DESIGN OF BY-PASS SLIP CONNECTORS IN COLD-FORMED STEEL CONSTRUCTION

SUMMARY: Slip connectors allow for vertical movement of studs or supporting structure without imposing additional axial load on wall studs and other wall elements. This Tech Note covers various types of slip connectors in bypass and below-structure conditions and gives design examples for some of the most common types. It does not address the common single or double slip track.

Introduction

In the design of structures, it is important to define the path of loads through the structure. When non-structural elements are installed within the structural envelope, they often end up unintentionally carrying axial loads. Beams, slabs and other floor elements are often designed for relatively long spans between columns. The unintentional loading of interior non-bearing walls can reduce the live load capacity of supporting elements. For interior drywall framing, relatively small axial loads can cause buckling of the studs and cracking of attached sheathing. Exterior members accidentally loaded can lead to excessive deflection, buckling and failure of the building envelope.

Gypsum drywall manufacturers have developed a detail to prevent overloading of interior drywall partitions. This detail, called “perimeter relief,” includes a gap at the top of the wall and allows a standard runner track to “slip” over the top of the stud wall framing. For many years, this detail has been applied successfully for interior partitions with light lateral loads. However, until recently, there have been few options for exterior wall and bypass slip connections other than the common slip track.

Determination of Need for Slip Connectors: Vertical Movement

Slip connectors are used in conditions where vertical movement of the main structure is anticipated, but axial loading of the stud could cause adverse effects. These effects may include, but are not limited to, failure of the connections, buckling of the studs, overstressing and cracking of wall components, and increasing the permeability of roof and wall systems to air and water.

Sometimes, by anticipating vertical movement and provid-

Definitions

**Bypass condition** – A type of connection involving cold-formed steel framed studs, in which the stud members are continuous vertically along a spandrel edge of a floor or roof, and may or may not be connected at the spandrel for lateral support.

**Curtain Wall Assembly** – An exterior wall system designed to carry only lateral loads. This type of assembly is typically not designed to carry gravity loads other than its own self-weight.

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

**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 legs while restraining out-of-plane stud movement. Slip tracks typically have longer legs than standard tracks, and often require additional mechanical bracing of the stud members.

**Spandrel Beam** – A structural member loaded in bending only supporting a floor slab or roof deck on one side only. Beams typically occur at the outside edge of a floor or roof, or along the edge of a floor opening such as openings for elevators or stairs. Bypass slip connectors are often connected directly to or adjacent to edge beams.

**Spandrel Window** – A continuous window condition between floors, usually made with non-vision glass.

**Story Drift** – The lateral movement of one level of a structure with respect to adjacent levels due to the effects of wind or seismic or other lateral loads.
ing adequate support, systems may be designed in a manner that eliminates the requirement for slip connectors. Exterior wall studs quite often have the capacity to carry large vertical loads in addition to the lateral loads for which they are designed. However, when considering these vertical axial loads, the designer must also consider how these loads will get into the stud (the bypass or top connection) and also how these loads will be carried by the foundation below.

The designer must also account for other wall elements, such as windows and doors, and provide a means for the vertical loads to bypass these elements (usually through headers and jamb studs). The footing or floor below the base of a stud wall must be capable of carrying additional loads from non-slip conditions, such as floor live loads and roof gravity loads.

Where the wall studs extend to the underside of the structure, it is much easier to justify the elimination of slip connectors or slip tracks at the tops of the walls. In bypass conditions, because of the eccentricity of the load from the stud centerline, it is usually best to include slip connectors if the anticipated movement and subsequent load is not small.

### Drift Connectors: Permitting Horizontal Movement in the Plane of the Wall

When the overall structure experiences lateral loads, such as from a wind or seismic event, story drift takes place. This is the differential movement of one floor level, or story, relative to the adjacent floors above and below. When this movement is parallel to a wall, and the wall is fixed to the floor planes above and below, the wall is racked out of shape from a rectangle to a parallelogram. If the wall is designed as a shear wall as a part of the building’s lateral system, it will have structural elements to resist this racking.

