Infrared Thermography Embodies True Green Construction

ABSTRACT

Construction isn't truly green and can't be expected to be sustainable if it doesn't thoroughly embrace adequate quality throughout the planning, design, construction, Owner maintenance and rehabilitation building life-cycle. Green construction involves an awareness of the need for satisfactory thermal performance in building envelope construction and ownership. Infrared thermography is a very cost effective tool that enhances the building industry's new focus on energy-efficient projects. We are a needy society and green jobs need to offer immediate and lasting value to the construction, property management, investor and tax payer groups. Because of the skill sets offered by knowledgeable infrared thermographers, infrared thermography embodies true green construction with careers that can provide immediate and lasting value to the design, professional services, constructor and quality assurance fields throughout our country.

INTRODUCTION

The purpose of this article is to explore some of the sustainable construction design-build job opportunities for a myriad of interesting, well paying, challenging, passive thermography jobs in the design, professional services, constructor and quality assurance fields. With historically low energy costs we have ignored countless opportunities to design and build more energy efficient buildings, and to improve energy savings and enhance energy efficiencies with existing facilities that range from the smallest residence to the largest skyscraper. We are a needy society and green jobs need to offer immediate and lasting value to the construction, property management, investor and tax payer groups. Because of the skill sets offered by knowledgeable infrared thermographers, infrared thermography embodies true green construction with careers that can provide immediate and lasting value to the cited entities throughout our country.

Green construction involves an awareness of the need for satisfactory thermal performance in building envelope construction and ownership. Infrared thermography is a very cost effective tool that enhances our industry's new focus on energy-efficient projects. That descriptive term, energy-efficient, opens a wide panorama of opportunities for quality minded construction and property management decision makers to contract with infrared thermographers for informative infrared scans and surveys. Infrared thermography may be used for Non-Destructive Evaluation, NDE, and Non-Destructive Testing, NDT, and with real-time results and recorded documentation over several phases possible both disciplines are being used with increasing frequency but with many more opportunities to provide proven diagnostic data. Look at too many service proposals and construction contracts and there is a glaring omission.

With the past ten or more year short-term industry focus on designing and constructing on time and under budget, we see far too many instances where the third leg of the three-legged milk stool analogy applicable to the design-build industry, project quality, isn't even mentioned and certainly doesn't appear to be a focus. Everyone knows a two-legged milk stool can't stand alone and gifts of money to chase and remediate construction problems have never been plentiful. Don't take our word; look for yourself in every media; the industry focus is on time and cost but all too often not quality. Hopefully while reading this paper many additional proactive design and construction infrared opportunities will occur to the reader committed to quality construction. Construction isn't truly green and can't be expected to be sustainable if it doesn't thoroughly embrace adequate quality throughout the planning, design, construction, Owner maintenance and rehabilitation building life-cycle.

With exciting new generalist and specialty job growth areas in green construction such as LEED building rating design and construction, and various project delivery options to achieve energy efficiency, we will identify opportunities where proactive, non-destructive, passive infrared thermography enhances many quality minded project deliverables. These deliverables apply to the designer, builder; professional services, property manager and Building Owner with infrared thermography services used to identify

concealed moisture intrusion, component wear, fatigue and failure, and thermal patterns indicating objectionable free-air movement out from or into a building contributing to costly energy loss. Conventional passive thermography involves qualitative and quantitative infrared thermography. Qualitative thermography involves detecting, displaying and documenting thermal patterns. Quantitative thermography involves those criteria and measuring an object's surface temperatures. Because of the relatively low cost, non-destructive aspects including minimal disruption to construction processes and ongoing operations, and speed with which infrared thermography scans and surveys can be conducted this tool can to some extent prove beneficial to every phase of the building life-cycle.

