

The Cost Effectiveness of Alpha SPF Roofs: Casa View Elementary School Roofing Case Study

Dean T. Kashwiagi, Ph.D., P.E, Dhaval Gajjar, Ph.D., Charles J. Zulanas IV, and Yasir Alhammadi, M.S.
Arizona State University
Tempe, AZ, USA

The performance of the Alpha Sprayed Polyurethane Foam (SPF) roofing system is perceived as an uneconomical option when compared to a 20-year modified roofing system. Today, the majority of roofs are being replaced, rather than newly installed. The coating manufacturer, Neogard, implemented the Alpha roofing program to identify the best contractors in the industry and to measure their roof performance. The Alpha roof system has shown consistent high performance on over 230 million square feet of surveyed roofs. The authors propose to identify if the Alpha roof system is renewable, has proven, competitive performance compared to the traditional modified roofing system, and is a more economical option by testing a 29-year-old Alpha roof system. The Casa View Elementary School roof system was installed with a Neogard Permathane roof system in 1987. This roof was hail tested with ten drops from 17 feet 9 inches of 1-3/4-inch steel ball (9 out of 10 passed) and four drops from 17 feet 9 inches with a 3-inch diameter steel ball (1 out of 3 passed). Over the 40-year service life, the main difference of purchasing a 61,000 square feet Alpha SPF roof versus modified bitumen roof are savings of approximately $1,067,500.

Keywords: Alpha roof system, sprayed polyurethane foam, roofing, sustainability, FM-SH hail testing.

Introduction

The performance of the Alpha Sprayed Polyurethane Foam (SPF) roofing system is perceived as an uneconomical option when compared to a 20 year modified roofing system. Roof installation websites claim that SPF roofs require more maintenance than modified bitumen and recoating every 10 years (Improvenet, 2014). Additionally, other sites claim that based off of cost and maintenance, built up roofs and modified bitumen are the best value, lasting up to 30 years (Maintenance Solutions, 2015). According to Mike Smith, a roofing expert for Dallas Independent School District (DISD), the average price to apply a traditional modified bitumen roof with tear off on a commercial building is approximately $16 to $19 per square foot. Today, the majority of roofs are being replaced, rather than newly installed, and the prices of replacing a modified bitumen system are far greater than the cost of a performing Alpha SPF roofing system.

SPF roofing requires significant contractor expertise in order to provide a high performance roofing system. Installation workmanship is one of the major reasons for SPF roofing defects. These SPF roofing defects can severely minimize the service period (Alumbaugh et. al, 1984; Kashiwagi & Tisthammer, 2002). In the past, it was common for the coating and SPF manufacturers to offer warranties but not honor those warranties, blaming the contractor. The poor performance of the SPF roof system has relegated the SPF roof system to 3% of the roofing market share in the United States (Kashiwagi, 2016).

In order to combat the stereotype of the SPF roofing system providing poor performance and low quality, the coating manufacturer, Neogard, implemented the Alpha roofing program to identify the best contractors in the industry and to measure the performance of their roofs. As a result of Neogard's motivation to change the industry, the performance on Alpha roofing system has been heavily documented. Table 1 below includes the performance metrics of Neogard's Alpha Contractors, Alpha Contractor Requirements, and an Overview of Neogard's Coating Warranty Coverage (PBSRG, 2016):

Table 1
Alpha Roofing System Performance Metrics (PBSRG, 2016)

No	Neogard's Alpha Program	Unit	Overall
1	Overall customer satisfaction of Alpha Contractors	(1-10)	**9.5**
2	Oldest job surveyed	Years	**36**
3	Age sum of all projects that never leaked	Years	**29,714**
4	Age sum of all projects that do not leak	Years	**37,057**
5	Percent of customers that would purchase again	%	**99%**
6	Percent of jobs that do not leak	%	**100%**
7	Percent of jobs completed on time	%	**98%**
8	Percent of satisfied customers	%	**100%**
9	Percent of inspected roofs with less than 5% ponded water	%	**90%**
10	Percent of inspected roofs with less than 1% deterioration	%	**95%**
11	Percent of inspected roofs with less than 1/4" slope	%	**62%**
12	Average job area (of jobs surveyed and inspected)	SF	**30,698**
13	Total job area (of jobs surveyed and inspected)	SF	**230 M**
14	Total number of jobs inspected	#	**2,286**
15	Total number of different customers surveyed or inspected	#	**2,834**
16	Average number of returned surveys per contractor	#	**23**
17	Total number of returned surveys and inspections	#	**5,223**

These performance metrics document significant results in the SPF roofing industry. The Alpha roof system has shown consistent high performance (9.5 out of 10 customer satisfaction rating and 99% of customers saying they would purchase an Alpha roof system again) on over 230 million square feet of surveyed roof. Neogard's Alpha roofing system's past performance outmatches any other roofing system's performance history.

