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Insulated metal panels (IMPs) are a prefabricated building material composed of two metal skins surrounding an insulating core. The metal skins are generally made of steel or aluminum and provide durability, unique aesthetics, and weather resistance, while the insulating core, most commonly a closed-cell foam material, contributes to durable thermal performance.

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Editorial Policy: The mission of CSI is to advance building information management and education of project teams to improve facility performance.

CSI's Impact Earns Official Recognition

The State of Tennessee honored all that CSI does to advance building information management and the education of project teams to improve facility performance within the commercial construction industry, with a state proclamation recognizing the association.

CSI board of directors' chair William Sundquist accepted the honor at the office of Rep. Yusuf Hakeem, along with Tara Mitchell, Harry Harris, and Lynn Jolley of the CSI Nashville chapter.

In the same clear, specific language many specifiers would respect, the state presented, "A resolution to honor the Construction Specifications Institute for outstanding service to the commercial construction industry, the members of this general assembly take great pleasure in recognizing those dedicated professionals who work to improve communication among stakeholders in their respective fields."

The proclamation, which was signed by Tennessee Gov. Bill Lee, along with Speaker of the House of Representatives Cameron Sexton and Speaker of the Senate Randy McNally, noted that "CSI chapters across the country do much more than provide networking opportunities, they also sponsor high-quality education programs and events that help members share real-world solutions and better understand the roles and responsibilities of each member of the construction team."

"What I love about the proclamation is how pretty much all of it speaks to all our members' valuable contributions to the industry," says Sundquist.

Tennessee Secretary of State Tre Hargett added his own praise in honor of Sundquist's value to the state and CSI, stating, "Proud of my friend William Sundquist. He continues to make our state proud."

In closing, the House and Senate's joint proclamation concurred, "That we honor the leadership and members of the Construction Specifications Institute for their outstanding service to the commercial construction industry and commend their ongoing commitment to improving communication among commercial construction professionals through extensive education, rigorous certification, and uniform standards."

Celebrate Leaders, Mentors, and Innovators: Submit Your CSI Honors and Awards Nominations

The deadline to submit nominations for CSI Honors and Awards is quickly approaching.

From the distinguished Fellowship honor to awards celebrating mentorship, innovation, technical writing, and environmental stewardship—these recognitions shine a light on the individuals, teams, and chapters who are making a lasting impact in our industry and in the CSI community.

The deadlines for the various CSI honor and award categories are at noon (EST) on the following dates:

- CSI Distinguished or Honorary Membership: May 6
- CSI Fellowship: May 20
- CSI National Awards: May 20

We'll come together to celebrate the honorees at the 2026 CSI National Conference, taking place October 7-9 in Phoenix, Ariz.

View the award categories and submit nominations at csiresources.org/honorsandawards

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CSI Foundation scholarships help aspiring architecture, engineering, construction, and owner (AECO) professionals transform their careers by providing access to professional development opportunities. Applications are now open for the following scholarships:

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- CSI Certification Scholarship (five available): Stand out with a prestigious CDT, CCCA, CCS, or CCPR certification and boost your confidence and credibility.

The deadline to apply for both scholarships is Tuesday, May 25. Learn more at csiresources.org/scholarships

A Deep Dive into Insulated Metal Panels

Performance, Compliance, and Best Practices

By David DeWulf, Ph.D.

PHOTOS COURTESY KINGSPAN INSULATED PANELS NORTH AMERICA

Insulated metal panels (IMPs) have become a popular material for modern commercial and industrial construction projects. One major driver of this growth is the rapid expansion in data center development. The surge in data center construction, driven by rising demand for cloud computing and artificial intelligence (AI), has helped fuel the demand trend. The global data center market is expected to grow from $418.2 billion in 2025 to $691.6 billion by the end of 2030, according to BCC Research.[1]

In sectors such as data centers, distribution centers, and manufacturing facilities, the sooner the building is completed, the sooner it can start generating revenue, driving the need for building envelopes that can be installed quickly and reliably on schedule.

As demand for construction schedule compression increases, IMPs offer a seamless solution that combines water, air, vapor, and thermal control layers into a single, easy-to-install assembly. By addressing envelope performance requirements, sustainability concerns, and financial considerations of employing IMPs, specifiers can understand their advantages in commercial construction and make informed decisions to successfully incorporate IMPs into design plans.

Overview of IMPs

IMPs are a prefabricated building material composed of two metal skins surrounding an insulating core. The metal skins are generally made of steel or aluminum and provide durability, unique aesthetics, and weather resistance, while the insulating core, most commonly a closed-cell foam material, contributes to durable thermal performance. The insulating core can be made from various materials such as polyisocyanurate (polyiso) foam or mineral wool, depending on the building envelope performance requirements.

IMPs offer several advantages over traditional wall systems, like tilt-up concrete or other multi-component wall systems, including faster installation times, reduced complexity, and fewer trades involved. Time-lapse installation comparisons indicate that IMP systems can be installed in roughly half the time required for traditional multi-component wall assemblies.[2]

As Joseph W. Lstiburek, PhD, P.Eng., of Building Science Corporation notes, "If you can't keep the rain out, don't waste your time on the air. If you can't keep the air out, don't waste your time on the vapor."

IMPs inherently align with this approach by integrating air, water, vapor, and thermal control into a single assembly. By addressing these layers collectively, rather than relying on

Rapid growth in data center construction is driving demand for building envelope systems that support accelerated schedules and high-performance requirements.

multiple, site-installed components, IMPs reduce the risk of discontinuities that can compromise envelope performance, particularly at transitions, penetrations, and interfaces between systems.

By integrating multiple functions into a single panel, IMPs reduce the complexity and cost of the building envelope while enhancing overall performance. Research shows that IMPs can lower overall installation costs by up to 25 percent in the U.S. compared to conventional tilt-up and precast concrete methods.[3]

Sustainability and resilience remain critical priorities across the built environment. Health Product Declarations (HPDs) and Environmental Product Declarations (EPDs) are rapidly becoming baseline requirements for the evaluation and specification of building products. The carbon impact of concrete construction is well documented, and the industry is actively pursuing strategies to reduce embodied carbon in these systems. IMPs offer a compelling alternative, with the potential to reduce a building's overall carbon footprint by up to 28 percent compared to conventional concrete assemblies, particularly when paired with low-carbon slab solutions.[4]

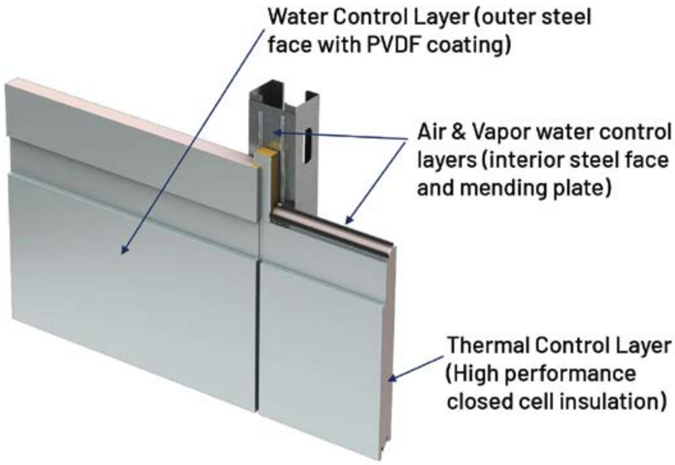
Key performance characteristics of IMPs

Thermal performance

One of the most significant advantages of IMPs is their high thermal performance, which directly impacts building efficiency. The insulation core of an IMP typically provides a high R-value, a measure of thermal resistance. IMPs commonly achieve initial R-values of 7.2 per inch of thickness, and up to R–8 per inch for some newer proprietary foam formulations, when tested at 24 C (75 F) in accordance with ASTM C518, *Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*. These values represent initial thermal resistance, as there is currently no codified industry standard in the United States for determining long-term thermal resistance (LTTR) for IMPs, and manufacturers typically report R-values based on ASTM C518 testing. This performance is significantly higher than that of traditional insulation materials such as fiberglass or mineral wool, which typically provide R-values of around 4 per inch of thickness.

This enhanced performance is largely attributable to the use of advanced low Global Warming Potential (GWP) blowing agents, such as hydrofluoroolefins (HFOs). These blowing agents are introduced during the manufacturing process to create the closed-cell structure of the foam, reducing thermal conductivity and improving long-term thermal stability.

These closed-cell materials, typically polyiso, provide higher thermal resistance and better moisture control than traditional batt insulation—pre-cut blankets made of fiberglass or mineral wool. This is due to the closed-cell foam's ability to durably capture these low thermal conductivity blowing agents within the closed cell structure, while fiber-based batt insulations rely on trapped or entrained air, limiting the achievable R-value and leaving the assembly vulnerable to "wind washing"—the reduction of insulation values due to the movement of air through the batt.



Insulated metal panels (IMPs) consist of two metal skins bonded to an insulating core, forming a single assembly that provides thermal, air, and moisture control.

Closed-cell foams retain their R-value over time significantly better than open-cell foams. And IMPs retain their R-value better than traditional board stock. Diffusion of blowing agents, moisture exposure, and thermal cycling all contribute to the thermal aging of insulation board stock and can be accelerated by improper installation. However, IMPs, closed and sealed systems, avoid many of these pitfalls, with long-term thermal drift often less than five percent, allowing some IMP manufacturers to offer 30-year thermal warranties on their systems.

Air and water leakage control

Air and water leakage are significant concerns for building envelopes. In multi-component wall designs, selection of the appropriate control layers, based on climate zone, code requirements, and hygrothermal analysis to ensure assembly compliance and long-term durability can be confusing and risky. Multiple vendors across multiple layers with differing performance properties within a single assembly means that expensive testing is often replaced by engineering judgment. Even with proper assembly design, specification, and detailing, issues with trade coordination and installation integration can result in energy losses, water intrusion, and structural damage.

IMPs offer robust solutions to these issues by integrating air and water control features directly into the single-component panel system installed by one contractor. IMPs are tested as complete barrier systems, simplifying code compliance compared to traditional multi-component wall systems.

IMPs are subjected to rigorous air leakage tests, such as ASTM E283, *Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen*, and water leakage tests, including ASTM E331, *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference*, and AAMA 501.1, *Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure*, which evaluate how well the panels withstand water pressure under changing field conditions. These tests ensure that IMPs can maintain their air- and water-tight integrity, even in harsh weather conditions.

Fire and durability testing

IMPs are designed to meet stringent fire resistance and durability standards, making them suitable for a variety of building types, including those in high-risk environments such as hurricane-prone areas. The fire performance of IMPs is tested using various methods, including ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*—also known as the Steiner Tunnel test—for flame spread, ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, for structural integrity under fire exposure, and NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components*, for full-scale facade fire testing.

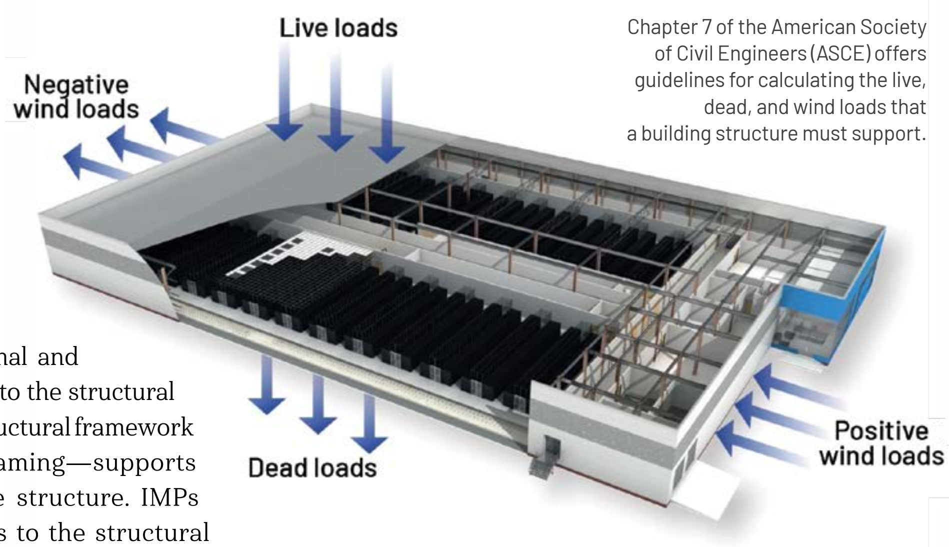
The NFPA 285 test, in particular, is critical for assessing vertical and lateral flame spread on the exterior of a building. This test simulates a fire breaking out near a window and exposes the entire cladding system to a fire for 30 minutes, measuring factors such as flame spread, temperature rise, and mechanical failure of the facade. IMPs are required to pass these tests to ensure they meet stringent fire safety standards for multi-story buildings.

IMPs are also tested for impact resistance, such as the Miami-Dade Notice of Acceptance (NOA) test, which simulates the effects of hurricane debris impacts. These include the launch of large projectiles, such as 2x4 lumber members, as well as smaller debris intended to replicate gravel and roof aggregate commonly generated during severe storm events.

After impact testing, the assembly is further evaluated for air and water penetration, verifying that the enclosure maintains its performance even after sustaining damage. This combination of structural overload, missile impact and post-impact air and water testing distinguishes the Miami-Dade NOA test from many other durability evaluations. It is essential for buildings in tornado- and hurricane-prone regions. IMPs that pass these tests provide assurance of their durability and resilience under extreme conditions.

In addition to hurricane and impact testing, IMPs are often evaluated against Factory Mutual (FM) standards, which are widely used by insurers to assess risk in large industrial and warehouse facilities. Standards such as FM 4880, *Approval Standard for Class 1 Fire-Rated Insulated Wall or Wall and*

Roof Panels and FM 4882, *Approval Standard for Interior Finish Materials,* are considered among the most stringent benchmarks for fire performance of panelized systems.



Chapter 7 of the American Society of Civil Engineers (ASCE) offers guidelines for calculating the live, dead, and wind loads that a building structure must support.

Design considerations for IMPs

Structural considerations

IMPs, while providing excellent thermal and weather protection, do not contribute to the structural integrity of the building. Instead, the structural framework of the building—typically steel framing—supports the loads and forces acting on the structure. IMPs are designed to transfer wind loads to the structural framework while maintaining the integrity of the building envelope.