Use of infrared thermography in a timely manner can be paramount to avoid or minimize the effects of deficiencies with immediate and possibly long-lasting consequences such as poor construction with costly compromises to be endured including the need for expensive remedial scopes of work having to be funded over the long-term because removal and replacement are just too costly and disruptive. Acceptable quality needs to be well planned, the intent adequately documented, communicated early and often, monitored by knowledgeable independent observers and documented during each phase of a new or remedial construction project. Thermal patterns detected via infrared thermography can identify quality issues in a proactive manner and facilitate new construction quality; and facilitate rifle-approach cost effective project budgeting, bidding and implementing remedial scopes of work. Meeting project needs for design parameters, scheduling, cost analysis, mockups and quality assurance efforts have never been more crucial to successful green construction that is energy-efficient and sustainable.

On a daily basis the largest single use of infrared thermography presently involves detection of heat signatures from problems with and deficiencies in electronic circuitry ranging from residential electric fuse and breaker boxes up to the largest and most sophisticated means of power generation and transport. Used as a proactive means of early detection to avoid costly failures and consequential damages, infrared thermography can rapidly and passively identify problem installations without contact in the most cost effective manner. Considering the many industries requiring sizeable amounts of electrical power that are crucial to our modern life styles, it is easy to envision many opportunities to implement passive, non-contact infrared thermography to detect wear, fatigue and failure problems early. Energy savings aren't the only driving force behind increased interest in proactive implementation of infrared thermography to detect heat signatures requiring attention.

Thermal patterns can range from the minute and subtle to the glaring and many lives have been saved and costly disruptions to building operations averted by proactive use of infrared thermography. Early detection of electrical panel short circuits can prevent deadly events for service personnel to innocent bystanders. For examples of the more subtle applications, with the explosive growth in cell phone, Smartphone and other PDA use, infrared thermal pattern detection can be most informative in large data centers constructed throughout the world in fairly heavily populated areas. Infrared thermography can detect thermal patterns along data center raised level flooring that may indicate elevated temperatures from faulty electrical connections, problematic cooling apparatus or less than airtight underlying ductwork.

When infrared thermography is mentioned most people also envision to some extent the use in the roofing and waterproofing industries to detect heat retained and radiated by concealed water with greater heat retention from solar gain energy or heat from a source in the building interior than heat retained in surrounding system components. The higher mass of the water means greater heat energy retention and the resulting thermal patterns identifying probable concealed moisture. The more absorptive the roofing and waterproofing system components the more distinctive thermal patterns that may be detected, displayed and documented because of concealed moisture. Infrared thermographers have been trained to obtain optimal thermal images and to document those images with informative digital and print mediums. Results from infrared thermography can be interpreted by knowledgeable roofing consultants and roofing contractors to inform commissioning agents and facility decision makers of their repair, recover roofing and roofing system replacement recommendations in a timely manner.

In general, to building envelope consultant and roofing consultant professionals it is clear that building envelope commissioning requirements and LEED requirements have been created and promulgated by mechanical engineers or others not familiar with the many nuances required for proactively ensuring

adequate building envelope and in particular roofing system installations to provide top performance over the long-term with minimal expected Owner maintenance. Because requirements contracted in the recent past don't adequately address identifying, avoiding or solving moisture intrusion issues, the dramatically increased employment of infrared thermographers by commissioning agents, program managers, general contractors, roofing contractors, building envelope and roofing consultants, property managers and Building Owners can identify probable moisture intrusion and with accurate interpretation by the roofing consultant or roofing contractor can minimize the future need for litigation, arbitration and mediation involving leakage issues.

The use of infrared thermography for roofing installations for example can be beneficial when early moisture intrusion detection occurs prior to substantial completion and timely replacement of water damaged components may be implemented and monitored for permanent repairs and replacement prior to the membrane system manufacturer's warranty inspection. Another milestone for implementing roofing infrared thermography occurs after a weather event or other construction damage. Further, roofing infrared may be contracted near conclusion of the installer's warranty coverage to identify moisture intrusion requiring repairs or component replacement prior to the membrane manufacturer assuming all warranty coverage responsibility.

