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PROJECTED LIFE CYCLE COSTS OF AN EXTERIOR INSULATION AND FINISH SYSTEM

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ABSTRACT: The purpose of this paper is to provide building owners and design professionals the necessary information to comprehend and estimate life cycle costs of wall assemblies that incorporate Exterior Insulation and Finish Systems (EIFS). Specific examples will be provided to compare these costs to those of exterior wall assemblies that utilize alternative cladding materials. Life cycle costs, in a general sense, can be used by owners and design professionals to evaluate total installation and operating costs of functionally similar exterior wall assemblies over a specific time frame. The scope of the paper will incorporate considerations such as comparative installation costs of EIFS versus other claddings, in addition to the costs of maintenance at suggested intervals. Since economics often plays a major role in the selection of a product or system, this study will provide comprehensive information to assist with the comparison of different exterior wall cladding systems and conditions. Using a life cycle cost method to compare the assemblies is of particular importance since it considers all the relevant costs (present and future) and projects the total operating cost associated with the system.

KEYWORDS: life cycle costs, thermal resistance (R value), thermal bridging, discount rate, inflation rate, straight-line depreciation, thermal efficiency, cladding, present value, future value

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Cladding the exterior of a building requires selection from numerous exterior wall systems or cladding options. Selection of a particular system is typically based on one or more criteria such as type/use of building, desired appearance, economic performance, building location, or local trends and conditions. Economic performance is generally one of the primary considerations due to its impact on the overall cost of the project. Life cycle cost, internal rate of return and benefit to cost ratio are some of the methods available that can be used to measure overall economic performance [1,2]. A life cycle cost analysis considers all relevant expenses for a building or building system and therefore is an appropriate method to compare costs of functionally similar exterior wall systems. A life cycle cost analysis for an exterior wall system should typically include costs related to items such as installation, maintenance, repair, energy savings, and inflation. Since the owning and operating costs are evaluated over a specific time period, this method defines the most cost effective system for satisfying specific conditions. It should be understood, however, that the analysis often contains some assumptions, judgments, and certain effects that must also be considered and evaluated in the final system selection.

The primary objective of this paper is to compare life cycle costs of several cladding assemblies including Exterior Insulation and Finish Systems (EIFS). The basis for the comparison is a theoretical commercial office building constructed in 1995. The building is located in Providence, RI and owned by a private investor. ASTM Standard Practice for Measuring Life Cycle Costs of Buildings and Building Systems (E 917) [3] method was used as a model to assist in computing the life cycle cost. It is important to realize that when measuring Life Cycle Costs of a building, certain factors such as residual values, as well as other applicable variables should be considered. The Life Cycle Cost analysis for an individual should suit the investors needs and future plans for the building; therefore, the Life Cycle Cost analysis performed may vary from owner to owner. The cladding assemblies under consideration for the theoretical building are described in Table 1.

TABLE 1--Cladding Assemblies[3]

Cladding	Structural/Framing Assembly
Exterior Insulation and Finish System (Class PB)	Metal Studs
Stucco	Metal Studs
Brick Veneer	Metal Studs
Brick Face Cavity Wall	Concrete Block
Stone Veneer	Metal Studs
Precast Concrete	Metal Studs (non-loadbearing)[4]
Reinforced Split Faced Block	Metal Studs (non-loadbearing)

The life cycle cost analysis for the assemblies under consideration are based on the data and assumptions that follow. The basic assumptions were developed with the intention that they would enable the assemblies to be evaluated as equally as possible given the conditions described.

CLADDING

All of the cladding assemblies and costs are based on a typical three story commercial office building with a 200 ft x 200 ft footprint (61 m x 61 m). The exterior walls which will receive the cladding are assumed to be non-loadbearing with a total wall surface area of 20 480 square feet (1 903 m^2).

