ZbD: Notes From the Field

Insights in High-Performance Construction

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Just Breathe: Of Buildings and People

By: Jon Haehnel

We talk about air tightness and air barriers a lot: in meetings, on site, and in plan reviews. Frequently in these discussions someone will ask a question along these lines, "Aren't buildings supposed to breathe?" This is a relevant question that deserves a thorough answer. First, if you will indulge me, I'd like to dissect the question a bit before I answer it.

The word "breathe" in this context means two things: 1. the people inside the building need ventilation – freedom from stale air, dust, volatile organic compounds and other contaminants. 2. The shell of the building needs ventilation so the building materials stay dry. So, in one sense "breathe" means "fresh air" and in the other sense it means "dry materials". So, back to our question, "Aren't buildings supposed to breathe?" Answer: Yes, occupants need fresh air and building materials must stay dry; same today as it has always been.

So, the follow up question might be, "Don't these tight buildings you propose violate the required criteria- fresh air for people and dry building materials?" The answer is "no" but our approach to meeting these criteria has necessarily changed over time because of one thing: energy efficiency.

When fossil fuel was cheap and air pollution was not a concern, using heat energy to exchange indoor and outdoor air through the walls and ceilings was a reliable system. By conductive heat loss we got drying potential and by convective heat loss we got fresh air. But when fuel got expensive and we wanted really low, or even reasonable heating bills, that option was lost. We added more insulation and tightened up the shell to save heating energy but the free drying and free ventilation system went away. We had to find a new way to get fresh air for the occupants, namely mechanical ventilation. We also had to find a new way to keep building materials dry- namely better envelope design. Both of these new methodologies are more complicated than the old way, but is that really a surprise? My 1980 Ford Fairmont was much simpler in design than my 2010 Mazda 3. The Fairmont got 20 mpg and the Mazda gets 35 mpg. The Fairmont never had O_2 sensors, fuel injection, or on-board diagnostics. You see an even greater change in efficiency and complexity if you compare my Mazda to a Toyota Prius. Increased efficiency comes at the expense of complexity. Occasionally this norm is broken by a particularly elegant solution, but not often.

So now we have to accept this new paradigm. With increased efficiency, ventilation and drying potential are no longer "free" byproducts of our building shell. We have to specifically account for both drying potential and occupant ventilation in our design. I think they need to be treated as two separate issues to be resolved in every building. Curiously, some of the language we use in the industry lumps the two concepts together. Allow me to explain.

The idea that occupant ventilation and dry building materials were considered one in the same is the result of reliable building practices that predated any concern for energy efficiency. I explained this above; in those days, occupant ventilation and dry materials came via the same route – a "breathing" envelope. However, when energy efficiency came along we had to abandon the concept that occupant ventilation and dry building assemblies came free. The other concept we had to abandon, one that bares specific mention, was that occupant ventilation was no longer synonymous with dry building assemblies. They are related, sure, occupant ventilation influences interior relative humidity (RH) and RH influences vapor drive through building

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materials, but they are no longer synonymous. In other words, proper ventilation for occupants does not dry out the building materials and drying out the building materials does not provide ventilation for the people. But on this point, we as an industry still seem to be clinging to some of the old ideas.

Many of us have heard the phrase "build tight-ventilate right". It seems to imply that as long as we have properly sized and balanced mechanical ventilation our air tight shell will stay dry too. This catchy phrase, like so many truncated phrases, is misleading. I have often heard the question being asked in discussion of a building envelope failure, "Do they have mechanical ventilation? Are they using it?" On all the high-performance failures that I've seen, the answer is "Yes, they have it and yes, they are using it, but the wall (or roof) assembly is still rotting."

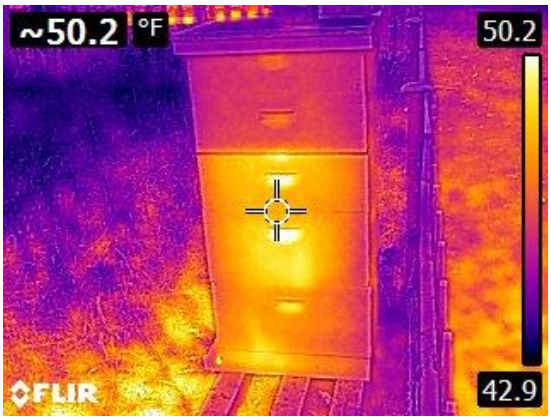
This idea that fresh air and assembly drying potential is linked is further reinforced by marketing that often emphasizes that when a home is tightened it becomes healthier for the occupants. I don't agree that air sealing automatically means a healthier home, nor do most practitioners, but it is implied all the time in the sales materials. Some could say, "Jon, we don't bother explaining that when we tighten a home we also add mechanical ventilation and that is why it is safe to say tighter homes, or weatherized homes, are healthier." I don't fully buy that argument because I know that many practitioners often tighten up a home to a point, the point that ASHRAE 62-89 says is still OK without adding mechanical ventilation, and then stop so that expensive mechanical ventilation does not need to be discussed with the homeowner.

