Focus

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Our Green Roofs

White Roofs: Are They Sustainable?

By Helen J. Kessler, FAIA

We often hear that white roofs are more "sustainable" and cooler than dark colored, ballasted or aluminum-coated roofs. I have long been a proponent of white roofs, especially for hot cooling-dominated climates. Additionally, I have often said that the energy cost savings available to a building with a white roof are not large if the R-value of the roof insulation is above 25. The main reasons to install a white roof include urban heat island mitigation and possibly cooler intake air for roof top units and increased longevity for the roof.

Characteristics of White Roofs

The primary characteristics of most white roofs are their high reflectivity and high emissivity. (Emissivity is the measure of a material's ability to release infrared radiation or heat.) The combination of high reflectivity and high emissivity means that the roof doesn't warm up much above the ambient temperature even on the hottest sunniest days. It is often suggested that aluminum coatings are just as good as white for keeping a roof cool; however, metals have a very low emissivity. In other words, the small amount of heat that is absorbed by an aluminum coating isn't easily released and will cause the aluminum roof to be warmer than the white roof.

The Re-examination of Roof Color

Discussions regarding roof color began in earnest during the energy crises in the 1970s when saving energy in buildings grew in importance and much research was done to understand passive approaches for solar heating and cooling. Lawrence Berkeley National Laboratory (LBNL) was in the forefront of this research and collected data and performed calculations on the effect of roofs on energy consumption.

In the mid-1990s, a heat wave in Chicago was implicated in the deaths of over 700 people. Architects and others sought to prevent such a tragedy from occurring again and the use of white roofs to reduce the urban heat island effect was re-examined. The urban heat island effect occurs in urban areas where, due to the thermal mass of the buildings, roads and parking lots, the ambient temperature rises higher during the day than in a rural or suburban environment and often stays higher at night due to the slow release of heat from those high mass materials.

Reflective Roofing Requirements

With these increasing concerns, a number of government entities, including California and Chicago, have provided incentives and/or mandates for cool, generally white, roofs. This was an especially controversial part of the Chicago Energy Conservation Code which became our standard in September 2002. Originally, the intent of the code was to mandate Energy Star roofs with the added requirement of an emissivity of 0.90. This would have required that new roofs with a slope of between 0:12 and 2:12 have a reflectivity of at least 0.65. The local roofing association lobbied against this part of the ordinance and the City changed it to require a minimum reflectivity of 0.25 through December 31, 2008 after which all roofs will need to meet the Energy Star minimum reflectivity requirement.

The U.S. Green Building Council's LEED rating system gives a point for Sustainable Sites Credit 7.2, Heat Island Effect, Roof. Their intent is to reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat and reduce the formation and impact of smog. LEED gives buildings with flat roofs (slope less than or equal to 2:12) a point for use of a white roof with a reflectivity of at least 0.65 and emissivity of at least 0.9 (total Solar Reflectance Index (SRI) of at least 79). Steep-sloped roofs may have an SRI of 29 (see table at right).

Research Results

Both LBNL and Oak Ridge National Laboratory (ORNL), among others, have researched cool roofs. LBNL created a Heat Island Group and more information can be found at http://eetd.lbl.gov/heatisland/coolroofs/. ORNL has written several research papers with enlightening results. One is called: Field Performance of High-Reflectance Single-ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates, August 2002, and the other is called Evaluating the Energy Performance of Ballasted Roof System - interim report, September 2007. These reports have concluded:

- The reflective benefit of a white roof is reduced over time if it is not cleaned.
- The energy efficiency benefits and roof membrane temperature of a ballasted roof appear to be similar to those of a white roof that has not been cleaned.
- A ballasted roof membrane stays warmer after the sun goes down than does a single ply roof.
- A black roof dramatically increases roof membrane temperatures, most likely increasing the urban heat island effect.
- Heavier (in weight) roof ballast

SRI Values for Typical Roofing Materials:

Example SRI Values for Generic Roofing Materials	Solar Reflectance	Infrared Emittance	Temperature Rise	Solar Reflectance Index (SRI)
Gray EPDM	0.23	0.87	68F	21
Gray Asphalt Shingle	0.22	0.91	67F	22
Unpainted Cement Tile	0.25	0.9	65F	25
White Granular Surface Bitumen	0.26	0.26	63F	28
Red Clay Tile	0.33	0.9	58F	36
Light Gravel on Built-up Roof	0.34	0.9	57F	37
Aluminum	0.61	0.25	48F	56
White-Coated Gravel on Built-up Roof	0.65	0.9	28F	79
White Coating on Metal Roof	0.67	0.85	28F	82
White EPDM	0.69	0.87	25F	84
White Cement Tile	0.73	0.9	21F	90
White Coating - 1 coat, 8 mils	0.8	0.91	14F	100
PVC White	0.83	0.92	11F	104
White Coating - 2 coats, 20 mils	0.85	0.91	9F	107

Values based on the Lawrence Berkeley National Laboratory Cool Roofing Materials Database.
Please note that actual reflectivity and emissivity should be based on manufacturer data.

and pavers reduce roof membrane temperatures more than lighter roof ballast.

Conclusions

Choice of roof color should be viewed as one element of a roof system with all elements contributing toward a particular purpose. Generally, the purpose of a roof system is to protect a building from the elements and keep its inhabitants comfortable. A white roof, as well as other colored roofs, can do that. In any case, good insulation is critical to comfort and effective in lowering utility bills. Good insulation also has a far greater impact on energy cost savings than the color of the roof. However, for buildings without roof insulation, a white roof will have a significant positive effect on summer comfort during hot sunny days. If your project has a particularly large roof, it is especially beneficial to consider use of a cool roof to reduce the urban heat island effect.

Additional Resources

The Cool Roof Rating Council, www.coolroofs.org, is a non-profit organization dedicated to implementing and communicating fair, accurate and credible radiative energy performance rating systems for roof surfaces. They also support research and provide education. Their website lists the reflectivity and emissivity characteristics of many manufacturers' roofing systems.

The U.S. Environmental Protection Agency created the Energy Star Program, which provides solar reflectance levels of individual roof products to meet the Energy Star labeling requirements. Learn more at: http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products.

"Cool Roofing: A 10-Year Retrospective," Thomas W. Hutchinson, Buildings, February 2007, pp. 52 - 56. This article provides an alternative perspective on many of the issues surrounding cool roofing. ■

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