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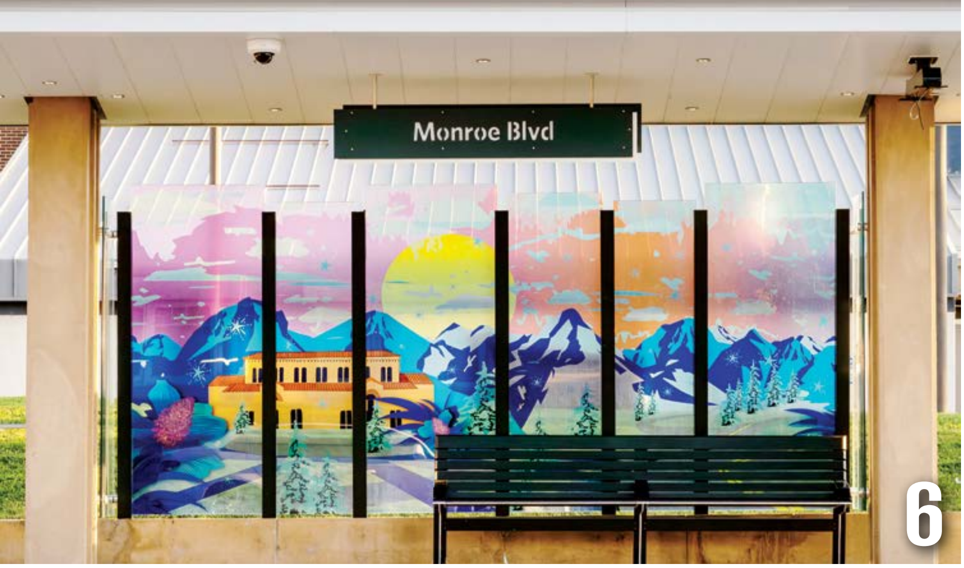

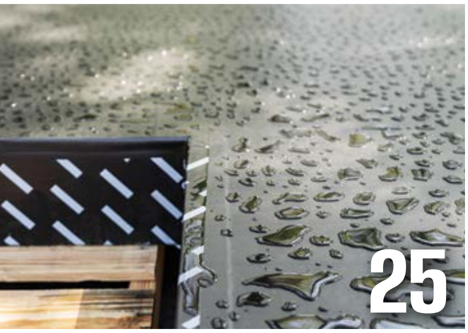

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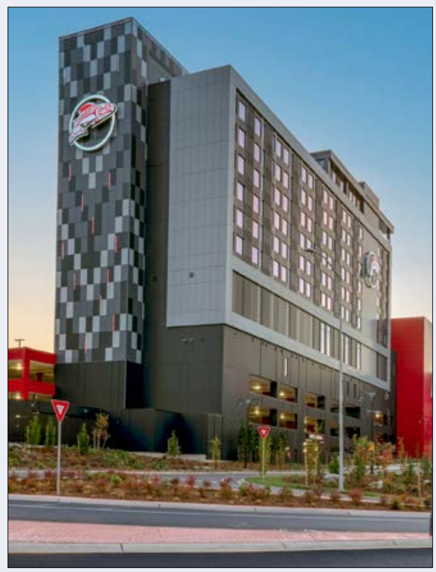

On the cover:

The Godfrey Hotel features insulated metal panels (IMPs) with a flat, uniform profile, concealed fasteners, and crisp edges that deliver both precision and performance.

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PHOTO COURTESY TOM STOCK PHOTOGRAPHY

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THE construction specifier

volume 78
number 10
OCTOBER 2025

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Rates	1 Year (12 issues):	2 Years (24 issues):	3 Years (36 issues):
U.S.	$59.00	$99.00	$139.00
Canada	$69.00	$109.00	$149.00
Foreign	$199.00		

For members of CSI, $16.50 of annual dues are allocated to the publication of *The Construction Specifier*.

Postmaster: Return undeliverables to: CSI, 123 North Pitt Street, Suite 450 Alexandria, VA 22314
Tel: (800) 689-2900 (703) 684-0300, Fax: (703) 684-0465 (703) 236-4600

The Construction Specifier (ISSN 0010-6925) is published monthly by Kenilworth Media Inc. for CSI, 123 North Pitt Street, Suite 450 Alexandria, VA 22314. Periodical postage paid at Alexandria, Virginia, and at additional mailing offices. Printed in the USA.

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CSI is excited to announce the 2025 Class of CSI Fellows.

Fellows are selected by their peers based on their achievements in the industry and above-and-beyond contributions to CSI at the national, regional, and chapter levels. The distinction of Fellow is one of the highest honors given to a CSI member. Here are the four new Fellows:

- Arthur "Cam" Featherstonhaugh IV, FCSI, Lifetime Member
- Charles Hendricks, FCSI, CDT
- Tom Lanzelotti, FCSI, CDT
- Randall Lewis, FCSI

The CSI community will honor and celebrate these individuals at the 2025 CSI National Conference, held October 15-17 in Cleveland, Ohio. Read more about these new Fellows at csireources.org/blogs

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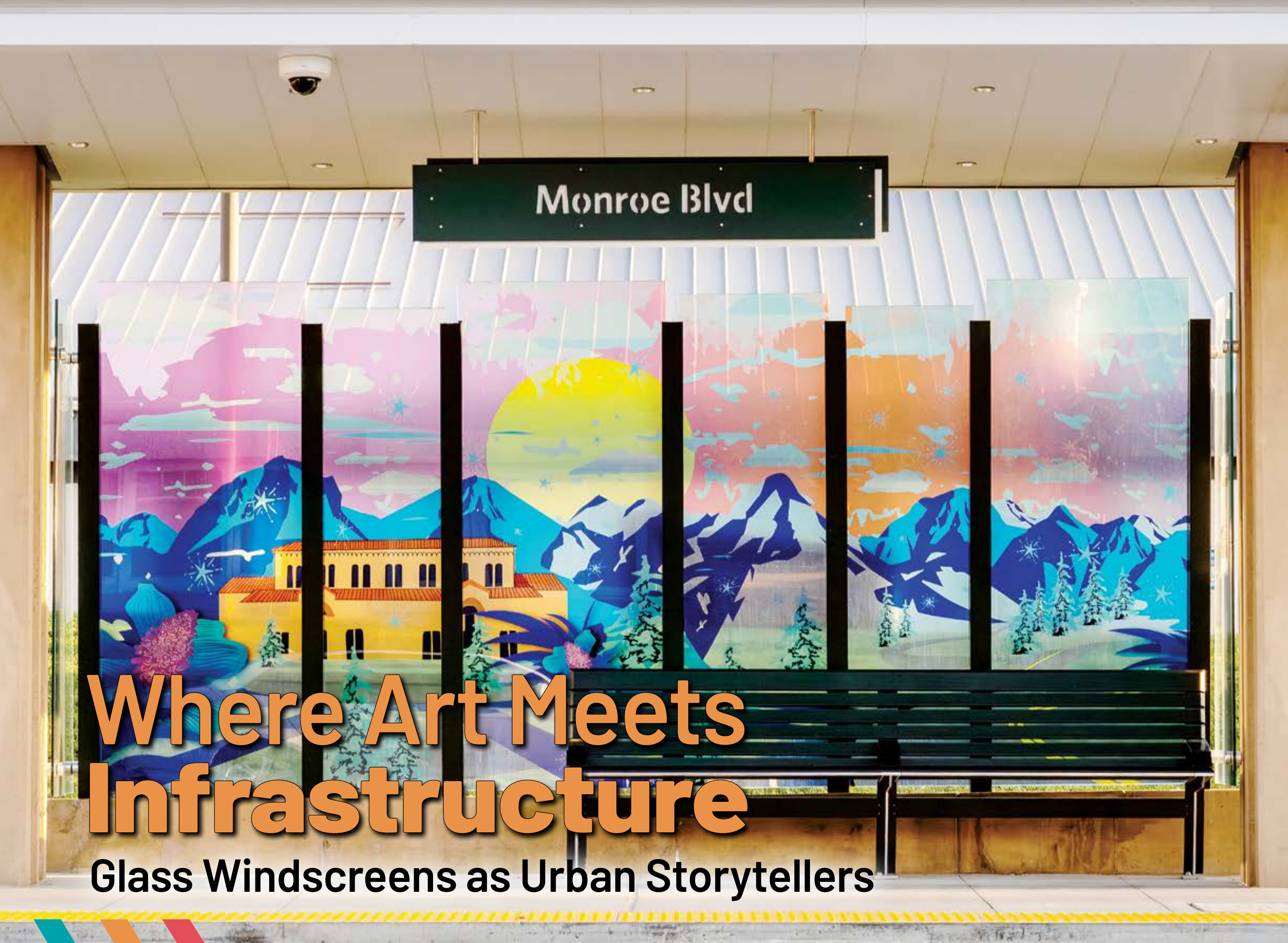


Where Art Meets Infrastructure

Glass Windscreens as Urban Storytellers

By Aubrie Nader

PHOTOS BY KYLE AHLSTROM/ARTWORK BY PRISCILA DE CARVALHO

Urban transit systems are evolving to meet growing demands for sustainable, accessible, and visually engaging public transportation. As part of this evolution, thoughtfully designed infrastructure elements such as windscreens play a vital role in improving commuter experiences and fostering community pride.

In Utah, the Ogden Rapid Transit Bus is a great project example that showcases how functional requirements and artistic ambition can align in the design of laminated glass. By examining design considerations, material selection, and installation methodologies, the project serves as a model for integrating art with public transportation infrastructure.

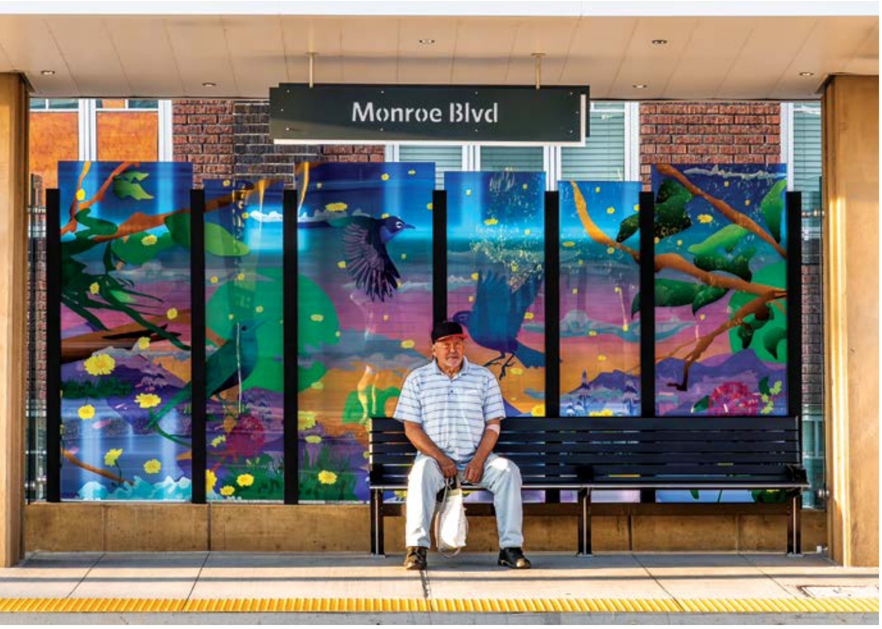
Design considerations for transit windscreens

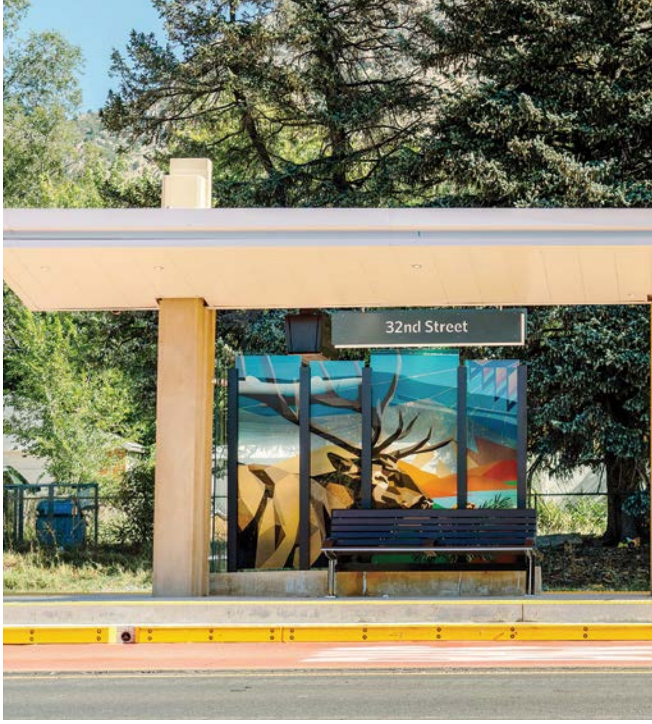
Windscreens in urban bus shelters serve a dual purpose: protecting commuters from environmental elements and enhancing the aesthetic character of transit spaces. The Ogden project required windscreens capable of withstanding wind, rain, snow, and UV exposure while reflecting the cultural vibrancy of the local community through integrated artwork.

A key aspect of the design intent involved creating four distinct bus station designs: Small Side, Center, Large Side, and Large Split, each tailored to its surrounding environment. Small Side stations used lower-profile windscreens to blend into residential neighborhoods, while Large Split stations employed expansive panels to serve as focal points in public spaces and on campus grounds. This variation ensured each shelter contributed to its context and reinforced a sense of place along the 21-station route.

Key design parameters included:

- Durability and safety—Laminated glass was specified to meet impact resistance and safety standards, complying with ANSI Z97.1, *Safety Glazing Materials Used in Buildings*, and ASTM C1048, *Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass*, requirements for public glazing.





A laminated glass windscreen at the Monroe Blvd. station features the artwork Dreamscapes of the West by Priscila De Carvalho. The installation integrates digital print within glass for durability and long-term vibrancy while providing acoustic benefits with a sound transmission class (STC) rating of 38.

