The Last Frontier of Building Systems: The Envelope & Structure

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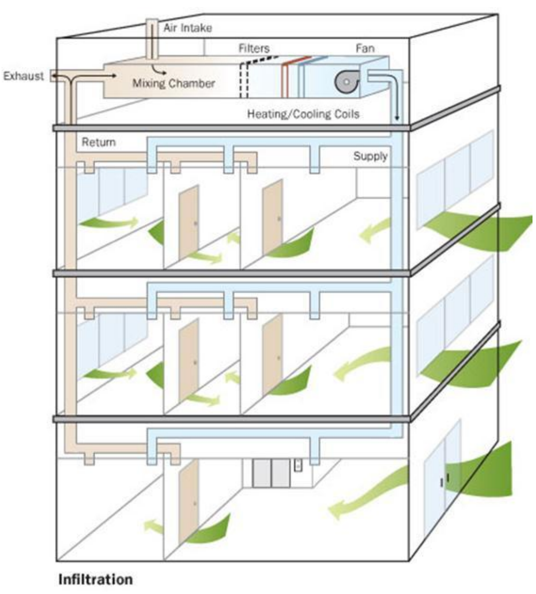
"*There exist limitless opportunities in every industry. Where there is an open mind, there will always be a frontier.*"
Charles F. Kettering, American engineer

For those most familiar with HVAC controls, lighting controls, security systems, IT networks, specialty systems, etc., the monitoring of steel, concrete and other inert materials as opposed to active equipment may sound a bit ridiculous or unnecessary. However, once you start to think about the effects of the building envelope on occupants and the internal building systems and the effects of the outside environment on the integrity of the envelope and structure, you will wonder why we're not also monitoring the envelope. Building envelopes have several functions: they protect occupants from adverse weather, let light into the building, provide security and safety, they're a major component for occupants' thermal comfort and the air change rate, they provide some acoustic isolation, and of course it can provide aesthetic attributes that occupants react or relate to.

Currently most monitoring of a building's envelope or structure is done through periodic manual inspections, possibly augmented with handheld devices, tools or instruments. Automating the monitoring process provides several benefits: more timely data, proactively addressing problems or issues, increased comfort and security, lower maintenance costs, data that can guide and support manual inspection, and generally better management of a building's performance.

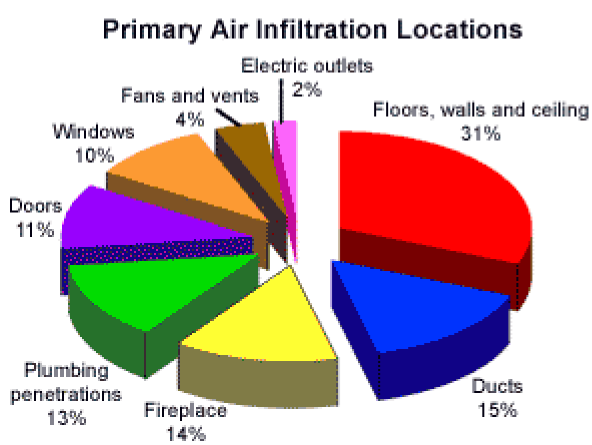


So if the envelope and structure consists of static materials what could possibly be monitored that would assist in measuring and managing the building's performance? It turns out there is plenty:

Moisture Intrusion – Obviously if there is moisture in the building envelope there's a water leak, there could be mold and the integrity of the envelope is breached. A facility technician can inspect for moisture leaks with a handheld device, but better yet, you can install moisture sensors and a data recorder to continuous monitor the envelope. In new construction, sensors can be embedded in the envelope or attached to the structure. Existing buildings are obviously more difficult and sensors would be attached or penetrations may need to be made in order to install sensors. You'll want to place sensors around locations such as parapet joint flashing, control joints, wall-window interfaces, window jambs, wall-concrete slab interface and all the other places water is likely to gather, settle or get into. There are a number of methods that moisture sensors use to sense moisture. Sensors can measure moisture using the electrical properties of the materials (resistance, capacitance, etc.) which varies with the moisture content of the materials; another method is thermal-based, that is the temperature of the materials caused by moisture.

Wireless is generally the preferred method of connectivity for moisture intrusion systems and related monitoring of the envelope or structure where the network can self-configure and connect back to a data recorder and eventually a workstation or Integrated Building Management Systems (IBMS).

