Feature

Insulated Masonry

Plastics and bricks work together for energy efficiency

All photos courtesy CBIS/Korfil

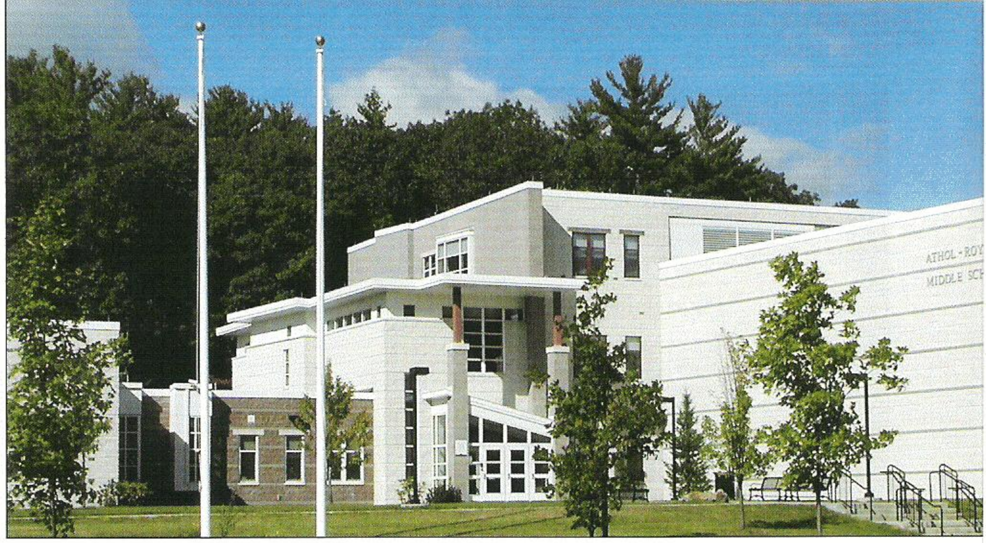
By Jeff A. Nickerson

Masonry construction has long been recognized for its durability, along with its structural, acoustical, and fire-resistant benefits. However, it is now also increasingly being seen as a means to stave off increasing energy costs. Providing thermal mass, masonry walls quickly absorb excess solar heat and stabilize indoor temperatures. These attributes are now being enhanced in a composite material—in-core plastic insulation blocks—that partners masonry with foam to help achieve increased thermal capacity and further inhibit heat flow.

Whether used in traditional structural walls or newer non-load-bearing ones designed for esthetic purposes, masonry has evolved into a highly engineered building component. Its versatility allows expanded polystyrene (EPS) and other foam plastic insulations to complement the energy profile for wall assemblies either as board insulation, custom-moulded core inserts, or an aggregate for lightweight concrete.

While these products first came onto the North American market in the 1970s, advancements in both concrete masonry and rigid foam insulation, along with improved construction methods, offer numerous options when designing for either residential or commercial building projects, including:

- interior and exterior insulated block;
- cavity-insulated block;
- pre-insulated block; and
- mortarless insulated block.



Masonry with in-fill plastic insulation can be a good option for those familiar with standard block construction. Lightweight metal brackets and rigid foam replace costlier traditional materials while improving moisture protection and allowing space for plumbing and electrical wiring. The finished product is virtually identical to standard masonry.

Types of insulated masonry

The energy-saving abilities of an insulated masonry wall assembly are significant. Its compatibilitywithotherconstructionmethods allows numerous design configurations that can meet the environmental demands of extreme and moderate climates. Depending on the materials and type of wall assembly selected, performance criteria can be specified to an exact degree. Designing for energy performance that exceeds minimum requirements is most easily achieved by adding foam plastic insulation.

As a basis of comparison, a 13-mm (0.5-in.) gypsum board on a single-wythe wall comprising 203-mm (8-in.) concrete masonry units (CMUs) without insulation has an R-value of 3.4. When adding 51-mm (2 in.) of EPS, the R-value increases to 10. However, this does not account for other key factors in determining the assembly's overall energy performance (*e.g.* airtightness, thermal lag, and thermal dampening), making R-value a part of a larger equation.

Measurement systems to determine the thermal performance of independent building materials are based on steady-state coefficients (*e.g.* R-value and U-factors), but are not geared to evaluate system performance. As such, they cannot deliver an accurate representation of the achievable interdependent energy savings.

For example, when accounting for the benefits of thermal mass, added insulation, and a 51-mm (2-in.) air space in a cavity wall, the theoretical R-value is 22 versus an R-14.5 when using steady-state data points. This emphasizes the benefit of newer computer software that can project overall thermal performance and further produce measurement gauges to evaluate their accuracy over time.

