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CFSEI
COLD-FORMED STEEL ENGINEERS INSTITUTE

TECHNICAL NOTE

On Cold-Formed Steel Construction

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SINGLE SLIP TRACK DESIGN

Summary: The AISI *Standard for Cold-Formed Steel Framing – Wall Stud Design* (AISI S211-07) provides a design methodology for wall framing members installed in a deflection track at a head-of-wall condition. There had been previous methods for this analysis; most notably that permitted by the U. S. Army Corps of Engineers Technical Letter 1110-3-439, and the SSMA Technical Notes on Single- and Double- Slip Track Design. This document covers the most common types of slip track connections, how to handle general and specific issues with slip track construction and design, provides a design example, as well as tabulated information on allowable slip track loads.

INTRODUCTION

This Tech Note addresses the design of a typical single slip-track connection. A slip track is a channel section (typically the top track) of a non-load bearing or curtain wall framing assembly that is fastened to the primary structure, but left unconnected to the vertical stud members. A nominal gap is left between the studs and track webs to allow for vertical movements without axially loading the studs. Stud horizontal reactions are resisted by the slip track flange.

A new series of design formulae were developed in April 2004 following work done at the Milwaukee School of Engineering and the University of Missouri-Rolla. The new criteria were presented to the American Iron and Steel Institute's Committee on Framing Standards for changes to Section C4.3 of the *Standard for Cold-Formed Steel Framing - Wall Stud Design* (AISI 2004.) These changes have been adopted and this Tech Note is based on the new provisions of the standard.

Note that the single slip track requires a different design methodology than the double slip track, as shown in Figure 1(D). The double track requires a specially formed outer track, against which the inner track bears along the full length of the outer track.

Other methods of accommodating structural movement include the use of slip connectors. These connections are covered in CFSEI Technical Note *Design of By-Pass Slip Connectors in Cold-Formed Steel Construction*.

Although the sizing of a slip track is not generally related to drift, where appropriate the occurrence of seismic drift should be considered in the selection of a deflection system.

Figure 1(A): **Single Slip (Deflection) Track Assembly**, which is the subject of this Technical Note. The basic components include the wall studs, the slip track, fasteners attaching the slip track to the structure, and the bracing or bridging members between the studs near the top (slip track) connection. There is no attachment between the stud and slip track.

Figure 1(B): **Reinforcement to Increase Capacity of Single Slip Track**, braces installed adjacent to the stud can add some capacity of the unloaded leg of the slip track, thus increasing the capacity of the single slip track. This configuration is not recommended for normal design for it is better to use thicker track or otherwise increase the load capacity of the system. Where this can be advantageous is for the retrofit of an existing slip track system for higher loads,

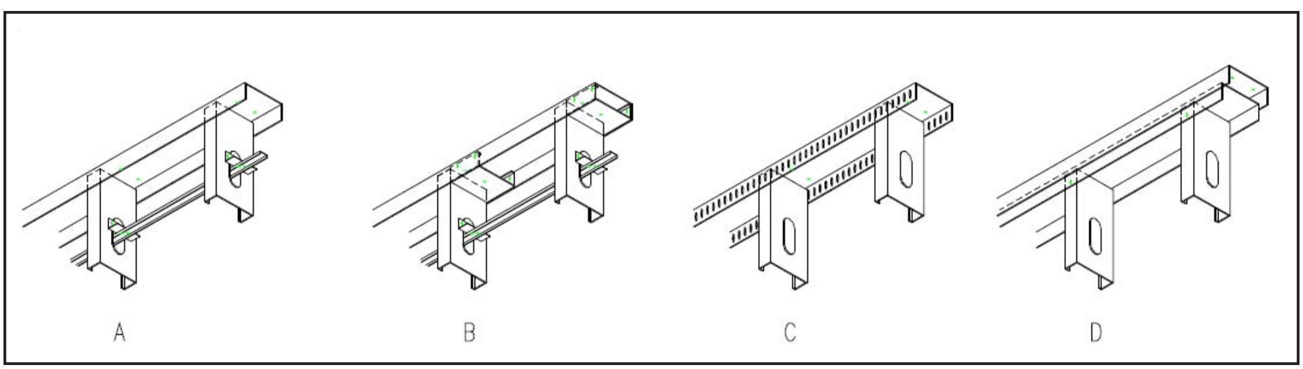

FIGURE 1

or for increasing the track capacity at a higher point load, such as at a jamb. Rational engineering analysis should be employed to determine the capacity of the reinforcement assembly. Note also that the slip track capacity is reduced at a track splice; so some sort of reinforcement detail may be required for studs adjacent to splice locations.

