High-Performing Envelopes Demand Know-How

SEVERAL NEW INITIATIVES WILL HELP ARCHITECTS BETTER APPLY BUILDING SCIENCE AND TECHNOLOGY TO THE DESIGN OF BUILDING ENVELOPES

By Nancy B. Solomon, AIA

A battery of tests was conducted on a mock-up for the exterior lab wall of the Children's Hospital of Milwaukee, designed by Shepley Bulfinch Richardson and Abbott.

PHOTOGRAPHY: COURTESY SHEPLEY BULFINCH RICHARDSON AND ABBOTT

We demand a great deal from the building envelope—the skin that shelters us from the outside world. For starters, it must protect us from rain and snow, provide appropriate amounts of sunlight and fresh air, retain interior warmth in the winter and resist exterior heat in the summer, all the while exuding an aesthetic that suits owner and public alike. To this intricate mix, add the tantalizing promises of new materials, products, and systems, and ever more stringent energy, security, and other requirements, and the job of designing a building's outer shell becomes very complicated indeed. So complicated, in fact, that some fear architects may be losing their grip on this most visible building component. "The exterior of the building is how architects identify ourselves—it's our calling card, yet we are no longer in control of it if we don't know the building science and the technology necessary to design high-performing envelopes," says Richard Keleher, AIA, a technical-quality and drawing-review consultant in Concord, Massachusetts, and former director of building-envelope technology at The Stubbins Associates. He predicts that, if things continue as they have in recent years, envelope consultants may one day be dictating the look of our buildings.

Fortunately, three recent national efforts to improve the performance of building envelopes are laudable steps toward remedying the current situation. These include the publication of the *Building Envelope Design Guide*, a comprehensive resource for the design and construction of institutional and office buildings; the *Exterior Enclosure Technical Requirements for the Commissioning Process*, which outlines a step-by-step process to ensure that a new envelope will function as intended; and the formation of building enclosure councils, which establish a forum within which practicing architects throughout the country can begin to learn the fundamentals of building science and discover regionally appropriate solutions.

Contributing editor Nancy B. Solomon, AIA, writes about computer technology, building science, and topics of interest to the architectural profession.

CONTINUING EDUCATION

Use the following learning objectives to focus your study while reading this month's ARCHITECTURAL RECORD/ AIA Continuing Education article. To receive credit, turn to page 222 and follow the instructions.

LEARNING OBJECTIVES

After reading this article, you should be able to:

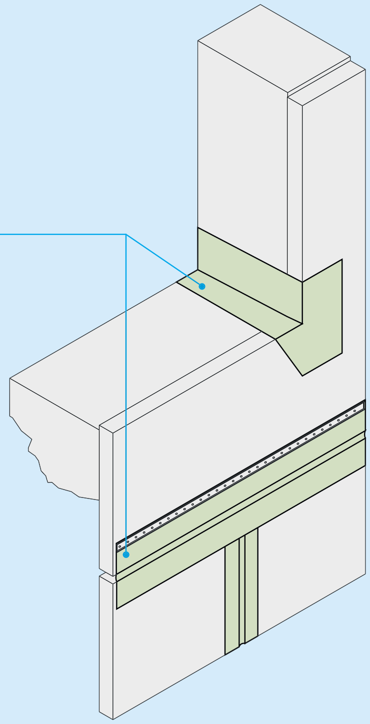
1. *Discuss recent national efforts to improve envelope performance.*
2. *Explain the role of the National Institute of Building Sciences.*
3. *Describe the purpose of building commissioning.*

For this story and more continuing education, as well as links to sources, white papers, and products, go to ***www.architecturalrecord.com***.

