Design Primer for Glazed Curtain Walls

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Among the many considerations for an architectural design team in developing building envelope components for a new facility are the fenestration elements. Even a cursory visual survey of the urban landscape reveals the many choices designers face when trying to satisfy both technical and aesthetic criteria. To select the appropriate system, designers and specifiers must understand the many variables affecting the design process for this critical part of the building envelope. One of the most popular types of fenestration for commercial buildings is the glazed curtain wall system.

General standards and terminology

Glazed curtain wall systems require a collaborative effort between designers, owners, manufacturers, and other project team members from conceptual design through construction. One common problem inherent in the collaborative design process is the use of inappropriate terminology and standards in specifications.

The American Architectural Manufacturers Association (AAMA) is the primary source for industry standards related to typical curtain wall types and components1 [NOTE]. As such, this article will focus on the following elements/systems as described by AAMA:

- Glazed curtain wall assemblies are a combined system of window lites within framing elements forming the building envelope.
- Designed new waterproofing systems for the balustrade and colonnade decks of the capitol dome.

Glass and glazing options

Glass and glazing options have multiplied in recent years, so a basic understanding of these elements is needed for specifying clear, concise, and correct requirements. The following summarizes the fundamental characteristics of different types of glass and glazing.

Standard float glass

This is the basic industry standard and has replaced standard glass in most commercial construction. Typical monolithic thicknesses of the standard float glass used in commercial construction ranges from about 2.4-mm to 25 mm (3/32 in. to 1 in.). Glass thickness is primarily a function of the various loads imposed by the building and outside forces, such as wind. Obviously, the thicker the glass, the more structurally capable it is for carrying loads.

Annealed float glass is also becoming somewhat standard in the industry. Annealing used in conjunction with the float process eliminates stresses imposed upon the glass during the manufacturing process, reducing breakage during handling and in service.

Tempered glass

This glass is typically used when better impact resistance, increased bending strength for wind loads, and shatter control for life safety are required. Tempered glass shatters into very small pieces instead of large shards, providing a greater degree of safety for occupants where there is a higher probability of glass breakage. As such, any cutting, drilling, or edging required in the manufacturing process must be done prior to tempering, else the glass will shatter. Although minimized in recent years, tempered glass still exhibits some visual distortion. Since tempered glass is relatively costly, selective use is recommended.

Heat-strengthened glass

This glass is stronger than standard annealed float glass but not as strong as tempered glass. It is a good compromise when there is a possibility of breakage but life safety is not an issue. When shattered, the shards of heat-strengthened glass are larger than those of tempered glass, though not as sharp as shards from annealed glass. Heat-strengthened glass exhibits less distortion and is less costly than tempered glass, making it appropriate for windows that are difficult to access and maintain were they to break, and have minimal life safety issues.

Laminated glass

Laminated glass is an effective solution for the many safety and security requirements becoming prevalent in architectural design. In the manufacturing process, a vinyl, polycarbonate, or cured resin interlayer is bonded to one or more layers of glass to form a monolithic lite. This interlayer holds the pieces together when the glass is broken and keeps the glass from shattering.

This glass can be assembled in combination with any other type of glass. For example, combining laminated and tempered glass in a single pane produces a very strong, secure lite. This combination provides an unsurpassed level of security from breakage, and is typically specified for overhead applications and areas vulnerable to impact damage, such as storm debris, bullets, or a bomb blast. Laminated glass also deadens sound impact, as in airports or near highways, but is very costly due to the additional manufacturing required.

Other glass considerations

Some additional glass options include:

- Tinted and reflective glasses block portions of solar light transmittance, and are typically used to control the amount of light entering a building or for aesthetic reasons.
- Spandrel glass is tinted, reflective-coated, or film-coated, and is typically used for aesthetic reasons in the fenestration. Solid insulated metal panels are often used in lieu of glass lites.
- Insulating glass units (IGUs) are manufactured with a powdered gas or air-filled space between two or more panes of glass to provide energy efficiency.

Types of glazing

Glazing is the system or process used to support the glass in the frame and seal the dissimilar mating surfaces from the elements. There are several basic glazing options for curtain walls:

- Relatively common in straightforward commercial and residential applications, wet glazing uses preformed tape or gunnable liquid sealant to set the glass in the frame. Versatility and adaptability to site conditions are its key strengths.
- Dry glazing involves a manufactured compression gasket of rubber or vinyl used to support the glass, and is very popular in larger, commercial-type installations. Dry glazing generally minimizes quality-control issues because it is pre-manufactured, unlike wet glazing where assemblies are glazed on-site.
- Structural glazing is designed to carry a portion of the live and dead loads imposed on or by the glass without the additional support of a window frame (i.e. any wind loads transferred by the glass to the building's structural framing are carried by the structural glazing). This capability provides the designer with the opportunity to maximize the transparency of the fenestration.

Wet and dry glazing can be used effectively for factory, shop, or on-site glazing. Structural glazing is primarily accomplished once the glass is installed on-site.

