commercial glass
FAÇADE & DOOR SYSTEMS

COURTESY WAUSAU WINDOW & WALL SYSTEMS

Tower Pinkster Titus Architects specified a silicone-glazed curtain wall for energy efficiency in this $8 million Wyoming, Mich., police station. Lakeshore Glass and Metals was the installer.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ DISCUSS the basic materials and product types available for commercial glass systems, entrances, and doors as they relate to occupant safety, environmental factors, and durability.
+ COMPARE storefronts, window walls, and curtain walls in terms of application types and performance characteristics, especially with regard to energy performance.
+ LIST considerations for glazing selection for commercial glass façade systems in terms of human health, indoor environmental quality, and safety.
+ EXPLAIN how to resolve performance attributes, system limitations, and sustainability requirements for glazed openings and entries in typical building projects.

BY C.C. SULLIVAN AND BARBARA HORWITZ-BENNETT

When it comes to selecting fenestration systems—particularly glass facades and door systems—a number of factors come into play, requiring a thorough evaluation of a project's individual requirements. However, some general guidelines can be helpful to get started.

Since door systems fall under the most "operable" part of the design realm, durability often tops the list of key considerations when selecting a product type, says Mark Schmidt, RA, CCS, LEED AP, Specification Writer/Coordinator, Fanning Howey (www.fhai.com), Dublin, Ohio. However, many project team leaders such as Duo Dickinson, AIA, NCARB, CORA (www.duodickinson.com), a veteran architect based in Madison, Conn., rank restorability as their number one concern.

"Many doors that look good in the showroom look horrific in one or two years," says Dickinson. "Doors are by their nature cantilevers and thus handle a great deal of 'dead load' that tends to wrack the entire panel of the door." Since even the best of doors will undergo a certain amount of wear and tear, a system that responds well to maintenance is essential.

Cost and *aesthetic appeal* are two other crucial factors that must be taken into account. Specifiers also need to understand the door's *anticipated function*, which encompasses *volume* and *type of traffic*. Meanwhile, external and internal *air forces* created by wind, HVAC pressures, and seasonal changes—which can cause the door to expand or contract—must also go into the equation.

In fact, the Window & Door Manufacturers Association (www.wdma.com) recently approved a new standard, No. 300-12, for the installation of exterior doors where there is "extreme wind/water exposure." Joined by the Fenestration Manufacturers Association (www.fmausaonline.org) and the American Architectural Manufacturers Association (www.aamanet.org), the WDMA says the standard is "specifically designed for installations subject to extreme wind/water climate exposure, particularly in the coastal southeastern United States."

Mark Heinaman, co-founder of Las Vegas-based Heinaman Contract Glazing (www.heinamen.net), lists safety, code requirements, water and air infiltration resistance, seismic and live-load deflection, and hardware compatibility as top considerations for Building Teams.

COURTESY CURTAIN WALL DESIGN & CONSULTING

This pre-assembled, factory-glazed window wall system, which offers enhanced quality control, was installed in precast concrete openings.

Other professionals state that the *choice of hardware* should be an early consideration for door selection. For example, many projects are often frustrated by faulty hardware packages, says Dickinson. "We have found that sometimes very well-made doors have undesirable hardware and occasionally have to work with blank doors and retrofit better hardware into them," he says.

In any case, once these variables are sorted out, the Building Team can move on to choosing between different door materials, each one with its pros and cons.

Wood—Beautiful but vulnerable. While it's difficult to rival the warmth and beauty of genuine solid wood and wood-veneered doors, the material's Achilles heel is undoubtedly weatherability. Consequently, wood is frequently reserved for doors within interior public spaces, or for exterior uses where other potential problems, such as aesthetics or historic matching, are the main considerations.

Woods exposed to the elements undergo three types of weathering forces, writes William C. Feist, a research chemist with Forest Products Laboratory, Madison, Wis., in a research summary from the 1980s. They are: 1) *sunlight*, which causes photodegradation; 2) *water*, which causes leaching, hydrolysis, and swelling; and 3) *microorganisms*, which may cause discoloration and degradation due to staining and decay. Of course, wood can be protected by paints, stains, and varnishes; according to Feist, opaque paints provide the most protection to exposed wood surfaces.

