

# The

Photo courtesy Venetian Hotel & Casino and the EPS Resin Suppliers Council



To achieve such a high level of architectural allusion, the Venetian Hotel and Casino incorporated innovative products like EIFS with glass fiber-reinforced concrete, and EPS foam detailing.

# Expanding Role of EPS in Construction

In 1965, the first expanded polystyrene (EPS) block molding plant was established in Grand Rapids, Michigan. It manufactured blocks measuring from 0.6 m to 4.9 m (2 ft to 16 ft) in thickness, but nowadays EPS blocks can be cut into any shape required. They are generally cut with hot wires into sheets for use as thermal insulation, but other uses for the large 'billets' include flotation, 'geofoam' landfill applications, and other large-scale uses.

EPS begins as a polystyrene bead or pellet. The pentane-loaded bead is then exposed to pressurized steam, which causes the polystyrene to expand and mold into the desired shape and density needed. Manufacturing EPS does not involve the use of ozone depleting chlorofluorocarbons or hydrochlorofluorocarbons (CFCs or HCFCs). The final product is a moisture-resistant, closed-cell structure consisting of 90-percent air, yet can possess a compressive strength of up to 276 kPa (40 psi). It is available in varying densities, usually from 14.4 kg/m<sup>3</sup> to 28.8 kg/m<sup>3</sup> (0.90 pcf to 1.8 pcf), depending on the intended application. (Higher densities can be manufactured for custom projects.)

EPS possesses ideal physical and mechanical properties for most insulating needs. As a result of its manufacturing process, aging does not effect the long-term thermal resistance (LTTR) of EPS. Due to its flexibility and versatility, it can be cut into sheets, slabs, or any desired design to meet specific building code requirements, as well as customized designs. EPS is used as insulation in walls, roofs, and foundations, and serves as an integral component of structural insulated panels (SIPs), insulated concrete forms (ICFs), and exterior insulation and finish systems (EIFS).

From humble beginnings, EPS has grown into one of the most versatile insulating materials in construction today.

## Floors, walls, and ceilings

Sheathing is one of the most basic and widely used applications for EPS insulation in residential and commercial construction. It helps create an envelope around the structure, covering wall cavities and studs to increase their resistance to heat transfer and moisture penetration.

Sheathing is available in many different materials, but it was not until the energy crisis of the 1970s that rigid foam insulation found any prevalence as sheathing. With its versatility, ease of installation, and consistent performance benefits, EPS foam-insulating sheathing has become an industry standard.

The sheathing is non-structural, and is primarily used as an exterior insulator, both below and above grade (though it can be used throughout the structure in roof, floors, and ceilings). Different densities help provide the R-value required to meet local building energy codes.

EPS sheathing is used in renovations as well as new construction because of its compatibility with wood and steel framing, and



EPS can be used for a variety of flotation devices, such as rafts, docks, and billets. They are safe for the environment, ozone friendly, no CFCs are used in their production, and they have no food value for marine animals.

masonry. The boards are installed vertically over the exterior sides of the studs, with the vapor retarder facing the heated side of the structure. It can be fastened with nails, screws, and/or staples (depending on the framing surface), while spot adhesive is the norm for masonry substrates.

Some adhesives contain petroleum-based solvents and should not be used, as they will dissolve EPS on contact. Sheathing joints are kept close and flush, seams are taped for added tightness, and corner braces are installed to increase structural stability. Air-barrier house-wrap may not even be needed when the sheathing is properly installed and seam tape used appropriately. A variety of sidings and finishes are easily affixed through the exterior sheathing to create an aesthetically pleasing building.

EPS insulated sheathing board is manufactured with an array of facers. Aluminum foil, polyethylene, and kraft paper are all used to enhance performance properties and protect the insulation from rough handling and UV degradation. EPS manufacturers use reflective aluminum foil to increase EPS' resistance to radiant heat absorption. (When a radiant barrier is combined with dead air space, it can actually add to the insulation value of a wall assembly.)

