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Connecting it All

The Role of Joints as a Primary Component

By Richard W. Off, AIA and Robert Fraguada, Associate AIA

Photos courtesy Hoffmann Architects + Engineers.

BUILDINGS ARE OFTEN PERCEIVED TO BE STATIC OBJECTS, EXISTING RIGIDLY WITHIN THE SPACE OF THEIR OWN FOOTPRINTS. HOWEVER, WHEN EXAMINED MORE CLOSELY, THEY ARE DISCOVERED TO BE CAPABLE OF DYNAMIC INTERACTIONS BETWEEN ASSEMBLY MATERIALS AND WITH THEIR SURROUNDING ENVIRONMENTS.

It is within the building enclosure, the exterior skin, where joints are found—one of the primary components responsible for facilitating these dynamic interactions. Joints allow buildings to stand firm as much as they allow them to operate responsively to ever-changing internal and external conditions, enabling the flexing, sweating, or breathing of the enclosure skin, as required. They have a ubiquitous presence within a building's visual language and physical fabric, yet are often overlooked or even fundamentally misunderstood. Why do certain combinations of joint materials and substrates succeed, while others fail? How can joints represent a marriage between pragmatic responsibility and visual poetry?

Defining joints

What is meant by the word "joint"? For the purposes of this discussion, a joint is an intentional break between two enclosure materials, components, or

Deteriorated and open mortar joint in a brick masonry wall resulting from jacking of the adjacent corroded steel window lintel and freeze/thaw damage.

Deteriorated sealant resulting from adhesion failure and inappropriate placement of sealant at a coping bed joint, where water became trapped in the adjacent mortar and caused freeze/thaw damage and biological growth.

systems. This might include a gap between two masonry wall units, between a glazing unit and adjacent walls, or between overlapping pieces of cladding. It could be argued that connections between structural framing members or between other linear components such as railings, gutters, and piping, might also be considered joints, but this discussion shall focus on a building's skin.

Enclosure assemblies more typically involve components that could be considered planes (*i.e.* sheets or thin panels) and masses (*i.e.* blocks, bricks, or thick panels). The linear frames and supports of windows and curtain wall systems are an exception to this, but the structural connections between those linear components are beyond the scope of this discussion. Flashing at roof-to-wall, window-to-wall, and roof-to-penetration interfaces might also be considered a type of joint in the broader sense, but flashing is an extensive topic in its own right and is therefore also excluded. However, flashing assemblies often contain various sub-joints which involve many of the same considerations that will be explored in this article. In addition, this text will exclude weatherstripping and joint materials used for sash-to-frame and leaf-to-frame intersections at operable portions of windows and doors, since they too involve their own complex and diverse configurations, materials, testing requirements, and performance criteria.

While many joints are partially or completely filled (closed) with one or more materials, some others are left as (open) voids without any filler, such as the aforementioned breaks between pieces of roof or facade cladding or open gaps between panels in rainscreen cladding. Open joints are no less important to the performance of building enclosures, as there are reasons for their use. When choosing to fill a joint or not, it is essential to understand its intended purpose within an assembly, and the properties the joint should embody to fulfill that purpose.

Joint responsibilities: Movement

One of the most important roles that joints serve is providing accommodations for movement. As noted, buildings are subject to dynamic interactions, including cyclical processes such as thermal expansion and contraction. When enclosures are heated from daytime solar radiation and hot outside air during warmer seasons, they become larger. Inversely, they become smaller during evenings and cooler seasons. Wetting and drying is another cyclical process, as porous exterior materials such as wood and stone can retain moisture when exposed to precipitation and high humidity, causing temporary swelling.

Cumulative movement is also a factor, such as the enlargement of clay masonry from gradual reabsorption of moisture, or the shrinking of concrete materials as they cure. Differential settlement is a cumulative movement that occurs when adjacent parts of an enclosure sink at different rates or to different degrees. This can be due to variations in soil conditions, foundation configuration, or the weight of the enclosure itself. Everchanging gravity loading from snow, people, and furniture, and lateral loads such as wind pressure and seismic activity, are also factors that cause structural deflection and building movement.