The point is, our current language inadvertently links mechanical ventilation with successful envelope assemblies. They are related, but in modern building practice, they should not be seen as synonymous.

Bees, Freeze and Building Science – Part 1: The Challenge

By: Mike LaCrosse

Ever since I was a kid in middle school I've always had an interest in keeping bees. Why? I have no clue, but I did, and so finally this past year I decided to take it up as a hobby and find out whether or not all this interest was going to be worth the countless stings and swollen appendages. Turns out that, for me, it is! I won't say that establishing a successful hive this past summer was without its challenges, but perhaps the biggest challenge is the one that I'm facing (and the bees are facing) right now. Getting them through a winter. Now, as a new beekeeper I readily admit that my level of expertise on the topic is about as good as Joe Shmoe's. However, as a professional in the building science game, I'd like to think I at least know something. And when it comes to wintering a hive, I've realized there can actually be a surprising amount of "building" science involved in its success. In our climate, establishing some kind of "envelope" can really help a hive along. However, this isn't establishing an envelope for humans, its establishing an envelope for insects. Unlike humans, these bees have to maintain the climate in which



Uninsulated Hive (Cool September Evening). The two boxes on top are "dummy" boxes, with nothing in them. Notice the difference. Even on an early fall evening, the hive is radiating heat to the cooler outdoors. Of course the only insulation at the time is an inch of pine wood.

Visible Light Image

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they live with their own bodies, and their ability to do so successfully is due to how they respond to the ambient environment.

There is just way too much information to possibly share in one small article about the behavior of a bee colony, and I don't even know the half of it myself. However, as it relates to their surrounding environment, here's what I consider the essential behavioral information in regards to wintering a colony:

- As temperatures drop below the 50F mark, bees begin to cluster into a ball, vibrating to generate heat. The colder it gets, the tighter the cluster gets. The center of the cluster can be as warm as 95 degrees, depending on the day. Bees rotate within the cluster so they all stay warm.
- Bees do not attempt to generate heat for the entire hive, just enough for their cluster and the nearby honey to be consumed.
- The colder it gets below 50F, the less the bees are able to physically move. If it gets cold enough they are essentially immobilized. While the center of the cluster is always warm, if the outside is too cold then the whole cluster is stuck in one place, limiting themselves to the food immediately around the cluster.
- As there are temperature breaks throughout the winter, bees perform cleansing flights. Essentially a chance for bees to relieve themselves outside of the hive and for old and exhausted bees, who are more a burden than anything, to sacrifice themselves.
- Not a behavior, but a major issue; condensing moisture and bees in the winter is a bad mix. Very bad. It will kill them. Everything you read will tell you this. The adage goes that "it's not the cold that will kill the bees, it's moisture."

As a person who spent way too much time thinking about all of this, these basic behaviors eventually enlightened me on why we can't just treat it like we would on a home and build a huge amount of insulation around the hive to reduce the heat load on the bees, which is what one might want to do after seeing the first image set above. But, here's why we can't:

- Actually, the bees would be comfortable. They might be so comfortable, in fact, that they are tricked into thinking that the environment around them is nearly as warm. This could lead the bees to attempt cleansing flights or maybe even foraging. Of course, they'd face a cold death once out in the open air.
- If the air around the cluster of bees becomes warm in addition to the cluster, then physics tells us that that air can hold more moisture. This moisture can come from periodic rains, periodic snow melt, or potentially even the uncapped honey currently being consumed in the hive. If the air is warm and holding more moisture than as it touches cold surfaces it is much more likely to condense. Versus if the air surrounding the cluster is generally cold, then there is a buffer of sorts between the bees and the condensing surfaces.
- Not a crucial reason, but full frames of honey are actually great thermal masses. By boxing them in completely with lots of insulation, that potentially useful benefit can't be employed.

As I was learning all of this, I slowly realized that successfully wintering a hive is about striking a balance in the envelope. And so, as I went into fall, I laid out a plan to create an envelope that would help the bees, but not do the work for them. I'll discuss this more in the next article. As a teaser, I'll say the envelope consisted of a hybrid of insulation, solar absorptive materials, and a small amount of ventilation.

Coming Next Month:

- Insulated Concrete Form (ICF) Homes: What We Love – Part 1
- Bees, Freeze, and Building Science – Part 2

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