LICENSED ARCHITECT

Association of Licensed Architects

A Publication of the Association of Licensed Architects

Spring 2023

Fiberglass Windows Come of Age

Adhered Masonry Veneer Systems

Low-Iron Acid-Etched Glass

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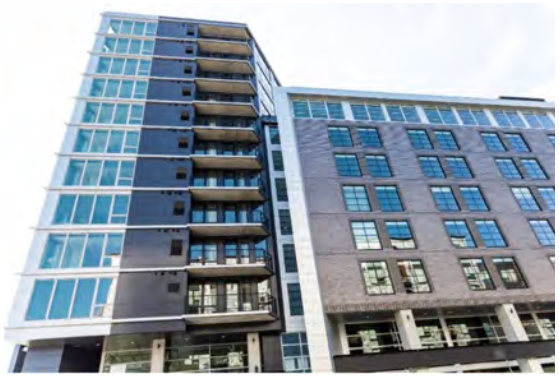
Fiberglass Windows Come of Age



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Cover Photo:
USX Chicago (HK Architects)
Photo by: Christopher Barnett

PRESIDENT'S message

Welcome to the spring issue of Licensed Architect Magazine. I want to extend a warm welcome to the many new members who have recently joined ALA.

We hope you will also consider featuring ALA membership as an employee benefit– we offer a 25% discount if four or more professionals from your firm join. In addition, we offer a new member referral incentive of $25 which is a credit applied to your next year's membership. By referring a colleague, you will be sharing practical professional development, access to key contracts, a community of professionals and more. The new member is asked to list the referral source on the membership application.

This summer we will announce a new ALA Mentorship Program for those looking for career and professional development. We will begin the program by collecting information on those interested in being mentors or mentees. For mentors, this is a great opportunity to give back and benefit as well. Mentees are encouraged to sign up for one-to-one discussions. More information will be available In July and August.

Also scheduled for the summer: A June 27 Lunch and Learn program on "Common Mistakes in Contracts" and the much-anticipated tour of the Edith Farnsworth House, a Mies van der Rohe modernist masterpiece, on June 21. Following the tour, there will be a luncheon at The Homestead 1854 in Plano, IL and a presentation: "Farnsworth House: A Collaborative Approach to Restoration."

We would like to encourage our members to consider serving on an ALA Committee and/or becoming an ALA Board member. No previous board experience is needed. Please reach out to Joanne Sullivan at ala@alatoday.org as soon as you can – our next two-year terms begin January 1, 2024.

Be sure to check out our summer issue, where we cover our Spring Conference. We have received many positive responses regarding the keynote address and the presentations.

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At HK, we believe “Good design is good business”. We strive to positively affect people’s lives with good design. In everything we do, our goal is to use our building spaces and the materials we build with in the most efficient, ethical, and sustainable way possible.

Credits: Photos By 161 Photography

Greenway Farms, Chattanooga, TN

A new, modern conference center located along the North Chickamauga Creek and positioned next to multiple trailheads at Greenway Farms, a local City of Chattanooga park.

Credits: Photos By Karen Culp Photography

Montessori Elementary, Chattanooga, TN

A one-of-a-kind charter school in downtown Chattanooga designed around natural light and the simplicity value that the Montessori method values. This project focused heavily on community, equity, and high- quality educational opportunities for young children in Chattanooga’s urban core.

Credits: Photos by 161 Photography & Nelson Worldwide

Variant, Atlanta, GA

A tenant build out focused on two floors in Midtown Atlanta. Design focus weighed heavy on client's branding and public and private workspaces providing a fresh and flexible design to help attract and retain talent.

Credits: Photos by Christopher Barnett

USX Chicago, Chicago, IL

The U.S. Xpress Chicago office is located in a classic 7-story building where historic architecture meets an urban addition. The original brick and timber building has been combined with a modern industrial concrete building to create a beautiful dichotomy of old and new.

Credits: Photos by 161 Photography

Visitors Center, Chattanooga, TN

Chattanooga has a notable downtown turn-around story including investments made in the Riverfront and the Aquarium. An 800 sq ft building in the Aquarium Plaza sat vacant for decades. It was renovated into an interactive and human-scaled information center drawing hundreds of visitors to the site.

Credits: Photos by 161 Photography

Cameron Harbor, Chattanooga, TN

This 23-acre mixed-use development is patterned on a street grid that ties together existing roads and features. Adjoining the Riverwalk, the project is a diverse mix with 486 apartments, 24 townhouses, 12 loft conversions, 30,000 SF of office space, a 4,000 SF restaurant, and 98 cottage homes.

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Since 2006, SDG has enabled our clients to achieve the best results in many forms of architecture, including religious, healthcare, education, and residential. Our unique environments include Sonoran Desert, pine tree mountains and dense urban centers. Therefore our designs strive to work as seamlessly as possible within each unique setting.

Great architecture is the product of the interweaving of different personalities and experiences, working together to achieve a common goal. Our wish is for every aspect of the design and building process to be a positive experience for all involved, in a God honoring fashion: Soli Deo Gloria.

Credits: Photos By SDG Architecture LLC

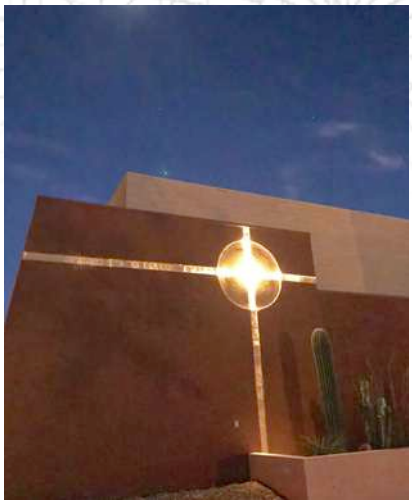
Door Church, Tucson, AZ

A new building with 2100 seat sanctuary, lobby, coffee bar and children's ministries. The placement creates a welcoming courtyard with the existing church and a new visual connection to the adjacent neighborhood.

Credits: Photos By SDG Architecture LLC

University of Arizona Marketing & Communications, Tucson, AZ

The need to combine the scattered University of Arizona Marketing department into one large space allows for better collaboration and social engagement. This energized the teams for better communication and innovation.



Credits: Photos By SDG Architecture LLC

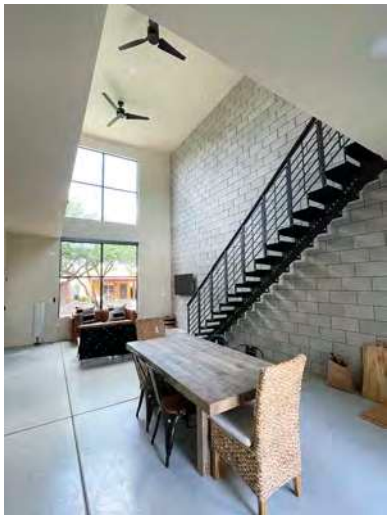
Sabino Road Baptist Church, Tucson, AZ

To create a welcoming entry and communal courtyard, the new sanctuary shelters the attendees from the adjacent road. The new building front includes desert species and an integrated cross.

