Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

In masonry cavity walls—a design that has been in use for more than a century—the cavity provides a path for drainage and ventilation and acts as a capillary break. However, adhered masonry veneers like stucco and stone have been installed for hundreds of years without drainage or ventilation. So why do we need to add drainage and ventilation planes to adhered masonry walls now? The short answer is Standard 90.1, *Energy Standard for Buildings Except Low-rise Residential Buildings* from the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE).

ASHRAE is an international organization that sets energy-use standards for commercial buildings, and its standards are frequently used as the basis for building codes throughout the United States and Canada. Increasingly strict energy codes derived from ASHRAE 90.1 as well as recent changes in building materials, have made drainage and ventilation for adhered masonry walls just as important as they are for masonry cavity walls. Here are the top 7 reasons to specify and install drainage planes in adhered masonry wall systems.

1 - Water Really Wants to Make Your Walls Wet

Every mason and masonry wall designer knows water gets into masonry walls either as liquid (such as rain or snow) or as vapor (the gaseous form of water). Water vapor does not cause any trouble until it condenses and becomes liquid water. Therefore, while providing a drainage mechanism for liquid water is vital, it is just as important to get vapor out of the wall system before it becomes liquid.

Two physical laws make water behave the way it does. The first is that water is constantly trying to move from wetter to drier. This tendency is enhanced if the water is under hydrostatic pressure, the force exerted by pressure differentials caused by air pressure, humidity differences or heat.

The second is that water molecules are attracted to each other, which results in surface tension, the skin-like film on the water's surface that makes water drops possible. This attraction is also responsible for capillary action and is what makes water condense from vapor into liquid drops when the vapor reaches the dew point. The dew point varies based on temperature, atmospheric pressure and humidity.

When water drops are larger than holes in the wall components, they won't penetrate the holes because surface tension holds the molecules together in a clump that's bigger than the holes. But if water drops are under hydrostatic pressure, they can be deformed and pushed through very small holes in the veneer or the weather-resistive barrier (WRB). They can also become vapor, pass through holes one molecule at a time, and condense into liquid.

In adhered masonry walls, the design challenge is to specify insulation and a WRB with performance characteristics that consistently put the dew point in the space outside the WRB. When it comes to keeping a building dry, managing the location of the dew point in the wall is every bit as important as flashing the windows or sealing the roof.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

For example, if the dew point is inside the interior wall, water can condense in the batt insulation and on the back of the drywall and wall sheathing, setting the stage for material degradation and mold growth. A drainage plane is vital in providing an area outside the WRB with enough air flow to allow water vapor to evaporate and open space for water to condense and run out.

Water penetrates the wall in three different ways. It can:

- enter as liquid or vapor through tiny mortar cracks or through gaps around wall penetrations and at places where different materials meet;
- be drawn as liquid by capillary action through porous masonry; or
- move as vapor from a warm, humid side of the wall to a cooler, drier side of the wall, where it can condense into liquid if dew point conditions are met.

In cool weather, water vapor can move from the warmer, more humid conditioned air inside the building to the exterior, and in warm weather, it can move from the more humid exterior toward the cooler, drier interior. In either case, the vapor can condense at the back of the veneer. In addition, capillary action means a molecule of water entering a small hole will draw other molecules with it. Even without hydrostatic pressure, once water molecules start moving through a small opening, like a fastener hole, they can form a continuous chain of water that over time, can soak a substrate or absorbent veneer.

If there is no bond break between the base, or "scratch" mortar coat and the WRB, higher moisture content in masonry will move through small holes in the WRB and into the drier substrate. When the scratch coat is first applied over the lath, water from the wet scratch coat will try and move to the substrate, and if there is no bond break and hydrostatic pressure is strong enough, it will move from the scratch coat, through WRB holes and into the substrate. After the scratch coat cures, the small cracks that inevitably form in mortar due to mortar shrinkage and building movement will draw water in through capillary action and conduct it to the substrate where water content is likely to be lower.