The Alpha SPF roof system has the following attributes (Kashiwagi, 2016; Kashiwagi, 2015):

1. It is lightweight.
2. It is renewable.
3. It is hail resistant to hail sizes up to 1-3/4 inch hail as tested by the Factory Mutual Severe Hail [FM-SH] test within the 15 year warranty period.
4. It is green as it provides the highest insulating value and minimizes the need to rip off the existing roof.

SPF roofing has an R-value of R6 per inch and is used by the owners of the building as a recovery system over existing roofs including built-up roof [BUR], modified bitumen, concrete, wood, asphalt shingles, clay tile, and

metal (Knowles, 2005). The advantage of the Alpha SPF roof system is that it does not require the removal of the existing modified or BUR system saving owners as much as $6/SF [50% less than the traditional BUR system] in removal costs and costs of a new modified or BUR system. A properly installed Alpha roof system has been documented to resist up to 4 inch diameter simulated hail stones [four inch diameter steel ball dropped from more than 17-3/4 feet height]. (Kashiwagi, 2015, Kashiwagi and Savicky, 2003)

Problem

The Alpha roof system was being questioned as being non-renewable, not having the proven performance that competes with the traditional modified roofing system, and not being an uneconomical option.

Proposal

The authors propose to identify if the Alpha roof system is renewable, has proven performance that competes with the traditional modified roofing system, and is a more economical option by testing out the performance of a 29 year old Alpha roof system.

Research Methodology

The research will be conducted as follows:

1. Identify the existing roof characteristics of the Casa View Elementary School roof.
2. Hail test the Casa View Roof with 1-3/4 inch steel ball as specified by FM-SH test.
3. Identify if the 10 drops pass the test requirement.
4. Identify if any of the drops do not pass the requirement due to extenuating circumstances such as insufficient coating.
5. Analyze the indentations of the hail drops.
6. Use a larger 3 inch diameter steel ball with OSH 2.75 hail tests to identify if the roof is potentially more robust than the perceived capability to pass the 1-3/4 inch test.
7. Run a lab test of a SPF core sample of the Casa View roof in the hail tested areas that passed and failed.

Research Findings

Casa View Roof characteristics.

Casa View roof system [61K SF roof area] was installed with a Neogard Permathane roof system in 1987. This means that the roof was 29 years old at the time of the visit. The authors performed a roof inspection on the Casa View Elementary school roof on June 27, 2016. On the 61,000 sq. foot roof, there was a total of 774 square feet of blisters, 65 penetrations, 102 sq. feet of delamination, and 6,000 square feet of repairs on the roof.

Table 2
Inspection Information

Insp. Date	6/27/2016
Roof Area	61,000
Penetrations	65
Aggregate % of Granules	0%

Table 3
Inspected Roof Defects

	Square Feet	**% of roof area**
Blisters	774	1.3%
Delamination	102	0.2%
Ponding	400	0.7%
Repair	6,000	9.8%

As is common with an older roof, the granules had worn off of the roof, and due to rain and hail frequently occurring in June, there was some ponding. The areas with extended ponding increased blisters. The repairs were applied mostly to the edges of the roof, most likely due to higher exposure to the heavy rainfall and runoff. The Alpha system installed with proper slope and drainage improves performance, and will result in fewer repairs. The Casa View Elementary School has the following roof characteristics:

Table 4
Overview of Casas View Roof Characteristics

No	**Criteria**	**Values**
1	**Owner**	Dallas Independent School District
2	**Contractor**	Phoenix1
3	**Foam Manufacturer**	BASF
4	**Coating Manufacturer**	Neogard
5	**Coating System**	Urethane
6	**Warranty Type**	Alpha 15 Year Warranty
7	**Service Life of the roof with an SPF Recoat**	45 years

Table 5
Specific Casa View Roof Characteristics

No	Criteria	Unit	2016
1	Overall customer satisfaction of Phoenix 1	(1-10)	**9.4**
2	Age of Casa View Elementary Roof	Years	**29**
3	Average age of Casa View when surveyed	Years	**21**
4	Age sum of all projects that do not leak	Years	**29**
5	Percent of customers that would purchase again	%	**100%**
6	Percent of jobs completed on time	%	**100%**
7	Percent of satisfied customers	%	**100%**
8	Percent of inspected roofs with less than 5% ponded water	%	**100%**
9	Percent of inspected roofs with less than 1% deterioration	%	**0%**
10	Percent of inspected roofs with less than 1/4" slope	%	**100%**
11	Total job area	SF	**61,100**
12	Total number of inspections	#	**7**
13	Year of installation	Year	**1987**