Credits: Photos By SDG Architecture LLC

Benson Hospital, Benson AZ

This small rural hospital lacked many current services, so improvements include a new imaging wing, renovated patient rooms, and central supplies. A new entry engages with the community with a conference center, which is used by many locals.



Credits: Photos By SDG Architecture LLC

Civano Residence, Tucson AZ

The new urbanist community of Civano has unique qualities, including passive solar design and rain catchment. This new residence strives to exemplify those qualities and engage with the neighborhood.

Fiberglass Windows Come of Age

BY: CHRIS CARPENTER, CSI, CCPR, CDT, ARCHITECTURAL CONSULTANT, PELLA WINDOWS & DOORS, INC.,
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Manufacturing

Fiberglass has existed since engineer/inventor Games Slayter of the Owens-Illinois Glass Company patented "glass wool" for thermal building insulation in 1933 with full commercial production going to market in 1936. Most of us are familiar with fiberglass being used in cars and boats, but the manufacturing process varies significantly. Cars and boats use a conventional "chopped strand mat" process in which fibers are laid randomly across each other into a mold and held together by a binder or "gel coat." Fiberglass has evolved over the years from being used in boats and bathtubs to being trusted by NASA for use on spacecraft [1].

Because of its impressive weight to strength ratio, fiberglass is structurally sound with a natural thermal break, making it a perfect material for windows and doors. Fiberglass is an inert, stable material and does not off-gas like PVC, making it better for the environment than other options.

Fiberglass windows are generally made through a pultruding process combining rovings and matting, followed by an injection of resin, all while being pulled through a die to create a shape or profile. Pultrusion patents were introduced in 1946 and have been commercially produced since 1952 [2]. The thermoset process produces a material that will not break down when exposed to elements or lose its shape in extreme hot and cold temperatures. Once it is molded and cured by heat, the molecules crosslink and it becomes a solid substrate that is irreversible. High ambient temperatures will not melt, warp, or become misshapen like some thermoplastics.

Finishes

Some fiberglass manufacturers may offer field-finishing, however pultrusions are generally factory finished by powder coating, painting or covering in a cap stock in a variety of colors to provide a long-term durable finish. Most of these finishes are maintenance free and are resistant to corrosion, blistering, peeling, chipping and chalking for long-lasting durability and beauty.

Coatings for thermoset fiberglass profiles use the AAMA 623, 624, 625 series for evaluating color uniformity, specular gloss retention, impact resistance, color fading and other attributes related to weathering and aesthetics.

- AAMA 623: Performance Requirements and Test Procedures for Organic Coatings on Fiber Reinforced Thermoset Profiles
- AAMA 624: Performance Requirements and Test Procedures for High Performance Organic Coatings on Fiber Reinforced Thermoset Profiles
- AAMA 625: Performance Requirements and Test Procedures for Superior Performance Organic Coatings on Fiber Reinforced Thermoset Profiles

Star Metals, Atlanta - multifamily project with fiberglass window frames
(PHOTO CREDIT: ©RAFTERMEN)

These AAMA standards define the capabilities of the finish and can be viewed as good-better-best from a performance perspective. Typical fiberglass finishes meet the AAMA 623 or 624 standards and as it shifts from 623 to 624, the performance requirements and longevity expectations of the coating increase. The Fiberglass Material Council has continued to evaluate and update the specifications - much of which is based on variances resulting from different coating colors. The goal is to keep specifications up to date to ensure the industry stays on the cutting edge.

Fiberglass vs Vinyl

Fiberglass testing shows it is 10 times stronger than vinyl (Based on Tensile Strength Test at peak load lbf/in^2). Because of this, fiberglass can provide thinner profiles - not only in the frames, but also in mullions also. Typically, fiberglass windows can use half-inch or one-inch structural mullions that keep total widths at a minimum, which is more comparable to aluminum sightlines than vinyl. Since vinyl lacks integral strength, overall sizes are constrained. Frames and mullions need to be wider and reinforced with aluminum or steel so there is much less visible glass in the openings. Many vinyl windows cannot be mulled with a four-way joint – that is, four windows mulled together into a composite window.

A single fiberglass fixed window can be manufactured up to 70 square feet. The thinner profiling enables fiberglass to achieve greater sight lines and more visible glass, which continues to be a design trend in the marketplace.

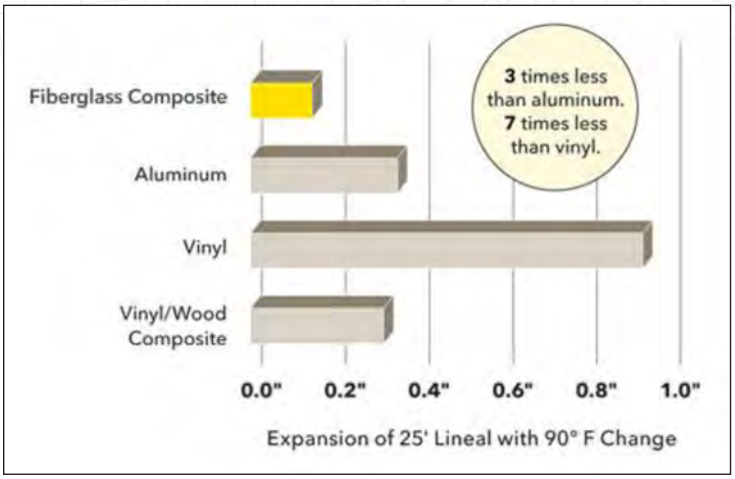
With the popularity of large expanses of glass and labor availability challenges, mulling capabilities are an important consideration when choosing windows and doors. Because of the material and manufacturing limitations of vinyl and vinyl composite windows, factory mulling options are often more limited than with fiberglass. Sleeker factory mulled combinations with reinforcing mullions are available with fiberglass windows and offer greater flexibility in design options.

Expansion and Contraction and Impact on Durability

When comparing thermal efficiency, both materials offer similar thermal performance for U-factors and solar heat gain, however, fiberglass has a better expansion and contraction coefficient than vinyl (also referred to as PVC or plastic) which can help with product durability. Vinyl frames expand and contract more than fiberglass with temperature changes. Fiberglass shows the lowest thermal expansion and contraction (See Table 1) among the most popular window materials.

Because fiberglass is partially made from glass, the frames expand and contract along with the insulated glass units (I.G.) to provide excellent protection against seal failure and provide long term durability.

Table 1



Oh, Hail!

Vinyl and wood/ plastic composite windows can struggle withstanding hits from large hail (ASTM D638 Standard Test Method for Tensile Properties of Plastics). These window materials are difficult to repair and usually must be replaced because of potential water and air infiltration. In some cases, the sash may be replaced if only the sash is damaged and the main frame survived unscathed.

Fiberglass has a high impact threshold and resists damage from a direct hit, but if damaged, can be repaired. Replacement is not necessary.

