JBED

Journal of Building Enclosure Design

An official publication of the National Institute of Building Sciences
Building Enclosure Technology and Environment Council (BETEC)

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Summer 2011

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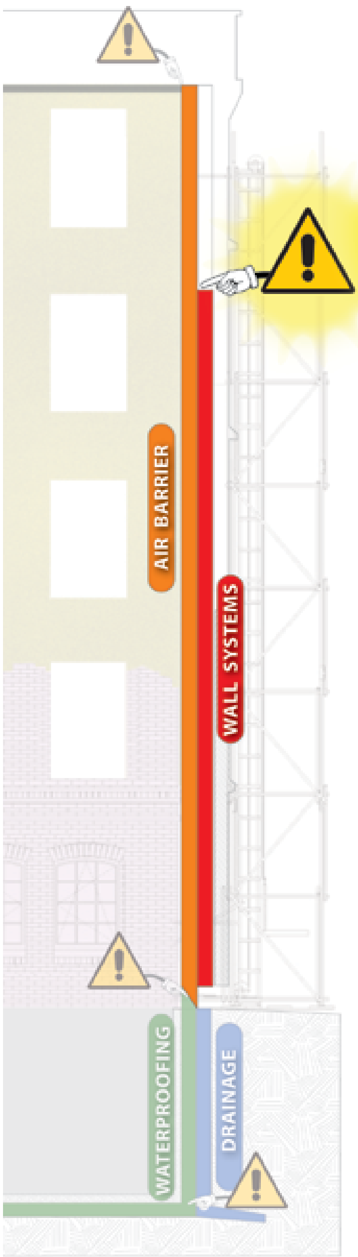

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1. Enclosures and Cladding AIA/CES Module, www.BDCnetwork.com/EnclosuresAndCladding

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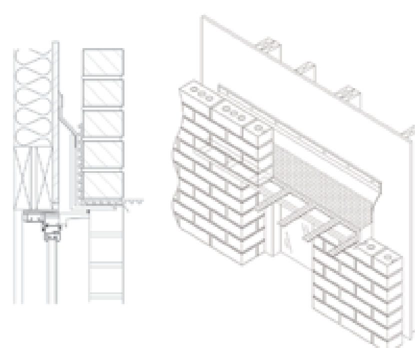

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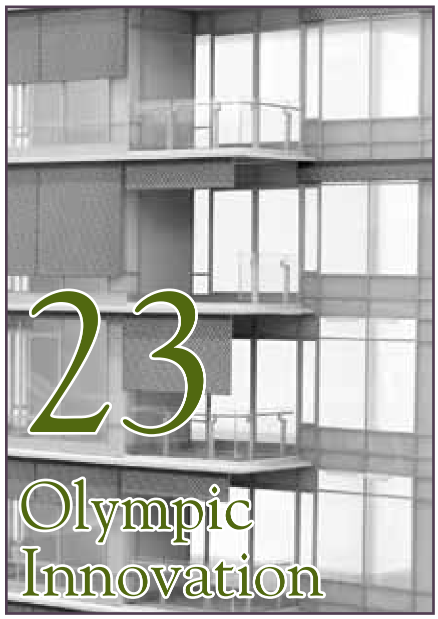

Messages:

IndustryUpdates:

On the cover: After the 2010 Olympics were over, the Athlete's Village transformed into a 1.4 million square foot (426,720 m.) mixed-use development that is made up of 1,100 residential units, commercial space and a community center. It is built on a former Brownfield site and was built to LEED standards. It features a number of environmental and sustainability initiatives including the creation of wildlife habitat, green roofs, water efficiency programs and heating captured from a sewage line. Photo by Bob Matheson.

Henry L. Green, Hon. AIA

IN EARLY MAY, I MET WITH MEMBERS of the Building Enclosure Technology and Environment Council (BETEC) Board of Directors during their spring meeting. We had planned to discuss the long-term direction of the program. In preparation for that conversation, I put together a brief historical overview, some of which I would like to share with you now.

Initiated by the U.S. Department of Energy (DOE), the original BETEC began in 1978 as a national program for building envelope systems. At that time the council was known as the Building Environment and Thermal Envelope Council. It then evolved to become one of the National Institute of Building Sciences' first programs in 1982. That same year, BETEC sponsored symposia on enclosure design and fenestration with the support of the Buildings and Mold Alliance. Over the next decade, BETEC continued to focus on advancing building enclosure design.

In 2004, the Institute signed a Memorandum of Agreement (MOA) with the American Institute of Architects (AIA) to establish a network of councils focused on building enclosure technology. Since then, 25 local councils have started in cities around the country, representing more than 3,000 affiliate architects, engineers, contractors, suppliers, manufacturers and others with an interest in building envelopes. These local Building Enclosure Councils (BECs) are at the forefront of improving the built environment. They provide an important service in identifying where improvements can be made in the delivery of buildings and structures—most importantly, at the local grassroots level—through an integrated design focus that includes envelopes as a part of the whole building concept, while taking into account sustainability, durability, resilience and high performance.

In 2005, the Building Environment and Thermal Envelope Council underwent an identity transformation to become the Building Enclosure Technology and Environment Council. The council would focus on building science that provides a diverse range of ideas for promoting clear and precise standards for building envelope design. Since then, BETEC has continued to focus on building envelopes, including in its discussion such priorities as security aspects, fenestration details, noise vibration issues and the effects of daylight, view and space perception.

Today, BETEC can be proud of what it has accomplished. It has an active membership that participates in a variety of workshops, symposia and conferences to share knowledge and improve the science of building enclosures. The Building Enclosure Science & Technology (BEST) Conferences are a perfect example of that community interaction. As I mentioned in my column in the Winter Edition of the *Journal of Building Enclosure Design (JBED)*, planning for the upcoming BEST3 Conference, scheduled for April 2012, is well underway. That event will address many of these important issues and related practical, field-applied experiences.

With the recently signed new MOA in place with AIA, BETEC can provide even greater focus on advancements in building enclosures. It will be better able to address how the "building skin" influences the overall performance of a structure and provides the means to improve the interior surroundings, which can lead to greater productivity and a healthier indoor environment.

Moving forward, BETEC is well positioned to address building skin issues and other topics within the codes and standards that influence enclosures, as well as new provisions in other areas of the codes that may affect building envelopes to assure that any changes do not adversely impact the core issues of good sound envelope protection.

Another area that will undoubtedly gain significant interest is the continued use and repurposing of existing buildings. I see BETEC playing an important role there as well. Since the number of new buildings to be constructed in the next several years is expected to be approximately one percent of our existing stock, the buildings already here will need to receive more attention if the nation is going to achieve its high-performance goals. Using existing buildings not only conserves resources, it provides for better stewardship of our communities and can result in cost savings and economic growth. BETEC can assist in understanding how repurposing existing buildings, with a particular emphasis on the building enclosure itself, can improve on the delivery of a built environment that meets the challenges and opportunities afforded by achieving high-performance buildings.

With the increased focus on development of high-performing, resilient buildings and structures, the role of the BETEC is becoming more important to this overall objective. BETEC has worked since its beginnings to improve building enclosure performance. In its nearly 30 years of being an Institute council, it has achieved many successes. If you are a BETEC member, I thank you for the role you have played in those achievements. If you are not yet a BETEC member, this is a great time to join and become involved in BETEC's activities to improve the built environment.

BETEC will be holding its Board meeting and the BETEC Symposium during the Institute's Annual Meeting and Ecobuild America Conference in December. I hope to see you there.

Henry L. Green, Hon. AIA
President
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Wagdy Anis, FAIA, LEED-AP

WELCOME TO THE SUMMER 2011 EDITION OF THE *Journal of Building Enclosure Design (JBED)*. Summer 2011 marks the fifth anniversary of this magazine. I hope you will enjoy the papers contributed in this anniversary edition, which focuses on "higher performance" in building enclosures.

The biggest piece of news I have to report is that on May 18, 2011, the National Institute of Building Sciences' Building Enclosure Technology and Environment Council (BETEC) and the American Institute of Architects (AIA) signed a memorandum of agreement to further collaborate on Building Enclosure Councils (BECs) and develop new ones. This new agreement comes exactly seven years after the initial startup agreement. Attending the signing ceremony and representing the National Institute of Building Sciences were Henry Green, Hon. AIA, Institute president; Jim Sealy, FAIA, chairman of the Board; RK Stewart, FAIA, Board vice chair; and myself, Wagdy Anis, FAIA, chairman of BETEC. Representing the AIA were Robert Ivy, FAIA, executive vice president and CEO; AIA president Clark Manus, FAIA; and AIA president elect Jeffery Potter, FAIA. The agreement was signed by AIA CEO Ivy, and Institute President Green.

BETEC had its Board meeting in May of 2011. Two very important topics were discussed. The first, the work of the Visioning Committee, was presented. The Visioning Committee, led by BETEC Board member Chris Mathis, has been working hard for six months, looking at where BETEC came from, where it has gone and where it needs to go in the future over the next ten years. I think they have done a great job. The Visioning Committee's results will go out by ballot to the membership for voting since they include important recommendations that would require bylaw changes and funding needs not presently accounted for in the budget.

The other important topic brought to the Board for a vote was the Education Committee's work. Thanks to the volunteer efforts of Paul Totten and others, the Education Committee has put together a list of webinars planned for the near future in collaboration with AIA, BETEC's strategic partner for the BECs. It is also worthy to note that BETEC, in its quest for quality building science education in architecture and engineering schools, has put together a pilot building science education curriculum with input and help from building science educators, including stars such as Bill Rose of the University of Illinois at Champagne-Urbana. The plan is coming together to teach this pilot building science course at the School of Architecture at Catholic University, with the help of BETEC Board member Professor Chris Grech.

The plans for the BETEC Symposium on continuous insulation in buildings, to be held December 7th in conjunction with the 2011 National Institute of Building Sciences Annual Meeting and Ecobuild America, are being finalized as we speak. BETEC Board member Craig Drumheller of the National Association of Home Builders Research Center has put together a top-level, high-end group of speakers to discuss the challenges and solutions of using exterior foam plastic insulation in buildings. For more information, visit www.nibs.org.

The Building Enclosure Science and Technology (BEST) 3 Conference Planning Committee is actively working on preparations for the 2012 conference in Atlanta, Georgia. That program promises to be magnificent, so please plan to be there…I certainly will! To get more details, go to www.thebestconference.org. I wish you a wonderful summer and look forward to seeing you at these exciting events in the near future.

Sincerely,

Wagdy Anis, FAIA, LEED-AP
Chairman, BETEC Board
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Feature

Improvement of Air Tightness in U.S. Army Buildings

By Alexander Zhivov and Dale Herron

IN THE RECENT PAST, ALL UNITED States (U.S.) Army facilities have increasingly been required to reduce site energy consumption in response to the Energy Policy Act of 2005 (EPACT), the Engineering and Construction Bulletin (ECB) 2010-14 (2010) and the Army Sustainable Design and Development Policy update, Environmental and Energy Performance (October 27, 2010).

EPACT 2005 requires new facilities to reduce site energy consumption, not including plug and process loads, by 30 percent compared to a baseline facility designed in accordance with the minimum requirements of ASHRAE 90.1-2004, provided it is life-cycle cost effective.

The Army Sustainable Design and Development Policy update requires new facilities to achieve reduced energy consumption using equipment and systems with efficiency at or below the levels specified in ASHRAE 189.1, Section 7.

To comply with the requirements of the Energy Independence and Security Act of 2007 (EISA 2007) to eventually eliminate fossil fuel use, army buildings that are either new or undergoing major renovations must be designed so that the consumption of energy generated by fossil fuels (including electricity generated by fossil fuels) is reduced by 55 percent starting in 2010, 65 percent by 2015, 80 percent by 2020, 90 percent by 2025 and by 100 percent, starting in 2030. The consumption will be determined by comparing it to energy consumption from a similar building in Fiscal Year 2003 (FY03), as measured by the Commercial Buildings Energy Consumption Survey or Residential Energy Consumption Survey data from the Energy Information Agency. Meeting FY10 EISA 2007 fossil fuel based energy use reduction will, in most cases, automatically result in compliance with the building site energy use reduction.