More recently, according to Jim Berg AHC/CDC, CSI, BMA, principal of Door Hardware Consulting (www.doorhardwareconsulting.com), Prairie Village, Kan., manufacturers have produced high-end wood door systems where the core construction—at around 2½ inches of thickness—doesn't absorb moisture. These products can come with a high price tag, however.

Consequently, some specifiers may look for alternatives, just as architect Adam Zimmerman, AIA, LEED AP, recently did for a religious facility project. "When we considered both the maintenance risks and cost deterrents of true cedar doors, we decided to start looking for alternatives to real wood and landed at a stain grade fiberglass," says Zimmerman, principal of Zimmerman Workshop (www.zimmermanworkshop.com), Brooklyn, N.Y. "The product we selected is a fully insulated door with a subtle woodlike grain that is able to absorb a stain for the look and feel of wood without all the headaches."

Fiberglass—Strong, easy to maintain. While not one of the more classic door material choices, fiberglass offers the benefits of strength, low maintenance, and resistance to denting and scratching.

"Aluminum doors with insulated cores and clad with fiberglass-reinforced polymer are attractive, colorful, and abuse-resistant," says Fanning Howey's Schmidt. "They can be used at secondary exterior access points where knowing what's on the other side of the door is not as important as at main entrances."

Metal—Flexible, but hold the salt. As for exterior entrances, glazed aluminum is frequently the system of choice for its weather resistance and visibility. "A metal door or a storefront-type door extruded in aluminum, bronze, or similar materials can provide the best flexibility in exterior applications in an offset configuration of the door and hardware," states Contract Glazing's Heinaman. "This particularly helps in achieving values needed for air and water infiltration."

One environment where metal doors don't perform well is in coastal or other saltwater conditions, as even the best paint or anodized finish will usually begin breaking down over time, according to Dickinson.

Another limitation of the metal/glass combination is its ability to resist heat transfer. Consequently, when fire resistance is a requirement, then hollow metal doors—with or without insulated cores—are a strong, economical, and secure choice, says Schmidt, based on his 25 years of experience specifying door systems. He notes, however, that the tradeoff in this case may be aesthetic appeal.

Glass—Modern touch, but heavy. While glass doors go a long way toward creating a beautiful, modern look within a space—not

SPECIALTY DOOR TYPES—plenty of functional variety

Beyond the door material, another important decision is determining whether a more sophisticated door system is required for the application. In the MasterFormat section 08 30 00, *Specialty Doors and Frames*, a number of door types are listed for special functions, access locations, sliding and folding hardware, and even pressure-resistant types. Among these, there are several mentioned by Building Teams for consideration today:

• **Pivoted or hinged doors.** Both pivots and hinges can be used interchangeably, although hinged, prefabricated doors are generally less expensive. The presentation of the door types is the key factor. A hinged door typically reveals a knuckle spanning 4½ inches, while a pivot door's profile is much smaller, with a 1½-inch knuckle. (*Means Illustrated Construction Dictionary* defines a door knuckle as "one of the enlarged, protruding, cylindrical parts of a hinge through which the pin is inserted.) The pivot door also offers a higher level of durability, making it a common choice for commercial applications.

COURTESY DORMA AMERICAS

An automatic revolving door (DORMA 1000-A Series) installed at Detroit's Greektown Casino as part of a major revitalizaton program for that section of the Motor City.

• **Balanced doors.** Ideal for windy climates, a balanced door is a more sophisticated, engineered system for exterior entrances. "The balanced door system is a complete assembly where the hanging and closing of the door is controlled by the door system, negating some of the effects of excessive wind conditions," says Jim Berg, a veteran door systems consultant.

If a balanced door isn't in the budget, then pivoted or hinged doors need to be designed with higher opening and closing forces, as more of the door leaf is exposed to the wind.

COURTESY DORMA AMERICAS

Automatic door installed at the Kansas City airport. The door shown here (DORMA ESA200 model) is an extruded aluminum stile and rail door designed for interior or exterior applications where emergency breakout of only the sliding panels is required. In general, automatic doors provide a common solution for meeting ADA requirements.

• **Automatic and revolving doors.** Automatic doors are commonly used to meet the requirements of the Americans with Disabilities Act, or simply to handle highly trafficked entrances, as in hospitals and grocery stores. Because the price difference between automatic and revolving doors is substantial, revolving doors are usually reserved for buildings with significant weather requirements.