However, non-loadbearing curtain wall assemblies typically are not designed as shear walls, even though they may experience sizable out of plane loads. When these walls are not a part of the building’s lateral system, and the designer does not want them to contribute unintentional support to the rest of the structure, they may be isolated with drift slip connectors (Figure 2). If the non-loadbearing wall supports a heavy exterior cladding such as masonry veneer, isolation of the wall helps prevent cracking of the veneer and may help reduce the hazard of falling debris during a lateral load event.
This isolation also reduces stresses on windows, fixtures, and other openings in curtain wall systems.

**Locations of Slip Connectors**

The most common location for a slip connection is at the top of a wall panel, where it comes to the underside of, or bypasses, a structural element, such as a floor slab or spandrel beam. Under load, this upper portion of the structure may deflect up or down. The connector is designed to allow this movement, without axially loading the stud. Note that in this configuration, the only axial load a wall component experiences is the dead load from its own self-weight, and the weight of any cladding that the wall is supporting.

Slip connectors may be located between individual panels that bypass a structure. The panel connections shown in Figures 1, 3 and 4 demonstrate this type of connector: each individual floor level can move independently of every other floor level. The panels are two stories tall, and the slip connector is located at a level that is convenient for the installer and finisher (usually at window sill level). Note that either the male or female portion of this connection (Figures 3 and 4) may be on top.

It is very rare for a slip connector to be at the bottom of a wall (Figure 5). In retrofitting existing structures (especially where multi-level roof systems are involved), when the lower portion of the roof cannot take the dead load of the wall in combination with drifting snow, the wall may be clipped to the upper portion of the structure and be seated inside a series of slip connectors or a slip track. Constructability of this type of system is more difficult because the wall studs must be suspended in place with the proper gap at the bottom before being connected to the structure above.

Note that this *Tech Note* addresses under structure, bypass, and horizontal slip conditions. In the bypass condition, the stud or panel system is located outside the structure, rather than underneath floor or roof elements. At a bypass condition, the slip connector must extend from the structural element out to the stud wall system. If there is no slip connec-
In a multi-story structure, there are often horizontal control joints to separate the cladding materials of an exterior wall between floors. At a spandrel condition, with continuous or partial ribbon windows around the entire building, this joint is typically at the top of the windows. With brick or masonry veneer, there is usually a shelf angle or relief angle at each floor level carrying the dead load of the veneer. In this case, the control joint is usually directly below this shelf angle.

When very long windows are not continuous around the structure, the location of the horizontal control joint is not always detailed at the same elevation. This can create a condition where wall segments immediately adjacent to one another are expected to slip vertically. Currently, there are no joints available on the market for wall systems to move in this manner. Therefore, detailing of the slip
Common Types of Slip Connectors

The following details show examples of slip connectors commonly used. Other connector configurations not shown here are also possible and permissible.

A. Slotted angle for attachment to vertical face of structure.

B. Slotted angle for attachment to underside or top of structure.

C. Mechanical clip or channel formed to fit inside or over stud, to allow for vertical movement while attaching to vertical face of structure.

D. Mechanical clip that fits around flange and lip or inside stud, which is attached to top or bottom of the structure.

E. Angle or clip made up of multiple pieces, where one part of the clip slides with respect to the other part: one part is anchored or fastened to the structure, and the other part is screwed or welded to the stud.
connections in this type of wall needs to prevent this type of adjacent vertical movement.

**Testing of Slip Connectors for Capacity**

The American Society for Testing and Materials (ASTM) currently does not have a test protocol specifically for slip connectors. The Center for Cold Formed Steel Structures (CCFSS) has developed one possible testing protocol based upon ASTM standards and the AISI North American Specification for the Design of Cold Formed Steel Structural Members. This test method is published as LGSEA Research Note “Testing and Establishing Design Values for Slip Clips” (RN 2-02).

In the CCFSS testing protocol, both strength and service-ability capacities are considered.

