Moisture Control

Envelope Strategies and Techniques for Protecting Building Value

By C.C. Sullivan and Barbara Horwitz-Bennett

Learning Objectives

After reading this article, you should be able to:

- ✔ Discuss how moisture affects buildings.
- ✔ Understand the general principles of control and protection against moisture-related effects and damage.
- ✔ List building materials and methods of value in protecting buildings from the negative effects of moisture intrusion.
- ✔ Describe the importance of climate and the use of air barriers in controlling moisture.

Among all the challenges plaguing buildings in the U.S., moisture-related problems are at the top of the list, according to the authoritative Whole Building Design Guide. About 80% of all premature facility-wear expenditures stem from poor moisture control, note building scientists at Cleveland's C.L.I. Group.

"Water in liquid and vapor states and temperature changes have long been recognized as the most destructive weathering elements affecting the entire building envelope, especially exterior walls," says Syracuse, N.Y.-based Peter J. Arsenault, AIA, LEED AP. "Accordingly, moisture management and thermal efficiency are critical keys to a successful exterior wall system."

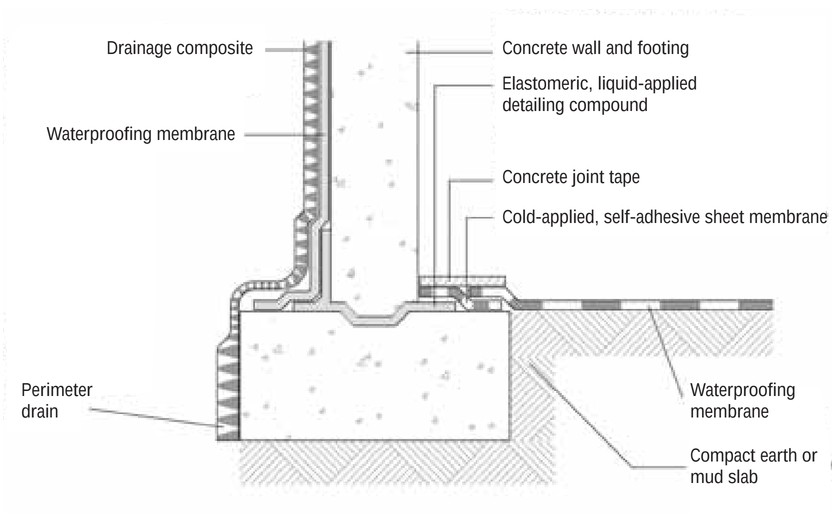
A long list of problems relates to poorly designed envelope systems for moisture management, such as corrosion, mold growth, materials deterioration, and even excess draw on a building's HVAC systems. Building Teams that execute well-planned, well-designed, and properly installed moisture management systems will enjoy key benefits. "If we build structures that won't rot or support mold growth, we will both increase the longevity of those buildings and reduce the health risks of living in them," says Alex Wilson, executive editor of *Environmental Building News*.

How moisture penetrates

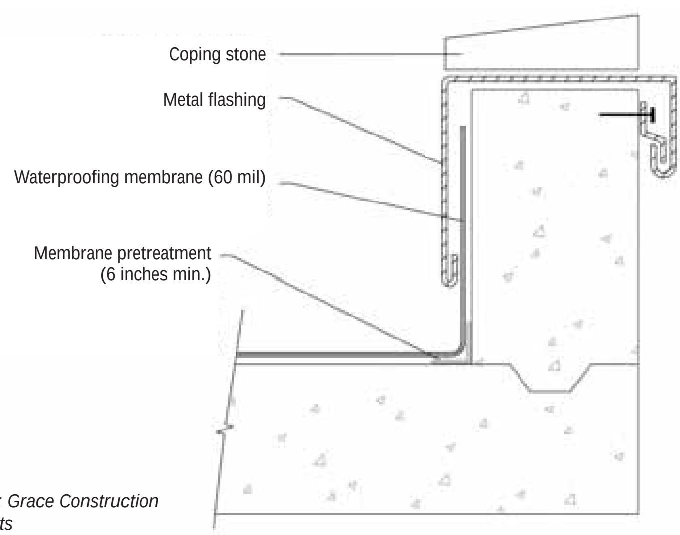
To succeed at integrating effective moisture-control technologies into the building envelope, it's important to understand basic principles of how moisture makes its way into building walls, roofs, and foundations.