In all these situations, thoughtfully designed joints facilitate overall or localized flexibility or rigidity of an enclosure where it is determined a building should sway with or brace against forces. Closed filled joints absorb the stress of stretched, compressed, or sliding adjacent enclosure parts. Open joints provide designated spaces for adjacent enclosure parts to move into or away from as they expand, contract, settle, or shear. For closed joints, selecting materials that provide necessary softness and elasticity is essential; otherwise, movement stress could rip the joint material apart and result in cohesive failure (cracking or tearing of the joint).

Movement stress can also cause adhesive failure if the joint infill is not properly bonded to its adjacent enclosure parts, causing the material to separate from its substrate. Although the entire enclosure may be subject to multiple forms of movement, some joints are more responsible than others for absorbing and mitigating these forces, depending on assembly type. Expansion joints, for example, typically installed at certain intervals along the length of an enclosure system, are specifically designated to help relieve cyclical thermal stress. Similarly, control joints may be installed at certain intervals in concrete systems to accommodate cumulative shrinking.

One of the most employed fillers for expansion and control joints is sealant caulking. Used for their highly elastomeric properties, silicone and polyurethane sealant products are specified most frequently. Silicone is an inorganic material with high resistance to ultraviolet (UV) light exposure. Polyurethane is an organic product well suited for use with wood substrates, and, unlike silicone, it can be painted. Latex and acrylic caulking are also paintable, but are prone to shrinking. Sealant caulking joints are often used in conjunction with compressible foam backer rod or polymer-based bond-breaker tape behind the sealant. The foam or tape does not adhere to the back of the sealant, preventing it from having a three-point connection, for when sealant adheres to more than two points, it can fail. Backer rod can be closed-cell rigid foam (allows a tighter seal but can off-gas if punctured and cause joint failure), open-cell (allows air movement and faster curing of the sealant), or hybrid (also allows a tighter seal but reduces the risk of off-gassing). As an alternative to field-applied caulking, preformed expanding high-density foam bellows are sometimes used for joints in commercial applications for their ability to bridge larger gaps and endure heavy traffic. In some historic masonry walls, copper expansion joints were employed, as with metal roofing. Typically, the joint incorporates a V-shaped piece of sheet metal with two flanges, secured behind the face masonry, which widens when the wall expands and narrows when it contracts.

Deteriorated sealant at metal window perimeter resulting from cohesion failure and a lack of backer material, and also from age and ultraviolet (UV) exposure, making the material dry and brittle. Also note open vertical mortar joint at masonry corner exhibiting adhesion failure from building movement.

Joint responsibilities: Structural integrity

Many joints play a critical role in bearing gravity loads or physically resisting lateral loads. This is especially true of most masonry assemblies, which contain mortar joints. Mortar allows individual masonry units to transfer their weight uniformly to adjacent units and facilitates chemical bonding between them, so the assembly acts as a unified whole to resist wind and seismic forces. However, in most cases, mortar alone is not sufficient to join masonry.

Historically, masonry wythes (vertical layers) were also joined through interlocking units by

Vertical cracking in historic stone masonry wall assembly resulting from a lack of movement joints to allow for differential settlement and thermal expansion.

alternating stretchers (the long side of a brick or block set parallel to a wall) and headers (the long side set perpendicular to the wall), creating different bonding patterns (*e.g.* common bond, Flemish bond, English bond, etc.). In walls with large blocks, ferrous metal anchors might be installed between mortar joints to further secure the assembly. Contemporary brick masonry wall assemblies typically rely upon steel reinforcement set in the joints to bond to the mortar, such as wall-ties secured to the back-up, ladder, or truss ties set every several courses.

Contemporary mortar is a mixture of Portland cement (chemical binder), aggregate (sand), lime (inorganic calcium oxide and hydroxides), and water. Grout, sometimes confused with mortar, differs in that it typically does not contain lime, may include epoxy, and, as a more viscous material, is primarily used to fill joints between tiles, bond metal reinforcement to masonry, or fill cracks in masonry and concrete. Depending on the precise ratio of its components, mortar can vary in strength and hardness.