Cost of Alpha SPF versus modified bitumen

The cost of recoating and continuing the Alpha roof system of the Casa View roof will be approximately $6.00 per square foot for a SPF recoat. The cost of tearing off the existing system and installing a new traditional modified bitumen roof will be approximately $16 per square foot. The Casa View Elementary School roof is 61,100 SF. Since there was a sunk cost already incurred to DISD with the installation of the roof, the only values to document was the current decision to recoat or to tear off the existing roof and install a traditional modified bitumen system. The Alpha recoat of Casa View's roof at $6/SF would cost $366,000 with a 15 year warranty (lasting 45 years), and the installation of a traditional modified bitumen roof at $16/SF with a 20-year warranty would cost $976,000 (lasting 50 years). Based on total costs, opting to install an Alpha recoat would result in a cost savings of $610,000 and cuts the cost down by 62.5% on the project, assuming that each roof lasts the same amount of time. The yearly cost of $24,400 for the Alpha recoat with a 15-year warranty ($366,000/15) would be 50% less than the yearly cost of $48,800 for a 20-year warranty for a traditional modified bitumen roof installation ($976,000/20). Based off of yearly costs, the Alpha recoat was 100% more cost effective than a new traditional modified bitumen roof installation (table 6).

Table 6

Cost Comparison of Modified Bitumen vs. Alpha SPF Roof

	Total Cost
Traditional Mod Bit	$976,000
Alpha SPF Roof	$366,000
Cost Savings	-$610,000
	Yearly Cost
Traditional Mod Bit	$48,000
Alpha SPF Roof	$24,000
Cost Savings	-$24,000

Results of Hail Tests

1 ¾ inch steel ball FM-SH test

The Casa View Elementary School roof was hail tested with ten drops of 1-3/4 inch steel ball from 17 feet 9 inches, which was equivalent to the industry standards of FM-SH hail tests on June 27, 2016. These hail tests were performed to determine the long-term performance of Neogard's Alpha roof system and the performance of Alpha contractors.

The Casa View Elementary roof passed in 9 of 10 drops. One drop ripped through the coating to reveal the foam. The other two drops ripped only to the top coat.

Table 7

1-3/4 inch steel ball hail tests

Number	**Result**	**Pass or Fail**	**Top Coat (mils)**	**Base Coat (mils)**
Test 1	No Damage	Pass	14.17	38.33
Test 2	No Damage	Pass	20.00	57.50
Test 3	No Damage	Pass	15.50	30.83
Test 4	Tear to Foam	Fail	8.17	21.67
Test 5	Crack to top coat	Pass	6.33	30.67
Test 6	Crack to top coat	Pass	6.50	33.33
Test 7	No Damage	Pass	10.33	40.83
Test 8	No Damage	Pass	13.00	47.50
Test 9	No Damage	Pass	16.67	45.83
Test 10	No Damage	Pass	14.00	48.33

During the 1 ¾ inch steel ball hail tests, the researchers found that only 1 out of 10 tests failed. On a 29 year old roof that was far past its warranty, the roof continued to show proven performance. Out of the 9 tests that passed, only 2 of those tests cracked to expose the top coat. All others had no damage or exposure to top coat or to the foam.

