Photo courtesy of Neolith®

The building's facade is a vital component of the building envelope, allowing daylight to enter while keeping unwanted air and moisture out of the building.

Blending Aesthetics and Sustainable Design Through Facades

Creating balance between beauty and function

Sponsored by 3A Composites USA, Inc., Cosentino, Endicott Clay Products, Hofmann Facades Group, Inpro, Neolith®, Vitro Architectural Glass

By Jessica Jarrard

The building's facade is the first thing people see when they gaze upon a skyline or down the street. The facade is not only there to evoke a feeling upon first impression, but it also serves as a vital part of the building envelope. In short, the building envelope is meant to keep the outside out and the inside in while providing occupants with a safe and comfortable environment that will promote their physical and mental health and welfare. The challenges presented by the environment and exacerbated by climate change put added pressure on the building envelope, which can lead to unwanted air and moisture intrusion and all the costly hazards and repairs that follow. Thanks to technological advancements, modern architectural features not only help protect the building envelope against wind, rain, water, and snow, occupants do not have to sacrifice comfort, energy efficiency, or sustainability to enjoy aesthetically pleasing facades. Striking the balance between beauty and function, a well-designed facade can provide the means to ensure that a building is both easy on the eye and easy on the environment, as high quality, long-lasting sustainable materials also require less maintenance and fewer updates or replacements.

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Learning Objectives

After reading this article, you should be able to:

1. Describe critical attributes of the facade that contribute to a watertight, energy efficient building, thus promoting the health, safety, and welfare of occupants.
2. Understand how quality, high performance materials lead to aesthetically pleasing, sustainable buildings.
3. Understand how the facade and building envelope are part of a systems approach.
4. Discuss how material coatings and low-emissivity coatings provide more durable exteriors and energy efficient, comfortable spaces for occupants.

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MATERIAL SOLUTIONS FOR HIGH QUALITY FACADE

With many different materials available on the market, building designers and architects have a myriad of options to choose from. High quality, sustainable materials are often a blend of naturally occurring and manufactured materials, thus combining the natural weatherproofing qualities provided by Mother Nature with man-made technology solutions.

A key attribute of sustainability is to ensure the balance of natural materials left in nature when extracting them or making a concerted effort to replenish them. Combining natural materials with man-made materials can help make them more durable and increase their life span, preventing an early trip to the landfill. Specifying products that can be recycled or repurposed at the end of their life span is another way to further decrease material impact on the environment.

After a material is selected, it can be treated with coatings or glazes not only to ensure an aesthetically pleasing facade, but also to provide additional protection against the elements, improving the health, safety, and well-being of occupants. Materials can be cut into various shapes and sizes. Coatings and treatments can be applied to update textures, colors, and even designs.

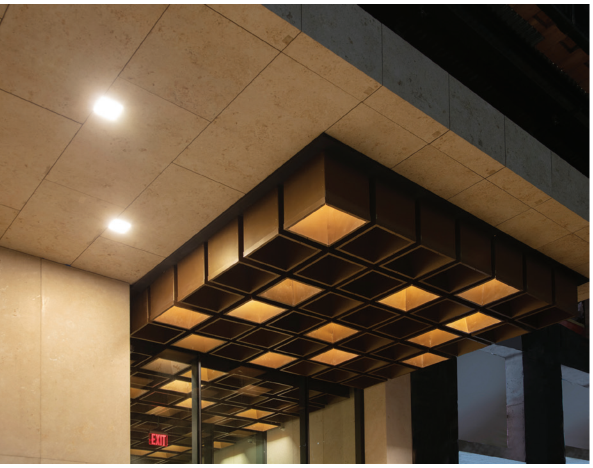
Sintered Stone

Sintered stone is a fairly new material that combines a perfect blend of man-made processes with natural materials to create surfaces that can withstand both natural elements (hurricanes, blizzards, driving wind and rain) and man-made elements (industrial smog, graffiti). This durable surface is resistant to water, chemicals, scratches, abrasions, and thermal shock, making it a facade material of choice for architects and specifiers worldwide.

Sintered stone can be used for exterior building projects, whether commercial or residential, especially in areas where added thermal and weather protection is needed to protect against extreme temperatures and driving rain or snow. While it is 100% natural in composition, sintered stone can be treated with another material agent to transform the slab into a self-cleaning, anti-pollution, air purifying surface perfect for use in busy, high-emission urban environments.

