Cool Construction Materials Offer Energy Savings

Source/Author: Hashem Akbari

Modern urban areas usually have darker surfaces than their surroundings. Use of dark roofs and pavements affects the climate, energy use, and habitability of cities. At the building scale, dark roofs are heated by the summer sun and thus raise the summertime cooling demand. Figure 1 shows the midday temperatures of various horizontal surfaces exposed to sunlight. For highly absorptive (low-albedo*) surfaces, the difference between the surface and ambient air temperatures may be as high as 50°C (100°F), while for less absorptive (high albedo) surfaces such as white paint, the difference is only about 10°C. For this reason, "cool construction materials" (which absorb little insolation) are effective in reducing cooling energy use. Cool surfaces incur no additional cost if color changes are incorporated into routine re-roofing and resurfacing schedules. Scientists at the Lawrence Berkeley National Laboratory and the Florida Solar Energy Center have measured cooling energy savings in the range of 10 to 50% (ranging from $10 to $100 per year per 100ft^2 (approx. 100m^2) in several residential and small commercial buildings. Numerous experiments on individual buildings in California and Florida show that painting roofs white reduces air conditioning load between 10 and 50%, depending on the thickness of the insulation under the roof. The savings, of course are strong functions of the thermal integrity of a building and climate conditions.

Most high-albedo surfaces are light-colored, although selective surfaces which reflect a large portion of the infrared solar radiation, but absorb some visible light, may be dark colored, yet have relatively high albedos. Figure 2 shows the steady-state surface temperature of some roofing materials on a cold November day. Note the 10°C drop in the black surface (sample 1) when it is covered with a selective "XIR" film (sample 5), which transmits visible light, but reflects in the near-IR. This phenomenon is better explained by inspecting the spectral reflectance of surfaces as shown on Figure 3. On a clear, sunny day, over 40% of the incoming solar radiation is near-infrared. Hence it is possible to develop cool materials that are highly reflective in the near infrared band with a choice of light colors in the visible spectrum.

Darker surfaces also more quickly warm the air over urban islands, leading to the creation of summer urban "heat islands." On a clear summer afternoon, the air temperature in a typical city can be about 1 - 5°C (2-9°F) hotter than the surrounding rural area. We have found that peak urban electric demand in five American cities (Los Angeles, Calif.; Washington, D.C.,; Phoenix, Ariz.; Tucson, Ariz.; and Colorado Springs, Colo.) rises by 2-4% for each 1°C rise in daily maximum temperature above a threshold of 15 to 20°C[1]. The additional air-conditioning use caused by this urban air temperature increase is responsible for 5-10% of urban peak electric demand at a direct cost of several billion dollars annually.

Scientists at LBNL have examined the impacts of using cool surfaces (cool roofs and pavements) on reducing the urban air temperature and hence further reducing cooling energy use and smog. At the community scale, increasing the albedo (solar reflectivity) of urban surfaces can limit or reverse an urban heat island effectively and inexpensively. Increasing the albedo of urban surfaces can be implemented by 1) rating and labeling roofing materials by their temperature rise on a cloudless summer day; 2) adopting relatively mild standards (for example, that new roofs run cooler than halfway between the surface temperature of typical white and black surfaces); and 3) electric utilities offering rebates on new roofs (or reroofs) for beating the standards.

LBNL researchers have simulated the cooling achieved by increasing the reflectivity (albedo) of roofs and roadways in the Los Angeles Basin.[3] About 17% of the urbanized area in the basin is covered by roofs and roads which can realistically have their albedo raised by 30% when they receive their normal repairs. The results are shown in Figure 4 - a 2°C (4°F) cooling by 3 p.m. This summertime temperature reduction has a significant effect on further reducing building cooling energy use. An estimate of the national impact of cooling surfaces (combining the cooling effect at the building level and community-wide cooling) is summarized in Table 1.

The effect of temperature on smog is also very significant. At low maximum daily temperatures (below 22°C), the maximum concentration of ozone is below the California standard of 90 parts per billion (ppb); at high temperatures (above 35°C) practically all days are smoggy. We have simulated the impact of urban-wide cooling in Los Angeles on smog; the results show a significant reduction in ozone concentration[3,4] as seen in Figure 5. The simulations predict a reduction in population-weighted smog (ozone) of 10-20%. This reduction, for some smog scenarios, is comparable to ozone reductions obtained by replacing all gasoline on-road motor vehicles with electric cars.