IMPs have defined span capabilities based on product type, panel gauge, core thickness, and specified design loads. These span limits must align with support conditions to ensure proper performance.

Span tables define the maximum allowable support spacing based on the panel (type, configuration, and facer gauge), load type, fastener type, and configuration and deflection limits. Span tables are developed from structural testing (ASTM E72, *Standard Test Methods of Conducting Strength Tests of Panels for Building Construction*) and validated engineering analysis.

By decoupling envelope performance from structural capacity, IMPs enable more efficient and flexible structural design. This allows architects and engineers to optimize framing systems without compromising enclosure integrity.

Detailing for performance

Effective detailing is crucial for the long-term performance of an IMP system. Proper detailing ensures the building envelope remains air- and water-tight, and thermally efficient throughout the building's life. Special attention should be given to areas where panels meet at corners, windows, doors, and roof intersections. Detailing at these intersections is critical to prevent water ingress, air leakage, and thermal bridging.

Manufacturers typically provide a library of standard details for common construction scenarios. However, specifiers should work closely with manufacturers to develop custom details for unique conditions, ensuring the IMPs perform as expected in all parts of the building.

Compliance with building codes

Evolving code requirements

As building codes continue to evolve, the demands on materials and systems, such as IMPs, become increasingly stringent. One of the most significant changes in recent years is the growing requirement for whole-building testing. Whole-building testing involves evaluating the entire building envelope as a system rather than testing individual components, such as windows or walls. This shift requires specifiers to ensure their building envelopes meet comprehensive performance standards, including air, water, and thermal control.

IMPs are well-positioned to meet these evolving code requirements, as they are tested as complete systems and have been shown to perform reliably across a wide range of conditions. Specifiers should stay informed about changes in local codes for the markets they operate in.

Meeting structural and thermal standards

In addition to meeting fire safety and impact-resistance standards, IMPs must comply with structural and thermal performance standards set forth in national codes. The American Society of Civil Engineers (ASCE) Chapter 7 provides prescriptive guidelines for calculating the live, dead, and wind loads that a building structure must withstand. IMPs must be integrated into the structural design to ensure they meet these load-bearing requirements, especially in areas with high wind or seismic activity.

Additionally, IMPs offer significant efficiency advantages. By integrating thermal control into the panel system, IMPs can help meet energy codes and reduce a building's overall carbon footprint. Specifiers must ensure that the correct panel thickness is chosen to meet both energy code requirements and long-term thermal performance.

Including IMPs in construction documents

When specifying IMPs for a project, it is important to include detailed and accurate information in the construction documents to ensure compliance and performance.

- Section 1—General conditions of the contract, including sustainability requirements and building warranties.

Special care should be taken in areas where insulated metal panels (IMPs) intersect at corners, windows, doors, and roof joints.

- Section 7—This section should describe the performance requirements of the panels, including the required values for air, water, and thermal leakage. Additionally, include the tests that the panels must pass. Some manufacturers provide model templates for structuring these specifications, which can be adapted to the specific needs of the project.

Specifiers should also ensure the construction documents clearly outline the expectations for detailing, particularly at panel intersections and transitions. This will ensure the IMP system functions as intended throughout the building's lifespan.

Conclusion

IMPs offer a comprehensive solution for modern building construction, providing high performance in thermal efficiency, air and water control, fire resistance, and durability. Their integrated design simplifies the construction process and reduces the number of trades involved, resulting in faster build times and fewer opportunities for error. By understanding the technical specifications, design considerations, and code compliance requirements, specifiers can confidently incorporate IMPs into their designs, ensuring long-term performance. As building codes evolve and demand for efficient, resilient structures increases, IMPs will remain an essential component of the modern construction landscape.

NOTES

[1] Refer to bccresearch.com/market-research/information-technology/data-centre-market.html?

[2] See kingspan.com/us/en/knowledge-articles/karrierpanel-all-in-one-solution/

[3] Learn more at kingspan.com/content/dam/kingspan/kip-na/us-ca/documents/kingspan-concrete-cost-comparison-white-paper-en-us-ca.pdf

[4] Refer to kingspan.com/us/en/campaigns/reducing-embodied-carbon/

additional information

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David W. DeWulf, Ph.D., is director of business development for Kingspan Insulated Panels North America. DeWulf brings more than 30 years of experience in sales, marketing, and product development within the building envelope industry. He has a deep understanding of the vital role that moisture and thermal control play in ensuring the performance and sustainability of modern construction practices. DeWulf was a developer of the first drainage wrap in the industry as well as the first non-perforated, woven microporous wrap.

KEY TAKEAWAYS

Driven by data center growth and schedule compression, insulated metal panels (IMPs) integrate air, water, vapor, and thermal control in one system—accelerating construction, improving resilience, reducing carbon, and simplifying code compliance for high-performance commercial envelopes.

MASTERFORMAT NO.

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Fenestration Alignment in the Exterior Wall Section

By Maria Raggousis, P.E., CPHC, Emily Beam, P.E., and John Karras, P.E.

PHOTOS AND DIAGRAMS COURTESY SIMPSON GUMPERTZ & HEGER INC.

Contemporary energy codes that emphasize insulation continuity and reduced thermal bridging, together with design trends, architectural preferences, and current fenestration product options, shape building enclosure design.

Fenestration within rough openings has become a critical, complex, and evolving aspect of that design. The fenestration alignment within the rough opening (in other words, how its vertical plane is positioned relative to the adjacent cladding, insulation, and air and water barriers) not only affects thermal performance, but also the air barrier continuity, the water penetration resistance of the overall wall assembly, and the more readily apparent aesthetics of the design.

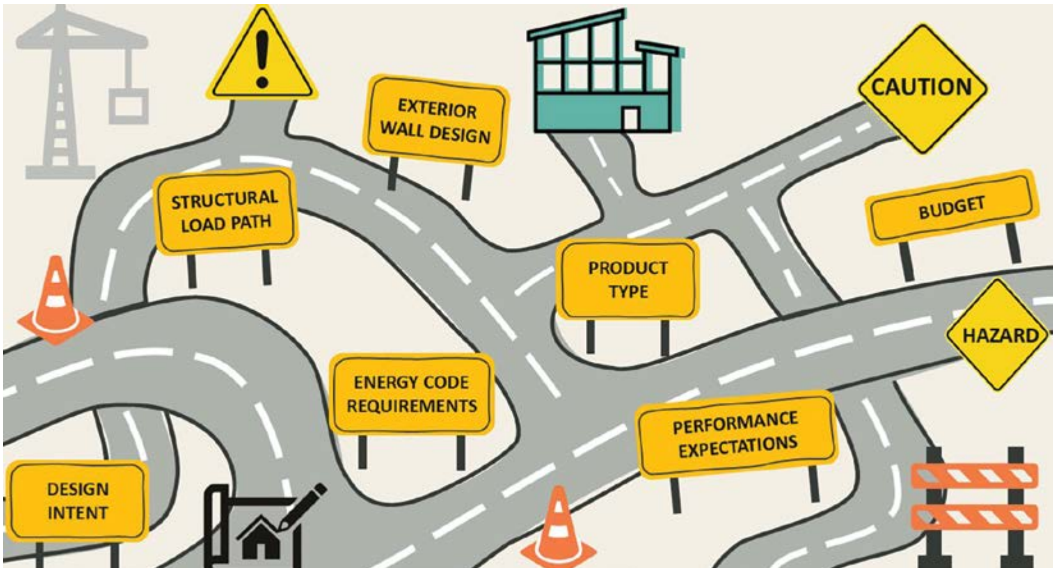
Fenestration alignment, therefore, demands early multidisciplinary design scrutiny, but the process is not always straightforward (Figure 1). Often, multiple interdependent, iterative, and competing interests influence fenestration alignment in the exterior wall section. These include architectural design intent, structural load path, fenestration product type (*i.e.* window, storefront, or curtain wall),[1] and the proprietary characteristics of the specific product.

In this article, the authors outline a structured, holistic decision-making framework for design professionals to use as a roadmap as they navigate today's interdependencies in fenestration alignment.

Introduction

Fenestration systems have evolved over time through technical innovation and in response to project needs and design trends. High-performance features once reserved for custom, high-end fenestration systems like curtain walls are now trickling down into the commodity market of more cost-effective product types like storefront and windows. The industry's desire for customization has led to fenestration products becoming increasingly proprietary, adding a new level of complexity to selecting an appropriate fenestration position in the exterior wall section.

Figure 1



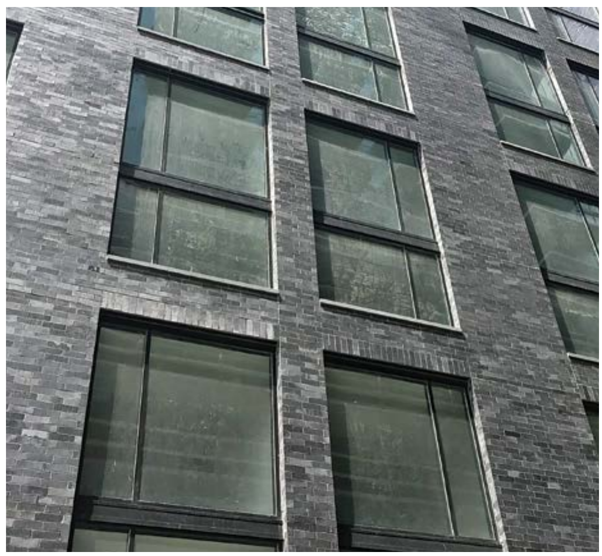
Navigating interdependencies of fenestration alignment decisions can be daunting.

This article primarily focuses on fenestration applications within single-story or multi-story punched openings in commercial buildings (Figure 2). A punched opening is defined as a discrete elevation of a glazing system that is entirely surrounded by another opaque building wall system.[2] These openings can be infilled with different fenestration types, including window, storefront, or curtain wall products.

Until the mid-20th century, fenestration systems in punched openings (generally window products up until that time) were often simply supported along each edge in a mass masonry wall assembly, and the surrounding masonry fulfilled the primary building enclosure functions. These functions include serving as a substrate for structural attachment, airtightness, watertightness, thermal resistance, and the finish material of the opaque exterior wall.

In contemporary cavity wall construction, model energy codes are pushing the envelope forward (including sometimes in a literal sense) by requiring increasing amounts of insulation in the opaque exterior wall cavity, where it can be more easily configured continuously. From a hygrothermal and thermal perspective, these code evolutions are beneficial. They can increase the building's energy efficiency, improve occupant comfort, and reduce the risk of condensation accumulation in undesirable areas of the exterior wall. But along with the benefits come design challenges at punched openings. Mainly, how does a building enclosure design account for the increased cavity insulation thickness relative to the position of the fenestration product (Figure 3, page 14) while maintaining the key features of fenestration perimeter design detailing?

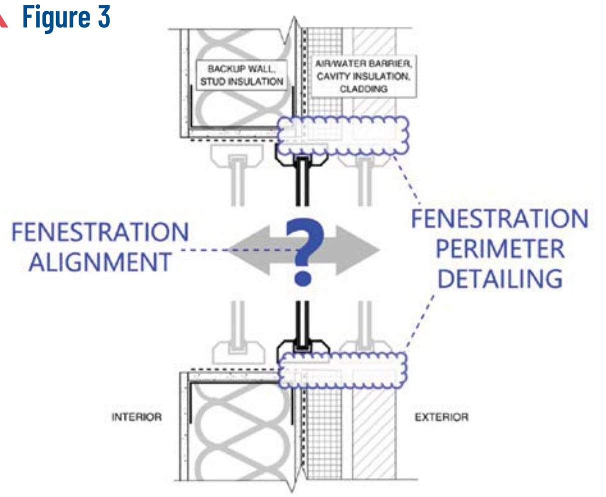
Figure 2



Example building elevation with two-story punched openings.

For example, design professionals often ask themselves whether they should push the fenestration out towards the exterior to achieve thermal barrier continuity and control thermal bridging, or to achieve a more planar appearance. Does shifting the fenestration out lead to unintended consequences and complications for fenestration structural attachment and air/water barrier integration? Alternatively, a design professional may ask themselves whether to inset the fenestration within the backup wall, either to achieve a facade appearance in which the glazing plane is deeply offset within

Figure 3



Graphical representation of fenestration alignment's impact on perimeter detailing.

the opaque facade, or out of necessity because the opaque exterior wall system is precast concrete with insulation on the inside. And if so, how might they deal with the associated complications, such as thermal bridging and gaps that may require cavity closures with this approach?

In any case, starting by outlining the design considerations impacted by the fenestration alignment in the rough opening is a valuable exercise.

Design considerations that influence fenestration alignment

While there are many factors that influence the fenestration alignment in the exterior wall section, these considerations are frequently the primary drivers:

Architectural design intent

Architectural design intent dictates the cladding and fenestration materials, as well as the fenestration product type. Materials and products are selected to achieve the desired geometry, size, exterior frame exposure, glazing makeup, and, ultimately, the preferred fenestration and glazing depth relative to the surrounding cladding. The design intent also informs the material selection and profile of trim or cladding treatment around the exterior perimeter of the opening. Additionally, the design intent is responsive to the project budget and project stakeholder requirements, and thus product selection often trends to the least costly option that can achieve the desired architectural intent.

Energy code requirements

Local jurisdictions and the selected compliance path (*e.g.* prescriptive versus performance path) determine the thickness of exterior cavity continuous insulation (c.i.). The effects of thermal bridging are also considered on a project-specific basis and some building codes. For example, in Washington, D.C., thermal bridges are incorporated in building analysis under certain compliance paths. Voluntary or mandatory sustainable accreditations (such as Passive Building Certification) also affect a project's energy performance requirements.

Structural load path

The fenestration's gravity load (*e.g.* self-weight) and the lateral load applied to the fenestration (*e.g.* wind) must transfer to the building structure. Fenestration products can be attached to the building using a variety of methods, such as clips, strap anchors, sill angles, wood blocking, receptor systems, or flanges. Some fenestration products offer several attachment options. Note that flanged windows inherently limit fenestration alignment options, whereas other fenestration types may offer greater flexibility. In general, the fenestration anchorage configuration and materials will depend on the rough opening size, construction type, design loads, and fenestration type.

