# Exterior Wall Solutions for Hot-Humid Climates

(Climate Zones 1 - 3)

# ROCKWOOL™ Exterior Wall Solutions for Hot-Humid Climates

Hot-humid climates are generally understood by the building science community to be those that receive more than 20 inches (508 mm) of annual precipitation and have one or both of the following characteristics:

- 67°F (19.4°C) or higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year; or
- 73°F (22.8°C) or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year.

These last two criteria are the same criteria used by ASHRAE to define warm-humid climates. Regions that satisfy these criteria are very closely aligned with areas where the monthly average outdoor temperature remains above 45°F (7.2°C) throughout the year. International Energy Conservation Code (IECC) climate zones 1, 2 and parts of 3 fall into the category of a hot-humid climate.

**Building in Hot-Humid Climates**

Hot-humid climates are among the most challenging, and certainly among the least forgiving of climate zones. Of course, builders and designers everywhere must accommodate the increasing requirements for thermal insulation and the development of tighter building enclosures - both of which reduce a wall's capacity to dry - in conjunction with the use of modern, more moisture sensitive building materials. But it is in hot-humid climates that the risk of water-related building failures such as mold, rot, and odors is exacerbated and accelerated by significant moisture and temperature loads from the exterior, as well as a greater likelihood that the building materials themselves will already be wet prior to occupancy.

Increased solar radiation and vapor drive, high winds and high flood potential are some of the building enclosure strains -- also known as damage functions -- that are encountered in hot-humid climates.

**Exterior wall designs must consider the wall's drying potential and the effects of:**

- Increasing requirements for continuous exterior insulation,
- Tighter building enclosures
- Increased construction moisture from building in high rainfall, high relative-humidity environments
- The use of moisture sensitive building materials such as oriented strand board (OSB), paper-faced gypsum, and wood-based interior finishes

Essentially, many of the things we do to improve our buildings, like using more insulation, designing tighter enclosures, etc. - can have the unintendedconsequence of making our buildings less durable, uncomfortable, and, in more extreme cases, unhealthy. The converse, however, is also true: if water is managed properly, we can take full advantage of modern materials to design extraordinarily comfortable, energy efficient, durable, and cost effective buildings.

# Common Building Failures in Hot-Humid Climates

Nearly all building enclosure related failures in hot-humid climates are related to decay associated with water: rain water, ground water, water in the air, and water already in the materials we build with.

**Image 1:** Corrosion of the studs and fasteners on a 7-story concrete and metal framed building in a hot-humid climate, 7 years after the building was completed. The exterior water and air control layer of this building was a mechanically-fastened building wrap that was not detailed to be sufficiently airtight, nor was it sufficiently water-vapor impermeable to counteract high moisture drive from the exterior to the interior.

**Image 2:** Saturated oriented strand board (OSB) sheathing due to insufficient drainage and insufficient vapor control behind stucco on a 3-story townhouse in a hot-humid climate, 8 years after construction. The stucco cladding was installed over two layers of mechanically-fastened building wrap. While this wall assembly complies with the current building code and the windows and penetrations were flashed correctly, two layers of building wrap do not provide enough of an air space behind the stucco to (1) relieve hydrostatic pressure, (2) act as a capillary break and receptor for capillary water and (3) facilitate hydric redistribution and moisture removal by air change.

In hot-humid climates a drainage mat paired with a water and air control membrane with a water vapor permeance of between 5 and 10 perms is recommended to control wetting, while still permitting drying to the exterior. The additional drainage and water vapor control is especially important for buildings with higher moisture risk factors such as those constructed in wet climates (more than 20 inches of rain per year), those that are multi-story (exposed to higher wind and moisture loads), and those that are architecturally complex. Where continuous exterior insulation is used in high moisture conditions, the drainage mat is recommended to be placed on the interior of the insulation, between it and the water control layer. In lower moisture load conditions, a textured building wrap can be used in lieu of the drainage mat.