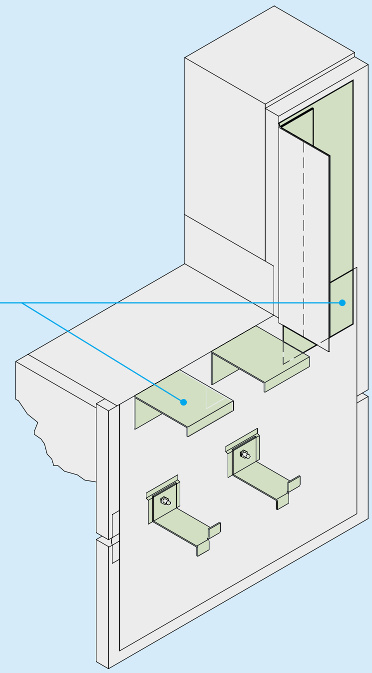
Although all three efforts evolved separately, the complementary programs have coalesced under the auspices of the National Institute of Building Sciences (NIBS), in Washington, D.C., a nonprofit, nongovernmental organization established by the U.S. Congress in 1974 to serve as a bridge between government and the private sector in order to improve the quality and efficiency of construction in this country. Among many other functions, NIBS disseminates technical information and helps introduce appropriate technologies into the building process. Referring to the advancement of high-performance envelopes, NIBS vice president Earle W. Kennett observes, "No one discipline figures this into their domain because of the multidisciplinary nature of the work." Nonetheless, to achieve high-quality enclosures, it is critical that the different disciplines interact and learn from each other. As an experienced intermediary among the varied facets of the design and construction industry, NIBS was well positioned to take on these new, inherently multidisciplinary initiatives.

The new *Building Envelope Design Guide*, which will be posted on the *Whole Building Design Guide* Web site, will include generic construction details in CAD format with extensive explanatory notes. The section on walls, for example, will include an overall isometric detail of "stone veneer sill and jamb flashing" (opposite, far right) plus a series of 12 step-by-step drawings (three of which are shown here) that illustrate air-barrier continuity, drainage plane, and flashing concepts at the various layers of the wall.

STEP 2
Seal all joints in the glass-mat-faced exterior sheathing (peel-and-stick self-adhesive flashing shown). Install corner section of flashing back-up material. Sealing all of the joints may allow the sheathing to be used as an exterior air barrier. Secure the upper edge of the horizontal joint membrane with termination bar and fasteners. The locations of the joints shown are for informational purposes only and are intended to convey exterior sheathing joint-sealing concepts.



STEP 6
Install drainage plane material along the cavity end-dam, and lap onto section installed below window a minimum of 6 inches. The drainage plane material needs to overlap onto the return leg of the cavity end-dam. Secure per manufacturer instructions. Depending on the membrane product used, impaling pins may be necessary to secture the rigid insulation outbound of the cavity. Some trowel-applied products that can be used in lieu of the membrane may be able to be used also as an insulation adhesive. Verify with the manufacturer. Install impaling pins, stone anchors, and membrane cover strips over the anchors and impaling clips.



Design and construction guidelines

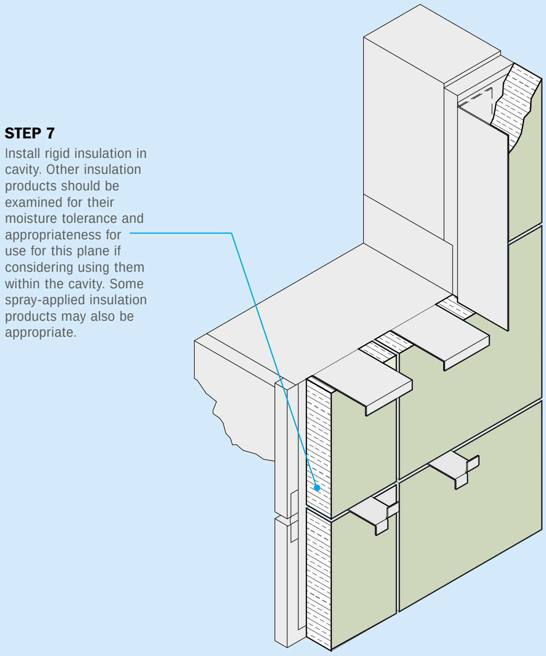
The *Building Envelope Design Guide* is being produced by NIBS to provide comprehensive guidance on the design and construction of high-quality, long-lasting enclosures for offices and other public buildings, such as courthouses and hospitals, under the purview of six federal agencies: the Army Corps of Engineers, the Naval Facilities Engineering Command (NAVFAC), the Air Force, the General Services Administration (GSA), the Department of Energy, and the Federal Emergency Management Agency. It is the first time ever that a group of federal agencies have joined forces to develop and rely on a single set of design and construction guidelines. Although intended to improve the performance of building envelopes within the public sector, the guide promises to be a great resource for architects and building owners within the private sector as well.