All of the exterior wall cladding surfaces were assumed to be monolithic and flat without aesthetic features such as raised bands, cornices, quoins, or recessed joints. Features such as these may be difficult and in some cases impossible to achieve with several of the assemblies, which is why they were not considered on the model building. However, using flat, monolithic walls for the model effectively penalizes the highly versatile wall claddings in that the full cost benefit of the cladding is not realized. All claddings are assumed to be installed in place with the exception of the precast concrete which must be installed as prefabricated panels.

STRUCTURAL/FRAMING ASSEMBLY

For equal comparison of the assemblies and because the exterior walls of the model building are non-loadbearing, it is assumed the main structural components (i.e.

[3]See Appendix for complete descriptions of the cladding/framing assemblies and components.

[4]For the precast concrete and reinforced split faced block, the metal stud back-up wall was designed for interior purposes only for attachment of the gypsum wallboard and is differentiated by a non-loadbearing design.

structural steel beams/columns, etc.) are in place and ready to receive the cladding and framing assembly. For comparison purposes, it is assumed costs of the main structural components are identical, regardless of the cladding/framing assembly selected. Costs for structural/framing assemblies include labor and materials (i.e. gypsum wallboard and supporting framing if required) necessary to receive the interior finish. The cost of the framing assembly can vary widely depending upon the cladding and therefore is included in the analysis, although it is generally not considered to be a component of the cladding. Design of the framing assembly is based upon cladding requirements and local wind loads calculated as per The Guide to the Wind Load Provisions of ASCE 7-88 (formerly ANSI A58.1) [4]. The design evaluation considered wind load coefficient, building importance factor, deflection, spacing of the framing, and pullover values for sheathed substrates. For purposes of design, floor to floor heights were assumed to be ten feet (3 m) which is typical for a commercial building. The results of the design evaluation yields design wind loads on the components and claddings, along with the required moment capacity and required moment of inertia. All of the cladding assemblies were designed to meet the minimum thermal resistance requirements (R value of 12.5 F•ft^2•h/Btu) of the local building codes [5]. However, some assemblies may slightly exceed the R value of 12.5 if commercially available materials and types could not achieve an exact 12.5 R value. These costs were considered since they can vary widely depending on the type of insulation utilized as well as the method of installation. The analysis also takes into consideration the reduction in R value of the wall assembly due to thermal bridging (for framed assemblies) as per the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. ASHRAE 90.1-1989: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings (ASHRAE 90.1-1989) [6]. Inside and outside air flows, and interior finishes were not included in the ASHRAE energy design due to their relatively low values with respect to the overall wall assembly and would have an insignificant overall cost impact.

COST/DATA

Estimated installation costs of the cladding and structural framing assembly shown in Table 2 were derived from nationally recognized construction cost data publications [7,8]. Nationally recognized publications were used to derive the cost since it was most desirable to use an unbiased source and costs representing national averages. The national average costs were adjusted with city cost indices to accommodate local conditions as indicated in the publication.

Estimated maintenance costs and frequencies were derived from sources such as consultation with various industry professionals, publications, as well as a nationally recognized facilities maintenance and repair cost data publication [9,10]. The latter item was not used as the sole source of the cost data since the reported accuracy is plus or minus 20% because of the wide range of maintenance tasks and diverse environments addressed by the publication. Consequently, multiple sources were utilized in an effort to enhance the reliability of the data.

All installation and maintenance cost data shown in Table 2 represent current dollar costs. Table 3 provides projected life cycle costs for each of the cladding and structural/framing assemblies. Although opinions may differ slightly with the cost data shown, it provides an overall relative comparison of the various wall system alternatives.

LIFE CYCLE COST CALCULATIONS

Net life cycle costs tabulated in Table 3 were calculated in present value terms. The analysis assumes a thirty year study period as it is a reasonable time frame for an investor-owned property. Projected annual discount and inflation rates were obtained from a national financial institution and assumed to be a constant 4-3/4% and 3% respectively over the entire study period. Tax benefits are based on a combined 40% federal and state tax rate. A thirty nine year straight-line depreciation period was used based on current tax law.

