Cavity Wall Construction

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Cavity wall masonry construction has come into its own in the last 40 years. Prior to that time masonry walls generally consisted of various types of solid masonry in multiple wythes.

The cavity wall, as it has come to be designed, consists of a masonry veneer, usually brick but can be stone or solid concrete block, separated from a support structure by a cavity generally 1" to 2" deep. The support structure began as concrete block masonry, but has evolved into steel stud wall construction with a wallboard type of sheathing.

The key to a good cavity wall design is to recognize that masonry is neither water resistant nor stable. Even new, freshly pointed brick masonry is porous to water. Masonry moves with moisture changes, temperature cycling, and chemical attack, in addition to wind and seismic forces.

Water Leakage Mitigation

The original masonry wall systems relied on the mass of the masonry to absorb water penetrating the exterior of the wall. The high lime content mortars were more absorbent than higher strength mortars containing Portland cement. This generally stopped the leakage before it reached the interior of the relatively thick walls. However, traditional wall systems that have experienced leakage for many years can loose a good deal of their absorbability due to the deterioration of the mortar as it is exposed to carbonation and freeze thaw cycling.

Most of the water leakage that penetrates masonry enters between the masonry units and the mortar, especially if the head joints were not filled during placement and are only filled at the surface during the pointing process. Over time, the joints around the masonry units can lose bond and form cracks that increase leakage. The masonry units themselves, brick, block or stone, are relatively non-porous to free water.

In cavity wall construction, the key to water leakage control is a properly designed and constructed drainage system between the backup wall and the masonry veneer. This system must include a water resistant membrane on the backup wall, a properly installed flashing membrane at the base of the wall and adequate weep holes through the wall to allow the collected water to drain.

Today's wall systems are quite thin by comparison to traditional walls, generally consisting of only one wythe of brick in front of a steel stud backup wall system. If water penetrates the waterproofing system built into the wall, it can deteriorate the structural backup system supporting the masonry, as well as damage the interior finishes. It is important to provide a *continuous* through-wall flashing system at the base of the masonry, i.e. on the foundation, at lintels and along relieving angles.

Sprint Building, Overland Park, KS

Flashing

Continuous means that the ends of the flashing need to be turned up and pocketed. Prime examples include where the flashing ends at a wall opening, and at inside and outside corners. The flashing materials need to have sealed joints; simply lapping materials does not work well. Applying flashing at wall penetrations, windows, doors, louvers, etc. is also a must. The joints between these materials and the masonry are usually filled with a bead of sealant. Without an adequate through-wall flashing, and flashing behind the sealant beads to direct water to the through-wall flashing, the wall is only a sealant bead away from potential disaster.

Through-wall flashings need an upturned leg along their inner edge, so that the water resistant covering on the backup wall deflects water penetrating the masonry into the flashing system. The outer edge of the flashing should extend to the face of the masonry. Extending a metal flashing pan beyond the face of the masonry with a turned down lip deflects water from the wall. Sealant below the pan reduces water penetration into the wall. There should not be a sealant bead placed in front of a relieving angle or lintel. This location of sealant slows or prevents the release of water trapped by the flashing or angle, and redirects it into the building through weaknesses in the flashing. It also prematurely corrodes the angles.

The cavity needs to be well drained by the proper use of weep openings. Weep holes need to be at the level of the flashing to prevent the collection of water on the flashing. When water does collect on the flashing, it will run and find weak points in the flashing. Using rope or plastic tubes to form weep holes is problematic. The holes are too small and the voids formed are usually sloped upward, entering the cavity well above the level of the flashing. Installing several levels of weep holes, a practice adhered to in some areas of the country, only adds to the water in the cavity and does not improve weeping. A good method of forming weep holes is to insert plastic fillers in the head joints that partially block the opening to insects, but allow free drainage and are less noticeable than a fully open joint.

Through-wall flashing must be durable and as long lasting as the design life of the masonry. Copper and stainless steel have been successful, but need expansion joints. A successful method is the installation of a metal pan covered with a modified bitumen self adhering membrane that is easily pocketed and lapped. During the last several decades, many walls were flashed using PVC membranes. Most of these membranes have failed prematurely by shrinking and splitting. The results were disastrous, requiring their replacement. Even PVC membrane concealed within the cavity, away from UV rays, deteriorates rapidly.

