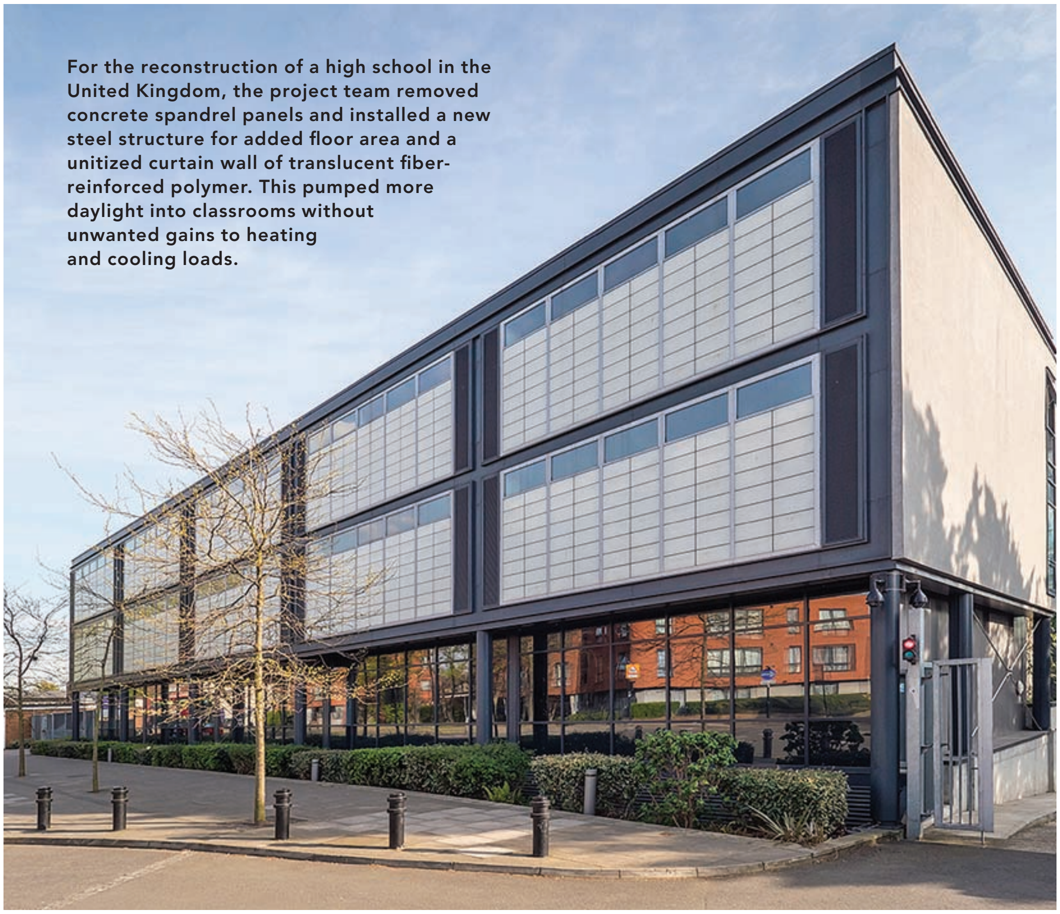
SANDWICH CLADDING PRIMER

COURTESY KALWALL



For the reconstruction of a high school in the United Kingdom, the project team removed concrete spandrel panels and installed a new steel structure for added floor area and a unitized curtain wall of translucent fiber-reinforced polymer. This pumped more daylight into classrooms without unwanted gains to heating and cooling loads.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- **DISCUSS the differences in design, structural integrity, and insulating capacity between various types of sandwich claddings.**
- **DESCRIBE the basic function of insulated claddings and how they impact building performance, including composite panels faced with stone, metal, and magnesium-oxide cement.**
- **LIST two or more cladding materials and technologies that can improve the performance of building enclosures.**
- **EXPLAIN how IMPs, CSIPs, and FRPs can contribute to façade function in composite panels exteriors.**

Sandwich claddings consist of a panel or shell made of two durable, resilient face sheets and a low-density insulating core, often with a decorative or otherwise attractive face. They can produce an exceptionally strong and sustainable system for enclosures. Enclosures systems made with these hybrids combine structural rigidity with low weight.