So-called 'perched' water can also wreak havoc on adhered masonry walls with trim elements such as lintels. When water becomes trapped in the narrow space between the trim and the veneer, it cannot drain due to the clumping effect of water-molecule attraction. The water then soaks into the masonry, substrate, or both. When the sun's heat causes the humidity in the space between the veneer and WRB to become higher than outside or inside the building, the solar energy drives the moisture both outward through the masonry and inward through the WRB, as well as through any holes in the WRB and sheathing.

Preventing the large rain drops we see running off an adhered masonry wall veneer during a rainstorm from getting into the building is the easy part of keeping a building dry. It's water at the molecular level we have to watch out for.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

2 - Old Adhered Veneer Installation Methods Do Not Work With Modern Walls

Traditional installation methods for veneers such as stucco, manufactured and cast stone, and thin stone and brick employ either wire mesh or expanded metal lath firmly attached to the substrate as the support for the veneer. A cementitious mortar scratch coat that fully encapsulates the wire or lath is then applied to provide a strong foundation for the veneer. Veneer materials—except stucco—are adhered to the scratch coat by applying a solid layer of mortar to the back of each veneer unit and pressing it tightly against the scratch coat for a few seconds. Stucco is applied continuously as one or two coats over the scratch coat.

When they first became popular, adhered masonry veneer walls did not have the sophisticated flashings, insulation, and WRBs used today, so they leaked a lot of air and would dry quickly if they got wet. Installation involved simply adding a layer or two of building paper over the substrate, then attaching the lath over it. 1 x planks installed horizontally over the studs were used before plywood and later Oriented Strand Board (OSB) became popular, so lath fasteners could go into any part of the wall without concern for whether they hit a stud or not.

Now contractors are installing continuous insulation (ci) and WRBs as the best way to meet ASHRAE 90.1 standards, plus they have to install modern flashings and sealants around wall openings, and make sure all fasteners hit the studs since fasteners will pull out of modern sheathings.

Installation methods that allowed lots of air leaks simply don't work with modern adhered masonry walls designed to leak very little air. This relative airtightness is a key difference between older adhered masonry walls and those of today, and is one reason drainage and ventilation planes behind the veneer are so important in modern structures. Using modern materials but installing adhered veneer the way it used to be done means water that penetrates the wall stays trapped in the wall unless drainage and ventilation are added between the WRB and veneer to get it out.

3 - Weather Resistive Barriers Have Changed

Changes to WRBs are another difference between older and newer building construction. WRBs are membranes applied continuously to a building envelope. They are rated in "perms", a measure of permeability to water vapor, with higher numbers indicating greater permeability. A WRB's appropriate perm rating, and whether it is placed on the inside or outside of the insulation, is determined by the average heat and humidity of the climate in which the building is constructed. Ideally, a WRB allows enough water vapor to pass through it that the substrate dries without allowing liquid water through. Using two layers of building papers such as Grade D asphalt impregnated building paper or Number 15 felt as a WRB has been considered adequate for decades.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

The thinking behind using two layers of building papers is the assumption that the outer layer will get wet when the scratch coat is applied. When the papers dry, they wrinkle, eliminating any mortar bonding by pulling away from the scratch coat and creating a rough enough surface that water will drain between the papers and the scratch coat. However, since the wrinkles are shaped randomly, they don't create continuous drainage channels running the height of the wall, so they can obstruct water flow and create pockets where water can collect. Any buildup of water can lead to lateral migration of water at the laps and allow a wider area of the substrate and scratch coat to get wet.

Using plastic house wraps instead of building papers is another key WRB change, because some brands can bond strongly to mortar, which minimizes potential drainage. They also don't wrinkle when they dry the way papers do so they don't create space for drainage, and some of them can lose their water repellency due to contact with the surfactants in the mortar.

Several companies have created textured WRBs specifically for use with stucco that are designed to facilitate drainage and drying, and they produce better results than building papers or regular building wraps. However, they are not as effective as a plastic mesh drainage plane with a minimum ¼-inch thickness, which creates a physical barrier between the scratch coat and WRB that makes it impossible for the mortar to touch the WRB, and therefore impossible for liquid water to migrate from the mortar to the WRB. A ¼-inch thick drainage plane also provides a significantly wider space for water to drain and water vapor to evaporate than even the textured WRBs. Since today's buildings leak very little air, and today's papers and plastic house wraps allow little ventilation, there is usually very little opportunity for drying behind the scratch coat with paper, felt, or house wraps. Considering the low cost of a drainage plane relative to the cost of the overall wall and the costs of callbacks and repairs, a drainage plane provides very inexpensive insurance against cracks, water damage and mold.