As a workable material, mortar allows for leveling and plumbing of load-bearing masonry units that commonly have subtle variations in size and surface texture. Enclosures with thin brick cladding can be the exception, as they are sometimes prefabricated as panels that are mechanically attached to their substrate; if the joints are filled with mortar, they generally do not serve a structural bearing, adhesive, or leveling purpose. Although mortar is relatively hard and rigid compared to some other joint materials, it is important that it is still softer than the surrounding masonry to provide flexibility to absorb movement stress. Otherwise, it can generate cracking or displacement in the masonry. Sand-swept joints may be used in lieu of mortar for masonry pavers, often set in a bituminous setting bed over grade. This is because such pavement can be more subject to movement from frost heave (the upward swelling of wet soil from freezing), and sand and bitumen will not crack like mortar, but rather help hold the masonry in place.

Structural securement of enclosure parts can be achieved with other joint materials. In many sheet-metal cladding systems, panels are anchored at their overlapping seams. The hemmed edges of adjoining metal parts interlock with one another, in a series of folded metal cleats concealed by the seams, which are mechanically fastened to the substrate. These joints can take on various configurations, including standing seams (interlocking projecting flanges with concealed anchor clips), batten seams (a historic system with sheet-metal-capped wood battens as the primary points of connection), and flat-lock seams (which have no projections and interlock directly). Since exposed sheet metal can be especially prone to thermal expansion, these joints also play an essential role in accommodating movement. Neglecting to regularly space joints at intervals appropriate to the type and thickness of the metal cladding can cause buckling and connection failure as it places excessive stress on the system. Providing sufficiently spaced cleats is also critical for these joints, as inadequate securement can result in loose and broken connections from wind uplift. For cladding that involves two or more metals, sealant or foam pad infill may be required at joints to separate the dissimilar metals, which would otherwise succumb to corrosion from galvanic action.

Joint responsibilities: Weatherproofing

Another important responsibility of joints is controlling the passage of water, vapor (water in gas form), and air. There are several ways water can move through enclosure joints. Bulk water enters primarily by gravity, as precipitation washes down enclosure surfaces and falls through openings, as well as through hydrostatic pressure, when accumulated water pushes through the surface. Wind and air pressure differentials between the two sides of an enclosure can also drive precipitation into openings. Smaller amounts of moisture can enter via capillary action (water working through microscopic pores) and surface tension (water adhering to internal surfaces and traveling along them). In general, air does not pass through most filled (closed) enclosure joints unless the joints have open cells or vents that intentionally facilitate air movement. A common misconception is that joints always should be filled with materials that completely seal against all moisture intrusion, to avoid leaks and reduce energy loss. However, there are scenarios where maintaining breathability is essential. Understanding the intended behavior of different enclosure assemblies is key to knowing if and how associated joints should be open or closed.

While dabs of roofing cement or mortar may be used for adhesion, many steep-slope roof systems, including metal, asphalt, slate, and clay shingles, have unsealed open joints. This is because they rely primarily on hydro-kinetic activity (the shedding of water down a steep pitch) to move bulk water off the roof before it accumulates and penetrates. Open joints also facilitate air and vapor movement through the roofing system to reduce condensation and mold in attic spaces and prevent decay of wood substrates. Many wall cladding and siding systems operate similarly, as boards or panels can be positively lapped to protect the top joints, but allow for incidental moisture to weep out bottom joints.

