

# Flush-Frame Connections 2.0

## Innovative Approach Optimizes Composite Joists in Multistory Construction



**C**omposite joists with flush-frame end connections are no stranger to the construction industry in this age of multistory fulfillment centers and warehouses. However, the design and coordination of flush-frame end connections have presented industry-wide challenges.

Until now.

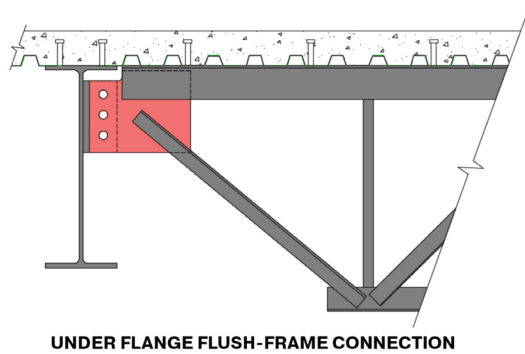
The refined engineering connections from New Millennium have a more efficient design to eliminate wide-flange girder torsion concerns and make it easier for structural engineers of record (SEORs) to design and specify them. This innovation in flush-frame connections enables SEORs, joist manufacturers, steel fabricators and developers to more quickly realize the added benefits of improved flush-frame connections in the multistory market.

### **Solving the Challenges of Flush-Frame Coordination**

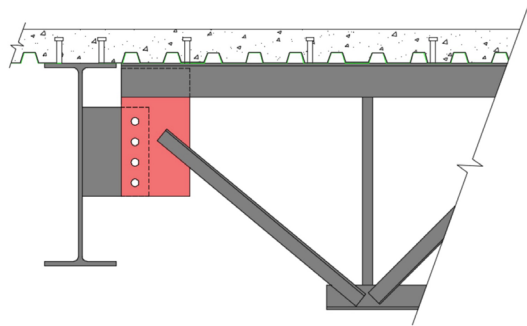
Since 2019, composite joists (CJ-Series) have been specified in multistory fulfillment facilities requiring

large, open-span floor systems. That's because CJ-Series joists have distinct advantages over traditional steel wide-flange girders, including significant weight and cost savings; an open-web system allowing for large mechanical passageways through the joist; and increased depth options for greater inertia, reduced deflections and increased clear spans. The benefits have taken composite joists from about 1 percent of the overall U.S. steel joist market in 2018 to a peak of more than 9 percent in the last several years.

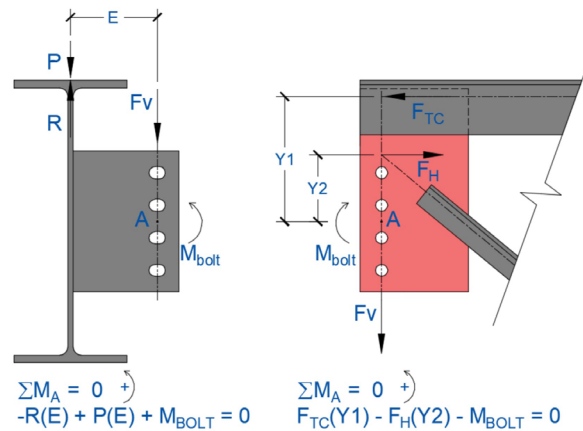
As composite steel joist use increased, a coordination challenge emerged in defining the connection between joists and wide-flange girders. Typically, on these floor systems, the joist top chord is set flush to the top of the wide-flange girder, like traditional wide-flange floor systems. The connection from the joist to the wide-flange girder is by means of a welded girder plate tab with a single line of bolt holes to be field-bolted to a joist end



**UNDER FLANGE FLUSH-FRAME CONNECTION**



**EXTENDED TAB FLUSH-FRAME CONNECTION**



**NOTES:**

- P = RESULTANT OF UNIFORM LOAD WHICH IS TRIBUTARY TO THE END OF THE JOIST (1/2 OF THE TOP CHORD END PANEL LOADING, WHICH IS NOT CARRIED BY THE END WEB)
- R = JOIST END REACTION
- E = DISTANCE FROM THE GIRDER  $\phi$  TO BOLT  $\phi$
- $M_{bolt}$  = DESIGN MOMENT OF BOLT GROUP ( $R \cdot E$ )
- $F_v$  = VERTICAL COMPONENT OF END WEB ( $=R \cdot P$ )
- $F_H$  = HORIZONTAL COMPONENT OF END WEB ( $=F_{TC}$ )
- $F_{TC}$  = TOP CHORD FORCE ( $=F_H$ )
- Y1 = DISTANCE FROM TOP CHORD CENTROID TO BOLT CENTROID
- Y2 = DISTANCE FROM INTERSECTION OF END WEB CENTROID AND BOLT  $\phi$  TO BOLT CENTROID

plate that is shop-welded to the end of the floor joist. This is commonly referred to as a flush-frame end connection.

The connection of the flush-framed joist to the wide-flange girder is originally specified in the structural drawings; however, at the time of initial design, the SEOR does not often know the project's steel erector or joist manufacturer. These two additional parties are necessary to finalize this connection. As a result, the original flush-frame joist to wide-flange girder connection may be revised and re-designed multiple times before all parties agree to the connection.

Simplifying design and specification, New Millennium joist engineers compiled a set of standardized steel joist to wide-flange girder connections. These connections and their accompanying calculations are available for review and download at [www.newmill.com](http://www.newmill.com). These standardized connections are intended to reduce the time spent in the connection design, set dimensions for coordination between the joist manufacturer and steel fabricator, and shorten the time in coordinating any changes requested by the erector.

Using the New Millennium standardized flush-frame end connection streamlines coordination and, more importantly, introduces a design improvement over competing options.

The standardized flush-frame connection features a joist reaction point that is now clearly specified and designed to occur at the centerline of the wide-flange girder, eliminating wide-flange girder torsion concerns during erection and/or due to final design loading of a perimeter wide-flange girder. This is especially important when considering extended tab connections where the connection bolts are placed outside of the girder flange to allow for panelized joist erection. The flush-frame connection bolts and plates are designed for the required bolt group moment in accordance with AISC Single Plate, Extended Configuration. The joist and joist end webs are designed for the full center-to-center span length of the bay.

## Benefits of Flush-Frame End Connections

Standardized joist flush-frame end connections can significantly reduce connection design time and coordination. This will, in turn, reduce the joist fabrication schedule and costs. The design is in accordance with AISC methodologies as well as multiple real-world test studies on single-plate, extended tab connections. Flush-frame design connections can now be determined and specified in a few simple steps by the SEOR.

- Up to 35 percent less weight utilizing composite joists as compared to wide-flange girders
- Allows for a composite wide-flange girder design, reducing girder size and increasing inertia
- Increased connection rigidity and reduced floor vibrations
  - Increased girder effective width and joist effective panel weight for vibration considerations
  - Floor vibration analysis can be completed with AISC Steel Design Guide 11, SJI Technical Digest 5 or FloorVibe 3.1 software ([www.floorvibe.com](http://www.floorvibe.com))
- Reduced overall framing depth as opposed to the joist seat being on top of the wide-flange girder
- Allows for a time-saving panelized floor joist erection process
- Reduced fabrication costs as opposed to a full-height wide-flange girder tab
  - The tab is welded to the wide-flange girder web and designed as a ductile fuse element in accordance with AISC extended girder tab design
- Joist camber is built into the joist manufacturing process with no additional time or cost, whereas cambering wide-flange beams is expensive, time consuming and not very precise

For more standardized flush-frame end connection information and resources, visit [www.newmill.com](http://www.newmill.com).