Building Teams should consider three basic forms of moisture: liquid, gas or vapor, and solid water (ice). A fourth "semi-state" is absorbed moisture, visualized as something between liquid and vapor in characteristics. The movement of moisture—that is, water or water vapor migrating into

Waterproofing system at foundation wall



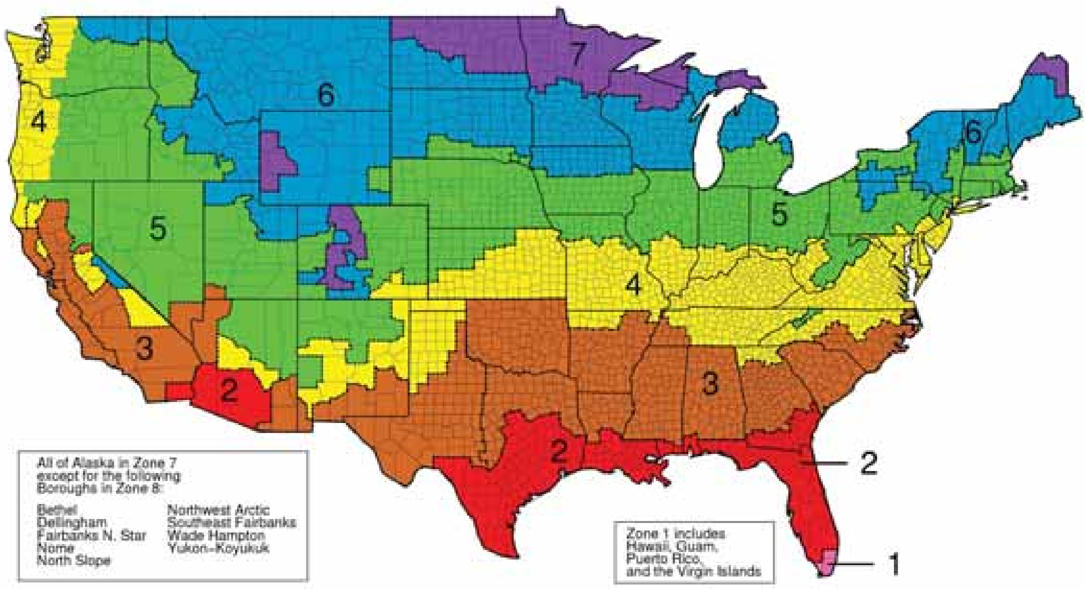
Waterproofing system at parapet with coping stone



Source: Grace Construction Products

Illustrations depict methods for waterproofing foundation walls (top) and parapets (above).

IECC climate zone map



Source: U.S. Department of Energy

Map depicts the International Energy Conservation Code climate zones as developed by the Department of Energy. DOE divides the country into eight climate zones based on the average temperature and humidity level. Zones 1 through 3 represent hot/humid or hot/dry regions, Zone 4 is warm/humid or warm/dry, and 5 through 8 range from cold to subarctic/arctic.

the building envelope from inside or outside a structure—occurs as a result of four main physical forces. As described by building researchers Anton Ten Wolde and William B. Rose, they are:

- ✔ *Liquid flow* by gravity or air-pressure differences.
- ✔ *Capillary suction* of liquid water in porous building materials.
- ✔ Water vapor by air movement, called *convection*.
- ✔ Water vapor *diffusion*.

Another important mechanism to consider is *temperature differential*, according to Wilson: "When brick siding gets soaked from rain, for example, and then the sun heats the outside of the brick, moisture in the brick is driven through the wall to the interior."

Wilson points out that a building's moisture dynamics are also driven largely by relative humidity (RH) and the phase change from vapor to liquid. "As a mass of air and water vapor is cooled, the relative humidity increases, until the mass reaches 100% RH, when liquid water condenses out," he explains. "This point is known as the *dew point*."

