Infrared building energy inspection

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Ron Newport and Austin Dunne of the Institute of Infrared Thermography explain how the energy efficiency of a building can be assessed with greater precision using infrared thermography, locating problems that were previously difficult to find using standard methods.
How does infrared thermography work?

In what ways can infrared imaging be used as a cost-saving measure?

Identifying energy-related problems of buildings in Europe has become a focus point in the last few years as countries, companies and individuals understand the need to reduce energy consumption in line with the Kyoto Accord and particularly to address ongoing changes by the EU described in the European Performance of Building Directive (EPBD). Inspection of a building to determine problem areas can be difficult using traditional inspection techniques.

Infrared thermography on buildings has been used extensively since the early 1970s and continues to be used effectively today. There are various applications for the analysis of the performance of building envelopes and associated facilities. The objective of thermography is to assess the efficiency of a building enclosure by locating surface temperature anomalies and identifying the cause mechanisms.

Performing infrared thermography inspections provides information that allows building owners to identify their energy-related problems, allowing the owner to understand areas of concern and remedy the anomalies thereby increasing the building energy efficiency as well as occupant health and comfort level.

Energy consumption
Generally energy consumption is divided into three sectors: industry, transport and residential/commercial sectors. Depending on the country, 40-50 per cent of energy usage is related to the last sector. With almost half of the energy consumed used for comfort purposes, this sector is of great importance when rationalising the reduction of energy. Increasing energy efficiency in the building sector is a priority today.

For new buildings and structures, changes to the building standards and codes will have a direct effect on the structures and the energy performance of the building if construction techniques ensure that the structure is built to a high standard. Construction methodology, including the installation of vapour barriers, wall and ceiling insulation and the sealing of doors and windows, must be carried out effectively.

Older buildings tend to be less energy-efficient; typically only a small proportion of existing buildings are renovated each year. For existing buildings it is difficult to access the quality, current condition and effectiveness of the structure. Without a problem visibly showing up, it is difficult to find the weaknesses for the repair and upgrade. This can present a major problem.

Infrared inspection and testing
Defects in thermal insulation and airtightness in the external envelope of a building cause inconvenience such as uncomfortable interior temperatures, air leakages, draughts and moisture damage. It causes discomfort to the inhabitants of the building and also excessive consumption of energy. The best solution is to identify the problem, determine the cause of the anomaly and then treat it accordingly. The main difficulty is to find suitable methods and equipment to initially identify the problem areas. Inspections and assessment of the building by visual means can be ineffective. Often the problems, their causes and consequences, simply cannot be seen until after costly damage has been done. At that point the only recourse may be extensive, costly reconstruction.

Infrared imaging is predictive, cost-effective and the least intrusive of all building diagnostic procedures. Thermal anomalies are caused by missing insulation, thermal bridges, air leakages, moisture and condensation. Each defect will cause changes in the wall temperature. With the use of infrared thermography, surface temperature patterns are used as indirect indicators of subsurface anomalies. However, the interpretation of these characteristics and the formulation of solutions to the resulting problems require the skills of a trained building thermographer and knowledge of building science. A Blowerdoor system can often be used to change the building pressure, highlighting air leakage paths within the structure

Conduction losses
In designing the thermal resistance of the envelope, the aim is to achieve the desired indoor climate in an economical way with regard to the specific outdoor climate. Experience has shown that lack of insulation, poor installation of insulation, air barrier and air sealing deficiencies reduces the thermal integrity of the envelope and gives rise to considerable higher rates of energy consumption.

For new or old buildings, it is important they meet the new energy ratings with regard to thermal insulation and airtightness and that any defects in construction that may occur should be identified and repaired.

Installation of the insulation within the wall cavity is critical. It should fill the cavity and be tight against the warm side of the wall. If this is not installed in this way the effective insulation value can be reduced dramatically by more than 50 per cent and has the possibility of becoming a pathway for convective air flow that reduces the insulation value.

Thermal bridges
Thermal bridges are paths of high conductivity that exist within an enclosure. They may be the framing members in insulated construction, the metal ties in cavity wall and panel constructions, certain structural members, metal window and door assemblies or any other element that penetrates a layer of the building envelope. Increased energy flow toward the exterior via thermal bridges results in temperature variations on the interior. Small temperature differences may not be serious, but add the energy loss up due to thermal bridging of a structure and significant losses may be revealed. More extreme differences may lead to condensation and subsequent deterioration.

Convection losses
Leakage of air through improperly sealed joints and junctions, and incorrectly installed or damaged air barriers, are frequently found defects. Air will flow quite easily through batt and loose fill types of insulation and through the joints between the sections of rigid insulation. Such defects give rise to unsatisfactory temperature distribution and air movements (draughts) in the living space and to local reductions in temperature on the building envelope risking condensation. The leakage pathway is often complex and, without infrared thermography, extremely difficult to find or to prove especially in case of disagreements between owning and construction parties.

Exfiltrating air is identified from the outside of the building. The interpretation of exfiltration is slightly more complex than infiltration because of the many layers of material that the exfiltrating air has to pass through. If one is examining a composite construction (e.g. construction brick with veneer), the thermal pattern may not represent a significant surface temperature difference, even though the air leakage is severe.

Moisture
Moisture is possibly the most important factor affecting the performance of a building enclosure. When it condenses to a liquid or a solid, it can create difficulties. Moisture in a building can originate from precipitation, condensation of vapour or building materials that release moisture.

Vapor travels from high pressure to low pressure. Moisture-laden air is literally 'pushed' through penetrations in the building envelope. The moisture could damage the insulation and even the framing members, but a continuous vapour retarder helps prevent this from happening.

Defects of the inner or outer air barrier of the envelope create air movement through the envelope causing moisture to collect. As building design and techniques produce tighter thermal envelopes, moisture from leaks or condensation can create further problems. The water can intrude through small cracks and then become trapped between the relatively impermeable building materials. Also, cracking of mortar or masonry produces openings through which moisture may enter. Water damage can occur and will continue to cause premature deterioration of finish materials, ruined equipment and furnishings. In worse case scenarios of prolonged moisture ingress, mold and mildew can grow and affect the indoor air quality

Moisture and mold
Mold, organic fumes or bacteria can play a significant role as either the result of or culprit of a variety of issues. Mold typically occurs when porous building materials are exposed to condensation, leaks or where inadequate ventilation promotes ambient moisture saturation. Unattended mold infections are likely to result in a condition commonly known as dry rot, and damage can become quite extensive. An airborne mold spore spread has also become a matter of concern involving Indoor Air Quality (IAQ).

Summary
Thermography has proven for over 30 years to be an efficient means of locating building energy deficiencies and effectively reduce energy costs. Infrared thermography for investigative and predictive inspections of all aspects of small and large buildings is one of the most powerful additions to the arsenal available to combat high energy and maintenance costs. Infrared thermography is an inspection tool that will continue to lend itself to more applications in every range of building investigations.