Along with improvements in energy consumption, building performance in hot humid climates has been a major concern of the army. Barracks facilities in these environments often experience significant problems with interior mold and mildew as a result of the inability to control relative humidity within the buildings. The major problem is created by a combination of leaky buildings and air conditioning systems operating at supply air temperatures below the dew point temperature. The army has been investing large sums of money to remediate mold and mildew damage and to maintain these facilities in a healthy and comfortable state.

During the past several years, the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) has been conducting investigations to develop design/construction strategies to improve energy efficiency, to prevent mold and to improve indoor air quality in newly constructed buildings and buildings undergoing major renovations. In the course of these studies, it became clear that building envelope air leakage needs to be addressed. To this end, ERDC-CERL has conducted building envelope leakage tests on some existing facilities to gain an understanding of the general leakiness of army buildings. These studies also analyzed the effect of increased air tightness on the building energy consumption and developed air tightness criteria and performance requirements to be included in the design/construction strategies.

TABLE 1 lists the results of a sample of tested buildings, including four barracks buildings with interior entry ways (older Buildings A, B and C and newly constructed Building D), a modular barracks building (Building G), a newly constructed dining facility (Building E), and a two-story classroom training facility constructed in 1997 (Building F).

Data shows that the envelope leakage in Buildings A, B, C and D was in the range of 0.56 to 0.77 cu. ft./min. sq. ft. (at 0.3 in. of water (75 Pa.) pressure difference. The envelope of the modular barracks (Building G) had an air leakage of 0.38 cu. ft./min. sq. ft. The newly constructed barracks (Building D) was no tighter than the other barracks that were constructed 30 years earlier. When examining the data for two buildings of like construction and configuration (Buildings B and C), the renovated Building C is more than a third leakier than the unrenovated Building B. This is because of poorly sealed ducts and pipe penetrations through building structure elements.

An analysis of data from 139 commercial and institutional buildings in the United States (Persily) revealed that the mean value of their envelope air leakage was 1.48 cu. ft./min. sq. ft. These buildings ranged in age from four years to several decades. The seven army buildings that were tested were all below this value, indicating that typical army construction is certainly no less airtight than other buildings in the United States. However, only two of the tested army buildings meet the 0.40 cu. ft./min. sq. ft. requirement of

TABLE 1. TEST RESULTS FOR SELECTED ARMY BUILDINGS

Building	Envelope Surface Area (sq. ft.)	Envelope Volume (cu. ft.)	Envelope Air Leakage @ 75 Pa. (cu. ft./min-sq. ft.)
A	23,300	137,300	0.57
B	37,200	269,100	0.56
C	33,600	230,200	0.77
D	55,000	590,200	0.65
E	80,700	690,000w	0.63
F	43,000	345,000	0.28
G	9,700	**	0.38

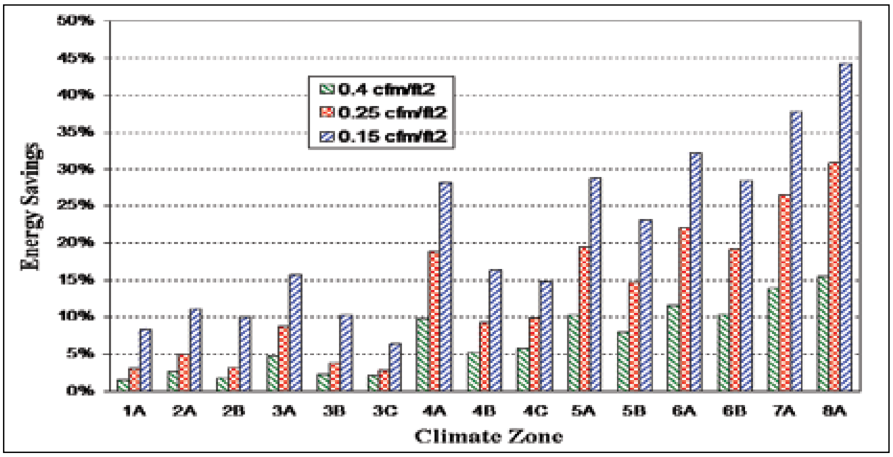


Figure 1. The percent of annual energy savings in a barracks building due to air tightness improvement for U.S. climate zones.

TABLE 2. AIR TIGHTNESS STANDARDS COMPARISON (FOR A FOUR-STORY BUILDING, 120 X 110 FT., N=0.65)			
Country	**Source**	**Requirement***	**cfm/ sq. ft. at 75 Pa.**
U.S.	ASHRAE 189.1-2009		0.40
UK	TS-1 Commercial Best Practice	5 $m^3/h/m^2$ at 50 Pa.	0.36
U.S.	LEED	1.25 sq. in. EqLA @ 4 Pa. / 100 sq. ft.	0.30
Germany	DIN 4108-2	1.5 1/h at 50 Pa.	0.28
UK	TS-1 Commercial Tight	2 $m^3/h/m^2$ at 50 Pa.	0.14
Canada	R-2000	1 sq. in. EqLA @10 Pa. /100 sq. ft.	0.13
Germany	Passive House Std	0.6 1/h at 50 Pa.	0.11
*USACE requirement is 0.25 cfm/sq. ft. at 75 Pa.			

TABLE 3. SAMPLE OF TEST RESULTS				
Location	**Building Type**	**Air Barrier Envelope Size (sq. ft.)**	**Result, (cfm/sq. ft.)**	**% Better than 0.25 cfm/sq. ft.**
Fort Bliss, TX	Barracks	71,312	0.05	81%
Fort Bliss, TX	Barracks	71,312	0.06	76%
Fort Sam Houston, TX	Medical Education and Training, Dorm	371,099	0.07	73%
Fort Bliss, TX	Barracks	71,312	0.07	72%
Fort Bliss, TX	Barracks	72,573	0.10	62%
Fort Polk, LA	Barracks (Renovation)	52,476	0.10	60%
Fort Sam Houston, TX	Medical Education and Training, Dorm	141,893	0.10	60%
Fort Bliss, TX	Maintenance Facility	24,632	0.13	48%
Fort Riley, KS	Company Operations	43,115	0.14	44%
Fort Leonard Wood, MO	Battalion HQ	63,276	0.14	44%

recently adopted ASHRAE Standard 189.1 for *Design of High Performance Green Buildings*.

To estimate the achievable savings from reduced air leakage in newly constructed and retrofitted buildings, ERDC and the Department of Energy's (DOE) National Renewable researchers conducted simulation studies using the EnergyPlus 3.0 building energy simulation software. The baseline building was assumed to be an existing barracks, dormitory or multi-family building built to meet the minimum requirements of ASHRAE Standard 90.1-1989 (ASHRAE 1989) by climate zone. The barracks are three stories high with an area of 30,465 sq. ft. (2,691 m^2) and include 40 two-bedroom apartment units, a lobby on the main floor and laundry rooms on each floor. Benne (2009) includes further details on the barracks and the baseline heating, ventilation and air-conditioning (HVAC) systems used. Note that energy costs used in this study are based on Energy Information Administration (EIA) 2007 average data for commercial rates in each state and may not reflect the utility rates at a specific location (EIA 2008).

Four representative air tightness levels were modeled: 1.0, 0.5, 0.25 and 0.15 cu. ft./min. sq. ft. (at 75 Pa. pressure difference). The first value is used as the baseline and comes from expert opinions of existing buildings based on pressurization tests. The other three values are considered to represent reasonable performance improvements achievable with a low, medium and best effort for sealing existing buildings.

FIGURE 1 shows the results of an analysis for improving the building air tightness for each climate zone. The energy savings are based on total building site energy consumption. Energy savings range between 2 and 16 percent with an air tightness improvement to 0.4 cfm/sq. ft. at 75 Pa., between 3 and 31 percent (0.25 cfm/sq. ft.) and between 8 and 44 percent with the air tightness at 0.15 cfm/sq. ft. The highest results are achieved in the coldest climates and decrease in warmer climates. These savings translate to roughly $0.10 to 0.50 per sq. ft. The results can vary with the change of baseline building air tightness, types of HVAC systems used and energy rates.

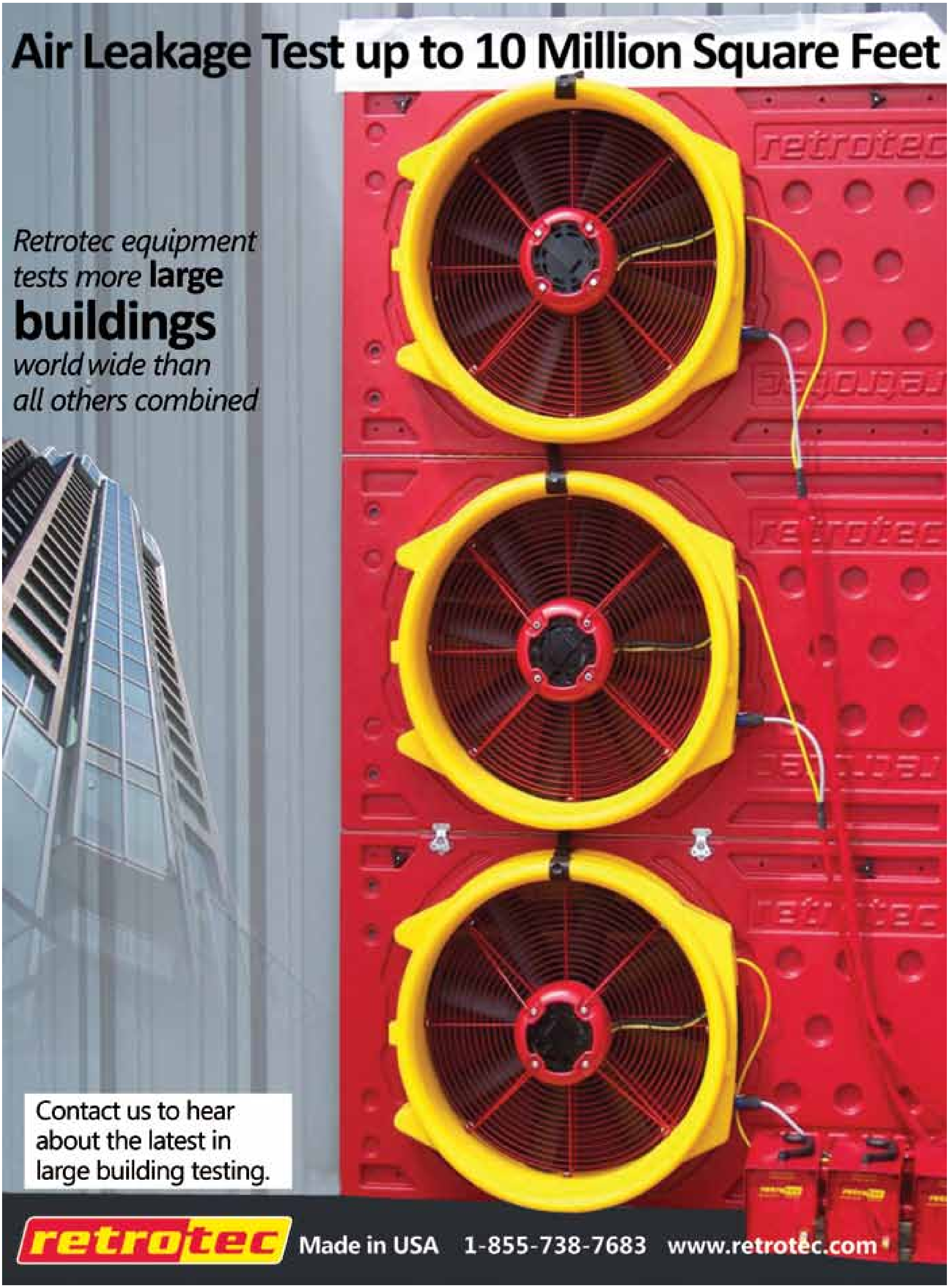
Based on the results of these studies, the USACE set a requirement (ECB 29-2009) that all new buildings and buildings undergoing major renovation shall pass an air leakage test where the results are less than or equal to 0.25 cfm per square foot of exterior envelope at 0.3 in. of water gage (75 Pa.) pressure difference. The test is to be performed according to the protocol outlined in the paper developed by ERDC, together with industrial partners.