Most building designers are familiar with the challenges of controlling the effects of dew point conditions, in particular condensation. When warm indoor air flows through cracks in drywall into envelope cavities during cold weather, for example, that air mass may cool enough to reach the dew point—and liquid water appears, wetting the insulation or the inboard surface of sheathing, reducing insulation values, destabilizing materials, and causing corrosion.

Moisture protection strategies

Project management expert Michael T. Kubal of A.J. Jones Construction describes two main principles in *Construction Waterproofing Handbook*:

- ✔ "The 90% –1% Principle": As much as 90% of all water intrusion problems occur within 1% of the total building exterior surface area.
- ✔ "The 99% Principle": About 99% of waterproofing leaks can be attributed to causes other than material or system failures.

The bottom line: Installation errors, poor detailing, improper system choices, inadequate surface preparation, and similar failings are the root cause of most moisture-related defects. Other related causes include poorly trained workers, poor terminations, and material incompatibilities, as well as improper attention to flashing, building pressures, and thermal bridging, according to C.L.I. consultants.

In crafting an overall approach to moisture management to sidestep such issues, Ten Wolde and Rose recommend the two-fold approach of 1) limiting moisture load and 2) constructing buildings to exhibit a high tolerance for moisture. As for specific strategies for this, Wilson lists:

- ✔ Keeping water and precipitation out
- ✔ Managing plumbing leaks
- ✔ Avoiding condensation inside the building and its envelope
- ✔ Controlling entry of humid outside air
- ✔ Controlling indoor sources of humidity
- ✔ Designing assemblies to dry out
- ✔ Providing mechanical ventilation and dehumidification

According to the Whole Building Design Guide, the *storage capacity* and *rate of drying* unique to each material and layer of an exterior wall assembly are critical to long-term durability and performance of the overall enclosure.

Related to these issues are basic building construction and operations concerns, notes Philip R. Morey, PhD, director of consulting services for Air Quality Sciences, Walnut Creek, Calif. For example, if construction materials are wet or even moist on the job site, allow them to dry before installing and sealing them into the structure. For material choices, specify materials resistant to "biodeterioration," such as glass-fiber-faced gypsum board or concrete board in place of boards with paper facing. In building operations, adds Morey, avoid cooling interior spaces below mean monthly dew-point temperatures to help avoid condensation.

Other ways to protect against condensation, even during the summer months when humidity levels are high and water pipes can be quite a bit colder than ambient air, include using high-performance glazing, insulative sheathing on steel framing and the foundation and slab, as well as proper insulation for walls and water pipes.

Thermal breaks are also vital, in aluminum frames for windows, storefronts, curtain walls, and skylights, and in the separator in insulated glass, adds enclosure expert George M. Blackburn III, AIA, general manager of Consulting Construction International, Carrollton, Texas. At the same time, however, he advises against insulating curtain wall and storefront framing on unexposed areas.

The role of air barriers

Air barriers play an important role in moisture control. "We didn't have moisture control problems until we insulated our buildings and then, to make matters worse, began using materials that were subject to moisture damage, corrosion, mold, and mildew, such as steel studs and gypsum sheathing," notes architect Richard Keleher, AIA, LEED AP. "We then added vapor retarders to solve the problem—which instead reduced the drying capacity—and we paid no attention to the need for air barriers. That meant that even if we got the moisture drive analysis right, we still had water intrusion due to the huge amounts of moisture that can be carried into the building enclosure in moist air."

