Solar Reflectance Testing of Steep-slope Roof Systems in the Field

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Abstract

This study is an evaluation of methods, techniques and standards for testing of roof surfaces for solar reflectance. Steep-slope roofing is highlighted and highly reflective low-slope roofing also is evaluated for validation of standards and cleaning of roof surfaces to restore reflectance. The evaluation of proposed ASTM E-1918A, "Procedure for Measuring the Solar Reflectance of Flat or Curved Roofing Assemblies," is central to this study.

The importance of reflective roof surfaces to provide enhanced energy performance of buildings and for heat island mitigation is well-accepted in the roofing industry and construction industry as a sustainable design strategy. Reflectance testing in the field for existing roof surfaces is important for monitoring performance of reflective surfaces and the evaluation of existing surfaces during building renovations and historic preservation projects. Currently, many testing standards used to evaluate reflectance for existing roof surfaces have been withdrawn or are under review.

This paper provides an evaluation of current and past roof reflectance testing standards, evaluates a proposed revision to ASTM International E-1918-06, "Standard Test Method

for Measuring Solar Reflectance of Horizontal Low Sloped Surfaces in the Field," and summarizes testing conducted at two test locations in Seattle. A review of papers written by others indicates that the proposed alternate test standard E-1918A is an acceptable method for roof slopes of up to 5:12 (23 degrees) with a standard deviation for reflectance of less than 0.01 and slopes between 5:12 (23 degrees) and 12:12 (45 degrees) with a standard deviation for reflectance of about 0.02. E-1918A also is reported to be acceptable for incident angles (defined as the sun angle to the normal from a surface) of up to 60 degrees. This study demonstrates that the proposed alternate standard E-1918A is an acceptable testing method for low-slope roofs (2:12 or less) at incident angles of as high as 60 degrees with a standard deviation in reflectance of 0.013, which represents about ± 2 percent of the reflectance value for highly reflective surfaces. For extreme slopes on steep-slope roofs greater than a 12:12 (45-degree) slope, it was determined the test method does not meet acceptable margins of error and should not be used.

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Introduction

In recent years, it has been determined that in certain climates, energy conservation in buildings can be achieved using reflective roof surfaces (Konopaki). Rising temperatures in urban environments resulting from heat absorption and radiation from horizontal surfaces, known as the heat island effect, also has been well-documented (Akbari 1998). Strategies to reduce the heat island effect and energy consumption through the use of reflective surfaces have been supported by the Department of Energy (DOE); federal, state and city ordinances; and private industry organizations, including the U.S. Green Building Council (USGBC) and Cool Roof Rating Council (CRRC), (Akbari 2008a and 2008b). Sustainability, in general, has been embraced by the construction industry. Some states and local jurisdictions have adopted laws, and a number of local building code revisions are proposed that may soon mandate sustainable design tenets, including the reflective properties of building materials. Code adoptions and performance standards such as USGBC's LEED® program rely on reflectivity test methods that ultimately predict energy savings for heating and cooling buildings. The roofing industry—and construction industry in general—needs reliable and accepted standards for the measurement of surface reflectivity to meet the goals of energy reduction in sustainable design and reduction of heat islands in our cities.

Field testing of roof reflectance is important because laboratory testing needs to be verified with in-place installations. Energy performance must be modeled using true solar heat loads. In-situ reflectance testing also is needed to monitor performance, verify that cleaning has restored reflectance values and evaluate the reflective properties of existing roof systems. If using reflective roof surfaces to reduce energy consumption in buildings is desirable, then as reflective roof surfaces become soiled, they no longer perform their task of reducing energy consumption through solar reflectance. Maintenance and cleaning of roof systems to restore reflectivity will become increasingly important in the years to come (Hutchison, and Levinson 2005) as life expectancies of roofing products continue to increase.