- Aesthetic integration—Artwork and photography from local artists were incorporated to promote community identity and visual engagement.
- Structural performance—Cantilevered panels and point-supported hardware achieved a floating glass appearance while ensuring structural integrity under dynamic loads.
- Maintenance—Choosing glass simplifies cleaning, extends the windscreen's lifespan, and protects its aesthetic.
- Transparent material—Using architectural-grade glass to house a translucent, yet vibrant digital print invites color to a space without losing ambient light.

In addition, the shelters were designed with accessibility in mind, ensuring compliance with *Americans with Disabilities Act* (*ADA*) requirements for clearances and reach ranges.

Material selection and fabrication

The primary material selected for the windscreens was 14 mm (0.56 in.) laminated glass. This material, composed of two glass lites bonded with an adhesive interlayer, provides shatter resistance and the ability to encapsulate artwork without degradation over time. Laminated glass also delivers acoustic benefits by helping to reduce ambient traffic noise. The laminated and monolithic glass gauge was chosen to balance safety precautions and acoustic performance criteria, offering increased rigidity and sound attenuation where safety and durability within high pedestrian and vehicular activity are critical.

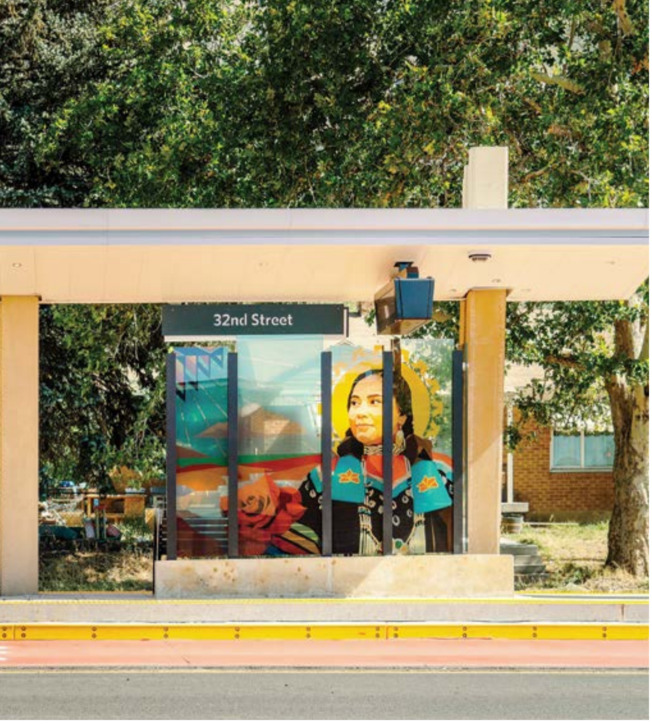
The laminated glass used in this application has a sound transmission class (STC) rating of approximately 38, compared to an STC of around 36 for 13 mm (0.5 in.) monolithic glass, as measured by ASTM E90. The lamination of two glass lites enhances acoustic performance by dampening sound vibrations and improving noise absorption, contributing to a quieter, more comfortable environment for occupants. The STC rating is derived from accredited lab testing and falls within the industry standard for laminated glass.

The project required 119 laminated glass panels to complete the 21 bus stations. Each panel was fabricated to precise dimensions, with sizes and configurations tailored to its designated station type.

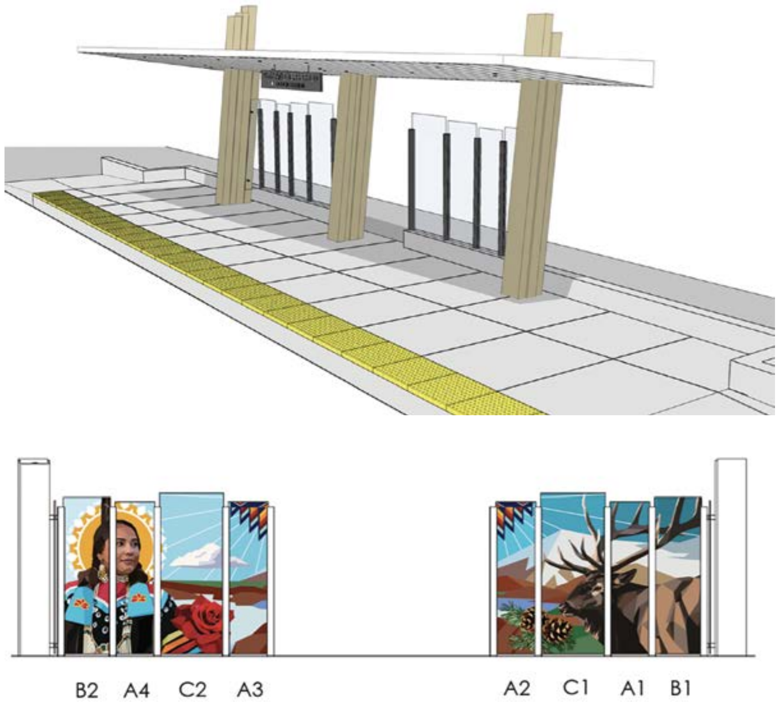
In addition to the laminated panels, 13 mm (0.5 in.) clear float monolithic glass panels were installed as side elements. These panels, secured with point-supported hardware, minimized visual obstructions while providing lateral protection from wind and rain. Any exposed glass edges were polished for safety and aesthetic purposes.

Long-term acoustic performance of laminated glass in exterior applications

In outdoor environments, long-term acoustic integrity is often questioned due to potential environmental stressors such as UV exposure, moisture ingress, temperature fluctuations, and physical degradation. However, in-field observations indicate that when properly specified and installed, laminated glass maintains its acoustic performance reliably over time. Although glass itself is a stable, non-degrading



A laminated glass windscreen at the Ogden BRT features Damme Sogope ("Our Land"), with a seasonal color palette honoring the Shoshoni people. The digital print artwork by Jhonattan Arango was developed with guidance from Dr. Katie Nelson of the Weber County Heritage Foundation.



A laminated glass windscreen for the Ogden BRT Large Side Split station is shown from concept rendering through scope-of-work drawings to final digital proof. The process illustrates design development, engineering detailing, and artistic integration.

RENDERING BY PIVOT ARCHITECTURE

material, the interlayer's longevity depends on several protective factors:

- UV resistance—Modern adhesives and UV-stabilized ink prevent breakdown or discoloration, preserving visual clarity and acoustic properties. Testing per ASTM G155 has shown that these interlayers can withstand prolonged UV exposure without significant degradation.
- Edge protection—Acoustic performance may be compromised if moisture penetrates the interlayer through exposed edges. To mitigate this, edge-sealing practices, such as full perimeter framing or structural silicone glazing, are employed to protect the laminate's bond line.
- Mechanical integrity—Structural support systems and frame seals must be maintained to prevent vibration-induced wear or delamination. Over time, degraded gaskets or shifting hardware may affect system performance more than the glass itself.
- Cleaning and maintenance—Routine cleaning with non-abrasive solutions and inspection of frame integrity are critical to maintaining optimal acoustic behavior in the long term.

Field observations and precedents

No industry data or peer-reviewed evidence indicates that UV exposure, delamination, or weathering causes measurable acoustic degradation in laminated glass panels when they are correctly installed and maintained. In fact, comparable installations with digitally printed laminated glass in exterior settings have demonstrated excellent long-term performance. After several years in service, such assemblies have remained free from visual distortion, interlayer separation, or fading, and have continued to exhibit sound transmission loss characteristics consistent with their original specifications.

Digital printing integration

Integrating digital printing into laminated glass required addressing several technical factors. To preserve the vibrancy of the commissioned artwork, high-resolution digital printing was applied between the glass lites and adhesive before lamination. This approach protected the imagery from external wear while maintaining color fidelity and detail over extended UV exposure.

- Color accuracy—Calibration between artist proofs and digital print outputs ensured consistent results across multiple production runs.
- UV stability—UV-cured inks prevented fading, tested to ASTM G155, *Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials*, for accelerated weathering.
- Lamination process—Controlled temperature and pressure prevented defects such as delamination or interlayer haze.

A laminated glass windscreen at the 28th Street station features Roundtrip, an artwork by Don Rimx inspired by the people and students who rely on transit. The flowing lines and vibrant colors, digitally printed within glass, contrast with the surrounding architecture and landscape.

A laminated glass windscreen at the 25th Street & Harrison Blvd. station features Fields, Folds, and Fabric by Monika Bravo. The artwork layers digital prints with collages and fabric imagery, incorporating Ogden High School's Art Deco outlines within the city and mountain skyline.

- Quality assurance—To ensure optimal performance, the panels underwent rigorous inspections, including optical distortion testing and environmental simulation trials.
- Image flexibility—Digital printing enables designers to tailor imagery with precision, adjusting scale, color, opacity, and orientation. Designers can reinforce brands with custom logos, colors, and images or showcase local and culturally significant artwork that will stay preserved and vibrant encased in laminated glass.

Close collaboration between artists, engineers, and fabricators ensured the artistic vision was translated seamlessly into durable, high-performance glass installations.

Local artistry collaboration and integration

To further strengthen the cultural connection to the community, Ogden City Arts issued a nationwide open call for artists to contribute artwork for the 13 bus stations. Artists were to draw inspiration from local themes, including Ogden's historical architecture, regional geology, prominent historical figures, literature, and Weber State University. Twelve artists were ultimately chosen, six of whom are based in Ogden, and were assigned a specific neighborhood to research and interpret through their design. Despite geographic diversity, the artists employed a shared visual language through color palettes and stylistic elements that reflect Ogden's natural landscape, topography, and cultural identity. The result is a cohesive visual narrative that aims to enhance the daily experience of BRT riders while celebrating the character of the city.

Engineering and hardware solutions

The structural system supporting the windscreens was designed to accommodate varying panel sizes and cantilevered configurations while resisting wind loads, seismic forces, and thermal expansion. Three primary panel sizes were used:

- Panel A: 488 x 1,867 mm (19 x 73 in.) with a 63 mm (2.5 in.) cantilever
- Panel B: 591 x 1,918 mm (23 x 75 in.) with a 114 mm (4 in.) cantilever
- Panel C: 794 x 1,969 mm (31 x 77 in.) with a 165 mm (6 in.) cantilever

Slotted metal framing channels and threaded rods provided primary support, enabling precise adjustments during installation. Stainless steel point-supported hardware (Spider XT joints) distributed loads evenly while achieving a minimalist aesthetic. Hardware was tested for compliance with AAMA and ASTM performance standards, including cyclic loading and corrosion resistance.

Expansion joints and neoprene gaskets allowed for thermal movement and prevented stress concentrations that could lead to cracking.

Installation process and collaboration

Installation was carefully planned to minimize traffic disruption and ensure worker safety. Certified installers and project managers:

- Used detailed templates and laser measurement tools for precise alignment.
- Pre-drilled glass panels for hardware connections, reducing field adjustments.

- Staggered installations over several months, balancing production timelines with seasonal weather considerations.
- Coordinated operations and material staging to minimize urban site disruptions.

The process underscored the importance of interdisciplinary collaboration among architects, engineers, and contractors.

Performance considerations and testing

Performance requirements addressed:

- Thermal stress—Glass thickness and interlayer composition were engineered to withstand thermal cycling without failure.
- Wind load resistance—The support system was analyzed per ASCE 7 wind load criteria.
- Impact resistance—Panels were tested to meet ANSI Z26.1 standards for hazardous glazing locations.

Additionally, the designs met snow load requirements and resisted uplift forces caused by aerodynamic effects around shelters.

Lessons learned and future applications

The Ogden windscreens illustrate how functional and aesthetic goals can harmonize in public infrastructure. Lessons include:

- Early collaboration between stakeholders minimizes rework and aligns artistic intent with technical feasibility. Clear communication with lead times and timelines is crucial.
- Digital print with UV-cured ink within laminated glass is viable for exterior use when material selection and processing are tightly controlled. Laminated glass protects from exterior elements and is optically clear.
- Modular, prefabricated designs simplify field installation and maintenance.
- Partnering with companies that offer integrated services, including engineering, hardware, materials, and installation, reduces miscommunication between contractors and specifiers, ensures comprehensive product knowledge from concept through completion, and supports more efficient, coordinated installation in the field.
- Community engagement through public art enriches user experience and strengthens civic identity.

A laminated glass windscreen at the Wildcat Village station features We Are Weber, a photographic series capturing daily life and events at Weber State University. The imagery is digitally printed within glass, ensuring durability and long-term vibrancy.

PHOTO AND ARTWORK BY BENJAMIN ZACK

A laminated glass windscreen at The Junction station features Finger Prints of a City by Chuck Landvatter, inspired by Ogden's underground music and counterculture. The laminated glass construction dampens sound vibrations, improving noise absorption.

PHOTO BY KYLE AHLSTROM

These insights can inform future projects aiming to integrate design innovation and community values into transit infrastructure.

Innovations for resilient urban design

The design and installation of laminated glass windscreens for Ogden's electric bus transit shelters demonstrate a successful fusion of engineering precision, artistic vision, and community-focused design. As cities increasingly prioritize sustainability and public engagement, laminated glass systems offer a durable medium for integrating art into functional spaces without compromising the longevity of the artistry it houses.

Looking ahead, emerging technologies such as dynamic shading, embedded sensors, and photovoltaic (PV) glass present new opportunities to transform transit shelters into multi-functional urban nodes. These innovations could elevate bus shelters beyond protection and aesthetics, enabling them to contribute to energy efficiency, wayfinding, and real-time data collection in urban systems. The Ogden project is a model for integrating these advancements into resilient, inspiring, and community-centered infrastructure.

additional information

AUTHOR

Aubrie Nader is a brand manager at 3form, a leading manufacturer of architectural-grade resin, glass, and acoustic materials. With more than three years of experience in B2B marketing and over a decade in creative production, she brings a strategic blend of storytelling, design knowledge, and technical expertise to the architectural materials industry. In her role, Nader leads brand messaging and campaign development to support sales teams, generate qualified leads, and drive market awareness. Her background in visual storytelling, production, and project management strengthens her ability to translate complex capabilities into compelling narratives. She is passionate about product innovation, cross-functional collaboration, and creating tools that empower designers and specifiers.

