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CFSEI
COLD-FORMED STEEL ENGINEERS INSTITUTE

TECHNICAL NOTE
On Cold-Formed Steel Construction

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TOP TRACK LOAD DISTRIBUTION MEMBERS

Summary: When in-line framing is not adopted as the structural framing scheme, the top track must be relied upon to provide load distribution. This Technical Note explores design issues and provides design guidance for some of the typical top track load distribution members and systems.

INTRODUCTION

When in-line framing is used, the top track is not considered a load transfer member for either gravity load or wind uplift load. However, for non-in-line framing the top track must be called on to contribute to the structural, load-transfer, framing system.

The standard top track member and its application (Figures 1 and 2), resist either gravity load or wind uplift loads by bending with respect to its weak axis. Unfortunately the standard track section possess little bending strength in this orientation because it is bending with respect to its weak axis. Therefore, when in-line framing is not adopted as the structural framing scheme, the top track must be called on to provide load distribution.

To enable load distribution, the standard track member must be reinforced or replaced with a cross section that can function as a bending member to provide the requisite load distribution. For analysis, the classical continuous span beam with multiple identical supports is valid when the axially loaded studs functioning as intermediate supports are of equal stiffness, AE/L. Where openings occur below the continuous track the analysis may consider the intermediate supports as springs of appropriate axial stiffness. The following discussion will explore design issues and provide design guidance for some of the typical top track load distribution members.

COLD-FORMED STEEL DISTRIBUTION TRACK

The top of wall track can be used as the basic element to fabricate a load distribution track. The potential built-up geometry will depend upon if the structure is being stick built or panelized. For a stick-built or a panelized wall assembly, a built-up track (Figure 3) can be fabricated by using another long leg track. This long leg track must be custom fabricated to fit over the standard track section. Allowance must be made for the self-drilling screw head to enable fastening of the standard track section to the stud.

If the wall is to be panelized, the built-up track in Figure 3 can be enhanced structurally by using a C-section instead of the additional track (Figure 4).

A more robust top track can be fabricated by assembling two C-sections to form a box-beam (Figure 5). When using the box-beam, care must be taken to ensure that the top of the wall is adequately braced. If a top-of-wall brace is not provided, rotation may occur at the junction of the top-of-wall track and the box beam. Using the detail illustrated by Figure 6 is definitely not recommended without the use of a top-of-wall brace.

For all of the sections illustrated, the design of the cross section will be based on evaluating the built-up section as a flexural member. Thus, the limit states of bending, shear, web crippling, combined bending and shear, and combined bending and web crippling as defined by the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07) will need to be considered.

Bending. The built-up track is assumed to be a continuous span beam. It is recommended that splices be located over the studs. The bending strength will be governed by AISI Section C3.1.1, $M_n = M_y$.

Caution: The AISI S100 web design provisions are based on a web element that is supported along both of its horizontal edges. Thus, for cross sections having an unstiffened element functioning as a web element, the design check may want to omit the contribution of this unstiffened element. That is, for the limit states of shear, combined bending and shear, web crippling, and combined bending and web crippling only the stiffened or partially stiffened web elements in Figures 4 and 5 may be considered effective. For the detail in Figure 3, if the fasteners are closely spaced, the web may be assumed to be stiffened.

Shear. The webs of the built-up track will be evaluated by using Section C3.2.1 of the AISI Specification.

Combined Bending and Shear. Section C3.3.1 of the AISI Specification contains the design rules for evaluating the combined bending and shear limit state. This limit state typically can be an issue at the track support locations which will be defined as the location of the wall studs.

Web Crippling. Depending upon the location of the joist or truss that is to be supported by the built-up track, either interior-one-flange loading or interior-two-flange loading must be considered. Section C3.4.1 of the AISI Specification provides the design guidance.

Combined Bending and Web Crippling. Section C3.5.1 of the AISI Specification stipulates the design rules for evaluating the combination of web crippling and bending- Because the built-up track is a continuous span member, the critical location for this combined loading is at the interior supports as defined by the wall stud locations.

