BY CLAYFORD T. GRIMM, P.E

Using Air Barriers

in Masonry Walls

Water in masonry walls creates numerous prolems: freeze/thaw fractures, cracks form, efflorescence appears, wall stains, insulation failure, material swelling, wood warp, gypsum decay, metal corrosion, paint peels, mold grows, mildew forms, and odors reek. Much thought is given to warding off wind-driven rain by using wall drainage cavities, flashing, and weep holes.

However, little attention is given to interstitial condensation that is often just as damaging. This form of condensation caused $68 million in mold and mildew damage in hotel-motel buildings in a single year. For example, all the brick veneer was removed from a hotel in Charleston, S.C. due to mold growth caused by condensation of infiltrating warm moist air.

Moisture movement

Wind, stack effect, and mechanical equipment create pressure differences that readily force air through masonry walls. In winter, warm moist air moves outward through the wall, becomes colder, and its relative humidity rises. When interior air at 70° F and 50% relative humidity is cooled to 50° F, its relative humidity increases to 100% and condensation occurs.

In summer, the sun drives water vapor inward by diffusion or warm moist air is forced inward by convection towards an air-conditioned space, which diminishes the air's ability to hold water and increases its relative humidity. If air at 85° F and 90% relative humidity is cooled just three degrees to 82° F, its relative humidity increases to 100% and condensation occurs.

Richard L. Quirouette in his paper "Difference Between a Vapor Barrier and an Air Barrier," Building Practice Note, No. 54 (National Research Council of Canada, Ottawa, Ontario, 1985) provides a steady state example to demonstrate that air leakage by convection transfers more than 200 times the amount of water transferred by vapor diffusion. However, traditional calculation methods cannot predict the amount of condensation because exterior and interior air and vapor pressures are constantly changing. For a description of a computer program that solves the problem go to *http://www.ornl.gov/ornl/btc/moisture/index.html.*

Paul R. Achenbach provides an example of interstitial condensation in his presentation "General Construction Principles," Moisture Control in Buildings (ASTM International, West Conshohocken, Pa., 1994, page 285).

"Air-conditioned buildings constructed of masonry block and finished with furring strips, insulation, vapor retarder between furring strips, and plasterboard interior frequently experience condensation on the back of the vapor retarder and softening of the plasterboard interior in humid and rainy climates. Even though the masonry block is painted, expansion and contraction can cause many hairline cracks in the painted surface. During heavy rains, water is absorbed into the cracks and is stored in the masonry block. Subsequent solar radiation drives the water vapor inward to condense on the vapor retarder and to be transferred through the furring strips to the plasterboard, causing it to soften and discolor. Enough solar heat can be stored in the masonry block during the day to continue vapor transfer to the vapor retarder and the plasterboard throughout the night. A surface coating on the ma-

Fig. 1

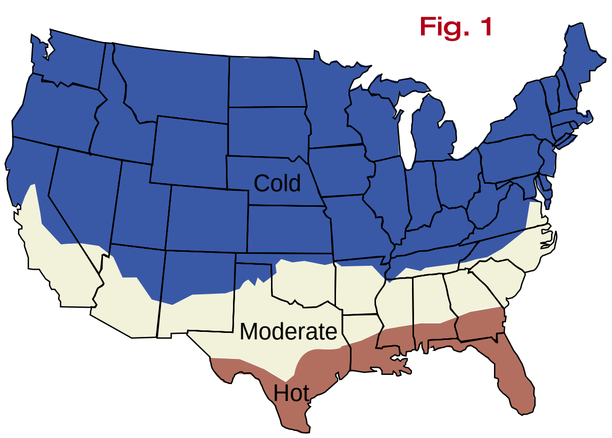
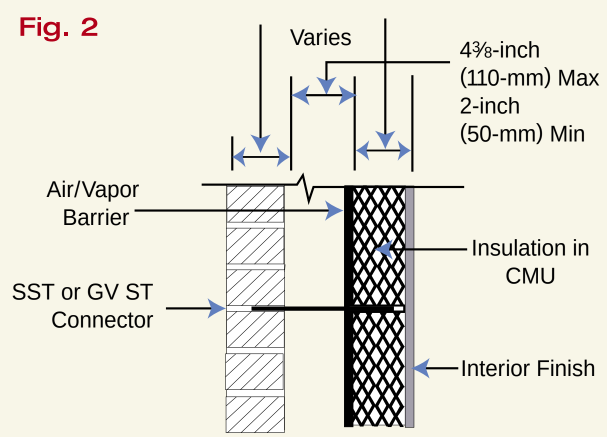