KEY TAKEAWAYS

The Ogden Rapid Transit Bus project demonstrates how laminated glass windscreens can merge durability, safety, and artistry in transit shelters. Incorporating local artwork, digital printing, and structural precision, the design enhances commuter comfort, accessibility, and civic identity while showcasing resilient, sustainable strategies for integrating public art into urban infrastructure.

MASTERFORMAT NO.

08 81 00—Glass Glazing

13 17 00—Transit Shelters

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B30—Exterior Enclosure

B2020—Exterior Windows/Glazing

KEYWORDS

Division 08, 13

Laminated glass windscreens

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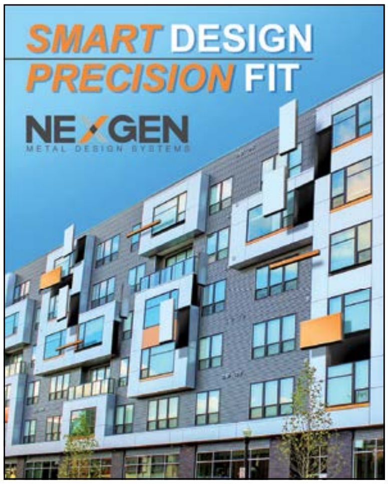

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Mass Timber's Hidden Carbon

The Role of Slash Management

By Varun Kohli and Mahdi Afkhami, PhD

RENDERING COURTESY CORGAN

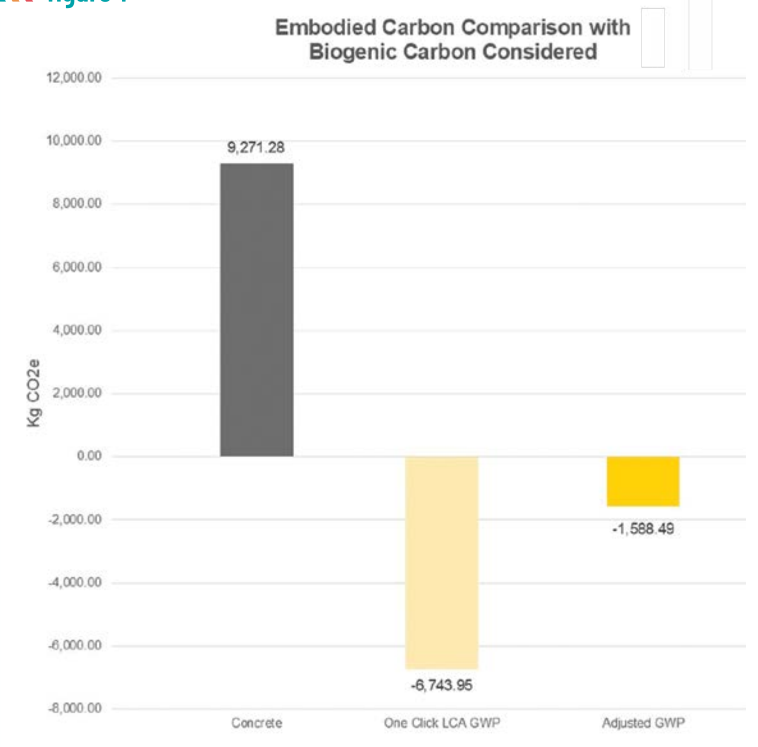
The use of mass timber in construction, which is gaining in popularity, is commonly thought to be carbon neutral—but is it? Corgan's Research and Development group, Hugo, alongside the firm's Sustainability team, Echo, conducted peer-reviewed research focused on identifying emissions in mass timber that result from harvesting. Explore slash management and why mass timber remains a more sustainable option than concrete or steel when considering carbon emissions.

A false positive

In the industry-wide effort to reduce its carbon footprint, AEC practitioners are paying close attention to embodied emissions, the carbon (and other greenhouse gas) emissions associated with the whole lifecycle of the materials used. Since these embodied emissions account for 20 percent of a building's total energy use over its lifetime, they are an important target for minimizing the environmental impact of new construction and renovations. Mass timber has gained attention as a more sustainable alternative to standard concrete and steel construction for low to mid-rise projects. This is because mass timber is seen as being carbon-neutral, since trees naturally sequester carbon during their lifetimes. Due to the interest in this seemingly sustainable building material, the global demand for wood products is expected to quadruple by 2050.

However, a 2023 report from the World Resources Institute states there are emissions associated with mass timber that are not considered, particularly as it relates to timber harvesting practices. Corgan's research seeks to fill this gap in understanding by identifying and estimating the emissions that are not typically accounted for in the harvesting of timber—the slash left behind on the forest floor and the way these materials are managed. The resulting report identifies tree species typically used in mass

figure 1



This graph compares the embodied carbon of the structure for concrete, mass timber with biogenic values, and mass timber with biogenic values that also account for slash emissions in the composting scenario. As shown, both mass timber scenarios result in negative values, indicating carbon sequestration and reinforcing mass timber as a sustainable choice even when slash emissions are considered.

ILLUSTRATIONS COURTESY CORGAN

TERMS TO KNOW

- **Embodied carbon**—The greenhouse gases (GHGs) released during the extraction, production, and transportation of materials used in construction.
- **Biological carbon sequestration**—The ability of natural ecosystems to store atmospheric carbon. Carbon can be stored in plants, soil, wetlands, and the ocean. This research focuses on carbon sequestration of trees.
- **Biogenic carbon**—The result of sequestration (also called biologically sequestered carbon) is carbon that is stored in biological materials (like trees). Biogenic carbon is stored during the life of the tree and released when it is destroyed (decays, burns, etc.)
- **Mass timber**—A construction modality that uses a wood product, usually made from multiple wood panels nailed or glued together for extra strength, instead of steel or concrete. It is growing in popularity due to its lower carbon footprint.
- **CO2e**—Carbon dioxide equivalent, a measurement used to compare the emissions of any GHG based on its global warming potential.
- **Cradle-to-site**—Stages A1 through A4 in a lifecycle assessment (LCA), starting where the raw material is harvested, transported, manufactured into a usable product, and transported again to the construction site.
- **Slash**—The material (branches, twigs, bark) left behind during mass timber harvesting; approximately 25 percent of the mass of the timber.

timber products, applies three common scenarios for managing the slash to determine the associated CO2e emissions, analyzes the impact of the transport of raw material on its embodied carbon, and makes recommendations to designers on how to manage this effectively. The research also resulted in the development of Corgan's Mass Timber Carbon Calculator,[1] a free-to-use tool that enables AEC professionals to easily improve their carbon emission estimates for mass timber projects.

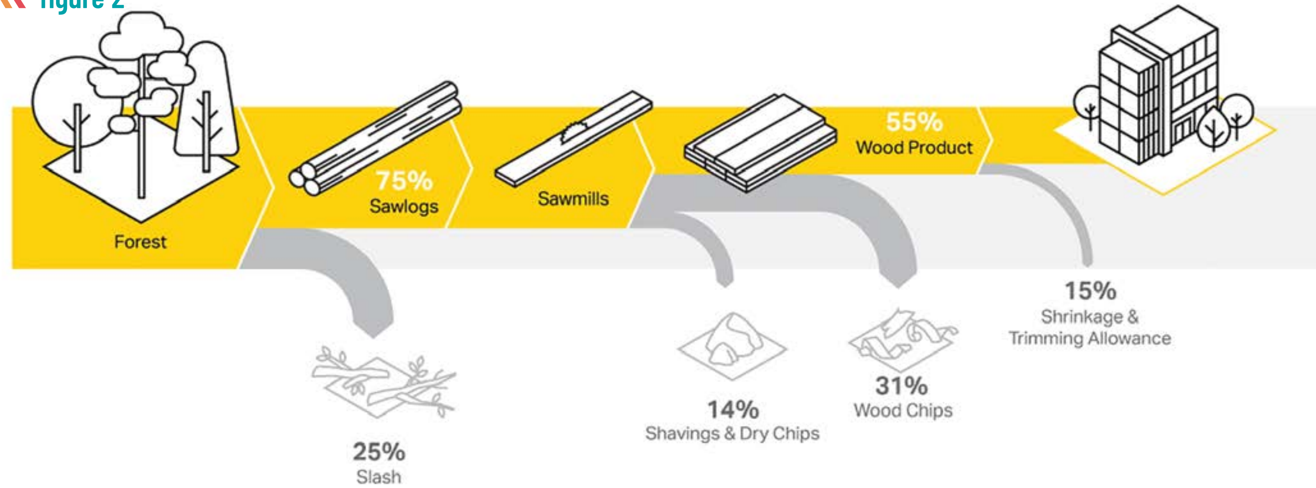
Status quo and study scope

To begin, the study helps understand what is currently missing in the timber harvesting process in lifecycle assessments (LCAs). From extraction through processing, around 65 percent of a tree's initial mass is lost—to slash in the forest, to shavings and wood chips in the sawmills, and to shrinkage and trimming allowance in the final wood product—meaning only 35 percent of what is cut down ends up in the building.

Of this, it is estimated that about 25 percent of the tree's mass is lost to harvest residuals—the twigs, bark, and other small pieces of wood left behind that are known as slash. Since the carbon stored in slash is eventually released back into the atmosphere, these residuals represent a significant source of emissions that are not generally accounted for in mass timber buildings. However, the way slash is managed can play a significant role in the level of emissions. Corgan's research includes three common slash management practices:

- Pile burning—Slash is gathered in piles, dried, and burned when conditions are favorable.
  - Pros: Clears woody debris quickly and reduces fire risk.
  - Cons: Releases 92–94 percent of the slash's carbon content in a short period of time, significantly increasing emissions.
- Mastication—Leftover vegetation is ground into mulch that is left on site.
  - Pros: Useful where burning is difficult and enhances soil health.
  - Cons: Requires specialized, costly equipment and may cause soil compaction.
- Site composting—Leaving all slash and log leftovers in the environment, as is.
  - Pros: Returns nutrients to the soil and helps to prevent soil erosion.
  - Cons: Can hinder forest regeneration and pose a fire hazard if not managed properly.

figure 2

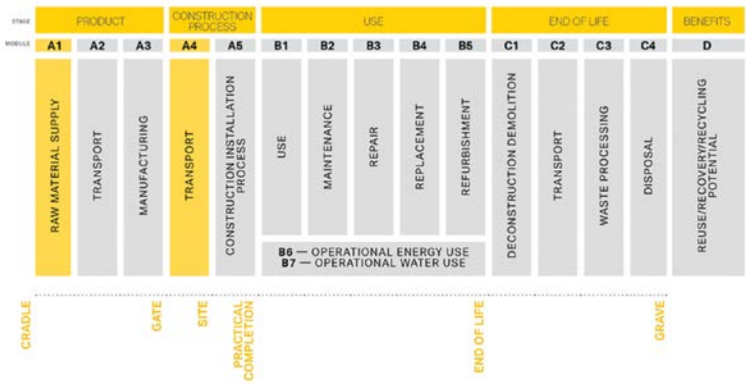


Only 35 percent of what is cut down in the forest ends up in the building—around a quarter is left in the forest to decay.

The study includes analysis of seven tree species most frequently used in mass timber construction: Alaska Yellow Cedar, Douglas Fir, Hemlock Fir, Ponderosa Pine, Southern Yellow Pine, Spruce Pine Fir, and Western Red Cedar. The Environmental Product Declarations (EPDs) for these wood products are sourced from OneClick LCA, as its A1 (extraction) to A4 (transportation) data includes detailed biogenic carbon storage information.

The study scope is defined by one question: What emissions are not fully accounted for in current mass timber carbon accounting models and how can designers properly integrate these into their carbon calculations?

figure 3



Corgan's carbon accounting model focuses on improving the accuracy of stages A1 and A4 in the lifecycle assessment (LCA).

Method and model

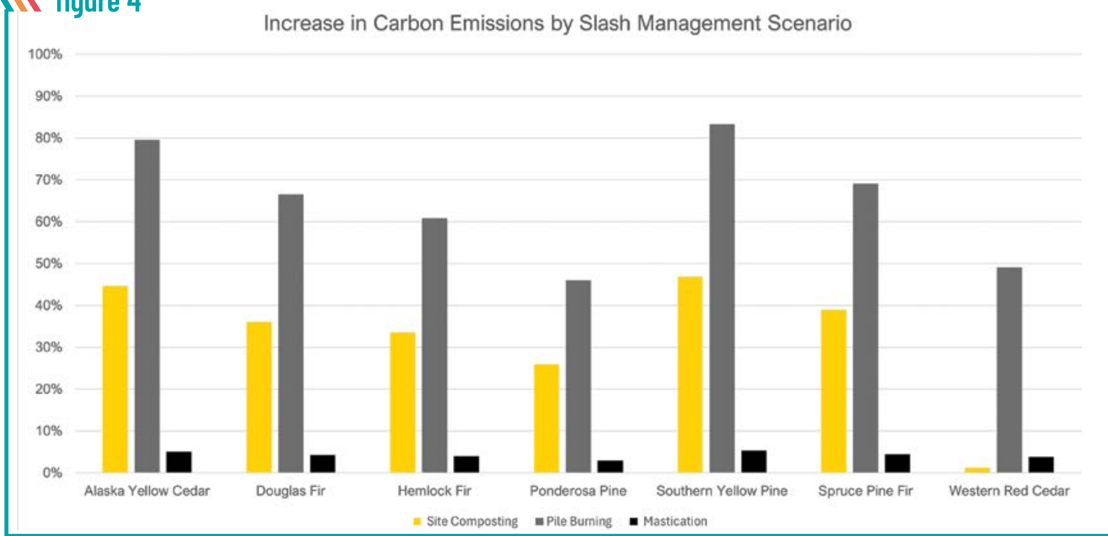
After completing a comprehensive literature review using United States Department of Agriculture (USDA) forestry and academic databases, a model to account for carbon emissions associated with the three main scenarios for slash's end-of-life was developed. The model considers several key factors:

- Below-ground biomass carbon stock—The carbon stored in the roots and soil of trees.
- Carbon emissions from slash—The residual biomass left after logging contributes to carbon emissions as it decays.
- Decay of CO2e over time—The gradual release of CO2e into the atmosphere as organic materials decompose.

