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RETROFIT: CONSIDERATIONS AND OPTIONS

REFERENCE: Egan, W.F., "**Retrofit: Considerations and Options**", Development, Use, and Performance of Exterior Insulation and Finish Systems (EIFS), ASTM STP 1187, Mark F. Williams and Richard G. Lampo, Eds., American Society for Testing and Materials, Philadelphia, 1995.

ABSTRACT: Although the majority of Exterior Insulation and Finish Systems (EIFS) are installed on new construction, the system is also well suited to renovate or retrofit exterior walls of existing buildings. The unique features and application methods that are characteristic of an EIFS make it one of the most practical and economical building materials available for this purpose.

Given the unique conditions that are often encountered when renovating an existing building, each project's specific needs and uses should be considered to satisfy distinct project conditions, as well as realize all of the benefits that an EIFS has to offer. Once these conditions are identified and addressed, the most appropriate EIFS or application method can be selected from the options currently available.

This paper will explore the benefits of EIFS in retrofit applications, as well as the primary considerations specific to retrofit that should be entertained prior to selecting a system or application method. The types of application methods that are available will also be discussed along with general information explaining when and how the different EIFS application methods and system options are utilized. The overall objective is to provide design professionals with general guidelines to evaluate an existing building and select the most appropriate system or application method to suit the particular needs of the building.

KEYWORDS: exterior insulation and finish system, Class PM, Class PB, in-fill panels, thermal resistance

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INTRODUCTION

New construction has been the mainstay of the exterior insulation and finish system (EIFS) market in the United States for the past two decades, yet EIFS are especially suitable to renovate or retrofit exterior walls of existing buildings.

According to some current construction industry predictions, the majority of non-residential construction activity in the next several years is anticipated in the renovation of existing structures. The growth of this sector is anticipated to be so strong that the value of renovation work could exceed the value of new construction by 1995 [1]. As a result of this growth, there will be increasing demand for versatile products and systems in the renovation market as building owners improve the aesthetics and energy efficiency of their properties and, in many cases, create totally new exterior wall or facade appearances in an effort to attract potential as well as satisfy existing tenants.

EIFS can be used to retrofit an entire building or wall surface, as well as for accent panels, bands or signage on a portion of the project. Existing buildings that currently incorporate more than one type of substrate or exterior wall system can be retrofitted with an EIFS to create an entirely new, monolithic appearance.

Although there are a number of alternative exterior wall systems such as metal siding, brick and stone veneer systems, EIFS offers a vast array of benefits that makes it an especially attractive option for retrofit applications. Additionally, with many different systems and application methods available, EIFS is extremely versatile and is easily adaptable to suit a wide variety of existing building types and conditions.

BENEFITS

There are a substantial number of benefits that an EIFS can potentially offer in a retrofit application. The items that are typically of primary significance are described below, although this information certainly is not intended to include all EIFS benefits.

Reduced Energy Costs

The base component of all EIFS is the insulation board. It can be made of several types of materials, but typically provides a thermal resistance value of 4 - 6 $ft.^2 \cdot h \cdot {}^\circ F/BTU$ (0.70-1.06 $m^2 \cdot K/W$) per inch (25.4 mm) of thickness. Additionally, since the insulation is applied to the exterior of the building, the system provides an effective air barrier as well as eliminates thermal bridging associated with conventional wood or steel framed buildings. In the extreme case of an old, poorly insulated building - which is a prime retrofit project - the cost savings benefit provided by a complete building retrofit could result in an attractive payback period to the building owner. An estimated payback period, based on a reduction in energy costs, can be projected through an energy analysis. Such an analysis should consider the condition and efficiency of other significant exterior surfaces such as roofs and windows, as they could effect projected payback periods.