Cost Considerations Fiberglass vs Vinyl

There are lower cost vinyl windows in the market that serves its purpose of filling an opening and providing views, daylight and ventilation, however lower cost vinyl windows lack the UV protection, structural integrity and durability higher quality windows offer. Lower cost vinyl windows used in multifamily projects will need to be replaced much sooner than fiberglass windows and these replacement costs are much higher than the initial cost of material, labor, and installation. Fiberglass is optimized for low maintenance and longevity making it a perfect fit for owners holding properties and looking to maximize their long-term ROI.

Fiberglass vs Aluminum

Aluminum windows gained popularity after World War II and rivaled wood windows by the 1970's[3]. While maintaining popularity, aluminum windows are notorious for their lack of energy efficiency. Despite advances in spacer and thermal break technology, it takes triple-pane aluminum windows to match dual-pane fiberglass windows for U-factors and Solar Heat Gain Coefficient (SHGC) values. There is also quite a difference in condensation resistance.

Table 2 THERM v. 7.6 and Window 7.6 software, LBNL

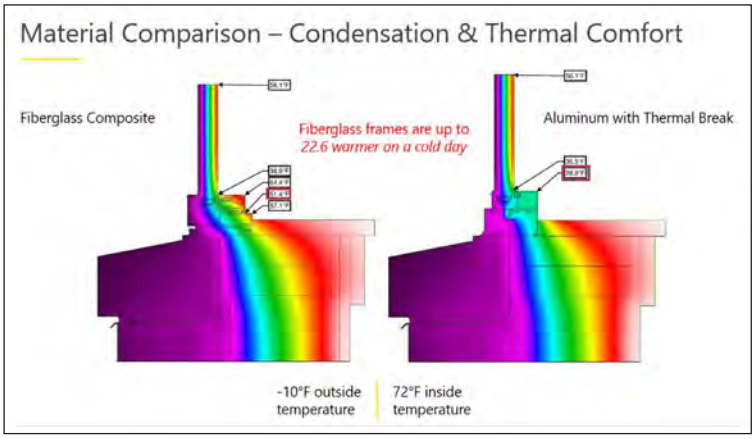
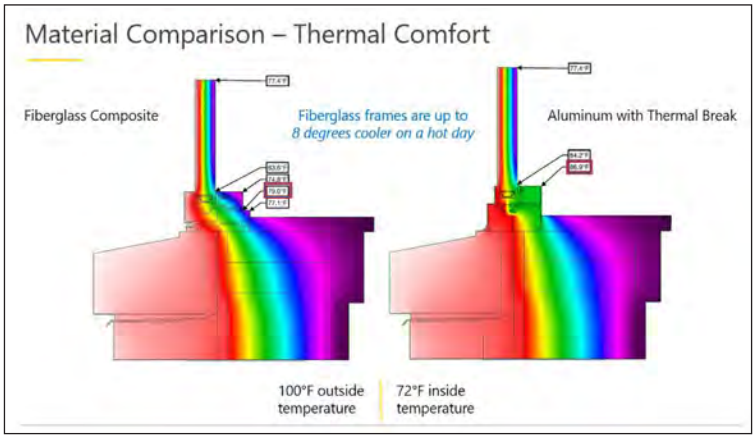


Table 3 THERM v. 7.6 and Window 7.6 software, LBNL



Expansion and Contraction

We noted the major effects of expansion and contraction for vinyl windows, but how does fiberglass compare to aluminum? Fiberglass has less than a third of the thermal expansion of aluminum[4] and has less than .02 percent *of the thermal conductivity of aluminum*. Aluminum has one of the highest thermal expansion coefficients of any metal type (ASTM E831-19 Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis). Over time, this can lead to increased maintenance, cause stress to sealants and fasteners, and may lead to faster air and water infiltration.

Performance Class and Grade

Many fiberglass windows are rated at CW-PG50 or above. Performance Class (CW) and Performance Grade 50 performance means that you can get floor to ceiling fixed windows with thin mulls. Based on ASCE 7, structural performance calculations show fiberglass windows can exceed 30 stories in most areas. This matches the look of aluminum and is something you cannot achieve with lower performance vinyl.

Fire Rating

Fiberglass windows are generally not fire rated. Always check with your window manufacturer on fire rating for frames and glazing.

Installation

Fiberglass windows can generally be installed any way aluminum windows can. Options include nail flange (fin), clips, screw through the frame, receptors, and additional trim accessories like brickmould and frame expanders offer plenty of options in any condition.

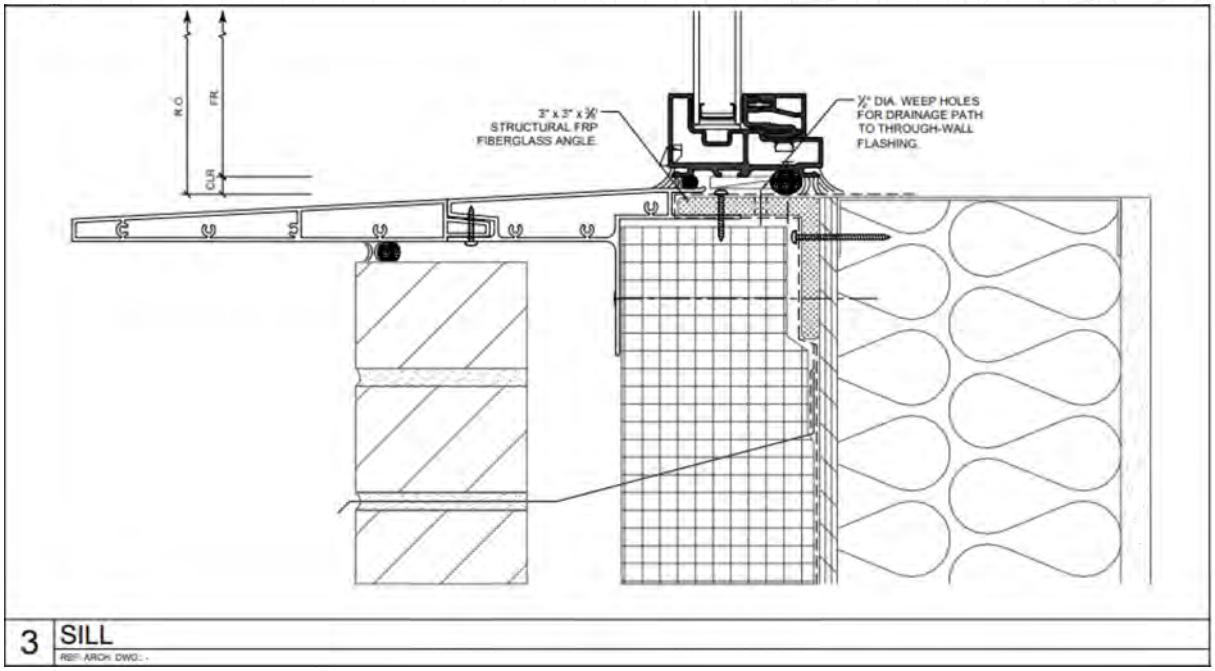
Shadow boxes

To meet the needs of Passive House and other energy saving initiatives, exterior solar shading is increasing in popularity. Shadow studies are being widely used not only

14 story IronClad mixed-use in Minneapolis

16 story HQ mixed-use project (Photo credit: ©VONDELINDE)

Drawing 1



for impact of the physical obstruction of the building, but for controlling solar heat gain. Depending on the amount and location of fenestration, reductions in annual cooling energy consumption of 5 percent to 15 percent have been reported [5] Custom extrusion capabilities allow for sunshades and shadowboxes to be added to the rough opening and integrated with the window frame.

