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TECHNICAL NOTE

On Cold-Formed Steel Construction

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CHASE THE LOADS: LOAD PATH CONSIDERATIONS FOR COLD-FORMED STEEL LIGHT-FRAME CONSTRUCTION

This Technical Note updates and replaces CFSEI Technical Note G200-15

Summary: Engineering students are admonished to “chase the loads” in their structural analysis and design courses. A “load path” is the direction in which each consecutive load will pass through framing members and the connected members of a framing assembly. The load path sequence begins at the point of load application, both vertical (gravity, wind uplift or seismic vertical) and lateral, on the structure and works all the way down to the footing or foundation system, ultimately transferring the load of the structure to the foundation. This tech note provides insight into the load path considerations for cold-formed steel framing.

INTRODUCTION

The goal of every structural framing system is to provide a load path. Figure 1 illustrates a typical load path that begins at the point of load application on the structure and progressively works its way to the foundation. A continuous load path is capable of transferring the applied loads that are imposed on the structure at various locations from the point of load application down to the foundation. For example, if a load is applied on top of a floor of a conventional steel framed structure,

1. The floor must be able to support itself and the load.
2. The beams supporting the floor must support themselves, the floor, and the load.
3. The girders must be able to support themselves, the beams, the floor, and the load.
4. The columns must be able to support themselves, the girders, the beams, the floor, and the load.
5. The foundation must be able to support the columns, the girders, the beams, the floor, and the load.

A structural analysis will typically assume a straightforward load path as defined by the conventional steel framed structure. However, for cold-formed steel framing, the actual load path may be more complex because of the structural configuration and system effects that can result in load sharing, partial composite action, influence of assumed non-load bearing partition walls, and a redistribution of forces. Thus, a full accounting of the load path requires a rigorous structural analysis. This tech note will provide insight into the load path considerations for cold-formed steel framing.

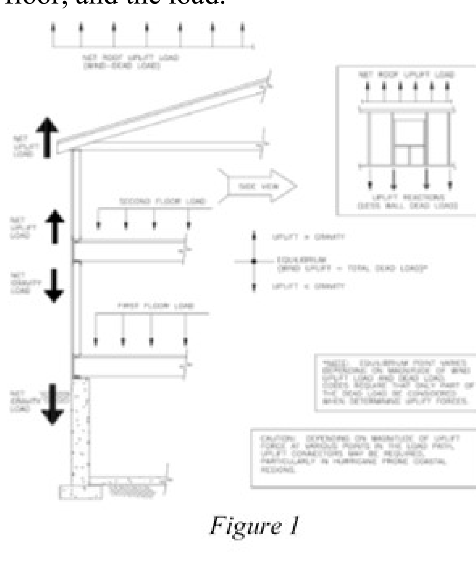

Figure 1

VERTICAL LOAD PATH

Figures 1 and 2 illustrate vertically oriented loads created, respectively, by gravity and wind uplift. Wind uplift load originates on the roof from suction forces that act perpendicular to the exterior surface of the roof as well as from internal pressure acting perpendicular to the interior surface of the roof-ceiling assembly in an outward direction.

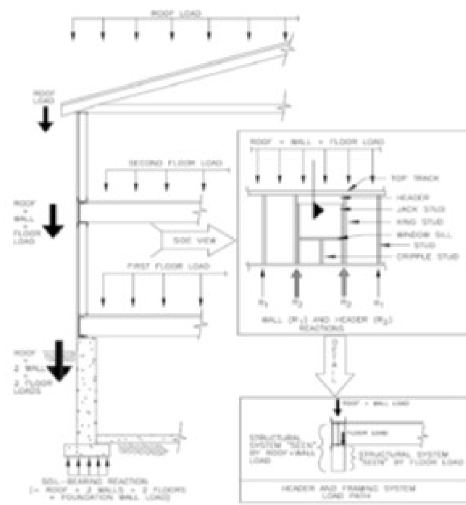

Figure 2

Cold-formed steel framing is commonly configured in either an in-line or ledger framing assembly (Figures 3 and 4). Thus, the inter-story load transfer depends upon the framing concept.