CONSTRAINTS

All of the claddings and framing assemblies considered are representative of typical construction methods and materials and are viable assemblies for the model considered. It should be understood that additional cladding and structural/framing options exist, however, they are outside the scope of this paper. Additionally, all of the claddings and structural/framing assemblies satisfy the same basic functional requirements (i.e. protect building occupants, contents, provide pleasing aesthetics, etc.), which is essential for comparison of the assemblies. The structural/framing assemblies are assumed to be located outboard of the slab resulting in an equivalent net rentable floor area for all wall system assemblies. Costs related to windows, doors, sealants, flashings, etc. were assumed to be similar regardless of the cladding alternative selected so they have not been considered in this analysis. The only exception is precast concrete which must be installed in prefabricated panels and therefore included the additional cost of sealant and related maintenance at the panel perimeters since it is not required by any of the other assemblies under consideration.

TABLE 2--Cost Data (Current Dollar Costs)

Cladding and Structural Framing Assembly	Estimated Initial Installation Costs[5] ($/ft²)	Description of Maintenance[6]	Maintenance Costs and Frequencies[7]
Exterior Insulation and Finish Systems (Class PB) with metal stud framing	$234 086 ($11.43/ft²)	Clean 100% of the EIFS	$9 421 at year 15
		Clean and recoat 100% of the EIFS	$18 432 at year 30
Stucco with metal stud framing	$216 269 ($10.56/ft²)	Repair cracks in stucco, 2% of wall surface	$1 273 per 10 years
		Clean 100% of the stucco	$9 421 at year 15
		Clean and paint 100% of the stucco	$18 432 at year 30
Brick Veneer with metal stud framing	$416 973 ($20.36/ft²)	Clean 100% of the brick Repoint 30% of the brick	$14 398 at year 25
Brick Face Cavity Wall with concrete block	$429 261 ($20.96/ft²)	Clean 100% of the brick Repoint 30% of the brick	$14 398 at year 25
Stone Veneer with metal stud framing	$572 006 ($27.93/ft²)	Clean 100% of the stone Repoint 30% of the stone	$14 398 at year 25
Precast Concrete panels with metal stud framing (non-loadbearing)	$357 886 ($17.47/ft²)	Recaulk 100% of the panels	$30 925 at year 20
		General cleaning on 100% of panels	$9 421 at year 25
Reinforced Split Face Block Wall with metal stud framing (non-loadbearing)	$300 032 ($14.65/ft²)	Clean 100% of the brick Repoint 30% of the brick	$14 398 at year 25

[5]See Appendix for maintenance and installation cost calculations.

[6]The cost of maintenance on a three story building will vary from floor to floor due to scaffolding costs. The costs noted for each cladding alternative is average of the costs for each floor.

[7]All maintenance costs assume a thirty year study period.

TABLE 3--Projected Life Cycle Cost (Present Value Dollars)

Cladding and Structural/ Framing Assembly	Estimated Installation & Maintenance Costs (Year)							Cash Outflow[8] (years 0-30)	Cash Inflow[9] (years 0-30)	Net Life Cycle Cost (Net cash outflow)
	0	5	10	15	20	25	30			
EIFS (Class PB)										
a) cash outflow (initial costs and maintenance)	234 086	0	0	7 318	0	0	11 119	252 523	0	
b) cash inflow (tax benefits)								0	41 813	210 710
Stucco										
a) cash outflow (initial costs and maintenance)	216 269	0	1 076	7 318	908	0	11 887	237 458	0	
b) cash inflow (tax benefits)								0	59 927	177 531
Brick Veneer										
a) cash outflow (initial costs and maintenance)	416 973	0	0	0	0	9 449	0	426 422	0	
b) cash inflow (tax benefits)								0	73 055	353 367
Brick Face Cavity Wall										
a) cash outflow (initial costs and maintenance)	429 261	0	0	0	0	9 449	0	438 710	0	
b) cash inflow (tax benefits)								0	74 574	364 136

[8]See Appendix for present value and tax benefit equations, sample calculations as well as methods to determine tax benefits.
[9]Total cash inflows (tax benefits) were provided for the thirty year study period.

