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Modern Metal Building Systems

Residential Applications of Vertical Stacking Doors

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Driving Progress with Metal Design

Melanie Kowal
EXECUTIVE PUBLISHER

Spring has a way of sharpening everything. The light shifts, job sites pick up speed, and design conversations seem to carry more urgency and ambition. This issue reflects that energy.

Metal roofing is arguably one of the most dynamic segments in the industry today. In "Transformative Metal Roofing Design," Lee Ann Slattery of ATAS International explores the ever-expanding palette available to architects.

In our focus on sunshades, Lyall Lawson of Construction Specialties examines powerful examples of how metal can unify performance, branding, and architectural expression in a single move.

Of course, great design is only as strong as the details behind it. As Joseph Goley of The Goley Companies explains, insulation plays a defining role in ensuring that what's envisioned on paper performs in the field.

Pre-engineered metal buildings (PEMBs) are also undergoing a quiet transformation. Amy Wirth of Sunward Steel challenges the lingering "boxy" stereotype, demonstrating how early and ongoing collaboration with PEMB partners can expand the systems' potential far beyond what many assume.

Perforated and expanded metals continue to push boundaries as well. Russ Naylor of BŌK Modern highlights how folding techniques and panel geometry can achieve strength through form, delivering airflow, visibility, and architectural impact without excess structure.

We also explore snow retention in alpine environments with Fiona Maguire-O'Shea of S-5!, and take a fresh look at vertically stacking residential doors with Heather Bender of Clopay, an elegant response to structural complexity and spatial constraints.

There's a distinct sense right now that innovation isn't happening at the edges; it's happening at the core of how we design, collaborate, and build. Metal continues to prove itself capable of shaping performance, identity, and long-term value in equal measure.

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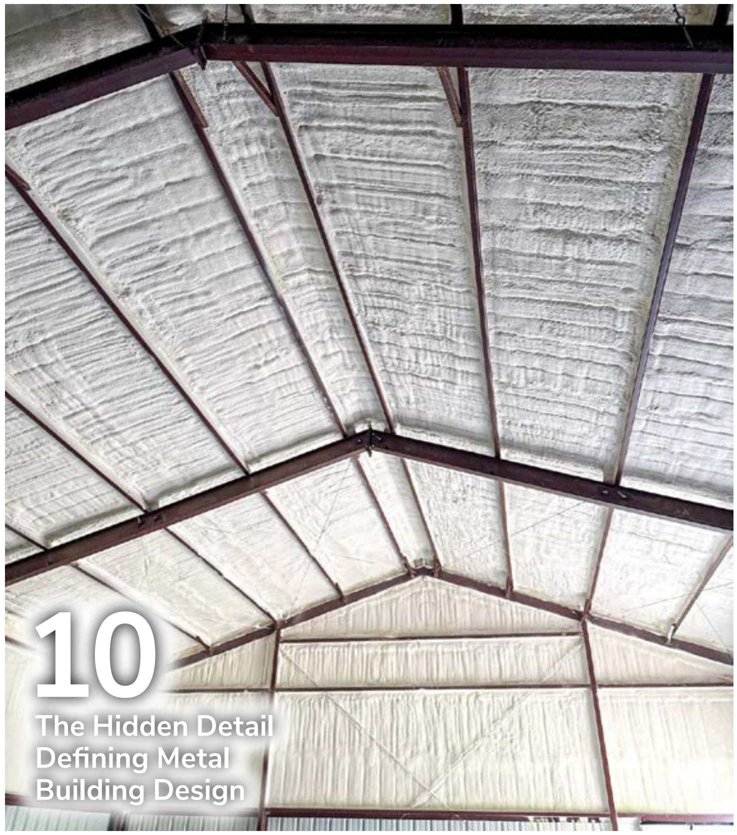

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On The Cover

Perforated metal panels elevate the appearance of a parking structure at 200 Twin Dolphin in San Francisco. The panels also provide ventilation. For more information, turn to page 30.

Photo by Brian's Perspective

Expressive Designs with Tomecek Studio Architecture

By Hanna Kowal

Tomecek Studio Architecture is a firm based in Denver, Colo., that brings authenticity to its designs. The firm weaves metal into projects, encompassing all-encompassing structural aspects, such as pre-engineered metal building systems (PEMBs), as well as more precise details, including aesthetic perforations. Brad Tomecek, FAIA, principal and founder of the firm, provides the history of his practice, which began in 2002 with the firm as it exists today, with the company officially established in 2013. The company typically ranges from six to eight people, intentionally small enough for Brad to be involved in the creative process of the projects the firm undertakes.

Design inspiration: the client, environment, and material

Tomecek affirms his "inherent love and passion for everything design," which is evident in his meticulous creative approach. Clients are often involved in the firm's collaborative and goal-oriented design process. Tomecek also shares, "I think education needs to be constant. I think we're always all learning." He explains that in his nearly 30 years of architectural practice, it has been essential to explore and embrace new and emerging technologies.

With deep dives into design concepts like transparency, porosity, and screens, he explains the way new products can inspire designs: "When people come in and tell us

On the outskirts of Denver, this residence, workshop, and van storage space features box ribbed and corrugated metal for a distinctive appearance.
Photos by Tahvori Bunting

On this spread:

Left and inset: A pre-engineered metal building (PEMB) system supports a durable and sustainable building envelope in this Nebraska lake house.

Photos courtesy Tomecek Studio

Middle: The standing seam metal on the main shade structures at Centennial Center Park provides acoustical insulation, mitigating traffic noise in an open-air space.

Right: The Centennial Folly, made of weathering steel in a woven formation, appears both solid and translucent, depending on the angle its observer is situated.

Photos by Sarah Vanderpool

about products, we're trying to keep our eyes looking forward and ears to the ground about new ways of making things. I think making is the key piece because that's what we do. We make spaces, and trying to figure out the how and why of each project is really important."

Quaint Quonset project: structural serenity in a metal building system

In tandem with embracing client input and material opportunities, the firm's process draws inspiration from the project environment, with a robust site analysis guiding decisions. This combination of factors guides the firm's designs, such as the selection of a Quonset hut PEMB for a lake house. Not a standard approach for a countryside residence, this design is ideally suited to its setting, blending seamlessly into the surrounding agricultural landscape. Its owner, a structural engineer, has an understanding and appreciation of Quonset hut systems.

The lake house by Lake McConaughey located in Ogallala, Neb., features a unique design. Corrugated metal provides a strong, stable, and durable exterior to the project, offering a cost-effective and comfortable option that facilitates other key factors, such as insulation. Its agrarian shell allows this residential design to immerse unassumingly with its Nebraskan farmland surroundings. The durability, efficiency, and longevity of the PEMB provided the opportunity for additional design considerations to be made regarding how to work with the interior to create a warmer experience inside a typically cooler material.

The door to a symbiotic design

Another prime example of environmental inspiration in action is the design of a residential, workshop, and transportation storage hybrid space situated on the outskirts of Denver. With elevation from a railway adjacent to the site as well as vast scenery—a park greenspace to the east, a skyline to the south, and mountains to the west—the opportunities for working with the surroundings were significant in what Tomecek calls the Railside Project. Including elements like decks and windows to emphasize the beauty of the surroundings and the daylight that the project's situation provides.

In the Railside Project, clients had a unique need: they required a garage for their modern-day Winnebago recreational vehicle (RV). The result was a living space situated above a large workshop garage with significant storage. For these accommodations to integrate seamlessly into the space, Tomecek explains the process involved in incorporating the garage door, which "was meant to not draw a ton of attention to itself." With the front door situated beside the garage, the main entrance is the focal point despite the garage door's size and placement. The surrounding structure features a combination of horizontal box ribbed and vertical standing seam metal, with juxtaposing lines that help the garage door blend unassumingly into the building's appearance. By introducing window elements into both the side and door of the garage, light provides a sense of synergy in its design.

Community care and artistic flair

At Centennial Center Park in Centennial, Colo., the firm's designs for pavilion structures provide shade, restroom facilities, and aesthetic focal points. Metal defines these projects, with standing seam metal roofing atop two pavilions offering acoustical insulation benefits, separating the space from surrounding traffic noise to embrace the serenity of the area.

The Centennial Folly is the focal point of this park, an artistic sculptural element made of weathering steel. The cage-like canopy frames the horizon, offering a picturesque view of one of the state's highest peaks. Tomecek describes aspects of the structure's visual impact, emphasizing: "the shade, shadow, and the textures that change throughout the day." He describes the project as spatial and explains that the movement of the slatted light draws people in. He elaborates, "people walk through it. You can sit at the end and look out at that hill, but it just becomes more like an oculus and like a viewfinder, if you will."

Metal, music, and light

Perforated metal panels serve as the unique focal point of a residential project titled the Pianoforte project by Tomecek. White aluminum panels over the entrance and garage door include a repeated pattern of perforated circles, modeled after the sizes of the pipes on a pipe organ, representing the client, an organist. Unique to itself, this design evokes the musical identity of its owner through this distinctive metal element, prominently displayed in the facade of the home.

Tomecek explores the sun shading strengths of metal in his designs, calling it a way to "deal with the sun, natural light, and enjoying the byproduct of interesting patterns changing throughout the day."

He shares, "We use metal because of all the different ways you can filter light with it," and says, "it adds a lot of layers and therefore sophistication to the space." Reflecting on the scope of metal used for light and shading in Tomecek Studio Architecture's projects, Tomecek explains the range available from thick bar stock to thin and punctured. Tomecek Studio Architecture makes use of the opportunities of light and landscape, while also conveying a profound representation of clients' identities, showcasing the expressive versatility of metal throughout the firm's designs. Ma

Exposed insulation is increasingly used as a visual design feature, with various clean and sleek options.

The Hidden Detail Defining Metal Building Design

By Joseph Goley

Photos courtesy The Goley Companies

Metal buildings give architects a powerful design tool—clean lines, modern profiles, and the flexibility to bring bold ideas to life across commercial, industrial, and institutional spaces. Turning a strong concept into a lasting structure requires more than just selecting the right exterior panels.

Insulation may not be the most visible part of a building, but it plays a key role in protecting its appearance and performance. When planned from the start, insulation can help prevent structural and aesthetic issues that quietly erode design intent over time.

From avoiding early design missteps to navigating exposed insulation and code requirements, understanding when and how to engage insulation experts can make all the difference in preserving a building's look and longevity.

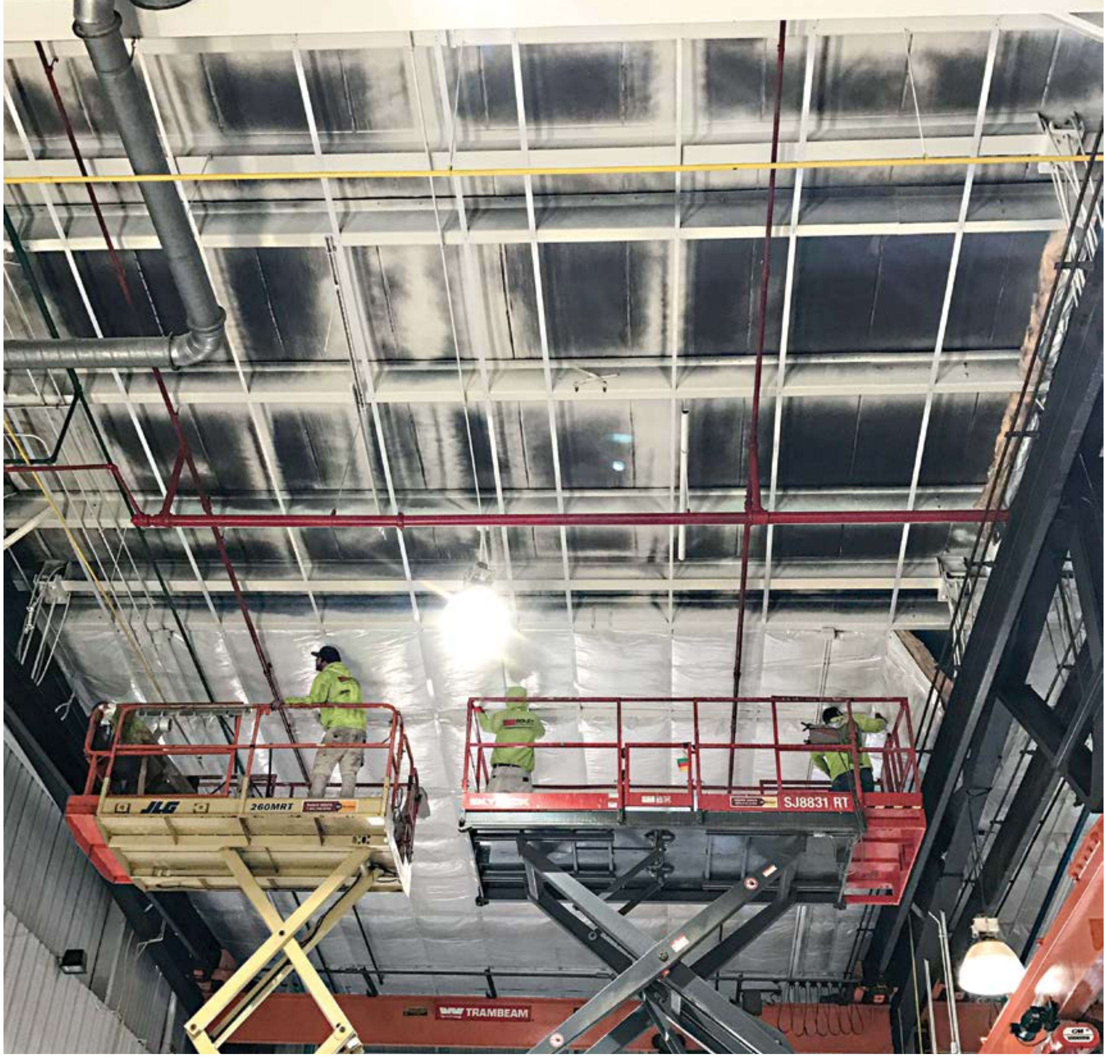
Warping, gapping, and the metal myth

Insulation is not just about energy performance. It is often the difference between a metal building that looks sharp for decades and one that starts showing visual flaws within its first year.

Despite their sleek appearance, thin-gauge metal panels are especially vulnerable to subtle but serious issues that compromise design intent. These include:

- Warping from thermal expansion and contraction.
- Gapping between panels due to poor material coordination.
- Thermal bridging, which can lead to condensation, corrosion, and uneven surface behavior.

Involving insulation partners early in the design process promotes strong choices that ensure metal buildings preserve their functionality and appearance.



- Rippling that distorts clean lines and creates visual "noise" on the facade.

Many of these problems stem from a common assumption—the "metal myth"—that metal is tough enough on its own to resist these forces. In practice, even high-end metal systems can deform when exposed to fluctuating temperatures and unmanaged moisture.

It is a scenario many architects have seen or heard about: a clean, modern metal facade that looks perfect on paper, but within months of occupancy, subtle distortions start to appear. Panels ripple, gaps form at the seams, and the crisp lines that defined the original concept begin to fade. Often, the root cause is not the metal itself, but a lack of proper insulation planning.

The fix comes from consulting with insulation experts early. With the right materials and a strategic installation plan, insulation both manages performance behind the scenes and actively protects the architectural vision from avoidable, appearance-altering failures.

Early insulation involvement

Engaging insulation specialists early in the design process can be the difference between a flawless metal facade and one that develops avoidable, frustrating visual issues. When insulation is treated as a core design element rather than an afterthought, experts can recommend materials and methods that support both the building's appearance and performance.

Managing temperature differentials is critical to overall performance. The contrast between indoor and outdoor temperatures, especially in extreme climate regions, can create conditions for thermal bridging, condensation, and eventual material degradation. For this reason, it is essential to work with a contractor who understands these risks, recognizes potential problem areas, and collaborates with the broader team to identify insulation solutions that protect both project efficiency and design integrity.

This kind of proactive planning is essential. It protects against costly rework and helps ensure that the final product looks and performs exactly as envisioned.

Exposed insulation: aesthetic strategies and technical guardrails

More architects are embracing the look of exposed insulation, leaning into its raw, utilitarian appeal as part of a broader industrial or rustic design approach. When handled well, it can add texture, depth, and even character to a space. Exposed insulation also brings a set of design and safety considerations that cannot be left to chance.

The first and foremost consideration is fire safety. In commercial or high-occupancy buildings, exposed insulation must meet strict code requirements—and not all materials qualify. Products must be properly tested and rated to remain exposed. In spray foam applications, intumescent coatings are often used to meet fire safety standards. These coatings expand when exposed to heat, forming a protective charred layer that helps contain flame spread without obscuring the underlying material.

Visual quality is another critical factor. Not all insulation is meant to be seen. Spray foam and fiberglass can vary in finish, and sloppy application or uneven surfaces can quickly undermine a clean, intentional look. If exposed insulation is part of the design, it needs to be installed with that in mind, from the selection of materials to the choice of the contractor.

It is also worth thinking about how the insulation will look five or 10 years down the line. Dust, moisture, and UV exposure can discolor or degrade certain materials. UV-resistant products or protective coatings can help preserve the original appearance and reduce maintenance headaches later on.

The bottom line: exposed insulation can be an eye-catching design feature, but only if thoughtful planning, proper materials, and high-quality execution back it.

