

The System Approach to Thermal Performance – “Control of Condensation & Mold in Buildings”

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Abstract

We are seeing headlines every day, advising that a school, office building or courthouse has been closed due to mold. The cost of remediation plus the damage to the reputations of building owners, architects, builders and the cost of litigation is immense. Why is this problem surfacing now when mankind has been building for thousands of years? Why are buildings suffering increased problems of structural deterioration? The answer is that over the last 25 years as we have insulated buildings to conserve energy inadvertently we have created the necessary conditions for mold growth.

This presentation will introduce the changes in thinking in Building Science which are leading us away from a reliance on R-Value based insulation to advances in air sealing which controls the leakage of air and moisture vapor into the building envelope. New soft foam insulation is now being used in retrofit and new buildings to solve mold and moisture condensation problems. At the same time downsizing of HVAC equipment and energy savings of up to 50% have been reported.

This presentation will provide an introduction to Building Physics and the importance of air movement to explain why we must approach the design of a building as a system, rather than a collection of building components thrown together.

Current Issues

Today's buildings are very much more complex than those built 100 years ago. Occupants want comfort and convenience and are unwilling to put up with the drafty, poorly lit buildings of the past with ever-present fire danger. However over the last few years we have become aware that something is wrong with the way we are building and that serious challenges exist both for those who design buildings and those who operate them.

It is increasingly obvious that buildings erected since the 1970's, while more comfortable than any built in history, are suffering from structural deterioration due to condensation and mold problems. Headlines

announce the closure of schools, courthouses and other public buildings all over North America due to mold, and “Sick Building Syndrome” and “Indoor Air Quality” have become terms in common use. What is causing these problems and how can we build structures with better defenses against the attack of bio-organisms and moisture intrusion?

The world's resources are being depleted at a rapid rate and the cost to find new reserves of oil and gas is increasing as we are forced to explore in remote frontier regions. Political events in the Middle East can make the price of energy volatile and California's experience with electricity price hikes in 2001 may be the harbinger of future shocks. How can we reduce our consumption of the world's resources and make buildings more efficient while maintaining or even increasing occupant comfort?

Concern for the health of the planet is growing as we see the effect of greenhouse gas emissions and the hole in the ozone layer caused by hydrochlorofluorocarbons. Droughts, depletion of water reservoirs, and melting of polar ice caps are all serious concerns and linked to our burning of fossil fuels and release of emissions into the atmosphere. Can we maintain our standard of living while reducing emissions, which are endangering the well being of the Earth?

Air Leakage

The role of air leakage in the building envelope is becoming more generally understood due to the work of building scientists over the last decade. Studies of residential and commercial construction have shown that air leakage is responsible for as much as 50% of the energy loss in a building, as well as problems with condensation and mold growth.^{1,2} Air leakage is also important in noise control since mid to high frequency sound passes from room to room by air movement through electrical boxes and other penetrations in wall cavities. Until the introduction of low density soft foam insulation in the late 1980's, controlling air leakage was very labor intensive and time consuming to accomplish properly, and most builders simply couldn't be bothered due to the expense.

The general introduction of fibrous insulation materials in the 1970's, after a dramatic rise in energy costs, served to tighten buildings significantly. However, without the provision of adequate sealing to prevent air and moisture vapor infiltration into the wall cavity, problems began to occur. At the same time the concept of resistance to heat flow or "R-value" was seized upon as the answer to controlling energy costs. This led to increasing costs for buildings as well-meaning legislators increased the required thickness of wall and attic insulation to meet code, which meant that the thickness of studs, windows etc. had to increase as well, adding extra expense. Building codes became "prescriptive" in nature focusing on a required thickness of insulation to meet a specified R-value rather than on the desired energy performance of the building. The R-value measures only resistance to conductive heat flows and ignores convection.

Mold

Medical doctors are becoming increasingly aware of the link between mold and health. Molds give off spores and mycotoxins to which a certain percentage of the population can have a serious reaction – sometimes with fatal consequences. The legal profession is increasingly aware of mold as the road to riches. "Mold is Gold" was the title of a paper at a recent conference of lawyers. Building designers, construction firms, facility managers and building owners are all potential targets of litigation if mold is implicated in a building with problems. Mold species have been with us for eons and of the more than 100,000 species of molds in the world there are some 14 that like to live inside buildings. Molds have certain basic needs to grow and multiply and we must control some of the conditions in our buildings to reduce the chance that molds will take hold. Mold needs a certain temperature range, a food source and moisture to thrive. We are not able to do too much about temperature since molds like the same temperatures as we do in the interior of our buildings. The foods that molds digest are carbon based organic materials such as cellulose, including wood and the paper on drywall. Certain insulations have shown that they support the growth of mold also. The factor that we can influence most is moisture, which can enter a wall cavity or attic area and come into contact with mold spores in two ways:

a) Bulk water intrusion caused by a flood, roof leak, rain water penetrating the building envelope or an interior source such as a burst pipe. This type of

moisture problem is usually obvious and if action is taken quickly a serious mold problem can be averted.

b) Moisture vapor condensation. This is the more insidious problem because it is not obvious and by the time we become aware of it, expensive remediation is usually required.