TABLE 3--Projected Life Cycle Cost (Present Value Dollars) (cont.)

Cladding and Structural/ Framing Assembly	Estimated Installation & Maintenance Costs (Year)							Outflow[10]	Inflow[11]	Net Life Cycle Cost
	0	5	10	15	20	25	30	(years 0-30)	(years 0-30)	(Net cash outflow)
Stone Veneer										
a) cash outflow (initial costs and maintenance)	572 006	0	0	0	0	9 449	0	581 455	0	
b) cash inflow (tax benefits)								0	99 836	481 619
Precast Concrete										
a) cash outflow (initial costs and maintenance)	357 886	0	0	0	22 079	6 183	0	386 148	0	
b) cash inflow (tax benefits)								0	69 446	316 702
Reinforced Split Face Block										
a) cash outflow (initial costs and maintenance)	300 032	0	0	0	0	9 449	0	309 481	0	
b) cash inflow (tax benefits)								0	52 881	256 600

[10]See Appendix for present value and tax benefit equations, sample calculations as well as methods to determine tax benefits.
[11]Total cash inflows (tax benefits) were provided for the thirty year study period.

ADDITIONAL CONSIDERATIONS

Projected life cycle costs for other buildings could vary greatly from the model described due to many factors such as the length of the study period, type and use of building, local conditions, taxes, as well as the assemblies under consideration. Criteria which were considered to be relatively minor in nature or extremely subjective for the model building under consideration were not included in the analysis. One example is adverse weather conditions which could affect system installation in terms of the speed/ease of system erection. This could be a factor since delays in the installation of labor-intense products could significantly affect the project completion schedule, thereby increasing the owner's financing costs. Another design consideration is the R value of each assembly which, for the model building, was based on minimum building code requirements. In some systems, such as EIFS, the R value can be significantly increased at very minimal additional costs. This could result in an increase in the building's thermal efficiency which would reduce heating/cooling costs, and therefore the system's life cycle costs.

Life cycle costs can be influenced by many other factors including study period, residual value, service life, system versatility, insurance premiums as well as the projected use(s) of the building. For example, public use buildings such as hotels, retail stores, restaurants, etc. are highly dependent on curb appeal to attract tenants and patrons. This being the case, the appearance of public use buildings will typically need to change and be updated more frequently to suit new tenants or to simply provide a different or more up-to-date appearance. Service life and maintenance costs in these applications is obviously less of a consideration. Some systems, such as EIFS, are much more versatile and cost effective than many other alternatives, particularly when incorporating special shapes, details, and other effects into the project design. It is important to realize that this potential advantage of EIFS was not factored into the model building.

EIFS is ranked high in cost effectiveness when compared to the alternative systems analyzed. In fact, EIFS has one of the lowest life cycle costs of the cladding and framing assemblies under consideration for the model building. The present value costs cited in the example can be considered conservative since the costs were calculated based on a model comprised of flat monolithic walls which are atypical of today's construction design and methods. Changing a building's appearance or achieving special effects such as quoins, cornices and aesthetic bands is very economical with EIFS whereas these effects are not readily achievable nor cost effective with most other cladding assemblies. In conclusion, EIFS attained it's high ranking in the analysis despite the fact that some of the most beneficial aspects of EIFS such as aesthetics, speed and ease of erection, and thermal efficiency were not considered.