Sandwich panels come in numerous composite combinations: structural insulated panels (SIP), insulated metal panels (IMP) including aluminum composites, translucent fiber-reinforced polymer (FRP) assemblies, high-strength and structural glazings, fiber-cement faced products, carbon FRP skins, and a variety of thin-stone claddings.

When sandwich panels (sometimes called *cassettes*) are produced, cured, and installed, they may react to temperature differentials acting upon the two face sheet materials—for example, they may be cooler on the outside and warmer on the interior side of the insulating core. The difference in linear expansion of the two sheets can cause residual stresses, including apparent deformation and *oil canning*—the visible waviness seen in metal sheets. In other materials it may cause cracking, delamination, or other modes of failure. Sandwich theory tries to help predict these subpar situations.

Metal system manufacturers and installers take great

DOMU

The playful façade of vertically oriented, reflective insulated metal panels, or IMPs, and window openings for a transit-oriented apartment building in Chicago carefully controls daylighting, thermal losses, and view corridors. The staggered windows create a sense of movement that is reflective of this fast-moving intersection, according to the project's architect, Wheeler Kearns Architects.

pains to prevent deformation or elastic buckling (also called *stress wrinkling*) in their products, according to the Metal Construction Association. "Generally, the period and amplitude of the wave will become more pronounced as the panel width increases (flat portion of the panel) and/or the panel thickness decreases," says the MCA. In most cases, says the MCA, oil canning occurs in the process of fabricating metal coils, slitting them, and forming and bending the panel shapes and will be apparent at the time of construction. Yet defects also can arise from thermal expansion, primary structure movement, or even misaligned substructures where contractors have forced the sandwich panels to conform to uneven mounting surfaces.

To avoid unsightly deformation, some project teams select thicker metal gauges, attachments that allow movement, or panels with backer rods. Matte and embossed finishes help camouflage the visual effects, too. In general, oil canning in IMPs will not exceed mill tolerances, making it almost invisible to the naked eye.

Composite cladding product must be carefully evaluated, properly produced and stored, and rigorously installed. Sandwich claddings should be specified and assembled with experienced crews and, where needed, manufacturer guidance to ensure effective functioning and a long lifetime.

SANDWICH CLADDING OPTIONS MENU

Following is a review of notable sandwich claddings and their application in selected building projects.

Thin-stone cladding. These sandwiches have a layer of quarried stone bonded with high-strength epoxy adhesive to a substrate of aluminum composite material, glass, polycarbonate, or a honeycomb matrix of aluminum or other materials. In some cases, the interior sandwich layer is applied on site, such as when the honeycomb-backed panels are fastened to a sheathed stud wall, which becomes its building-side face sheet.

The resulting claddings, typically about an inch or so in thickness, are highly stable and offer an average 60 times the impact strength of solid stone, with potential earthquake- and blast-resistance in some combinations. Typical panels weigh 80% less than the same-sized solid-stone panels.

These systems are being used for office, retail, and multifamily buildings, including high-rises.

The recent preservation of a classic International Style façade for the Arkansas Power and Light building in Little Rock (now the headquarters of Entergy) is one such example. Exposure to the elements and long-term bowing led to the failure of its original 1953 Georgia Pearl Gray marble panels. To retrofit the stone to meet preservation rules for a property listed on the U.S. National Register of Historic Places, the project team specified quarter-inch matching thin slabs (from the same quarry where the original panels were mined) bonded to aluminum honeycomb panels. The lighter-weight bands of cladding also avoided a potential problem with the three-story building's older substructure, which might have been unable to bear the weight of thicker, 1½-inch-thick marble slabs.

The design firm on the project, Cromwell Architects and Engineers, also reported that the thin-stone panels also obviated the problem of the expansion and contraction of calcite crystals in the historic marble slabs. "As the marble warms under direct sunlight, the calcite crystals expand and contract at different rates along different internal axes," according to the manufacturer StonePly. “Over time, the combination of bowing and weathering weakens the marble cladding panels.” The thin-stone replacements deflect minimally under similar conditions.