The evaluation of existing roof systems also is important to provide verification of the reflective surfaces for energy performance during building renovations. Tile, shingle and metal roof systems on historic buildings may have reflective properties that contribute to energy conservation. These roof systems may not need to be replaced based on their reflective properties. Still, methods for in-situ testing are needed to verify the reflective properties of the materials. Sustainable design tenets advocate reuse of materials if at all possible. Extending roofing materials' life cycles and leaving them in place longer creates less waste in landfills, less production waste and reduces transportation emissions.

Standards for testing roofing materials' reflectance have been introduced and evolved during the past 15 years. In 1996, only one ASTM standard, E-903, "Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Material Using Integrating Spheres (ASTM 1996)," was available for the purposes of testing roofing materials for reflectance (Akbari 1996); but in the years following, ASTM E-1918, "Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field" (ASTM 2006); ASTM C-1549, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Reflectometer" (ASTM 2009); and ASTM E-1980, "Standard Practice for Calculating

Solar Reflective Index of Horizontal and Low Sloped Opaque Surfaces" (ASTM 2001) were introduced. The limitations of these standards preclude reflectance testing on steep-slope roof systems and, currently, ASTM E-903 has been withdrawn and ASTM E-1918 is under review.

A brief history and summary of roof reflectance standards will be presented in this paper followed by a description of field testing conducted in Seattle that used many of the existing, withdrawn and proposed ASTM standards. The focus of this paper will be on ASTM E-1918-06. Currently, this standard is under review because of concerns related to the test's repeatability. Recent work at the Lawrence Berkeley National Laboratory, Berkeley, Calif., (Akbari 2008b, Levinson 2010a, and 2010b) has addressed some of the concerns related to ASTM E-1918-06 test inconsistencies, including air mass corrections and related solar angle inconsistencies, glossy surfaces and related incident angle consistencies, and the standard's roof slope limitations. ASTM E-1918-06 currently limits the roof slope that accurately can be measured for reflectance to 2:12 (9.5 degrees), which essentially eliminates most steep-slope roofs from using this method. There currently is no ASTM standard specific for reflectance testing of steep-slope roof**s** in the field.

One of this study's goals is to evaluate methods for testing solar reflectance of steep-slope roof surfaces in the field through testing at two test sites in Seattle. Testing will compare ASTM E-1918-06 and a proposed alternate test method E-1918A, "Procedure for Measuring the Solar Reflectance of Flat or Curved Roofing Assemblies (Akbari 2008b)." E-1918A was proposed as an alternate to address inconsistent results obtained using ASTM E-1918-06 and allow for testing of smaller sample areas and curved surfaces.

Background of Test Standards

Test standards for measuring the reflectance of roofing materials have been developed over time to monitor the production of materials and verify materials meet performance standards developed by various private and public organizations such as DOE and USGBC. The purpose of these performance standards is ultimately for energy conservation and reduction of heat islands in our cities resulting from the heat island effect (LEED 2002). Some of the most common test methods for measuring roof reflectance cited in the performance standards include ASTM E-903, ASTM C-1549 and ASTM E-1918.

Fourteen years ago, only ASTM E-903 had been established for testing the solar reflectance of roofing materials (Akbari 1996), and there was no effective method for measuring the reflective properties of roofing materials in the field. In 1997, ASTM E-1918 was introduced for field testing of reflective properties. In 2002, ASTM C-1549 became active as an alternate test method to ASTM E-903 and ASTM E-1918.

