Journal of Constructional Steel Research 67 (2011) 1554–1566

Contents lists available at ScienceDirect

Journal of Constructional Steel Research

Experiments on sheathed cold-formed steel studs in compression

L.C.M. Vieira Jr. *, Yared Shifferaw, B.W. Schafer

Department of Civil Engineering, Johns Hopkins University, Baltimore, MD, USA

ARTICLE INFO

Article history:
Received 14 December 2010
Accepted 30 March 2011
Available online 8 May 2011

Keywords:
Cold-formed steel
Sheathed
Studs
Experimental analysis

ABSTRACT

The stability and strength of cold-formed steel lipped C-section columns (studs) with sheathing attached to the flanges is the subject of this paper. Stud configurations both with and without sheathing, either oriented strand board or gypsum board, are tested for failure in compression. A total of twenty-six tests covering short, intermediate and long specimens, varied sheathing configurations, and varied end boundary conditions are completed. Dimensions and geometric imperfections of the specimens are measured in detail. The measured geometric imperfections are reduced to scalar magnitudes consistent with local, distortional, and global buckling modes. During the testing, mid-height cross-section deformations are recorded using five position transducers. The deformations indicate the impact of the different combinations of sheathing, and of the end boundary conditions, on the strength and stability of the studs. Composite action between the stud and sheathing, and isolating direct loading of the sheathing, are shown to be significant in determining the strength and controlling limit state of the stud. Tested strengths are compared with existing North American (American Iron and Steel Institute) specification methods and potential improvements are explored.

1. Introduction

Buildings systems framed from cold-formed steel are increasingly common in the built environment, motivating the need to efficiently account for the interaction of different components in such systems. Cold-formed steel studs, which generally form the walls of such buildings, can be braced by bridging or blocking, as depicted in Fig. 1a. However, the studs are also commonly attached to wallboards (sheathing): oriented strand board (OSB) or gypsum board are common (Fig. 1b), and these boards may potentially provide the necessary bracing instead of discrete bridging or blocking. To examine this problem a single stud in isolation with sheathing attached, as depicted in Fig. 1c, is utilized in studies performed herein.

Past research has long examined the effect of attaching sheathing to the stud. In 1947 George Winter and his colleagues [1] proposed a design method based on a minimum stud-to-sheathing stiffness, determined by test, and incorporated into a simple flexural buckling model of the stud, as depicted in Fig. 1d. This method was incorporated by the AISI Specification in 1962 [2]. In 1976 Simaan and Peköz [3] developed a new method based on the premise that the sheathing is a shear diaphragm. The AISI Specification adopted the method from [3] in 1980 [4], but it was abandoned in 2004 and replaced by a simplified version of Winter's earlier method [1]. Other recent research on sheathed walls includes [5–8].

Existing research has focused on full-scale testing of stud walls with identical sheathing fastened to the two flanges. Full scale testing of walls is critical for fully exploring the system effects that exist in the wall; however, it does not economically allow for an exploration of the impact of unbraced length. Such variation in unbraced length is fundamental to understanding cold-formed steel studs where the dominant/expected limit state is length dependent: changing from local, to distortional, and finally to global buckling modes interacting with local buckling as unbraced length increases. Thus, the testing conducted herein is specifically detailed to examine sheathed studs with unbraced lengths from 0.61 m (2 ft) to 2.44 m (8 ft). Companion full-scale tests with 2.44 by 2.44 m (8 by 8 ft) walls have also been conducted [9].

The use of identical sheathing on the two flanges of the studs, which has been the norm in existing testing, eliminates any additional torsion that may develop from the unequal bracing response from the two different sheathing types. For dissimilar sheathing on the two flanges (a common occurrence in practice) current design requires that the weaker of the two sheathing be considered on both sides of the stud [10]. In this work dissimilar sheathing is specifically examined from the limiting case of sheathing on one flange only, to

* Corresponding author at: 3400, North Charles Street, Johns Hopkins University, Dept. of Civil Engineering, 309 Latrobe Hall, Baltimore, MD 21218, USA. Tel.: +1 410 608 2549.
E-mail address: luizvieirajr@gmail.com (L.C.M. Vieira).