The architect's insulation checklist

Before locking in design decisions, it is critical to ask the following questions:

1. *What is the building's purpose, and where is it?*
   Climate and use case drive insulation choice.

2. *Will any insulation be visible?*
   If yes, it needs to meet code—and look good doing it. Use fire-rated products and consider protective finishes.

3. *Does the installation plan match the design intent?*
   Crisp lines require precise work. Coordinate with contractors early to avoid gaps or surface inconsistencies.

4. *How will it sound inside?*
   Metal buildings echo. Certain insulations can help control acoustics while supporting the overall design.

Answering these questions early can help ensure the design holds up over time. The best way to find those answers is by finding the right partner.

It is critical to understand that insulation decisions made too late, or without expert input, can quietly derail even the most well-designed metal building.

What do the best partners bring to the table?

Experienced insulation professionals understand how materials interact with metal in real-world conditions, how thermal bridging creeps in, how condensation can quietly undermine cladding, and how small installation missteps can lead to visual flaws architects never intended.

The right partner can deliver:

- Strategic foresight through helping plan for temperature shifts, moisture control, and material movement before they cause problems.
- Hands-on collaboration for coordinating with HVAC, structural, and enclosure teams to ensure everything works together.
- Craftsmanship that shows, especially when insulation is exposed, as the quality of the install directly affects how the building looks.
- A commitment to code and quality through an emphasis on fire safety, thermal performance, acoustics—all aligned with the architect's vision.

Bringing these specialists in early is design insurance. It protects the architect's vision and reputation, as well as the client's investment.

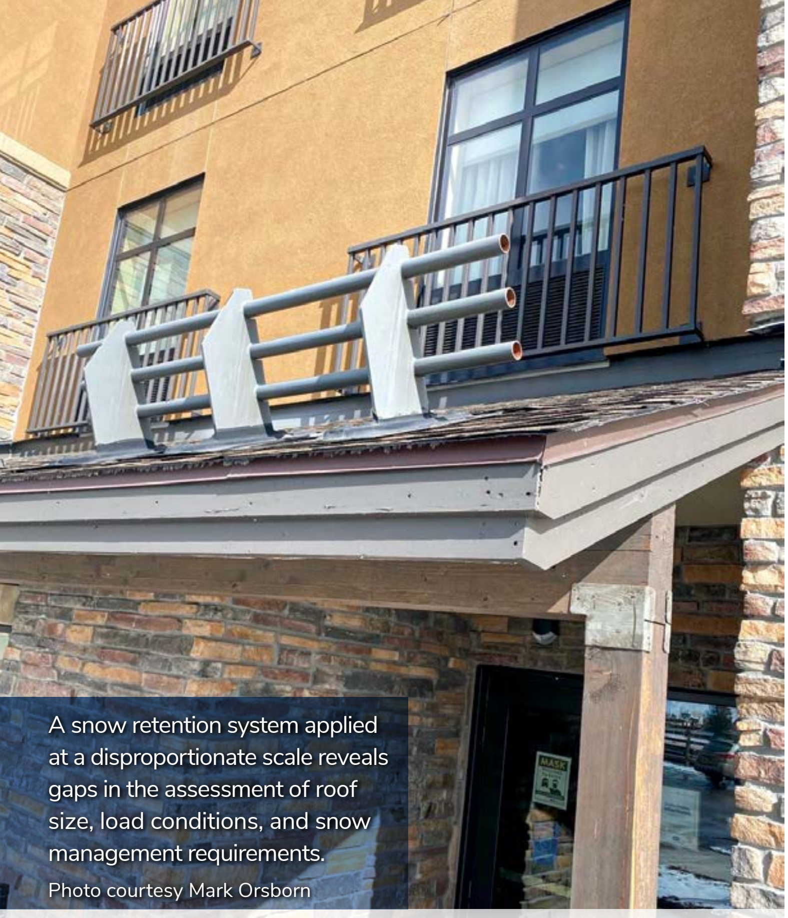
Closing the gap between vision and reality

In metal architecture, details matter, especially the ones that are not always visible. Insulation might not show up in the renderings, but it shows up in the results: straighter lines, smoother finishes, and designs that last.

Whether it is planning around thermal movement, specifying exposed materials, or simply getting ahead of the unexpected, insulation experts help bridge the gap between design intent and built reality. Their insights are both technical and instrumental to the architecture itself.

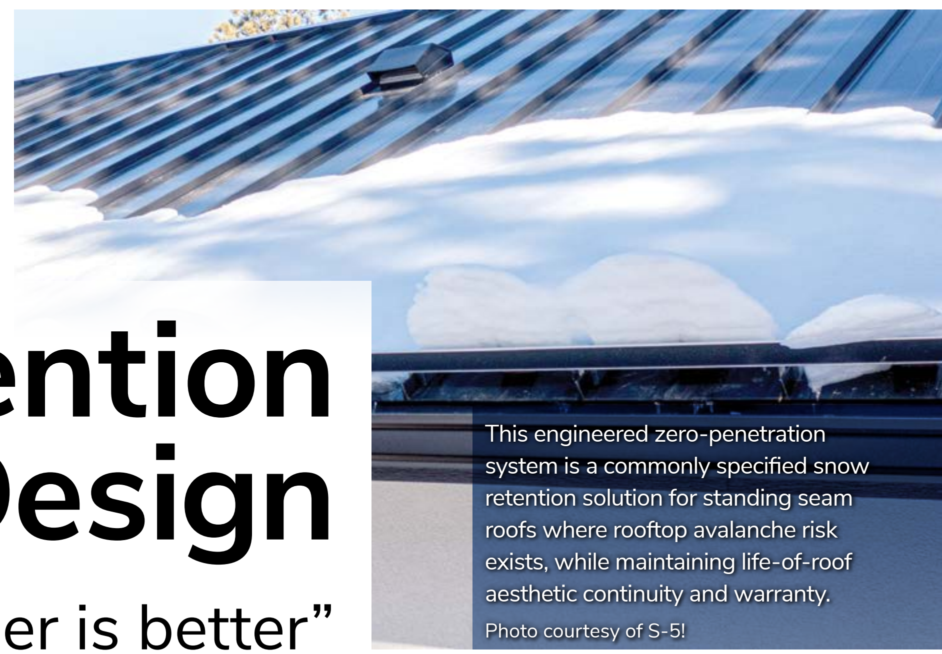
The opportunity is clear: involve the right insulation partner early, and insulation stops being a potential risk; it becomes a strategic advantage. For architects, this means fewer compromises, stronger outcomes, and buildings that look as good in 10 years as they did on day one. Ma

__Joseph Goley__ is the vice president and third-generation leader of The Goley Companies. He has worked for the Dupo, Ill.-based insulation contractor since 2019. He is a member of the Owens Corning CEE Customer Advisory Council, the Knauf Insulation Customer Advisory Board, the Home Builders & Remodelers Metro East Association Board, and Southern Illinois University Edwardsville's Construction Management Industry Advisory Board. The Goley Companies specialize in delivering building performance solutions—insulation, air sealing, firestopping, energy testing—for new and existing homes and commercial buildings. For more information, call (618) 286-3355 or visit thegoleycompanies.com.



A snow retention system applied at a disproportionate scale reveals gaps in the assessment of roof size, load conditions, and snow management requirements.
Photo courtesy Mark Orsborn

This system distributes snow loads in high-snowfall environments, including ski resort areas and mountain towns.
Photo courtesy S-5!



This engineered zero-penetration system is a commonly specified snow retention solution for standing seam roofs where rooftop avalanche risk exists, while maintaining life-of-roof aesthetic continuity and warranty.
Photo courtesy of S-5!

Snow Retention in Alpine Design

Thinking beyond “bigger is better”

By Fiona Maguire-O’Shea

In mountain resort environments, roofs play an active role in pedestrian circulation, outdoor gathering spaces, and the overall guest experience, not merely in weather protection. At ski resorts in particular, people routinely occupy areas directly below the eaves—entries, terraces, walkways, and après-ski zones—making roof behavior under snow load a critical life-safety issue rather than a secondary design consideration.

Each year, rooftop avalanches cause injuries, fatalities, and significant property damage in snow-prone regions. In high-occupancy resort environments, designers should treat snow retention as a core architectural and engineering decision, addressed early in the design phase and supported by verifiable performance data rather than an afterthought added late in the process.

A certifiably tested, scientifically engineered snow retention system is essential to protect guests, staff, and building infrastructure while preserving the long-term performance of metal roofs.

Engineering for mountain conditions

Effective snow retention design begins with project-specific engineering, not generalized assumptions. In some mountain resort communities, roofs carry 1.8 m (6 ft) or more of accumulated snow during the season. These conditions elevate snow retention from a detailing concern to a structural issue, as these accumulations represent resultant forces on snow retention systems and large masses subject to sudden release.

Roof slope, roof geometry, and the distance from eave to ridge directly influence the forces imposed by the snowpack on the roof assembly. These forces must be evaluated against the tested holding capacity of the snow retention system as installed on the specific roof profile and material. Appropriate factors of safety are then applied to ensure the system performs reliably throughout its service life.

This level of analysis is especially important in resort architecture, where multiple roof planes often overlap pedestrian circulation zones. Entries, outdoor decks, après-ski terraces, and walkways are often located beneath stepped or terraced rooflines, increasing both the likelihood and the consequences of snow release. Properly engineered snow retention systems rely on measurable variables and validated load data, ensuring the correct amount of restraint without unnecessary material or visual impact.

Despite this, many systems installed at ski resorts are selected without engineering analysis. Rob Haddock, CEO and founder of S-5!, notes that familiarity often replaces calculation: "More often than not, two- or three-pipe systems in ski resorts are built by a local general or roofing contractor or fabricated by a local blacksmith or stamping shop. They're often dictated by the desire to keep the architectural look consistent across the resort or surrounding town—but are they actually engineered?"

Bigger is not stronger

Snow retention systems generally fall into two categories: continuous systems, such as snow rails or fences that run laterally across the roof, or discontinuous devices, such as snow stops or cleats arranged in various patterns. Both can perform effectively when engineered to resist the sliding forces of the cohesive snow blanket—particularly near the eave where snow density and compressive strength are greatest—and when supported by validated load testing.

In resort design, selection is frequently driven by perception. Large pipe systems are often assumed to be stronger simply because they appear substantial. In reality, snow behaves as a monolithic slab rather than as loose material flowing over a barrier.

"People think bigger is better," says Haddock. "But snow doesn't go over the top—it moves as one cohesive mass. When the base of that mass is restrained—job done. Taller or heavier-looking snow retention doesn't necessarily mean safer or stronger."

Architecture, aesthetics, and habit

Snow retention systems are among the most visible functional components of a metal roof, making aesthetic integration an important consideration in resort architecture.

"Powder-coated tube systems are common, in part because they align with expectations of a high-end mountain aesthetic," says Brian Cross of Rocky Mountain Snow Guards.

He observes that familiarity strongly influences decision-making. "Ski resorts like the look of powder-coated tube systems," says Cross. "They're perceived as higher-end and more expensive—the clientele doesn't want cheap. Most of the time, selection isn't based on testing; it's based on what people are used to and what they feel comfortable specifying."

However, proven performance must be paired with visual integration. When selection is driven primarily by familiarity or appearance, opportunities for performance-driven solutions can be overlooked, particularly when snow retention is treated as a visual accessory rather than a load-resisting, structural system integrated with the roof assembly.

Durability and roof compatibility

Mountain roofs are exposed to intense UV radiation, repeated freeze-thaw cycles, and prolonged contact with snow and ice. Snow retention components must be fabricated from materials and finishes that match the service life of the metal roof. Systems relying on plastics or adhesive-only attachment methods are generally ill-suited for these conditions, as material degradation can lead to premature failure and long-term performance issues.

Equally important is compatibility between the snow retention system and the roof material—whether steel, aluminum, copper, or zinc—to avoid galvanic corrosion and long-term degradation. Attachment methods must respect roof technology, particularly on standing seam systems, where non-penetrating clamp-based systems can preserve waterproofing and warranty coverage. Designers should confirm that the materials specified are consistent with those used in performance testing and that manufacturers can provide documentation verifying quality-controlled production. The best assurance is evidenced by up-to-date, certified ISO 9001-audited compliance of the production facility.

Mark Orsborn, retired owner of Colorado Custom Metal, now a ski instructor, has seen the consequences of overbuilt, underperforming systems: "Some architects specify very large pipe systems that clutter the roof, and they still don't work. I've seen snow fences bolted through the roof, fail under load, and then get removed—leaving gaping holes behind. Bigger is not better; larger systems don't automatically solve the problem."

Risk, liability, and design responsibility

In high-traffic resort environments, the consequences of snow retention failure can be severe or even fatal. The sudden release of snow can endanger guests and staff, damage property, block egress routes, and disrupt daily operations. These risks place a heightened responsibility on design teams to specify systems supported by independent testing and documented engineering under recognized evaluation criteria.

"There are a lot of people walking around, a lot of eaves and a lot of après-ski areas," Haddock says. "Ski resorts carry enormous liability, and snow retention plays a direct role in managing that risk."

Integrating snow retention early

When snow retention is considered early—alongside roof geometry, circulation planning, and material selection—it becomes a cohesive part of the architectural system rather than a reactive add-on.

From early design through construction, collaboration with experienced manufacturers and engineers is essential. Project-specific calculations, transparent documentation, and meaningful warranties provide confidence that the snow retention system will perform as intended throughout the building's life.

When snow retention is treated as an integral part of the roof system rather than a secondary accessory, it supports more than just safety. It protects the guest experience, preserves resort operations, and reinforces the durability and quality expected of premier ski and retreat-style destinations. MA

Fiona Maguire-O'Shea *is a seasoned writer and public relations consultant with extensive experience developing technical content for the metal construction industry.*

Transformative Metal Roofing Design

By Lee Ann Slattery

Photos courtesy ATAS International

Left: The aluminum tile roofing on this condominium, Pheonix West in Orange Beach, Ala., boasts a clay-like finish for a visually appealing texture and vibrant contrast to the structure's white facade.

Right: Aluminum diamond-shaped shingles create a seamless transition between wall cladding and roof in this off-campus housing structure for students of Cornell University in Ithaca, N.Y.

Metal roofing has experienced a profound evolution over the years. Once associated primarily with agricultural structures, factories, and warehouses, modern metal roofing systems are now specified for a wide range of project types, from luxury homes and museums to hospitals, schools, stadiums, and civic icons. This shift reflects not only advances in coatings, fabrication, and engineering, but also a growing understanding that metal is among the most expressive and high-performing roofing materials available to designers today.

For architects, designers, and building owners, metal roofing no longer represents a tradeoff between performance and aesthetics; it has become a catalyst for design innovation. Whether through nuanced texture and refined color or bold geometry and intricate forms, metal enables designers to bring ambitious architectural concepts to life, often in ways that other roofing materials cannot match. When thoughtfully integrated, metal roofing becomes one of the most impactful visual and functional components of the building envelope.

Design freedom through versatile metal roofing

Metal roofing offers an unusual combination of strength and malleability. While the material is rigid enough to provide long-term structural integrity, it can also be roll-formed, curved, tapered, folded, and fabricated into an almost unlimited range of shapes. This makes metal uniquely suited to both traditional and modern architectural styles.

Standing seam profiles can deliver a crisp, contemporary aesthetic, while batten seam, shingle, tile, and slate profiles can replicate historic or handcrafted appearances. Designers are not limited to a single look, as metal roofing systems can be mixed and layered, or even transition seamlessly into metal wall panels, creating a unified exterior skin.

This versatility is particularly valuable in today's architecture, where hybrid styles and bold forms are increasingly common. Whether the goal is to complement a traditional streetscape or make a striking modern statement, metal roofing can be adapted to match the architectural intent.

A more expressive color palette

One of the most overlooked design advantages of metal roofing is color. Modern paint technologies, including polyvinylidene fluoride (PVDF) and silicone-modified polyester (SMP) coatings, allow manufacturers to offer hundreds of standard and custom colors with long-term color retention and fade resistance.

Metal roofing can be finished in everything from subtle earth tones and natural metals to vibrant hues and deep, saturated shades. Designers can select colors that harmonize with surrounding materials, reinforce branding, or create visual contrast. Matte, gloss, metallic, and textured finishes further expand the palette, allowing roofs to be understated or expressive depending on the project goals.

Color also enables creative strategies such as:

- Roof plane delineation, where different roof planes are highlighted or differentiated.
- Brand integration for corporate, institutional, or retail buildings.
- Contextual architectural blending with surrounding landscapes or historic districts.
- Solar reflectance optimization for energy performance.

Unlike many roofing materials that limit designers to a narrow range of factory colors, metal roofing provides true freedom of expression.

Surface texture, light, and depth

Beyond color, metal roofing introduces texture and shadow, adding depth to building design. Panel ribs, seams, folds, and surface treatments create changing patterns of light throughout the day. As the sun moves, metal roofs come alive with subtle shifts in tone and contrast.

This dynamic quality can be used intentionally to emphasize roof geometry, highlight architectural features, or add visual interest to large roof expanses. Profiles such as standing seam or batten seam naturally create rhythm, while staggered or tapered panels, or custom seam spacing can introduce movement and scale.

Textured finishes, including embossed metals, stone-coated steel, or brushed surfaces, add another layer of sophistication, particularly on highly visible roofs.