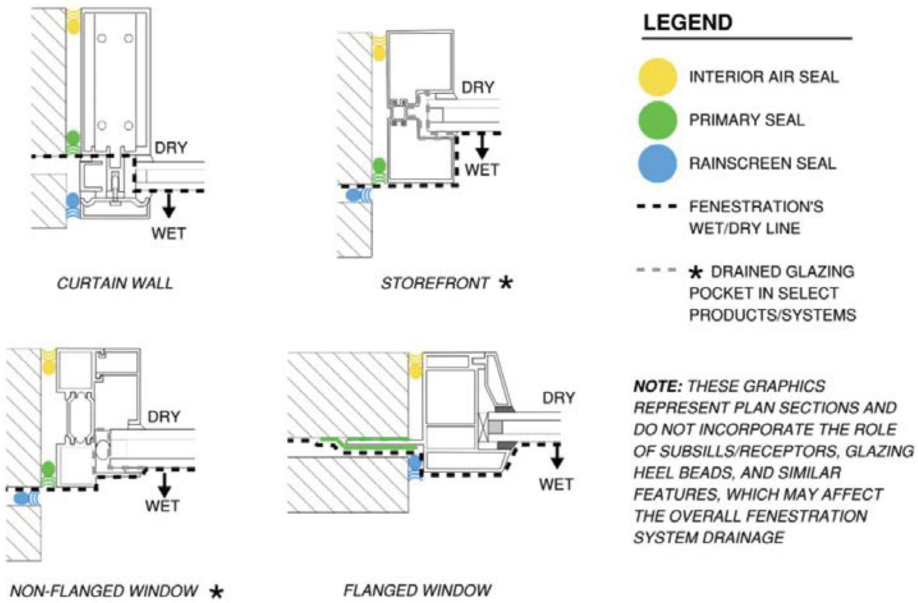
Air barrier continuity and water penetration resistance

Fenestration products must integrate with surrounding building enclosure systems to maintain air barrier continuity and avoid water penetration. How exactly this occurs depends on wall type (rainscreen cavity wall versus barrier wall), fenestration product type, and rough opening flashing detailing.

Fenestration product type

Aside from a design choice guided by architectural preference, the fenestration's product type also directly influences alignment. Each product includes, by manufacturer design, a "wet-dry" line, meaning portions of the product outboard of the wet-dry line are intended to manage and drain incidental moisture that penetrates the outer plane of the system. The wet-dry line of the fenestration product must integrate with the wet-dry line of the adjacent opaque wall assembly with a primary weather seal. The position of the wet-dry line for window, storefront, and curtain wall products is conventionally different. Non-flanged window products and storefront products typically have the primary weather seal positioned at the outboard edge of the frame, while curtain wall products often have the primary weather seal positioned at the "shoulder" of the curtain wall mullion, which is inset from a wept rainscreen seal located near the outboard edge of the frame. Flanged window products typically achieve their primary weather seal to the surrounding rough opening flashing by bed-setting the jamb and head flanges in sealant and stripping-in the jamb and head flanges to the air/water barrier with a self-adhering flashing. The primary weather-

Figure 4



Common primary weather seal and wet-dry line locations (at jamb condition) by fenestration product type.

seal location can also vary by fenestration product within a given type. Common primary weather seal and wet-dry line locations are illustrated in Figure 4. Although this is not the focus of this article, an interior air seal is also a key design feature (to restrict air infiltration/exfiltration and benefit water penetration resistance) for all fenestration types.

Interdependency and iterations

Throughout the facade and fenestration design process, mindful decision-making informed by the factors highlighted above can help develop coordinated rough opening perimeter details. Some of these decisions, like modifying the material or profile of perimeter trim to conceal the exterior cavity, are easier to adjust later in the design timeline compared to others, such as changing the fenestration product type or load path and attachment to the structure. Regardless of the magnitude and consequence of the change, altering one factor will generally impact others.

Adding to the challenge of this inherent interdependency is the notion of design iterations. The authors' experience is that even if the ownership, design, and construction teams agree at the start of a design on the primary factors, it is reasonable to expect some level of decision-making iteration throughout the design phase that affects the fenestration product itself and the surrounding conditions. For example, someone working on a project that begins with a particular basis-of-design window product that is designed to cantilever off its supporting condition by a certain distance could learn during contractor pricing that the product exceeds the project budget. This results in substitute products being presented. Aside from the substitute product's performance characteristics requiring review, the team would need to evaluate whether it can similarly cantilever at its sill or whether a supplemental structural support element, such as a steel shelf angle attached to the building structure, would become necessary. But if a steel angle is added to the design, how does this affect thermal bridging at the windowsill, associated interior condensation potential, and code compliance? This is an example of iteration converging with interdependency.

Sometimes, even the construction buyout and/or submittal phase can introduce changes (*e.g.* substitution of an alternate product based on contractor input or preferences) that, by their mere lateness relative to the design schedule, present a greater probability and magnitude of pitfalls than if they were introduced earlier.

Decision-making framework—A fenestration alignment road map

Fenestration perimeter design detailing that is not conceived systematically or that changes without revisiting and coordinating with other relevant design considerations can lead to problematic outcomes. No one wants to continually reroute back to the beginning of the decision-making process and duplicate effort, but failure to consider interdependent factors can result in leaky, inefficient, or unnecessarily costly details. So how can project teams leverage the list of design considerations introduced above in a manner that is not only comprehensive but also conducive to the iterative design process?

The authors suggest a road map that includes the following steps:

1. Establish surrounding exterior wall systems

Determine adjacent cladding types, exterior wall water management function (rainscreen cavity wall or barrier wall), exterior cavity insulation type and thickness, depth of backup wall construction, and depth of exterior cavity. This includes determining the energy conservation code compliance approach and whether the building enclosure design is affected by regulatory or voluntary sustainability programs. Determine if a hygrothermal analysis of the opaque exterior wall is necessary and evaluate the make-up of the wall from the standpoint of moisture accumulation potential. For cavity wall systems that include combustible components, identify how code-required standards such as NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components*, influence the exterior wall design (*e.g.* air cavity depth constraints for tested assemblies). Size each exterior wall component. Essentially, establish the opaque exterior wall's dimensional characteristics at the outset of this process.

2. Establish performance expectations and overall project budget compatibility

Identify appropriate fenestration product type and basis-of-design product based on project-specific loads, available support conditions, dimensions, appearance and sight lines, and desired airtightness, watertightness, thermal, and other performance requirements (*e.g.* acoustic, condensation resistance). Engage the manufacturer's technical support in this process if the project procurement method allows. At this stage, it is typically helpful to review the differences in performance characteristics between product categories.[3] If window products are a category under consideration, review designations such as window class and grade with the project ownership team.[4] This will inform the ownership team of the rationale behind the selected fenestration type, facilitate their engagement in budget-related decisions at the appropriate time, and emphasize the implications of interchanging products. When the project delivery method includes early contractor involvement, the construction team can helpfully provide product pricing comparisons to verify budget compatibility at a reasonably early stage in the design (*e.g.* early design development).

3. Establish a preliminary fenestration alignment based on architectural design intent

Using the basis-of-design fenestration type and product, position the plane of the glazing in accordance with the architectural design team's preference.

4. Establish the general geometry and structural load path

The fenestration product type selected in the earlier step provides the backdrop for refining critical design decisions regarding the fenestration's frame depth/profile and structural load path (including the attachment scheme). Available attachment strategies are influenced by the fenestration product type, manufacturer's offerings, and surrounding wall construction. Note that some fenestration products have attachment options (*e.g.* strap versus bracket attachment) that affect the dimensions required gravity support. This step identifies:

(a) whether the fenestration's structural attachment and gravity load support dictate a certain position for the frame and vertical plane of the glazing

(b) whether the backup wall of the rough opening itself can serve as the fenestration's gravity load support or whether the sill of the rough opening needs to be extended with a supplemental structural shelf.

This step should also include an evaluation of whether the fenestration's structural load path must accommodate differential movement. For example, if the head of the rough opening coincides with the underside of a structural slab that experiences live load deflection, the fenestration must accommodate that deflection within the fenestration system itself or through the rough opening using receptors or other means. Note that flanged windows do not lend themselves to such differential-movement applications.

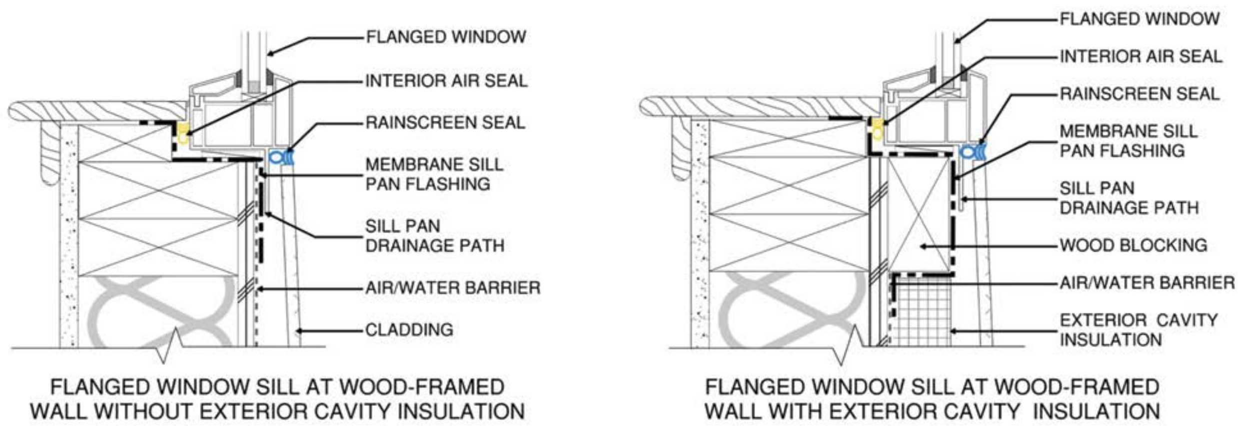
5. Establish the wet-dry line

The wet-dry line is specific to each product (and not all products in the same product type have the wet-dry line at the same location) and dictates the primary weather seal locations, fenestration system drainage paths, and weep locations. Once the wet-dry line is confirmed, draw accurate, enlarged perimeter section details showing the primary weather seal location, rainscreen seal location (if applicable), and interior air seal location. Remember that the wet-dry line and position of primary seals on the fenestration frame are established by the manufacturer and validated through laboratory testing during product development.[5] Deviating from the established locations of these features changes the performance of the system.

6. Configure rough opening perimeter flashings and cavity closure systems

The primary weather seal of the fenestration must engage the building's air/water barrier. In a rainscreen cavity wall, this can occur either directly to the air/water barrier's flashing accessories that turn into the rough opening, or, if the fenestration is aligned so that its primary seal is outboard of the vertical plane of the sheathing and air/

Figure 5



Example flanged window sill alignment on wood-frame building with and without continuous exterior cavity insulation.

water barrier, the primary seal can engage membrane or liquid flashing accessories that encapsulate an element (*e.g.* steel shelf angle at the sill or heavy gauge sheet metal "cavity closures" at the jambs and/or head). These elements, often metal, effectively bring the rough opening flashing out to meet the position of the primary seal. In a precast concrete barrier wall, the cavity closure concept may be applied on the interior side of the precast panel's rough opening. In both cases, in the authors' experience, relying on the cavity closure metal itself to serve as the airtight and watertight connection between the fenestration and the air/water barrier is fraught with performance pitfalls (given the splices that are involved) relative to fully encapsulating the closure element in liquid or membrane flashing. Also note that if differential movement can occur between the head and jamb conditions of the rough opening (see Step 4), then the head-jamb interface of the cavity closure system must also be designed to accommodate movement.

7. Develop exterior trim systems

Architectural trim may be required to close a wall cavity surrounding fenestration. Some fenestration manufacturers offer integral trim pieces attached to the fenestration product (*e.g.* via mechanical snap-in connections). These trim pieces, especially large ones that project substantially from the fenestration to cover a deep cavity, should have their wind resistance scrutinized to avoid the risk that they dislodge from the building during a design wind event. Calculations for trim are often delegated to the fenestration trade contractor. As with the fenestration's structural attachment and perimeter flashing extensions, exterior trim must be designed for differential movement, if applicable. These elements are typically architectural only and should not be relied upon in lieu of a dedicated air/water barrier, though they can help deflect bulk water from reaching the exterior cavity.

8. Backcheck the preliminary fenestration alignment

Assess whether the positioning established in Step 3 allows the fenestration to satisfy Steps 4 through 7, and if not, adjust fenestration positioning.

Practical examples

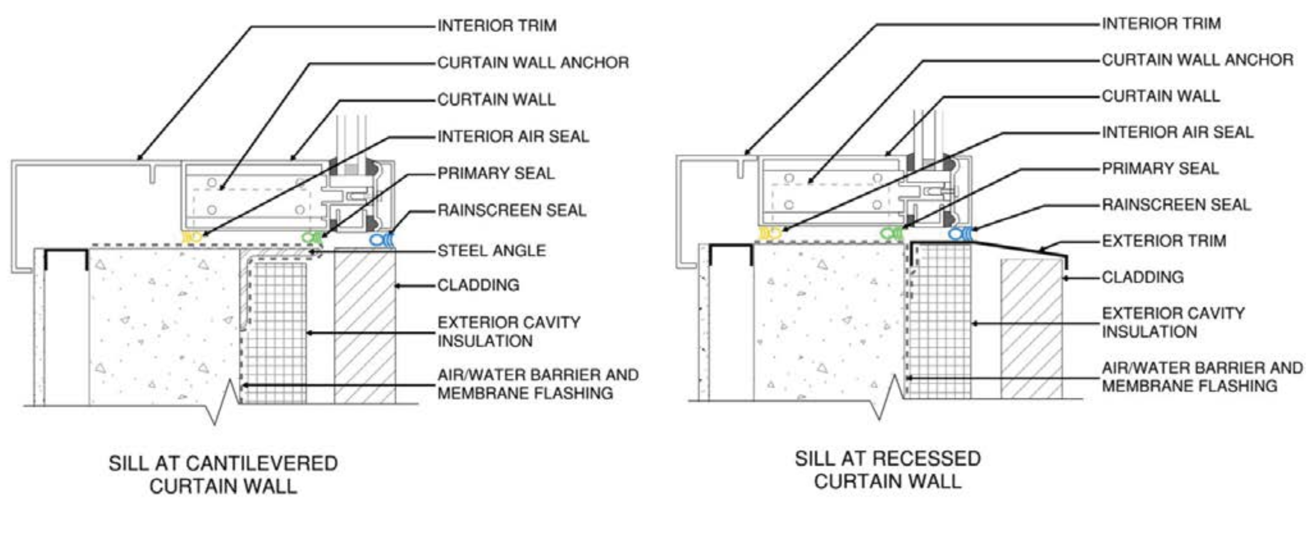
Since it is impossible to anticipate every project-specific scenario, this section does not endeavor to illustrate all possible fenestration alignments or perimeter detailing outcomes; however, the generic practical examples of common design configurations shown below can be used as points of reference to complement the decision-making framework in the previous section.