APPENDIX

CLADDING/FRAMING ASSEMBLY DESCRIPTIONS & INSTALLATION CALCULATIONS

Exterior Insulation and Finish System (EIFS, Class PB)

System Components--	Cost per square foot ($)
Framing, 3-5/8 in. (92 mm) metal studs	3.01
Exterior grade gypsum sheathing, 1/2 in. (13 mm)	0.93
EIFS	
Expanded polystyrene insulation board (EPS)	
EIFS base coat	
Reinforcing mesh	
Finish coat	6.70
Total unadjusted present value cost =	$10.64

Assembly Specifics--

- Framing = 16 gauge, 16 in. on center (o.c.) (407 mm)
- Cavity insulation = none
- EPS thickness = 3 in. (76 mm)

R Value Calculations--To achieve the minimum required R value of 12.5, 3 in. (76 mm) of EPS insulation board will be utilized. The 3 in. (76 mm) thick EPS insulation will yield an approximate R value of 12.51.

Cost Analysis--Adjustment from the national average:

$$(\$10.64/\text{ft}^2) \times (107.4/100) = \$11.43/\text{ft}^2\ (\$123.04/\text{m}^2)$$

Total Installation Cost-- Cost/square foot = $11.43

Total Installation Cost = Cost/square foot x Wall area

$$= (\$11.43/\text{ft}^2) \times (20\ 480\ \text{ft}^2) = \$234\ 086$$

Stucco

System Components--	Cost per square foot ($)
Framing. 3-5/8 in. (92 mm) metal studs	3.01
Extruded polystyrene insulation board	0.88
Building paper, asphalt felt, 15 lb. (6.8 kg)	0.12
Self-furring metal lath	0.24
Stucco, 3 coats 7/8 in. (22 mm) thick, float finish	4.39
Fiberglass insulation, batt	0.42
Paint exterior stucco, brushwork, primer and 2 coats	0.76
Total unadjusted present value cost =	$9.83

Assembly Specifics--

- Framing = 16 gauge, 16 in. o.c. (407 mm)
- Extruded polystyrene = 1-1/2 in. (38 mm) thick, R-7.5
- Metal lath = 3.4 lb./yd^2 (1.84 kg/m^2), painted
- Fiberglass insulation = 15 in. (381 mm) wide, foil faced, R-11

R Value Calculations--The insulation selected for the framing cavity was a foil faced batt yielding an R-11. The effective R value of this assembly is calculated per ASHRAE standard 90.1-1989 as follows:

Effective framing/cavity R value = cavity insulation x correction factor

Therefore, utilizing the values from the wall assembly:

Effective framing/cavity R value = R-11 x 0.50 = 5.5

To achieve the minimum required R value, an additional 1-1/2 in. (38 mm) of extruded polystyrene insulation was added to the wall assembly.

The total R value of the wall assembly, taking into account the effective R value and the additional insulation, is 13.0.

Cost Analysis--Adjustment from the national average:

$$(\$9.83/\text{ft}^2) \times (107.4/100) = \$10.56/\text{ft}^2\ (113.67/\text{m}^2)$$

Total Installation Cost-- Cost/square foot = $10.56

Total Installation Cost = Cost/square foot x Wall area

$$= (\$10.56/\text{ft}^2) \times (20\,480\ \text{ft}^2) = \$216\,269$$

Brick Veneer

System Components--	Cost per square foot ($)
Standard brick wall, 4 in. (102 mm) common bond	10.81
Wash smooth brick	0.68
Joint backer rod and sealant	0.26
Wall ties, corrugated, 7/8 in. x 7 in. (22 mm x 178 mm) 22 gauge	0.10
Shelf angle	1.18
Steel stud partition	3.16
Sheathing, 1/2 in. (13 mm)	0.92
Extruded polystyrene insulation board	0.88
Building paper, asphalt felt, 15 lb. (6.8 kg)	0.12
Fiberglass insulation, batt	0.53
Flashing, copper, paperbacked	0.32
Total unadjusted present value cost =	$18.96

Assembly Specifics--

- Face brick = standard
- Framing = 18 gauge x 6 in. (153 mm), 16 in. o.c. (407 mm)
  [Note: A 6 in. (153 mm) stud was used in lieu of 3-5/8 in. (92 mm) in order to meet the deflection requirement.]
- Extruded polystyrene = 1-1/2 in. (38 mm) thick, R-7.5
- Fiber glass insulation = 6 in. (407 mm) thick with foil facing

R Value Calculations--The insulation selected for the framing cavity was a fiber glass, foil faced, batt yielding an R-19. However, due to the fact that the framing in the wall can make up as much as 30% of its area, this in turn reduces the wall's overall insulation value. The adjusted R value below shows the newly calculated R value.