Additionally, without a drainage and ventilation plane, building papers can absorb enough water to degrade and develop holes, which allows water to get to the substrate. They can also become saturated with water, creating an intensive vapor source inside the wall. If water stays in contact with the substrate, it can migrate through fastener holes and other penetrations and be absorbed by interior materials. If even small amounts of moisture stay in contact with the substrate long enough, it can cause fastener corrosion, nail pullout, mold, and sheathing degradation.

Since continuous rigid insulation (ci) is now commonly used to meet energy standards, manufacturers have developed rigid insulation with sealed seams, which serves as both ci and a WRB. These systems can be more efficient to install and more resistant to damage during installation than the WRBs mentioned above, but they still need drainage and ventilation.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

4 – Sheathing Has Changed

Water in the substrate can potentially lead to mold growth, as well as structural, fastener, and veneer degradation. Water damage in this area can be made worse by using OSB sheathing instead of plywood. According to Joe Lstiburek of Building Science Corporation, today's use of OSB is important when it comes to water management behind adhered veneers because it reacts to moisture very differently than plywood.

Plywood becomes more vapor-permeable as it gets wet, going from about 0.5 to 1.5 perms to more than 20 perms, which means its drying rate will increase as it gets wetter. However, OSB's vapor permeability—and therefore its drying rate—stays low and relatively unchanged no matter how wet it is. Water in plywood also moves laterally much more easily than it does in OSB, so it will migrate out faster and have a significantly lower tendency to concentrate in one area. With OSB, moisture will concentrate at the OSB/building paper interfaces, which can cause localized moisture stresses and damage such as softening, swelling, delamination, and fastener pullout. Moisture is most likely to collect around wall openings. With stucco veneers, control joints—especially horizontal joints—can also collect and hold water, meaning cracks most often appear around windows, doors, and control joints first.

Water moves through the pores of masonry from wetter to drier areas, and if enough water stays in contact with the masonry long enough, it will saturate the masonry through capillary action. While the rate at which a masonry wall dries is dependent on temperature, humidity, wind, altitude, and sun exposure, a good rule of thumb is it takes about 30 days for water to move one inch in porous masonry. Since a scratch coat and the mortar used to hold the veneer are, together, normally close to one inch thick, adhered masonry walls without drainage and ventilation that are exposed to wetting events more than once every 30 days are unlikely to fully dry once the masonry becomes saturated. And as we saw earlier, if the masonry is saturated, the water in the masonry will constantly try to move into the drier substrate.

5 – Insulation Has Changed

A material in today's buildings that was not commonly used even 30 years ago is continuous rigid insulation. Ci installed outboard of the substrate creates a high level of thermal resistance so heat will not easily move through the wall—good for occupant comfort, but not so good for drying. In poorly insulated buildings, temperature differentials between the interior and exterior walls create a heat flow across the wall that warms moisture and air in the wall and can make moisture move through the wall as vapor.

Combining this high vapor movement with lots of air leaks means the wall and veneer dry efficiently, because the vapor is carried away by the air movement. More efficient insulation means less heat flow, and therefore less vapor movement. Combine this effect with the much lower airflow inside today's relatively airtight walls, and walls exhibit much less drying.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

In addition, veneers in cold climates operate at colder temperatures in a ci-insulated building, so if the cladding temperature is at or below the dew point, any water vapor that touches it will condense into liquid water more readily than if the cladding is close to the same temperature as an uninsulated substrate.

Colder claddings also go through more freeze/thaw cycles and will freeze harder than warmer claddings, so water in the wall has the potential to cause more damage.

Finally, OSB and plywood sheathings may increase in moisture content during heating periods as insulation efficiency rises, because conditioned warm air inside the building carries moisture that gets absorbed by the sheathing but cannot move past the insulation. Ci means more moisture in the sheathing, more moisture in the masonry, and more trouble if it does not get out.