In-line framing provides a fairly direct load path with the axial load from the upper stud being transferred through the floor joist web and web stiffener into the lower stud. Load eccentricities need not be considered when designing the wall studs. The load transfer through the interface or joist and web stiffener is also considered to be axial loading only. The web stiffener is designed as a stub column per the provisions of either AISI S100 (CSA S136) or AISI S240. An illustrative example for the floor joist web stiffener is provided in AISI D110, Cold-Formed Steel Framing Design Guide.

A modified in-line framing concept utilizing a top track distribution member is required when the joist and studs do not align. AISI S240 stipulates installation tolerances as summarized in Figure 5. When these tolerances are not met, a top track load distribution member is required. For more information regarding the design of top track load distribution members refer to TN W104-Top Track Distribution Members.

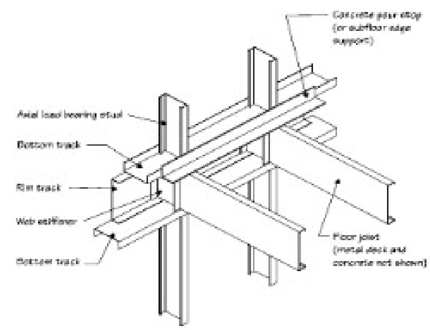

Figure 3 – In-Line Framing

Ledger framing (Figure 4), however, imposes an eccentric loading on the wall stud as follows:

- Floor load is transferred by connectors to the outstanding clip angle leg
- Load is transferred by the clip angle in shear and bending to the clip angle connectors to the carrier track web
- Load from the carrier track is transferred to the wall stud flange
- Wall stud is designed as a beam-column with an axial load equal to the joist end reaction and an end moment equal to the joist end reaction times ½ the stud depth. This loading is in addition to a pure lateral loading due to wind or seismic forces. The load combinations of the applicable building code must be addressed.

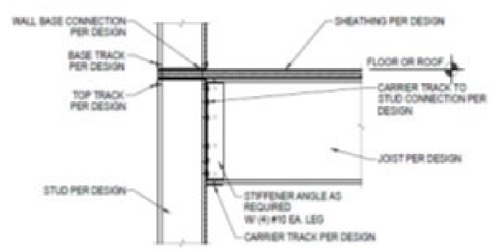

Figure 4 - Ledger Framing

AISI D110 provides a detailed example (Example #5) of a cold-formed steel framed floor system supported by a steel stud wall, including a window opening, using the ledger framing approach. The example "chases the load path" through the system and includes member selection and the design of the clip angle/web stiffener using the provisions of AISI S240. A rule of thumb used to control deflection is to choose a clip angle one thickness heavier than the connected members, but not less than 0.0566". A more rigorous analysis of this connection is also acceptable and may result in a thinner angle.

LATERAL LOAD PATH

Wind or seismic loads produce lateral forces on a structural framing system, both the individual components, and the structure as a whole. These forces must also be provided with a load path such that they are ultimately resolved to the foundation.

Lateral wind or seismic loads create uplift or overturning forces and an analysis of the lateral load path must address these overturning forces. It may be feasible to combine the vertical (wind uplift) and lateral overturning forces and investigate a simple load path to accommodate wind uplift and overturning force simultaneously.

The overall system that provides lateral resistance and stability to a building is known as the lateral force resisting system (LFRS). In cold-formed steel-framed construction, the LFRS may include diagonal strap bracing, shear walls and horizontal diaphragms. Shear walls are walls that are typically braced or clad with structural sheathing panels to resist racking forces. Horizontal diaphragms are floor and roof assemblies that are also usually clad with structural sheathing panels. Thus, the lateral forces imposed on a building from wind or seismic action also follow a load path that distributes and transfers shear and overturning forces from lateral loads in a series of conversions from horizontal forces into vertical forces to collect down to the foundation.