Considerable savings may be realized with accurate detection and documentation of probable and possible moisture intrusion in that moisture damaged roofing system components concentrated or grouped in well defined areas may be marked on the roofing system surface. Based upon the infrared scan results and markings on the roof or detailed CAD roof plan indicating scan results, a professional roofing contractor may surgically remove and replace water damaged components with new, dry components to restore the plane of the roof and at least the original insulation thermal resistance.

Historically, satisfactory installer warranty coverage repairs and component replacement may be obtained fairly smoothly with minimal paperwork and inconvenience to the facility's roofing decision maker. If problems are identified they may be documented and remedial work performed in a timely manner so the membrane manufacturer assumes warranty coverage of a sound, dry roofing system installation. Weather events or construction trades damaging the roofing or suspected of damaging the membrane and creating leaks need to trigger contracting with a knowledgeable thermographer to detect thermal patterns that indicate probable moisture intrusion. Another valuable time to have an infrared scan to detect concealed moisture is near the end of membrane manufacturer warranty coverage. Moisture intrusion problems detected may be corrected under the warranty and save the Building Owner from incurring undue costs after the roofing system installation is out of warranty coverage. In many ways these same proactive concepts apply to waterproofing systems and wall systems to identify moisture intrusion before it greatly damages system components and possibly the interior.

The International Energy Conservation Code, 2009, IECC, calls for vastly increased thermal resistance to roofs and walls throughout our country. The intent is to greatly reduce our dependence on foreign oil by conserving more energy in our buildings. The DOE has stated that our buildings account for up to 66% of total US energy consumption; and that as much as 42% energy loss occurs through free-air movement from and through wall construction. Hence, there are federal mandates from October 30, 2009 for US Corps of Engineers compliance:

1) With ASTM E 2178 (2003) Standard Test Method for Air Permeance of Building Materials, ASTM E 779 (2003) Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, ASTM E 1827 (1997; R 2007) Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door, ISO 6781 (1983) Thermal Insulation – Qualitative Detection of Thermal Irregularities in Building Envelopes – Infrared Method First Edition, ASTM C 1060 (1990; R 2009) Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings, ASTM E 1186 (2003; R 2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems, and US Army Corps of Engineers Air Leakage Testing Protocol for Measuring Air Leakage in Buildings. Specifically, infrared thermography is mandated in ASTM E 1186, ISO 6781 and ASTM C 1060.

2) From ASTM E 1186, “The infrared scanning technique for air leakage site detection has the advantage of rapid surveying capability. Entire building exterior surfaces or inside wall surfaces can be covered with a single scan or a simple scanning action, provided there are no obscuring thermal effects from construction features or incident solar radiation.” Another useful area for infrared thermography involves the detection of conditions indicative of adequate filler grout or insulation, or their absence, in cores of concrete masonry units, CMU, also called cinder blocks or just concrete block walls. Because of the availability, wall strength and economy to the construction budget, CMU wall construction including the use of split face and ground face concrete blocks has been increasing. While many split face block and ground face block walls are initially left uncoated, those blocks and other CMU walls may be coated with a breathable acrylic, acrylic-latex or silicone wall coating, clad with EIFS or stucco systems, or constructed to shed water with a cladding system including the code required water-resistive barrier, EPS insulation boards, metal lath and two or three coat stucco. The stucco may or may not be coated with breathable waterproofing coating. Missing grout and missing insulation in block cores or cells mean energy loss through those areas in the wall construction. If the thermographer can perform the scan early in the construction process omission of grout or insulation can fairly readily be corrected and prevent the need to tear down the defective wall. Not having to tear down a wall or several walls can be very significant to CPM project schedules and better ensure enhanced integrity to the construction delivery. Further, an experienced infrared thermographer may be capable of detecting moisture intrusion in some CMU wall construction. Success depends upon the quantity of the moisture in the wall, the thickness of EPS and board placement of EPS insulation as applicable to the cladding system, and whether or not there is dampproofing or waterproofing applied onto the exterior of the wall that would prohibit water intrusion into the block core and into the interior.