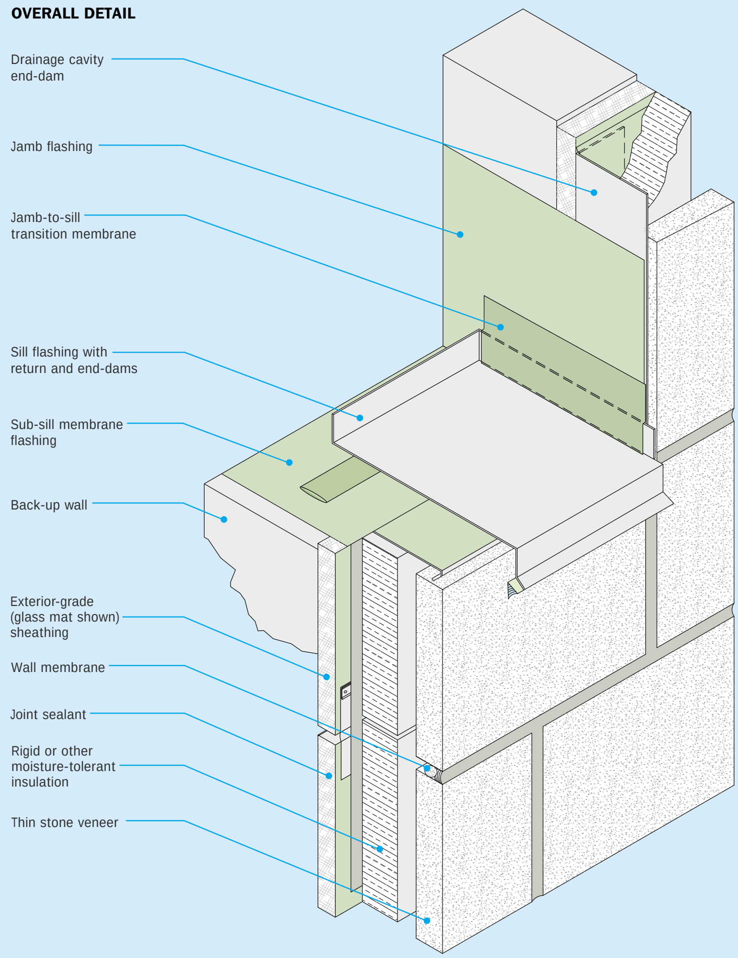
The guide will be a Web-based rather than hard-copy document so that it can be more easily accessed and searched by users and expanded and updated on an ongoing basis by NIBS. It will be one of a series of guides posted on a relatively new Web site called the *Whole Building Design Guide* (www.wbdg.org), which is provided by NIBS, with support from the NAVFAC Criteria Office, GSA, the Department of Energy's National Renewable Energy Laboratory, and the Sustainable Buildings Industry Council, to facilitate the dissemination of regulatory and technical information to the building community. The first version of the *Whole Building Design Guide* will be available, free of charge, on the *WBDG* Web site later this year.

The new guide builds upon an earlier one, called *Envelope Design Guidelines for Federal Office Buildings: Thermal Integrity and Airtightness*, which was developed for GSA by Andrew K. Persily of the National Institute of Standards and published in 1994. "The earlier guidelines are being rounded out, filled in, and updated," explains Wagdy Anis, AIA, director of technical resources at Shepley Bulfinch Richardson and Abbott, in Boston, and chair of the Building Environment and Thermal Envelope Council (BETEC), a long-standing NIBS committee whose mission is to encourage optimum energy use of buildings through a better understanding of how overall, complex building components interact with each other and with the environment.

The new guide consists of an introduction plus five chapters on below-grade construction (including the basement walls, foundation, and floor slab that divide the interior from the exterior environment); structural and nonstructural exterior walls; low- and steep-slope roofing; fenestration (windows and curtain walls); and atria. Discussions of each system will include a basic description; fundamental principles of design; appropriateness of applications in terms of building function and climatic conditions;

ILLUSTRATIONS: COURTESY FEDERAL BUILDING ENVELOPE GUIDE, DETAILS PREPARED BY WISS, JANNEY, ELSTNER ASSOCIATES





generic construction details in CAD format with extensive explanatory notes; a survey of significant current research and development; a summary of applicable codes and standards; and additional resources.