ASTM E-903-96 uses a spectrophotometer to measure spectral reflectance. This test method has been an active standard for many years with recent revisions in 1989 and 1996. ASTM E-903 was withdrawn in 2005 primarily because ASTM standards require updating at the end of their eighth year or they must be withdrawn until a revision is proposed and accepted through balloting of the committee in charge of the standard. ASTM E-903 still is widely used and referenced in many other standards and industry literature despite its withdrawal. The test is used for smooth homogeneous surfaces (uniform in color and surface texture), uses a small sample area of only 0.1 square centimeters, and must be conducted in a laboratory. ASTM E-903 measures reflectance at various predetermined wavelengths that simulate the solar spectrum and generates a solar reflectance percentage based on a mathematical formula. The required laboratory conditions mean ASTM E-903 is not suitable for testing roof reflectance in the field. The test also has a number of limitations because of its small sample size, but it is useful for measuring small homogeneous samples. This method was used in this study to determine the base reflectance of the white and black reference masks required for alternate test method E-1918A.

ASTM Standard C1549-09 measures reflectance in a sample area of about 5 square centimeters using a portable reflectometer. This test method was introduced in 2002 and revised in 2004 and 2009. Because of sample size limitations, it is used primarily for homogeneous surfaces, and the testing most often is conducted in the laboratory. The test methodology is onerous. Each test location requires 30 separate measurements that must meet a prescribed standard deviation or the test is deemed invalid and must be repeated. The test equipment is expensive and unlikely to be purchased by roofing contractors or roof consultants. Slate tile roof system samples for one of the test sites in this study were removed from the building and shipped to an accredited lab for testing using the ASTM C-1549 test method.

A third common test method for measuring reflectance is ASTM E-1918-06. The standard was introduced in 1997 and revised in 2006. ASTM E-1918 uses a standard pyranometer and sample area of “at least 4 meters in diameter” which is about 13 square meters (135 square feet). The larger test area, much greater than ASTM C-1549 and ASTM E-903, allows measurement of variegated surfaces (not smooth or uniform in color or surface texture) such as roof tiles and shingles. The test method measures solar irradiance, which typically is measured in watts/square meter. The test procedure measures solar irradiance first with the pyranometer facing directly away from the surface and then with the pyranometer rotated back to face the surface. The reflectance is a simple ratio or percentage of the target irradiance over the solar irradiance. Limitations of this method include clear skies with no haze, incident angles (defined as the sun angle to the normal from a surface) of 45 degrees or less, and the method is limited to roof slopes of less than 2:12 (9.5 degrees). This last limitation makes this test method, as it currently is written, unsuitable for steep-slope roofing. This test method currently is under review by an ASTM committee related to concerns about common errors and inconsistent results.

In August 2008, E-1918A was proposed as an alternate test method to ASTM E-1918-06 (Akbari 2008b). This proposed alternate method is a modified version of ASTM E-1918-06 that employs black and white masks in the test method, which allegedly reduces some of the reported inconsistencies and allows measurement of a 1-square-meter (10.8-square-feet) roof area instead of the 13-square-meter (135-square-foot) area required by ASTM E-1918-06. This alternate test method also allows for measurement of curved surfaces.

A recent technical paper (Kinoshita) presented at the 2009 International Conference on Countermeasures to Urban Heat Islands reported that when using test method E-1918A, the calculated reflectance increased with increasing incident angles. This phenomenon was reported to be significant at angles of incidence more than 50 degrees. A more recent paper (Levinson 2010a and 2010b) stated that the E-1918A test method was within the accepted standard deviation of 0.01 for incident angles of as great as 60 degrees and for roof slopes of up to 5:12 (23 degrees). Roof slopes of between 5:12 (23 degrees) and 12:12 (45 degrees) were reported to have a standard deviation of 0.02. The studies by Levinson et al. also examined inconsistencies in the alternate test method related to glossy surfaces and air mass corrections. Errors in reflectance values related to air mass corrections include an underestimation during hazy skies and reduced reflectance values for high solar angles (defined as the sun angle from the solar zenith or normal to the ground) when the sun is lower in the sky and solar rays need to travel through a greater distance in the atmosphere.

One other standard that deserves mention is ASTM E-1980 *"Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces."* This standard is not a testing standard but references the testing standards mentioned here (including the withdrawn ASTM E-903) and is used to define the Solar Reflective Index (SRI). SRI is a measure that includes reflectance and emittance properties of materials and has become an industry standard for manufactured materials. The most recent versions of LEED NC use this metric but ASTM E-1980 is not appropriate for sloped roofs.

