

The Role of the Building Façade – Curtain Walls

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Abstract

The building envelope remains one of the most important exterior elements for building functionality. While the façade is an elegant component that helps to define the unique architectural aesthetics of the building, it also has the critical role related to energy performance and interior function of a building. As technology continues to improve, different options for improvement become available for incorporation into building facades. These elements are geared toward improvement of the building envelope performance.

By definition, the curtain wall is an independent frame assembly with self sufficient components that does not brace the building structure. While curtain wall systems are proprietary systems, there are many available to the industry but not all systems have the same function. In commercial and similar buildings, the building envelope components, especially, the curtain wall provides two key functions: Weather barrier against the environmental factors for air and water infiltration and light transmittance to the interior space.

Considering the function of these components, we have to address existing buildings performance and access or improve the dynamics related to the environment. At times, the professional community misapplies material choices and system application to environment due to a lack of understanding or familiarity of said systems. The existing buildings thus provide reference information demonstrating the merits and/or lessons learned from those choices. The importance of dialogue and knowledge sharing with the construction community should not be understated.

Review of components and functions are important in relating to how the building performs. Not only are component choices in the curtain wall important, the installation scheme of the system and subsequent maintenance by the building management are complementary of the performance of the curtain wall.

The paper discusses several aspects of the curtain wall as it relates to building performance: design parameters, building type, material components, assemblage, maintenance and retrofit. Considering the fiscal investment in the commercial property, at times the expectation of these systems sometimes doesn't synchronize with performance for varied reasons. It then becomes important to discuss the dynamic, learn about improvement in design approach and constructionability in order to enhance a building performance.

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Introduction

The building envelope remains one of the most important exterior elements for building functionality. The building envelope is the first line of defense against environmental and physical exposure based on its intrinsic design and location. Given its unique location, there is high expectation of performance for this building element.

A key component of the building envelope is the curtain wall. By definition, the curtain wall is a non-load bearing exterior skin that does not contribute stiffness to the building structure [Photo 1, Figure 1]. Key requirements of the curtain wall are to provide/maintain air/water integrity in the cladding system, adequate wind, thermal and seismic response in addition to provide light transmittance to the interior space. The actual constitution of a curtain wall is very important. This curtain wall often is a combination of several system types and combined to express the architectural intent and aesthetically define the building profile. The system schemes may be an all-glazed façade (aluminum framed systems, point-supported systems, cable net systems), an opaque façade (such as precast, natural stone and/or metal panels) or a combination of schemes dependent on the building intent [Photos 2, 3].

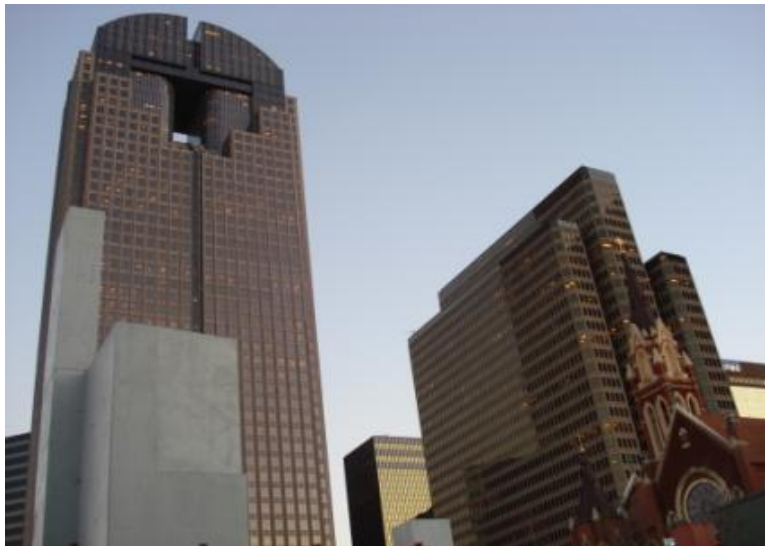


Photo 1 Examples of Highrise Curtain Wall Facades.

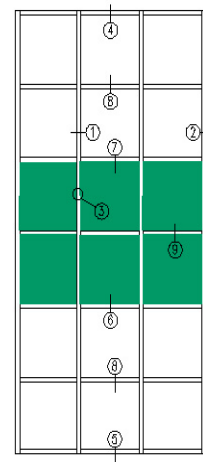


Figure 1 Typ Elevation

In a glazed application, the curtain wall often consists of two sections referred to as the vision area and the spandrel area (i.e. opaque) area as shown in Figure 1. One of the most inherent features related to curtain wall is the utilization of aluminum extrusions. This allows a myriad of profile depths and orientations to define the glazed or panelized grid system as seen on a building from an exterior or interior perspective.