6- Veneer Options Have Changed

Hundreds of years ago, stucco was used primarily in dry climates and consisted of dried mud applied directly over mud or clay bricks without lath. Whenever there was appreciable rain or snow, the stucco had to be reapplied. Early in the 20th century, lime and sand and later cement was added to make it more durable. Today lime, sand, Portland cement and water are stucco's and adhered masonry mortar's key ingredients. During the 20th century, manufactured and cast stone and thin brick were introduced as alternatives to dimensional stone and full-sized brick. These thinner veneers opened up a wide range of design possibilities in adhered masonry, as did the introduction of stud framing.

So-called mass framing, the piling of materials on top of each other such as brick, stone, logs or rammed earth, was the common way to build walls for most of mankind's history. Some time in the early to mid 1800s, balloon framing using wooden studs began to gain favor in North America. It used much less material than mass framing per square foot of wall and was much cheaper and easier to build. As the system of using vertical wood studs as structural members became more common, builders started nailing wood strips across them horizontally to act as lath and to support the stucco as it dried, often without sheathing. Insulation wasn't used or even available back then and these wood strips moved a lot due to material expansion and contraction as the building temperature varied, so cracks were very common. As we've already discussed, these cracks let a lot of air in so the walls dried quickly and drainage wasn't necessary.

Today, substrates for adhered masonry are usually wood or metal studs or concrete masonry units (CMUs). For stud walls, sheathing such as OSB, plywood or gypsum is attached to the studs, then metal or plastic lath is solidly attached over the sheathing, which provides much more stable support to the adhered masonry than the old wood lath method. Some manufacturers are now making rigid ci that is attached directly to the studs and which acts as both insulation and a WRB. With this design, lath is attached directly on top of the insulation, although we recommend installing a drainage plane between the lath and ci. Lath fasteners must be driven at least ¾-inch into the studs, and advances in fastener and washer strength and design have made it possible for designers to include up to 2 inches of ci if the properly engineered attachments are used.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

Stucco and mortar mixes are still a mix of sand, Portland cement, lime and water, but acrylics and glass fibers are sometimes added to improve the stucco's structural qualities. In addition, many manufacturers utilize sophisticated chemistry to create climate-specific mortar mixes designed to produce the best long-term performance under expected local weather conditions. Acrylic stucco finish coats that are strong and flexible enough to cover small cracks and resist cracking as the building moves are now available in any color.

Thin brick, also called extruded brick, are usually made by extruding a clay brick material into a mold, then slicing the wet clay into the desired length and width before firing. They can also be cast or handmade, and are usually ½-inch to ¾-inch thick. Cast stone is a cementitious material cast in molds and colored to look like stone. It varies in thickness from about 1¾-inch to 3 inches. Thin stone is natural stone that has been cut into nominal 1¼-inch thickness.

Modern thin veneers provide a much wider range of design choices than traditional dimensional veneers while reducing installation costs and allowing thinner walls. Their reduced weight allows taller adhered masonry walls, precast dimensional details allow more complex designs, and control joints and weep screeds help improve wall performance. As a result, designers are now using adhered veneers in more areas of the country and on a wider variety of residential and light commercial buildings than in the past. As these wall types are used more often and in a wider climate range, they more often require proper drainage to perform properly because, as we saw in reason #1, water really wants to get into your walls, no matter how modern the design.

7 - Drainage and Ventilation Options Have Changed

The best way to let both the masonry and the substrate dry rapidly between wetting events is to install a drainage and ventilation plane at least ¼-inch thick between the WRB and scratch coat. Canadian codes require a minimum 10-mm (⅜-inch) thick drainage plane.

Think of the drainage plane as serving the same function in an adhered masonry wall as the cavity in a masonry cavity wall—it allows water and air to move freely behind the veneer for both drainage and ventilation, and acts as a bond break to prevent mortar bridging so water cannot travel from the masonry to the substrate. It also helps eliminate localized water stresses on the sheathing and other components because it allows moisture to migrate rapidly away from areas like wall openings and control joints. Further, a drainage plane allows water vapor to rapidly migrate from behind the veneer so hydrostatic pressure cannot build up and force it through small holes into the substrate, and it allows masonry to dry from the back, so even if wetting events are frequent, the masonry can dry more quickly and avoid saturation.

