INSULATION IS NOT ENOUGH

HOW TO IMPROVE THE ENERGY, COMFORT, COST OF OWNERSHIP AND DURABILITY OF BUILDINGS

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Demand for Sustainability Prompts Growing Trend Towards Air Barrier Systems

State Codes, ASHRAE and United States Green Building Council leading the call for airtight construction

In the United States, they were once known as "that strange Canadian phenomenon." Five years ago, things began to change when Massachusetts mandated them under its Commercial Energy Code.

Air barriers.

Massachusetts is no longer alone. Wisconsin and Michigan require air barriers now, too. And continuous air barrier systems will be required by ASHRAE under Addendum z to Standard 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings*. Even the United States Green Building Council's Leadership in Energy and Environmental Design (LEED®) program is starting to recognize the impact of air barrier performance and incorporates some cautious building envelope language in the draft LEED for Schools standard. Decades after our neighbors to the north mandated the technology, what has made design professionals in this country suddenly latch onto the idea?

It all comes down to building owners demanding better energy efficiency performance and reduced environmental impact, and that's just what an air barrier system provides. A ground-breaking report, *Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use*, issued in June 2005 by the National Institute of Standards and Technology (NIST) confirmed that air barrier systems can reduce air leakage by up to 83 percent and energy consumption by up to 40 percent.

Air leakage occurs through cracks, gaps, holes, pores in materials and other openings in the building envelope. Air flow is the result of pressure differences. When air leaks, it takes with it heat, water vapor, smoke, pollutants, dust, odors, allergens, and anything else it can find and carry. Energy moves from regions of high to regions of lesser potential: hot and cold, high pressure to low, and so on.

There are three major sources of pressure that cause air to leak: wind pressure, stack pressure and HVAC fan pressure. Of the three, wind is usually the greatest. When averaged out over the course of a year, it is about 10-15 mph (0.2-0.3psf or 10-14Pa) in most locations in North America. If it hits the building straight on, air enters the envelope on the windward side and exits on the other three sides and at the top, through the roof. If the wind hits at an angle, air exits the building on the two leeward sides and the roof.

Stack effect, also sometimes referred to as chimney effect, is caused by buoyancy or the simple physics lesson that hot air rises. The weight of the column of conditioned air inside the building compared with that outside creates a pressure difference across the building envelope. The taller the building is, the greater the stack pressure will be. Warm, conditioned air escapes through holes at the top of the building and at the roof. The resulting lower pressure at the bottom of the building draws in air from the surrounding environment.

The third pressure comes from the mechanical system itself. Mechanical engineers and on-site managers often choose to bring in makeup air

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Storm Warning!

ELASTOSPRAY® spray-applied polyurethane foam roofing systems stand up to hurricanes

Katrina. Andrew. Wilma. Charley. Ivan. These were the five costliest hurricanes in United States history, responsible for an estimated $172 billion in damages collectively.

The insurance industry identifies roofing as the primary contributor to disaster-related insured losses. The reason for roof failure can often be found in the very design of membrane roof systems. Wind often grabs the edge flashing or coping and peels back portions of the membrane and tosses traditional insulation systems away. In comparison, ELASTOSPRAY® spray-applied polyurethane foam (SPF) roofing has gained recognition for its ability to withstand high wind uplift and blow off because its smooth, continuous surface grips the deck and walls. It offers superior adhesion with no need for fasteners and there are no joints or edges for the wind to grab onto. Lightweight yet rigid, it provides extra strength to help the roof stand up to the forces of nature.

FIELD-PROVEN PERFORMANCE

The Spray Polyurethane Foam Alliance (SPFA) reports that during laboratory testing of various SPF systems, SPF's wind-uplift resistance exceeded the capacity of the equipment at Underwriters Laboratories Inc. (UL). UL also observed that SPF roofs applied over BUR and metal increased the wind uplift resistance of those roof coverings. FM Global testing showed similar results over concrete, metal and wood.

Lab tests are a good indication of potential, but how does the technology fare when faced with a real storm?

