial expansion joints are applied at many intersection locations to separate the movement of the adjacent out-of-plane wall from the in-plane wall. Several locations use Construction Specialties FWFC-600 gasketed joint (Fig. 4a) to accommodate 4" of relative movement in each direction. At the intersecting corner of the shaft wall and the conventional interior wall, the fire rating of the shaft wall should be maintained. Here Construction Specialties model RFX-4W fire barrier is applied to separate the movement of the out-of-plane segment of the shaft wall from the two connecting in-plane walls (Fig. 3b). While the slip mechanisms are different, the outer top track and Fire Rated J-Track will be notched to allow the aligned interior wall and shaft wall segments to move together (Fig. 4f). Standard corner details are applied in some locations for a direct comparison to the innovative solutions.

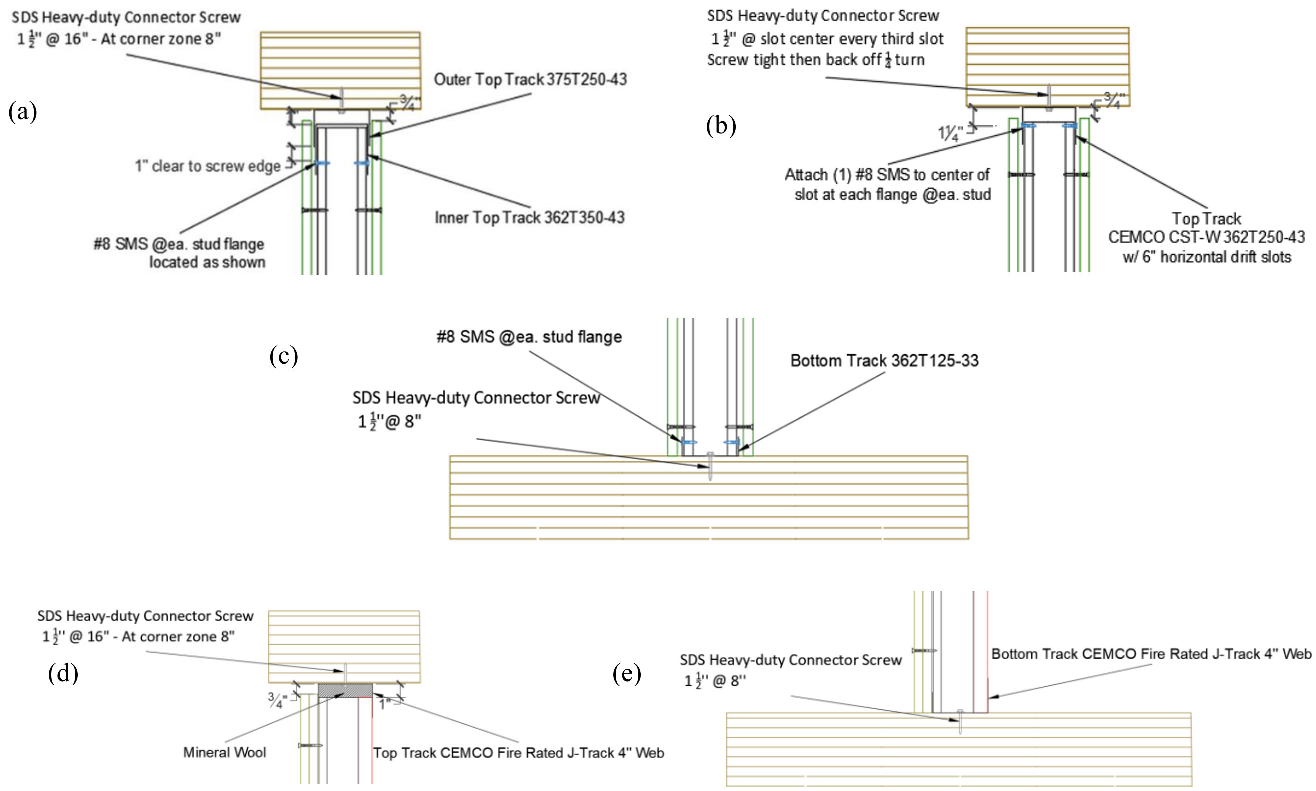

Figure 2. Section view of walls: a) double slip top of wall, b) slotted slip top of wall, c) conventional wall bottom of wall, d) shaft wall top of wall, and e) shaft wall bottom of wall.