Each system will be examined in terms of material durability, maintenance, thermal performance, moisture protection, fire safety, acoustics, and—in the case of fenestration and atria—daylighting and visual qualities. In addition, the connections between any nonstructural components of the enclosure and the building structure will be addressed.

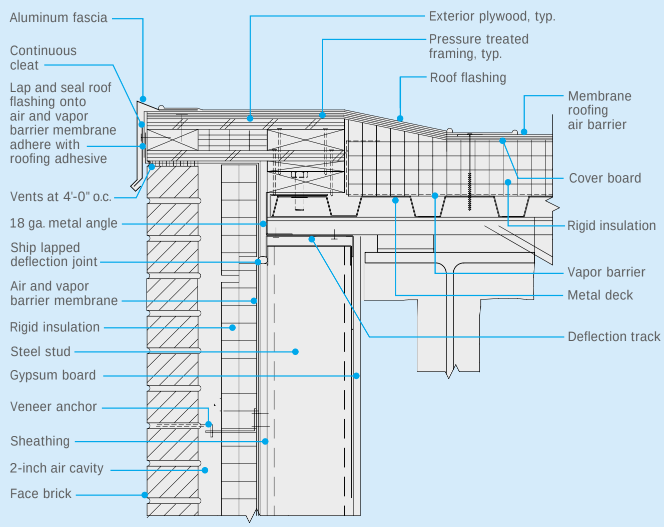
An accompanying series of papers will discuss sustainability; indoor air quality and mold prevention; HVAC integration; and the following safety issues: extreme wind; seismic activity; flood; blast attacks; and chemical, biological, and radiation (CBR) attacks.

Exterior enclosure commissioning process

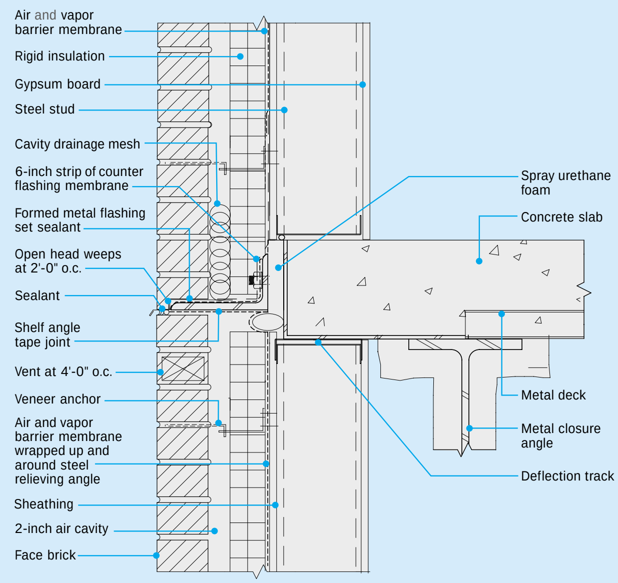
Meanwhile, on another front, NIBS is in the process of preparing a building-envelope commission guideline to be called *NIBS Guideline 3-2005: Exterior Enclosure Technical Requirements for the Commissioning Process.* This publication builds on—and is to be used in conjunction with—*ASHRAE/NIBS Guideline 0-2005: The Commissioning Process. Guideline 0-2005*, which outlines—without reference to a specific discipline—the basic procedures in the commissioning of any building component within a new or renovated project, was just approved in January by the ASHRAE board. A total of 14 guidelines, in addition to *Guideline 0-2005*, are anticipated to address the gamut of systems to be considered in a total building commissioning program.

Building commissioning is a systematic process of quality control through the predesign, design, construction, occupancy, and operations phases to assure that the owner gets a building that functions as intended. "The intent is to prevent errors before they occur," says Joseph J. Deringer, AIA, president of The Deringer Group in Berkeley, California, and chair of the NIBS Enclosure Commissioning Guideline Committee. Historically, commissioning had focused on the start-up of the mechanical system toward the end of the construction phase to assure that it was running properly and efficiently before handing the keys over to the owner. But as greater emphasis was placed on building performance as a whole, it became clear that such a quality-assurance program had to start at the beginning of a project and include other critical components, such as the building's skin, which is at the interface of so many environmental systems, from temperature and lighting to moisture control.

