Multi-Story Building with Ribbon Windows. Courtesy of ProCon Construction.

Cold-Formed Steel Façade Framing

Design Considerations

By Anthony D. Coviello, P.E., S.E.

Cold-formed Steel (CFS) is often used as the intermediate structural framing system, transferring the loads on the building façade into the floor and roof diaphragms. It is important that structural engineers have a good understanding of the limitations of CFS, as well as its possibilities. The façade attachments and fenestrations need to be considered in the initial design phase by the Engineer of Record (EOR). Too often it is passed onto the Specialty Engineer for coordination with the Architect, after construction has commenced. This is too late in the process and can lead to change orders with additional unanticipated project costs. This article outlines some common CFS façade framing issues and how the EOR can resolve them with early consideration.

Common pitfalls in CFS façade framing can be categorized into five areas:

- Stud Sizing
- Ribbon Windows
- Parapets
- Masonry Veneer at Wall Openings
- Fire-Proofing

Stud Sizing

The two most prevalent stud sizes in building envelopes are 3⅝-inch and 6-inch wide. The stud size is often chosen by the architect; however, the engineer should play a larger role in this decision process. In choosing the stud size, one should consider;

- Wall height
- Deflection limitations
- Header and Sill sizes
- Top and bottom track connection details

Both 3⅝-inch and 6-inch studs can span most common floor-to-floor heights by adjusting flange widths and steel thickness. However, as in hot-rolled steel, the cost of cold-formed steel framing is based predominately by weight. Therefore, the more efficient material sections will be less expensive. For example, a 600C162-54 stud (1⅝-inch x 6-inch x 54-mils) has a nearly equivalent section modulus as a 358C162-100 stud. However, the 3⅝-inch stud weighs 60% more and has a 40% smaller moment of inertia. Of additional concern are the lengths of the wall openings. Long windows will require longer headers and sills. Studs can be nested within track sections for a "built-up" section. However, code limitations allow for only two nested sections. The EOR should determine if cold-formed steel headers and sills will be feasible. It may be more cost effective to increase the wall stud size. In rare cases, hot rolled steel framing (channels or angles) might be the better solution.

The studs will typically be supported by U-shaped steel tracks at the bottom and tops of the wall. Consideration must be made for the placement of the track relative to the edge of slab or deck. Tracks are usually fastened to steel or concrete with powder actuated fasteners (PAFs) or, less commonly, self-tapping screws. PAFs are required to be no closer than 3-inches to the edge of concrete. Tracks flush to the outside edge of concrete, or overhanging the edge of concrete, may not allow for adequate space to place the fastener. Concrete screws have a small capacity within 1¼ inches of a concrete edge, and may be an option. If considered early on in the design process, the EOR can include steel embedments in the slab for attachment of the track when the smaller stud size is required.

A cautionary note, ASCE 7-05 requires that most walls be designed for a small seismic force, as outlined in Chapter 13. The limitations on post-installed anchors in structures of Seismic Design Category C or greater outlined by ACI 318 will require an anchorage system approved for the cracked concrete condition. PAF anchors are not currently an acceptable anchor under those requirements.

Ribbon Windows

The look of continuous windows across the façade of the building is sleek. Architects like the appearance of the roof floating above a ribbon of glass. Structural Engineers are charged with the difficult task of making the structure "float". These window systems are extremely problematic to the CFS engineer if they have not been thought-out well in advance.

It is obvious that CFS headers and sills cannot span across the entire length of the building. Each stud or groupings of studs will need to be constructed to prevent the lateral movement of the wall. The placement of the continuous windows in the mid-height of the typical floor-to-ceiling stud creates two hinges (top and bottom of window) between the two supporting elements (floor below and above). This requires cantilevered construction of the stud framing.

The header detail is considered here first, since it is usually the easiest to resolve. The first and most common way to brace the stud above a window is with a kicker (diagonal brace) hidden above a dropped ceiling. The vertical weight of the wall above the window is supported by the

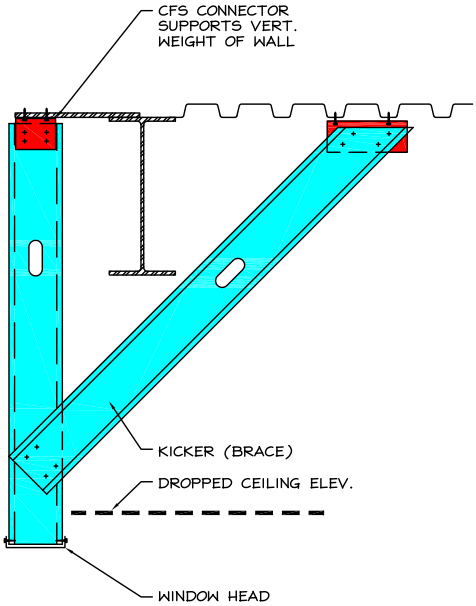


Figure 1: Wall framing above ribbon-type windows.

vertical stud, and half of the lateral force from the window and half of from the stud above are transferred into the diagonal member. Special attention has to be made to the vertical stud connection at its top. The stud is typically outside the face of the steel framing for reasons discussed later. This requires that the stud be fastened to the side of the spandrel beam, pour stop, or to the underside of corrugated metal decking. The metal decking may require reinforcing depending on its orientation, span length, and/or thickness.