Recent studies and field tests have shown air barriers to be crucial to the success of exterior enclosures of every type, notes Judd Peterson, AIA, president of the Judd Allen Group, Edina, Minn. "While a 100% vapor barrier is still important, stopping air infiltration is now the highest priority, not only for energy efficiency, but for control of moisture condensation," says Peterson, who adds that air infiltration accounts for 70-90% of the water transmission through

Waterproofing/air barrier on steel frame

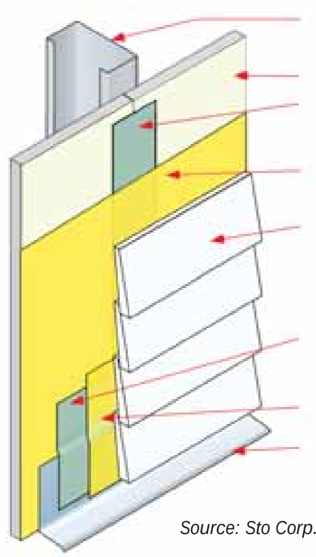


Illustration depicts one method for creating a proper waterproofing and air barrier system for common steel frame wall applications.

an exterior wall, while diffusion only accounts for 10-30%. "Not only do air barriers limit the air infiltration and exfiltration, but uncontrolled air flow through a one-inch hole in an exterior wall can carry 30 to 200 times the amount of moisture that can pass through a 4x8-foot area simply lacking a vapor barrier."

Air barriers comprise a near-airtight seal around the roof, walls, and foundation structure of the building. An effective system requires continuity, even at electrical penetrations and metal studs and at roof-wall and window-wall connections. The barrier system should be continuous and rigid enough to survive wind loading and air pressures across it, durable enough to remain intact throughout construction, and installed in such a way as to be continuous between building elements, according to the Whole Building Design Guide.

According to the National Institute of Standards and Technology, a well-designed air barrier system can slash a building's HVAC costs by as much as 40%. Unfortunately, in many cases, architects and contractors are so focused on making the outer veneer watertight that gaps in the air barrier often go undetected, claims RMJM Hillier's director of technology David Altenhofen.

Selection, specification, and installation of the air barrier require extra effort from the Building Team. "There's an important difference between an air barrier material and a true air barrier system that addresses all the details and field conditions that actually occur in construction," notes Phil Kabza, FCSI, CCS, AIA, a specification consultant based in Charlotte, N.C., adding that not all product manufacturers offer architects and contractors the technical guidance needed to ensure proper field application.

The importance of climate

In terms of moisture management and overall performance, the most critical design variable for the building envelope is the geographic region and climate. "Moisture loads can originate from internal or external sources," Ten Wolde and Rose point out. "In warm, humid climates, much of the load is external, while in cold winter climates, most of the load is internal."

This distinction affects, for example, the design and installation of *vapor barriers*, says Altenhofen. "Vapor barriers must be installed on the warm side of the insulation, so in Miami, Phoenix, and Los Angeles, that's the exterior face, while in Chicago and Boston, it's the inside face," he explains. In mixed climates, Altenhofen says, the proper approach is not so straightforward, as the heating and cooling seasons are relatively equal.

Because many envelope assemblies are designed to allow components to dry out, building scientists like Joseph Lstiburek, principal of Building Science Consulting, Westford, Mass., contend that in most U.S. climates, the envelope should have some drying potential in both directions because moisture-driving forces change dramatically throughout the year.

For this two-way drying situation, solutions include "smart" air/vapor barriers made from materials like two-mil nylon, which become more permeable as the humidity increases. Taking another approach, Peterson (whose projects are mainly located in harsh, cold climates) suggests "perfecting vapor barriers 100%" on each side of an exterior wall, for example, by using sealed curtain wall or insulated metal panel assemblies. "Then there's no uncontrolled moisture within the exterior wall," he explains.

Detailing wall assemblies for moisture control

Before setting out to design a building envelope, Lstiburek recommends the following three-step procedure:

❶ **Identify the climate:** hot, cold, or mixed

❷ **Determine potential moisture-transport mechanisms in each part of the exterior envelope:** liquid flow, capillary suction, air movement, and/or vapor diffusion

❸ **Select moisture-control strategies:** control moisture entry, control liquid-moisture accumulation (condensation), or remove moisture (by venting, diffusion, or draining).

Next, consider the behavior of specified building materials and assemblies. For example, Arsenault notes that porous materials such as masonry, concrete, stucco, and some exterior insulation finish systems may absorb and retain moisture, whereas nonporous metal, glass, and polymer-based walls generally will not. At the level of the assembly, any enclosure designs that may leak, such as metal claddings, should be treated as *rainscreens* with complete moisture control behind them. "As a barrier, these types of walls are only as good as the field application of their sealants, and owners don't maintain sealants," says Kabza.