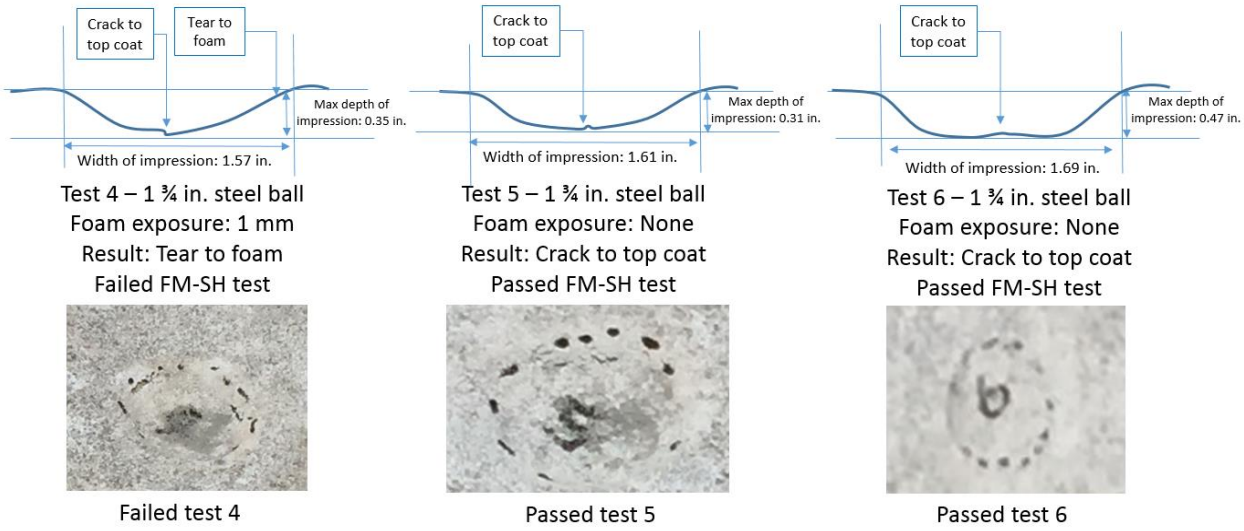

Figure 1: 1 ¾ in. hail tests that tore to the foam or cracked to expose the top coat.

3-inch steel ball FM-SH test

Additionally, the researchers dropped a 3 inch diameter steel ball three times from the same height of 17 feet 9 inches. One of the steel ball drop damaged the coating to the SPF. The other two drops resulted in tears to the top coat. This far exceeds the FM SH test requirements.

Table 8
3-inch steel ball hail tests

Number	Result	Pass or Fail	Top Coat (mils)	Base Coat (mils)
Test 11	Crack to top coat	Pass	15.83	35.00
Test 12	Crack to top coat	Pass	9.00	45.00
Test 13	Break to Foam	Fail	8.00	30.00

During the 3-inch steel ball hail tests, the researchers found that 1 out of 3 tests failed. On a 29-year-old roof that was far past its warranty, the roof continues to show proven performance. Due to the heavy impact, the ball caused the roof to crack to topcoat on the two tests that passed the test. The average width of the dent was very similar on all of the tests, averaging to about 88 mm. The average indent size was about 12 mm, due to the size of the ball being dropped.

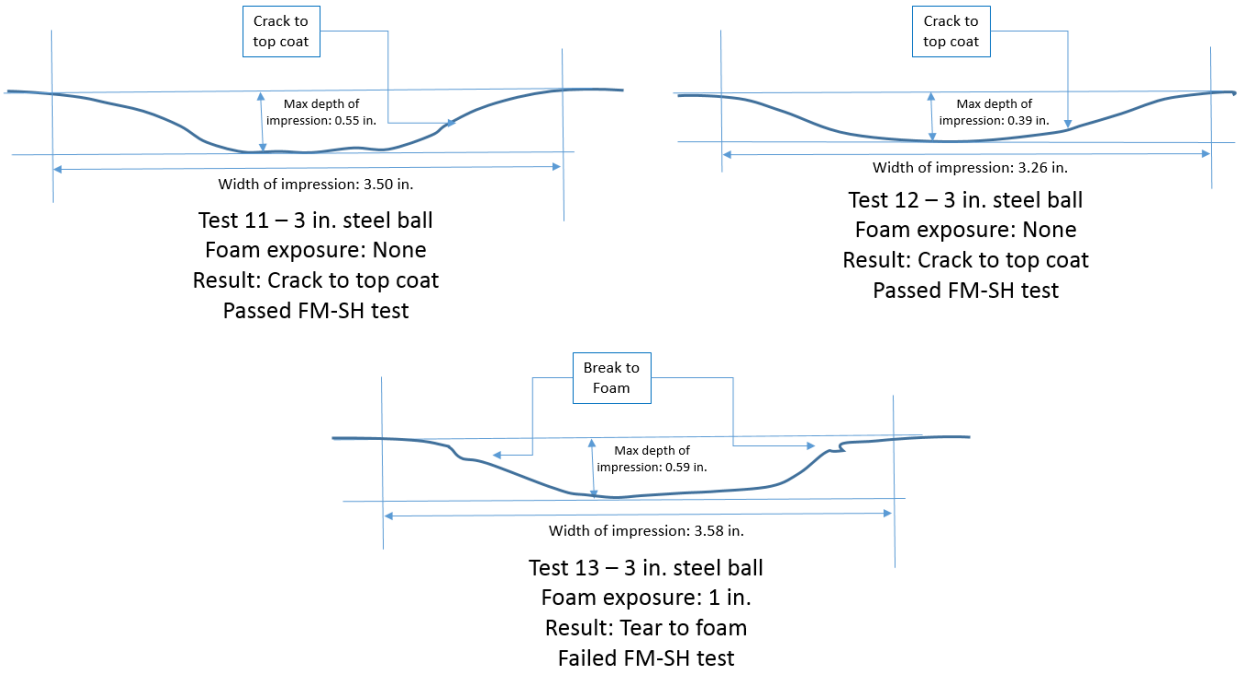

Figure 2: 3-inch. hail tests that broke to the foam or cracked to expose the top coat.