Here is a detail drawing (Drawing 1) showing an extruded aluminum shadow box integrated with a window installed above 4 inches of mineral wool with a fiberglass support bracket. Because fiberglass is naturally thermally broken, thermal bridging is kept to a minimum.

Storefront & Window Walls

Fiberglass windows can reach up to 70 square feet in a fixed frame and can be factory mulled and field mulled into storefront and window wall configurations. Because of the improved energy efficiency, remember fiberglass frames can stay almost room temperature even on cold days, condensation resistance is much better. Triple pane is available up to 50 square feet and offers even better U-factors.

With glazing pre-installed into the frames at the factory and easy-to-install field mullions, installation for fiberglass storefront windows can save costs involved with panning, field glazing and mullion installation.

Cost Considerations Fiberglass vs. Aluminum

Fiberglass frames are very competitive with aluminum frames. It is difficult to directly compare prices because of wide swings in quality and location. One important consideration to remember is fiberglass frames are factory

Storefront windows shown in fiberglass frames

glazed and factory mulled when possible (depending on sizes – these storefront windows are 50 square feet each and factory mulled two wide), considerable savings can be realized when comparing installation costs of site glazing aluminum frames.

Innovation

There are many window manufacturers in North America and Europe utilizing all kinds of materials and glazing science, so innovation and cost savings are the driving force for gaining competitive advantage. One new development is a new style of operator for casements and awnings. For years, casements and awnings have opened and closed with a crank – crank to open, crank back to close – an operation we are all familiar with. Now, a totally new sliding style of operation has been introduced that also meets the difficult five lb. operating force ADA requirement up to certain sizes. Because the slider mechanism is located in the jamb, it does not interfere with shades and blinds opening or closing.

Summary

While similar in thermal efficiency, fiberglass frames are much stronger and more durable than vinyl frames. While generally more expensive than vinyl, the strength of fiberglass allows for larger frame sizes, narrow mulls, and storefront capabilities.

Fiberglass window frames offer the strength, durability and narrow sightlines of aluminum but are much more thermally efficient - smoothing out heating and cooling peak loads and providing better condensation resistance. Similar in cost to mid-priced aluminum windows, significant savings may be realized with installation labor when installing factory glazed and factory mulled fiberglass frames.

New casement/awning sliding operator

Fiberglass window frames are rapidly gaining popularity in commercial projects from multifamily to hospitality and new innovations in operating hardware make it attractive for senior livings.

Offering flexible design and installation options, high-performance structural and thermal attributes, and sleek, contemporary sightlines, fiberglass windows make a great alternative to vinyl and aluminum windows and worth considering on your next project.

Resources

1. Francis, Scott “Composites in the race to space” Composites World, retrieved 4.27.21 https://www.compositesworld.com/articles/composites-in-space(2)

2. “Brandt Goldsworthy: Composites Visionary” Composites World, retrieved 5.5.21 https://www.compositesworld.com/articles/brandt-goldsworthy-composites-visionary

3. Preservation Tech Notes, National Park Services, 2008

4. CTE testing ASTM E831 Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis and ASTM D696 Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics

5. https://www.wbdg.org/resources/sun-control-and-shading-devices

Test Questions

Fiberglass Windows Come of Age

1. Fiberglass windows are generally made through:
   a. an extrusion process involving custom dies
   b. a pultruding process combining rovings and matting
   c. a thermoplastic bonding process
   d. any of the above

2. Coatings for thermoset fiberglass profiles use:
   a. AAMA 504
   b. ASTM E2112 and AAMA 300
   c. AAMA 623, 624 and 625
   d. ASTM C1193 and AAMA 851

3. Fiberglass testing shows it is ___ times stronger than vinyl:
   a. 4
   b. 6
   c. 8
   d. 10

4. A single fiberglass window can be manufactured up to ____ square feet:
   a. 30
   b. 50
   c. 65
   d. 70

5. When comparing fiberglass windows to vinyl, fiberglass offers significantly better:
   a. STC and OITC ratings
   b. Thermal performance
   c. Coefficients of expansion
   d. Visible light transmission

6. Significant differences in _____ can exist between fiberglass and aluminum windows:
   a. U-factors
   b. Solar heat gain coefficient
   c. Condensation resistance
   d. Any of the above

7. Fiberglass has less than _____ of the thermal expansion of aluminum:
   a. One tenth
   b. One quarter
   c. One third
   d. 80%

8. Many fiberglass windows are rated:
   a. for fire resistance
   b. CW-PG50 or above
   c. LC-PG40 or below
   d. Fiberglass windows have not yet been rated

9. Fiberglass window frames may offer factory _____ finishes:
   a. Powder coated
   b. Painted
   c. Cap stock
   d. Any of the above

10. One new fiberglass window innovation is:
    a. Self-sealing frames
    b. ADA-friendly operators
    c. Bird-safe glazing
    d. STC 60 glazing

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Peeling Back the Layers of Adhered Masonry Veneer Systems

BY: RENAE B. KWON, ASSOCIATE PRINCIPAL
JEAN J. WU, ASSOCIATE PRINCIPAL AND UNIT MANAGER
WISS, JANNEY, ELSTNER ASSOCIATES, INC.

Adhered masonry veneer (AMV) systems are being constructed in all climates across the United States with increased frequency. Today, this type of construction is not only seen on high-end residential buildings, but is becoming a common facade element on educational institutes, hospitals, healthcare facilities, airports, museums, and other types of commercial buildings.

The AMV systems have been commonly, and perhaps erroneously in some cases, perceived as cheaper and faster to install than the traditional anchored masonry veneer cavity walls. With the increase in popularity of AMV systems, the variety of assembly options, including air and water resistive barriers, continuous insulation, drainage, cladding materials, and even installation techniques, have also expanded. Due to the increased diversity of AMV systems, coupled with the lack of well-known or understood code requirements and industry standards, the design and installation of these systems can be challenging. Additionally, due to the system's heavy reliance on workmanship, these systems can be vulnerable to failure, especially in freeze-thaw climates that can tax this type of wall assembly.

By exploring some of the more critical design considerations and workmanship issues, along with quality control measures and methods for testing the adhesion of these AMV systems, we hope to better inform the readers on the ins and outs of this increasingly popular cladding system.