Fig. 2



sonry block that retains sufficient elasticity to avoid cracking under the temperature changes to which it is exposed would alleviate this problem. A saturated sheathing paper installed between the masonry block and the insulation would also protect the insulation and the interior plasterboard."

If a vapor retarder is placed on or near the interior wall surface of an air-conditioned building in a hot humid climate and there is no air barrier to prevent inward air movement, condensate may form immediately behind the vapor retarder. Mold growth may flourish if wallboard behind an interior vinyl wall covering becomes moist. The smell may make human occupancy intolerable and cause evacuation of the property.

An air barrier should be placed on the outside of the insulation if an interior vinyl wall covering is used in warm climates.

Air barrier systems

The purpose of an air barrier is to prevent the air from reaching a point in the wall cool enough to cause precipitation. Air barrier membranes are available in sheet form in a variety of materials: liquid applied rubber copolymers; "peal-and-stick" self-adhesive rubberized asphalt, EPDM (ethylene propylene diene monomer), and elastomeric bitumen.

An air barrier system is a continuous and durable network of materials and joints providing air tightness with adequate strength and stiffness to prevent excessive deflection under air pressure differences. An air barrier system requires continuity at four connections:

1. Joints between sheets of the air barrier membrane

2. Interfaces between walls and wall openings

3. Intersections between exterior walls and interior walls and floors

4. Cracks at wall penetrations.

Air barriers must be continuous, durable, impermeable, and structurally capable of sustaining the anticipated air pressure differential. Every effort should be made to ensure the tightest possible enclosure. However, it is practically impossible to completely seal the entire building envelope, although every effort should be made to do so.

Not all cracks can be sealed to ensure absolute air tightness. Specifications that simply require a continuous air barrier are not likely to achieve that effect in actual construction. Because it may be impossible to anticipate every airflow path, craftsmen should be encouraged to understand the importance of the problem and to make onsite suggestions for practical sealing solutions.

Ensure that materials joined as part of the air barrier system are compatible. Asphalt-based materials are incompatible with polyvinyl chloride, polyethylene, and polystyrene. Synthetic rubber adhesives may not be compatible with EPDM flashing. Some adhesives are highly flammable and give off noxious vapor.

Follow instructions on the Material Safety Data Sheets. Manufacturers should be consulted regarding compatibility of their products with other materials.

Fig. 1. Recommended U.S. climatic regions
Fig. 2. Air/vapor barrier in a masonry cavity wall in a hot climate
Fig. 3. Air/vapor barrier in a masonry cavity wall in a cold climate
Fig. 4. Air/vapor barrier in a single wythe wall in a hot climate

Fig. 3

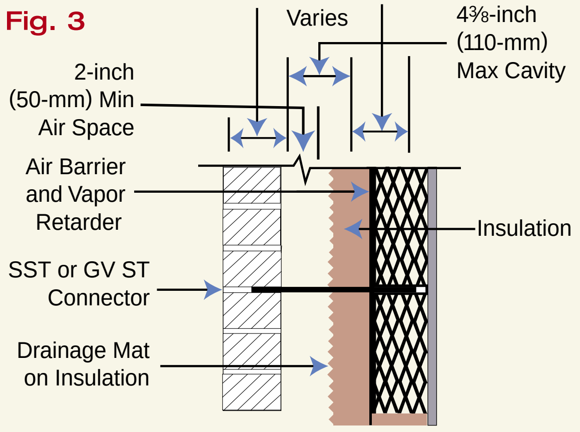
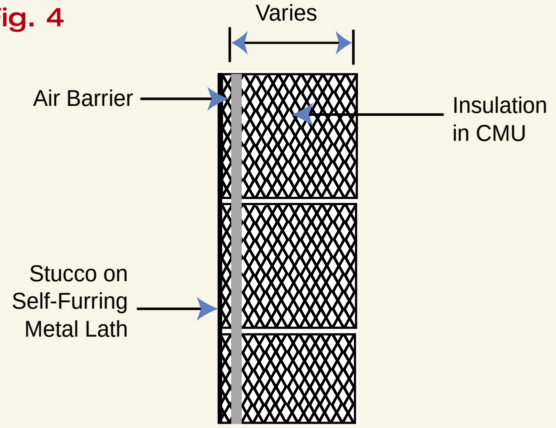