Transforming architecture with metal

One of the greatest design opportunities for metal roofing lies in its ability to follow complex shapes. Unlike rigid roofing materials that require flat planes and simple slopes, metal panels can be curved, arched, or tapered to accommodate dramatic roof forms.

This allows architects to design:

- barrel vaults
- conical towers
- wave-like rooflines
- faceted geometries
- dome structures
- free-form curves

Custom-fabricated metal panels can be engineered to match precise radii and angles, ensuring that even the most ambitious roof designs are weathertight and structurally sound. This makes metal a natural choice for signature architecture, cultural buildings, transportation hubs, and civic projects where roof form plays a defining role.

Coordinated building envelope integration

Metal roofing does not have to stop at the eave. Increasingly, architects are using metal to create a continuous exterior skin that flows from roof to wall. By using compatible metal wall panel systems, parapet details, and trim components, designers can achieve a clean, modern appearance with minimal visual interruptions.

This roof-to-wall continuity offers both aesthetic and functional benefits. Visually, it allows for strong geometric forms and unified color schemes. Technically, it simplifies detailing, reduces potential water infiltration points, and improves overall building performance.

In mixed-material designs, metal roofing also pairs well with glass, wood, concrete, masonry, stucco, and fiber cement panels, making it easy to balance warmth and texture with precision and durability.

Performance as the foundation for design

Great design is not only about appearance, but also about how a building performs over time. Metal roofing enhances design freedom by removing many of the limitations associated with other roofing materials.

As metal roofs are lightweight, they can often be installed over existing roofs (depending on local building codes). This opens the door to renovations, additions, and adaptive reuse projects where other roofing options might be too heavy.

Metal roofs are also engineered to handle:

- high wind loads
- heavy snow and ice
- thermal movement
- seismic activity
- extreme temperature swings

This reliability allows architects to push the boundaries of roof geometry and scale without compromising safety or longevity.

Design that lasts—visually and environmentally

Sustainability is now a driver of design decisions, and metal roofing aligns naturally with sustainable architecture. Most metal roofing contains a high percentage of recycled content and is 100 percent recyclable at the end of its life. Unlike asphalt shingles or composite roofing materials, metal does not degrade into landfill waste.

Metal roofing also supports energy-efficient design through reflective coatings, cool roof technologies, and compatibility with insulation and ventilation systems. In warm climates, reflective metal roofs can significantly reduce heat gain, while in cold climates they shed snow efficiently and support continuous insulation (c.i.) strategies.

From a design standpoint, sustainability is also about visual longevity. Metal roofs retain their appearance for decades, avoiding the streaking, fading, and deterioration common with many other materials. A building that looks good decades after construction is a sustainable achievement.

Integrating renewable energy solutions

Modern roofs do far more than keep out the weather; they host solar panels, skylights, and mechanical equipment. Metal roofing is uniquely suited to support these technologies without compromising aesthetics.

Standing-seam metal roofs, for example, allow solar panels to be attached with clamp systems that do not penetrate the roof surface. This preserves the roof's weather-tight integrity while allowing clean, visually integrated solar installations. Snow guards, walk pads, and rooftop equipment can also be added without damaging the panels.

For architects, this means sustainability features can be incorporated without cluttering the roof or detracting from the overall design.

Design realized in detailing

The true design potential of metal roofing is realized in the details. Trim, flashing, fascia, soffits, and edge conditions can be customized to reinforce architectural themes and ensure a high-end finished appearance.

Unlike many roofing systems that rely on off-the-shelf accessories, metal roofing components are often fabricated to match the project. This allows designers to specify clean edges, sharp corners, hidden fasteners, and custom profiles that elevate the roof from a technical necessity to a design feature.

Attention to detail also improves durability by ensuring that water, wind, and thermal movement are managed properly, protecting both the building and the design intent.

Versatility across multiple building sectors

The design flexibility of metal roofing makes it suitable for virtually every building type:

- Residential—from modern homes to traditional cottages and mountain lodges.
- Commercial—retail, office, hospitality, and mixed-use developments.
- Institutional—schools, universities, hospitals, and government buildings.
- Cultural—museums, performing arts centers, and places of worship.
- Industrial—where performance and aesthetics increasingly go hand-in-hand.

In each case, metal roofing allows architects to tailor the roof to the project's specific visual and functional needs.

Confidence in every detail

Perhaps the greatest advantage of metal roofing is that it allows architects to design with confidence. The material's proven durability, extensive testing, and long service life mean that creative ideas need not be sacrificed for fear of premature failure or excessive maintenance. With proper specification and experienced installers, metal roofing systems routinely last over 50 years. This gives building owners a long-term return on investment (ROI) while preserving the original design vision.

Inspired roofline solutions with metal

Metal roofing has evolved far beyond its utilitarian roots to become one of today's most compelling instruments for architectural expression. With exceptional flexibility in color, profile, texture, and performance, it empowers designers to challenge conventions, explore new forms, and create buildings that are as striking as they are durable.

When metal roofing is approached not as a commodity, but as a creative material, architects and specifiers open the door to remarkable possibilities. From quiet sophistication to bold statements and high-performance sustainability, metal roofing offers a foundation for inspired design to flourish.

As buildings are called upon to perform more, endure longer, and communicate stronger design intent, metal roofing is uniquely positioned to help shape what comes next. It defines the future of architecture, one distinctive roofline at a time. Ma

Lee Ann M. Slattery, *FCSI, CDT, CCPR, LEED AP BD+C, is the sales support manager at ATAS International and the chair of the Metal Construction Association (MCA). She has more than 30 years of experience in sales and marketing in the architectural building products industry. Slattery served as the Middle Atlantic Region institute director on the national board of the Construction Specifications Institute (CSI) for four years and was elevated to fellowship in CSI in 2020. She currently serves as a director of the Greater Lehigh Valley AEC Foundation and of the Lehigh Valley Let's Build Construction Camp for Girls. In 2024, she received the Women of Influence and Circle of Excellence awards from Lehigh Valley Business. In 2025, Slattery was recognized with a Lehigh Valley Business Icon Award for her notable success and strong leadership, both within her field and in the wider community.*

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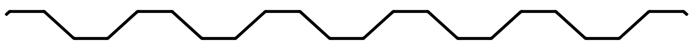

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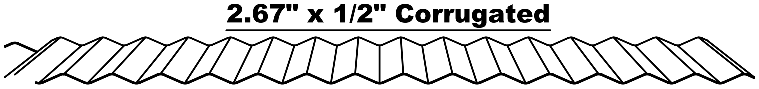

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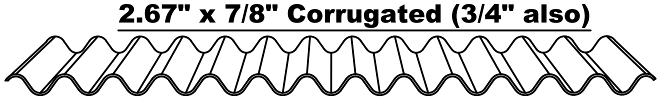

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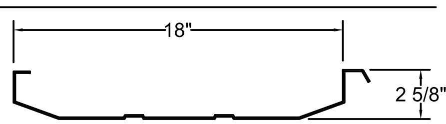

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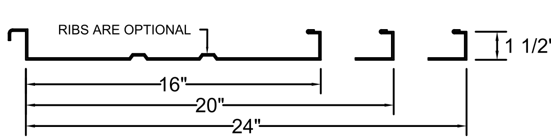

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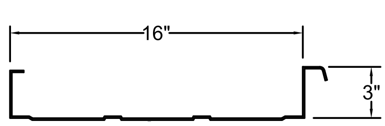

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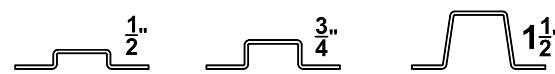

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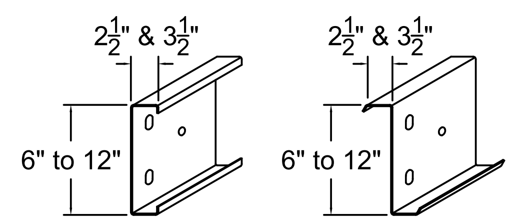

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Modern Education, Metal Solutions

Exemplifying integrated branding and sun shading

By Lyall Lawson

Photos courtesy Construction Specialties

Left: Rectangular perforated fins emerged as the most effective option, seamlessly integrating performance with aesthetics in Hutto High School's modernization.

Right: In Hayward, Calif., Chabot College Library is a modern educational facility designed to enhance both the academic experience and the campus environment.

Fueled by a growing student population and demand for flexible teaching spaces, design and construction in the education sector have experienced explosive growth. Compounding those factors is the aging of educational buildings; the average age of main instructional buildings in U.S. schools is 49 years.[1] Beyond practical requirements, districts are also prioritizing the student experience, recognizing that design aesthetics contribute to supportive learning environments, influencing mood, behavior, and well-being. As these elements converge, designers nationwide are seeking innovative solutions that address evolving needs, promote sustainability, and unite operational goals with a positive educational environment.

Driving factors

Although individual school requirements vary, several common factors are accelerating construction and renovation throughout the education landscape:

- Student restructuring—Student populations are rapidly growing in many school districts, while declining numbers in others are causing school consolidations.[2]
- Aging infrastructure—Many schools built in the 20th century are unable to satisfy current educational needs, which are focused on modern, flexible, and high-tech learning spaces.
- Technology—A strong push for STEM education and digital learning requires significant upgrades, including new labs, better connectivity, and advanced security systems.
- Higher education expansion—Universities are investing in athletic upgrades and research facilities. For example, in 2024, the Texas A&M University System's Board of Regents approved more than half a billion dollars in construction projects that supported "everything from space exploration to national defense to people's beloved pets."[3]

While some schools address constraints through new construction, a recent trend is to modernize existing buildings. Rising costs and urgent demands, weighed against available funding, are increasing the momentum toward renovation and repurposing, offering a cost-effective approach while maintaining the character of existing schools.

Modernizing Hutto

In Central Texas, the Hutto Independent School District (ISD) was facing the growing pains of rapid expansion. In less than a decade, it had grown by almost 30 percent, and a comprehensive review revealed its facilities were reaching full capacity.

Hutto ISD took a pre-emptive approach, creating a long-term facilities planning committee to assess current conditions and create a plan for the district's future needs. Deciding upon a dual strategy, the plan combined major renovations and new school construction. Soon after, residents passed two school bonds in 2019 and 2023 for facility improvements, expansions, and compliance.

Funds from the 2019 bond launched the campus-wide modernization of Hutto High School, with a projected cost of almost $61 million. Addressing rapid student growth, the multi-phase renovation focused on delivering a flexible, contemporary learning environment and enhanced spaces for STEM, fine arts, and career and technical education (CTE).

The design process

As part of Phase III of the 2019 bond, the district developed a unique concept to showcase the school mascot as an integral architectural element on the high school facade. Desiring a 3D feature that could be viewed from multiple perspectives, the district's vision had merit but needed a concrete plan to bring it to reality. From the outset, builders were unclear about what was being constructed, much less how to build it. Equipped with a single graphic concept and little else, the manufacturer's facade design team began exploring options to create the architectural feature.

The design process unfolded in multiple phases. Without established plans to direct them, the team chose a starting point and moved forward iteratively. The first step was to assess the pros and cons of different products.

"At the beginning of the design process, all we really started with was a mascot graphic loosely layered onto metal staves on the building in the shape of a fin. The concept was very abstract, and we needed to consider a range of possible product solutions," says James Clayton, architectural representative at Construction Specialties. "This process evolved. Initially, we considered vertical airfoil blades, but then we moved to rectangular fins. We later added perforation to the mix."

The team considered airfoil blades, which would provide clean, strong vertical lines to the facade, offering a traditional louver or sunshade appearance. The individual, extruded aluminum blades offer an aerodynamic, wing-like shape. They effectively block heat and glare while allowing for open, unobstructed views between the blades.

In the end, rectangular perforated fins emerged as the most effective option, seamlessly integrating performance with aesthetics. Fins consist of a continuous or panelized flat metal sheet with a pattern of small holes. Though it appears as a solid plane from a distance, the perforations filter light, creating a dappled effect on the building. Additionally, they allow airflow to pass through, reduce noise, and provide a greater level of privacy by making it easy to see out and difficult to see in.

The planned location for the Hutto facade was the second story of a building with a bank of windows. While both products would allow light to reach the interior, the district preferred a material that the students could see through, rather than a solid blade that would block daylighting and views to the outside. The flat plane of the perforated fin was also a deciding factor, as it would provide a more uniform surface to enhance the visual appearance of the mascot graphic rather than the convex shape of the airfoil blade system.

Special requests

After settling on the product to be used, the team turned their attention to visual and engineering considerations, as well as specific requests from the school district:

- The Hutto Hippo graphic had to be prominently featured against a designed backdrop.
- The installation had to maintain legibility from both northbound and southbound sightlines.
- The district requested the facade wrap around the corner of the building without interruption.

Canyon High School's new STEM Building in Anaheim, Calif., incorporates sunshades into the design, reducing heat gain and glare while creating a dynamic visual element that complements the building's sleek exterior.

Each factor required careful consideration and a flexible design process, along with close collaboration among designers, engineers, and manufacturers to ensure the final solution met both aesthetic goals and structural requirements.

Hippo nation

The complexity of designing visual variables for a large metal facade meant that elements that appeared straightforward, such as typography, required careful evaluation. The school district provided the design team with a graphic showing their initial idea: an image of a hippo and the words "Hippo Nation" in the district's brand font. However, initial models revealed that the font was difficult to read.

"We landed on the right font through a process of trial and error," says Clayton. "We would progress, and then we would realize, 'nope, that doesn't work.' There was more graphics time required than anyone expected as we worked through many different iterations."

Additionally, the interaction of light with the graphic would significantly impact material properties, color values, and surface finishes, particularly given the facade's multiple directions. A northern-facing facade receives diffused light, requiring high-contrast color or reflective elements to remain legible. A southern-facing facade will receive direct sunlight, which can wash out colors or create harsh shadows. To address these challenges, each fin was wrapped in a custom terracotta tone to match the school district's signature color and paired with a contrasting white font. The fins are powder-coated, scratch- and fade-resistant, and AAMA 2604 compliant.

Tackling potential distortion caused by different viewing angles required careful calculations to align the graphic so it reads clearly from opposing directions. Determining the best angle required testing and on-site adjustments as the team moved around the property. Using the school drive as a point of origin, they used drone footage to view the graphic from varying heights and perspectives. After the angle was set, the team used it to determine the spacing required between the fins to keep the graphics readable. The determined distance is precise: exactly 0.6 m (1.96 ft).

Attachment styles

With only the installation to complete, the design team found the project would require persistence and flexibility to the end. Its location above a pedestrian sidewalk necessitated that torque tolerances and measurements be meticulously assessed to ensure long-term safety and performance. During calculations, the team discovered the structure was not level. Given that the frame would be anchored directly to the structure, the integrity of the design would be compromised if the blades followed the building's slant and angled downward. To rectify the issue, the manufacturer designed a custom bracket with an elongated hole, allowing installers to adjust the panels laterally as needed to maintain level alignment.

Installation revealed another unexpected challenge. "The frame structure was fully installed and galvanized, and all the splice joints were reinforced with flat brackets and bolts," says Clayton. "However, the brackets couldn't be accommodated in our designs as we had planned for the fins to come all the way across. The brackets actually interfered with the design. So, to keep everything in the right place and looking correct, we redesigned the substructure to support the facade. Through this entire project, there was a lot of coordination back and forth with structural engineers and the general contractor."

The finished product

In July 2025, the Hutto High School facade was mounted along the western front of the building, wrapping around the corner to the

north facade. Spanning 41.5 m (136 ft) along the front, the installation includes a 5.5 m (18 ft) radius curve and extends an additional 13.4 m (44 ft) along the northern side, bringing the total length to 60.4 m (198 ft). Each of the 158 fins measures 6 m (20 ft) tall and is mounted to the school with a T-bracket. The completed facade strengthens the school's architectural presence and school spirit while standing as a lasting example of innovative design that balances aesthetics and functionality.

Modern education approach

Hutto ISD is just one of many districts and higher education institutions across the country applying metal facades as design features. In Hayward, Calif., Chabot College Library is a modern educational facility designed to enhance both the academic experience and the campus environment. Featured prominently on the exterior of the library are solutions that include a linear sunshade system spanning the glass facade and a cantilevered trellis extending over the balcony. These elements work in unison to reduce direct sunlight while creating a visually compelling architectural presence. Through this collaboration, the library transforms from a functional space into an iconic structure, demonstrating how thoughtful design can elevate the aesthetic and environmental impact of campus buildings.

In Anaheim, Calif., the new STEM Building for Canyon High School is a state-of-the-art facility designed to foster innovation and hands-on learning for the next generation of engineers and scientists. By incorporating sunshades into the design, the school reduced heat gain and glare while creating a dynamic visual element that complements the building's sleek exterior. The controls provide essential solar protection, ensure a comfortable indoor environment for students and staff, and enhance the building's performance and appearance.

Canyon High School's new building provides students with an optimal environment for learning and growth. In this project, sun control provides essential solar protection while supporting its modern design. These sunshades effectively reduce heat gain and glare, ensuring a comfortable interior environment for students and staff, while adding a dynamic visual element to the building's sleek exterior.

Located in Tonawanda, N.Y., the Tonawanda Central School District serves more than 1,800 students from pre-kindergarten through 12th grade. During a recent renovation, architects chose to install frameless sun controls to shade and enhance the elementary school. The sunshades maintain their architectural interest at night with LED lighting integrated into the blades. By looking beyond mere necessity and emphasizing beauty and visual impact, architects elevated both the school's exterior and interior.

