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Wed, Aug 07, 2024 2:38PM 34:13

SUMMARY KEYWORDS

building, vapor, important, occupants, high, heat, control, vapor barrier, radon, ventilation, energy, moisture, air, assembly, indoor air quality, voc, materials, good, walls, operable windows

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All right, I imagine everyone can see this. Yeah, my name is Grant. I'm a building envelope engineer and a bit of a high performance building guru, building science guru. So this one is on the myth of, does a building need to breathe? And that

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is pretty common to hear

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your build your building too tight. The building needs to breathe. You know, it affects the health of the indoor occupants and of the building itself. So let's get through it. So just quickly going through the outline here, the purpose of this quick presentation to differentiate the needs of of that topic of building needs to breathe based on both looking at it from the occupant perspective and the building itself perspective. When we look at the building, we're looking kind of thinking more on the moisture management, the water, air and vapor control of the of the building walls, explore the indoor and outdoor pollutants that affects the the occupants, and kind of take a review of where the older buildings, The old uninsulated buildings, did. Were they any better because they they breathed? Were they? Were they better for everyone and for the building? So at the end of it, hopefully we have a bit of an open conversation to design and build better based on what what we what I review here, and better understand indoor air quality and energy loss through the building envelope. Okay, so building needs to breathe two parts of it. I'm going to break it up into the building side of things, the building envelope, the health of the building itself, and then the occupants, the health of the people that use the buildings. So looking at from the from the building side of things, so do buildings need to breathe? Why? Why do? Why do people say that? So I think the biggest reason is the thought of moisture management. Buildings get wet. Building materials get wet through seasons, rain events, groundwater, they need to dry, so it's okay. It's okay for most building materials to get wet as long as they readily can dry. We also have interior moisture sources from people, their breathing, showering, cooking, their activities, drawing, your clothes and plants as well.

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So I've heard of this before,

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and this saying is kind of the most durable building is actually one that has no occupants, because occupants provide a lot of moisture load to buildings. As long as that building, this is true, as long as that building is actually still heated, even though no one's in it, if it's not heated, then there could be issues, because you don't have that waste heat to dry dry out the walls. Okay, so if we look at it from the perspective of the four principal control layers of a building assembly, which are water, air, vapor and thermal, water is more important than air, air is more important than thermal and or air is more important than vapor, and vapor is more important than thermal. So it's it's in the order of importance there, and you can see kind of waters is rainwater, groundwater, that is the most important, that destroys buildings. It results in mold. And the least important thermal, the installation of the of a building assembly is kind of the one that the codes has the most to say about, and and kind of, when we talk about high performance buildings, is kind of what, what's referred to as an important metric, what's your our value of your wall assembly, though? Okay, it's high. So it must be a good building, but not necessarily, because that's the lowest ranked of importance. All these four, these four principal control layers, have one thing, one common thing in common, and that is heat and water, and specifically latent heat, which is when it's heat is released or absorbed in the change of a phase between a solid, liquid and gas. So vapor is water that has evaporated, and so is water vapor. Water is still in that form. For water to evaporate, heat needs to be added to the system and. Heat flow is prevented through thermal insulation, through through the walls, and then air itself carries a lot of

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a lot of moisture.

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So air carries a lot more moisture than than vapor diffusion through a building assembly. All energy is heat or on its way to becoming heat. Okay, so we look at these four principal control layers. We'll look at water and thermal here. So water, so buildings need to dry. Buildings naturally get wet when it rains. Water can can get in. We protect against water from penetrating your building, but it can still come in through construction defects or failed sealants, deteriorated materials, etc. It naturally gets comes into a building. It needs a dry so we need latent heat for that to happen, for that energy change from a liquid water to a vapor, to water vapor, it happens from the inside using that that energy comes from the inside using waste heat. So when you you're heating a building, there's energy flow from the inside of the building through your walls, and that helps dissipate that water and dry that that assembly, you add more insulation that reduces it and from the outside, we have a good energy source of the sun. Rain screens are really important to a drying to aid in drying from the outside and from the inside. Moisture flow from the inside through the assembly. If it can adequately, adequately move through and not condense, then it can also dry thermal control. So thermal reduces that drying potential, because it slows the heat flow, so it slows energy so the more we insulate buildings, the less waste heat, latent heat, can get to the building assembly and dry. So with that in mind, for the people that say buildings need to breathe in order for the building to last a long time. Well, the same so the it could be said, then, therefore, the buildings need to be uninsulated, which is unpractical from a comfort perspective of the occupants. And that's the primary importance of a building is is for shelter and protection and comfort, looking at vapor control. So climate specific vapor profiles are very important, depending what your climate is, where you're located, we want that building. We want to protect against moisture moving through your building and condensing in the winter time, because the warm, humid air on the inside of a building will will move through that assembly, that wall assembly, and condense. So you want to prevent against that using Vapor retarders, but using ones that are appropriate for your climate and application. So a building a swimming pool requires a different type of vapor barrier, vapor retarder than, say, a single family house. So our code mandates for part nine, single family house to be no greater than one perm, which is considered a class two vapor retarder. So Vapor retarders prevent wetting and interstitial condensation, which is which is great, but they also prevent drying in in one, in both directions. So they only so we want to promote drying in the in the correct direction. So, and that's only true for one of the seasons. So when we pretty much guard against winter time, when we have our vapor barrier on the warm side of the wall, and but then in the summertime, our vapor retarder, or vapor barrier, is actually on the incorrect side, because we are hot outside, and in an air conditioning building, it's cool inside, and so it's a little bit reversed. So we want to guard against we want to guard against that and provide vapor barriers that are correct for the climate and use of the building to maximize drawing of the assembly, because vapor barriers prevent drawing in the direction of the vapor barrier, vapor retarder and the last one is air control. So air transports. Heat and water, vapor and water holds a lot more energy and a lot more heat than air, four times as much by weight and 1000 or 3000