For comparison, **TABLE 2** lists this requirement with other national and international standards.

Since the introduction of air barrier requirements and a maximum allowable air leakage rate in 2009, more than 250 newly constructed and renovated buildings have been tested to meet or significantly exceed these requirements. Some of them were proven to have an air leakage rate between 0.05 and 0.25 cfm/sq. ft. at a pressure difference of 75 Pa. during the first test **(TABLE 3)**. Few buildings have to be sealed and retested to meet these requirements. This experience has proven that when buildings are designed and constructed with attention to details, U.S. Army requirements to air tightness can be met with a minimal cost increase (primarily for development of architectural details and testing). ■

Alexander Zhivov and Dale Herron work at the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) in Champaign, Illinois.

A full list of references for this article is available upon request. Please email ssavory@matrixgroupinc.net.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An Experimental Procedure to Quantify Air Intrusion in Commercial Roofing Systems

By Suda Molleti and Bas Baskaran

APPROXIMATELY ONE FOURTH OF NORTH AMERICAN commercial buildings (which include hospitals, schools, offices and lodging, as well as the retail sector, with its big box stores, enclosed malls, strip malls, grocery stores and fast food restaurants), are roofed with Flexible Roof Systems (FRS) (NRCA 2004). In FRS, the waterproofing membrane is on the top of the building and exposed to environmental forces. Other roofing components, such as the insulation and cover board, are below it and are integrated into the structural substrate using mechanical fasteners.

Field observations have identified that air intrusion in mechanically attached roof systems can affect roof system performance. However, the question of how much air movement occurs and which components provide the required resistance to air movement has never been addressed. To measure air intrusion in mechanically attached roof systems, the National Research Council (NRC) of Canada, as part of its Special Interest Group for Dynamic Evaluation of Roofing Systems (SIGDERS) research, recently completed an experimental study.

WHAT IS AIR INTRUSION?

In FRS, the waterproofing membrane is available in three different types: modified bituminous (Mod-Bit), thermoplastic (polyvinyl chloride [PVC] and thermoplastic olefin [TPO]), and Thermoset (ethylene propylene diene terpolymer [EPDM]). The Mod-Bit is asphaltic based and comprises of two-ply membranes, a base and cap sheet, which, when integrating as a roof system, perform together as a one-ply membrane. Both these membranes are available in different sheet widths ranging from 6 ft. to 12 ft. (1.8 m. to 3.6 m.).

The waterproofing membranes, material wise, are inherently impermeable to air and, if constructed properly as a system, they can certainly perform as an air barrier, impeding any air leakage from the exterior environment to the interior and vice versa. Therefore, the water proofing membrane can be designated as the air barrier to control air leakage (Kalinger 2008). However, the flexibility and elastic nature of membranes and their discrete fastener attachment mechanisms can cause membrane ballooning or fluttering due to wind induced suctions and interior mechanical pressurization.

The volume change of the membrane ballooning causes negative or bubble pressure below the membrane, which is equalized by the indoor conditioned air moving into the system. This is called air intrusion, when the conditioned indoor air enters into a building envelope assembly, such as roofs, but cannot leave the assembly to go to an exterior environment (Molleti 2009) (FIGURE 1). The pressure equalization depends on the air intrusion resistance of the components below the membrane (insulation, deck and other).

WHAT ARE THE EFFECTS OF AIR INTRUSION?

Cautions regarding air intrusion are not new (Dregger 2002). There are existing technical notes, manuals and papers that have identified how air intrusion affects roof assembly performance. However, no information is available regarding the amount of air intrusion that can occur in mechanically attached roof systems and their sensitivity to air movement.

The wind-uplift resistance of a mechanically attached roof system depends on the membrane's response to wind dynamics. Fluttering during wind action creates a region of low pressure below the membrane. To equalize the pressure, indoor air intrudes into the system. If the roof components below the membrane do not provide sufficient resistance to air intrusion and the rate of air intrusion is rapid, the combination of the positive and negative uplift forces on the membrane, which resists the entire uplift load, could lead to the failure of the membrane and system. This is illustrated in FIGURE 2.

Apart from diffusion, which causes water vapor transportation into roof systems, the other significant mechanism of moisture entry into a roof system from a building's interior is air intrusion. Dew point temperature can occur below the membrane and within the insulation. When warm humid air, which can hold a high quantity of water vapor, is drawn into a roof assembly and contacts surface materials at the dew point temperature, it condenses as shown in FIGURE 2. Condensation can lead to wet insulation, which reduces thermal performance and affects the roof assembly's energy performance.

HOW TO QUANTIFY AIR INTRUSION

To measure air intrusion in flexible roof systems, an experimental study was recently completed at the NRC as part of its Special Interest Group for Dynamic Evaluation of Roofing Systems (SIGDERS) research. Since 1994, SIGDERS has done pioneering

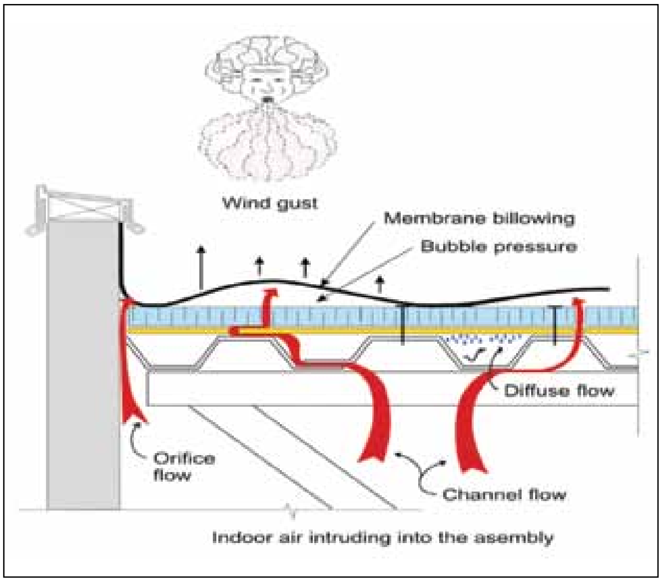

Figure 1. Concept of air intrusion.

Figure 2. Air intrusion impacts on the life-cycle performance of flexible roofing systems.

research work on the wind uplift performance of flexible roofing systems. This led to the development of the technical guide, *A Guide for the Mechanically Attached Flexible Membrane Roofs*, and national standard CSA A123-21-10, *Standard test method for the dynamic wind uplift resistance of membrane-roofing systems*. As part of this ongoing research, air intrusion quantification was determined to be an influential parameter on the performance of flexible roofing systems and SIGDERS focused on determining control data for air intrusion in these roofing systems.

Air intrusion involves volumetric measurements, so it is technically different from air leakage. Similar to air leakage, a differential pressure and flow path is required for air intrusion. However, the air intrusion measured is the volumetric flow into the flexible roofing system. To quantify the volumetric flow, a new test laboratory was developed at the NRC, called the Dynamic Roofing Facility for Air Intrusion Quantification (DRF-AI). The test apparatus is shown in **FIGURE 3**. It is composed of a movable two-section top chamber and closed bottom chamber; each has a dimension of 20 ft. by 8 ft. by 3 ft. (6 m. by 2 m. by 1 m.).

The test consists of installing a roof specimen between the two chambers. Then, prescribed suction pressures in the range of 5 psf. to 25 psf. (240 Pa. to 1,200 Pa.), in increments of 5 psf. (240 Pa.), are applied across the system in the top chamber through a controllable blower. This is done while the resultant air intrusion into the system is measured from the airflow measurement system installed on the air-tight bottom chamber. The bottom chamber supports a height-adjustable lever that can accommodate roofing assemblies with different thicknesses. The differential pressure across the test specimen is measured by installing two pressure measuring devices, one on top of the membrane and the other above the insulation.

The above experimental method recently became an ASTM standard, D7586/D7586M-11 *Standard Test Method for Quantification of Air Intrusion in Low-Sloped Mechanically Attached Membrane Roof Assemblies*. This test method is intended to measure only air intrusion associated with the opaque roof assembly, free from penetrations such as those associated with mechanical devices, roof junctions and terminations.

HOW WAS THE CONTROL DATA DEVELOPED?

Towards developing control data for the flexible roofing systems, a series of tests were conducted following the ASTM D7586. Three types of roof systems, polymer-modified bitumen (MB), thermoplastic (TP) and thermoset (TS), were tested. Within each type, roof configurations with and without air barriers were tested. Apart from the membrane type and installation, all other roof components were similar. They were comprised of 22-gauge, 80-ksi steel deck, 48 in. by 48 in. by 2 in. polyisocyanurate insulation boards fastened with 5 fasteners per board and 3 mil. (0.076 mm.) thick self-adhering film as an air retarder for the specimens with air retarders.

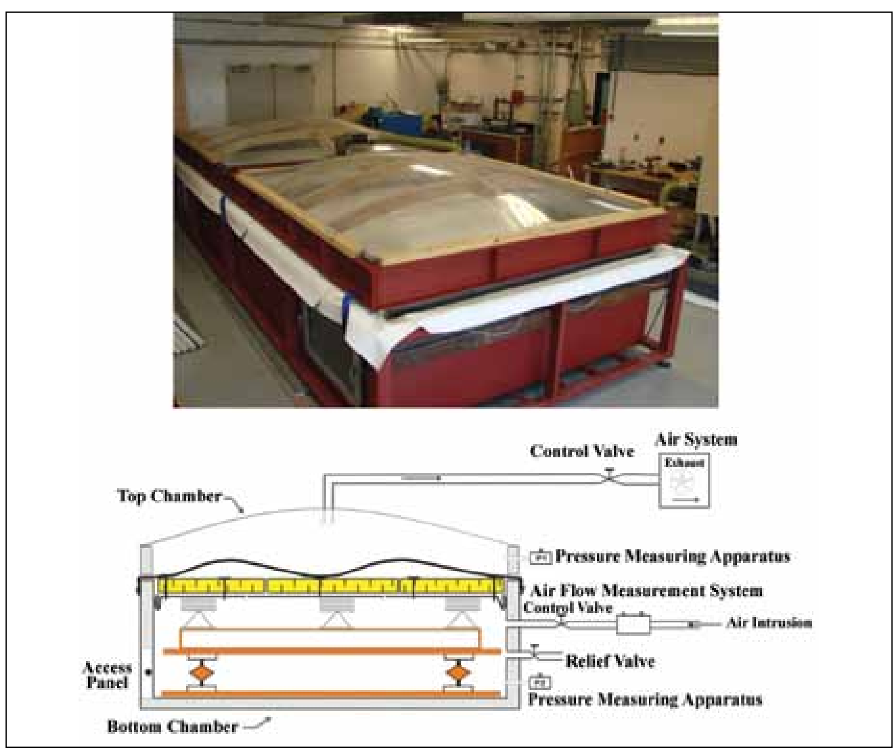

Figure 3. Dynamic roofing facility for air intrusion quantification (DRF-AI).

Following the ASTM D7586 test protocol, the analysis of the measured data involves plotting the relation between air flow and applied pressure. FIGURE 4 shows typical air intrusion measured data for a flexible roofing system without air retarder at the test pressure of 25 psf. (1,200 Pa.). Integrating the area under the measured air flow quantifies air intrusion of the roofing system at that pressure level. For relative comparison among the tested systems, the ASTM D7586 selects a reference test pressure of 25 psf. (1,200 Pa.) for reporting the air intrusion volume per linear length [ft.^{3}/ft.], as shown in FIGURE 4.