Stone sandwiches by manufacturers such as StonePly, TerraCore, and Stone Panels International have been used at Delnor Hospital, Geneva, Ill., and at a new NASA biomedical laboratory, designed by HDR, that opened last July in Houston. The façade of the NASA facility has Mars-mimicking red sandstone that contrasts with panels of black granite and Texas cream limestone. “The north-side wall is covered in contrasting black glossy and flat black stone, designed to mimic a DNA sequence,” says Joel Walker, Director of Center Operations for NASA.

Structural insulated panels. Applications of SIPs have expanded in recent years, many with uniquely architectural and structural attributes. The facer or sheathing material most often used has been oriented strand board (OSB), but fiberglass-mat gypsum, sheet metal, plywood veneer, fiber-cement siding, and even magnesium-oxide board and composite structural siding panels are being used. The result: greater expression and more fine-tuned performance for the enclosures.

SIPs have an insulated foam core between the sheathing panels, according to Keith Simon, AIA, LEED AP, of Wiss, Janney, Elstner Associates, the engineer and enclosure consultancy. The foam core is either expanded polystyrene (EPS), extruded polystyrene (XPS), or polyurethane foam, Simon and his coauthors note in the *Whole Building Design Guide.* “With EPS and XPS foam, the assembly is pressure-laminated together. With polyurethane foam and polyisocyanurate, the liquid foam is injected and cured under high pressure.”

SIPs are generally applied as bearing walls, roofs, or floors, and are acceptable as shear walls in all seismic design categories. Because they can support structural loading, they are usually reserved for vertical cladding in buildings up to four stories in height, and typically allow less open or windowed area at lower floors. “SIPs are designed to resist not only axial loads, but also shear loads and out-of-plane flexural loads,” according to the *WBDG.* This gives them good resistance to bi-axial bending and lateral shear, a sought-after quality for roofs and floors. SIPs were used as an infill panel with a structural steel frame to construct the Silvis Middle School, East Moline, Ill., according to the design team BLDD Architects and consulting structural engineers Steven Schaefer Associates.

SIPS are commonly used in schools, senior facilities, low- or mid-rise multifamily housing, and college buildings. The University of Minnesota Duluth employed net-zero, LEED Platinum, and passive house rubrics in the design of an academic building in its Bagley Nature Area. According to the nonprofit Structural Insulated Panel Association,

BDCuniversity’s Technical Lessons Learned

TIPS FOR BUILDING SOUND BRICK VENEER CAVITY WALLS

Brick veneer cavity walls remain one of the most popular exterior choices for a variety of building types. Brick’s traditional, rugged aesthetic and proven performance make it a solid choice for commercial, institution, and multifamily residential structures.

But there are key considerations to keep in mind when designing, detailing, and building a brick wall assembly. Here are tips for ensuring moisture control, thermal performance, integrity, and longevity of brick walls, from several BDCuniversity continuing education providers:

1. **Don’t skimp on flashing materials within the cavity.** Traditional materials–copper, lead-coated copper, stainless steel–can be more costly, but they remain the most durable and reliable options.

2. **Plan for thermal expansion/contraction of brick and concrete.** Brick assembles often incorporate brick and concrete components, both of with expand and contract at different rates and in different conditions. This makes detailing critical for horizontal and vertical expansion joints, shelf angles, and adjustable veneer anchors.

3. **Select the weakest mortar for the job.** Mortar that is too hard does not permit movement of adjacent brick and can cause cracks and spalls.

4. **Provide at least one inch of air space behind brick veneer.** This gap functions as the drainage cavity where water is directed downward to the flashing and weeps and out of the brick veneer. If open weeps are used, this air space also helps to vent the cavity, allowing interior components to dry out quicker.

5. **Understand vapor flow direction, and detail accordingly.** For typical buildings, the direction of water vapor flow will vary by season and sometimes on a daily basis, depending on the climate.

For more continuing education content, visit: BDCuniversity.com.

SOURCES
#1-#3: Hoffmann Architects; tinyurl.com/HoffmannBrick
#4: Brick Industry Association; BDCnetwork/BIA09
#5: Simpson Gumpertz & Heger; tinyurl.com/yawdx2fr

COURTESY STONEPLY

Thin-stone sandwich panels replaced the failing 1950s-era Georgia Pearl Gray marble slabs with matching quarter-inch cuts from the original quarry for the modern façade of the Arkansas Power and Light Building in Little Rock, now the headquarters of Entergy.