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times by volume,

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so there's far more moisture moved through air movement than vapor diffusion. So air control is much more important. That's why air control is much more important than vapor control. On

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that on that hierarchy list

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in a an example. Here is this figure. So sheet of drywall in the top is vapor diffusion movement pushing through a third of a quart of water in the in the bottom, the same area, but with a instead of vapor diffusion, it's a hole, a one inch hole with a pressure differential of five Pascal, which can be a regular amount of pressure difference that you could expect to see, and that one inch hole could be the free area of a electrical receptacle. And so you can see 30 quarts compared to a third of a quart. So it's it's 100 times greater of moisture movement, with through air leakage than it is vapor diffusion. Summer time we have high relative humidity, and in winter time we have low relative humidity. So if we don't protect against air movement and provide good continuous air control, we will have a lot of moist air coming into the building in summer and a lot of dry air exchange, we want to guard against that for occupant comfort and also building durability. So with that in mind, from the perspective of buildings, they shouldn't breathe. Buildings shouldn't breathe.

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They should be air airtight

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and vapor permeable in the right direction,

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with the with the right membranes. So now, for the other part, looking at the occupant part of the statement of buildings need to breathe. We as occupants need good air, good air quality, we need to not have pollutants in the air. And so what type of pollutants we have? We have CO two, which is carbon dioxide. It's a really good metric of people's exhaust, exhaust, air so and it's directly related to to occupants. So 11 by 13 size office room had atmospheric carbon dioxide increased from 500 parts per million to 1000 within 45 minutes of ventilation, cessation and closure of windows and doors that causes and affects cognitive ability. So CO two levels over 1000 parts per million, a study had found that they were linked to higher complaints of headaches, fatigue and eye and throat irritation, and another one showed that poor or or no ventilation in a bedroom with closed doors routinely exceeded 2500 parts per million and cause signal and significant. It can be a significant in the the sleep and next day performance can be significantly improved by increasing the clean outdoor air supply rate in the bedrooms, was what a study found. So it's incredibly important. Carbon monoxide co caused by incomplete combustion, it's odorless and can cause death. The sources are combustion appliances. So gas furnaces, gas water heaters, fireplaces, etc, all electric buildings that also don't have a fireplace are unaffected by carbon monoxide. So it's kind of a reason. One of the reasons why going all electric is can be healthy, also for the indoor air, for the indoor indoor air, and affect the the occupants. Another one is volatile organic compounds. So it's that new car smell, salted candles, have it perfumes, those aren't necessarily good healthy smells for you, they might smell good, but not necessarily, and more than likely, they are not good. Vocs, also includes formaldehydes and other known cancer causing toxins and caused by off gassing building materials. A lot of Engineer. Wood Products have formaldehydes in the glues. Insulation products are manufactured with their binder with formaldehydes. A lot of them claim or indicate that the formaldehydes are pretty much off gassed after the the production of the of the insulation product, but it's still there as part of as part of it, and remnants still might be, might be within that material. And another one is refrigerants. Radon is really important for it's for indoor air quality. It's a isotope. It's released from soil and rock. It comes from the ground. So it's a number one cause of lung cancer in non smokers, and the second number and the number two cause in smokers, it's odorless. It takes the path of least resistance to the to the ground surface, the ground surface so leaky basements, air leaky basements are an easy path for radon to enter your your building. Radon levels are typically the highest in winter time because ground cover provides a barrier, and so the path of least resistance is typically through building basements, and that same goes from days of of high rainfall, it kind of blankets that and provides an impermeable layer where radon levels can increase. So it's important to monitor or to measure radon levels in buildings, and if they are high, to provide mitigation against them, particulate matter, so commonly referred to as pm 2.5 there's also two point there's also pm 10 and pm one 2.5 is kind of the most common. It's known as fine particles, very small, smaller than human hair, and small enough to enter your bloodstream. There is no known safe amount of pm 2.5 that would be healthy or acceptable for for us to breathe. So we want as as little of it as possible. And the sources come from daily routine, things like like cooking and combustion appliances outdoor forest, fire, smoke, etc,

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humidity control.