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Serviceability. Deflection of the distribution member should also be considered. Consistent with the assumption for bending, the track is assumed to be a continuous span beam spanning from wall stud to wall stud. A reasonable deflection limit must be chosen, for example span/240 for total load deflection.

HSS DISTRIBUTION TRACK

Design for the hot-rolled tube (Figure 7) will be governed by the AISC Specification (Specification, 2005) but the limit states will be similar to above limit states for the cold-formed section that is illustrated by Figure 5.

Tests (Daudet, 2003) have indicated that because the HSS section does not bear on the full width of the track section, the wall stud may not be uniformly loaded.

Therefore, to reflect the potential loss in capacity when computing the nominal capacity of a wall stud, P_n, the effective area should be reduced as follows:

$$P_n = A_e \; F_n$$

Where F_n is defined by Section C4 of the AISI Specification and the effective A_e is based on only the web and 70% of the corner radii adjacent to the web (per Daudet tests). The effective width of the web is to be calculated per AISI Section B2.1(a) with $f = F_n$ and $k = 4.0$.

HOT-ROLLED ANGLE DISTRIBUTION TRACK

Design for the hot-rolled angle will be governed by the AISC Specification (Specification, 2005) but the limit states will be similar to limit states of the cold-formed section that is illustrated by Figure 5.

