Enclosure Strategies

For Better Buildings

PHOTO: COURTESY RMJM

Learning Objectives

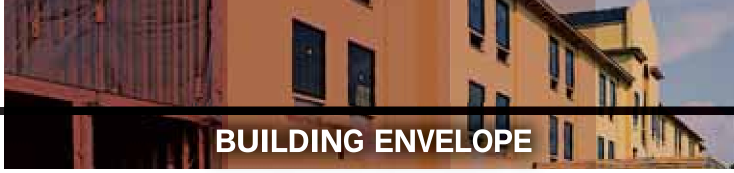
After reading this article, you should be able to:

- ✔ Describe how heat, air, and moisture can compromise a building envelope and overall building performance.
- ✔ List key systems and components for proper enclosure performance.
- ✔ Discuss how design and construction practices affects enclosure performance.
- ✔ Describe two or more novel technologies that can improve the energy efficiency of a building enclosure.

By C.C. Sullivan and Barbara Horwitz-Bennett

Sustainability and energy efficiency in building projects depend not only on the overall design of the structure but more specifically on the proper design and construction of its enclosure system, according to Mark Lucuik, corporate sustainability leader for Morrison Hershfield Consulting Engineers, Ottawa, Ont. “Everything beyond that is gravy,” he says.

That sentiment was echoed by many of the U.S. attendees and presenters at the Canadian Conference on Building Science and Technology held recently in Montreal. While the Canadians are especially focused on envelope performance because of the harsh climate in many parts of Canada, Americans are equally intent on getting enclosures right. Proof of this new movement is the emergence of Building Enclosure Councils, or BECs, in 23 cities. What’s pushing this renewed interest in energy conservation is the need to reduce the carbon footprint of buildings and the cost of commercial building operations.



The movement has been further enhanced by government research efforts over the last several decades. Designers, construction professionals, and manufacturers are being aided by such groups as the National Institute of Building Science's Building Enclosure Technology and Environment Council, the Oak Ridge National Laboratory's Building Envelope Program, the Center for the Built Environment's building envelope research program, and Lawrence Berkeley National Laboratory (LBNL) studies on glazing materials.

New building and renovation strategies now reflect these advances and increased scrutiny. Whether it's via better air-infiltration control, thermal insulation, and moisture control, or more advanced strategies such as active façades with automated shading and venting or novel enclosure types such as double walls, Building Teams are delivering more efficient, better performing, and healthier building enclosures.

"An investment in enclosure and façade design works double duty, improving energy performance as well as representing the owner's and architect's design intent," says Anica Landreneau, AIA, LEED AP, the sustainable design practice leader for HOK (www.hok.com), Washington, D.C. "In fact, many of the world's most distinctive buildings owe as much to the enclosure design as they do to form—for example, the New York Times Building, Paris's Institut du Monde Arabe, and London's Darwin Center."

AIR MOVEMENT AND CONTROL

Much of what makes such buildings special, says Landreneau, is unseen: air and moisture transport, control of heat and daylight, and other important factors to do with occupant comfort and environmental control. Performance, not aesthetics, is the ultimate test of the team's success.

"Air infiltration and leakage can have numerous deleterious effects on the structure and the occupants' well-being, in addition to the costs and environmental impact of increased energy consumption," says John Flanagan, AIA, associate principal, technical design leader, RMJM, New York City. Perhaps the greatest threat posed by the movement of air through the building assembly is the moisture carried with it.

The general passage of air will occur wherever air pressure differences exist; in some cases, air movement can drive rain into places it shouldn't penetrate. Surprisingly, one of the most effective ways for moisture to enter the envelope assembly and interior building spaces is by means of water vapor diffusion, which is the movement of water along a concentration gradient. This often results in condensation wetting during cold weather, yet diffusion also allows for drying of the enclosure under certain conditions.

Modeling the Route to a Well-designed Wall

Modeling building enclosures is an increasingly common way to ensure a successful wall solution.In addition to the hygrothermal modeling tool WUFI distributed by Oak Ridge National Laboratory (http://web.ornl.gov/sci/btc/apps/moisture/), which helps assess moisture and thermal performance, initiatives are under way to simulate energy requirements.

Examples include work on an energy simulation tool, EnergyPlus, which seeks to create and model a virtual building by applying different glass façade controls and analyzing different operational modes.

