Dow Construction Chemicals

Acrylic Roof Coatings:
A Valuable Tool for Sustainable Roofing

Introduction

Roofs are expensive. They are expensive to repair and maintain and they are very expensive to replace. Leaking roofs account for additional untold dollars of damaged internal property and inventory, lost occupancy, business interruption, increased heating and air conditioning costs, and, all too often, litigation. Many of these expenses can be avoided if roofs are treated as construction assets requiring the same maintenance as elevators, heaters, air conditioners and other mechanical equipment. All of these other assets require routine maintenance. Minor repairs can be made, which will prevent or greatly reduce the possibility of major or catastrophic breakdown of the equipment (roof).

Life cycle analyses have become valuable tools to the construction industry as a better method of measuring the value of a product over its service life. They have been used recently by roofing material manufacturers to position more costly but higher valued materials over lower cost analogs.[1,2,3,4] The mechanism for life cycle cost analysis is rather simple: merely compute the long-term cost of several different products. The numbers include the initial cost as well as associated maintenance and routine costs for upkeep. The numbers are then normalized to their net present value (NPV or PV) to eliminate inflationary and investment effects. The Discount Rate, or Factor, helps to compare different options where the costs and benefits occurring at different times can be evaluated at a common time. This number is actually the rate of interest reflecting the investor's (building owner's) time value of money. The discount rate should reflect the rate of interest that makes the investor indifferent between paying or receiving a dollar now or at some future point in time.

Life Cycle Cost Analyses Comparing Two Roof Maintenance Scenarios

The technique for conducting a life cycle cost analysis has become formalized through the use of ASTM E917, *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems*.[5] This mathematical model enables the user to evaluate the life cycle cost of a building (roof) and compare it to alternative designs or practices that satisfy the same functional requirements. Other ASTM methods have been developed to determine the rate of return and payback for investments and net benefits for investments in buildings.

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The objective of this study is to compare two scenarios for roof maintenance and management, ranging from no inspection or maintenance to a very comprehensive roof asset management program. The building is an industrial research laboratory located in Spring House, PA, a suburb of Philadelphia. The roof is a 37,000 ft² smooth, asphalt surfaced, three-ply organic felt built-up roof and its size has been rounded off to 100,000 ft² for computational ease.

The roof history is actually Scenario #2, while Scenario #1 represents a similarly roofed building located nearby whose conditions and history were monitored. However, this building is not an exact replica of the Scenario #2 building due to differences in occupancy, roof exposure and use. The study period is 20 years. The discount rate is 10% and the escalation rate is 0%. (This is the factor that will influence the increased rise in certain factors such as energy.) The two scenarios consider a number of complex factors, including the use of visual and non-destructive moisture surveys, the cost of repairing leaks, interior damage to walls and ceiling tiles, wasted heating and cooling energy caused by wet roof insulation, and saved energy through the use of reflective roof coatings.

Scenario #1

This scenario assumes no formalized roof management or maintenance program. Repairs are made only when the roof leaks. No efforts are made to maintain the roof, and the roof will be replaced at the end of 10 years. The initial cost is $3/ft² or $300,000 and the replacement cost is $5/ft² or $500,000. We assume total removal of the wet insulation and some deteriorated decking and nailers. No inspections are made of the roof and leaks are repaired by a roofing contractor at $750 each. We assume no leaks in the first two years (contractor's warranty in effect). From years 3 to 7, assume one leak/repair per year, two leaks in year 8, three in year 9 and four in year 10.

As the roof develops leaks, wet insulation will reduce the "R" value of insulation. Each year 25 ft² of insulation becomes wet due to damage to the roof. Wet insulation costs $1.88/ft² in wasted energy. A detailed economic analysis used to drive this datum is presented in the Appendix. Interior damage as wet ceiling tile is stained and damaged walls will cost $500 in repair. This will be incurred in years 5, 8, 11, 15 and 18.