For clarity, not all detail components are shown in Figures 5 through 7 (pages 18 and 19). These graphics focus on design features related to fenestration type, alignment, primary and interior air seals, structural load path, and perimeter flashings and cavity closures.

Fenestration alignment example #1: Multi-family wood-framed building with flanged windows

In Table C402.1.3 of the 2021 *International Energy Conservation Code* (*IECC*), construction with wood-framed walls allows the option to forgo continuous exterior cavity insulation and only provide batt insulation between studs. Presently, many buildings are still designed and constructed this way, but wood-framed buildings with continuous insulation are likely to become more common either by virtue of design choice or jurisdiction-specific mandates (Figure 5).

Figure 6



Example curtain wall sill alignment flush with, and inset from, face of cladding.

Fenestration alignment example #2: Curtain wall with supplemental steel shelf angle at sill

In ground-floor applications such as retail and entry fenestration, design professionals often choose to elevate the fenestration on a curb with a robust cladding, such as dimension stone (*e.g.* granite), to improve water-penetration resistance and durability. The concrete curb backup is classified as a mass wall, and if the prescriptive path of the energy conservation code is used, exterior cavity insulation is often required. The cladding thickness, along with an air gap or grout collar joint, further increases the depth of the exterior wall relative to the fenestration frame. If the design seeks to align the exterior face of the fenestration with the underlying cladding, a structural shelf encapsulated by a membrane flashing in the rough opening is a reasonable approach, subject to assessing the interdependencies described previously (*e.g.* thermal bridging). With respect to thermal bridging at the steel shelf angle, designers can consider specifying solid plastic shims (provided the shelf angle is designed for eccentric loading) or exploring thermally broken steel components or non-conductive structural elements for this purpose.

If the design seeks to inset the exterior face of the fenestration relative to the cladding, exterior trim is required.

Figure 6 illustrates these examples using a captured curtain wall product type. In both cases, careful attention to the continuity of the primary seal and maintaining a drainage path to the exterior (*e.g.* wept rainscreen seal) is important.

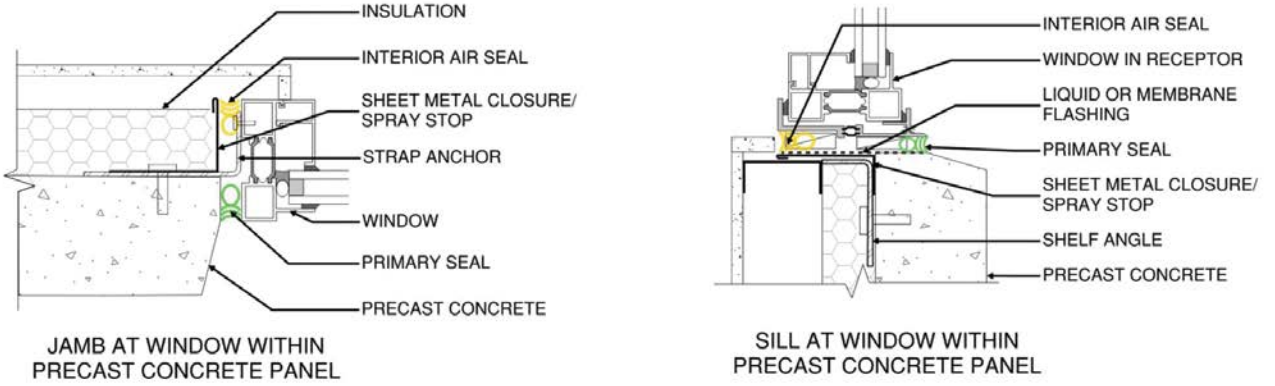
Fenestration alignment example #3: Window set within precast concrete panels

Precast concrete wall panels function as a barrier wall, serving as the substrate for the primary seal, the air/water barrier, the finished exterior wall surface, and part of the fenestration's load path. Insulation is installed only on the interior of the panel, and strategies (*e.g.* offsetting interior wall studs) can be used to achieve reasonable continuity between floor slabs. Contemporary architectural design intent often aims for an inset appearance between the panel's exterior face and the fenestration. Also, to align the fenestration's thermal break with the thermal insulation (commonly closed-cell sprayfoam or foil-faced insulation), the fenestration is typically partially set within the precast and partially cantilevered towards the interior, with a structural steel shelf or engineered cold-formed metal framing supporting the sill condition as necessary. The use of sprayfoam as the insulating material requires that an interior cavity closure serve as a "spray stop" for the insulation. Figure 7 (page 19) illustrates this example using a window.

Closing

Many of the considerations discussed above related to fenestration alignment are intertwined and, in some cases, have competing interests. The fact that the fenestration portion of building enclosure designs is often a moving target adds to the challenge. There is never only one perfect solution. But with an understanding of the relevant design considerations and a framework to tackle this portion of the design, the authors hope that design professionals will be empowered to leverage the concepts presented above to

Figure 7



Example inset window jamb and sill alignment with precast concrete exterior wall panel.

arrive at an appropriate combination of alignment and perimeter detailing.

NOTES

[1] Refer to "FGIA Glossary." Fenestration & Glazing Industry Alliance (2024), page 87.

[2] Refer to "FGIA Glossary." Fenestration & Glazing Industry Alliance (2024), page 58.

[3] Review "Window Walls: Blurring the Line Between Glazing Products." *The Construction Specifier* (November 2017), constructionspecifier.com/window-walls-blurring-line-glazing-products/

[4] See "Back to Some Basics." Door & Window Manufacturer (October 2011), page 18-20.

[5] Refer to ASTM E331-00 (2016), *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.*

additional **information**

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KEY TAKEAWAYS

Fenestration alignment impacts thermal performance, air/water barrier continuity, structural load, and aesthetics. Early, iterative multidisciplinary planning using a structured framework ensures efficient, code-compliant, and visually cohesive exterior wall design.

MASTERFORMAT NO.

07 21 00—Thermal Insulation
08 41 00—Entrances and Storefronts
08 44 00—Curtain Wall and Glazed Assemblies

UNIFORMAT NO.

B2020—Exterior Windows
B2030—Exterior Doors
B2010—Exterior Walls
B2020.30—Glazing and Curtain Walls

KEYWORDS

Division 07, 08
Exterior walls
Fenestration
Punched openings

Ask The Expert

Do you have a question regarding the specific use of a product, material, or technique for a project that you are currently working on?

If so, these experts may have the answers you are looking for. These leading manufacturers and suppliers have provided solutions to some of the more common questions asked by AECO community. From the simplest questions relating to which product may be best suited for inclusion in specifications to how materials can assist in achieving green certification, you will find the answers here. In addition, you can also discover best practices related to installation to ensure product longevity.

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Q: What do designers often overlook in IBC requirements for noncombustible construction with foam plastic ci?
A: Beyond NFPA 285 fire propagation and other assembly testing, foam plastic CI must achieve a flame spread index of 25 or less (Class A) and meet smoke development limits.

Q: How does polyiso compare when R-5, R-7.5, or R-13 is specified?
A: EnergyShield XR provides higher R-value per inch, allowing thinner wall assemblies to meet energy codes more easily, with simpler detailing, fewer attachment challenges, and reduced thermal bridging. Imagine tightening up your wall assembly by 1/2" to 1", or putting that space back into your cavity. What could that unlock for your design?

Q: From an environmental and specification standpoint, what matters most in continuous insulation?
A: Polyiso insulation offers significant carbon benefits combining low embodied carbon with substantial Operational Carbon savings over time.
EnergyShield XR has used proven formulations with responsible blowing agents for more than 30 years, containing no CFCs, HCFCs, or HFCs, resulting in zero Ozone Depletion Potential and negligible Global Warming Potential.
It is GREENGUARD Gold certified, and contributes to LEED credits.

Q: In a concrete sandwich panel, why use polyiso to balance thermal performance and thickness?
A: EnergyShield PanelCast delivers better thermal performance than polystyrene insulation. This allows flexibility for designers to increase R-value or reduce panel thickness to improve weight efficiency, handling, structural design, connections, embeds, and transportation, while also reducing tension on fasteners.

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Tina Cannedy is a Materials Science Engineer with 30+ years in building envelopes. She focuses on continuous insulation, EIFS and stucco, gypsum substrates, and WRB systems, with strong experience in testing, code compliance, and performance.

ATLAS

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Email: RWImarketing@atlasroofing.com
Website: www.atlasrwi.com

Q: How does the performance of a low-slope roof assembly differ when a cover board is included?
A: A cover board is always going to enhance the performance of your roof. In a low-slope assembly, it's the critical interface between insulation and membrane, improving durability by protecting against impact from hail, foot traffic and equipment. Without it, insulation is more vulnerable and the system can be compromised.

Cover boards also play a key role in fire resistance, helping assemblies achieve higher ratings. From a wind-uplift standpoint, they provide a stable substrate that improves fastening and helps systems meet uplift requirements. They also extend membrane longevity by reducing stress, preventing punctures and maintaining integrity over time.

It's clear a cover board is a smart investment in performance and risk reduction when you consider the roof represents roughly 9% of total building cost, yet a disproportionate share of construction litigation is tied to roofing failures.

Q: How essential are cover boards for meeting FM 4450 and FM 4470 VSH ratings?
A: Cover boards are a best practice for FM 4450 and essential for achieving FM 4470 VSH ratings. For 4450, they strengthen assemblies, while for 4470 VSH, they provide the impact resistance needed to meet stringent hail standards. Another essential is choosing the right cover board material for specific performance demands and environments. Impact resistance, compressive strength, moisture tolerance and fire performance aren't one-size-fits-all, and different product types – cementitious, glass mat gypsum – meet different needs.

Q: What changes are you seeing in performance expectations?
A: Here are three important changes: First, impact of changing weather, from expanded hail zones to wind pressures moving inland. Second, R-value requirements, whether by changing codes or insurance mandates. Finally, the intent of the owner in protecting what's underneath – can you afford downtime or damage to critical operations?

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Designing for Quiet

How Fenestration Impacts Building Acoustics

By Rich Rinka

PHOTO BY JEFF WHYTE/COURTESY SHUTTERSTOCK.COM

Defined as the movement of sound, acoustics are a critical component of any building design. The importance of acoustics is demonstrated by the fact that 65 percent of office workers surveyed said that workplace noise impacted their ability to complete their work accurately and efficiently.[1] Further, 44 percent stated that noise in their workplace negatively impacted their overall well-being, and more than 40 percent said the noise made them feel stressed. This was one of many surveys investigating the effects of poor acoustics in assorted business types and settings, and it demonstrated the importance of selecting the right materials, products, and systems, as well as well-sealed building enclosures, to optimize acoustics, which is growing in importance.

This article addresses noise reduction in the interior environment through the use of materials and assemblies that reduce the transmission of exterior noise through fenestration in the building enclosure.

AMAA standard

A source of guidance and education for specification professionals, architects, fenestration designers, and building owners, the Fenestration Glazing Industry Alliance (FGIA) is currently updating its AAMA TIR-A1, *Acoustical Performance of Exterior Fenestration Products*.[2] The new document is anticipated in 2026. This report walks professionals through key sound and noise definitions and values, explains how sound travels through and around windows, skylights, and other exterior glazed assemblies, and how it is impacted by materials, products, exposure, and building layout. The goal is to familiarize professionals with key concepts for understanding and measuring sound so they can speak intelligently about the topic.

Ultimately, the guideline is intended to support the specification of higher-performing acoustical products for glazing, windows, curtain wall, and storefront systems.

STC versus OITC

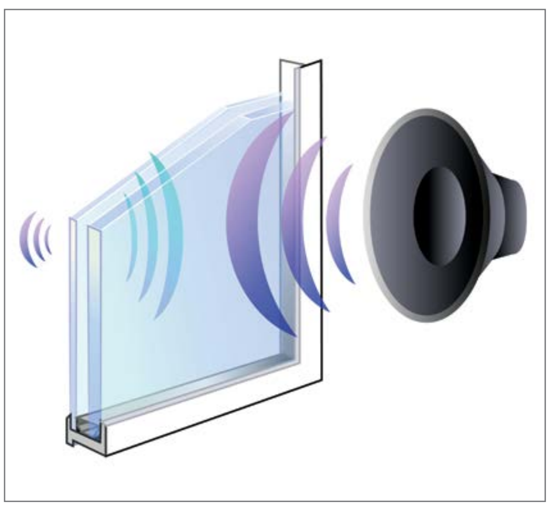
Key to this discussion of acoustics is clarifying and differentiating between the two methods of product classification, Sound Transmission Class (STC) and Outdoor Indoor Transmission Class (OITC). Most architects are familiar with STC, which measures the performance of building construction by how sound is transmitted through interior walls and floors. This article discusses the importance of OITC as a measure of the performance of the building enclosure in terms of sound transmission through exterior walls and roofs.

The technical STC and OITC definitions per AAMA TIR-A1 are as follows:

- **STC:** "A single number rating, that is calculated using the ASTM[3] E413 Classification for Rating the Sound Insulation characteristics of interior wall and floor partitions that are exposed to noise typical of offices and buildings (*e.g.*, speech, radio, television, etc.). An STC contour curve is applied to the actual measured one-third octave band transmission loss data at frequencies from 125 to 4000 Hertz (Hz [cycles per second]). The transmission loss value on the contour curve at 500 Hz is the STC single number rating."
- **OITC:** "A single number rating calculated using ASTM E1332 [Standard Classification for Rating Outdoor-Indoor Sound Attenuation] to evaluate the transmission loss of facade element, when they are exposed to transportation noise (planes, trains, and automobiles). To obtain the OITC rating, a transportation spectrum and logarithmic summation is applied to the transmission loss data in the one-third-octave band frequencies from 80 to 5000 Hz."

