

Performance Measurement System for Maintenance of SPF Roofing System: A 4 Year Case Study

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Quality has been an area of increased focus for the last couple of decades. Along with maintaining the construction quality, achieving a high performing quality building in the post –construction phase by the facility managers is critical for the smooth functioning of the facility. This paper focuses on measuring the performance of one of the types of roofing systems i.e. Sprayed Polyurethane Roofing Systems (SPF) during the post-occupancy stage. The objective of this study is to implement a measurement system on SPF roofs that will shift low performing roofs to high performing roofs with the use of performance. Ninety (90) SPF roofs were inspected at a school district over a period of four years in 2011, 2012, 2013 and 2014 to identify the performance of roofs by measuring the defects on the roof. During the second year, the category for "risky roofs" were created that had major defects on the roofs and were reported to the facility managers for preventative maintenance. The measurement system led to a decrease in defects by 64% providing the facility manager a clear snapshot of the roofs that needed immediate attention, and achievement of high performance optimal quality of all the SPF roofs at the school district.

Key Words: Facility Manager, Roofing, Performance, Quality

Introduction

A high performing facility can be achieved by maintaining the optimal quality of all the components of a building like mechanical, electrical, plumbing, roofing, etc. in the post-construction phase. There are multiple quality models proposed in the construction industry that can assist the facility managers transform their facility from low performing to high performing. Key Performance Indicators (KPI) is one of the most common tools used by the facility managers to maintain the quality of the facility (Lin et. al. 2011; Lavy, 2011). Performance measurement has also been used in the industry to improve and maintain the quality of a facility (Armentrout, 1986). Performance can also help in determining the future courses of actions and help in strategic and tactical planning (Gunasekararn et. al. 2003). A high performing facility maintained at the optimal quality enhances the confidence of the buyer in their investment (Lin et. al. 2011). Hence, it is critical for continued evaluation of the finished product to measure the quality of the construction facilities known as Post Occupancy Evaluation (POE) (Wicks and Roethlein, 2009). One way of achieving this is through regular inspections during the occupancy stages to identify defects in the construction facilities and propose corrective actions through various maintenance approaches. (Chong & Low, 2005).

Maintenance of a facility is big business, and needs to be managed properly (Allen, 1993). Maintenance has also been seen as one of the five main aspects of being a facility manager; the other four being security, cleaning, landscape and general management (Lai & Yik, 2010). The main objectives of building maintenance are to ensure that the buildings are in safe condition, fit for use, meets all the requirements, maintains the value of physical assets and carry out the work necessary for maintenance (Horner et. al. 1997). Brian Wood (2005) suggests that developing and evaluating alternative approaches of maintenance is important. Aligning the organizational goals and objective to the maintenance objectives is important for facility managers to justify their maintenance approach (Lee & Scott,

2008). Based on the literature review it can be concluded that maintenance is more than just repairing a failed equipment and ensuring everything is working in a building. A proper maintenance approach can lead to a high performing facility.

This study focuses on measuring the performance of one of the types of roofing systems i.e. Sprayed Polyurethane Foam (SPF) roofs through visual inspections to assure a high performing roofing system, and to provide a maintenance schedule to the facility manager. Regular inspections help identify the defects at an earlier stage and tackle the maintenance issues before they occur (Christer, 1982). The roofing system is one of the key systems components in a facility since it forms the exterior surface on the top of a building. There are two types of roofing systems in the industry – low-slope roofs and steep-slope roofs. SPF roofs are categorized as low-slope roofs.

The SPF roofing system is composed of two liquid components that are mixed together. The first component is the rigid, closed cell, foam insulation and the second component is a protective surfacing ("Roof System Types", n.d.). The R-value (insulation factor) of an SPF roofing system is 6 per inch and can be used as a recovery system over any existing roofs (Knowles, 2005). The performance of an SPF roof is defined by no leaks, no open blisters and no defects which are caused by improper surface preparation, high moisture in the air and installing the roofs at low temperatures. For SPF roofs, any defects in the actual structure and the application can be revealed by visual inspection of a roof envelope (Bailey & Bradford, 2005).

Methodology

A school district that has 90 installed SPF roofs was selected for this research. The criteria for selecting the roofs were the ease of the accessibility, different roof sizes and the age. A measurement structure to measure the performance of all the installed roofs by identifying the defects through visual inspections was implemented over a period of four years in 2011, 2012, 2013 and 2014. The performance measurements were reported back to the facility manager every year that provided the list of "risky roofs" that needed immediate attention.