Revolving doors can also be helpful in mitigating the effects of strong negative and positive air pressures created by the HVAC systems and outdoor conditions, which cause wear and tear to a typical door. Consequently, the number of service calls is reduced with revolving or vestibule door systems.

According to Studio 08 Principal Rick Lewis, the most common type of revolving door is the single-post door. However, "Many of the airports are now using a type that allows more people to be in the door unit at one time, to move more traffic," he says. Today there are small, three- and four-wing models for lower-traffic applications, while the large, two-wing or three-wing automatic revolving doors are more common in retail centers, hospitals, and transportation centers.

In most applications, a low-energy power operator meeting ANSI A156.19 (Standard for Power Assist and Low Energy Power Operated Doors) is specified as an ADA-compliant installation. However, for industrial settings, a heavy-duty power operator compliant with ANSI A156.10 (American National Standard for Power Operated Pedestrian Doors) is used. The industrial types are often specified with a ramp and guides, as the doors generally don't stop and reset if a person or object enters the sensory field.

While the lower energy operators do stop and reset, this action can eventually wear down the mechanism. "Currently, manufactured units are considerably better than the ones that first came out 20 years ago," says Lewis. "However, an ANSI A156.10 unit requires a lot of maintenance because the door operator is used each time a person, cart, or motorized vehicle passes through the opening." Lewis says there is considerable power and momentum in the door as an operator is functioning, and "this causes not only the operators to receive a lot of abuse, but also the doors and frames."

While retrofitting ordinary doors into automatic doors can be difficult and expensive, there are cases where there is no way around the problem for certain types of buildings, such as churches, temples, mosques, and other religious institutions, which are now required by ADA standards to update their access points.

to mention enhancing natural light—their application as exterior doors is somewhat limited as they don't seal well against water and air infiltration. In warmer settings, an overhang should be installed to protect the door from blowing rain.

Another difficultly is the weight of a glass door. That's why metal frames are much more common than wood for glass door systems, as the metal corners can transfer the glass weight load to the hinge side of the door, according to Dickinson.

CURTAIN WALL VS. STOREFRONT—WHEN SIZE DOES COUNT

Automatic and revolving door systems are generally integral to a glass and metal façade system or storefront. Moving beyond the front door, these glass components of the building's façades are a major architectural design element. Curtain wall, storefront, and window-wall systems are highly competitive—even redundant—and employ very similar assemblies and materials.

Because these glass enclosure systems each have specific criteria for their basis of design (BOD), Building Teams must consider function, aesthetics, performance characteristics, and system limitations for the specific project at hand as guidelines for initially choosing a system. However, certain general guidelines apply when it comes to a specific building type.

"Generally, the size of an opening is one of the biggest determining factors for using storefront or curtain wall," says Allen Cradler, AIA, CCS, LEED AP BD+C, a project manager for Fanning Howey. "Openings 10 feet to 12 feet high are about the maximum for typical storefront systems." Common aluminum-and-glass installations can span floor to ceiling, or can be installed as fixed windows set into brick, stucco, EIFS, or precast concrete openings, and are usually limited to one- and two-story buildings due to the system's wind-load resistance limitations.

"Typical aluminum storefront framing systems using monolithic or insulated glass generally are low-performance systems, having limited capacity to control water and air infiltration, and no means to control secondary water from the surrounding conditions at the head/top of the window opening," explains Kirk Osgood, Principal and Senior Vice President, Curtain Wall Design & Consulting (www.cdc-usa.com), Dallas. This being the case, Osgood—based upon his 40 years' experience in the curtain wall industry—recommends these storefront systems exclusively for projects where the expectations match the performance, such as retail and restaurant settings. In these cases, the system would be installed with a pre-engineered subsill component for better sealing.

With window-wall systems, a higher level of performance can be expected and the aesthetics can be clean and modern. At the same time, there are a limited number of suppliers and options for these products, reports David Walker, Vice President of Association Services with the National Glass Association (www.glass.org), Vienna, Va.

The head and sill of window walls can either be installed continuously or with vertical mullions that run through, with the horizontals cut in between the verticals. Berg prefers the continuous approach, as it provides the potential to design a system to collect, control, contain, and discharge the entry of secondary water from the head of the window surrounding conditions.

Curtain wall systems can be engineered to span greater vertical

WINDOWS AND DOORS: Do they match?

While custom-designed and custom-manufactured window and door products are the most surefire way to ensure that all windows and doors on a given project are a visual match, there are other options.

