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Journal

Tips for Success with Exterior Insulation and Finish Systems

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Exterior insulation and finish systems, or EIFS (pronounced "ee-fus" or "eefs"), are proprietary wall cladding assemblies that combine rigid insulation board with a water-resistant exterior coating. EIFS are popular chiefly for their low cost and high insulating values, and they are used on a range of construction types from hotels to office parks to homes.

For retrofit projects aiming to improve performance and update appearance, EIFS provides a practical option.

Unlike traditional stucco, which is composed of inorganic cement-bonded sand and water, EIFS uses organic polymeric finishes reinforced with glass mesh. As an energy-efficient, economical wall covering, EIFS can be effective for both new construction and recladding applications. However, successful use of EIFS is highly dependent on proper design and sound construction practices. Without correct design and detailing, EIFS wall systems have been known to fail dramatically.

Origins of EIFS in America

After the ravages of World War II destroyed vast swathes of Europe, cities looked to rebuild quickly and inexpensively. EIFS was first introduced in Europe during the post-war years as a wall system that enabled the rapid redevelopment of devastated areas. Later, in 1969, EIFS was introduced in the United States by Dryvit, and it gained popularity during the energy crisis of the 1970s, when retrofitting walls with exterior insulation improved performance and cut energy costs.

The EIFS industry continued to enjoy steady growth through the 1980s, thanks chiefly to its insulating properties, light weight, aesthetic flexibility, low cost, and versatility. In addition to new construction, EIFS was commonly used for retrofits, where it could be applied easily over existing exterior walls to improve energy profile and provide a fresh appearance. Available in a wide range of colors, shapes, and textures, EIFS allowed architects the flexibility to design new facade profiles at a relatively low construction cost.

This versatility led to the proliferation of EIFS in the residential and light commercial markets. In 1981, the EIFS Industry Members Association, or EIMA, was formed to advocate for EIFS manufacturers and improve product performance.

Arthur L. Sanders, AIA, Senior Vice President with Hoffmann Architects, has spent over 30 years resolving EIFS failure in a range of building types and climates. Benjamin J. Robinson, Assoc. AIA, Project Manager, develops rehabilitation solutions for leaks and other signs of distress in EIFS cladding.

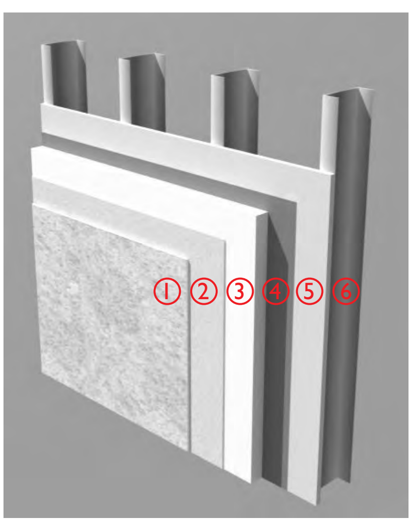
Elements of an EIFS Wall Assembly

EIFS is a multi-layer system that consists of six basic components:

- Substrate, usually exterior gypsum board, oriented strand board (OSB), or plywood;
- Membrane or rainscreen (some systems);
- Exterior insulation (adhesively or mechanically fastened);
- Base coat, consisting of proprietary acrylic copolymer dispersions and powder additives;
- Reinforcing glass fiber mesh; and
- Finish coat, or "lamina," comprised of copolymer dispersions, colorants, and stabilizers.

Primer may be applied to the substrate prior to waterproof membrane application, or it may be used on the insulation board before applying the base coat. Although primers are usually optional for EIFS, they may be used to minimize water absorption, reduce efflorescence, improve trowelability and coverage, and promote color consistency.

There are two major classes of EIFS. The first, Class PB, represents the majority of EIFS used in North America.



EIFS components: (1) finish, (2) reinforcing mesh, (3) rigid foam, (4) adhesive, (5) substrate, and (6) steel stud.