A variety of EPS sheathing products are available, depending on the application. One of the primary functions of sheathing is to control moisture by acting as a vapor retarder. A perforated foil increases breathability when used above grade, thereby avoiding any type of condensation build-up between the interior and exterior of a structure.

In addition to acting as a vapor retarder, polyethylene facers improve the surface adhesion of the board for taping and adhesives. The tape used over the foam's seams sticks better to the polyethylene-faced board rather than unfaced. Kraft paper is bonded between the facer and foam sheathing, increasing the strength and durability of the product for protection during transportation and handling.

The strength of expanded polystyrene is sometimes questioned, but when greater strength is needed, EPS can be obtained in compressive strengths as high as 414 kPa (60 psi). Type I EPS material as prescribed in ASTM C 578, *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*, adequately accommodates reasonable building movement without transferring stress to building joints.

EPS has been used successfully for many years in areas where moisture is a concern, especially below grade. Fungus, bacteria, and rot do not hurt its performance. Performance properties will not deteriorate when the material is exposed to moisture and/or water.

The use of EPS rigid insulation has grown steadily over the last decade. While most building materials may fluctuate widely in price, the cost of EPS has remained relatively consistent. Manufacturers can provide the builder with insulation of varying densities, which translates into a structure meeting or exceeding energy code standards without the added expense of increased stud widths.

### Exterior insulation and finish systems

For 30 years, the stucco-like appearance of EIFS has given commercial buildings high curb appeal, broad design and color flexibility, low maintenance, durability, and high energy efficiency.

A traditional EIFS exterior wall comprises EPS foam, fiberglass mesh, and a cement-like stucco material. The first step in creating an EIFS exterior is to glue a layer of EPS foam directly onto the sheathing of a house or building. Then, a base-coat of cement is applied, followed by fiberglass mesh, and a finish coat of cement. This type of system is called a face-sealed barrier EIFS, resisting water penetration at its outer surface.

Commercial work accounts for more than 95 percent of all EIFS-clad system applications, yet they experience virtually no moisture problems. In commercial construction, the EIFS material was originally applied over concrete block or masonry structures, or to buildings built with steel or other non-wood products. Unlike 2x4s, these materials do not readily absorb moisture. Furthermore, commercial applications generally employ higher-quality construction practices, workmanship, and materials than residential buildings.

However, when door openings and windows are of poor quality—or improperly sealed—they can allow water penetration. Rainwater and wind-driven rain can work their way past the acrylic polymer coating and foam insulation glued directly to the wood framing and sheathing members of an EIFS-clad house.

For this reason, many EIFS manufacturers developed moisture-mitigation systems to prevent moisture build-up on the rare occasions it makes its way behind the EIFS exterior.

## Moisture-draining EIFS

Following a similar flashing and weep hole strategy used in brick construction, EIFS manufacturers redesigned EIFS to allow for moisture run-off. Here is how the system works with most manufacturers:

- An asphalt felt is placed over sheathing to prevent moisture penetration.
- A mesh or other medium is applied directly over the building paper to create an opening between the sheathing and backside of the insulation board through which water can escape to the outside. (Some manufacturers add grooves or ridges to the EPS foam to allow water to pass to the bottom of the wall.)
- Metal flashing is placed at the bottom of the wall, around windows and doors, and any other place where the synthetic stucco abuts another material. The flashing catches any water and diverts it out of the EIFS wall through weep holes.

According to the June 1999 issue of *Professional Builder*, comprehensive testing conducted by the National Research Council (NRC) of Canada and USG Corp. supported the EIFS water-mitigation system as an effective means of preventing moisture build-up. They concluded water-managed, EIFS-clad walls perform effectively, efficiently handling any water penetrating the system. Any water breaching the exterior skin was stopped at the building paper and directed out of the wall through flashing and weep details.

