EF 7: MINIMIZE AIR LEAKAGE THROUGH BUILDING EXTERIORS

ANSI/ASHRAE/IESNA 90.1 (2007) and Energy Conservation Construction Code of New York State, as incorporated in Chapter 13 of the New York City Building Code
This proposal was developed by the Energy & Ventilation Committee.

Summary

Issue:
Energy code requirements for air barriers are insufficient to prevent air leakage both in and out of buildings. An effective air barrier permits controlled levels of ventilation, prevents drafts, lowers heating loads and contributes to overall energy savings.

Recommendation:
Strengthen the energy code to include requirements for more-effective air barriers.

Proposed Legislation, Rule or Study

Amendments to ANSI/ASHRAE/IESNA 90.1 (2007), as incorporated in Chapter 13 of the New York City Building Code:

1. Amend Section 5.4.3.1 as follows:

5.4.3.1 Building Envelope Sealing. [The following areas of the building envelope shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:

a. joints around fenestration and door frames
b. junctions between walls and foundations, between walls at building corners, between walls and structural floors or roofs, and between walls and roof or wall panels
c. openings and penetrations of utility services through roofs, walls, and floors
d. site-built fenestration and doors
e. building assemblies used as ducts or plenums
f. joints, seams, and penetrations of vapor retarders
g. all other openings in the building envelope]

Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

5.4.3.1.1 Continuous Air Barrier. Except in unheated structures and as permitted by this section, a continuous air barrier shall be installed and shall have all of the following characteristics:

a. continuous throughout the building envelope with all joints and seams sealed and with sealed connections between all transitions in planes and changes in materials and at all penetrations
b. joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components
c. installed in accordance with the manufacturer’s instructions and in such a manner as to achieve the performance requirements as contained in Section 5.4.3.1.2
d. penetrations of the continuous air barrier shall be made in a way such that the integrity of the continuous air barrier is maintained

5.4.3.1.2 Requirements for Continuous Air Barrier. The continuous air barrier must meet one of the following three criteria:

a. Materials. Using individual materials whose air permeability shall not exceed 0.02 L/s·m² under a pressure differential of 75 Pa (0.004 cfm/ft² under a pressure differential of 0.3 in. water (1.57 lb/ft²)) when tested in accordance with ASTM E2178.
b. Assemblies. Using assemblies of materials and components whose average air leakage shall not exceed 0.2 L/s·m² @ 75 Pa (0.04 cfm/ft² under a pressure differential of 0.3" w.g. (1.57 psf)) when tested in accordance with ASTM E2357 or ASTM E1677. In addition these assemblies must meet the requirement for joints per Section 502.4.3.

3. Building. Demonstrating through testing that the air leakage rate of the completed building envelope shall not exceed 2.0 L/s·m² @ 75 Pa (0.40 cfm/ft² at a pressure differential of 0.3" w.g. (1.57 psf)) in accordance with ASTM E779 or an equivalent approved method.

5.4.3.1.3 Moisture Control. All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7x10⁻¹¹ kg/Pa.s.m²²) or less, when measured in accordance with the desiccant method using Procedure A of ASTM E96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

Exceptions:

a. Construction where moisture or its freezing will not damage the materials.

b. Where the department approves other means to avoid condensation in unventilated framed walls, floors, roofs, or ceiling cavities.

Amendments to the Energy Conservation Construction Code of New York State, as incorporated in Chapter 13 of the New York City Building Code:

1. Amend Section 402.4.1 as follows:

402.4.1 Building [thermal] envelope. [The building thermal envelope shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The following shall be caulked, gasketed, weatherstripped, or otherwise sealed with an air barrier material, suitable film or solid material:

1. All joints, seams, and penetrations
2. Site-built windows, doors, and skylights
3. Openings between window and door assemblies and their respective jambs and framing.
4. Utility penetrations
5. Dropped ceilings or chases adjacent to the thermal envelope.
6. Knee walls
7. Walls and ceiling separating a garage from a conditioned space.
8. Behind tubs and showers on exterior walls.
9. Common walls between dwelling units.
10. Other sources of infiltration. ]

Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

402.4.1.1 Continuous Air Barrier. Except in unheated structures and as permitted by this section, a continuous air barrier shall be installed and shall have all of the following characteristics:

1. Continuous throughout the building envelope with all joints and seams sealed and with sealed connections between all transitions in planes and changes in materials and at all penetrations;

2. Joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components;

3. Installed in accordance with the manufacturer’s instructions and in such a manner as to achieve the performance requirements as contained in Section 402.4.1.2; and
4. Penetrations of the continuous air barrier shall be made in a way such that the integrity of the continuous air barrier is maintained.

402.4.1.2 Requirements for Continuous Air Barrier. The continuous air barrier must meet one of the following three criteria:
1. Materials. Using individual materials whose air permeability shall not exceed 0.02 L/s·m$^2$ under a pressure differential of 75 Pa (0.04 cfm/ft$^2$ under a pressure differential of 0.3 in. water (1.57 lb/ft$^2$)) when tested in accordance with ASTM E2178;
2. Assemblies. Using assemblies of materials and components whose average air leakage shall not exceed 0.2 L/s·m$^2$ @ 75 Pa (0.04 cfm/ft$^2$ under a pressure differential of 0.3" w.g. (1.57 psf)) when tested in accordance with ASTM E2357 or ASTM E1677. In addition these assemblies must meet the requirement for joints per Section 502.4.3;
3. Building. Demonstrating through testing that the air leakage rate of the completed building envelope does not exceed 2.0 L/s·m$^2$ @ 75 Pa (0.40 cfm/ft$^2$ at a pressure differential of 0.3" w.g. (1.57 psf)) in accordance with ASTM E779 or an equivalent approved method.

402.4.1.3 Moisture Control. All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7x10$^{-11}$ kg/Pa.s.m$^2$) or less, when measured in accordance with the desiccant method using Procedure A of ASTM E96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

Exceptions:
3. Construction where moisture or its freezing will not damage the materials
4. Where the department approves other means to avoid condensation in unventilated framed wall, floor, roof, ceiling cavities.

Supporting Information

Issue - Expanded
A well-sealed building plays an important role in energy savings. Preventing the flow of cold winter air and warm summer air into a building reduces the amount of energy needed to condition the space. When the leakage occurs around a window frame, the increase in heating and cooling is direct. When it occurs through an opaque wall, infiltration can also result in a reduction in the effective R-value of the insulation. A good air barrier can lessen these heat losses and lower fuel use.

However, traditional buildings relied on air leaks to ensure adequate ventilation. Increased building tightness can result in inadequate air exchange if pursued without regard for other building systems. A tight envelope must be combined with correct design and operation of mechanical ventilation to insure adequate indoor air quality.

An air barrier is made of a material that is specifically permeable to water vapor, while preventing the flow of liquid water or air. A vapor barrier, conversely, is impermeable to the passage of any of these substances. Vapor barriers can consist of metal foil or solid polymer films (such as polyethylene), while air barriers are made from microscopically porous films engineered to permit the passage of water vapor (e.g., Tyvek). The theoretically optimal design for a building in the New York City climate zone will have an impermeable vapor barrier on the interior to prevent the flow of moist, heated air into the wall cavities in winter, and an air barrier under the exterior cladding to keep drafts and liquid water out of the wall cavities. If quantities are small, any moisture that does accumulate in the wall cavities can evaporate out through the air barrier when heated in summer.

However, when there is a large difference between inside and outside temperatures, any air infiltration into walls through leaks in the barriers in the interior in winter can result in moisture condensation. Likewise, contaminants from outside and from within the walls can also be brought into the interior via air infiltration. A correctly installed air barrier can prevent this flow and these effects, but errors in installation or subsequent damage can cause leakage, giving rise to problems.