Effective framing/cavity R value = cavity insulation x correction factor

Therefore, utilizing the values from the wall assembly:

Effective framing/cavity R value = R-19 x 0.37 = 7.1

Additional insulation will need to be added in the wall cavity to achieve the minimum required R value.

A 1-1/2 in. (38 mm) thick extruded polystyrene insulation board yielding an R value of 10 has been selected. This will now yield a total R value of 14.6 for the exterior wall assembly.

Cost Analysis--Adjustment from the national average:

$$(\$18.96/ft^2) \times (107.4/100) = \$20.36/ft^2\ (\$219.16/m^2)$$

Total Installation Cost-- Cost/square foot = \$20.36

Total Installation Cost = Cost/square foot x Wall area

$$= (\$20.36/ft^2) \times (20\,480\ ft^2) = \$416\,973$$

Brick Face Cavity Wall

System Components--	Cost per square foot (\$)
Face brick veneer, common bond	10.81
Wash brick	0.68
Concrete block wall back-up	4.94
Wall ties	0.15
Extruded polystyrene insulation board	1.04
Flashing, aluminum	0.32
Shelf angle	1.18
Control joint	0.14
Backer rod and sealant	0.26
Total unadjusted present value cost =	\$19.52

Assembly Specifics--

- Face brick = standard
- Back-up wall = 6 in. (153 mm) concrete block with Perlite filled cores
- Cavity insulation = extruded polystyrene, 2 in. (51 mm) thick

R Value Calculations--The 6 in. (153 mm) concrete wall yields an R-value of approximately 4.2. The fact that Perlite was poured into the cores of the block enabled the back-up assembly to achieve this high R-value.

In addition to the above, 2 in. (51 mm) of extruded polystyrene insulation board will be added to the cavity to yield an R-value of 10. This added insulation will be necessary to achieve the minimum local code requirement of an R-value of 12.5. The full exterior wall assembly will now yield a total R-value of approximately 14.2.

Cost Analysis--Adjustment from the national average:

$$(\$19.52/ft^2) \times (107.4/100) = \$20.96/ft^2 \ (\$225.62/m^2)$$

Total Installation Cost-- Cost/square foot = \$20.96

Total Installation Cost = Cost/square foot x Wall area

$$= (\$20.96/ft^2) \times (20\ 480\ ft^2) = \$429\ 261$$

Stone Veneer

System Components--	Cost per square foot (\$)
Ashlar veneer	19.75
Framing, steel stud partition back-up	3.16
Wall ties for stone veneer, galvanized corrugated 7/8 in. x 7 in. (22 mm x 178 mm), 22 gauge	0.24
Asphalt felt sheathing paper, 15 lb. (6.8 kg)	0.12
Sheathing, 1/2 in. (13 mm)	1.03
Fiberglass insulation, batt	0.53
Flashing, copper, paperback 1 side, 3 oz (85 g)	0.30
Extruded polystyrene insulation board	0.88
Total unadjusted present value cost =	\$26.01

Assembly Specifics--

- Ashlar veneer = 4 in. (102 m) thick, sawn face, split joints, high priced stone
- Framing = 2 in. x 6 in. (51 mm x 153 mm) 18 gauge, 16 in. o.c. (407 mm) [Note: A 6 in. (153 mm) stud was used in lieu of 3-5/8 in. (92 mm) in order to meet the deflection requirement.]
- Fiberglass insulation = 6 in. (152 mm) thick with foil facing
- Extruded polystyrene = 1-1/2 in. (38 mm) thick, R-7.5

R Value Calculations--The framing cavity insulation selected yields an R value of 19. The adjusted R value is as follows:

Effective framing/cavity R value = cavity insulation x correction factor

Effective framing cavity R value = R-19 x 0.37 = 7.1

To achieve the minimum code R value, 1-1/2 in. (38 mm) of extruded polystyrene insulation will be needed. This assembly will now have a total R value of 14.6.