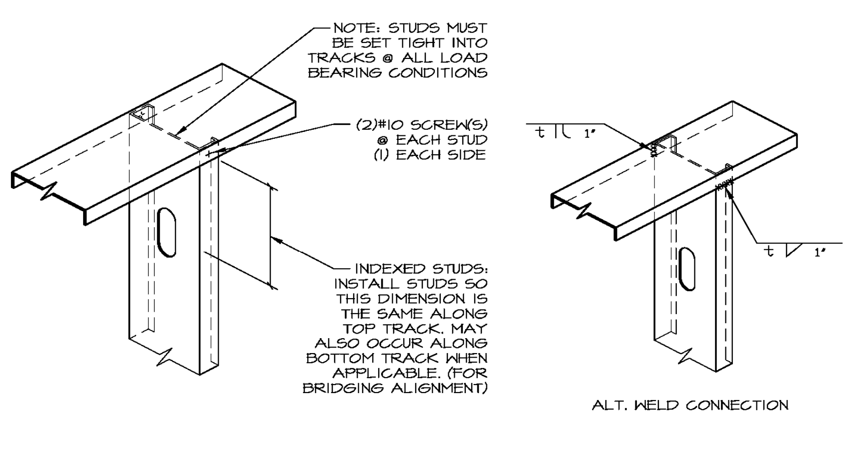

FIGURE 1: TYPICAL INDUSTRY STANDARD TRACK SECTION

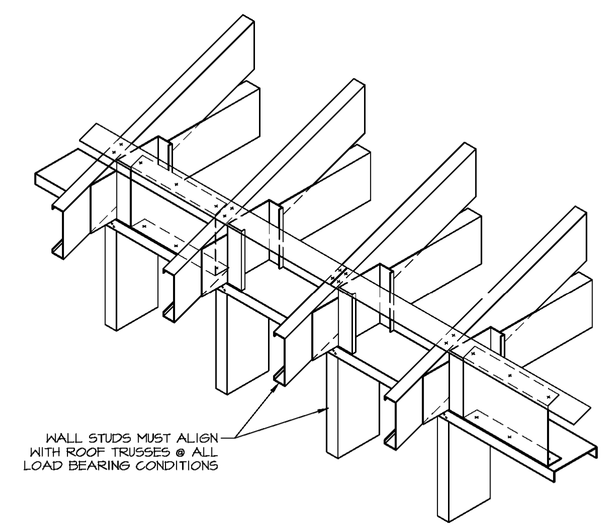

FIGURE 2: TYPICAL IN-LINE FRAMING APPLICATION

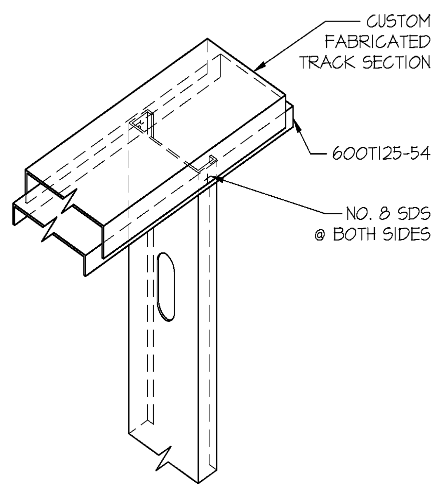

FIGURE 3: BUILT-UP DISTRIBUTION TRACK

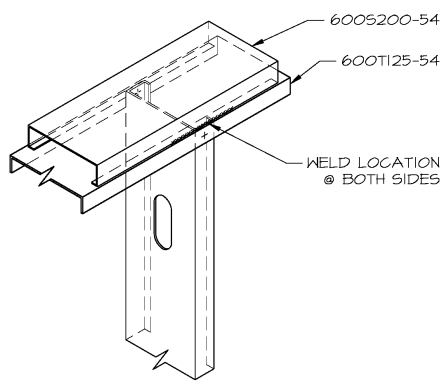

FIGURE 4: BUILT-UP C-SECTION DISTRIBUTION TRACK

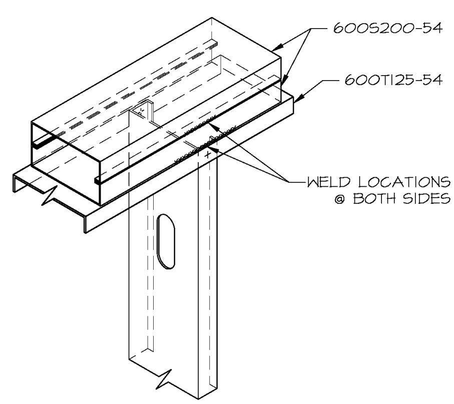

FIGURE 5: BUILT-UP BOX C-SECTIONS DISTRIBUTION TRACK

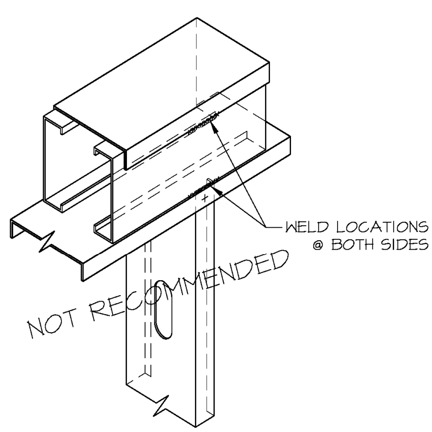

FIGURE 6: ALTERNATE BUILT-UP BOX C-SECTIONS DISTRIBUTION TRACK

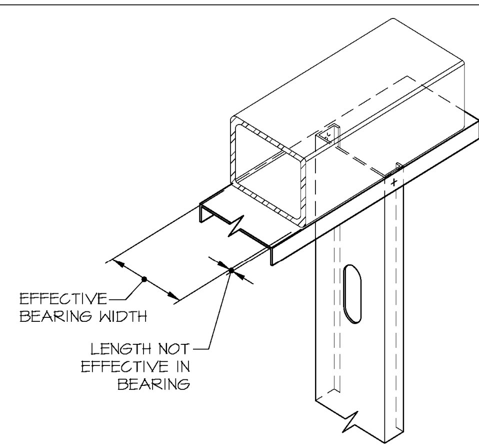

FIGURE 7: HSS DISTRIBUTION TRACK

EXAMPLE PROBLEM: LOAD DISTRIBUATION TOP TRACKS

An axial load bearing wall system that consists of 600S162-54 studs and 600T125-54 tracks is supporting 30 ft. span floor trusses. The studs are spaced 24 inches on center and trusses also are spaced 24 inches on center. However, the truss spacing is offset from the stud by 12 inches (Figure 8). Therefore the top track must support the trusses and transfer the load to the studs.

For this wall system, the track must function as a continuous span beam with equal 24 inch spans. The loading for the continuous span beam is a concentrated load at midspan (Figure 9).