Moisture vapor can move into a wall cavity by vapor diffusion or by airborne vapor transport through cracks and leaks in the building envelope. One very common pathway is through electrical outlet boxes. Studies have shown that airborne moisture represents the vast majority of moisture vapor intrusion.³ Clearly, sealing air leaks through the use of foam insulation can be a major weapon in defending against mold. Soft, low density foam of the polycynene type offers the advantage of flexibility to allow for building movement due to thermal cycling without losing the air seal. The foam uses water as its agent of expansion and contains no HCFC's or VOC's. Its open cell structure but low perm rate prevents moisture vapor intrusion into wall cavities but allows liquid water to pass through, which facilitates drying in the event of a flood situation. The foam is applied using spray equipment by licensed contractors and expands 100 times in less than ten seconds. Soft foam is typically used in interior applications only. The tenacious adhesion of foam to steel, wood, masonry, and glass make it especially suited for horizontal surfaces such as under a roof deck or crawl space as well as for stud cavities, chases etc. It has been shown that soft foam will not support the growth of mold because it does not provide a food source.⁴

Air Leakage Control

Primary Benefits

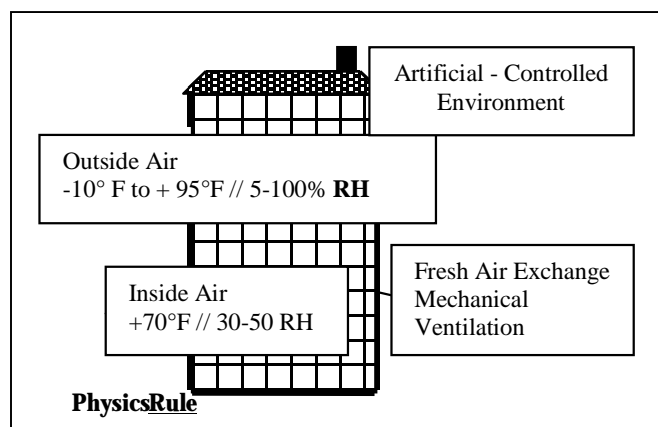
- ◆ Control of moisture transport/condensation
- ◆ Controls mold/mildew in assemblies
- ◆ Structural integrity/durability
- ◆ Air quality
- ◆ Health – building and occupant
- ◆ Control – drafts
- ◆ Energy conservation, 30-40% loss due to Air Leakage

As well as preventing moisture condensation, the use of soft foam provides substantial savings in energy consumption by preventing the leakage of conditioned air to the outside in the case of the northern climate in winter, or the penetration of hot

humid air from the outside into the building in a southern climate in summer.

Building Basics: The Laws of Physics Apply

We are attempting to keep our buildings at a temperature of 70 degrees and 30 to 50% Relative Humidity in order to maximize occupant comfort. On the outside, conditions can range from cold and dry such as in Alaska or hot and humid such as in Louisiana. The building envelope is our shield against the efforts of Nature to make the conditions inside our building equal to what is going on outside. For too long we have simply thrown building materials together without any regard for how they interact or where the building is going to be built. An example is the use of vinyl wallpaper on the walls of buildings in the Southeast. In this climate where vapor barriers should be placed on the warm or exterior side of the wall cavity, the vinyl wall covering functions as a vapor barrier on the inside or cold side of the wall cavity. Moisture condensation and mold problems are becoming epidemic as a result.



Building Basics

What is Causing Problems?

- ◆ Deterioration of buildings due to moisture build up from air leakage and condensation
- ◆ Increased Air Pressures
 - Increased use of HVAC
 - Increased height of buildings / stack effect
 - Mechanically forced air leakage – leaky ducts

We have to think of a building as a system where the components should be chosen to interact appropriately with each other. For example, insulation and ventilation have to operate as a system to maximize indoor air quality and energy savings. Currently we see air conditioning equipment being routinely oversized which leads to short cycling and humidity problems. Tightening the building to achieve energy savings by using a performance insulation such as soft foam requires that the HVAC system be downsized by as much as 50% to work efficiently and avoid occupant complaints. At the same time we have to design an adequate ventilation system to make sure that fresh air is supplied in sufficient quantity.

In conclusion the problems we are currently experiencing with buildings are now leading to a change in thought in relation to how we build. The concept of air leakage has become recognized as key while the importance of R – value is declining. The technology exists today to enable us to construct buildings, which are durable, healthier for occupants and much more energy efficient.

References

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