**Image 3:** Mold on the backside of a vinyl wall covering at a 4-story hotel. Vapor barriers such as polyethylene sheeting, foil-faced batt insulation, reflective radiant barrier foil insulation, and any impermeable wall coverings should be avoided on the interior of air-conditioned spaces in any climate, but especially hot-humid climates where buildings experience increased vapor drive from the exterior to the interior. Interior vapor barriers provide both a cold condensing surface for water vapor and restrict interior drying.

# Codes and Standards

The International Energy Conservation Code (IECC) and ASHRAE Standard 90.1 are most commonly referenced by local jurisdictions as well as building certification programs such as the U.S. Green Building Council's LEED. Both the IECC and ASHRAE Standard 90.1 have changed substantially in recent years, making it increasingly difficult for wall systems to comply without including continuous exterior insulation (ci), even in warmer climates. As these codes and standards are adopted – and as occupants and owners demand more energy efficient, thermally comfortable, and quiet buildings – builders and designers will be challenged to manage cost and risk with these new exterior wall assemblies.

### IECC 2018 Minimum Insulation Requirements by Climate Zone and Exterior Wall Type

| Climate zone (Representative City) | 1 (Miami, FL) | | 2 (Houston, TX) | | 3 (Atlanta, GA) | |
|---|---|---|---|---|---|---|
| | All Other | Residential Occupancy | All Other | Residential Occupancy | All Other | Residential Occupancy |
| **Mass Walls** | R-5.7ci | R-5.7ci | R-5.7ci | R-7.6ci | R-7.6ci | R-9.5ci |
| **Metal Framed** | R-13 + R-5ci | R-13 + R-5ci | R-13 + R-5ci | R-13 + R-7.5ci | R-13 + R-7.5ci | R-13 + R-7.5ci |
| **Wood Framed** | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 |

### IECC 2018 ROCKWOOL® Insulation Solutions by Climate Zone and Exterior Wall Type

| Climate zone (Representative City) | 1 (Miami, FL) | | 2 (Houston, TX) | | 3 (Atlanta, GA) | |
|---|---|---|---|---|---|---|
| | All Other | Residential Occupancy | All Other | Residential Occupancy | All Other | Residential Occupancy |
| **Mass Walls** | 1.5″ COMFORTBOARD™ or CAVITYROCK® | 1.5″ COMFORTBOARD™ or CAVITYROCK® | 1.5″ COMFORTBOARD™ or CAVITYROCK® | 2.0″ COMFORTBOARD™ or CAVITYROCK® | 2.0″ COMFORTBOARD™ or CAVITYROCK® | 2.5″ COMFORTBOARD™ or CAVITYROCK® |
| **Metal Framed** | 3.5″ COMFORTBATT® +1.5″ COMFORTBOARD™ or CAVITYROCK® | 3.5″ COMFORTBATT® +1.5″ COMFORTBOARD™ or CAVITYROCK® | 3.5″ COMFORTBATT® +1.5″ COMFORTBOARD™ or CAVITYROCK® | 3.5″ COMFORTBATT® +2.0″ COMFORTBOARD™ or CAVITYROCK® | 3.5″ COMFORTBATT® +2.0″ COMFORTBOARD™ or CAVITYROCK® | 3.5″ COMFORTBATT® +2.0″ COMFORTBOARD™ or CAVITYROCK® |
| **Wood Framed** | 3.5″ COMFORTBATT® +1.0″ COMFORTBOARD™ or CAVITYROCK® or 5.5″ COMFORTBATT® | 3.5″ COMFORTBATT® +1.0″ COMFORTBOARD™ or CAVITYROCK® or 5.5″ COMFORTBATT® | 3.5″ COMFORTBATT® +1.0″ COMFORTBOARD™ or CAVITYROCK® or 5.5″ COMFORTBATT® | 3.5″ COMFORTBATT® +1.0″ COMFORTBOARD™ or CAVITYROCK® or 5.5″ COMFORTBATT® | 3.5″ COMFORTBATT® +1.0″ COMFORTBOARD™ or CAVITYROCK® or 5.5″ COMFORTBATT® | 3.5″ COMFORTBATT® +1.0″ COMFORTBOARD™ or CAVITYROCK® or 5.5″ COMFORTBATT® |

Note: The cladding attachment method and cladding weight will dictate the use of either ROCKWOOL COMFORTBOARDTM or ROCKWOOL CAVITYROCK®. The thickness available may also vary depending on the product chosen.