Software tools available from Lawrence Berkeley National Lab (http://windows.lbl.gov/software/default.htm) can give accurate optical and thermal properties of different façade elements.

"It is critical to incorporate building modeling software as a tool that informs the design process and guides the analysis and the impact of design concepts on the performance of the building envelope," says David Altenhofen, AIA, technical design principal, RMJM, Philadelphia, and BEC National Council co-chair.

Modeling can help designers evaluate different building enclosure design options and examine tradeoffs and potential energy savings of one system versus another, according to Peter E. Nelson, senior principal with Simpson Gumpertz & Heger, Waltham, Mass.

"The models are extraordinarily valuable in this regard," adds Taylor Gonsoulin, PE, CIAQP, LEED AP, general manager for building consulting with Air Quality Sciences, an IAQ testing and consulting firm based in Marietta, Ga. "Numerous what-if scenarios can be analyzed without the physical experimentation that can burn through real materials and incur actual energy costs."

Anica Landreneau, AIA, LEED AP, sustainable design practice leader at HOK, Washington, D.C., adds, "Energy modeling can support the evaluation process by clarifying which envelope and systems options have the greatest operational benefit, while balancing these savings with first costs."

SGH's Nelson warns, however, that "the information entered into the models must be accurate and the energy modeler must understand the interaction between the mechanical system and the building enclosure."

Many enclosure experts predict that building information modeling, in conjunction with enclosure analysis, could enable net-zero or near-net-zero energy use in future buildings.

In all situations, airflow can be controlled to keep enclosure systems relatively dry and effective. A presentation at BEST1, the Building Enclosure Science & Technology conference held last year in Minneapolis, summarized the reasons that this should be a primary design goal. According to the presenters, an airtight building enclosure is essential to:

- Limit potential heat and humidity effects—also known as hygrothermal performance.
- Reduce the risk of excess moisture being deposited in the construction.
- Cut down the amount of volatile organic compounds (VOCs), as well as particulates and mold spores carried from the outdoors or from construction materials into the indoor space.
- Improve the efficiency and effectiveness of HVAC systems.

Despite the general recognition of these benefits among building professionals, many building enclosures are still designed incorrectly, says Phil Kabza, FSI, CCS, AIA, partner and director of technical services for The SpecGuy, a Charlotte, N.C.-based specification consulting firm. "Much construction still takes place with no thought for the quality level of air- and moisture-control barriers," says Kabza. "They're deceptively simple, inexpensive membranes that don't get adequate attention in architectural detailing. They get even less attention on the job site, where they're often being installed by semi-skilled laborers as an accessory to another product."

Air and moisture barriers are critical to building envelope design. They help reduce risk of excess moisture and improve HVAC efficiency.

Sample Building Envelope Construction Details

The Boston Society of Architects was commissioned by the Massachusetts Board of Building Regulations and Standards to produce sample construction details to support the state energy code. Building envelope details such as air barriers, insulation, vapor barriers, and back-up walls can be found inside the documents listed at this link: http://bit.ly/14mf6D

When it comes to air barriers, Building Teams should envision a system of assemblies that work together to remain structural and completely airtight. "Careful attention to the details of the interconnection of all systems, field inspection of all work, and testing of typical conditions are critical components," says Richard Keleher, AIA, CSI, LEED AP, an enclosure consultant and founder of the Boston Society of Architects' Building Enclosure Council, the first of its kind in the U.S.

Sealants, gaskets, and other applied joint treatments are one area of focus. Keleher recommends carefully following the manufacturers' installation recommendations, paying special attention to the places where different products and trades must interface, such as the roof and wall, wall and window, and wall and foundation. For these transition points, notes RMJM's Flanagan, "The design must allow for movement, and the entire air-barrier system must be able to withstand both positive and negative wind pressures."

Taylor Gonsoulin, PE, CIAQP, LEED AP, general manager for building consulting with Air Quality Sciences, an IAQ testing and consulting firm based in Marietta, Ga., stresses that air-barrier products be installed "pin-hole free," with all joints and seams covered, and that any service penetrations through the barrier be sealed effectively. "Special fasteners are often made by the manufacturer to secure the barrier to the sheathing," he says. "As for liquid-applied barriers, they must be installed with no gaps in coverage and at the minimum specified thickness."