As construction in the education sector continues to rise, the need for creative methods that balance practical requirements with mindful solutions is also rising. Thoughtful design integrates color, light, shape, and texture to create nurturing, functional environments that augment the student experience. As more schools turn towards modernization, recognizing that functional requirements need not compromise design, integrity opens the door to a wide range of architectural possibilities. Using metal facades, louvers, and sunshades is one way to significantly enhance a building's performance while supporting a better learning environment.

Notes

[1] Read more from the National Center for Education Statistics, nces.ed.gov/fastfacts/display.asp?id=94

[2] Visit the U.S. Census Bureau, "Population estimates show continued international migration growth" (2024), census.gov/newsroom/press-releases/2024/population-estimates-international-migration.html

[3] Learn more from the Texas A&M University System, "Regents approve more than a half a billion dollars in construction," news.tamus.edu/stories/regents-approve-more-than-a-half-a-billion-dollars-in-construction/

***Lyall Lawson** is the senior product specialist of facade solutions at Construction Specialties (CS). He has more than 20 years of experience in the construction industry, building a career rooted in technical expertise with a deep focus on architectural product solutions. He has been with CS for two years as a senior product specialist within the architectural product solutions group. From the early stages of product estimating to strategic market engagement, he is involved in complex, design-driven building solutions, with a focus on growing this high-skill, technically intensive division, expanding CS's market presence, and delivering tailored solutions for custom exterior systems.*

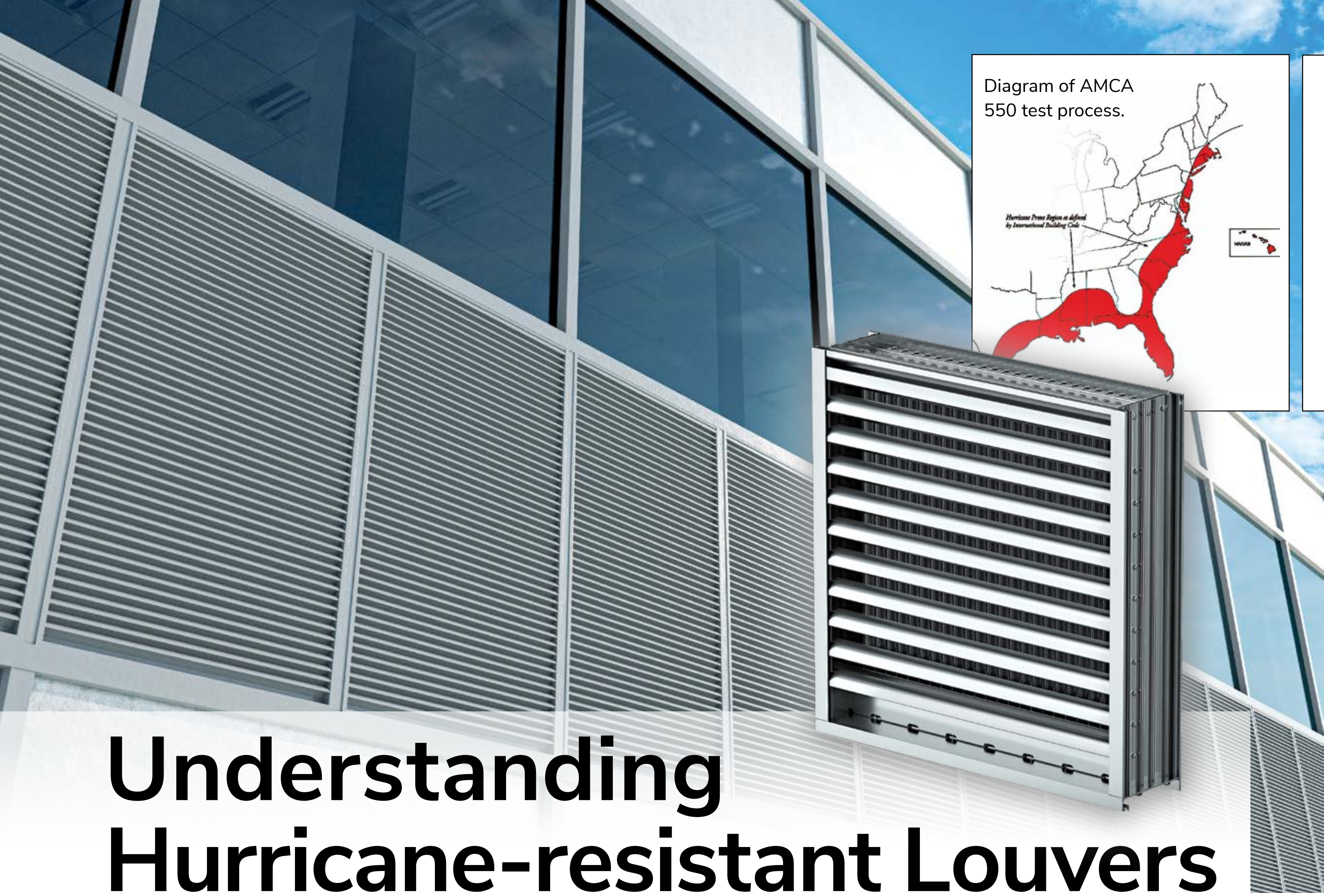


Diagram of AMCA 550 test process.

Understanding Hurricane-resistant Louvers

By Steve Groff

Images courtesy Airolite

Architects designing buildings along the Atlantic Coast—from Miami to Boston—and the Gulf Coast—from Tampa to Houston—are likely familiar with the Hurricane-Prone Region (HPR). Defined by the *International Building Code* (*IBC*), the HPR also includes Hawaii, Puerto Rico, and Guam. In these areas, the design wind speed for typical buildings meets or exceeds the threshold used to define high wind risk.

Hurricanes and tropical cyclones pose serious threats to both life and property in the HPR. As a result, building envelopes must be designed to withstand extreme wind forces and wind-driven rain. Special attention is required at envelope penetrations, where failure can compromise the integrity of the entire structure.

Louvers play a critical role in protecting these penetrations. In the HPR, louvers must prevent the intrusion of water, wind, and debris while still allowing airflow and complementing the building's architectural facade. To ensure this performance, hurricane-resistant louvers are evaluated under one of the industry's most demanding standards: AMCA 550.

How AMCA 550 evaluates storm performance

The Air Movement and Control Association International (AMCA) establishes the most widely accepted performance standards for the HVAC industry. While AMCA 500-L is commonly used to evaluate louver air performance and wind-driven rain resistance, far fewer products meet the more rigorous requirements of AMCA 550, which is based on the latest versions of the *International Mechanical Code* (*IMC*).

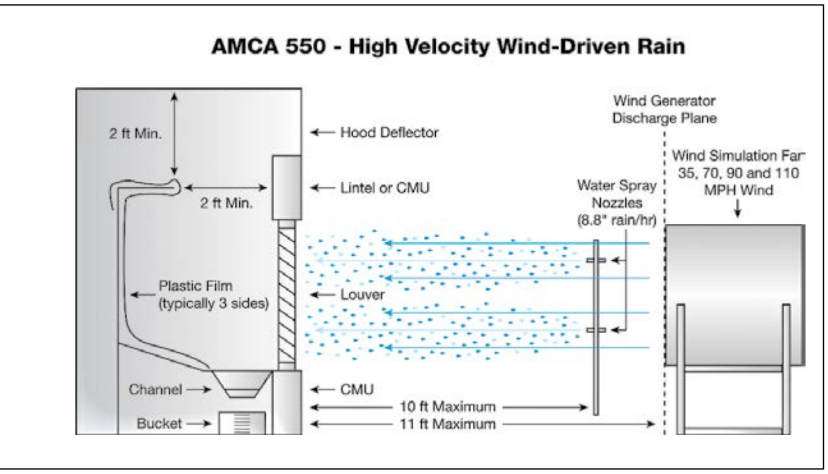
Louvers certified to AMCA 550 are proven to protect buildings against wind-driven rain at wind speeds of up to 177 km/h (110 mph).

AMCA 550 test procedure

During the test, a fan and water spray nozzles are positioned in front of the louver to simulate high-velocity horizontal rain. Wind speed:

- begins at 56.3 km/h (35 mph) for 15 minutes
- increases to 112.7 (km/h) 70 mph for 15 minutes
- escalates to 114.8 km/h (90 mph) for another 15 minutes
- peaks at 177 km/h (110 mph) for five minutes

Approximately 946.4 L (250 gal) of water is sprayed during the test, simulating an extreme rainfall rate of 223.5 mm (8.8 in.) per hour.



AMCA 550-certified louvers often have two modules. The front horizontal module protects against debris and provides a bold sightline. The interior vertical module protects against wind-driven rain.

AMCA 550 is a pass/fail test. To pass, the louver must block 99 percent of the sprayed water. If more than 1 percent, or about 9.5 L (2.5 gal), collects behind the louver, the product fails.

Design characteristics of AMCA 550-certified louvers

Only a limited number of louver designs can withstand the severe conditions imposed by AMCA 550 testing. Products that achieve certification typically fall into one of two categories: either high-performance vertical blade louvers or dual-module louvers with horizontal front blades and vertical rear blades.

Vertical blade performance

Vertical blades are particularly effective against wind-driven rain, which tends to move horizontally rather than downward. Blades oriented perpendicular to the dominant wind direction are better able to block lateral water movement. In addition, vertical blades do not provide horizontal surfaces where water can accumulate, unlike horizontal blades that can catch and carry water along their length.

Dual-module louver design

Dual-module louvers address additional storm hazards, including wind-borne debris. These designs incorporate thick, reinforced, closely spaced horizontal front blades that deflect debris downward. They also include vertical rear blades that prevent wind-driven rain from entering the building.

Beyond their protective function, horizontal front blades also provide a strong architectural sightline that many designers find visually appealing.

Structural integrity and anchorage

AMCA 550-certified louvers feature heavier, deeper, and more rigid frames than standard louvers. Their extruded blades are thicker and engineered to resist vibration and deflection under extreme wind loads.

Anchorage requirements are equally stringent. Louvers must be mechanically fastened to the building structure, and the anchoring method cannot interfere with blade function or compromise performance.

Storm performance in occupied facilities

AMCA 550 allows both open and closed-device products to be tested. As a result, combination louver/damper assemblies are often evaluated with the damper in the closed position. These products are intended for unoccupied buildings, where dampers are closed during tropical storms or hurricanes.

By contrast, fully open louvers are required for facilities that must remain operational during severe weather events. These include emergency and critical facilities that may be occupied or unoccupied during a storm.

Special considerations for storm shelters

Storm shelters and safe rooms present unique design challenges. When constructed using Federal Emergency Management Administration (FEMA) funds, these spaces must comply with FEMA and International Code Council (ICC) requirements.

Louvers used in storm shelters are often tested to AMCA 500-L to verify resistance to water penetration while still allowing the airflow necessary to maintain habitable conditions.

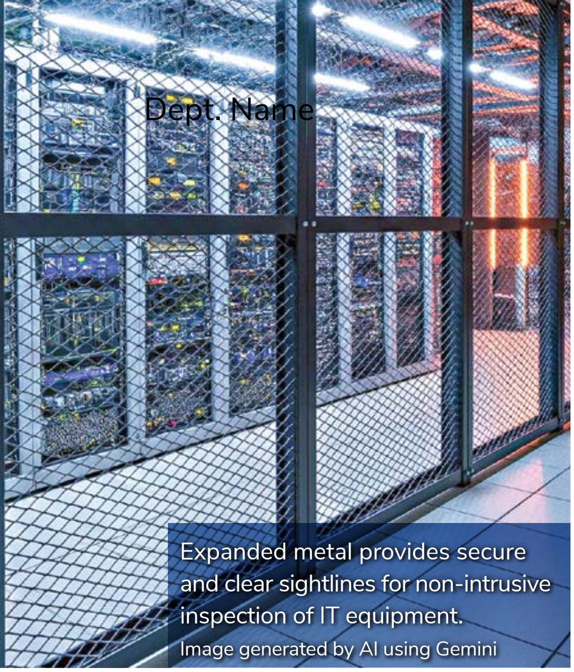
A limited number of louver products meet both FEMA requirements and AMCA 550 certification. These designs are especially well-suited for storm shelters in the HPR. They combine horizontal front blades capable of deflecting high-velocity wood debris with vertical rear blades that protect occupants from wind-driven rain while maintaining comfortable ventilation rates.

Resilient louvers support durable building design

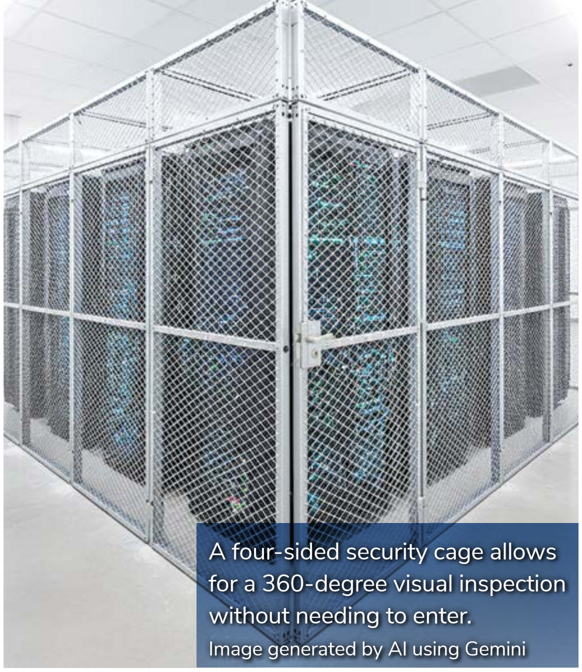
Tropical storms and hurricanes cause tens of billions of dollars in damage each year in the United States, in addition to the immeasurable costs associated with injuries and loss of life. Architects, mechanical engineers, and other design professionals play a vital role in mitigating these risks.

Specifying louvers certified to AMCA 550 strengthens the building envelope and helps ensure that structures can provide shelter, protection, and comfort during extreme weather events. Safeguarding envelope penetrations with louvers designed, manufactured, and tested for the most demanding conditions is essential to resilient building design in the HPR.

Steve Groff *is Airolite's product manager. He has more than 30 years of facade design experience and has been with Airolite since 2006. For more than 100 years, Airolite has helped construction professionals worldwide design, select, and specify architectural louvers, grilles, equipment screens, sun controls, and canopies. For more information, visit www.airolite.com.*



Expanded metal provides secure and clear sightlines for non-intrusive inspection of IT equipment.
Image generated by AI using Gemini



A four-sided security cage allows for a 360-degree visual inspection without needing to enter.
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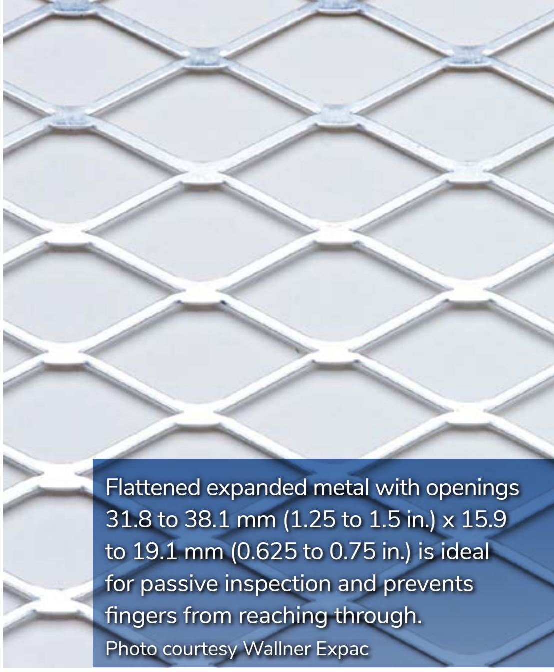

Flattened expanded metal with openings 31.8 to 38.1 mm (1.25 to 1.5 in.) x 15.9 to 19.1 mm (0.625 to 0.75 in.) is ideal for passive inspection and prevents fingers from reaching through.
Photo courtesy Wallner Expac

Protective Expanded Metals for Keeping Networks Online

By Manuel E. Menchaca, MBA

The rise of Artificial Intelligence (AI) has led to an exponential demand for data centers and the numerous servers that populate them. According to McKinsey & Company, current projections estimate that global data center capacity demand could more than triple by 2030, driven largely by the expansion of AI workloads and cloud computing.[1] When it comes to ensuring a network is secure, protection from cyberattacks is often the first consideration; however, protection from sabotage is equally important. Physical barriers serve as a network's first line of defense, and expanded metal offers a solution that excels at securing IT server rooms, data centers, and communications rooms by establishing a secure zone around or within a larger structure.

A network security architect designs, builds, and maintains an organization's overall cybersecurity framework, whereas a traditional architect designs the physical barriers that prevent intrusions. For architects and designers, a fence is not just a boundary; it is an essential component of a project's security and aesthetics. Outside the data center, protective expanded metal fencing provides a visual solution that balances these demands with high performance and versatility. Its unique, single-piece construction eliminates the weak points often found in traditional fencing, making it exceptionally resistant to cutting, tampering, and cannot be unraveled. Its small, rigid openings restrict visibility and prevent climbing by eliminating hand and footholds.