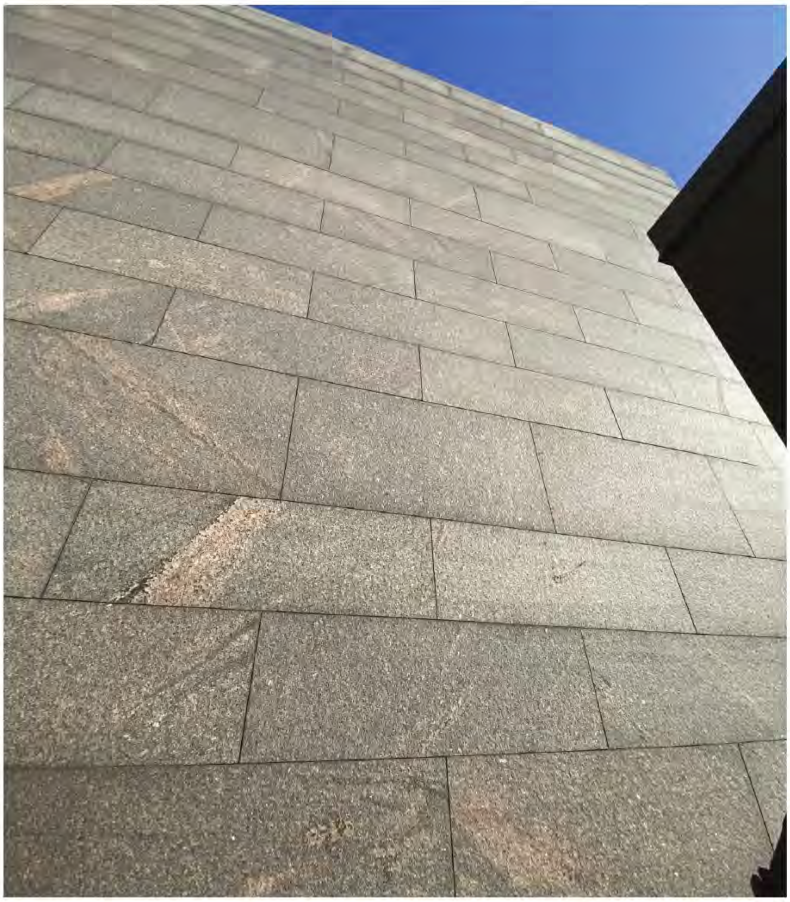
Although open joints in many rainscreen wall cladding systems are not lapped, unless designed in a louver or shingle configuration, they still shield against bulk water from precipitation. Moisture can work its way through the open joints by wind and surface tension, but the air cavity behind the cladding facilitates moisture evaporation through ventilation. Some rainscreen systems are pressure equalized, vented in a way to allow air flow inside the cavity to equal outside air pressure, reducing the likelihood of moisture penetration from wind-driven rain. In addition, anchor straps, which secure the cladding to the substrate, often have profiles that facilitate water drainage through the cavity. Most open-joint systems incorporate underlayments or

Vertical copper sheet metal expansion joint in a historic stone masonry wall.

membranes attached to the substrate to further protect from moisture, vapor, and air infiltration.

Unlike steep-slope roofing, low-slope assemblies contain sealed, closed joints. This is because their lack of significant pitch requires them to deal with hydrostatic pressure, so the entire system must be watertight. For flat-seam sheet metal roofing, this is achieved with solder, a tin-lead mixture melted into the joints with an iron. For membrane roofing, joints are closed by positively lapping the membrane sheets and then sealing laps together. This can be accomplished in various ways, including cold-applied roofing adhesive, heat welding (which fuses modified bitumen membranes together with torch application), seam tape (common for single-ply synthetic rubber and plastic membranes), or liquid-applied membrane sealing (frequently used with modified bitumen roofing).

For masonry wall assemblies, mortar joints also play a key role in managing moisture. Although properly filled mortar joints keep out bulk water from precipitation, as a porous material, they do admit moisture through capillary action. Masonry assemblies handle moisture in different ways depending on wall type. In multi-wythe masonry with solid filled collar joints (vertical joints between wythes), the wall acts like a sponge that absorbs moisture but is usually too thick for the moisture to reach interior surfaces. In dry weather, the moisture evaporates, as mortar is vapor permeable (capable of allowing gaseous water to pass through it). This system is referred to as a "mass wall," the most



Stone masonry joints with recessed rigid foam pad infill in a mid-century modernist style building.

common type of masonry assembly for thousands of years.

Developed in the 20th century, the cavity wall system operates like a rainscreen. It consists of one wythe of masonry separated from the back-up by an air cavity. Moisture that infiltrates the joints by capillary action drains inside the cavity to weep holes at the base of the wall, at relieving angles, and at window and door lintels. It can also evaporate from ventilation provided through the weep holes. Given the absence of a bonded mortar collar joint or header blocks to tie the face masonry to the back-up, regularly spaced wall ties are critical for structural securement.

For both masonry wall systems, the reason porous mortar is used is because brick and stone are also porous. This means some moisture intrusion is inevitable, even if joints are watertight. Therefore, joint mortar that is more porous and vapor-permeable than the masonry itself is used to facilitate breathability. Inappropriate, non-breathable joint materials could trap moisture and cause the adjacent masonry to spall from freeze/thaw damage or from corrosion of the underlying metal, or it could cause joints themselves to fail if the substrates become compromised.