The water-managed systems worked even when sealant around the windows was made to fail completely. The EPS located below the windows in this scenario contained no significant amount of moisture. Finally, NRC and USG Corp. found any moisture remaining in the system was effectively kept from moisture-sensitive materials by the sheathing membrane.

## Insulating concrete forms

Insulating concrete forms (ICFs) are hollow EPS forms erected at a construction site, then filled with five or six inches of reinforced concrete. Unlike traditional concrete forms, which are removed after the concrete cures, ICFs are left in place.

ICFs provide superior R-values and sound-deadening qualities because the concrete core is enshrouded with EPS insulation. Furthermore, ICFs withstand the forces of nature that destroy traditionally built homes because of that concrete core. (ICF homes are becoming very popular in southern and midwestern states, where hurricanes and tornados are more likely to strike.)

### *Greater comfort and lower energy bills*

ICFs boast high thermal performance. An ICF wall consisting of 102 mm (4 in.) of Type II ASTM C 578 polystyrene foam insulation and 127 mm (5 in.) of concrete is rated above R-17 (at 75-degree mean test temperatures). Air barriers provided by the EPS insulation and concrete eliminate convection currents, while the high thermal mass of the concrete walls buffers a home's interior from extreme outdoor temperatures. The result is a 25–50 percent energy savings over traditional stud-wall or steel-framed homes.

### *Sound-deadening walls*

In sound transmission tests, ICF walls allowed less than one-third as much sound to travel through as compared to traditionally framed walls insulated with fiberglass.

### *Design flexibility*

Excellent design flexibility can be realized with insulating concrete forms. They can accommodate tall or curved walls, large openings, long ceiling spans, custom angles, and cathedral ceilings. Foam is easy to cut and shape, so it lets contractors build curved walls and custom angles without worrying about structural load considerations.

### *Environmentally responsible aspects*

ICFs can minimize the use of lumber, unlike stud-wall construction, which typically involves a lot of cutting and trimming, and consequently, a lot of waste. The superior thermal performance of ICF homes can provide significantly lower energy requirements for heating and cooling, saving homeowners money and curbing fossil fuel depletion.

## Interested in an ICF Home?

According to the Insulating Concrete Form Association (ICFA), EPS shape-molders should expect to see a tremendous increase in the production of ICF products. As most ICF homes are designed and marketed by companies who have developed their own system, one should call the ICFA Concrete Homes Hotline at (888) 333-4840 for a list of ICF home companies.

## Habitat for Humanity Uses SIP Technology

The mission of Habitat for Humanity International is to eliminate poverty housing and homelessness around the world. Thanks to structural insulated panel (SIP) technology, Habitat is achieving its goal faster. In November 1999, a team of volunteers arrived at a construction site in Lothian, Maryland, to participate in a Habitat 'building blitz.' The goal was to construct a home from start to finish in less than one week.

The blitz actually began months before actual construction with a contest sponsored by *Residential Architectural* magazine for the design of this Habitat for Humanity home. Architects were asked to propose a high-quality, high R-value home that could be constructed quickly and affordably. To maximize field installation speed and quality, the winning design incorporated pre-engineered, factory-built components, including structural insulated panels (SIPs). In fact, the entire house—exterior walls and roof—was framed with SIPs.

The SIPs arrived on-site with the window and door openings, and electrical chases already cut out. Along with fast and easy SIP connections, this allowed the home to be framed within four hours, and completely enclosed by early afternoon.

## Improving Curb Appeal

For more information on using EIFS-clad exteriors, the National Association of Home Builders (NAHB) Research Center offers two publications: *Quality Plan for the Installation of EIFS*, and, *Before You Use EIFS*. Both can be obtained by calling NAHB at (800) 898-2842.

### Future market trends

Nearly 200 ICF homes were constructed in 1993. According to the National Association of Home Builders, the above-grade residential market for ICFs increased from one percent of the market share in 1998 to 2.7 percent in 2001. The Insulating Concrete Form Association and Portland Cement Association (PCA) predict ICFs will account for more than eight percent of the above-grade residential market by 2005. These homes currently cost three to 10 percent more than homes built of 2x4s, but construction costs will level out as contractors and subcontractors become familiar and efficient with the technology.