Floor truss loads: Top chord, 30 psf dead load and 40 psf live load. Bottom chord, 10 psf dead load.

Uniform load = 80 psf x 2 ft = 160 lbs/ft

End reaction, W = 160 lbs/ft x 30 ft/2 = 2,400 lbs = 2.4 kips

Nominal moments and shear: Figure 9 illustrates the moment and reaction coefficients for the continuous span beam (i.e. top track).

Moment, M = C x W x L and Reaction, R = C x W

Maximum M = 0.170 x 2.4 kips x 2 ft x 12 in./ft
= 9.79 in.-kips

Maximum R = 0.339 x 2.4 kips = 0.82 kips

Maximum shear, V = 2.4 kips – 0.82 kips = 1.58 kips

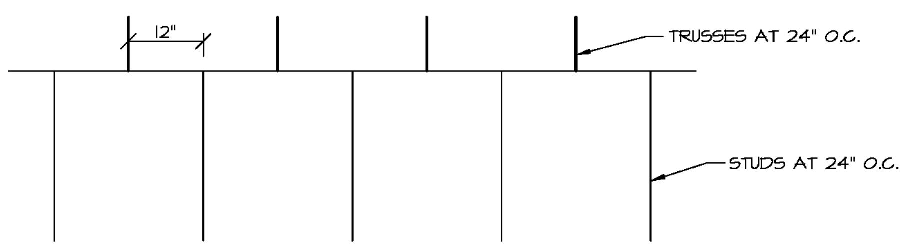

FIGURE 8: SCHEMATIC OF WALL STUDS, TRACK AND TRUSS FRAMING

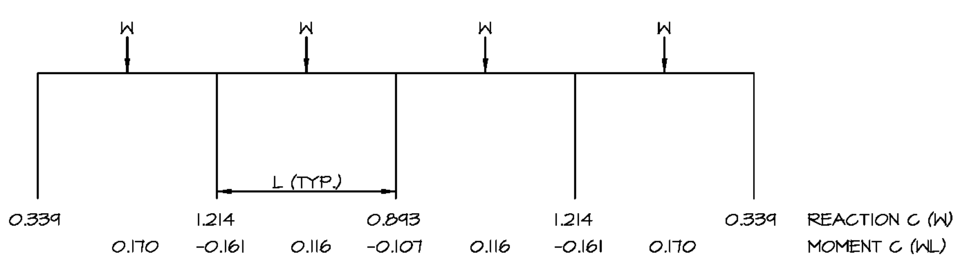

FIGURE 9: 4 SPAN CONTINUOUS BEAM REACTIONS AND MOMENTS

Design of Top Distribution Track

Three built-up cold-formed steel sections will be evaluated in an effort to develop a cold-formed steel solution for the top distribution track. The examples are intended to demonstrate the AISI Specification design process, not necessarily achieve a final design solution.

Built-up Tracks:
Figure 3 illustrates the proposed built-up section. Software was used to compute the following allowable design strengths for the built-up composite section:

M_a = 7.79 in.-kips (AISI S100 Section C3.1.1)

V_a = 6.20 kips (AISI S100 Section C3.2.1)

Member Design Checks:

Bending: 7.79 in.-kips < 9.79 in.-kips Inadequate!

Shear: 6.20 kips > 1.58 kips Adequate!

The proposed built-up section is inadequate and a thicker long leg track is required.

Self-drilling Screw Requirements:

To achieve a built-up section behavior adequate number spacing of self-drilling screws is required to transfer the horizontal shear between the two track sections.

Shear flow = VQ/I

Where V is the nominal shear force, Q is the first moment of the area above the self-drilling screw location and I is the full moment of inertia for the built-up section.

I = 0.6008 $in.^4$ (computed using software)

Q = 1 in. x 0.0566 in. x (1.66 in. – 0.375 in.) = 0.072 $in.^3$

Shear flow = 1.58 kips x 0.072 $in.^3$ / 0.6008 $in.^4$ = 0.189 kips/in.
Screw allowable design strength = 496 lbs (computed in accordance with AISI S100 Section E4.3)

Screw spacing = 0.496 kips / 0.186 kips/in. = 2.62 in.