For these reasons, and because there may be limitations in the skills available at the job site or other difficulties, it may not be practical to execute the requirements we propose exactly as written. This proposal includes a substantial exception, allowing the designer to propose an alternative method to control the migration of water vapor, as long as it is approved by the Department of Buildings.

Environmental & Health Benefits
Reduced energy use will result in increased energy efficiency and reduced greenhouse gas emissions. Reduced drafts inside the building will increase comfort, and lower the risk of colds and long-term breathing ailments.
Research conducted at Oak Ridge National Laboratories, the Canadian Mortgage Housing Corporations, Sweden and Germany has found that controlled air flow reduces moisture problems such as corrosion, deterioration, and the growth
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of mold, mildew and fungus. Air flow has the ability to transport substantially more moisture into and through the building enclosure system than occurs through vapor migration.1

This proposal was found to have a low, positive environmental impact per building and to impact a large number of buildings. It was thus given an environmental score of 2.

This proposal was found to have a positive, indirect health impact.

Cost & Savings
As described in the Executive Summary, Bovis Lend Lease prepared cost estimates for each Task Force proposal in the context of well-defined construction projects in specific buildings. Where possible, members of the Technical Committees prepared savings estimates for some of these projects and buildings. These cost and savings estimates are presented in the February 1st draft version of Appendix A. The innate uncertainty in how construction and operation will vary from one building to another, the complexity of the Task Force proposals, and the wide range of applications in which the proposals may be realized mean these figures are truly estimates.

This proposal was estimated to increase first capital costs by 0.10% to 1.5%, depending on building type. It was thus categorized as incurring a medium to higher capital cost increment. This proposal was also estimated to generate financial savings that will pay for the capital costs in three to ten years for some building types.

Precedents
There are several related sections already in place within New York City and New York State codes:

Relevant NYC BC Entries:
1403.2 Weather protection. Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing, as described in Section 1405.3. The exterior wall envelope and its drainage system shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior veneer, as described in Section 1404.2 and a means for draining water that enters the assembly to the exterior of the veneer, unless it is determined that penetration of water behind the veneer shall not be detrimental to the building performance. Prevention against condensation in the exterior wall assembly shall be provided in accordance with the New York State Energy Conservation Construction Code.
1403.3 Vapor retarder. An approved vapor retarder shall be provided.

Relevant NYS ECCC item:
The following item from the NYS ECCC was incorporated into these modifications of ASHRAE 90.1 since 90.1 does not include a comparable section on moisture control.

802.1.2 Moisture Control. All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7x10^-11 kg/Pa.s.m²) or less, when measured in accordance with the desiccant method using Procedure A of ASTM E96. The vapor retarder shall be installed on the warm-in-winter side of the insulation. (2 exceptions)

The NYS ECCC now contains the first paragraph of the addition proposed above:

“802.3.3 Sealing of the Building Envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.”

But the NYS ECCC lacks the succeeding three detail sections. 802.3.3 and those three detailed sections are currently scheduled to be included in the 2009 NYS ECCC, numbered as 502.4 due to reorganization. However, the future of the 2009 NYS ECC is currently uncertain.

MA Energy Code:
This proposal (except moisture control) is essentially the same as language that has been adopted and implemented in Massachusetts since 1995.

NIST Study
There are considerable energy, comfort and cost savings to be realized by providing air barriers in commercial buildings, as substantiated by the NIST study cited below. Further, there is a great deal of support from the ABAA and materials manufacturers, as well as several different types of air sealing materials and dozens of products to address the market.2
LEED
An air barrier could qualify as an energy-saving system under the EAc1 “Optimize Energy Efficiency.”

Implementation and Market Availability
There are no known implementation issues for this proposal. Air barriers are readily available and in widespread use.

ENDNOTES:

1 Air Barrier Association of America, Upcoming Events, http://www.airbarrier.org/events/index_e.php (last visited Jan. 28, 2010).