Typical Assembly

An AMV wall system is defined as "masonry veneer secured to and supported by the backing through adhesion." The components of an AMV wall system can vary; however, the typical components of AMV are similar to a stucco system. They include: the backup (i.e., stud framing with exterior sheathing, concrete masonry, concrete, or cement backer), water resistive barrier (required for stud framing with exterior sheathing backup), scratch coat with embedded metal lath (metal lath is optional for a concrete or concrete masonry backup), adhesive mortar, and veneer units (manufactured or natural stone). Also, omitted mortar joints, commonly referred to as "dry stacked," has become a popular AMV feature. Figure 1 shows a diagram of a typical AMV system assembly.[1]

Additional components such as continuous insulation, drainage layer, and/or an additional air and water barrier for increased energy performance, drainage capability, and added moisture protection are more commonly being included in AMV systems, and in some cases may currently be required by code or will be in the future. These components can significantly improve the performance of an AMV. However, they typically increase the cost and installation time, which may make a rain screen or traditional cavity wall system a more practical consideration due to its superiority in terms of water management and mechanical anchorage.

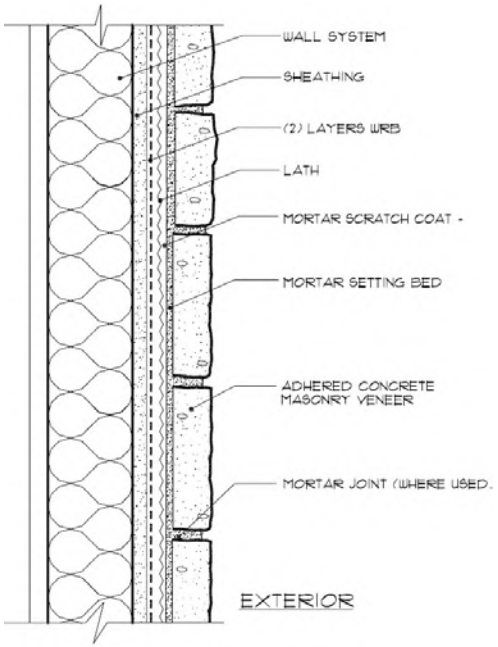

Figure 1. AMV System Assembly

Aesthetically, an AMV system has the appearance of a traditional mass masonry wall or masonry veneer cavity wall; however, from a water management and anchorage perspective, they are significantly different. The typical AMV has minimal drainage capability, and therefore methods for limiting water penetration are critical, especially when constructed in a freeze-thaw environment where expansion of freezing

The typical components of AMV are similar to a stucco system

water increases the rate of deterioration or even lead to bond failure of the masonry veneer cladding. Additionally, anchorage of the cladding relies solely on the adhesion of the scratch coat and adhesive mortar since, by definition of the system, mechanical anchorage is typically not provided. If adhesion fails, there is no redundancy to keep the masonry veneer units from falling off the wall.

The following items are some critical design considerations that should be carefully considered when designing and installing an adhered masonry veneer system.

Water Resistive Barrier

Masonry, both manufactured stone and nature stone to a lesser extent, is a naturally absorptive material and must be detailed to manage water penetration. Recent changes to the International Building Code (IBC) have differentiated the requirements for water resistive barriers (WRB) between Climate Zone B (dry) versus Climate Zone A (moist) and Climate Zone C (marine). Climate zones are geographically defined within 2021 International Energy Conservation Code (IECC). In general, Climate Zone B (dry) includes the western mountain region, Climate Zone A (moist) includes the area between the midwest and eastern coast, and Climate Zone C (marine) includes the western coastline. According to Section 2510.6 of the IBC, the following WRB options, based on climate zone locations, will provide code compliance[2]:

Climate Zone B (dry)

- Two layers of 10-minute Grade D paper or equivalent two layers of WRB complying with ASTM E2556, Type I. Layers installed independently to provide a drainage plane that interfaces with the base flashing.[3]
- One layer of 60-minute Grade D paper or equivalent to one layer of WRB complying with ASTM E2556, Type II. Separate the WRB from scratch coat with nonwater absorbing layer or drainage space.[4]

Climate Zone A (moist) and Climate Zone C (marine)

- In addition to complying with Climate Zone B requirements, provide minimum 3/16 inch drainage space or material on the exterior side of the WRB with a minimum drainage efficiency of 90 percent (per ASTM E2273 or Annex A2 of ASTM E2925).[5]

Regardless of the climate zone or selected WRB product, it is critical that the WRB be integrated and detailed at all rough openings, cladding transitions, and flashings to provide continuity of the moisture barrier.

Figure 2. Corroded Lath

Scratch Coat

The first adhered masonry veneer systems propagated from the stucco industry and borrowed much of the same technology and methods of installation. The scratch coat for a traditional adhered masonry veneer is installed identical to stucco scratch coat and is commonly reinforced with corrosion-resistant lath. Full encapsulation of the lath with the scratch coat is critical to protect the lath from water penetration and potential accelerated corrosion (Figure 2). Per IBC, a nominal ½-inch thick layer of mortar shall encapsulate the lath and the mortar shall be scored horizontally. TMS 402 allows the scratch coat to be comprised of either Type M or S mortar, or polymer modified mortar.[6]

Adhesive Mortar

The adhesive mortar, or setting bed, bonds the veneer unit to the scratch coat. In situations where metal lath is not required, the adhesive mortar and the scratch coat can be one and the same given the design considers differential movement between the veneer and the backing if these materials are different. Historically, the most common types of adhesive mortars were Type N or Type S mortars. However, polymer modified mortars, which have superior bond strength compared to Type N and S mortars, have become more common within the industry. The most recent version of the TMS 402/602 code requires the adhesive mortar (i.e., setting bed mortar) of prescriptively designed systems to use polymer modified mortar (meeting ANSI A118.4 or ANSI A118.15). While the use of a polymer modified mortar can greatly increase the bond strength, its use does not guarantee that bond failures will not occur. Based on our first-hand involvement in bond failure investigations, polymer modifiers cannot compensate for careless mortar proportioning, inadequate surface preparation, or poor AMV installation practices. Additionally, care must be taken when using a bonding agent since mortar dropping can be difficult to remove after curing.

The thickness of the adhesive mortar behind the veneer unit can vary, but typically ranges between 3/8-inch and 1-1/4 inches. IBC section 1404.10 indicated veneer units shall be adhered to the mortar scratch coat with nominal ½-inch thick setting bed with full coverage that should result in a nominal 3/8-inch thick setting bed after the veneer units are worked into place. The most recent version of TMS 402-16, *Building Code Requirements for Masonry Structures*, is silent on the thickness of the adhesive mortar, but instead limits the distance between the exterior surface of the adhered masonry veneer unit to the interior surface of the scratch coat or cement backer to 4-5/8 inches to limit eccentric loading.[7] Per ASTM C1242, *Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems*,[8] minimum coverage of the cladding unit included 100 percent coverage at the four-inch perimeter and 95 percent coverage at the remaining center. Due to the size of the typical veneer units, this often leads to full coverage at the back of the units, which is required by IBC and specified by ACI. Sufficient coverage of the bonding surface with the adhesive mortar is a critical step. Many failures have been attributed to insufficient coverage. This is discussed further in the later part of this article. By code, an AMV system must have a minimum 50 psi (pounds per square inch) shear bond strength.

