THE HIDDEN RISKS OF GREEN BUILDINGS:

Why Building Problems Are Likely in Hot, Humid Climates

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The great irony of building green is that the very concepts intended to enhance a building's performance over its entire lifetime are many of the same things that make a building highly susceptible to moisture and mold problems during its first few years of operation.

While green buildings have many positive benefits, there is also strong evidence to suggest a direct correlation between new products/innovative design and building failures. Simply put, departing from the "tried and true" often means increasing the risk of building failure.

Two strong characteristics of most green buildings are: 1) the use of innovative, locally-produced products and 2) the implementation of new design, construction, and operation approaches that are intended to reduce energy usage and be environmentally sound.

The accompanying graphic (see *Table 1)* summarizes some of the differences between green buildings and the concepts the authors have found in lower-risk buildings. For example, lower-risk buildings do not exceed industry guidelines on mechanically introduced outside air but, instead, emphasize humidity control (especially in hot, humid climates). Green buildings, on the other hand, reward the introduction of more outside air than current industry standards, which can lead to indoor humidity problems and mold growth.

Green building environmental goals are typically organized around a set of nationally accepted benchmark guidelines such as those of LEED® (Leadership in Energy and Environmental Design), which is the guideline established by the United States Green Building Council (USGBC). LEED® certification is a checklist and point system of recommended practices in which achieving various point levels can certify the building as having achieved silver, gold, or platinum status. These practices involve such issues as efficient water and energy use, the reuse of waste materials, and the use of renewable and regionally produced products.[1]

The overall goal of these new materials and procedures is to achieve a structure with reduced negative environmental impact — both during construction and throughout the building's life. The intent of building green is unquestionably noble and good, and should be aggressively pursued. However, because of the dramatic change that this will present to the design and construction industry, its implementation will present new risks that are likely to be both technical and legal in nature.

Some of the legal risks are fairly obvious, such as the risk of not meeting a building owner's expectation of achieving a certain level of LEED® certification (i.e., implied

Green Buildings vs. Lower-Risk Buildings

GREEN BUILDINGS	LOWER-RISK BUILDINGS
Add additional outside air (>ASHRAE by 30+%).	Minimize outside air (do not exceed ASHRAE guidelines).
Emphasize energy conservation.	Emphasize dehumidification.
Stress VOC reduction. • Emphasize exhaust (>5 Paschals). • Building flush-out.	Minimize VOC concern. • Very tight control of exhaust. • Reject building flush-out.
Stress new, innovative materials.	Stress proven materials.
Stress carbohydrate-based materials.	Stress hydrocarbon-based materials.
Stress extra envelope thermal insulation.	Stress drying potential of envelope (walls and roof).

Table 1

or even written warranties). Other risks are more obscure, such as:

- The failure of new products to meet their promoted performance levels, which is more likely with new materials compared to proven materials found in traditional buildings.
- Accepting the higher standard of care that a green building might present. What is currently considered "best practices" may now become the new expected "standard of care."
- Failing to recognize (or prepare for) the unknowns in cost and schedule impacts that a green building might present.

It is even unclear if a LEED®-certified building can be built under a design/build method without the construction team assuming huge amounts of unknown risks because of the vague definition of what is considered "green."

The building industry has been historically conservative, relying on time-proven construction materials and methods. The introduction of new materials and methods has not always proven to be successful and sometimes has resulted in notable building failures, especially those related to moisture intrusion and mold contamination. Many of the time-tested materials found in lower-risk buildings are hydrocarbon based. The long-term efficacies and performance levels are unproven for some of the new carbohydrate-based materials being promoted for green buildings.

The proliferation of new products and innovative building approaches related to green development is challenging the design and construction community in such a dramatic fashion. These changes virtually guarantee an increase in building failures and lawsuits. Past experience indicates that many of these failures will be predictable, and some are likely to be catastrophic.[2]

EXAMPLES OF TECHNICAL RISKS FOR CONTRACTORS & DESIGNERS

Moisture intrusion, whether bulk water intrusion through the building envelope or a relative humidity increase due to the heating, ventilating, and air conditioning (HVAC) system, results in a large percentage of construction claims in the United States. Moisture intrusion not only results in building deterioration but also has been linked to occupant comfort and health issues, especially in those buildings that become contaminated with mold.[3] Sustainable building practices, some of which are part of the LEED® accreditation process, can increase the potential for moisture intrusion if not carefully considered and implemented. Examples include:

- Vegetated roofs, which are more risky than conventional roofs (due to the constantly wet conditions) and must be carefully designed, constructed, and monitored after construction.
- Improved energy performance through increased insulation and the use of new materials, which may change the dewpoint location in walls, resulting in damaging condensation and a reduced drying potential for wall assemblies. Lower-risk buildings emphasize the drying potential of the envelope over increased insulation. While it is desirable to increase insulation for energy savings, the designer must also evaluate moisture impacts.
- Reuse of existing buildings or recycled components, which may not provide optimum water-shedding performance in new configurations or may not be readily integrated to the adjacent new materials.
- Use of new green construction materials that have not been field tested over time. The designer needs to assess new materials and their risks compared to traditional materials found in lower-risk buildings.
- Increased ventilation to meet indoor air quality (IAQ) goals that may unintentionally result in increased interior humidity levels in hot, humid climates. The designer must consider the increased energy load (and cost) and HVAC equipment sizing required to properly dehumidify a building when exceeding the minimum outside air requirements recommended by the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE).
- Building startup procedures, such as "building flush-out," which could result in increased humidity levels and mold growth. Lower-risk buildings rely almost exclusively on source control (which is also a green-building goal) rather than relying on "flush-out" and increased building exhaust. Building "flush-out" along with building "bake-out" were concepts developed in the late 1980s by the indoor air quality industry, which often caused more problems than it solved.

New green construction materials are entering the market at a staggering rate. Because many of these products help to achieve multiple LEED® credits, designers working on green buildings are eager to specify these materials. The risk to contractors is that many of these new items are not time-tested, and designers often do not have the time to fully research their efficacy. If the new product fails, it may be difficult to determine if it is a design error, an installation error, or a product defect. Additionally, general contractors must rely on subcontractors to install new materials that they are inexperienced in installing.

Some of the expandable foam insulation products are examples of green materials that pose increased risks. The water absorption properties of these insulation materials can be quite different than what designers expect with traditional insulation. Additionally, some of the carbohydrate-based foam insulation materials may retain more water than traditional hydrocarbon-based foam insulation. Increased absorption of water into the insulation could negatively affect the wall performance. This is not to say that such materials should not be used; however, their properties need to be recognized and accommodated in the design.

The amount of ventilation (outdoor air) necessary for occupant health and comfort has been debated for decades. Although there are sound arguments on both sides of the debate, the emphasis on increasing ventilation to achieve LEED® environmental quality credits has increased the incentive to add more outdoor air to a building through its HVAC system (a minimum of 30% more outside air above ASHRAE recommended minimums is required to obtain a LEED® credit for ventilation).[1]

Increased ventilation is especially risky in the southeastern U.S., where outdoor relative humidity levels are elevated for a good part of the year. Experience in the Southeast, as well as other areas of the country with humid summers, has shown a direct correlation between the number of moisture problems and increased ventilation rates.

To effectively minimize the risk of moisture problems while increasing ventilation, designers may need to increase the complexity and capacity of the HVAC components and control systems to achieve proper dehumidification. This adds to contractor risk, since complex systems historically fail more often than simple systems. Additionally, the complexity of the system operation can result in unintended pressurization relationships where local depressurization causes humid outdoor air to be drawn into interstitial building cavities, causing condensation and mold growth.[4]

Building owners, designers, and contractors all assume more risk when they deal with complex and possibly untried technologies not generally found in traditional buildings. Pinpointing whether the problem is design- or construction-related may be very difficult after problems have already occurred.[5]

Building startup procedures to meet LEED® credits include a credit flush-out of indoor containments using increased outdoor air, either at the end of construction or during the initial occupancy period. The intent is to remove pollutants from off-gassing of volatile organic compounds (VOCs) from new materials. The amount of air needed to meet the flush-out requirements places a building at increased risk because of the amount of moisture introduced with the increased outdoor air. LEED® requirements are that a minimum of 14,000 cubic ft per sq ft of floor area is required for flush-out. This presents multiple problems: most HVAC systems are not designed to dehumidify that amount of outdoor air, which, in a 100,000-sq-ft building, is 1,400,000 cubic ft of outside air. Depending on outside conditions at the time of the flush-out, as much as 240,000 gallons of water can be added to a 100,000-sq-ft building. This added moisture will be absorbed into building materials, finishes, and furnishings, increasing the risk of mold growth.[6]

Most specifications put the general contractor in charge of the flush-out, including controlling relative humidity levels during flush-out. If the system is not designed to handle such loads, the contractor is faced with a difficult challenge that may require the addition of a temporary and extremely costly dehumidification system. Lower-risk buildings tend to avoid flush-out.