Figure 1(C): **Proprietary Slotted Track**
Several manufacturers have configurations or attachments that allow a connection to be made between the stud flanges and the slip track. The configuration shown requires a screw through the slot into the stud; other configurations include clips restraining either the flange or return lip. The advantage of these proprietary tracks is that the stud flanges are braced; additional bracing is not required through the punchout, as shown in the single track details. In addition, these systems transfer lateral loads through both track flanges. Disadvantages include the need to purchase and specify a proprietary product, availability of the product, the requirement for the proper installation of the screw in the slot, and the need for access to both sides of the wall for installation.

Figure 1(D): **Double Slip Track**
The advantage of this system is that there is continuous bearing of the inner track on the outer track thereby increasing the lateral load capacity of the asembly. The disadvantages are that the outer track requires a non-standard web depth to fit over the inner track and the added build-up of material may create difficulties with the finishing. Additional information on a double track assembly is available in a Steel Stud Manufacturers Association's Technical Note that can be found at www.ssma.com.

DEFINITIONS

Curtain Wall Assembly: Exterior wall system designed to carry lateral loads only, not gravity loads other than its own weight.

End Gap: Distance between the top of a stud and the underside of a slip track web. This dimension appears as variable "e" in equation C4.3-1 of the Wall Stud Standard[1].

Slip Connector: A clip, brace, angle, plate or other device that restrains a stud in at least one lateral direction while permitting vertical movement.

Single Slip Track: A cold-formed steel shape consisting of a web with two flanges without stiffening lips, designed to allow the vertical movement of studs installed between the flanges while restraining their out-of-plane movement. Slip tracks typically have longer flanges than standard tracks.

BACKGROUND

The single slip track is one of the most commonly used connections in cold-formed steel framed curtain wall assemblies and there was very little research on this design condition until recently. The American Iron and Steel Institute (AISI) *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07)[2] does not provide guidance on this subject. The previous most common design model, attributed to several originators and eventually finding its way to the Army Corps of Engineers[3], was based on basic elemental theory. The slip track resisting leg thickness is based on an allowable stress along with an effective width (b_{eff} in Figure 2) of the resisting leg or flange. Some initial research was conducted at the University of Missouri-Rolla (UMR)[4] with more extensive research at the Milwaukee School of Engineering (MSOE)[5]. The intent of the research was to present the nominal capacities for deflection track connections as well as their effective load distribution widths. These are critical aspects of the analytical solution for the