DriPlane™ is a new 90% open-weave polypropylene drainage mesh from Mortar Net Solutions with a factory-adhered water- and vapor- permeable fabric bonded to one side. It is installed between the WRB and lath with the fabric facing the lath to prevent mortar bridging. DriPlane is currently available in 4-ft wide rolls of ¼-inch, ⅜-inch (10-mm) and ¾-inch nominal thicknesses.

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

LathNet™, also from Mortar Net Solutions, offers an alternative method of providing a drainage plane. It is a 100% American-made lath/drainage system consisting of a 90% open-weave polyester mesh factory-assembled to a galvanized, G-60, 2.5-lb expanded metal lath. It is installed over the WRB and allows contractors to install the drainage plane and lath in one pass, which cuts labor time. It also cuts the number of fastener penetrations in half compared to installing the drainage plane and lath separately. LathNet is also available with a 3.4-lb metal lath and ¾-inch mesh thickness.

Conclusion

A drainage plane between the veneer and substrate is not yet required by most North American building codes for adhered masonry. However, building materials and construction methods are changing to meet more stringent energy codes and increase building design options and sustainability, which means the old ways simply do not work anymore. Further, modern building science has proven drainage planes can significantly reduce or eliminate moisture problems in adhered masonry veneer walls in the same ways that the cavity in masonry cavity walls do.

25 years ago, mortar-dropping collectors in masonry cavity walls were not part of code either, but as their value was demonstrated over and over, codes caught up, and now no mason or masonry designer would consider building a cavity wall without them. Drainage planes for masonry veneers are currently at the same stage as mortar-dropping collectors were then—quality builders and designers are using them even if they're not required by code because they reduce problems and callbacks, and because they make the buildings that use them a source of pride for both the builder and the designer. When codes catch up and start requiring drainage behind adhered masonry veneer, everyone will benefit.

For more information about topics covered in this white paper:

- "BSI-057: Hockey Pucks and Hydrostatic Pressure" Joseph Lstiburek, Building Science Corporation
- "BSD-105: Understanding Drainage Planes" Joseph Lstiburek, Building Science Corporation
- "The Sleeping Giant Awakes: NFPA 285" Owens Corning
- "Condensation and Rigid Insulation Placement" Norbert V. Krogstad, masonryconstruction.com
- "The Performance of Weather-Resistant Barriers in Stucco Assemblies" Karim Allana, Allana Buick & Bers, Inc., October 2016 RCI Symposium on Building Envelope Technology
- "Adding Drainage to Stone Veneers and Adhered Masonry" Steven Fechino, Mortar Net Solutions, Masonry Magazine
- "Building Things Right: Rainscreen Siding Systems" Professional Remodeler, 2/2016, Michael Anschel
- "Modeled and Measured Drainage, Storage and Drying Behind Cladding Systems". Research Report – 0905, 2009. John Straube and Jonathan Smegal
- BSI-038: "Mind The Gap, Eh?" Joseph Lstiburek, Building Science Corporation
- "The Energy Code and Plaster Assemblies" Western Conference of Wall and Ceiling Institutes, CIBTSIB082010

Top 7 Reasons to Include a Drainage and Ventilation Plane in Adhered Masonry Walls

Special thanks to Steven Fechino, Engineering and Construction Manager for Mortar Net Solutions, Jim Lucas of Lucas and Associates, and Scott Wylie of Wytech Building Envelope Solutions for their invaluable advice and expertise.

This White Paper is provided by Mortar Net Solutions. www.mortarnet.com 800-664-6638

For more information about DriPlane, LathNet, and other Mortar Net Solutions products, email info@mortarnet.com.

For free product samples, email samples@mortarnet.com or visit http://mortarnet.com/free-sample-request/
For design, bid and installation help, contact Steven Fechino, sfechino@mortarnet.com, 219-850-4514