High Performance

By Tony Woods

Cutting Energy Demand and Consumption

Many energy managers either ignore, or pay little attention to, the potential cost savings that can be obtained from a better building envelope. From experience they know that measures such as insulation and windows have very long paybacks. When they are presented with a proposal to repair or upgrade the envelope they usually lose interest as soon as they find out the company making the proposal can't support the measures with documented savings.

Fortunately, this is changing. Proof showing that envelopes retrofitted to perform better will actually reduce energy demand and consumption, is now readily available. What's more, many envelope repairs or upgrades make significant contributions in "non-energy" areas. Many retrofits are initiated because building owners and managers want to improve thermal and other perceived comfort levels for their occupants. Such expenditures can now be justified based on expected energy cost savings, and can be supported by actual case studies. Some managers are finding that the upgrades can lengthen a building's life expectancy and improve esthetics.

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High-rise apartment savings

A detailed before-and-after study of two electrically-heated high-rise apartment buildings (one 10-storey in Toronto, one 21-storey in Ottawa), assesses the impact of envelope improvement measures on energy and peak demand requirements.

The areas of the envelope that were upgraded included windows, exterior doors, baseboards, shafts and several vertical penetrations (see Table 2). Windows and doors were re-weatherstripped using top-of-the line industrial quality retrofit weatherseals and baseboards, service penetrations and other holes were made airtight using various polyurethane foam and caulking materials. The results are startling.

Peak space heating demand was reduced by 4W to 7W per square meter of floor space and heating energy consumption was also cut by 7.5kWh to 11.5 kWh per square meter per year (see Table 1). Additional tests showed that there was no negative impact on comfort or air quality in either building. Payback on the retrofit was between four and six years.

The object was to reduce the energy waste and comfort problems associated with stack effect. This phenomenon occurs in buildings with air leakage both at ground level and at the top. Wind, mechanical systems and temperature differences create a convection current which causes an inflow of air at the bottom of the building. The air is then sucked upwards in the natural chimney formed by the building itself. It exits typically through elevator shafts and leaky rooftop mechanical penthouses.

No energy savings without a high-performance envelope

Envelope upgrades may be the least understood energy-saving opportunity that a building owner has to assess. The technology, however, is surprisingly simple. You pay money to condition air inside a building; if leaks in the envelope allow that conditioned air to be replaced too quickly by unconditioned air, you waste money. What is needed is an air barrier system

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that performs properly. And properly means that it is impermeable, continuous and durable enough to give you greater control over the movement of conditioned air.

Energy savings from an envelope upgrade can only be obtained if the shell of the building has been retrofitted to perform as a more complete system. Simply repairing a few holes or leaks is not enough, because air will simply find another way to go where it shouldn't. As energy managers become more familiar with the concept of air barrier systems and aware of the documented savings others have achieved, they are connecting the two and investing in a high performance building envelope in order to reduce air leakage and reduce their energy costs.

Air leakage: the largest source of heat loss or gain

It is worth noting that continuity of the air barrier system is now entrenched in the Canadian Building Code, one of the few jurisdictions in the world which mandates a continuous air barrier system in new construction. The air barrier system exists to control air leakage – which has been shown to represent the single largest source of heat loss (or gain) through the envelopes of nearly all types of building.

Tests carried out by the National Research Council of Canada (NRCC) on high-rise and low-rise buildings have shown that 30 to 50 per cent of heat loss can be attributed to air leakage.

If we look at a typical multi-storey commercial building, we see how an HVAC system provides conditioned air and satisfies ventilation requirements. In most high-rise buildings, mechanical ventilation counteracts the flow of air leakage through the envelope by keeping a slightly positive indoor air pressure. This approach results in a loss of conditioned air through the envelope's air leakage paths. The consequence:

- ❑ energy used to condition the air has been wasted, and
- ❑ moisture is deposited in the envelope, causing deterioration.