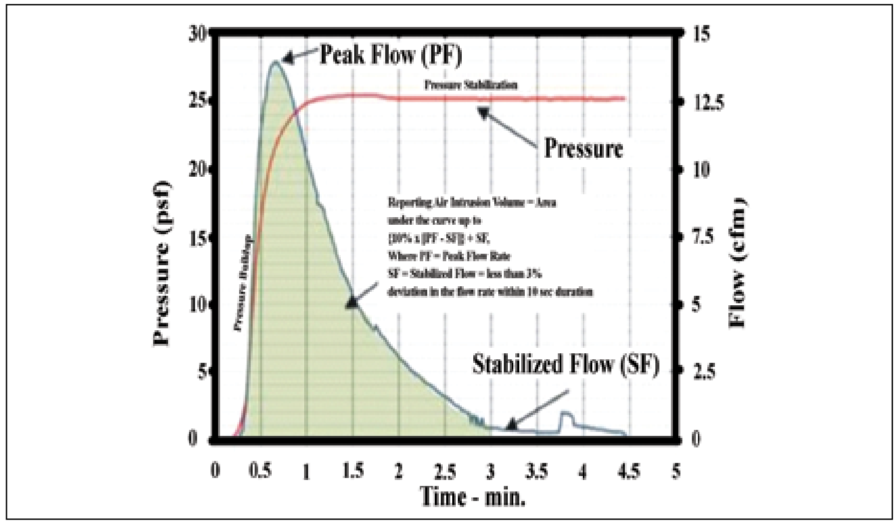

Figure 4. Typical time history plot of the air intrusion data and the reporting air intrusion calculation.

Air intrusion data for the seven tested systems shown in FIGURE 5 not only defines the control data but also identifies the influencing parameters on the air intrusion performance of FRS. It could be said that sheet width is one of the significant parameters for air intrusion. The experimental study evaluated three sheet widths, 3 ft., 6 ft. and 10 ft. (1 m., 1.8 m. and 3 m.), and of the three, the roofing system with the 3 ft. (1 m.) sheet had minimum air intrusion. With the increase in the sheet width to 6 ft. and 10 ft. (1.8 m. and 3 m.), the air intrusion volume was measured to be almost three times higher compared to the smaller sheet of 3 ft. (1 m.). Although the air intrusion and the sheet width might not show a linear relationship, the data indicates that with the increase in the bubble volume the air intrusion into the roof system increases.

The data also shows that the membrane material type is not a major contributor compared with the bubble volume. Both the 10 ft. (3 m.) thermoset and thermoplastic membranes were reinforced and, with all similar roof system components, the thermoset system showed a 10 percent higher air intrusion compared to the same width thermoplastic system.

The air retarder is an element in the roof system intended to limit air flow.

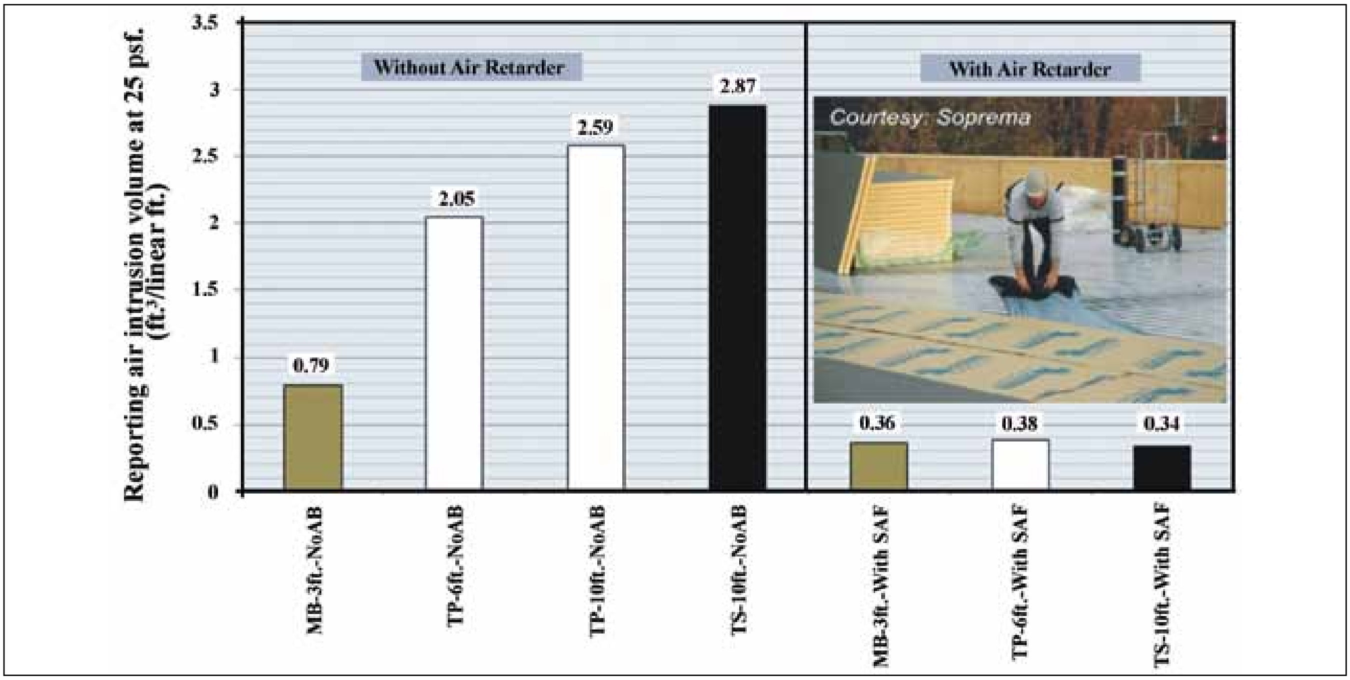

Figure 5. Air intrusion of flexible roofing systems. The photo shows the installation of air retarder.

For the control data testing, a bituminous modified reinforced self-adhered film was installed as an air retarder on the steel deck for all three tested systems. The air retarder had two overlaps in the system layout and it underwent fastener penetrations from the installation of insulation and membrane. Relative performance indicates that the air intrusion rate reduced 50 percent in the 3 ft. (1 m.) polymer-modified bitumen systems, about 75 percent in the 6 ft. (1.8 m.) thermoplastic systems and about 85 percent in the 10 ft. (3 m.) thermoset systems, compared with systems without air retarders. The air intrusion volume of the three assemblies is almost similar, with an average air intrusion volume of 0.36 $ft.^3$/linear ft., indicating that irrespective of the system type and configuration, the presence of an air retarder at deck level, if constructed properly, minimizes air intrusion.

HOW MUCH AIR INTRUSION IS TOO MUCH?

Research conducted at NRC for the SIGDERS consortium has demonstrated the wind-uplift resistance of mechanically attached roof systems can be increased by as much as 50 percent by including an air retarder, regardless of the air retarder type (Baskaran et.al. 2003). This finding can be justified from the measured air intrusion data. The air intrusion reduction is what differentiates the wind-uplift performance of assemblies with and without air retarders.

ASHRAE 189.1, *Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings*, provides guidelines for the use and design of air barriers in roof assemblies. It accepts fully adhered single-ply membrane systems as continuous air barriers but not the mechanically attached single-ply membrane roof systems. The rationale behind this assumption could be that the single-ply membrane undergoes fluttering action, thereby not meeting the air barrier requirement of structural strength.

It should be understood that the primary function of the roofing membrane is waterproofing and, as it successfully performs its intended function by sustaining high wind uplift pressures, it certainly performs as an air barrier. Due to its inherently flexibile nature, the membrane undergoes fluttering or billowing during wind action but that doesn't affect its membrane porosity or its integrity with the system. This is verified in FIGURE 4.

During the pressure buildup to a target of 25 psf. (1,200 Pa.), the air intrudes into the system illustrated by the peak flow. Once the pressure stabilizes, the flow does not stabilize but the flow rate is gradually reduced. Had the roofing membrane been permeable or its continuous joints not been air tight, the flow, rather than gradually descending, would have stabilized with pressure stabilization. Rather than contemplating on the issue of air barrier and air leakage in flexible roofing systems, code requirements should be focused on air intrusion.

Good design practice tells us to prevent the movement of moisture-laden air into roof assemblies, which can be achieved by installing a continuous air retarder at the deck level. Complete air tightness, however, can lead to trapped vapor between two impermeable air retarders. To determine the limits of air intrusion for building code recommendations and quantify air intrusion's effect on condensation control and energy performance, further research is being conducted in collaboration with the National Roofing Contractors Association and the Canadian Roofing Contractors' Association. ■

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A full list of references for this article is available upon request. Please email ssavory@matrixgroupinc.net.

High-Performance Building Enclosures: Combining View With Energy Efficiency

By Stephen Selkowitz

BUILDINGS ARE THE SINGLE LARGEST end use of energy in the United States and the largest source of CO2 emissions. They are responsible for over 70 percent of all electricity consumption and an even larger fraction of peak electricity on a hot summer day. Despite some improvement in overall building energy use intensity (EUI), a measure of energy use per unit floor area, the overall building sector energy use has grown at a faster rate than industrial use or transportation.

Windows are responsible for about 10 percent of total building energy use (about 4 to 5 percent of total U.S. energy consumption). They lose heat in winter, thus increasing heating energy use. They admit solar radiation in summer, thus increasing cooling energy use. However, they have the potential of offsetting an additional one percent of total energy use if they can provide useful daylight that allows electric lighting to be dimmed or turned off.

Unfortunately, there is no silver bullet or single action that can dramatically reduce energy use due to windows. Glazing and fenestration are key elements in the architectural expression of the building and also provide occupants with a visual connection with the outdoors.

In the aftermath of the 1970s energy crisis, a leaky single-glazed window was a classic reference to the poor state of building design. Fast forward 40 years. Athough codes still constrain window design, the highly glazed building façade has become the iconic image for green buildings, placing new demands on designers and manufacturers. We believe there is both great opportunity to reframe the role of the façade in buildings but also great risk that the potentials will remain illusory and exist solely in the rhetoric of a glossy brochure. The new challenge is to provide a fully functional façade and integrated lighting system that operates appropriately under a wide range of environmental conditions and addresses the full breadth of occupant subjective desires as well as energy performance requirements.

These rigorous performance goals must be achieved with solutions that are initially affordable and cost-effective, and the windows must operate over long periods with minimal maintenance. If not, they will not be purchased by building owners.

FENESTRATION PERFORMANCE REQUIREMENTS IN BUILDINGS

The United States has an informal dialogue underway about the role of glazing in highly energy-efficient buildings, and, in particular, the use of highly glazed façades. The two positions, in oversimplified form, are as follows:

1. **Highly glazed façades are bad for energy-efficient buildings:** Most glazing has poor thermal performance relative to insulated walls and even worse summer impacts for cooling energy and peak cooling loads. Furthermore, highly transparent façades create severe glare that results in shades being pulled closed much of the time, thus limiting the ability to reduce lighting energy use. In addition, dimmable lighting controls are too expensive and too complex to implement effectively in most buildings. As such, glazing should be kept to code minimum areas with static solutions such as overhangs wherever possible, to minimize the chance of control system failure.
2. **Glass is a key component in an energy-efficient building:** People desire a connection with the outdoors. The need to provide adequate daylight deeper into occupied spaces requires moderate to large glazed façades of reasonably high transmission (for example, 30 to 60 percent). Glare can be managed in design by separating the glazing into "view elements" and "daylight elements." Each, with appropriate glazing and dynamic shading, can manage glare and contrast levels while offsetting 60 to 80 percent of lighting in the perimeter and 30 to 60 percent deeper in the space. The overall cooling load and peak cooling can be effectively managed with static spectrally selective glazings and with dynamic solar control via smart glass or operable shading systems. The thermal loads in heating seasons can be minimized with the proper selection of U-value and with the ability to collect useful solar gain when needed.

These arguments define two separate worlds which might be relabeled "standard practice today with routine design" versus "best practice with aggressive performance goals and enhanced budgets." There are other key issues related to design, installation and commissioning, which also differentiate these approaches. Our major focus here, however, is on developing a range of flexible solutions that will support the creation of high-performance buildings.