Glazed curtain wall types and limitations

It is important for designers to remember glazed curtain walls are classified by how they are built, unlike punched opening windows which are classified by how they operate.

Stick system

The stick system was the first curtain wall type developed by manufacturers, and remains the most common. This system comprises off-the-shelf components assembled on-site with individual mullions and rails to frame the vision and/or spandrel panels. Stick systems offer a number of methods for assembling and glazing the units, and accommodating varying site conditions. The cost is relatively low and lead times are short because of the system's off-the-shelf components. However, field labor costs are typically higher with longer installation periods because the system is entirely assembled in place. This can lead to quality control issues depending on the skill of the installer.

Unit panel system (unitized)

This system comes pre-assembled; it can be pre-glazed at the factory or shop, or glazed on-site. As such, it minimizes field labor and erection costs, and promises a shorter installation period than the stick system. Quality control issues can be significantly reduced in terms of site labor, especially with pre-glazed units, but assembly at the plant and transportation (due to bulk) increases its cost. Another disadvantage to pre-assembly is any site changes become difficult to accommodate. Assembly must be carried out in a specific sequence to ensure a proper fit.

Unit mullion system

This system is a compromise between the stick and unitized systems. Pre-assembled units—pre-glazed or glazed on-site—are installed behind one- or two-story individual mullions. The system offers some of the factory quality control of the unitized system, a little less cost, and a shorter lead time because there is less customization than with a fully unitized system. Field labor time and erection costs are more in line with the stick system. The unit mullion system does not accommodate varying site conditions well, and must be assembled in sequence.

Column cover and spandrel systems

These systems are relatively new and are becoming increasingly popular because they offer some aesthetic options. These units can be pre- or site-assembled with infill vision glass and spandrel panels between the columns, and with column covers. The vision glass units can be entirely pre-assembled or assembled on-site. The systems allow for the structural framework of the building to be expressed in the facade and visually integrated with the fenestration. Since these systems are customized, lead times are longer and framing construction tolerances more critical because the units are manufactured to fit precisely within the column bays.

Point-loaded structural glazing systems

Point-loaded structural glazing systems are structural-quality, laminated and tempered or heat-strengthened glass supported with proprietary hardware embedded at fixing points laminated into the glass, eliminating the visible metal framework of conventional systems. The variety of available support systems available—including tension cables, trusses, and glass mullions—provide considerable freedom and aesthetic options within varying degrees of transparency, stiffness, and cost.

Glass mullions are the most transparent and are the usual choice for very large, monumental spaces, such as convention centers and airport lobbies. These systems have very long lead times and are more proprietary in nature; manufacturer involvement early in the design process is typical for defining available components and structural capabilities. Product and installation costs are higher than conventional frame-supported curtain wall systems.

Building code issues

Certain code issues must be considered when specifying glazed curtain walls:

- Natural light for habitable spaces. Glass manufacturers offer numerous charts for determining code compliance with respect to specifying light transmittance values.
- Thermal insulation values. ASTM International and the National Fenestration Rating Council (NFRC) standards are available for calculating assembly U-values based on individual component values.2 [NOTE]
- Structural resistance to wind loads. Wind load charts published by the American Society of Civil Engineers (ASCE) allow designers to determine the structural resistance requirements needed for the assembly.3 [NOTE] Basic allowable load charts available from the curtain wall manufacturers provide guidelines for the limitations of specific types of systems in meeting these requirements.
- Safety-rated glass is required by code at specific locations where shattering and breakage create life safety issues, and in coastal regions where damage from debris is more likely. Once again, glass manufacturers can offer numerous combinations of glazing options to satisfy these requirements.4 [NOTE]
- Fire-rated assemblies are more attainable with the newer glass technology available today (wired glass was the only option just a few years ago).5 [NOTE]

Ultimately, as with all elements of the design, the authority having jurisdiction for the project area will be the determining factor for any code requirements.

Flashings and sealants

It is important for the designer to understand the difference between the weatherproofing provided by the glazing versus the perimeter flashing and sealing of the curtain wall assembly. Glazing seals are most appropriately selected by the curtain wall manufacturer to meet the performance standard set by the designer, and are incorporated into the product warranty for the system. Perimeter seals are primarily selected by the designer and must be considered within the limitations of the installer's ability to execute the design. The variety of materials available to construct perimeter seals offers the opportunity to selectively match materials with design criteria. However, the same variety can introduce confusion into the bid and construction phases of the project.

Flashing Materials

The cause of flashing failures is often be traced back to coordination issues during construction. When selecting flashing materials, designers should consider how construction of the various components of the building envelope will be sequenced so coordination issues can be identified early in the process. Specifications should clearly delineate materials and proper detailing is crucial.

