Window Walls

Blurring the line between glazing products

by Philip Frederick, PE, Brian Rose, PE, and Brad Carpenter, PE

'WINDOW WALL' HAS BECOME A COMMON TERM IN THE CONSTRUCTION INDUSTRY, TYPICALLY REFERRING TO A LARGE SECTION OF GLAZING INSTALLED BETWEEN FLOORS, OR SOMETIMES IN VERTICAL STACKS, OFTEN COVERING LARGE PORTIONS OF THE BUILDING FAÇADE. HOWEVER, WHAT EXACTLY IS A WINDOW WALL, AND WHAT DO YOU NEED TO KNOW IF IT IS ON YOUR PROJECT?

The definitions for window wall, also called a 'ribbon window' in some markets, vary depending on where you look. Several publications describe them as a curtain wall frame containing fixed or operable glazing, opaque panels, or a combination thereof.[1] However, many glazing manufacturers market window wall products fabricated from individual window units ganged (or 'mulled') together to span between floor slabs and form horizontal bands. Further, the American Architectural Manufacturers Association/Window and Door Manufacturers Association/Canadian Standards Association (AAMA/WDMA/CSA) 101/I.S.2/A440, *North American Fenestration Standard* (*NAFS*), defines a window wall as:

> a non-loadbearing fenestration system provided in combination assemblies and composite units, including transparent vision panels and/or opaque glass or metal panels.

These definitions all accurately describe possible window wall systems, but there is no industry consensus on what specific glazing system product—window, storefront, or curtain wall (as defined by AAMA)—should be used in window wall applications, and rightfully so. The truth is 'window wall' is a general term describing a common application of a glazing system that can be constructed from several different types of glazing products, which each have relative advantages and

disadvantages that must be evaluated for the specific product conditions.

Window walls can be built from:

- a storefront product;
- a stick-built or unitized curtain wall product positioned horizontally between slabs (as shown at left); or
- a combination of two or more individual window units (Figure 1) mulled together in a horizontal or vertical configuration between slabs.

Window walls can also be designed to include fixed and operable lites with other glazing materials aside from the vision glass, such as opacified panels (*e.g.* spandrel glass, metal panels), louvers, and other materials 'glazed' into the system.

The market appears to be trending toward window wall systems because the system can essentially allow the entire enclosure assembly (except the slab edge cover assembly) to be provided by a single subcontractor, offering potential cost savings beyond traditional curtain wall products. Many of the industry's window and curtain wall manufacturers recognize this trend and now offer specific glazing system products marketed as 'window walls.' It should be no surprise such assemblies are actually a collection of window, storefront, and curtain wall products engineered and optimized for use in a window wall application between floor slabs.

The intent of this article is not to highlight one particular glazing system product over another, but instead, to clarify the typical products and configurations commonly utilized in window wall applications while also providing insight on performance requirements and expectations. When properly evaluated, designed, fabricated, and installed, each type of glazing system product—windows, storefronts, or curtain walls—can provide reasonable and reliable performance in a window wall application. However, this does not necessarily mean each of these products is easily interchangeable among all possible window wall applications on any given project. Architects, specifiers, owners, and contractors should all be aware of differences in performance, constructability, detailing, and price when evaluating and selecting an appropriate glazing system product.

Parsing performance

The more recent generalized use of the 'window wall' term has begun to blur the differences and distinctions between different glazing system products. As designers, it is important to understand not only the differences in attachment and detailing between glazing system product types, but also the performance expectations and possible product limitations. This way, designers can set appropriate performance criteria early based on the glazing being considered. For contractors and owners, it is similarly important to realize these differences when evaluating glazing system products and substitutions for window wall applications.

Figure 1

Example of individual window products mulled together as a window wall system between slabs, with independent slab edge and column covers at a mixed-use residential building.

Images courtesy Simpson Gumpertz Heger

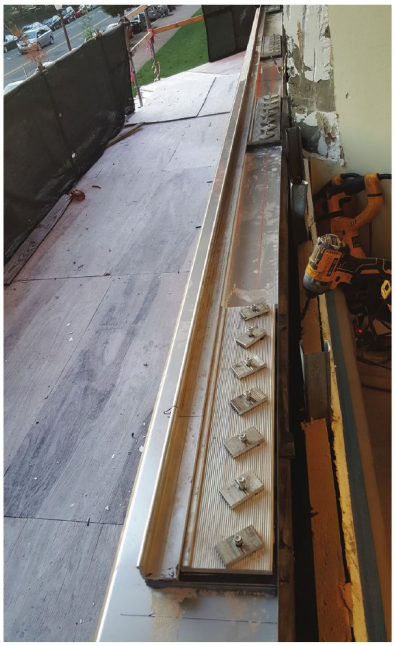
Windows

Window products are manufactured products evaluated and divided into performance classes (AW, CW, LC, R) and grades (ranging from 15 to 100) per AAMA 101, *Voluntary Performance Specification for Windows, Skylights, and Glass Doors*. Windows are typically specified by the performance class and grade that meets the building code and project requirements. These ratings take into account typical performance criteria, such as design pressure, structural test pressure, air leakage resistance, and water penetration resistance.

