Durability of High-Albedo Roof Coatings

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SYNOPSIS

This paper describes the effect of weathering on cooling energy savings from high-albedo roof coatings.

ABSTRACT

Twenty-six spot albedo measurements of roofs were made using a calibrated pyranometer. The roofs were surfaced with either an acrylic elastomeric coating, a polymer coating with an acrylic base, or a cementitious coating. Some of the roofs' albedos were measured before and after washing to determine whether the albedo decrease was permanent.

Data indicate that most of the albedo degradation occured within the first year, and even within the first two months. On one roof 70% of one year's albedo degradation occured in the first two months. After the first year, the degradation slowed, with data indicating small losses in albedo after the second year. Measurements of seasonal cooling energy savings by Akbari et al. (1993) include the effects of over two months of albedo degradation. We estimate ~20% loss in cooling energy savings after the first year because of dirt accumulation.

For most of the roofs we cleaned, the albedo was restored to within 90% of its initial value. Although washing is effective at restoring albedo, the increase in energy savings is temporary and labor costs are significant in comparison to savings. Our calculations indicate that it is not cost-effective to hire someone to clean a high-albedo roof only to achieve energy savings. It would be useful to develop and identify dirt-resistant high-albedo coatings.

INTRODUCTION

High-albedo roof coatings can be used to reduce building air-conditioning use and, if implemented at large-scale, might reduce summer urban temperatures. By lowering absorption of solar energy, high-albedo coatings reduce building surface temperatures, and heat-transfer to the building interior. The lower surface temperatures also reduce the building's contribution to urban air temperature (Akbari et al., 1988). To maximize cooling energy savings, high-albedo roof coatings should 1)have high solar reflectance (both in the visible and near-infrared bands), 2)have high infrared emittance, and 3)maintain these properties for the service life of the coating.

This paper addresses the albedo durability of solar reflective roof coatings, as part of a joint project between this Laboratory and a utility to assess the use of high-albedo building materials for cooling-energy savings. A more detailed version of this paper that contains a review of research on durability appears as LBL No 34974. Roof albedo measurements, with implications of the results for the use of high-albedo roof coatings for cooling-energy savings are presented here.

BACKGROUND REVIEW

Definition of Albedo

In this paper, we use the term albedo to refer to the integrated hemispherical reflectance within 0.28 and 2.8 micrometers (um). The term "albedo" as applied to a sloped roof is not a clearly defined parameter. Since a sloped roof receives some radiation that is reflected from surroundings and re-radiated by the ground, the spectral distribution of incoming radiation is different than that on a horizontal roof. The spectral distribution of radiation reaching the roof from surroundings can also be temporally variable. To estimate the albedo of sloped roofs in this study, we measured the hemispherical incident radiation as measured on a plane parallel to the roof surface, as close to the peak of the roof as possible (to minimize the detection of outgoing radiation).

Techniques for Measuring Albedo

Albedo can be measured in the field or the laboratory. Typically, laboratory measurements include the use of a spectrophotometer with an integrating sphere. This device is capable of measuring the spectral characteristics of a material over the solar region of the electromagnetic spectrum, from approximately 0.3 to 2.5 um. Spectral reflectance is measured in reference to a working standard, such as barium sulfate. Solar spectral reflectance is then calculated using a standard spectral irradiance distribution.

The advantage of albedo calculations based on laboratory measurements is that the laboratory measurements are more easily controlled than field measurements. Thus, it is easier to make comparisons between materials under similar environmental conditions. Such spectral reflectance data and infrared emittance data have been reported for a number of high-albedo roof coatings (Yarbrough and Anderson, 1993; Parker et al., 1993). Measurements indicated that coatings must be applied at a minimum critical thickness to obtain optimum solar reflectance (Yarbrough and Anderson, 1993). Of course, this minimum critical thickness depends on the coating. The implication is that a cost comparison should compare cost per unit thickness, which depends on percent solids by volume, rather than cost per unit volume.

Field measurements of albedo typically involve the use of a radiometer for measuring the incident and reflected radiant flux. We use a high precision pyranometer that is sensitive of radiant energy in the 028 to 2.8 micrometer range. The pyranometer is mounted on a stand described in Taha et al. (1992). The stand LBL uses is designed to minimize the effects of the pyranometer's shadow and radiation reflected by surroundings. Uncertainties in the field measurements include the effect of the shadow of the pyranometer when it is facing down, error resulting from 1)radiation that is reflected by surroundings other than the surface in question, 2)solar incidence angle, and 3)nonuniformity of the surface. In contrast to the spectrophotometer, which measures the albedo of a small (~3 cm^2) sample, the pyranometers measures reflected radiation from a large area. A ratio of 1/10 between the pyranometer's height and the diameter of a test area is required for a view factor of 95% or better from the roof to the inverted pyranometer.

Measurements of solar albedo should not be confused with reflectivity measurements, based on surface reflectance of visible radiation. Roof coating manufacturers may claim reflectances of over 90%, citing various test methods that involve a visual comparison of a test sample and standard (ASTM, 1992a).

Effects of Weathering

The performance of reflective roof coatings as an energy-efficiency measure is directly related to albedo. The temperature of a roof is approximately equal to the sol-air temperature, T_{sa}.

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