PERFORMANCE POTENTIALS: SYSTEMS, BUILDINGS AND BUILDING STOCK

Performance goals can be defined in several different manners, ranging from the properties of the individual glazing units to the performance of the façade system. For existing older buildings, often with punched windows (many of which are single glazed even in cold climates), heating loads dominate. For newer buildings with thermally improved glazing but larger window areas and higher solar impacts, and with higher internal loads, cooling is the dominant factor.

Climate obviously is a driver. FIGURE 1 compares the national energy consumption of the current stock of windows in U.S. commercial buildings to hypothetical scenarios where all the glazing is replaced with alternative improved products. Current stock consumes about 1.4 quads[1] of energy (with about 2/3 heating and 1/3 cooling). Using the mix of windows sold today, that meet current codes, would reduce the energy use modestly. Converting all windows to spectrally selective Low-E makes a more dramatic reduction to about .85 quads, by reducing both heating and cooling. Dynamic window systems—solutions where the solar optical properties of the window/shading system can be dynamically controlled from a clear to

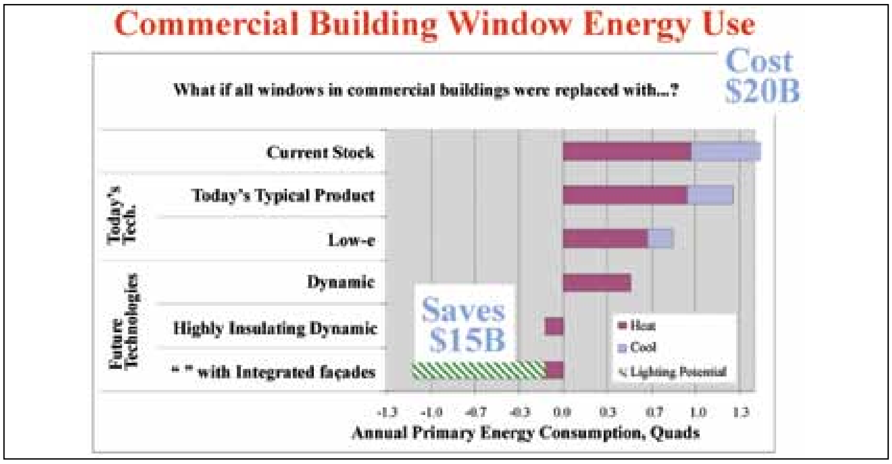

Figure 1. Potential savings from the complete conversion of fenestration in U.S. commercial building stock to the technologies indicated.

a dark state—can virtually eliminate the cooling impacts and provide modest further reductions in heating. Making a big improvement in the insulating value provides an additional one quad of savings and shifts the windows to net positive energy flow (on average). The final row shows the impact of adding daylighting strategies, such as dimming the electric lights when daylight is available.

Following are the technical requirements and opportunities to capture much of these savings with solutions that approach the net-zero annual impacts goal outlined in FIGURE 1.

Heating energy control: Thermal losses through the façade in winter can be addressed by specifying highly insulating glazings and frames. Highly insulated façades can greatly simplify the design and layout of heating, ventilation and air conditioning (HVAC) systems, minimizing, or even eliminating, perimeter heating. Glazing options include multiple glazed units with three or four glazings (glass and plastic), which utilize one or more Low-E coatings as well as low conductance gas fills. Research is still underway on improved vacuum and aerogel windows, which might provide additional options in the future. Metal framing systems can be improved with better thermal breaks and/or by changing some or all of the framing to a non-metallic structural material. There are further approaches that can be taken to incorporate air flow within a multi-glazed or double façade system. The best insulating options available today are not commonly available and thus tend to be costly. These costs will fall over time.

Solar gain and daylight control: The bigger future challenge is the dynamic control of sunlight to modulate solar gain, daylight, view and glare. There are several fundamental issues to address in the control of daylight and sunlight and these control functions are somewhat climate and orientation dependent. These include 1) the mechanism(s) to physically control intensity (for example, absorption and reflection); 2) strategies to separate solar heat gain from daylight admittance and potentially to redirect light; and 3) the controls infrastructure by which the dynamic façade states are triggered and activated, and by which the lighting responds.

Further improvements in energy and peak load performance are achievable if we consider "smart" façades where properties can change dynamically over time. These are very important since we must consider thermal and visual comfort and occupant response, which is a critical attribute of good building design and essential for any building that is highly glazed. Note that actuation can occur automatically via sensors or by the action of occupants.

ADVANCED FAÇADE SYSTEMS WITH DYNAMIC GLAZING OR AUTOMATED SHADING

Given the variability of human needs, flexible, responsive façade systems are a desirable goal. We have undertaken a series of simulation studies and limited field tests to explore the performance of responsive, dynamic façade and lighting systems integrated with the space conditioning system. We are convinced they can yield significant energy and peak demand reductions when compared to conventionally designed systems. These integrated whole building control systems accept inputs from interior and exterior sensors, the occupant(s), the utility pricing signal and other operational inputs, then rely on a "smart" control algorithm to achieve energy-efficiency, comfort and environmental quality objectives in real-time. The conceptual diagram for such a system is shown in FIGURE 2.

We see continued progress toward this conceptual vision along two parallel pathways. In the first case we consider the use of "smart glazings" with an emphasis on electrochromic and thermochromic glazings. These are just becoming commercially available in sizes and at costs that allow their use in buildings. In the second case we examine automated shades and blinds to provide dynamic control of solar gain and glare. These are widely available although not commonly used.

In both cases, integrated daylight dimming controls are essential elements and control strategies that address occupant needs for comfort and performance are balanced against building owner needs to minimize building operating costs. While extensive parametric computer simulations of façade and building performances have been completed, computer modeling alone is insufficient to understand and solve

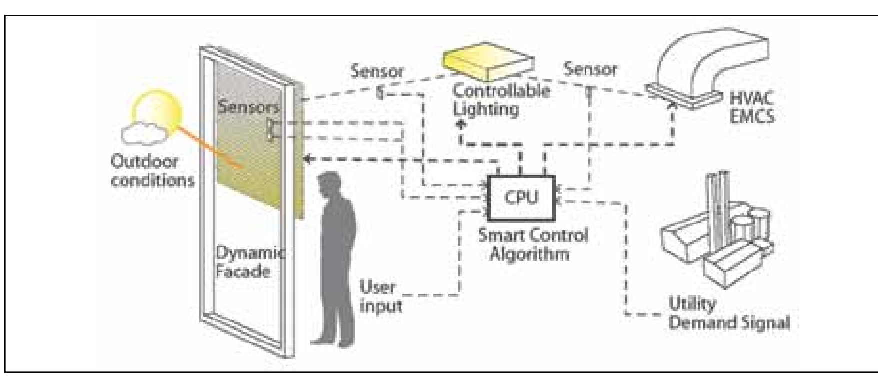

Figure 2. A conceptual diagram of an integrated whole building control system.

problems in a manner that leads to change in the marketplace. Therefore, each of these research efforts now relies heavily on field tests.

Smart glazing systems: electrochromic and thermochromic glazings

Electrochromic glazings and other types of smart glass have been under development for over 20 years. The current generation has excellent dynamic switching range and good durability. However, to extract maximum performance from such glazings requires that they be fully integrated with other building systems, as shown in FIGURE 2.

To explore these integration and operational issues, we extensively tested electrochromic glazings; first in two side-by-side rooms in an existing office building in Oakland, California, and later in a testbed building at the Lawrence Berkeley National Laboratory (LBNL) in Berkeley, California. The LBNL testbed has three side-by-side identical test rooms, one of which is shown in FIGURE 3. These glazings are now being tested in operation buildings. Results can be downloaded at http://windows.lbl.gov/comm_perf/electrochromic.

Thermochromic glazings are now reaching the market. More experience, however, will be needed with both passive and active systems to optimize the best fits between technologies and applications.

Commercially available solutions: automated blinds and shades

Interior shades and blinds are commonly used in U.S. buildings but, unlike in Europe, virtually none are automated or motorized and few are externally mounted. Building designers assume that these shading systems are available for occupants to control, primarily for glare, but they are not relied on to control cooling loads or overall building performance.

Most energy standards do not provide credits for systems that rely on occupant action, since the response is unknown and uncertain. Furthermore, engineers will generally size HVAC systems assuming worst case operating procedures. This means that the economic case for conventional blinds and shades as an energy savings strategy is often hard to make. As the industry moves towards larger energy savings, peak load control, demand response and, eventually, toward net-zero buildings, we will demand much better performance from these shading systems. Using simulation studies,

Figure 3. A photo of a façade test room with electrochromic windows configured for occupant response testing.

outdoor testbed experiments and building demonstrations, we are currently exploring how best to adapt and adopt these systems into more buildings.

However, there is a gap between the simulation world and measuring performance in a testbed. There is an equally large gap in deploying technologies in a 100 square meter test bed and in a 100,000 square meter building. We partnered with the owners of the *New York Times*, their design team and several manufacturers on the development of an automated, motorized shading system with dimmable photocell-based lighting controls for use in conjunction with a high transmittance, all glass façade for their new headquarters in New York City.

The 51-story, 140,000 square meter building utilizes fixed exterior shading and fritted glass in some locations. The owner, however, felt it required automated shades for sun and glare control, thermal and visual comfort, and energy management. Extensive studies were carried out over 18-months in a full-scale, 450 square meter mockup of a corner of one floor. The performance of different shading and dimmable lighting systems was accurately measured and compared and extensive performance specifications were developed. The specifications required a fully dimmable and addressable lighting control system and a motorized shade with sensors at each bank of windows. This ensures shades would be responsive to local glare conditions, as viewed by occupants in their workstations. This resulted in new products being developed to meet these specifications and further testing of these final products in the mockup. Special mobile commissioning carts were developed to help the owner verify that the automated shading and lighting were operating properly after installation.

The building was occupied in 2007. Initial reports say the systems are operating properly and the occupants are pleased with the operations. A comprehensive energy measurement study and post occupancy evaluation is now underway. More information can be found at: http://windows.lbl.gov/comm_perf/newyorktimes.htm.

TOOLS AND DATA FOR OPTIMIZING DYNAMIC GLAZING AND AUTOMATED SHADING FOR ENERGY AND COMFORT

The success of the *Times* project and the extensive industry interest in utilizing similar solutions made it clear that technology solution sets to easily and reliably optimize, specify and deploy these systems were not available to architects and engineers. As such, over the last three years we have been trying to fill this gap by evaluating available and emerging dynamic façade systems, conducting field studies to better understand occupant responses to the systems and developing the data and tools to characterize these systems and reliably predict performance.

One of the key design objectives is to be able to manage a view window to effectively reduce glare while it admits adequate daylight to reduce electric lighting needs and minimize cooling loads. We conducted a series of tests in our façade test facility to explore the performance of various shades and blinds that adjust to changing outdoor conditions and indoor needs in order to optimize energy use and comfort.

We have developed a new optics lab to measure the properties of each shading system layer and tools to characterize complete façade system properties. We have also developed an early design simulation tool

Continued on page 33

Airtightness Testing
NOT JUST FOR HOMES ANYMORE

Airtightness testing of homes has been around for more than 20 years. Various energy programs and fluctuating energy bills have provided homeowners an incentive to improve the airtightness of their homes. Energy tax credits can also be received by the homeowner but only if the house airtightness has been verified that it is less leaky after remodeling than before.

Efforts to make commercial buildings more energy efficient in the US has only recently been incorporated into various "green" initiatives. Tests of commercial buildings show that they tend to be more leaky than the average house, based on air leakage per square foot of surface area. That means that commercial buildings are less energy efficient than the average house.