There are masonry assemblies where watertight joints are appropriate, including copings at parapet walls (the portion of facades which extends above the roof). This typically involves installing sealant caulking at sky-facing transverse joints between masonry coping blocks, sometimes complemented with T-shaped lead joint covers to protect the sealant from UV degradation. An alternative approach is placing sheet metal copings over the top of the parapet and joining them with sheet metal splice plates set in beads of caulking. As the most exposed part of the wall, copings play a key role in avoiding freeze/thaw damage to masonry or corrosion of its underlying metal reinforcement, which can generate safety hazards if parts become cracked, spalled, loose, or displaced. Preventing water infiltration at copings also helps keep moisture from working its way under roofing.

Some modern masonry wall claddings use sealant or foam gaskets in lieu of mortar joints, such as stone panel systems supported by metal anchor straps secured to structural backup. These systems often employ a less porous, less moisture-absorbent stone such as granite, but typically still provide a means for infiltrated incidental moisture to weep out from an air cavity behind the panels.

Fenestration systems, including windows, curtain walls, storefronts, and doors can involve much more complex joint assemblies. Where window and door frames meet opaque facade systems, joints are typically sealed with caulking at both the exterior and interior. This is to fully protect against air and water leaks, since fenestration openings are among the weakest points in a building enclosure, as the gaps are otherwise only filled with intermittent shims and anchors. The flexible caulking also allows for inevitable movement, especially given that wind loads applied to fenestration can cause deflection, which is compounded by the material differences between adjacent systems (*e.g.* masonry walls with metal or wood windows).

Some modern curtain wall systems include open joints in their projecting metal components to allow for drainage and evaporation of intruded moisture, or to facilitate air movement for pressure equalization, as with rainscreens. Closed joints in these systems include a variety of foam or synthetic rubber gaskets to seal various metal-to-metal and metal-to-glass connections and, once again, allow for movement. Semi-rigid preformed gaskets are typically used because they more firmly hold glazing units in place than sealant caulking alone yet provide enough flexibility to avoid cracking. To seal glazing units to the gaskets, butyl caulking is often used, but it can be difficult to handle and provides poor abrasion resistance, which is why it tends to be reserved for this type of concealed condition.

Historic restoration considerations

When correcting deterioration in existing and historic enclosures, joint replacement is often a key part of a repair program. Joint materials such as sealant become dry and brittle as they age and are exposed to sunlight, and mortar is subject to freeze/thaw damage as it absorbs moisture and can crack from movement. Given the important responsibilities of joints, maintaining them helps prevent other issues from developing. If failed joints are left unattended, they can accelerate deterioration in adjacent materials and decrease energy performance. However, it is not always clear if old joints should be replaced in kind, or if a contemporary alternative material should be introduced.

Windows

For many historic steel and wood windows, joints between glass and sash frames and muntins were secured and sealed with glazing putty, a mixture of chalk, calcium carbonate, and oil. When these joints deteriorate and begin to leak, there is often an inclination to seal over or replace putty joints with caulking. However, even when sealant is properly installed with a bond-breaker, it typically will not outlast glazing putty if the latter is regularly maintained with linseed oil coating and painting. Similar inclinations to caulk leaking joints often occur with stained-glass windows, which were historically joined with lead cames (soldered metal supports) and sealed with a mixture of linseed oil and calcium carbonate. This provided a durable glazing joint system with a balance of rigidity and flexibility. Although expensive, the most preservation-minded and longest-lasting approach involves removing the windows and reassembling them in a specialized glass restoration shop, so all cames can be replaced and resealed, and the delicate single-pane stained glass can be handled carefully.

Masonry

While most masonry construction since the early 20th century has used cement mortar, many older structures used lime mortar. Since cement is several

Overlapping copper sheet metal wall cladding with lock seam joints.

times stronger, harder, and less vapor permeable than lime, using cement mortar for repointing deteriorated joints in these structures could damage old and weathered masonry units, which have become softer over time. Once again, moisture can become trapped in the masonry and cause it to spall. Although some manufacturers provide pre-engineered restoration mortars for historic applications, where feasible, it is best to have the original mortar tested to confirm its composition and have a matching mortar custom reproduced. It is also important to use appropriate hand tools when performing repointing work at historic thin joints, as saw-cutting can unnecessarily enlarge original joints, degrading performance and character. Further, for historic buildings designated as landmarks, repair projects are often subject to review from municipal preservation boards, and it is commonly required that repointing mortar match the original in color, texture, and profile (tooling).