Early in the design phase, when it's still uncertain which manufacturers' products will be used in the final project, it's important coordinate carefully as shop drawings are being created and reviewed. "Although it's not often done, coordination drawings of these interfaces by the general contractor are very helpful to the process," says Keleher.

Peter E. Nelson, senior principal with Simpson Gumpertz & Heger, Waltham, Mass., notes that in addition to being continuous, the air barrier system must also "be durable and capable of withstanding the process of construction as well as all air pressures across it, including wind-, stack-, and mechanically induced pressures."

To simplify the process, engineers from SGH, which specializes in building enclosure design, recommend picking a flat, continuous plane for the air barrier, usually on the outside of the building, as this makes it easier to detail joints, beams, and columns. In cases where adjacent conditioned spaces have significantly different environmental requirements, interior air-barrier systems need to help separate and environmentally contain those spaces. Potential air leaks from the HVAC system and the effect of ducts and plenums on airflow through the building enclosure must also be taken into account.

Paul E. Totten, a senior project manager in SGH's Washington, D.C., office, warns about connecting air barriers to dissimilar materials; for instance, sealing with a sealant requires a hard surface of up to one inch, he says. Inadequate bonding surfaces are a well-recognized problem with window edges, for example. "Installations have failed because they tried to caulk to a thin edge that was only 1⁄16-inch thick," says Totten.

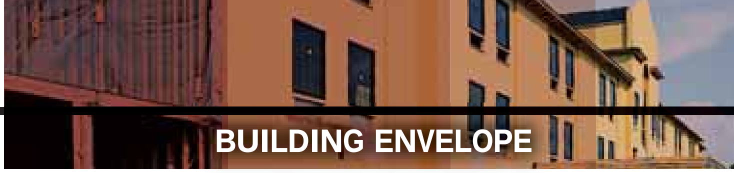
In general, while gasketing and mechanical fastening and termination bars work well, with some substrates, rubberized asphalt, or peel-and-stick flashings may tend to peel away and funnel water into laps that are not properly fastened and sealed, these experts caution.

Keleher adds that, when the work is done, the owner or engineer can test for leaks. He predicts that blower-door testing, which is common practice for clean room and biohazard-rated spaces, will become more prevalent for whole buildings as a means of assuring performance. "The Army Corps of Engineers is already doing this, and it is common practice in Great Britain" for all building types, he says.

THERMAL INSULATION

Thermal insulation is another key variable in the building enclosure equation. "Insulation is a cost-effective way to reduce heat transfer through building envelopes," explains Air Quality Sciences' Gonsoulin. He notes that insulation can be installed in a number of configurations, such as flexible batts, matted-fiber sheets, rigid boards, blown-in material, or spray-applied foam.

Keleher warns, however, that insulation works only if there is a complete air barrier system. "Air leakage makes insulation a waste of time and also encourages condensation problems in cold climates and in very hot and humid climates," he says. Continuity of the insulation barrier is also crucial, he adds. If not, thermal bridges can cause condensation, particularly in cold climates.



RMJM's design for the University of Puerto Rico Molecular Science Complex incorporates a pressure-equalized unitized curtain wall system with connections to the roofing membrane, an air/vapor barrier system at the base, and an underslab vapor barrier.

Andre Desjarlais, program manager for Oak Ridge (Tenn.) National Laboratory's Building Envelope Program, stresses these basic design guidelines: "Insulation should be installed so that there is a continuous layer between the conditioned inside space of the building and the outside environment. Breaks in this layer will form thermal bridges and will lead to excessive energy loss or gain into the building."

As codes and building designs evolve, Keleher predicts, the focus on insulation levels will increase. For example, exterior insulation and finish systems (EIFS), which were recently voted to be included in the 2009 International Building Code, can have up to 12 inches of insulation. On the other hand, says Kabza, a past chair of AIA MasterSpec's Architectural Review Committee, "There is a point of diminishing returns, where piling on higher insulation levels wastes money that could otherwise go toward an energy-generating investment, such as photovoltaics."

Glass as an insulator. Glass is another important element of the building insulation system. The properties of well-made fenestration systems and advanced glazings make them an even better performing part of the overall enclosure assembly than ever before.