0143-974X/$ – see front matter
doi:10.1016/j.jcsr.2011.03.029

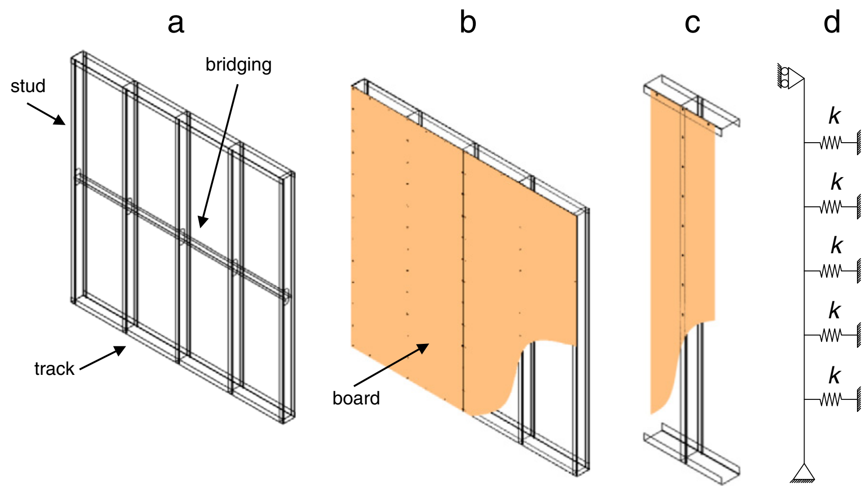

Fig. 1. Stud bracing, practice and simplifications. a) Bare wall with bridging, b) sheathed wall without bridging, c) isolated single column with sheathing, d) spring-column model.

the common case of OSB sheathing on one flange and gypsum board on the second flange. By also varying the unbraced length, the impact of dissimilar sheathing on local, distortional, and global (flexural–torsional) buckling modes are also directly explored.

2. Stud compression tests

2.1. Test apparatus and loading details

The tests are completed using (a) a universal two-post MTS machine capable of compressive load up to 448.5 kN (100 kips) for the 0.61, 1.22 and 1.83 m (2, 4, and 6 ft) specimens and (b) for the longest 2.44 m (8 ft) specimens a custom built multi-degree-of-freedom (MDOF) testing rig capable of 897 kN (200 kips) compressive load that is being utilized for testing of full walls in a companion research project [9].

For the 0.6, 1.2 and 1.8 m (2, 4 and 6 ft.) long tests conducted in the MTS machine compressive load is applied through the bottom, and vertical displacement is measured through the built-in position transducer (PT). During testing it was determined that a small isolation plate should be provided between the loading platen and the track, as labeled in Fig. 2a and shown in Fig. 2a and b.

For the MDOF machine, compressive loading is applied through four actuators at the top and the vertical displacement is measured as the average of the vertical displacements measured through built-in PTs in these actuators.

Five PTs and two string pots (SP) are set up at the midpoint and ends of the members respectively, as shown in Fig. 2c, to capture local and global buckling for the different test configurations.

2.2. Cross-sections

Average cross-section (out-to-out) dimensions of the tested 362S162-68 (SSMA/ASTM nomenclature [11] see footnote 3 in Table 1) studs (Fig. 3) and 362T125-68 tracks are given in Table 1 and provided for each stud specimen in Appendix A. To account for the variation in cross-section, three measurements are taken at the ends and center of the studs for each of the dimensions reported. In the case of the tracks, only one measurement is taken at the center for each of the dimensions. Thicknesses of the web and flange include

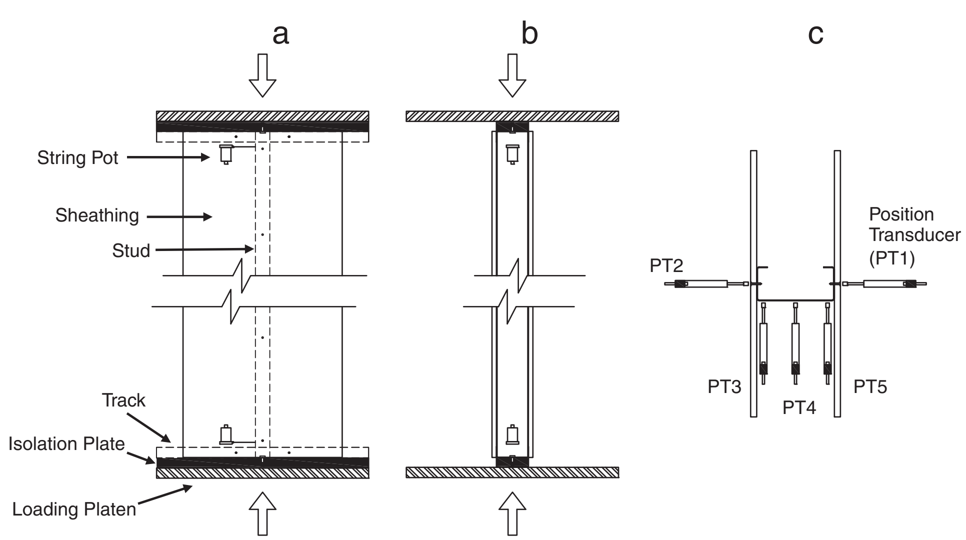

Fig. 2. MTS and MDOF test schematic. a) Side view of the specimen components and isolation plate, b) front view of specimen with emphasis on string pots (SP) and isolation plate, c) PTs placed at mid height of the column.