Inside the data center, secure zones can be delineated using modular expanded metal panels. Whether the perimeter has one or multiple sides, partnering with an expanded metal manufacturer provides insight and guidance for project success. Steel is recommended for its strength. The panels' openings should be expanded from 31.8 to 38.1 mm (1.25 to 1.5 in.) along the Long Way of the Diamond (LWD), 15.9 to 19.1 mm (0.625 to 0.75 in.) along the Short Way of the Diamond (SWD), and strands measuring 1.4 mm (0.056 in.) wide. This creates a mesh that allows for non-intrusive inspection while preventing fingers from passing through. Decorative expanded metal patterns are an excellent choice to elevate aesthetics without sacrificing performance. The metal sheets should be flattened post-expansion to provide clear sightlines for monitoring equipment. The sheets are then welded to a frame, with paint or powder coating applied before installation. This system is completed with the integration of matching framed door assemblies, ensuring a cohesive aesthetic and a continuous security threshold across the facility's floor plan.

A single-sided assembly spans the width of the room, using the remaining walls as a solid barrier. This installation enables contactless inspection of the front of the equipment, while the back remains out of view. The panels are attached end-to-end, with a locking door providing access for servicing the equipment. The assembly is mechanically anchored to the concrete floor slab, with perimeter terminations either bolt-fastened to structural walls or held within tolerances of ±3.8 mm (±0.15 in.) to prevent unauthorized bypass. Additionally, the panels can be manufactured tall enough to be attached to the ceiling, preventing individuals from climbing over the top.

The most common assembly is a modular cage. This arrangement works especially well when the IT equipment is located in the center of the room, allowing for a 360-degree visual inspection without requiring entry into the cage. The entire cage is bolted to the floor, and the top of the cage can also be screened to create a fully enclosed, six-sided security envelope.

To protect against forced entry through a wall, flattened expanded metal sheets can be attached to the wall studs. When the walls are finished with drywall, the mesh is concealed, creating an additional formidable barrier.

Expanded metal also allows for effective ventilation and cooling. IT equipment generates significant heat. Some server cabinets have locking front doors with solid acrylic panels. Although this allows for a visual inspection of the equipment, the heat that is generated can only escape through the back. This may lead to overheating and premature failure. Expanded metal's open mesh architecture mitigates this risk by facilitating passive ventilation and multidirectional airflow around equipment.

Expanded metal offers a unique combination of design flexibility, robust performance, and environmental responsibility. Its near waste-free manufacturing process maximizes material usage, and its ability to contribute to LEED certification makes it an ideal choice for architects committed to sustainable design. Consistent quality and sizing are dependent on expanded metal manufacturers, and research is required in the specifying stage to provide architects with confidence that the material will perform as desired, regardless of the application. This combination of form, function, and green building principles establishes expanded metal as a valuable tool that is more than just a facade solution. It empowers architects to push design boundaries—from perimeter fencing to high-security environments—expanded metal delivers form, function, and environmental responsibility in a single, versatile material. Ma

Notes

[1] Read more at www.mckinsey.com/industries/private-capital/our-insights/scaling-bigger-faster-cheaper-data-centers-with-smarter-designs

Manuel E. Menchaca, *MBA, is the senior marketing manager for Wallner Expac, a leading manufacturer of custom-designed expanded metals for architecture, construction, and the world's largest manufacturer of expanded metals for HVAC filters. For more information or to request samples, visit www.expac.com.*


Safety, airflow, and daylight permeability are all supported by the perforated metal guardrails on the Lillian Murphy Housing complex exterior corridors and balconies.


Perforated aluminum offers long-lasting visual appeal at the Lillian Murphy Housing Complex in outdoor spaces.

Perforated Metal, Expanded Possibilities

Performance, utility, and design opportunities across the building envelope

By Russ Naylor

Photos by Brian's Perspective

Perforated and expanded metals have become increasingly valuable tools for architects, striking a balance between aesthetics, environmental performance, durability, and cost efficiency. While these materials have long served utilitarian roles, such as screens and protective enclosures, their capabilities have expanded significantly with advances in digital fabrication and modeling. Perforated metals now offer opportunities to control light, air, visibility, shading, and security while delivering long service life and reliable performance in demanding exterior environments.

This article examines the functional benefits of perforated and expanded metal systems, the principles that guide their design and fabrication, and strategies for integrating them into the building envelope.

Longevity and lifecycle performance

Perforated metals offer predictable, long-term durability in exterior applications. Aluminum resists corrosion even if its finish is compromised. Weathering steel develops a controlled patina that protects the underlying metal, providing a unique aesthetic. Stainless steel maintains reliable performance in highly corrosive environments. These materials do not delaminate or peel and rarely require refinishing during their service life.

Their longevity is a primary reason architects use them in exposed environments such as parking structures, exterior circulation paths, and mechanical enclosures. A long service life also reduces replacement frequency, lowering embodied carbon over the lifecycle of a building component.

Opportunities for customization

The ability to laser cut, perforate, and fold metal panels enables a high degree of customization without the tooling complexity associated with other materials. Designers can specify a wide range of open area percentages, perforation shapes and spacing, gradients or density shifts, panel geometries, folded edges for rigidity, and attachment strategies.

This level of control enables perforated metal to fulfill multiple roles simultaneously, from solar screening and visual privacy to ventilation and safety.

Functional benefits and applications

Parking structures: airflow and screening

Perforated metal solutions are widely used in parking structures where building codes often require a minimum percentage of open area for ventilation. Perforation patterns allow designers to meet airflow requirements while minimizing the visibility of vehicles from surrounding streets. In some cases, pattern density is increased at street level to limit views into the garage, then decreased above for improved ventilation.

Screens can also mitigate headlight glare, manage solar heat gain, and introduce opportunities for patterning or storytelling on an otherwise utilitarian building type. Since ventilation is achieved through passive means, mechanical systems can sometimes be reduced or eliminated, thereby lowering both the initial cost and operational energy use.

At 200 Twin Dolphin in San Francisco, BDE Architecture's designs, constructed by Truebeck Construction, used perforated aluminum panels in the parking structure to satisfy passive ventilation requirements while addressing visual concerns. The design team calibrated perforation density to shield views of the interior from the street while maintaining airflow. The panels also helped diffuse headlight glare and contributed to the facade's overall aesthetic. This project demonstrates how perforated systems can strike a balance between performance and urban integration.

Multifamily housing: safety, transparency, and durability

Exterior circulation systems in multifamily buildings often require materials that balance resident safety, comfort, and visibility. Perforated metal guardrails can satisfy code requirements for fall protection while allowing air movement and daylight. When used in corridors, bridges, and stair towers, perforated panels create a protected environment that still feels open and inviting.

In housing developments with limited maintenance budgets, perforated systems provide long-term resilience. Scratches on weathering steel can blend back into the patina, and aluminum's corrosion resistance ensures that minor surface wear does not affect structural integrity. This stability makes perforated systems well-suited for facilities with high foot traffic.

The Lillian Murphy housing development, designed by Paulett Taggart Architects and erected by Cahill Contractors, uses perforated aluminum guardrails throughout exterior corridors and balconies. The perforation pattern meets safety requirements, provides daylight permeability, and allows air movement in warm conditions. The metal's resistance to corrosion and abrasion makes it suitable for high-traffic environments. The system supports long-term durability with minimal upkeep, an important consideration for housing developments with tight maintenance budgets.

Lightweight security enclosures

In applications where security is a concern, perforated metal can obscure views of interior spaces without creating a sense of enclosure. Custom perforation densities allow clear lines of sight for occupants while reducing visibility from outside, improving safety without relying on opaque barriers. Since panels can be shaped or folded, they can span larger distances with reduced support framing, making them efficient for retrofits or tight urban sites.

The 900 Innes community facility is situated in a neighborhood where enhanced security was deemed necessary. The design team developed a perforation pattern inspired by the geometry of boat hulls. The pattern obscures views into the building while preserving visibility outward for occupants. This approach combines safety, daylighting, and contextual expression in a single system.

Calibrating open area and airflow

The open area percentage is one of the most critical performance parameters. Selecting the right open area ensures that ventilation, shading, privacy, and security goals are met. Supportive strategies include:

- 50 percent open area for parking structures requiring passive ventilation.
- 30 to 40 percent open area for applications, balancing airflow with visual screening.
- Gradient perforations for daylight modulation or site-specific views.

Shifts in perforation density can also reinforce architectural rhythm or respond to local environmental conditions.

Using folds to increase stiffness

Metal panels gain significant rigidity when edges are folded. A folded perimeter can transform a thin sheet into a stiff panel capable of spanning long distances without secondary framing. This reduces material use, simplifies installation, and limits the number of penetrations through the building envelope.

Deep folds or intermediate bends can also add visual depth. When deployed across a facade, these folded geometries create shadows, modulate scale, and enhance dimensionality.

Integrating multiple functions into a single assembly

Perforated metal can combine several roles that might otherwise require separate building components. For example, a panel can simultaneously serve as a guardrail, ventilation screen, and shading device. Integrating these elements reduces the number of materials required, clarifies the building's visual language, and streamlines the installation process.

A multifamily project with exterior corridors, for instance, can use one perforated panel assembly to address fall protection, airflow, and privacy. A mixed-use structure with a parking podium can integrate screening, pedestrian-level security, and pattern-based wayfinding into a single system.

At the mixed-use development Sango Court, David Baker Architects' design features perforated metal in sunshades, guardrails, fencing, and a rooftop trellis. The consistent use of material ties the facade and landscape elements together. The use of a single material family creates a cohesive identity for the project and prevented installation complexity for the general contractor, Nibbi Brothers.

Reflectivity, daylight, and shading

The reflectance of the metal surface influences daylight performance. Light-colored aluminum reflects significant amounts of sunlight, which can brighten shaded walkways or reduce heat buildup. Weathering steel provides a matte, absorptive surface that eliminates glare. Designers can tune shading performance by adjusting perforation size and orientation, providing precise control over solar exposure.

At night, designers can add backlighting to perforated metals for visual interest.

Accommodating graffiti, wear, and vandalism

In high-traffic areas, perforated metal provides practical advantages. Graffiti on weathering steel can be removed through sanding, and the patina will reform, blending with the repaired surface. Aluminum resists corrosion even when scratched, ensuring that vandalism does not lead to component failure.

Cost considerations

Perforated metal often compares favorably to other facade materials when evaluated on a lifecycle cost basis. Several factors contribute to cost efficiency:

- Laser cutting and brake forming require relatively simple fabrication processes.
- Panels can be optimized for sheet yield, reducing waste.
- Folded panels can replace heavier structural systems.
- Installation is streamlined due to reduced framing requirements.
- Maintenance needs are minimal over the product lifecycle.

These efficiencies make perforated metals suitable for both budget-constrained projects and those requiring long-term durability.

Environmental performance and sustainability

Metal can be recycled repeatedly without degrading its structural properties. Perforated systems are typically composed of a single material, which simplifies end-of-life recycling. This supports circularity goals and aligns with broader environmental criteria now common in institutional and public projects.

Materials with a long service life reduce the frequency of replacement, thereby lowering the overall embodied carbon over the life of a building. Since perforated metal systems resist UV degradation, corrosion, peeling, and delamination, their durability directly contributes to sustainable lifecycle performance.

Design trends and emerging directions

Several trends are shaping the use of perforated and expanded metal in contemporary architecture:

- panels with large-format perforations or irregular geometries
- gradient patterns that shift openness across a facade
- integration of lighting to animate perforated elements at night
- multi-layer assemblies that create depth and changing opacity
- expanded metal meshes that combine strength with transparency

As digital fabrication becomes more accessible, designers are exploring perforations as a medium for storytelling, environmental response, and cultural expression.

Perforated and expanded metals provide designers with adaptable solutions for addressing airflow, shading, durability, and visual identity. Their flexibility comes not only from the shape of the perforations but also from the ways they can be folded, structured, and integrated into larger facade assemblies. As buildings are increasingly expected to achieve high performance with fewer resources, perforated metal offers a balance of efficiency and longevity while maintaining design intent.

In practice, these systems deliver clarity and utility. They respond to functional requirements while supporting design intent, offering solutions that adapt as surfaces weather or light conditions change. For architects seeking dependable and flexible materials, perforated metal remains a compelling choice. Ma

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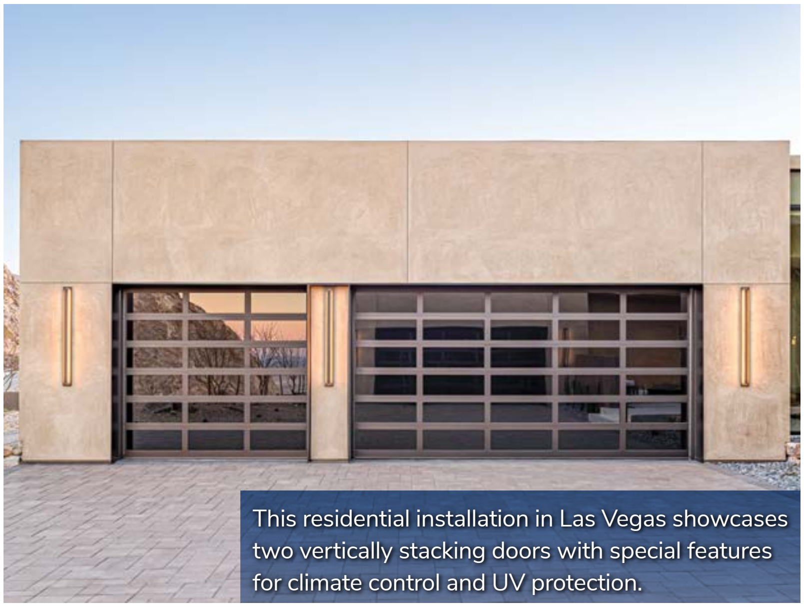
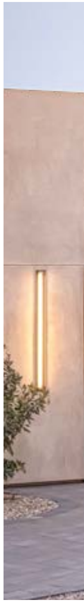
Vertically stacking doors eliminate undesirable overhead tracks, creating an attractive modern aesthetic for a variety of residential applications.



This residential installation in Las Vegas showcases two vertically stacking doors with special features for climate control and UV protection.



Vertically Stacking Doors for Residential Applications

By Heather Bender

Photos courtesy Clopay Corporation

Modern architecture reflects homeowners' desire to blend indoor comfort with outdoor living. This trend has encouraged designers to explore solutions that balance indoor/outdoor spaces and has inspired manufacturers to develop products that solve design challenges and bring an architect's vision to life.

Compact vertically stacking doors exemplify how manufacturers confront structural complexities and pioneer innovative solutions. Offering striking aesthetics and practical considerations for space, these aluminum and glass artworks are anything but standard garage doors. A myriad of customization options, sleek styles, and thoughtful engineering address aesthetics, privacy, and light control, as well as ceiling space constraints, empowering architects and homeowners to reimagine how and where these doors can be used.

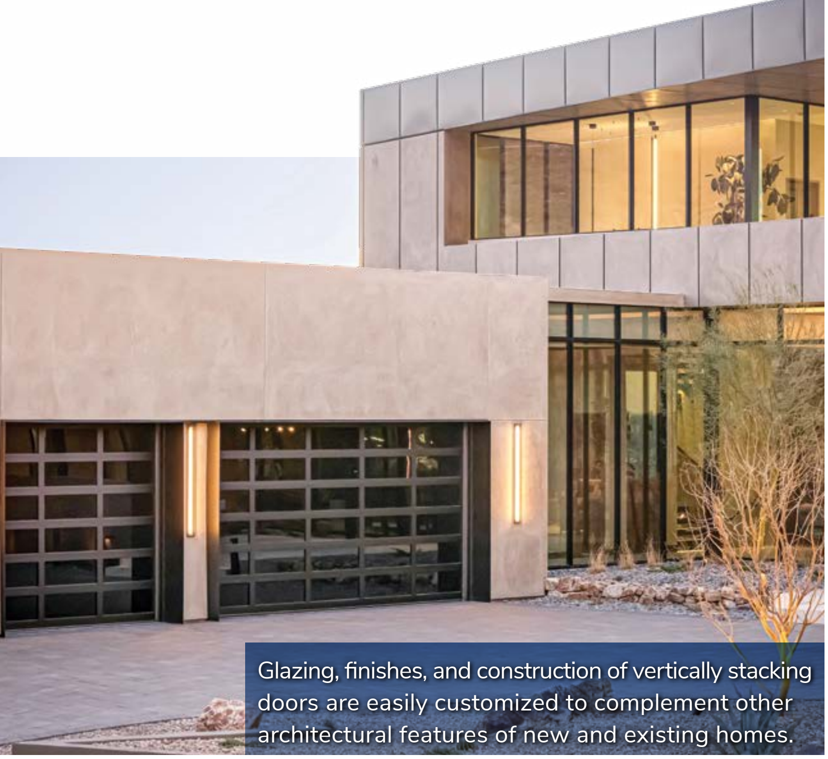
Building on a solid foundation

Compact vertically stacking doors are an evolution of the traditional garage door, and the right choice depends on the desired look, functionality, and installation requirements. Like traditional doors, vertically stacking doors are known for their endurance and style and are constructed with high-quality aluminum and glass. It is their unique space-saving design that sets them apart from their predecessors. This newer stacking style neatly folds the door sections above the opening. This approach eliminates the need for an overhead track system, preserving the fifth wall—or ceiling space—for lighting, mechanical systems, and decorative ceiling elements. Some vertically stacking doors include the option to stow the sections in a recessed area above the door, making them virtually invisible when the door is open.