In some cases, it may be sufficient to use similar framing systems such as hollow metal or extruded aluminum, according to Mark Schmidt, RA, CCS, LEED AP, Specification Writer/Coordinator, Fanning Howey, Dublin, Ohio.

While using the same trim for the windows and doors is another strategy, Schmidt finds wood trim on door frames highly vulnerable to damage. "Also, field-constructing wood frames with trim for doors is labor-intensive and prevents other work from taking place concurrently in the immediate area," he says.

On a recent project, Adam Zimmerman, AIA, LEED AP, Principal of Zimmerman Workshop, Brooklyn, N.Y., had to rely on trim to match different kinds of doors and windows. Since his budget prevented him from specifying one type of fenestration, his team had to get creative with fiberglass doors, steel clad doors, and PVC windows.

The solution: Using painted steel doors on all upper balcony doors, which are physically separated from the lower fiberglass doors. "Ninety-five percent of visitors to the building never get close enough to the steel doors to notice the difference, and in no case are there two differing doors within direct view of one another," Zimmerman explains.

However, when it came to the fiberglass doors and PVC windows, which were in direct proximity to one another, "We had to trim each out very carefully on both the interior and the exterior to create the aesthetic unity between the different products," he adds.

While cedar wood was the primary exterior element for Saint Elias Ukrainian Church Parish House, Brampton, Ont., Zimmerman Workshop got creative with fiberglass and steel doors, as well as PVC windows, to keep the project on budget while still presenting a high-end, well-coordinated look. The 5,000-sf facility, designed by the late Robert Greenberg, was built in part using volunteer labor supplied by parishioners.

and horizontal distances; many provide built-in water management and weeps. In addition, curtain walls offer more flexibility with aesthetics, glazing selections, and structural integration, according to Cradler. However, curtain walls also are more expensive and require a highly competent contractor or installer. There is greater potential for site-assembled and even prefabricated curtain wall products to present leakage issues if installed poorly or inconsistently.

NARROWING DOWN THE CHOICES

In terms of what's available, curtain wall comes as 1) a *stick-built* system, 2) a factory-assembled and glazed *unitized* system, or 3) a *hybrid* stick system with preglazed cassette frames. The preglazed hybrid types have fabricated frames that slide into field-installed vertical and horizontal framing members.

Stick-built curtain walls—right for smaller projects. With this design approach, the curtain wall's vertical and horizontal framing members are installed on site as individual pieces, then filled in with glass or other infill materials. Although stick-built systems do require more on-site labor, if it's a smaller project and doesn't have a lot of repetitive modules, then it might be the right choice, according to Osgood.

"Vertical mullions generally span two floors," he adds. "This twin-span design increases the dead-load reactions at every other floor line, so coordination with the project structural engineer to accept this increased loading is required."

Unitized curtain walls—allow enough lead time. With unitized systems, the individual units are fabricated, assembled, and glazed in the factory and then shipped to the project site for storage and eventual erection. Because these systems are more complex and require more engineering, lead times are longer, as the majority of the work is done off site.

Osgood lists the reasons why a unitized curtain wall system is usually specified: project size, complexity of the architectural features, façade geometry, incorporation of exterior shading elements, performance criteria, project logistics, schedule, a desire for factory-controlled quality control, and the sophistication level of the curtain wall contractor and manufacturers.

One critical aspect of the fabrication process is ensuring that the gaskets in the horizontal and vertical mullions are sealed well with the framing members. In other words, the four-way intersection of these units must be continuously sealed if the system is going to meet air and water infiltration performance criteria. Once the curtain wall is installed, there is no way to access and correct these seals, so it must be executed correctly the first time around.

Although general guidelines are helpful, Osgood emphasizes that every project is unique in its own local access to materials, schedule, logistics, and location, in addition to requirements for air and water infiltration, thermal performance, wind loads, seismic movement, blast resistance, and acoustics, to name a few. Consequently, project conditions must be fully vetted before a system is chosen.

"The prudent architect or project owner, or both, would also be wise to enlist the services of an independent, qualified, professional curtain wall consulting firm experienced in all facets of the building

envelope design and materials selection process," he adds. "The consulting firm should be multilevel and multidimensional in capabilities and expertise, with a proven track record."