3) From ASTM C 1060 (1990; R 2003), “This practice is a guide to the proper use of infrared imaging systems for conducting qualitative thermal inspections of building walls, ceilings, roofs, and floors, framed in wood or metal, that may contain insulation in the spaces between framing members. This procedure allows the detection of cavities where insulation may be inadequate or missing and allows identification of areas with apparently adequate insulation. This practice offers reliable means for detecting suspected missing insulation. It also offers the possibility of detecting partial-thickness insulation, improperly installed insulation, or insulation damaged in service. Proof of missing insulation or a malfunctioning envelope requires independent validation. Validation techniques, such as visual inspection or in-situ R-value measurement, are beyond the scope of this practice. This practice is limited to frame construction even though thermography can be used on all building types.” Energy loss and moisture intrusion detection uses for infrared thermography are rapidly growing areas of interest regarding green construction for residential, commercial, institutional, industrial, government and religious facilities. Not only satisfactory air barrier and vapor barrier performance can be identified and monitored with infrared thermography. Water intrusion into wall systems, faulty windows, storefronts and curtain walls may be identified by the resulting thermal patterns and consequences such as loss of thermal resistance with insulation impacted by moisture intrusion detected, displayed and documented. While not specifically identifying leaks or even leak sources, with infrared thermal patterns identifying paths of water intrusion in many wall constructions, in many instances the true source or sources for damaging water intrusion and energy loss may be identified and accurate remedial scopes of work described, documented with specifications and CAD detailing of plans, elevations and details, budgeted, bid, implemented and monitored.

4) From ISO 6781 (1983), “Specifies a qualitative method, by thermographic examination (infrared method), for detecting thermal irregularities in building envelopes. The method is used to identify wide variations in the thermal properties, including air tightness, of the components constituting the external envelopes of buildings. Does not apply to the determination of the degree of thermal insulation and air tightness of a structure.” Infrared thermography has been successful in detecting fatigue in concrete and steel structures including bridges and buildings. Traditional stress-strain comparisons can be made with fatigued or damaged concrete and steel.

5) Particularly regarding concrete bridge construction, non-destructive and non-contact infrared thermography may be used to identify and define concrete properties (1) to establish strength, (2) to optimize design values and (3) to ensure quality control. Because the infrastructure across the country is in such poor condition increased use of infrared thermography can be predicted as the cost effective means of determining the scope of work needed and the extent of the problem nationally for allotment of limited funding. Disbonded ceramic tiles may be detected accurately with infrared thermography for cost savings to the cladding condition discovery process. Use of infrared thermography to detect concealed impact damage in Carbon Fiber Reinforced Polymer, CFRP, and materials for aircraft parts is increasing and we envision possible green construction use of these lightweight but strong materials as building components of the future.

SUMMARY

In closing, damage to construction work in progress, substantially completed work and work after final completion involving moisture intrusion or other loss of energy may be detected, displayed and documented with proactive timing of infrared thermography scans to better limit objectionable damage to building components and into the interior furnishings, finishings, equipment and inventory. There are numerous exciting and meaningful green construction career opportunities involving the knowledgeable practice of infrared thermography. We've cited examples where proactive use of infrared thermography can identify new construction deficiencies permitting moisture intrusion and causing the need for costly remedial scopes of work including complete roofing system tear off and disposal, and the costs and risks associated with reroofing large roof areas. We encourage innovative and inquisitive exploration of uses for infrared thermography in the construction process from the need for early detection of moisture intrusion in building envelope systems to ongoing proactive inspection of the building envelope throughout the building life-cycle.

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Mr. Hixson formed Hixson Consultants, Inc., an applied technical resource consulting company to provide expert roofing, architectural sheet metal, glazing, wall system and waterproofing consulting services. He has over 33 years of experience in building science and technology, including experience with infrared thermography since 1989. He received a B.A. in Chemistry from Vanderbilt University in 1973 and is uniquely able to correlate building envelope product chemistry to predictable field performance. He is a

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