Building Blocks

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Advanced Steel Framing Emerges For Demanding Curtain Wall Applications

By Chuck Knickerbocker

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When it comes to framing materials for curtain wall systems, building and design professionals have two primary options – aluminum and steel. For years, aluminum has been the widely accepted material of choice. Lightweight, available in various back mullion profiles and corrosion resistant, it combined design flexibility with long-term performance in a way that steel previously could not replicate.

Today, due to advances in manufacturing processes, steel framing is now reemerging as a high-performance material in glazed curtain walls. It outperforms traditional aluminum framing systems in terms of long spans, narrow sightlines, thermal conductivity and design flexibility.

The Manufacturing Transformation

Before the advent of modern roll-formed steel framing, common types of frames were hollow-metal steel and hot-rolled steel.

To form hollow metal steel frames, manufacturers bend flat pieces of steel into shape using a brake press. However, due to processing limitations, the resulting profiles tend to be bulky with corners that are rounded, not sharp. Such methods also restrict frame profile length. Given these materials' size restrictions and the adverse visual impacts of the way the frames wrap around the window opening to attach to the building, hollow-metal steel frames are not generally suited for glazed curtain walls.

The other traditional type of steel framing, hot-rolled steel, is a higher-end option than hollow-metal frames. While such frames provide a narrower steel profile, they are not well suited for curtain walls since they do not have thermal breaks, have limited profile sizes and require wet sealing to prevent water infiltration.

Moving beyond these earlier processing methods, manufacturers can now use cold roll-forming techniques in which they feed continuous steel coils through dies. The process allows for the production of continuous, long-length framing members, which can then be joined together with hidden shear blocks and unexposed fasteners.

For additional design flexibility, manufacturers also can produce advanced laser-welded steel profiles. Such profiles are available in a multitude of complex mullion shapes, featuring only slight weld beads on the inside corner. When accessible, manufacturers can grind the weld smooth.

Slender, versatile, and strong, cold-roll formed and advanced laser-welded steel frames offer several significant technical and design advantages over traditional aluminum curtain wall systems.

Technical Advantages

Approximately three times stiffer than aluminum, modern steel framing is well suited for large curtain wall assemblies. It has a Young's modulus (E) of about 207 million kPa (30 million psi), compared to 69 million kPa (10 million psi) for aluminum. As a result, steel frames deflect less, providing a substantially greater load capacity. This allows for significant increases in the size of glass lites in steel frames versus aluminum frames of the same shape. Depending on product selection, some steel systems can support glazing infills up to 76 mm (3 inches) thick. By incorporating framing members that support high-performance double- or triple-glazed units, the building team can balance the admission of natural light with energy costs.

Another performance benefit of steel's load carrying capacity is that it can handle larger spans than an aluminum system of similar dimensions and applied loads. For example, given a 1.5-meter (5-foot) mullion spacing at a 146-kg-force/m^2 (30-lb/sf) wind load, a conventional aluminum mullion of 64 by 191 mm (2.5 by 7.5 in., including the glass and exterior cap) can span a total of 3.81 meters (12.5 feet).

Slender, versatile and strong, cold-roll formed steel allows the glazing to take center stage at a company's headquarter building. Courtesy TGP.

By comparison, if that aluminum mullion were steel, sized at 60 x 192.5 mm (2.375 by 7.563 inches), it would only deflect one third as much under the same conditions. Due to this inherent stiffness, the length of the steel mullion can be increased to span almost 5 meters (16.33 feet) – a 30% increase over its aluminum counterpart.

Another way of looking at this is that steel allows for thin profiles that can support large glazed lites. Consider the frame face dimensions for new steel frame glazing systems, which typically range between 45 mm (1.75 inches) to 60 mm (2.375 inches) wide, compared to 64 mm (2.5 inches) for conventional aluminum assemblies. Slender steel frame profiles improve sightlines and reduce hindrances to occupant views, as well as reduced cast shadow sizes.

In addition to its strength, steel is thermally superior to aluminum. Its thermal conductivity is approximately 74 percent less (approximately 32,7000 joule/hour [31 Btu/hour]) for steel versus approximately 124,500 joule/hour [118 Btu/hour] for aluminum). Steel's thermal conductivity is also equivalent to that of thermally broken aluminum frames. (Due to the design of modern steel profile systems, steel frames do not necessitate a typical thermal break). This lower potential for heat transfer can help save heating and cooling costs, particularly when paired with low-E glass or other energy-efficient glazing, such as insulated glass units (IGUs).

Steel also expands and contracts at a rate of about 50 percent less than aluminum. Its thermal expansion coefficient of about 12 x 10^{-6} x 1/Kelvin is comparable to glass and concrete, which are approximately 9 x 10^{-6} x 1/Kelvin and 10 x 10^{-6} x 1/Kelvin respectively, while aluminum is about 24 x 10^{-6} x 1/Kelvin. As a result, steel works in close conjunction with its surrounding materials to help ensure a sound building envelope as the temperature changes. Furthermore, because steel, glass and concrete expand and contract at similar rates, steel frames require fewer expansion joints – if any. This helps create continuous and uninterrupted appearances across the frame face.

Curtain Wall Design

Curtain walls that incorporate modern steel frames can support nearly any design scheme. Steel veneer connectors, for instance, which allow for attachment to virtually any structural component that can support the curtain wall system's weight and imposed glazing loads (i.e., wind loads, snow loads, etc), provide exceptional design freedom. Modular systems are available with hollow-, I-, T-, U-, and L-shaped mullions or custom profiles; they also allow for attachment to glue-laminated beams, I-beams, or round steel tubes, among other structural members. Steel curtain walls can also be structural silicone glazed (SSG) for a smooth, monolithic appearance.

Today's advanced steel curtain wall systems also retain their aesthetics over the long term. To defend against corrosion, fabricators provide anti-corrosion protection, such as double-sided pre-galvanization. Some even provide an extruded silicone back gasket that isolates the steel from contact with water.

Conclusion

Nearly half a century after aluminum framing entered the scene, steel is once again empowering building and design professionals to push the limits of curtain wall design.▪