There are also *technological advances* to weigh against cost and performance expectations, says Walker. For example, he sees unitized curtain walls making progress, with newer systems offering U factors below 0.30, with easier installation. In that context, Osgood calls out dual durometer and copolymer gaskets—as well as more extruded silicone gaskets—as components that are enabling tighter air seals and better compatibility with silicone sealants. Oswald says he is also pleased with the newer engineered subsills for storefront systems. However, because manufactures are still trying to utilize as little aluminum as possible, the jamb perimeter conditions in some cases may be inadequate to provide the proper perimeter sealant conditions for this component, he explains.

WINDOW GLAZING—MAKING CONTINUOUS IMPROVEMENTS

From dynamic glazing to vacuum-insulated glass to fourth-surface coatings, the glazing industry continues to make advances, particularly in the face of stricter Energy Star criteria coming down the pike in 2014. For example, Walker points to developments in the electrochromic and thermochromic glass industries, where a handful of well-established companies are busy researching, refining, and manufacturing both high-end electrically tinted glass (electrochromic) and heat-activated switchable surfaces (thermochromic).

"The key with all of these products will be improvement on the energy-efficiency side," he says, noting that the manufacturers are working with industry partners to create myriad products and assemblies using the glazing types.

While thermochoromic and photochromic glass rely on chemical reactions to alter shading levels, electrochromics require electrical wiring, necessitating a higher level of coordination between the design team and the building trades, with MEP engineers playing a more active role, notes Osgood. "This involves more training and education to implement and more design to effectively incorporate the wiring into the framing systems," he says.

Another goal currently being pursued by the industry is significantly boosting thermal performance to help counter the trend of decreasing window-to-wall ratios. One of the keys to achieving this may be vacuum glass insulation, which would potentially offer insulation levels equal to, or even greater than, triple-glazing, but only utilizing two panes of glass instead of three.

At this time, the technology is not seen as adequately cost-effective and may require further development to achieve anticipated performance, according to experts consulted for this course. Yet, the industry may very well see strides toward this end within the next couple of years.

Meanwhile, the industry is catching up with triple-glazed insulated glass units, as framing systems capable of handling the thickness of the glass in the glass pockets are now available, says Osgood. However, while triple glazing is becoming a more viable option in the residential market, it's less common for commercial projects; only for commercial buildings in northern climates are triple-glazed IGUs specified with any regularity, according to the experts.

Dickinson offers a unique take on noteworthy hardware developments in the window industry. "The most exciting part of windows is the ever-more refined, easy-to-use, and durable hardware used, especially for casement windows," he explains. "We've come a long way in the last 20 years."

THE RIGHT DECISION ON GLAZING

Whether it's choosing a door type or glass façade system, a project's unique factors will always inform these decisions from a cost, aesthetics, and performance standpoint.

Only based upon the building's intended use, climatic conditions, code requirements, building orientation, and other salient factors can designers and specifiers make informed decisions about what glazing solution will work best for a given facility. +

BUILDING-INTEGRATED PHOTOVOLTAICS—on the road to net-zero

No discussion of the openings market would be complete without mention of glazing-related photovoltaics, especially with the net-zero building trend gaining momentum.

Essentially, the main problem with PVs is return on investment. "Currently, we expect a 20- to 30-year payback for thin film and all other photovoltaic systems," says Dennis Hacker, AIA, CSI, CCS, CCCA, LEED AP BD+C, Specification Writer/Manager at Fanning Howey. "At that rate of return, these systems are limited to clients who either have extremely high energy costs, an unreliable energy supply, or a strong philosophical commitment to sustainability beyond just lowering operating costs. For the technology to gain broader acceptance, the payback period would need to be five years, maximum."

Osgood points to aesthetic issues with PVs, the limited number of manufacturers producing these products, and the fact that the wiring requires penetration through the façade system, creating a potential for water infiltration. But the energy-efficient, sustainability-conscious building industry is nevertheless pushing for further development of the technology.

"This form of electric energy production will probably increase in the future," says Osgood, "as there become more incentives, more manufacturers of viable commercially available products, and as greater returns on the investment are realized."

Toward this end, industry leaders are partnering to better leverage their expertise and capabilities, in an effort to address these concerns. "The three keys for future progress are price, performance, and aesthetics," says Walker. "The price has to come down to make it more achievable for the building owner or developer. The performance has to improve the ROI, and the looks have to be appealing to the architect."

> EDITOR'S NOTE

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