# Designing Wall Assemblies in Hot-Humid Climates

**The two requirements for building enclosure design in Hot-Humid climates that most challenge builders and designers are:**

- keeping water out (including water vapor)
- letting water out if it gets in

Designing in hot-humid climates is complicated because sometimes the best strategies to keep water out also trap water in. This can be a real problem if the assemblies start out wet because of rain or the use of inherently wet building materials. By definition, hot-humid climates receive more than 20 inches of rain per year, and often this rain occurs during construction, before building materials have been protected by a roof, a water-shedding cladding, and a water control membrane. Inherently wet building materials include but are not limited to concrete, masonry, damp spray cellulose, drywall joint compound and paint. The problem of construction moisture is exacerbated by a lack of drying to the interior before the building's mechanical systems are conditioning the interior space.

The good news is that water vapor moves only two ways: vapor diffusion and air transport. Understanding the two ways and the climate conditions will inform the most appropriate design strategy.

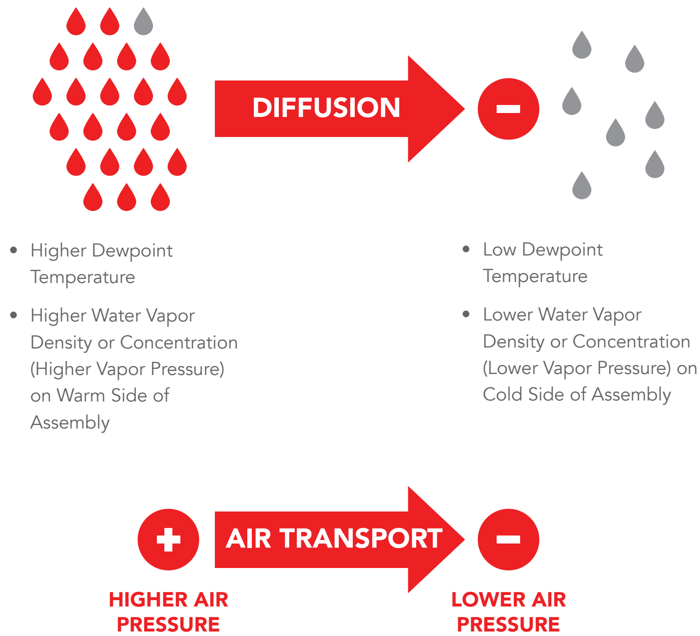



**Figure 2 - Water Vapor Movement:**

- Vapor diffusion is the movement of moisture in the vapor state as a result of a vapor pressure difference (concentration gradient) or a temperature difference (thermal gradient).
- Air transport is the movement of moisture in the vapor state as a result of an air pressure difference

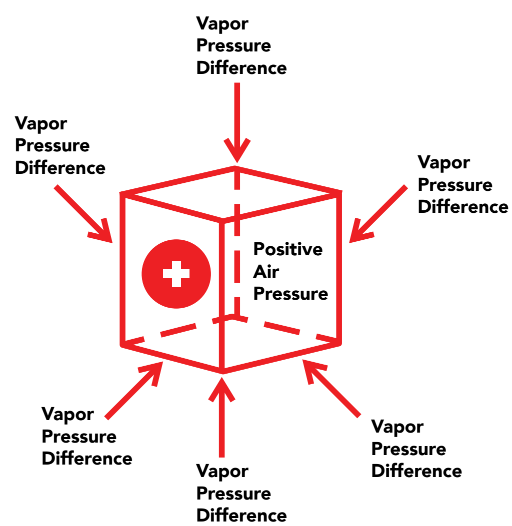



**Figure 3 - Opposing Air and Vapor Pressure Differences in Hot-Humid Climates:**

- Condensation on the exterior side of drywall can occur in high humidity environments even when the house is maintained at a positive pressure.
- The atmosphere within the cube in under higher air pressure but lower vapor pressure relative to surroundings
- Vapor pressure acts inward in this example
- Air pressure acts outward in this example