One popular technology for improving the performance of glass is the use of low-emissivity, or low-e, coatings on glazing or glass to control heat transfer through windows

IMAGES: COURTESY RMJM

These section drawings of the University of Puerto Rico Molecular Science Complex show the air flow and rainscreen design. Note how the pressure-equalized unitized curtain wall system forms a continuous control layer on all sides of the building envelope.

glazing. "According to the U.S. Department of Energy, windows manufactured with low-e coatings typically cost about 10-15% more than conventional windows, but they reduce energy loss by as much as 30-50%," says Gondoulin.

However, John Straube, PhD, PEng, principal and founder of Building Science Corporation, Waterloo, Ont., points out that the best available low-e coated, argon-filled, double-glazed units offer a center-of-the-glass R-value of 4; if the window is enclosed in a thermally broken aluminum frame, the R-value falls to 3. "If the goal is low-energy buildings, why cover large portions of any building with such a low R-value system, particularly in cold climates?" he asks. "Even very good commercial clear glazing still allows about one-third of the sun's heat to enter."

Consequently, reduced window and curtain wall area is often the low-cost prescription for high-performance buildings, says Straube, a professor of building science at the University of Waterloo. At the same time, novel technologies such as "super windows" and dynamically operable shading devices are becoming more available and affordable, which will allow an increase of glazing areas without compromising performance.

Enclosure expert Kabza sees the "four-sided glass box" of modernist design being challenged by what he calls "much more thoughtful work" that utilizes combinations of glazed and opaque façade elements to increase the overall thermal resistance of the envelope.

In addition, of course, to the owner's needs and desires, the following factors should be considered in the planning stage of glazing design: code compliance, constructability, first cost, life cycle cost, functionality, and aesthetics. "Different types of glazing will provide different insulating performance, methods of incorporation into the building skin, and energy efficiency," says Kabza. "As performance and the quality of the product increases, so does the cost."

Double-glass façade. One relatively new architectural development is the double-wall glass façade with interstitial cavity. Properly designed and in suitable climate zones, these enclosures help improve acoustics, solar control, and ventilation. According to a team of LBNL researchers at Greenbuild last November, the cavity in the double wall can serve as:

- A protected location for shading systems.
- A space for extracting excess heat gain.
- A way to introduce natural ventilation.
- A safe way to introduce operable windows in high-rises.

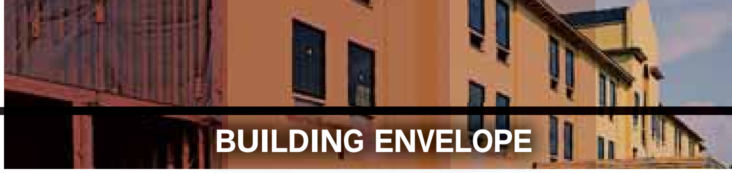
These double glass walls—like the triple glazing now emerging in some cutting-edge designs—are expected to become more popular as the building industry slowly moves toward near-zero net energy use, says Keleher.

MOISTURE CONTROL OPTIONS

While sound thermal insulation and air-barrier systems are essential to a successful enclosure system, "If the building envelope allows moisture penetration, all other envelope control systems are a wasted effort," warns RMJM's Flanagan. And because there is no such thing as a "perfect wall," he adds, "as architects, we need to understand and control how moisture will both enter and be drained from the cladding system."

Since it is a virtual certainty that moisture will eventually make its way inside the envelope, wall systems need to allow water vapor to flow through the wall assembly as easily as possible so that accumulation does not occur somewhere within the system, says ORNL's Desjarlais. "Controlling bulk liquid flow is performed by minimizing the number of penetrations and sealing them as best as possible, providing a drainage plane within the wall assembly such that water that penetrates the cladding can flow out of the system and does not get trapped," he says.

Joseph Lstiburek, PhD, PEng, Westford, Mass., an internationally recognized expert on building IAQ and moisture, says that, as a rule of thumb, assemblies should be designed to dry as follows: to the outside in cold climates; to the inside in hot-humid climates; and to both sides in mixed-dry climates and hot-dry climates. As for mixed-humid climates, Lstiburek advises designing assemblies to dry to the inside and to control exterior sheathing temperatures during the warm season with insulating sheathing.



