The Dangers of Uncontolled Air Flow

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The truth is that just about every building does it — high-rise, low-rise, office or residential, it makes no difference — they actually pull in air at the bottom and let it out the top and sides. If you have ever noticed that parts of your building are draftier than others, that people on the 10th floor can smell second-hand cigarette smoke from the 5th floor, that there's a whistling sound in the elevator lobby, that the outside trim on the upper floors is beginning to deteriorate or that static electricity is a real problem on cold windy days, it's almost certainly because your building pulls in unwanted air.

This phenomenon is called stack, or chimney, effect and is the cause of many of the everyday problems which occupants complain about to building owners and managers.

Why does that matter? It matters because buildings that suffer from uncontrolled air flow cost more money to heat and air condition, are drafty and uncomfortable, have poorer quality indoor air, deteriorate faster, and generate more occupant complaints than buildings where air leakage is properly controlled.

Can't Take The Pressure

Stack effect is usually accompanied by two other effects, wind and ventilation, that change pressure in the building and cause uncontrolled air flow. (See Fig. 1). None of this could take place without leaks, cracks, gaps and holes in the shell or envelope of your building — if you don't believe it, try sucking through a straw with your finger tightly over the end. Unfortunately, most of our buildings are full of different kinds of holes, which encourage these effects, and eventually make your building a less pleasant place to occupy than it should be.

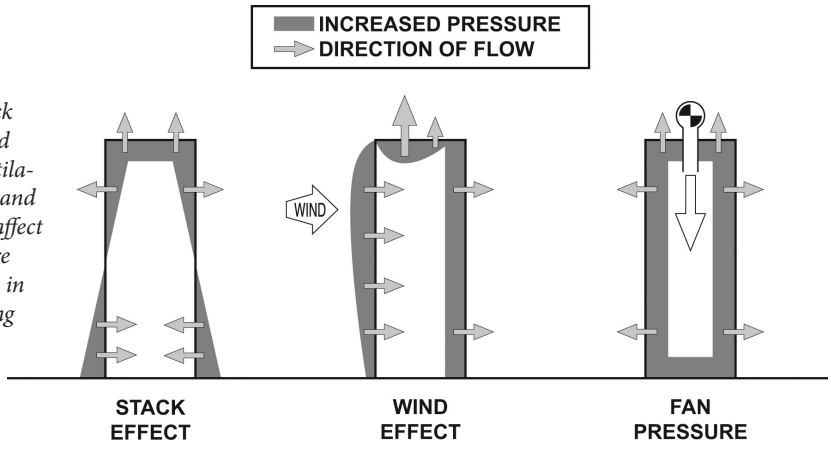

Fig.1: *Stack effect, wind effect, ventilation effect and how they affect air pressure differences in the building envelope.*

All these problem effects happen because of uncontrolled air leakage, which building envelope specialists define as 'uncontrolled migration of conditioned air through the building envelope.' In a typical multi-story commercial building, an HVAC system provides conditioned air and satisfies ventilation requirements. All other movement of air in and out of the building is uncontrolled.

More than a decade ago, Rick Quirouette, a building science consultant with Quirouette Building Sciences, documented how stack and the other problem effects make buildings 'poor performers.' He wrote that air leakage through the openings in a building envelope is caused by air pressure difference caused by one or more of the three effects: stack, wind and ventilation.

Stack effect results from warmer inside air rising to the top of the building where it exfiltrates through available holes. In a high-rise building, these could be elevator shafts or the walls and doors of the mechanical penthouse. In a single-family dwelling it could be the potlights on the second floor! Just as important are the holes at the bottom that make the airflow possible. In a high-rise these could be ground level entrance doors, or even the ramp to the underground parking.

Wind causes infiltration on the windward side of a building and exfiltration on the leeward and sides parallel to the wind direction by changing the balance of air pressure inside the building. Ventilation air provided by fans, whether set to introduce fresh air or exhaust stale air, also causes air pressure difference. Alone, or in combination, the three effects add up to a sucking effect in the building.

High Energy Costs, Poor Indoor Air and Structural Deterioration

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 results in a loss of conditioned air through the envelope's air leakage paths. The result: (1) the energy used to condition the air has been wasted, and (2) moisture is deposited in the envelope, causing deterioration.

The ASHRAE Handbook states that air leakage in a high-rise commercial building typically represents 15 to 30% of the building's thermal load, or roughly 4 to 8% of the total energy requirement.

As stack effect causes air to rise through the building, humidity, corrosives and contaminants, which are always present, do untold damage to everything they touch as they look for and find ways to exfiltrate through leaks in the upper half of the building. What they touch can include insulation, brickwork, cladding and decorative facing. As corrosion and decay progress, the integrity of the structure is weakened and its life expectancy is reduced.

For the building owner, the economic cost of decaying building materials is very high. The life of an expensive building can be shortened, maintenance costs increased and, most seriously from a liability point of view, the safety of people passing by who might be hit by pieces of the building falling off.

In the unfortunate event of a fire, stack effect truly comes into its own, fuelling the vertical spread of flames and smoke. Aesthetically, the appearance of a building often shows the tell-tale scars of air leakage. These are visible as efflorescence, water stains, flaking bricks, rust streaks, large holes in masonry and cracked and peeling finishes.

Strong drafts caused by stack effect can be unpleasant and sometimes dangerous. During the winter, leaky buildings often feature low humidity levels, which have been shown to affect comfort, morale, health and even absenteeism. One study shows that airborne bacteria, viruses and fungi all become more evident when relative humidity remains below or above the 40 to 60% range for extended periods of time.

Repairing the Leaks

According to John Gibson, an Edmonton energy conservation consultant and former mechanical contractor, tight envelopes are the best solutions to stack effect and wind pressure. If air cannot leave the top of a building, he says, it will not enter the bottom. The mechanical system should not be used to try to overcome problems caused by poor envelope design and construction. Pressurizing buildings in attempt to counteract stack effect wastes energy.

So how can you make the building tight, and how can you justify the expense? Specialist contractors control air leakage by sealing gaps, cracks and holes with appropriate materials and systems. Their aim is to repair or create a continuous plane of airtightness, known as the air barrier system. This will encompass the complete building envelope. The priorities for sealing to prevent stack effect are: top and bottom of the building first, then the shafts, then the outer shell. 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.

Several buildings have been repaired in this way and the results documented. Typically, energy demand and consumption is reduced. In addition, these 'building envelope upgrades' make significant contributions in 'non-energy' areas. Many retrofits are cost justified simply because the building owner/managers want to improve thermal and other perceived comfort levels of the occupants in order to stop complaints. Such expenditures can also be justified based on expected energy cost savings supported by actual case studies.

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.