## Understanding Air Transport and Vapor Diffusion

Vapor diffusion is the movement of moisture in the vapor state through a material as a result of a vapor pressure difference (concentration gradient) or a temperature difference (thermal gradient). It is often confused with the movement of moisture in the vapor state into building assemblies as a result of air movement. Vapor diffusion moves moisture from an area of higher vapor pressure to an area of lower vapor pressure, as well as from the warm side of an assembly to the cold side, moving through the materials that comprise the wall assembly. Air transport of moisture will move moisture from an area of higher air pressure to an area of lower pressure, if moisture is contained in the moving air.

Vapor diffusion and air transport of water vapor act independently of one another. Vapor diffusion will transport moisture through materials and assemblies in the absence of an air pressure difference if a vapor pressure or temperature difference exists. Furthermore, vapor diffusion will transport moisture in the opposite direction of a small air pressure difference, if an opposing vapor pressure or temperature difference exists.

For example, in a hot-humid climate, the exterior is typically at a high vapor pressure and high temperature during the summer. In addition, it is common for an interior air conditioned space to be maintained at a cool temperature and at a low vapor pressure through the dehumidification characteristics of the air conditioning system. This causes vapor diffusion to move water vapor from the exterior toward the interior. This will occur even if the interior conditioned space is maintained at a higher air pressure (a pressurized enclosure) relative to the exterior.

## Water Vapor Permeability

The key physical property that distinguishes vapor retarders from other materials is permeability to water vapor. Materials that retard water vapor flow via diffusion are said to be impermeable. Materials that allow water vapor to pass through them are said to be permeable. However, there are degrees of permeability. It is helpful to understand materials as being generally water vapor impermeable, vapor semi-impermeable, vapor semi-permeable, and vapor permeable.

It is important to note that all building materials have physical properties making them either more or less permeable – not just those materials sold and marketed as "air barriers" or "vapor barriers." In selecting a wall assembly, builders and designers must be conscious of all the materials that comprise the system to achieve the desired effect: an exterior wall that sufficiently limits the amount of wetting, while also allows the greatest possible drying.

| Building Materials by Permeability | |
|---|---|
| **Impermeable**<br>(Class 1 vapor retarder, less than 0.1 perms) | Rubber Membranes, Polyethylene Film, Glass, Aluminum Foil (radiant barrier films/insulation), Sheet Metal, Foil-Faced Insulating Sheathings, Foil-Faced Non-insulating Sheathings |
| **Semi-impermeable**<br>(Class 1 vapor retarder, less than 0.1 perms) | Oil-based Paints, Vinyl Wall Coverings, Unfaced Extruded Polystyrene Greater than 1" Thick |
| **Semi-permeable**<br>(Class III vapor retarder, 1-10 perms) | Bitumen Impregnated Kraft Paper, OSB, Unfaced Expanded Polystyrene (EPS), Heavy Asphalt Impregnated Building Papers (#30 Building Paper), Most Latex-based Paints |
| **Permeable**<br>(More than 10 perms) | Unpainted Gypsum Board and Plaster, Unfaced Fiberglass Insulation, Cellulose Insulation, Stone Wool Insulation, Synthetic Stucco, Most Latex-based Paints, Lightweight Asphalt Impregnated Building Papers (#15 building Paper), Asphalt Impregnated Fiberboard Sheathings, Most "House Wraps" |

# Overall Strategy in Hot-Humid Climates

Building assemblies need to be protected from wetting by rainwater, ground water, air transport, and vapor diffusion. The typical strategies used involve water control layers (such as membranes, building papers, and house wraps), flashings, overhangs, site drainage, and capillary breaks to control rainwater and ground water.  Vapor retarders, air barriers, air pressure control, and control of interior moisture levels (ventilation and dehumidification) are used to minimize wetting by air transport and vapor diffusion.  Figures 4a and 4b illustrate the mechanisms of wetting and drying for exterior walls.