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This is important. We touched up on this about moisture sensitive materials and in hardwoods, in buildings you don't want to have you don't want to have low humidity. You want to have high humidity. It it also affects comfort and health of occupants. So there's a bit of a comfort, an optimum comfort zone. So ASHRAE recommends for the best performance of the building envelope and occupant indoor air quality, I AQ of approximately 35% in the winter time. That's based in climate zone like Chicago, we're a little bit colder. An Rh of 35 for our housing stock would be a little would be wouldn't perform very good. We would have a higher risk of interstitial condensation, which is condensation occurring inside your wall assembly from the warm waste air traveling through and condensing. So we're a little bit 35% is a little bit high, except for the really like high performance homes that are buildings that have good air tightness and vapor control. So to guard against this, EVS ERVs, which are energy recovery ventilation systems to provide that fresh air, it also transfers, not only recovers heat, but it recovers some moisture, so that can reduce the moisture load in summer and also buffer it in winter, so it's not too drastically dry. Okay, so how do we get good indoor air quality?

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Fresh air ventilation is the most obvious,

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and through operable windows is a little bit difficult, because they're not reliable, and they also need input from people to open them and to close them. Nighttime. Be nighttime cooling. It can it can be cool at nighttime, but if you forget to close them then some in the daytime, it can get hot again. In the summer, it can be an issue, and it's not reliable. So mechanical ventilation is the best type of system. There is ERVs, which can provide that ventilation system. Controlled and balanced, so you have the same amount of incoming air than you do exhaust air. It's important to know that outdoor air is not necessarily fresh, and so it needs to be filtered. There's pollens, pollutants, smoke, etc, the air outside air is is dirty, and so it needs to be filtered. And so that is, that's an important aspect from operable windows, because operable windows can't be filtered. So mechanical ventilation wins there too, because you can put a ventilation or a filter with that. And all mechanical ventilation systems routinely come with with with filter. So what type of filter typically is recommended is a MERV 11. MERV stands for the minimum efficiency reporting value. The higher the number the better. Round MERV 13 is close to close to HEPA, kind of on the on the same lines of HEPA, you might hear that reference and then to control order odors and wildfire smoke, where charcoal filters can be added, included with that, and that can help and deter against those now to ERVs and HRVs, the importance of them, so these are done, rather than supply only or extract only. Ventilation Systems, the older type of buildings typically in our climate, in our area, in Winnipeg, typically had exhaust only so systems. So that would be, that would be a your kitchen exhaust coupled with your bathroom exhaust fans, so they're set on timers or whatever. So when you're taking a shower or or whatever, you can turn on your exhaust fun, and that turns on so it's actively pulling air out, but that air needs to be replaced, so it's all seeping in at different locations throughout your building. ERVs are good because ERVs and HRVs are good because they can provide controlled and balanced ventilation and filtered they also reduce the energy penalty, which is which can be quite high. So in our climate zone, we're looking about about 10, 10,000 BTUs per square foot per year, which equates to about the energy penalty of the ventilation alone, greater than 200% of the Passive House heating limit. Metric. It's quite substantial. And in terms of dollars, what that relates to is approximately two is about $600 per year for a typical 2000 square foot house with with that that's heated electrically at at 10 cents a kilowatt hour. This this screenshot here I took from my my own personal ERV system that I have in my house, and I've had it for three seasons, three winters, anyways. So it records the amount of heating that I've avoided through through recovery of of energy. And so you can see I've saved uh, 16,000 kilowatt hours. So at 10 cents a kilowatt hour, I saved $1,600 over over three years. So we're three winters, so it's very close to that $600 per year savings. Now it's important to note that when you're using an ERV or HRV, your ventilation rate is is typically greater than if you don't have ventilation if you don't have a controlled and balanced ventilation system, if you're only using extract then, then the amount of ventilation you're getting is a lot less, but that means your air quality is also reducing. So ERVs, HRVs, are worth it. So. Um, how else do we get good indoor air quality? So a continuous and robust air barrier is really important. So continuous everywhere, all the way from the foundation to the roof and through all penetrations wall penetrations through your walls, windows, doors, etc. It's important that improves the delivery of the filtered fresh air and removing the stale air, it averts infiltration of pollen and smoke, especially wildfire smoke, is becoming a lot more predominant these past summers, and it's for CASA to not get any better. So an improved and continuous air barrier is really important for that and preventing those pollutants from coming inside from radon. Radon infiltrates through the ground, and as I said before, it takes the path of least resistance. So if you have a very air leaky building, that makes it a very easy target for it to to for it to come in through something called stock effect,

