EIFS Performance Review

For a durable EIFS exterior, follow installation details to the letter and avoid the use of gypsum sheathing

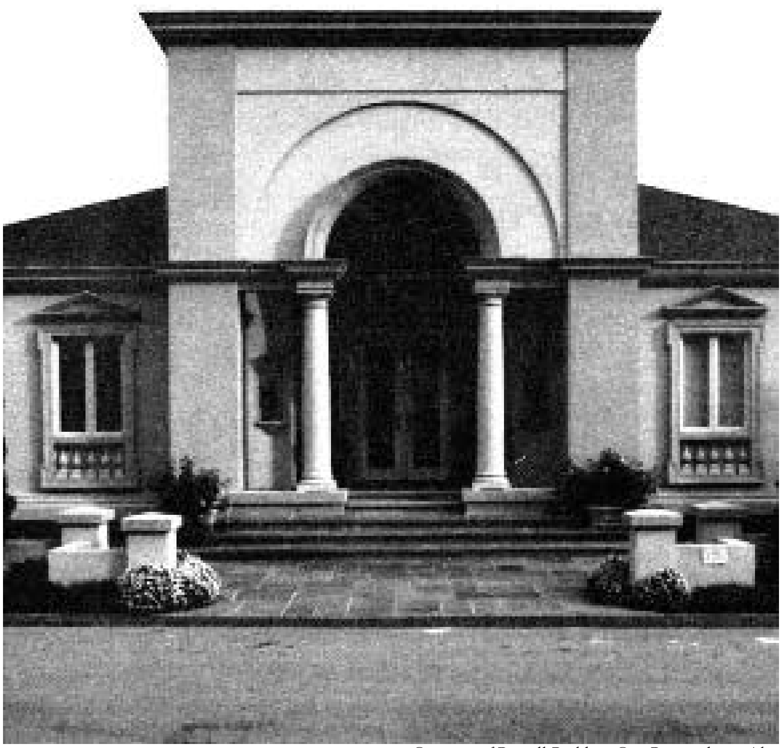
The use of exterior insulation finish systems (EIFS) has grown dramatically in recent years, in both commercial and residential markets, accounting for more than 200 million square feet of building exteriors in 1991. The systems, sometimes called "synthetic stucco," are economical and give designers a lot of flexibility with colors and architectural details. In addition, they provide good insulation without thermal gaps and greatly reduce air infiltration.

Of the two generic types of EIFS, polymer-based (PB) and polymer-modified (PM), the PB systems are by far the more commonly used in the U.S. today. PB systems, sometimes called "soft-coat," are typically thin (approximately 1/8 inch total thickness), adhesively attached, and flexible, and they require few control joints. They cannot tolerate prolonged wetting.

PM systems, on the other hand, are typically greater than 1/4 inch in total thickness, mechanically attached, rigid, and insensitive to moisture, and they require frequent control joints, similar to cement stucco. Sometimes called "hard-coat," PM systems do offer several significant advantages:

- They are mechanically attached, so 15-pound felt or similar moisture protection can be placed over the sheathing. This prevents any water that enters the system from damaging the sheathing and studs.
- They have greater puncture and abrasion resistance and better tolerate abuse from traffic at grade.
- They are more resistant to damage from internal moisture.
- They use metal or vinyl casing beads, which provide a more durable substrate for sealants.

PB systems, however, are far more popular, primarily because of lower cost, greater design freedom (because fewer control joints are needed), and more marketing by manufacturers. In fact, PB systems account for approximately 80% of the current EIFS market. Because of its wide use, the rest of this article will address only the PB type of system.



Courtesy of Russell Building Co., Birmingham, Ala.

Soft-coat synthetic stucco gives designers a lot of flexibility with colors and architectural details.

The HUD Experience

Unfortunately, the increased use of EIFS has been accompanied by an increase in problems and failed applications. The U.S. Department of Housing and Urban Development (HUD) has a large number of buildings with EIFS that have required extensive repairs or total replacement within ten years of installation. This high rate of early failure has caused HUD to reevaluate the acceptability of EIFS for use on HUD-funded construction. In the past, HUD required little more than a 20-year warranty and compliance with manufacturer specifications. Because of the high failure rate, however, HUD is in the process of reviewing the material and may establish new criteria for EIF systems.

As part of an ongoing study being conducted with the cooperation of HUD's Washington Office of Materials and Standards and the HUD area offices in Boston, Kansas City, and Pittsburgh, we reviewed a random selection of more than 30 buildings with EIFS exteriors, ranging from jobs under construction to buildings twelve years old. None of the buildings included in the study were known to have EIFS problems. The review included visual inspection, non-destructive moisture readings at random locations, and test cuts at a few buildings. The results to date strongly support HUD's desire to improve the quality standards for EIFS materials and application.