The Outdoor Indoor Transmission Class (OITC) rating was developed to address the sound isolation of exterior walls, windows, and doors.

PHOTO BY HANNATOR/COURTESY SHUTTERSTOCK.COM

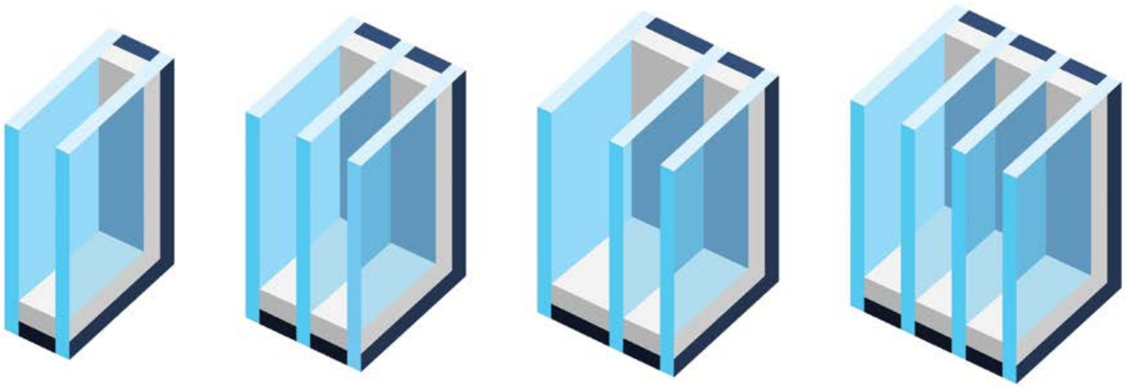


When designing glazed facades for acoustic performance, the characteristics of the glazing influences sound block levels.

PHOTO BY ANAITSMI/COURTESY SHUTTERSTOCK.COM

STC is typically used to evaluate interior partitions, including interior doors and windows, as well as floor/ceiling assemblies. However, when specifying exterior fenestration products such as windows, doors, curtain wall, framing, and glazing, OITC is the relevant metric, as it defines the fenestration's ability to block exterior noise from entering a space.

It is important to note that the Noise Reduction Coefficient (NRC) is a separate acoustical measure that evaluates the ability of construction materials and assemblies to reflect or absorb sound that originates within an interior space, whereas STC and OITC measure how much external noise is transmitted through its enclosure. For example, office design teams use NRC when recommending and specifying furniture for its sound-absorbing characteristics. As such, NRC also has an impact on the noise experienced within interior spaces, but it is not discussed in this article.



Outdoor Indoor Transmission Class (OITC) and Sound Transmission Class (STC) values will vary based upon glazing thickness and air space. Multiple glass lites and asymmetrical air spaces in an insulated glass unit (IGU) usually result in higher acoustic performance.

PHOTO BY INCOMIBLE/COURTESY SHUTTERSTOCK.COM

Ratings and calculations

AAMA TIR-A1 Section 2 is where specifiers will find details on how to understand and calculate acoustic values.

STC ratings

Since the Sound Transmission Class (STC) remains the most widely recognized and commonly referenced acoustic rating in North America, despite being frequently misapplied to exterior assemblies, it is useful to establish its basis and limitations before comparing it to other metrics, such as OITC.

Breaking down the origins of the number rating systems, the STC classification system used in North America was first introduced in 1970 by ASTM E413, *Classification for Rating Sound Insulation*. The metric is based on the amount of attenuation required to reduce each octave-based level of a somewhat arbitrary "standard household noise" spectrum, which includes noise emanating from sources, such as speech, radio, television, a vacuum cleaner, or air conditioner.

The number classification system makes it easy for users to evaluate and compare the acoustical performance with higher numbers denoting better acoustics.

As explained in ASTM E413:

These single-number ratings correlate in a general way with subjective impressions of sound transmission for speech, radio, television, and similar sources of noise in offices and buildings. This classification method is not appropriate for sound sources with spectra significantly different from those sources listed above. Such sources include machinery, industrial processes, bowling allies [sic], power transformers, musical instruments, many music systems, and transportation noises such as motor vehicles, aircraft and trains. For these sources, accurate assessment of sound transmission requires a detailed analysis in frequency bands. A single-number sound transmission rating for building facade elements is given in Classification E1332.

STC classification is considered adequate for assigning numbers to products with acceptable accuracy when the incident sound is broadband and dominated by mid- and high-frequency sound energy, *i.e.* 500 Hz and greater. STC numbers for products also work well with broadband sounds with somewhat lower-frequency characteristics, such as those of automobiles, trucks, and aircraft, if the Transmission Loss (TL) performance of the product is free of low-frequency "notches." A "notch" is defined as a significant local weakness in any portion of the TL spectrum.

The STC rating will usually provide the same ranking as the Weighted Sound Reduction Index (Rw) if there are no significant notches in the TL spectrum. The Rw is used for building facades that are exposed to transportation and other airborne noise and covers the frequency range of 100 to 3,150 Hz.

Cases where the STC classification system can be misleading occur when the incident sound is dominated by low-frequency energy—125 Hz and below—as is the case with railway, airport, and highway noise.

Of note, ASTM E413 specifically states that the STC calculation should not be used to measure the acoustics of partitions exposed to outdoor machinery, industrial, and transportation noise, such as motor vehicles, aircraft, and trains.

AAMA TIR-A1 Section 2 continues with the procedure of converting STL data to an STC single rating number as described in ASTM E413.

To determine the STC for an acoustical barrier, the STL is recorded for a series of 16 frequency bands. Each band encompasses one-third of an octave over the range of 125 to 4,000 Hz per ASTM E90, *Standard Test Method for Laboratory*

Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

As noted, STC is a well-known value and more commonly referenced in acoustical literature, building codes, and many governmental regulations.

Enter OITC

To address the different criteria for sound transmission through exterior enclosures, a different metric is needed to measure the level of noise entering from the outside. ASTM developed the single-number OITC rating to evaluate the noise reduction of exterior partitions such as walls, windows, and doors exposed to transportation noise. In other words, the OITC value quantifies a building enclosure's ability to reduce the perceived loudness of ground and air transportation noise transmitted into buildings.

As stated in AAMA TIR-A1 Section 2.2:

With the majority of windows installed in exterior walls, the OITC rating is the logical single number rating used to rate their acoustical performance. As acoustical data has been made available and the acoustical community (architects, consultants, etc.) becomes more aware of its existence, OITC has replaced STC as the preferred single number rating for acoustical performance of exterior windows, doors and wall systems.

OITC testing evaluates low-frequency incident sounds and is suitable for comparing the sound isolation performance of building facades. When low-frequency sounds typically associated with outdoor environments, such as vehicular, aircraft, and railway noise, are present to a lesser extent, the advantages of the OITC method over STC are less significant.

For cases where the incident sound band has a narrow range, *i.e.* tone in place of a broadband noise, neither the OITC nor the STC methods are appropriate. Further, when incident sound is dominated by frequency energy below 63 Hz, OITC is not suitable.

Since the calculation methodologies used to compute STC and OITC values differ, the resulting numbers are not comparable. The OITC rating is calculated for the frequency of 80 to 4,000 Hz, whereas the STC rating only covers 125 to 4,000 Hz.

The Outdoor Indoor Transmission Class (OITC) value quantifies a building enclosure's ability to reduce the perceived loudness of ground and air transportation noise transmitted into buildings.

PHOTOS COURTESY SHUTTERSTOCK.COM

Further, the OITC rating was developed to address the sound isolation of exterior walls, windows, and doors, while the STC rating targets the sound isolation of interior partitions.

If specifiers are seeking a basis of comparison between the OITC and STC numbers, additional evaluation of the individual one-third octave TL results can be performed by an acoustical professional. This type of comparison may be necessary when available test data is reported as STC, but project requirements specify OITC, due to the longer history and familiarity of STC. The ease of use and applicability of the single-number classification system are often preferred. The more technical computations of the one-third octave band TL data typically will be done on a specific case basis.

Glass selection

When designing glazed facades for acoustic performance, the characteristics of the glazing will have a large influence on sound block levels.

As explained in AAMA TIR-A1 Section 3, the following factors should be evaluated:

- Glass thickness—By increasing the thickness of an insulated glass unit (IGU), the STL will increase, assuming other variables are held constant. IGUs with asymmetrical glass thicknesses also enhance acoustical performance by reducing resonance effects.
- Non-laminated versus laminated—In general, glass has very low inherent damping. With laminated glass, the interlayer provides constrained-layer

The Sound Transmission Class (STC) rating targets the sound isolation of interior partitions and is commonly referenced in office designs.

damping, which improves the TL in a way that can only be achieved through significant increases in glass thickness. Along these lines, special plastic interlayers have been developed to increase glass damping and further enhance TL.

- Cavity space—While average cavity spaces do not affect TL performance, if the space is significantly increased, for example, from 12 to 100 mm (0.5 to 4 in.), this will boost TL ratings by several points.
- Gas filling—While the gas used inside an IGU may affect acoustical performance, the differences between air-filled and argon-filled units is negligible.
- IGU spacer systems—Softer spacer systems, like foam, typically outperform more rigid spacer systems, like metal.
- Size—The larger the glass lite, the more flexible it might be. And the more flexible, the more the glass will vibrate when exposed to a sounds source if resonant frequencies and mass-air-mass coupling are not considered. Consequently, it is possible to consider testing results of different-sized glass modules to estimate the acoustical performance of smaller vs. larger glass lites for a project.
- Vacuum Insulating Glass (VIG)—VIG tends to have excellent acoustic performance, producing higher STC and OITC ratings than monolithic glazing or an equivalent glass-thickness IGU. VIG incorporates a vacuum layer between the glass lites, which acts as a sound barrier by eliminating the medium for sound wave propagation, thereby reducing noise transmission. VIG excels in the low-frequency range, which helps reduce common urban noise, such as traffic and construction. Of note, there are variations in VIG manufacturing techniques and materials, so acoustical testing of the finished fenestration product incorporating VIG is recommended.

Windows and curtain wall

In addition to glazing, the main factors to consider with windows and curtain wall systems are the acoustical characteristics of the framing and the airtightness of the glazed assembly.

Higher air leakage levels may lead to lower acoustical performance, so well-sealed systems are important for enhancing acoustic performance.

Mass and air space can impact the design of framing members because a portion of the incident sound field will strike these areas. Adding cavities or sound-deadening materials between the innermost and outermost frame surfaces can be a strategy for improving acoustical performance of the frame at certain frequencies.

OITC and STC values will vary based on glazing thickness and air space. As a broad generalization, residential windows using relatively small glass lites exhibit an OITC of 19 and up, and an STC of 24 and up.

For example, a smaller residential IGU unit with two 3 mm (0.125 in.) glazed lites separated by 12 mm (0.5 in.) of air space will produce an OITC range of 22 to 26 and an STC range of 26 to 30.

With larger windows, curtain wall, and storefronts using larger lites, exhibit an OITC of 25 or higher and an STC of 29 or higher.

For instance, with an 8 mm (0.3125 in.) and a 6 mm (0.25 in.) glazing lite, sandwiched with a 12 mm (0.5 in.) air space, the OITC range will be between 29 and 34, and the STC range, 32 to 40.

To achieve the highest performance ratings, a dual-glazed window configuration with two sets of sashes, or a prime window with an exterior or interior storm panel, is generally required. The air space between the primary and secondary windows must be at least 25 mm (1 in.).

The cladding design of the non-glazed portions of an exterior wall is one final factor that weighs into the extent to which the building enclosure can keep out sound. If the exterior wall system is poorly designed, in regards to acoustical

A source of guidance and education, FGIA's updated AAMA TIR-A1, *Acoustical Performance of Exterior Fenestration Products*, is anticipated in 2026.

performance, even the highest quality acoustical window will not keep noise from entering the building. In other words, the composite TL of an exterior facade is based on the TL of the individual aspects of the facade, including walls, curtain wall, storefront, windows, and doors.

It is important to understand this component of building design well before ground is broken to avoid dissatisfaction of building inhabitants. AAMA TIR-A1, *Acoustical Performance of Exterior Fenestration Products*, in the FGIA online store, supports specification and design professionals with a shared understanding toward achieving their project goals.

NOTES

[1] Refer to *HR News*, "Noise at work is having a negative impact on health and productivity, new survey reveals," hrnews.co.uk/noise-at-work-is-having-a-negative-impact-on-health-and-productivity-new-survey-reveals

[2] See AAMA TIR-A1, *Acoustical Performance of Exterior Fenestration Products*, will be available at store.fgiaonline.org

[3] Refer to ASTM E413, *Classification for Rating Sound Insulation*, ASTM E1332, *Standard Classification for Rating Outdoor-Indoor Sound Attenuation*, and ASTM E90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*.

additional **information**

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KEY TAKEAWAYS

Understanding Sound Transmission Class (STC) and Outdoor Indoor Transmission Class (OITC) ratings helps specifiers select fenestration systems that reduce noise transmission. Proper glazing, framing, and enclosure design are essential for improving acoustic comfort and occupant well-being.

MASTERFORMAT NO.

08 80 00—Glazing

UNIFORMAT NO.