"Exterior walls that employ a rainscreen approach are becoming much more prevalent in our practice—assemblies faced with stone veneer, metal panels, resin-based panels, and brick veneer," says Kevin Krumdieck, AIA, LEED AP, principal with Carrier Johnson in San Diego. "For the National City Library project, for example, the zinc rainscreen creates a very long-lived wall system, lasting up to 70 years or more." Krumdieck adds that rainscreens contribute to sustainable design practice, maximize the installed life of products, and minimize long-term waste. Rainscreens also reduce the maintenance challenge associated with resealing larger buildings.

Similar principles apply to other types of wall assemblies, even those that hope to provide a "perfect moisture barrier." A positive weather barrier membrane on the sheathing of the backup wall allows water to weep out from metal walls, for example, and drainage planes with slots at soffit corners will allow moisture to escape from soffits in EIFS and stucco structures, says Peterson.

In general, Ten Wolde and Rose recommend *capillary breaks*—such as air spaces and nonporous building materials—to minimize liquid entry. Also, novel sheet membranes recently introduced on the market incorporate drainage channels within the layers of sheet membrane, allowing water to weep out without becoming trapped or developing a hydrostatic pressure into the wall construction.

Just as important, however, are basic design considerations: proper site grading, careful detailing of gutters and downspouts, and thoughtful flashing and detailing around windows, doors, chimneys, and vent stacks. Adequate roof overhangs in some instances will help keep rainwater off walls and windows.

Fundamental moisture-control components, such as sealants, flashings, and gaskets, require an investment of time and attention. "There's so much pressure to save money in construction that the project teams are constantly putting owners at risk by considering minor savings for critical elements without considering the long-range implications," says Kabza. "Why cut $1 per square foot on a roofing system for a $200 per-square-foot building? Why would you *not* prime a surface before applying a joint sealant? Why make a watertight wall dependent on some flashing adhesive that may fail in seven or 10 years?"

In the absence of building scientists

As part of any discussion of effective moisture control strategies for wall and roofing systems, it's worthwhile to point out the unfortunate fact that building science principles are often neglected in building envelope designs.

"There is rarely anyone filling the role of building scientist on design teams today," says Alex Wilson, executive editor, Environmental Building News. "It is up to architects to either learn enough to play that role, or hire consultants who can work through every detail of the envelope and mechanical and plumbing systems with them."

Phil Kabza, FSI, CCS, AIA, a specification consultant based in Charlotte, N.C., states, "There aren't a lot of physicists in the construction industry; it runs on rules of thumb and habit. It also runs on misconceptions. That's why we have specialists—and lawyers. Architects and builders must understand the principles of vapor diffusion and air diffusion in walls in order to design and build walls correctly."

According to the Whole Building Design Guide, "In particular, architects, engineers, contractors, building scientists owners and others involved in the construction and maintenance of the building enclosure must understand the wetting and drying process, the safe storage capacity for moisture of the materials specified, and the manner in which those materials are likely to behave in a given climate. They must understand how poor design and/or construction with limited regard to the wetting-drying-storage process can have a potentially devastating impact on the long-term durability and performance of the building enclosure."

Detailing roof assemblies for moisture control

Often the first line of defense for moisture protection, roof systems tend to receive the brunt of weather effects, temperature swings, and other forces, making them a critical element of overall moisture control. In general, Oak Ridge National Laboratory building scientists Andre O. Desjarlais and J.E. Christian assure that through proper roof design and material selection, leaks and other moisture challenges can be prevented.

Kabza recommends following NRCA and Factory Mutual Global requirements when designing the roof, as well as keeping in mind that roofs tend to fail at perimeters and penetrations, so these points require solid support and fastening, while the membrane flashings need flexibility. Blackburn adds: "Perimeter flashing must lap over the top of parapets or over the fascia substrate if there is no parapet, and over the top of penetration curbs."