Photo 2 Curtain Wall Framing with integral granite panels
Courtesy of Bank of America, Houston TX



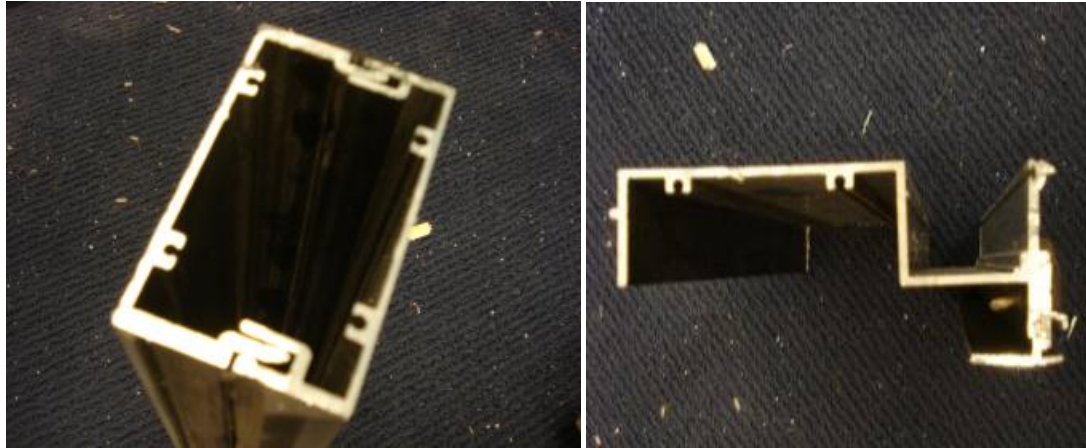
Courtesy of Atlantic Exterior Wall Systems

Photo 3 Precast panels and Window Wall framing with integrated sunshades.
It appears to be traditional brick at the glazed areas but they are actually panelized.

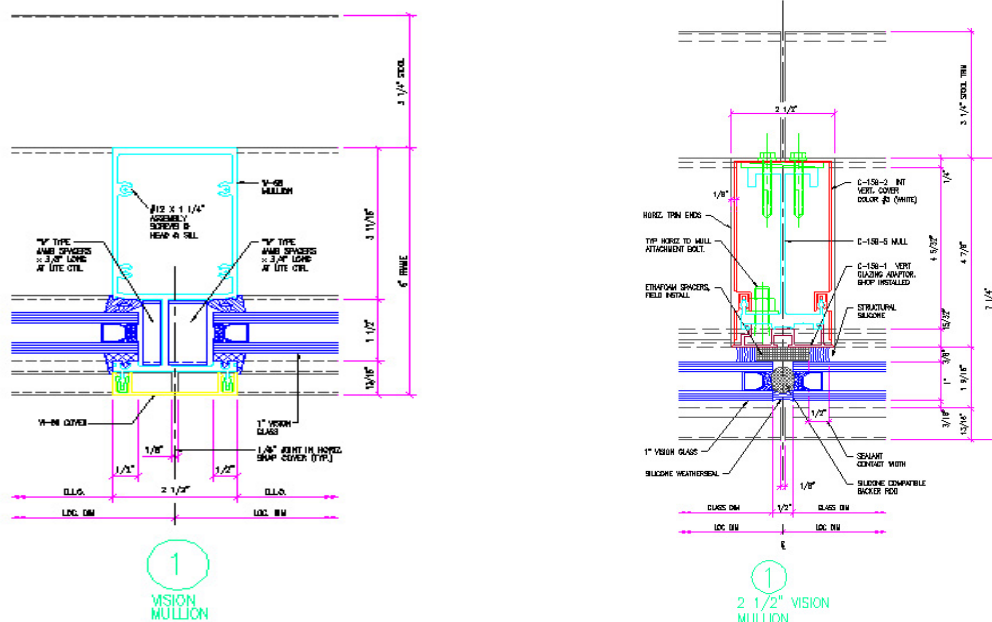
Curtain Wall Components

Curtain wall may be comprised of multiple substrates including aluminum framing, stainless steel components, glazing, rubber gaskets, sealant, insulation and metal connections. The vision area allows light transmittance and the spandrel areas are designed to conceal the building floor beam structure and related mechanical elements. While the spandrel area is an opaque area, the architectural community always finds interesting ways to address the aesthetics by making the spandrel area pronounced (e.g. façade element glazing color change, material type change such as granite) or subtly blended as an all-glass façade when viewed from the exterior. To appreciate some of the nuisances in design approach, here are examples of system schemes that adapt two methods for system attachment: captured glazed system and