<u>Aesthetics/New Appearance</u>

The design flexibility and versatility offered through the use of different types and colors of finish coats as well as the ease and ability to create special shapes such as quoins, cornices and reveals is unique to EIFS. In essence, it provides the ability to create an entirely new look or theme for an existing building, generally without costly structural modifications. This is extremely important,

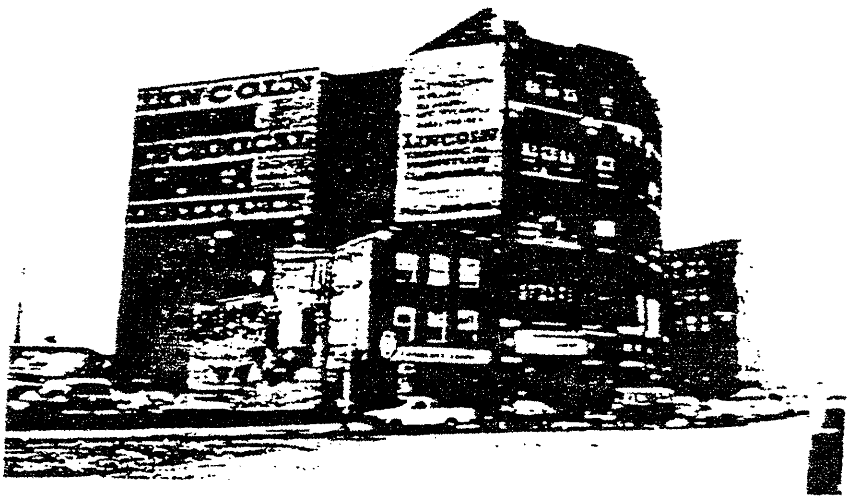

FIG. 1 -- Pre-retrofit.

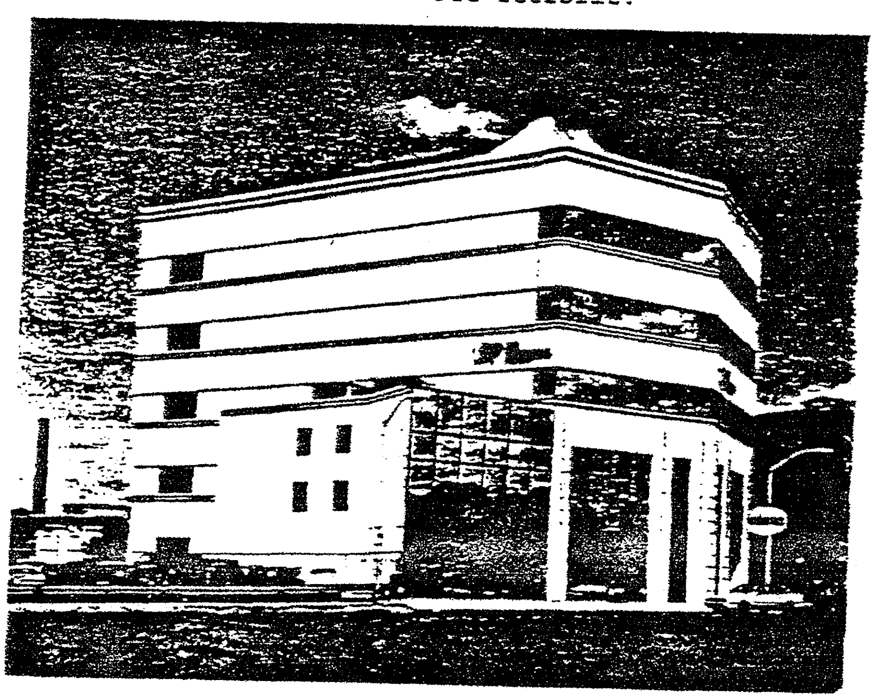

FIG. 2 -- Post-retrofit.

.cularly for public-use buildings such as hotels and retail space must maintain curb appeal in order to remain competitive. Figures 2 provide before and after examples of an existing building that iven a totally new appearance through the use of an exterior ation and finish system.