In designing a wall assembly for a hot-humid climate, the overall strategy is to keep building assemblies from getting wet from the exterior, from getting wet from the interior, and allowing them to dry to either the exterior, the interior or both, should they get wet or start out wet, as a result of the construction process or through the use of wet materials. Accordingly, air barriers and vapor retarders are installed on the exterior of building assemblies, and the building assemblies are able to dry toward the interior by using permeable wall finishes, installing cavity insulations without integral vapor retarders (i.e. unfaced insulations) and avoiding interior “non-breathable” wall coverings such as vinyl wallpaper.

**Strategies to reduce wetting include:**

- Providing a water control layer to control rainwater and ground water
- Providing flashings, overhangs, site drainage
- Protecting materials during construction
- Providing a continuous air barrier
- Providing an under-slab vapor barrier, and a capillary break at wall to slab interfaces
- Providing a vapor retarder on the exterior (10 perms or less)
- Ventilating the cladding
- Maintaining a slight positive air pressure with conditioned (dehumidified) air to limit infiltration of exterior humid air

**Strategies to maximize drying include:**

- Designing a flow-through assembly: provide permeable exterior insulation, avoid impermeable interior wall coverings such as vinyl or epoxy and alkyd paints, foil or plastic faced cavity insulations, and exterior vapor barriers (i.e. the water and air control membrane should not be less than 5 perms)
- Ventilating the cladding

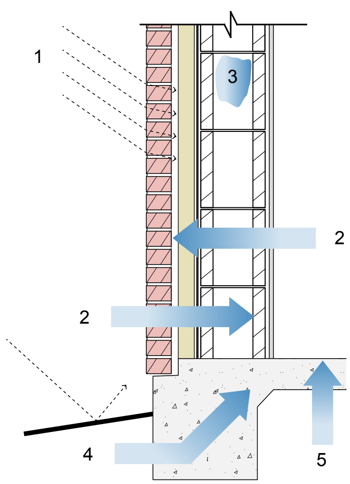



**Figure 4a: Wetting Mechanisims for Walls**

- Rain Water
- Water vapor in the air transported by diffusion and/or air movement through the wall (both to interior and exterior)
- Construction moisture and leeks
- Liquid and bound groundwater, driven by capillarity and gravity

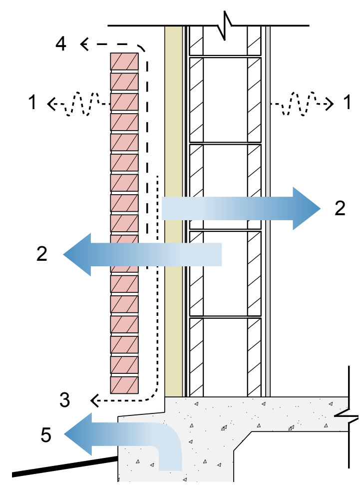



**Figure 4b: Dry Machanism for Walls**

- Evaporation liquid water transported by capillarity to the inside and outside surfaces
- Evaporation and vapor transport by diffusion, air leakages, or both either outward or inward
- Drainage of unabsorbed liquid water, driven by gravity
- Ventilation by convection through intentional (or unintentional) vented air cavities behind the cladding