Class PB (Polymer Based). Known as "soft coat" EIFS, Class PB systems use adhesively fastened expanded polystyrene (EPS) insulation with glass fiber reinforcing mesh embedded in a nominal 1⁄16 to 1⁄8 inch base coat.

Class PM (Polymer Modified). "Hard coat" EIFS was developed for improved impact resistance. Reinforcing mesh is mechanically attached to extruded polystyrene (XPS) insulation, over which a thick, cementitious base coat of 1⁄4 to 3⁄8 inches is applied.

Direct-applied Exterior Finish System (DEFS). DEFS is the exterior finish part of EIFS without the insulation. Base and finish coats are applied directly to the substrate. Mainly used for soffits, stairwells, and high-impact-prone areas that don't require insulation, DEFS may be applied to cement board, concrete block, exterior grade plywood, polyisocyanurate board such as Quick-R, or proprietary products including Dens-Glass Gold.

EIFS with Drainage. Also known as "rain screen EIFS," EIFS with drainage is installed over a waterproofing barrier with drainage channels for removal of incidental moisture behind the insulation board. Often, these channels are formed by applying adhesive in longitudinal strips or by using insulation board with vertical grooves. The effect is similar to that of a cavity wall, where the space behind the exterior facing drains or dries any moisture that manages to penetrate the cladding. EIFS with drainage was introduced in 1996, following a 1995 class-action lawsuit involving widespread failure of traditional barrier EIFS.

Although EIFS with drainage does address the water intrusion problems of face-sealed EIFS, it is not a foolproof solution. Should the vapor barrier or moisture retarder fail, water can still enter the wall assembly. Therefore, air and water barriers must be designed to last the life of the system.

Impact damage that is not repaired promptly provides a pathway for leaks.

Common EIFS Failures and How to Prevent Them

Originally, EIFS was designed as a "perfect barrier" system; that is, one which provides waterproofing protection at the exterior face of the cladding. The idea of barrier cladding assemblies is to create a face-sealed facade that repels moisture to keep the building dry.

Unfortunately, barrier systems are rarely perfect. All it takes to compromise water-tightness is a small breach in the exterior finish, such as cracks due to expansion, sealant failure at joints, or impact damage. Once water finds its way into a barrier system, it usually can't find its way back out. Water trapped in the wall can lead to leaks, wet substrate, mold, deterioration of building components, and, eventually, collapse of the weakened cladding.

Any number of deficiencies can lead to EIFS failure. The major culprits are poor workmanship, damp climate, impact damage, building movement, and incompatible or unsound substrate.

Poor Workmanship

Sealant joints are a major source of problems with EIFS cladding. Incorrect selection or application of sealants, or missing sealants, provides an easy path for water entry and premature deterioration. Inappropriate sealant may even lead to cohesive failure of the EIFS finish coat. Sealant erroneously applied to the finish coat, rather than to the mesh-reinforced base coat, is a common source of problems.

Flashings that are incorrectly installed or missing provide a conduit for water infiltration. Door and window openings should incorporate flashings to direct water away from headers and sills. At roof/wall intersections, drip-edge flashings should be installed to channel rainwater away from the wall face.

Base coat thicknesses that don't meet the manufacturer's guidelines are another typical source of trouble for EIFS facades. A base coat that is too thin provides insufficient waterproofing protection, whereas a base coat that is too thick may lead to cracking.

Reinforcing mesh that reads through at joint edges or terminations can indicate inadequate coating thickness. Alternatively, the mesh may have been insufficiently embedded in the base coat. Continuing the mesh-reinforced base coat around to the back of the insulation board, known as "backwrapping," is critical to providing continuous waterproofing protection at edges, penetrations, and terminations. Where appropriate, factory-formed track may be used at foundation terminations instead of backwrapping.

Aesthetic joints (V-grooves) that align with insulation board joints can lead to cracks as the building moves. Mesh-reinforced base coat should be continuous at recessed features.

Window and door corners, like aesthetic joints, should not align with insulation board joints. "Butterfly" reinforcement, whereby rectangular pieces of reinforcing mesh are laid diagonally at the corners of windows, doorways, and other openings, is important to preventing cracking.