This natural premium surface is produced in a carbon neutral environment and is one of the most sustainable facade materials on the market. Using 100% natural raw materials, a variety of surface designs can be manufactured including wood, marble, and metal. High performing, ultra-resistant, and low maintenance, sintered stone is available in over fifty colors, patterns, and finishes, providing a striking appearance by combining aesthetic appeal with longevity and resilience.

Photo courtesy of Neolith®



Sintered stone surfaces are available in many colors and finishes, providing durability, resilience, and aesthetic appeal.

Natural Stone

Natural stone works well in exterior facades. It has the lowest embodied carbon of any fascia/cladding material – four times lower than timber, 3.3 times lower than brick, and 10 times lower than terracotta, ceramic, or architectural precast with high cement or steel content. Natural stones such as sandstone, limestone, and granite can be combined with ultra-high performance concrete (UHPC) into a thin, lightweight, high performance cladding system. This innovative low-weight facade system does not require the use of aluminum, steel, or precast concrete, leaving a much lower carbon footprint. Brick, terracotta, and wood also can be unitized on thin, lightweight cladding panels made of UHPC.

Natural stone can emulate and achieve the look of other less sustainable materials. Faux joints in large natural stone panels can mimic the look of brick or terracotta, as well as yellow or red sandstone.

Performing as a decorative rainscreen, or even a load-bearing outer wall, natural stone has a high thermal mass and a low U-value which reduces the amount of heat loss in the winter and heat gain in the summer.

Photo courtesy of Hofmann Facades Group

While the exterior of this building appears to be brick, the facade is made from limestone using natural stone panels, with each stone panel containing multiple faux joints to achieve the look of smaller bricks.

Photo courtesy Cosentino

Ultracompact surface materials are an ideal material to specify for exterior facades because the raw materials are blended together to make a new product that is resistant to thermal shock, extreme heat and cold, and is practically nonporous.

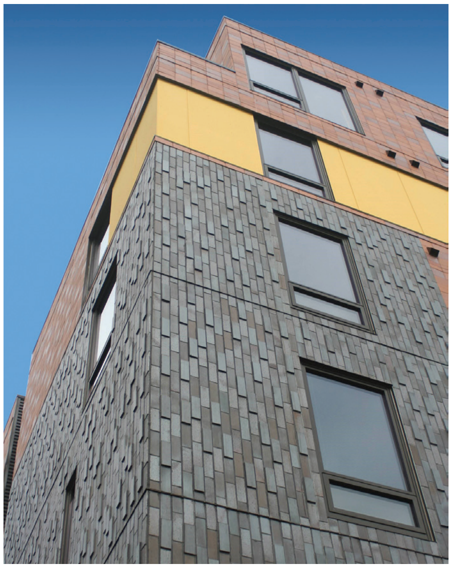
Natural stone is also highly durable. A well-maintained natural stone facade can easily last 150 to 200 years as it does not use or require structural silicone like glass curtain wall.

Ultracompact Surface Material

The ventilated facade is a high performance solution for building enclosures, which takes advantage of mechanical anchoring elements. Through connections between the siding material and the mechanical assembly, design loads are effectively transferred back to the structural wall, providing a safe and secure facade.

For facades fixed with glue, it is very important to select the appropriate adhesives. Mechanical tiebacks or safety brackets can also be incorporated as needed.

Photo courtesy Endicott Clay Products



Thin brick is a thinner version of full-face brick and can be applied to places and large expanses that were once too physically impractical or too costly for application.

Photo courtesy of Vitro Architectural Glass

The Comcast Center Atrium utilizes low-iron glass with low-e coatings to provide occupants with clear, crisp views while also preventing unwanted heat transfer.

Spandrel panels are used in place of glazing units in curtain wall systems when hiding the edges of floor slabs, celling details, insulation, or other building elements.

Ultracompact surface material is available in large format panels (126-by-56-inch) and varying thickness (8 mm, 12 mm, and 20 mm). This material has excellent dimensional stability with a reduced number of joints needed, thus limiting the number of openings in the building envelope.

These panels come in many colors and styles leading to endless design possibilities. Reduced porosity means this material is easy to clean, and resistant to water absorption, thermal shock, extreme heat, graffiti, and freezing.