structural glazed system [Figures 2, 3]. In order to accomplish this effort, the use of aluminum extrusions provide significant flexibility in design profiles and are limited to the size of the die from which they are extruded or required wall thicknesses. The other important aspect is the intricacies of the system profile and the required method of attaching profiles. Often observers view the vertical or horizontal framing as “tubular shaped” elements, but as Photos 4 and 5 demonstrate, there may be multiple components to the overall shape. Examples of details in Figures 2 and 3 further illustrate some of the intricacies involved in the design of curtain wall systems and the tight tolerances needed for mating or connecting elements.



Photos 4, 5 Examples of aluminum extrusions (vertical mullion and horizontal respectively)



Figures 2, 3 Showing the difference between a captured glazed system and a structural glazed system.



Courtesy of Oldcastle Building Envelope, Terrell

Photo 6 Typical captured aluminum horizontal framing utilizing a pressure plate system. Note the rubber gaskets in reglets and the neoprene glazing setting blocks.

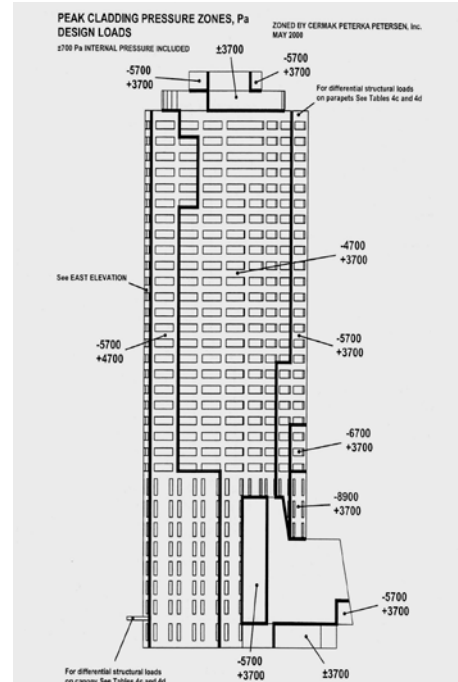
The profile shown in Photo 6 is indicative of some of the key components that are utilized in glazing curtain walls. The proper sizing and profile of the rubber gaskets are very important to performance of the glazing under wind and thermal loading. The hardness of the setting blocks that support the glass is also prescribed by the GANA, AAMA, and ASTM [1, 3, and 4].

Design Considerations

As previously mentioned, curtain wall may be designed to resist environmental loads (wind, rain, thermal) but also physical loads such as seismic and blast loading. The components should be designed and selected with duration in mind. However, expectancy level of duration depends on building type, size, ownership, management team and intended building usage. A brief review of some of the loading conditions is as follows:

Wind Loading

Curtain wall systems are designed to comply with prescribed Building Codes inclusive of ASCE-7 [6], AAMA [3] and AA [2] recommendations. Depending on the building complexity, a wind tunnel study (physical scaled modeling) is used to identify design pressures and also to highlight areas with expected elevated pressures. Examples are illustrated in Figures 4 and 5. These tools provide a mechanism to efficiently design a curtain wall system. Full-scale testing at accredited laboratories for air/water/lateral/seismic loads may also be conducted. Buildings along the coastline subjected to Hurricane loading often incorporate requirements for missile impact designs.



Courtesy of CPP, INC

Figures 4, 5 Wind Tunnel Study Scaled modeling showing wind pressure contours.

Blast Loading

Blast loading is a very important constraint which some systems have to be designed for. There has been a concerted effort to design new buildings or upgrade several buildings to prescribed threat levels. In addition to computational analysis, full-scale test such as arena tests or shocktube tests assist in evaluating performance. There are specific guidelines and requirements that are primarily prescribed by the governing Federal Agency.

Seismic Loading

This may be incorporated in a full-scale laboratory test. In addition, after a natural occurrence, due diligence on the wall performance also provides information on the envelope performance. There are task Groups developed or assigned to regions to observe and retrieve information pertinent to building structure as well as the building envelope performance. These studies contribute to improvement in component design in the curtain wall.

Thermal Loading

The performance of the curtain wall under thermal loading is also important. Depending on the interior environment, one of the challenges that must be met is good moisture condensation resistance capability. Condensation on the framing is a significant concern for building ownership for varied reasons. Theoretical modeling techniques and tools such as THERM and WUFI, allow the designers to perform parametric studies by varied parameters. The response information may then be used by the design community to economize and make the systems

more efficient. Within the curtain wall systems themselves there are internal elements such as thermal breaks and thermal isolators that assist in improving the framing performance.