Inspection Survey

A total of six contractors have installed the SPF roofs at the school district. An inspection survey was created to measure the percentage of defects on the roofs (Appendix A). Poor workmanship has been one of the major issues in the SPF roofing industry (Kashiwagi & Tisthammer 2002). Hence an inspection survey was created that revealed the poor workmanship through blistering and surface defects.

Data Collection

The inspections were conducted in the summer by a certified roof inspector during the months of July to August. The defects are observed the most in the summer time as the system heats up and the water that remained in the substrate during the application causes blisters (Jaegermann et. al. 1989). The inspection survey (Appendix A) was filled out immediately on the roof to avoid human error.

Post Inspections

The results of the percentage of blister, the defects, and reported leaks were reported to the facility manager. The "risky roof" category was created after the inspections in 2011 that met the following criteria:

- Roofs that have percentage of blisters of over 1% of the total roof area
- Roofs that have open blisters
- Roofs that have a blister size of more than 1 SF
- Roofs that have current leaks

The facility manager used the warranty and notified the contractor and the manufacturer for preventative maintenance on all the "risky roofs".

Analysis

Based on the inspection data, the total square feet (SF) and percentage of blisters were documented for 2011, 2012, 2013 and 2014 as shown in Table 1. The total SF of blisters and defects decreased from 4,117 SF in 2011 to 1,515 SF in 2014 (63% decrease). The overall percentage of roof area blistered also decreased from 0.131% in 2011 to 0.047% in 2014. The decrease in the percentage of blisters and defects infers that the quality of the roofs have increased providing a high performance roofing system to the school district.

Criteria	2014	2013	2012	2011
Average age of jobs surveyed (Yr)	7	6	6	7
% of total roof area blistered & defected	0.047%	0.050%	0.122%	0.131%
Total blisters (SF)	1,515	1,599	3,915	4,117
Total job area (SF)	3.2 M	3.2 M	3.2 M	3.2 M

Table 1. Percentage of Blisters & Defects

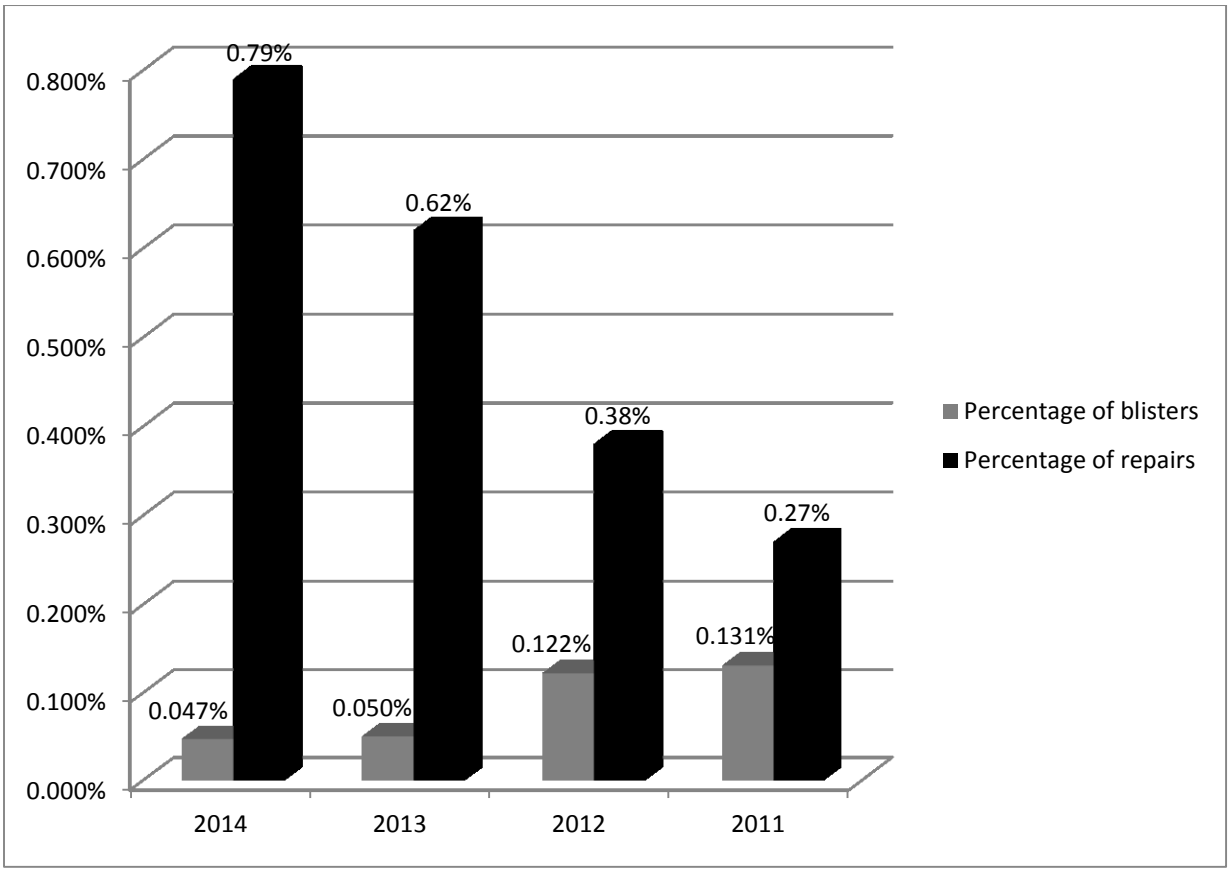
Criteria	2014	2013	2012	2011
Total # of blisters > 1 SF	95	125	159	N/A
Total # of open blisters	25	32	35	N/A
Total # of jobs leaking during inspections	0	0	0	N/A
Total # of Risky Projects	23	20	23	N/A