The diagonal stud above the window is fastened back to the ceiling above with a CFS angle. The connection of the CFS angle to the metal deck is often the weakest link in the system. This is because metal deck gauges are usually much smaller than typical CFS framing. Several screws may be required to resist the combined tension (pullout) and shear condition. In addition, as *Figure 1* illustrates, the flutes of the corrugated metal deck may not align with the location of the required screws. Options for accommodating this are: 1) Add a wide piece of continuous sheet steel screwed to the metal deck. This provides a flat working surface for the CFS angles. The sheet steel needs to be analyzed for the transmission of loads. 2) Add a hot-rolled steel section beneath the metal deck specifically for the attachment of the kickers.

The space below the window is more complicated. Kickers are normally not allowed due to interruption of the floor space. The ideal method of framing the wall in this area is to have the studs bypass the slab edge and spandrel beam along the outside of the building. The vertical weight of the wall is transferred into the spandrel beam or the slab edge through CFS angle connectors. Horizontal loads are resolved through a force couple at the slab level and at the bottom of the spandrel beam.

If bypassing the floor system is not an option, one might try to use a proprietary moment-resisting connector. Most of the major CFS manufacturers produce products that can fasten the base of a stud to a floor or beam with a nominal moment capacity. However, the capacities are often very small and the connectors allow a significant rotation (approximately 1.1 degrees). For example, a 3-foot tall window sill would deflect ¾ inches with a 1.1 degree rotation. For this reason, these connectors will usually only work with short sill heights, less than 12 inches.

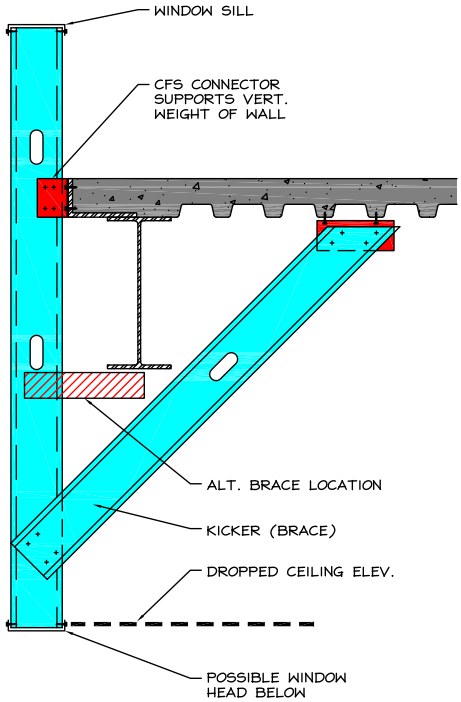
Another option is to frame HSS or Angle steel posts at an interval (usually 4 feet or less) beneath the windows. Vertical studs are fastened to the posts and a track section spans between them. Infill studs are placed in between. This requires coordination from the initial design phase.

Parapets

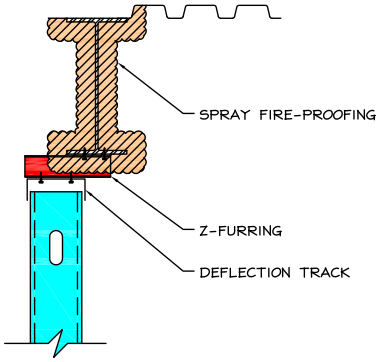
The wind loads on parapets are very high when compared to the wall elements below the roof line. ASCE 7-05 requires that two conditions be considered. The first is the presence of a positive wall pressure on the outside face of the parapet, in combination with a negative roof pressure on the inside face. The second considers the wind in the other direction. A positive wall pressure is placed against the inside face of the parapet in combination with a negative wall pressure on the outside face. The worst case governs. Parapet loads are usually about twice the magnitude of typical wall loads.

Parapet wall studs have similar connection detail issues as the studs beneath ribbon windows and, therefore, are handled similarly. Parapets are commonly constructed by cantilevering the wall stud from below the roof, bypassing the spandrel beam. This type of parapet framing represents the fastest construction methodology. However, the size and gauge of the wall stud will most likely be controlled by the parapet loads.

Some parapets are constructed as a separate element on top of the roof framing. When this is the case, the same options discussed previously for the window framing below ribbon windows are used here, except, an additional option of a kicker back to the roof deck might be employed. The diagonal brace does present some challenges for the roof membrane installation and flashing.



Wall framing below ribbon-type windows.



Wall stud connection at spray fire-proofed beams.

Masonry Veneer at Wall Openings

Masonry veneer is usually supported by loose lintels at smaller windows or door openings. At larger openings, structural lintels are secured to the building frame for support. Whenever possible, these supports should be constructed with hot rolled steel framing. Lintels should never be secured to cold-formed steel box headers. The eccentric load from the brick veneer produces torsion in a header. At present, there is no code-approved method to deal with torsion in built-up CFS sections. The possibility does exist to support brick lintels when the CFS framing is balloon-framed; where each stud above the window is supported both vertically and horizontally. This is not a preferred construction detail due to the amount of welding required with thin steel members.

Fire-Proofing

Framing elements that are to receive spray-applied fire-proofing and cold-formed steel wall framing must be identified in the construction documents. The CFS specialty engineer can accommodate fire-proofing with a variety of framing options. The most common method is the use of Z-furring members providing an offset for the top of wall deflection track and the steel beam bottom flange. The spray fire-proofing can occur anytime after the Z-furring is installed. Ideally, it is done prior to the installation of wall studs as this improves the spray applicator's accessibility. Both the top track and the Z-furring members have to be designed for the eccentric load from the wall studs and the span between the support locations.

Conclusion

Costly delays and design changes can be avoided with proper coordination of the CFS framing at the early design phases of a project. Realizing the limitations and possibilities of CFS framing will greatly improve the building construction process and the building's long-term performance.▪

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