To measure the actual airtightness of a large building means more air is needed to maintain a reasonable test pressure. The Energy Conservatory, a leader in airtightness testing, has kits available to directly measure more than 18,000 cubic feet per minute of air leakage. Multiple kits and fans can be used simultaneously to generate

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Feature

From Innovation to Reality: A 2010 Olympic Village Perspective

By David Fookes

THE VILLAGE AT FALSE CREEK IS A mixed-use development comprised of 1.4 million square feet (426,720 m.[2]), including 1,100 residential units, commercial space and a community center. The neighborhood, which was Vancouver, British Columbia's Olympic Village for the 2010 Winter Games, was occupied by 2,800 athletes and temporary services during the games. Following the Olympics, permanent residents have moved in and the new community is beginning to take shape.

The village achieved LEED Platinum Neighborhood Development by the U.S. Green Building Council (USGBC), LEED Gold certification for all of the residential buildings and LEED Platinum for the community center. One of the buildings, a 68-unit affordable housing facility for seniors, is targeting net zero for annual energy consumption. Other features of the development include 50 percent green roofs, rainwater harvesting and a district heating system.

To meet these ambitious goals, buildings were designed to respond to their specific environment. For example, the orientation of the buildings takes advantage of local wind patterns and harnesses the winds for use in natural ventilation. Shading devices such as deep balcony overhangs, operable exterior shades and movable panels are used to control heat gain by limiting the amount of sunlight and solar radiation that can penetrate the building (FIGURE 1). Buildings were designed with single-loaded corridors, with exterior corridors where possible, to allow cross breeze and improved circulation of air.

LEED Gold certification required that the building envelope be high-performing for durability and thermal performance. To meet the rainwater management and durability requirements, exterior insulated walls and inverted roof systems were selected. To meet the project's ambitious energy performance goals, the envelope was optimized to support whole building energy efficiency. Whole building energy modelling determined the target thermal transmittance (U-value) of the building assemblies. Thermal modeling was utilized to determine the required insulation levels to meet the target thermal transmittances of opaque envelope assemblies and quantify glazing U-values.

Figure 1. The shading strategy included automated vertical shades on the west façade (left) and horizontal shades on the southern elevation (right).

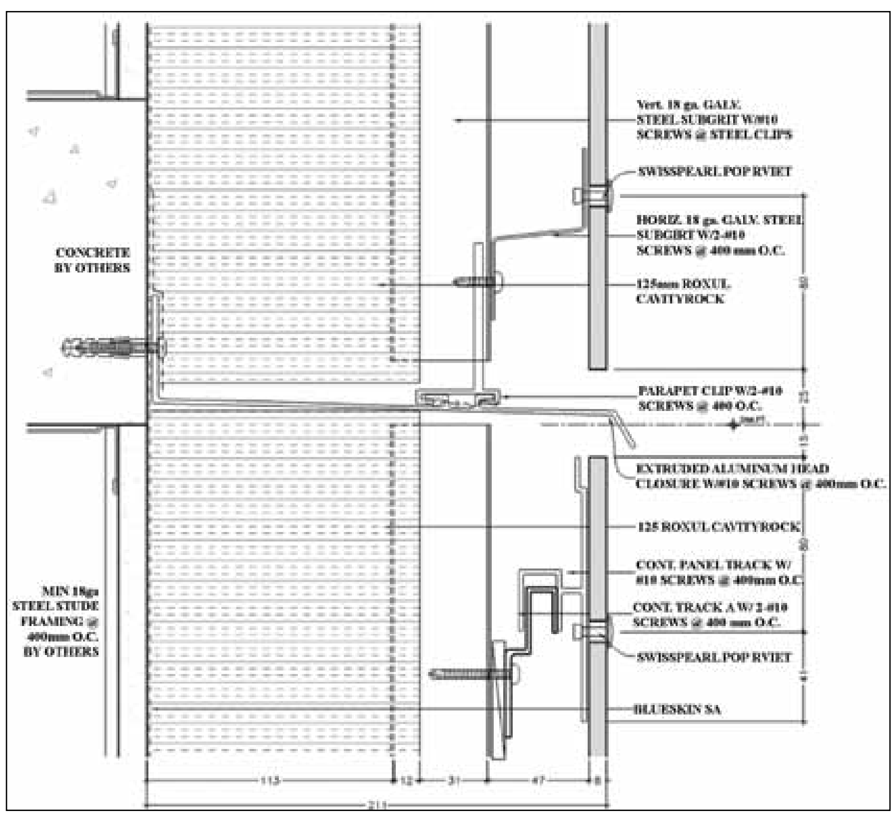

Figure 2. A typical exterior insulated wall assembly.

Nominal Wall R-Value	Insulation Thickness (Inches)			Effective Wall R-Value for Various Cladding Attachments			
	Mineral Wool	EXPS	Spray foam	Vert. Girts	Hor. Girts	Broken Vertical Girts	Vert. & Hor. Girts
33.1	7.0	5.9	4.9	10.6			
28.9	6.0	5.0	4.2	9.8	13.5	14.6	16.8
24.7	5.0	4.2	3.5	9.0	12.3	13.4	15.0
20.5	4.0	3.4	2.8	8.2	11.0	12.1	13.2
16.3	3.0	2.5	2.1	7.3	9.5	10.5	11.3
12.1	2.0	1.7	1.4	6.1	7.7	8.6	8.8
7.9	1.0	0.8	0.7	4.8	5.6		
5.8	0.5	0.4	0.4	3.9	4.2		
3.7	0.0	0.0	0.0	2.6	2.6		

Table 1. Summary of effective thermal resistances for exterior insulated walls (no insulation in frame cavity, slab effects ignored).

All buildings were constructed to meet a 50-year design service life (DSL). The DSL was established for the buildings using CSA S478 - Table 2 as a minimum. Design for the building envelope components and assemblies was undertaken so that the predicted service life (PSL) exceeds the DSL. Rainwater management is the most significant factor affecting durability of the building envelope in Vancouver and the Pacific Northwest. Exterior insulated rain-screen walls were designed to meet both energy efficiency and rainwater management design requirements **(FIGURE 2)**.

In order to establish the PSL of the building components, the designers drew from lessons learned from *BC Leaky Condominiums*, Best Practice Guides, and their local experience from working in Vancouver's climate. Building components were selected with consideration of initial cost, maintenance and renewal requirements, occupant comfort and well-being, and sustainability.

In addition to all the typical performance, constructability and budget constraints imposed on designers, the architectural teams were required to design envelope systems that met the project's performance requirements. Many of the architects were surprised to learn that the wall systems that they had used in previous highrise residential construction in Vancouver's market fell far short of the target thermal transmittance, when considering the impact of thermal bridges within the proposed exterior insulated wall assemblies. The proposed method of attaching cladding systems and associated thermal bridges required higher insulation levels than initially anticipated by the team to meet the target thermal transmittance.

The team, therefore, questioned whether they could simply modify the assemblies familiar to them or whether they had to make a dramatic departure from their initial design assumptions and, if so, to what? In an effort to assist the project team, Morrison Hershfield completed thermal modeling to provide thermal transmittance values that aided in decision making. **TABLE 1** summarizes the effective thermal resistance of various assemblies in determining the method of cladding attachment.

Various steel stud wall assemblies were modeled with both 3.5 in. and 5.4 in. (9 cm. and 14 cm.), 18 gauge steel stud framing, and for both exterior insulated and conventionally insulated (in the interior steel stud cavity) frame cavities. Exterior insulation was modeled in a range of insulation thicknesses and for several different insulation and cladding attachment arrangements. For each of the earlier cases, modelling was also carried out to determine the thermal transmittance (effective assembly R-value) of exposed concrete slabs from cantilevered balconies and eyebrows. The resulting assembly R-values were lower than that of the surrounding wall due to the thermal bridging of the concrete slab. This information was provided to the design team to be incorporated into the whole building energy simulations.

Important assumptions and simplifications made in the modelling procedure include the following:

- Generic cladding was modeled using a consistent resistance value since the cladding is bypassed by cavity ventilation for rainscreen assemblies;
- Use of a 2D model, when actual heat flow is in 3D. Reported assembly R-values for wall sections represented an approximation of the actual heat flow path and thermal resistance; and
- Steady-state model (thermal mass is typically considered separately in whole building energy simulations).

An effective envelope plays an important role in achieving the building's

Figure 3. Green roof with solar hot water heating panels; a net-zero building.

energy performance targets. Buildings at the Village at False Creek were expected to achieve thermal performance targets of R-15 for the opaque walls assemblies, a U-value of 0.41 (Btu/hr ft2 °F) for the complete window system and R-24 for the roofs. The ratio of wall to vision window was controlled (60 percent glazing overall) to balance unit market value and energy efficiency.

The net-zero building required an ongoing integrated design process in order to meet its stringent energy targets. The building will substantially reduce energy consumption through the application of advanced building technologies and passive design techniques, including enhanced envelope design (triple-glazed windows, R-20 walls and R-30 roofs), glazing systems and shading devices. The building will rely on renewable energy systems to provide its own supply of clean, green power. Heating loads will be met using waste heat from an adjoining supermarket.

The remainder of the building's energy use will be offset using two rooftop solar thermal arrays **(FIGURE 3)**, which were found to be both the most cost effective and appropriate technology for Vancouver's climate. The solar thermal collectors cover the roof of the net-zero building as well as the roof of a neighboring building.

The Village at False Creek is a hallmark of sustainable building design in Canada. The scale of the project and the high level of green design that was incorporated into the buildings are unprecedented in this part of the world. Integrated design between the building envelope, energy systems and passive strategies were required to meet the project's ambitious goals. The design team is confident that this approach will be successful in achieving the sustainability targets for the Village at False Creek, and, moreover, the approach is an important one to carry over to all projects in the future. The benefits are far-reaching in terms of building performance, occupant comfort and the environment. ■

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BEC Corner

AUSTIN

By Keith Simon, AIA, LEED-AP, Beck Architecture LLC; BEC-Austin Chair

It is hard to believe that BEC-Austin is only four months old! There has been tremendous enthusiasm from speakers; members who want to be involved; and companies that want to support us. We already have a very fortunate problem—it's hard to get a seat at our meetings. Our board members and co-chairs have decided to focus our initial presentations on the fundamental knowledge of air, heat, moisture and moisture vapor transport. We are interspersing this "core-skills" series with presentations that focus on systems and technologies. For example, our June presentation focused on using high-mass wall systems for energy efficiency in a hot and humid climate. Our panel of speakers included the owner of EarthCo Building Systems (a local manufacturer of compressed earth blocks); architect Larry Speck, FAIA, who showed historical precedents as well as local designs using high-mass wall systems; and engineers from Wiss, Janney, Elstner, Associates, Inc., who presented their thermal and moisture analysis of local high-mass wall systems.

Next month, we'll take a 180-degree turn with a presentation on the passive house system in hot and humid climates, from high-mass walls to super insulation!

CHARLESTON

By Witney E. Okon, Applied Building Sciences; BEC-Charleston Chair

BEC-Charleston is flying through its sixth year of bringing building enclosure science and technology to South Carolina. This past winter/spring, we enjoyed presentations entitled, *Next Generation Roofs and Attics,* by Oak Ridge National Laboratory's (ORNL) Bill Miller; *Bugs, Buildings and Change: Termite Control, Moisture Control and New Construction Trends*, by Bert Snyder; *Curtain Walls: Proper Detailing, Installation and Pitfalls***,** by Karol Kazmierczak; and *Energy Monitoring,* by Jeff Beck.

BEC-Charleston's effort to fund and construct a net-zero energy house, in association with the East Cooper Breakfast Rotary Club and Habitat for Humanity, is well underway! From the building envelope perspective, the group has successfully installed structural insulating panels (SIPs) and ceiling panels, Henry's Blueskin sheet adhered weather resistive barrier, and Pella high-efficiency fiberglass casement windows. With those components in place, the group undertook a blower door test and reported that the house has 1.46 ACH at 50 Pa. and a leakage area of only 17.7 square inches. These preliminary results are prior to the exterior cladding being installed and spray foam insulation going into the floor system.