Expansion joints are too often neglected in EIFS construction, but they are no less critical here than with other types of cladding. Expansion joints should be used:

- At changes in building height,
- At areas of anticipated movement,
- At floor lines (particularly for wood frame construction),
- Where the substrate changes,
- Where prefabricated panels abut one another,
- At intersections with dissimilar materials, and
- Where expansion joints exist in the substrate or supporting construction.

Moisture meters may be used as part of an EIFS failure investigation.

Insulation board should not bridge expansion joints in masonry or concrete substrates. Instead, an expansion joint should be created in the EIFS insulation over the underlying joint.

Insulation board should meet the manufacturer's recommended minimum thickness (usually ¾ inch), even at aesthetic joints and recesses. Vertical joints in the insulation should be staggered in a running bond pattern in successive courses, with boards abutted tightly to one another. Gaps between boards should never be filled with base coat or adhesive, which can cause cracking; rather, slivers of insulation may be wedged between boards where needed. Selecting a board adhesive that is compatible with both the insulation and the substrate is critical to successful performance of EIFS.

Climate Factors

A humid climate with limited drying potential can devastate some EIFS assemblies, particularly when the rate of wetting exceeds the rate of drying. Poor design and installation exacerbate this problem by providing avenues for water to penetrate the cladding, while the humidity prevents damp walls from drying out.

The amount of rain deposited on a wall is dependent not only on climate, but also on the architecture and siting of the structure. Building height, overhangs, exposure, and facade details all affect the path of rainfall, channeling more or less moisture toward the cladding.

Cold climates may also lead to premature failure, particularly when EIFS coatings are applied at temperatures below the manufacturer's design range.

Impact

EIFS consists of a thin, brittle coating over a soft substrate and is easily damaged by impact. Holes, dents, or scrapes can lead to water infiltration, so it's prudent to provide extra reinforcement at susceptible locations.

Areas needing impact protection should use heavy-duty mesh, usually 12 to 20 ounces, rather than standard 4.5-ounce mesh. For outside corners, the design professional may specify a heavier corner mesh to guard against excess wear and damage. Intricate decorative elements require a lightweight, flexible detail mesh, which conforms to fine contours and ornamental details while still providing some measure of impact protection.

Building Movement

Wood substrates tend to exhibit cross-grain shrinking, along with expansion and contraction from changes in humidity. For concrete, movement tends to come in the form of frame shortening, whereby concrete deforms over time due to shrinkage and creep. Steel structures are not immune to the effects of building movement, particularly at long-span beams, where transverse forces are greatest and deflection more likely. To prevent irregular cracking, sufficient provision for expansion and control joints should be part of the design.

Unsound Substrate

Poor quality control in the production of oriented strand board (OSB), a common substrate for EIFS, has raised concerns about premature failure, so use a reputable manufacturer with a good track record. Gypsum board, often used with EIFS, tends to exhibit problems with moisture absorption, so avoid using it in damp or humid climates. Even if the substrate is of high quality and suitable for the building location, failure to correctly specify or install substrate attachment may lead to premature cladding problems.

Catastrophic EIFS Failure

In 1995, a task force of the American Institute of Architects (AIA) conducted a survey of over 200 homes with a dozen different EIFS systems in Wilmington, North Carolina. Of those homes, 68% had incorrect or missing sealant joints and 94% experienced water intrusion. Earlier that year, homeowners in New Hanover County, North Carolina filed a class action lawsuit, *Ruff v Parex*, against multiple EIFS manufacturers. Under the settlement agreement, an EIFS Inspection Protocol was introduced, which involves moisture detection through resistance probe moisture meters and electronic impedance scanning meters. The testing procedures and criteria established in this protocol have become the standard for EIFS failure investigations.

