At the second official meeting of the Building Enclosure Council of Greater Detroit, I had the privilege of speaking to the assembled group of architects and engineers about the different types of masonry walls, and specifically, about insulated masonry cavity walls and the advantage this wall system has when it comes to resisting environmental loads.

Environmental loads, both natural and man-made, discussed were fire, thermal, water, air, sound and accidental loads — all elements which challenge the long-term performance of a building envelope and should be considered in design along with structural integrity and aesthetic appeal.

More Than Just Enclosure — the Premier Wall System

Masonry Standards Joint Committee’s (MSJC) Code stipulates that a wall is “a vertical element with horizontal length to thickness ratio greater than three, used to enclose a space.” That means, for an 8” block used, the length must be greater than 24”. Masonry wall systems may be reinforced or un-reinforced. They may also be loadbearing or non-loadbearing.

Masonry walls are made up of a single wythe or multiple wythes. A wythe is a continuous vertical layer or width of a masonry material. A 4” single exterior wythe of brick is also called a veneer. A veneer connects to the back-up, including masonry, wood, steel or concrete, with anchors.

Years ago, walls would be comprised of multiple wythes of brick laid tight to each other producing a solid wall. Multi-wythe walls now are usually either composite or non-composite. Composite walls fasten the exterior and interior wythes together with ties or headers with the collar joint grouted or mortared to allow the two walls to work together resisting vertical and lateral loads. It is much more common to see a masonry cavity wall, or non-composite wall. The unique element of this wall is the air space between the two wythes, which are still connected with ties. Today, a single wythe wall of clay or concrete can also provide a structural enclosure. Any of these configurations enables a wall to “keep the outside out and the inside in,” the purpose of a wall, according to Joseph Lstiburek, PhD, PEng, ME, principal of Building Science Corp., Ontario, in his article “The Perfect Wall,” which appeared in the ASHRAE Journal, vol. 49, no.5, May 2007.

Details for a multi-wythe wall system are available on the MIM website free of charge (www.mim-online.org). There are details for base, sill, control joints, expansion joints and head joint details. Attention to these details at design and installation are crucial to a wall functioning properly as an enclosure.

Fire Resistance

In an insulated masonry cavity wall, both the interior and exterior wythes play a role in the fire resistance. So does the air space between the two. When calculating the fire resistance rating of a typical multi-wythe wall, the following equations show the outstanding results of a cavity wall assembly.

Fire Resistance

Inherent properties of masonry make it well suited as a material of choice when designing for fire safety. They provide solid, noncombustible barriers to prevent spread of fire from area to area and, therefore, can be useful in creating safe escape routes out of a building.

A wall’s fire resistance rating is the time it endures fire without any signs of failure, rounded down to the nearest whole hour. Maximum fire resistance rating typically allowed by code is four hours.

The fire resistance of clay masonry walls and concrete masonry assemblies are available in the International Building Code.

Thermal Efficiency

The envelope of a building is constantly shielding occupants from the elements of nature, while also affecting the environment around it. An entire insulated masonry cavity wall participates in thermal resistance.

For example, the thermal resistance or R-value of an insulated masonry cavity wall can be calculated as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Air Film</td>
<td>0.17</td>
</tr>
<tr>
<td>Clay Brick</td>
<td>0.44</td>
</tr>
<tr>
<td>2” Air Space</td>
<td>0.97</td>
</tr>
<tr>
<td>2” Rigid Insulation</td>
<td>10.00</td>
</tr>
<tr>
<td>8” CMU Hollow (115 pcf)</td>
<td>2.10</td>
</tr>
<tr>
<td>Inside Air Film</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>R-Value</strong></td>
<td><strong>14.36</strong></td>
</tr>
</tbody>
</table>

Masonry’s thermal lag is its ability to slowly soak up heat during the day (from the sun, from body heat, from electrical equipment in use) and slowly release it back into the space at night, also requiring less work from the heating and cooling system.

Thermal bridging is caused when heat is able to “short circuit” insulation. Any metal
or steel component acts as a bridge for heat to escape from the inside out. Gaps in insulation can increase the amount of heat transfer allowed. Detailing can minimize the opportunities for thermal bridging to occur. Insulation in the cavity will minimize thermal bridging. When detailing a spandrel section where the insulation on the interior face of the back-up wythe is interrupted by the spandrel detail, there is tremendous heat loss at the perimeter steel beams. NCMA TEK Note 6-13A provides detailing for slab edges that minimize thermal bridging.

**Water Barriers - Liquid**

Precipitation annually, while the lower half receives 30". When it is raining straight down, walls typically don’t leak. Wind-driven rain can potentially cause problems for building enclosures. In Michigan, we are in a 90 mph region to design elements to resist wind load. An insulated masonry cavity wall acts as a moisture barrier and provides three lines of defense. Exterior brick and mortar veneer will resist water. Should water penetrate the veneer, the air space in the cavity will cause the water to collect at the bottom, where it will escape through weep holes and flashing, as the second line of defense.

Third, in the case that it bridges the air space, a moisture barrier applied to the CMU wythe will prevent the water from entering the interior of the building. Keeping water out of the interior of a building and allowing it to escape from within a wall protects and preserves the long-term performance of a wall. Water damage within a wall can negatively effect the insulative ability of insulation, could cause freeze-thaw damage to masonry units and mortar joints, could corrode metal or rot wood components, could cause efflorescence or promote conditions favorable to mold growth on an organic substance.