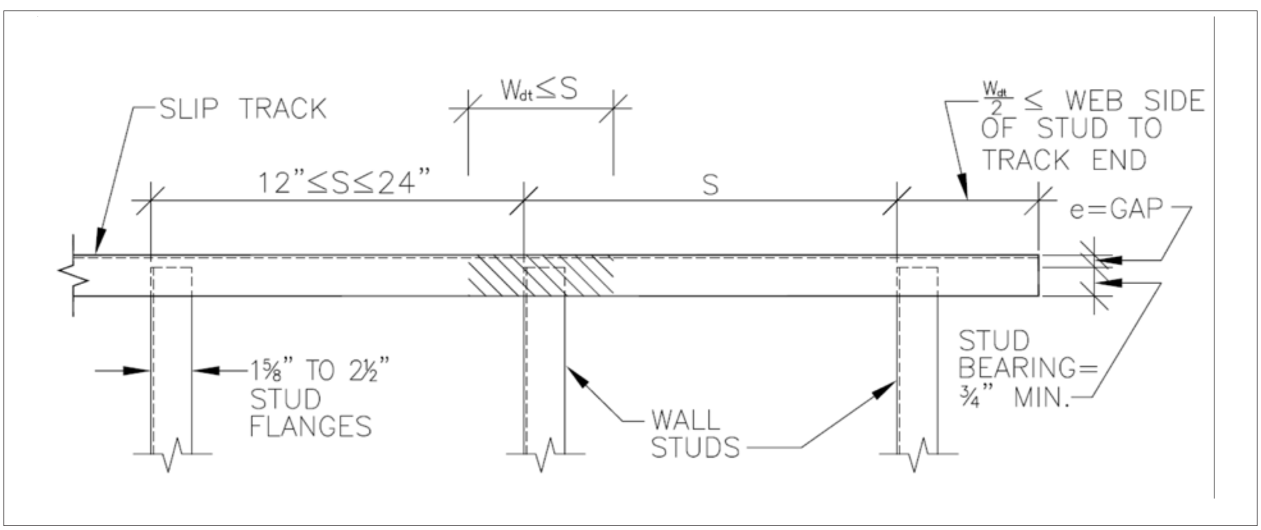

FIGURE 2: ELEVATION OF SLIP TRACK AT STUD BEARING

capacity of the connection detail. Several existing methods of analysis were reviewed, along with finite element modeling, as part of the parametric study. A total of 108 specimens were tested in different combinations of stud flange widths (1-5/8" and 2-1/2"), stud spacing (16" and 24"o.c.), end gap (1/2" and 1"), and 68, 54, and 43 mil track thicknesses (design thicknesses of 0.0713", 0.0566" and 0.0451" respectively). One third of the tests were conducted with offset track connection locations (with fasteners midway between the studs as opposed to directly at or very near the studs) - which resulted in slightly higher failure loads. In the interests of erring conservatively rather than unconservatively, the tests with track connections coinciding with the stud locations were used in determining the nominal capacities. The finite element analysis was completed following the tests, using a stud spacing of 24", a 1-5/8" stud flange, an end gap of ½", and varying track thicknesses. Based on this later research, it was determined that the stud flange width (as well as the slip track fastener locations) contributes very little to the capacity of the connection. In addition, most existing analytical models are overly conservative in determining the capacity of the slip track.

The final results of this research have been adopted into the AISI *Standard for Cold-Formed Steel Framing - Wall Stud Design* (AISI S211-07).

SPECIFICATION / FORMULAS

SECTION C4.3 of the Wall Stud Standard addresses the nominal capacities of the slip track connection and the effective distribution width (of the applied load or stud reaction to the track flange) as described by the following equations:

$$P_{ndt} = \frac{w_{dt} t^2 F_y}{4e} \qquad \text{(Eq. C4.3-1)}$$

$w_{dt} = 0.11\,(\alpha)^2\,(e^{0.5} / t^{1.5}) + 5.5\alpha \le S$

Where:

P_{ndt} = Nominal capacity of the slip track leg
w_{dt} = Effective distribution width
t = Nominal thickness of the slip track
F_y = Yield strength of the slip track
e = Design end or slip gap
S = Stud spacing, center to center
α = conversion coefficient: 1.0 when e, t, and S are in inches
25.4 when e, t, and S are in mm
Ω = 2.80 for Allowable Stress Design (ASD)
Φ = 0.55 for Load and Resistance Factor Design (LRFD)

The specific applicability of the equations from the AISI Wall Stud Standard is for the following range of parameters:

<u>Stud Section:</u>

• Design Thickness:	0.0451" to 0.0713" (1.14mm to 1.81 mm)
• Design Yield Strength:	33 ksi to 50 ksi (228 MPa to 345 MPa)
• Nominal Depth:	3.50" to 6.00" (88.9 mm to 152.4 mm)
• Nominal Flange Width:	1.625" to 2.50" (41.3 mm to 63.5 mm)
• Stud Spacing:	12" to 24" (305 mm to 610 mm) on centers
• Stud Bearing Length:	0.75" (19.1 mm) minimum bearing of stud on track flange, measured vertically

<u>Track Section:</u>

• Design Thickness:	0.0451" to 0.0713" (1.14mm to 1.81 mm)
• Design Yield Strength:	33 ksi to 50 ksi (228 MPa to 345 MPa)
• Nominal Depth:	3.50" to 6.00" (88.9 mm to 152.4 mm)
• Nominal Flange Width:	2.00" to 3.00" (50.8 mm to 76.3 mm)

For cases outside those shown above the designer should follow specific code provisions along with proper discretion and good engineering judgment. In the common case where a stud is supported near the end of the slip track or at a track splice location, the designer should show an option for reinforcement or other device such as a proprietary clip to transfer the load.