CONCLUSIONS

"There's one sure way to kill an idea: Sue it to death."

— Quote from *ENR*, July 2008

What is the greatest risk to the green building movement? It's likely not the increased costs associated with green buildings—it's more likely green buildings that don't perform up to expectations and, in some cases, may experience significant failures.

The increased costs of litigation and insurance that could result from underperforming green buildings will be absorbed by designers (in a highly competitive marketplace), but in most cases, it will be passed onto building owners. These increased costs, along with the negative publicity on failed green buildings, could dramatically influence building owners not to build green.

Only recently has the marketplace begun to recognize the various contractual, legal, and technical risks that are inherent in green buildings. A growing number of experts have suggested that the first two steps to improved green building risk management are to 1) recognize the unique risks for green buildings; and 2) develop a set of guidelines that merge the unique regional challenges with green building guidelines, recognizing the lessons learned in lower-risk buildings.

The design and construction community must not assume that if one builds green, then one will be building regionally correct or even lower-risk buildings. Until the gaps between lower-risk buildings and green buildings are addressed, the design community would be advised to prioritize the lessons of lower risk-buildings already learned from the waterproofing, humidity control, and building forensics community. Without these priorities, poorly functioning green buildings are the likely result, and this could be the ultimate killer for the green building movement, especially in demanding climates.

In our opinion, the solution to well-performing, lower-risk green buildings is at least threefold:

- Development of a set of climate design criteria that integrate (and prioritize) climate-specific criteria with current green building practices. Best practices for moisture control must take priority over green building practices.
- Development of a detailed green building risk management plan that provides guidelines for the design and construction team from concept through the one-year warranty period. These guidelines would incorporate the best ideas of green building specialists, moisture control specialists, construction attorneys, and insurance companies.

Apply the lessons learned from past building successes and failures and make green building concepts subservient to these past lessons.

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NNSA Praises BTA Roof Project Managers for Cost Savings

The National Nuclear Security Administration (NNSA) announced the completion of a construction project at NNSA's Nevada test site more than two years ahead of schedule and at only 20% of the original cost estimate. NNSA officials have made it a priority to promote project management best practices throughout the nuclear security enterprise.

During a ceremony honoring the accomplishment, NNSA Principal Assistant Deputy Administrator for Military Application Brig. General Garrett Harencak applauded the project managers at the Device Assembly Facility (DAF) for saving U.S. taxpayers $7.8 million. "To fix the issue as quickly as they did while saving taxpayers nearly 80% of the original price tag is a major accomplishment and is the latest example of the excellent project management skills employed across the nuclear security enterprise."

The DAF is a collection of more than 30 individual steel-reinforced concrete buildings connected by a rectangular common corridor. The entire complex is covered by compacted earth and spans an area of 100,000 sq ft. The operational buildings in the DAF include five assembly cells, four high bays, and three assembly bays. Five staging bunkers provide space for staging nuclear components and high explosives. One of the safety features of the DAF is its compacted earth overlay (cut-and-cover construction) roof system. Besides weather protection, the DAF roof provides for the filtration of escaping gases should there be an accident involving high explosives inside DAF.

Over time, the porosity of the roof enabled water to infiltrate the building, causing unexpected maintenance expenses and industrial safety issues. In the summer of 2008, NNSA initiated a project under its Roof Asset Management Program to address the problem and awarded a contract to Building Technology Associates (BTA). The project was originally projected at a cost of $10 million, with an estimated completion date of September 2011. The project was completed in June at a cost of $2.2 million. The program streamlines the management of its roofs by implementing a single multisite construction activity – a program that in the past would have required multiple projects.

Engineers came up with a waterproof membrane structure to cover the entire area of the DAF roof. The engineered membrane structure allows for the gas filtration safety system to work as designed yet prevent water from filtering into the facility. Using this material allowed the project to be completed more quickly and at a substantial savings.