Solution to Existing Building Problems

EIFS can be used to retrofit or renovate a wide range of exterior wall substrates, although unit masonry, concrete, stucco, and metal buildings are some of the most common applications. Existing buildings are renovated for a wide variety of reasons and conditions that might include deterioration of existing paints, coatings, or materials, a desire to create a new appearance and enhance energy efficiency or solve water infiltration problems. Generally all of these conditions, as well as many others, can be resolved by renovating with an EIFS.

To create a "new" exterior facade, new windows and flashing or trim as well as other decorative building shapes can be incorporated into the system's design. In many cases all of the renovation work can be accomplished without disruption to the building occupants and without reduction in floor space.

Cost Effective

TABLE 1 -- Typical exterior wall system costs.

Description	Typical installed cost
Integrated siding, fabric-reinforced synthetic exterior finish on 1" (25.4 mm) polystyrene insulation board (EIFS). Add $0.78/ft.² ($8.39/m²) for 2" (50.8 mm) polystyrene.	$5.40/ft.² ($58.13/m²)
Simulated brick including mastic, cement base.	$8.05/ft.² ($86.65/m²)
Simulated stone face including mastic.	$11.75/ft² ($126.48/m²)
Steel siding, colored, corrugated/ribbed on steel frame 24-gauge.	$2.42/ft.² ($26.05/m²)
Aluminum siding, 0.019" (0.48 mm) thick on steel construction, painted.	$2.21/ft.² ($23.79/m²)
Metal facing panels field-assembled over 5,000 ft.² (464.5 m²) 16-gauge aluminum exterior, 1-1/2" (38.1 mm) fiberglass and 18-gauge galvanized steel interior.	$11.05/ft.² ($118.95/m²)
Wood siding, sheets, texture 1-11, cedar, 5/8" (15.86 mm) thick, two coats stain, sprayed.	$2.16/ft.² ($23.25/m²)
Stucco, three coats 3/4" (19.05 mm) thick with mesh, masonry construction, colored, trowel-finished.	$3.08/ft.² ($33.15/m²)
Steel siding, factory sandwich panel, 26-gauge, 1" (25.4 mm) insulation, galvanized, colored one side	$6.15/ft.² ($66.20/m²)

Variables in existing conditions, project location and size, different application methods as well as numerous other factors render it difficult to accurately predict the installed costs of any building material without evaluating each project individually. However, general costs for budget purposes and a comparison to some common exterior wall systems are available through a number of published resources. Table 1, although not geared specifically to renovation projects, provides approximate installed cost data including overhead and profit for a variety of exterior wall systems [2]. On many renovation projects, EIFS will be cost-competitive solely on the basis of the system's ability to adapt to a wide range of existing building conditions without the costly building and structural modifications needed to accomodate many other exterior wall systems.

CONSIDERATIONS

Existing exterior walls or facades may be renovated to fulfill a wide range of needs or conditions. Therefore, each project's specific needs should be considered and addressed prior to selecting a particular type of EIFS or application method. The considerations that follow are of primary significance particularly with respect to a retrofit application and are intended to assist in selecting the most appropriate EIFS option or application method. They can also help the building owner realize all of the benefits offered by an EIFS. General considerations that also need to be addressed but do not pertain specifically to retrofit applications are outside of the scope of this paper but are readily available through many previously published articles [3].

Substrate Type/Condition

One of the primary considerations is evaluation of the type of substrate to which the EIFS will be attached. This includes substrate conditions with respect to existing paints or coatings, soundness and integrity, and planar irregularities. The importance of determining the substrate condition cannot be overemphasized, as it plays an integral role in selecting the most appropriate and cost effective EIFS from the system options and application methods currently available. These are important considerations, as the costs for substrate preparation and special conditions can vary greatly depending upon the method of application or retrofit system that is selected, which ultimately affects upon the final installed cost of the EIFS to the building owner.