According to both the ASHRAE Handbook and NRCC findings, this loss significantly contributes to a

	Peak Demand		Energy Consumption During Heating Season (kWh)			
	Before Air Sealing (kW)	After Air Sealing (kW)	Difference in Demand (kW)	Percent Reduction	Difference in Energy (kW)	Percent Reduction (kW)
Building A *(21-Storey)*	772	687	85	11.0%	165	12.0%
Building B *(10-Storey)*	496	454	42	8.5%	63.3	6.5%

Table 1: Summary of measured energy consumption before and after air sealing of two high-rise apartment buildings

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Windows	38kW	42%
Exterior Doors	22kW	28%
Shafts	11.6kW	14%
Miscellaneous	10kW	12%
Remainder of Building Envelope	1.6kW	2%

Table 2: Potential peak demand reductions from specific air leakage control measures in two high-rise apartmentbuildings

Right:

A twenty-year-old 21-storey seniors' apartment building in Ottawa.

Below:

(Bridleview) is a twenty-year-old 10-storey condominium in Scarborough, Ontario

building's total energy requirements. One study published by Public Works and Government Services Canada (PWGSC) showed that, in a whole building air tightness test, a 17-storey office building (Brooke-Claxton - 19,730 square meters floor area), the exhibited an improvement in air tightness by 37 per cent. The improvement was due to window weatherstripping, caulking and sealing vertical shafts from inside.

In another example, the exterior metal panel of a 20-storey, 12,800 square meter floor area, office building (Dunton Tower) was replaced with a curtain-wall cladding system. This remodeling improved air tightness by 43 per cent and reduced the annual energy consumption by more than 11 per cent.

Ways to improve building envelope performance

Typically, specialist contractors control air leakage, and therefore improve building envelope performance, by sealing gaps, cracks and holes with appropriate materials and systems. The aim is to create a continuous plane of air tightness which will encompass the complete building envelope. Floors will be decoupled from each other to prevent vertical leakage and other areas of the building will be compartmentalized to help equalize pressure differences. The priorities for sealing to prevent stack effect are: top and bottom of the building first, then the shafts, then the outer shell.

Permanently disconnected load is a term used by utilities for electrical saving measures which qualify for demand side incentives. It also describes what can be achieved with a building envelope upgrade. Successfully control air leakage and

you permanently reduce demand for heating, cooling, etc. It is a measure whose performance cannot be changed by the lifestyle of the occupants – unless they choose to blast holes in the wall, of course.

Special air leakage control materials are available to improve the energy efficiency of buildings. To deliver savings, these materials must qualify as components of a high performance air barrier system, and they must do so at the lowest possible cost.

Performance requirements for an air barrier component include:

- Continuity throughout the building envelope.
- Ability to fasten to supporting structures (self-adhesive).
- Ability to resist peak wind loads, sustained stack effect, and pressurization from ventilation equipment.
- Virtual air impermeability
- Durability and long service life.

In most instances, geographical location and indoor environmental requirements are not the major causes of air leakage. Worst areas for leakage typically include mechanical penthouses, soffits, parapets, punched windows, overhang parapets, doors, links connecting below grade areas to other buildings and joints between one system and another. Reductions in peak demand that can be expected from a complete envelope upgrade are summarized in Table 1, which was calculated from the results of the before-and-after tests on the two high-rise apartment buildings.

Other examples of energy-saving successes with high-performance envelopes include many schools in the province of Ontario. John Rankin, a former Chief Architect with the province's Ministry of Education, reported the average payback within the school system for air sealing measures to be approximately two years.

A recently completed Honeywell energy performance contract for the Muskoka Board of Education, Ontario, produced considerable savings. Retrofit work, included, among other things, sealing of air leaks. Results varied from school to school. In one school, where there was an accompanying lighting retrofit, the air sealing more than made up for the increased heating load caused by the lighting reduction. Where air sealing was the only measure taken, for example in the Gravenhurst High School, the natural gas bill for heating was reduced by $4,893 in the two coldest months, for a saving of 33 per cent. The cost of the work was $6,740.

Making more accurate predictions for the future

Accurate predictions are becoming easier. Some years ago, the air leakage control industry made many unsubstantiated claims, but today a variety of predictive programs are being used with greater success. These include the modified Public Works Canada EC 128 and the Air Leakage Control Assessment Procedures (ALCAP) originally developed by Ontario Hydro. Wise energy managers will look for more proven savings. When these are added to the non-energy benefits such as comfort, durability and indoor air quality. We can expect to see a great deal more of the high performance building envelope.

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