At landfall on August 29, 2005, Hurricane Katrina was categorized by the National Hurricane Center (NHC) as a Category 3 storm with estimated maximum sustained wind speeds of approximately 125 mph. Less than one month later, Hurricane Rita hit with maximum sustained winds of approximately 115 mph. In June 2006, the National Institute of Standards and Technology (NIST) released *Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report*, a documentation of damage to major buildings, infrastructure, and residential structures resulting from wind and wind-borne debris, storm surge, surge-borne debris and surge-induced flooding.

Overall, the NIST team estimated that about 20 to 30 percent of the commercial and industrial roofing observed during the reconnaissance was damaged in some fashion. For individual buildings (or wings of large buildings), the extent of damage ranged from less than five percent of the roof area to greater than 50 percent or more of the roof area. For a small number of buildings, the roof was essentially totally stripped.

Not so for the SPF roofs, which scored well above the average when it came to weathering Katrina and Rita. The NIST report states:

> "A number of spray polyurethane foam (SPF) roofing systems were observed…Some of these roofs were estimated to be about 20 years old. With one minor exception, all were found to have sustained Hurricane Katrina extremely well without blow-off of the SPF or damage to flashings. In the case where damage was observed, the SPF had been applied to a wood fiber insulation that had been mechanically fastened to the metal deck with an inadequate number of fasteners. Failure likely occurred when the insulation board delaminated from the deck. The area of the failure was less than one percent of the total roof area".

This level of performance in high-wind events is not new for SPF systems. Independent inspections of roofs following the 2004 season – one of the worst hurricane seasons Florida has ever seen with four major hurricanes hitting in just over one month – show that SPF roofing fared exceptionally well. There were no instances where the SPF failed or separated from the substrate. Many SPF roofs survived undamaged or with minor surface damage. Application of SPF as a repair and patch method between storms was very successful, proving to be more wind resistant than the original roof system.

Likewise, studies by Thomas L. Smith of TLSmith Consulting Inc. after Hurricane Andrew devastated Dade County, Florida, in 1992 were positive for SPF roofing. Two SPF roofs sustained minor damage from flying debris, while other buildings with traditional roofing systems in a 200-foot radius suffered significant damage, including one building that had reportedly had its BUR blown off.

PREPARING FOR THE NEXT ROUND

With the arrival of the hurricane season, design professionals, building owners, consultants and contractors are focused on the inspection and repair of roofing systems to help ensure their survival and subsequent protection of the building interior and occupants.

In addition to its wind uplift resistance, ELASTOSPRAY SPF roofing technology provides improved building energy efficiency, durability and low lifecycle cost. Because it installs directly to the existing substrate in most retrofit applications with no tear-off, it diverts thousands of pounds of waste from the landfill – and in hurricane zones, SPF's speed of application can mean turning a storm-damaged roof into a veritable fortress between onslaughts from Mother Nature.

ASHRAE Sustainable Metrics Group to Develop Design Guidance

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has formed a new technical research group focusing on sustainable building guidance and metrics. The group will develop design guidance, performance metrics and rating systems to integrate indoor environmental quality, energy efficiency and other aspects of sustainable building performance.

The group will work with other organizations to integrate HVAC & R systems with other building systems, including the building envelope and air barrier systems, to enhance the effectiveness of total building design and integrated practice.

The relationship between a building's HVAC operation and air leakage control has been gaining understanding and attention in recent years. Perhaps most notably, continuous air barrier systems will be required by ASHRAE under *Addendum z to Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings*.

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ASHRAE Sustainable Metrics Group to Develop Design Guidance

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Why do HVAC engineers care about air leakage? Because insulation by itself is not enough to make a building truly energy efficient. Without an effective, continuous air barrier system, conditioned air escapes through the building envelope, and the HVAC system has to work harder to keep the indoor environment comfortable. A hard working HVAC means higher energy bills.

ASHRAE has some 100 technical committees, task groups and technical resource groups. These committees drive the ASHRAE research program, support the development of standards, develop and sponsor technical seminars and symposiums for ASHRAE meetings, review and draft technical articles, special publications and educational courses and write the ASHRAE Handbook.

Improve Performance of Precast Concrete Wall Systems with Walltite® Insulating Air Barrier

Precast concrete wall systems have been in use for decades and remain a popular choice among architects thanks to the aesthetics options they provide, as well as the benefit of improved speed of construction.