As well, Don Easson, a local engineer and regular BEC attendee, put together a consortium of vendors and professionals to provide and install a geothermal heating, ventilation and air conditioning (HVAC) system. The wells were drilled earlier this year and the equipment is now starting to be installed inside the house. This includes a 2-ton ClimateMaster heat pump and a RenewAire energy recovery ventilator. Velux and the Muhler Company installed a solar hot water system and the solar panels are already on the roof.

All of this work has taken place with the associated Learning Days for the BEC-Charleston membership. This has been a great hands-on learning experience. We are grateful to those who have donated their time, experience and materials to make this project one of BEC-Charleston's proudest accomplishments to date!

BEC-Charleston has over 200 professionals on our membership list and greets 40 to 50 members at each meeting. For additional info, contact Whitney Okon at wokon@appliedbuildingsciences.com or visit www.bec-charleston.org.

CHICAGO

By Richard E. Fencl, AIA, CSI, LEED-AP; BEC-Chicago Chair

BEC-Chicago will be electing several new officers at the end of 2011. Kevin Kalata (Wiss, Janney, Elstner, Associates, Inc.) will become the new chairperson, succeeding Richard Fencl (Gensler), who is the current chair. Kenneth Lies (Raths, Raths & Johnson, Inc.) has become the new BEC-Chicago treasurer. Elections will be held for secretary and vice chair/chair elect.

Here is a quick synopsis of what's new at BEC-Chicago:

- Membership of our local council has doubled in the past year. We are now 120 members strong and still growing.
- Our "new" website is under development! BEC-Chicago is raising money to improve our current website design to make it more member interactive and a portal for all things envelope. The development site can be viewed at http://dev.bec-chicago.org.
- We have an ambitious monthly schedule of programs planned for the remainder of 2011. We are also beginning to plan for the monthly programs for 2012. Our program directors are Jeff Diqui (STO Corporation) and Ken Soch (SCB Architects). Programs this year have included discussions on *Vapor Movement in Roofing*, *NFPA 285 / Foam Plastic Insulation*, *Siphonic Drainage* and *Post-Occupancy Evaluations of Buildings.* Upcoming programs will address façade access (Lerch-Bates), brick veneer ties and a program where BEC-Chicago will host a contractor discussion panel facilitated by Steve Nadler (HDR).
- Our September 2011 meeting will be an evening of refreshments, fellowship and a discussion on the advancement of fuel cell technology in buildings.
- Attendance at meetings has risen to 50 people per meeting and the goal is to regularly engage 100 local architects in building envelope issues.
- Meetings are held on the second Friday of the month at the office of Gensler (11 East Madison Street, Chicago).

GREATER DETROIT

By Steve Robbins, The George W. Auch Company; BEC-Greater Detroit Chair

The BEC-Greater Detroit's 3rd annual symposium is scheduled for October 18, 2011, at the Laurel Manor Banquet Center, in

Livonia, Michigan. Its theme is *Understanding Hygrothermal Performance.* Four national experts in the field of building enclosure research, investigation, assessment and execution will discuss this theme, along with a distinguished panel of speakers who will discuss the past, present and future methodologies for evaluating and analyzing building enclosure hygrothermal performance.

Here is the lineup:

- *Why Buildings Matter: A Look into the Past, Present and Future of Building Performance*, will be presented by R. Christopher Mathis, President, MC2 Mathis Consulting Company. This informative and fun-filled presentation will show attendees, in no uncertain terms, the importance of our buildings, from minimum code to net zero and from business-as-usual to what defines truly sustainable building practice. The presentation will quantify the importance of buildings in ways we may not have previously considered, challenging our status quo and giving real numbers to the size of risks and opportunities we face. It will provide valuable new perspectives on the energy-efficiency, durability and sustainability decisions we make for our buildings.
- *Dr. Seuss Does Building Science: Fundamentals of Moisture and Vapor Transport Mechanisms*, will be presented by Robert J. Kudder, S.E., Ph.D, Senior Consultant, Raths, Raths, & Johnson, Inc. This will be a presentation on the fundamentals of both liquid and vapor moisture transport mechanisms in wall systems and customary methods to combat water infiltration and condensation problems. The objective is to provide an intuitive appreciation of building science related to wall behavior.
- *Vapor Barriers Do Not Protect Buildings; Vapor Barriers Protect Architects*, will be presented by William Rose, R.A., Research Architect, Building Research Council, University of Illinois. The basis for most hygrothermal building science analyses performed in the United States today is based on methodology developed in the late 1930s. But is this fundamental basis truly accurate? Did it comprehensively include all the significant variables one must consider when evaluating moisture transport? This presentation will provide a short description of the, perhaps controversial, evolution of hygrothermal issues and analyses. It will trace the development of analysis methods and it will explain the short-comings of the initial methodology, the legacy which followed, the impact of this approach on our enclosures today and a look to the future.
- *Confusion About Diffusion: Stuff You Thought You Knew About Moisture But Didn't Really,* will be presented by Joseph Lstiburek, B.A.Sc., M.Eng., Ph.D., P.Eng., Principal, Building Science Corporation, Inc. This presentation will cover the stuff you thought you knew about moisture related performance but really didn't. This presentation will demystify and re-mystify hygrothermal performance of building enclosures. It will start to include the 3D effects of airflow networks and show why current analysis methodology and software will not suffice. The objective is to blow your mind.

For more information, contact Andrew Dunlap at dunlap@smithgroup.com. For sponsorship information, contact Dan Zechmeister at dan@mim-online.org. Or go to www.bec-gd.org for additional information.

MIAMI

By Karol Kazmierczak (Kaz), AIA, ASHRAE, CDT, CSI, LEED-AP, NCARB, Building Enclosure Consulting, LLC; BEC-Miami Chair

BEC-Miami celebrated its forth anniversary in June of this year. Our group recently managed to cap the attendance at our meetings—we met the room occupancy limit! In return, we doubled the frequency of events and added an interactive calendar of events to our webpage, www.bec-miami.org. In addition to our regular monthly meetings, which are held at AIA Miami in Coral Gables, we organized the Facade Engineering University at the Florida Atlantic University in Davie. This is held on the third Saturday of every month. The event consists of a three-hour seminar and a one-hour workshop that includes practical demonstrations on how to solve architectural details on the basis of principles discussed during the seminar. The current program is based on a series of my lectures, focusing on areas typically overlooked by building enclosure consultants, architects and engineers who are in the process of building envelope design, engineering and construction. This series will also be available via webcast and in form of DVDs.

Recent topics included *Principles of Building Enclosure Design*, *Impact Resistance*, *Fluid Applied Air Vapor and Water Resistive Barriers*, *Translucent Daylighting*, *Anchoring Systems*, *Fundamentals of Air Barriers*, *EIFS*, *Single-ply Roofing*, *Below Grade Waterproofing*, *Common Mistakes in Designing a Roof* and *Metal Wall Systems*.

In December 2010, we attended the eleventh international conference on Thermal Performance of the Exterior Envelopes of Whole Buildings XI, which was organized by ORNL.

MINNESOTA

By Judd Peterson, AIA; BEC-Minnesota Chair

With deep snow and cold, and then heavy downpours and tornadoes this year, Minnesotans are now much more aware of the utility of high-performance buildings.

During the recent Building Enclosure Technology and Environment Council (BETEC) board meeting in Washington, D.C., Henry Green, President of the National Institute of Building Sciences; Ryan Colker, Director of the Consultative Council/Presidential Advisor; Dave Altenhofen, National American Institute of Architects (AIA) Representative to the BETEC Board; Marcia McNutt, Director of the U.S. Geological Survey; and I met with Minnesota Senator Al Franken and his staff to discuss various initiatives of the Institute to help improve the nation's infrastructure and develop high-performance building programs that generate better energy-efficiency.

In Minnesota, we've had lots of speakers and presenters at our monthly meetings. The list includes Terry Dieken, owner of Extreme Panel Technologies, who talked about Structural Insulating Panels (SIPs); McRae Anderson, of McCaren Designs, who explained Greenwall's Vertical Planting Systems; Dave LaPage, of Big Wood Timber Frames, who led a discussion on heavy timber framing, the methods of assembly and ways of installing window and door openings, and sealing and insulating the exterior shell; and Harley Simonson, of Knight Wall Systems, Mike Herbst of Cladding Corp's System 5 and Craig Hall, of Moeding by Shildan, who discussed how rainscreen solutions provide a high-performance building envelope, particularly in rehabilitation situations.

In addition, Dave Bohac, of the Center for Energy and Environment (CEE) and Martha Hewett, Director of Research at CEE,

presented a terrific seminar on their recent efforts and studies measuring the energy-efficiency improvements from retrofitting older commercial curtainwall buildings in Minnesota. Along with Gary Nelson of The Energy Conservatory, who provided the blower doors and digital manometers, they described diagnosing and repairing local buildings with problems due to air leakage. This is a field survey effort funded by the Department of Energy (DOE) through the Institute/BETEC to help understand the extent of air infiltration, the cost of improvement and the subsequent degree of improvement.

NORTH CAROLINA

By W. Blake Talbott, AIA, NCARB, IFMA, CSI, ASTM, NIBS, AAMA, BBH Design; BEC-Research Triangle Chair

The Research Triangle (RT) region of North Carolina is the newest location to establish a Building Enclosure Council (BEC). Both a BEC and a committee of the AIA Triangle, this group of architects, engineers, contractors, educators, manufacturers, facilities personnel, building scientist/researchers, state building officials, code officials, consultants and others have joined together to collaborate and share ideas about building enclosure design, science and construction. BEC-RT meets monthly to discuss a topic of interest.

The group's first event, a presentation, *Why Buildings Matter*, by Chris Mathis, principal of MC2 Mathis Consulting Company, Asheville, North Carolina, was attended by more than 120 people. In September, BEC-RT is planning to host renowned building scientist Dr. Joseph Lstiburek for an all-day session.

The inaugural BEC-RT Board includes: Chair Blake Talbott (BBH Design), Vice-Chair Rita Ray (Wiss, Janney, Elstner, Associates, Inc.) Treasurer Kevin Turner (The Freelon Group) and Secretary Rodrigo Reyes (Perkins+Will).

PORTLAND

By David C. Young, P.E., RDH Building Sciences, Inc.; Portland-BEC Chair

This year, in addition to the Webinars Series that the Portland-BEC chapter offers, we were able to bring in a national speaker. Chris Benedict of Architecture and Energy Limited, located in New York, presented *Building Enclosure Fundamentals From the Perspective of a New York Architect*. Her interesting perspective on sustainable design was well received. We continue to consistently attract 40 to 50 members to our regular monthly program and the ability to include national speakers is a significant benefit.

Oregon has adopted a new energy code based on the ICC *2009 International Energy Conservation Code*. With the drive to increasing energy efficiency in buildings, it was particularly timely to have Mark Campion from the State of Oregon present on the new COMcheck 3.8.1 software. This is DOE software and the only program used by the State of Oregon to verify the Simplified Trade-off Approach (STA) for meeting the *2010 Oregon Energy Efficiency Specialty Code*. Campion is the programmer for the Oregon amendments to COMcheck. His presentation and demonstration of the software helped demystify the STA for attendees.

The Eugene Chapter of the Construction Specifications Institute (CSI) recently asked for our help in presenting a half-day building enclosure seminar. In less than a month, our BEC executive was able to prepare the seminar, which was attended by 80 CSI members. Three topics were presented:

- *Building Science Basics and Practical Solutions*, presented by RDH Building Sciences, Inc.;
- *Performance Testing*, presented by the Façade Group; and
- *High R-Value Walls*, presented by Walsh Construction.

Finally, we wish to congratulate the Seattle Building Enclosure Council (SeaBEC) on their successful full-day Building Enclosure Symposium in May 2011. SeaBEC and Portland-BEC will alternate providing a full day symposium each year. At the time of writing this update, our BEC chapter is headed into its Strategy Session for the 2011-2012 season. We are looking forward to Portland's first full-day symposium in 2012. The date is yet to be announced but we are leaning toward the fall to avoid conflicting with the Building Enclosure Science and Technology (*BEST3*) Conference, which is scheduled for April 2012 Atlanta, Georgia.