Cost Analysis--Adjustment from the national average:

$$(\$26.01/ft^2) \times (107.4/100) = \$27.93/ft^2 \ (300.65/m^2)$$

Total Installation Cost-- Cost/square foot = \$27.93

Total Installation Cost = Cost/square foot x Wall area

$$= (\$27.93/ft^2) \times (20\ 480\ ft^2) = \$572\ 006$$

Precast Concrete

System Components--	Cost per square foot (\$)
Flat precast concrete panel, white face	14.55
Metal studs, non-loadbearing, galvanized	1.02
Fiberglass insulation, batt	0.43
Total unadjusted present value cost =	\$16.00

Assembly Specifics--

- Framing = 25 gauge, 3-5/8 in. (92 mm) 16 in. o.c. (407 mm)
- Fiberglass insulation = 15 in. (381 mm) wide, foil faced, R-11
- Precast concrete panel = 10 ft x 10 ft (3.0 m x 3.0 m), 7 inch thick

Sealant is used around the perimeter of all precast concrete panels. This cost will be adjusted and added to the total cost.

Backer rod, polyethylene, 1/2 in. (13 mm) diameter	\$69.00/100 ft (\$69.00/30.5 m)
Polyurethane, bulk	\$45.00/ gal (\$45.00/3.8 L)

R Value Calculations--Additional insulation was necessary in the framing cavity to achieve the required R value by local building code. The precast concrete panel itself has 2 in. (51 mm) of rigid insulation yielding an R value of 10. After calculating the adjusted R value of the framing cavity insulation, the total R value of the wall assembly is approximately 15.5.

Cost Analysis--Adjustment form the national average:

$$(\$16.00/ft^2) \times (107.4/100) = \$17.18/ft^2\ (\$184.93/m^2)$$

$$(\$0.69/ft + \$0.45/ft) \times (107.4/100) = \$1.51/\text{linear ft}\ (\$4.95/m)$$

Total Installation Cost-- Cost/square foot = \$17.18
(Not including sealant at \$1.51/ ft)

Total Installation Cost = Cost/square foot x Wall area + Cost/ foot x wall area

$$= (\$17.18/ft^2) \times (20\ 480\ ft^2) + (\$1.51/ft) \times (4\ 000\ ft) = \$357\ 886$$

Reinforced Split Face Block Wall - Regular Weight

System Components--	Cost per square foot ($)
Metal studs, non-loadbearing, galvanized	1.02
Fiberglass insulation, batt	0.43
Split face block wall, hollow	
Control joints every 20 ft (6.1 m)	
Horizontal joint reinforcing, alternate courses	11.31
Extruded polystyrene insulation	0.88
Total unadjusted present value cost =	$13.64

Assembly Specifics--

- Framing = 25 gauge. 3-5/8 in. (92 mm), 16 in. o.c. (407 mm)
- Fiberglass insulation = 15 in. (381 mm) wide, foil faced, R-11
- Reinforced split face block = 12 in. x 8 in. x 16 in. (305 mm x 203 mm x 407 mm) blocks, 8 ribs, #5 bars at 32 in. (813 mm) reinforcing
- Extruded polystyrene = 1-1/2 in. (38 mm) thick, R-7.5

R Value Calculations

In order to achieve the minimum required R value, a fiberglass batt insulation and 1-1/2 in. (38 mm) of rigid insulation were incorporated into the wall assembly. The total R value, after adjusting for the framing, is 13.0.