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buoyancy of air,

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comfort. It affects comfort, energy efficiency, quietness and fire resilience. John Straub, which is a building scientist and and professor at the University of Waterloo, said in one of his articles, 1/3 of the energy probably by leaks through the holes in your house. We are at a colder climate than where he is, and so we're likely it's more around a it's a at least a half, if not more, depending on how efficient your your building is. But it's a lot early air leakage is a lot. And lastly, source control. So with ventilation systems

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providing supplying fresh air,

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filtered fresh air, outdoor fresh air to bedrooms and living areas and extracting through kitchens and bathrooms. Methodology, has kind of changed in the high performance world, from extracting from the kitchen hood or from the sorry, from the from the kitchen itself, and having a research hood over your cooktop. Now the methodology is to actually provide direct exhaust for your kitchen, kitchen exhaust fan,

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but with a balanced ventilation system, there

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would still be an extract zone somewhere in your kitchen, just a little bit away from where you're actually Cooking, so those greases don't clog your filtration system. Source of control also includes an active radon control system where required when it's when it's tested. And this is important too, from building to buildings, not necessarily. If your neighbor has high radon or low radon, that that you'll you'll be the same. Every building is different. Soil conditions are different, and the building building shapes and air control barriers are all different. Removing voc volatile organic compound, emitting materials are important, so synthetic carpets, using low VOC paints prevent or low or no VOC paints manufactured wood products, chipboards. I mean, they're always, it's always going to be there, like your Ikea furniture, but to be cognizant that there's a risk associated with these products. Is there a low VOC particle board and glues? Possibly Yes, but most of them, they all have formaldehydes and other that voc is associated with them and properly store cleaning chemicals, paints attached garages. Not to have gasoline containers in your attached garages, because those are still coupled indirectly, but coupled to your to your building, to your house. Have those in your garages, etc.

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Okay, lastly, so past buildings.

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What has changed? Were they any better? So ventilation with them? They was provided. It was provided, not naturally, through the air, leaky envelopes and and operable windows, including the commercial buildings. Um. The the office buildings, they had high exchange rate, but energy was cheap, and so they just provided and and threw more energy at it.

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Building walls were

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largely uninsulated. They were either empty or solid cavities, which meant that latent there was a high latent heat potential, and that was able to readily dry

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the walls, very easily,

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but obviously not comfortable and or energy efficient, and that less toxic building materials were were pretty prevalent, including the furnishing. So wood and steel furniture back then was now replaced with the plastic and particle board materials that we now readily see, and so off gassing of the formaldehydes and other VOCs wasn't common.

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It wasn't really a thing.

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So older buildings weren't also healthier. So summary, do buildings need to breathe? Short answer is no, it's saying is purely an excuse for carelessness air leaky buildings are poor or strategy to protect buildings and their occupants health and comfort. If we want to maximize durability, then we shouldn't insulate, nor should we occupy the building which is both unrealistic and pretty done. And remember that insulation slows heat flow, which reduces the drying potential. So higher performance buildings require high perform higher performance detailing, because we need better moisture management. Those buildings need higher moisture management. So the goal controlled mechanical ventilation with the correct filtration using ERVs and HRVs, they save significant energy. Proper distribution and design of of fresh air and exhaust

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air tight construction,

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which includes providing the correct vapor profiles, the correct Vapor retarders. Poly vapor barriers are a complete are a complete vapor barrier, and they totally prevent drawing in that one direction. So you install that and you only, you technically only have drawing in the outward direction to the outside, so using the highest vapor permeability material acceptable to control vapor for your Building assembly and source control, including direct exhaust kitchen fans and and that the Passive House and high performance methodology has changed in that perspective, and finally, using low VOC materials and furnishings. And that is the conclusion why buildings don't need to don't need to breathe.

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Excellent. Well, thank you so much for all of that information you just shared there. Grant, I don't know if you've heard, but after all the wildfires that has happened in the past little while, Canada has now the most polluted air polluted cities in North America? Is there? Like, how did that information hit you when you heard it, or if you just heard it here for the first time?

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Yeah, I've heard I've heard that before. I haven't heard that. It's the most but it is pretty shocking, right? Because everyone thought that Canada is this nice northern country with landscapes of green trees and and lakes. So yeah, it's not it's not great to hear. I.