Veneer Units

The two most common types of veneer units are manufactured stone and natural stone. Manufactured stone is defined as a non-load bearing unit that is made from a concrete mix (i.e., cement, aggregates and water) that is cast and colored to simulate natural cut stone. ASTM C1670, *Standard Specification for Adhered Manufactured Stone Masonry Veneer Units*, establishes minimum product requirements for manufactured stone.[9], More recently, ASTM C1877, *Standard Specification for Adhered Concrete Masonry Units*, was developed to outline requirements for dry-cast adhered veneer units. Natural stone is typically quarried from the earth and fabricated into veneer units to meet the size and weight requirements of an AMV system. The most common types of adhered natural stone units are sandstone, limestone, marble, and granite.

When comparing manufactured stone and natural stone, the following physical properties should be noted.

Natural and Manufactured Stone Property Comparison[10]

	Manufactured Stone	Natural Stone
Water Absorption	13% to 29%	0.2% to 12%
Typical compressive strength	1,500 psi	1,800 to 20,000 psi

Installations using natural stone can be more susceptible to bond failures if the material has a low absorption and/or a smooth cut surface, which can reduce bond of the adhesive mortar. The orientation of the naturally occurring veins in the natural stone can also be a factor, where separation within the natural stone at these veins can occur if the plane of the veins is parallel to the wall surface (Figure 3). Bond problems with manufactured stone typically occur less frequently since the absorption rate is higher and manufactured stone is often fabricated with grooves or irregularities at the backside to key in the adhesive mortar.

The TMS 402[11] code specifies the following sizing and weight limits for adhered masonry units: not exceed 2-5/8 inches in average thickness, bonded surface area of each veneer unit not exceed 720 square inches (bonded surface areas greater than 360 square inches are to be approved by licensed design professional), and not weigh more than 30 psf (pounds per square feet). For prescriptively-designed systems, the height of the AMV system is limited to 60 feet above grade and installed in a vertical application only (not a soffit condition). ASTM C1242 limits the height of the natural stone AMV system to thirty feet above grade.

Deflection

A steel or wood stud framed wall with exterior sheathing is a common backup construction for AMV systems. An AMV system is a rigid system with limited ability to accommodate deflections. Standards and industry guidelines vary significantly regarding the deflection limit for AMV systems; however, the majority of technical references recommend limiting deflection to anywhere from L/360 (TMS 402 and the Tile Council of America (TCA)) to L/1000 (outlined in ASTM C1242), where L denotes “span length.” Tighter spacing of the framing or stiffer framing members may be necessary to achieve this range of deflection.

Mortar Joint Profile

An AMV system can be finished by either filling the joints with mortar or leaving the joints open (i.e., “dry stack”). From a water management perspective, filling the joints between the veneer units will reduce moisture penetration.

Figure 3. Delaminated Stone

A concave joint that is properly compacted is the optimal profile, whereas a raked joint can hold water on the exposed ledge of the units and allow increased moisture penetration. A "dry stack" installation is commonly desired for its aesthetic character; however, this installation can be significantly more susceptible to moisture penetration and subsequent freeze-thaw deterioration and failure. The open joints between the veneer units act as ledges that can collect water and allow water to travel to the adhesive mortar layer behind the veneer units. Overall, it is the authors' opinion that a "dry stack" installation is prone to failure in freeze-thaw environments. Although a "dry stack" installation is allowed by code, the technical guide *Adhered Natural Stone Veneer Installation Guide* recommends against its use in freeze-thaw climates.[12] Additionally, commentary within TMS 402, section 13.3.1.3 states that dry stack applications should be carefully considered in wet climates that include freeze-thaw conditions.

Installation and Workmanship

As previously discussed, an AMV system contains many components. Proper installation and quality workmanship are critical to the success of a multi-component system that does not have the redundancy of traditional anchored wall systems. With so many failures being attributed to poor AMV installation, detailed attention to workmanship and implementing quality control measures and testing are highly recommended. Recent changes within TMS 602 require periodic special inspections for adhered masonry veneers that exceed 60 feet above grade. The following industry standards and guidelines are available for reference regarding installation best practices:

- ASTM C1780, *Standard Practice for Installation Method for Adhered manufactured Stone Masonry Veneer*[13]
- *Installation Guide and Detailing Options for Compliance with ASTM C1780 for Adhered Manufactured Stone Veneer* produced by Masonry Veneer Manufacturers Association (MVMA)[14]
- *Adhered Natural Stone Veneer Installation Guide* produced by Building Stone Institute (BSI) and Rocky Mountain Masonry Institute.[15]
- *Handbook for Ceramic, Glass, and Stone Tile Installation* produced by Tile Council of North America, Inc.[16]

Based on these installation guidelines and lessons learned from investigations performed by the authors, below is a summary of some of the key points of installation and workmanship:

1. Two separate layers of WRB are generally required by code. Proper installation of the WRB, which includes sealing all penetrations, proper overlap and integration with flashings, is critical to protecting water sensitive material within the wall system.

An AMV wall system is defined as "masonry veneer secured to and supported by the backing through adhesion."

2. The lath must be securely fastened to the backup at the required spacing with approved fasteners. The scratch coat should fully encapsulate the lath and have a scored surface. Reference standards vary on the recommended cure time for the scratch coat; however, 48 hours is the most commonly recommended time frame.
3. Setting the cladding units with mortar is generally performed by one of two methods: back buttering the unit with mortar and setting onto the scratch coat; or applying a trowel application of the adhesive mortar to the scratch coat with additional back buttering of the unit prior to setting. With either approach, pressing and working the unit into place is critical to achieving the required bond strength. Achieving full coverage of the unit with adhesive mortar and full contact of the adhesive mortar to the backup substrate are both critical steps to a successful installation (Figure 4). Setting the unit slightly above its final position and sliding it into place while firmly pressing and working the unit is another useful installation technique.
4. The adhesive mortar should completely cover the backside of the veneer units without any voids. ASTM C1780 states that adhesive mortar should be installed "to achieve setting bed with complete coverage of the back of the unit and full contact between the mortar setting bed, unit, and prepared backing surface". The fact that it is common during failure investigations of AMV systems to find a large void at the center of the veneer units (Figure 5) proves that the somewhat common belief that buttering only the perimeter and leaving a void at the center of the unit will create a "suction" effect is categorically false.
5. Wetting either the scratch coat and/or adhered masonry cladding unit may be a good practice. However, over-wetting the unit or

Figure 4. Limited Adhesive Coverage

Figure 5. Void in Adhesive Mortar

Figure 6. "Frothy" Appearance

the presence of free water on the scratch coat or unit, especially on a dense natural stone with low absorption, can lead to failures. During failure investigations of AMV systems, this condition is typically indicated by a "frothy" appearance (Figure 6) in the adhesive mortar at the failure plane, which is usually between the veneer unit and the adhesive mortar.