The number of trees needed to produce cross-laminated timber (CLT) and glue-laminated timber (GLT) products was calculated using Revit and takes into account material losses that occur during the harvesting process. Striving to make the calculations as accurate as possible, the model employs established models and empirical data, detailed fully in the resulting white paper, to establish CO2e emissions for the A1 stage.

The model also includes the emissions from the shipping process of the raw material (A4). It calculates the number of trucks required to transport the material and uses the emission factor for a 36-ton (40-ton) heavy truck sourced from the United States Environmental Protection Agency (EPA). This emission value was then doubled to account for the round trip, as each truck returned to its origin. The A2 and A3 stages have been considered constant but have not been omitted. This approach ensures a comprehensive analysis of emissions throughout the entire supply chain.

figure 4



Pile burning consistently results in the largest increase in carbon emissions compared to the industry baseline, while mastication shows high sequestration.

While the model was developed to be as comprehensive and accurate as possible, there are certain limitations. In terms of method, the model relies on existing formulas, forestry data, and industry averages; it does not include on-site data collection, which may impact its accuracy. In terms of scope, the research is focused on the A1 through A4 phases, is restricted to regions within North America, and does not include sustainable sourcing practices other than slash. Recognizing these limitations, readers can better interpret the results and conclusions of the research.

Case study and findings

To demonstrate the practical use of the dynamic carbon accounting model, a case study was conducted. The theoretical building is a 20,067-m^2 (216,000-sf), six-story office building in Dallas, Tex., with mass timber structural elements. For this scenario, Douglas Fir was selected for the flooring and structural columns and Spruce was selected for the framing. The total volume of mass timber calculated in the case study was 3,264 m^3 (115,250 cf).

The results show that effective slash management is crucial for maintaining the carbon sequestration benefits of wood products. The pile burning scenario consistently shows the highest carbon release, while the mastication scenario shows minimal carbon release. When compared to site composting, mastication releases less CO_2e in the environment, as the materials are spread thinly over a large area, providing soil protection and nutrients.

The tree species used can also be an important factor in carbon sequestration; Hemlock Fir and Southern Yellow Pine showed large variations in sequestration potential depending on the slash management scenario applied, while Alaska Yellow Cedar, Douglas Fir, and Western Red Cedar consistently show high sequestration potential, especially under mastication. These species can be prioritized in reforestation and timber production projects to maximize carbon sequestration benefits.

The case study also analyzed CO_2e emissions from transporting mass timber from different U.S. regions to a construction site in Dallas. As expected, emissions associated with transportation increase with distance. This exercise demonstrates the impact of a designer's selection of wood species on transportation-stage emissions and hence overall embodied carbon. Though clients often prefer specific types of wood due to their cost or appearance, AEC clients and professionals should consider using local wood options when possible.

The case study confirms that while there are additional emissions associated with slash management that are not always accounted for, mass timber remains a better option than standard concrete or steel in terms of embodied carbon.

Conclusion

The efforts of Corgan's sustainability and research teams are intended to start the dialogue on the true emissions of mass timber and provide some guidance to industry peers in accounting for often omitted biogenic carbon. The dynamic biogenic EPD calculator for designers allows them to see the impact of slash management scenarios for different tree species, leading to more sustainable project outcomes. The calculator enables near real-time decision-making for selecting lower carbon-intensive timber types at every project phase, facilitating discussions with contractors and engineers.

Looking ahead, the next step involves fostering industry collaboration and transparency about the slash created in the A1 stage. Designers can focus on sourcing materials locally, prioritizing low-carbon tree species, and being vigilant about slash management practices. Educating stakeholders, including clients, contractors, and suppliers, about the importance of reducing hidden embodied carbon and fostering collaboration to implement best practices throughout the project lifecycle is an important step in reducing the embodied carbon (and therefore the global warming potential) of mass timber buildings.

Ensuring all aspects of mass timber production are comprehensively evaluated and optimized for minimal environmental impact is a collective effort, but improving carbon accounting practices and promoting more sustainable construction processes is a vital step in the effort to build a more sustainable future.

Mass timber is a construction modality that uses a wood product, usually made from multiple wood panels nailed or glued together for extra strength.

PHOTOS COURTESY CORGAN

Notes

[1] See Corgan's mass timber carbon calculator by visiting corgan.com/MTcarboncalculator

additional information

AUTHORS

Varun Kohli, principal and director of sustainability at Corgan, has more than 20 years of experience integrating environmental analytics and sustainable design in architecture. His work spans urban resiliency, decarbonization, and large-scale projects worldwide. Passionate about ecology in the built environment, he champions net-zero design and climate adaptation. Kohli has collaborated with Yale Center for Ecosystems + Architecture (CEA) researchers on novel pedagogical models for environmental design, taught courses at Harvard GSD and RPI (CASE), authored a chapter in *Energy Modeling in Architecture: A practice guide*, published by RIBA, and serves on the Pokhrama Foundation board.

Mahdi Afkhami, PhD, is a design researcher with Corgan's research and innovation team, Hugo. He leads evidence-based design strategies through mixed-method research, helping teams prioritize user needs and optimize outcomes. With expertise in user research, data science, and applied statistics, he explores emerging trends to deliver user-centric, future-ready solutions. Afkhami holds a PhD in Civil Engineering from Purdue University, an M.S. in architecture and sustainability studies from the University of Oklahoma, and a B.Arch. from the University of Tehran.

KEY TAKEAWAYS

Mass timber is widely seen as a carbon-neutral alternative to steel and concrete, but uncounted emissions from harvesting and slash management challenge this assumption. Corgan's research highlights the importance of slash management, species selection, and local sourcing—while offering a carbon calculator to help designers make more sustainable timber decisions.

MASTERFORMAT NO.

01 81 13—Sustainable Design Requirements

06 17 00—Shop-Fabricated Structural Wood

UNIFORMAT NO.

B10—Superstructure

KEYWORDS

Division 01, 06
Embodied carbon
Harvesting emissions
Mass timber

Insulated Metal Panels

The Lightweight Heavyweight

By Amanda Storer

PHOTOS BY TOM STOCK PHOTOGRAPHY

Since they first gained serious traction during the post-World War II construction boom, tilt-up concrete walls have been a trusted mainstay in commercial and industrial construction, particularly for warehouses, manufacturing facilities, data centers, storage facilities, and even retail centers.

However, as the pressure to reduce costs, accelerate timelines, and meet ambitious sustainability goals continues to mount, more and more of the architects and contractors driving these types of projects are now turning to high-performance insulated metal panels (IMPs) as a preferred alternative for both exterior cladding and interior firewalls.

The following is a deep dive into the advantages of using IMPs over tilt-up concrete walls, supported by industry data and real-world applications.

Foundation costs

IMPs are lightweight compared to concrete walls, which translates into significant savings at the foundation level. Since concrete tilt-up panels are heavy and dense, they impose a high dead load that requires deeper and more robust foundations (*i.e.* heavier panels mean heavier, more expensive foundations).

For example, since a 152 mm (6 in.) thick, 3 x 7 m (10 x 23 ft) tilt-up panel weighs around 8 tonnes (9 tons), a 30 x 122 x 7 m (100 x 400 x 23 ft) building would need to support roughly 816 tonnes (900 tons) of concrete, requiring expensive site preparation and reinforced foundations. The equivalent building with 51 mm (2 in.) IMPs would only require foundational support for about 25 tonnes (28 tons) of IMPs.

By switching to the much lighter IMPs, builders can use shallower footings, reduce reinforcing steel and concrete volumes, and lower excavation and labor costs. This can be particularly beneficial on sites with challenging soil conditions, high water tables, or other geotechnical constraints.

Lead times and streamlined procurement

Concrete tilt-up systems are subject to longer lead times, particularly during high-demand seasons when concrete plants and crews are booked months in advance. By contrast, IMPs can be manufactured and shipped far more efficiently, thanks to centralized production in specialized facilities, prefabrication based on precise architectural specifications and reduced dependence on weather-sensitive onsite work. This results in faster procurement, reduced schedule risk, and greater predictability for owners and general contractors

Onsite installation and accelerated construction schedules

In addition to the ability to get IMPs to project sites quicker, they are also much easier to install once they are there. IMPs arrive ready to install—with insulation and finished surfaces integrated—and can be erected at a rapid pace. Compared to tilt-up concrete walls, which require casting beds, rebar and formwork setup, pouring, curing, and bracing, and crane-lifted placement. IMPs eliminate most of these time-consuming steps and can typically be installed (by a single crew) in about half the time as a concrete tilt-up system, dramatically accelerating the dry-in process and allowing interior trades to start work sooner.

Fire rating and performance

Fire safety remains a top priority for commercial and industrial buildings. IMPs offer excellent fire performance and code compliance, meeting a wide range of U.S. and Canadian fire standards. Most IMPs are tested in accordance with ASTM E84, demonstrating flame spread indices below 25 and smoke development under 450—key indicators of a material's lower burn rate and smoke production in early fire stages.

When enhanced fire protection is needed, such as in firewall applications or buildings with specific insurance requirements, IMP assemblies can achieve one- to three-hour fire resistance ratings per ASTM E119. These ratings are typically achieved by adding gypsum board layers as specified in UL design listings such as BXUV.U053. IMPs also meet FM 4880 Class 1 fire performance criteria and have been tested to comply with National Fire Protection Association (NFPA) 285, NFPA 286, and *International Building Code* (*IBC*) requirements for foam plastics.

In Canada, IMPs comply with rigorous standards such as CAN/ULC S101 (fire resistance), S102 (surface burning), and S134 (full-scale wall fire exposure). These certifications offer peace of mind for architects and builders needing to meet stringent local and national codes without compromising design flexibility or speed of construction.

While tilt-up concrete panels offer inherent fire resistance due to their mass, achieving equivalent performance with IMPs is achievable as well.

Thermal performance for cold and controlled environments

Another significant advantage of IMPs is their high insulating value, which is especially important for cold storage facilities, food processing plants, pharmaceutical and biotech labs, and data centers.

IMPs can achieve R-values as high as R-7 to R-8 per inch with a foam core, significantly outperforming concrete tilt-up walls, which typically require separate layers of insulation (and additional labor and material) to meet energy codes.

At the Nassau County Police Department, insulated metal panels (IMPs) and integrated design elements create a bold, modern civic presence.

Weather resistance and climate performance

Once installed, IMPs require minimal upkeep. Panels are designed and manufactured for weather resistance. Their resistant exterior keeps moisture out and prevents corrosion, ensuring durability with minimal maintenance throughout the building's lifespan. On the contrary, tilt-up walls can face corrosion and water damage over time. Concrete's biggest drawback is its tendency to absorb moisture, leading to potential problems such as damp odor and mold growth at the base, and rust stains. These issues can add up, diminishing a building's curb appeal and requiring frequent repairs.

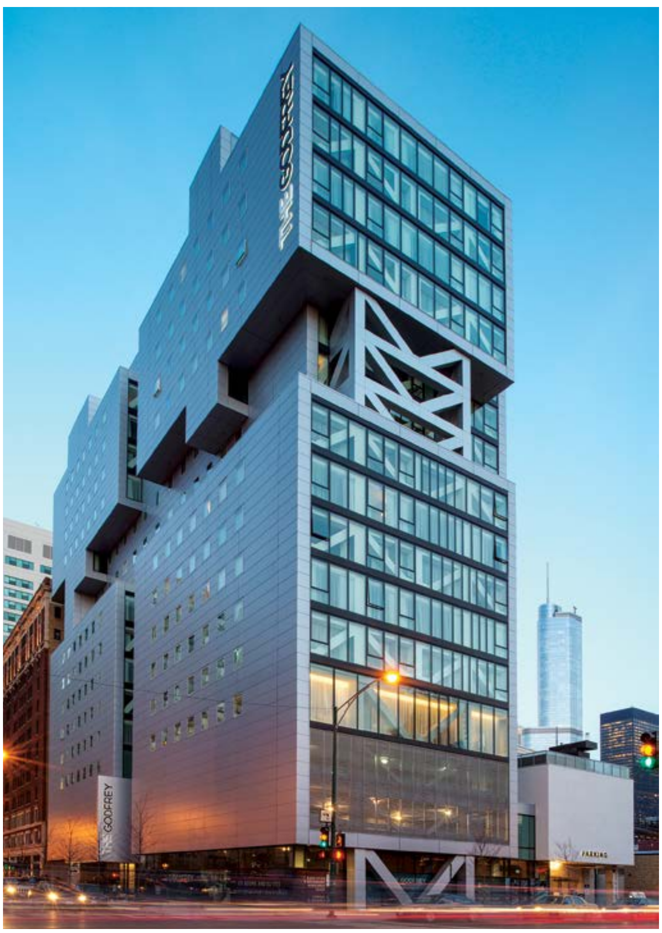
IMPs are also built for all-weather performance, from the hot, humid South to the cold northern regions—aligned with requirements from the *International Energy Conservation Code* (*IECC*) climate zone map. Each zone has specific insulation (R-value) targets, and IMPs can be tailored to meet or exceed them without additional layers or assemblies.

While older testing like ASTM C518 only measures the foam's R-value, modern standards like ASTM C1363 evaluate

PHOTO BY JOHN D'ANGELO PHOTOGRAPHY

At the Flint Cultural Center in Michigan, insulated metal panels (IMPs) deliver a striking presence with long-term durability and minimal maintenance.

PHOTO BY TOM STOCK PHOTOGRAPHY



At the Godfrey Hotel, insulated metal panels (IMPs) deliver a polished facade with clean, contemporary lines.

the entire wall system—including metal skins and joints—giving a more accurate U-factor that reflects real-world energy performance. Leading manufacturers also use computer modeling to ensure code compliance across all climate zones.

In addition to thermal efficiency, IMPs provide strong protection against air, water, and weather with minimal maintenance. Unlike tilt-up concrete, which can absorb moisture and require regular sealing, IMPs resist corrosion, leaks, and temperature-related wear—making them a durable and efficient choice for any region.

Seismic performance

In regions with seismic activity, structural resilience is a critical factor in material selection. While tilt-up concrete walls often serve as part of a building's lateral force-resisting system, IMPs function primarily as cladding and are not typically used to resist seismic loads directly. That said, IMP systems are engineered with features that help maintain envelope integrity and performance during seismic events.