The body of the envelope commissioning guidelines will be general enough to address the basic process for all building types, sizes, functions, ownership structures, and delivery methods. To begin the



DETAIL AT ROOF EDGE



DETAIL AT FLOOR SLAB

The Massachusetts Board of Building Regulations and Standards asked BSA's Building Envelope Committee—the precursor to BEC-Boston—to develop a series of sample construction details in support of the state's commercial energy code, which had been revised to introduce, among other changes, requirements for air barriers within the building enclosure. The committee's task force, chaired by Wagdy Anis, AIA, of Shepley Bulfinch Richardson and Abbott, produced drawings of six common wall assemblies for educational purposes only. The designs assume exterior conditions typical of Massachusetts, and a maximum of 35 percent interior relative humidity in winter. Air-barrier continuity is emphasized.

process, for example, the owner or owner's representative should develop a comprehensive list of project requirements as early as possible in the building delivery process, preferably before design begins. These requirements will take into account the inherent trade-offs between quality and cost. The ASHRAE/NIBS guidelines call this the "Owner's Project Requirements," or OPR. The design team, in turn, responds to the OPR with the "Basis of Design," or BOD. In the case of the building envelope, the BOD typically includes a description of each exterior envelope system option considered, including subsystems, materials, and components; a description of the interaction of the building exterior enclosure system with other building systems; the reasoning for the selection of the final building exterior enclosure system; and documentation of related assumptions, calculations, codes, and standards that were used in this decision-making process.

With the OPR and BOD established, the project team then proceeds according to a methodical and transparent series of checklists, peer reviews, mock-ups, in-situ testing, documentation, and staff training at appropriate stages in the process in order to avoid any miscommunication or misconceptions among the various parties.

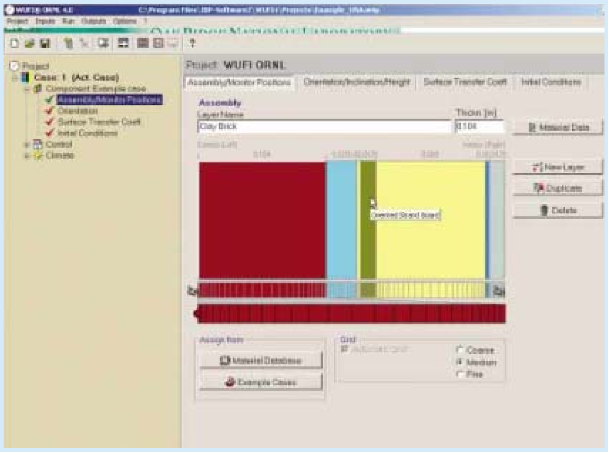
Deringer emphasizes that these guidelines do not require an outside commissioning agent: "It's okay if an architecture or engineering firm commissions its own projects, as long as the people who undertake the quality-control work are different from those who do the design."

An attached series of annexes will provide specific tools, delve further into certain key topics, and discuss issues pertinent to particular building projects. It is within the annexes that readers will be presented with actual case studies. The proposed annexes include:

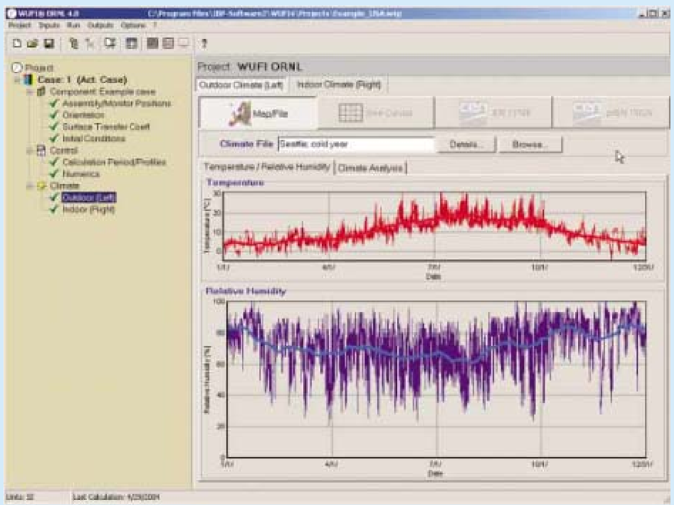
- Commissioning Process Flowchart
- Roles and Responsibilities of the Commissioning Team Members
- Owner's Project Requirements Checklist
- Basis of Design
- Exterior Enclosure Specifications
- Construction Checklists
- Systems Manual
- Integration Requirements
- Interference and Coordination with Other Systems
- Communications: What, When and Who
- Test Procedures and Data Forms
- Performance Criteria
- Example Calculation Procedures and Tools

