United States
November 2009 White Paper

The Dow Chemical Company
www.dowpmr.com

Protected Membrane Roof (PMR): Lowest Cost and Longest Life Roof

Roof System Cost: Beyond the Bottom Line

When selecting a roof system, the bottom line is often top of mind – particularly in today's challenging economic environment. Consider these figures:

- 16 years – Average life of a roof system in North America
- 50 billion pounds (annually) – 5 percent – of waste in registered landfills in the United States comes from the roofing industry[1]
- 39 years – Depreciation period for a commercial roof in the United States

In calculating roof system cost, it is important to look beyond the bottom line and, in particular, beyond "lowest first cost" design criteria. Determining the real cost of a roof system factors in life cycle cost, maintenance and environmental impact. This paper takes a closer look at those issues.

Life Cycle Cost Analysis

In 2008, Dow commissioned SmithGroup, a nationally recognized architectural and engineering firm, to conduct a study to determine the true cost of various commercial roof types under different climate conditions over a 39-year life. Dow asked SmithGroup to investigate the following:

- Installation costs of each type of roof system when compared to other high-quality roof systems
- Long-term or life cycle costs of each type of roof system when compared to other high-quality roof systems
- Benefits of each type of roof system

The following building types were evaluated for three different geographic regions (Minneapolis, Phoenix and Atlanta):

- Two-story government office building – gross roof area of 12,000 ft^2
- Three-story university lab – gross roof area of 14,000 ft^2
- Three-story hospital – gross roof area of 36,000 ft^2

Table 1 (see page 2) lists the roof systems included in the study with the anticipated service life for each.

These criteria resulted in a total of 45 different combinations. Initial costs and life cycle costs for each of these 45 combinations were prepared for comparison. Each roof system was designed to provide a high-quality solution for that specific roof type, and each roof system provided very similar thermal insulation levels.

For complete details and to request a presentation of the full report, contact Dow at 1-866-583-BLUE (2583).

Highlights:

A PMR system provides the lowest life cycle cost on a yearly basis.

PMR Benefits

- *Helps accelerate/ streamline the construction process*
- *Enables scheduling flexibility*
- *Greater quality control possible*
- *Reduces overall material and labor cost*
- *Reduces annual energy consumption of building*
- *Reduces landfill and environmental costs*

Table 1: Typical Roof Systems and Anticipated Service Life

Roof System	Anticipated Service Life
1. Fully adhered 60-mil EPDM thermoset rubber membrane, on concrete roof deck	18 years
2. Built-up asphalt membrane on concrete roof deck, with gravel or slag surface	24 years
3. Hot rubberized asphalt PMR (with STYROFOAM™ Brand XPS Foam Insulation) on concrete deck	39 years
4a. Fully adhered 60-mil PVC thermoplastic membrane, on concrete roof deck	20 years
4b. Fully adhered 60-mil PVC thermoplastic membrane, on steel roof deck	20 years

Major Findings

While initial costs for a PMR can be 16 percent to 57 percent higher per square foot vs. other high-quality roofing systems, a PMR system provides the lowest life cycle cost* on a yearly basis (between 6 percent and 22 percent less) per square foot of the five roof systems evaluated. This was true for all three building types and all three geographic locations.

Table 2: Life Cycle Cost Comparison(1) of Roofing Systems

Roof System Type	Built-up Conventional	EPDM Conventional	PMR
Quantity Needed for 39-Year Span	2	2	1
Life Cycle Cost	$223,680	$204,910	$175,450

(1) Based on 39-year life cycle of 12,000 ft^2 roofing system in a typical two-story office building located in Minneapolis; does not consider maintenance cost or environmental impact

*Cost estimates assume 15% general conditions, overhead and profit, in addition to roof contractor's price. Pricing prepared utilizing Means Building Construction Cost Data as the primary information source, with some modifications as suggested by a reputable roofing contractor.