Figure 3: Passed dent from 3 in. steel ball test compared to dents from a 1 ¾ in. steel ball tests

These 3 inch steel ball hail tests show the durability of Neogard's Alpha Roof System and the performance of the contractors within the Alpha program. The roof has lasted a substantial amount of time without a recoat. With another Alpha SPF recoat, the roof can easily last another 15 years.

Analysis of hail drop information

The results of the hail drop on the 29 year old Alpha roof not only prove that the Alpha roof system has FM-SH hail test performance, but it has outlived its warranty by 14 years. The level of performance far outlives a traditional

modified bitumen roof due to the average repair and tear off of 20 years. The longevity of the roof has far outlasted the traditional modified bitumen with greater hail resistance as well.

Conclusion

Casa View roof system (61K SF roof area) was installed with a Neogard Permathane roof system in 1987. This means that the roof was 29 years old during the hail test (June 27, 2016). The Casa View Elementary School roof can be recoated to perform another 15 years for less than half of the cost of a modified bitumen system for a better value. Over the 40 year service life, the main difference of purchasing a 61,000 square feet Alpha SPF roof versus modified bitumen roof are savings of approximately $1,067,500. The existing 29 year SPF could not be differentiated from new SPF. In terms of base coating, the core sample near the site where the 3 inch diameter steel ball passed the FM-SH hail test had similar SPF thickness to the new SPF core sample.

The Casa View Elementary School roof was hail tested with ten drops of 1-3/4 inch steel ball from 17 feet 9 inches, which was equivalent to the standards of FM-SH industry hail tests. The Casa View Elementary roof passed in 9 of 10 drops. One drop ripped through the coating to reveal the foam. The other two drops ripped only to the top coat.

The researchers dropped the 3-inch diameter steel ball three times from the same height. One drop damaged the coating to the SPF. The other two drops resulted in tears to the top coat. This far exceeds the FM-SH test requirements.

A roof inspection was conducted and identified approximately 1% blisters and delamination and 9.8% recoated areas (around the edges of the roof). Alpha roof system is resistant to FM-SH damage (1-3/4 inch hail stone damage) within the warrantied 15 year time period. The authors advise that the Alpha system installed with proper slope and drainage improves performance, and will result in less repairs.

References

Alumbaugh, R. L., & Humm, E. F. (1984). Experimental Polyurethane Foam Roof Systems. *Journal of Cellular Plastics*, 257-273.

Gajjar, D. R., Kashiwagi, D. T., & Kashiwagi, J. (2012). Manufacturer's New Approach To Risk. *RICS COBRA 2012*, 1859-1868.

Improvenet. (2014, June 17). How Much Does Foam Roofing Cost? Retrieved July 26, 2016, from http://www.improvenet.com/r/costs-and-prices/foam-roofing

Kashiwagi, D., Gajjar, D., Kashiwagi, J., & Sullivan, K. (2016). Hail Study on a 15 Year Old Sprayed Polyurethane Foam Roofing System. Journal for the Advancement of Performance Information & Value, 8(1).

Kashiwagi, D., Gajjar, D., Kashiwagi, J., & Sullivan, K. (2015). The Replacement of Warranties with Logic and Common Sense. Journal for the Advancement of Performance Information & Value, 7(1).

Kashiwagi, D. T. and Tisthammer, T. (2002) Information Based Delivery System for Sprayed Polyurethane Foam on Roofing, *Journal of Thermal Envelope & Building Science*, (26), 33-52.

Knowles, M. (2005, September 29). *Specifying SPF Roofing Systems*. Retrieved April 17, 2013, from http://www.buildings.com/article-details/articleid/2753/title/specifying%20spf%20roofing%20systems.aspx.

Maintenance Solutions. (2015). Built-up Roofing and Modified Bitumen Systems: A Smart Roofing Decision. Retrieved July 26, 2016, from http://www.asphaltroofing.org/press-room/press-releases/built-roofing-and-modified-bitumen-systems-smart-roofing-decision

PBSRG. (2016). Performance Based Studies Research Group Internal Research Documentation, Arizona State University, Unpublished Raw Data.