## Ventilated Claddings

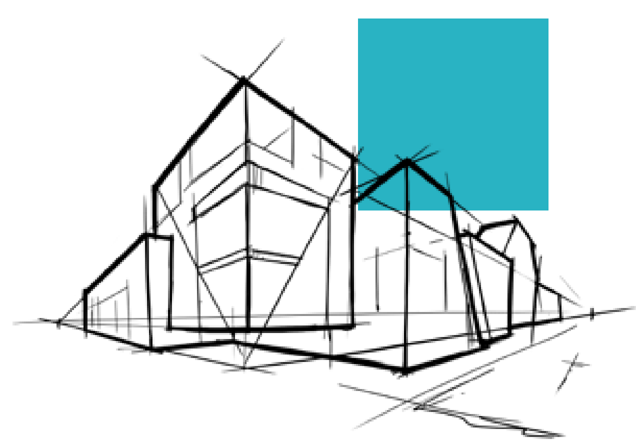
Ventilation (exterior airflow behind the cladding) is driven by wind pressure differences on the face of the building, or solar heated air rising ("stack effect"). It is useful because it accelerates drying by removing moisture from the drainage space behind the cladding. The ventilation essentially decouples the cladding system (the exterior finish) from the rest of the wall system, and increases the durability of both. Note that providing a ventilated space behind the cladding is included as a strategy that both reduces wetting and maximizes drying in flow-through wall assemblies – it accelerates drying of the cladding after it rains, and permits the rest of the wall to dry to the exterior after: wetting from leaks, using wet construction materials, and an excess of interior sources (high interior relative humidity). In order to maximize this type of drying, vents need to be provided at both the top and the bottom of the wall, and a clear air space, drainage mat, or draining insulation should link the vents at the bottom of the wall with those at the top. When exterior insulation is used, vapor open insulation such as stone wool is preferred because it accelerates this type of drying, and thus provides a more forgiving wall assembly.

Water vapor control is particularly important for reservoir claddings exposed to frequent sunshine. When absorbent cladding materials or retained water in the drainage space is heated by solar exposure, very large inward vapor drives can result. These inward drives can cause dangerous summertime condensation within wall cavities.

## Vapor Retarders in Hot-Humid Climates

The exterior vapor control layer in hot-humid climates should not exceed 10 perms. However, it is important here to note that builders and designers should be careful to not overshoot the mark: selecting a material that is too vapor closed (less than 5 perms) will also restrict drying. In a well-constructed wall this may not be problematic. However, in a wall that starts off wet or one that has a flashing defect or two, it can be devastating. The 5 to 10 perm recommendation represents a sweet spot for exterior vapor control in hot-humid climates.

Exterior rigid insulations may be used as the exterior vapor retarder, however, their permeability is relatively low which restricts drying to the exterior. Vapor-open exterior insulations such as stone wool, used in conjunction with a vapor retarder of approximately 10 perms, provides a more forgiving assembly with increased exterior drying. Additionally, this assembly is more capable of tolerating leaks and construction moisture. The 5-10 perm vapor retarder can be achieved by selecting an appropriate fluid applied, self-adhered, or mechanically fastened water control membrane applied over the sheathing or CMU back-up wall. Alternately, if plywood or OSB sheathing is used, a more vapor-open water control layer is permitted since the plywood or OSB itself provides the vapor control.x



# Walls that Work in Hot-Humid Climates

Designing a flow-through assembly in hot-humid climates will vary depending on the wall's structural system, the most popular of which are: masonry block walls (typically CMU), and wood or metal framed walls. Cladding systems will also vary, the most popular of which are: brick or stone veneers, stucco or adhered stone, panel sidings, and lapped siding.

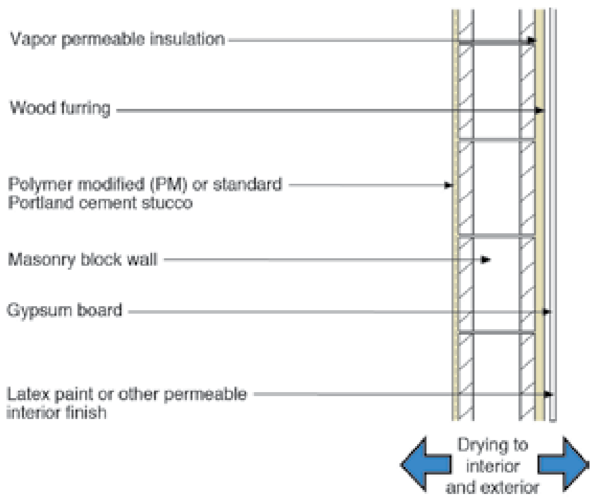



**Figure 5, 6 & 7:**
The above configurations work because the claddings are all ventilated, they include vapor control (but not a vapor barrier) at the face of the exterior sheathing or block wall, and do not include vapor barriers on the interior. Note that these configurations can be adapted to any cladding type. Stucco and adhered stone can be installed directly over continuous insulation by using a paper-backed lath. In high moisture load conditions, a drainage mat or textured building wrap can be added to the assembly, behind the insulation (between the insulation and the water and air control membrane). Fiber cement and other panel claddings can be installed over furring strips. For more information on cladding attachment with exterior insulations, refer to ROXUL Cladding Attachment Solutions for Exterior Insulated Commercial Walls.