Thin Brick

Thin brick is a thinner version of a full-face brick that can both functionally and aesthetically work with traditional face brick. Thin brick uses less material and so proves more cost-effective, creates a smaller carbon footprint, and is less expensive to ship. Thin brick is also easy to install. This product can be used in places that were once thought to be physically impractical or too costly for application, such as large stadiums and massive sports arenas.

Thin brick is available in many colors and textures to match the aesthetics of face brick counterparts. Some thin brick comes with a "keyback" design that protects the wall system from having the brick pull out when used in precast or tilt-up applications, allowing the thin brick to be better used in a panel system when applied. The keyback design also offers a seamless look and feel when transitioning from thin to face brick on a single facade.

Glass Expanses with Low-e Coatings

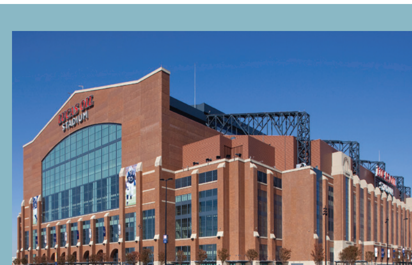
To achieve bright beautiful buildings with plenty of daylighting for occupants, architects can specify low e-coated glass in larger expanses without sacrificing energy efficiency and sustainability. Low-emissivity (low-e), low-iron glass can be used to create views so clear and crisp that it's hard to believe the glass is even there. Low-e coatings are engineered to minimize the amount of harmful ultraviolet (UV) and infrared light that can pass through the glass without compromising the amount of vis-ible light that is transmitted. A microscopically thin transparent coating allows low-e glass to reflect exterior heat in warm temperatures and hold in heat during cold temperatures. This helps prevent unwanted heat exchange, reduc-ing the need for HVAC to maintain occupant safety and comfort.

Building-Integrated Photovoltaics (BIPV) options are also available, allowing the integration of solar cells into the building envelope. BIPV materials simultaneously serve as the facade, the building envelope barrier, and as a source of power generation.

LUCAS OIL STADIUM INDIANAPOLIS, INDIANA

The 1.8-million-square-foot Lucas Oil Stadium conjures a charming, turn-of-the-century look for one of the most distinctive, multi-use venues in the United States. Home to the Indianapolis Colts, the NFL Combine and multiple major collegiate tournaments, the brick, steel, and glass structure reflects the traditional forms and historical feel of the state's revered, old-school basketball arenas. Perhaps the most striking aspect of the exterior is the attractive reddish-brown brick, commanding the attention of visitors from all four sides of this massive structure. The Medium Ironspot #77 thin brick from Endicott was selected for its warm, classic feel that enhances the muscular steel-framed design while complementing the city's captivating skyline. Thin brick allowed construction of large brick-and-mortar panels to be assembled offsite and then brought in for efficient on-site installation.

Photo courtesy of Endicott Clay Products



Lucas Oil Stadium's exterior is clad with thin brick, a versatile and cost-effective option for larger arenas with many angles and large surfaces that could not be clad in traditional brick.

The systems can help increase the value of the building by enabling it to produce energy while also reducing electricity costs, use of fossil fuels, and emissions.

Expansion Joint Systems

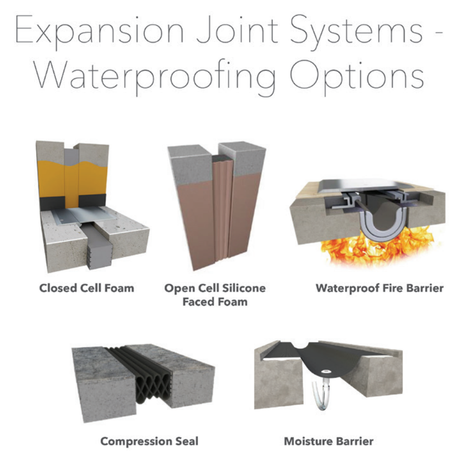
To ensure that the building envelope is designed, specified, and installed to protect the interior and its occupants against the elements, facades must ensure that all seams and joints are adequately sealed. These systems are an integral part of many buildings due to expected movement that naturally occurs over time. Expansion joint systems not only allow for movement but are also designed to provide additional moisture and fire protection and to handle unique conditions within a building.