Interior insulated masonry is a good choice for those familiar with the more traditional block construction. Lightweight metal brackets

Thermal Properties of 203-mm (8-in.) Two-core Masonry Unit

Concrete block density	Without insulation R-value	Without insulation U-factor	With EPS core inserts	R-value
1281.5 kg/m³ (80 pcf)	2.86	0.35	7.74	0.13
1521.8 kg/m³ (95 pcf)	2.61	0.38	6.55	0.15
1682 kg/m³ (105 pcf)	2.46	0.41	5.83	0.17
1842 kg/m³ (115 pcf)	2.33	0.43	5.17	0.19

The thermal efficiency of masonry walls can be measured using ASTM C 1363-05, *Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot-box Apparatus.* American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) offers an alternative calculation method known as the 'series-parallel' or 'isothermal planes' method, which also accounts for thermal bridging.

Most energy codes use the U-factor to define thermal efficiency. This refers to the thermal transmittance of the wall and includes all resistance to heat flow, including surface resistance. It also represents the BTUs per hour per square foot of wall area per degree Fahrenheit rise in temperatures between the inside and outside of the wall.

The R-values and U-factors are based on the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) 'series-parallel' or 'isothermal planes' method as detailed in the *ASHRAE Handbook of Fundamentals.* Physical block dimensions were obtained from ASTM International C 90, *Standard Specification for Load-bearing Concrete Masonry Units.*

and rigid foam insulation replace more costly traditional materials while allowing ample space for plumbing and electrical wiring and improved moisture protection. Lightweight aggregates can reduce the weight of the concrete block by up to 25 per cent, when compared to traditional units. They also effectively reduce installation time by substantially increasing the number of units per hour a mason can lay.

In an exterior insulated system, the insulation is mounted onto the outside of the block wall and then finished with a simulated stucco or stone facing. These siding systems effectively stop moisture penetration since the insulation and finish are uninterrupted. Wiring or plumbing can be run through the block cavities or traditional furring for drywall can be used on the inside surface. With EPS insulation, increasing foam board thickness/density can help improve energy performance. This is ideal in climates experiencing temperature swings—the concrete mass on the inside is optimal for storing heat or coolness.

There are several methods available for in-block insulation, which is most commonly used to insulate single-wythe construction. Although there are various masonry 'fills' that can be mixed and forced under pressure into the concrete core, a newer approach has been developed using EPS inserts fitted into the block cavity. This can eliminate the need for insulation on the interior of the wall, resulting in considerable cost savings versus alternative methods. This strategy can be suitable for occupied warehousing that does not require finishing on either side of the wall.

With in-block insulation, the masonry units are either shipped to the site with the insulation already inserted between the interior and exterior surfaces of the block, or the insulation is added at the point of installation. Due to its light weight, transportation of building materials with built-in insulation is minimized by eliminating the need for a separate shipment to the job-site.

Another type of in-block insulation that offers even higher R-value is referred to as a pre-insulated block. By using partially expanded or recycled-content regrind EPS, bead-sized particles are used as an aggregate in the concrete to increase the block R-value from 2.0 (representing a 203-mm [8-in.] hollow CMU of 2242.6 kg/m³ [140 pcf]) up to 8.0. When adding EPS foam inserts, the block can deliver an R-value as high as 20.[1]

Other benefits for these blocks are their ability to be cut, nailed, and screwed like wood, facilitating inside mechanical installations without furring strips. Mortar-less insulated block is yet another version using foam inserts, where the CMUs are dry-stacked and then stabilized with a cementitious bonding on the wall's interior and exterior planar surface.

Masonry walls are often grouted and/or steel-reinforced by using designated block cavities within the assembly for placement. However, this eliminates their ability to be insulated.

For instance, if a wall assembly has vertical and horizontal grouted steel at every 1219 mm (48 in.) on centre (oc) to meet structural requirements, it is conceivable that up to 31 per cent of the wall could remain uninsulated. However, expanded polystyrene offers a significant advantage in its ability to be used within the block cores where grouting and reinforcement are placed without interfering with the structural function of these supports.