Traditionally, there have been three options when it comes to insulating precast walls and providing air barrier continuity:

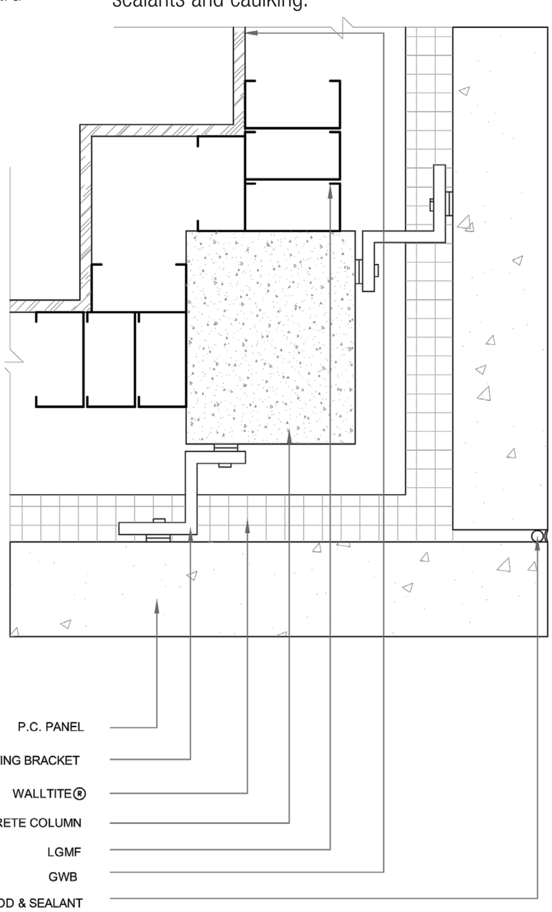
1) Insulating the cavity using in-board insulation
2) Insulating the cavity using out-board insulation
3) Using the precast itself as the plane of air barrier tightness

A growing trend, however, is to apply closed-cell, spray-applied polyurethane foam (SPF) to the backside (interior) of the precast slabs after they're installed.

This option allows for improved sequencing, greater speed of construction – one crew with one spray rig can spray up to 10,000 square-feet of material per day – and a more effective insulation and air barrier system.

Polyurethane technologies like the WALLTITE® insulating air barrier system offer a tenacious, fully-adhered bond to the precast substrate, meaning it will not shrink, sag or drop into the cavity over time. It also provides redundant air sealing properties when face-sealed precast systems are used for the wall system. WALLTITE technology offers an air permeance rating of less than 0.001 L/s/m² @ 75 Pa at an application thickness of 1.5 inches. The material also offers an effective insulation R-value of 6 per-inch and in many states also qualifies as a vapor barrier if used at adequate thickness.

Gaps and seams between the precast units and windows are made airtight using acceptable polyurethane air barrier transition membranes, backer rods and ZERODRAFT® insulating air sealants and caulking.



Closed-Cell Foam Approved for Flood-Prone Regions

The Federal Emergency Management Agency (FEMA) approves the use of closed-cell polyurethane foam (SPF) insulation in flood-prone regions. Classified as a flood-resistant construction material, closed-cell foam can withstand direct contact with flood waters for at least 72 hours without being "significantly" damaged; defined by FEMA as any damage that requires more than low-cost, cosmetic repair (such as painting).

Spray-applied polyurethane foam is a two-component product that is manufactured on-site, but engineered on the molecular level to optimize performance for a specific application. By varying key components, the finished product can be modified to meet specific performance requirements for roofing applications, insulating air barrier systems, adhesive applications or wall insulation.

Medium density foams are formulated to have a closed-cell content of greater than 90 percent, combined with an effective R-value of 6 per-inch. Low density, open-cell foams have approximately 60 percent open-cell content and offer an R-value between 3.0 and 3.6 per-inch.

One of the significant differences between them is their absorbency. Closed-cell foam absorbs moisture at a rate of less than four percent volume for volume (v/v), while open-cell foam can absorb at a rate as high as 40 percent v/v.

In a flood, closed-cell foam resists water, protecting the wall system and building interior from damage that can include structural deterioration, rotting of building materials and, eventually, mold infestations.