In addition to the streamlined functionality of stacking doors, several key construction features enhance their durability and control privacy and visible light transmittance (VT), including:

- Commercial-grade aluminum frames. Aluminum is renowned for its lightweight strength and resistance to corrosion, which contributes to the door's smooth, quiet operation, low maintenance, and extended lifespan.
- Heavy-duty rollers and track systems. Robust steel ball-bearing rollers, combined with nylon tires, deliver quiet and consistent operation. A concealed track mechanism enhances the appearance by keeping the door's hardware hidden and maintaining clean, uninterrupted visual lines.
- Glass styles and glazing. For security and durability, glass styles can include single-pane, tempered, acrylic, and insulated options. Additional glazing choices control light transmittance, provide privacy, or, with low emissivity (low-e) glass, improve energy efficiency.

These construction features provide both engineering strength and light and privacy options essential in modern home designs. However,



Glazing, finishes, and construction of vertically stacking doors are easily customized to complement other architectural features of new and existing homes.

what has propelled vertically stacking doors into the spotlight is the evolution of their design.

Merging structure with style

Compact vertically stacking doors have evolved from their pragmatic origins to become integral design elements celebrated for their visual appeal and versatility. Modern iterations combine sleek lines with clean, unobtrusive profiles, thanks to their hidden mechanics and absence of overhead tracks. The result is an uncluttered look that brings a contemporary feel to any residence, whether the style is minimalist modernism, industrial chic, or updated traditional.

The door's aluminum frames are available in multiple finishes, which complement the glazing options. Anodized options are available in clear, dark bronze, or sleek black, adding understated elegance and outdoor weather protection. Additional finishes such as white, chocolate, and bronze introduce rich color and warmth, harmonizing with interior palettes. Custom colors also extend the aluminum palette to more than 1,500 shades, empowering designers and homeowners to achieve their architectural visions.

The array of customization possibilities works flawlessly with various architectural narratives, from urban townhomes to sprawling estates. Experimenting with this aesthetic versatility, architects and homeowners are finding increasingly innovative ways to incorporate these doors into home designs.

Applications in residential design

The growing popularity of using stacking doors to transform the home environment is the result of the demand for more flexible spaces with abundant natural light and seamless indoor-outdoor living. Some creative examples of vertically stacking doors in modern home design include:

- Oversized vehicle or overhead equipment storage. A vertically stacking door system is ideal for garages that house taller vehicles or specialized overhead equipment, such as car lifts or ceiling-mounted storage. Eliminating traditional overhead tracks maximizes the ceiling space that can be allotted for other uses.
- Pool houses and outdoor kitchens. The effortless blending of indoor comforts with outdoor environments enhances recreational and entertainment spaces. Homeowners appreciate the ability to expand usable space and experience natural airflow and social connection when hosting gatherings.
- Party barns, studios, and workshops. Versatile accessory buildings seamlessly transition from private, enclosed spaces to vibrant, open-air venues, significantly enhancing the usability, property appeal, and market value of a home.

With such versatile applications, vertically stacking door systems are redefining what is possible in the modern home. From the Gulf Coast to the Pacific Northwest, doors can be customized to meet rigorous regional performance standards, including ASHRAE 90.1, *International Energy Conservation Code* (*IECC*) 2021, wind-rated construction and glazing, impact resistance, security, UV protection, and more. It is important to consult the manufacturer's guidelines before specifying and installing, as vertically stacking door systems are not suitable for all applications. Recommended applications are often dependent on climate zone and weather conditions. Online tools available from some manufacturers further aid door customization and specification by allowing users to upload home images, preview door styles, explore colors and glazing options, and request color samples to match door finishes to design visions.

Opening the door to imagination

Compact vertically stacking doors have become much more than practical installations. Moving from the humble garage to the outdoor kitchen and beyond, these ever-evolving architectural elements notably enhance residential design. With an impressive range of colors, styles, and configurations, along with performance standards to match, vertically stacking doors empowers architects, designers, and homeowners to express their creativity and individuality without compromise. Ma

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Some American aluminum entry doors have been in service since the 1950s.

Photo courtesy Apogee Architectural Metals

Architectural Advantages of Aluminum Doors

By Brian Tobias

Trine University's Steel Dynamics Inc. Center of Engineering and Computing (SDI Center) features a transparent, jewel-like exterior with bright, daylit interiors. Merging renovated and newly constructed spaces, standard wide-stile entrance doors offer style and longevity with minimal maintenance.

Photo ©Abstract Photography by Terry Wieckert/courtesy Apogee Architectural Metals

One of the hardest-working elements of a building, entrance doors experience hundreds of thousands, or even millions, of openings and closings every year. Much more than utilitarian access points, exterior doors are integral to a building's identity and the experience of its occupants. Architects carefully balance durability, security, accessibility, sustainability, and visual appeal when selecting entrance systems. Understanding the flexibility offered by standard, modified, and custom doors expands aesthetic and functional options.

Advantages of aluminum

Aluminum is the material of choice for manufacturing commercial doors and other fenestration systems such as windows, curtain wall, and storefronts. Aluminum's strength, light weight, corrosion resistance, recyclability, and ease of fabrication make it suitable for a broad range of applications. Approximately one-third the weight of iron, steel, copper, or brass, aluminum extrusions are easier to handle, less expensive to ship, and an architecturally attractive material.

Millions of aluminum entry doors are installed across the country, and some have been in service since the 1950s.

The extrusion process forms metal products by pushing a heated billet of aluminum through a die. The shape of the die determines the shape of the extrusion. Using aluminum billet and a powerful hydraulic press, extruders can produce almost any shape imaginable. A painted or anodized finish can be applied later, or the extrusion may be left unfinished (mill).

Aluminum extrusions in door and entrance systems include varying wall thicknesses and internal reinforcement in the profile design. Cold-weather applications are particularly well served by thermally improved extrusions. Aluminum becomes stronger as temperatures fall, and in warm weather applications, it will not warp. Aluminum also combines strength with flexibility; it can flex under loads or spring back from the shock of impact, such as from an explosive blast or from windborne debris in storms and hurricanes.

The material does not burn, even at extremely high temperatures, and does not produce toxic fumes. Extrusions also offer excellent corrosion resistance, as they do not rust. Aluminum surfaces are protected by their own naturally occurring oxide film, a protection that can be enhanced by anodizing, painting, or other finishing processes.

Supporting environmentally responsible building projects, aluminum is the third-most abundant element in the Earth's crust (in the form of bauxite), next to oxygen and silicon. At the end of its useful life as a door or entrance system, aluminum can be recycled infinitely without degradation of its mechanical properties. Green building guidelines, including the LEED rating system, recognize the performance and sustainability of aluminum products.

Stiles, rails, and key components

A single door may be called a leaf, and two doors together are called a pair. The extruded aluminum components of commercial entrance systems include stiles, rails, and framing.

Framing

The framing that surrounds an operable door includes a header across the top and jambs along the sides. The hardware attached to these components allows the doors to open, close, and lock. Thresholds are installed at the bottom of a door frame to keep water and weather out, and to facilitate a smooth transition from one side to the other.

Stiles and rails

Stiles are the vertical members of a door that span the full height. Rails are the horizontal members of a door that run between the stiles. Typically, the bottom rail is 101.6 to 254 mm (4 to 10 in.) high, and the stiles are 50.8 to 127 mm (2 to 5 in.) wide.

Glass stops

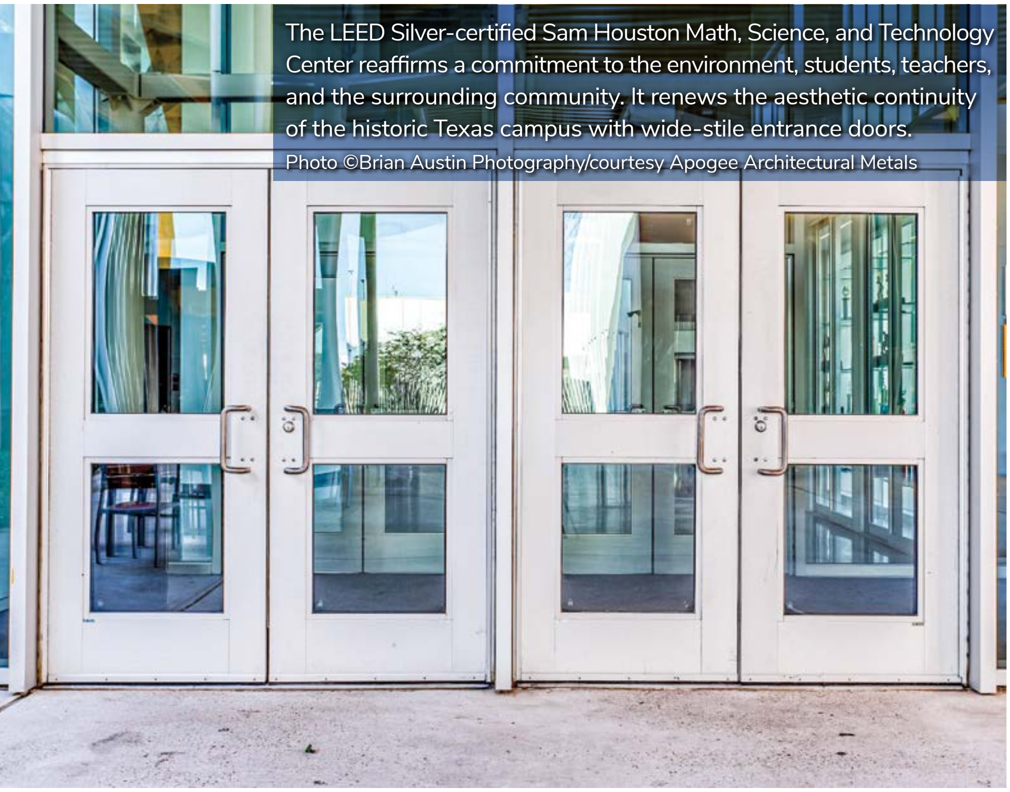
Glass stops in the rails and stiles hold the glass in place. As standard, these supports have thicknesses ranging from 6.4 to 25.4 mm (0.25 to 1 in.). An elastomer glazing gasket, normally composed of ethylene propylene diene monomer (EPDM), is used in conjunction with glass stops to hold the glass in place. Varying the width of the gasket allows for variance in glass infill thickness.

Modifications

Modifications to the standard templates can be offered that feature a variety of rail and stile sizes and support nonstandard glass thicknesses. The height of the top rail usually matches the width of the vertical stiles. The height of the bottom rail is generally larger than the width of the vertical stiles.

Medium and wide vertical stiles also accommodate the use of many non-standard panic exit devices commonly found in public and educational buildings. Modified top rails increase the face dimension of the extruded member to accommodate a door closer or other hardware item. Modified bottom rails increase the height for appearance or to prevent foot contact with the glass, and support accessibility compliance with the *Americans with Disabilities Act* (*ADA*). Modified doors may also add a vertical intermediate stile or a horizontal mid-rail.

The facility type and expected usage of its entrance will influence the robustness of its design. Light-duty doors may be opened and closed only 500 times (cycles) a day, and heavy-



The LEED Silver-certified Sam Houston Math, Science, and Technology Center reaffirms a commitment to the environment, students, teachers, and the surrounding community. It renews the aesthetic continuity of the historic Texas campus with wide-stile entrance doors.
Photo ©Brian Austin Photography/courtesy Apogee Architectural Metals

duty doors can exceed 1,500 cycles. The doors' construction, hardware, and other components must be selected to withstand their setting.

Custom doors are specialized beyond modified entrance systems, such as heavy wall institutional doors with 50.8 mm (2 in.) thick profiles, 4.8 mm (0.19 in.) thick extrusion walls, and face dimensions of 76.2 to 152.4 mm (3 to 6 in.). Other examples include blast-mitigating doors, hurricane impact-resistant doors, and doors with hardware that is not provided as standard by the manufacturer.

Framing dimensions

Standard door leaf dimensions are 0.9 x 2.1 m (3 x 7 ft) or 1.1 x 2.1 m (3.5 x 7 ft). The framing dimensions add 44.45 mm (1.75 in.) or 50.8 mm (2 in.) vertically, and 88.9 mm (3.5 in.) or 101.6 mm (4 in.) horizontally. To accommodate transom units above the doors, the frames may extend up to 3 m (10 ft) in height.

Profiles on standard door frames are 44.5 x 114.3 mm (1.8 x 4.5 in.) or 50.8 x 114.3 mm (2 x 4.5 in) for 25.4 mm (1 in.) thick insulated glass units (IGUs). Some manufacturers offer 50.8 x 165.1 mm (2 x 6.5 in.) door profiles as standard. Pile weathering strips are used at the door stops of standard products with optional sweeps at the bottom rail.

Modified and custom door frames are available in larger sizes, up to 1.2 x 2.7 m (4 x 9 ft) for a single door, with reveal and flush-with-frame options, as well as nonstandard frame configurations, such as continuous headers and banks of doors. Transom frames on modified doors may reach up to 7.3 m (24 ft) in height.

Strength and longevity

In an aluminum door dominated by glazing, the outer perimeter of the door must do structural work. The intersection of the rails and stiles creates a corner that can be constructed using tie rods, shear blocks, and corner blocks, welding, or a combination of these methods. The strength of a door depends on the strength of its corners.

Doors with welded or tie-rod corner construction methods are equally durable, but they have different advantages. Considering installation, serviceability, and longevity for the doors, tie-rod construction delivers greater savings and flexibility. If the door needs to be modified in the field, the tie rods can be unfastened, and the door can be taken apart without compromising its structural integrity, durability, or finish.

During their long lifespan of operation, aluminum doors with tie-rod construction can be refurbished by replacing worn parts. An installer can adjust the glass blocks and fasteners to bring door leaves back to square with the openings. Replacing the weatherstripping and seals optimizes air tightness. Worn-out individual elements, such as a rail or a stile, can be replaced on tie-rod doors.

Hardware packages

Manufacturers of aluminum doors offer inexpensive options for push bars, pull handles, closers, hinges, pivots, and locks. Assisted operators and accessible thresholds also may be considered part of the standard offering to comply with the *ADA*. Standard hardware is

Designed by Stantec Architects, the Sam Houston Math, Science, and Technology Center's doors support the project's performance, sustainability, and aesthetic requirements.
Photo ©Brian Austin Photography/ courtesy Apogee Architectural Metals

made from aluminum, and sometimes from steel, such as mortised hinges. Be cautious in selecting other metals, such as brass. Placing incompatible metals in direct contact with one another can cause a galvanic chemical reaction, which can result in corrosion of the aluminum extrusions.

Hardware for modified doors may include push bars and pull handles mounted back-to-back or in special locations, continuous hinges, and intermediate hinges and pivots for doors that are larger or heavier than standard doors. Beyond standard deadbolts and panic exit devices, modified locking mechanisms are available as latch locks, hook and short-throw bolts, thumbturns, and electric strikes and panic devices. Nonstandard panic devices may reduce the clear opening of a door, making it noncompliant with the *ADA*.

Electric/magnetic card readers and other keyless entry systems, as well as electric hardware that requires power transfer from the frame to the door, are also available on standard, modified, or custom doors. Special-order push/pulls, hinging, or any other item not readily supplied by the manufacturer will also be included in a custom door.

If customization is essential, ask for an overview of the door manufacturer's capabilities and services. Some may only prepare the door to accept the custom hardware. Others will also provide installation of the hardware.