Masonry Movements

Brick units are never as small as when they come out of the kiln, due to moisture absorption. Conversely, concrete masonry units shrink following forming. Thermal expansion of masonry occurs both horizontally and vertically. Horizontal and vertical control joints are recommended to allow this movement to occur without cracking the brick. The thermal difference of masonry from one side of a building corner to the other can be sufficient to create stresses in the brick that cause cracks to form at the corner, or create other movement related distress, if a control joint is not near the corner.

Constraints on masonry by the structure itself can load the masonry and cause cracking. The downward creep of concrete structures has over stressed brick veneer where the horizontal control joints were insufficient to allow for this movement. Deflection of the floor beams from floor loading, and from rolling, can also be a problem.

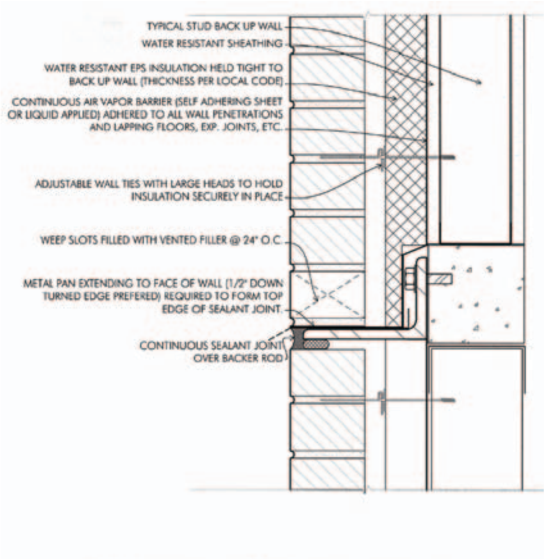
The thermal cycling of the masonry can also cause the masonry to "grow" from its original size. In areas of numerous thermal cycles, a hysteresis effect occurs where masonry grows because the thermal shrinkage effect is never as great as the expansion effect. Thermal cycling can also cause the masonry to walk off the supporting angle or shelf if not adequately restrained by wall ties. This is especially true with parapet masonry that usually is not too tall and therefore applies a relatively small dead load on the support, decreasing the friction factor and increasing the likelihood of unwanted movement.

Carbonation of the free lime, from calcium oxide to the greater volume calcium carbonate, and other chemical changes in the mortar also cause the masonry to expand. This is why brick chimneys seem to bend towards the sun – the chemical changes are greater on the colder and damper side of the chimney.

The attachment of the masonry needs to be designed to accommodate these movements, and still maintain the attachment of the masonry to the structure. Mechanical two-piece ties with sufficient adjustment are needed to allow the mason to install the tie in the correct location to provide vertical movement and be properly embedded in the mortar. At one time, corrugated metal straps were used as ties. Time has shown that these types of ties can fail from bending fatigue and are generally no longer recommended. Additionally, the flat stock of corrugated metal may not have the required compression to deliver wind loads from the veneer to the backup structure.

Moisture Movement through Walls

The concerns for energy efficient buildings have brought about changes in the way walls are constructed. A growing concern is the increase in



1 TYPICAL WALL SECTION (NORTHERN CLIMATE) WITH INSULATION IN CAVITY

mold related problems in buildings, especially as structures are being built "tighter" with less air leakage through the walls. While walls are getting thinner, the insulation requirements have increased. Problems can occur when the moisture generated in the building passes through the walls faster than it can be diffused through the wall materials.

The free flow of moist air through an opening in a wall will transport hundreds of times the amount of moisture diffusing through the wall materials. This can cause condensation in the cavities of cavity walls. The additions of vent openings in the veneer, in addition to weep openings, are being recommended by some experts. The air and vapor barrier, as well as the flashing system, needs to be well thought out with the addition of more openings in the veneer. Weep and vent openings will permit wind driven water to enter the wall cavity, as well as drain and vent it out.

Air and vapor barriers can be combined in one membrane, as long as the membrane is on the warm side of the insulation. The plane of the wall cavity is a convenient location for this barrier, for ease of installation and continuity. In cold climates, the insulation needs to be located on the exterior side of the air/vapor barrier, which is in the cavity. Extruded polystyrene [EPS] insulation is usually used in the cavity for its minimal moisture absorption qualities. It must be well butted and fastened in place to limit air flow around the insulation that would reduce its effectiveness. In warm climates, the air/vapor barrier is located on the exterior side of the insulation. This will protect the backup wall from moisture in the cavity, and the insulation can then be installed within the stud cavity. The user of vinyl wallpaper in warm, humid climates has proven to be a problem. This type of material acts as a vapor barrier on the wrong side of the insulation.