Case Studies

Two project sites are referenced in this paper. The first test site is a small to medium-sized warehouse of about 30,000 square feet located in an industrial area of Kent, Wash. The original low-slope built-up roof system was replaced in June 2009 with a highly reflective single-ply thermoplastic roof membrane. The roof membrane was tested for reflectance Sept. 30, 2010, using test methods E-1918A and ASTM E-1918-06 to verify reflectance performance and cleaning.

The second test site is Savery Hall (Figure 1) at the University of Washington, Seattle. Savery Hall is more than 80 years old and underwent a major renovation from 2005 50 2009 that included new roof systems on low-slope roofs. The original Vermont unfading green slate tile mansard roof system was evaluated and deemed acceptable to remain in place. The slope of the mansard roof was about 14:12 (49 degrees).

Figure 1Savery Hall, University of Washington, Seattle

Figure 2 Savery Hall, Slate assembly

The renovation project achieved LEED Gold Certification under LEED Version 2.1 (LEED 2002). During design and construction, the LEED 2.1 Sustainable Sites credit, SS7.2, *Heat Island Effect: Roof*, was considered and the slate roof system was tested for reflectance using test method ASTM C-1549. One slate tile sample was removed from each representative roof slope (north, south, east and west) and shipped to an

ASTM-accredited laboratory. The tiles tested in a range of reflectance values from 0.191 through 0.249 with an average value of 0.218.

The samples from Savery Hall were not cleaned before testing, and samples from the north and west slopes tested lowest because of limited solar exposure over time, shading from trees on-site and organic growth on the surface. The average reflectance of 0.218 is less than the 0.25 reflectance value prescribed by LEED 2.1 but greater than the required three-year aged reflectance value of 0.15. The slate roof system on this building has been in service for more than 80 years. By using LEED-accepted area averaging techniques and including a highly reflective coating on the upper low-slope roof areas, it would have been possible to build an argument for receiving the SS7.2 credit.

During the intial evaluation of the slate at Savery Hall in 2006 ASTM C-1549 was selected for reflectance testing because ASTM E-1918 was not prescribed in LEED Version 2.1 and limitations related to roof slopes made ASTM E-1918 a poor choice at the time. New information related to roof slopes and smaller test samples proposed in alternate method E-1918A spurred this study to evaluate new methods for testing reflectance on Savery Hall's steep-slope slate roof system. Additional reflectance testing in the field was conducted Oct. 1, 2010, using comparative test methods E-1918A and ASTM E-1918-06.

Hypotheses

Reflectance testing of steep-slope slate roof systems in the field was to be performed on Savery Hall's slate tile roof system, which could be classified as a variegated surface. Slate tile edges and gaps between tiles were slightly discolored (Figure 2) and likely would lead to lower reflectance values than those acquired from testing conducted on the single tile samples using test method ASTM C-1549. The expectation is that the in-situ reflectance test results would be somewhat lower than the C-1549 test results because of the roof assembly's configuration. It was anticipated the lower reflectance values will remain above 0.15, which is the lower limit for three-year aged reflectance requirements according to LEED 2.1.

It was anticipated that calculated reflectances would increase or be overestimated as incident angles increased, especially in the range of more than 50 or 60 degrees, as reported by others (Kinoshita, Levinson 2010a). The expectation was these errors would not be too great to affect the overall standard deviation and the test method would remain valid.

Test Methodology

The proposed alternate test method E-1918A (Akbari 2008b) was used for solar reflectance measurements. The test method required solar irradiance measurements taken using a standard pyranometer similar to the equipment required by ASTM E-1918-06 but with three additional measurements. The test procedure included the following measurements:

1. Solar irradiance—The pyranometer faced upward, directly away from the surface (in the direction of the normal to the surface).