Moisture Storage Capacity of Building Materials

Water Stored at 70% Relative Humidity (lb/cubic foot)	
Concrete (B45)	4.32
Concrete block (pumice aggregate)	0.96
Fiberglass	0.00
Gypsum board	0.38
Gypsum plaster	0.09
Softwood	3.16
Solid brick masonry	0.61
Steel studs	0.00

Source: Whole Building Design Guide

Because the way in which water vapor moves through envelope assemblies is so complex, however, especially in mixed climates, hygrothermal simulation programs can be helpful. Oak Ridge National Laboratory WUFI program can help designers verify the drying properties of the building envelope.

Flashing. Enclosure experts like Lstiburek categorize flashings as one of the most underrated building components—and arguably the most important. Flashing is critical to moisture management, and its success depends on careful detailing, smart specification, and skilled installation.

Kabza warns that "embedded flashing materials should be selected to outlive the building and be recyclable—they are too important to get wrong, and too expensive to fix. The same goes for air- and moisture-control membranes."

Maintainability and durability are important criteria in choosing flashing materials. "Don't choose an inexpensive flashing system or water barrier if the cladding system is expected to outlast the material's expected lifespan," says SGH's Totten. "Also, flashings and membranes need to be overlapped vertically, shingle style, to avoid mislaps, and the wall system's temperature needs to be evaluated to verify that the temperature threshold of these membranes will not be exceeded in service, which could cut short the material's lifespan."

Gonsoulin, an expert in building diagnostics and moisture intrusion evaluations, also is bullish on flashings, particularly when viewed as part of the larger moisture-control system strategy. "A good approach is to design primary and secondary barriers to the entry of liquid water, so that no single point of failure exists," he explains. "Designing a physical dam against water entry using flashings and barriers, as well as including a mechanism for rejecting water back to the exterior, is the best plan for designing a wall system. In this way, failures in any secondary barrier, such as caulk and sealant, have a reduced chance of damaging the building."

Another straightforward strategy is to slope surfaces such as roofs, flashings, windowsills, and copings, to allow them to drain. "Surfaces that are sloped to the exterior are critical to maintaining water tightness," says Keleher. "A non-sloped sill below a window, for example, will lead to deterioration of the sealant at the bottom of the window, as sealants do not tolerate being in standing water." RMJM's Flanagan adds, however, that sloped surfaces are only effective when they work in conjunction with the building envelope systems.

What about water-repelling materials? Experts say these products can provide a first line of defense to reduce water migration into building assemblies, but they need to be specified and detailed with great care. "They are not a substitute for air- and moisture- control membranes, and by themselves are suitable only for protecting non-conditioned structures," says Kabza. "Water repellents cannot substitute for proper rainscreen detailing of brick construction, and they aren't a good fix for leaking masonry."

In the same way, barrier walls need to be specified, designed, and maintained rigorously. "There are often imperfections in this one layer, which can then lead to leakage," says Keleher. "And if there are no imperfections to begin with, the weather usually will cause imperfections over time, particularly in sealants at interconnections with adjacent systems." SGH's Nelson and Totten point out that barrier walls require adequate storage capacity, as with older brick mass walls, and may require waterproofing retrofits, such as flashings, for improved weatherability.

Overall, the SGH designers recommend cavity-wall systems designed with a drainage plane and through-wall flashings, which have a proven long-term performance history. SGH's Nelson says that for most building types, the building should be under positive pressurization. However, certain lab spaces, and buildings in high-humidity climates, should be at neutral or a slight negative pressure. It all depends on the climate and building use.

Building pressurization is most useful for moisture management within a facility with highly varied moisture control issues, such as a natatorium or conservatory, says Kabza. He cautions, however, that "it's difficult to rely on positive pressure as a tool to control envelope moisture infiltration, due to varying pressures resulting from wind."

MITIGATING MOLD GROWTH

Outside of compromised energy efficiency, one of the biggest threats to a leaky, moisture-laden building assembly is the potential for mold growth and the consequent poor indoor air quality.

In fact, as reported by Roger Morse, AIA, president, and Don Acker, PE, Morse Zehnter Associates, West Palm Beach, Fla., in the authoritative Whole Building Design Guide, internal moisture degradation is a leading cause of premature failure in building envelopes via rot, corrosion, and deterioration. It is well known, of course, that mold and bacteria—

which thrive in warm, moist environments—can adversely affect IAQ and potentially compromise the health of building occupants.