Plastic Masonry and ASHRAE 90.1

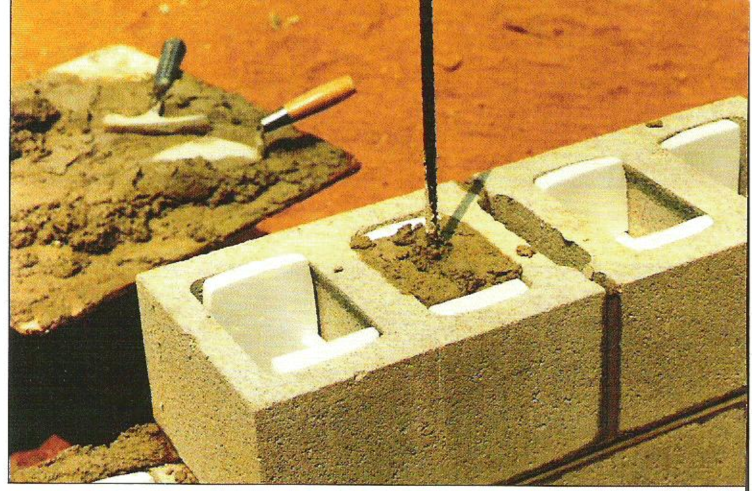
American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) 90.1-2004, *Energy Standard for Buildings Except Low-rise Residential Buildings,* serves as the basis for U.S. energy code requirements at the federal level and within most states and is also recognized within the *International Energy Conservation Code (IECC).* As such, it is the most commonly referenced standard in the United States for establishing minimum energy efficiency parameters in the design and maintenance of indoor environments. Some Canadian municipalities—including Vancouver—have also embraced ASHRAE 90.1 for their local regulations.

ASHRAE 90.1 addresses the building envelope's vital role in optimizing energy efficiency, covering both prescriptive and performance-based criteria. The prescriptive method is a straightforward process using tables assigning minimum requirements for the designated climate zones. Performance methods, on the other hand, can be used to assess or project actual energy use, allowing for trade-offs in meeting the minimum requirements rather than dictating specifics.

In the prescriptive method, most energy codes make adjustments for walls with thermal mass, such as concrete and masonry, recognizing R-values are not a true indicator of energy performance. In most climates, buildings with insulated mass walls save energy, compared to those that have the same R-value but lack mass. While this is particularly true for warmer regions with a lower amount of degree days, Canadian projects can still benefit.

Since the mass reduces peaks in the mechanical system loads, first costs for HVAC equipment may also be reduced in some climates. In Tulsa, Oklahoma, ASHRAE 90.1 requires an R-8.3 frame wall or an R-4.3 mass wall in some buildings. These requirements are based on the fact an R-4.3 mass wall is as energy-efficient on an annual basis as an R-8.3 frame wall for this particular climate. (Thermal storage benefits in mass wall construction are influenced by frequent temperature variations, solar radiation, wind, and the building's design, operation, and maintenance.)

ASHRAE 90.1 has undergone numerous revisions since its first publication in 1975. Tied to the sustainable design movement and increasing utility costs, many of the 2004 changes are intended to facilitate improved energy conservation. This includes a new appendix to rate the energy efficiency of buildings exceeding the standard's minimum requirements and to provide guidance on how to design for certification programs, such as the Canada Green Building Council's (CaGBC's) Leadership in Energy and Environmental Design (LEED Canada).



Often relying on the properties of polystyrene, in-core plastic insulation blocks are frequently competitive with insulating concrete forms (ICFs) and structural insulating panels (SIPs) in terms of price. Further, esthetic possibilities are wide-ranging, since there are the same finishes as traditional masonry.

Continuing evolution

To meet the more stringent requirements in energy codes, single-wythe masonry blocks have been re-engineered to further enhance performance. The majority of these efforts have focused on reducing the web area of the block and occasionally eliminating it altogether. EPS has become just one of the plastic materials for the insulation used in the redesigned blocks. (Other materials include extruded polystyrene [XPS] and polyisocyanurate [polyiso], but these can be more expensive.)

One non-proprietary system reduces the web area by nearly 50 per cent, providing an EPS insert nearly 76 mm (3 in.) thick that also overlaps to insulate the mortar joints. This wall system has been used extensively in correctional facilities and schools because of its ability to provide higher thermal values while allowing walls to be grouted and reinforced both vertically and horizontally at 203 mm (8 in.) oc. This can offer a more cost-effective means to employ masonry construction within stricter budget requirements.

Other examples include blocks designed with a series of staggered cores to retard heat flow through the wall. It is important to consider these various blocks that are redesigned for energy conservation should be sufficiently evaluated for structural performance as they are not considered equivalent to standard masonry materials until properly tested.

Whether as individual systems or working in tandem, plastic insulation and masonry meet numerous environmentally responsible building criteria. In-core plastic insulation blocks are cost-competitive with insulating concrete forms (ICFs) and structural insulating panels (SIPs). At the same time, the esthetic possibilities are equal to that of traditional masonry—the same faces and finishes are also available with pre-insulated blocks.

Notes

[1] See the Masonry Institute of British Columbia's *Masonry Technical Manual.* Visit www.masonrybc.org/index.php?p=ManualIndex.

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