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Use of Exterior Insulation Systems to Reduce Building Energy Demand

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History of Exterior Insulation Systems

Exterior Insulation Systems (EIS) were developed in Europe after World War II and were initially used to retrofit solid masonry walls. EIS started to be used in North America in the late 1960's and became very popular in the mid-1970's due to the oil embargo and the resultant surge in interest in highly energy efficientwall systems. In North America, EIS were initially used exclusively on commercial buildings. As the market grew, prices dropped to the point where its use became widespread on normal single family homes. The use of EIS over stud-and-sheathing framing (instead of over solid walls) is a North American technique. EIS is now used all over North America, as well as in many others areas around the world, especially in Europe and the Pacific Rim.In contrast to this developing countries in tropical climate have not experience use EIFs despite increase number of building required to be insulated from outdoor conditions. Countries like India have relied on conventional masonry wall construction. In last two decades, burnt clay brick has been replaced by fly ash bricks, hollowcore cementconcrete blocks or even autoclaved aerated concrete blocks, but introduction of EIFs have not become a norm.

In the late 1980's problems began developing when attention to details was lacking in areas where water can penetrate the system (i.e. around architectural details such as windows and doors). The EIS industry found that the EIS itself was not leaking, but rather most problems where due to a lack of attention to details at the perimeter of the EIS. In conjunction with the building codes, the EIS industry developed drainage systems and mandated an independent EIS inspection. Such development make use for EIS more effective in the countries such as India, which receives substantial amount of rain in short period of time. The U.S. 2009 building code incorporates EIS drainage systems into prescriptive method construction and an independent inspection will no longer be necessary. Energy ConservatyionBuildig Code, India prescribes use of insulation material to save energy, but is silent on construction practices.

Testing done by Oak Ridge National Laboratory in coordination withEIMA (EIFS Industry Manufacturing Association) has found EIS to be superior among all exterior veneers including brick and stone. Oak Ridge National Laboratory states, "Exterior Insulation Systems outperformed all other walls in terms of moisture while maintaining superior thermal performance."The National Institute of Standards and Technology (NIST) have evaluated the 5 life cycle stages of the environmental impact of EIFS. The test compares EIS, brick, aluminum, stucco, vinyl, and cedar. The conclusion of this study is that EIS saves money in construction costs, is greener and has energy efficient operation, and is the most environmentally responsible material tested. EIS is the superior cladding in all phases of building construction.

Types of Exterior Insulation Systems

The most common type of EIS is the polymer based (PB) system. This system has a nominally 1.6mm thick reinforced base coat applied to the insulation prior to application of the finish coat. The insulation typically consists of expanded polystyrene (EPS) or mineral fiber (MF) and can be either adhesively or mechanically attached to the sheathing. The second and less common type of EIS is the polymer modified (PM) system. This system has a nominally 5 to 13mm thick reinforced base coat applied to the insulation prior to application of the finish coat. The insulation typically consists of extruded polystyrene (XPS) and is mechanically attached to the sheathing and/or wall structure.

EISareavailable in two basic types: a barrier wall system or a wall drainage system. Barrier EIS rely primarily on the base coat portion of the exterior skin to resist water penetration. Therefore, all other components of the exterior wall must either be barrier type systems or be properly sealed and flashed to prevent water from migrating behind the EIS and into the underlying walls or interiors. Wall drainage EIS are similar to cavity walls; they are installed over a weather resistive barrier behind the insulation that acts as a secondary drainage plane. The weather resistive barrier must be properly flashed and coordinated with all other portions of the exterior wall to prevent water from migrating into the underlying walls or interiors.

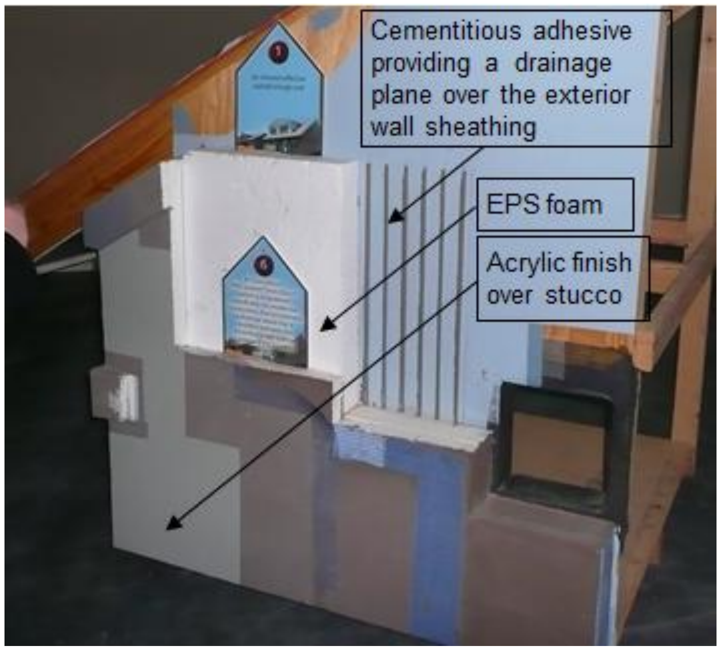
Typical Insulation Materials Used in Exterior Insulation Systems