Common Problems

The most common deficiencies found were caused by poor workmanship and were evident on the majority of projects reviewed.

Thin base coat. Applications with base coats thinner than the manufacturer's required thickness were very common.

Exposed mesh. Many jobs had exposed mesh at joint edges and at terminations (see Figure 1, next page). We observed mesh on the surface of the base coat on some jobs under construction, and we could see mesh patterns through the finish coat on a few jobs. These are signs of thin base coats and mesh that is not adequately embedded in the base coat.

Mesh that's not fully embedded is exposed to moisture and won't provide good impact resistance. Moisture alone can reduce the tensile strength of reinforcing mesh, and it is well-known that moisture combined with alkalinity (from the cement) speeds the strength reduction of the mesh.

Sealant failure. The majority of projects, including some less than six months old, had some sealant failure. Failures at EIFS field joints were more common than at perimeter joints (Figure 2, next page). The typical failure was a *cohesive* failure of the finish coat. This means that the sealant didn't pull away from the finish coat; rather, the finish coat itself pulled apart. This is because some acrylic finish coats soften when kept damp and therefore do not generally provide a durable surface for elastomeric sealants. Nevertheless, most EIFS and sealant manufacturers still either require or allow sealants to be applied to the finish.

by Richard Piper and Russell Kenney

Figure 1. *Mesh that's exposed on the surface of the base coat is likely to get wet and lose tensile strength. Once weakened, it will not provide adequate impact resistance.*

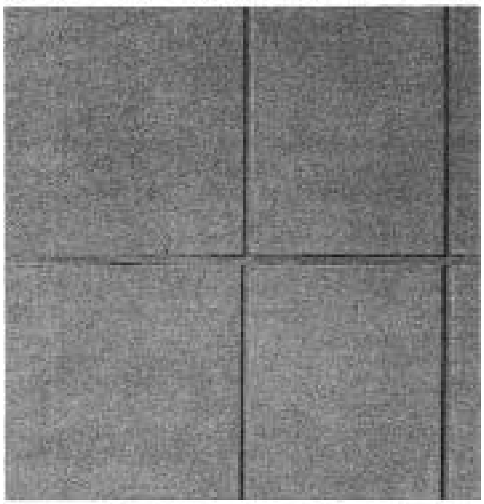


Figure 2. *The sealant at this control joint failed within six months of installation, allowing water into the system. To prevent this, use a low-modulus sealant and apply it to the base coat, not the finish coat.*

Figure 3. *V-grooves, added for decorative effect, should never line up with window or door openings. This one cracked, was recoated with the manufacturer's elastomeric coating, and cracked again within a year.*

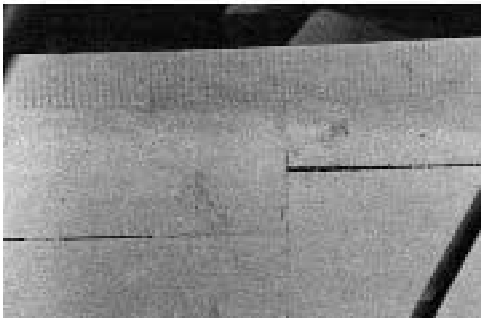


Figure 4. *Gaps between EPS insulation boards are a common cause of cracks. To prevent problems, fill any cracks with insulation slivers.*

Figure 5. *Moderate wetting will cause the facing of gypsum sheathing to delaminate. With increased wetting, the core will deteriorate, as seen in this cut-away section.*

Cracking in V-grooves. V-grooves are sometimes added for decorative effects. Approximately one half of all projects with V-grooves had some cracking in the grooves sufficient to allow water penetration. Cracking is most common when the V-groove falls on the insulation board joint beneath (see Figure 3).

Cracking at openings. Approximately one third of all projects had some cracking at the corners of windows and similar openings. These cracks are caused by stresses at the reentrant (inside) corners. Almost all projects with vertical V-grooves extending from window to window, in line with the jambs, had some cracks in these grooves, and many cracks were continuous the full height of the V-groove.

Cracking at board joints. More than 10% of all projects had some cracking not associated with openings or joints. These cracks mostly occur over the gaps between insulation boards (Figure 4) and grow worse as the reinforcing mesh loses tensile strength from exposure to moisture and alkalinity.

Workmanship Falls Short

We observed three projects while the EIFS was being applied. In one of these, mediocre workmanship resulted in gaps between insulation boards and poorly embedded mesh at sealant joints. A few V-grooves had already cracked before the job was completed.

On the second project, workmanship was poor, resulting in large gaps between boards, exposed mesh at joints, and a thin base coat. The third project showed very poor workmanship, resulting in a thin, brittle base coat, large areas of exposed mesh, inadequate board adhesion, and other serious violations of the manufacturer's standards.