Design Considerations

The performance and longevity of any cladding assembly is dependent upon the proper design and installation of the system, and EIFS is no exception. Sequential coordination of work is one way to avoid defects, particularly at intersections and terminations. The general contractor, framers, window installers, sealant contractor, EIFS installer, and other trades should be organized such that the work of one does not adversely impact the work of another. For large areas, sufficient workforce should be on site to permit application without cold joints or staging lines. Whenever possible, EIFS application should proceed on the shaded side of the building.

Sealant Joint and Flashing Design

The design professional is responsible for determining the appropriate size and location of joints, and for

EIFS and Green Building

As new building codes require more stringent energy standards, there has been greater demand for improved thermal regulation and moisture control at the building envelope. One of the main benefits of EIFS cladding is its strong environmental performance with low initial cost. By moving insulation outside the wall cavity, EIFS brings the dew point to the exterior of the sheathing, minimizing condensation within the wall, which can lead to heat loss. Adhesively fastened EIFS further reduces the incidence of moisture intrusion, in that it does not puncture air barriers with cladding fasteners. Thermal bridging, the process through which heat is transferred across thermally conductive elements of the wall assembly, can be reduced, or even eliminated, through the use of continuous exterior insulation.

For retrofit projects aiming to improve performance and update the building appearance, EIFS can be a practical option. Lightweight and easy to install, EIFS is often selected for recladding of existing buildings, where it provides a quick, low-cost facade makeover that can also cut energy costs.

EIFS projects aiming for Leadership in Energy and Environmental Design (LEED) certification can earn credits for reduced energy consumption. By providing a highly insulated building envelope, EIFS permits the downsizing of heating and cooling equipment, resulting in a net energy savings.

On the downside, EIFS isn't going to earn many points for materials and resources. At present, none of the commonly used systems incorporate recycled or otherwise sustainable content, and the lifespan of EIFS may be shorter than that of other cladding materials. So, while EIFS can improve building envelope performance at a low initial cost, owners should consider the long-term impact of an EIFS facade that may eventually need to be replaced. ■

specifying a compatible sealant. In general, low-modulus sealants that maintain their properties when exposed to ultraviolet radiation are recommended for EIFS. Sealant selection should consider anticipated joint movement, substrate material, cyclical movement, and exposure to temperature extremes. To prevent premature degradation at the bond line, closed-cell backer rod should be used in lieu of open-cell, which tends to retain moisture.

At points where water can enter the wall, such as at roof/wall intersections, window and door openings, and through-wall penetrations, it should be directed to the exterior with appropriate flashing. Flashing should be integrated with air seals, sealants, rough opening protection, and other waterproofing materials.

Surface Texture Anomalies

The phenomenon of "critical light" occurs when natural or artificial light strikes a wall surface at an acute angle, less than 15 degrees, such that tiny surface irregularities cast a shadow. To minimize the negative aesthetic impact of critical light, the EIFS installer should remove planar irregularities, high spots, and shallow areas with a high-quality *rasp* (file with projecting teeth). Mesh overlaps should be feathered to minimize read-through, and a skim of base coat may be applied to blend laps. To correct critical light defects in existing EIFS, the design professional may specify re-skimming of the original finish coat with an appropriate base coat, followed by application of a new finish after the base coat has dried.

Cool Weather Application

Damage to EIFS components from low-temperature application may be undetectable in the short term, but tends to emerge later as coatings crack, flake, soften, and delaminate. For most acrylic and cementitious coatings, application is restricted to temperatures of 40°F and rising. Below the design minimum, these coatings won't develop proper physical and chemical strength, and they may not coalesce correctly to form a film.

When scheduling EIFS installation, avoid those times of year when thermal cycling is at its highest, such as autumn, when it is warm during the day and cold at night. Materials with controlled set times will set up more slowly in the cold, so the project schedule will need to allow additional time for curing between coats. Take into consideration not only ambient temperature, but the surface temperature of the substrate, as well, which may be significantly lower. It is advisable to warm certain substrates before application.

Patches and repairs to existing EIFS are particularly susceptible to cold-weather cracking, since seasoned material is combined with material that hasn't yet developed its full strength. After initial set, patch areas should be kept warm to assist in curing and reduce thermal stress.