Light Transmittance

Occupant comfort is a significant requirement of the curtain wall response. The amount of transmitted lighting through the vision areas may be controlled in different methods by glazing choice, tint choice, glass fritting, insulating glazing composition (2 or more glass lites) [Figure 6] and shading. The expected parameters are provided by glazing manufacturers from testing and included in the mechanical system study for the building. The architectural design community is always challenged to improve visibility by varying sitelines, module spacing and material choice and these aspects have direct bearing on the level of transmitted light into the occupied space.

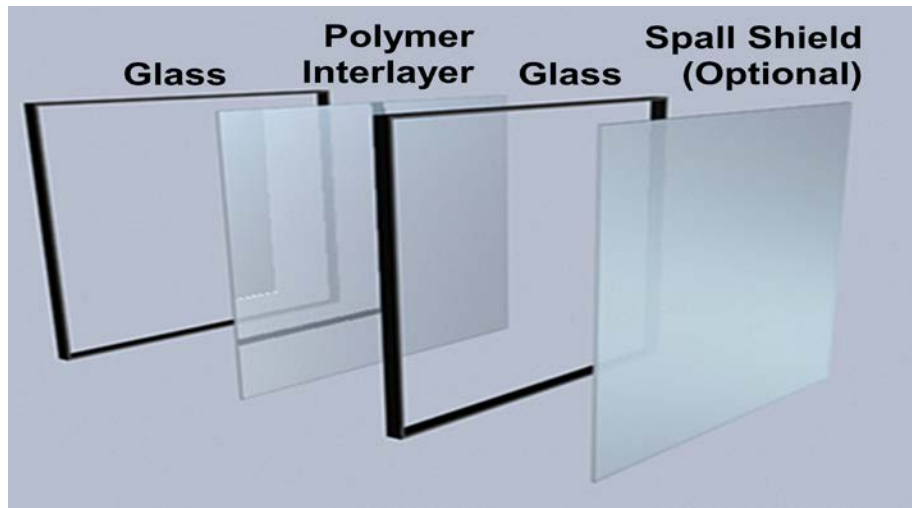


Figure 6 Example of Glazing Composition with optional components.

The goal of improving visibility and lighting inside the space is illustrated in Photos 7 thru 9. It should be noted that for wall systems such as cable net walls or point support glazed walls, there is a lot of engineering involved and critical coordination.

A different example of controlling the interior environment is by the use of shading. There are differing methods that may be adopted. These can be incorporated in varied methods. Typical windows may have individual sunshades (Photo 10) while a macro application would be a louvered canopy at an Opera House Venue (Photo 11). These indicate different strategies were used



Photo 7 Winter Garden, World Trade Center (Reconstructed)
Courtesy of Thornton Tomasetti



Photo 8 Cable Net wall, UBS Tower Chicago IL
(Courtesy of Thornton Tomasetti)



Photo 9 Interior space Winspear Opera House, Dallas TX
(Courtesy of Kendall Heaton)



Photo 10 Individual Sunshades



Photo 11 large canopy

Installation

The performance of the curtain wall is dependent on design and workmanship but can also be enhanced by installation techniques. Traditional curtain faring may be built as a “stick system” but more use of unitized systems for varied reasons such as quality control, pre-assemblage of small or large units (typically floor-to-floor), field storage constraints, construction site constraints. Examples of two system types show a glazed unit installed in Photo 12 and a steel truss frame of brick panels shown in Photo 13. Both cases require good co-ordination but allow the installation of significant square footage. Both methods have enhanced quality control attributes.



Photo 12 Glazed Unitized Curtain wall



Photo 13 Steel truss with brick façade.

Maintenance

For the building to perform in an efficient manner, it is paramount that building management conduct routine maintenance checks on the envelope enclosure. This can be incorporated in regular scheduled washing of the building where elements such as sealant, glazing and gaskets can be reviewed. Photo 14 is an illustration of a gasket in a failed condition and it is not maintaining efficiency. This illustrates one key reason for routine building maintenance.



Photo 14 Example of aged gasket underperforming.

Summary

The curtain wall is a defining aesthetic element on the building and its inherent tasks include providing protection and comfort from the elements. The effectiveness of its performance is also related to the level of maintenance implemented at the facility. Since there are so many components involved in a curtain wall system, the design, installation and workmanship all contribute to its successful performance. As technology introduces new components into the construction market, it is important to access the synergy of these components and qualitatively assess what improvement can be achieved. Curtain wall maintains a key role in the performance of a building.

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