B2020—Exterior Windows

KEYWORDS

Division 08
Acoustics
Sound Transmission Class (STC)
Outdoor Indoor Transmission Class (OITC)

Engineering the Sphere

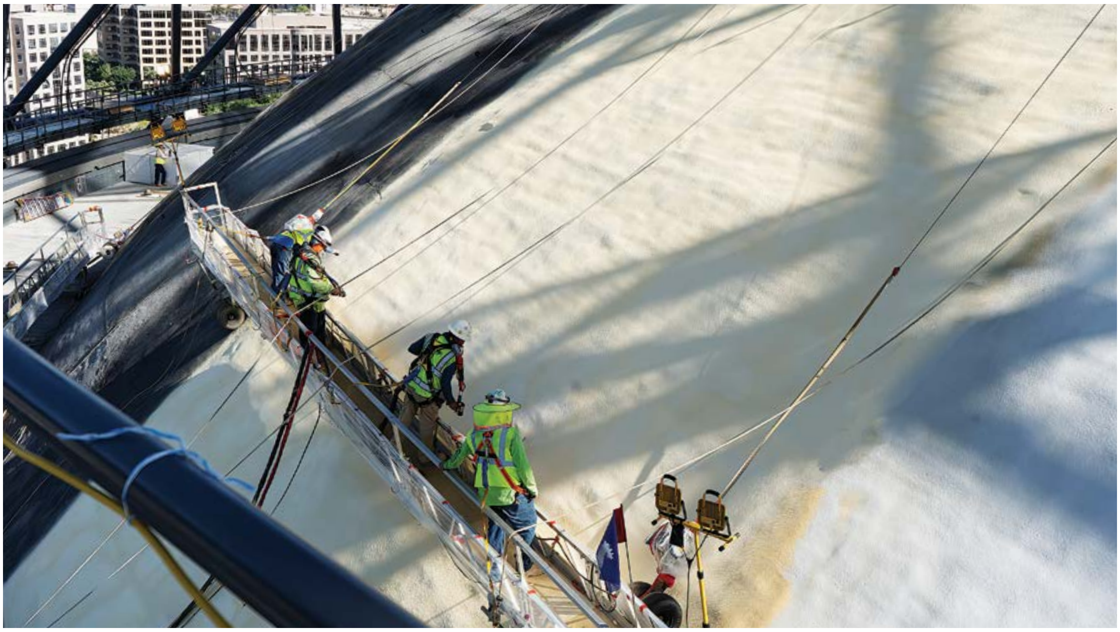
A Watertight Roof for Las Vegas' Iconic Dome

By Steve Goold
PHOTOS COURTESY GENERAL COATINGS MANUFACTURING CORPORATION

The dome-shaped Las Vegas entertainment complex is wrapped in a high-resolution screen that transforms its entire surface into a dynamic visual display.

From realistic eyeballs and sports balls to themed holiday scenes and advertising, the facade can showcase a wide range of immersive content. The structure is large enough to be seen from space and dominates the Las Vegas skyline, often creating a surreal "living billboard" effect. Specifically, the facility spans 111 x 157 m (366 x 516 ft) and rises 111 m (366 ft) above ground.

The $2-billion facility includes a steel-framed, dome-shaped roof trusses weighing more than 11,793 tonnes (13,000 tons) that were welded and bolted together, presenting the challenge of ensuring it was watertight. The exterior shell was made watertight using specialized sprayfoam insulation (SPF) and elastomeric coatings, rather than the steel trusses themselves being inherently sealed. This waterproof system includes an elastomeric basecoat and topcoat applied to create a robust, weather-resistant envelope over the structure.



Crews inspect the inner dome construction ahead of applying the sprayfoam. The manufacturer had a technical applicator on site throughout application processes to provide product assistance when needed.

Nuts and bolts

The engineering and selection of structural steel castings were driven by the need to address complex geometry, tight tolerances, and load demands. The design process began with parametric modeling followed by more advanced 3D finite element analyses of the superstructure but was intertwined with hand sketching to determine optimal shapes for the nodes. Early collaboration between design and fabrication teams ensured the feasibility of castings versus fabricated nodes.[1]

Construction began with installing the trusses to form the domed roof, designed to create a column-free, 14,864 m^2 (160,000 sf) interior display plane. The framework relies on high-strength structural steel, which provides the necessary support for the massive structure. The project required 25,401 tonnes (28,000 tons) of total steelwork to create the main sphere and its associated structures.

Due to their immense size, the roof trusses were assembled at the site, with 91 tonnes (100 tons) pieces lifted by a 177-m (580-ft) crane. The trusses are covered with corrugated metal decking and hold 2,722 tonnes (3,000 tons) of rebar and 5,040 m^3 (6,600 yd^3) of concrete on the roof. The crews then placed 2,722 tonnes (3,000 tons) of rebar and pumped 5,040 m^3 (6,600 yd^3) of concrete—weighing 9,072 tonnes (10,000 tons)—onto the roof to provide full weight-bearing capabilities. The outer shell, or exosphere, uses a geodesic design consisting of hundreds of interlocking triangles connected to the structural steel framework.

The steel-framed dome roof was engineered for efficiency and function, providing substantial load-carrying capacity and adequate stiffness to facilitate the precise placement of LED tiles. The design of the dome roof optimizes its depth and the quantity of circumferential rings, ensuring it can support the considerable weight of both the roof and the media plane.

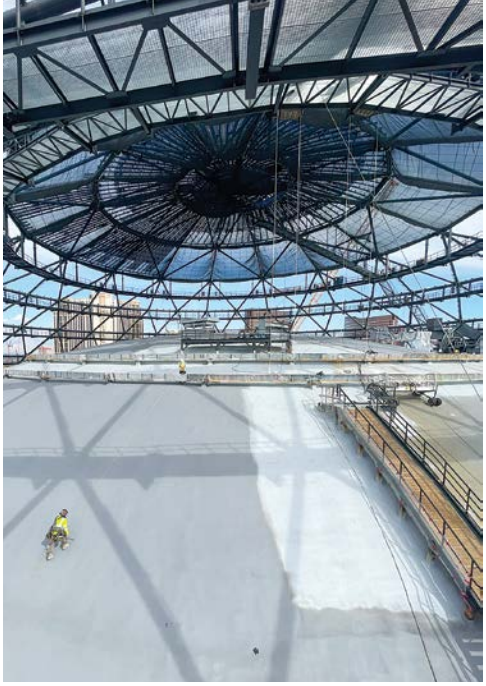
The original specs for the 16,722-m^2 (180,000-sf) dome underneath the exoskeleton called for a single-ply polyvinyl chloride (PVC) roof with an R–30 insulation board anchored down to the concrete deck.

But when the roofing contractor realized that about 45 truckloads of material would need to be brought onto the roof during construction of the sphere's exterior, the team began seeking alternative systems. They determined that the ideal solution would be to install a sprayfoam roofing system with a coating overtop. This would eliminate the material loading issue and avoid the 20–25 percent waste that would occur trying to install PVC on the round sphere.

The concrete dome was formed by pumping 4,590 m^3 (6,000 yd^3) of shotcrete onto a prefabricated steel roof frame, creating a 254-mm-thick (10-in.-thick), 9,072-tonne (10,000-ton) concrete shell.

Foundations

The foundation is comprised of 610-mm (24-in.) diameter auger cast-in-place (ACIP) piles supporting cast-in-place concrete pile caps and tie beams. These piles extend up to 30 m (100 ft)


Above: The swing stage platform carriages allowed three sprayfoam applicators to work simultaneously, installing the polyurethane foam that creates a waterproof barrier, while a crew followed behind to apply the elastomeric base coat and topcoat at five gallons per square feet to finish at 40 dry mils.

Middle: With much of the pitch being 8:12, or even steeper in some areas, the sprayfoam and coating installers contracted with a scaffolding company for swing stage platform carriages. They utilized oversize balloon tires to protect the foam, while moving up and down, applying the coating.

Far right: A special slate gray color formulation was developed for the top coating, allowing visitors to look at the LED monitors and not see the roof behind it, making it appear as if the roof had vanished. The crew was able to apply the coating while being tied off and scaling the dome.

down into the bearing stratum (generally comprised of dense sand) to provide the necessary support for the massive structure, ensuring stability and load distribution throughout with minimal potential for differential settlement. The piles and foundation elements are arranged in two closely spaced rings at the perimeter; the outer ring supports both the outer venue columns and the geosphere base, while the inner ring supports the inner column of the venue's ring of paired columns. An array of individual pile caps supports the seating bowl and concourses. Pile supported concrete mats support the shear wall cores, providing additional stability and resistance for overturning moments and shears induced by lateral loads.[1]

Seamless partnership and effective collaboration efforts

Early collaboration among stakeholders was instrumental in guaranteeing success. Integrating casting expertise into the design process from the start ensured that components aligned with architectural, structural, and construction goals. Collaboration among the design-construct team, Severud Associates, Populous (the architect), W&W | AFCO Steel (steel fabricator and erector), CastConnex (casting designer and supplier), SDL (erection engineer), and MJ Dean (GC/CIP concrete contractor) allowed for precise integration of structural components and optimized the structural design.

During construction, Severud Associates had a full-time onsite presence to assist with immediate action to any construction issues as they arose. This involved working closely with various contractors to solve issues as quickly as possible, ensuring the project continued to move along smoothly. This hands-on approach allowed for rapid problem-solving and maintained the project's momentum, adhering to the planned schedule and quality standards.[1]

The roofing contractor partnered with a long-time sprayfoam and roof coating manufacturer known for their unique product engineering. Despite the ongoing material shortage at the time, the manufacturer assured everyone that they could deliver a quality product on time, with technical support. A special slate-gray color formulation was created for the top coating, allowing visitors to look at the LED monitors, which run 24/7, without seeing the roof behind them, making it appear as if the roof had vanished. This uniquely developed coating also withstands the hot Las Vegas sun without blistering.

Prefabricated panels of continuous insulation was key to streamlining the facade installation and ensuring quality control. The base included an angled collar that was designed using uniquely angled prefabricated exterior insulation and finish systems (EIFS) wall panels; 232,258 m^2 (2.5 million sf) of rigid fiberglass insulation was installed on the walls and under the steel dome. Cut to specification, the pieces of rigid board insulation were installed in an array of different 102 mm (4 in.) and 51 mm (2 in.) thicknesses that included radial, dome and double-curved designs.[2]

Ensuring a safe installation

With much of the pitch at 8:12, or even steeper in some areas, the sprayfoam and coating installers

contracted with a scaffolding company for swing-stage platform carriages. They had to use some ingenuity and modify the wheels so they would not crush the foam, yet still allow the workers to be close enough to effectively spray and build up the required 127 mm (5 in.) of foam.

Installers began the work relying on these five swing stage platform carriages, about 9.14 to 12.19 m (30 to 40 ft) long. This allowed three sprayfoam applicators to work simultaneously, installing the polyurethane foam that creates a waterproof barrier while a crew followed behind to apply the elastomeric base coat and topcoat at 18.93 L (5 gal) per square feet to finish at 40 dry mils. Once the circumference of the dome was completed, crews moved to the top of the dome, where they were able to stand while being tied off in the case of a fall.

The crew had to be cognizant of overspray during the application since it was done during a very windy time of year. When the wind would pick up, the crew would shut down, causing them to lose a lot of days due to the weather. The installation also required some coordination with the iron workers who were building the exoskeleton of the sphere, at the same time, the roofing system was being installed. They had to work closely with all parties to ensure the workers remained safe.

Once the dome portion was complete, the crew moved on to the tension ring around the bottom. This ring was 396 m (1,300 ft) in circumference and similarly coated. The SPF needed to be applied in a way to create a positive water flow to the drains within the valley, the high points, the crickets, and the tapers all being important. To apply SPF in this way requires precision, technique, and pre-planning, along with mindfulness to ensure the fluid is not carried by the wind and lands on surrounding property. The coatings manufacturer provided support during the installation by positioning their technical team on-site to observe and answer any questions when needed.

Communication is key to success

The engineering and logistics of this roofing project were immense. However, open communication and collaborative problem-solving made it successful. The owner of this iconic facility is extremely pleased and knows the roof will remain watertight.

NOTES

[1] Refer structuremag.org/article/the-structural-genome-of-sphere/

[2] Read more at wconline.com/articles/97666-sphere-of-influence-how-teams-insulated-the-most-complex-venue-ever-built

additional information

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KEY TAKEAWAYS

The Las Vegas dome roof combined innovative sprayfoam roofing, precision engineering, and collaborative installation to handle complex geometry, massive steel trusses, harsh conditions, and LED integration while ensuring watertight performance.

MASTERFORMAT NO.

07 16 00—Lightweight Insulation
07 54 00—Thermoplastic Roof Systems
05 12 00—Structural Steel Framing

UNIFORMAT NO.

B3010—Roof Structure

KEYWORDS

Division 07, 05 | Structural steel | Roof trusses

SOUND Advice

Specifying Interior Wood Doors

By Maria Leddin

PHOTOS COURTESY FORTE OPENING SOLUTIONS (FORTEOPENINGS.COM)

Acoustic performance has become a defining factor in the design of interior commercial environments. Rising expectations for speech privacy and auditory comfort continue to shape how designers manage sound. While walls and ceilings typically receive most of the attention, interior wood doors also contribute positively when properly specified. To achieve optimal acoustic performance, doors must be approached as a complete assembly in which the door leaf, frame, glazing, hardware, and seals all work together. Because each component contributes to acoustic control, durability, safety, and aesthetics, recognizing this interdependence allows architects and designers to strike the right balance and ensure the door assembly is greater than the sum of its parts.

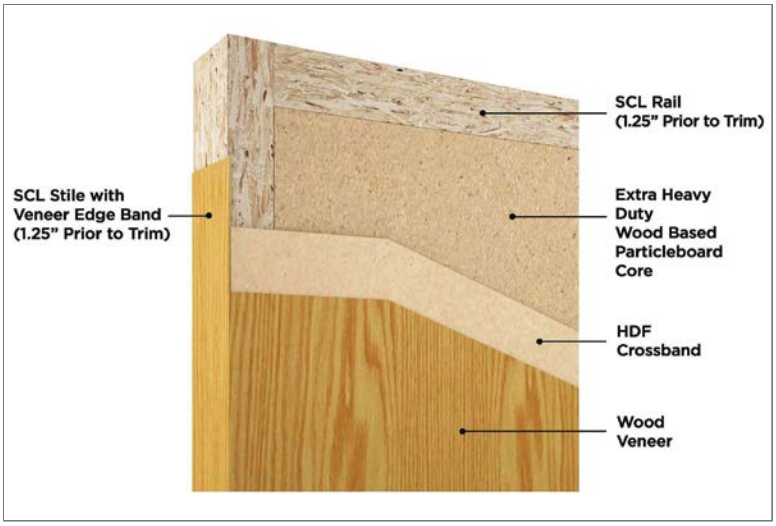
Acoustic needs in context

Since acoustic priorities vary widely by building type, door assembly features must be based on how the space will be used. Assemblies that perform well acoustically in one environment may fall short in another if all requirements are not considered collectively. Understanding these application-specific needs is the first step in selecting doors that support acoustic goals without compromising other performance criteria.