Generally, the project architect or engineer evaluates the condition of the substrate. Substrate requirements for the various retrofit systems are generally determined via visual observations, along with field screening tests. The visual observations reveal physical characteristics concerning the building, indicate details and conditions that may require special consideration, as well as provide information including existing surface conditions such as paints/coatings, mildew and residue.. The field screening tests typically consist of field adhesion and/or fastener pullout (tensile load) tests, which provide valuable performance data for various system options, and application methods that the EIFS manufacturer offers. Component compatibility tests may also be of assistance in some situations to verify compatibility between the substrate and EIFS components. This type of data is crucial for retrofit applications, due to the unknown or concealed conditions often encountered on renovation projects.

Once all of the field data has been compiled, it can be used to help determine the system options or application methods that can potentially satisfy the substrate requirements, as well as local conditions and appropriate safety factors.

Details

Conditions where the EIFS will adjoin existing penetrations such as doors and windows or existing flashings require consideration in order to provide proper details and assure an overall watertight building envelope. Treatment of these conditions, which will vary from project to project, can range from providing an isolation or sealant joint between the penetration and EIFS to replacing or adding additional flashings. In some cases, new windows or doors are incorporated to create a totally new appearance, as well as resolve potential transition difficulties between dissimilar materials. As an example, the need for additional or modification of flashings is very common, particularly at the transition from the EIFS to a roof parapet cap or gravel stop. Figure 3 illustrates a relatively easy and cost effective method to counterflash the EIFS at a typical parapet cap.

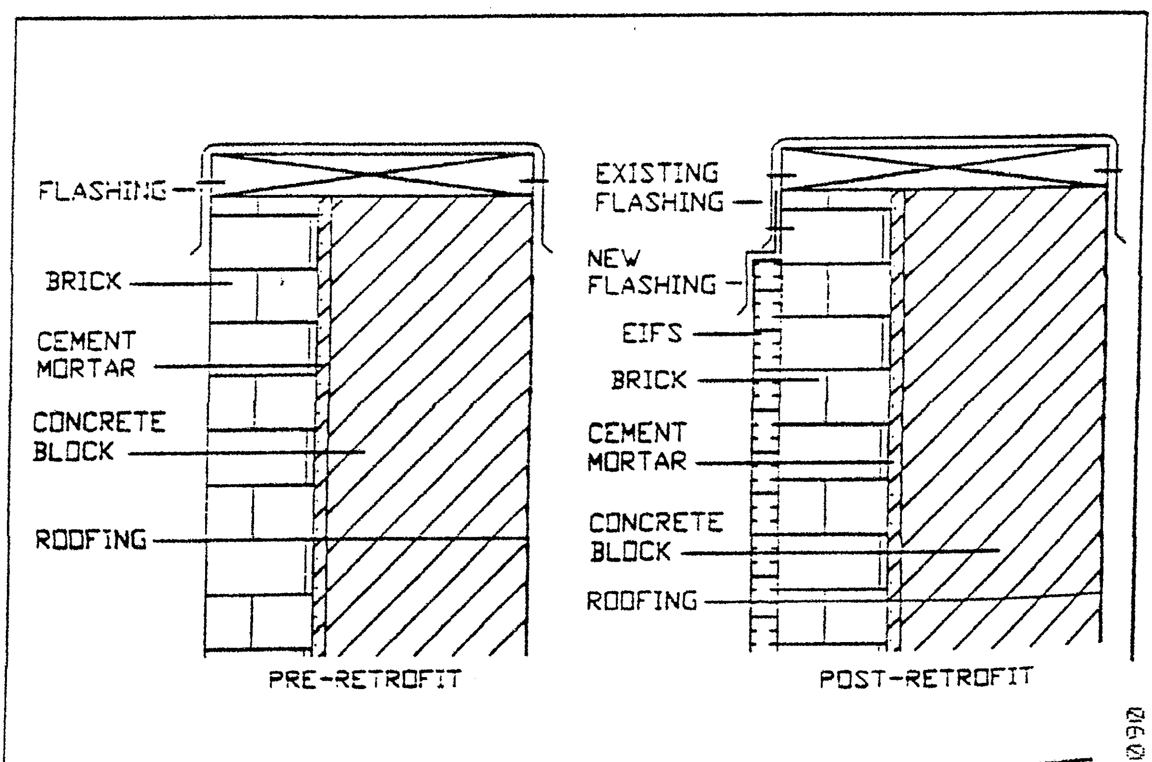

FIG. 3 -- Typical parapet cap details.