Sealant caulking was not typically used in historic masonry assemblies, but there are scenarios where introducing such joints may be beneficial. An example is the lack of expansion joints in existing walls, often revealed by cracking near corners or at transitions between components, such as windows. In these situations, large sections of masonry may require rebuilding with the introduction of sealant and backer materials between new and existing sections, often in conjunction with steel relieving angles supporting the masonry. However, such installations

Historic stained-glass window with fully restored lead came and linseed oil joints between glazing panes.

can present aesthetic concerns, especially when the structure is landmarked. Such modifications not only generate material differences, as sealant cannot replicate mortar texture, but introducing expansion joints can visually interrupt the existing brick or stone layout. Masonry reconstruction can also break bonding patterns and requires the use of new steel reinforcement to achieve integrity. While such alterations may be more easily justified to preservation boards at less visible facades, when introduced along walls that face public spaces, approvals can become challenging, and details may require special sensitivity to historic configuration. Moreover, verifying sealant adhesion may require performing field tests and/or applying a chemical primer before sealant installation.

Roofing

Although many steep-slope roofs have open joints, some historic terra cotta roofing, such as Mission Style and Spanish Style tiles, can be mortar set in lieu of nailed. When these joints fail, it likely means the tiles have begun to de-bond from the substrate, and while selective tile repairs are possible, replacement of the system may eventually be required. While the system could potentially be replaced with a mechanically fastened tile roof, which may provide cost savings, there are considerations to weigh before adopting such a retrofit strategy. Landmark status may require mortar setting unless there is a structural justification to prevent replacing the assembly in-kind. Also, mechanical attachment requires a suitable substrate for fasteners to resist pull-out loads, so the decking and support structure may require retrofitting. Further, while not watertight, mortar does play a role in weatherproofing, and therefore different underlayments may be required to mitigate air and water infiltration.

Joints: Form and history

Technical knowledge of joint design is not isolated to advancements made in the past decade or even the past century; it is an inheritance born out of millennia of trial and error, as builders learned the advantages of different materials and configurations. A review of structures dating to antiquity reveals the trajectory of joint evolution. In the case of mortar, ancient Egyptians combined clay with mud and sand to bind the stone blocks of the early pyramids thousands of years ago. For the Great Pyramid of Giza, mortar consisting of gypsum and rubble was used to fill gaps between roughly cut stones that formed the core. However, the outer cladding used no mortar, but it contained stones cut so precisely that it is said not even a sheet of paper could pass through the open joints. Without mortar delineating the borders of each block, the uninterrupted sloped walls became more visually monolithic, reinforcing the overall pyramidal geometry, and emphasizing the monumental role of the structure. Ancient Greeks similarly used dry-stacked stone to erect temples such as the Erechtheion, in the fifth century BC. Their technique involved laying stones on a tight, compact bed of sand, and once again, the thin joints aided in the expression of Herculean form.

Jumping from antiquity to the late 19th and early 20th centuries, there are numerous examples of masonry buildings that employed ultra-thin lime mortar joints to again reinforce the monolithic appearance of buildings. An example that did not use mortar is the Morgan Library in Manhattan, designed by Charles McKim. The stone façade blocks are separated only by a layer of sheet lead, approximately 1/64 inch thick, allowing the joints to visually render as nearly two-dimensional lines along the face of the blocks, providing a subtle and highly controlled joint expression.

Joints can also be used to emphasize directionality of form. Architect Frank Lloyd Wright, known for his distinct Prairie Style, used masonry in tandem with mortar joints to further emphasize horizontality and connection to the open planar landscape of the Midwestern U.S. At Robie House in Chicago, the long masonry facade and site walls contain horizontal bed joints between bricks that are raked back to create shadow lines. In contrast, the vertical head joints are flush with adjacent brick and colored to match it to further deemphasize verticality. The use of deep raked joints reinforced Wright's architectural philosophy, but different mortar tooling profiles have performance implications. Raked and struck joints do not shed water from facades, as well as V-shaped and especially concave shaped profiles, which also better seal against the outer face of the masonry. Squeezed and beaded joints involve building up mortar beyond the surface of the masonry to create a more rustic appearance, but can also be problematic as they create exposed ledges where water can sit and facilitate premature joint failure from freeze/thaw damage.