Closed-cell foams are absolutely watertight and do not allow moisture to enter the body of the foam. This is the best application for horizontal runs where water could pool. The other key advantage of closed-cell foams is that they take well to heat welding of seams. This renders a monolithic installation that reduces risk of water infiltration.

Compression seal joint systems are installed into a joint block out and absorb movement and flexing through compression of the seal. The product is also an excellent option for exterior applications where waterproofing is required.

The hybrid design of a compression seal system is designed to deliver a greater level of waterproofing in split slab construction. A key benefit of this system is its integrated

Photo courtesy of Inpro



These are the various expansion joint system options that can be used to help prevent water intrusion in the building envelope, facade, and facade seams.

counterflashing, which is engineered to channel water away from the joint opening.

A roof bellows system uses either an ethylene propylene diene terpolymer (EPDM) or a neoprene seal that flexes to accommodate seismic movement. As with counterflashing, the seal must run under the metal flanges to allow water to be shed away from the joint opening. In addition, a compatible non-reacting mastic should be used to ensure watertight adhesion of the seal.

A reinforced vapor barrier (RVB) is another option that can be specified to prevent water infiltration or channel water via an integrated drain tube to drain locations.

A SYSTEMS APPROACH

In the design and planning stages, architects and specifiers must consider how all aspects of the building will work together to ensure that the end result is a high performance building that provides occupant health, safety, and comfort.

The building envelope is the first line of defense when it comes to keeping outside air out and inside air in. Whether designing and constructing a new building or renovating/retrofitting an old building, it's important to understand the entire building envelope system as having a direct impact on energy use and indoor air quality (IAQ). According to a 2015 report from the U.S. Department of Energy, "about 50% of the heating load in residential buildings and 60% in commercial buildings results from flows through walls, foundations, and the roof." Energy created within the home that flows to the exterior is just one of the problems caused by a poorly sealed building envelope. Unwanted intrusions from outside the building also can penetrate the envelope, flowing inside and harming the building's structure and its occupants.

Over the past several decades, huge technological advancements have been made to materials, products, and construction best practices. The adoption of new technology and high quality products is becoming increasingly important as the effects of climate change are leading to increased instances of extreme weather that can directly impact

Photo courtesy of Neolith

570 BROOME
NEW YORK CITY, NEW YORK

Standing at nearly 330 feet tall in downtown New York City is 570 Broome, a brand-new 25-story building nestled between bustling Soho and Hudson Square. This marvel of modern design, clad with a stunning glazed curtain wall, consists of 54 luxury boutique residential units as well as a commercial component at ground level.

The skyscraper is inspired by its setting: a whimsical combination of contemporary and contextual elements which define its environment

Sintered stone was specified across the whole facade, framing three-story-high expanses of glass which capture spectacular vistas of downtown and the Hudson River. The overall design is symbolic of NYC's rich history by way of the tower's soaring ceiling heights and a silhouette evocative of staggered cubes.

Due to the project's location near the heavily congested Holland Tunnel, the client wanted to deliver a durable, low-maintenance building that could withstand physical damage. Also stain-resistant and impervious to natural and man-made atmospheric deterioration, such as UV-rays and car exhaust fumes. Sintered stone had all these features, proving to be the ideal material.

The application of this exclusive water-based solution the sintered stone slabs enhances the surface, transforming it into a self-cleaning air purifier which helps to improve air quality and keep the surfaces clean.

The skyscraper at 570 Broome in New York City stands 330 feet tall with sintered stone specified across the facade to protect the building against sun and rain.

A custom color that is similar to limestone was used, as limestone is a traditional cladding choice for luxury buildings, and beautifully contrasts the smooth glazed surfaces of the building's curtain wall.

Photo courtesy of Vitro Architectural Glass

CALGARY CENTRAL LIBRARY ALBERTA, CANADA

When it opened as one of Architectural Digest's most anticipated buildings of 2018, the Calgary Central Library in Alberta, Canada, was already being celebrated for its beauty as well as its brains, thanks in large part to an extraordinary glass-and-metal facade featuring ultra-clear glasses. Variously described as resembling an open book, snowflakes, snowdrifts, or ice cracking on a lake, the library's curved exterior surface is outfitted with a hexagonal pattern of alternating clear, glazed, and ceramic-fritted glass and iridescent aluminum panels — an arrangement meant to convey the ideas of collective and community embodied in one of the city's most treasured assets. A more functional purpose of the alternating panels, according to project architect Dennis Rijkhoff, is to diffuse light inside the building while preserving views outside.