Water Vapor Transmission Analysis

The possibility of condensation occurring within the wall system should be assessed. If condensation is severe, it could adversely affect the assembly. This is a particularly important consideration on retrofit projects, as sealers/coatings on the existing exterior walls may, in effect, create a vapor retarder within the wall system once the EIFS is applied. Fortunately, it is relatively easy to determine if condensation can be expected, particularly with some of the programs, such as WVT, that are available commercially [4]. If it is determined there is a vapor problem, a change in one or more of the system components can typically resolve the concern.

Thermal Resistance

Regardless of the type of thermal insulation board used, many thicknesses are available which provides a wide range of potential thermal resistance values.

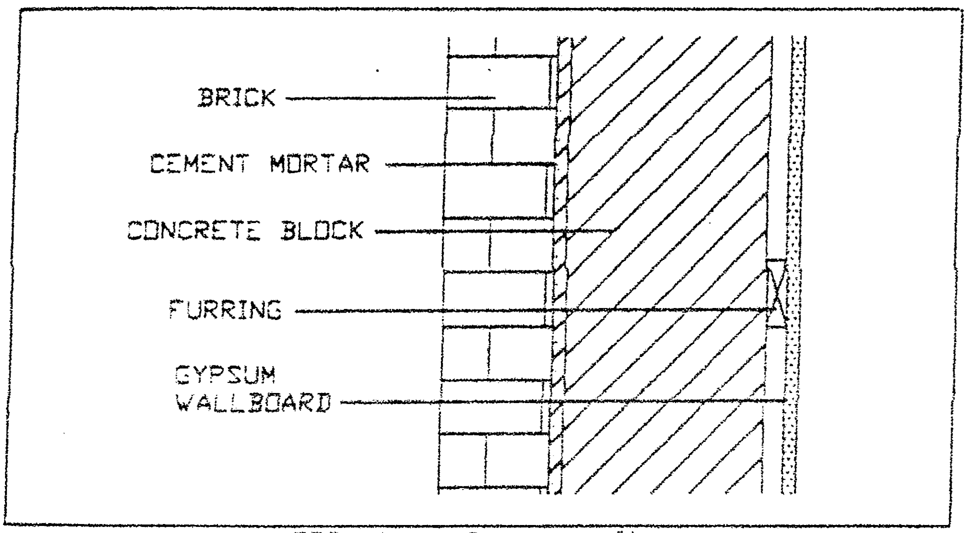

FIG. 4a -- Pre-retrofit.