For example, an AW-80 fixed window is a Commercial-grade window with a performance grade of 80. In other words, it has been tested to meet a design pressure of 3840 Pa (80 psf), and has an allowable air leakage rate of 0.5 L/s*m^2 (0.1 cfm/sf) when tested at a static pressure differential of 300 Pa (6.27 psf). It also has a static water penetration resistance test pressure of 580 Pa (12 psf), which is equivalent to 15 percent of the design pressure.

It is important to note the rating applies only to individual window units of a tested size or smaller. This performance class and grade does not apply to a series of individual windows mulled together, as is typical in window wall applications. AAMA 450, *Voluntary Performance Rating Method for Mulled Fenestration Assemblies*, provides guidance for designing and evaluating mulled window assemblies. However, as indicated in the title, this standard is voluntary and not always implemented or followed for mulled window assemblies.

Figure 2



Curtain wall anchors, installed at a window wall sill condition, include dozens of grooves and ridges offering ample flexibility for installation and final positioning of the curtain wall frame within the opening.

Storefront and curtain walls

Alternatively, storefront and curtain wall systems are typically designed for project-specific applications, based on the fenestration opening size and span, glazing components and configurations, and the allowed air leakage rate and water penetration resistance to meet the desired performance criteria. Project specifications should typically include a list of performance criteria or requirements for storefront or curtain wall products from which to design and evaluate the proposed assemblies. Typically, storefronts and curtain walls are capable of achieving taller spans, resisting high design pressures, and having different air infiltration and potentially more stringent water penetration performance requirements than windows.

For example, a curtain wall product shall:

- be designed and tested in accordance with ASTM E330, *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference*, to meet most service-level wind pressure/suction loads indicated in a project's performance requirements;
- have a typical allowable air leakage rate of 0.33 L/s*m^2 (0.06 cfm/sf) when tested at 300 Pa (6.24 psf) in accordance with ASTM E283, *Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen*; and
- have a typical static water penetration resistance test pressure of up to 730 Pa (15 psf) when tested in accordance with ASTM E331, *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.*

Curtain wall products are also typically tested for a dynamic water penetration resistance of up to 730 Pa (15 psf) in accordance with AAMA 501.1, *Standard Test Method for Water Penetration of Windows, Curtain Walls, and Doors Using Dynamic Pressure.*

Substituting one for the other

Obvious differences in appearance and performance between window products and storefront/curtain wall products can restrict interchanging these systems in window wall applications. For example, taller floor-to-floor spans achievable with a single curtain wall mullion may result in more bulky sightlines if using window products with reinforced mulled joints to achieve the same span. However, even subtle differences between window products and storefront/curtain walls—such as how they are evaluated, specified, and attached—can limit or complicate interchanging these systems as part of value engineering exercises or substitutions.

For instance, in the product examples cited in the previous paragraphs, both the AW-80 window and the generic curtain wall may meet project requirements, but if the former is substituted for the latter in a window wall assembly, the AW-80 windows may no longer have the same performance rating they had as individual units, unless tested per AAMA 450. Without performing this testing, the project team may not be able to confirm beforehand whether the series of window products of a certain size, mulled together in a window wall application, meets the performance criteria for the original curtain wall product or for the project.

In addition to the aforementioned performance criteria, field quality control testing is often specified and performed on glazing systems while completing installation, and is prudent for window products installed in window wall applications that have not

Figure 3

Perimeter sill, jamb, and head receptors are installed around a rough opening to receive a mulled window assembly at a window wall application.

been previously tested per AAMA 450. Waiting to conduct performance verification testing of window products until installation is ongoing (*i.e.* concurrent with field quality control testing) can leave the product team attempting to repair, redesign, and retest the window wall assembly if testing failures are encountered, potentially costing the project team additional time and money. This article's authors recommend verification testing be performed on a mockup installation as early as possible during a project so performance issues or necessary supplemental detailing can be identified prior to wholesale installation of window wall products.