Another group of three projects used prefabricated panels adhesively applied to either precast concrete or gypsum sheathing. Two of these buildings had been occupied for less than six months and one for 18 months. The latter project had many failed sealant joints, V-groove cracking, exposed mesh at joints, a thin base coat, and water weeping out of the system in a few locations. The first two projects showed failed sealant joints, exposed mesh, a thin base coat, and V-groove cracking. Several panels had blown off the most recently completed project.

In summary, less than half of the buildings more than seven years old were in good condition, and none over two years old were without visible deficiencies.

This survey suggests that the high rate of EIFS failure on HUD-funded buildings is primarily due to improper application. It also suggests that improved standards for materials and application are critical if PB EIF systems are to provide a reasonable service life without extensive maintenance and early repair.

Gypsum Sheathing Vulnerable

Most of the cracks and sealant failures we saw in the survey were sufficient to allow water to enter the EIF system. From our earlier investigations of several hundred EIFS buildings, we know that such leaks can lead to water damage of the gypsum sheathing underneath (Figure 5). When wet, the sheathing is prone to deterioration and delamination. Water also tends to collect at horizontal terminations and joints that are "back-wrapped" with mesh. The water often collects well below the point of entry, and it can cause the gypsum sheathing to delaminate and the sealant joints to fail.

Because EIFS as typically applied often cracks and allows water penetration, we believe that EIFS should not be adhesively applied to gypsum sheathing (ASTM C79). The fact that the current systems continue to be adhesively applied to gypsum sheathing on high-rise buildings in locations exposed to high winds and heavy rains is hard to understand or justify. Projects with masonry, concrete, or cement fiberboard substrates are less vulnerable to water penetration.

Application

For EIF systems to last, quality workmanship is critical. Good materials and details, alone, will not guarantee a durable finish. The work must be inspected during installation by those knowledgeable about EIFS. Unfortunately, such knowledge is not commonplace in the architectural and construction industry today, which results in a large number of EIFS applications failing to meet the manufacturers' minimum requirements. The major concerns during application are:

- ***Board application.*** Provide good adhesion between the insulation board and substrate. Offset board joints from sheathing joints and door and window openings. Also, offset them from any decorative V-grooves. Fill any gaps larger than 1/16 inch between boards with insulation. Rasp all insulation surfaces to rough them up and remove weathered material before applying the finish.
- ***Base coat.*** Make the base coat at least 3/32 inch thick, and apply it in two layers. Use primer on all cementitious base coat surfaces.
- ***Mesh.*** Offset any laps in the mesh from edges of openings, grooves, and corners. Use diagonal mesh for reinforcing at door or window (reentrant) corners. Use a double layer of mesh, lapped at least 4 inches, at all

outside and inside corners. Fully embed the mesh, leaving no mesh ends or mesh pattern visible. Use high-impact (heavy-weight) mesh at all surfaces near grade or near balconies or walkways, where they will face additional wear and tear (see Figure 6).

- ***Sealant joints.*** Provide smooth, straight, sound surfaces to receive sealants, with no mesh or mesh pattern visible. Allow adequate joint width for the expected movement. Use primer on all surfaces to receive sealant. Apply sealant to the base coat only, never to the finish coat, and tool all sealant joints.

Properly detailed and applied, PB EIFS can provide durable, cost-effective exterior walls with a service life of twenty to thirty years. Improperly designed and applied systems, on the other hand, will have a greatly reduced useful life, and many will require extensive repairs or early replacement. ■

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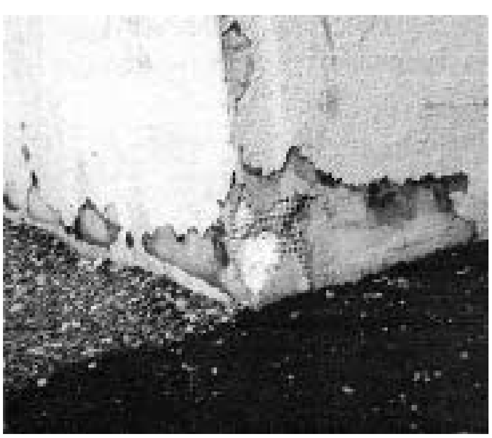


Figure 6. *Areas near walkways face greater wear and tear. Use high-impact mesh in these locations.*

A Better EIFS

Despite the problems described in this article, we believe PB EIF systems can be modified to provide good durability and service life. The modified systems cost more than most current systems, yet still compare favorably with other exterior wall materials. The following requirements are, in our opinion, the minimum necessary to assure good durability, and they have been used successfully on a number of recent projects:

- The substrate should be masonry, concrete, or cement fiberboard. Gypsum sheathing has been a contributing factor in the failure of many applications. When water enters the system for whatever reason, it is absorbed by the sheathing, and when gypsum sheathing is kept moist (20% or more water by weight), the paper facing delaminates from the gypsum core, debonding the system. At approximately 30% moisture, the gypsum core deteriorates and wood studs can rot. These problems can occur with relatively small amounts of water penetration, minor cracking, and no water leakage into the building interior.