Sheet membranes

Sheet membranes include PVC (polyvinyl chloride), self-adhering modified bitumen, EPDM (ethylene propylene diene monomer), and neoprene. Wide availability and relative ease of application is the overriding characteristic of these sheet flashings. Self-adhering mod-bit sheets are a good choice for many applications because of their ability to conform to irregular mating surfaces and aggressive adhesion at seams. The difficulty in performing field seams for PVC, EPDM, and neoprene can lead to quality control issues, but all membrane sheets are vulnerable to damage during construction. As such, protection, inspection, and repair prior to curtain wall assembly should be prominently specified.

Sheet metal flashing

These materials include aluminum and stainless steel. Galvanized steel should be avoided due to corrosion and compatibility issues. Sheet metal flashings provide more durability during construction and service life. However, the proper techniques of fabricating and installing metal flashing in a watertight manner require more highly skilled workers than a sheet membrane application. The sheet metal flashing needs to be compatible with the curtain wall material, wall infill materials, and structural framing. Aluminum, while easier to fabricate, does not provide good service life in masonry. Stainless steel, while more difficult to fabricate, is generally compatible with most common materials, and is durable during handling and construction. Sealing of joints and end dams is critical for sheet metal flashing performance.

Flashing design recommendations

Complement the window manufacturer’s standard details, as his standard head and sill details are often incorporated in a design without modifications. Typically, these details are specific to the curtain wall construction but do not address any additional flashing materials needed to complete the wall assembly.

Ensure flashing materials slope to the exterior and have a weep system to prevent moisture from collecting within the wall or window assembly.

Include requirements for end dams and tie-ins to air or vapor barriers in adjacent walls.

When specifying mock-up and leak testing requirements for curtain wall assemblies, include the flashing and sealant construction. This will set a specific standard of quality control and help identify any design or coordination issues.

Sealant selection

Acrylics, butyls, and polysulfides

These materials are available on the market, but are generally considered older technology and not recommended for the perimeter sealing of curtain walls.

Urethanes

Urethanes are an effective, all-purpose choice with good availability, relatively lower initial cost, and a wide variety of colors. They have good compatibility with masonry, pre-cast concrete, and stone, and boast a relatively slow skin and cure rate allowing for longer working time. However, this can be a disadvantage when the curtain wall assembly is subject to movement prior to a complete sealant cure. Urethanes require a primer for high-performance finishes on metal, and service life limitations may require more intensive maintenance.

Silicones

Silicones are the high-performance sealant for curtain wall construction, offering a wide selection of cure mechanisms and times, and adhesion characteristics. They are capable of carrying structural loads imposed on a curtain wall, performing as both glazing and perimeter seals with one application. They are in the same chemical family as glass, which explains their excellent adherence to it. Initial cost and compatibility with masonry and concrete must be considered when selecting silicone sealants, and color selection is more limited than with urethane.

Sealant joint design recommendations

- Perimeter sealants must accommodate the dynamic movements imposed on the curtain wall. Early analysis and consideration of the thermal coefficient of the window frame materials (i.e. aluminum or steel) and dynamic wind loads imposed must be performed to allow for proper joint design.
- Joint width should typically be about four times the anticipated movement. Consult sealant manufacturers to determine proper joint width-to-depth ratios and specify accordingly. Very small (< 19 mm [< 0.75 in.]) joints are not recommended due to difficulties with applying sealants effectively.
- Indicate backer materials and how they will be held in place within the joint. Consider pre-formed foam sealant tapes for providing both the backer material and a secondary joint sealant.

Conclusion

The selection of glazed curtain wall systems and components has advanced on both aesthetic and technical fronts, and the many options and terminology tempts many architects into simply designing and specifying general concepts for these fenestration elements. This approach, unfortunately, frequently leads to something undesired by the owner or architect. This article serves as a primer for learning the terminology, sources of additional information, and basic issues related to designing glazed curtain wall systems.

Notes

1 See AAMA MCWM-1, Metal Curtain Wall Manual.
2 See ASTM C 1199, Standard Test Method for Measuring the Steady-State Thermal Transmittance of Fenestration Systems Using Hot Box Methods, and NFRC 100-SB, Procedure for Determining Site-Built Fenestration U-factors and Thermal Performance Characteristics.
3 ASCE 7-02, Minimum Design Loads for Buildings and Other Structures, gives current requirements for dead, live, soil, flood, wind, snow, rain, ice, and earthquake loads, and combinations thereof. It is a complete revision of ASCE 7-98.
4 See "Test Methods and Common Sense Solve Safety Glazing Requirements" in The Construction Specifier (May 2003, Vol. 56, No. 5).
5 See "User's Guide to Fire-Rated Glazing" in The Construction Specifier (January 2003, Vol. 56, No. 1).

Additional information

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08900–Glazed Curtain Wall

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Abstract
This article details the different types of glass and glazing to help specifiers choose the most appropriate option based on many variables, including building use, schedule, budget, etc. The author also describes the different classifications of glazed curtain walls, building code issues, flashing materials and details, sealant selection, and joint design.