Ironically, moisture-related damage has actually increased in recent decades as a result of evolving construction methods and materials. While today's architectural designs produce more airtight insulation assemblies, the flip side is a reduced ability to dry and decreased resistance to moisture damage. According to Morse and Acker, many high-performance building materials are commonly made from paper and resins, which are more vulnerable to mold and bacteria.

Another weak link in the chain is the wetting of building materials on the job site. In the past, for example, slower construction schedules allowed traditional timber-frame structures more opportunity to dry out. But today's fast-paced construction, coupled with the use of absorbent materials such as plywood and oriented-strand board, makes it more likely for moisture to be trapped behind the finished wall.

"Fast-track construction has us installing drywall before the roof goes on," confirms Kabza. "The smart contractors are purchasing moisture- and mold-resistant drywall because the cheaper conventional drywall isn't worth the risk."

A recent study from the National Institute of Building Sciences, "Moisture in Building Materials and Assemblies: Pitfalls and Error Assessment," recommends delaying the final completion of wall systems for as long as possible. Similarly, vapor barrier installation, which will prevent the assembly from drying to the interior, should also be delayed, if possible. One other factor to take into consideration is wall orientation in relation to solar gain and wind-driven rain to best protect the walls from heat and moisture during construction.

Air Quality Science's Gonsoulin cites the following construction practices from the Greenguard Building Construction program, a best-practice guide to preventing moisture and mold accumulation in new construction, as ways to reduce the potential for water damage to moisture-sensitive materials and subsequent mold growth:

• Keep storage time on site to a minimum for moisture-sensitive materials.

• Establish effective temporary waterproofing.

• Limit wet processes once drywall is installed.

In addition, fireproofing installation must be managed with adequate protection and drying time. Specialty dehumidification equipment is frequently deployed to bring building moisture levels down before finish materials are delivered. "Smart contractors have also discovered that the use of higher-quality air and moisture barriers, such as the elastomeric fluid-applied membranes, give them interim moisture control that allows them to begin finishing operations earlier without the concerns for water infiltration, long before final cladding is complete," says Kabza.

PHOTO: COURTESY AIR QUALITY SCIENCES

Example of building envelope failure combined with a vapor barrier on the interior face of the walls covered with vinyl wallpaper.

The experts agree that to protect the building from the start, you should:

• Cover materials vulnerable to moisture intrusion during construction.

• Monitor wetness, either on the surface or stored in hygroscopic systems.

• Remove any damaged materials.

"This requires effort by all to understand the materials, building process, seasonal change, and the weather to ensure that if the materials get wet, that they dry out in such a fashion that they remain serviceable and do not cause damage to adjacent systems and components," says SGH's Totten.

Kabza adds that model specifications such as MasterSpec now incorporate industry best practices for construction site management to help avoid exposing new construction to undue moisture. "The age-old directive to cover the tops of masonry construction at the end of the day still applies," he says.

Another useful tool, recommended in the NIBS study, is the use of moisture meters on construction sites in order to identify, diagnose, and ultimately avoid excessive built-in wetness. Similarly, infrared imagers can be used as a diagnostic device. Although they can't detect mold, they quickly and easily measure moisture intrusion into the building structure.

Preventing mold requires a cradle-to-grave approach, say the experts. This starts with a properly designed building. "If designers adequately control the envelope with the [recommended] strategies, in conjunction with the correct sizing of the HVAC system, that will maintain a humidity level that will not promote the growth of mold," says RMJM's Flanagan.

He further recommends a "mold mitigation plan" for both renovations and new construction. "The construc-

tion manager, general contractor, and owner should take steps to formulate a detailed plan so interior materials and HVAC components arrive after the exterior envelope of the building has been sealed," says Flanagan. "Where possible, schedule installation of moisture-sensitive materials for dry weather periods and keep interior materials dry prior to and during installation. Another option is to obtain third-party services to test the building envelope for water tightness."

During facility operations, the building staff should identify potential problems early by performing routine inspections for moisture intrusion. "Air-conditioning equipment that is intended to pressurize and dehumidify a building should be kept in good condition and operating at all times, and preventive maintenance should be carried out according to manufacturers' guidelines and best practices," says Gonsoulin.