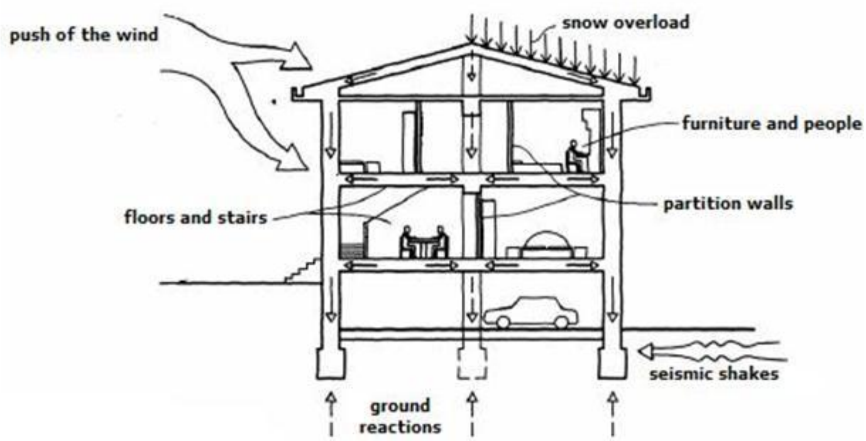
Air Leakage - Air leaking through a building envelope not only wastes significant amount of energy but decreases thermal comfort for occupants and allows dust, moisture, noise and airborne pollutants into the building. The detection of air leakage is usually done manually. However, walls can be instrumented to measure air pressure differences which can at least indicate potential issues that may require inspection via a manual air leakage test. Analyzing trending data in a BMS or IBMS can also assist in identifying issues. Trending data would be able to determine changes in space humidity, building pressure, outdoor airflow and temperatures. For example, high relative humidity might indicate negative building pressurization, which may lead to inspection of seals, leaks or equipment.



Structural Loads - Building materials age and degrade over time affecting their structural integrity. Building structures should be monitored for stress, strain, vibration, deflection, displacement and tilt. Then analyze the data fully to determine the current health of the structure. One common building example is steel joist construction used in many commercial buildings to support the roof; the use of strain gauges or sensors can assist a building owner in monitoring the load of the roof when it snows or rains.

Monitoring structural loads in buildings and other assemblies is not new. Probably the best known project involving such monitoring is the rebuilding of the St. Anthony Falls Bridge in Minnesota in 2009 where over 300 sensors were embedded in the bridge to monitor the structure in real-time.

Seismic Monitoring - Seismic monitoring is a highly specialized system. It uses accelerometers (devices that measure motion and vibration) at specific locations in a building to measure the response of a building's structure to an earthquake event. Seismic monitoring has several important benefits. For a building owner, real-time data showing how an earthquake affected the structure is quicker than and can assist in the physical inspection of the building, thus increasing the chances the building can remain functional or quickly regain functionality. From a government or community response, data from multiple buildings affected by earthquakes can be correlated to assess how the larger area was affected. In many cases, the governmental entity responsible for monitoring earthquakes or geology will have real-time connections and feeds to the building's seismic data recorder.



Openings in the Structure - Fenestrations

- *Doors and Operative Windows* **-** It's a good practice to monitor each of the major fenestrations in the envelope simply to identify whether they are open or closed. That is each exterior door and operative window should have a switch in its frame to indicate the position of the door or window. Doors that have access control already have such switches but other doors not covered by access control should have the door position switch as well. If you have a facility or building management system that monitors the switches you can create some "exceptions" or times as to when open doors or windows are acceptable and when they're not, and use the information to better manage the building.
- *External Shading* - Exterior shading (adjustable and automated shading that is attached to the building's envelope) has become one of the popular tools related to energy efficiency. It is not a true fenestration or opening but impacts the performance of the related window. Shading can reduce the demand for cooling and provide a modification of the lighting for a space to improve the amount and dispersal of the light. Most exterior shading systems (as well as some lighting control systems) are driven by the sun position, solar intensity, sky position, BTU Load, readings from indoor and outdoor photo sensors and radiometers (devices that measure radiation). The shading system will position itself based on the control software application to determine the best position for the shade as indicated from the sensor data. The shading system, because it will control the thermal load and amount of light entering the space, will drive lighting levels and impact the HVAC system.
- *Electrically Switchable Glass* **-** Electrically switchable glass is basically glass, glazing or coatings that change light transmission properties when voltage is applied. There are a variety of technical means to accomplish this including electrochromic, suspended particles and liquid crystals devices with different approaches and capabilities among the technical means. When voltage is applied to electrically switchable glass it changes to tint and absorbs light. The tint level can be controlled manually or automated via integration into a BAS system. Much like motorized shades electrically switchable glass can be manually operated via a switch or automated based on light sensors, schedule, occupancy sensors, lighting control or thermostats.

The automation industry, as well as facility designers and managers, do not yet fully appreciate the value and wide-ranging impact of monitoring and management systems designed specifically for the envelope and structure of their buildings. If the main premise is that we cannot manage what we do not monitor" these systems will be developed, integrated and brought into the fold. The big idea is quite simply that basic data for the entire building must be transformed into relevant information which in turn provides the foundation for better building operations.

For more information about smart buildings, technology design or to schedule a Continuing Education program, email info@smart-buildings.com.