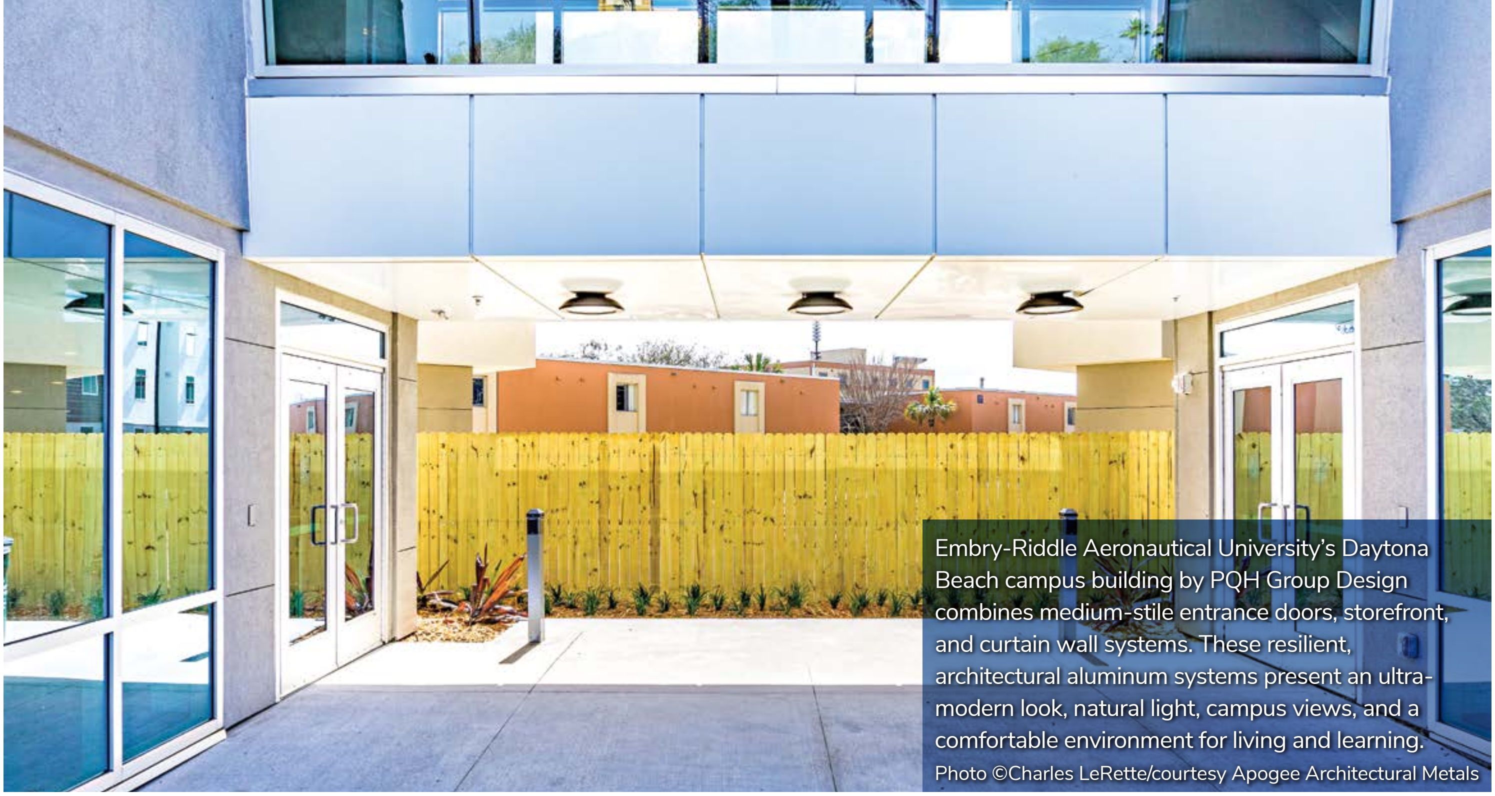
Performance expectations

Most manufacturers classify thermally improved doors and frame extrusions as modified doors. To maintain the door's structural integrity while reducing the transfer of heat through the aluminum components, a thermal break or barrier is necessary between the interior and exterior surfaces of the extruded profile. Thermally broken exterior entrance doors may be required in the northern two-thirds of the United States.

There are two principal types of thermal barriers used in North America: polyurethane poured and debridged, and polyamide insulating strut. In addition to supporting energy efficiency goals and comfortable interior temperatures for occupants, thermally insulated door and frame extrusion components also reduce the occurrence of condensation and frost in cold climates.

In coastal climates prone to hurricane-force winds, building products must demonstrate their resilience to windborne debris. Depending on the size of the tested missile that a door can withstand, manufacturers may consider their hurricane impact-resistant products as either modified or custom.

Like hurricane-impact-resistant doors, blast-mitigating doors may be designated as modified, but are most often considered custom, as blast load requirements are project-specific. For more regular security considerations, modified and custom door products also may be specified to resist forced entry.



Embry-Riddle Aeronautical University's Daytona Beach campus building by PQH Group Design combines medium-stile entrance doors, storefront, and curtain wall systems. These resilient, architectural aluminum systems present an ultra-modern look, natural light, campus views, and a comfortable environment for living and learning.
Photo ©Charles LeRette/courtesy Apogee Architectural Metals

Glass options

By creating distinctive designs and improved functionality, entrances can incorporate glass and glazing with different interlayers, tints, patterns, prints, coatings, and more.

Polyvinyl butyral (PVB) interlayers are the standard for laminated architectural glass, commonly specified for safety glazing and enhanced sound attenuation. Colorful PVB interlayers can add a welcoming appearance and visual distinction. Rigid ionoplast interlayers can also enhance safety, security, structural integrity, and impact protection.

Low-e coatings remain a staple for high-performance entrance systems in buildings with energy-efficiency goals. In colder climates, room-side low-e coatings may provide additional thermal performance, but be cautious not to compromise condensation resistance.

Increasingly, bird-friendly glazing is being specified across the country and is required in certain jurisdictions and by some property owners. These glazing options can be created through a variety of techniques, including coated, printed, or etched patterns, or with laminated layers.

Finish choices

The aesthetic longevity of aluminum doors and entrances is closely tied to the specified performance of their painted coating or anodized finish. Selecting finishes that contain no or low volatile organic compounds (VOCs) also supports a healthy indoor environment.

Anodized finishes are produced through an electrochemical process that enhances the natural oxide layer on aluminum. Highlighting the natural metallic tones, anodized colors range from clear to bronze to black, with specialty colors like copper also available.

For high-performing finishes on exterior entrances, choose Class I anodize that meets the AAMA 611 specification, published by the Fenestration and Glazing Industry Alliance (FGIA). This ensures the anodized finish resists temperature, corrosion, humidity, and warping, and provides excellent wear and abrasion resistance with minimal maintenance.

When color choice is a priority, high-performance 70 percent fluoropolymer coatings offer nearly any conceivable hue, as well as specialty textured coatings. FGIA's AAMA 2605 is the highest performance specification standard for these architectural coatings to shield against weathering, pollution, and aging.

The bottom line

Not surprisingly, the most economically priced entrance systems are standard doors. Modified doors are moderately priced, and custom doors are the most expensive.

Similarly, standard doors offer quicker lead times from order placement to arrival on the job site. With standard components and finishes, these doors may be ready for pickup or shipping in a couple of days. Modified doors with non-standard components, finishes, and hardware may take several weeks to arrive. Custom doors may take two months or longer to produce as specified.

Manufacturers' warranties for aluminum entrance systems vary greatly, and it is critical to review them carefully before making a final selection. Working with a dependable manufacturer early in the project will ensure the highest quality, reliable thermal performance, within budget, and on-time, damage-free delivery. Ma

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Pre-Engineered Metal Buildings in Modern Architecture

Moving beyond the box

By Amy Wirth

Photos courtesy Sunward Steel Buildings

The Edge Fieldhouse in Littleton, Colo., is a multi-functional pre-engineered metal building (PEMB) that is home to the Sport Court of the Rockies headquarters and the EDGE volleyball club.

From a design standpoint, a common misconception is that metal buildings are "boxy" or restrictive; however, this assumption is no longer accurate. On the contrary, architects and engineers can leverage the latest design and material innovations without compromising the speed and practicality that make metal buildings so appealing by initiating the process early and collaborating with the right pre-engineered metal building (PEMB) partners.

Structural advantages

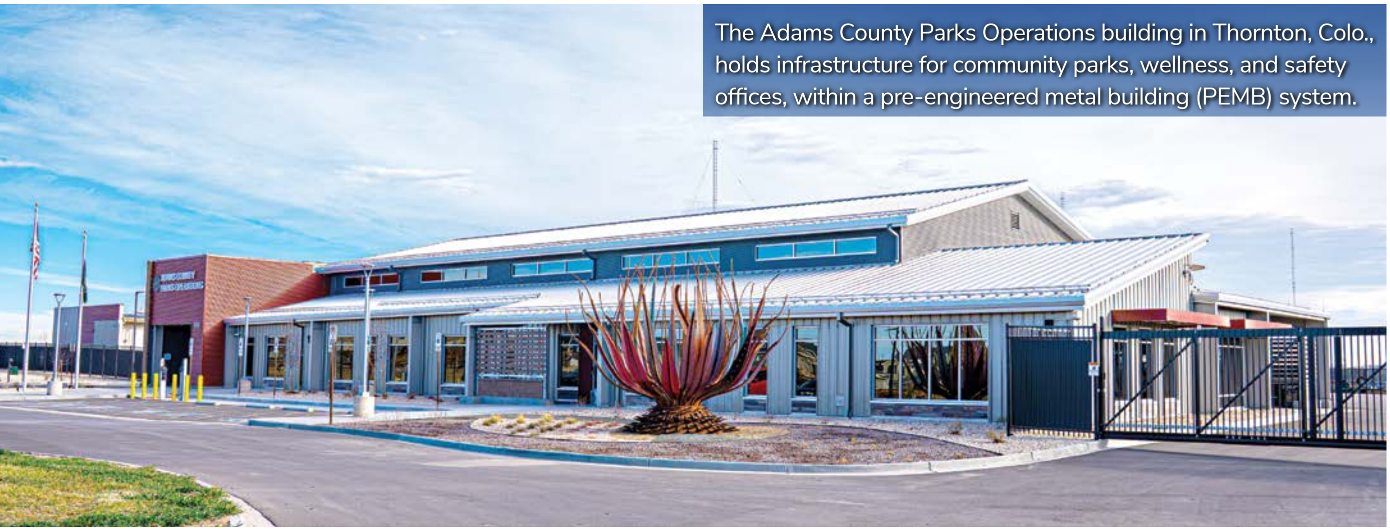
PEMB systems offer numerous benefits. By nature, they are efficient and quick to fabricate, due in part to the fact that manufacturers create them using standardized steel sections under tightly controlled conditions to ensure uniformity.

PEMB components are manufactured for efficiency and precision. All parts are pre-punched, pre-drilled, cut to length, and shop-primed, allowing for immediate assembly upon arrival at the jobsite. This streamlined fabrication process reduces field labor, minimizes errors, and accelerates construction schedules.

In addition, the fabrication process can include downloading job-specific data directly from design software into automated manufacturing systems across multiple product lines. This data is electronically processed and transmitted to production equipment, eliminating manual operator input, reducing downtime, and significantly minimizing fabrication errors.

Automation programs further improve machine efficiency and reduce material scrap, which in turn helps control raw material costs and deliver greater value to the customer.

PEMB systems are also quicker to raise compared to most alternatives because they arrive on-site already partially assembled, significantly reducing construction costs. As long as the design parameters are clear and in place, PEMB systems also have predictable costs,



The Adams County Parks Operations building in Thornton, Colo., holds infrastructure for community parks, wellness, and safety offices, within a pre-engineered metal building (PEMB) system.

minimizing the likelihood of unpleasant budget surprises that could potentially impact a project.

Unpacking the "box" perception

Many metal building manufacturers focus on speed and simplicity, and therefore favor clean, rectangular systems. This approach suits certain straightforward projects, such as storage and manufacturing spaces; however, it can limit flexibility and reduce the range of design options available to architects.

When manufacturers enter the scene late in the design process or focus solely on standard configurations, it can limit opportunities to explore alternatives. When this happens repeatedly, it leads to an influx of rigid, "boxy" buildings, even though other outcomes could have been feasible with earlier collaboration. When collaboration starts early on, manufacturers can have a hand in shaping the building system while the design is still in flux, enabling them to adjust rooflines, exterior features, and other elements to create an aesthetic that transcends the standard "box."

Evolving municipal and district aesthetics

Design expectations continue to evolve in many cities and towns, with a greater emphasis on aesthetic appeal and street presentation. Roof forms, facade variations, and similar elements often come into play, becoming increasingly important aspects of the approval process.

In other words, basic metal box-style buildings no longer meet the requirements in many municipalities, making it difficult, if not impossible, to secure approval for these projects.

Complex design environments

Architects can optimize PEMB efficiencies even when design standards are more demanding, and review processes become increasingly unpredictable. The difference comes down to selecting PEMB partners that welcome iteration and engage early on, rather than locking projects into rigid solutions too soon.

When manufacturers support concept testing during early design phases, teams can explore numerous options while keeping costs manageable. This early collaboration enables architects to respond to municipal feedback, refine their design intent, and address any design constraints before they impact budgets and schedules.

Flexibility and iteration

Flexibility is critical when projects evolve. Design requirements can change as a result of zoning reviews or site conditions, requiring adaptability on the part of the PEMB partner.

Iteration, meanwhile, works well when accompanied by clear, timely information. Some PEMB partners provide structural input and budgetary feedback in real time, giving architects a chance to assess the strength of their ideas and designs without having to estimate costs or potential impacts.

Cost-effective design decisions

Virtually every design change comes with cost implications. Costs can be seen as design drivers, rather than something restrictive. It is critical for all parties involved in the design process to know how to solve steel building design problems without busting a client's budget, and this starts with early and consistent collaboration with the PEMB partner. By working in close conjunction from the outset, teams can identify where flexibility exists (*e.g.* bay spacing and roof slopes) and how minor adjustments can help achieve a desired look without inflating the project's price tag. Generally speaking, early adjustments allow for reasonably priced fixes, whereas making changes later in the game tends to come at a higher cost.

Why collaboration matters

Designing buildings today involves more moving parts than previously required, with many cities and towns now expecting more detailed documentation and buyers seeking structures that outperform and outlast those of earlier generations. Timelines and budgets are also

The Sport Court of the Rockies headquarters has a large capacity and includes multiple indoor volleyball courts.

shrinking, giving architects numerous considerations to juggle while working to preserve the original design intent.

Engaging PEMB manufacturers early on helps architects recognize possibilities, necessary adjustments, and cost variables, whereas waiting until later can limit options, making it harder to create designs that move beyond a simple "box."

In the current design landscape, architects need PEMB partners that are available beyond the initial pricing stage. It is critical to collaborate with entities that have established themselves as trustworthy, responsive, and supportive of an architect's design intent. The longer a PEMB partner has been in business, the more efficient it is likely to be in terms of structural designs and detailing, which means fewer surprises, clearer plans and instructions, and a smoother path from conception to completion.

PEMB partners can help architects take their designs beyond the "box" by collaborating early and often throughout the design development process. The earlier the process starts, the more time teams have to experiment with different aesthetic elements, panel and framing options, roof slopes and shapes, and material combinations, among other areas. In some cases, it may also make financial or structural sense to merge several PEMBs together into one structure, which can save space and money while reducing project complexity. On the other hand, when communication ceases after setting a price or executing a contract, this is a clear red flag and a sign that the partner is prioritizing sales over the success of the design.

True collaboration starts with steady communication between manufacturers and architecture, engineering, and design (AED) teams. When these parties maintain close contact, it fosters open dialogue. It also helps eliminate assumptions, keeping everyone involved in a particular project on the same page.

Maintaining open dialogue promotes clarity and ensures the components and assembly of PEMBs satisfy a design's intent. Staying in close collaboration also helps all parties remain accountable for their own responsibilities, allowing creativity and practicality to come together rather than compete with one another.

The strongest PEMB partner is not one that upholds rigidity or regurgitates the same design and plan for each project. Instead, it is one that values flexibility, responsiveness, and collaboration, expressing a willingness to "move beyond the box" and create something truly striking.

This mindset distinguishes transactional suppliers from true partners, providing architects and engineers with the utmost confidence that their design intent remains intact throughout every phase of a project, from start to finish. Ma

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Clearing the Air

Crucial protections with standard and acoustical smoke vents

By Thomas Renner

NoDa Brewing in Charlotte, N.C., installed eight smoke vents in a recent project. The beer-making process makes breweries susceptible to fire hazards.
Photo by Thomas Kemp

All structures have unique requirements that depend on their function and environment. When designing for multiple considerations, including noise intrusion and smoke ventilation, metal building systems can support multi-function designs.

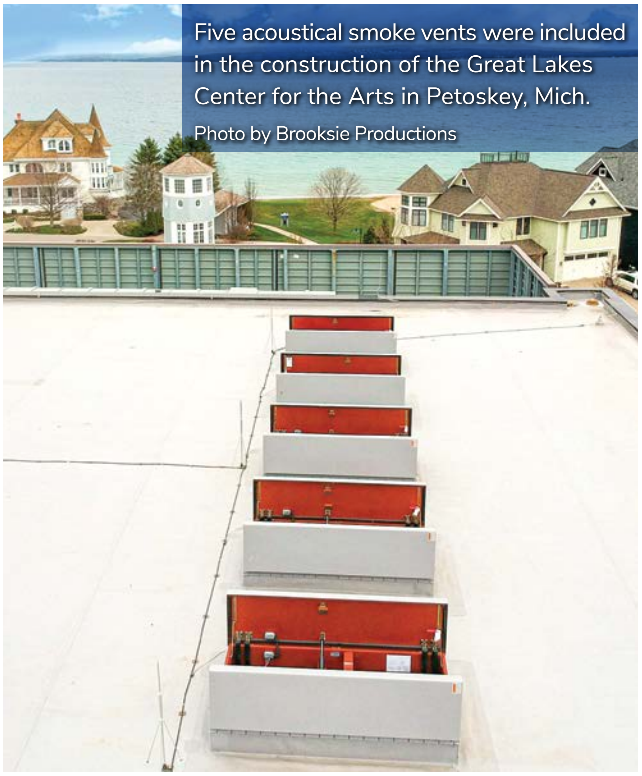
In most instances, architects for theater or performance venue construction projects specify acoustical smoke vents to help mitigate exterior noise. In a 2017 project in Sandy, Utah, architects selected 20 acoustical smoke vents for the construction of the Hale Center Theatre, a 12,356.1 m^2 (133,000 sf) building with a seating capacity for 1,368 guests.

The Ruth and Nathan Hale Theatre at dōTERRA, a new venue that opened in 2025 in Pleasant Grove, Utah, features two theaters spanning 7,241.8 m^2 (77,950 sf). Pleasant Grove, however, does not have the same exterior noise mitigation needs as Sandy. Architects specified three smoke vents, but they were not concerned with the potential for disruptive noise.