**Water-Vapor**

Vapor can occur everywhere: inside and outside. It can be just as damaging as water in its liquid form. Air saturated with moisture can be measured as relative humidity. A psychrometric chart is used to determine both saturation temperature and humidity ratio. The point at which the temperature gradient and the saturated vapor pressure intersect is known as a dewpoint. If these two do not intersect, no problem, no dewpoint. The two dewpoint analysis examples shown, provided by Dow Chemical, illustrate where a dewpoint may occur in a wall under certain circumstances. If a dewpoint is going to occur, the best place for that to happen is within the drainage cavity of a wall, because the condensation will escape through weepholes and flashing, just as water will.

**Minimizing Air Flow**

For pressure inside and outside of a building may be different and, by nature, pressure wants to equalize. There are a variety of forces creating pressure differences across walls. In a tall building, heat rises, creating a pressure differential from top to bottom. From the outside, wind pressure on a building could push air in. In a pressurized building, a fan brings air in, some of which could be pushed out through the walls. A building with an exhaust fan pulls air out, but the reduced pressure inside could suck air in through the walls.

Areas of a wall especially susceptible to air flow are those around openings, where a wall intersects with other building components or those with holes formed as a result of an error in design, detailing or workmanship. 100% coverage of an applied air barrier to CMU facing onto the cavity face of an insulated masonry cavity wall is the best option for minimizing air flow from the inside out and outside in.  

**Sound**

Masonry walls come into play in two ways in regard to sound control. The first is sound transmission. Insulated cavity masonry walls are effective barriers to sound transmission from room to room or outside in and inside out. Working and living environments resistant to ambient noise from surrounding areas are generally preferable.

Noise transmitted through a wall can be calculated as a single number in accordance with ASTM E413. The higher the number, the less sound transmitted. A Sound Transmission Class (STC) rating of 50 is a common building standard. Ratings can be improved by adding mass to a wall, increasing air space or adding an absorptive material. Insulated masonry cavity walls, with their mass, air space and insulation may easily exceed the requirements for most walls.

Sound absorption is the second method by which masonry may control sound. The sound level within a space can be lowered by using materials that absorb sound energy rather than reflecting it back. Porous materials with a rough texture will be more absorptive than dense hard surfaces. CMU, with its variety of face textures, are absorptive materials.
Additionally, there are some special masonry units created specifically for acoustical performance. Noise reduction coefficients (NRC) are used to quantify a material’s absorptive quality. Refer to NCMA TEK Note 13-1B or Masonry Structures Behavior and Design, 2nd Edition for NRC ratings of building materials.

Another option for providing both effective sound absorption and sound transmission loss is the use of acoustical CMU. These units typically have an opening molded into the face shell, to allow sound energy to readily enter the masonry cells. They are designed to incorporate systems such as metal septa and/or fibrous fillers to dissipate the sound energy and minimize sound transmission.

**Strength Against Accidental Loads**

Accidental loads occur as a result of both natural and man-made causes. They include natural phenomena such as fire, tornado, hurricane, earthquake, hail and snow in areas not normally exposed to them and severe subsidence or erosion of foundation, as well as impact from vehicle, aircraft or crane and violent changes in air pressure, such as high explosives or service system explosions. Because these occurrences are termed accidental, it is impossible to fully plan for them when designing a building. Federal buildings take blast resistance into consideration, buildings in earthquake regions make seismic considerations, etc, but no one can plan whether these accidents will occur and to what degree of force.

Because of the uncertain nature of these occurrences, the priority must be to limit the extent of the collapse, minimize the loss of life and facilitate effective evacuation and rescue. For blast and impact resistant walls, masonry walls grouted solid and/or reinforced with steel provide structural integrity and can be designed to minimize progressive collapse. Clay or concrete units laid in a running bond pattern—one over two—provide inherent arching action, strengthening a wall. Masonry’s reputation for long term durability has been proven over and over again when exposed to Mother Nature’s elements of wind, hail, snow and ice in a way other cladding materials cannot.

The Building Enclosure Council is an interdisciplinary forum open to anyone interested in how enclosure systems of a structure function together to optimize building performance. Members are encouraged to also belong to AIA or the Building Enclosure Technology and Environment Council (BETEC).

The Council was formed primarily because of energy concerns facing the construction industry and general population in the future.

**Solution for the Future**

As Joseph Lstiburek, PhD, PEng, ME describes in his article “Energy Security and Saving the Planet”, ASHRAE Journal, July 2008, buildings consume 40% of all energy in the US and the design/construction industry will soon be competing with the automotive industry and their hybrid electric vehicles for that energy.

“…We are going to have ultraefficient buildings. We will double and triple the amount of thermal resistance in the typical building enclosure. We will insulate, and insulate big time.

This is good and bad. Good for energy security, bad for building durability. Insulation reduces energy flow.

There is no such thing as a free thermodynamic lunch. Reducing the energy exchange across building enclosures reduces drying potentials. As we change our building technology to account for the new energy cost realities, we are in for a world of hurt in terms of corrosion, decay, mold and other moisture induced deterioration.”