There are numerous waterproofing techniques for the roof plane, but Cindy Meehan-Patton, a design consultant and co-founder of the Western North Carolina Green Building Council, recommends the use of a self-sealing ice-and-water barrier for sloped roofs in cold climates, a continuous layer under the roofing material which will protect against water penetration. Meehan-Patton also recommends basic roofing protections, such as effective water drainage and channeling; for example, via gutters and downspouts that are kept clean all year long and that terminate well away from the building enclosure.

For today's low-slope roof applications, however, there are other challenges of moisture control. Fully adhered membranes, for example, which may be considered air barriers as well, tend to effectively control moisture movement by infiltration, say Desjarlais and Christian. "The complete attachment of the membrane to the outermost surface of the insulation prohibits the transfer of low pressures induced by winds blowing over the roofing system through the membrane," they explain. "In roofing systems that employ a loose or mechanically attached membrane that can transfer outdoor air pressure, precautions to eliminate air movement must be considered. An air-tight deck or the addition of an air retarder should be considered."

Other roofing technologies, such as sprayed polyurethane foam, have been shown to work well in preventing moisture and air transfer, even during severe weather. Regardless of the system used, however, proper detailing and application are vital to performance and longevity.

Codes and standards for moisture control

In terms of moisture control and the building envelope, the biggest news in codes and standards has been the growing interest in air barriers. Finally catching up to the Canadian Building Code, which has required air barriers in buildings since 1990, Massachusetts, Wisconsin, and Michigan have mandated and codified the use of air barriers. In addition, Louisiana, New Jersey, Ohio, and Vermont have adopted ASHRAE 90.1-2004 requiring all critical details in buildings to be airtight.

However, since ASHRAE's current standards are somewhat limited in this regard, newer standards are being developed, such as ASHRAE Standard 160P, *Design Criteria for Moisture Control in Buildings*. "Standard 160 gives us a methodology for the first time to make consistent design recommendations, such as the need, type, and placement of vapor retarders, in any climate," says Ten Wolde, who chairs the ASHRAE committee that drafted the standard. "The standard requires the designer to think about the interior conditions that will be maintained in the building and the effect that may have on the building envelope."

Currently on ASTM's development docket is a standard for air leakage testing of windows and the "Standard Guide for the Selection and Use of Modeling for Moisture Control Design in Building Envelopes." Since modeling is becoming a useful technique for moisture-control design, there has been interest in developing a standardized approach.

One other related effort, being developed by the American Architectural Manufacturers Association, is a standard for pressure-equalized rainscreens, according to Keleher.

Although there is a lack of standardization and enforcement for building envelope design, Kabza reassures that the codes are slowly catching up to the increase in understanding and available products for vapor and air control. Further, he points out that national specification systems, such as MASTERSPEC, regularly update the sections affected by these developments.

The zinc rainscreen wall system at National City Library in San Diego is designed to last 70 years.

Moisture: A perennial concern

Overall, due to the costs and health risks associated with moisture-plagued buildings, sound building envelope design has become more emphasized and critical in recent years.

"With the proliferation of mold and water damages in today's building construction, better moisture control design of building systems is demanded by the public and other institutions," says Achilles Karagiozis, PhD, a senior research engineer at Oak Ridge National Laboratory.

However, executing such designs takes a firm commitment, investment, research, and coordination among the Building Team members to make it happen.

"By making use of today's best building science, we can not only design and construct buildings that will last well over a century, but also greatly reduce the risk of moisture-related health problems, including exposure to molds and other allergens," concludes Wilson.

In addition to the basic building science and design principles related to envelope design, choice of building materials and systems is crucial to effective moisture control. This portion of this continuing-education module addresses some of the typical challenges of envelope design and construction, with attention to specific materials and systems noteworthy for their effectiveness in preventing moisture intrusion or moisture-related damage, or both. Two critical areas of design and detailing—as well as installation—are sealants and flashing, according to experts.