Some or all of the following design items should be considered when designing slip connectors:

1. **In-Plane Movement of Wall**

With seismic or high-wind loading of a wall system, wall components may experience forces along the length of the wall. The connection at the base to the structure below, as well as the diaphragm action of the sheathing, is usually enough to prevent lateral wall movement. However, if slip connectors at the top of a wall restrain such movement, they may become loaded during a seismic event. Relative to seismic forces, this load may be calculated based on the wall weight, and should be considered in design of wall slip connections in high seismic zones.

2. **Anticipated Amount of Vertical Movement**

Slip connectors are typically designed for live load deflection only, and possibly some anticipated deflection due to creep of concrete or wood structures. For roof systems, there could possibly be some upward deflection due to wind uplift conditions. Additional downward gravity loads due to snow accumulation and ponding should be considered. Also, multi-span or cantilevered floor and roof conditions can deflect
upward when adjacent spans are loaded downward. Standard rational engineering analysis, appropriate to the type of structure and loading conditions, should be used to calculate the anticipated deflection. Once this is done, a connector should be selected that has the capacity to accommodate the anticipated movement. Several of the connectors have a limited range of movement, based on the length of a slot or gap in the connector. Note that most manufacturers recommend that the screw or bolt be centered in the slot, which effectively reduces the allowable movement in any one direction to half the slot length. It is recommended that designers do not specify that connectors be “bottomed out” in either the top or bottom of a slot, since if the fastener is installed in the wrong end of the slot, the slip connector will be completely ineffective.

3. Amount of Lateral Load on the Connector

Based on lateral wind and seismic loads, the connectors must be capable of carrying the lateral loads from the studs back to the structure. Not only must the connectors be capable of carrying the load, but the fasteners used for both the stud and the structure must be investigated separately. Some slide clip manufacturers have tested the entire assembly, which includes their clip, the connection to the structure, and the connection to the studs. Design tables from the manufacturer often give different values for different mil thickness studs, because the stud itself or the connection at the stud will fail before the slip connector will. Designers are responsible for ensuring the validity of published data from manufacturers, and verifying that the appropriate $\Omega$ or $\phi$ factors are used, based on AISI Chapter F design requirements.

4. Control Joints

Walls are typically made up of multiple types of materials. Where a structural slip connector allows for movement of the structure with respect to the cold-formed steel system, additional consideration must be given to movement of the other wall materials. Locations where this occurs include, but are not limited to:

- At face of slab edge, where a control joint may be needed on the exterior finish system.
- At the roof side of a bypass parapet (see Figure 9).
- Below relief angles.
- At the inside face of bypass walls (see Figure 8). At this location, allowance for movement is typically not as critical, since movement does not compromise the building envelope and allow for thermal or moisture penetration.

Stacked Wall Conditions

In tall, multi-story bypass conditions, it is difficult and sometimes impractical to ship and install studs longer than 40 - 45 feet. For one-, two-, and sometimes three-story structures, a single stud is usually used (Figure 7). Most often, wall stud systems in taller, multi-story bypass conditions are made to span two stories, and stud panels above are “stacked” on top of the lower panels (Figure 8). This configuration has
the dead load of the system bear on the strip footing or foundation at the ground wall, and at each floor a slip connection is installed. This slip connection carries only the lateral load from the stud, and all vertical load is transferred to the ground below.

Similarly, some projects will have slip connections at every other floor, and fixed connections at the floor below (Figure 1, page 2). With this configuration, less dead load is transferred to the foundation at the wall perimeter, and only half as many slip connectors are required. However, the fixed connections must be designed for both vertical and lateral load. At the interface between panels, a connection must be made that prevents dead loads from the upper panel from being transferred to the lower panel, yet allows lateral loads to be transferred. This may be done with a plate and pin connection, as shown in Figures 3 and 4 (shown on page 3).

**Other Conditions**

In certain conditions, slip connections are either not functional or not appropriate for the system being designed. Below is a summary of some of these special conditions:

- Very high vertical movement, exceeding the capacity of typical connectors.
- Connections where exterior cladding will not tolerate excessive movement of substrate, or detailing does not include control joints at slip locations.
- Bridging across building expansion joints.
- Anticipated building movements will be very small.

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