Savings

Traditional methods of determining initial cost have limitations. It's not surprising, then, that it takes a non-traditional perspective to understand how a PMR can impact cost in other ways, too:

- The building can be weatherproofed sooner, allowing interior trades to start work quicker
- The insulation is laid after the membrane – and can be laid in any weather
- Greater quality control is possible, as the membrane can be inspected or flood-tested before insulating and ballasting
- Fewer components are used compared to many conventional roofing systems, helping reduce overall labor and material costs

PMR systems have significantly lower maintenance costs than conventional low-slope roofs.

An investment in a PMR assembly is paid back in about seven to 10 years, after which the savings in maintenance costs continue to help the operations budget.

Lower Maintenance Costs Without Compromising Performance

For purposes of the SmithGroup evaluation, roof maintenance for each system throughout its service life was assumed to be minimal. However, in commercial roofing, maintenance costs can be significant if patching, cleaning or rejuvenating is required.

In a recent three-year study[2] conducted by Oak Ridge National Laboratory and sponsored by Single-Ply Research Institute (SPRI), it was determined that 17 lbs of #5 stone ballast has equal thermal performance to a white reflective "cool roof." More important, the thermal performance of the stone ballast is maintained as long as it is in place - and it does not degrade. In comparison, white reflective membrane on a conventional cool roof typically must be cleaned at least yearly in an attempt to restore its reflective surface. The 2002 SPRI study[3], "White Roofs Get Dirty," outlined the need for this maintenance and the challenges in restoring reflectivity. The foot traffic for maintenance on conventional roofs increases the potential for membrane damage - and a damaged membrane must be repaired.

PMR systems have significantly lower maintenance costs than conventional low-slope roofs, in large part due to the insulation in the inverted assembly protecting the roof membrane from:

- Mechanical damage - both during and after construction
- Temperature extremes that cause tremendous stress
- Ultraviolet radiation that can lead to premature failure

For example, the owner of a 50,000 ft^2 PMR can reduce roof maintenance costs from 3 percent of initial roof cost to 1 percent of initial roof cost, providing a significant cost savings.

In addition, an investment in a PMR assembly is paid back in about seven to 10 years, after which the savings in maintenance costs continue to help the operations budget.

Environmental Impact

A PMR system performs year after year. Not only does it reduce the total annual energy consumption of the building, but the longer a roof can be kept in use, the more it contributes to the overall sustainability of the building by delaying the impact of eventual tear-off. Deferring a roof replacement by 10 years can save hundreds of thousands of dollars.

A PMR can help reduce downstream waste during construction, maintenance and demolition phases because the insulation, fabric and ballast are loose-laid and thus are often able to be reused. This reduces landfill costs as well as environmental costs.

Dow Building Solutions
1605 Joseph
200 Larkin Center
Midland, MI 48674

1-866-583-BLUE (2583)

Dow Products for Cost-Effective PMR

The insulation in a PMR assembly is an important consideration.

Extruded polystyrene is widely used in PMR applications and is the only foam insulation recommended by the National Roofing Contractors Association (NRCA) for PMR applications requiring a minimum compressive strength of 40 psi (e.g., green roof and plaza deck designs).

Dow's portfolio of STYROFOAM™ Brand Extruded Polystyrene Foam Insulation products for PMR applications includes:

STYROFOAM™ Brand HIGHLOAD 40

STYROFOAM™ Brand HIGHLOAD 60

STYROFOAM™ Brand HIGHLOAD 100

STYROFOAM™ Brand PLAZAMATE™ (U.S. only)

STYROFOAM™ Brand ROOFMATE™
STYROFOAM™ Brand Ribbed ROOFMATE™ (U.S. only)

References

(1) NRCA White Paper (2003) "Roofing, Energy and the Environment"
(2) Desjarlais, A.O., Petrie, T.W., Atchley, J.A., ORNL, Gillenwater, R., Carlisle SynTec, Inc. and Roodvoets, D., SPRI (2008) "Evaluating the Energy Performance of Ballasted Roof Systems." ORNL Report Number UF-04-396
(3) Miller, W.A., Cheng, M-D, Pfiffner S. and Byars, N. (2002) "The Field Performance of High-Reflectance Single-Ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates"
(4) www.nrca.net
(5) www.rci-online.org
(6) www.smithgroup.com
(7) www.spri.org

Form No. 179-05281-1109P&M