  One alternative is Georgia Pacific's Dens Glass (ASTM C1177). This product is significantly more water resistant than standard gypsum sheathing, although more testing and field experience are necessary to determine its long-term durability.
- The expanded polystyrene (EPS) insulation board must have good bead fusion to resist the passage of water when the surface is damaged. You can check for bead fusion by snapping a piece of board. At least 50% of the beads should break in two, rather than pull apart and remain whole.
- EPS board joints must not align with door and window openings and must be offset from sheathing joints (see illustration). Board joints aligned with openings are a common cause of cracks. When V-grooves align with board joints at openings, cracking is very common.
- Decorative grooves must not align with EPS board joints or openings, and their use should be held to a minimum. Rounded grooves are preferable to V-grooves.
- The base coat should have no more than 33% cement by weight. Many U.S. products currently use 50% cement. The main problem is that the high alkalinity of cementitious base coats weakens the fiberglass reinforcing mesh. Although mesh has an alkali-resistant coating, the quality and quantity of the coating is inconsistent, and the amount of coating on U.S. mesh is substantially less than on European mesh. In addition, base coats with higher amounts of cement are less flexible and can become brittle with age.
- The base coat should be applied in two layers with at least 24 hours between applications. This has several distinct advantages over a single application. In this system, the mesh is troweled onto the surface of the first layer, and the second application then easily fully covers the mesh. No mesh or mesh pattern is visible.

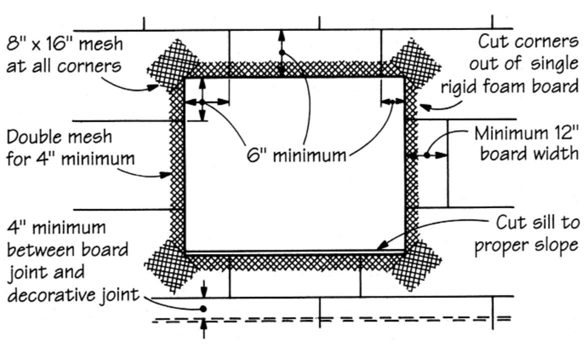
  Because the polymer-modified base material is more "sticky" than traditional cement stucco, it is difficult to apply in thick layers. With a double-layer application, however, the typical installer can get adequate thickness and fully cover the mesh.
- The minimum base-coat thickness should be 3/32 inch. This is the actual minimum allowed at any location, not an average or nominal thickness. Thinner base coats do not adequately protect the mesh from moisture and have inadequate impact resistance.
- No mesh or mesh pattern should be visible at any surface, including corners and joints. Corners and surfaces that will receive sealant are especially critical because thin base coats provide a weak substrate for sealants, and exposed mesh will wick moisture into the system. A third application of base material is often necessary to touch up corners and joints.
- Cementitious base coats must be primed before the finish is applied. The acrylic primers improve the water resistance of the base coat and provide a surface with uniform suction to receive the finish. Some newer non-cementitious base coats are being developed that may not require primer.
- Failed elastomeric sealant joints are a major cause of water entry in EIF systems. To prevent these failures, the sealant must be applied to the primed base coat, not to the finish coat, which can soften when wet. And because EIFS is a relatively weak substrate for elastomeric sealants, you must choose a *low-modulus* sealant that maintains its low-modulus over the life of the sealant. (When a low-modulus sealant stretches, it exerts less stress on a joint.)

  Ideally, the sealant should last as long as the system, because it is difficult to remove and replace sealant without damaging the thin layers. In general, silicone sealants are less affected by aging and cold temperatures than urethane sealants. Dow 790 Silicone Sealant is the recommended sealant for most EIFS applications, although its appearance may be an issue with some designers.
- Window sills, parapet tops, and similar sloped surfaces should be protected with metal flashing. EIFS is not an acceptable roofing material, even for very small "roofs." The manufacturers' requirements for a 1:2 pitch is not adequate to shed snow and prevent lengthy wetting. A minimum 1:1 (45-degree) pitch is preferred when it is not possible to properly flash the surface.

The only PB EIF systems currently marketed in the U.S. that meet all these criteria are Premium Cementitious System 3 and Premium Full Synthetic System 3 by Parex Inc., Redan, Ga. We have successfully used other systems, however, when they have been modified to meet our criteria.

— R. P. & R. K.

Insulation Board Layout Around Windows



Insulation board joints aligned with door and window openings are a common cause of cracks. To prevent problems, joints must be offset from the openings and the corners reinforced with diagonal mesh. In addition, decorative joints should not align with board joints or openings; board joints should not align with sheathing joints; and laps in the mesh should be offset from the edges of openings, grooves, and corners.