After studying how daylighting and views affected interior spaces and the overall composition of the facade, the architect settled on a mix of 60% insulating metal panels and 40% triple-pane insulating glass units (IGUs).

The finished IGUs were then supplied to Ferguson Corporation, which engineered, assembled, and installed the library's curtain wall. A big part of that job included fabricating 462 uniquely shaped unitized panels, which were painted in three different colors for various interior and exterior surfaces and infilled with clear, glazed, or fritted IGUs.

The panels, which took eight months to fabricate, were placed randomly around the building to create a consistent aesthetic and to enable each side to function as its front.

The Calgary Central Library in Alberta, Canada, incorporates a beautiful and functional glass and metal facade that features ultra-clear glass panels resembling an open book, snowflakes, snowdrifts, or ice cracking on a lake.

Photo courtesy Hofmann Facades Group

20 ROPEMAKER STREET LONDON, ENGLAND

A new commercial building of 400,000-square-feet of Grade A, BREEAM Outstanding office space and premium retail space resides at 20 Ropemaker Street in London, England. The BREEAM rating benchmark levels enable a client or other stakeholder to compare an individual building's performance with other BREEAM-rated buildings and the typical sustainability performance of new non-domestic buildings in the UK.

The exterior facade of 20 Ropemaker Street uses two different materials, natural stone, and terracotta. The natural stone exterior is 50 millimeters in thickness and is a combination of limestone and granite. The terracotta exterior is 40 millimeters in thickness, but is double-fired, leading to a much larger carbon footprint than materials that are solely processed without heat, like natural stone.

If the entire building had been made from terracotta instead of a combination of natural stone and terracotta, 20 Ropemaker Street would have led to 900 additional tons of carbon released into the atmosphere. The use of natural stone only creates 131 tons of carbon, thus using natural stone as opposed to terracotta led to an 85% reduction in overall carbon creation. 769 tons of carbon were saved.

The 400,000-square-foot commercial and premium retail space building located at 20 Ropemaker Street in London uses a combination of beige limestone and titanium-colored terracotta in its striking facade, thus reducing the carbon footprint compared to using terracotta alone. At nearly 130 meters (427 feet) high, it will be the tallest stone building in the City London.

the building envelope. Dramatic temperature swings as well as increased flooding in some areas – while others experience extreme drought – can leave an area susceptible to wildfires, and unprepared buildings are more vulnerable to costly damage. Areas that typically have precipitation are suffering from larger and more intense storms such as hurricanes that can produce dozens of inches of rain in a single storm, or blizzards that drop large amounts of snow.

All of these conditions strain buildings and threaten to damage the building envelope, allowing unwanted air and water to penetrate building materials. As flood waters recede or blizzard snows melt, the buildup of water can flow into spaces around exterior flashings or expansion joints. If not prevented or quickly remedied, unwanted moisture intrusion can cause catastrophic physical damage that is not only expensive to fix but also can be harmful to building occupants. Mold and mildew can easily grow in water-damaged spaces, leading to poor air quality and causing physical harm to occupants.

By keeping outside air and moisture outside, the building envelope assists other systems. For example, the HVAC system works more efficiently to keep occupants comfortable with consistent temperatures and safe with improved air quality.

Many natural and man-made materials can help seal the exterior facade by providing natural water and moisture resistance.

Sintered stone has a porosity of less than 0.09 percent, so it doesn't easily absorb water. By keeping water out of the surface material, the building is less likely to be affected by water penetrations and subsequent staining, mold, or mildew on the exterior facade. Sintered stone is also resistant to thermal shock, making it suitable for any climate.

Ultracompact surface materials are shown to be impervious with an average water absorption rate of 0.03 percent. They also have an average moisture expansion of 0.02 percent and an average abrasive wear index of 182.2.

Natural stone can be manufactured in large panels that contain faux joints to achieve the look of brick or terrracotta; a single panel may appear to have more than a dozen bricks. Fewer seams and fewer spaces

TOHA BUILDING TEL AVIV, ISRAEL

In the center of Tel Aviv, the ToHA building was designed by Ron Arad with the local team of Avner Yashar. The ToHa building offers a unique office complex complete with a public garden, an observation deck, and a restaurant.