When specifying and evaluating field quality control or verification testing, it is important to keep in mind window and storefront/curtain wall products are evaluated by different standards, regardless of whether or not they are installed in a window wall application. Window products are covered by AAMA 502, *Voluntary Specification for Field Testing of Newly Installed Fenestration Products,* whereas storefront and curtain wall products are covered by AAMA 503, *Voluntary Specification for Field Testing of Newly Installed Storefronts, Curtain Walls, and Sloped Glazing Systems.*

Constructability and detailing

There are key differences between window products and storefront or curtain wall products in window wall applications. Specifics on how these different systems are designed, detailed, and constructed are beyond this article's scope, but the following paragraphs highlight some critical design elements and differences that must be considered.

Anchorage

Curtain wall products offer inherent flexibility in how the glazing system is constructed and where it is structurally attached, often using clips that either are slotted or slide within the vertical mullions to accommodate differential movement (Figure 2, page 26). This allows the curtain wall anchorage to be more easily customized to suit project-specific conditions. Meanwhile, window products in window wall applications are more sensitive to concrete tolerances, since they are almost always gravity loaded at the sill, with lateral support at the head that should be designed to accommodate differential building movement, such as by utilizing a receptor frame or slotted anchors (Figure 3).[2]

It is important all perimeter frame anchors be coordinated with the building structure and structural engineer to confirm whether steel embeds or additional structural supports are required. This also helps ensure fastener embedment depth and edge spacing do not pose conflicts with the building structure (such as tendons for prestressed or post-tensioned slabs) or anticipated movements.

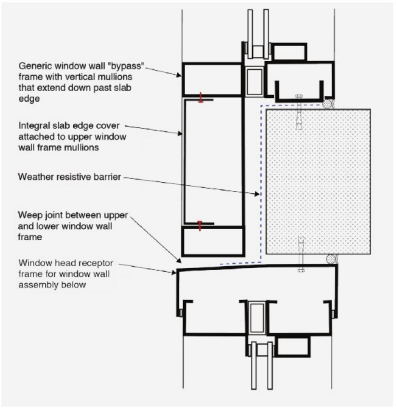
Positioning

Traditionally, perimeter framing for window wall systems was positioned along the slab edge or on top of the backup wall structure (*i.e.* knee wall), where the support and attachment is straightforward. As energy codes evolve and performance expectations advance requirements for increased thermal insulation in opaque exterior walls and reduced thermal bridging in exterior walls, building designs are increasingly pushing window wall components further outboard

Figure 4

Positioning window walls proud of the slab edge improves thermal continuity, but may require additional detailing components for support and to maintain the air and water barrier.

Figure 5



Schematic section detail of a 'bypass' window wall framing assembly, which includes an integral slab edge cover.

of the rough opening (*i.e.* past the slab edge or knee wall) in order to align the insulated glazing with the exterior cavity insulation to the greatest extent possible (Figure 4). While this configuration maximizes thermal performance to mitigate risks of condensation and increase occupant comfort in the proximity of the glazing system, it also impacts the structural support conditions and perimeter detailing for each family of glazing system products.

The support conditions and perimeter detailing required to successfully integrate with the adjacent weather-resistive barrier (WRB) varies depending on the type of glazing system product, and the field work required to construct the perimeter detailing can have a substantial impact on the overall installation sequence and installed cost. Recently, more manufacturers have been developing window walls with 'bypass' frames (Figure 5) that allow the front portion of the glazing assembly to sit proud of the slab edge or backup wall structure without requiring additional support, and that incorporate integral slab-edge covers or spandrel panels into the system between stacked window wall sections to alleviate some of the slab-edge detailing and coordination.

Slab-edge detailing

Traditional curtain wall applications are generally installed outboard of the slab edge and are continuous past the floor line (Figure 6, page 32). Window wall applications, on the other hand, typically include glazing systems installed continuously—floor to ceiling—between slabs to maximize daylighting and occupant visibility while minimizing requirements for fire blocking or fire-resistant insulation at the slab edge. Positioning window walls between the slabs also allows the glazing system to be primarily installed from the interior. This limits the amount of exterior access required to complete the glazing system installation, which is often desirable to contractors and owners since it is perceived as providing flexibility in the construction sequence and scheduling.

However, it is important to keep in mind exterior access is still required to install and integrate the exterior wall components at the slab edges separating window walls, or at perimeter transition details to other cladding systems on the same floor level (Figure 7, page 32). The authors find the slab-edge components in particular—WRB, perimeter seals, exterior insulation, and cladding—are often overlooked or considered an afterthought when evaluating the different glazing system options (*e.g.* continuous curtain wall outboard of the slab versus window wall applications spanning between slabs). Nevertheless, these components warrant considerable evaluation and care when selecting an appropriate glazing system given their significant impact on both design (*e.g.* detailing, air/water barrier continuity, and water management) and construction (*e.g.* sequence, access, and coordination with multiple trades).