"The university envisioned creating a home base for students in the form of a satellite classroom facility which takes full advantage of its natural environment and amenities." The design team of Salmela Architects and Certified Passive House Consultant Carly Coulson, AIA, LEED AP, complemented the SIP façades with triple-insulated glass and renewable energy systems.

Translucent fiber-reinforced polymers. For buildings where interior daylighting and a modular, modern appearance may be desired, translucent sandwich claddings now have very high-performance assemblies, including some with space-age aerogel core materials. The very lightweight translucent FRP systems provide a structural sandwich cladding wall system that also admits diffuse daylighting while controlling thermal gain. As a result, translucent sandwich systems compare favorably with curtain walls and storefronts, and even with opaque cladding systems with polycarbonate fenestration or insulated glass unit openings.

Still, there are long-term questions to consider, according to the American Composites Manufacturing Association. One is *fiberbloom*, the occurrence of unsightly fiber prominence with a bleached or sparkling appearance on the surface of glass-fiber-reinforced structures. Fiberbloom is often caused by ultraviolet surface degradation. To protect against it, some translucent composites employ a synthetic surfacing veil or a permanent glass-veil erosion barrier, which effectively encapsulates the FRP materials and eliminates fiberbloom.

There is also the matter of using translucent FRP panels to meet code requirements for finish, flame, and smoke performance. Weathering thermoset polymer systems made for the exterior side of the cladding sandwich can be specified for high-impact, hurricane high impact, and typical fire ratings, as well as for roofs rated for Class A performance on flame spread per UL 790.

Last, there have been reports of degradation of aerogel insulation materials, but the concern seems unwarranted. Yes, aerogels do lose significant R-value over time, as shown in research by the U.S. Army Engineer Research and Development Center's Construction Engineering Research Laboratory. Yet "the aerogels still had the highest R-value after aging under high humidity conditions at elevated temperatures," according to Ed FitzGerald of the National Park Service's National Center for Preservation Technology and Training.

Aerogel-filled FRP walls were used in Featherstone High School in Middlesex, U.K. The extensive reconstruction of the 1958 concrete-framed facility was led by DSP Architecture and Structura, a design-build glazing fabricator and installer. The team repaired and encapsulated the frame to address material deterioration and water ingress, and selectively demolished original concrete spandrel panels. With the structure stabilized, the contractor installed a new steel frame to extend the floor area and support a 25-foot-tall translucent FRP claddings as a unitized curtain wall in sections up to five feet wide.

The school had used FRP cladding before and wanted it for this renovation. "The advantage of it being fabricated off-site meant disruption and time on site were minimized, while the combination of high insulation, natural daylight, and ventilation meant reduced energy costs," says Geraldine Walder, DSP's Project Architect

According to Mike Ford, Structura's Quality/ Design Manager, "The new wall has delivered an increase in thermal performance. Each classroom now has natural daylight with no solar heat gain and without the need for shading blinds as there is no glare and no hot spots."

Insulated metal panels. The recent ascent in the use of IMPs reflects a move toward green, net-zero, and Passive House–type construction that favors a more opaque façade area.

Designing façades with lower window-to-wall

COURTESY IFAI

The Miami Seaquarium's exhibit for African penguins is a temperature-controlled volume made entirely of highly insulating structural magnesium-cement-board SIPs under a sun-blocking canopy.

ratios (WWR) for certain building types is recommended by Brett Bridgeland, CEM, LEED AP, an architect and engineer with sustainability nonprofit Seventhwave. "Lowering the WWR of multifamily high-rises offers an opportunity to save energy, improve occupant comfort, construct superior buildings, and differentiate a developer's multifamily portfolio," says Bridgeland, who has supported the ComEd Energy Efficiency Program in Chicago.

A new apartment building near the CTA station in Chicago's Wicker Park neighborhood offers a mix of studios and one- and two-bedroom apartments behind a playful façade of vertically oriented, reflective metal panels and window openings. The irregular composition of 1611 West Division, designed by Wheeler Kearns Architects, is "stitched across horizontal floor slabs, folding around the building like a woven textile to create a sense of movement," according to the developer, 1611 Management.