The number of "risky projects" was identified in 2012, 2013 and 2014 shown in Table 2. The facility manager used the measurement system implemented to measure the performance of the installed SPF roofs at the school district. Upon reporting to the contractor they fixed all the "risky projects" that were under warranty shifting the low-performance roofs to high-performance roofs.

Table 2. Risky Projects

Since 2011 there have been an increase in the percentage of repairs (of total roof area) and decrease in the percentage of defects (also of total roof area) as shown in Figure 1. The measurement system provided a clear snapshot to the school districts facility manager and help them focus on the roofs that needed immediate preventative maintenance.

Figure 1. Percentage of blisters and repairs



Conclusion

The facility manager at the school district was successfully able to implement a measurement system that tracks the performance of the installed SPF roofs. Since the measurement system has been implemented it has resulted in a significant decrease (64%) in the percentage of blisters and defects of the SPF roofs at school district over a period of four years. This has resulted in the increase in the percentage of repairs leading to high performing roofs. The measurement system provided the facility manager a clear snapshot of the overall performance of the SPF roofs that led to an immediate preventative maintenance on the roofs under warranty that were classified as "risky projects". The facility manager was able to maintain the optimal quality of the SPF roofs providing a high performing roofing system to the school district.

Similar measurement systems needs to be implemented that can measure the on-going performance of other components in a building. Continual on-going performance measurement can shift a low performing facility to a high performing facility.

Appendix A

OWNER INFORMATION

User Name			
Building Name		Date Installed	
Street Address	City	State	Zip Code
Point of Contact	Phone		Area (sq. ft.)

INPSECTION DATA

Date Inspected	
Is the Roof Slope Less Than ¼" (1 = Yes / 0 = No)	
Does the Roof Have More Than 5% Ponding Water	☐ **YES** ☐ **NO**
Area if Roof has More than 5% Ponding Water (SF)	
Does the Roof Have Granules/Aggregate/None	
Number of Roof Penetrations (#)	
Total Blisters (SF)	
Delamination (SF)	
Mechanical Damage (SF)	
Bird Pecks (SF)	
Repairs (SF)	
Is the Roof More Than 1% Deteriorated (Yes / No)	☐ **YES** ☐ **NO**
Area if Roof is More Than 1% Deteriorated (SF)	
Coating Type (Acrylic, Urethane, Silicone, etc.)	
Is Roof Recoated? Date if recoated	
Risky Roof Identification	
Average Blister Size on the Roof (SF)	
Any blisters over one foot? (Yes / No)	☐ **YES** ☐ **NO**
If yes, # of blisters over 1 foot	
Any open blisters on the roof? (Yes / No)	☐ **YES** ☐ **NO**
If yes, # of blisters on roof	
Does roof area have blisters > 1%? (Yes / No)	☐ **YES** ☐ **NO**

Other Comments (Blister, Mechanical Damage, etc.):

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