2. White mask irradiance—Pyranometer directed at the surface with a 1-square-meter white mask of known reflectance (according to ASTM E-903) covering the target area
3. Black mask irradiance—Pyranometer directed at the surface with a 1-square-meter black mask of known reflectance (according to ASTM E-903) covering the target area
4. Target irradiance—Pyranometer directed at the surface with masks removed in the target area
5. Solar irradiance—The pyranometer faced back upward, directly away from the surface.

The formula for calculating solar reflectance (Akbari 2008b) is:

$$\mathrm{R}_t = \mathrm{R}_b + \frac{\mathrm{I}_3 - \mathrm{I}_2}{\mathrm{I}_1 - \mathrm{I}_2}(\mathrm{R}_w - \mathrm{R}_b)$$

Where R_t = Calculated reflectance of target

R_b = Known reflectance of black mask

R_w = Known reflectance of white mask

I_1 = Measured solar irradiation of white mask (watts/m^2)

I_2 = Measured solar irradiation of black mask white (watts/m^2)

I_3 = Measured solar irradiation of target (watts/m^2)

Calculated reflectance, R_t, is to be compared to incident angles, so in addition to reflectance measurements, incident angles were measured for each test.

Experiment Design

A standard pyranometer, model CMP3 by Kipp and Zonen, was used for solar measurement and 26-gauge coated sheet metal was used for the white and black masks. The surface of the sheet metal masks could be considered to have glossy surfaces. The pyranometer was fixed to a stand that allowed the device to be extended over test areas (Figure 3) without producing a significant shadow that might introduce errors related to shading or shadows. A specially designed solar angle calculator (Figure 4) measured the sun angle from the roof surface for each irradiance measure. The solar angle calculator was placed on the surface of the roof at each test location, and the angle between the sun's rays and roof surface recorded. The incident angle to be used in comparisons is 90 degrees minus this measured surface angle.

Figure 3. E-1918A set up on low-slope roof

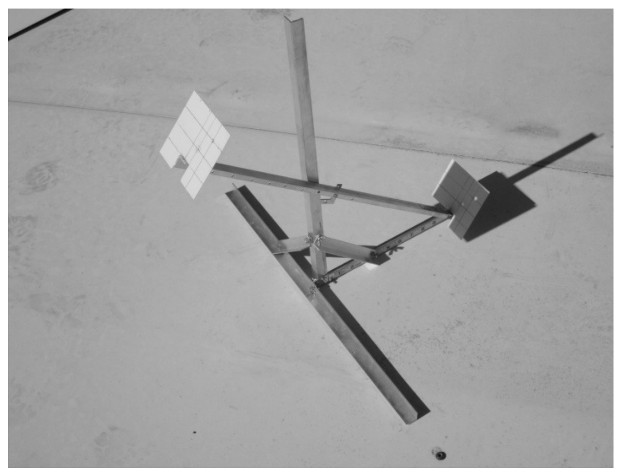

Figure 4. Specially designed solar angle calculator

Solar reflectance testing was conducted on two buildings in Seattle Sept. 30 and Oct. 1, 2010.

The first test site was the Pool Manning Building, a small to medium-sized warehouse located in an industrial area of Kent, Wash. The highly reflective white single-ply thermoplastic, low-slope roof membrane was about 15 months old and appeared to have considerable soiling. In one location on the low-slope roof, the target area was tested for reflectance, cleaned lightly using a mild detergent and a rag, and retested to determine how much of the product's published reflectance had been restored.

The second test site was Savery Hall at the University of Washington, Seattle. The support for the pyranometer was placed on the upper, low-slope roof**s** and the arm was extended down over the target location for mansard test locations. Sheet-metal hooks inserted under the tiles held the masks in place. Much of the work to place and remove the masks was accomplished from a ladder because of the steep 14:12 slope (Figure 5).