Table 1 describes potential savings from increased albedo. However, achieving this potential is conditional on receiving the necessary federal support. An important step in initiating an effective program in this area was to work with ASTM Committee E-6 on Performance of Buildings, E06.42 on Cool Construction Materials, was formed as part of a national plan to exploit cool construction technology and materials.

In 1994, a group of industry representatives, including several ASTM members, from the public and private sectors, attended two workshops on cool construction materials. The group formed the National Committee for the Planning of the Cool Construction Materials Program. One of the major tasks in this National Plan is to develop performance data and standard procedures for the evaluation of cool construction materials. Subcommittee E06.42 was formed as the vehicle to develop standard practices for measuring, rating, and labeling of cool construction materials.

The subcommittee has determined that two optical properties (solar reflectance and emissivity) need to be measured in both the laboratory and the field. In response to lack of standards for field measurements of solar reflectance, the subcommittee has drafted a test method for measuring solar reflectance of horizontal and low-sloped surfaces. The subcommittee believes that two existing ASTM standards, E 903, Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials using Inspection-Meter Techniques, meet the needs for laboratory measurement of these properties.

Another activity of the subcommittee includes developing a Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Surfaces. It is the objective of this standard to define a Solar Reflectance Index (SRI) which measures the relative steady-state of temperature of a surface with respect to the standard white (SRI = 100) and standard black (SRI = 0) under the solar and ambient conditions.

Besides the ASTM activities, the National Plan for Cool Construction Materials includes other major tasks such as:

1. Developing a cool materials data base and making it widely available to the industry, utilities, contractors, architects, roofers, state and local procurement officers, consumers and communities.
2. Incorporating cool roofs into the Building Energy Performance Standards of the American Society for Heating, Refrigeration and Air Conditioining Engineers (ASHRAE), the Council of American Building Officials (CABO), California Title 24, and Air Quality Management Plans. Standards can be relatively mild if accompanied by Step 4.
3. Developing programs for utilities to offer rebates or other incentives to beat the standards. This will require support from state public utility commissions.
4. Initiating information programs for all the groups mentioned in Step 2, and distributing information by grassroots support networks to building owners and local governments.
5. Demonstrating savings in selected "Cool Communities," including Federal and state facilities. This will require support by local utilities.
6. Establishing aggressive policies for the procurement of cool roofing materials by Federal, state and local governments.
7. Expanding the Los Angeles Basin "RECLAIM" NOx-credit trading market to include air temperature reduction by cool surfaces. The California South Coast Air Quality Management District (SCAQMD) has initiated a program to monetize any growth of smog feedstocks (specifically in NOx) can be traded on a "credit stock-market" called "RECLAIM." SCAQMD and the U.S. Environmental Protection Agency (EPA) now recognize that air temperature is as much a cause of smog as the feedstocks themselves (NOx and volatile organic compounds) so that cool surfaces should be monetized in RECLAIM along with NOx.

References:

- [1]Akbari, H.; Rosenfeld, A.; and Taha, H. 1989. "Recent Developments in Heat Islands Studies, Technical and Policy," Proceedings of the Workshop on Urban Heat Islands, Berkeley, CA, (February 23-24).
- [2]Akbari, H.; Davis, S.; Dorsano, S.; Huang, H.; and Winnett, S. (editors). 1992. Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing. U.S. Environmental Agency, Office of Policy Analysis, Climate Change Division.
- [3]Taha, H. 1995. "Modeling the Impacts of Increased Urban Vegetation on the Ozone Air Quality in the South Coast Air Basin," LBL-37317.
- [5]Berdahl, P. and Bretz, S. 1994. "Spectral Solar Reflectance of Various Roof Materials," presented at the Cool Building and Paving Materials Workshop, Gaithersburg, Md., July 1994.

Energy Seal Coatings

Our high albedo roof coatings will not only protect and prolong the service life of a roof they can also have a positive affect on the air temperature on and around the roof of a building. Our coatings solar reflectance has proven valuable in the drive to reduce the Heat Island effect on many major metropolitan areas in the United States.

- Energy Seal Coatings have been given the Energy Star rating by the Department of Energy and the Environmental Protection agencies of the United States.
- Our coatings comply with California’s Title 24 mandate for high albedo roofing materials’.
- Our coatings also qualify for the LEED Green Building programs drive to make commercial, industrial and residential structures’ more energy efficient.
- Our coatings energy efficiency qualifies for cash rebates from power companies in several large metropolitan communities.