Another useful resource is the U.S. Environmental Protection Agency report "Mold Remediation in Schools and Commercial Buildings," which offers guidelines for investigating, evaluating, and remediating mold problems.

ENCLOSURE TYPES: A GUIDE

As technology improves and field research grows, the construction industry is learning more about the benefits and performance of different enclosure types. For example, preliminary reports from an ongoing ORNL comparative study of wall systems have revealed a higher quality performance for EIFS assemblies. The study showed that EIFS with four-inch foam insulation outperformed brick, stucco, concrete block, and cementitious fiberboard cladding in terms of moisture handling and thermal performance. Building scientist Lstiburek points out that thermal bridges account for the majority of heat loss and gain in buildings, and EIFS is the best way to shore up the cladding's thermal resistance.

Rainscreens. Another popular enclosure system is the rainscreen, which is especially useful in climates with significant rainfall and wind, according to Kabza.

"The common cavity wall, perhaps the best general-use exterior wall system, is a weeped rainscreen," says Keleher. However, even though weeped or back-vented and drained enclosures can work well, Keleher notes that pressure-equalized rainscreens, while expensive, are your best option.

Kabza supports that position. "We learned long ago that masonry cavity construction with good flashing and weeps work, and the concept carries forward into curtain wall and metal panel cladding as well," he says. "Now, the development of sophisticated air- and moisture- control membranes has boosted the effectiveness of rainscreens. In fact, vapor-permeable membranes have allowed us to use these systems in the Southeast, where the trapping of moisture within wall assemblies is an issue, and vapor drive from the outside, as well as the inside, must be addressed."

There may, however, be some confusion when it comes to defining rainscreen technology, says RMJM's Flanagan. "A critical step in controlling moisture lies in promulgating a fuller understanding what a rainscreen is and how it functions as a cladding system. There appears to be no common terminology, let alone a common understanding, of what constitutes a rainscreen system. Is it an open-jointed cladding system, or simply a drained cavity with the primary function of protecting the building envelope control layer?"

Insulating concrete forms. Another enclosure choice, insulating concrete forms (ICFs), score well in terms of air infiltration and thermal insulation. A typical system is rated about R-17 at 75ºF, according to the Glenview, Ill.-based Insulating Concrete Form Association.

According to Michael Knopoff, AIA, with Montalba Architects in Santa Monica, Calif., a firm that frequently specifies ICFs, waterproofing needs to be carefully addressed. "In monolithic concrete construction, there is nothing to brunt wind-driven rain, as would be the case with a modern rainscreen assembly, which allows air pressure to equalize behind the screen, minimizing the force of the wind before moisture reaches the waterproof membrane," he explains. In addition, concrete inevitably cracks, which eventually allows water to find its way through the building envelope.

Yet these issues can be mitigated by creating as dense a concrete mix as possible. "Since a denser mix has less water, water-reducing or plasticizing agents may be required for workability," says Knopoff.

Novel enclosures. Although still under development, phase-change materials, or PCMs, show promise for improving building enclosure performance, reports the National Association of Home Builders. These novel substances exist in a solid state at room temperature. As the air temperature increases, they become liquid and are then able to absorb heat; when the temperature drops, the PCMs solidify and give off that stored heat. Consequently, heating and cooling loads are reduced and energy savings are reaped, according to a report at Toolbase.org.

Another trend is multifunctional building enclosures, which can pre-heat or pre-cool indoor air. Through the use of filters and dehumidifiers, the enclosure also modifies the indoor environment, according to the National Institute for Building Sciences.

ACTIVE FACADES

One area of sustained excitement for enclosures is the "active façade." These enclosures have more automation and interactive components and are considered integral to the next generation of high-performance buildings, predicts HOK's Landreneau. "As enclosure materials, technology, and design become more sophisticated, the enclosure has an increasingly significant role to play in the energy and IAQ performance of buildings," she says.

Although more R&D and field testing must be done to make façade more active and viable, new projects in Germany, the Netherlands, and the U.K. have made headlines. In the U.S., RMJM and other firms are exploring the use of "smart windows" and sensor-actuated shading systems with optical and thermal properties, often with integration to the main building automation system. Some "smart" materials include switchable electrochromic and passive thermochromic glazing, which work by reacting to glass temperature, as well as photochromic glazing, which reacts to sunlight intensity.