To accommodate building movement, IMPs use slotted or flexible connections that allow panels to shift without compromising the air, water, or thermal barrier. Testing under protocols like ASTM E72, E283, E331, and Fenestration and Glazing Industry Alliance (FGIA)/AAMA 501.7 has demonstrated IMP systems' ability to handle inter-story drift and building racking, ensuring continued weather resistance and envelope performance even in dynamic loading conditions.

While tilt-up concrete panels may have an advantage when used structurally for in-plane seismic resistance, IMPs offer significant benefits in terms of lighter dead loads and adaptability. Their lower mass reduces the seismic forces transferred to the structure, potentially decreasing the demand on structural elements like bracing and footings. As ongoing research explores the diaphragm strength and potential load-transfer capabilities of IMPs, future iterations may further enhance their role in seismic design strategies.

Acoustic performance

As noise control becomes a growing concern in sensitive environments like data centers, manufacturing facilities, and urban warehouses, IMPs offer strong acoustic performance that rivals—and often exceeds—traditional tilt-up systems. IMP assemblies can be engineered to deliver impressive sound transmission class (STC) ratings, with some configurations achieving STC values in the high 50s to low 60s, based on ASTM E90 testing. These high-performance assemblies help contain operational noise and reduce external sound infiltration, a key requirement in many mission-critical applications.

PHOTO BY TOM KESSLER PHOTOGRAPHY

At Myrtle Beach International Airport, insulated metal panels (IMPs) in copper tones create a striking facade that elevates the architectural presence.

For standard applications, individual IMP panels often deliver STC ratings in the mid-20s, which can be sufficient for warehouses or storage facilities where acoustics are less critical. However, with tailored assemblies and additional layers, the acoustic isolation can be scaled to meet more stringent requirements.

Noise reduction coefficient (NRC) for IMP systems varies widely, ranging from 0.1 to 1.05, depending on panel construction, surface finishes, and installation configuration. While NRC and STC values are not always directly correlated, IMPs provide architects and engineers with multiple paths to achieve desired acoustic performance levels without sacrificing thermal efficiency or installation speed. In contrast, tilt-up concrete walls may provide decent mass-based sound control but lack the integrated insulation and modular assembly options available with IMPs.

Reduced embodied carbon

Sustainability is no longer optional. When comparing building envelope materials, IMPs stand out for their lower embodied carbon footprint. In fact, according to research by the Metal Construction Association (MCA), the average embodied carbon value of IMPs is significantly less than that of precast or tilt-up concrete systems—up to 28 percent lower in some cases.

This is largely due to lower raw material weight and volume, a less energy-intensive manufacturing processes and reduced transportation emissions (*i.e.* lighter loads mean less fuel).

Specifically, for builders aiming for LEED certification or other ESG benchmarks, IMPs offer a measurable environmental advantage.

Conclusion

When adding it all up—lower dead loads, faster lead times, quicker installs, and built-in insulation—IMPs provide meaningful savings in both time and money over tilt-up concrete and represent a future-forward choice for developers and designers seeking high-performance, sustainable, and efficient solutions for commercial and industrial buildings.

additional information

AUTHOR

Amanda Storer serves as the western sales manager for Nucor Insulated Panel Group, guiding the commercial sales teams for both Centria and Metl-Span, based in Lewisville, Tex. With full oversight of sales operations across the Western region, she leads initiatives in national account strategy, promotional development, and business acquisition. Backed by more than 15 years of expertise in sales, marketing, product management, and key account management within B2B sectors, Storer brings a dynamic, results-driven approach to advancing growth and customer engagement.

KEY TAKEAWAYS

Insulated metal panels (IMPs) offer lighter loads, lower foundation costs, faster procurement, and easier installation than tilt-up concrete. With superior thermal performance, weather resistance, and reduced embodied carbon, IMPs deliver significant time, cost, and sustainability advantages. For developers and designers, IMPs represent a forward-looking, high-performance alternative for modern building envelopes.

MASTERFORMAT NO.

07 42 13—Metal Wall Panels (Insulated Metal Panels)

UNIFORMAT NO.

B2010—Exterior Walls

KEYWORDS

Division 07
Building envelope
Embodied carbon
Insulated metal panels
Sustainability
Thermal performance

Beyond the Forecast

The Rise of Weather-resistant Systems

By Craig Belrose

PHOTOS COURTESY STO CORP.

General contractors, building owners, and specifiers across the construction industry are familiar with the climate zone map. You know the one with colorful zones swooping across the country. Those colors denote regional norms, some of which include extreme heat, cold, and high moisture. However, the "Acts of God" often seen in the fine print of contracts can occur in any of these zones, at any time, disrupting construction timelines and potentially nullifying contracts. Even without the extreme weather events, environmental concerns have always been a challenge for contractors. Fortunately, building science has heard the call. Innovative products and systems are helping construction teams push past seasonal limitations and stay on track.

As weather extremes become more frequent, manufacturers are developing materials engineered to perform in unpredictable conditions. At the forefront are advanced air and water-resistive barriers (AWRBs), featuring cutting-edge chemistries such as silyl-terminated polyether (STPE) and UV-cured acrylic adhesives. These materials not only withstand winter but also enable construction to continue during this season.

Traditionally, mechanically attached building wraps served the purpose of waterproofing, but today's air, water, and permeance requirements have led to innovation. Thanks to advances in chemistry and adhesive technologies, contractors now have a range of options that cater to various climates, substrates, and installation conditions while reducing or eliminating concerning penetrations from fasteners.

The role of AWRBs

An AWRB is a protective layer that helps prevent air and water infiltration and is a critical component of the complete exterior wall system. While the term "AWRB" is commonly used in the industry to describe products that perform both functions, building codes treat air barriers and water-resistive barriers as separate requirements.

Air barriers are mandated by energy codes such as ASHRAE 90.1 and the *International Energy Conservation Code* (*IECC*) and are referenced in both the *International Building Code* (*IBC*) and *International Residential Code* (*IRC*) through their adoption of these standards. Water-resistive barriers, on the other hand, are required by the *IBC* and *IRC* to protect against bulk water intrusion in most wall assemblies. Depending on the wall system and climate zone, a project may require one or both—making it essential to select materials that satisfy multiple code requirements while also supporting long-term building performance.

Controlling air leakage through the building envelope is crucial for achieving high energy efficiency, while managing moisture is equally important for ensuring durability. The key is selecting the right product for the specific wall system and environmental conditions, but a one-size-fits-all solution does not exist. Top manufacturers offer "complete wall systems" in an effort to provide a variety of AWRB options to match system approvals and project needs. Self-adhered, roll-applied, spray-applied, trowel-applied, acrylic, hybrid, or cementitious—all have a long list of manufacturers for each category. Still, the right choice often depends on application method, system compatibility, and project budgets, in addition to the preferences of architects, building envelope specialists, and specifiers.

Seal it and keep moving

The AWRB installation serves a critical purpose in protecting the sheathing from the weather. It must be installed quickly amidst sometimes challenging environmental conditions. Leading the way in premium AWRBs are liquid-applied hybrids, such as STPE and self-adhered membranes with UV-cured acrylic adhesive. These advanced barriers enable fast installation and effective protection even in less-than-ideal conditions. Once the air and water barrier is installed, a sealed environment is created, eliminating concerns about moisture and condensation affecting materials on the job site.

Cure times and chemistry

Liquid-applied AWRBs cure through different mechanisms based on their chemistry, with the three most common being water evaporation, solvent evaporation, and chemical reaction. Water-based acrylic AWRBs cure as water evaporates from the coating, allowing the polymer particles to fuse into a continuous, protective

film. Temperature, humidity, and airflow can strongly affect dry time. Solvent-based AWRBs, such as asphaltics, depend on the evaporation of carrier solvents, leaving behind a cured polymer layer. They can present challenges related to colder temperatures, substrate adhesion, odor, and VOC compliance. In contrast, reactive or moisture-cure AWRBs, such as silyl-terminated polyether systems, harden through a chemical reaction with ambient moisture, forming a more durable, crosslinked film that is less affected by adverse climate conditions. Challenges may include curing in arid climate zones and cost. Each curing method has its advantages and limitations, and understanding these differences is crucial for selecting the proper product and ensuring a successful installation.

Why is proper curing essential? Since the curing process transforms the wet material into a continuous, durable membrane that provides its intended performance. If curing is incomplete or interrupted, the barrier may stay soft, weak, or tacky, leading to less adhesion, lower water resistance, or higher risk of wash-off. Complete curing allows the material to reach its intended film thickness, continuity, and strength, which are essential for preventing bulk water penetration, stopping uncontrolled air leakage, and supporting long-term flexibility.

STPE in action

STPEs are shaping the next generation of high-performance air and water barriers. These premium, roll-on or sprayable membranes provide excellent adhesion and typically do not require

A vapor-permeable, self-adhered air and water-resistive barrier (AWRB) that delivers fast, primerless application and cold-weather adhesion.

priming for common substrates. STPEs have additional advantages over other products in this premium category, including ease of handling, paintability, low odor, and stable viscosity.

While water-based acrylic AWRBs remain the workhorse of the liquid-applied category, STPE delivers added versatility in challenging environments. STPE moisture-cured formulas do not rely on water evaporation to cure like other products. Where high humidity, low temperatures, and rain defeat other products, STPE thrives. STPEs can be applied in temperatures as low as -6 C (20 F). While they still require the temperature to hit 0 C (32 F) to cure, other chemistries are compromised and never cure properly when exposed to these low temperatures, regardless of how high the temperature subsequently rises. As with any AWRB, the wall system, substrate condition and type, and the environment will guide the choice.

Premium STPEs are formulated for maximum performance, often featuring wider application tolerances, greater movement accommodation, and improved environmental resistance compared to basic STPE chemistries.

Benefits of premium STPEs include:

While all STPEs offer inherent benefits, the best versions enhance these properties and provide unique benefits.

- Moisture cure chemistry—Premium STPEs cure effectively across a broader range of humidity and temperature conditions compared to standard formulas, making them ideal for cold, damp, or humid environments.
- Fast tack-free and cure times—The best formulas minimize the wait between application steps with the lowest tack and cure times.
- Low-odor, low VOC content, and isocyanate-free—A feature of most premium STPE formulations that supports indoor air quality (IAQ) standards and safe application. A tin-free formula is the pinnacle of respiratory safety in spray applications.
- Excellent adhesion to allow primer-free bonding—Bonds effectively to a wide range of substrates without additional surface treatments.
- Low dirt pick-up—Quick skin times keep jobsite applications cleaner and maintain long-term visual appeal.
- Non-sag formula—Maintains shape and coverage on vertical surfaces and in joints without running or slumping. Premium versions require a lower application thickness for performance and opacity.
- Highly resistant to moisture and weathering—Provides robust, long-lasting protection against the elements in all climates.

Adhesives breaking the cold

Innovation is not always obvious; sometimes, it is subtle and hidden in the details. Membrane adhesives, for example, continue to improve as scientists develop application-specific variants. Instead of simply using an adhesive intended for the roof, flashing tape, or below-grade applications, today's self-adhered membranes (SAMs) are being developed to achieve excellent and targeted performance in the vertical wall space. Increasingly demanding building codes,

Applied in temperatures as low as -6 C (20 F), a moisture-cured, fluid-applied air and water-resistive barrier (AWRB) is specifically designed for use in humid and damp conditions.

environmental concerns, and sustainability requirements have driven innovation. UV-cured acrylic adhesive is a good example and a leading choice for SAMs in low-temperature applications, offering very aggressive adhesion and primerless compatibility with most substrates.

Most common adhesives for SAMs

Best—Acrylic. Typically comprised of acrylic or methyl acrylic polymers, these adhesives are renowned for their cohesive properties, strong adhesion, and primerless application. Three main types: UV-curable, solvent-based, and water-based.

Better—Butyl. Made of specialized, synthetic rubber, this adhesive was designed to combat the disadvantages of natural rubber adhesives.

Good—Asphaltic. Initially used in roofing applications, this cost-effective option offers good adhesion but provides a limited temperature window for application. It may require primers on many common substrates and can have limited UV exposure times.

Benefits of SAMs

- No cure time—Full adhesion is achieved once the adhesive is activated through pressure rolling. Immediate waterproofing.
- Consistent quality—Factory-controlled production ensures uniform membrane thickness and reliable performance across every roll.
- Fast installation—The peel-and-stick design simplifies application, making it ideal for large field areas and time-sensitive projects.
- Equipment-free— Eliminates the need for on-site sprayers or mixers, reducing setup time and the potential for equipment failures in cold conditions.
- Durable seams—Delivers excellent seam integrity and long-term protection against air and moisture intrusion. Many SAMs do not require pre-treat static joints and seams.
- UV and weather resistant—Withstands exposure during construction and provides lasting performance in demanding climates.
- Available in vapor-permeable or non-permeable versions—Allows design team to select the right vapor control strategy based on climate and wall assembly needs.

Additional benefits of premium SAMs with UV-cured acrylic

- Ultra-cold weather application—Can be applied and maintain adhesion at low temperatures and on damp surfaces.
- Primerless application—Strong bond to most common substrates without the need for primers, thereby reducing installation time and material costs.
- Very aggressive adhesion—Confident bond even to imperfect and porous substrates.
- Ideal for hybrid systems—Easily integrates with fluid-applied materials for a comprehensive, cold-weather-ready AWRB solution. Premium acrylic SAMs have compatibility with many liquid-applied detail components, including STPE chemistries.

Design flexibility with cold-weather barrier systems

Today's AWRB options perform beyond compliance with performance standards—they support greater design flexibility across climates and various construction types. Both fluid-applied and self-adhered barriers are available in vapor-permeable and non-permeable formulations, allowing architects to align AWRB performance with the wall assembly's intended drying potential.

STPE-based fluid-applied systems adapt easily to complex geometries, irregular penetrations, and dynamic joints, which are ideal for expressive facades or buildings with movement demands. Meanwhile, premium self-adhered membranes provide clean, uniform application over large field areas and simplify transitions in hybrid wall systems. With a range of adhesive chemistries, curing profiles, and compatibility-tested components, these systems give design teams the flexibility to meet both aesthetic and environmental goals without sacrificing constructability.