Figure 5. E-1918A set up on a steep-slope roof

Results

According to instructions proposed in E-1918A, small 1.5-inch samples from the white and black coated sheet-metal masks were shipped to an ASTM-accredited laboratory to be analyzed using ASTM E-903 before on-site reflectance field testing. The white-coated metal achieved a reflectance value of 0.730, and the black-coated metal has a reflectance value of 0.064.

The average reflectance of the white, reflective thermoplastic membrane at the Pool Manning Building was 0.667 using the alternate test method E-1918A. The standard deviation was 0.013, which represents an error of ± 1.9 percent at this reflectance level. Using test method ASTM E-1918-06, the average reflectance value was 0.616 with a standard deviation of 0.019 and an error of ± 3.1 percent. When cleaned, the test areas have an average reflectance of 0.741 using E-1918A. This represents an 11 percent increase in reflectivity and brought the product back to within 6 percent of its published value of 0.79. This published value is reported to have been tested using test method ASTM C-1549.

The calculated solar reflectance of the low-slope test areas were compared to the incident angles and prove**d** to be relatively consistent through incident angles of 48 degrees through 60 degrees (Figure 6).

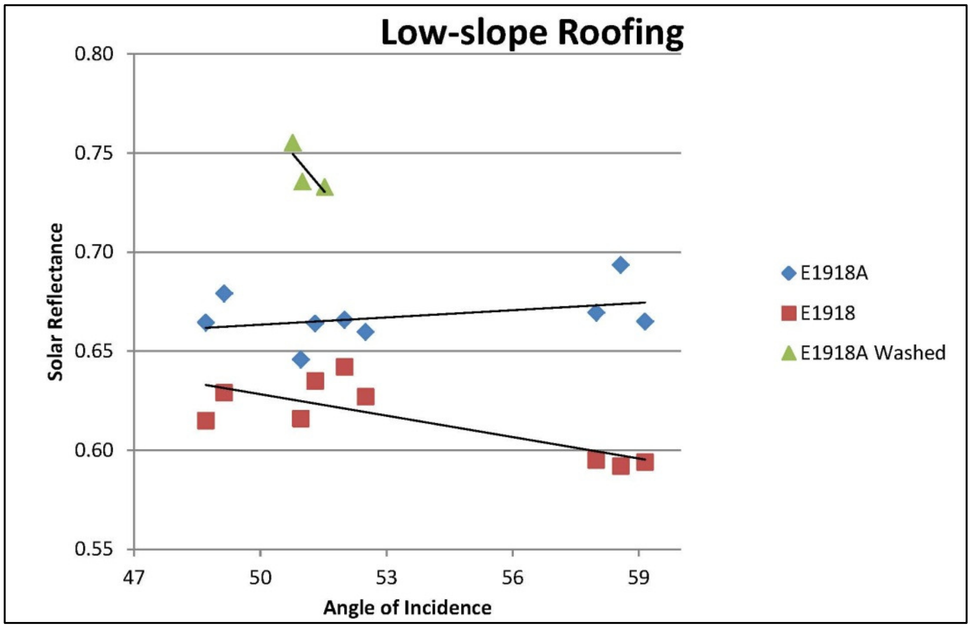

Figure 6. Measured solar reflectance of low-slope roof membrane.

For the steep-slope slate tile roof at Savery Hall, the average reflectance using test method E-1918A was 0.146. Using test method ASTM E-1918-06, it was 0.158. The standard deviation for E-1918A was 0.008 which appears to be a reasonable error margin, but it represents a deviation of ± 5.5 percent for a reflectance value of this magnitude. The standard deviation for ASTM E-1918 was a little better at 0.005, which represents a deviation of ± 3.2 percent. These results are about 27 percent lower than the C-1549 test average of 0.218 for single slate tiles. It was anticipated this would be the case because of the variegated surface of the in-situ tile assembly.