Fig. 4



Air barriers should be placed in cavity, masonry veneer, and single wythe masonry walls.

Placement

Air barriers are placed in three primary types of masonry walls: cavity, masonry veneer, and single wythe. All these walls have metal anchors, ties, and fasteners that cause thermal bridges.

In winter, connectors provide cool interior surfaces on which exfiltrating warm moist air can condense. In summer, infiltrating warm moist air can condense on metal ties cooled by interior air conditioning. For this reason, plus the permeance of masonry to wind-driven rain, corrosion protection for metal connectors in masonry often necessitates the use of stainless steel versions.

The table on page 38 provides recommendations for the position of air/vapor barriers and insulation in masonry cavity, veneer, and single wythe walls in hot and cold climates. Those recommendations depend on climatic regions (Fig. 1).

Cold climates have more than 4000 annual heating degree-days. Hot climates have less than 2200 annual heating degree-days. Moderate climates are between the two figures.

Air/vapor barriers are not usually necessary in moderate climates, with two exceptions. They are recommended on the warm side of the wall in air-conditioned buildings within 50 miles of the Atlantic coast south of Cape Hatteras and in buildings with refrigeration or other cold occupancies.

For any 24-hour day, the number of heating degree-days is the difference between 65° F and the mean outdoor temperature for that day. The number of annual heating degree-days is the sum of those values for a year. The number of annual heating degree-days can be found for 284 United States cities in *Local Climatological Data – Annual Summary with Comparative Data*, National Climatic Data Center, Ashville, N.C.

In cavity walls, location of the air barrier indicated in the table should prevent exfiltration or infiltration of moist air from reaching a point in the wall cold enough to cause condensation.

In veneer and single wythe walls in cold climates, an air barrier may be located on the interior face of the wall where it can serve also as a vapor retarder. This location facilitates inspection. However, care must be taken to ensure proper installation in plenum spaces, at intersecting partitions, and behind cabinets, pipes, and equipment.

Insulation

Foamed-in-place plastic, plastic inserts, and loose fill insulations are used to fill cells in single wythe walls of hollow masonry units. Rigid board insulation is placed in wall cavities and on interior wall surfaces. A drainage mat on the cavity face of board insulation drains mortar-clogged cavities.

Board insulation is usually 1- to 2-inches thick and is cut or kerfed to fit between metal ties in cavity walls. Boards are attached to the air barrier on the exterior face of the interior wythe in cold climates. Insulation boards may be attached to a wall's interior surface in single wythe walls. The boards may be held in place by stainless steel screws with large plastic washers.

Masonry walls should be parged to provide a smooth surface when adhesives are used to attach board insulation. A full bed of adhesive should be fully troweled to within 1 inch of each edge on clean and dry boards using a ¼-inch deep, notched trowel. Other methods such as spot daubs or beads should not be used because they allow air to circulate behind the insulation, which reduces insulation effectiveness. After adhesive application, the board is positioned on the wall and pressed firmly over the entire surface. Joints between boards should be staggered and tightly butted.

When board insulation has a reflective foil surface facing an air space in a well-insulated wall, the foil may have very little effect on the wall's thermal resistance. Furthermore, the corrosive effects of mortar on aluminum are well known. For these reasons, reflective foil on board insulation is of dubious value.

Batt insulation with a vapor retarder is placed between studs in masonry veneer walls and may be placed between interior furring strips in single wythe walls.