6. Filling the joints in lieu of a "dry stack" installation is recommended in freeze-thaw environments. The adhesive mortar should be "thumb-print hard" prior to pointing the joints. Installing a joint that is concave and properly compacted will provide the best protection against water penetration.

Quality Control and Testing

Due to its heavy reliance on workmanship, quality control during AMV installation is critical. Adhesive mortar extruded from around the perimeter of the veneer unit is visual evidence of sufficient application of mortar, and of the installer working the veneer unit into the backup. However, since the veneer units are adhered, it is impossible to verify full coverage of the adhesive mortar behind the veneer units without removing them. It is therefore recommended that periodic removal of the veneer units be performed to "spot check" the workmanship during installation. This method is typically recommended by manufacturers of the adhesive mortar as well as the masonry veneer units.

A mockup of the AMV system at the beginning of the project can be invaluable. This is an opportunity to verify installation procedures, workmanship issues, and aesthetics. This is also an opportunity for the installer to work out the kinks and establish an installation standard. The mockup can be stand-alone, and is used as a reference for the rest of the project.

Testing of the installed AMV system can be performed to verify adhesion. As mentioned earlier, the code requires that the AMV system achieves a minimum shear bond strength of 50 psi. Recently published ASTM C1823, *Standard Test Method for Shear Bond Strength of Adhered Dimension Stone*, outlines a procedure for in-situ shear bond testing performed on installed natural stone veneers. This test is applicable to adhered manufactured masonry veneers as well. The application of shear load at the veneer unit/adhesive mortar interface is similar to the laboratory test method prescribed in ASTM C482, *Standard Test Method for Bond Strength of Ceramic Tile to Portland Cement Paste*. However, the tests differ in that, rather than solely evaluating the shear strength between the mortar and unit as in ASTM C482, this adapted field test also evaluates the shear strength between the mortar and substrate. The test involves testing the assembly to failure and measuring the shear load applied at the time of the failure (Figure 7). If this number is at or higher than 50 psi, the system is deemed to have sufficient bond strength to meet the code. However, it is important to note that the effect of freeze-thaw, which can degrade the AMV bond over time, cannot be evaluated with this test method. Performing additional testing after at least one winter season may be warranted.

Conclusion

Successful installation of adhered masonry veneer systems requires careful attention to both design and workmanship. Installation with natural stone, smooth surfaces, and dry stack application can make the system particularly vulnerable to bond failures in freeze-thaw environment. Water/moisture management and protection of water sensitive wall components is critical to the success of the installation. Mockups and quality control testing is strongly recommended with possible additional review of installation and testing after the system has been exposed to at least one winter season.

Figure 7. Shear Bond Test

Footnotes

[1] Diagram reprinted from "Installation Guide And Detailing Options for Compliance with ASTM C1780 for Adhered Manufactured Stone Veneer," Masonry Veneer Manufacturers Association (MVMA), 4th edition, 3rd printing.

[3] ASTM Standard E2556, 2022: Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment, *Annual Book of ASTM Standards*, Vol. 04.12, ASTM International, West Conshohocken, PA.

[4] ASTM Standard E2556, 2022.

[5] ASTM Standard E2273, 2022: Standard Test Method for Determining the Drainage Efficiency of Exterior Insulation and Finish Systems (EIFS) Clad Wall Assemblies, *Annual Book of ASTM Standards*, Vol. 04.12, ASTM International, West Conshohocken, PA.

[6] International Code Council, "International Building Code," Falls Church, VA.: International Code Council, 2018; TMS Standard 402/602-16, 2016: Building Code Requirements and Specification for Masonry Structures, The Masonry Society (TMS).

[7] TMS Standard 402/602-16, 2016: Building Code Requirements and Specification for Masonry Structures, The Masonry Society (TMS).

[8] ASTM Standard C1242, 2022: Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems, *Annual Book of ASTM Standards*, Vol 04.07, ASTM International, West Conshohocken, PA.

[9] ASTM Standard C1670, 2021: Standard Specification for Adhered Manufactured Stone Masonry Veneer Units, *Annual Book of ASTM Standards*, Vol 04.05, ASTM International, West Conshohocken, PA.

[10] Building Stone Institute (BSI) and the Rocky Mountain Masonry Institute, *Adhered Natural Stone Veneer Installation Guide, updated edition June 2010*, Chestertown, NY.

[11] TMS Standard 402/602-16, 2016: Building Code Requirements and Specification for Masonry Structures, The Masonry Society (TMS).

[12] Building Stone Institute (BSI) and the Rocky Mountain Masonry Institute, *Adhered Natural Stone Veneer Installation Guide, updated edition June 2010*, Chestertown, NY.

[13] ASTM Standard C1780, 2023, Standard Practice for Installation Method for Adhered manufactured Stone Masonry Veneer, *Annual Book of ASTM Standards*, Vol 04.05, ASTM International, West Conshohocken, PA.

[14] *Installation Guide and Detailing Options for Compliance with ASTM C1780 for Adhered Manufactured Stone Veneer, 5th edition 5th printing*. Masonry Veneer Manufacturer's Association (MVMA), Herndon, VA.

[15] Building Stone Institute (BSI) and the Rocky Mountain Masonry Institute, *Adhered Natural Stone Veneer Installation Guide, updated edition June 2010*, Chestertown, NY.

[16] Tile Council of North America (TCNA), *Handbook for Ceramic, Glass, and Stone Tile Installation*, 2023, Anderson, SC.

Designing with Low-Iron Acid-Etched Glass

BY: VITRO ARCHITECTURAL GLASS

Focus is on comfort these days. You can see it on the pages of architectural and décor magazines: natural materials like wood and wool, warm colors, and diffused light. Stainless steel finishes seem to be losing popularity, and no wonder. It's well known that in stressful times people gravitate toward more comfortable environments that foster a sense of well-being. With the economic and political insecurity of the last few years, designing for comfort is trendier than ever. Low-iron acid-etched glass is an ideal fit for this humane aesthetic.

What's so special about low-iron glass? It's an extra-clear substrate without the greenish tint inherent to regular "clear" glass, so it delivers a cleaner, purer light. The clarity of the glass becomes even more apparent when you add a full surface acid-etched finish. It's the perfect blank canvas for designers and architects. It's also one of the most impactful ways to improve daylighting, by increasing visible light transmittance (VLT) and reducing glare.

Showing True Colors

Lighting can make or break a space. As interior décor shifts toward warmer palettes, glass must keep up. The aqua tint of "clear" glass can dilute the cozy look of earth tones and warm colors, making the overall effect appear muddy and dull. On the other hand, low-iron glass fits seamlessly into its environment and does not affect the overall palette.

Acid-etched finishes on low-iron glass open up even more possibilities. The etch adds some opacity to the glass and reduces surface reflections that could interfere with the appearance of back painting or colored laminates. A dash of just the right color can enliven mirrors, counters, cabinets, accent windows, tabletops, and other focal points, and a neutral base like low-iron acid-etched glass lets these colored accents stand out.

Whether colored or not, acid-etched low-iron glass is also an ideal option for classic opaque applications like shower partitions because it provides a neutral look that won't interfere with the room's color palette.

