Viridiant Lecture Series:

Water in Buildings

Moisture is nature's solvent.
Water intrusion is the most common cause of building and building material failure, not to mention indoor air quality issues associated with organic growth. In this report, we review the different ways moisture and condensation occur in buildings and how both can be remediated and often prevented.

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wall assemblies

Preventing water intrusion starts at the design phase. Material choices have a major impact on the prevention of moisture intrusion and subsequent moisture issues. By using the right materials and proper installation, you can remove a lot of moisture from the equation. The building is a system and should be designed with moisture movement in mind.

- Get your drainage details right. The most effective wall assemblies will vary based on climate zone.
- Moisture Control layers are done shingle fashion, beginning with the roof.
  - Roof penetrations, roof/wall Intersections, window and door flashing, downspouts, and foundation drains all need to be installed properly.
- Just like the air barrier, moisture control layers should be continuous and contiguous.
  - Air barriers warrant specific attention due to air flow's influence on moisture flow within buildings.
  - Buildings should be dried in prior to installing cladding.
- Pressurized rain screens are a great best practice. A pressurized rain screen will create drying potential between the wall assemblies and cladding.
- Enclosing and pressurizing the crawl space is a moisture mitigation strategy.

ventilation & dehumidification

If all details are properly executed in the field, dedicated dehumidification may not be necessary. That being said, elevated interior relative humidity must be actively dealt with in one way or another.

- Bath fans with proper air flow move the hottest, wettest air out of the building. Kitchen range hoods ventilate the water vapor & particulate produced during cooking.
- Ventilation ductwork must be well sealed and should be insulated to prevent condensation.
- HVAC systems need to be accurately sized for the building and the loads associated with the actual specifications of the structure.
  - Longer run times during the cooling season allow for the latent load to be reduced and sometimes eliminated within the space.
  - HVAC systems are typically not dehumidifiers. If the latent load can't be removed by the A/C, dehumidification may be necessary.
- Mixed-humid climates, such as Virginia, should consider a balanced or slightly positive pressure fresh air ventilation strategy.
- Sometimes dedicated dehumidification may be necessary.

source control

Source control, avoiding the use of wet or damaged building materials is necessary during construction. Often construction schedules are rushed and materials are not given enough time to dry out. Moisture content should be monitored to prevent future construction related moisture problems.

- Moisture content should be monitored in lumber and other building materials throughout the construction timeline.
- Damp blown cellulose needs to dry out before drywall goes up.
- Slabs can take years to cure; a dehumidifier in the basement will help mitigate the moisture given off.
- Allowing proper drying of the structural elements in the home can help avoid call-backs for drywall cracking and nail-pops once the structure finally does dry out.

water in buildings

Moisture will inevitably enter buildings, thus buildings should be designed and built to shed water away from the building assemblies in all instances, and when water gets in, that moisture must be allowed to dry out. There are a number of strategies to minimize water intrusion in buildings. Below you will find water movement basics, best practices, and mitigation strategies.

There are four ways in which water is driven into buildings: bulk water[1], capillary action[2], infiltration[3], and inward solar vapor drive[4] (to say nothing of interior generated moisture).

Bulk water is the most obvious and the first form of water intrusion that must be addressed. Water in the form of precipitation must be provided a direct path away from the building. Careful attention should be paid to drainage details. Roof penetrations should be minimized and laid out ahead of time to abate opportunities for bulk water to enter through the roof assembly. Large penetrations such as skylights are difficult to flash properly. Window flashing should be integrated with the drainage plane (house wrap) whenever applicable. When utilizing newer sheathing systems, follow the manufacturer's instructions for proper head flashing integration. With regard to windows and doors, flashing should be installed starting at the sill and working up so that the end product is shingle fashioned and encourages water to shed away from the building. Large overhangs will help protect wall assemblies from a constant barrage of precipitation. Gutter extensions should be used off downspouts to maintain at least a five foot distance between the foundation and water draining off the roof surface. Ideally these should be buried to drain water well away from the building's foundation and prevent removal during grounds maintenance.

source: buildinggreen.com

Buildings should be dried in prior to the installation of cladding. When installing cladding, a best practice is to utilize pressurized rain screens. The pressurized screen will create an air space between the wall assemblies and cladding. Moisture will inevitably get behind cladding, which is why we rely on things like weep holes in brick clad buildings and perforated siding assemblies such as those found in typical vinyl siding. Rain screens help protect both the cladding and the sheathing and add a level of drying to the wall assembly. Various products are available that create the desired air space, but one could also utilize furring strips and a mesh system to prevent insects from entering the air space created behind the cladding.

