The HVAC/Building Envelope Connection

By Tony Woods, Former President, Canam Building Envelope Specialists Inc.

Should property managers know about the relationships going on in their buildings? Yes, when they can affect indoor air quality, occupant comfort and energy costs. The way in which your HVAC system and building envelope relate to each other is critical.

The interaction between a heating, ventilation and air conditioning system and the building envelope directly affects the health, safety, durability, comfort and energy efficiency of the building.

Understanding this relationship is key to taking measures that will improve a building's health, safety, durability, comfort and energy efficiency. According to Rick Quirouette, B. Arch., of Quirouette Building Specialist Ltd, Ottawa, air leakage through the building envelope can lead to condensation and moisture damage in hidden cavities, rain penetration, poor indoor temperature and humidity control, unnecessary heat loss in winter or heat gain in summer.

Air leaks directly through roofs and exterior walls, but most often it travels through the joints of assemblies such as roof/wall junctions, parapets, low level soffits, the intersections of different cladding systems, and through numerous internal vertical and horizontal pathways.

Two conditions are needed for air to leak. First there must be a hole, gap, crack or leak from one side of the envelope to the other. Second, there must be an air pressure difference.

There are three principal causes of air pressure difference: wind, stack effect and the HVAC system.

Wind pressurizes the windward side of the building and depressurizes the back, sides and roof. It can account for up to 25% of total leakage...and it cannot be controlled, only reduced by plugging the holes in the envelope.

Stack or chimney effect is a buoyancy phenomenon where warm inside air rises through the building and exerts continuous pressure against the roof and upper parts of the exterior walls. The resulting lower pressure at the bottom of the building sucks in air.

Build tight; ventilate right

The third pressure comes from the mechanical system itself. Mechanical engineers, and on-site managers, often choose to bring in makeup air to increase pressure and overcome this infiltration at the base of the building. Unfortunately, this increases pressure at the top, causing greater exfiltration problems in that area. This overpressurization at the top of the building cannot be controlled at the same time as controlling infiltration at the base of the building. The only solution is to seal air leaks at the top and the bottom of the building.

Better building techniques, especially tighter building envelopes, play an important role in improving health, safety, durability, comfort and energy efficiency. These techniques can only achieve the desired goal if they are accompanied by new approaches to ventilation. Think of it this way: 'Build tight; ventilate right.'

A mechanical engineer who fails to ask about a new building's proposed level of air tightness, says Quirouette,

often creates a ventilation design that causes excessive indoor pressure. This excessive pressurization causes condensation or moisture damage within building envelope cavities.

Failure to understand the relationship between mechanical systems and the building envelope causes other indoor air quality and comfort issues. When owners and tenants complain of dry indoor conditions, annoying static electricity and poor indoor air temperature control in winter, the building is leaking too much air. When indoor humidity and temperature are not comfortable during warm summer days, this is generally because excessive heat and moisture loads represent too great a load for the cooling equipment. Again, leaking air causes this excess heat and moisture.

The common solution is to use ventilation to improve comfort conditions. Such strategies do not improve energy efficiency and do not prevent moisture damage. Upgrading the air tightness of a building, however, can always improve comfort, increase energy savings and extend building durability at the same time, and at reasonable cost, says Quirouette.

Wagdy Anis, a principal and Director of Technical Resources at Shepley Bulfinch Richardson and Abbott, a major Boston architectural firm, is a leader among a growing group of architects demanding a new approach to these problems. In the ASHRAE Journal, December 2001, in his article *The Impact of Airtightness on System Design*, he concluded that the building envelope is designed by architects who, most of the time, do not realize the interaction between the envelope and the mechanical system. It is then built by many contracting trades to what they think is required by the design, without particular concern for air tightness. For this reason an informed collaboration is essential between all, particularly when the desired result is the air tightening of the building envelope.