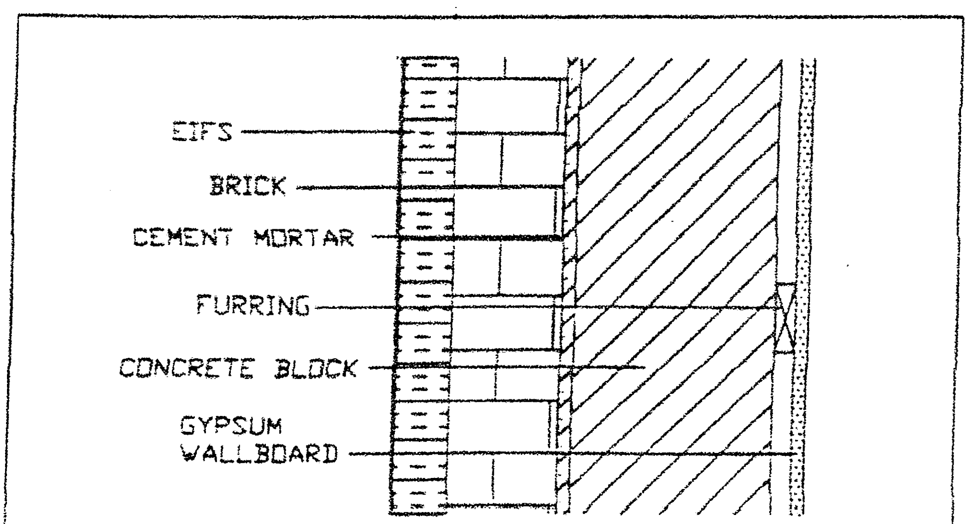

FIG. 4b -- Post-retrofit.

Since the EIFS is applied to the exterior face of the building, increasing the insulation board thickness should not reduce the interior floor area. In general, unless dictated by unique details, aesthetics or building code requirements, the insulation board thickness used is a function of the necessary or optimum thermal resistance value desired for the entire wall assembly including the existing components. For illustration purposes, Figures 4a and 4b show a theoretical existing masonry building sections before and after renovation with an EIFS.

Determining the optimum insulation board thickness or thermal resistance value for the EIFS based upon the projected payback period for the installed system cost can be estimated via one of many energy analysis methods. Methods of analysis can range from a simple payback that is determined by dividing system costs by annual savings to highly complex analyses that incorporate items such as owning/operating costs, life-cycle costs, taxes, building use and occupancy, daily heat cycles, cooling costs (if applicable), and significant heat loss via doors, windows and roofs, among other factors. Additionally, the net benefits of the various systems/thermal insulation values versus their installed costs should be analyzed for optimum economic performance (barring design considerations) to take into account the monetary value of the investment.

TABLE 2a--Projected payback analysis for a theoretical retrofit project in Providence, RI.

Description	Thermal Resistance (R) Values [6] Ft.^{2}·h·°F/BTU / M^2·K/W		
	Existing Construction	EIFS Retrofit #1	EIFS Retrofit #2
EIFS with 1" (25.4 mm) insulation R = 5.0/.88	...	5.0/0.88	...
EIFS with 2" (50.8 mm) insulation R = 10.0/1.76	...	...	10.0/1.76
Outside surface 15 MPH (24.14 K/H) winds	0.17/0.03	0.17/0.03	0.17/0.03
Face brick 4" (101.6 mm)	0.44/0.08	0.44/0.08	0.44/0.08
Cement mortar, 0.5" (12.7 mm)	0.100/0.02	0.10/0.02	0.10/0.02
Concrete block, cinder aggreggate 8" (203.2 mm)	1.72/0.30	1.72/0.30	1.72/0.30
1" x 3" (25.4 mm x 76.2 mm) furring	0.94/0.17	0.94/0.17	0.94/0.17
Gypsum wallboard, 0.5" (12.7 mm)	0.45/0.08	0.45/0.08	0.45/0.08
Inside surface	0.68/0.12	0.68/0.12	0.68/0.12
Total Thermal Resistance	4.50/0.80	9.5/1.68	14.5/2.55

TABLE 2b--EIFS Retrofit #1.

Year	Fuel (MBTU/MJ)	Projected Energy Costs (Present "R")	Projected Energy Costs (New "R")	Projected Savings*
1992	$38.09/$40.19	...	...	($54 000)
1993	$39.23/$41.39	$14 657	$6 943	$7 714
1994	$40.41/$42.63	$15 096	$7 151	$7 945
1995	$41.62/$43.91	$15 549	$7 365	$8 184
1996	$42.87/$45.23	$16 016	$7 586	$8 429
1997	$44.16/$46.59	$16 496	$7 814	$8 682
1998	$45.48/$47.98	$16 991	$8 048	$8 943
1999	$46.85/$49.43	$17 501	$8 290	$9 211
2000	$48.25/$50.91	$18 026	$8 539	$9 487