A variety of insulation materials can be used as part of the EIS. In North America, the predominant insulation type used is expanded polystyrene that meets the requirements of ASTM C578, Type 1. This type of EPS has a minimum density of 15 kg/m^3, an R-value of 0.63 $K\text{-}m^2/W$ (for a 25mm thick section), and a compressive resistance of 69 kPa at 10 percent deformation. Other products that are also used to a lesser extent in North America include extruded polystyrene that meets the requirements of ASTM C578, Type X (minimum density of 21 kg/m^3, an R-value of 0.88 $K\text{-}m^2/W$ (for a 25mm thick section), and a compressive resistance of 104 kPa at 10 percent deformation) and polyisocyanurate foam that meets the requirements of ASTM C1289, Type 1, Class 2 (approximate density of 29 kg/m^3, an R-value of 1.06 $K\text{-}m^2/W$ (for a 25mm thick section), and a compressive resistance of 110 kPa at 10 percent deformation). In Europe, mineral fiber insulation is used extensively. These products are similar to those that meets the requirements of ASTM C612, Type IVA (minimum density of 128 kg/m^3, an R-value of 0.70 $K\text{-}m^2/W$ (for a 25mm thick section), and a compressive resistance of 50 kPa at 10 percent deformation).

Methods of Attachment for Exterior Insulation Systems

Both barrier and drainage EIS are typically attached to the outside face of exterior walls with an adhesive (cementitious or acrylic based) or mechanical fasteners. Adhesives are commonly used to attach EIFS to gypsum board, cement board, or concrete substrates. EIFS is attached with mechanical fasteners (specially designed for this application) when installed over sheet-good weather barriers such as those that are commonly used over wood sheathings. The supporting wall surface should be continuous (not "open framing") and flat. Mechanical fasteners are also needed when foil faced polyisocyanurate insulation is used since the adhesives do not bind well to the foam facers.

Types of Drainage Planes Employed



Drainable EIFS are among the most robust and advanced moisture control assemblies available. To create the drainage plane, an airspace must be created between the inboard side of the insulation and the exterior sheathing which has been covered with a weather resistive barrier. All systems must be designed such that water in the drainage plane has a direct means to exit on the exterior side of the wall assembly. There are many methods to create this airspace. Plastic lath or furring can be installed to create the airspace. Alternatively, vertical cement “ribbons” can be troweled onto the weather resistive barrier prior to the application of the insulation creating both the airspace and the needed adhesive to hold the insulation in place. The rigid insulationwith grooves(drainage channels)on the backsurface can bemechanically attached through the weather resistive barrier into the exterior sheathing. Double layers of building paper or membrane air barriers have been used as well as drainage mats.

Energy Performance of Exterior Insulation Systems

The thermal performance of the exterior insulation is based on the thickness of the insulation selected. The insulation should never be installed or modified to less than 19mm in thickness. Because the insulation is applied as a continuous layer, the thermal performance of the wall system due to the addition of insulation is maximized.

Hygrothermal Performance of Exterior Insulation Systems

A report from Oak Ridge National Laboratory summarizes a family of computer simulations that have been performed to assess the hygrothermal performance of EIS and discusses the validation of the model prior to its use. This research dealt with evaluation of the performance of a number of selected wall systems in all 8 U.S. International Energy Conservation Code (IECC) USA climate zones. The research produced a range of performances that are representative of generic exterior insulation wall systems, and not for a specific manufactured product. A comparison was performed between three different drainable exterior insulation system walls and a brick wall system.

Two steps were reported in this work. The first step required the validation of wall systems previously monitored in Charleston, SC. The validation was performed using the WUFI-ORNL version 5 software and a comparison of the measured vs. simulated results from these wall systems indicated that the simulation model accurately captured the hygrothermal response of the wall systems.

The second step was to simulate four wall systems in the eight climate zones. Each wall system was modeled with and without a vapor retarder and with and without a "leak". All of the simulations followed the recommendations prescribed in ASHRAE Standard 160, "Design Criteria for Moisture Control in Buildings." Thecriterion extracted from the simulations to assess the hygrothermal performance of the wall systems was the average monthly moisture content of the exterior sheathings.

For all climate zones, with the combination of no leak and no vapor retarder, all the walls depict acceptable performance. This is also true for all wall systems with no leak and a poly vapor retarder. The addition of the vapor retarder increases the sheathing moisture contents for all walls in Climate Zones 1-4 but this addition is relatively small and on the order of 2-3 mass percent. That addition of moisture does not compromise the durability of the wall systems. In the more northern zones, the addition of a vapor retarder is neutral; all wall systems behave similarly with or without the vapor retarder. See the discussion of the individual climate zones in the Discussion of Results Section of the report.

When a leak is added to the wall assemblies, their hygrothermal performance changes appreciably. The addition of a leak substantially increases the moisture contents of all wall assemblies. In Climate Zones 1 through 4, the wall systems without a vapor retarder flirt with the 80 percent relative humidity threshold (levels above 80 percent for extended periods of time are detrimental). When a vapor barrier is added, the moisture contents rise even further and are at levels above 80 percent relative humidity for months per year. These systems will fail. In Climate Zones 5-8, the increase in moisture content after adding a vapor retarder is less severe and the amount of time the sheathing is at moisture contents exceeding 80 percent relative humidity is substantially shorter.