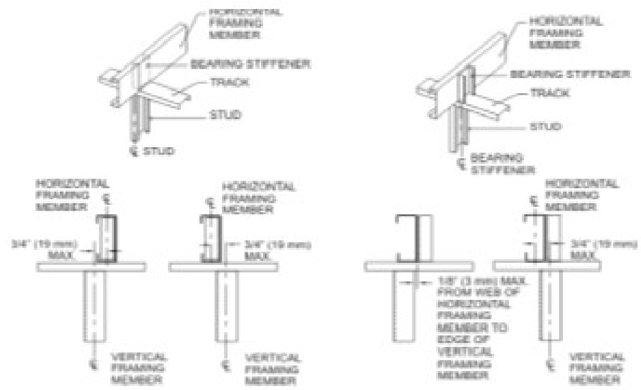

Figure 5 – In-line Framing Tolerances (AISI S240)

For additional design guidance on diagonal strap bracing as illustrated in Figure 6, including an example calculation, refer to L001-Design of Diagonal Strap Bracing Lateral Force Resisting Systems. Additional design guidance for shear wall and floor diaphragm design can be found in TN L202, TN 558b-1 and AISI D113 – Cold-Formed Steel Shear Wall Design Guide.

A lateral load path is also required for the end reactions of the individual members in curtain wall framing, where the wall stud is primarily a flexural member. In this application the cold-formed steel wall stud is primarily a flexural member. For additional guidance refer to TN W102, Introduction to Curtain Wall Design Using Cold-Formed Steel.

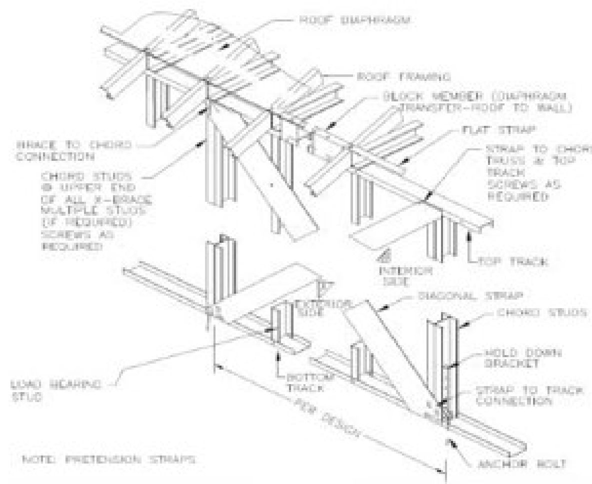

Figure 6 – Strap Bracing

REFERENCES:

- AISI S100-16, *North American Specification for the Design of Cold-Formed Steel Structural Members*, American Iron and Steel Institute
- AISI S240-15, *North American Standard for Cold-Formed Steel Structural Framing*, American Iron and Steel Institute

- AISI D110-16, *Cold-Formed Steel Framing Design Guide*, American Iron and Steel Institute

  AISI D113-19, *Cold-Formed Steel Shear Wall Design Guide*, American Iron and Steel Institute

CFSEI Tech Notes:

- TN W102, *Introduction to Curtain Wall Design Using Cold-Formed Steel*
- TN W104, *Top Track Distribution Members*
- TN L001, *Design of Diagonal Strap Bracing Lateral Force Resisting Systems*
- TN L202, *Diaphragm Design with Pneumatically Driven Pins*
- TN 558b-1, *Lateral Load Resisting Elements: Diaphragm Design Values*

REFERENCES FOR CANADA:

- CSA S136, *North American Specification for the Design of Cold-Formed Steel Structural Members, Canadian Standards Association*

Original Authors of this Technical Note:
Jeffrey Klaiman, P.E., ADTEK Engineers, Inc.
Roger LaBoube, Ph.D, P.E., Wei Wen Yu Center for Cold-Formed Steel Structures.

Technical Review and Updating for Revised Edition:
Jon-Paul Cardin, P.E., American Iron and Steel Institute.

Original Technical Note Reviewers:
John P. Matsen, P.E., Matsen Ford Design Associates, Inc.
Rob Madsen, P.E., Devco Engineering, Inc.
Maribeth Rizzuto, Cold-Formed Steel Engineers Institute.