Show us the money. . . real energy cost efficiency

Of the five improvements described: health, safety, durability, comfort and energy efficiency, the last one, which can be measured in dollars, can be a property manager's trump card. Safety is a must, tenant complaints are a pain, but reduced energy costs that deliver 'soft' benefits can sometimes get P.O.s issued fast.

Proof of the connection between a retrofitted building envelope and reduced HVAC operating costs is available from many documented projects. Simple air sealing of roof/wall joints in single-story Toronto public schools in the seventies delivered 17% average electricity cost reductions. Perimeter air sealing of high rise apartment buildings in Ottawa and Toronto showed an average of more than 10% reduction in electrical demand and about 9% reduction in electricity consumption. Recently, a project to improve smoke control and thermal comfort at Forest Laneway, a large North Toronto apartment complex, delivered unexpectedly large energy cost savings.

'Payment by results' energy efficiency projects in the eighties also demonstrate the financial benefits of understanding the envelope/HVAC relationship. Performance contractors and ESCOs quickly accepted the real contribution that can be made by a high performance building envelope. Engineers working for these new companies focused on what would get the 'biggest bang for the buck.' They arrived at the planning table with no-surprise strategies such as heat pumps, high efficiency boilers, building automation, and perhaps heat recovery. Fortunately, they quickly realized proven savings from building envelope upgrades.

The concept was simple: If 'the envelope is tight and the ventilation right,' the heating and cooling systems can be downsized and control system can do its job more efficiently.

How do you improve the building envelope?

Sealing air leaks in any kind of building has to start with an assessment. Cracks, gaps, leaks and holes are easily made visible with an air leakage detector or

smoke pencil. Sometimes a large-scale depressurization fan is used to create negative pressure in the building and increase the visibility of leaks. In some instances, infrared thermography from outside the building can show patterns of air leakage. Energy saving potential is analyzed using EC 128/ALCAP software.

Once the air leakage pathways have been identified throughout the building, including their exit and entry points, the building envelope specialist can prepare the air barrier continuity plan. This addresses air sealing in

five critical areas. First, the top of the building; second, the bottom; third, the vertical shafts; fourth, the outside walls and openings; and finally compartmentalizing by sealing internal horizontal air leaks.

Examples of typical pathways that need to be sealed include:

Top of the building:

- Roof/wall intersections
- Mechanical penthouse doors and walls
- HVAC equipment
- Various roof penetrations

Bottom of the building:

- Underground parking access doors
- Exhaust and air intake vents
- Soffits and ground floor access doors
- Pipe, duct, cable and other service penetrations into core of the building
- Sprinkler hanger penetrations, inspection hatches and other holes
- Core wall to floor slab

Vertical shafts:

- Stairwell fire doors
- Fire hose cabinets
- Plumbing, electrical, cable and other penetrations within service rooms
- Elevator rooms, cable holes, door controller cable holes, bus bar openings
- Garbage chute perimeter and access hatches
- Hallway pressurization grill perimeters
- Elevator shaft smoke control grill
- Service shafts

Outside walls and openings:

- Weatherstripping on windows, doors, balcony and patio doors
- Window trim
- Exhaust fans and ducting
- All service penetrations
- Baseboard heaters
- Electrical receptacles
- Baseboards

Compartmentalization:

- Vented mechanical rooms
- Garbage compactor room
- Emergency generator room
- High voltage rooms
- Shipping docks
- Elevator rooms
- Workshops

Conclusion

A high performance, functioning building envelope is vital to the effective, efficient operation of an HVAC system. The success of both is vital to the health, safety, durability and energy cost-efficiency of the building and the comfort of its occupants.

About Canam Building Envelope Specialists Inc. *Canam Building Envelope Specialists Inc. is an affiliate of the Tremco Roofing & Building Maintenance Division of Tremco Incorporated. Canam offers a comprehensive range of environment and energy related services in all types of buildings. These include insulation, ventilation, air leakage control, air tightness and window testing, auditing and total tune-ups.*

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