BUILDING ENVELOPE SEALANTS AND FLASHING

Offering some specific design tips for sealants, Judd Peterson of Edina, Minn., recommends the following general principles for all building envelopes as well as specific recommendations for colder climates:

- ✔ Use flexible sealants that will last, particularly at exterior joints. Use either non-staining silicone sealants or two-part polyurethane sealants on the exterior; one-part polyurethanes are acceptable at interior joints.
- ✔ Beware of incompatible substrates, particularly asphalt-based membranes. Do not seal to porous substrates like raw wood.
- ✔ Provide sealant joint gaps that have bondable substrates and provide two-sided (not three-sided) adhesion.
- ✔ Clean the substrate surfaces with xylol or solvent to make sure the sealant bonds.

With regard to flashing, Peterson recommends hemming edges, using keeps, and in long runs of sheet metal flashing, always create a gap between pieces. "Do not fasten the ends of the longer pieces," he says. "Rather, place a cap flashing over the gap and fasten that."

FLASHING AT WINDOWS AND PENETRATIONS

Perimeter flashing for window openings, whether for aluminum-clad wood windows with nailing flanges or for aluminum windows or even curtain wall, benefit from dual layers of subflashing around the opening, sandwiching the nailing flange. Single layers are more likely to fail and leak around these nailing flanges, say enclosure experts, particularly at the sill/jamb corners where the water falls and enters the building and rots the sheathing and wood framing.

Other building experts also encourage building design teams to make sure that all membranes and sealants are compatible in each layer. In many situations, subflashing membranes often have asphaltic interlayers that are incompatible with the primary seals of the windows; architects and contractors should check with each manufacturer to verify that compatibility. Butyl-based subflashing membranes may help avoid that solvent incompatibility, and sometimes it is necessary to clad the corners of the rough openings with either stainless steel or aluminum angles to provide a clean, positive sealant surface for the windows/curtain wall and the primary seal.

Care must be taken to embed these claddings in a gasketed seal or bed of compatible sealant so that water does not bypass the primary seal under the cladding.

MOISTURE CONTROL FOR BRICK VENEER WALLS

Although the design and application of different kinds of walls vary based upon project type, availability, cost, and climate, one thing remains constant: the need to keep out moisture. Consequently, when it comes to brick veneer walls, Peterson shares the following pointers:

- ✔ Use appropriate brick and mortar for the weather conditions.
- ✔ Create enough cavity space to accommodate rigid insulation thickness and about a 2-inch width of air space.
- ✔ Use a flexible, strong through-wall flashing membrane that will not disintegrate over time (5 ounces/sf copper is time proven), and run it to the exterior face of the mortar joint.
- ✔ Where laps are required in through-wall flashing, make them a minimum of 6 inches and fully seal them.
- ✔ Provide 12-inch-high upright legs on the backup wall, and provide sealed end dams at all corners and discontinuities
- ✔ Step-flash and overlap the through-wall flashings by 8 inches to 16 inches along slopes.
- ✔ Use stainless steel brick ties, reinforcing, termination bars, and fasteners.
- ✔ Spray-foam the joints in the rigid insulation.
- ✔ Consider applying a flexible, impermeable membrane on the backup surface.
- ✔ Use 100% cotton rope wick weeps (not polyester strands) to weep the through-wall flashing at 16 inches on center, linking each wick by running it horizontally in the cavity 16 inches to the next wick, and then turning it vertically for 8 inches. Extend the wick out the face of the wall by ½ inch to catch air and evaporate and wick the moisture out.
- ✔ Do not use any chlorides in the mortar.
- ✔ Install expansion joints at spacings and locations recommended by the Brick Institute of America. Do not run expansion joints through lintels: either space the joints away from lintel bearings, or support the lintels independently of the brick veneer. Do not insert them into the jamb masonry.
- ✔ Use mortar net mesh above each level of through-wall to prevent mortar droppings from clogging the cavity.

THE ROOF: 10 TIPS FOR MOISTURE CONTROL

One of the most exposed elements in a building, the roof is the most vulnerable to moisture penetration. As a result, a solid roof design, as part of the building envelope, is most essential. To aid the Building Team, Peterson offers the following 10 tips:

❶ Refer to National Roofing Contractors Association details and FMG standards (FM Global, formerly known as Factory Mutual) Property Loss Prevention Data Sheets.