Giving Buildings their Best Light

Public spaces benefit from great daylighting just as much as private ones. After all, light is a major part of how people feel in a space. That's why it's so important to use high-quality glazing in public and commercial buildings, especially when they're meant to make a good impression. Often, architects will insist on low-iron glass for gathering areas like lobbies and atriums, even if the rest of the building uses standard clear glass. It's also popular in luxury settings like pools, spas, museums, and cultural hubs – in short, anywhere that ambiance makes a difference.

Low-iron glass is particularly useful in skylights, which use thicker lites that would exacerbate the green tint of standard clear glass. Skylights also benefit from an etched surface, which cuts the glare from the daylight streaming in yet still allows the skylight to fully illuminate the space below. A low-iron product with an acid-etched finish is the perfect choice for a skylight. This kind of installation will bathe the space in pure, glare-free light.

Acid-etched low-iron glass is also popular in schools, hospitals, and other public institutions due to its light-optimizing capabilities. The etched surface eliminates glare while maintaining high visible light transmittance (VLT) levels, which helps structures to meet daylighting requirements for health and educational institutions and contributes to occupants' well-being.

Additionally, acid-etched glass can help with privacy and

Amazon's Day 1 Tower (Photography provided by Walker Glass)

security in these facilities because it can selectively block sightlines into the buildings.

Bird-Friendly Glass

In addition to its visual character and aesthetic value, low-iron acid-etched glass can be used to create bird-friendly glass and glazing solutions.

With countless bird deaths attributed annually to building collisions, choosing the right building materials can make a huge difference. As the problem of bird-to-building collisions becomes more widely known, an increasing number of states, cities and municipalities are adopting legislation that recommends, and in some cases, requires, bird-friendly materials be used on new construction and building renovations.

To help solve the problem of bird collisions, advocacy groups, standards organizations and product manufacturers are working with states, cities and municipalities. In recent years glass manufacturers have expanded their product lines to include bird-friendly options that satisfy aesthetic, performance and bird safety objectives.

"Through our involvement in the glass industry, we heard about birds colliding into glass and we were curious to see if there was anything we could do to help" said Danik Dancause of Walker Glass, a pioneer of bird-friendly acid-etched glass. "Through testing products, analyzing results and talking to leading experts in architecture and conservation, we came to understand the challenges and opportunities that bird-safe glass offers."

When it comes to making glass safe for birds, the key phrase both manufacturers and designers must consider is "visual marker."

"No matter which form you're using, bird-safe glass will have a pattern covering the entire window or glass surface," said Dancause. "This is what makes bird-safe glass different from regular clear glass, and while Walker Textures produces acid-etched glass, other types of markers can include UV patterns, ceramic frits – anything that creates a contrast."

Bird-safe glass should follow the "2 by 4 rule," an industry standard that dictates that rows of visual elements in a bird-safe glass pattern should not be more than 2 inches apart, and columns of visual elements should not be more than 4 inches apart. This helps birds "see" the glass as they approach a building.

Currently, the rise in bird-safe glass products largely comes from legislative pushes. In 2019, U.S. Representative Mike Quigley reintroduced the Federal Bird-Safe Buildings Act that would require "each public building constructed, acquired, or significantly altered by the General Services Administration (GSA) incorporate bird-safe building materials and design features, to the maximum extent possible." Despite the lack of meaningful movement, the bill's consideration has kicked off conversations about bird-safe glass that may inspire tomorrow's contractors to follow similar guidelines.

With countless bird deaths attributed annually to building collisions, choosing the right building materials can make a huge difference.

Oregon Zoo Education Center (Photography by Rick Keating)

Tips from the Experts

- Acid-etched finishes are a great choice for back-painted and laminated glass. The etched surface reduces reflections and lets color stand out.
- Exterior applications are also good candidates for an acid-etched finish. This type of finish is easy to clean and withstands wear better than untreated glass, so you can enjoy the full effect of your low-iron glazing.
- Bird-safe glazing is gaining momentum across North America. However, bird-deterrent product and legislation can vary widely. When planning a bird-safe project, be sure to check what the legislation is in your region. When it comes to choosing materials, look for proven solutions with a history of successful performance in the field.
- If you're working with laminates, choose an ultra-clear product, since regular laminates often come with a yellowish tint.
- For the purest effect, use low-iron glass for all lites in an insulating glass unit.

The National Aviary, Wetlands (Photography by Jim Cunningham)

On a regional level, Bill AB 454 was introduced in California in 2019 and strengthens aspects of the Migratory Bird Treaty Act of 1918 that call for more stringent bird safety measures. Additionally, Minnesota legislators passed bird-safe building codes that follow LEED's "Reducing Bird Collisions" guidance, and additional states may choose to do so as well.

Several American cities have taken steps to propose mandatory bird safety legislation, including San Francisco, which was the first to do so in 2011. Large cities like Oakland, Chicago, and New York have since proposed similar laws, and industry experts expect to see more cities do so in coming years.

While local legislation as well as involvement from environmental groups are big factors in choosing bird-safe glass, more architects are electing to use bird-safe glass, and some firms are even starting to recommend it on their own.

Every project is unique, and while bird-safe glass is more costly than clear glass the cost of doing nothing to protect the environment can be damaging.

"A billion birds are injured by glass surfaces every year – that's a lot of birds," said Dancause. "It's affecting our planet and the places we live. There's a lot of flexibility in bird-safe glass designs that can make them more affordable, including optimizing the glass sheets with low-emissivity coatings to increase performance and save on energy costs."

AviProtek® E with *Solarban*® glass is just one example of an advanced architectural glass that unites bird-friendly, acid-etched patterns by Walker Glass with high-performance solar control low-e coatings by Vitro Glass. Walker Glass with AviProtek® patterns can be manufactured with either horizontal, vertical or non-directional visual markers on both clear and *Starphire Ultra-Clear*® glass substrates by Vitro or with *Solarban*® 60 or *Solarban*® 70 glass on the second (interior) surface of an insulating glass unit (IGU) for greater energy efficiency.

The Value of Acid-Etched Low-Iron Glass

Architects and designers use acid-etched low-iron glass in a multitude of ways. However, with all their variety, these contexts speak to a few essential values.

- **Well-being**. Enhance human comfort by delivering the purest daylight possible, without any glare or greenish tinge.
- **Design**. Protect your creative vision by displaying the true hue of back painting, laminates, and interior surfaces.
- **Security**. An acid-etched finish on low-iron glass offers privacy in sensitive settings, without sacrificing VLT.
- **Sustainability**. Low-iron glass substrates can easily be coupled with energy-efficient enhancements like low-emissivity (low-e) coatings, and acid-etched bird-friendly glass reduces bird collisions to support a safer environment for local wildlife.

Low-iron acid-etched glass is an added-value product, best suited to projects that prioritize design and human well-being. However, since there is no ASTM specification for low-iron glass, clarity levels can vary widely based on how they are manufactured, and the levels of iron found in their formulae. For this reason, some low-iron glasses may be more appropriate for your project than others.

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