In educational settings, doors are often tasked with limiting corridor noise and maintaining speech clarity inside classrooms. Depending on the level of separation required, openings may target Sound Transmission Class (STC) ratings in the mid-30s to mid-40s to reduce distraction while supporting clear instruction. Frequent use, visibility requirements, and evolving safety and security expectations add to specification complexity, making it essential to choose assemblies that balance acoustic performance with durability and life-safety requirements.

In office or workplace environments, acoustic requirements often center on speech privacy in conference rooms, collaborative workspaces, and private offices. Openings in meeting rooms or executive offices where confidential discussions occur may target STC ratings of 45 or

In healthcare facilities, doors for patient rooms, exam spaces, and consultation areas commonly require Sound Transmission Class (STC) ratings in the 40 to 50 range to protect patient privacy.



The largest contributor to a door assembly's ability to attenuate sound is the door leaf, which comprises the core, face construction (veneer, laminate, or metal skins), and edge detailing.

higher. At the same time, doors must align with broader interior design strategies and reflect the organization's brand.

For healthcare facilities, doors must protect patient privacy and contribute to a healing environment. Openings between patient rooms, exam spaces, or consultation areas commonly require STC ratings in the 40 to 50 range, depending on adjacent spaces and facility standards. Acoustic performance must be achieved alongside strict requirements for cleanability, durability, and safety, often within high-traffic, high-contact conditions.

By starting with the unique demands of the space and establishing realistic performance targets, specifiers can more clearly define how door assemblies must perform. Manufacturers can then match door designs, materials, and supporting components to meet both acoustic expectations and broader project requirements.

Coordinating laboratory ratings with field performance

Acoustic performance for door assemblies is specified by an STC rating. STC values are determined through laboratory testing in accordance with ASTM E90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*, and calculated under ASTM E413, *Classification for Rating Sound Insulation*, providing a standardized measure of how effectively a door assembly reduces airborne sound transmission across a range of frequencies.

While STC offers a useful benchmark for comparing products, it reflects controlled laboratory conditions. In the field, installed performance is typically evaluated as Noise Isolation Class (NIC) under ASTM E336, *Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings*. Because field conditions introduce variables such as installation tolerances, seal integrity, adjacent wall construction, and ceiling plenums, measured NIC values may differ from laboratory STC ratings.

For specifiers, this distinction underscores an important principle: achieving the desired acoustic outcome requires more than selecting a door with a target STC value. The surrounding wall assembly, frame integration, gasketing, and installation quality all influence acoustic performance. Approaching the opening as a coordinated system helps ensure that laboratory-tested ratings translate into predictable results once the building is occupied.

Breaking down the door: Key components that contribute to acoustic control

Once application needs are determined, the next step is understanding how a door assembly supports acoustic performance, as the core alone does not determine the final STC rating. Rather than simply specifying an acoustic-rated core, it is more effective to break down the entire door assembly into its component parts and specify them individually with manufacturer guidance.

Door leaf

The largest contributor to a door assembly's ability to attenuate sound is the door leaf, which comprises the core, face construction (veneer, laminate, or metal skins), and edge detailing. In acoustic doors, the core is not a conventional solid

Gasketing and perimeter seals close the gaps between the leaf, frame, and floor, preventing airborne sound from bypassing the assembly.

insert but an engineered internal construction. Its interaction with the surrounding faces and edges determines the leaf's overall mass, stiffness, and ability to resist vibration. As sound waves strike the surface, energy is transferred into the leaf and must be controlled within its layered construction to limit airborne sound transmission.

While proprietary configurations vary by manufacturer, most acoustic cores are designed around three core performance strategies:

- Engineered multi-layer construction—Acoustic cores commonly use laminated wood-based or composite layers arranged to disrupt vibration paths and reduce internal resonance.
- Increased surface mass—Added mass improves transmission loss in accordance with mass law principles, requiring greater energy for sound to pass through the door.
- Internal damping—By combining materials with differing stiffness characteristics, acoustic cores reduce the amplitude of vibration as energy moves through the assembly, limiting how much sound reaches the opposite side.

Together, these strategies elevate acoustic doors beyond conventional solid-core constructions of similar thickness.

Frame

While the door leaf provides most of a door assembly's sound attenuation, the frame is essential for realizing that performance in practice. The frame forms the structural boundary around the leaf, supporting alignment, hardware, and seals while controlling indirect sound transmission paths. A properly engineered frame works with the leaf to maintain acoustic continuity at the perimeter and at the interface between the opening and the surrounding wall.

Acoustic door frames achieve performance through several key design principles:

- Continuous, stable construction—Frames are built to provide a rigid, uninterrupted connection to the surrounding wall assembly. Stability at this junction is critical, as movement, voids, or incomplete anchoring can create flanking paths that allow sound to flow around the leaf rather than through it. Proper anchorage at the frame-to-wall interface helps preserve the integrity of both the opening and adjacent construction.
- Precision alignment and tolerances—Frames are manufactured and installed to tight dimensional standards, ensuring the door leaf closes squarely and consistently. Accurate alignment allows latching hardware and gasketing to fully engage, maintaining the designed seal pressure and limiting sound transmission at the perimeter.
- Control of indirect transmission—Special attention is given to transitions between the frame, the wall assembly, and adjacent building elements. Openings at these transitions, including alignment gaps and unsealed penetrations, can reduce effective isolation, even when the door assembly carries a high laboratory STC rating. Attention to detail in these areas helps ensure sound energy does not bypass the opening.

When properly specified and installed, the frame does more than support the leaf. It also helps integrate the door assembly into the overall acoustic envelope of the space, maintaining consistent performance across the opening.

Vision lites and glazing

When visibility, daylighting, or safety requirements call for vision lites in the door leaf, the size, location, and construction of the opening directly influence acoustic performance. In acoustic doors, vision lites are designed to preserve as much of the door leaf's sound-attenuating properties as possible while also meeting functional and aesthetic goals.

An effective acoustic vision lite design includes:

- Optimized size and placement—Smaller openings preserve more of the leaf's mass, which is essential for sound blocking. Thoughtful positioning of the lite within the door can also minimize structural interruptions that may reduce performance.

- Acoustic-rated glazing—Specialty glass or laminated units add mass and internal damping, helping limit sound transfer through the lite. The specific thickness and composition of the glazing are coordinated with the surrounding leaf construction to achieve the desired STC rating.
- Precision framing and sealing—Glazing is installed in frames designed to maintain tight tolerances and full seal compression around the lite perimeter. Properly engineered lite frames prevent gaps that could create flanking paths and ensure the vision opening does not compromise overall acoustic performance.

These considerations allow vision lites to provide daylighting, visibility, and safety while preserving the acoustic integrity of the door assembly.

Hardware

Hinges, latching mechanisms, locks, and closers are not just operational elements. They also help ensure the door maintains alignment, seal compression, and acoustic continuity over time. Even the best-engineered leaf and frame cannot achieve STC-rated performance if the hardware has gaps, misalignments, or uneven compression.

Effective acoustic hardware attends to:

- Weight support and alignment—Hinges must adequately accommodate the weight of the door, particularly heavier acoustic cores or doors with glazing, to maintain long-term alignment. A properly supported leaf prevents sagging that could reduce gasket compression or create gaps at the perimeter.
- Full engagement and consistent seal compression—Latching mechanisms, locks, and closers work together to ensure the door fully engages the frame every time it closes. Consistent engagement compresses perimeter seals and prevents sound from bypassing the leaf through gaps.
- Durability under frequent use—High-traffic environments such as schools, hospitals, and offices require hardware that withstands repeated operation without loosening, warping, or failing. Durable components maintain proper alignment and seal pressure, preserving acoustic performance throughout the life of the door.

By specifying and installing hardware in coordination with the leaf and frame, designers can ensure that the door assembly functions as a cohesive acoustic system.

Manufacturers can match door designs, materials, and supporting components to meet both acoustic expectations and broader project requirements.

Gasketing and seals

Even the most carefully specified door leaf, frame, and hardware cannot achieve rated acoustic performance without proper gasketing and perimeter seals. These elements close the gaps between the leaf, frame, and floor, preventing airborne sound from bypassing the assembly and undermining the STC rating.

Effective acoustic gasketing and seal design rely on:

- Continuous sealing around the perimeter—Perimeter gaskets must maintain an uninterrupted barrier along the top and sides of the door. Continuous, properly aligned perimeter gaskets prevent flanking paths and help the leaf and frame achieve their full acoustic potential.
- Compatibility with hardware and door operation. Seals and door bottoms must be matched to the door's weight, swing, and frequency of use. Proper coordination with latches, closers, and hinges ensures that compression is consistent and that the seals function over the life of the assembly without excessive wear or deformation.
- Floor and threshold integration—Automatic or drop seals at the bottom of the door, or gasketed thresholds, prevent sound from escaping beneath the leaf. These components are engineered to fully engage when the door closes yet allow smooth operation and durability in high-traffic areas.

Acoustic priorities vary widely by building type, so door assembly features must be based on how the space will be used.

By understanding the contribution of each component and coordinating with an experienced manufacturer, designers can specify assemblies that reliably achieve their intended acoustic performance targets.

Balancing acoustic performance with other requirements

Acoustics are only one priority that interior doors must meet in real-world environments. Schools, hospitals, offices, and other high-traffic spaces require doors that are also durable, safe, and visually appropriate for the intended area. When properly specified, acoustic door assemblies can satisfy these additional requirements without compromising sound control, allowing designers to achieve a truly integrated solution.

Durability and high use

In classrooms, patient rooms, and busy offices, doors must withstand repeated operation, impacts, and general wear over time. Acoustic doors meet these demands through robust core constructions, reinforced edges, and durable hardware. Selecting hardware rated for heavier acoustic cores and ensuring proper frame installation helps maintain alignment and seal compression over years of use, preserving both durability and sound attenuation. High-quality face materials, such as resilient laminates or wear-resistant veneers, further protect the leaf against scratches and dents while maintaining acoustic performance.

Fire and safety performance

Depending on building codes and the location of the door, assemblies may need to meet fire-resistance ratings, smoke control standards, or other safety requirements. Acoustic doors can be configured with fire-rated cores, glazing, and compatible hardware when required, without reducing sound attenuation.

Aesthetic integration

Veneer species, cuts, paints, stain finishes, and laminate options provide flexibility for color, texture, and pattern without impacting acoustic cores and perimeter seals. Designers can coordinate vision lites, hardware finishes, and door leaves to align with branding or interior themes while still achieving the desired STC rating.

By considering durability, fire and safety, and aesthetics alongside acoustic goals, specifiers can select door assemblies that meet multiple project requirements.

Selecting a manufacturer that supports specification

Today's interior wood doors are expected to deliver more than visual appeal, making the choice of manufacturer an important part of managing the specification process. The ideal manufacturer is one that simplifies decision-making and helps ensure both design and performance intent are realized in the finished environment.

Start with a system-based approach

Manufacturers that offer performance data for complete door assemblies are better able to help specifiers achieve predictable results. Acoustic performance, durability, fire ratings, and aesthetics are all outcomes that depend on how the door leaf, frame, glazing, hardware, and seals interact. Look for a manufacturer that tests and documents performance at the assembly level and that can clearly explain how each component contributes to the overall result. This approach reduces guesswork and helps specifiers avoid unintended performance gaps.

Prioritize verified performance

A reliable manufacturer provides clear, easily accessible documentation, such as acoustic ratings, security certifications, fire listings, and compliance with applicable standards, so specifiers can compare options with confidence. Equally important is transparency about limitations and tradeoffs. Manufacturers that are knowledgeable about how factors like glazing, core selection, and hardware choices

Acoustic doors in meeting rooms target Sound Transmission Class (STC) ratings of 45 or higher to protect confidential discussions.

affect acoustics help specifiers make more informed decisions.

Look for a balance of aesthetics and performance
Manufacturers of high-performing acoustic wood doors offer a wide range of aesthetic options that do not require specifiers to sacrifice design for performance. The right manufacturer supports architectural expression with a range of wood veneer options as well as stains, paint finishes, and edge profiles that work in harmony with the door assembly's strength and durability.

Consider early and ongoing technical support
The best manufacturers act as technical partners, not just product suppliers. Early engagement in the development of the door's design helps identify and resolve potential conflicts among acoustics, code requirements, and budgets before they become costly issues. Ongoing support throughout submittals and installation further ensures the specified performance is preserved through construction.

Assess long-term value, not just first cost
High-quality acoustic wood doors that meet multiple performance priorities should deliver lasting value. Manufacturers that emphasize durability, consistent quality control, and serviceability help protect the building owner's investment while reducing maintenance and replacement costs over time.

Ultimately, specifying interior wood doors for acoustic performance requires more than selecting a product with a target STC rating. Success depends on coordinating the entire assembly and adjacent structures with the support of a knowledgeable manufacturer. Taking this approach supports better-informed and better-designed acoustic solutions that meet the demands of today's commercial interiors.

additional information

AUTHOR

Maria Leddin, senior product manager at Forte Opening Solutions (forteopenings.com), brings more than a decade of product management experience in manufacturing and commercial project solutions. She oversees Forte's full product portfolio—from doors to components—ensuring performance, consistency, and value across complex commercial environments, with particular expertise in wood-based solutions. Leddin holds an MBA from the University of Iowa and a BA from the University of Wisconsin, and is known for her strategic, data-driven approach and collaborative leadership that help deliver reliable results for Forte's customers.

KEY TAKEAWAYS

Achieving acoustic performance in interior wood doors requires a system-based approach. The door leaf, frame, glazing, hardware, and seals must be coordinated with surrounding construction and installation practices to ensure laboratory Sound Transmission Class (STC) ratings translate into effective sound control in real-world commercial environments.

MASTERFORMAT NO.

08 14 00—Wood Doors

UNIFORMAT NO.

C1020—Interior Doors

KEYWORDS

Division 08
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Beyond Windows

The Fundamentals of Effective Daylighting Design

By Neall Digert, Ph.D., MIES

PHOTO BY WILLIAM LEMKE/COURTESY OF KINGSPAN LIGHT + AIR

Natural daylight matters on several levels—it enhances occupants' well-being, reduces energy consumption, and provides biological and psychologically meaningful variation in architectural spaces. It follows that daylighting design should sit at the heart of architectural and interior design, helping to shape functional and inspiring spaces. However, achieving effective daylighting in buildings is more complex than 'just adding windows.' Architects and designers must carefully balance internal, external, and product considerations to craft spaces that optimize daylighting performance.