Total system compatibility: When materials work together

Details matter. Liquid-applied and self-adhering membrane AWRBs provide the majority of the protection. However, the compatibility of detailing components is critical to overall system integrity. Compatibility amongst products depends on factors such as material chemistry, adhesion properties, and substrate conditions. Proper integration requires careful selection of products from manufacturers who test and approve their materials for combined use, ensuring chemical compatibility and cohesive bonding. Compatibility between these materials is critical at transitions, rough openings, joints, and terminations to prevent failures that compromise performance and longevity. When compatible, a combination of liquid-applied and self-adhered components can deliver the best of both worlds. Liquid-applied components are well-suited for complex shapes, corners, and penetrations. Self-adhered membranes are particularly effective for covering large areas, quick seam work, gap bridging, and joints, especially in field conditions where substrate irregularities or misalignments may be common. Both can work synergistically, combining the flexibility and seamless coverage of liquid-applied systems with the robust, pre-engineered qualities of self-adhered membranes to create a durable and efficient wall assembly.

Testing for cold-weather AWRBs

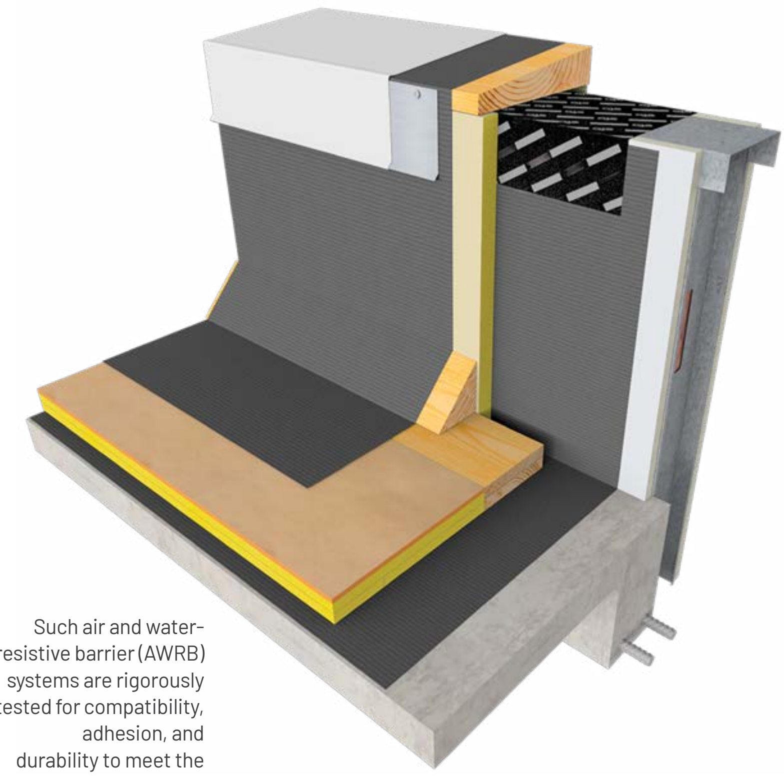
Industry standards give everyone peace of mind. Whether developing a full-field AWRB or a detailing and flashing component, manufacturers are required to pass a significant number of tests. For cold weather, there is no single ASTM or AAMA (FGIA) standard dedicated exclusively to cold-weather applications. However, several relevant standards and guidelines address aspects such as low-temperature flexibility, adhesion, and overall durability, which are critical for AWRBs used in cold climates. Key standards and references include ASTM, AAMA, and ICC-ES. Some of the key tests that are indirectly related to cold-weather performance include:

ASTM standards

These standards test characteristics that are indirectly related to cold-weather performance:

A non-permeable self-adhered that delivers continuous air and water-resistive protection, along with the added benefit of vapor barrier performance, making it ideal for wall assemblies that require inward vapor control.

- ASTM D1970—*Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection.* Includes low-temperature flexibility and adhesion testing. Often referenced for cold-climate membrane performance, particularly in roofing applications, it is also relevant to wall applications.
- ASTM C1305—*Standard Test Method for Crack Bridging Ability of Liquid-Applied Waterproofing Membranes*. Measures a material's ability to stretch and remain intact at low temperatures (down to -15 C [5 F] or lower). Relevant for liquid-applied AWRBs in freeze/thaw conditions.
- ASTM D903—*Standard Test Method for Peel or Stripping Strength of Adhesive Bonds*. Used to test the peel adhesion of self-adhered membranes. Can be modified for low-temperature conditions to evaluate cold-weather adhesion performance.
- ASTM C836/C836M—*Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course*. Includes some cold-weather material performance characteristics, though not focused on vertical wall AWRBs.
- ASTM E2357—*Standard Test Method for Determining Air Leakage of Air Barrier Assemblies.* Measures whole-system air leakage, but not temperature-specific; however, it is often repeated after environmental conditioning, including cold.



Such air and water-resistive barrier (AWRB) systems are rigorously tested for compatibility, adhesion, and durability to meet the demands of year-round construction—even in extreme weather.

- ASTM D3330 (tape adhesion) or ASTM D903—Some manufacturers perform modifications at subfreezing temperatures to support cold-weather use claims.

AAMA standards

- AAMA 711—*Voluntary Specification for Self-Adhering Flashing Used for Installation of Exterior Wall Fenestration Products.* Tests include adhesion at room and low temperatures (*e.g.* 18 C [0 F]). Typically used to evaluate membrane flashings used with AWRBs.
- AAMA 714—*Voluntary Specification for Liquid-Applied Flashing Used to Create a Water-Resistive Seal Around Exterior Wall Openings in Buildings.* Includes evaluation of durability and application in varied conditions.

ICC-ES

ICC-ES evaluation Reports, referred to as ESR reports, often include proprietary cold-weather adhesion and application temperature limits, as no mandatory standard requires all products to pass a specific cold-weather test.

In summary, manufacturers validate performance through internal testing and evaluation reports, often supplementing existing standards with cold-weather conditions. For confidence, specifiers should use trusted and reputable manufacturers and consult ICC-ES reports, technical data sheets, and project-specific mock-up testing under realistic environmental conditions.

Building without pause

The construction calendar no longer follows the seasons. With the right materials and application strategies, teams can overcome traditional limitations and keep jobs on track and on time throughout the year. Advanced AWRBs, such as STPEs and UV-cured acrylic SAMs, are more than just seasonal workarounds; they form the foundation of smarter, more resilient building envelopes.

Extreme weather may be unpredictable, but a project does not have to be.

additional information

AUTHOR

Craig Belrose is a senior product manager at Sto Corp., headquartered in Atlanta, Ga. He specializes in the StoGuard family of air and water-resistive barrier (AWRB) systems and supports the StoVentec Rainscreen Systems and Prefabricated Wall Panels business units. With more than 25 years of experience in the plastics industry and 12 years in roofing membrane development, Belrose brings deep expertise in product innovation, building envelope solutions, and materials science. His leadership helps drive advancements in high-performance, durable, and energy-efficient construction technologies.

KEY TAKEAWAYS

Extreme weather challenges construction timelines, but advanced air and water-resistive barriers (AWRBs) keep projects moving year-round. Innovations such as silyl-terminated polyether (STPE-based) liquid-applied systems and UV-cured acrylic self-adhered membranes deliver strong adhesion, fast curing, and cold-weather performance. Together, they ensure durability, energy efficiency, and code compliance while enabling flexible, resilient building envelopes.

MASTERFORMAT NO.

07 25 00—Weather Barriers
07 27 00—Air Barriers

UNIFORMAT NO.

B2010—Exterior Walls

KEYWORDS

Division 07
Air and water-resistive barriers (AWRBs)
Self-adhered membranes (SAMs)
Silyl-terminated polyether (STPE)
Weather-resistant systems

Burn to Last

Yakisugi's Architectural Comeback

By William Beleck

PHOTOS COURTESY NAKAMOTO FORESTRY

The use of wood as a building material has evolved with human innovation and civilization—from early shelters to complex architectural forms such as temples. As construction techniques have advanced, so have methods for preserving and enhancing wood's natural properties. One such innovation is *yakisugi*, a traditional Japanese charred wood siding material. Historically only for thin plank wall and ceiling cladding, it is now steadily gaining traction in the global architectural community.

The history of *yakisugi*

One of the oldest known methods for manipulating and enhancing wood is fire treatment, a technique that dates back thousands of years, as evidenced by archeological discoveries all over the world. One of the most common examples is early humans using fire to harden wooden tools. Boatbuilders also adapted a technique using flames to bend wood planks to form the hulls of boats.

In Japan, charred wood, known as *yakisugi*, has been used as a siding material for several centuries. Traditional Japanese builders understood that this flame-treated wood had several longevity advantages over untreated wood. At the same time, it had a unique aesthetic beauty that changed over time as it weathered.

What is *yakisugi*?

Yakisugi refers to *sugi* wood that has been intensely burned. *Yaki* means burnt or charred and *sugi* is a species of indigenous Japanese cedar (*Cryptomeria japonica*).

Like all wood, *sugi* is primarily made up of the structural component lignin. It also contains hemicellulose carbohydrates—a material that serves as food for fungi and insects, as well as fuel for fire. The charring process used for manufacturing *yakisugi* burns off the hemicellulose, leaving behind only the lignin and a layer of soot. This transformation provides protection from fire, repels pests, and resists a wide range of weather damage, making it an ideal building material for wall, fence, and soffit cladding installations.

Sometimes referred to as *shou sugi ban* outside of Japan, *yakisugi* is becoming a popular choice for siding and paneling in modern commercial construction projects—and for good reason.

Spanning 150 m (500 ft), the Discovery Center's *yakisugi* facade and site wall transforms charred wood into a bold urban landmark.

PHOTOS ©2025 HALKIN MASON PHOTOGRAPHY LLC.

Durability

With proper manufacturing and installation, authentic *yakisugi* is estimated to last as long as 80 to 150 years without any maintenance. The charring process not only hardens the wood against pests and environmental forces, but it also protects it from UV damage. *Yakisugi's* carbonized surface both absorbs and deflects harmful radiation, preventing it from penetrating and breaking down the lignin within the wood.

Yakisugi's exceptional durability significantly enhances its sustainability profile, reducing the need for frequent replacements and minimizing material waste over time.

Sustainability

Wood is inherently a carbon-negative material. During growth, trees absorb CO2 from the atmosphere through photosynthesis and store it in their fibers. When the wood is harvested and used in construction, the carbon remains sequestered within the material, preventing it from re-entering the atmosphere.

Sustainably sourced timber is crucial to ensuring the environmental benefits of *yakisugi*. Leading manufacturers use selective thinning techniques rather than clear-cutting, maintaining forest health and promoting long-term resource regeneration. Suppliers who are dedicated to providing a sustainable alternative to carbon-intensive, engineered products also pursue a chain of custody audited sustainability certification. Environmental Product Declarations (EPDs) and Carbon Footprint (CFP) standards also verify their materials' environmental impact.

Economic value

From a financial perspective, *yakisugi* offers significant savings. It costs less than many other high-end wood siding options and approximately half as much as traditional brick or stone facades. *Yakisugi's* durability reduces the frequency of repairs and replacements versus untreated wood. With minimal maintenance requirements, such as the absence of regular refinishing or sealing, it can yield substantial long-term cost benefits for building owners and developers.

Aesthetics

Beyond functional advantages, *yakisugi* is prized for its striking appearance. The precise milling and charring processes used to produce authentic *yakisugi* accentuate the wood's natural grain, resulting in a distinctive textured finish. Depending on the desired look, *yakisugi* can be surface brushed to remove varying degrees of soot. When the soot layer is left intact, the surface has a near-black color with an alligator-skin-like

Charred *yakisugi* cladding in black and silver creates a striking exterior for the Gladys Valley Marine Studies Building, echoing nature and sea.

PHOTOS COURTESY NAKAMOTO FORESTRY

texture. Removing most of the soot layer, on the other hand, reveals a unique striped grain pattern.

In addition to its textural variety, *yakisugi* can be customized with a range of stains, enhancing its aesthetic versatility while providing color consistency and longevity. When left unoiled, as is the tradition in Japan, *yakisugi* develops a beautiful patina over time, further enhancing its character as it weathers in response to environmental conditions.

Real-world applications of *yakisugi*

The myriad benefits of *yakisugi*—its durability, sustainability, economic value, and striking aesthetics—make it an attractive option for modern construction. These qualities are being harnessed in innovative projects that not only showcase the material's potential but also highlight its adaptability in various architectural contexts. The following case studies illustrate the successful application of *yakisugi* in contemporary design, demonstrating how this age-old material is being reimagined in today's built environment.

Gladys Valley Marine Studies Building

Oregon State University's Gladys Valley Marine Studies Building is a 14-m (47 ft), 2,800-m^2 (30,000-sf) academic and research facility located on the coast of Oregon in a tsunami inundation zone. Designed by Integrus Architecture to withstand a 9.5 magnitude earthquake, it is twice its height below ground and incorporates state-of-the-art architectural and engineering techniques to meet unprecedented resilience goals. It also serves as one of the first vertical evacuation tsunami sites in the U.S.

Yakisugi was chosen for the exterior cladding due to its resilience to the region's wet and windy coastal climate. The majority of the cladding consists of *yakisugi* that has been brushed once to remove some of the soot layer and finished with the manufacturer's proprietary acrylic black stain for maximum color longevity. As an accent, the design also incorporates *yakisugi* that has been brushed twice to remove most of the soot layer and then finished with a silver stain. This provides tonal and textural contrast, creating a visually striking exterior.

The primary driver in specifying *yakisugi* was the Tohoku earthquake and tsunami in 2011. At the time of design, debris from the disaster was washing up on Oregon's beaches. As the project site lies in a tsunami zone, the designers chose the traditional Japanese material—known for its resiliency—as both a practical and symbolic response, honoring nature and the region's marine heritage.

Kure City Civic Center

Designed by Japanese firm Kengo Kuma and Associates, the Kure City Civic Center is an example of modern architecture deeply rooted in Japanese heritage. Situated on the coast of Japan's Seto Inland Sea, this public facility serves as a branch of city hall, a community center, and a library.