More than 300,000 square feet of ultracompact surface clad the ensemble and appear on the ventilated facades, fixed facades, cladding on the exterior insulation and finish system (EIFS), flooring, elevators, ceilings, and the interior partitions. The ultracompact surface pieces are 126-by-56-inches with thicknesses of 30 mm, 20 mm, 12 mm, 8 mm, and 4 mm.

One of the main strategies in the design of the project was that of reducing the built area at street level to create a large park with the idea of giving the surroundings a public character. The building emerges atop two large legs that widen gradually and create a twisting volume. Because of its geometric versatility, the ultracompact surface manages to adapt with precision to this formal complexity thanks to its endless range of formats, with many thicknesses and ultra large format. In the building's intermediate levels, the jagged perimeter of the concrete slabs is clad with panels measuring 12-mm- thick and 79-inches-wide that, with their careful detailing, define the vertices and edges, conveying an image of perfection.

The ultracompact surface material used has a carbon neutral certification is noncombustible, making it perfect for building facades. The surface material has an extremely minimum porosity with maximum resistance to scratching and impact and will not expand. The large format allows for dimensional stability and resistance to sunlight (UV) rays. It is also stain and graffiti resistant. The low porosity also makes it freeze and thaw proof.

Photo courtesy of Cosentino

The ToHA building is an artistic marvel, utilizing a mix of architecture and sculpture, and featuring an ultracompact surface facade that is not only aesthetically pleasing, but functional.

between panels leaves fewer ways for water to penetrate the building envelope.

Thin brick fastened using the "keyback" method is less likely to separate or pull out from the main structure, reducing the risk of wall damage that can lead to air and/or moisture intrusion. Thin brick also is lighter and creates fewer seismic concerns as it requires less structural support while providing a genuine brick appearance. Thin brick is significantly less expensive than classic full brick because it is much thinner and therefore uses less material.

Low-e glass coatings help prevent the amount of heat transfer on either side of the glass. They help keep hot air outdoors in summer but warm air from the HVAC system indoors in winter. With low-e coatings preventing heat transfer, an HVAC system doesn't have to work as hard to maintain temperatures for occupants, and energy costs are reduced. Occupants also experience the added benefit of comfortable temperatures without needing to use curtains, blinds, or other means to block light from the outside to keep unwanted heat or glare from entering a space.

Expansion joint systems help seal gaps between panels and spaces in the building envelope. These joint systems are vital in preventing air and moisture intrusion from entering the building.

Allowing the building envelope and the HVAC system to work together rather than in opposition of one another not only saves the occupant energy costs, it also promotes the health, safety, and welfare of occupants by preventing them from exposure to toxic mold, mildew, or other harmful materials in the wall structure.

DESIGN AND AESTHETICS

When specifying materials and products for facades, it is also important to consider how the material will be manufactured, shipped, and installed. For large scale commercial projects, large panels can provide options for unique, visually stunning facades. Panels can be cut into custom shapes and offer infinite options as to how they are displayed. Large panels can even include designs that give the illusion that the panel is made up of many smaller pieces of different shapes and sizes. However, the major benefit to having large sheets and panels is that there are fewer seams or areas where water and moisture can seep into the building.

Sintered stone is a lightweight product that can be cut to almost any requirement, making it cost-effective to ship and easy to fabricate and install. The material can be affixed to a building's structure by using one of the following systems:

Hidden Fixing with Longitudinal Adhesion (HC): Comprised of a hidden support system that uses a longitudinal elastic chemical adhesive with a vertical support featuring T- or L-profiles.

Visible Mechanical Fastening Fixation (VM): Comprised of a self-supporting metal structure for ventilated facades designed to support ceramic tiling in different formats and thicknesses.

Strongfix: A longitudinal mixed (chemical and mechanical) hidden profile system.

Natural stone can be shipped as large-scale, thin, lightweight prefab panels on UHPC. Natural stone not only creates a unique facade, but it also reduces the carbon footprint in manufacturing processes, transportable weight on the roads, and the structure.

Ultracompact surface materials can be specified, manufactured, and cut into large panels for a visually appealing facade that has fewer seams that need to be sealed in the building envelope.

Glass panels can be manufactured, cut into various large panel shapes and sizes, and installed on the exterior facade. Tempering processes during manufacturing as well as glass coatings help reinforce the glass, making it more durable and aesthetically pleasing both for occupants indoors and for those viewing the structure from the outside. Coatings also can be used to reduce heat transfer and glare.