"We have utilized acoustical vents on other projects to mitigate noise from flight paths, light rail and transit, and adjacent sound sources, but the site conditions for this project allowed us to select non-acoustical smoke vents comfortably," says Todd Kelsey of Method Studios, the architectural firm for The Ruth. "This afforded some cost savings to the project with some of the other upgraded features that were a priority for the selection of smoke vents."

Smoke vents are an important component of any commercial space. They assist firefighting efforts by removing heat, smoke, and gases from a burning building. They also promote safe and fast evacuation. While standard and acoustic smoke vents are similar, it is beneficial to understand their differences, the important


Straughn High School in Alabama installed a white roof to help curb energy costs and installed four smoke vents that were painted with a durable powder coat finish.
Photo by Bryan Strickland/courtesy Promise Media


Five acoustical smoke vents were included in the construction of the Great Lakes Center for the Arts in Petoskey, Mich.
Photo by Brooksie Productions

life- and property-saving properties they offer, and how they have come to play a crucial role in commercial construction.

Tragedy drives code changes

A fire tragedy in Michigan in 1953 led to significant changes in the construction of commercial buildings and the adoption of smoke vents.

The blaze at the General Motors (GM) facility in Livonia, Mich., is considered the worst industrial fire in the United States, resulting in the death of six people. The fire caused $80 million in damage to the building, which spanned more than 139,354.6 m^2 (1.5 million sf) across 14 ha (34.5 acres). The nearly new building represented state-of-the-art construction in post-World War II plant design, and more than 4,000 workers were employed across all three shifts at the facility, which manufactured transmissions.

A welder's torch started the fire, which raced through the structure in minutes. "It was literally raining fire all over the building," says John Stinson, a construction superintendent for GM.

The roof, which lacked smoke vents, partially collapsed before firefighters arrived, rendering the building too hazardous to enter. Workers used fire extinguishers in an attempt to stop the fire, but they were emptied before the blaze was under control.

As a result, new commercial building codes pertaining to fire safety were adopted. "The major change," Stinson says, "was the demand for smoke and heat vents."

Following the fire, it became a common practice to install automatic smoke vents in large commercial buildings. They are designed to open automatically when excessive heat is detected, releasing smoke and heat from the building. Metal provides several key elements: durability, fire resistance, and sound absorption. The metal frame holds insulation to create an insulated, sound-dampening barrier.

Nixing noise

Architects at Beecher Walker in Holladay, Utah, faced roofing challenges in the construction of the $80 million Hale Center. Besides being positioned directly in the flight path of a nearby airport, the theater is situated adjacent to Interstate 15, where 260,000 vehicles pass by daily.

"The sound issues were pretty intense," says architect Lyle Beecher. "We knew it was going to be an issue."

Noise from aircraft, vehicular traffic, and trains can disrupt any theatrical performance. Designing with this key consideration in mind, and specifying accordingly, can support and enhance the overall enjoyment of the structure's intended use. Acoustical smoke vents are frequently specified for concert halls, school auditoriums, and other performance venues where exterior noise can cause disturbances. The metal material ensures optimal durability, fire resistance, and sound absorption. Further, mineral wool insulation, 101.6 mm (4 in.) thick, inhibits sound transmission. Heavy-gauge steel ensures the vent maintains its shape and functions reliably in the event of a blaze.

"There are also helicopters that fly directly overhead," says Beecher. "The air traffic was one of the primary concerns that we had when we discussed what roofing components we would use. Those acoustic smoke vents are the only thing stopping noise from the outside at the loading level. We could not have any noise infiltrating the building."

In a project at The Venue at Thunder Valley in California, Gary Martinez, senior principal at OTJ Architects, remembers attending a

Workers replaced an aging "doghouse" style smoke vent, likely installed in the 1950s, with a custom-made acoustical smoke vent.

Photo by Rich Redfern/courtesy Flyover Productions

comedy performance at an amphitheater that had been used prior to the construction of The Venue. "There's a major train line about 400 or 500 yards [365 or 457 m] away," says Martinez. "We could hear it coming as it was crossing a street. Horns were blowing, and the comic just went wild. I turned to my colleague and said, 'We're going to have to do something about that.' It wasn't a huge piece of land, so we had to be conscious of how we addressed that."

The OTJ Architects team specified six acoustical smoke vents to help mitigate exterior noise. The motorized smoke vents feature an industry-high Outdoor/Indoor Transmission Class (OITC) rating of 46 and a Sound Transmission Class (STC) rating of 50. The OITC figure is the preferred rating when addressing sound insulation from exterior noise, as it rates the transmission of sound between outdoor and indoor spaces.

Ratings for acoustical smoke vents are divided into two categories: STC and OITC. The difference in the ratings is essential for architects, designers, and construction teams to understand.

OITC rates the transmission of sound between outdoor spaces and indoor spaces in a structure. The OITC rating was developed in 1990 and is typically used to measure sound transmission loss (TL) over a frequency range from 80 to 4000 Hz. It is most applicable for measuring the prevention of low-frequency exterior sounds such as automotive traffic, construction, and low-flying airplanes through exterior building surfaces.

"OITC is the preferred rating when addressing sound insulation from exterior noise—especially when transportation noise sources are impacting a building facade with significant low-frequency (bass) sound," says Harold Merck, principal and acoustician for Merck & Hill Consultants of Atlanta. "While STC ratings may be fine for typical interior noise sources such as voices, STC doesn't adequately address the extended low-frequency noise contribution of aircraft, traffic, or even large rooftop equipment. This also applies to large rooftop equipment noise sources. The OITC better addresses low-frequency noise impacts and is the more applicable sound rating for roof-mounted automatic smoke vents."

STC measures the extent to which sound is prevented from being transferred from one area to another. The higher the STC value, the less sound can be transferred through a building product. STC is typically used to measure sound transmission loss over a frequency range of 125 to 4,000 Hz and is most applicable for interior areas that experience mid-to-high frequency noises, such as conversations, television, telephones, and office equipment.

Enhanced safety

While acoustical smoke vents are often specified for theater projects, The Ruth in Pleasant Grove is largely isolated from unwelcome exterior noise.

Smoke vents are particularly important in large industrial warehouses, which have become increasingly common with the shift toward online shopping. In Texas, McKinney National Business Park encompasses more than 92,903 m^2 (1 million sf) of industrial space. The project includes 16 smoke vents. Metal is ideal for smoke vents, as it is non-combustible, preventing it from catching fire and dripping hot plastic into the building. It also resists cracking, warping, and deterioration from weather and offers better structural rigidity.

Smoke vents are activated upon the melting of a fusible link and are the most economical way to add fire venting in large areas. In a project in North Carolina, plans for a new building for NoDa Brewing included sprinkler activation. Fire protection officials mandated that the design include smoke vents.

In Ohio, Dick Cold Storage was forced to rebuild its facility after a fire destroyed the site. The company built a new structure that included 18 smoke vents. The metal vents were a critical component of the rebuild, as the structure destroyed by fire did not include smoke vents. More than 400 firefighters tackled the blaze, which began on Friday night and was not extinguished until the following day.

"Two of the biggest challenges we face in fighting any fire are heat and smoke," says Steve Martin, Battalion Chief for the Columbus Fire Department. "The heat of the fire radiates on everything surrounding it, causing the flames to spread and causing rapid degradation of structural elements."

"Buildings that do not lend themselves to ventilation, such as cold storage buildings, are especially dangerous to firefighters," says Martin. "If there is no known life-safety issue, firefighters will retreat to a defensive position and fight the fire from outside the building instead of going inside."

The previous facility did not have smoke vents, and, similar to the Livonia fire, it was destroyed quickly.

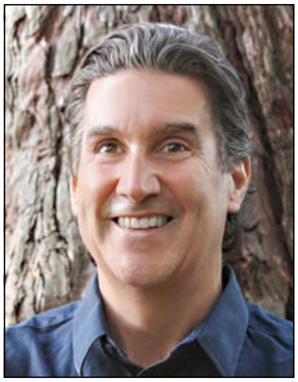
Martin says vents "permit firefighters to see and enter the building, to possibly extinguish the fire early, preventing the entire building from becoming a loss."

Thermally broken smoke vents are also a material option, an energy-efficient alternative that features an innovative frame and cover design to minimize heat transfer and the effects of condensation. Ma

Thomas Renner writes on building, construction, and other trade industry topics for publications throughout the United States.

Digital twins allow designers intuitive insights into building performance.

Parallel Realities: Digital Twins for High-Performance Buildings



By Alan Scott

Digital twins allow designers intuitive insights into building performance.

Photos generated using MidJourney/courtesy Alan Scott

Technology invites both fascination and unease in the workplace. It has the potential to unlock extraordinary gains in efficiency and insight, yet tools often fail to meet expectations or overwhelm users with their complexity. Few innovations embody both sides of this tension more than digital twins, which promise near continuous visibility into building performance while demanding new workflows, new skills, and sometimes new ways of thinking.

Still, the needs driving digital twin adoption have not changed: users are swimming in data but hungry for insights. The industry faces mounting challenges, economic pressure, rising tenant expectations, decarbonization, circularity, and escalating natural hazards.

Digital twins are emerging not as a flashy add-on but as a practical tool to manage these pressures and help build teams convert information into action. This article examines emerging applications, addresses adoption barriers, and highlights key considerations for metal buildings, a sector particularly well-positioned to benefit from this technology.

What is a digital twin?

A digital twin is a synchronized virtual representation of a real-world facility, system, or process.

Unlike static building information modeling (BIM) models, digital twins continuously update through two-way data flows, using real-time Internet of Things (IoT) signals, analytics, and simulations to mirror the behavior of a building. They analyze, predict, and sometimes act autonomously, helping owners and operators optimize performance throughout the building's lifecycle.

Digital twins are typically composed of four interdependent layers:

1. A geometric model, usually originating in BIM.
2. Simulation and analytics, including predictive performance modeling.
3. A data platform, or "data lake," combining historical data and real-time sensor inputs.
4. Performance requirements and constraints, such as design criteria, codes, and operating priorities.


Digital twins offer streamlined logistics in the construction process, supporting reduced transportation emissions and efficient project delivery.

This structure enables digital twins to support decision-making across multiple project stages, including design, construction, operations, and end-of-life, spanning predictive maintenance, resilience, and circularity.

Expanding the value proposition

Energy and carbon optimization: a continuous commissioning engine

Running buildings efficiently is no longer a luxury; it is a climate and financial necessity. A growing trend is the use of digital twins as a continuous commissioning platform, comparing real-time performance against predicted baselines to identify faults, adjust controls, and optimize energy use on an hourly basis. Digital twins can adjust HVAC start-up logic based on predicted indoor conditions, rather than adhering to a set schedule.

Opportunities for reducing embodied carbon complement the operational carbon benefits. During the design phase, digital twins can model structural and cladding quantities more accurately, thereby reducing over-specification and waste. During construction, they can optimize sequencing and logistics to reduce transport emissions.

Indoor environmental quality: precision control

As occupant expectations grow, static setpoints and time-of-day control strategies are falling short of meeting these expectations. New digital twin applications allow buildings to dynamically balance energy efficiency with thermal comfort and indoor air quality (IAQ). These systems can integrate occupancy sensing with weather forecasts to optimize performance. The result is fine-tuned environmental control that is difficult to achieve with traditional automation systems.

Resilience: real-time hazard navigation

Demand for resilience and hazard preparedness is rising across the built environment. Digital twins support this through both forecasting and real-time response. Hazard-oriented simulations can help a building respond to extreme conditions:

- Wildfire smoke: Digital twins can automatically and dynamically adjust HVAC operating modes (filtration and recirculation) to protect occupant health during wildfire smoke events and other poor outdoor air quality conditions.
- High-wind events: Sensors embedded in roofs or walls can detect unusual uplift movement or fastener deformation, informing predictive maintenance before a failure occurs.
- Flooding: Systems can de-energize vulnerable equipment, monitor water infiltration behind cladding, and trigger protective barrier deployment based on rising waters.
- Extreme heat: Digital twins can adjust shading, ventilation, and cooling to compensate for major thermal changes.

These capabilities reduce the risk to people and property, and support faster recovery after hazardous events.

Circularity: material passports and future value recovery

Circularity in the building industry is moving from concept to requirement. Digital twins support the circular economy by functioning as digital material passports, tracking the characteristics, quantities, and expected lifespans of building components. Metal buildings are especially well-suited because their materials hold substantial residual value. Digital twins can:

- Catalog material and component types, dimensions, coatings, and fastener systems.
- Track maintenance histories to inform replacement and reuse decisions.
- Identify which components are bolted versus welded for easier disassembly.
- Connect future owners with recyclers or secondary markets.

Material passports transform building materials and systems from one-time capex costs into future resources.

New applications in construction: smarter, safer, leaner

The construction phase remains a fertile ground for digital twin innovation. Pioneering contractors are increasingly adopting digital twins for:

- Clash detection, quality assurance/quality control (QA/QC), and sequencing, reducing rework and material waste.
- Critical path and supply-chain visualization, especially for key project long-lead components.
- On-site safety simulations, including crane paths, panel installation strategies, and fall-protection planning.
- Tracking prefabricated assemblies, ensuring wall and roof modules arrive and are installed in optimal order.

Metal-clad buildings often rely on prefabrication and precise tolerances, making digital twins a natural complement to their delivery models.

Adoption challenges

Upfront cost and return on investment (ROI) uncertainty

Digital twins require initial investment in modeling, data infrastructure, and sensors. Although returns often materialize through operational savings, the timeline can be slow and difficult to quantify during budgeting.

Data interoperability and siloed systems

A recurring challenge is that sensors, building automation system (BAS) platforms, and software tools do not all speak the same language. Building portfolios often mix old and new systems, complicating integration.

Skill gaps and organizational readiness

Workforces trained on traditional BAS interfaces may not feel equipped to manage AI-driven platforms. Digital twin governance—who owns the data, maintains the model, and decides what gets shared—can also stall adoption.

Cybersecurity concerns

As with any connected system, digital twins introduce risk. Owners worry about exposing building infrastructure to cyber-attacks.

Cultural barriers

Perhaps most underestimated is resistance to transparency. Digital twins expose underperforming systems, as well as underperforming processes or decisions, creating friction between humans and technology.

Overcoming these barriers requires a phased approach: starting small, focusing on a high-value use case, establishing governance protocols early, and expanding as internal competency grows.

Metal buildings: a high-potential testing ground

Metal buildings, with their predictable structural grids, standardized components, and increasingly modular delivery models, are naturally aligned with the implementation of digital twins.

Specific opportunities include:

- Facade performance monitoring: IoT sensors can track thermal movement, moisture intrusion, panel deflection, and corrosion risk. Digital twins can compare real and predicted performance to identify anomalies.
- Roof condition forecasting: Metal roofs are durable but susceptible to fastener failure, coating degradation, or seam separation. Digital twins can evaluate cumulative stress loads from wind, temperature cycling, and foot traffic.
- End-of-life value recovery: Metal components retain high recycling value, making material passports especially powerful. Digital twins can streamline deconstruction planning decades in advance.

The future of digital twins

The next stage of digital twin evolution includes:

A structure's operation and maintenance (O&M) status can be continuously monitored through the use of a digital twin.

- AI-driven prediction and autonomous operation.
- Standardization across industry sectors.
- Cross-lifecycle integration, from design through deconstruction.
- Broader adoption across scales from individual buildings to smart-city ecosystems.

This means moving beyond individual building twins toward portfolio-level or district-scale insights, shared specification libraries, and circularity-focused material exchanges.

Time to double down

Digital twins are no longer futuristic abstractions; they are pragmatic tools for decarbonization, resilience, and enhanced building stewardship. They help owners and operators turn data into action, designers turn intent into performance, and contractors turn plans into efficient delivery. For metal buildings in particular, digital twins amplify the strengths of the material, durability, precision, and modularity, while helping mitigate challenges such as rapid thermal response and long-term envelope maintenance. Adoption will take commitment, but doubling down on digital twins can foster a built environment that is smarter, more adaptable, and more circular.

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Safe Storage with Style

By Hanna Kowal

Photos by Trina Koster/ courtesy Kingspan Insulated Panels North America

A new large storage building uses insulated metal panels (IMPs) to create a safe, sustainable, and functional facility. Aging populations are opting to downsize their residences, and expanding student and workforce communities are increasingly focused on sustainable means of growth in their communities. These evolving lifestyles have rapidly increased the demand for self-storage centers. In Guelph, Ont., Apple Self Storage boasts an eye-catching, sleek, and modern facade with black panels making up most of the exterior, and red-coated panels offering a bright contrast that highlights the building's entrance.

The IMPs used are lightweight, easily installed, and fulfill multiple performance and safety requirements. Meeting the community's storage needs promptly without compromising the structure's appearance or functional success, the material expedited the construction process for the general contractor, Fieldgate Construction Management, and installer, Frost Building Systems.

The design, by Cspace Architecture and Rick Brown and Associates, prioritizes efficiency. The facility comprises 7,357.9 m^2 (79,200 sf) of rentable storage space and is strategically located in a growing community with a strong population of students and working professionals. IMPs support the building in meeting sustainability goals, fire protection requirements, and creating a thermally efficient building envelope. Beyond the cladding's functional merits, it supports a synergetic aesthetic and wraps around the building, sporting a contemporary style with a geometric and angular exterior.