Conditions and Assumptions

10 000 ft.^{2} (929 m^2)	Area to be retrofitted with EIFS
$5.40/ft.^{2} ($58.13/m^2)	EIFS installation cost (Table 1)
4.5/0.80	Present "R" value (ft.^{2}·h·°F/BTU / m^2·K/W) Fig. 4a
5.0/0.88	"R" value to be added with EIFS Retrofit #1 (ft.^{2}·h·°F / m^2·K/W) Fig. 4b
$54 000	Cost to retrofit with EIFS (area x EIFS installation cost)
3.00%	Inflation rate of fuel
5 954	Annual degree days [7]
85%	Heating system efficiency
$0.13	$/KWH Electricity
6.4	Projected years to payback.

* Projected savings do not reflect net present values of future cash flows.

TABLE 2c--EIFS Retrofit #2

Year	Fuel (MBTU/MJ)	Projected Energy Costs (Present "R")	Projected Energy Costs (New "R")	Projected Savings*
1992	$38.09/$40.19	...	...	($61 800)
1993	$39.23/$41.39	$14 657	$4 549	$10 108
1994	$40.41/$42.63	$15 096	$4 685	$10 411
1995	$41.62/$43.91	$15 549	$4 826	$10 724
1996	$42.87/$45.23	$16 016	$4 970	$11 045
1997	$44.16/$46.59	$16 496	$5 120	$11 377
1998	$45.48/$47.98	$16 991	$5 273	$11 718
1999	$46.85/$49.43	$17 501	$5 431	$12 070
2000	$48.25/$50.91	$18 026	$5 594	$12 432

Conditions and Assumptions

10 000 ft.^{2} (929 m^2)	Area to be retrofitted with EIFS
$6.18/ft.^{2} ($66.52/m^2)	EIFS installation cost (Table 1)
4.5/0.80	Present "R" value (ft.^{2}·h·°F/BTU / m^2·K/W) Fig. 4a
10.0/1.76	"R" value to be added with EIFS Retrofit #2 (ft.^{2}·h·°F/BTU / m^2·K/W) Fig. 4b
$61 800	Cost to retrofit with EIFS (area x EIFS installation cost)
3.00%	Inflation rate of fuel
5 954	Annual degree days [7]
85%	Heating system efficiency
$0.13	$/KWH Electricity
5.7	Projected years to payback.

* Projected savings do not reflect net present values of future cash flows.

Tables 2a-c provide an example of a projected payback analysis based upon heating costs for two assemblies calculated with a commercially available energy analysis program [5].

The data provided takes into account fuel costs, wall area to be retrofitted, existing and proposed thermal resistance values, annual heating degree days, as well as estimated fuel inflation rates, heating system efficiency and installed costs for the EIFS based upon the data in Table 1. Projected savings are provided in Tables 2b and 2c over a one- to eight-year time period. Based on the example, EIFS Retrofit #2 with 2" *(50.8 mm)* thick insulation board (R 10.0) provides a shorter payback period, and barring design or other considerations should be the assembly that is selected.

APPLICATION METHODS AND SYSTEM OPTIONS

Once the considerations are identified and addressed, the most appropriate class of system or application method can be selected from the system options or application methods that are currently available.

Class of System

Class "PB" and Class "PM" have been established by the EIFS Industry Members Association (EIMA), the industry trade group, as the two types or classes of EIFS [8]. The typical Class PM system is attached to the substrate with a mechanical anchor system, while the typical Class PB system is attached via an adhesive application method. A mechanical anchor system, which may or may not include adhesives, may also be a suitable method of attachment for the Class PB system, depending upon the project requirements and the EIFS manufacturer's recommendations. Choosing the class of system - whether for a new or renovation project - is generally a function of numerous items including budget and building types. With the exception of retrofit projects, the method of attachment generally does not play a role in selecting the class of system. However, for retrofit projects, the condition of the substrate, particulary with respect to existing coatings, may be such that some substrate preparation may be needed in order to adequately support the application of an adhesively applied (Class PB) EIFS. Although the installed cost of a Class PM system is generally 10% to 30% higher than a Class PB system on typical new construction projects, the Class PM system may be financially favorable in a retrofit project, since it generally does not require the substrate preparation required with a Class PB system.