❷ Provide wood (not treated) cants around parapet perimeters. Lap subflashing membranes over parapet blocking. Use neoprene-gasketed stainless-steel screws to attach sheet metal flashings and counterflashings.

❸ Elevate perimeters of the roofing deck surface with canted and tapered insulations; keep water away from curb flashings.

❹ Use polyisocyanurate roof insulation covered with fiberboard on flat, built-up roofing.

❺ On flat roofs, use coal tar pitch built-up roofing or liquid neoprene spray membrane for 1/8 inch per linear foot or less roof slope. For asphalt built-up roofing, ¼ inch per linear foot slope is required for warranties. Use CPVC sheet membranes, fully adhere and heat weld seams thoroughly for low-slope roofs between 1/8 inch and ¼ inch per foot slope. Consider spray-applied neoprene membrane. When using EPDM, use a minimum thickness of 60 mil. and fully adhere. Fully adhere any sheet membrane roofings.

❻ Provide continuous vapor barriers on the decks, under the roofing insulation.

❼ Double-check the rain leader piping runs down through the building for chases and conflicts with structure and building spaces.

❽ Verify thicknesses of insulation, deck height elevations, and perimeter through-wall flashing elevations. Verify tapered insulation requirements and determine whether an additional drain would minimize tapering work.

❾ Show detailed drawings requiring base flashings and curb flashings.

❿ Beware of the following:

✔ Coal tar pitch will flow even in the coldest temperatures and must be designed with correct slope, perimeter felt layer enveloping, and sump scuppers with grates to avoid sloughing off down drains.

✔ Asphalt roofing will release its solvent oils and dry out, particularly where not sloped enough and ponding occurs.

✔ Heat-welded or solvent-glued membrane seams can be discontinuous or fail even if installed well, particularly if below grade.

✔ Leaks through loosely laid membranes are impossible to find and repair. Always fully adhere roofing membranes.

GENERAL CONSIDERATIONS FOR MOISTURE CONTROL

In terms of a larger, overall strategy to keeping water out of light commercial and residential-type framed structures, a number of approaches may be considered. Cindy Meehan-Patton, a design consultant and co-founder of the Western North Carolina Green Building Council, offers the following points:

✔ Provide proper flashing on all windows and doors. All components should be layered so that water is shed down and outward.

✔ Provide a rainscreen behind siding. To facilitate drying of siding and to provide a capillary break between the siding and the sheathing, most experts now recommend rainscreen detailing in wetter climates. This can be provided with vertical strapping, a specialized rainscreen product, or, with brick siding, a bottom-draining air space behind the brick facing.

✔ Seal wood and fiber-cement siding. Porous siding materials should be sealed on all sides. Pre-priming is recommended prior to installation, with multiple coats as needed, especially on end-grain. Sealed siding will not absorb moisture, thereby reducing moisture migration driven by solar heat.

✔ Provide a capillary break above footing. Paint the top of the footing with a damp-proofing coating or install an impermeable layer before installing the foundation wall to block the upward migration of soil moisture.

✔ Provide a drainage layer and poly vapor retarder under the concrete slab. Before pouring a concrete floor slab, install a minimum layer of crushed stone—with no fines—and a poly vapor retarder. The concrete should be poured right on top of the poly without a layer of sand between the poly and slab.

✔ Provide perimeter drainage at the footing. Install crushed stone, with no fines, and a perforated drain pipe around the footing. The drainage pipe should be slightly pitched, but it should not extend below the bottom of the footing nor above the top of the footing.

✔ Paint the outside of foundation wall with a damp-proofing layer. Several layers are suggested, with the minimum thickness depending on the material.

✔ Install a free-draining layer next to foundation wall. Install a specialized drainage layer—such as free-draining insulation, kinked nylon mesh, or corrugated plastic—against the foundation wall, or backfill against the wall with crushed stone, or do both.

✔ Slope ground away from the building and provide an impermeable cap. BD+C