The Enclosure Commissioning Committee, which includes architects, engineers, builders, scientists, and representatives from building-owner organizations, plans to have a draft available for public

ILLUSTRATIONS: COURTESY SHEPLEY BULFINCH RICHARDSON AND ABBOTT



***WUFI ORNL/IBP* is a one-dimensional transient heat and mass transfer simulation tool that has been designed to be easily understood and used. The model contains all of the physics needed to perform transient analyses of building envelope components. An extensive database of common building materials with the requisite material properties is accessed by simply selecting the required material from a listing (left). While the model is calculating the hourly heat and moisture flow through the selected building envelope component, a graphical image is updated to depict changes in energy flows and moisture accumulations.**



ILLUSTRATIONS: COURTESY OAK RIDGE NATIONAL LABORATORY

comment by summer. Once finalized later this year, the *Exterior Enclosure* guideline will be a voluntary NIBS document available from either ASHRAE or NIBS to encourage best practices in the industry.

Building enclosure councils

Last, but far from least, is the May 2004 agreement between the AIA and BETEC to establish a network of building enclosure councils (BECs) in major cities across the United States. These regional groups are designed to:

- provide a forum at the local level for those with an interest in building enclosures and the related discipline of building science;
- encourage discussion, training, technology transfer, and the exchange of information regarding local issues, including appropriate climatic factors;
- initiate dialogue among the design professions and between the designers and all other players in the building process, from contractors and product suppliers to developers and insurance companies;
- facilitate improvements in regard to inspection, approvals, regulations, standards, liability, and other issues or processes.

The new BECs, sponsored by AIA's Building Science Knowledge Community, will function as committees of their respective local AIA components. AIA will also host the councils' Web site (www.BEC-national.org). In addition, each local BEC president will become a BETEC board member. Says Anis, who is spearheading this national effort, "We are going to begin to populate BETEC with technically oriented architects."

BECs are up and running in Boston, Philadelphia, Pittsburgh, Dallas, Seattle, and Washington, D.C. And the formation of additional BECs is currently being considered for Denver, Minneapolis, Chicago, San Francisco, Houston, Atlanta, Miami, Los Angeles, New York, and St. Louis.

The regional councils are modeled after the Boston Society of Architects' Building Envelope Committee, which was founded in 1996 by Keleher, with the support of Anis. Keleher's own inspiration, in turn, had been a network of similar councils already operating in Canada. Because of their climate, explains Keleher, "The Canadians have to build very robust, high-performing enclosures." Keleher learned about this program while working with Canadians, and reasoned that it would be applicable in the States as well. After all, the basic principles of building science still need to be understood and appropriately applied by architects to achieve the most efficient high-performance envelopes in any climate. Although the winter in most parts of the U.S. is not as severe as in

Canada, this country has a wide range of climates—cold, mixed-humid, hot-humid, mixed-dry, and hot-dry—and these differences necessitate different envelope assemblies. It turns out, in fact, that some of the most egregious building-science failures, such as the mold problems in the Southeast, occur in the warmer climates in the U.S. [record, September 2004, page 171].

"I thought it was a fantastic idea," says Anis, who has focused his architectural career on the building enclosure and the science behind it. For years, building scientists have felt like they have been talking to themselves. And, until this new initiative, BETEC was largely populated by government and industry representatives, with a very minimal architectural presence. "It's really the architects who need to learn more and get on board because they detail the enclosures, and it is regarding the building enclosure where the lawsuits are flying," he adds.

Anis believes the regional BECs will provide architects with the opportunity to discuss locally driven conditions, such as the climate, codes, and readily available materials. The network will also offer a mechanism for individual designers to stay abreast of national and even international initiatives, research efforts, and innovative case studies from other comparable geographic zones and assist architects trained in one region when working on a project located in another. In addition, he envisions the establishment of a dialogue between the U.S. network and that of Canada and even Europe, so that Americans can learn from the experiences of their counterparts abroad.