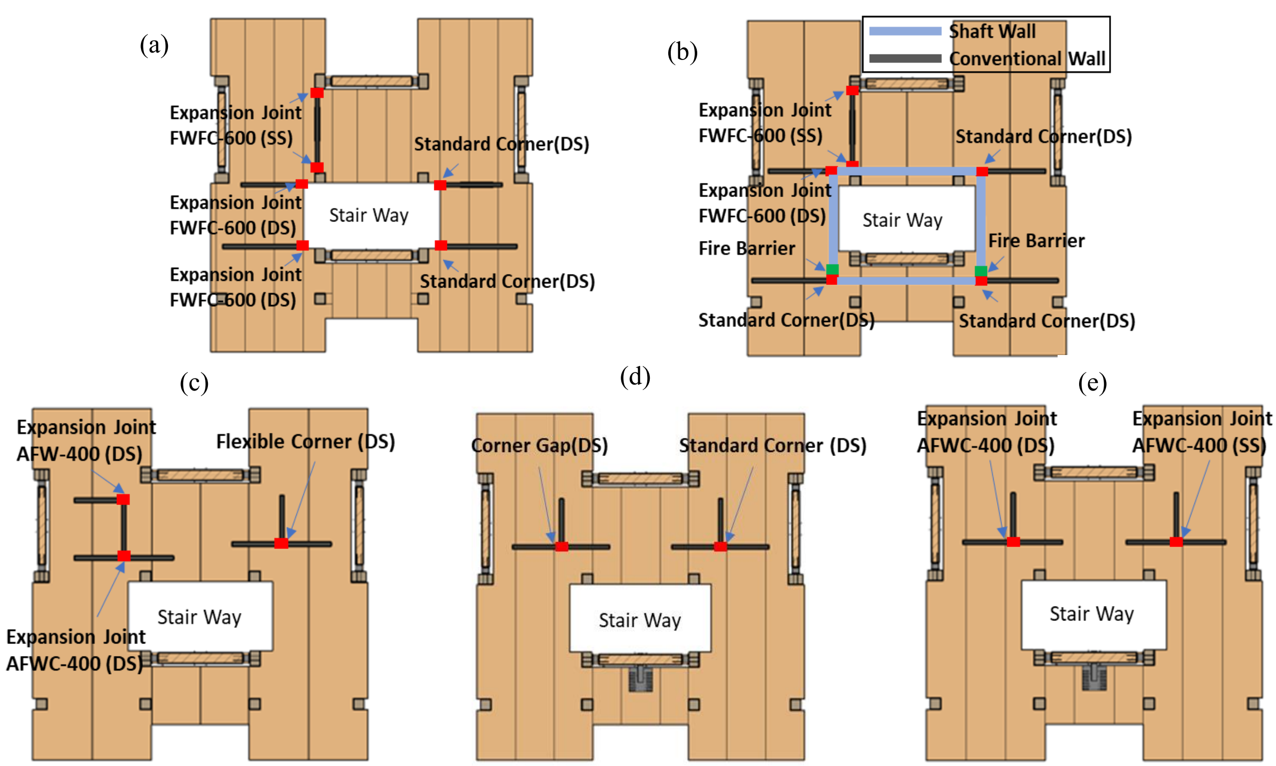

Figure 3. Interior walls plans: (a) story 5 residential floor plan, (b) story 6 residential floor plan with shaft walls; (c)-(e) isolated walls on stories 7-9, respectively; DS = double slip and SS = slotted slip.

In addition to the residential floor plans, six isolated walls are to be built, two each on stories 7 to 9. The majority are T-shaped with intersection 5’ and 10’ long wall segments. Different details are utilized to connect the adjoining in-plane and out-of-plane wall at the intersection region:

- Standard Corner (Fig. 4c) – All studs and tracks are fully connected through the intersection.
- Corner Gap (Fig. 4d) – The tracks are discontinued just outside the intersection and the nearest studs are 2” from the intersection; this allows the adjacent walls to move into the corner region from each direction when subjected to slip.
- Flexible Corner (Fig. 4e) – The outer top track is discontinued 2’ away from the intersection region; this allows some bending of the in-plane wall to accommodate the slip in the adjoining wall.
- Expansion Joint (Fig. 4f) – This solution uses CS Group’s AFWC-400 joint with extruded aluminum cover plates to completely separate the movement in the adjoining walls.