Figure 6

View of a unitized curtain wall assembly with integral spandrel panels being installed continuously past a slab edge.

Figure 7

View of window products installed in a window wall application between slabs. However, exterior access is still required to complete the exterior perimeter seals and install the slab edge covers.

Vertical mullions and sightlines

Glazing designs with zero sightlines, such as butt-glazed or structurally sealed vertical mullions, typically cannot be constructed with window products in a window wall application, and instead require a curtain wall product. Similarly, concept designs with 45-degree corner mullions at inside or outside corners typically require a curtain wall product in a window wall application. This is because window wall systems made with window products are 'mulled' together, where the individual window frames utilize male/female frame extrusions that can engage the adjacent window frame.

For tall spans, some window products may require a three-piece mullion consisting of a center structural mullion that receives the window frames on each side (Figure 8, page 34). Ultimately, these mulled joints between window products can create larger sightlines at the internal vertical mullions than storefront or curtain wall products and are a potential weak point for air and water infiltration, which otherwise must be managed by the perimeter receptor frame and associated flashings and seals.

Air and water management

There are fundamental differences in how window, storefront, and curtain wall products manage air and water. Often, window and storefront products do not include the drained and pressure-equalized glazing pockets that are integral to most curtain wall systems. Therefore, continuous sill pan flashings are commonly recommended for below window and storefront products, but can be unnecessary and sometimes excluded in curtain wall systems.

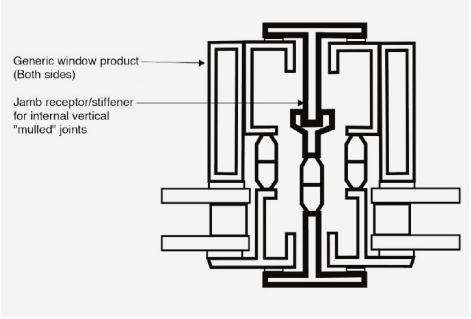
Cost considerations

It is difficult to compare window, storefront, and curtain wall products in window wall applications without talking about relative cost. When comparing only the glazing system itself, window walls (especially those utilizing window products) are generally less expensive than curtain wall systems. This is why window wall systems are often proposed as value engineering alternatives on projects.

Curtain wall systems, specifically unitized assemblies, have a high degree of prefabrication. This contributes to the higher initial cost, but also reduces the labor and duration of field installation. Installing curtain walls often requires a crane or specialty hoists and a combination of interior and exterior façade access. The ability to install window wall systems from the interior can provide inherent benefits to the construction schedule and overall installed cost when compared to curtain wall installations. This installation sequence also frees up exterior access so other façade work can be completed, and it allows the building to be 'dried in' one floor at a time. This follows the typical sequence of the interior framing and finishes work, rather than proceeding by elevation, which can fall out of sequence with the crane operation, framing installation, and other work.

However, most window wall systems, even those with 'bypass' frames, require a considerable amount of slab-edge detailing to complete the exterior enclosure, including installation of a WRB, perimeter flashings and sealant joints, exterior insulation, and cladding. Many of these components require exterior access to complete the installation. These material and installation costs are not always accounted for when comparing the overall installed costs of window wall assemblies to curtain wall assemblies.

Figure 8



Schematic plan detail of a typical 'three-piece' mullion used for connecting adjacent window frames in a window wall application.

Ultimately, it is difficult to predict the final installed cost of window wall applications installed slab to slab versus curtain wall applications installed outboard of the slab edge without performing a detailed cost estimate based on the proposed design and installation. More recently, construction budgets have been determined before the glazing system details are fully developed; these budgets include general square-foot prices that do not account for project-specific slab-edge detailing or installation sequencing constraints, and may not accurately compare the various glazing systems.

Conclusion

All things considered, window walls are becoming more common in the building industry. It is critical to not lose sight of the subtleties in performance, detailing, fabrication, and installation that define these systems in order to avoid potential pitfalls as project teams continue to balance performance, constructability, schedule, and cost. This is why it is important for project teams to review, plan, and set performance expectations appropriate for the type of glazing system(s) selected at the start of a project. **CS**

Notes

[1] Examples can be found with the *Dictionary of Construction* (www. dictionaryofconstruction.com/definition/window-wall.html) and third edition (2000) of the *Dictionary of Architecture and Construction*, as well as the Window and Door Manufacturers Association (WDMA) "The Window Glossary" at www.wdma.com/page/TheWindowGlossary.

[2] For more, see the article by Derek McCowan and Michael Louis, "Window Receptor Frames: What You Need to Know," which appeared in the June 2007 issue of RCI International's *Interface* magazine.

ADDITIONAL **INFORMATION**

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Abstract

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