When referring to daylight and daylighting, it is important to understand the difference between the two terms, as it affects how solutions are developed and applied to real-world buildings:

- Daylight—The lighting resource provided by light from the solar disk (the sun/sunlight), and/or light from the diffuse sky vault
- Daylighting—The artful application of the daylight resource (sky and sun) and architecture/products to achieve interior lighting objectives (task illuminance for visibility and/or illumination for visual effect)

This article explores the critical factors that influence daylighting design and offer strategies for creating luminous, sustainable spaces.

External considerations

As a starting point, determine how the structure's location will affect its daylighting solution—its surrounding

environment significantly influences which daylighting strategies will work best. Designers must evaluate site-specific factors that determine how light enters a building, which include:

Building orientation

The orientation of a building dictates the directionality and quantity of sunlight different facades receive throughout the day and year. In the northern hemisphere, south-facing orientations, for instance, maximize sunlight, while east and west-facing facades introduce challenges such as glare during mornings and evenings.

Surrounding structures

Adjacent buildings, trees, and topography can block or reflect light. Conducting a shading analysis helps identify potential obstructions and opportunities for light redirection.

Climate and weather patterns

The intensity and angle of sunlight vary by geographic location and climate. In regions with frequently overcast skies, strategies should prioritize diffuse light. In sunny climates, daylighting design needs to consider shading devices and glare control.

Urban and environmental context

Urban areas with dense development demand careful planning to balance daylight access and privacy. Environmental factors, pollution or dust—may also reduce light penetration and will need to be addressed during the design phase. Real-time particle sensors can continuously measure dust and pollution throughout a property, and passive samplers like diffusion tubes can measure pollutants such as nitrogen dioxide over long-term intervals. A variety of daylighting solutions can help to address the optical impacts of pollution and dust. In high-dust areas, designers can specify steeper pitches for skylights to enable natural runoff to provide a self-cleaning effect. In polluted environments with hazy conditions, skylights with highly engineered geometric shapes can help capture low-angle daylight by catching and bending diffuse light rays downward, distributing daylight even in overcast conditions.

Internal considerations

Once light enters a building, its journey is shaped by interior surface geometries and design choices. These factors ensure daylight is effectively distributed and visually enhances the space. In daylighting design, the building's architecture (the location and finish of architectural surfaces) serves as the "light source" or "luminaire," and the building's interior becomes the "light fixture."

Utilizing glass glazing can add aesthetic impact to a space, providing maximum daylight and eye-catching views of the sky.
PHOTO BY WILLIAM LEMKE/COURTESY OF KINGSPAN LIGHT + AIR

Space layout

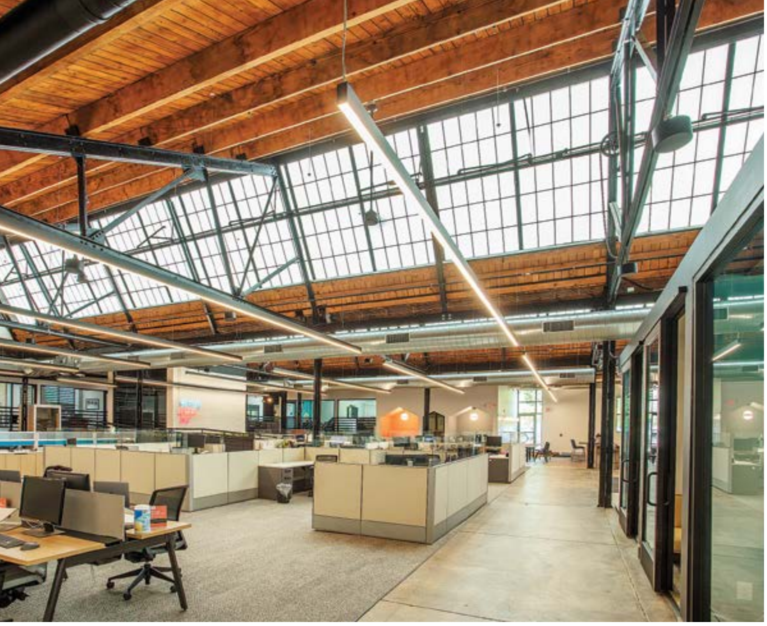
Open floor plans and strategically placed partitions mean light can travel deeper into the building's core. Using atriums, light wells, or clerestory windows can also bring daylight to lower levels.

Surface reflectance

Interior surfaces play a vital role in bouncing light through the space. Light-colored walls, ceilings, and floors reflect more daylight, reducing the need for electric lighting. Additionally, the color of those surfaces can play a key role in how the reflected light is perceived. Surfaces with a warm tone (think white paints with a slight wheat-colored cast) will help interiors feel "warm and inviting" on extremely overcast days. Conversely, interior finishes with cool blue/gray undertones will make the space feel cold and clinical on highly overcast days.

Room depth and window placement

Rooms that are too deep relative to the window size can leave areas underlit. Ensuring an optimal ratio between window height and room depth helps achieve uniform light distribution. Effective daylighting typically reaches a distance



Translucent panel daylighting systems are an excellent tool for offices and other spaces where glare can be a factor.
PHOTO BY WILLIAM LEMKE/COURTESY OF KINGSPAN LIGHT + AIR

of approximately two times the head-height of the window relative to the floor, significantly dropping off past that point. Therefore, a standard window measuring 2.1 m (6.9 ft) high will deliver an effective daylight depth of 4.2 m (13.8 ft).

Additionally, top-lighting daylighting technologies, such as tubular daylighting devices (TDDs) and architectural skylights, can be used to provide robust and controlled daylight to illuminate interior occupied zones and architectural surfaces.

Control of glare and heat

Glare from uncontrolled sunlight can make spaces uncomfortable. Designers should consider using translucent glazing materials, TDDs, shading devices, or adjustable louvers to maintain comfort without sacrificing light quality.

Building function

Who will use the building or space, and why, will dictate how much light is necessary. Here, regulations come into play, with different guidance for different space uses and/or building types. Around 300 lux is the norm for most space types, with a higher requirement of around 500 lux in workspaces.

While task illuminance requirements vary due to a number of factors, The Illuminating Engineering Society (IES) currently standardizes on approximately 300 lux (30 footcandles) for most commercial and institutional spaces (offices and classrooms), with 500 lux (50 footcandles) or more being reserved for spaces with more critical visual tasks such as manufacturing and other critically important visual tasks such as laboratory work and food preparation in commercial kitchens. These more moderate illuminance requirements are also deemed more conducive to the science of daylighting.

Beyond official guidelines, sustainable building standards have their own requirements. For instance, the U.S. Green Building Council's (USGBC's) Daylight Standard states that at least 75 percent of regularly occupied areas should have a daylight factor (DF) of at least two percent in all spaces used for critical visual tasks.[1] This equates to around 300 lux under overcast sky conditions.

Additionally, in North America, modern design standards such as LEED and WELL now incorporate metrics like Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE) as preferred assessments of annual daylighting sufficiency, replacing outdated traditional measures such as the DF.

Accessibility and inclusivity

Daylighting design should consider the needs of people with disabilities, ensuring that spaces are comfortable and functional for all occupants.

For example, individuals with visual impairments may benefit from enhanced lighting in critical areas, such as entrances, hallways, or workspaces. Thoughtful daylighting can make spaces more inclusive and supportive of diverse occupant needs.

Product considerations

The choice of materials, glazing, and daylighting technologies can make or break a daylighting design strategy. What product factors should one bear in mind?

Glazing types

High-performance glazing can enhance daylight penetration into the space while managing solar heat gain. Options include translucent polycarbonate or fiberglass reinforced panels (FRP panel) glazing, low-emissivity (low-E) glass, tinted glass, or TDDs.

The choice of materials, glazing, and daylighting technologies can make or break a daylighting design strategy.

Shading devices

External solutions, such as brise-soleil and overhangs, or internal mechanisms, such as blinds and curtains, help modulate light levels. Automated shading systems can adapt to changing conditions throughout the day.

Light-redirecting technologies

Innovations such as prismatic glazing, light shelves, and reflective louvers direct sunlight deeper into interiors, improving daylight access in challenging spaces.

Tubular daylighting devices, skylights, and roof glazing

Top-down daylighting solutions—such as TDDs and skylights—bring in daylight and can be used to balance the

When designing daylighting systems for manufacturing or working environments, it is essential to consider the tasks being performed to ensure appropriate light levels reach occupants and workstations.
PHOTO COURTESY OF SOLATUBE

Internal corridors and other areas that cannot be daylit via perimeter glazing can often benefit from skylights or tubular daylighting devices (TDDs) that can direct sunlight into otherwise hard-to-reach spaces.
PHOTO COURTESY OF SOLATUBE

potential brightness from perimeter windows and glazing systems. They can also provide controlled daylighting into core building areas far from windows. They can be particularly effective for commercial spaces or large open-plan environments.

Integration with electric lighting

Daylighting and electric lighting should work together harmoniously. In practical terms, this can mean installing daylight sensors and dimmable electric light fixtures to ensure consistent illumination while achieving significant annual energy savings.

Testing daylighting design

The performance of a proposed design can be assessed using Climate-Based Daylight Modeling (CBDM), also known as dynamic daylight metrics, to account for external factors. Similarly, specialist software can model a new building in 3D and analyze the hourly, daily, and annual levels of daylighting achieved through the design. This modeling can account for average pollution and dust levels, drawing from Typical Meteorological Year (TMY) climatic and daylight resource datasets that account for historical/measured aerosol particles and how those particles affect the way daylight is scattered and absorbed.

Environmental analysis, thoughtful spatial planning, and innovative material selection all play a part in effective daylighting design. By considering daylighting design in the round, architects can create buildings that are not only aesthetically pleasing but also energy-efficient and responsive to occupant needs. As natural daylight becomes an increasingly valued resource in sustainable design, skillful daylighting design is an essential facet of shaping spaces that are fit for the future.

NOTES

[1] Refer to usgbc.org/credits/eq8

additional information

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Neall Digert, Ph.D., MIES, vice president, innovation and market development for Kingspan Light + Air North America, has over 30 years of consulting and education experience working in the energy/lighting/daylighting design and research fields, specializing in the design and application of advanced lighting and daylighting systems for commercial building applications.

KEY TAKEAWAYS

Effective daylighting requires balancing site conditions, interior design, and material choices to optimize natural light. When thoughtfully integrated, it enhances occupant well-being, reduces energy use, and creates visually dynamic, high-performing architectural spaces.

MASTERFORMAT NO.

26 51 00—Interior Lighting (daylight + electric lighting integration)

UNIFORMAT NO.

D5020—Lighting and Branch Wiring

KEYWORDS

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The Brick Matching Challenge

Repair of existing brick masonry must address a seemingly simple yet often difficult conundrum: finding new brick. Matching the size, color, and texture of an existing brick can be surprisingly complex. Part of the appeal of brick to a designer is the tremendous variety of colors, textures, and geometries it can achieve. Bricks can be highly uniform in surface appearance or provide a variegated range of colors or textures, sometimes in a single application. But the aesthetic considerations that make a masonry design appealing can pose a substantial challenge during repair, since bricks produced to current standards likely do not exactly match older bricks. When new bricks do not match the existing in size or texture, custom bricks may be required. When new bricks that match the existing in color are not available, several options can be considered.

If only a few bricks in a wall are being replaced, one effective strategy is to salvage original bricks from an unobtrusive or architecturally separate location (such as a penthouse, chimney, the reverse face of a parapet wall, or a site wall) for repairs, and to install new bricks where they will be minimally visible. For example, in one recent project, an original garden wall partially collapsed and required reconstruction. The original bricks from the garden wall were salvaged for repairs to the building, while entirely new bricks similar to the originals—though not an exact match—were used for the rebuilt garden wall (Figure 1).

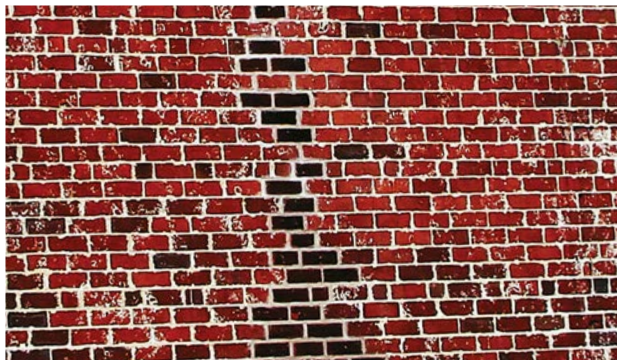
Staining brick can be a viable option if new mass-produced bricks that match the size and texture of the existing bricks are available, even if the color is not a good match. In one recent project, replacement bricks of appropriate size and texture were installed to repair cracks. Based on initial samples, the color was approved (since it was close to the dark end of the original brick color range), but when installed in a continuous row, the new bricks were visually obvious (Figure 2). Staining the individual new bricks with a mineral stain provided a much closer color match that blended in with the original masonry (Figure 3). Varying the stain color also allowed for a variegated appearance that matched the original brick.

Custom-produced bricks are an option, albeit one with cost and schedule constraints. Specifiers should be aware that custom brick may not have test data available for the exact combination of size, color, and texture that is desired. For large, critical repairs, project-specific testing of the custom brick may be required.

Figure 1

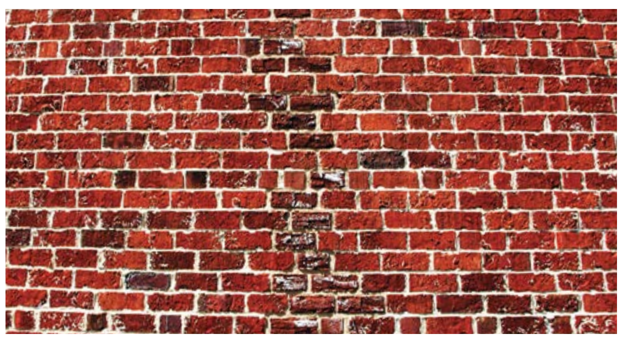
Original bricks salvaged from the garden wall were used to repair the building facade (at right), and the garden wall was rebuilt with new bricks similar to the original (at left).

Figure 2



The new bricks matched the texture of the original but were judged to be too dark in color when concentrated at a crack repair.

Figure 3



Staining the new bricks provided an improved color match.

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