Scenario #2

This is a comprehensive roof maintenance program. A formalized roof asset management program is established, costing $1,000/year. Visual inspections are made semi-annually and after severe storms. Non-destructive moisture surveys are made every five years at a cost of $500 each. In year 10, the roof is coated with a white elastomeric 100% acrylic roof coating costing $0.75/ft² or $75,000 as a capital cost. The white roof reduces the air conditioning load but increases the heating load (black roofs are warmer in the winter), but still saves the building $8,070 the first year. Dirt build-up on the white coated roof reduces the savings to 80% or $6,460/year. This documentation is based on an Oak Ridge National Laboratory report entitled *"Guide to Estimating Differences in Building Heating and Cooling Energy Due to Change in Solar Reflectance of a Low Slope Roof"*[6] and has also been confirmed experimentally (USM study).[7] The 20% reduction in reflectivity of white roof coatings due to dirt pickup has been observed experimentally in this study and has also been demonstrated in studies conducted by Lawrence Berkeley Laboratory.[8] No interior repairs are necessary.

Life Cycle Cost Summary

	Scenario #1	Scenario #2
Capital Costs (PV)		
Initial Investment	$300,000	$ 300,000
Roof Replacement	$175,000	$0
Roof Coating	$0	$28,950
Maintenance Costs (PV)		
Program	$0	$8,505
Visual Survey	$0	$17,010
Moisture Survey	$0	$6,970
Repairing Leaks	$7,142	$1,693
Interior Damage	$928	$0
Wasted Energy	$1,486	$0
Saved Energy	$0	($18,393)
PV of 20 Year Expenditure	TOTAL $484,556	TOTAL $344,735
Equivalent Annual Value (Cost) UCR i=10% 20 Years (.1175)	$56,936	$40,506
Depreciated Annual Value (Cost) Straight Line 39 Years 40% Tax Rate PV	$49,563	$35,646
Cost Savings over Scenario #1		$0.14/ft²/Year

Conclusions

The data clearly demonstrate the economic value of a proactive roof maintenance strategy. The last line item, "Cost Savings over Scenario #1," should easily convince the building owner or facility manager of the value of regular professional roof inspections and the use of maintenance coatings as the economically preferred alternative to tearing off and reroofing every 10 years.

While the use of a reflective roof coating in the study only provided an energy savings of $0.14/ft^2/year, the reader is reminded that this study was conducted in the Philadelphia, PA, area. Actual energy studies, as well as mathematical modeling, have shown significant energy cost saving benefits in the "sun belt" areas of the country. It is not uncommon to amortize the cost of the coating in less than 5 years solely through reduced air conditioning energy use.

With proper maintenance and coating, a low slope roof can last significantly longer than its predicted life. This will reduce the life cycle cost of the roof and reduce demand for dwindling natural raw materials, precious energy resources and shrinking landfill space. Acrylic coatings can truly make "sustainable roofing" a reality.

Bibliography

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[6]Griggs, E.I., et al., "Guide to Estimating Differences in Building Heating and Cooling Energy Due to Changes in Solar Reflectance of a Low-Sloped Roof," August 1989.
[7]"Building For The Future," Boutwell, Dr. Colen J. and Solinas, Ysidro, University of Southern Mississippi, December 13, 1986.
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Appendix

Roof Coating Costs

Assume 3 gallons/square with a selling price of $12/gal or $0.36/ft^2. Assume $0.25/ft^2 for roof preparation and $0.13/ft^2 for coating application.

Material	$0.36
Labor	$0.13
Preparation	$0.25
	$0.74/ft^2

Energy Savings Attributable to White Coating Location is Philadelphia, PA, and building is type **IA** (Office) with R=4.0. Fuel costs: $0.80/gal for #2 oil and $0.10/KWH for electricity at P.D. rate.