Cost Analysis:

Adjustment from the national average:

$$(\$13.64/ft^2) \times (107.4/100) = \$14.65\ (\$157.70/m^2)$$

Total Installation Cost-- Cost/Square foot = $14.65

Total Installation Cost = Cost/Square Foot x Wall Area

$$= (\$14.65/ft^2) \times (20\ 480\ ft^2) = \$300\ 032$$

Note: All present value costs for each wall assembly were adjusted from the national average by using a ratio incorporating the total weighted average for Providence, RI. The equation utilized in this calculation is the following:

$$\text{National average cost} \times \frac{\text{total weighted average (Providence, RI)}}{100} = \text{cost in Providence, RI}$$

LIFE CYCLE COST EQUATIONS AND SAMPLE CALCULATIONS

Equations used to calculate Cash Outflow in Table 3

Total cash outflow is equal to the initial installation cost of the cladding plus the present value amount at each scheduled maintenance period. The following formulas were used to compute the above calculation:

$$\text{Future value of current dollars (Fn)} = P\,(1 + r)^{N} \quad (1)$$

where r = interest rate of inflation (3%)
N = number of periods (years)
P = present value of $1.00

$$\text{Present value of future dollars (P)} = Fn\,(1+r)^{-N} \quad (2)$$

where Fn = future value of current dollars
r = discount rate (4 3/4%)
N = number of periods (years)

Sample calculation to compute the total Cash Outflow for EIFS from Table 3--

Total cash outflow = initial cost + present value at each scheduled maintenance period (P)

At 0 years (initial cost) P = $234 086

At 15 years

$$Fn = P\,(1+r)^{N}$$
$$= \$9\,421\,(1+0.03)^{15}$$
$$= \$14\,678$$

$$P = Fn\text{ 15 years }(1 + r)^{-N}$$
$$= \$14\,678\,(1+0.0475)^{-15}$$
$$= \$7\,318$$

At 30 years

$$Fn = P\,(1 + r)^N$$
$$= \$18\ 432\ (1+0.03)^{30}$$
$$= \$44\ 740$$

$$P = Fn\ 30\ years\ (1+r)^{-N}$$
$$= \$44\ 740\ (1+0.0475)^{-30}$$
$$= \$11\ 119$$

Therefore, the total outflow in present value dollars would be:

Initial cost + P at 15 years + P at 30 years
\$234 086 + \$7 318 + \$11 119
= \$252 523

Equations and Sample Calculations used to calculate Cash Inflow in Table 3

Total cash inflow is equal to the sum of the present values of the tax benefit over the entire study period (30 years). The following formulas were used to compute the above calculation. A sample calculation is also shown.

a) Depreciation method = straight-line method (39 years)

Depreciation and maintenance costs at year 1 = initial costs/39 + Fn year 1* (3)
= \$234 086/39 + 0
= \$6 002

* Note: Fn should only be added at periods where maintenance is scheduled.

b) Tax rate = percentage based on federal and state taxes (40% was the assumed combined tax rate).

c) Tax benefit (future value) = depreciation x tax rate

Tax benefit (future value) year 1 = depreciation x tax rate (4)
= 6 002 x 0.40
= \$2 401

d) Tax benefit (present value) = tax benefit (future value) x $(1+ \text{discount rate})^{-N}$
where N = number of periods (years)

Tax benefit (present value) year 1 = tax benefit (future value) x P year 1 (5)
= 2 401 x $(1+0.0475)^{-1}$
=\$2 292

The total cash inflow is the sum of the annual tax benefits (present value) for the entire study period (30 years).

Equation used to calculate the Net Life Cycle Cost in Table 3

$$\text{Net life cycle cost} = \text{Cash Outflow} - \text{Cash Inflow} \tag{6}$$

Sample calculation to compute the Net Life Cycle Cost for EIFS from Table 3--

$$\text{Net Life Cycle Cost} = \$252\,523 - \$41\,813$$
$$= \$210\,710$$

Note: Calculations for other systems are similar to above sample EIFS calculations.

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