The solar reflectance test values of slate roof systems when compared to incident angles demonstrated a decreasing value as the incident angles increased (Figure 7). The data also shows that for an extremely steep slope, such as the mansard roofs at Savery Hall that face partially south, the incident angle changes quickly. On average, the incident angle changes by 1 degree every four minutes.

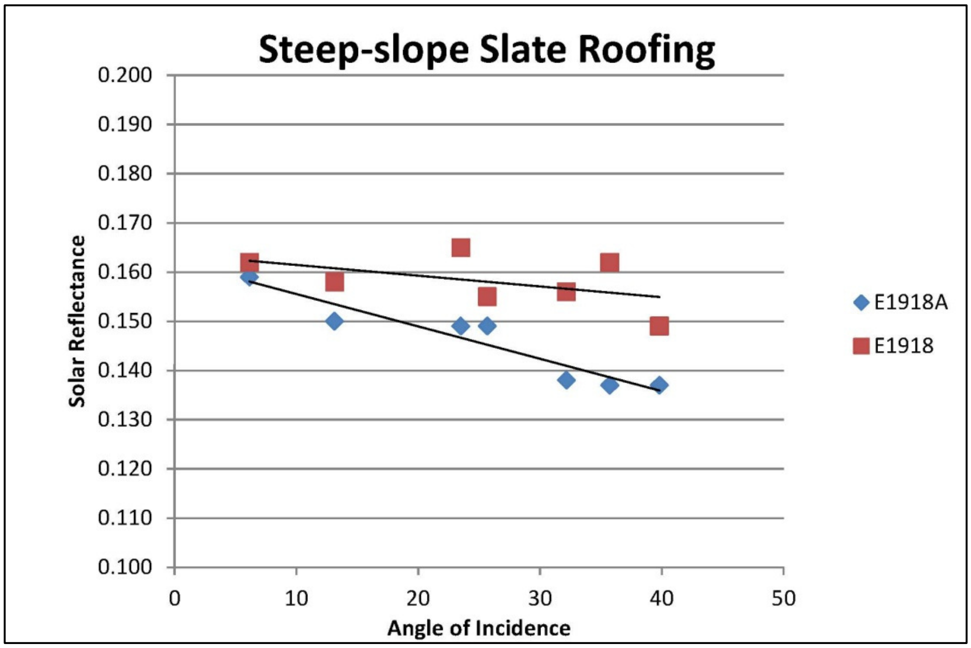

Figure 7— Measured Reflectance of steep slope slate roofing.

Discussion

Test results for low-slope roof reflectance demonstrated a number of positive results. First, the testing for E-1918A proved to be relatively consistent with a standard deviation of 0.013, and the trend of increased reflectance with increased incident angles was recorded as expected. This deviation represented an error of less than ± 2.0 percent. The standard deviation for ASTSM E-1918-06 is slightly higher at 0.019 (± 3.1 percent) and the reflectance decreased with increased angles of incidence. The trend of increased reflectance relative to increased incident angles was not excessive at high angles of incidence, showing the proposed test method E-1918A is able to reduce errors associated with high incident angles known to present errors using ASTSM E-

1918-06. These results were achieved with incident angles as high as 59.15 degrees, validating the published limit of 60 degrees (Levinson 2010a).

Test results for cleaning also were positive as the soiled surface recorded an average reflectance of 0.663, which would be expected after 15 months in-service in an industrial area. Light cleaning brought the membrane to 0.741, within 6 percent of its published reflectance value of 0.79, which also is a reasonable expectation. If anything, the results here may have been underestimated because of air mass corrections for high incident angles and errors associated with the glossy surfaces of the masks and roof membrane. Test method E-1918A appears to be appropriate for testing low-slope roofs as a method to validate cleaning and monitor reflectance over time.