The project team planned the 11-story tower's cladding of metal and insulating glass to achieve LEED Silver certification at minimum. The partially opaque façade cuts energy use as compared to an all-glass curtain wall. The insulated metal panels have a 1⅛-inch-thick core of continuous, rigid polyisocyanurate ("iso") insulation that delivers good R-values and airtightness at a relatively modest cost per square foot of façade area. The panel widths range from eight inches to 30 inches and can be installed vertically or horizontally.

Cement-fiber insulated panels. CSIPs are a new energy-efficient cladding product that employs thin cement-fiber skins instead of hardwood or other engineered woods such as oriented-strand board (OSB). Typically made with an expanded-polystyrene insulating foam core of one to three pounds in density, the composite panels are less prone to rotting or corrosion than wood and OSB because the entire sandwich resists moisture absorption. In some applications, the panels can also serve as a substitute for gypsum board typically used in building enclosures. Exterior finishes include paint and other coatings, stucco, and EIFS.

Similar products include SIP-type composites faced with glass-fiber gypsum board. Another, called MGOSIPs, uses panels of magnesium oxide over the EPS stuffing. These hybrids are known for having very good fire ratings and are also suggested for below-grade uses, including foundations and structural basement walls at at-grade enclosures. MGOSIPs are being used in wellness-oriented projects because the panels are free of organic solvents and other materials considered toxic by some specifiers.

Structural magnesium-cement-board SIPs were used recently in a highly insulated enclosure under an arched tensile fabric structure for Penguin Isle, a new exhibit at the Miami Seaquarium. The 6¾-inch-thick SIP sandwiches line the floor, walls, and roof of the structure to create a chilled habitat for the African penguins, who enjoy about 800 square feet of dry, rocky area next to their 9,000-gallon refrigerated pool. Visitors enter the enclosure and view the flightless birds through large acrylic windows and an acrylic underwater swimming tunnel.

According to the cladding supplier, Innova Eco Building System, the MGO-faced product meets Miami and Dade County's building code requirements for a coastal impact zone, tested at wind speeds exceeding 230 mph without failure. MGO-faced SIPs resist humidity and wetness as well as mold, rot and termites. MGO board can be painted for a smooth stucco look on the exterior; it can be taped and finished like drywall on the interior.

Wood-faced SIPs contributed to the Bagley Nature Area academic center, designed for the University of Minnesota Duluth according to passive house principles to achieve net-zero operations and LEED Platinum certification.

A study conducted by Oak Ridge National Laboratories (ORNL) concluded that SIP construction can be 15 times tighter than light-gauge steel or wood-framed assemblies, making CSIP and MGO-faced assemblies a reasonable alternative for load-bearing walls in multifamily and senior housing and various commercial and institutional facilities of two to four stories high, as well as for roof panels (up to 20 feet) and floors spanning supports (up to 16 feet). SIPs can help you create tight, protective enclosures with equivalent performance on walls, overhead, and underfoot.

ENERGY CONSERVATION PLUS

Insulated sandwich claddings are proving valuable for green building and passive house construction in a range of occupancy types, from small-scale multifamily to large-scale mixed-use towers. Detailed properly, with good joinery and continuous air barriers, the panels offer high thermal resistance and minimal air infiltration.

ORNL studies of a hut enclosure have shown that whole-wall R-values for a four-inch SIP wall rated at R-14 will outperform a balloon structure with 2x6-inch studs packed with R-19 fiberglass insulation.

Proper sealing between sandwich panels and enclosure continuity through and behind the cladding layer is essential to optimize building performance. It is important to work with manufacturers and fabricators to fine-tune building enclosure detailing at key intersections, such as at fenestration and roof connections or in areas where there are changes in materials. Contractors may insist on full-scale mockups or signoffs on specific methods recommended by key trades. Inspections by construction administrators and independent third parties may also be worthwhile.

The benefits of sandwich panel cladding systems—high insulation values, shorter project time frames, custom shapes and widths, and a wide range of colors and finishes—are enhanced because they can be fabricated to custom specifications and applied vertically or horizontally. Many systems offer pre-engineered integration capabilities with fenestration assemblies, solar shading, foundations, and parapets.

The structural genius of sandwich claddings—excellent dimensional stability in a lightweight package—assures that they will remain a viable option for commercial and institutional projects for years to come.+

+EDITOR'S NOTE

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