Panelization/In-Place

The most suitable application for the overwhelming majority of retrofit projects is in-place or on-site, due primarily to cost effectiveness, ease of satisfying unique field conditions, as well as practical problems encountered with erecting prefabricated panels on most existing buildings. However, panelization on retrofit projects should be considered on in-fill applications where existing building materials or windows, such as on an old manufacturing facility, are to be totally removed and replaced with an EIFS. Conditions such as these can create an ideal in-fill panelization project since there will typically be many identical style and size panels. Additionally, there should be sufficient panel attachment points along the head, sill, and jambs of the opening. Since the panels are complete and ready to install prior to arriving at the site, the existing windows can be removed and the EIFS panels quickly installed, decreasing the potential exposure of the building interior. Other potential retrofit panelization projects might include accent bands, penthouse screens and signage.

TABLE 3 -- Common retrofit application options.[1]

Class of system	Substrate type/condition	Substrate preparation options
PB (Adhesively fastened)[2]	A) Unpainted and uncoated stucco, unit masonry, concrete, wood-based sheathing, terra cotta and cement board.	1) Remove dirt, mildew, etc.
	B) Painted or coated stucco, unit masonry, concrete, wood-based sheathing, and cement board.	1) Sandblast existing surface to remove paint, coatings, etc.[3] 2) Attach metal lath or sheathing to the existing substrate. 3) Remove dirt, mildew, loose paint/coatings, etc. Apply manufacturer's adhesion intermediary or primer. 4) Remove dirt, mildew, loose paint/coatings, etc. Install mechanical fasteners following adhesive application.
	C) Unpainted and un-coated tile, glazed unit masonry and metal buildings.	1) Attach metal lath or sheathing to the existing substrate. 2) Remove dirt, mildew, etc. Apply manufacturer's adhesion intermediary or primary.
PM (Mechanically fastened)	All of the above.	1) No special substrate preparation typically required.

1. All options must comply with the EIFS manufacturer's recommendations. A field evaluation, such as fastener pullout (tensile load) and/or adhesion tests may be required to qualify a particular option.
2. Adhesive or adhesive/mechanical fasteners are the predominant methods of attachment. Mechanical fastener attachment only is generally limited in use to low-rise construction. Contact the EIFS manufacturer for mechanical fastener system requirements.
3. Except wood-based sheathing and cement board.

Substrate Preparation Requirements

Substrate preparation requirements are a function of numerous items. However, the class of system, type and condition of the existing substrate, method of system attachment, and local design conditions play a primary role in determining these requirements. Also of significance are the EIFS manufacturer's recommendations, as they may vary from manufacturer to manufacturer. Although industry standards for substrate preparation on retrofit projects do not formally exist, there are a number of practices that are successfully used in the United States today.

Table 3 provides a synopsis of many common substrate preparation requirements that are necessary prior to application of the EIFS, although there may be slight differences depending upon the manufacturer. Additionally, due to specific project conditions, all options may not be applicable in all cases. This exemplifies the need to evaluate the project prior to selecting a particular option or application method.

The substrate preparation requirements shown are intended to address special or unique conditions generally encountered on retrofit or renovation project. Table 3 is not intended to address standard substrate requirements typical of all EIFS projects, such as being dry and free of planar irregularities.

CONCLUSION

EIFS are extremely versatile exterior wall systems with the unique ability to adapt to a wide variety of conditions often encountered on retrofit or renovation projects. The needs of each individual project should be considered in order to assure the system or application method selected will suit the project. Once these needs or requirements are determined, the most appropriate and cost-effective system option or application method can be selected from those that are available. Evaluating the project in this type of manner will assist in addressing potential areas of concern prior to commencement of the job, and should result in use of the system that is most appropriate for the project.

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