Code Compliance

Widespread incidences of failure have prompted code restrictions on the use of EIFS. The architect or engineer should check local building codes to ensure compliance before installation.

Fire rating. In January 2008, the Monte Carlo Hotel in Las Vegas caught fire, prompting concerns about flame propagation and EIFS safety. A follow-up investigation found that the cladding in the area of the fire had non-code-compliant lamina that was significantly thinner than required, as well as large decorative elements that exceeded maximum allowable EPS thickness. Manufacturers test EIFS systems for fire resistance; however, substituting untested coatings, insulation, or substrates for approved EIFS materials has been shown to increase flammability. The system installed should be identical to the one that has been fire-tested and approved.

Energy code. Mounting energy concerns have driven the International Energy Conservation Code (IECC) and other relevant codes, such as ASHRAE 90.1: "Energy Standard for Buildings," to ever more stringent requirements. Since 2006, the IECC has required both stud cavity insulation and continuous exterior insulation. Because continuous insulation is integral to EIFS, retrofitting an existing building with EIFS can be a simple and inexpensive way to comply with increasingly rigorous energy codes.

Wind load. Compared with mechanical attachment, adhesive attachment of EIFS board insulation has been demonstrated to provide superior wind load resistance. To achieve full design performance, the supporting construction must be free from damage, defects, and contamination before insulation is adhered. Sheathing must be capable of independently resisting anticipated wind loads.

To true the wall surface, the installer should level the insulation board, rather than build up base coat.

International Building Code (IBC). Beginning with the 2009 edition, the IBC has included a section on EIFS. The model code incorporates information on both traditional EIFS and EIFS with drainage. However, the section remains brief and directs users to refer to manufacturers' guidelines.

Field Verification and Quality Control

With construction underway, the design professional should verify that the proper materials have been ordered and delivered, and that materials have been shipped and stored at appropriate temperatures and conditions. Before EIFS application, the architect or engineer should check the substrate for correct surface preparation, cleanliness, and proper tolerances. To confirm that construction complies with drawings, specifications, and manufacturers' recommendations, the design professional may conduct periodic field evaluations of the EIFS installation progress. He or she should confirm the correct installation of critical related elements, including flashing, sealant, windows, and doors.

EIFS are proprietary systems. Each manufacturer conducts their own research and development for compatibility and performance of their independent EIFS product. Therefore, it is important to specify an entire system from a single-source manufacturer to avoid compatibility issues. Part of the field verification process should include confirmation that the entire assembly, from base coat to finish, functions as one integral system.

Maintenance and Repair

To keep EIFS looking and performing its best, building owners should implement inspection and maintenance practices to address incipient problems promptly.

This infrared thermographic scan reveals trapped moisture at insulation board joints.

Cleaning

At least twice a year, inspect EIFS finish and sealants for damage or wear. Every five years, EIFS should be cleaned thoroughly; in locations prone to algae and fungal growth, more frequent cleaning may be required. Options for EIFS cleaning include commercial detergent, pressure washing, or trisodium phosphate (TSP) solution. Cold water washing is recommended, as hot water can cause acrylic finishes to soften. Difficult stains, such as those from wood, tar, asphalt, efflorescence, graffiti, or rust, may require sealing and re-coating the surface.

Coating

Elastomeric coatings can provide a fresh appearance and added waterproofing protection for worn EIFS surfaces. However, such coatings may alter the texture, sheen, and vapor permeability of the original cladding. Existing sand finish with a small aggregate size may lose its texture after recoating. Avoid dark-colored coatings, which absorb heat and tend to crack.

Refinishing

To address EIFS damage or persistent stains, resurfacing may be necessary. First, the installer should clean and dry the area, then trowel a skim base coat to fill voids in the surface. Once the base coat dries, a new finish coat should be applied, per the manufacturer's instructions. When color-matching a new finish with an old one, use a physical sample; age and exposure may have affected the original color. Differing application technique may prevent refinished areas from blending completely with the existing finish, so resurfacing an entire panel to a termination usually produces better results than does a smaller patch.