The locations of each wall configuration are designated in Fig. 3c-3e. The expansion joint solution is repeated in double slip and slotted slip configurations, and applied twice in one wall subassembly to assess interaction.

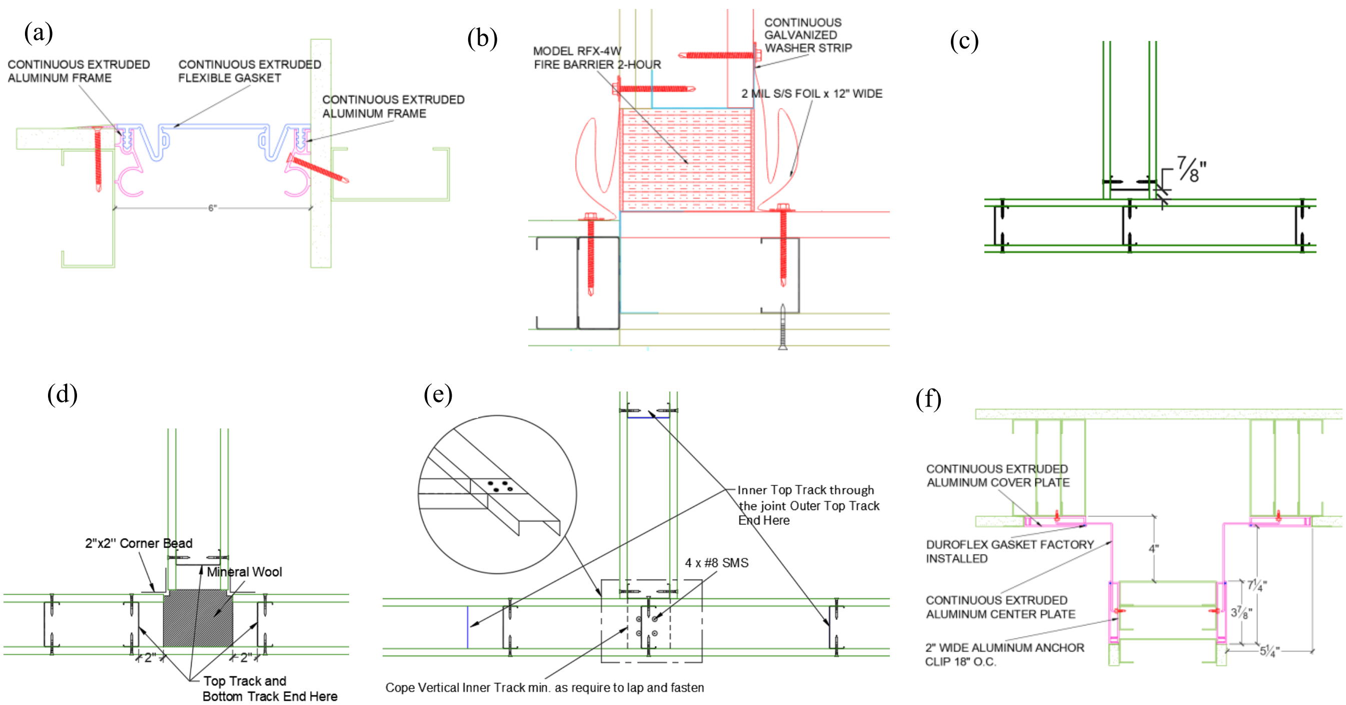

Figure 4. Intersecting wall details: a) FWFC-600 expansion joint, b) fire barrier expansion joint, c) standard corner, d) corner gap, e) flexible corner, and f) AFWC-400 expansion joint.

Conclusions

Interior partition walls are easily damaged and in earthquakes and constitute a major proportion of economic losses in moderate earthquakes. While the seismic response of partition walls has been extensively studied, there is no consensus solution and damage at intersections remains a difficult problem to solve. The upcoming tests will advance knowledge by combining best slip track details with various corner details. Commercial expansion joints offer promise and have not yet been investigated; this new approach will be compared against other solutions that have been reported in the literature.

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