No. 8 screws would be required at 2.62 inches on center.

NOTE: If over-track is held up off of the top track of the wall, local buckling of the over-track needs to be checked. In addition, the no. 8 screws will have to transfer the added shear load from the trusses to the bottom track and stud; thus be designed for that additional load.

Built-up C-section and Track:

Figure 4 illustrates the proposed built-up section. Software was used to compute the following allowable design strengths for the built-up composite section:

M_a = 14.67 in.-kips (AISI S100 Section C3.1.1)

V_a = 6.50 kips (AISI S100 Section C3.2.1)

Member Design Checks:

Bending: 14.67 in.-kips < 9.79 in.kips Adequate!

Shear: 6.50 kips > 1.58 kips Adequate!

The proposed built-up section is adequate.

Weld Requirements:

To achieve a built-up section behavior adequate number and spacing of weld is required to transfer the horizontal shear between the two track sections.

Shear flow = VQ/I

Where V is the nominal shear force, Q is the first moment of the area above the weld location and I is the full moment of inertia for the built-up section.

I = 1.2230 $in.^4$ (computed using software)

Q = 0.4804 $in.^2$ x (1.87 in. + 0.2043 in.) = 0.996 $in.^3$

Shear flow = 1.58 kips x 0.996 $in.^3$ / 1.223 $in.^4$ = 1.287 kips/in.

Weld allowable design strength = 905 lbs for a one inch long weld computed in accordance with AISI S100 Section E2.4.

Each weld must transfer 50 percent of the shear flow or 0.644 kips/in.

Weld spacing = 0.905 kips / 0.644 kips/in. = 1.40 in.

Welds would be required at 1.40 inch on center (assuming a one inch long weld).

NOTE: Web crippling of the flanges of the horizontal C-section needs to be checked.

Built-up Box C-Sections:

Figure 5 illustrates the proposed built-up section. Note, this built-up section configuration should only be considered if a top-of-wall brace is provided. The track section is not considered as contributing as a load carrying member. Software was used to compute the following allowable design strengths:

M_a = 21.58 in.-kips (AISI S100 Section C3.1.1)

V_a = 7.09 kips (AISI S100 Section C3.2.1)

P_a = 1.50 kips per web (AISI S100 Section C3.4.1)

Combined Bending and Web Crippling Check (AISI S100 Section 3.5.1)

Member Design Checks:

Bending: 21.58 in.-kips < 9.79 in.-kips Adequate!

Shear: 7.09 kips > 1.58 kips Adequate!

Web Crippling: 3.00 kips > 2.4 kips Adequate!

Combined Bending and Web Crippling: 0.711 < 0.782 Adequate!

The proposed built-up section is adequate.

NOTE: Web crippling of the flanges of the horizontal C-sections needs to be checked.

Weld Requirements:

To achieve a built-up section behavior adequate number and spacing of weld is required to transfer the horizontal shear between the two C-sections.
Shear flow = VQ/I

Where V is the nominal shear force, Q is the first moment of the area above the self-drilling screw location and I is the full moment of inertia for the built-up section.
kips/in.

I = 1.9942 in.^{4} (computed using software)

Q = 0.556 in.^{2} x (1.214 in.) = 0.675 in.^{3}

Shear flow = 1.58 kips x 0.675 in.^{3} / 1.9942 in.^{4} = 0.535

Weld allowable design strength = 905 lbs for a one inch long weld computed in accordance with AISI S100 Section E2.4

Each weld must transfer 50 percent of the shear flow or 0.267 kips/in.

Weld spacing = 0.905 kips / 0.267 kips = 3.39 in.

Welds would be required at 3.39 inches on center.

References

1. Daudet, R. “Research Study Using Tube Steel Distribution Headers.” Newsletter for the Light Gauge Steel Engineers Association, Winter edition, 2003.
2. AISC. *Specification for Structural Steel Buildings, 13th edition,* American Institute of Steel Construction, Chicago, IL. 2005.
3. AISI. *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07), American Iron and Steel Institute. Washington, DC, 2007.

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