In contrast to masonry assemblies, glass enclosures offer a fundamentally different visual impact. Typically used to express a lightweight, often minimalist design philosophy, glazed walls can promote varying degrees of exhibitionism. Apple Fifth Avenue, designed by Bohlin Cywinski Jackson, features an all-glass cube entrance. The glass panels invite outsiders to view the Apple logo that hangs from the top of the glass cube, and to look down into the underground retail space. Rather than opaque metal mullions, the glass is supported by a interior glass fins that meet the panels at the joints, connected only by clear structural silicone sealant, further emphasizing transparency.

Maximizing glazing in facades came to fruition with Mid-Century Modernism. Architects such as Ludwig Mies Van Der Rohe used glass curtain wall systems in numerous high-rise buildings. While more recent constructions can trace their material lineage back to buildings such as Mies' Seagram Building, opened in 1958, they inherently stand in contrast in the way they employ glazing joints. Whereas Miesian structures contained large sheets of glass separated by metal mullions and non-load-bearing I-beams, with concealed gasket joints, Apple Fifth Avenue uses barely any metal at all, but rather employs technological advancements in joint materials to achieve an aesthetic goal.

For some glass facades, joints can become a means of introducing planar shifts. Peter Zumthor's Kunsthaus Bregenz, an art gallery building located in Austria, utilizes translucent glass panels mounted to steel clips in a rainscreen cladding system. The panels are angled so each one overlaps adjacent panels in a way that echoes the textures of historic open joint shingle roof systems, such as slate and terra cotta, but using glass further plays with light and shadow. Not only do the sloped lapped panels facilitate water drainage, but they also enrich the otherwise flat facade with creative three-dimensional manipulation of repeating joints.

Technical and aesthetic balance

As functional a role as joints perform within building enclosures, these historic and contemporary examples demonstrate that they can also serve as a primary component of building style and identity. It is for this reason, combined with their responsibilities of facilitating movement, structural integrity, and weatherproofing, that joints demand careful consideration, whether designing new buildings or rehabilitating existing ones.

The aesthetic and technical design considerations of joints are not necessarily distinct; formal decisions can directly impact a joint's technical capabilities, and the inverse is also true, making joint material selection and placement an integral part of both design process and building performance. Joints are the vehicle through which the rest of the building enclosure can be understood and often the first line of defense in its integrity, as they are, both literally and conceptually, what connects it all together. **CS**

ADDITIONAL **INFORMATION**

Authors

Richard W. Off is a senior project manager and registered architect at Hoffmann Architects + Engineers in Manhattan, New York. With a focus in historic preservation, and expertise in traditional and modern facade, roofing, and window systems, he oversees A+E teams complete numerous multimillion-dollar investigation, rehabilitation, renovation, and adaptive reuse projects throughout the New York metropolitan area. He graduated with a master of architecture and urban design from Columbia University and a bachelor of architecture from Rensselaer Polytechnic Institute. Off has lectured at APTi and Traditional Building conferences, the APT DC Symposium, and both his alma maters.

Robert Fraguada is a project coordinator at Hoffmann Architects + Engineers in Manhattan, New York. He uses his multi-tasking skills to manage and assist with a diversity of projects throughout New York City, including building enclosure investigation, facade rehabilitation and recladding, roof replacement, window replacement, and plaza replacement. Fraguada is also an avid photographer with a passion for urban environments and has been featured at the annual AIA Art by Architects show at the New York Center for Architecture. He graduated with a bachelor of architecture with a minor in construction management from Pratt Institute.

Key Takeaways

Buildings are often perceived to be static objects, existing rigidly within the space of their own footprints. However, when examined more closely, buildings are discovered to be capable of dynamic interactions between assembly materials and with their surrounding environments. These interactions include processes such as expansion, contraction and differential settlement, and factors such as temperature and moisture presence that can cause buildings to "sweat" and "breathe" via the controlled movement of water, vapor, and air through the building enclosure. It is within the building enclosure, the exterior skin, that joints exist, one of the primary components responsible for facilitating these dynamic interactions. Joints allow a building to stand firm and rigid as much as they allow it to operate responsively to ever-changing internal and external conditions. They have a ubiquitous presence within a building's visual language and physical fabric, yet they are often overlooked or even fundamentally misunderstood.

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