The results for steep-slope roofs were not as consistent as the low-slope roof results with a standard deviation of 0.008 for E-1918A. This represents an error of ± 5.8 percent. The reflectance decreased with increasing angles of incidence in the range of 5 to 45 degrees, which is the opposite of what was expected and counter to research by others (Levinson 2010a). One factor for this discrepancy is the rapidly changing incident angles on south-facing slope surfaces. On average, the incident angle changed by 1 degree every four minutes during testing at Savery Hall. It is apparent that testing on a roof with this steep of a slope during September and October, a time of year where the true solar angle is high (the sun is lower in the sky) in Seattle, introduces additional errors associated with the distance that light travels through the atmospheric air mass as the sun moves across the sky. This error is coupled with incident angle errors associated with the glossy surfaces of not only the target but also the masks. It is likely the reflectance was underestimated for most of the steep-slope testing.

It also is apparent ASTM E-1918-06 and E-1918A are not appropriate test methods for steep-slope roofs similar to the 14:12 (49-degree) slopes of Savery Hall's slate mansard roof. The errors and inconsistencies likely create an underestimation that may reduce the opportunity to prove traditional roofing materials such as slate is energy-efficient in terms of roof reflectance.

A positive result for steep-slope slate roofs of this type and color is that the ASTM E-1918-06 test result is 0.158, which is higher than the three-year aged reflectance performance standard for sloped roofs of 0.15 prescribed by LEED 2.1 standards (LEED 2002). The slate roof system at Savery Hall was capable of achieving the LEED SS7.2 credit for heat island reduction. This is a significant finding for historic preservationists and designers of renovation projects intent on pursuing LEED certification. This study shows traditional materials such as slate are can meet LEED standards and be retained on a building for sustainable design tenets such as reuse, waste reduction and reduction of new materials and associated production and transportation energy, as well as for energy conservation during the life of a building through reduced energy for heating and cooling.

Conclusions

We have shown here that within acceptable margins of error, the proposed alternate E-1918A is repeatable and acceptable for incident angles of as high as 60 degrees when used on low-slope roofs. E-1918A would be an acceptable standard to use for monitoring reflectance over time and verifying cleaning of roof surfaces to restore reflectance and provide energy conservation.

For steep-slope roofs, especially slopes more than 12:12 (45 degrees), ASTM E-1918-06 and E-1918A appear inappropriate as a number of errors were identified. The slope limitations cited by others (Levinson 2010a and 2010b) appear valid. This begs the question, “How do we evaluate steep-slope roofs such as the one at Savery Hall?” The underestimation of solar reflectance at steep slopes and high incident angles does appear somewhat predictable, and perhaps error corrections could be introduced into the ASTM E-1918 standard to account for this. Considerable study with sufficient data points will be required to create a mathematical model that is acceptable and repeatable. This would be the subject of another paper.

Alternately, a new test method for measuring solar reflectance could be developed that would reduce the errors and inconsistencies found in this study. A new test method might use an artificial light source that would address the challenges associated with testing using natural light. Limitations of natural light include the need for clear skies and the limited times of day and year with acceptable levels of sunlight. Although the sun is the ideal light source, especially when modeling solar heat gain, test method ASTM C-1549, with an artificial light source that mimics the solar spectrum, generally is accepted in the industry. ASTM C-1549 has been proven to approximate reflectance values using solar field testing. A new test method for field testing also could use an artificial light source that approximates the solar spectrum; however, the light source would need to be strong enough to cover a large sample area to account for variegated and curved surfaces and assemblies. Hopefully, this type of research currently is being conducted, and by the time this paper is presented, there already will be a new method available that is similar to what is described here.

This paper validates alternate test method E-1918A for certain uses and advocates for inclusion of the proposed revisions of the next version of ASTM E-1918. It also is a call-to-action for industry researchers and manufacturers of sensing devices to develop a new sensing device that can make solar reflectance measurements in the field easier and more accurate for roofing contractors, roof consultants and the construction industry in general.

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