CMU block walls such as the one shown in Figure 6 may also be insulated from the interior. The insulation is not moisture sensitive and does not restrict drying in either direction.

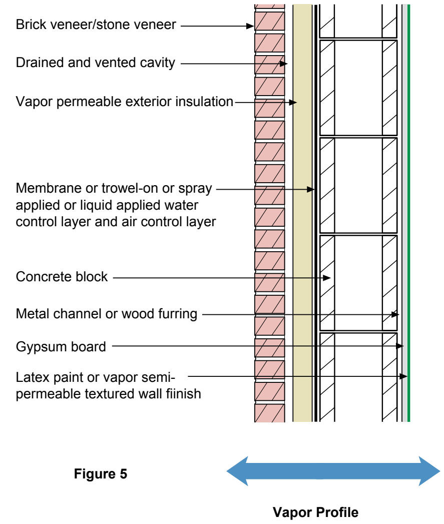



**Figure 5**

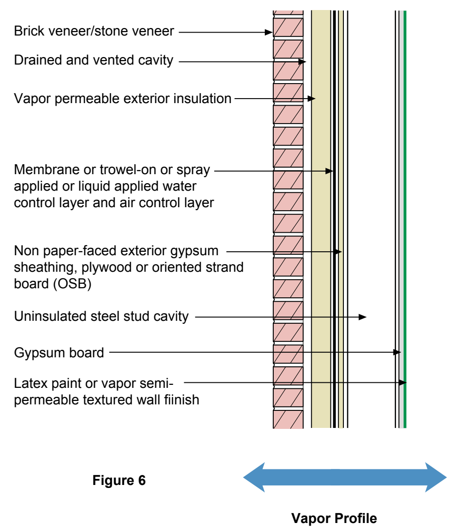



**Figure 6**

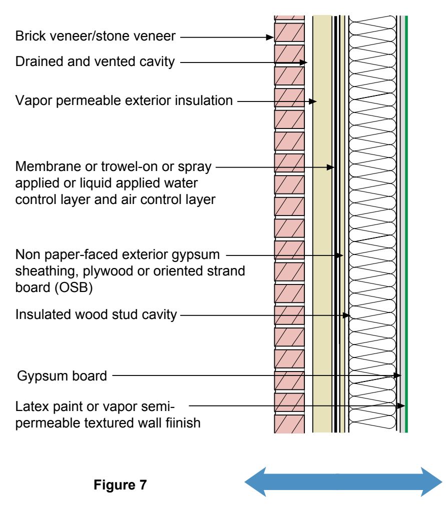
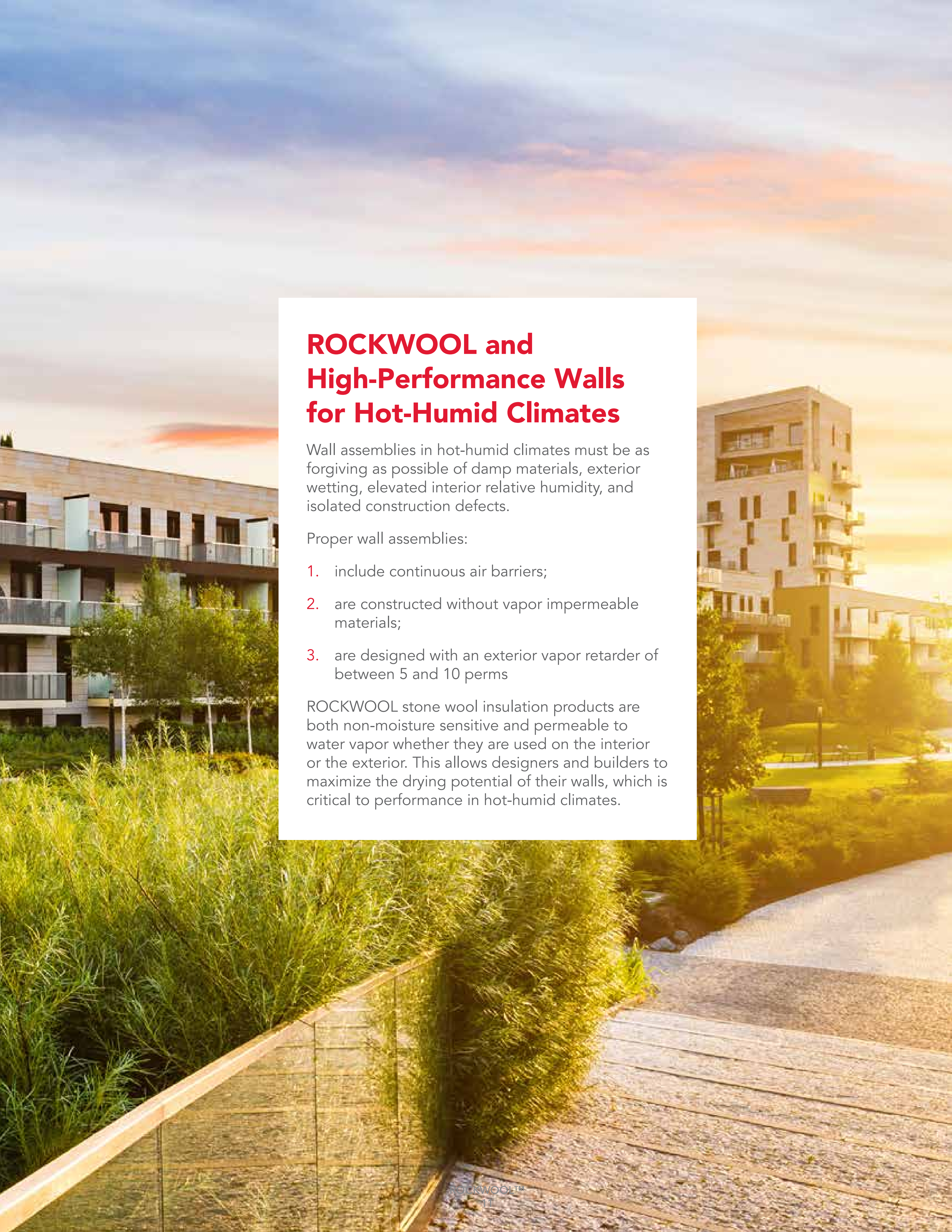



**Figure 7**



# ROCKWOOL and High-Performance Walls for Hot-Humid Climates

Wall assemblies in hot-humid climates must be as forgiving as possible of damp materials, exterior wetting, elevated interior relative humidity, and isolated construction defects.

Proper wall assemblies:

1. include continuous air barriers;
2. are constructed without vapor impermeable materials;
3. are designed with an exterior vapor retarder of between 5 and 10 perms

ROCKWOOL stone wool insulation products are both non-moisture sensitive and permeable to water vapor whether they are used on the interior or the exterior. This allows designers and builders to maximize the drying potential of their walls, which is critical to performance in hot-humid climates.

At the ROCKWOOL Group, we are committed to enriching the lives of everyone who comes into contact with our solutions. Our expertise is perfectly suited to tackle many of today's biggest sustainability and development challenges, from energy consumption and noise pollution to fire resilience, water scarcity and flooding. Our range of products reflects the diversity of the world's needs, while supporting our stakeholders in reducing their own carbon footprint.

Stone wool is a versatile material and forms the basis of all our businesses. With more than 11,000 employees in 39 countries, we are the world leader in stone wool solutions, from building insulation to acoustic ceilings, external cladding systems to horticultural solutions, engineered fibres for industrial use to insulation for the process industry and marine and offshore.

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