The air/vapor barrier must be connected to wall penetrations, windows, doors, louvers, pipes, etc, in order to form a continuous barrier to air/vapor movement through the wall system. The tracing of a line on the plans through the wall sections, indicating the location of the continuous air/vapor barrier, shows the builder the intent of the design to separate the conditioned interior space from the exterior air. The tracing of this line can be difficult within the building construction. Utilizing the wall cavity for this separation is much more convenient. However, the addition of the insulation within the wall cavity results in the need to move the masonry outward, requiring larger relieving angles and longer wall ties.

Examples of moisture migration through existing construction, similar to that in a poorly sealed cavity, include the following interesting examples. The owner of an exercise gym in a building in Vermont complained of leakage through the garage deck above the gym whenever snow began to melt from parked cars. This leakage turned out to be melting ice that had formed on the underside of the deck, a result of moist air from poorly vented showers. The moist air penetrated a poorly installed polyethylene vapor barrier on the underside of the deck. In a second example, water leakage was reported in a tomato factory. Green tomatoes are warmed and gassed to turn the tomatoes red, and they loose 10% of their moisture in the process. This leakage was determined to be the excess moisture condensing on the walls and roof sheathing of the structure due to the lack of ventilation in the building, and the unsealed laps in the vapor barrier.

Mold

The flow of moisture through building walls follows the flow of heat from the warm to the cold side of the wall. In cold climates, the moisture within the building tries to pass through the wall to the exterior. In warm climates, the moisture flow is from the exterior to the air conditioned interior. This has been a major problem for buildings in areas of high humidity. Several southern buildings have had to have the exterior walls rebuilt to control excessive moisture penetration from the exterior. Moisture vapor passing through a poorly installed vapor barrier in the cavity will condense on the exterior side of the wallpaper, and contribute to mold growth.

Mold requires moisture, warmth and food to grow. Mold spores are in the air and can travel everywhere. Common construction products such a wood and the paper facers on wallboard contribute the food source. The flow of air through the wall needs to be restricted by the use of a continuous air barrier, and moisture flow needs to be controlled by the use of a vapor barrier. The air barrier can be located anywhere in the wall if it has a high permeability to water vapor. A vapor barrier must be located on the warm side of the insulation to prevent condensation of moisture on the vapor barrier.

Conclusion

Important things to consider when designing a masonry cavity will include: masonry is far from water tight, masonry moves for a variety of reasons, and masonry walls need to be constructed to restrict the flow of moisture laden air and water vapor. The proper design and construction of continuous through-wall flashings at masonry supports and around wall openings are critical to controlling leakage through the masonry, and direct it to drain from the wall cavity. The proper design and construction of a continuous air/vapor barrier is needed to reduce the flow of moisture through the wall system to levels that can be handled by the wall materials, without condensing in the walls to produce mold, ice or other conditions that contribute to the deterioration of the wall.

The proper placement and sizing of control joints, properly sized and placed wall ties, and support angles or shelves stiff enough to limit masonry movements are important considerations. These controls are important in light of the likelihood that the veneer masonry will move over time, and will move differently than the backup wall materials.

Cavity Inserts

What's Up with Mortar Droppings?

Beyond workmanship and materials, proper and well developed detailing for cavity walls is essential. Decisions regarding flashing and weep holes, as a portion of the system for collecting and diverting moisture, is an integral part of that detail.

Mortar droppings and other obstructions must be prevented from bridging the air space that separates the masonry wythes. Secondarily to good workmanship, there are a number of approaches available to keep an open drainage path to weep holes.

Although not required in all situations, drainage materials can be installed above the flashing, allowing water to flow around any mortar droppings. The downside is that the use of drainage materials may result in mortar bridging the airspace in certain locations, possibly above the flashing level. This could lead to isolated damp spots, or lead to a path for water penetration.

A layer of pea gravel can be placed on top of flashing installations within the wall system. A bed of mortar, placed under the flashing and conforming to its curve, can provide additional support for the pea gravel. The weight of the gravel on flashing can cause tearing or puncturing at the bolt head.

Other types of cavity inserts are gaining popularity in addressing the problem of mortar droppings. Several open cell inserts are available, including, but not limited to, base inserts of synthetic woven plastics (which keep mortar dropping at different levels), full height cavity inserts, galvanized metal screens spanning the air space above the weeps, and full height drainage boards.

A good starting place for resources on masonry topics, including cavity walls, can be found at the Masonry Institute of America website, **www.masonryinstitute.org,** on their *Industry Sites* pages.