Closed-Cell Spray-Applied Polyurethane Foam (SPF) Excels in Whole-Wall Thermal Performance Testing

Whole-wall thermal performance testing, conducted on behalf of the Spray Polyurethane Foam Alliance by Architectural Testing, Inc., shows that wall assemblies that include closed-cell spray-applied polyurethane foam (SPF) insulation deliver superior insulation performance.

For the tests, performed in accordance with *ASTM C 1363-05 Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus*, a series of wall assemblies was constructed using various combinations of insulating materials and weather barriers. Each specimen was tested in a guarded hot box for thermal resistance performance, including the effects of air leakage. A pressure differential was maintained throughout all the tests to induce air leakage through the system and simulate real-world conditions.

The test specimens were built with 2 x 4 framing members 16-inches on-center, with no exterior weather barrier. The exterior sheathing was half-inch polyisocyanurate board and the interior sheathing was half-inch gypsum board. 1.5 inches of closed-cell SPF comprised the cavity insulation.

TEST RESULTS SUMMARY – ARCHITECTURAL TESTING INC. (09-01-06 valid through 08-06-10)

	Exterior Temperature (Deg F)	Interior Temperature (Deg F)	Pressure (in WC)	Overall Thermal Resistance	Air Flow	Heat Flow (BTU/hour)
No wind	25.03	70.00	0.026	15.695	0.00	188.210
15 mph wind	25.01	70.01	0.114	13.643	0.36	216.623
15 mph wind	-14.99	70.00	0.125	12.384	0.53	450.753
15 mph wind	70.01	115.01	0.096	11.521	0.62	256.522

The concept of whole-wall thermal performance testing was developed by Oak Ridge National Laboratory (ORNL) in 1994, with the goal of a nationally-accepted procedure for estimating the whole opaque wall R-value (whole-wall R-value), independent of system type and construction materials. Whole-wall R-value includes the thermal performance of not only the clear-wall area, with insulation and structural elements, but also typical envelope interface details, including wall/wall (corners), wall/roof, wall/floor, wall/door, and wall/window connections. Results from these detailed computer simulations are combined into a single whole-wall R-value estimation and compared with simplified center-of-cavity and "clear wall" R-values.

HOW DOES CLOSED-CELL SPF'S PERFORMANCE COMPARE WITH TRADITIONAL SYSTEMS?

ORNL's website features whole-wall interactive calculators as part of its material database for whole-wall building energy calculations. The results for closed-cell polyurethane foam from the Architectural Testing Inc. study are consistent with those listed in the ORNL database.

By setting the ORNL interactive calculator to specific framing and structural parameters, then simply switching the cavity insulation material, visitors can compare different systems and assemblies. Results returned below*.

For a direct link to the ORNL interactive whole-wall calculator, or to download a copy of the Architectural Testing Inc. report, visit www.basf.com/res

	Whole-Wall R-Value	Exterior Corners	Wall/ Slab on Grade	Wall/ Partition Wall	Wall/ Roof	Window Header	Window Sides	Window Sill	Door Header	Door Sides
Closed-Cell Polyurethane Foam	15.1	12.61	11.1	17.1	14.23	8.78	8.08	8.21	7.79	8.05
Glass Fiber (R-11 batts)	11.59	9.44	9.02	12.61	11.89	7.93	7.48	7.44	6.96	7.31
Cellulose	12.32	10.09	9.44	13.44	12.4	8.12	7.48	7.61	7.21	7.48

*Values for Wood Frame, 2 x 4 16 o.c., 0.5" Foam Sheathing, Wood Siding

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to increase pressure and overcome the infiltration at the base of the building. Unfortunately, this increases pressure at the top, causing more exfiltration problems in that area.

When uncontrolled air leakage occurs, the HVAC system has to work harder to maintain the indoor environment. An effective air barrier system, quite simply, controls air movement into and out of the building. This allows the HVAC system to do its job uncompromised by having to make up for a disproportionately large amount of the air it is conditioning leaving the building.

And of course, increasing the operating efficiency of the HVAC system reduces energy consumption and, therefore, operating costs. In fact, the inclusion of an effective air barrier system may allow the HVAC system to be downsized at the design stage – in some cases by a substantial amount.

With a national move towards a new awareness of our energy consumption and a desire to improve the sustainability of our buildings, air barriers can make a significant contribution to both goals.

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