SUSTAINABILITY

In addition to creating aesthetically pleasing and unique facades, natural and durable materials promote sustainability in a few

EXPLORATORIUM SAN FRANCISCO, CALIFORNIA

The Exploratorium was opened by Frank Oppenheimer in 1969 and is located at the Palace of Fine Arts in San Francisco. Nearby are Pier 17, built in 1912, and Pier 15, built in 1915, with a major renovation in 1931. During a recent renovation of The Exploratorium, the architect wanted to create a LEED Gold, net-zero facility that was resistant to seismic movements, while also providing protection against fire and moisture from precipitation and the nearby saltwater from the San Francisco Bay. The facade of this contemporary building would still blend in with its historical surroundings while utilizing the latest technology to keep occupants safe and comfortable.

A single manufacturer was specified to provide the entire expansion joint and barrier package for the Exploratorium project. Almost 1,500 linear feet of interior and exterior seismic expansion joints are used throughout the building. Joint widths varied from 8 inches to as wide as 27 inches. Of the 1,500 linear feet, nearly 95 percent of the joint systems were custom designed and built, including several joints incorporating 3/8-inch-thick aluminum diamond plate. Where these joints bridged fire separation areas, waterproof fire barriers were specified and installed. The fire ratings were needed to maintain the safety of the walls, floors, and roof systems that made up the fire separations. The waterproof component was needed to withstand the moist and humid conditions of being over the water. Designers also specified specific coatings on many of the exposed joint systems to fight saltwater degradation and assure durability.

Photo courtesy of Inpro

The Exploratorium in San Francisco is a modern, net-zero facility with a facade that fits its history and surroundings. The expansion joint system contributes to the energy efficiency and sustainability of this structure.

different ways. The first is by reducing the carbon footprint through a reduction in energy usage during manufacturing as well as for the life of the material.

Manufacturing of thin brick uses significantly less energy when compared to manufacturing full-width brick. A larger number of thin bricks can be transported in a single shipment, thus reducing carbon emissions used in transit. Thin brick also can help increase efficiency by absorbing and then storing heat, slowing its movement through the wall. The thin brick veneer can hold the heat on the exterior rather than releasing it to the inside of the building, in this way helping to reduce strain on the HVAC system and lowering energy costs.

Natural materials such as natural stone do not require additional firing or processes compared to man-made materials such as glass, concrete, steel, brick, or terracotta. This ensures additional heat and carbon are not released into the atmosphere by a kilning/sintering or firing that can be 2000°F or more.

Waste created in the quarry and during fabrication, can be reused and recycled to make aggregate, calcium carbonate, and substitute recycled content. Stone sludge from sawing blocks can also be used in green brick which contains up to 60% recycled content.

High performance materials can be thinner and therefore use less carbon, not only in the incorporation of materials but also during manufacturing and transportation to job sites. The weight reduction of the large-scale thin facade natural stone panels on UHPC is light enough to be floor-loaded, leading to a tremendous reduction in weight during transportation as well as on the superstructure and foundations, all of which allows an additional reduction in carbon emissions.

Durable materials are built to withstand the elements and therefore do not regularly require extensive repairs or early replacement. Long-lasting materials like natural stone can be employed for extended periods of time. While the initial cost of some materials may be higher when specified and installed, costs can be recuperated in energy savings over time and a longer lifespan. Additionally, materials that have a longer life do not need to be replaced, and so they do not end up in the landfill or need to be recycled as frequently.

In thin brick applications, the keyback design provides a mechanical lock into the concrete for maximum durability and permanence. This design brings added strength and performance with an increased sheer value and pull-out strength. Both of these attributes lead to a longer product life and fewer replacement costs along with less material waste. When brick does reach the end of its life, it can be recycled as it is made from abundant, natural materials.

END NOTE

[1]Quadrennial Technology Review. An Assessment of Energy Technologies and Research Opportunities. Chapter 5: Increasing Efficiency of Building Systems and Technology. Department of Energy. 2015

Continues at ce.architecturalrecord.com

Jessica Jarrard is an independent writer and editor focusing on health, science, and technology. She contributes to continuing education courses and publications through Confluence Communications. ***www.confluencec.com***