To give a feel for what a BEC can accomplish, Keleher describes a few of the projects already undertaken by the original Boston committee. In 2001, for example, the local group developed a series of six sample wall details for the Commonwealth of Massachusetts's Board of Building Regulations and Standards (www.mass.gov/bbrs/sample_details.htm) in support of the state's revised Commercial Energy Code. This new version of the code, which took effect in 2001, introduced requirements for air barriers within the building envelope to prevent uncontrolled airflow through and within exterior walls, for the first time in the United States. The BEC-developed details illustrate appropriate relationships among insulation, vapor retarder, and air barrier within various assemblies for that region of the country.

And in 1999 and 2000, the BSA committee was the only logical forum of interested architects that BETEC could find to sponsor regional conferences on air barriers. The committee also sponsored a workshop that featured demonstrations of user-friendly design software that had been and continues to be developed collaboratively by scientists at the Fraunhoffer Institute in Munich, Germany, and at the U.S. Department of Energy's Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. Called *WUFI-ORNL/IBP* (relating to "Heat & Moisture Transfer in Building Envelopes"), the Windows-based simulation tool quickly ranks different wall designs for a particular location according to their propensity toward moisture-related problems and evaluates the drying potential of alternative wall assemblies. Now that BECs are popping up across the country, ORNL plans to provide similar workshops that discuss the free WUFI-ORNL software, and the building physics behind it, to other architects and building professionals eager to improve the quality of their building enclosures. ■

AIA/ARCHITECTURAL RECORD CONTINUING EDUCATION

INSTRUCTIONS

- **Read the article "High-Performing Envelopes Demand Know-How" using the learning objectives provided.**
- **Complete the questions below, then fill in your answers (page 254).**
- **Fill out and submit the AIA/CES education reporting form (page 254) or download the form at www.architecturalrecord.com to receive one AIA learning unit.**

QUESTIONS

1. Which is not one of the recent national efforts to improve building envelope performance?
a. the *Exterior Enclosure Technical Requirements for the Commissioning Process*
b. the *Building Envelope Design Guide*
c. the National Renewable Energy Laboratory
d. the formation of building enclosure councils

2. Which describes the *Whole Building Design Guide*?
a. a Web-based guide to disseminate technical and regulatory information
b. a document listing all federal guidelines for building design
c. a document for *Envelope Design Guidelines for Federal Office Buildings*
d. a Web-based guide for construction of high-quality public buildings

3. The purpose of the National Institute of Building Sciences is which?
a. to serve as a bridge between government and the private sector
b. to assure that mechanical systems function efficiently
c. to promote the advancement of high-performance envelopes
d. to assure owners get buildings that function as intended

4. The purpose of building commissioning is which?
a. to assure that the mechanical system functions efficiently
b. to assure that the owner gets a building that functions as intended
c. to improve the quality and efficiency of construction in the U.S.
d. to serve as a bridge between government and the private sector

5. Who should not perform the commissioning of a building?
a. the project designer
b. the same firm that designs the building
c. an outside commissioning agent
d. both a and b

6. The mission of the Building Environment and Thermal Envelope Council is which?
a. to prevent errors before they occur
b. to address the basic processes for all building types, sizes, and functions
c. to encourage optimum energy use of buildings through an understanding of how overall, complex building components interact with each other
d. to promote the advancement of high-performance envelopes

7. Building enclosure councils are composed of people from which group?
a. members of the BETEC
b. members of the NIBS
c. members of the AIA
d. members of the GSA

8. The goal of the building enclosure councils is which?
a. to make U.S. architects as knowledgeable as Canadian architects
b. to lobby the BETEC to limit lawsuits
c. to make sure only AIA members are on the BETEC
d. to put technically trained architects on the BETEC

9. The ORNL simulation software ranks wall designs by which?
a. their propensity toward moisture-related problems
b. the amount of uncontrolled airflow within exterior walls
c. the cost of wall assemblies
d. their efficiency at keeping exterior air out

10. In the exterior enclosure commissioning process, the BOD includes which?
a. a description of each exterior envelope system option considered
b. a comprehensive list of project requirements
c. actual case studies of buildings
d. roles and responsibilities of the commissioning team members