While the future seems promising, the current economy and a pragmatic viewpoint may temper the courage of Building Teams to pursue active façades. "The cost and complexity of these systems must be weighed carefully against the potential benefits as these systems are new to the industry and not widely adopted," Gonsoulin points out. Flanagan says he recognizes the potential energy savings and enhanced daylighting benefits, but admits that in the current economic climate he is mindful of a "fine balance between design aesthetic, budget, first cost, and life cycle cost savings."

SGH's Nelson and Totten point out that active enclosure systems utilize moving parts and software, both of which usually require maintenance. The automation needs to be protected from extreme weathering events, and the energy required to run the automation should be compared to potential energy savings, they explain.

Even so, LBNL researchers estimate that active façades could reduce peak electric loads in commercial buildings by 20-30%. To get there, LBNL's Advanced Window Systems Test Facility is currently testing electrochromic window systems under realistic sun and sky conditions. Based upon thousands of data readings and analyses, this test project has conclusively determined that electrochromic windows are capable of saving more energy than the most state-of-the-art, static, low-e windows.

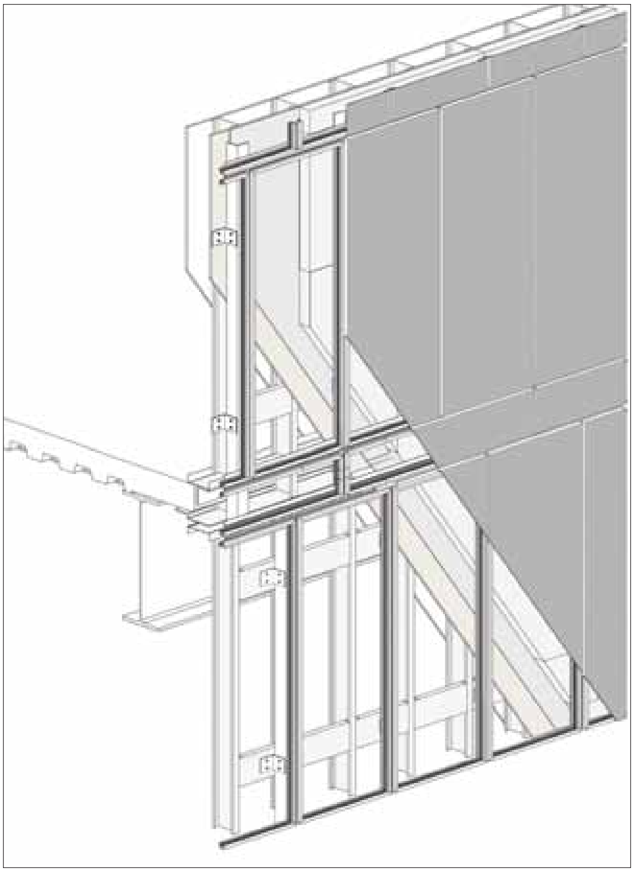
CLOSING THE ENVELOPE

In sum, SGH's Nelson and Totten emphasize the importance of addressing the building envelope as four different barriers or systems, all of which require definition and continuity:

1) The water management system, including all roofing, waterproofing, and flashings.
2) The air barrier.
3) The thermal barrier.
4) Elements for any necessary diffusive vapor control.

"In preparing drawings, four lines should be traced to ensure all components for the four barriers have been accounted for and special detailing is needed at key interfaces," says Nelson. Depending on the robustness and functionality, he says, redundancy may be needed for key systems or details. "The redundancy should be designed so that if one of the key barrier leaks water, air, or vapor, the system is robust enough to manage the leakage and dry out, remaining durable in service."

Although such preparation requires time and investment, Landreneau stresses the benefits. After orientation and massing have been addressed, the single largest contribution to building energy performance is the envelope. "This is where energy is truly saved or wasted," she says. "An investment in quality design and construction of the enclosure, as well as the building systems, provides for a durable and economic building." BD+C



For the high-performance rainscreen in the design of Gouverneur Healthcare Services in New York, RMJM used a pressure-equalized system designed to meet the demanding conditions of high-rise wall applications.