The exterior walls are clad in *yakisugi*, which was brushed once and prefinished with a black stain. The *yakisugi* boards were installed horizontally in a shiplap pattern, with each bottom edge set over the top of the board below to create

Yakusugi's weather-resistant finish helps safeguard Oregon State's tsunami-resilient Marine Studies Building while honoring traditional craft.

subtle depth and shadowing. Thin, vertical cross-pieces were added in a random rhythm to mimic the waves of the nearby sea, connecting the structure to the region's natural beauty.

Beyond its visual appeal, *yakisugi* was an ideal material choice for this coastal location due to its natural resistance to rot, salt, and humidity. It is also most commonly used in the Kure region, making it a vernacular material choice.

Discovery Center

Located in Philadelphia's Strawberry Mansion neighborhood, the Discovery Center is a unique urban sanctuary that serves as both a bird habitat and leadership development facility. A collaboration between the Audubon Society of Pennsylvania, Outward Bound Philadelphia, and the local community, the center, designed by DIGSAU, hosts diverse programming aimed at connecting city residents with nature. The project site surrounds a decommissioned 14-ha (37-acre) reservoir, helping to revitalize an integral part of the city's 19th-century water infrastructure for public use.

The design of the Discovery Center integrates *yakisugi* for its main facade and site wall, spanning 150 m (500 ft). This charred wood cladding was chosen for its ability to balance natural beauty with urban durability. In addition to its striking aesthetic appeal, the *yakisugi*, which was sourced from sustainably managed timberland, also aligns with the center's environmental mission. This design choice underscores the center's commitment to nature and contributes to the long-term preservation and accessibility of this important urban green space.

Considerations when choosing *yakisugi*

When sourcing *yakisugi*, it is essential to thoroughly research the manufacturer to ensure the authenticity and quality of the product. Authentic *yakisugi* can only be crafted from native Japanese *sugi* (*Cryptomeria japonica*). This species possesses high mineral content and low resin levels, making it naturally rot-resistant and exceptionally well-suited to a deep-burning process.

Consider the manufacturer's processes, including their approach to heat treatment and millwork. Some treatments are superficial, aiming primarily at achieving an aesthetic char layer. While this method may create an appealing look initially, it lacks the structural benefits of authentic *yakisugi*'s deep heat treatment, which case-hardens the wood for extra durability. Additionally, expertly milled *yakisugi* has increased weather resistance, particularly valuable for exterior applications.

Lastly, evaluate the coating options, which dictate how the *yakisugi* aesthetically ages. For those seeking a living finish, unoiled *yakisugi* will naturally patina over time, gradually evolving in color and tone depending on environmental conditions. Alternatively, coatings offer a broad range of colors and transparencies, allowing for diverse aesthetic outcomes—from a subtly evolving, organic patina to an architectural-grade, colorfast finish.

Tips for proper installation

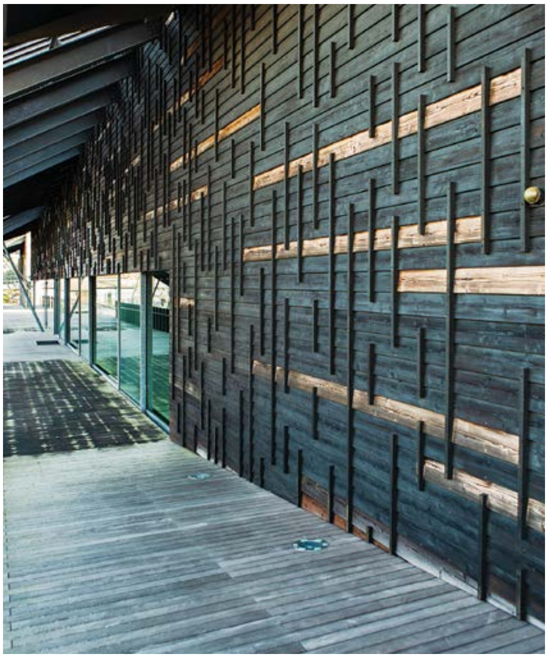
Maximizing the benefits of *yakisugi* requires proper installation. Prior to installation, *yakisugi* boards should be acclimated at the site to adjust to local humidity and temperature conditions. To

Kengo Kuma's Kure City Civic Center features *yakisugi* cladding arranged to mimic the waves of the Seto Inland Sea.

prevent warping or other moisture-related issues, the wood should be stored out of direct sunlight and rain, but with ample ventilation.

Once acclimated, exterior *yakisugi* should be installed as part of a rainscreen assembly. A rainscreen is a system designed to create an air gap between the siding and the underlying weather-resistant barrier (WRB). This ventilation prevents moisture build-up, which can lead to fungal growth and long-term damage to both the siding and the building's structure.

For best results, use a solid wood or engineered furring screen wall assembly with a furring layout of 406-mm (16-in.) on center (o.c.) and two-headed face fasteners per row. While the upfront cost of installing a rainscreen may be higher, it is a small long-term investment compared to the potential costs of remediation and health risks from mold exposure.



Horizontal *yakisugi* siding with rhythmic vertical accents ties the Civic Center's design to its coastal setting.

additional information

AUTHOR

William "Bill" Beleck is the president of Nakamoto Forestry North America. Raised in Texas and Oregon, he graduated from the University of Oregon and Keio University in Tokyo. As a fourth-generation carpenter, Beleck developed a strong passion for woodcraft, which deepened during his studies in Japan. There, he gained firsthand experience of traditional Japanese woodworking. He spent several years working in a family remodeling business before managing machinery distribution for a Japanese multinational corporation. After discovering the authentic Japanese *yakisugi*. Beleck partnered with Nakamoto Zourin, one of the world's largest *yakisugi* manufacturers, to launch Nakamoto Forestry North America in 2016.

KEY TAKEAWAYS

Yakisugi, a traditional Japanese charred wood material, has enhanced durability, sustainability, and aesthetics compared to unburned wood. By burning away hemicellulose, it resists fire, pests, and weathering while reducing maintenance costs. Increasingly used in modern architecture, it offers longevity, eco-benefits, and striking visual appeal, making it a sustainable alternative to conventional cladding materials.

MASTERFORMAT NO.

07 46 23—Wood Siding

UNIFORMAT NO.

B2010.10—Exterior Wall Cladding

KEYWORDS

Division 07
Architectural wood panels
Charred wood
Fire-treated wood
Yakisugi

Back To Basics

Understanding Sprayfoam Insulation

By Maxime Duzyk

PHOTOS COURTESY HUNTSMAN BUILDING SOLUTIONS

Spray polyurethane foam, also referred to simply as sprayfoam, is commonly used across the United States in a wide variety of commercial building projects as insulation. Professionally spray applied by trained contractors, the material is used in both new construction and in retrofit projects across most major real estate types, including office, retail, industrial, mixed-use, agricultural, institutional, and apartment (as well as in for-sale residential) properties.

Notably, the range of spray polyurethane foam insulation available for specification has shifted over the past few years. Many traditional and long-standing sprayfoam insulation systems have been eliminated from production and sale, specifically within the United States. The phased-out sprayfoam insulations are those produced using hydrofluorocarbons (HFCs).

The challenge with HFCs

HFCs are a group of organic compounds composed of hydrogen, fluorine, and carbon. These have been widely used in a range of cooling systems (including refrigerators, freezers, and automotive air conditioning units), as well as in the blowing agents used in the production of polymer foams (including sprayfoam insulation),[1] aerosols, and fire extinguishing systems. A blowing agent is the substance that produces the cellular structure of the foam during the foaming process, which then leads to the foam hardening (*i.e.* curing).[2]

HFCs are considered greenhouse gases (GHGs) with high global warming potential (GWP). Greenhouse gases trap heat in the atmosphere and while HFCs typically emit in lower quantities in comparison to other greenhouse gases, they are potent and thus considered high-GWP gases. This is because for a given amount of mass, they trap substantially more heat than CO_2.[3] These factors have led to ongoing concerns about the negative impacts of HFCs on the environment, especially as economic growth spurs demand for increased usage.[4]

The HFC ban explained

Mandated by the U.S. Environmental Protection Agency (EPA) as of January 1, 2025, certain technologies may no longer use high-GWP HFCs or HFC blends. The prohibition encompasses the manufacture, distribution, sale, installation, import, and export of products containing restricted HFCs as well as the installation of new systems that use restricted HFCs.[5] This ban necessitated the U.S. market's at-large sunsetting of spray polyurethane foam insulations with HFC-based blowing agents.

The ban necessitates contractors to work with other sprayfoam systems, while delivering a silver lining to specifiers, architects, builders, and the end users of buildings. Each group now benefits from newer generation spray foams with reduced environmental impacts. Spray polyurethane foam insulations with HFC-based blowing agents have been fully replaced in the U.S. with sprayfoam insulations using hydrofluoroolefin (HFO-based) blowing agents. HFOs are compounds consisting of hydrogen, fluorine and carbon, and typically have very low GWPs.[6]

Specifying sprayfoam insulation

Even with the removal of HFC sprayfoam insulation from the marketplace, there are still numerous options to choose from when specifying materials for a commercial building project, whether new construction or retrofit. All sprayfoam insulation options will fall into two major categories: open- or closed-cell sprayfoam. No matter the category, all options are designed to perform as both thermal insulation and an air barrier. Closed-cell spray foam insulations take that a step further, functioning as a combined one-product solution for thermal, air, and moisture control in the building envelope.

When professionally installed by a sprayfoam contractor, sprayfoam insulation adheres to most typical construction substrates, expanding in place where applied and sealing the building envelope. Substrates that would be difficult to adhere to are surfaces that are wet, dirty, or have a wax/resin finish.

The following is a review of the open- and closed-cell sprayfoam categories with guidance, common application uses, characteristics, and additional considerations for each. Notably, density and cell structure vary between open- and closed-cell sprayfoam, and these two factors impact both performance and uses.

A sprayfoam contractor applying closed-cell sprayfoam in a ground-level application aimed at preventing harmful radon gas from infiltrating the structure.

Open-cell sprayfoam insulation

Open-cell spray polyurethane foam systems are lower-density foam options with an open-cell structure. The density of open-cell foams is approximately 0.5 to 1.4 lb/cf (8 to 22 kg/m^3), and the cell structure and density properties make these foam options more flexible or spongy to the touch compared to closed-cell alternatives.

Open-cell sprayfoams improve the energy efficiency of the building enclosure. The escape of conditioned air inside the structure (such as when indoor air was heated during cold months or cooled during warm months) is reduced. This, in turn, lowers the consumption of energy required by the structure to reheat or recool the air.

Additional considerations for open cell specification

Sound attenuation—One attribute specific to open-cell sprayfoams is sound attenuation. When installed in a structure, open-cell sprayfoam insulation reduces the detectable magnitude of noise present on the other side of the wall. Thus, if there is loud noise in the street, it is much less likely to be heard indoors if the insulation is installed in the building enclosure. If the material is installed in an interior wall, noise will be less detectable in the adjacent room on the other side of the partition wall.

Vapor permeability—Vapor permeability is another primary difference between open- and closed-cell sprayfoams. With higher vapor

Open-cell sprayfoam insulation installed in a commercial building.

permeability, open-cell sprayfoams more freely release any vapor they absorb. This characteristic makes them much more suitable for interior applications, including installation in interior walls and ceilings, where water exposure risk is low and in warmer climates where vapor barriers are not required. Closed-cell spray foam, on the other hand, is better for controlling moisture and acting as a vapor barrier, therefore more suitable for colder climates where a vapor barrier is required and energy efficiency requirements are higher.

Closed-cell sprayfoam insulation

Closed-cell sprayfoam insulations are medium-density options, measured at 1.5 to 2.3 lb/cf (24 to 37 kg/m^3). As the name implies, the cell structure of this category of foams is closed. These sprayfoams are significantly more rigid than open-cell foams.

The structure and density of closed-cell spray foams are physical attributes that help them achieve a higher R-value per inch (or RSI value per mm) than their open-cell counterparts. The greater the insulation's R-value (or RSI value), the measurement of an insulation's resistance to conductive heat flow, the more effective the material. Thus, closed-cell spray foams provide greater thermal insulation performance than open-cell options.

The advised R-value (or RSI value), or amount of insulation needed to be applied in any given structure depends on the climate zone, capabilities of the HVAC system, and location in the structure where the insulation will be installed.[7] The *International Energy Conservation Code* (*IECC*), provides a map of climate zones by U.S. counties and territories with designations for each. It also offers product rating, marking and installation requirements for insulation (and other materials).[8]

Closed-cell sprayfoam insulation is ideally suited for use as continuous insulation (c.i.) to reduce or even eliminate thermal bridging. The material can be used in both interior and exterior applications where it replaces commonly used rigid extruded polystyrene insulation (XPS), mineral wool, and polyisocyanurate (polyiso) foam boards. It offers low water absorption and mold resistance, as demonstrated with ASTM C1338. Closed-cell sprayfoam excels as a water-resistant barrier on exterior applications and is tested in accordance with ASTM E2357 with a pressure up to 300 Pa (6.2 pfs) for air barrier assemblies, which includes the ASTM E331 (AC71) water penetration testing. The result was no leakage through the sprayfoam.

Additional considerations for closed-cell specification

Flood resistance—FEMA rates closed-cell sprayfoam insulation a Class 5 material, the highest classification for products indicating strong resistance to floodwater damage, specifically when the material is applied in walls, ceilings, and floors. Class 5 materials do not require special waterproofing protection, can survive wetting and drying, and may be cleaned after a flood to free them of most harmful pollutants.[9] Due to these attributes, closed-cell sprayfoam saves time and money for owners of sprayfoam-insulated commercial structures, which have experienced flooding. Notably, the FEMA Class 5 rating applies when the closed-cell sprayfoam is installed as either cavity insulation or as c.i. The material is also the only cavity insulation approved by FEMA with the highest floodwater resistance. When applied under slab as insulation, closed-cell sprayfoam is also flood-resistant.

Vapor requirements—Closed-cell sprayfoam insulation installed at a thickness of 25.4 mm (1 in.) meets Class II vapor requirements for colder climates. Therefore, it removes the need for an additional vapor barrier when Class II is required.