Two other factors will contribute to moderating the costs of ICF homes. First is the cost of concrete. According to the Portland Cement Association (PCA), the price of concrete has been fairly stable for the past decade, while other building materials, such as lumber, have risen considerably. Secondly, ICF design plans are being made more and more efficient.

### Structural insulated panels

A structural insulated panel (SIP) fuses a foam core—like expanded polystyrene—between two outer skins of oriented strandboard (OSB) to create a strong building panel used to construct exterior walls, roofs, ceilings, and floors. First introduced in the 1950s, homes and buildings constructed of SIPs can offer superior insulating qualities, fast installation, and a host of environmental benefits.

#### *Superior insulation*

The foam core of a SIP provides higher insulation values than many other insulation materials used in traditional stud-wall construction, and because they have fewer gaps—no studs to interrupt the insulation—SIP homes prove less drafty. Owners of homes employing SIP technology may qualify for the U.S. Environmental Protection Agency's (EPA's) Energy Star® Home designation, which could lead to other benefits, such as lower-interest mortgages.

#### *Exceptional strength*

SIPs are an integrated building product; acting as structural components, they can withstand—even surpass—typical loads caused by wind, snow, and seismic activity.

#### *Fast construction and finishing*

SIPs are joined together quickly and easily using inset splines. An experienced three-person crew can complete the panel erection of a standard, 186-m<sup>2</sup> (2000-sf) house in as little as one day, and completely dry-in the SIPs in as little as three days. Windows, door openings, and roof gables can be precut at the point of panel manufacture, so precision measuring and cutting on-site are significantly reduced.

SIPs make inside finish work easy to complete, as well. Gypsum wallboard and cabinetry go up fast because they are affixed directly to the interior side of the OSB panel. Electrical distribution is easily accomplished by running wire through the horizontal and vertical chases running inside each panel.

#### *Environmental benefits*

According to the Structural Insulated Panel Association (SIPA), SIPs offer several benefits to the environment. They effectively replace conventional stud-wall construction, meaning fewer mature forest products need to be harvested. The outer OSB skins of SIPs are made from engineered wood—that is, manufactured from renewable, fast-growing trees. Finally, SIPs can reduce heating and electric bills, so fewer fossil fuels need to be burned for heat and energy.

### SIP applications

SIPs are available in a variety of shapes and sizes, and can be used to construct a number of different residential and commercial buildings.

#### *Timber- and metal-framed buildings*

SIPs have been greatly responsible for the surge in popularity of timber- and metal-framed buildings, because they can be constructed quickly and affordably.

#### *Cathedral ceilings*

SIPs are ideal for cathedral ceilings in log cabin or timber-framed roof applications. The panels are simply affixed to the exterior of the roof trusses, followed by shingles.

#### *Custom applications*

SIPs can be made in a variety of thicknesses and skin materials to meet different load-span and insulation requirements. In many cases, window and door openings, gable end walls, and plumb-cuts can be made in the factory according to specifications, avoiding headaches on-site.

### Marketplace advancements

More than 100 U.S. panel manufacturers produce in excess of 2.9 million m<sup>2</sup> (32 million sf) of panels every year, says SIPA. In a recent industry survey, SIPA found SIPs production increased 15 percent in 2002, totaling approximately 4.8 million m<sup>2</sup> (51 million sf). The facts speak for themselves: the overall cost of construction is very competitive because of the efficiencies and ease of building a SIP home.

### Conclusion

#### EPS in the long run

As expanded polystyrene offerings grow in popularity and acceptance, new technologies and uses for the material will continue to evolve. The material has already proven itself and its capabilities in numerous construction applications—the main thing holding it back from achieving its fullest potential is the design community's lack of knowledge about it. However, through education and exposure, an increasing number of construction professionals will come to know EPS, specify the material, and push the envelope of design. ○