Four ways water is driven into buildings: bulk water, capillary action, infiltration & inward solar vapor drive

Capillary action is what allows trees to pull water out of the ground, and it works extremely well. In buildings, however, it can contribute to some serious moisture movement. Water will move up through porous building materials, from wet to dry. Brick, a durable, and often maintenance free building material, is also very absorbent. Through capillary action, water can move from the damp ground up through the foundation and wall assemblies of a building. Ensuring that proper site grade of 5% is achieved for 10 feet (or about 1/2 inch per foot of fall) will prevent the 'roots' of the building, the foundation, from pulling water out of the often saturated ground. In addition, capillary breaks can and should be utilized between the foundation and ground, foundation and framing, and then again below the bottom plates in contact with the floor system around the perimeter of the building.

Enclosing, or sealing up vents in traditional vented crawls, and slightly pressurizing the space is another moisture mitigation strategy. A slightly positive pressure will drive out water vapor and even radon in some cases. If HVAC equipment is present, a small duct register can be added to provide pressurization. Alternatively, a small in-line fan can be utilized to either supply conditioned air from the home or to expel it out of the crawlspace. Either way, some pressure must be working on the crawl. In addition to sealing the space, a vapor barrier should be properly installed, sealed to foundation wall and piers, with taped or sealed overlapping seams to prevent ground moisture from entering what will now be conditioned space. Remember, this strategy should not be pursued in areas where the water table is high enough that flooding may occur unless a sump-pump or other active drainage system is utilized.

Infiltration is the movement of water into buildings through air movement. Water vapor and air are not stopped by insulation and thus actual air sealing strategies must be developed and executed in the field. The building envelope needs a defined air barrier and vapor barrier, and these barriers should be continuous (no breaks) and contiguous (touching). In a mixed-humid climate zone such as Virginia, ensuring that wall assemblies have the ability to dry, at least to the inside, if not both ways, is paramount. Because the interior environment is typically dryer, with respect to relative humidity, than the exterior environment, our buildings typically dry to the inside. Avoiding a wall system which incorporates a double vapor barrier, such as OSB on the exterior and poly on the interior surface of the studs, can go a long way to ensure our structures remain durable and are allowed to dry when moisture gets in.

Wall assemblies will vary depending on the climate zone. In cold climates, builders will use plastic on the interior surface of the studs because the interior relative humidity tends to be higher than on the exterior –

the opposite is true in a place like Miami, where the exterior environment is typically quite wet. Moisture wants to move from wet to dry, or areas of higher relative humidity to areas of lower relative humidity. Wall assemblies in mixed-humid climates will ideally have the ability to dry both ways, but at minimum should be able to dry to the inside where we are passively, and sometimes actively, dehumidifying.

Inward solar vapor drive means that the heat from the sun on a wet building will multiply the water's movement into the building. Water moves from wet to dry and heat moves from hot to cold. So on a rainy, sunny spring day, both forces can potentially be at work, driving water into buildings.

Wet or damaged building materials are a major source of water in buildings. Source control is one of the easy ways for a builder to prevent future moisture issues. Most nail pops are caused by the drying out of wet framing. Moisture content should be monitored. Ideally, lumber should be in the 12-14% moisture content range before moving to the next stage of construction. Large scale construction dehumidifiers and large fans are options to speed up the drying process. Damp blown cellulose needs to dry out before drywall goes up, when in doubt, always follow manufacturer's guidance. Slabs can take years to cure, giving off water vapor into the basement. A dehumidifier will help combat this source of moisture.

Designers and builders also need to consider the right ventilation strategy for the building. Humid climates should consider a balanced or positive ventilation strategy. There are many products on the market that can achieve either, and more are added every day. A negative, or exhaust only strategy, should be avoided in our climate zone. Putting a building under constant negative pressure encourages uncontrolled infiltration through building assemblies. Every Cubic Foot per Minute (CFM) of air exhausted must be replaced by one CFM entering the building. If a pathway for this air has not been pre-determined and controlled, unfiltered, moisture laden air will enter the building through holes in the building envelope. As well as we seal homes today, they are not air tight and gaps the thickness of a business card will allow large amounts of unfiltered raw air to enter the building envelope. Not only will this contribute to high interior relative humidity but it can also affect comfort and indoor air quality for the occupant.

While plenty of moisture mitigation strategies have been covered, sometimes active, dedicated dehumidification is necessary. Condensation and water vapor movement will occur within buildings that have high interior relative humidity and cold surfaces. Metal surfaces such as duct registers and range hoods, made of material with little thermal resistance and often directly attached to cooling systems, will tend to show signs of condensation first. You may either raise the surface temperature or lower the interior relative humidity to solve such issues. During the cooling season, raising the temperature of duct registers can be difficult if comfort for the occupant is also maintained. This leaves one with dehumidification. Dehumidification is an investment helping to protect your building materials and indoor air quality.

Moisture has been a concern in buildings throughout history. As we tighten the envelope of buildings, we also decrease the drying potential of the assemblies within the structure. We continue to learn ways to build better and with special consideration given to how water will move around and through the building system, steps can be taken to prevent and curtail moisture problems with the home. Despite our best efforts to minimize water in buildings, we cannot account for tenant behavior. Once the construction details, timeline, and materials are addressed, occupant education will go a long way to prevent occupant related moisture issues from occurring.