SEATTLE

By Peter M. Ryan, AIA, Wiss, Janney, Elstner Associates, Inc.; SeaBEC Chair

In May, the Seattle Building Enclosure Council (SeaBEC) conducted our first symposium, titled, *Flying Above the Standard; Building Enclosure Innovation*. It was held at the Museum of Flight, located in Seattle. Our program opened with Jason McLennan**,** LEED-AP, Chief Executive Officer of the Cascadia Green Building Council, with his presentation, *The Future of Architecture and the Role of the Envelope*.

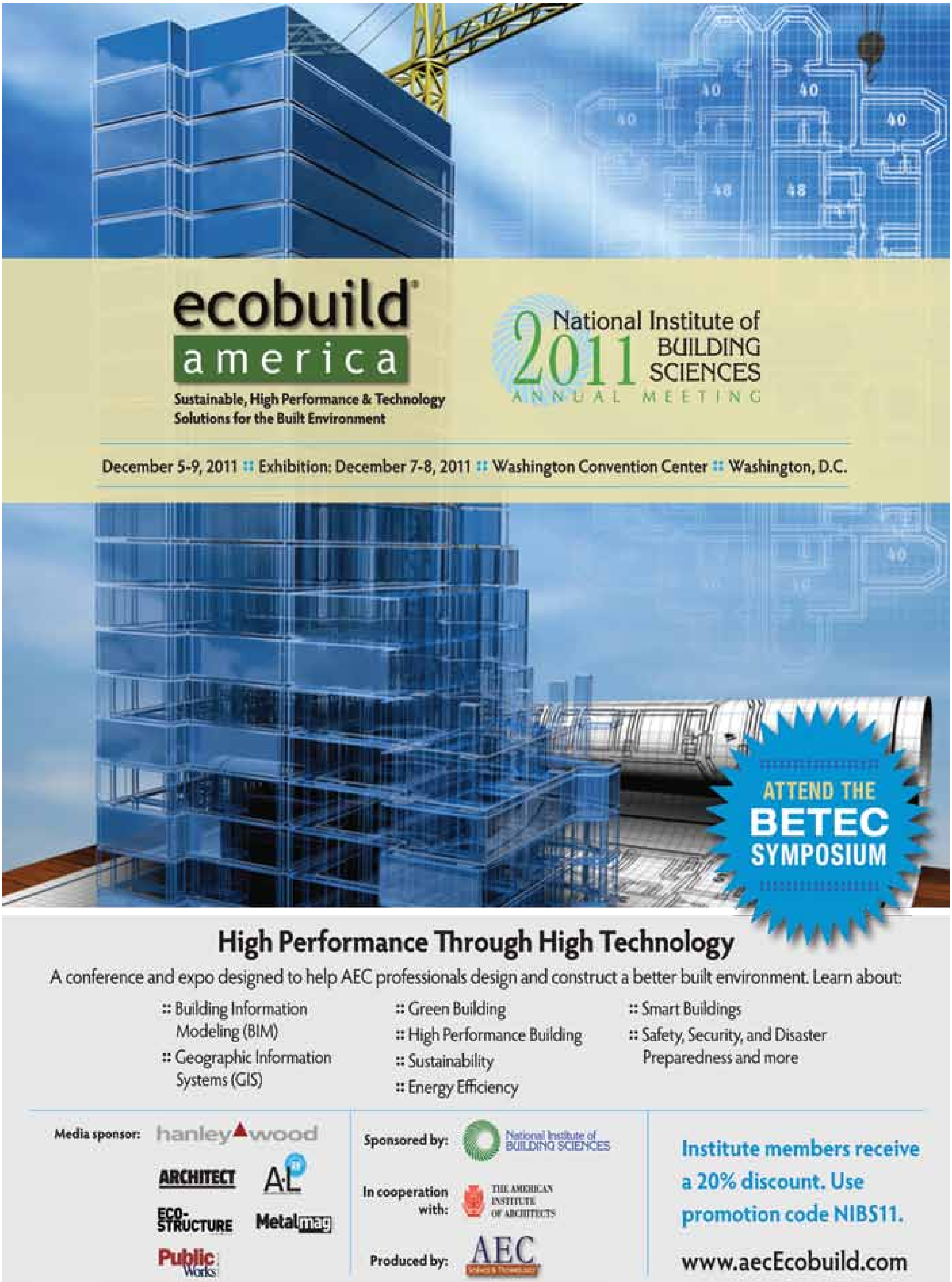
The day continued with presentations by Rodney Lock and Stéphane Hoffman of Morrison Hershfield Corporation; David Deress of Wiss, Janney, Elstner, Associates, Inc.; Sean Scott of SERA Architects; Robert Bombino of RDH Building Sciences Inc.; and Mark Perepelitza of Zimmer Gunsul Frasca and Steve Selkowitz of Lawrence Berkeley National Laboratory. The day concluded with our keynote speaker, Captain Wendy Lawrence, and her presentation *Building the International Space Station*.

This presentation was well received and noted to have complemented many of the themes and ideas presented earlier in the day, including functionality versus the cost of exterior enclosure cladding materials, the difficulties involved in assembling air barrier systems and the environmental effects of living in a closed loop setting. Captain Lawrence also reflected on her career as a naval aviator and space shuttle mission specialist and the challenges and excitement of space travel.

In June, we elected two new board members and reorganized our board member responsibilities. I am ending my three-year term as president and handing over leadership to Roxanne Navrides of the Seattle Housing Authority.

Our Education Committee has started to plan our next year, which starts in September, with presentations geared to show solutions to past mistakes. Possible field trips to window, glass and/or insulation manufacturing plants here in the Puget Sound region are being planned. This should prove to be a different direction for most of our members and we hope to attract new members with some new programs. The rest of our year will be rounded out with presentations on building maintenance and historic preservation.

We meet on the third Thursday of the month (except July and August). If you are in Seattle, feel free to stop by and be our guest at our monthly meeting. For more information please visit our website at www.seabec.org. ■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for architects and engineers, called Commercial Fenestration Façade Design Tool (COMFEN). It supports the systematic evaluation of alternative fenestration systems for project-specific commercial building applications. Under the hood is Energy Plus, a sophisticated analysis engine that dynamically simulates the effects of these key fenestration variables on energy consumption, peak energy demand, and thermal and visual comfort (you can download these tools at: http://windows.lbl.gov/software).

CONCLUSIONS

In the United States, interest in energy efficiency solutions has grown rapidly in the last several years for both new and existing buildings. Windows can provide key performance contributions to these aggressive goals but will perform best when the windows themselves are designed as part of an integrated system that links envelope, HVAC, lighting and utility services, and when the window systems are highly insulated and operated as responsive, dynamic elements to control glare, daylight and solar gain.

While the challenge to get this right is a difficult one, there are several new systems and projects that we have tested that appear to provide useful solutions which can be further developed, improved and replicated. It will take better and cheaper hardware, additional exploration of system integration solutions, new sensors and controls, improved commissioning, a better understanding of occupant needs and preferences, and better real-time, adaptive controls to fully realize the potentials of these emerging technologies. This will allow the design community to reliably and cost-effectively reach their aggressive energy performance goals. ■

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Program, of the U.S. Department of Energy under contract no. DE-AC03-76SF00098, by the California Energy Commission, Public Interest Energy Research Program, and by the New York State Energy Research and Development Authority. We acknowledge the active support of numerous LBNL colleagues on the teams that carried out the projects described here, our partners at the New York Times, and numerous other public and private firms that worked with us in these projects. A detailed listing of project partners can be found on the websites.

Stephen Selkowitz is the program head of the Building Technologies Department at the Lawrence Berkeley National Laboratory (LBNL). He leads a group of architects, engineers and scientists who are studying all aspects of the thermal and daylighting performance of glazing materials and window systems.

This entire article, as well as a full list of references, is available upon request. Please email ssavory@matrixgroupinc.net.

REFERENCE

1. The quad is a unit of energy equal to 1 Quadrillion BTU. One quad has an economic value of about $25B and is equal to 293 billion kilowatt hours, or, for fuels of average heating values, 183 million barrels of petroleum, 38.5 million tons of coal, or 980 billion cubic feet of natural gas.

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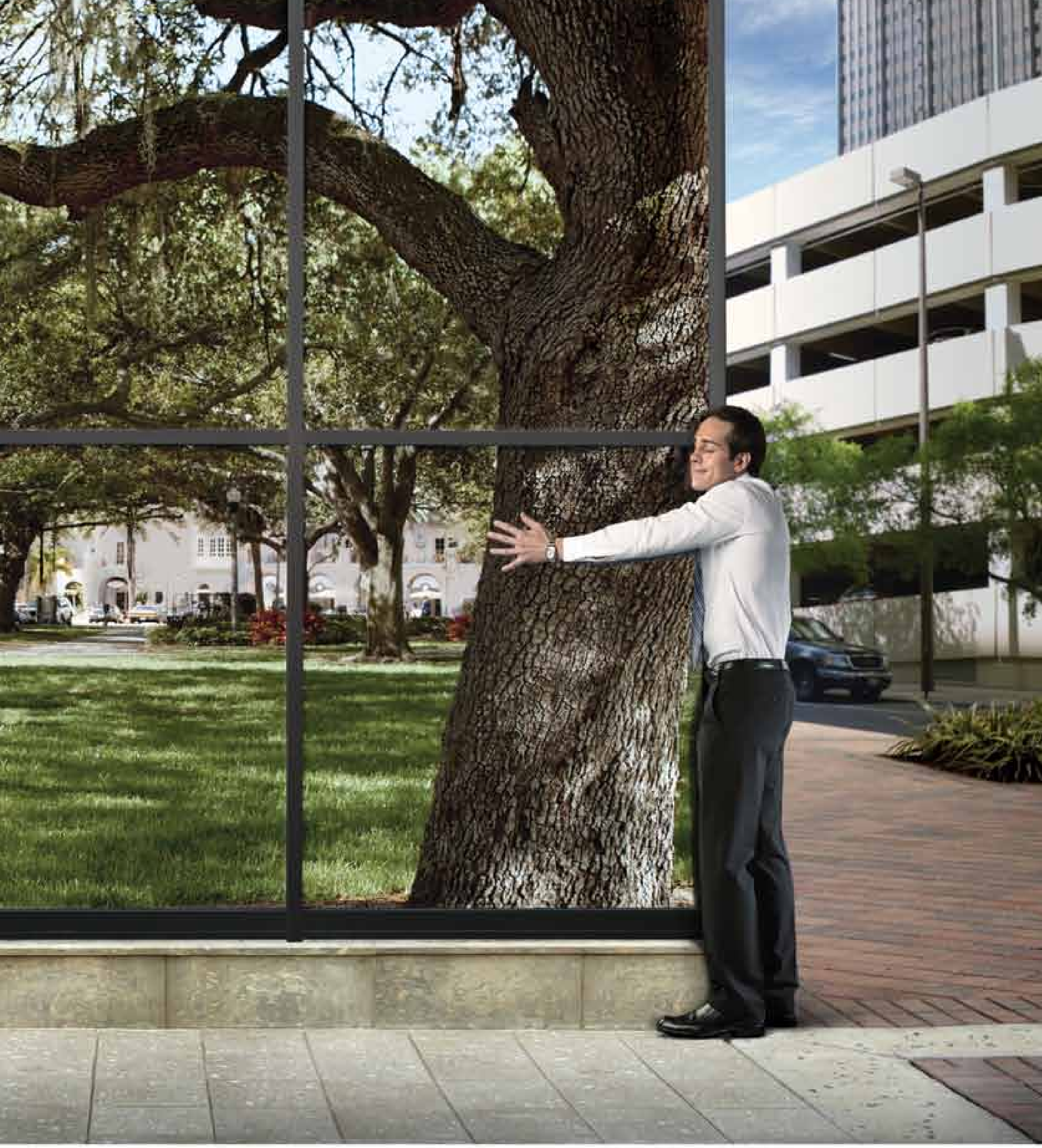

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