Radon prevention—The leading cause of lung cancer in non-smokers in the United States is exposure to radon, a naturally occurring radioactive gas that occurs when uranium in soil and rocks breaks down. Outdoors, there is little human health risk posed by radon, however, the gas can accumulate in buildings and homes, especially in basements and on ground levels, if it seeps into the structure.[10] Closed-cell sprayfoam insulation can be used to prevent the gas from entering the structure at common points of entry in a seven-step process that includes: subfloor preparation, installation of a depressurization pipe, installation of water drains, installing closed-cell sprayfoam insulation to act as an air barrier, sealing joints with the sprayfoam, sealing all openings and penetrations with the sprayfoam, and installing a sealed lid on sumps.

Structural strength and wind resistance—When installed, closed-cell spray polyurethane foam insulation essentially glues the assembly together, reducing potential for movement and adding an approximate tensile strength in the range of 103 to 172 kPa (15 to 25 psi).[11] Installed in above-grade walls, the material can also increase wind resistance. The degree of hardening primarily depends on the initial strength of the structure. As a comparison, an I-beam modular constructed metal building with a 22-gauge metal panel will benefit much less from an interior application of closed-cell sprayfoam than a post-frame constructed building with 29-gauge corrugated metal panels.

In 1992, 1996, and 2007, the Spray Polyurethane Foam Alliance (SPFA) completed racking performance tests at Architectural Testing, Inc. in Pennsylvania. The testing demonstrated that medium-density closed-cell sprayfoam installed at 32 kg/m^3 (2.0 lb/cf) increases racking strength by 70 to 200 percent in wall assemblies sheathed with oriented strand board (OSB), plywood, gypsum wallboard, vinyl siding, and polyiso board. The research also proved closed-cell SPF improved the rack and shear strength in wood and metal construction. Installed sprayfoam also increases the strength of weaker variety substrates, including gypsum drywall, vinyl siding, and polyiso foam insulation, to a larger degree than stronger substrates such as OSB and plywood. Special wind resistance bracing is also not required to strengthen when applying the material to walls.[12]

A professional sprayfoam contractor installing closed-cell sprayfoam insulation into a metal construction building.

Closed-cell sprayfoam insulation applied in a metal construction building.

Pests, pollution, and allergens—Due to its sealing capabilities, closed-cell sprayfoam insulation reduces the number of pests (*e.g.* insects), harmful pollutants, and allergens that can enter the structure. Additionally, it acts as a secondary water barrier, protecting the structure and its users from mold and mildew formation.

Closed-cell sprayfoam applied in a commercial building.

When considering spray polyurethane foam insulation for commercial projects, it is always advisable to review the attribute and performance characteristics of the various options against the project's building envelope performance goals, climate zone and weather considerations, budget, and any other project parameters. Some sprayfoam insulation applications can reduce the number of other materials needed for specification, while other options may provide different benefits such as noise reduction. A variety of options are available to meet specific needs.

Notes

[1] See britannica.com/science/hydrofluorocarbon

[2] Refer to sciencedirect.com/topics/materials-science/blowing-agent

[3] Learn more at epa.gov/ghgemissions/overview-greenhouse-gases

[4] See epa.gov/snap/reducing-hydrofluorocarbon-hfc-use-and-emissions-federal-sector-through-snap

[5] Review epa.gov/climate-hfcs-reduction/technology-transitions-hfc-restrictions-sector

[6] See sor.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&vocabName=Ozone%20Protection%20Glossary

[7] Refer to energy.gov/energysaver/insulation

[8] See the code at codes.iccsafe.org/content/IECC2021V1.0/chapter-3-ce-general-requirements

[9] Refer to FEMA, Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program, Technical Bulletin 2, August 2008

[10] Visit cancer.org/cancer/types/lung-cancer/causes-risks-prevention/risk-factors.html

[11] Refer to Honeywell, Insulation and Waterproofing for Metal Buildings and Metal Roof Systems: The Case for Using Better Insulation and Waterproofing Technologies in Metal Roof Systems and Metal Buildings.

[12] See Architectural Testing, Performance Test Report Rendered to Spray Polyurethane Foam Alliance, Project: Racking Load Tests, 2007.

[13] To learn more about open- and closed-cell density range, refer to *The Construction Specifier*, "Navigating the Different Densities of Sprayfoam," from the September 2017 issue.

additional **information**

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KEY TAKEAWAYS

Spray polyurethane foam (SPF) insulation is widely used in U.S. commercial and residential projects. With the Environmental Protection Agency's (EPA's) 2025 hydrofluorocarbon (HFC) ban, only low-global warming potential (GWP) hydrofluoroolefin (HFO)-based sprayfoams remain. Open- and closed-cell systems provide insulation, air sealing, and performance benefits, with closed-cell delivering higher resistance values, moisture protection, and structural strength.

MASTERFORMAT NO.

07 21 29—Sprayed Insulation

UNIFORMAT NO.

B2010.20—Exterior Wall Insulation

KEYWORDS

Division 07
Closed-cell sprayfoam
Open-cell sprayfoam
Spray polyurethane foam (SPF)

All cracked up: Assessing and repairing deteriorated concrete

Deteriorated concrete is frequently encountered in existing structures and can result from several causes. Given the potential consequences associated with such conditions, it is necessary to understand the appropriate steps for assessing and remediating concrete exhibiting various types and degrees of deterioration.

One of the most common causes of concrete deterioration in older structures is the corrosion of embedded steel reinforcing bars due to exposure to moisture. Corrosion can be further promoted by the presence of chlorides at the depth of the embedded steel. Carbonation, the absorption of atmospheric CO2 into the concrete through water or air, can also diminish the concrete's natural alkaline properties that protect embedded steel from corrosion and contribute to it.

Structures such as bridges and parking garages are especially vulnerable, as they are exposed to the elements and deicing salts (chlorides) during winter. Moisture and chlorides can migrate into the concrete through absorption, cracks, or failed or inadequate coatings or sealants, promoting the corrosion of the embedded steel. When corrosion occurs, it produces an expansive byproduct as the steel oxidizes. Confined by the surrounding concrete, this buildup of corrosion product exerts expansive forces against the concrete, leading to cracks, spalls, and delamination. This process further exposes the reinforcement to additional moisture and possibly chlorides, typically accelerating deterioration and potentially reducing the structural capacity due to the loss of cross-sectional area of the steel reinforcement.

In addition to corrosion of steel reinforcement, concrete deterioration can also result from less obvious causes such as alkali silica reaction (ASR), freeze-thaw distress, as well as design and construction issues (*e.g.* improper mix design, placement, or curing), or a combination of these factors.

Evaluation of deteriorated concrete requires the expertise of a structural engineer familiar with such conditions. Typically, a visual condition assessment, combined with mechanical sounding of the concrete, is conducted to determine the nature and extent of the deterioration. Concrete core samples are often removed for laboratory analysis to understand the deterioration mechanisms better. Laboratory analysis to determine compressive strength, determine depth of chloride and/or carbonation ingress, and petrographic studies of the concrete samples can be performed.

figure 1

PHOTO COURTESY WISS, JANNEY, ELSTNER ASSOCIATES (WJE)

Concrete deterioration at the underside of the concrete slab due to corrosion of embedded steel reinforcement.

Once the mechanisms and extent of deterioration have been characterized, an appropriate repair strategy can be developed. Although repair methods may differ depending on the cause(s) of the deterioration, a common approach involves removing the deteriorated concrete, cleaning and protecting the exposed reinforcement with a corrosion-inhibiting coating, and patching with an appropriate repair material. Replacing or supplementing the reinforcement is required when corrosion has resulted in structurally detrimental section loss. In some instances, applying protective breathable coatings to exposed concrete surfaces may be recommended as part of the repair process to reduce future moisture, chloride, and/or carbonation ingress, thereby extending the life of the repairs and adjacent concrete. Further guidance on repairing concrete structures can be found in numerous publications by the American Concrete Institute (ACI) and the International Concrete Repair Institute (ICRI).

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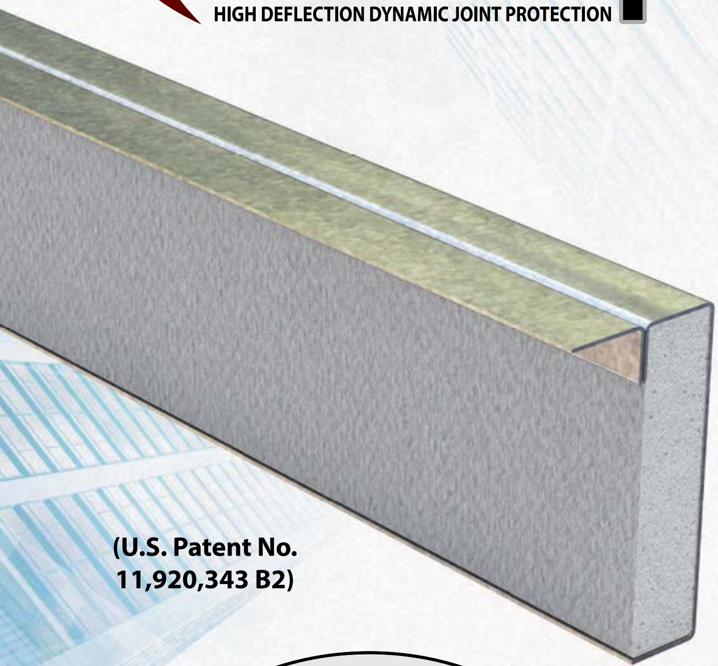

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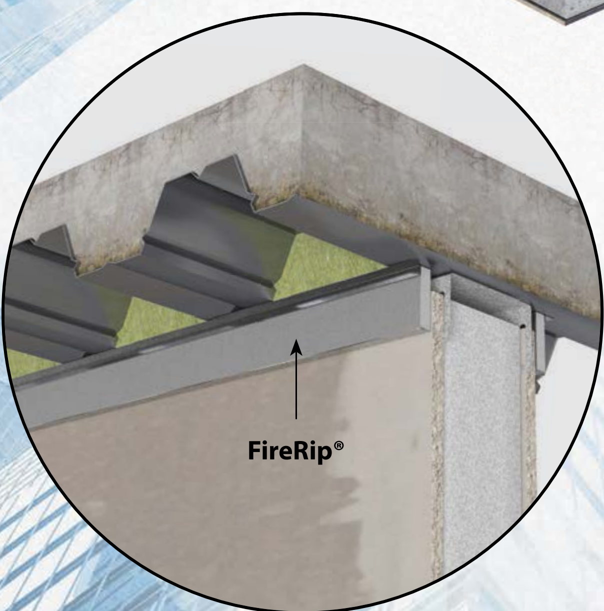

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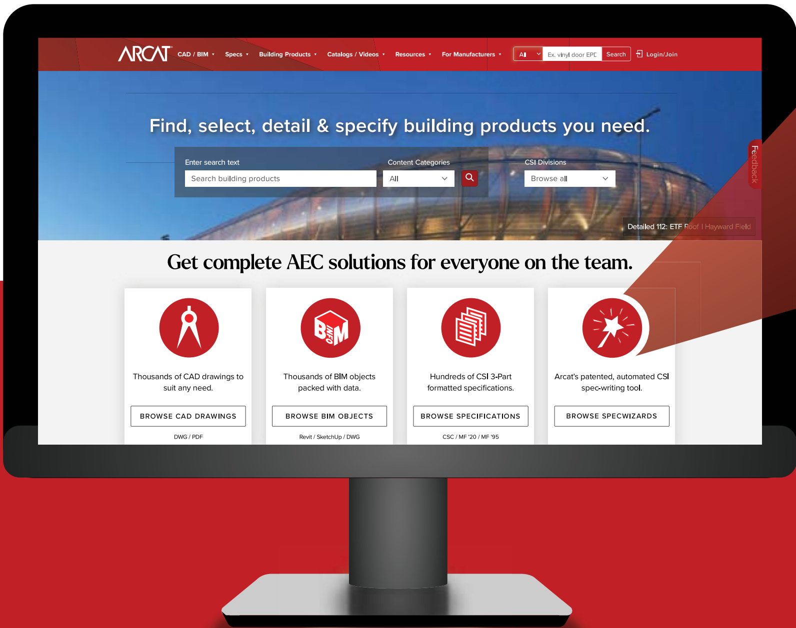

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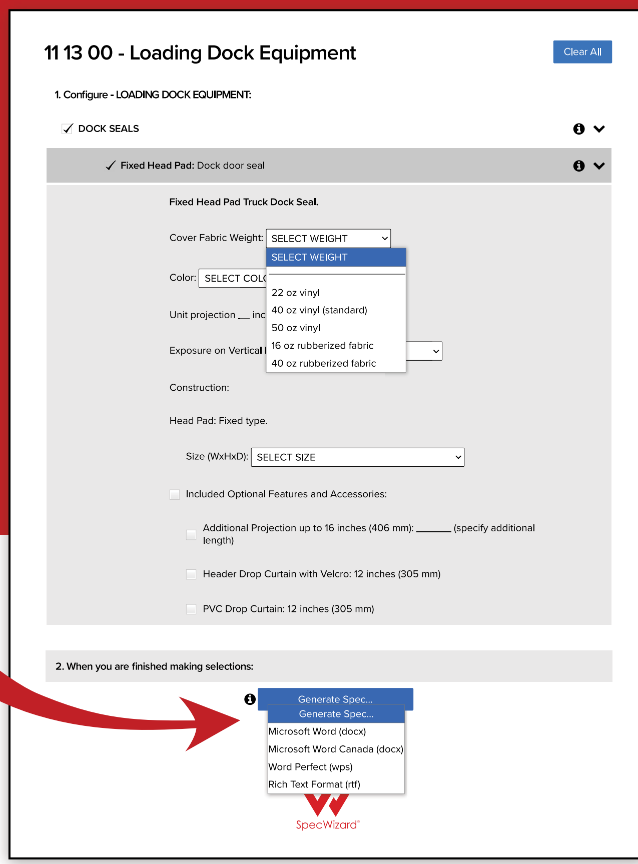

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