Building code requirements

Section 1403.3 of the International Building Code [30] requires an interior vapor retarder in exterior walls, but specifically excludes masonry single wythe walls, composite walls, and cavity walls designed in accordance with Chapter 21. However, that code requires a vapor retarder for veneer

Fig. 5

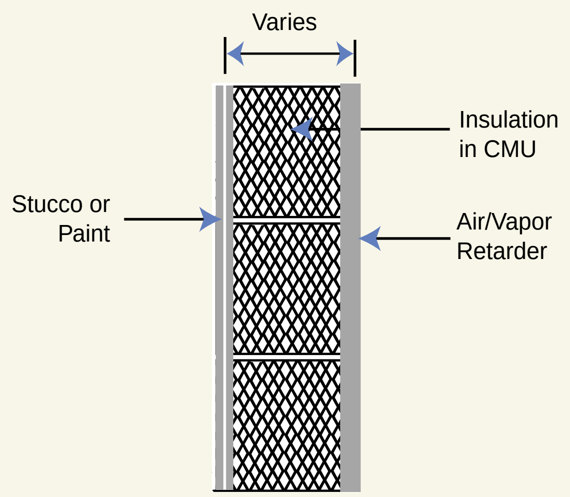


Fig. 5. Air/vapor barrier in a single wythe wall in a cold climate

walls designed in accordance with Section 1505.5.

Occupants and buildings can be adversely affected by the absence of a vapor retarder and an air barrier in building walls in many parts of the United States, whether or not the exterior masonry wythe is in a cavity wall or a veneer wall. A vapor retarder in the interior of a veneer wall in a hot-humid climate can be very damaging.

The National Building Code of Canada requires both a vapor retarder and an air barrier in all walls, except where an analysis shows that the safety of the building and the health of its occupants are not adversely affected.

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Additional information on this subject is found in "Masonry: Opportunities for the 21st Century, ASTM STP 1432," ASTM International, West Conshohocken, Pa., 2003.

Recommended Position of Air/Vapor Barriers and Insulation*

Wall Type	Climatic Region	
	Hot	Cold
Cavity	Place air/vapor barrier on exterior face of interior masonry wythe. Place insulation in the core/cells of hollow masonry units in the interior wythe and/or between furring on the interior face of the interior masonry wythe (Fig. 2).	Place air/vapor barrier behind board insulation on exterior face of interior masonry wythe (Fig. 3).
Veneer	Place air barrier on exterior face of sheathing. Place insulation between studs and vapor retarder at or near the interior surface (Fig. 4).	Place insulation between studs and place air/vapor barrier at or near the interior surface (Fig. 5).
Single Wythe	Place air/vapor barrier behind stucco at the exterior wall face. Insulate cores/cells of hollow masonry units and/or between furring on the interior surface (Fig. 6).	Insulate cores/cells of hollow masonry units and/or between furring on the interior surface. Place air/vapor barrier on the interior surface (Fig. 7).

** Buildings with low interior design temperatures, such as cold storage or ice rinks, should have the air barrier and vapor retarder on the exterior side of the insulation.*

Fig. 6. Air/vapor barrier in a veneer wall in a hot climate

Fig. 7. Air/vapor barrier in a veneer wall in a cold climate

Fig. 6

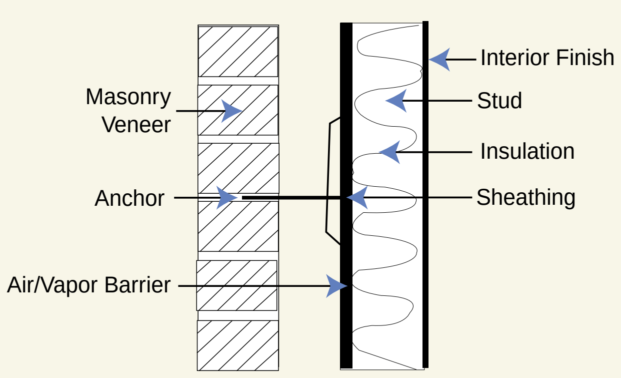

Fig. 7