Energy Calculations for Increased Heating and Cooling Costs Due to Wet Insulation

Fuel Oil

$$\frac{\$0.80}{\text{Gal}} \times \frac{\text{Gal}}{140{,}000\ \text{BTU}} \times \frac{100{,}000\ \text{BTU}}{\text{Therm}} = \$0.57/\text{Therm}$$

Electricity

$$\frac{\$0.10}{\text{KWH}} \times \frac{1\ \text{KWH}}{3{,}413\ \text{BTU}} \times \frac{100{,}000\ \text{BTU}}{\text{Therm}} = \$2.93/\text{Therm}$$

Energy Loss (Heating Season)

Energy Loss of One =
°F 25 ft^2 Leak/Year

$$\frac{1\ \text{BTU}}{\text{Hr/ft}^2/°\text{F}} \times \frac{25\ \text{ft}^2}{\text{Day}} \times 24\ \text{Hr} \times \frac{\text{Degree Day}}{\text{Year}} = 2{,}953{,}800\ \text{BTU} = 29.54\ \text{Therm}$$

Assume a 'C' Factor of Dry Insulation of 0.25 (R=4) and When Wet 'C'=1 and R=1

Thus, 29.54 Therm x .25 = 7.38 Therm

29.54 Therm - 7.38 Therm = 22.16 Therm/Year Wasted Energy for 25 ft^2 section of wet insulation

Energy Loss (Cooling Season)

Heat Gain = U x Roof Area x ETD x Operating Hours/Year

$$\frac{1\ \text{BTU}}{\text{Hr/ft}^2/°\text{F}} \times 25\ \text{ft}^2 \times 60°\text{F Light Construction} \times \frac{820}{\text{Year}} = 1{,}230{,}000\ \text{BTU} = 12.3\ \text{Therm/Year}$$

12.3 Therm - 3.08 Therm = 9.22 Therm/Year Wasted Energy for 25 ft2 section of wet insulation

Cost of Heating One Wet Area (25 ft²)

$$\frac{22.1\ \text{Therm}}{\text{Year}} \times \frac{1}{0.75\ \text{Efficiency Therm}} \times \$0.57 = \$16.80/\text{Year}$$

Cost of Cooling One Wet Area (25 ft²)

$$\frac{9.22\ \text{Therm}}{\text{Year}} \times \frac{1}{0.90\ \text{Efficiency Therm}} \times \$2.93 = \$30.02/\text{Year}$$

Energy Savings from Reflective Surface Coating
Cooling Cost Reduction

Roof Area x Solar Radiation (Philadelphia) x Change in Roof Reflectance x Cooling Energy Factor (ASHRAE) x Cooling Energy (Electricity) Cost ÷ Cooling System Operating Performance Coefficient ÷ 106

$100{,}000 \times 1{,}168.9 \times 0.6 \times 7.73 \times \$29.30 \div 1.7 \div 106 = \$9{,}344/\text{Year}$

Heating Cost Penalty (from White Roof)

Roof Area x Solar Reflectance x Change in Roof Reflectance x Heating Energy Factor (ASHRAE) x Heating Energy Cost ÷ Heating System Efficiency (Oil) ÷ 106

$100{,}000 \times 1{,}168.9 \times 0.6 \times 2.38 \times 5.72 \div 0.75 \div 106 = \$1{,}273/\text{Year}$

Net Cost Savings
$8,071/Year = $9,344 - $1,273

80% Savings*
$6,457 After First Year

*Based on LBL DOE data, after the first year, energy savings is estimated to be only 80% of the first year value due to dirt pickup and accompanying decrease in albedo.8 Similar results were obtained in independent studies conducted by Rohm and Haas Company (now a wholly owned subsidiary of The Dow Chemical Company).

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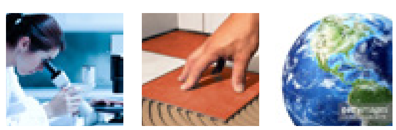

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