EXAMPLE / LOAD TABLE

Example 1:
<u>Exterior stud wall under wind loading</u>
Stud height =10'-0" (600S162-43 studs, selected using wall stud design)
Stud spacing =16" o.c. (S)
End gap = ½" (e)
Wind load = 20 psf (<u>Check a 43 mil, 33 ksi slip track</u>)

$w_{dt} = 0.11\,(\alpha)^2\,(e^{0.5} / t^{1.5}) + 5.5\alpha \le S$
$= 0.11\,(0.5^{0.5}\text{ in.}/ 0.0451^{1.5}\text{ in.}) + 5.5 = 13.62$ in.

$P_{ndt} = w_{dt}\, t^2\, F_y / 4e$
$= [13.62\text{ in.}(0.0451^2\text{ in.})\ 33{,}000\text{ psi}] / [4\,(0.5\text{ in.})]$
$= 457$ lb.
$P_{allow} = P_{ndt} / \Omega$

$= 457/2.8 = 163.3$ lb. > R = 10.0 ft. (20 psf) (16 in./12 in.) / 2 = 133.3 lb. **<u>OK</u>**

<u>Use a 33 ksi. 600T200-43 slip track, continuous</u>

Design End Gap (e)	Stud Spacing (S)	Track Yield (ksi)	Slip Track Thickness (in)	P_{allow} (Stud Reaction) (lb)
1.0”	16	33	0.0451 (43 mil)	96
“	“	“	0.0566 (54 mil)	129
“	“	“	0.0713 (68 mil)	169
0.75”	16	33	0.0451 (43 mil)	123
“	“	“	0.0566 (54 mil)	158
“	“	“	0.0713 (68 mil)	210
0.5”	16	33	0.0451 (43 mil)	163
“	“	“	0.0566 (54 mil)	213
“	“	“	0.0713 (68 mil)	287
0.5”	24	50	0.0566 (54 mil)	323
“	“	“	0.0713 (68 mil)	435
“	“	“	0.1017 (97 mil)	729
“	“	“	0.1242 (118 mil)	1002

Allowable Reaction Table

Note: tabulated values based on allowable stress design (ASD) with design values in inches. Some designers have developed expanded spreadsheets and tables based on different thicknesses and configurations. (Highlighting above indicates the tabular solution for the previous example.)

Slip Track Leg Length

For the leg length, some typical dimensions are as follows:

- For the upper levels of multi-story structures, use a leg length equal to 2xgap + 1”.
- For walls resting on a foundation, use a leg length of gap + 1”.

SUPPLEMENTAL SLIP CONNECTORS:

The most common solution to a point load situation is to use a specialty slip connector; one specifically designed by the engineer or a specialty item fabricated specifically for this purpose. Several options are available; most are made with two or more vertical slots in the clip to allow fasteners, bushings or other pieces of the clip to bear on the slot. Manufactures provide load tables for designers. Note that most tables are based on a serviceability limit of 1/8” deflection of the assembly; if this is too large for the configuration you are specifying, consult with the manufacturer to see if different load values are required for different deflection limits. (Note that the AISI Wall Stud Standard, Section C4.3, does not include any serviceability limits, but indicate that they should be based on the intended function of the wall system and evaluated by the provisions of Section B1 of the Standard.)

References

1. *Standard for Cold-Formed Steel Framing - Wall Stud Design* (AISI S211), American Iron and Steel Institute, Washington, DC.
2. *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100) , American Iron and Steel Institute, Washington, DC.
3. U.S. Army Corps of Engineers Technical Letter 1110-3-439, "Design of Deep Leg Track to Accommodate Vertical Deflections", U.S. Army Corps of Engineers, Washington, DC, 1992.
4. Bolte, William G. “Behavior of Cold-Formed Steel Stud Top Track Connections” Masters Thesis, University of Missouri-Rolla, Rolla, Missouri, 2003.
5. Gerloff, James R. “Cold-Formed Steel Slip-Track Connection” Masters Thesis, Milwaukee School of Engineering, Milwaukee, Wisconsin, 2004.

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