Flashing and Sealant Repair

Periodically check common points of water entry, including window and door perimeters, expansion joints, intersections with dissimilar materials and roofs, penetrations, and terminations. Removing worn sealant may damage the existing EIFS, which must then be repaired and allowed to dry before new sealant may be installed. The design professional should confirm that new sealant is compatible with the surface of application.

EIFS Damage Repair

Depending upon the depth and severity of EIFS damage, repair may entail removal and replacement of finish, base coat, reinforcing mesh, and even insulation board. Prolonged and pervasive water infiltration may also require replacement of substrate materials and possibly of the entire wall, including structural support members. For puncture or impact damage, such as dents or holes, contact the manufacturer for instructions, particularly if the system is still under warranty. Shopping plazas, for instance, are vulnerable to damage from store signs that have been removed without repairing fastener holes. Check with the manufacturer to determine whether such punctures void the warranty.

EIFS Performance

If correctly designed, installed, and maintained, EIFS provides durable envelope protection. The oldest systems in the U.S. were installed in the late 1960s, and some are still in service.

(continued on page 8)

representative projects

EIFS Rehabilitation

Specifying and troubleshooting Exterior Insulation and Finish System (EIFS) wall assemblies demands an understanding of the material properties of proprietary systems; it also requires in-the-field experience in identifying defects and developing cost-effective solutions. At Hoffmann Architects, we have a long history of correcting EIFS problems, from material defects and accidental damage to poor workmanship and design flaws.

Hoffmann Architects' experience with EIFS includes:

New York State Office of Mental Health, Rockland Psychiatric Center
Orangeburg, New York
Building Envelope Condition Assessment

New Jersey City University Gilligan Student Union
Jersey City, New Jersey
Building Envelope Rehabilitation

Windsway Condominium in Norwalk, Connecticut. *Water Infiltration Investigation.*

Mill Hill Elementary School and Tomlinson Middle School
Fairfield, Connecticut
Facade Rehabilitation and Replacement

Hospital Corporation of America Seven Medical Facilities
Various locations, Florida
Building Envelope Surveys

University of Connecticut School of Social Work
West Hartford, Connecticut
Building Envelope Rehabilitation

Sheraton Tarrytown Hotel
Tarrytown, New York
Facade and Roof Consultation for New Construction

The Larstrand
New York, New York
Facade Recladding

Westfield South Shore Mall
Bay Shore, New York
Westfield Garden State Plaza
Paramus, New Jersey
Facade Consultations

Spectrum Office Park
Newington, Connecticut
Facade Replacements

University of Hartford Sports Center
West Hartford, Connecticut
Facade Repair Design

Ballpark at Harbor Yard
Bridgeport, Connecticut
Facade Recladding

Pfizer, Inc., North Maple Inn in Basking Ridge, New Jersey. *Facade Rehabilitation.*

Schering-Plough del Caribe in Toa Baja, Puerto Rico. *Facade Reconstruction.*

Alexander Centre
Princeton, New Jersey
Building Envelope Rehabilitation

Century Plaza
Lansdale, Pennsylvania
Facade Investigation

Fifth Avenue Residence
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For those concerned about the long-term viability of EIFS in light of the series of cladding failures in the 1990s, a 2006 study from the Oak Ridge National Laboratory (ORNL) should put those apprehensions to rest.

Over a 15-month period, ORNL tested a number of cladding types, including brick, stucco, concrete block, cementitious fiber board, and EIFS, in the challenging mixed-coastal climate of Charleston, South Carolina. Of those wall systems tested, the best performing was an EIFS assembly that included a liquid-applied water-resistive barrier coating and four inches of EPS insulation board. The study validated that vertical ribbons of adhesive provide an effective means of drainage within an EIFS wall assembly.

The ORNL study demonstrates that the new generation of EIFS successfully rectifies problems inherent to earlier systems. When designed with attention to moisture management, modern EIFS can be a reliable, cost-effective option for an energy-efficient building envelope. ■

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